Ecological Soil Screening Levels for Beryllium

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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 (US EPA, 2003). The derivation procedures represent the collaborative 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 beryllium and the documentation for their derivation. This document provides guidance and is designed to communicate national policy on identifying beryllium 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 BERYLLIUM

Beryllium occurs naturally in the earth's crust, in coal, and in minerals, such as beryl, bertrandite, bromellite, chrysoberyl, and beryllonite. Plagiocase feldspar contains most of the world's beryllium. The greatest known concentrations of beryllium are found in certain pegmatite bodies, where crystals of beryl account for a few percent of the total pegmatite volume, and may be found in several of the strata of zoned dykes. The element is sometimes concentrated in hydrothermal veins, and some granitic rocks contain sufficient amounts to permit the crystallization of small

amounts of beryl (http://toxnet.nlm.nih.gov). Beryllium's production and use in alloys, microelectronics, aerospace technology, aircraft brakes, X-ray windows, neutron reflectors, and as a solid-propellant in rocket fuels may result in its release to the environment through various waste streams. Beryllium enters the environment principally from coal combustion. (http://toxnet.nlm.nih.gov).

Data concerning the fate of beryllium in the environment are limited. Since the major source of atmospheric beryllium is coal combustion, the most prevalent chemical form is probably beryllium oxide, mainly bound to particles smaller than 1 μm. The residence time of these particles in the atmosphere is about 10 days (US EPA, 1987). Beryllium returns to earth by wet and dry deposition in a similar manner to other metals and on particles of comparable size distribution (Kwapulinski & Pastuszka, 1983 as cited in IPCS, 1990).

Reactions of beryllium in solution and soil depend on the pH. At environmental pH ranges of 4 to 8, beryllium oxide is highly insoluble, thus preventing mobilization in soil. Beryllium is strongly adsorbed by finely dispersed sedimentary materials including clays, iron hydroxides, and organic substances (Izmerov, 1985). Thus, very little is released into ground water during weathering. If beryllium oxide is converted to the ionized salts (chloride, sulfate, nitrate) during atmospheric transport, solubility upon deposition and, hence, mobility in soils would be greatly enhanced, but this has not been reported in the literature as cited in IPCS, 1990.

If beryllium is bioavailable in the soil matrices, it can be assimilated by plants. Beryllium is classified as a fast-exchange metal, and can potentially interfere with the transport of nutritive metals, such as calcium, into eukaryotic cells (Wood & Wang,1983). Although there is a lack of data on beryllium levels in environmental organisms representing high trophic levels and on the fate of beryllium in ecosystems, it is not believed to biomagnify within food chains. Some plant species, however, including hickory trees (*Carya* spp.), act as accumulators of beryllium (Griffitts, 1977; Nikonova,1967, Sainsbury et al., 1968), and plant ash may contain greater amounts of beryllium in comparison to soil as cited in IPCS, 1990.

Eco-SSL values for beryllium were derived for soil invertebrates and mammalian wildlife (Table 2.1). Eco-SSL values for beryllium could not be derived for plants or avian wildlife. For these receptor groups, data were insufficient to derive soil screening values. The Eco-SSLs for beryllium are 21 mg/kg dry weight (dw) for mammalian wildlife and 40 mg/kg dw for soil invertebrates. The Eco-SSLs are higher than the reported range of background soil concentrations in eastern and western U.S. soils (Figure 2.1). The reported background concentrations of many metals in U.S. soils are described in Attachment 1-4 of the Eco-SSL guidance (U.S. EPA, 2003).

Table 2.1 Beryllium Eco-SSLs (mg/kg dry weight in soil)

Plants	Soil Invertebrates	Avian Wildlife	Mammalian Wildlife
NA	40	NA	21

NA = Not Available. Data were insufficient to derive an Eco-SSL.

3.0 ECO-SSL FOR TERRESTRIAL PLANTS

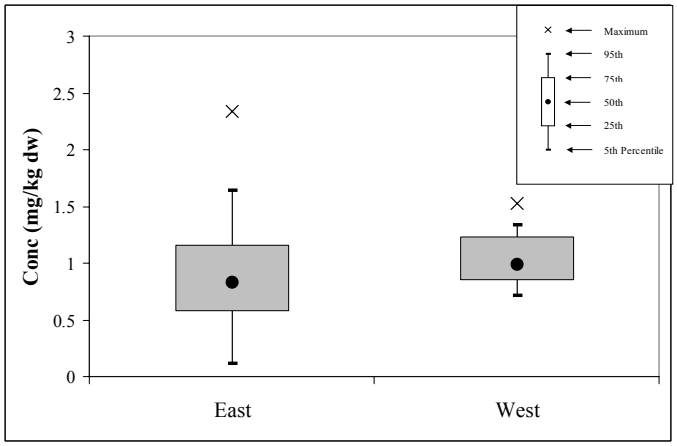


Figure 2.1 Typical Background Concentrations of Beryllium in U.S. Soils

Of the papers identified from the literature search process, 32 were selected for acquisition for further review. Of those papers acquired, three met all 11 Study Acceptance Criteria. Each of these papers was reviewed and the studies were scored according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 3-2). Five studies received an Evaluation Score greater than ten. These studies are listed in Table 3.1. There was only one study result with an acceptable endpoint; the other four results are unbounded lowest observed adverse effect concentrations (LOAECs) which cannot be used to derive an Eco-SSL. Therefore, an Eco-SSL could not be derived for beryllium for plants according to the Eco-SSL guidance (US EPA, 2003; Attachment 3-2).

4.0 ECO-SSL FOR SOIL INVERTEBRATES

Of the papers identified from the literature search process, six were selected for acquisition for further review. Of those papers acquired, three met all 11 Study Acceptance Criteria. Each of these papers was 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. These studies are listed in Table 4.1.

The studies in Table 4.1 are sorted by bioavailability score and all three studies are used to derive the soil invertebrate Eco-SSL according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 3-2). The Eco-SSL is the geometric mean of the EC_{20} values reported for each of three test species and is equal to 40 mg/kg dw.

5.0 ECO-SSL FOR AVIAN WILDLIFE

The literature search completed according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-2) identified 167 studies with possible toxicity data for beryllium for mammalian species. There were no studies identified for the toxicity of beryllium to avian species; therefore an Eco-SSL could not be derived for beryllium.

Table 3.1 Plant Toxicity Data - Beryllium

Reference	Study ID	Test Organism		Soil pH	OM%	Bio-availability Score	ERE	Tox Parameter	Tox Value Soil Conc. (mg/kg dw)	Total Evaluation Score	Eligible for Eco-SSL Derivation?	Used for Eco-SSL?
Kaplan, D.I., 1990	a	Kale	*Brassica oleracea v.acephalia L.*	6.5	1.9	2	GRO	MATC	56.8	16	Y	N
Sajwan, K.S., 1996	a	Soybean	*Glycine max*	4.9	1.9	2	GRO	LOAEC	25	12	N	N
Sajwan, K.S., 1996	b	Soybean	*Glycine max*	6.5	1.9	2	GRO	LOAEC	25	12	N	N
Sajwan, K.S., 1996	c	Soybean	*Glycine max*	5.5	3.2	2	GRO	LOAEC	25	12	N	N
Sajwan, K.S., 1996	d	Soybean	*Glycine max*	6.0	3.2	1	GRO	LOAEC	25	12	N	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 - Beryllium

Reference	IP Number	Test Organism		Soil pH	OM%	Bio-availability Score	ERE	Tox Parameter	Tox Value Soil Conc. (mg/kg dw)	Total Evaluation Score	Eligible for Eco-SSL Derivation?	Used for Eco-SSL?
Kuperman et al., 2002	62344	Pot worm	*Enchytraeus crypticus*	4.29 - 5.29	1.2	2	REP	EC_{20}	45	17	Y	Y
Phillips et al., 2002	62345	Springtail	*Folsomia candida*	4.29 - 5.29	1.2	2	REP	EC_{20}	28	18	Y	Y
Simini et al., 2002	62343	Earthworm	*Eisenia fetida*	3.83 - 5.29	1.2	2	REP	EC_{20}	52	16	Y	Y
								Geometric Mean	40			

EC_{20} = 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 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).

6.1 Mammalian TRV

The literature search completed according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-2) identified 167 studies with possible toxicity data for mammalian species. Of these studies, 163 were rejected for use as described in Section 7.5. The remaining papers four papers were reviewed and the studies were scored according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-3). The results of the data extraction and review are summarized in Table 6.1. The complete results are included as Appendix 6-1.

There are six results for biochemical (BIO), pathology (PTH), growth (GRO), and survival (MOR) endpoints with a total Data Evaluation Score of > 65 that are used to derive the TRV (U.S. EPA, 2003; Attachment 4-4). 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 reproduction could not be calculated as only one NOAEL is available for growth or reproductive effects. There are no bounded LOAELs for comparison. Therefore, the TRV is equal to the lowest NOAEL for effects on growth, reproduction, or survival which is equal to 0.532 mg beryllium/kg bw/day.

6.2 Estimation of Dose and Calculation of the Eco-SSL

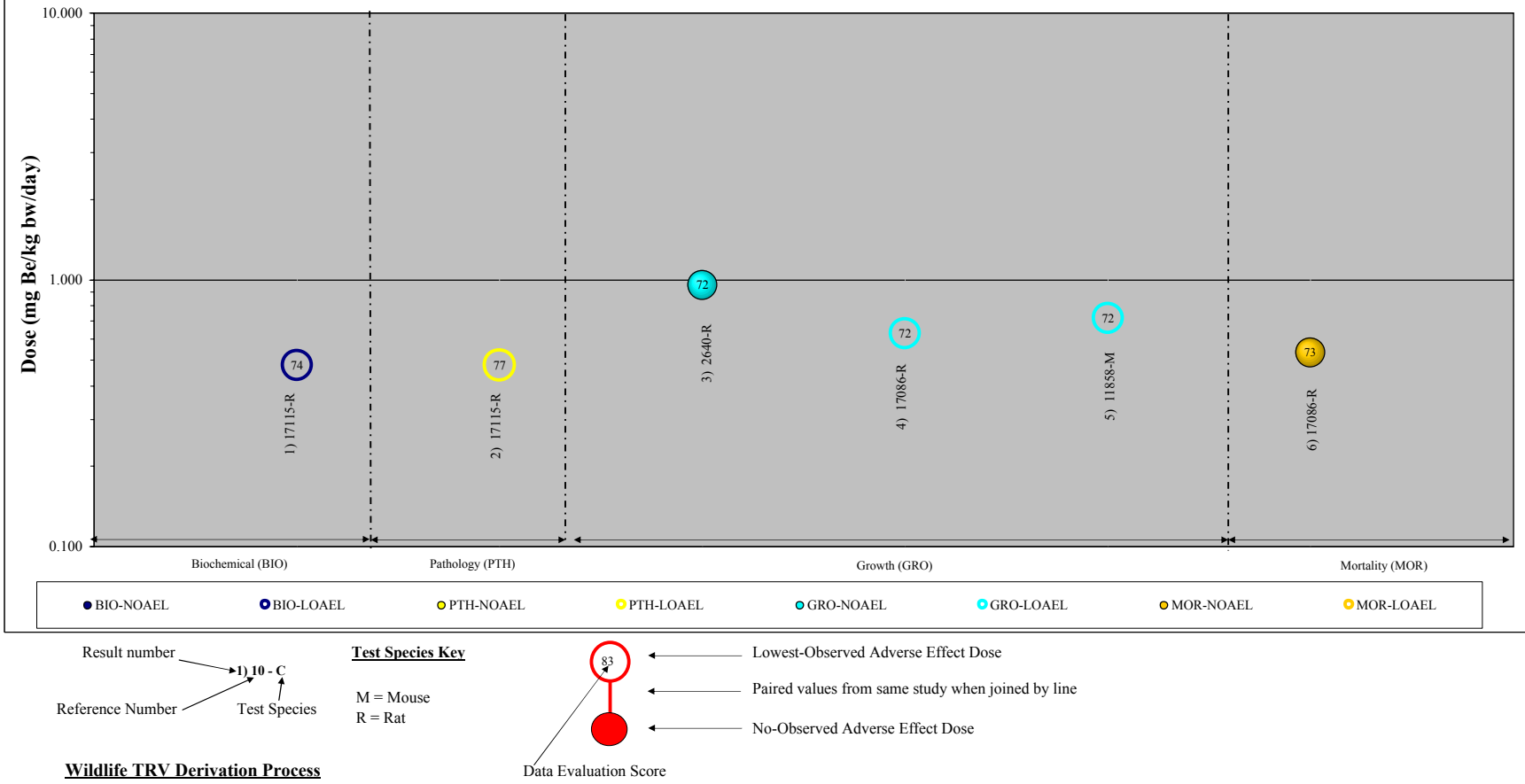
Three separate Eco-SSL values were calculated for mammalian wildlife, one for each of three surrogate receptor species representing different trophic groups. The mammalian Eco-SSLs derived for beryllium were calculated according to Eco-SSL guidance (U.S. EPA, 2003; Attachment 4-5) and are summarized in Table 6.2.

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

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 Effects																		
1	Goel et al, 1980	17115	Rat *(Rattus norvegicus)*	2	U	OR	75	d	NR	NR	JV	M	ENZ	ALPH	LU		0.478	74
Pathology Effects																		
2	Goel et al, 1980	17115	Rat *(Rattus norvegicus)*	2	U	OR	75	d	NR	NR	JV	M	HIS	GHIS	LU		0.478	77
Growth Effects																		
3	Freundt and Ibrahim, 1990	2640	Rat *(Rattus norvegicus)*	2	U	DR	91	d	NR	NR	SM	F	GRO	BDWT	WO	0.953		72
4	Schroeder and Mitchener, 1975	17086	Rat *(Rattus norvegicus)*	2	U	DR	39	d	21	d	JV	M	GRO	BDWT	WO		0.630	72
5	Schroeder and Mitchener, 1975	1858	Mouse (*Mus musculus*)	2	U	DR	70	d	19-20	d	JV	F	GRO	BDWT	WO		0.718	72
Effects on Survival																		
6	Schroeder and Mitchener, 1975	17086	Rat *(Rattus norvegicus)*	2	U	DR	1464	d	21	d	JV	B	MOR	LFSP	WO	0.532		73

ALPH = alkaline phosphatase; B = both; BDWT = body weight changes; bw = body weight; d = days; DR = drinking water; ENZ = enzyme; F = female; GHIS = general histological changes; GRO = Growth; HIS = histology; JV = juvenile; kg = kilogram; LFSP = lifespan; LOAEL = lowest observed adverse effect level; LU = lung; M = male; mg = milligram; mo = months; MOR = effects on survival; NOAEL = no observed adverse effect level; NR = not reported; OR =other oral (e.g. capsule); Score = Total Data Evaluation Score as described in US EPA (2003; Attachment 4-3); SM = sexually mature; U = unmeasured; WO = whole organism.

Figure 6.1 Mammalian TRV Derivation for Beryllium



Result number → 1) 10 - C ← Test Species

Reference Number

Test Species Key

M = Mouse
R = Rat

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 not three NOAEL results available for calculation of a geometric mean.

4) There is one NOAEL value for reproduction or growth effects

5) There are no bounded LOAELs for comparison. The TRV is equal to the lowest NOAEL for effects on growth, reproduction, or survival.

6) The mammalian wildlife TRV for beryllium is equal to 0.532 mg beryllium/kg bw/day which is the lowest NOAEL for effects on growth, reproduction, and survival.

Table 6.2 Calculation of the Mammalian Eco-SSL for Beryllium						
Surrogate Receptor Group	**TRV for Beryllium (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 Beryllium in Biota Type (i)[2,3] (B_i) (mg/kg dw)**	**Beryllium in Diet of Prey [4] (C_{diet})**	**Eco-SSL (mg/kg dw)[5]**
Mammalian herbivore (vole)	0.532	0.0875	0.032	$\ln(B_i) = 0.7345 * \ln(Soil_j) - 0.5361$ where i = plants	NA	21
Mammalian ground insectivore (shrew)	0.532	0.209	0.030	$B_i = 0.045 * Soil_j$ where i = earthworms	NA	34
Mammalian carnivore (weasel)	0.532	0.130	0.043	$B_i = C_{diet} * 0.05$ where i = mammals	$C_{diet} = 0.045 * Soil_j$	90

[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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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 ligature, 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, *Bacillus thuringiensis*, 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)	*In vitro* 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 Efct)	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 then 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) - Beryllium

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February 2005

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

Ref		Exposure																			Effects						Conversion to mg/kg bw/day				Result		Data Evaluation Score										
Result #	Ref No.	Chemical Form	MW%	Test Species	Phase #	# of Conc/ Doses	Conc/ Doses	Conc/Dose Units for Study NOAEL/LOAEL	Wet Weight Reported?	Application Frequency	Method of Analyses	Route of Exposure	Exposure Duration	Duration Units	Age	Age Units	Lifestage	Sex	Control Type	Test Location	Sor t Order	General Effect Group	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 Data Evaluation Score
Biochemical																																											
1	17115	Beryllium nitrate	6.77	Rat *(Rattus norvegicus)*		2	0/1.06	mg/org/d		40	U	OR	75	d	NR	NR	JV	M			2	BIO	ENZ	ALPH	LU		1.06	Y	0.150	N	0.014		0.478	10	8	10	10	7	1	4	10	10	4	74
Pathology																																											
2	17115	Beryllium nitrate	6.77	Rat *(Rattus norvegicus)*		2	0/1.06	mg/org/d		40	U	OR	75	d	NR	NR	JV	M			1	PTH	HIS	GHIS	LU		1.06	Y	0.150	N	0.014		0.478	10	8	10	10	7	4	4	10	10	4	77
Growth																																											
3	2640	Beryllium sulfate	8.58	Rat *(Rattus norvegicus)*		2	0/100	mg/L		ADL	U	DR	91	d	NR	NR	SM	F			2	GRO	GRO	BDWT	WO	100		N	0.315	N	0.035	0.953		10	5	5	10	6	8	4	10	10	4	72
4	17086	Beryllium sulfate	100	Rat *(Rattus norvegicus)*		2	0/5	mg/L		DLY	U	DR	39	d	21	d	JV	M			1	GRO	GRO	BDWT	WO		5.00	Y	0.090	N	0.011		0.630	10	5	5	10	6	8	4	10	10	4	72
5	1858	Beryllium sulfate	100	Mouse (*Mus musculus*)		2	0/5	mg/L		NR	U	DR	70	d	19-20	d	JV	F			1	GRO	GRO	BDWT	WO		5.00	Y	0.024	N	0.0035		0.718	10	5	5	10	6	8	4	10	10	4	72
Survival																																											
6	17086	Beryllium sulfate	100	Rat *(Rattus norvegicus)*		2	0/5	mg/L		DLY	U	DR	1464	d	21	d	JV	B			3	MOR	MOR	LFSP	WO	5.00		Y	0.486	N	0.052	0.532		10	5	5	10	6	9	4	10	10	4	73
Data Not Used to Derive Wildlife Toxicity Reference Value																																											
7	17086	Beryllium sulfate	100	Rat *(Rattus norvegicus)*		2	0/5	mg/L		DLY	U	DR	475	d	21	d	JV	B			4	BIO	CHM	CHOL	SR		5.00	Y	0.497	N	0.053		0.531	10	5	5	10	6	1	4	10	10	4	65
8	2640	Beryllium sulfate	8.58	Rat *(Rattus norvegicus)*		2	0/100	mg/L		ADL	U	DR	91	d	NR	NR	SM	F			1	BEH	FDB	WCON	WO	100		Y	0.315	N	0.035	1.00		10	5	5	10	6	4	4	1	10	4	59
9	1858	Beryllium sulfate	100	Mouse (*Mus musculus*)		2	0/5	mg/L		NR	U	DR	520	d	19-20	d	JV	F			3	PTH	HIS	EDMA	WO	5.00		Y	0.030	N	0.0042	0.703		10	5	5	10	6	4	4	1	10	4	59
10	1858	Beryllium sulfate	100	Mouse (*Mus musculus*)		2	0/5	mg/L		NR	U	DR	520	d	19-20	d	JV	B			3	MOR	MOR	LFSP	WO	5.00		Y	0.030	N	0.0042	0.703		10	5	5	10	6	9	4	1	10	4	64
11	17086	Beryllium sulfate	100	Rat *(Rattus norvegicus)*		2	0/5	mg/L		DLY	U	DR	540	d	21	d	JV	B			2	PTH	ORW	ORWT	HE	5.00		Y	0.497	N	0.053	0.531		10	5	5	10	6	4	4	1	10	4	59

All abbreviations and definitions are used in coding stuides are available from Attachment 4-3 of the Eco-SSL guidance (U.S. EPA 2003).