Ecological Soil Screening Levels for Barium

Interim Final

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U.S. Environmental Protection Agency
Office of Solid Waste and Emergency Response
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Washington, DC 20460

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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>
<thead>
<tr>
<th>Plants</th>
<th>Soil Invertebrates</th>
<th>Wildlife</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Avian</td>
</tr>
<tr>
<td>NA</td>
<td>330</td>
<td>Mammalian</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2000</td>
</tr>
</tbody>
</table>

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

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

**Table 4.1 Invertebrate Toxicity Data - Barium**

<table>
<thead>
<tr>
<th>Reference</th>
<th>Test Organism</th>
<th>Soil pH</th>
<th>OM %</th>
<th>Bio-availability Score</th>
<th>ERE</th>
<th>Tox Parameter</th>
<th>Tox Value (Soil Conc. mg/kg dw)</th>
<th>Total Eval. Score</th>
<th>Eligible for Eco-SSL Derivation?</th>
<th>Used for Eco-SSL?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kuperman et al., 2002 Pot worm <em>Enchytraeus crypticus</em></td>
<td>4.36 - 5.29</td>
<td>1.2</td>
<td>2</td>
<td>REP</td>
<td>EC20</td>
<td>585</td>
<td>17</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Phillips et al., 2002 Springtail <em>Folsomia candida</em></td>
<td>4.47 - 5.29</td>
<td>1.2</td>
<td>2</td>
<td>REP</td>
<td>EC20</td>
<td>165</td>
<td>18</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Simini et al., 2002 Earthworm <em>Eisenia fetida</em></td>
<td>4.26 - 5.29</td>
<td>1.2</td>
<td>2</td>
<td>REP</td>
<td>EC20</td>
<td>370</td>
<td>17</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
</tbody>
</table>

EC20 = Effect concentration for 20% of test population  
ERE = Ecologically relevant endpoint  
OM = Organic matter content  
REP = Reproduction  
Y = yes  

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

<table>
<thead>
<tr>
<th>Result #</th>
<th>Reference</th>
<th>Test Organism</th>
<th>NOAEL Dose (mg/kg bw/day)</th>
<th>LOAEL Dose (mg/kg bw/day)</th>
<th>Data Evaluation Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Perry et al, 1983</td>
<td>Rat (Rattus norvegicus)</td>
<td>0.060</td>
<td>0.60</td>
<td>73</td>
</tr>
<tr>
<td>2</td>
<td>Dietz et al, 1992</td>
<td>Rat (Rattus norvegicus)</td>
<td>4.3</td>
<td>17.0</td>
<td>78</td>
</tr>
<tr>
<td>3</td>
<td>Perry et al, 1989</td>
<td>Rat (Rattus norvegicus)</td>
<td>49.7</td>
<td>66</td>
<td>76</td>
</tr>
<tr>
<td>4</td>
<td>Borzelleca et al, 1988</td>
<td>Rat (Rattus norvegicus)</td>
<td>17.0</td>
<td>32.9</td>
<td>83</td>
</tr>
<tr>
<td>5</td>
<td>Tardiff et al, 1988</td>
<td>Rat (Rattus norvegicus)</td>
<td>46</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>6</td>
<td>Dietz et al, 1992</td>
<td>Rat (Rattus norvegicus)</td>
<td>61.1</td>
<td>121</td>
<td>83</td>
</tr>
<tr>
<td>7</td>
<td>Dietz et al, 1992</td>
<td>Mouse (Mus musculus)</td>
<td>4.3</td>
<td>17.0</td>
<td>78</td>
</tr>
<tr>
<td>8</td>
<td>Perry et al, 1983</td>
<td>Rat (Rattus norvegicus)</td>
<td>0.060</td>
<td>0.60</td>
<td>73</td>
</tr>
<tr>
<td>9</td>
<td>Perry et al, 1989</td>
<td>Rat (Rattus norvegicus)</td>
<td>49.7</td>
<td>66</td>
<td>76</td>
</tr>
<tr>
<td>10</td>
<td>McCauley et al, 1985</td>
<td>Rat (Rattus norvegicus)</td>
<td>17.0</td>
<td>32.9</td>
<td>83</td>
</tr>
<tr>
<td>11</td>
<td>Perry et al, 1989</td>
<td>Rat (Rattus norvegicus)</td>
<td>49.7</td>
<td>66</td>
<td>76</td>
</tr>
<tr>
<td>12</td>
<td>Tardiff et al, 1988</td>
<td>Rat (Rattus norvegicus)</td>
<td>46</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>13</td>
<td>Dietz et al, 1992</td>
<td>Rat (Rattus norvegicus)</td>
<td>61.1</td>
<td>121</td>
<td>83</td>
</tr>
<tr>
<td>14</td>
<td>Dietz et al, 1992</td>
<td>Mouse (Mus musculus)</td>
<td>4.3</td>
<td>17.0</td>
<td>78</td>
</tr>
<tr>
<td>15</td>
<td>Schroeder and Mitchener, 1975</td>
<td>Mouse (Mus musculus)</td>
<td>2.1</td>
<td>9.7</td>
<td>81</td>
</tr>
<tr>
<td>16</td>
<td>Dietz et al, 1992</td>
<td>Rat (Rattus norvegicus)</td>
<td>121</td>
<td>74</td>
<td>74</td>
</tr>
<tr>
<td>17</td>
<td>Borzelleca et al, 1988</td>
<td>Rat (Rattus norvegicus)</td>
<td>138</td>
<td>198</td>
<td>87</td>
</tr>
<tr>
<td>18</td>
<td>Dietz et al, 1992</td>
<td>Mouse (Mus musculus)</td>
<td>4.3</td>
<td>17.0</td>
<td>88</td>
</tr>
<tr>
<td>19</td>
<td>Schroeder and Mitchener, 1975</td>
<td>Rat (Rattus norvegicus)</td>
<td>0.57</td>
<td>72</td>
<td>72</td>
</tr>
<tr>
<td>20</td>
<td>Stoewsand et al, 1988</td>
<td>Rat (Rattus norvegicus)</td>
<td>16.5</td>
<td>76</td>
<td>76</td>
</tr>
<tr>
<td>21</td>
<td>Dietz et al, 1992</td>
<td>Rat (Rattus norvegicus)</td>
<td>61.1</td>
<td>121</td>
<td>87</td>
</tr>
<tr>
<td>22</td>
<td>Dietz et al, 1992</td>
<td>Mouse (Mus musculus)</td>
<td>4.3</td>
<td>17.0</td>
<td>83</td>
</tr>
<tr>
<td>23</td>
<td>Borzelleca et al, 1988</td>
<td>Rat (Rattus norvegicus)</td>
<td>138</td>
<td>198</td>
<td>87</td>
</tr>
<tr>
<td>24</td>
<td>Schroeder and Mitchener, 1975</td>
<td>Mouse (Mus musculus)</td>
<td>0.74</td>
<td>67</td>
<td>67</td>
</tr>
</tbody>
</table>

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.

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**Eco-SSL for Barium**

February 2005
**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

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

---

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
7.0 REFERENCES

7.1 General Barium References


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


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.


### 7.4 References Used for Derivation of Wildlife TRVs


7.5 References Rejected for Use in Derivation of Wildlife TRVs

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.


Diss Autografts and allografts of the anterior cruciate ligament of the knee: experimental study of its revascularization and histology original title: aloinjertos y autoinjertos de ligamento cruzado anterior de la rodilla: estudio experimental de su revascularizacion e histologia 01358818

Diss Calcium-activated Potassium Channels from Rabbit Renal Brush Border Membrane Vesicles in Planar Lipid Bilayers: Basic Single-channel Properties, Block by Amiloride Analogs and the Effect of Magnesium on Calcium-activation (Calcium Activation) 01233575 ORDER NO: AAD92-21462

Diss a Characterization of the Effects of Cannabinoids in Rat Hippocampus (Marijuana, M Current, Win 55,212-2, Gaba) 01647233 ORDER NO: AAD98-33504

Diss Desensitization of the Capsaicin-activated Current in Rat Dorsal Root Ganglion Neurons (Tachyphylaxis) 01448091 ORDER NO: AADAA-I9538425

Diss the Effect of Intermittent Noise Exposure on the Rate of Wound Healing in Albino Rats (Image Processing, Bioacoustics) 927073 ORDER NO: AAD86-18596

Diss Elemental Analysis of Bone for Ancient Diet Reconstruction 01157970 ORDER NO: AAD91-14659

Influence of Myocardial Fiber Organization on Ventricular Function (Hypertrophic Cardiomyopathy) 01664135 ORDER NO: AAD99-04816

Mechanics and Model Identification in the Coronary Circulation (Blood Flow, Impedance, Capacitance) 01160086 ORDER NO: AAD91-15105

Neuroprotection Against Excitotoxic Cell Damage in Rat Striatum and Hippocampus 01183033 ORDER NO: AADDX-93755


Osteophilic Implant Materials: Design, Development and Applications 902284 ORDER NO: AAD85-28677

Patch Clamp Study of a Large Conductance, Inward Rectifying, Potassium Channel in Cultured Mouse Hippocampal Neurons (Ion Channels, Neurophysiology, Electrophysiology) 950038 ORDER NO: AAD87-08323


Regulation of Duodenal Ion Transport by Uroguanylin and Cloning of Murine Intestinal Clc-2 Chloride Channel 01698611 ORDER NO: AAD99-24893


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No COC Hayano Chieko(A), Nakanishi Takahiro(A), Katayama Hideki, Tani Tadato= (A), and Hirotsu 

Mix Heffron, C. L., Reid, J. T., Furr, A. K., Parkinson, T. F., King, J., Bache, C. A., St. John, L. E. Jr., 

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cynomolgus monkey (Macaca fascicularis): a complication of monozygotic monochorial Twinning. 

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sodium absorption in the coprodeum of the chicken embryo role of extracellular calcium. Journal of 
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Drug

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Unrel


Unrel


Unrel


FL


FL


No Dose


HHE


Unrel


In Vit


In Vit


In Vit


CP


Unrel


No Dose Hui, Clifford A. University of California Davis and Beyer, W. Nelson USGS Laurel MD. Sediment Ingestion of Two Sympatric Shorebird Species *Sci Total Environ.* v224, n1-3, p227(7)


CP  Jacobson, K. B., Turner, J. E., Christie, N. T., and Owenby, R. K. 1981. Toxic and Biochemical Effects of Divalent Metal Ions in Drosophila: Correlation to Effects in Mice and to Chemical Softness Parameters. CONF-811035-3


Unrel  James, S. W. and Eason, R. W. 1992. Extraordinary Polarised Light does not always yield the Highest Reflectivity from Self-Pumped BaTiO sub 3

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**Eco-SSL for Barium**  35  February 2005


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<tr>
<td>Surv</td>
<td>LaDelfe, C. M.</td>
<td>1981. Detailed Geochemical Survey Data Release for the San Andres-Oscura Mountains Special Study Area, New Mexico. GJBX-215-81; LA-8016-MS</td>
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Drug


Unrel


Unrel


Unrel


Nut def


Unrel


Unrel


Unrel

Leaper, D. J. A method for the study of the vasculature of the abdominal wall and gastrointestinal tract in experimental animals. *Microcirculation* 2(1). 1982. 35-44.

In Vit


Unrel


Unrel


Unrel


Unrel


Unrel


In Vit


Unrel


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Popova, O. YA. Experimental materials for substantiation of the maximum permissible concentration of barium fluoride in the air of work area *Gig Tr Prof Zabol*. (5). 1978 34-37
Phy

CP

No Oral

Unrel

In Vit

Unrel

Phy

Alt

No Control

Unrel

No Oral

Chem Meth

In Vit

In Vit


Unrel Rovira, C. and Ben Ari, Y. 1994. Benzodiazepines modulate calcium spikes in young and adult hippocampal cells vol. 5, no. 16, pp. 2125-2129 *Neuroreport*


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**Eco-SSL for Barium**  
57  
February 2005
Drug

No Oral

Unrel

HHE

Phy

In Vit

Phy

Surv

Unrel

Phys

Alt

Phys

Unrel

Unrel

FL    Shubochkin, L. N., Gerasimova, I. L., and Rozinskii, B. F.  Hygienic standards for barium tri carbonate aerosols in the air of work areas  *Gig Tr Prof Zabol*; 0 (6). 1980. 55.


Stratmann, K. Comparison of embryotoxic effects of inorganic fluorides *Dtsch Zahnaerztbl* 34:484-486,1979

Stratmann, K. and Eifinger, F. F. Toxicological threshold values of various fluoride compounds *Kariesprophylaxe* 3:15-17,1981


FL  Talalaenko, A. N. and Degonskii, A. I. Characteristics of the effect of barium titanates on the body. *Gig Sanit*; (6). 1974 102-103


<table>
<thead>
<tr>
<th>Type</th>
<th>Authors</th>
<th>Title</th>
<th>Journal, Volume, Issue, Pages</th>
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<tr>
<td></td>
<td>Morino, H., and Tsuchiyama, M.</td>
<td>antibiotic]</td>
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<td>No Dose</td>
<td>and Van Gool J.</td>
<td>injury on immunoglobulin e-mediated systemic anaphylaxis in the rat.</td>
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<td></td>
<td>and Scholtz Anna J.</td>
<td>biochemical and production responses in lambs to maternal treatment.</td>
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*Eco-SSL for Barium*  
February 2005  
64


<table>
<thead>
<tr>
<th>Rejection Criteria</th>
<th>Description</th>
<th>Receptor</th>
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<tbody>
<tr>
<td>ABSTRACT (Abstract)</td>
<td>Abstracts of journal publications or conference presentations.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>ACUTE STUDIES (Acu)</td>
<td>Single oral dose or exposure duration of three days or less.</td>
<td>Wildlife</td>
</tr>
<tr>
<td>AIR POLLUTION (Air P)</td>
<td>Studies describing the results for air pollution studies.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>ALTERED RECEPTOR (Alt)</td>
<td>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.).</td>
<td>Wildlife</td>
</tr>
<tr>
<td>AQUATIC STUDIES (Aquatic)</td>
<td>Studies that investigate toxicity in aquatic organisms.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>ANATOMICAL STUDIES (Anat)</td>
<td>Studies of anatomy. Instance where the contaminant is used in physical studies (e.g., silver nitrate staining for histology).</td>
<td>Wildlife</td>
</tr>
<tr>
<td>BACTERIA (Bact)</td>
<td>Studies on bacteria or susceptibility to bacterial infection.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>BIOACCUMULATION SURVEY (Bio Acc)</td>
<td>Studies reporting the measurement of the concentration of the contaminant in tissues.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>BIOLOGICAL PRODUCT (BioP)</td>
<td>Studies of biological toxicants, including venoms, fungal toxins, <em>Bacillus thuringiensis</em>, other plant, animal, or microbial extracts or toxins.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>BIOMARKER (Biom)</td>
<td>Studies reporting results for a biomarker having no reported association with an adverse effect and an exposure dose (or concentration).</td>
<td>Wildlife</td>
</tr>
<tr>
<td>CARCINOGENICITY STUDIES (Carcin)</td>
<td>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.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>CHEMICAL METHODS (Chem Meth)</td>
<td>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.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>CONFERENCE PROCEEDINGS (CP)</td>
<td>Studies reported in conference and symposium proceedings.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>DEAD (Dead)</td>
<td>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.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>DISSERTATIONS (Diss)</td>
<td>Dissertations are excluded. However, dissertations are flagged for possible future use.</td>
<td>Wildlife</td>
</tr>
<tr>
<td>DRUG (Drug)</td>
<td>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.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>DUPLICATE DATA (Dup)</td>
<td>Studies reporting results that are duplicated in a separate publication. The publication with the earlier year is used.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
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<tr>
<td>Rejection Criteria</td>
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<tr>
<td>ECOLOGICAL INTERACTIONS (Ecol)</td>
<td>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).</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>EFFLUENT (Effl)</td>
<td>Studies reporting effects of effluent, sewage, or polluted runoff.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>ECOLOGICALLY RELEVANT ENDPOINT (ERE)</td>
<td>Studies reporting a result for endpoints considered as ecologically relevant but is not used for deriving Eco-SSLs (e.g., behavior, mortality).</td>
<td>Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>CONTAMINANT FATE/METABOLISM (Fate)</td>
<td>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.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>FOREIGN LANGUAGE (FL)</td>
<td>Studies in languages other than English.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>FOOD STUDIES (Food)</td>
<td>Food science studies conducted to improve production of food for human consumption.</td>
<td>Wildlife</td>
</tr>
<tr>
<td>FUNGUS (Fungus)</td>
<td>Studies on fungus.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>GENE (Gene)</td>
<td>Studies of genotoxicity (chromosomal aberrations and mutagenicity).</td>
<td>Wildlife Plants and Soil Invertebrates</td>
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<tr>
<td>HUMAN HEALTH (HHE)</td>
<td>Studies with human subjects.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>IMMUNOLOGY (IMM)</td>
<td>Studies on the effects of contaminants on immunological endpoints.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>INVERTEBRATE (Invert)</td>
<td>Studies that investigate the effects of contaminants on terrestrial invertebrates are excluded.</td>
<td>Wildlife</td>
</tr>
<tr>
<td>IN VITRO (In Vit)</td>
<td>In vitro studies, including exposure of cell cultures, excised tissues and/or excised organs.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>LEAD SHOT (Lead shot)</td>
<td>Studies administering lead shot as the exposure form. These studies are labeled separately for possible later retrieval and review.</td>
<td>Wildlife</td>
</tr>
<tr>
<td>MEDIA (Media)</td>
<td>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.</td>
<td>Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>METHODS (Meth)</td>
<td>Studies reporting methods or methods development without usable toxicity test results for specific endpoints.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>MINERAL REQUIREMENTS (Mineral)</td>
<td>Studies examining the minerals required for better production of animals for human consumption, unless there is potential for adverse effects.</td>
<td>Wildlife</td>
</tr>
<tr>
<td>MIXTURE (Mix)</td>
<td>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.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
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<tr>
<td><strong>MODELING</strong> (Model)</td>
<td>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.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>NO CONTAMINANT OF CONCERN</strong> (No COC)</td>
<td>Studies that do not examine the toxicity of Eco-SSL contaminants of concern.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>NO CONTROL</strong> (No Control)</td>
<td>Studies which lack a control or which have a control that is classified as invalid for derivation of TRVs.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>NO DATA</strong> (No Data)</td>
<td>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).</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>NO DOSE or CONC</strong> (No Dose)</td>
<td>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.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>NO DURATION</strong> (No Dur)</td>
<td>Studies with no exposure duration. These are usually identified after examination of full paper.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>NO EFFECT</strong> (No Efect)</td>
<td>Studies with no relevant effect evaluated in a biological test species or data not reported for effect discussed.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>NO ORAL</strong> (No Oral)</td>
<td>Studies using non-oral routes of contaminant administration including intraperitoneal injection, other injection, inhalation, and dermal exposures.</td>
<td>Wildlife</td>
</tr>
<tr>
<td><strong>NO ORGANISM</strong> (No Org) or NO SPECIES</td>
<td>Studies that do not examine or test a viable organism (also see in vitro rejection category).</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>NOT AVAILABLE</strong> (Not Avail)</td>
<td>Papers that could not be located. Citation from electronic searches may be incorrect or the source is not readily available.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>NOT PRIMARY</strong> (Not Prim)</td>
<td>Papers that are not the original compilation and/or publication of the experimental data.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>NO TOXICANT</strong> (No Tox)</td>
<td>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.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>NO TOX DATA</strong> (No Tox Data)</td>
<td>Studies where toxicant used but no results reported that had a negative impact (plants and soil invertebrates).</td>
<td>Plants and Soil Invertebrates</td>
</tr>
<tr>
<td><strong>NUTRIENT</strong> (Nutrient)</td>
<td>Nutrition studies reporting no concentration related negative impact.</td>
<td>Plants and Soil Invertebrates</td>
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<tr>
<td><strong>NUTRIENT DEFICIENCY</strong> (Nut def)</td>
<td>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.</td>
<td>Wildlife</td>
</tr>
<tr>
<td><strong>NUTRITION</strong> (Nut)</td>
<td>Studies examining the best or minimum level of a chemical in the diet for improvement of health or maintenance of animals in captivity.</td>
<td>Wildlife</td>
</tr>
<tr>
<td><strong>OTHER AMBIENT CONDITIONS</strong> (OAC)</td>
<td>Studies which examine other ambient conditions: pH, salinity, DO, UV, radiation, etc.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
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<td>Rejection Criteria</td>
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<tr>
<td>OIL (Oil)</td>
<td>Studies which examine the effects of oil and petroleum products.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>OM, pH (OM, pH)</td>
<td>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.</td>
<td>Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>ORGANIC METAL (Org Met)</td>
<td>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.</td>
<td>Wildlife</td>
</tr>
<tr>
<td>LEAD BEHAVIOR OR HIGH DOSE MODELS (Pb Behav)</td>
<td>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.</td>
<td>Wildlife</td>
</tr>
<tr>
<td>PHYSIOLOGY STUDIES (Phys)</td>
<td>Physiology studies where adverse effects are not associated with exposure to contaminants of concern.</td>
<td>Wildlife</td>
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<tr>
<td>PLANT (Plant)</td>
<td>Studies of terrestrial plants are excluded.</td>
<td>Wildlife</td>
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<tr>
<td>PRIMATE (Prim)</td>
<td>Primate studies are excluded.</td>
<td>Wildlife</td>
</tr>
<tr>
<td>PUBL AS (Publ as)</td>
<td>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.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>QSAR (QSAR)</td>
<td>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.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>REGULATIONS (Reg)</td>
<td>Regulations and related publications that are not a primary source of data.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
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<tr>
<td>REVIEW (Rev)</td>
<td>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.</td>
<td>Wildlife Plants and Soil Invertebrates</td>
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<td>SEDIMENT CONC (Sed)</td>
<td>Studies in which the only exposure concentration/dose reported is for the level of a toxicant in sediment.</td>
<td>Wildlife</td>
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<td>Plants and Soil Invertebrates</td>
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<tr>
<td>SCORE (Score)</td>
<td>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.)</td>
<td>Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>SEDIMENT CONC (Sed)</td>
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<tr>
<td>SLUDGE</td>
<td>Studies on the effects of ingestion of soils amended with sewage sludge.</td>
<td>Wildlife</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>SOIL CONC (Soil)</td>
<td>Studies in which the only exposure concentration/dose reported is for the level of a toxicant in soil.</td>
<td>Wildlife</td>
</tr>
<tr>
<td>SPECIES</td>
<td>Studies in which the species of concern was not a terrestrial invertebrate or plant or mammal or bird.</td>
<td>Plants and Soil Invertebrates Wildlife</td>
</tr>
<tr>
<td>STRESSOR (QAC)</td>
<td>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.</td>
<td>Wildlife</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>SURVEY (Surv)</td>
<td>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.</td>
<td>Wildlife</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>REPTILE OR AMPHIBIAN (Herp)</td>
<td>Studies on reptiles and amphibians. These papers flagged for possible later review.</td>
<td>Wildlife</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>UNRELATED (Unrel)</td>
<td>Studies that are unrelated to contaminant exposure and response and/or the receptor groups of interest.</td>
<td>Wildlife</td>
</tr>
<tr>
<td>WATER QUALITY STUDY (Wqual)</td>
<td>Studies of water quality.</td>
<td>Wildlife</td>
</tr>
<tr>
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<td></td>
<td>Plants and Soil Invertebrates</td>
</tr>
<tr>
<td>YEAST (Yeast)</td>
<td>Studies of yeast.</td>
<td>Wildlife</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plants and Soil Invertebrates</td>
</tr>
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</table>
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Appendix 6-1

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

February 2005
### Appendix 6.1 Mammalian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV) — Barium

| Ref No. | Common name | Conc/Doses | Application Frequency | Conc/Dose Units | Method of Chem Analyses | Route of Exposure | Exposure Duration | Duration Units | Age Units | Lifestage | Sex | Control Type | Test Location | Test Conditions | Ingestion Rate Reported? | Ingestion Rate (kg or L/day) | Statistical Power | Dose Range | Endpoint | LOAEL Dose (mg/kg/day) | Test Concentrations | Dose Route | Effect Measure | Study NOAEL | Study LOAEL | Body Weight Reported? | Total | Data Evaluation Score |
|---------|-------------|------------|----------------------|----------------|------------------------|-------------------|------------------|-----------------|-----------|------------|-----|---------------|----------------|----------------|------------------------|--------------------------|-----------------|------------|-----------------|------------------------|-----------------|----------------|-------------|---------------|-----------------|-----------------|-----------------|-------------|-----------------|
| 1       | 16584       | Rattus norvegicus | 5 50/100/145/209/300 | N | 100 10 37 | Y | 1.48 | U | CHM | UREA | 100 | Y | 0.0180 | 6.00 | 10 8 10 10 10 10 8 10 10 10 4 77 |
| 2       | 16532       | Rat (Rattus norvegicus) | 5 100 | N | 10 4 | Y | 1.48 | U | CHM | UREA | 100 | Y | 0.0180 | 6.00 | 10 8 10 10 10 10 8 10 10 10 4 77 |
| 3       | 16530       | Rat (Rattus norvegicus) | 2 2 | 10 | Y | 1.48 | U | CHM | UREA | 100 | Y | 0.0180 | 6.00 | 10 8 10 10 10 10 8 10 10 10 4 77 |
| 4       | 16530       | Rattus norvegicus | 5 50/100/145/209/300 | N | 100 10 37 | Y | 1.48 | U | CHM | UREA | 100 | Y | 0.0180 | 6.00 | 10 8 10 10 10 10 8 10 10 10 4 77 |
| 5       | 16592       | Rat (Rattus norvegicus) | 1 50 | N | 10 4 | Y | 1.48 | U | CHM | UREA | 100 | Y | 0.0180 | 6.00 | 10 8 10 10 10 10 8 10 10 10 4 77 |
| 6       | 16592       | Rat (Rattus norvegicus) | 1 50 | N | 10 4 | Y | 1.48 | U | CHM | UREA | 100 | Y | 0.0180 | 6.00 | 10 8 10 10 10 10 8 10 10 10 4 77 |

All abbreviations and definitions are used in coding studies are available from Attachment 4.3 of the Eco-SSL guidance (U.S. EPA 2005).