

Ecological Soil Screening Levels for Barium

Interim Final

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1.0 INTRODUCTION

Ecological Soil Screening Levels (Eco-SSLs) are concentrations of contaminants in soil that are protective of ecological receptors that commonly come into contact with and/or consume biota that live in or on soil. Eco-SSLs are derived separately for four groups of ecological receptors: plants, soil invertebrates, birds, and mammals. As such, these values are presumed to provide adequate protection of terrestrial ecosystems. Eco-SSLs are derived to be protective of the conservative end of the exposure and effects species distribution, and are intended to be applied at the screening stage of an ecological risk assessment. These screening levels should be used to identify the contaminants of potential concern (COPCs) that require further evaluation in the site-specific baseline ecological risk assessment that is completed according to specific guidance (U.S. EPA, 1997, 1998, and 1999). The Eco-SSLs are not designed to be used as cleanup levels and the United States (U.S.) Environmental Protection Agency (EPA) emphasizes that it would be inappropriate to adopt or modify the intended use of these Eco-SSLs as national cleanup standards.

The detailed procedures used to derive Eco-SSL values are described in separate documentation (U.S. EPA, 2003). The derivation procedures represent the effort of a multi-stakeholder group consisting of federal, state, consulting, industry, and academic participants led by the U.S. EPA Office of Solid Waste and Emergency Response.

This document provides the Eco-SSL values for barium and the documentation for their derivation. This document provides guidance and is designed to communicate national policy on identifying barium concentrations in soil that may present an unacceptable ecological risk to terrestrial receptors. The document does not, however, substitute for EPA's statutes or regulations, nor is it a regulation itself. Thus, it does not impose legally-binding requirements on EPA, states, or the regulated community, and may not apply to a particular situation based upon the circumstances of the site. EPA may change this guidance in the future, as appropriate. EPA and state personnel may use and accept other technically sound approaches, either on their own initiative, or at the suggestion of potentially responsible parties, or other interested parties. Therefore, interested parties are free to raise questions and objections about the substance of this document and the appropriateness of the application of this document to a particular situation. EPA welcomes public comments on this document at any time and may consider such comments in future revisions of this document.

2.0 SUMMARY OF ECO-SSLs FOR BARIUM

Barium is a yellowish-white, soft metal that is strongly electropositive. In nature, barium occurs in a combined state, the principal forms being barite (barium sulfate) and witherite (barium carbonate). Barium is also present in small quantities in igneous rocks such as feldspar and micas and may also be found as a natural component of fossil fuel. The production and use of various barium compounds in pyrotechnic devices, ceramics, paints, enamels, optical glasses, and as a getter to remove traces of gas from vacuum and television tubes may result in its release to the

environment through various waste streams. Barium is emitted into the atmosphere mainly by the industrial processes involved in the mining, refining, and production of barium and barium-based chemicals and as a result of combustion of coal and oil (<http://toxnet.nlm.nih.gov>).

Particulate phase barium is expected to be physically removed from the air by wet and dry deposition. Soluble barium compounds, such as barium nitrate, barium cyanide, barium permanganate, and barium chloride, are expected to be mobile in the environment. Soluble barium can react with sulfates and carbonates in water forming insoluble barium sulfate and barium carbonate salts (<http://toxnet.nlm.nih.gov>).

The solubility and mobility of barium is greater in sandy soil increasing with decreased pH and decreased organic matter content. Barium can react with metal oxides and hydroxides in soils, thus limiting its mobility and increasing adsorption. Barium mobility decreases in soils with high sulfate and calcium carbonate content. In biological organisms, barium possesses chemical and physiological properties that allow it to compete with and replace calcium in processes normally mediated by calcium, particularly those relating to the release of adrenal catecholamines and neurotransmitters, such as acetylcholine and noradrenaline (<http://toxnet.nlm.nih.gov>).

The Eco-SSL values derived to date for barium are summarized in Table 2.1.

Table 2.1 Barium Eco-SSLs (mg/kg dry weight in soil)			
Plants	Soil Invertebrates	Wildlife	
		Avian	Mammalian
NA	330	NA	2000
NA = Not Available. Data were insufficient to derive an Eco-SSL.			

Eco-SSL values for barium were derived for soil invertebrates and mammalian wildlife. Eco-SSLs could not be derived for plants or avian wildlife. For these receptor groups, data were insufficient to calculate an Eco-SSL. The Eco-SSLs for barium for soil invertebrates and mammalian wildlife are 330 mg/kg dry weight (dw) soil and 2000 mg/kg dw, respectively. The soil invertebrate Eco-SSL for barium is lower than the 75th percentile for background concentrations in eastern and western U.S. soils (Figure 2.1). The mammalian Eco-SSL for barium is higher than the range of background concentrations in eastern and western U.S. soils (Figure 2.1).

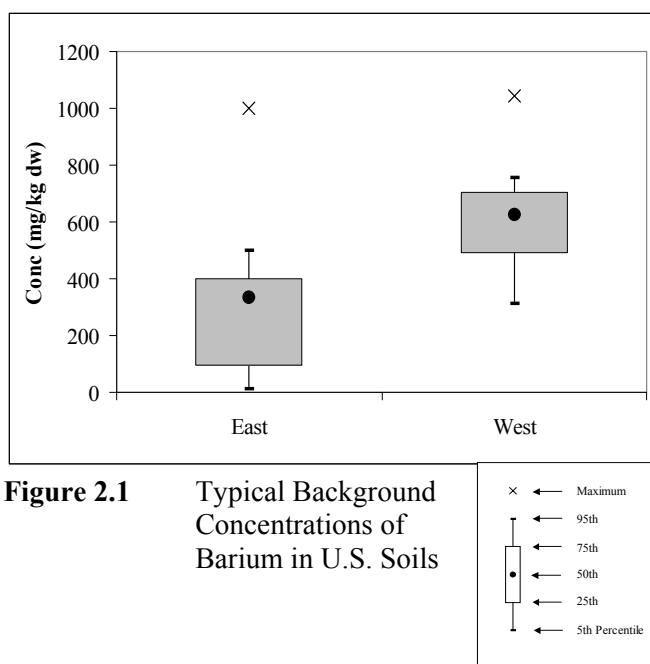


Figure 2.1 Typical Background Concentrations of Barium in U.S. Soils

The reported background concentrations of metals in U.S. soils are described in Attachment 1-4 of the Eco-SSL guidance (U.S. EPA, 2003).

3.0 ECO-SSL FOR TERRESTRIAL PLANTS

Of the papers identified from the literature search process, 30 were selected for acquisition for further review. Of those papers acquired, three met all 11 Study Acceptance Criteria (U.S. EPA 2003; Attachment 3-1). Each of these papers were reviewed and the studies were scored according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 3-2). One study received an Evaluation Score greater than ten. This study is listed in Table 3.1. An Eco-SSL could not be derived for barium according to the Eco-SSL guidance because only one study result is available for one test species with an Evaluation Score greater than ten (US EPA, 2003; Attachment 3-2).

4.0 ECO-SSL FOR SOIL INVERTEBRATES

Of the papers identified from the literature search process, 152 papers were selected for acquisition for further review. Of those papers acquired, four met all 11 Study Acceptance Criteria (U.S. EPA 2003; Attachment 3-1). Each of these papers were reviewed and the studies were scored according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 3-2). Three studies received an Evaluation Score greater than ten. The data from these studies are provided in Table 4.1.

The data in Table 4.1 were sorted by bioavailability score and all study results with a bioavailability score of two are used to derive the plant Eco-SSL for barium according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 3-2). The Eco-SSL is the geometric mean of the EC₂₀ values reported for each of three test species under three separate test conditions of pH and is equal 330 mg/kg dw.

5.0 ECO-SSL FOR AVIAN WILDLIFE

The derivation of the Eco-SSL for mammalian wildlife was completed as two parts. First the toxicity reference value (TRV) was derived according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-5). Second the Eco-SSL (soil concentration) was back calculated for each of three surrogate species based on the wildlife exposure model and the TRV (U.S. EPA, 2003).

The literature search completed according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-2) identified 837 papers with possible toxicity data for either mammalian or avian species. Only a single paper (Johnson et al., 1960) with data on the toxicity of barium to one avian species was identified; therefore, a TRV could not be derived and an Eco-SSL could not be calculated for avian wildlife (calculation requires a minimum of three results for two test species) (Johnson et al., 1960).

Table 3.1 Plant Toxicity Data - Barium

Reference	Test Organism		Soil pH	OM%	Bio-availability Score	ERE	Tox Parameter	Tox Value (Soil Conc. mg/kg dw)	Total Eval. Score	Eligible for Eco-SSL Derivation?	Used for Eco-SSL?
Chaudhry, A., 1977	Bush bean	<i>Phaseolus vulgaris</i>	7.1 - 8.4	1.0 - 2.4	0	GRO	MATC	1,414	11	Y	N

ERE = Ecologically relevant endpoint

GRO = growth

LOAEC = Lowest observed adverse effect concentration

MATC = Maximum acceptable toxicant concentration. Geometric mean of NOAEC and LOAEC.

N = no

NOAEC = No observed adverse effect concentration

OM = Organic matter content

Y = yes

Bioavailability Score described in *Guidance for Developing Eco-SSLs* (U.S. EPA, 2003)

Total Evaluation Score described in *Guidance for Developing Eco-SSLs* (U.S. EPA, 2003)

Table 4.1 Invertebrate Toxicity Data - Barium

Reference	Test Organism		Soil pH	OM %	Bio-availability Score	ERE	Tox Parameter	Tox Value (Soil Conc. mg/kg dw)	Total Eval. Score	Eligible for Eco-SSL Derivation?	Used for Eco-SSL?
Kuperman et al., 2002	Pot worm	<i>Enchytraeus crypticus</i>	4.36 - 5.29	1.2	2	REP	EC ₂₀	585	17	Y	Y
Phillips et al., 2002	Springtail	<i>Folsomia candida</i>	4.47 - 5.29	1.2	2	REP	EC ₂₀	165	18	Y	Y
Simini et al., 2002	Earthworm	<i>Eisenia fetida</i>	4.26 - 5.29	1.2	2	REP	EC ₂₀	370	17	Y	Y
Geometric Mean								330			

EC₂₀ = Effect concentration for 20% of test population

ERE = Ecologically relevant endpoint

OM = Organic matter content

REP = Reproduction

Y = yes

Bioavailability Score described in *Guidance for Developing Eco-SSLs* (U.S. EPA, 2003)

Total Evaluation Score described in *Guidance for Developing Eco-SSLs* (U.S. EPA, 2003)

6.0 ECO-SSL FOR MAMMALIAN WILDLIFE

The derivation of the Eco-SSL for mammalian wildlife was completed as two parts. First, the TRV was derived according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-5). Second, the Eco-SSL (soil concentration) is back-calculated for each of three surrogate species based on the wildlife exposure model and the TRV (U.S. EPA, 2003).

6.1 Mammalian TRV

The literature search completed according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-1) identified 837 papers with possible toxicity data for either mammalian or avian species. Of these studies, 826 were rejected for use as described in Section 7.5. Of the remaining papers ten contained data for mammalian species. These papers were reviewed and data extracted and scored according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-3 and 4-4). The results of the data extraction and review are summarized in Table 6.1. The complete results are included as Appendix 6 -1.

Within the ten papers there are 27 results for biochemical (BIO), behavior (BEH), physiology (PHY), pathology (PTH), reproduction (REP), growth (GRO), and survival (MOR) endpoints with a total Data Evaluation Score of > 65 that were used to derive the TRV. These data are plotted in Figure 6.1 and correspond directly with the data presented in Table 6.1. The no-observed adverse effect level (NOAEL) results for growth and reproduction are used to calculate a geometric mean NOAEL. This mean NOAEL is examined in relationship to the lowest bounded lowest observed adverse effect level (LOAEL) for reproduction, growth and survival to derive the TRV according to procedures in the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-5).

A geometric mean of the NOAEL values for growth and reproductive effects was calculated at 51.8 mg barium/kg bw/day. This value is lower than the lowest bounded LOAEL for reproduction, growth and survival (Figure 6.1). Therefore, the TRV is equal to the geometric mean of the NOAEL values for reproduction and growth (Figure 6.1) and is equal to 51.8 mg barium/kg bw/day.

6.2 Estimation of Dose and Calculation of the Eco-SSL

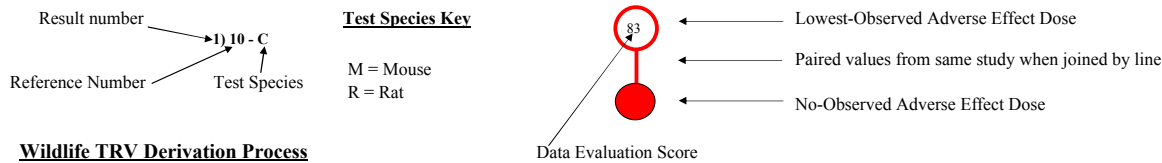
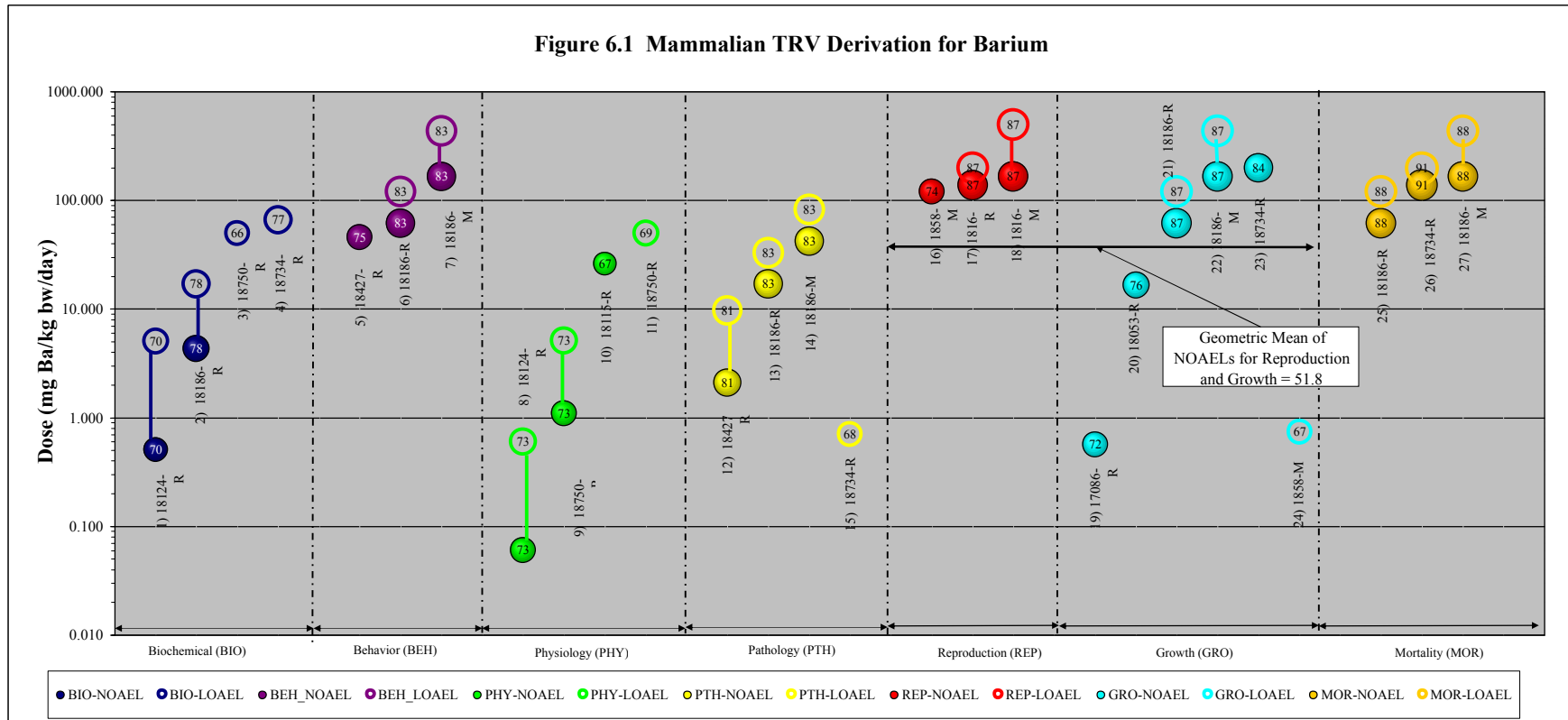
Three separate Eco-SSL values were calculated for mammalian wildlife, one each for three surrogate species representing different trophic groups. The mammalian Eco-SSLs derived for barium are calculated according to Eco-SSL guidance (U.S. EPA, 2003) and are summarized in Table 6.2.

**Table 6.1 Mammalian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)
Barium**

Result #	Reference	Ref No.	Test Organism	# of Conc/ Doses	Method of Analyses	Route of Exposure	Exposure Duration	Duration Units	Age	Age Units	Lifestage	Sex	Effect Type	Effect Measure	Response Site	NOAEL Dose (mg/kg bw/day)	LOAEL Dose (mg/kg bw/day)	Data Evaluation Score
Biochemical																		
1	Perry et al, 1983	18124	Rat (<i>Rattus norvegicus</i>)	4	U	DR	16	mo	NR	NR	JV	F	CHM	ATPT	HE	0.506	5.1	70
2	Dietz et al, 1992	18186	Rat (<i>Rattus norvegicus</i>)	6	UX	DR	92	d	43-44	d	JV	F	CHM	PHOS	SR	4.3	17.0	78
3	Perry et al, 1989	18750	Rat (<i>Rattus norvegicus</i>)	2	U	DR	16	mo	NR	NR	JV	F	ENZ	Other	HE		49.8	66
4	Borzelleca et al, 1988	18734	Rat (<i>Rattus norvegicus</i>)	5	U	GV	10	d	37	d	JV	F	CHM	UREA	BL		66	77
Behavioral																		
5	Tardiff et al, 1988	18427	Rat (<i>Rattus norvegicus</i>)	4	M	DR	13	w	4	w	JV	B	FDB	FCNS	WO	46		75
6	Dietz et al, 1992	18186	Rat (<i>Rattus norvegicus</i>)	6	UX	DR	92	d	43-44	d	JV	M	FDB	WCON	WO	61.1	121	83
7	Dietz et al, 1992	18186	Mouse (<i>Mus musculus</i>)	6	UX	DR	92	d	43-44	d	JV	M	FDB	WCON	WO	165	436	83
Physiology																		
8	Perry et al, 1983	18124	Rat (<i>Rattus norvegicus</i>)	4	U	DR	8	mo	NR	NR	JV	F	PHY	BLPR	WO	0.060	0.60	73
9	Perry et al, 1989	18750	Rat (<i>Rattus norvegicus</i>)	4	U	DR	8	mo	NR	NR	JV	F	PHY	BLPR	WO	1.1	5.1	73
10	McCauley et al, 1985	18115	Rat (<i>Rattus norvegicus</i>)	2	U	DR	5	mo	NR	NR	NR	NR	PHY	HTRT	HE	26.0		67
11	Perry et al, 1989	18750	Rat (<i>Rattus norvegicus</i>)	2	U	DR	16	mo	NR	NR	JV	F	PHY	BLPR	WO		49.7	69
Pathology																		
12	Tardiff et al, 1988	18427	Rat (<i>Rattus norvegicus</i>)	4	M	DR	8	w	4	w	JV	M	ORW	SMIX	AR	2.1	9.7	81
13	Dietz et al, 1992	18186	Rat (<i>Rattus norvegicus</i>)	6	UX	DR	92	d	43-44	d	JV	F	ORW	ORWT	KI	17.0	32.9	83
14	Dietz et al, 1992	18186	Mouse (<i>Mus musculus</i>)	6	UX	DR	92	d	43-44	d	JV	M	ORW	SMIX	LI	41.9	82.9	83
15	Schroeder and Mitchener, 1975	1858	Mouse (<i>Mus musculus</i>)	2	U	DR	520	d	19-20	d	JV	B	HIS	EDMA	WO		0.71	68
Reproduction																		
16	Dietz et al, 1992	18186	Rat (<i>Rattus norvegicus</i>)	6	UX	DR	92	d	43-44	d	JV	M	REP	RHIS	TE	121		74
17	Borzelleca et al, 1988	18734	Rat (<i>Rattus norvegicus</i>)	5	U	GV	10	d	37	d	JV	F	REP	RHIS	OV	138	198	87
18	Dietz et al, 1992	18186	Mouse (<i>Mus musculus</i>)	6	UX	DR	92	d	43-44	d	JV	F	REP	RHIS	TE	165	499	87
Growth																		
19	Schroeder and Mitchener, 1975	17086	Rat (<i>Rattus norvegicus</i>)	2	U	DR	520	d	21	d	JV	B	GRO	BDWT	WO	0.57		72
20	Stoewsand et al, 1988	18053	Rat (<i>Rattus norvegicus</i>)	2	U	FD	29	d	NR	NR	JV	M	GRO	BDWT	WO	16.5		76
21	Dietz et al, 1992	18186	Rat (<i>Rattus norvegicus</i>)	6	UX	DR	92	d	43-44	d	JV	M	GRO	BDWT	WO	61.1	121	87
22	Dietz et al, 1992	18186	Mouse (<i>Mus musculus</i>)	6	UX	DR	92	d	43-44	d	JV	M	GRO	BDWT	WO	165	436	87
23	Borzelleca et al, 1988	18734	Rat (<i>Rattus norvegicus</i>)	5	U	GV	10	d	37	d	JV	B	GRO	BDWT	WO	198		84
24	Schroeder and Mitchener, 1975	1858	Mouse (<i>Mus musculus</i>)	2	U	DR	10	d	19-20	d	JV	F	GRO	BDWT	WO		0.74	67
Survival																		
25	Dietz et al, 1992	18186	Rat (<i>Rattus norvegicus</i>)	6	UX	DR	92	d	43-44	d	JV	M	MOR	MORT	WO	61.1	121	88
26	Borzelleca et al, 1988	18734	Rat (<i>Rattus norvegicus</i>)	5	U	GV	10	d	37	d	JV	F	MOR	MORT	WO	137	197	91
27	Dietz et al, 1992	18186	Mouse (<i>Mus musculus</i>)	6	UX	DR	13	d	43-44	d	JV	M	MOR	MORT	WO	165	436	88

AR=adrenal; ATPT = adenosine triphosphate; B = both; BDWT = body weight changes; BL = blood; BLPR = blood pressure; bw = body weight; CHM = chemical; d = days; DR = drinking water; EDMA = edema; ENZ = enzyme; F = female; FCNS = food consumption; FD = food; FDB = feeding behavior; GRO = Growth; GV=gavage; HE= heart; HIS = histology; HTRT = heart rate; JV = juvenile; kg = kilogram; KI = kidney; LI = liver; LOAEL = lowest observed adverse effect level; M = measured; M = male; mg = milligram; mo = months; MOR = effects on survival; MORT = mortality; NOAEL = no observed adverse effect level; NR = not reported; ORW = organ weight changes; ORWT = organ weight; OV = ovary; PHOS = phosphate; PHY = physiology; REP = reproduction; RHIS = reproductive organ histology; Score = Total Data Evaluation Score as described in US EPA (2003; Attachment 4-3); SMIX = organ weight changes relative to body weight; SR = serum; TE = testes; U = unmeasured; UREA = urea; UX = reported as measured but measurements not reported; w = weeks; WCON = water consumption; WO = whole

Figure 6.1 Mammalian TRV Derivation for Barium



Wildlife TRV Derivation Process

- 1) There are at least three results available for two test species within the growth, reproduction, and mortality effect groups. There are enough data to derive a TRV.
- 2) There are at least three NOAEL results available for calculation of a geometric mean.
- 3) The geometric mean of the NOAEL values for growth and reproductive effects equals 51.8 mg barium/kg BW/day.
- 4) The geometric mean NOAEL value is lower than the lowest bounded LOAEL for reproduction, growth, or mortality effects.
- 5) The mammalian wildlife TRV for barium is equal to 51.8 mg barium/kg bw/day which is the geometric mean of the NOAEL values for growth and reproduction.

Table 6.2 Calculation of the Mammalian Eco-SSL for Barium						
Surrogate Receptor Group	TRV for Barium (mg dw/kg bw/d) ¹	Food Ingestion Rate (FIR) ² (kg dw/kg bw/d)	Soil Ingestion as Proportion of Diet (P _s) ²	Concentration of Barium in Biota Type (i) ^{2,3} (B _i) (mg/kg dw)	Barium in Diet of Prey ⁴ (C _{diet})	Eco-SSL (mg/kg dw) ⁵
Mammalian herbivore (vole)	51.8	0.0875	0.032	B _i = 0.156 * Soil _j where i = plants	NA	3200
Mammalian ground insectivore (shrew)	51.8	0.209	0.030	B _i = 0.091 * Soil _j where i = earthworms	NA	2000
Mammalian carnivore (weasel)	51.8	0.130	0.043	B _i = C _{diet} * 0.0075 where i = mammals	C _{diet} = 0.091 * Soil _j	9100

¹ The process for derivation of wildlife TRVs is described in Attachment 4-5 of U.S. EPA (2003).
² Parameters (FIR, P_s, B_i values, regressions) are provided in U.S. EPA (2003) Attachment 4-1 (revised February 2005).
³ B_i = Concentration in biota type (i) which represents 100% of the diet for the respective receptor.
⁴ C_{diet} = Concentration in the diet of small mammals consumed by predatory species (weasel).
⁵ HQ = FIR * (Soil_j * P_s + B_i) / TRV solved for HQ=1 where Soil_j = Eco-SSL (Equation 4-2; U.S. EPA, 2003).
 NA = Not Applicable

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7.0 REFERENCES

7.1 General Barium References

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7.2 References Used for Derivation of Plant and Soil Invertebrate Eco-SSLs

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7.3 References Rejected for Use in Derivation of Plant and Soil Invertebrate Eco-SSLs

These references were reviewed and rejected for use in derivation of the Eco-SSL. The definition of the codes describing the basis for rejection is provided at the end of the reference sections.

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Literature Rejection Categories		
Rejection Criteria	Description	Receptor
ABSTRACT (Abstract)	Abstracts of journal publications or conference presentations.	Wildlife Plants and Soil Invertebrates
ACUTE STUDIES (Acu)	Single oral dose or exposure duration of three days or less.	Wildlife
AIR POLLUTION (Air P)	Studies describing the results for air pollution studies.	Wildlife Plants and Soil Invertebrates
ALTERED RECEPTOR (Alt)	Studies that describe the effects of the contaminant on surgically-altered or chemically-modified receptors (e.g., right nephrectomy, left renal artery ligation, hormone implant, etc.).	Wildlife
AQUATIC STUDIES (Aquatic)	Studies that investigate toxicity in aquatic organisms.	Wildlife Plants and Soil Invertebrates
ANATOMICAL STUDIES (Anat)	Studies of anatomy. Instance where the contaminant is used in physical studies (e.g., silver nitrate staining for histology).	Wildlife
BACTERIA (Bact)	Studies on bacteria or susceptibility to bacterial infection.	Wildlife Plants and Soil Invertebrates
BIOACCUMULATION SURVEY (Bio Acc)	Studies reporting the measurement of the concentration of the contaminant in tissues.	Wildlife Plants and Soil Invertebrates
BIOLOGICAL PRODUCT (BioP)	Studies of biological toxicants, including venoms, fungal toxins, <i>Bacillus thuringiensis</i> , other plant, animal, or microbial extracts or toxins.	Wildlife Plants and Soil Invertebrates
BIOMARKER (Biom)	Studies reporting results for a biomarker having no reported association with an adverse effect and an exposure dose (or concentration).	Wildlife
CARCINOGENICITY STUDIES (Carcin)	Studies that report data only for carcinogenic endpoints such as tumor induction. Papers that report systemic toxicity data are retained for coding of appropriate endpoints.	Wildlife Plants and Soil Invertebrates
CHEMICAL METHODS (Chem Meth)	Studies reporting methods for determination of contaminants, purification of chemicals, etc. Studies describing the preparation and analysis of the contaminant in the tissues of the receptor.	Wildlife Plants and Soil Invertebrates
CONFERENCE PROCEEDINGS (CP)	Studies reported in conference and symposium proceedings.	Wildlife Plants and Soil Invertebrates
DEAD (Dead)	Studies reporting results for dead organisms. Studies reporting field mortalities with necropsy data where it is not possible to establish the dose to the organism.	Wildlife Plants and Soil Invertebrates
DISSERTATIONS (Diss)	Dissertations are excluded. However, dissertations are flagged for possible future use.	Wildlife
DRUG (Drug)	Studies reporting results for testing of drug and therapeutic effects and side-effects. Therapeutic drugs include vitamins and minerals. Studies of some minerals may be included if there is potential for adverse effects.	Wildlife Plants and Soil Invertebrates
DUPLICATE DATA (Dup)	Studies reporting results that are duplicated in a separate publication. The publication with the earlier year is used.	Wildlife Plants and Soil Invertebrates

Literature Rejection Categories		
Rejection Criteria	Description	Receptor
ECOLOGICAL INTERACTIONS (Ecol)	Studies of ecological processes that do not investigate effects of contaminant exposure (e.g., studies of “silver” fox natural history; studies on ferrets identified in iron search).	Wildlife Plants and Soil Invertebrates
EFFLUENT (Effl)	Studies reporting effects of effluent, sewage, or polluted runoff.	Wildlife Plants and Soil Invertebrates
ECOLOGICALLY RELEVANT ENDPOINT (ERE)	Studies reporting a result for endpoints considered as ecologically relevant but is not used for deriving Eco-SSLs (e.g., behavior, mortality).	Plants and Soil Invertebrates
CONTAMINANT FATE/METABOLISM (Fate)	Studies reporting what happens to the contaminant, rather than what happens to the organism. Studies describing the intermediary metabolism of the contaminant (e.g., radioactive tracer studies) without description of adverse effects.	Wildlife Plants and Soil Invertebrates
FOREIGN LANGUAGE (FL)	Studies in languages other than English.	Wildlife Plants and Soil Invertebrates
FOOD STUDIES (Food)	Food science studies conducted to improve production of food for human consumption.	Wildlife
FUNGUS (Fungus)	Studies on fungus.	Wildlife Plants and Soil Invertebrates
GENE (Gene)	Studies of genotoxicity (chromosomal aberrations and mutagenicity).	Wildlife Plants and Soil Invertebrates
HUMAN HEALTH (HHE)	Studies with human subjects.	Wildlife Plants and Soil Invertebrates
IMMUNOLOGY (IMM)	Studies on the effects of contaminants on immunological endpoints.	Wildlife Plants and Soil Invertebrates
INVERTEBRATE (Invert)	Studies that investigate the effects of contaminants on terrestrial invertebrates are excluded.	Wildlife
IN VITRO (In Vit)	<i>In vitro</i> studies, including exposure of cell cultures, excised tissues and/or excised organs.	Wildlife Plants and Soil Invertebrates
LEAD SHOT (Lead shot)	Studies administering lead shot as the exposure form. These studies are labeled separately for possible later retrieval and review.	Wildlife
MEDIA (Media)	Authors must report that the study was conducted using natural or artificial soil. Studies conducted in pore water or any other aqueous phase (e.g., hydroponic solution), filter paper, petri dishes, manure, organic or histosoils (e.g., peat muck, humus), are not considered suitable for use in defining soil screening levels.	Plants and Soil Invertebrates
METHODS (Meth)	Studies reporting methods or methods development without usable toxicity test results for specific endpoints.	Wildlife Plants and Soil Invertebrates
MINERAL REQUIREMENTS (Mineral)	Studies examining the minerals required for better production of animals for human consumption, unless there is potential for adverse effects.	Wildlife
MIXTURE (Mix)	Studies that report data for combinations of single toxicants (e.g. cadmium and copper) are excluded. Exposure in a field setting from contaminated natural soils or waste application to soil may be coded as Field Survey.	Wildlife Plants and Soil Invertebrates

Literature Rejection Categories		
Rejection Criteria	Description	Receptor
MODELING (Model)	Studies reporting the use of existing data for modeling, i.e., no new organism toxicity data are reported. Studies which extrapolate effects based on known relationships between parameters and adverse effects.	Wildlife Plants and Soil Invertebrates
NO CONTAMINANT OF CONCERN (No COC)	Studies that do not examine the toxicity of Eco-SSL contaminants of concern.	Wildlife Plants and Soil Invertebrates
NO CONTROL (No Control)	Studies which lack a control or which have a control that is classified as invalid for derivation of TRVs.	Wildlife Plants and Soil Invertebrates
NO DATA (No Data)	Studies for which results are stated in text but no data is provided. Also refers to studies with insufficient data where results are reported for only one organism per exposure concentration or dose (wildlife).	Wildlife Plants and Soil Invertebrates
NO DOSE or CONC (No Dose)	Studies with no usable dose or concentration reported, or an insufficient number of doses/concentrations are used based on Eco-SSL SOPs. These are usually identified after examination of full paper. This includes studies which examine effects after exposure to contaminant ceases. This also includes studies where offspring are exposed in utero and/or lactation by doses to parents and then after weaning to similar concentrations as their parents. Dose cannot be determined.	Wildlife Plants and Soil Invertebrates
NO DURATION (No Dur)	Studies with no exposure duration. These are usually identified after examination of full paper.	Wildlife Plants and Soil Invertebrates
NO EFFECT (No Efect)	Studies with no relevant effect evaluated in a biological test species or data not reported for effect discussed.	Wildlife Plants and Soil Invertebrates
NO ORAL (No Oral)	Studies using non-oral routes of contaminant administration including intraperitoneal injection, other injection, inhalation, and dermal exposures.	Wildlife
NO ORGANISM (No Org) or NO SPECIES	Studies that do not examine or test a viable organism (also see in vitro rejection category).	Wildlife Plants and Soil Invertebrates
NOT AVAILABLE (Not Avail)	Papers that could not be located. Citation from electronic searches may be incorrect or the source is not readily available.	Wildlife Plants and Soil Invertebrates
NOT PRIMARY (Not Prim)	Papers that are not the original compilation and/or publication of the experimental data.	Wildlife Plants and Soil Invertebrates
NO TOXICANT (No Tox)	No toxicant used. Publications often report responses to changes in water or soil chemistry variables, e.g., pH or temperature. Such publications are not included.	Wildlife Plants and Soil Invertebrates
NO TOX DATA (No Tox Data)	Studies where toxicant used but no results reported that had a negative impact (plants and soil invertebrates).	Plants and Soil Invertebrates
NUTRIENT (Nutrient)	Nutrition studies reporting no concentration related negative impact.	Plants and Soil Invertebrates
NUTRIENT DEFICIENCY (Nut def)	Studies of the effects of nutrient deficiencies. Nutritional deficient diet is identified by the author. If reviewer is uncertain then the administrator should be consulted. Effects associated with added nutrients are coded.	Wildlife
NUTRITION (Nut)	Studies examining the best or minimum level of a chemical in the diet for improvement of health or maintenance of animals in captivity.	Wildlife
OTHER AMBIENT CONDITIONS (OAC)	Studies which examine other ambient conditions: pH, salinity, DO, UV, radiation, etc.	Wildlife Plants and Soil Invertebrates

Literature Rejection Categories		
Rejection Criteria	Description	Receptor
OIL (Oil)	Studies which examine the effects of oil and petroleum products.	Wildlife Plants and Soil Invertebrates
OM, pH (OM, pH)	Organic matter content of the test soil must be reported by the authors, but may be presented in one of the following ways; total organic carbon (TOC), particulate organic carbon (POC), organic carbon (OC), coarse particulate organic matter (CPOM), particulate organic matter (POM), ash free dry weight of soil, ash free dry mass of soil, percent organic matter, percent peat, loss on ignition (LOI), organic matter content (OMC). With the exception of studies on non-ionizing substances, the study must report the pH of the soil, and the soil pH should be within the range of \$4 and #8.5. Studies that do not report pH or report pH outside this range are rejected.	Plants and Soil Invertebrates
ORGANIC METAL (Org Met)	Studies which examine the effects of organic metals. This includes tetraethyl lead, triethyl lead, chromium picolinate, phenylarsonic acid, roxarsone, 3-nitro-4-phenylarsonic acid, zinc phosphide, monomethylarsonic acid (MMA), dimethylarsinic acid (DMA), trimethylarsine oxide (TMAO), or arsenobetaine (AsBe) and other organo metallic fungicides. Metal acetates and methionines are not rejected and are evaluated.	Wildlife
LEAD BEHAVIOR OR HIGH DOSE MODELS (Pb Behav)	There are a high number of studies in the literature that expose rats or mice to high concentrations of lead in drinking water (0.1, 1 to 2% solutions) and then observe behavior in offspring, and/or pathology changes in the brain of the exposed dam and/or the progeny. Only a representative subset of these studies were coded. Behavior studies examining complex behavior (learned tasks) were also not coded.	Wildlife
PHYSIOLOGY STUDIES (Phys)	Physiology studies where adverse effects are not associated with exposure to contaminants of concern.	Wildlife
PLANT (Plant)	Studies of terrestrial plants are excluded.	Wildlife
PRIMATE (Prim)	Primate studies are excluded.	Wildlife
PUBL AS (Publ as)	The author states that the information in this report has been published in another source. Data are recorded from only one source. The secondary citation is noted as Publ As.	Wildlife Plants and Soil Invertebrates
QSAR (QSAR)	Derivation of Quantitative Structure-Activity Relationships (QSAR) is a form of modeling. QSAR publications are rejected if raw toxicity data are not reported or if the toxicity data are published elsewhere as original data.	Wildlife Plants and Soil Invertebrates
REGULATIONS (Reg)	Regulations and related publications that are not a primary source of data.	Wildlife Plants and Soil Invertebrates
REVIEW (Rev)	Studies in which the data reported in the article are not primary data from research conducted by the author. The publication is a compilation of data published elsewhere. These publications are reviewed manually to identify other relevant literature.	Wildlife Plants and Soil Invertebrates

Literature Rejection Categories		
Rejection Criteria	Description	Receptor
SEDIMENT CONC (Sed)	Studies in which the only exposure concentration/dose reported is for the level of a toxicant in sediment.	Wildlife Plants and Soil Invertebrates
SCORE (Score)	Papers in which all studies had data evaluation scores at or lower than the acceptable cut-off (#10 of 18) for plants and soil invertebrates).	Plants and Soil Invertebrates
SEDIMENT CONC (Sed)	Studies in which the only exposure concentration/dose reported is for the level of a toxicant in sediment.	Wildlife Plants and Soil Invertebrates
SLUDGE	Studies on the effects of ingestion of soils amended with sewage sludge.	Wildlife Plants and Soil Invertebrates
SOIL CONC (Soil)	Studies in which the only exposure concentration/dose reported is for the level of a toxicant in soil.	Wildlife
SPECIES	Studies in which the species of concern was not a terrestrial invertebrate or plant or mammal or bird.	Plants and Soil Invertebrates Wildlife
STRESSOR (QAC)	Studies examining the interaction of a stressor (e.g., radiation, heat, etc.) and the contaminant, where the effect of the contaminant alone cannot be isolated.	Wildlife Plants and Soil Invertebrates
SURVEY (Surv)	Studies reporting the toxicity of a contaminant in the field over a period of time. Often neither a duration nor an exposure concentration is reported.	Wildlife Plants and Soil Invertebrates
REPTILE OR AMPHIBIAN (Herp)	Studies on reptiles and amphibians. These papers flagged for possible later review.	Wildlife Plants and Soil Invertebrates
UNRELATED (Unrel)	Studies that are unrelated to contaminant exposure and response and/or the receptor groups of interest.	Wildlife
WATER QUALITY STUDY (Wqual)	Studies of water quality.	Wildlife Plants and Soil Invertebrates
YEAST (Yeast)	Studies of yeast.	Wildlife Plants and Soil Invertebrates

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Appendix 6-1

*Mammalian Toxicity Data Extracted and Reviewed for Wildlife
Toxicity Reference Value (TRV) - Barium*

February 2005

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**Appendix 6.1 Mammalian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)
Barium**

Ref	Exposure														Effects					Conversion to mg/kg bw/day		Result		Data Evaluation Score																				
	Result #	Ref No.	Chemical Form	MW%	Common name	Phase #	# of Conc/ Doses	Conc/ Doses	Wet Weight Reported?	Application Frequency	Conc/Dose Units	Method of Chem Analyses	Route of Exposure	Exposure Duration	Duration Units	Age	Age Units	Lifestage	Sex	Control Type	Test Location	Effect Type	Effect Measure	Response Site	Study NOAEL	Study LOAEL	Body Weight Reported?	Body Weight (kg)	Ingestion Rate Reported?	Ingestion Rate (kg or L/day)	NOAEL Dose (mg/kg/day)	LOAEL Dose (mg/kg/day)	Data Source	Dose Route	Test Concentrations	Chemical form	Dose Quantification	Endpoint	Dose Range	Statistical Power	Exposure Duration	Test Conditions	Total	
Biochemical																																												
1	18734	Borzelleca et al, 1988	Barium chloride	65.95	Rat (<i>Rattus norvegicus</i>)	1	5	0/100/145/209/300	N	X per d	mg/kg bw/d	U	GV	10	d	37	d	JV	F	C	Lab	CHM	UREA	BL		100	Y	0.196	N	0.0180		66.0	10	8	10	10	10	1	4	10	10	4	77	
2	18124	Perry et al, 1983	Barium chloride	100	Rat (<i>Rattus norvegicus</i>)	1	4	0/1/10/100	N	NR	mg/L	U	DR	4	mo	NR	NR	JV	F	C	Lab	CHM	ATPT	HE	10.0	100	Y	0.435	Y	0.0220	0.506	5.06	10	5	5	10	7	1	8	10	10	4	70	
3	18186	Dietz et al, 1992	Barium chloride dihydrate	100	Rat (<i>Rattus norvegicus</i>)	2	6	0/4.3/17/32.9/61.1/120.7	N	ADL	mg/kg bw/d	UX	DR	92	d	43-44	d	JV	M	C	Lab	CHM	PHOS	SR	4.30	17.0	Y	0.197	N	0.0230	4.30	17.0	10	5	10	10	10	1	8	10	10	4	78	
4	18750	Perry et al, 1989	Barium chloride	100	Rat (<i>Rattus norvegicus</i>)	2	2	0/100	N	ADL	mg/L	U	DR	16	mo	NR	NR	JV	F	C	Lab	ENZ	Other	HE		100	Y	0.045	Y	0.0224		49.8	10	5	5	10	7	1	4	10	10	4	66	
Behavior																																												
5	18427	Tardiff et al, 1988	Barium chloride	100	Rat (<i>Rattus norvegicus</i>)	1	4	0/2.1/9.7/45.7	N	DLY	mg/kg bw/d	M	DR	13	w	4	w	JV	B	C	Lab	FDB	FCNS	WO	45.7		Y	0.497	N	0.0528	45.7		10	5	10	10	10	4	4	8	10	10	4	75
6	18186	Dietz et al, 1992	Barium chloride dihydrate	100	Rat (<i>Rattus norvegicus</i>)	2	6	0/4.3/17/32.9/61.1/120.7	N	ADL	mg/kg bw/d	UX	DR	92	d	43-44	d	JV	B	C	Lab	FDB	WCN	WO	61.0	121	Y	0.340	N	0.0375	61.0	121	10	5	10	10	10	4	10	10	10	4	83	
7	18186	Dietz et al, 1992	Barium chloride dihydrate	100	Mouse (<i>Mus musculus</i>)	1	6	0/12.4/41.9/82.9/164.7/436.2	N	ADL	mg/kg bw/d	UX	DR	92	d	43-44	d	JV	M	C	Lab	FDB	WCN	WO	165	436	Y	0.038	N	0.0052	165	436	10	5	10	10	10	4	10	10	10	4	83	
Physiology																																												
8	18124	Perry et al, 1983	Barium chloride	100	Rat (<i>Rattus norvegicus</i>)	1	4	0/1/10/100	N	NR	mg/L	U	DR	8	mo	NR	NR	JV	F	C	Lab	PHY	BLPR	WO	1.00	10.0	Y	0.348	Y	0.0210	0.060	0.60	10	5	5	10	7	4	8	10	10	4	73	
9	18750	Perry et al, 1989	Barium chloride	100	Rat (<i>Rattus norvegicus</i>)	1	4	0/0.05/0.2292/2.029	N	ADL	mg/org/d	U	DR	8	mo	NR	NR	JV	F	C	Lab	PHY	BLPR	WO	0.050	0.23	Y	0.045	Y	0.0224	1.10	5.10	10	5	5	10	7	4	8	10	10	4	73	
10	18115	McCauley et al, 1985	Barium chloride	100	Rat (<i>Rattus norvegicus</i>)	4	2	0/250	N	ADL	mg/L	U	DR	5	mo	NR	NR	NR	NR	C	Lab	PHY	HTRT	HE	250		N	0.600	N	0.0625	26.0		10	5	5	10	5	4	4	10	10	4	67	
11	18750	Perry et al, 1989	Barium chloride	100	Rat (<i>Rattus norvegicus</i>)	2	2	0/100	N	ADL	mg/L	U	DR	16	mo	NR	NR	JV	F	C	Lab	PHY	BLPR	WO		100	Y	0.045	Y	0.0224		49.8	10	5	5	10	7	4	4	10	10	4	69	
Pathology																																												
12	18427	Tardiff et al, 1988	Barium chloride	100	Rat (<i>Rattus norvegicus</i>)	1	4	0/2.1/9.7/45.7	N	DLY	mg/kg bw/d	M	DR	8	w	4	w	JV	M	C	Lab	ORW	SMIX	AR	10.0	50.0	Y	0.497	N	0.0528	2.10	9.70	10	5	10	10	10	4	8	10	10	4	81	
13	18186	Dietz et al, 1992	Barium chloride dihydrate	100	Rat (<i>Rattus norvegicus</i>)	2	6	0/4.3/17/32.9/61.1/120.7	N	ADL	mg/kg bw/d	UX	DR	92	d	43-44	d	JV	M	C	Lab	ORW	ORWT	KI	17.0	32.9	Y	0.191	N	0.0223	17.0	32.9	10	5	10	10	10	4	10	10	10	4	83	
14	18186	Dietz et al, 1992	Barium chloride dihydrate	100	Mouse (<i>Mus musculus</i>)	1	6	0/12.4/41.9/82.9/164.7/436.2	N	ADL	mg/kg bw/d	UX	DR	92	d	43-44	d	JV	M	C	Lab	ORW	SMIX	LI	41.9	82.9	Y	0.028	N	0.0039	41.9	82.9	10	5	10	10	10	4	10	10	10	4	83	
16	1858	Schroeder and Mitchener, 1975	Barium acetate	100	Mouse (<i>Mus musculus</i>)	1	2	0/5	N	NR	mg/L	U	DR	520	d	19-20	d	JV	B	C	Lab	HIS	EDMA	WO		5.00	Y	0.027	N	0.0038		0.710	10	5	5	10	6	4	4	10	10	4	68	
Reproduction																																												
16	18186	Dietz et al, 1992	Barium chloride dihydrate	100	Rat (<i>Rattus norvegicus</i>)	2	6	0/4.3/17/32.9/61.1/120.7	N	ADL	mg/kg bw/d	UX	DR	92	d	43-44	d	JV	M	C	Lab	REP	RHIS	TE	121		Y	0.307	N	0.0342	121		10	5	10	10	10	10	4	1	10	10	4	74
17	18734	Borzelleca et al, 1988	Barium chloride	65.95	Rat (<i>Rattus norvegicus</i>)	1	5	0/100/145/209/300	N	X per d	mg/kg bw/d	U	GV	10	d	37	d	JV	F	C	Lab	REP	RHIS	OV	209	300	Y	0.196	N	0.0180	138	198	10	8	10	10	10	4	10	10	10	4	86	
18	18186	Dietz et al, 1992	Barium chloride dihydrate	100	Mouse (<i>Mus musculus</i>)	1	6	0/12.4/41.9/82.9/164.7/436.2	N	ADL	mg/kg bw/d	UX	DR	92	d	43-44	d	JV	M	C	Lab	REP	RHIS	TE	165	436	N	0.016	N	0.0024	165	436	10	5	10	10	10	10	10	10	10	4	89	
Growth																																												
19	17086	Schroeder and Mitchener, 1975	Barium acetate	100	Rat (<i>Rattus norvegicus</i>)	1	2	0/5	N	DLY	mg/L	U	DR	520	d	21	d	JV	B	C	Lab	GRO	BDWT	WO	5.00		Y	0.245	N	0.0279	0.570		10	5	5	10	6	8	4	10	10	4	72	
20	18053	Stoewsand et al, 1988	Barium chloride	100	Rat (<i>Rattus norvegicus</i>)	1	2	0/4.714	N	DLY	mg/org/d	U	FD	29	d	NR	NR	JV	M	C	Lab	GRO	BDWT	WO	4.70		N	0.267	N	0.0232	16.5		10	10	5	10	5	8	4	10	10	4	76	
21	18186	Dietz et al, 1992	Barium chloride dihydrate	100	Rat (<i>Rattus norvegicus</i>)	2	6	0/4.3/17/32.9/61.1/120.7	N	ADL	mg/kg bw/d	UX	DR	92	d	43-44	d	JV	B	C	Lab	GRO	BDWT	WO	61.0	121	Y	0.340	N	0.0375	61.0	121	10	5	10	10	10	8	10	10	10	4	87	
22	18186	Dietz et al, 1992	Barium chloride dihydrate	100	Mouse (<i>Mus musculus</i>)	1	6	0/12.4/41.9/82.9/164.7/436.2	N	ADL	mg/kg bw/d	UX	DR	92	d	43-44	d	JV	M	C	Lab	GRO	BDWT	WO	165	436	Y	0.038	N	0.0052	165	436	10	5	10	10	10	8	10	10	10	4	87	
23	18734	Borzelleca et al, 1988	Barium chloride	65.95	Rat (<i>Rattus norvegicus</i>)	1	5	0/100/145/209/300	N	X per d	mg/kg bw/d	U	GV	10	d	37	d	JV	B	C	Lab	GRO	BDWT	WO	300		Y	0.253	N	0.0222	198		10	8	10	10	10	8	4	10	10	4	84	
24	1858	Schroeder and Mitchener, 1975	Barium acetate	100	Mouse (<i>Mus musculus</i>)	1	2	0/5	N	NR	mg/L	U	DR	10	d	19-20	d	JV	F	C	Lab	GRO	BDWT	WO		5.00	Y	0.018	N	0.0026		0.741	10	5	5	5	6	8	4	10	10	4	67	
Survival																																												
25	18186	Dietz et al, 1992	Barium chloride dihydrate	100	Rat (<i>Rattus norvegicus</i>)	2	6	0/4.3/17/32.9/61.1/120.7	N	ADL	mg/kg bw/d	UX	DR	92	d	43-44	d	JV	M	C	Lab	MOR	MORT	WO	61.0	121	Y	0.340	N	0.0748	61.0	121	10	5	10	10	10	9	10	10	10	4	88	
26	18734	Borzelleca et al, 1988	Barium chloride	65.95	Rat (<i>Rattus norvegicus</i>)	1	5	0/100/145/209/300	N	X per d	mg/kg bw/d	U	GV	10	d	37	d	JV	F	C	Lab	MOR	MORT	WO	209	300	Y	0.196	N	0.0180	138	198	10	8	10	10	10	9	10	10	10	4	91	
27	18186	Dietz et al, 1992	Barium chloride dihydrate	100	Mouse (<i>Mus musculus</i>)	1	6	0/12.4/41.9/82.9/164.7/436.2	N	ADL	mg/kg bw/d	UX	DR	13	d	43-44	d	JV	M	C	Lab	MOR	MORT	WO	165	436	Y	0.038	N	0.0052	165	436	10	5	10	10	10	9	8	10	10	4	86	
Data Not Used to Derive Wildlife Toxicity Reference Value																																												
28	17086	Schroeder and Mitchener, 1975	Barium acetate	100	Rat (<i>Rattus norvegicus</i>)	1	2	0/5	N	DLY	mg/L	U	DR	1173	d	21	d	JV	B	C	Lab	MOR	LFSP	WO	5.0		Y	0.486	N	0.0517	0.532		10	5	5	10	6	9	4	1	10	4	64	
29	17086	Schroeder and Mitchener, 1975	Barium acetate	100	Rat (<i>Rattus norvegicus</i>)	1	2	0/5	N	DLY	mg/L	U	DR	540	d	21	d	JV	B	C	Lab	ORW	ORWT	HE	5.0		Y	0.486	N	0.0517	0.532		10	5	5	10	6	4	4	1	10	4	59	
30	757	Mercado and Bibby 1973	Barium chloride	100	Rat (<i>Rattus norvegicus</i>)	1	2	0/50	N	ADL	mg/L	U	DR	50	d	23	d	JV	M	C	Lab	PHY	GPHY	TH	50.0		N	0.267	N	0.0302	5.65		10	5	5	10	5	4	4	1	10	4	58	
36	757	Mercado and Bibby 1973	Barium chloride	100	Rat (<i>Rattus norvegicus</i>)	1	2	0/50	N	ADL	mg/L	U	DR	50	d	23	d	JV	M	C	Lab	GRO	BDWT	WO	50.0		N	0.267	N	0.0302	5.65		10	5	5	10	5	8	4	1	10	4	62	
30	18115	McCauley et al, 1985	Barium chloride	100	Rat (<i>Rattus norvegicus</i>)	1	5	0/1/10/100/250	N	ADL	mg/L	U	DR	36	w	NR	NR	NR	M	C	Lab	HIS	HYPL	AR	250		N	0.600	N	0.0625	26.0		10	5	5	10	5	4	4	1	10	4	58	
31	18750	Perry et al, 1989	Barium chloride	100	Rat (<i>Rattus norvegicus</i>)	3	4	0/0.058/0.279/2.5	N	ADL	mg/org/d	U	DR	16	mo	NR	NR	JV	F	C	Lab	GRO	BDWT	WO	2.50		Y	0.045	Y	0.0224	55.6		10	5	5	10	7	8	4	1	10	4	64	
32	18750	Perry et al, 1989	Barium chloride	100	Rat (<i>Rattus norvegicus</i>)	3	4	0/0.058/0.279/2.5	N	ADL	mg/org/d	U	DR	16	mo	NR	NR	JV	F	C	Lab	CHM	CALC	HE	2.50		Y	0.045	Y	0.0224	55.6		10	5	5	10	7	1	4	8	10	4	64	
33	17086	Schroeder and Mitchener, 1975	Barium acetate	101	Rat (<i>Rattus norvegicus</i>)	2	3	0/5	N	DLY	mg/L																																	