

# **Ecological Soil Screening Levels for Polycyclic Aromatic Hydrocarbons (PAHs) Interim Final**

**OSWER Directive 9285.7-78**



**U.S. Environmental Protection Agency  
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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, 2005). The derivation procedures represent the group 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 polycyclic aromatic hydrocarbons (PAHs) and the documentation for their derivation. This document provides guidance and is designed to communicate national policy on identifying PAH 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 PAHs

Polycyclic aromatic hydrocarbons (PAHs) (CASRN: 130498-29-2) constitute a class of organic substances made up of carbon and hydrogen atoms grouped into at least two condensed aromatic ring structures. These are divided into two categories: low molecular weight compounds composed of fewer than four rings and high molecular weight compounds of four or more rings. PAH derivatives are PAHs having an alkyl or other radical attached to a ring. Heterocyclic aromatic compounds (HACs) include PAHs having any one carbon atom in a ring replaced by a

nitrogen, oxygen, or sulfur atom PAHs are also referred to as polynuclear hydrocarbons, polynuclear aromatic hydrocarbons, or polycyclic organic matter (HSDB).

Polycyclic aromatic hydrocarbons (PAHs) are found throughout the environment in air, soil, water, and sediment. PAHs enter the environment from both natural and anthropogenic sources. Natural sources include volcanic eruptions and forest fires (ATSDR, 1995). Primary anthropogenic sources are from the extraction, transport, and refining of petroleum products and combustion products resulting from their use (International Labor Office, 1998). Other industrial sources include machine lubricating and cutting oils, and color printing oils (WHO, 2002). PAHs are also found in creosote (NTP, 2003), coal tar, roofing materials, and surface coatings. PAHs are not currently produced for commercial use in the United States, although several compounds are distributed for research purposes by specialty chemical companies (NTP, 2003) (HSDB).

The primary mode of toxicity for PAHs in soil dwelling terrestrial invertebrates is non-specific, nonpolar narcosis (Sverdrup et al., 2002a). The uptake of PAHs by earthworms occurs primarily by direct contact with the soluble phase of the soil solution (interstitial porewater) (Fairbrother, 2005). Soil porewater concentrations of PAHs are more predictive of biological responses (toxicity and/or bioaccumulation) in soil organisms than are bulk soil concentrations. Several studies show a relationship between bioaccumulation of or toxic effects of PAHs and soil porewater concentrations. The relationships are more predictable for low molecular weight compounds and show significant variability for high molecular weight PAHs (Ma et al., 1998) (Fairbrother, 2005).

The bioavailability of PAHs in soils is influenced by organic carbon quality and quantity, aging and weathering, microbial action, methylation/hydroxylation, adsorption/desorption hysteresis and ultra-violet light interaction (Fairbrother, 2005). The soil organic carbon-water partition coefficients ( $K_{oc}$ ) for PAHs vary depending on the size of associated soil particles with the highest values in silt (fine particles) followed by sand and clay (Krauss and Wilcke, 2002).

Microbial degradation of PAHs is a key process in environmental fate in soils. The rate of biodegradation is dependant on the nutrient content and bacterial community in the soil. PAHs in soils undergo a weathering process such that the lighter chain fractions are removed (primarily by volatilization). Heavier fractions bind more readily to the soil organic matter and remain behind in the top soil horizon. As the mixture of PAHs age, bioavailability changes as the fraction remaining bind more tightly (Fairbrother, 2005). Aging reduces the bioavailability of PAHs in soils (Johnson et al., 2002). Chemicals in soils “age” by becoming incorporated inside the crystal lattice structure of the soil particle, or partitioning onto organic matter or soil nanopores (Nam et al., 1998), so they are no longer available for uptake by organisms. Bulk sediment chemistry methods can measure PAHs sequestered in this manner but it is not biologically available to organisms. Aging is, however, influenced by biodegradation and soil characteristics and is not a linear predictive relationship (Sverdrup et al., 2002b). PAHs that result from combustion processes are inserted into particulate lattices during formation, and appear to be “aged” even when recently deposited into soils (Fairbrother, 2005).

In general, the more-soluble a PAH, the higher the uptake by plants while the reverse is true for

uptake by earthworms and uptake in the gastrointestinal tract of animals (Wilcke, 2000). The most important source of PAHs for plants is the atmosphere where they enter via the gaseous phase or deposit bound to particles on the plant surface (Sims and Overcash, 1983; Wilcke, 2000). Shoots and leaves, above-ground plant parts and root surfaces generally contain larger PAH concentrations compared to seeds, below-ground plant parts and root interior parts (Sims and Overcash, 1983; Wilcke, 2000).

Animals may be exposed to PAHs in soils either as the result of direct ingestion or indirect ingestion in food items. In general, the acute toxicity of PAHs to animals increases as the molecular weights increase (Kulig and Pike, 2001). Animal studies have shown that exposure to PAHs can cause harmful effects on the skin, hematopoietic system, small intestine, kidneys, mammary gland and immune response (Shore and Rattner, 2001). PAHs are metabolized in the liver, where toxicity is associated with cytochrome P450-mediated conversion of the parent compound to toxic metabolic intermediates (Shore and Rattner, 2001) (HSDB).

### **Peer Review of Eco-SSL Methodology for PAHs**

The methodology for deriving Eco-SSLs was primarily designed for deriving soil concentrations for single compounds and not a group of compounds with multiple forms. When the current Eco-SSL methods are applied to PAHs as a group (with data for all individual compounds considered together) the results for derivation of a wildlife toxicity reference value (TRV) is a focus on the most toxic PAH compound. There is no consideration of the relative toxicity of less toxic compounds. For plants and soil invertebrates, the focus is on the geometric mean of values across all PAH compounds.

In August of 2006, EPA sought a peer-review of the Eco-SSL methodology as to its applicability for derivation of values for PAHs as group of compounds with multiple forms. Five peer reviewers were identified who were experienced with either the toxicity of PAHs and/or risk assessment of these substances. The peer review process and results are summarized in Appendix 2-1. The consensus among the peer reviewers was that grouping both toxicity and exposure data into two classes based on molecular weight was a reasonable approach to derivation of Eco-SSLs. Although it would be ideal to use a toxicity equivalency approach in developing values, this is not possible due to limitations of the existing data. Grouping PAHs into the two classes (low and high molecular weight) is a means to address the differences in physical/chemical properties of individual PAHs which influence toxicity and environmental fate.

### **Derivation of Eco-SSLs**

Eco-SSL values were derived for low molecular weight (LMW) and high molecular weight (HMW) PAHs for soil invertebrates and mammalian wildlife (Table 2.1). Eco-SSLs could not be derived for plants or avian wildlife. For these receptor groups, data were insufficient to derive soil screening values. Eco-SSL values calculated for LMW-PAHs range from 29 mg/kg dry weight (dw) for soil invertebrates to 100 mg/kg dw for mammalian wildlife. Eco-SSL values calculated for HMW-PAHs range from 1.1 mg/kg dw for mammalian wildlife to 18 mg/kg dw for soil invertebrates.



Table 2.1 PAH Eco-SSLs (mg/kg dry weight in soil)				
	Plants	Soil Invertebrates	Wildlife	
			Avian	Mammalian
Low Molecular Weight (LMW)	NA	29	NA	100
High Molecular Weight (HMW)	NA	18	NA	1.1

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

### 3.0 ECO-SSL FOR TERRESTRIAL PLANTS

Of the papers identified from the literature search process, 162 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). Thirteen studies received an Evaluation Score greater than ten. These studies were either for the LMW-PAHs anthracene or a mixture of PAHs and are listed in Table 3.1.

There were no studies that were eligible to derive an Eco-SSL according to the Eco-SSL guidance (U.S. EPA, 2003; Attachment 3-2). An Eco-SSL could not be derived for plants for either group of PAHs.

### 4.0 ECO-SSL FOR SOIL INVERTEBRATES

Of the papers identified from the literature search process, 94 papers were acquired for further review. Of those papers acquired, five 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).

For LMW-PAHs, 16 studies received an Evaluation Score greater than ten. These studies are listed in Table 4.1. There are 11 studies eligible for Eco-SSL derivation that were used to derive the soil invertebrate Eco-SSL for PAHs (U.S. EPA, 2003; Attachment 3-2). The Eco-SSL is the geometric mean of the MATC and EC<sub>10</sub> values for four test species under different test conditions (pH and OM%) and is equal to 29 mg/kg dw.

For HMW-PAHs, six studies received an Evaluation Score greater than ten. These studies are listed in Table 4.2. There are six studies eligible for Eco-SSL derivation that were used to derive the soil invertebrate Eco-SSL for PAHs (U.S. EPA, 2003; Attachment 3-2). The Eco-SSL is the geometric mean of the MATC and EC<sub>10</sub> values for four test species under different test conditions (pH and OM%) and is equal to 18 mg/kg dw.

**Table 3.1 Plant Toxicity Data - PAHs**

Reference	IP Number	Study ID	PAH	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?
Mitchell et al., 1988	15861	g	Anthracene	Oats	<i>Avena sativa</i>	5.5	2.0	2	GRO	EC <sub>50</sub>	30	15	N	N
Mitchell et al., 1988	15861	h	Anthracene	Cucumber	<i>Cucumis sativus</i>	5.5	2.0	2	GRO	EC <sub>50</sub>	720	15	N	N
Leyval and Binet, 1998	15848	c	Mixture	Perennial ryegrass	<i>Lolium perenne L.</i>	6.80	1.50	2	GRO	LOAEC	100	11	N	N
Mitchell et al., 1988	15861	a	Anthracene	Oats	<i>Avena sativa</i>	5.5	2.0	2	MOR	LC <sub>50</sub>	525	14	N	N
Mitchell et al., 1988	15861	b	Anthracene	Cucumber	<i>Cucumis sativus</i>	5.5	2.0	2	MOR	LC <sub>50</sub>	>1000	12	N	N
Mitchell et al., 1988	15861	c	Anthracene	Soybean	<i>Glycine max</i>	5.5	2.0	2	MOR	LC <sub>50</sub>	>1000	12	N	N
Mitchell et al., 1988	15861	d	Anthracene	Heath banksia	<i>Banksia ericifolia</i>	5.5	2.0	2	MOR	LC <sub>50</sub>	>1000	12	N	N
Mitchell et al., 1988	15861	e	Anthracene	She-oak	<i>Casuarina distyla</i>	5.5	2.0	2	MOR	LC <sub>50</sub>	>1000	12	N	N
Mitchell et al., 1988	15861	f	Anthracene	Yellow bloodwood	<i>Eucalyptus eximia</i>	5.5	2.0	2	MOR	LC <sub>50</sub>	>1000	12	N	N
Mitchell et al., 1988	15861	i	Anthracene	Soybean	<i>Glycine max</i>	5.5	2.0	2	GRO	EC <sub>50</sub>	>1000	15	N	N
Mitchell et al., 1988	15861	j	Anthracene	Heath banksia	<i>Banksia ericifolia</i>	5.5	2.0	2	GRO	EC <sub>50</sub>	>1000	15	N	N
Mitchell et al., 1988	15861	k	Anthracene	She-oak	<i>Casuarina distyla</i>	5.5	2.0	2	GRO	EC <sub>50</sub>	>1000	15	N	N
Mitchell et al., 1988	15861	l	Anthracene	Yellow bloodwood	<i>Eucalyptus eximia</i>	5.5	2.0	2	GRO	EC <sub>50</sub>	>1000	15	N	N

EC<sub>50</sub> = Effect concentration for 50% of test population

ERE = Ecologically relevant endpoint

GRO = Growth

LC<sub>50</sub> = Concentration lethal to 50% of test population

LOAEC = Lowest observed adverse effect concentration

N = No

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 - Low Molecular Weight (LMW) PAHs**

Reference	IP Number	Study ID	PAH	Test Organism		Soil pH	OM%	Bio-availability Score	ERE	Tox Parameter	Tox Value (Soil Conc at mg/kg dw)	Total Evaluation Score	Eligible for Eco-SSL Derivation?	Used for Eco-SSL?
Crouau et al., 1999	18893		Phenanthrene	springtail	<i>Folsomia candida</i>	6.0	10.0	1	REP	MATC	175	17	Y	Y
Sverdrup et al. 2001	20-6-1332	b	Fluoranthene	springtail	<i>Folsomia fimetaria L.</i>	6.2	2.8	0	REP	EC <sub>10</sub>	37	14	Y	Y
Sverdrup et al. 2001	20-6-1332	c	Phenanthrene	springtail	<i>Folsomia fimetaria L.</i>	6.2	2.8	0	REP	EC <sub>10</sub>	23	14	Y	Y
Sverdrup et al. 2001	20-6-1332	d	Fluorene	springtail	<i>Folsomia fimetaria L.</i>	6.2	2.8	0	REP	EC <sub>10</sub>	8	14	Y	Y
Sverdrup et al. 2002a	21-1-109	b	Fluoranthene	potworm	<i>Enchytraeus crypticus</i>	6.2	2.8	0	REP	EC <sub>10</sub>	15	14	Y	Y
Sverdrup et al. 2002a	21-1-109	c	Phenanthrene	potworm	<i>Enchytraeus crypticus</i>	6.2	2.8	0	REP	EC <sub>10</sub>	40	14	Y	Y
Sverdrup et al. 2002a	21-1-109	d	Fluorene	potworm	<i>Enchytraeus crypticus</i>	6.2	2.8	0	REP	EC <sub>10</sub>	25	14	Y	Y
Sverdrup et al. 2002b	21-3-489	b	Phenanthrene	springtail	<i>Folsomia fimetaria L.</i>	6.2	2.8	0	REP	EC <sub>10</sub>	9	14	Y	Y
Sverdrup et al. 2002c	21-9-1927	b	Fluoranthene	earthworm	<i>Eisenia veneta</i>	6.2	2.8	0	GRO	EC <sub>10</sub>	113	14	Y	Y
Sverdrup et al. 2002c	21-9-1927	c	Phenanthrene	earthworm	<i>Eisenia veneta</i>	6.2	2.8	0	GRO	EC <sub>10</sub>	25	14	Y	Y
Sverdrup et al. 2002c	21-9-1927	d	Fluorene	earthworm	<i>Eisenia veneta</i>	6.2	2.8	0	GRO	EC <sub>10</sub>	31	14	Y	Y
Geometric Mean											29			
<b>Data Not Used to Derive Invertebrate Eco-SSL</b>														
Neuhauser et al., 1985a	17707	a	Fluorene	earthworm	<i>Eisenia fetida</i>	6.0	10.0	1	MOR	LC <sub>50</sub>	173	15	N	N
Neuhauser et al., 1986	1214	a	Fluorene	earthworm	<i>Allolobophora tuberculata</i>	6.0	10.0	1	MOR	LC <sub>50</sub>	206	15	N	N
Neuhauser et al., 1986	1214	b	Fluorene	earthworm	<i>Eisenia fetida</i>	6.0	10.0	1	MOR	LC <sub>50</sub>	173	15	N	N
Neuhauser et al., 1986	1214	c	Fluorene	earthworm	<i>Eudrilus eugenia</i>	6.0	10.0	1	MOR	LC <sub>50</sub>	197	15	N	N
Neuhauser et al., 1986	1214	d	Fluorene	earthworm	<i>Perionyx excavatus</i>	6.0	10.0	1	MOR	LC <sub>50</sub>	170	15	N	N

ERE = Ecologically relevant endpoint  
 LC<sub>50</sub> = Concentration lethal to 50% of test population  
 LOAEC = Lowest observed adverse effect concentration  
 MATC = Maximum acceptable toxicant concentration  
 MOR = Mortality  
 N = No

NOAEC = No observed adverse effect concentration  
 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)

**Table 4.2 Invertebrate Toxicity Data - High Molecular Weight (HMW) PAHs**

Reference	IP Number	Study ID	PAH	Test Organism		Soil pH	OM%	Bio-availability Score	ERE	Tox Parameter	Tox Value (Soil Conc at mg/kg dw)	Total Evaluation Score	Eligible for Eco-SSL Derivation?	Used for Eco-SSL?
Brown et al. 2004	57-1675		Pyrene	earthworm	<i>Lumbricus rubellus</i>	NA	10.0	0	REP	MATC	80	11	Y	Y
Herbert et al. 2004	57-175	a	Pyrene	springtail	<i>Folsomia candida</i>	6.0	10.0	0	REP	MATC	10	13	Y	Y
Sverdrup et al. 2001	20-6-1332	a	Pyrene	springtail	<i>Folsomia fimetaria L.</i>	6.2	2.8	0	REP	EC <sub>10</sub>	10	14	Y	Y
Sverdrup et al. 2002a	21-1-109	a	Pyrene	potworm	<i>Enchytraeus crypticus</i>	6.2	2.8	0	REP	EC <sub>10</sub>	11	14	Y	Y
Sverdrup et al. 2002b	21-3-489	a	Pyrene	springtail	<i>Folsomia fimetaria L.</i>	6.2	2.8	0	REP	EC <sub>10</sub>	10	14	Y	Y
Sverdrup et al. 2002c	21-9-1927	a	Pyrene	earthworm	<i>Eisenia veneta</i>	6.2	2.8	0	GRO	EC <sub>10</sub>	38	14	Y	Y
Geometric Mean											18			

ERE = Ecologically relevant endpoint

GRO = Growth

LC<sub>50</sub> = Concentration lethal to 50% of test population

LOAEC = Lowest observed adverse effect concentration

MATC = Maximum acceptable toxicant concentration

N = No

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)

## **5.0 ECO-SSL FOR AVIAN WILDLIFE**

The derivation of the Eco-SSL for avian 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 5,478 papers with possible toxicity data for either avian or mammalian species. Of these papers, 5,432 papers were rejected for use as described in Section 7.5. Of the remaining papers, two contained data for avian test species. These papers were reviewed and the data were 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 Appendix 5-1 for LMW-PAHs and Appendix 5-2 for HMW-PAHs. Within the results there are data available for only one species exposed to LMW-PAHs and one species exposed to HMW-PAHs. There were not enough data to derive TRVs for either class of PAHs.

## **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) 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 5,478 papers with possible toxicity data for PAHs for either avian or mammalian species. Of these papers, 5,432 were rejected for use as described in Section 7.5. Of the remaining papers, 46 contained data for mammalian test species. These papers were reviewed and the data were 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 for LMW - PAHs and Table 6.2 for HMW - PAHs.. The complete results are provided in Appendix 6-1 for LMW-PAHs and Appendix 6.2 for HMW-PAHs.

Within the 46 papers there are 76 results for LMW - PAHs for biochemical (BIO), behavior (BEH), physiology (PHY), pathology (PTH), reproduction (REP), growth (GRO), and survival (MOR) endpoints with a total Data Evaluation Score >65 that were 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 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 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 was calculated at 170 mg

PAHs/kg bw/day. However, this value is higher than the lowest bounded LOAEL for reproduction, growth, or mortality. Therefore, the TRV is equal to the highest bounded NOAEL below the lowest bounded LOAEL for reproduction, growth, or survival and is equal to 65.6 mg PAHs/kg bw/day.

There are 45 results for HMW - PAHs, for biochemical (BIO), behavior (BEH), physiology (PHY), pathology (PTH), reproduction (REP), growth (GRO), and survival (MOR) endpoints with a total Data Evaluation Score >65 that were used to derive the TRV (U.S. EPA, 2003; Attachment 4-4). These data are plotted in Figure 6.2 and correspond directly with the data presented in Table 6.2. The 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 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 was calculated at 18 mg PAHs/kg bw/day. However, this value is higher than the lowest bounded LOAEL for reproduction, growth, or mortality. Therefore, the TRV is equal to the highest bounded NOAEL lower than the lowest bounded LOAEL for reproduction, growth, or survival and is equal to 0.615 mg PAHs/kg bw/day.

## **6.2 Estimation of Dose and Calculation of the Eco-SSL**

For each group of PAHs (LMW and HMW), three separate Eco-SSL values were calculated for mammalian wildlife, one for each of three surrogate species representing different trophic groups. The mammalian Eco-SSLs derived for PAHs were calculated according to the Eco-SSL guidance (U.S. EPA, 2003) and are summarized in Table 6.3 for LMW-PAHs and Table 6.4 for HMW-PAHs.



**Table 6.1 Mammalian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)  
Low Molecular Weight Polynuclear Aromatic Hydrocarbons (LMW-PAHs)  
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Result #	Reference	Ref No.	Test Organism	# of Conc/ Doses	Method of Analysis	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)	Total
59	Booth et al, 1983	1234	Naphthalene	2	U	GV	8	d	61-71	d	GE	F	GRO	BDWT	WO	300		82
60	Pharmakon Resesarch, 1986	26017	Naphthalene	4	U	GV	12	d	>=24	w	GE	F	GRO	BDWT	WO	400		84
61	Ramesh et. al, 2000	32253	Fluoranthene	4	U	FD	60	d	6-7	w	JV	M	GRO	BDWT	WO	725	1460	87
62	Knuckles et al., 2004	48537	Fluoranthene	4	UX	FD	90	d	9	w	JV	M	GRO	BDWT	WO	735	1470	92
63	Poole and Buckley, 1989	26157	1-Naphthol	4	U	GV	30	d	6-7	w	JV	B	GRO	BDWT	WO		50.0	84
64	Hardin, et al, 1987	1335	Naphthalene	2	U	GV	17	d	NR	NR	GE	F	GRO	BDWT	WO		300	84
65	Tao et al, 1991	28360	Naphthalene	2	U	GV	60	d	NR	NR	JV	F	GRO	BDWT	WO		700	84
<b>Survival (MOR)</b>																		
66	Germansky and Jamall, 1988	28793	Naphthalene	2	U	GV	2	w	NR	NR	JV	M	MOR	MORT	WO	50.0		85
67	Navarro et al, 1992	28813	Naphthalene	4	U	GV	13	d	6	mo	GE	F	MOR	MORT	WO	120		85
68	Shopp et al, 1984	30980	Naphthalene	4	U	GV	90	d	6-7	w	JV	B	MOR	SURV	WO	133		85
69	Booth et al, 1983	1234	Naphthalene	6	U	GV	8	d	61-71	d	JV	F	MOR	MORT	WO	250	500	91
70	Pharmakon Research, 1985	26016	Naphthalene	5	U	GV	24	d	>=24	w	GE	F	MOR	MORT	WO	250	630	91
71	Shopp et al, 1984	30980	Naphthalene	4	U	GV	14	d	6-7	w	JV	B	MOR	SURV	WO	267		76
72	Anonymous, 1992	26028	Naphthalene	4	U	FD	4	w	NR	NR	JV	NR	MOR	MORT	WO	294		82
73	Pharmakon Resesarch, 1986	26017	Naphthalene	4	U	GV	12	d	>=24	w	GE	F	MOR	MORT	WO	400		85
74	Navarro, et al, 1991	28943	Naphthalene	4	U	GV	9	d	8-10	w	GE	F	MOR	MORT	WO	450		85
75	Booth et al, 1983	1234	Naphthalene	2	U	GV	8	d	61-71	d	GE	F	MOR	MORT	WO		300	85
76	Hardin, et al, 1987	1335	Naphthalene	2	U	GV	11	d	NR	mo	GE	F	MOR	MORT	WO		300	85

AD = adult; AHHD = aryl hydrocarbon hydrolase; AR = adrenal; B = both; BDWT = body weight changes; BEH = behavior; BL = blood; bw = body weight; CHM = chemical changes; CREA = creatinine; d - day; DOPA = dopamine; ENZ = enzyme level changes; EY = eye; F = female; FCNS = food consumption; FD = food; FDB = feeding behavior; FDCV = feed conversion efficiency; GBCM = general biochemical changes; GE = gestation; GENZ = general enzyme changes; GHIS = general histology; GREP = general reproduction; GRO = growth; GRS = gross body weight changes; GV = gavage; HEMT = hematocrit; HIS = histological changes; HMGL = hemoglobin; HRM = hormone changes; JV = juvenile; kg = kilograms; KI = kidney; LADH = ; L = liter; LI = liver; LOAEL = lowest observed adverse effect level; mo = months; M = male; M = measured; MOR = effects on mortality and survival; MORT = mortality; NOAEL = No Observed Adverse Effect Level; NR = Not reported; OR = other oral; ORW = organ weight changes; ORWT = organ weight changes; PHY = physiology; PL = plasma; PORP = porphyrin; PROG = progeny numbers/counts; PRTL = protein, total; PRWT = progeny weight; PTH = pathology; REP = reproduction; RSEM = resorbed embryo; SM = sexually mature; SMIX = weight relative to body weight; SR = serum; SURV = survival; TE = testes; TEWT = testes weight; TRII = triiodothyronine; TS = ; TY = ; U = unmeasured; UR = urine; USTR = ultrastructural changes; UX = measured but values not reported; w = weeks; WCON = water consumption; WO = whole organism; yr = year.

\*NOAEL and LOAEL values that are equal and from the same reference represent different experimental designs.



**Table 6.2 Mammalian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)**  
**High Molecular Weight Polynuclear Aromatic Hydrocarbons (HMW-PAHs)**  
 Page 1 of 1

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)	Total	
<b>Biochemical (BIO)</b>																			
1	De Jong et al, 1999	25983	Benzo(a)pyrene	Rat ( <i>Rattus norvegicus</i> )	5	U	GV	5	w	6	w	JV	M	CHM	HMGL	BL	2.11	7.04	81
2	Knuckles et al, 2001	25982	Benzo(a)pyrene	Rat ( <i>Rattus norvegicus</i> )	4	UX	FD	60	d	9	w	JV	M	CHM	HMCT	BL	4.90	49.0	86
3	Yamauchi et al, 1991	28204	Benzo(a)pyrene	Rat ( <i>Rattus norvegicus</i> )	3	U	GV	10	d	5	w	JV	M	ENZ	GSTR	LI	5.0	50.0	81
4	Burchiel et al., 1990	28439	7,12-Dimethylbenz(a)anthracene	Mouse ( <i>Mus musculus</i> )	4	U	GV	14	d	10-11	w	JV	F	CHM	GBCM	SP		0.0970	77
5	Ramesh et al., 2000	32253	Benzo(a)pyrene	Rat ( <i>Rattus norvegicus</i> )	4	U	FD	90	d	6-7	w	JV	M	ENZ	AHHD	LI		5.39	74
6	Hood et al., 2003	48370	3-Methylcholanthrene	Mouse ( <i>Mus musculus</i> )	5	U	FD	21	d	7	w	JV	M	HRM	TRII	SR		7.94	69
7	Bosveld, et al, 1996	27748	Benzo(a)pyrene	White toothed shrew ( <i>Sorex araneus</i> )	3	U	FD	9	d	NR	NR	NR	F	ENZ	ECOD	LI		10.0	70
8	Reuber and Glover, 1969	30150	7,12-Dimethylbenz(a)anthracene	Rat ( <i>Rattus norvegicus</i> )	2	U	FD	12	w	12	w	JV	M	CHM	GBCM	SR		20.7	70
9	Polidoro et al., 1985	30641	3-Methylcholanthrene	Guinea pig ( <i>Cavia porcellus</i> )	2	U	FD	14	d	NR	NR	JV	F	ENZ	GLPX	LI		30.0	77
10	Das et al, 1994	27335	Benzenanthrone	Guinea pig ( <i>Cavia porcellus</i> )	2	U	GV	4	w	NR	NR	JV	M	CHM	HMGL	BL		50.0	77
<b>Behavior (BEH)</b>																			
11	Knuckles et al, 2001	25982	Benzo(a)pyrene	Rat ( <i>Rattus norvegicus</i> )	4	UX	FD	90	d	9	w	JV	M	FDB	FCNS	WO	49.0	98.0	91
12	Ramesh et al., 2000	32253	Benzo(a)pyrene	Rat ( <i>Rattus norvegicus</i> )	4	U	FD	90	d	6-7	w	JV	M	FDB	FCNS	WO	53.9	90.2	83
<b>Physiology (PHY)</b>																			
13	Lambelin et al. 1967	26033	6-Aminochrysene	Rat ( <i>Rattus norvegicus</i> )	3	U	FD	360	d	1	mo	JV	M	PHY	FDCV	WO	24		68
14	Lambelin et al. 1967	26033	6-Aminochrysene	Rat ( <i>Rattus norvegicus</i> )	3	U	FD	360	d	1	mo	JV	F	PHY	FDCV	WO	26.4		68
<b>Pathology (PTH)</b>																			
15	De Jong et al, 1999	25983	Benzo(a)pyrene	Rat ( <i>Rattus norvegicus</i> )	5	U	GV	5	w	6	w	JV	M	ORW	ORWT	TS	2.11	7.04	84
16	Gao et al., 2005	48343	7,12-Dimethylbenz(a)anthracene	Mouse ( <i>Mus musculus</i> )	4	U	GV	5	d	8-10	w	JV	M	ORW	SMIX	SP	3.23	9.50	86
17	Yamauchi et al, 1991	28204	Benzo(a)pyrene	Rat ( <i>Rattus norvegicus</i> )	3	U	GV	10	d	5	w	JV	M	ORW	SMIX	LI	5.0	50.0	84
18	Bosveld, et al, 1996	27748	Benzo(a)pyrene	White toothed shrew ( <i>Sorex araneus</i> )	3	U	FD	9	d	NR	NR	NR	F	GRS	BDWT	WO	10.0	100	77
19	Knuckles et al., 2001	25982	Benzo(a)pyrene	Rat ( <i>Rattus norvegicus</i> )	4	UX	FD	90	d	9	w	JV	M	ORW	SMIX	LI	49.0	98.0	91
20	Uno et al., 2006	48539	Benzo(a)pyrene	Mouse ( <i>Mus musculus</i> )	4	U	FD	18	d	NR	NR	JV	M	ORW	SMIX	LI	125		68
21	Seidel, 1977	25987	7,12-Dimethylbenz(a)anthracene	Mouse ( <i>Mus musculus</i> )	2	U	GV	2	w	8-10	w	JV	F	ORW	ORWT	TS		0.140	80
22	Reuber and Glover, 1969	30150	7,12-Dimethylbenz(a)anthracene	Rat ( <i>Rattus norvegicus</i> )	2	U	FD	12	w	12	w	JV	M	ORW	ORWT	TY		20.7	73
23	Das et al, 1994	27335	Benzenanthrone	Guinea pig ( <i>Cavia porcellus</i> )	2	U	GV	4	w	NR	NR	JV	M	ORW	SMIX	LI		50.0	80
<b>Reproduction (REP)</b>																			
24	Mackenzie and Angevine, 1981	26128	Benzo(a)pyrene	Mouse ( <i>Mus musculus</i> )	4	U	GV	9	d	NR	NR	GE	F	REP	PRWT	WO	10.0	40.0	90
25	Lambelin et al. 1967	26033	6-Aminochrysene	Rat ( <i>Rattus norvegicus</i> )	3	U	FD	3	mo	1	mo	GE	F	REP	PROG	WO	13.3	26.4	89
26	Rigdon and Neal, 1965	26164	Benzo(a)pyrene	Mouse ( <i>Mus musculus</i> )	2	U	FD	17	d	NR	NR	LC	F	REP	PRWT	WO		45.9	79
<b>Growth (GRO)</b>																			
27	Culp et al., 1998	48317	Benzo(a)pyrene	Mouse ( <i>Mus musculus</i> )	4	M	FD	55	w	5	w	JV	B	GRO	BDWT	WO	3.09	12.4	86
28	Yamauchi et al, 1991	28204	Benzo(a)pyrene	Rat ( <i>Rattus norvegicus</i> )	3	U	GV	10	d	5	w	JV	M	GRO	BDWT	WO	5.0	50.0	88
29	Kristensen et al. 1995	2743	Benzo(a)pyrene	Mouse ( <i>Mus musculus</i> )	2	U	GV	9	d	9	w	GE	F	GRO	BDWT	WO	10.0		70
30	Lambelin et al. 1967	26033	6-Aminochrysene	Rat ( <i>Rattus norvegicus</i> )	3	U	FD	360	d	1	mo	JV	F	GRO	BDWT	WO	11.8	24.0	87
31	Lambelin et al. 1967	26033	6-Aminochrysene	Rat ( <i>Rattus norvegicus</i> )	3	U	FD	360	d	1	mo	JV	F	GRO	BDWT	WO	13.3	26.4	87
32	De Jong et al. 1999	25983	Benzo(a)pyrene	Rat ( <i>Rattus norvegicus</i> )	5	U	FD	2	w	6	w	JV	M	GRO	BDWT	WO	21.1	63.4	88
33	Gao et al., 2005	48343	7,12-Dimethylbenz(a)anthracene	Mouse ( <i>Mus musculus</i> )	3	U	GV	5	d	8-10	w	JV	F	GRO	BDWT	WO	28.5		75
34	Rigdon et al, 1967	30203	Benzo(a)pyrene	Mouse ( <i>Mus musculus</i> )	4	U	FD	66	d	18-30	d	JV	NR	GRO	BDWT	WO	31.7		68
35	Knuckles et al, 2001	25982	Benzo(a)pyrene	Rat ( <i>Rattus norvegicus</i> )	4	UX	FD	60	d	9	w	JV	M	GRO	BDWT	WO	49.0	98.0	95
36	Ramesh et al., 2000	32253	Benzo(a)pyrene	Rat ( <i>Rattus norvegicus</i> )	4	U	FD	60	d	6-7	w	JV	M	GRO	BDWT	WO	53.9	118	87
37	Uno et al., 2006	48539	Benzo(a)pyrene	Mouse ( <i>Mus musculus</i> )	4	U	FD	18	d	NR	NR	JV	M	GRO	BDWT	WO	125		72
38	Reuber and Glover, 1969	30150	7,12-Dimethylbenz(a)anthracene	Rat ( <i>Rattus norvegicus</i> )	2	U	FD	12	w	12	w	JV	M	GRO	BDWT	WO		20.7	77
39	Rigdon and Neal, 1965	26164	Benzo(a)pyrene	Mouse ( <i>Mus musculus</i> )	2	U	FD	6	d	20	d	JV	M	GRO	BDWT	WO		27.3	78
40	Das et al, 1994	27335	Benzenanthrone	Guinea pig ( <i>Cavia porcellus</i> )	2	U	GV	3	w	NR	NR	JV	M	GRO	BDWT	WO		50.0	84
<b>Survival (MOR)</b>																			
41	Culp et al., 1998	48317	Benzo(a)pyrene	Mouse ( <i>Mus musculus</i> )	4	M	FD	65	w	5	w	JV	B	MOR	MORT	WO	0.615	3.07	87
42	Lambelin et al. 1967	26033	6-Aminochrysene	Rat ( <i>Rattus norvegicus</i> )	3	U	FD	3	mo	1	mo	GE	F	MOR	MORT	WO	13.3	26.4	88
43	Rigdon and Neal, 1965	26164	Benzo(a)pyrene	Mouse ( <i>Mus musculus</i> )	2	U	FD	6	d	20	d	JV	M	MOR	MORT	WO	27.3		79
44	Rigdon et al, 1967	30203	Benzo(a)pyrene	Mouse ( <i>Mus musculus</i> )	4	U	FD	77	d	18-30	d	JV	NR	MOR	MORT	WO	31.7		78

AD = adult; AHHD = aryl hydrocarbon hydrolase; B = both; BDWT = body weight changes; BEH = behavior; BL = blood; bw = body weight; CHM = chemical changes; d = day; ECOD = ethoxycoumarin O-deethylase; ENZ = enzyme level changes; F = female; FCNS = food consumption; FD = food; FDB = feeding behavior; FDCV = feed conversion efficiency; GBCM = general biochemical changes; GE = gestation; GLPX = glutathione peroxidase; GRO = growth; GRS = gross body weight changes; GSTR = glutathione S-transferase; GV = gavage; HA = hair; HE = heart; HIS = histological changes; HMCT = hematocrit; HMGL = hemoglobin; HRM = hormone changes; JV = juvenile; kg = kilograms; L = liter; LC = lactation; LI = liver; LOAEL = lowest observed adverse effect level; mo = months; M = male; M = measured; MOR = effects on mortality and survival; MORT = mortality; NOAEL = No Observed Adverse Effect Level; NR = Not reported; OR = other oral; ORW = organ weight changes; ORWT = organ weight changes; PHY = physiology; PROG = progeny numbers/counts; PRWT = progeny weight; PTH = pathology; REP = reproduction; SM = sexually mature; SMIX = weight relative to body weight; SP = spleen; SR = serum; TRII = tridethyrynine; U = unmeasured; UX = measured but values not reported; w = weeks; WO = whole organism; yr = year.

\*NOAEL and LOAEL values that are equal and from the same reference represent different experimental designs.

**Table 6.3 Calculation of the Mammalian Eco-SSL for LMW-PAHs**

Surrogate Receptor Group	TRV for PAHs (mg dw/kg bw/d) <sup>1</sup>	Food Ingestion Rate (FIR) <sup>2</sup> (kg dw/kg bw/d)	Soil Ingestion as Proportion of Diet (P <sub>s</sub> ) <sup>2</sup>	Concentration of PAHs in Biota Type (i) <sup>2,3</sup> (B <sub>i</sub> ) (mg/kg dw)	PAHs in Diet of Prey <sup>4</sup> (C <sub>diet</sub> )	Eco-SSL (mg/kg dw) <sup>5</sup>
Mammalian herbivore (vole)	65.6	0.0875	0.032	$B_i = 2.09 * Soil_j$	NA	350
Mammalian ground insectivore (shrew)	65.6	0.209	0.030	$B_i = 3.04 * Soil_j$ where i = earthworms	NA	100
Mammalian carnivore (weasel)	65.6	0.130	0.043	$B_i = 0 * C_{diet}$ where i = mammals	0	1,200

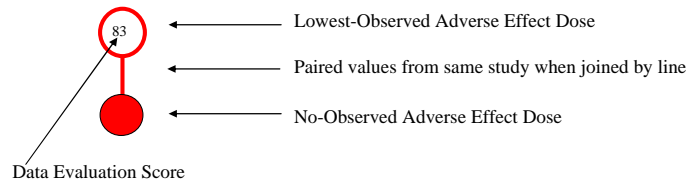
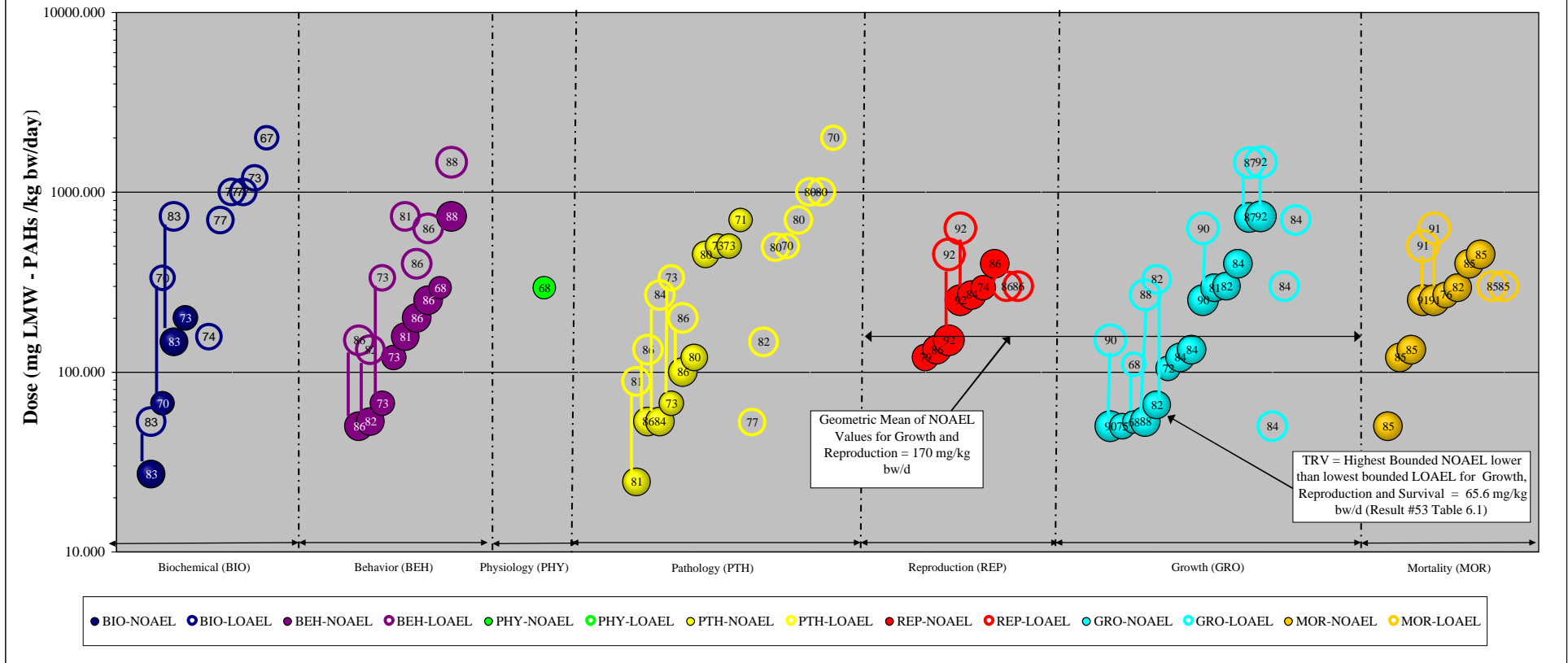
<sup>1</sup> The process for derivation of wildlife TRVs is described in Attachment 4-5 of U.S. EPA (2003).  
<sup>2</sup> Parameters (FIR, P<sub>s</sub>, B<sub>i</sub> values, regressions) are provided in U.S. EPA (2003) Attachment 4-1 (revised February 2005).  
<sup>3</sup> B<sub>i</sub> = Concentration in biota type (i) which represents 100% of the diet for the respective receptor.  
<sup>4</sup> C<sub>diet</sub> = Concentration in the diet of small mammals consumed by predatory species (weasel).  
<sup>5</sup> HQ = FIR \* (Soil<sub>j</sub> \* P<sub>s</sub> + B<sub>i</sub>) / TRV solved for HQ=1 where Soil<sub>j</sub> = Eco-SSL (Equation 4-2; U.S. EPA, 2003).  
 NA = Not Applicable  
 BAF for earthworms is the median of values for individual PAHs in U.S. EPA (2003) Attachment 4-1 (revised February 2005).

**Table 6.4 Calculation of the Mammalian Eco-SSL for HMW-PAHs**

Surrogate Receptor Group	TRV for PAHs (mg dw/kg bw/d) <sup>1</sup>	Food Ingestion Rate (FIR) <sup>2</sup> (kg dw/kg bw/d)	Soil Ingestion as Proportion of Diet (P <sub>s</sub> ) <sup>2</sup>	Concentration of PAHs in Biota Type (i) <sup>2,3</sup> (B <sub>i</sub> ) (mg/kg dw)	PAHs in Diet of Prey <sup>4</sup> (C <sub>diet</sub> )	Eco-SSL (mg/kg dw) <sup>5</sup>
Mammalian herbivore (vole)	0.615	0.0875	0.032	$\ln(B_i) = 0.9469 * \ln(Soil_j) - 1.7026$	NA	39
Mammalian ground insectivore (shrew)	0.615	0.209	0.030	$B_i = 2.6 * Soil_j$ where i = earthworms	NA	1.1
Mammalian carnivore (weasel)	0.615	0.130	0.043	$B_i = 0 * C_{diet}$ where i = mammals	0	110

<sup>1</sup> The process for derivation of wildlife TRVs is described in Attachment 4-5 of U.S. EPA (2003).  
<sup>2</sup> Parameters (FIR, P<sub>s</sub>, B<sub>i</sub> values, regressions) are provided in U.S. EPA (2003) Attachment 4-1 (revised February 2005).  
<sup>3</sup> B<sub>i</sub> = Concentration in biota type (i) which represents 100% of the diet for the respective receptor.  
<sup>4</sup> C<sub>diet</sub> = Concentration in the diet of small mammals consumed by predatory species (weasel).  
<sup>5</sup> HQ = FIR \* (Soil<sub>j</sub> \* P<sub>s</sub> + B<sub>i</sub>) / TRV solved for HQ=1 where Soil<sub>j</sub> = Eco-SSL (Equation 4-2; U.S. EPA, 2003).  
 NA = Not Applicable  
 BAF for earthworms is the median of values for individual PAHs in U.S. EPA (2003) Attachment 4-1 (revised February 2005).

**Figure 6.1 Mammalian TRV Derivation for Low Molecular Weight PAHs (LMW - PAHs)**



**Wildlife TRV Derivation Process**

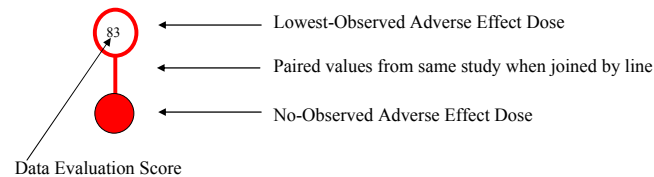
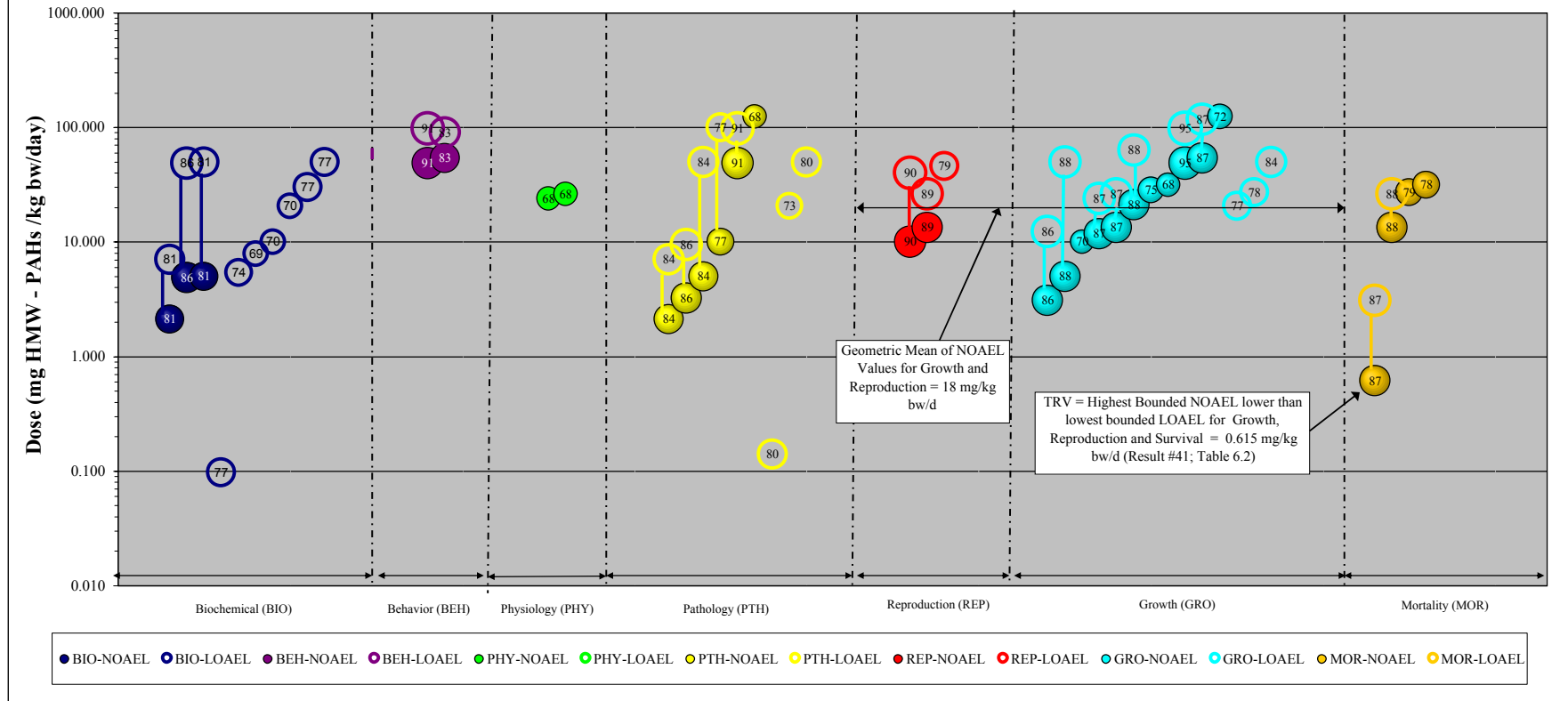
There are at least three results available for two test species within the growth, reproduction, and mortality effect groups. There are enough data to derive a TRV.

There are three NOAEL results available within the growth and reproduction effect groups for calculation of a geometric mean.

The geometric mean is equal to 170 mg LMW - PAHs/kg bw/d and is higher than the lowest bounded LOAEL for results within the reproduction, growth, and survival (MOR) effect groups.

The mammalian wildlife TRV for LMW - PAHs is equal to 65.6 mg/kg bw/day which is the highest bounded NOAEL lower than the lowest bounded LOAEL value for reproduction, growth or survival.

Figure 6.2 Mammalian TRV Derivation for High Molecular Weight PAHs (HMW - PAHs)



**Wildlife TRV Derivation Process**

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.

There are three NOAEL results available within the growth and reproduction effect groups for calculation of a geometric mean.

The geometric mean is equal to 18 mg HMW - PAHs/kg bw/d and is higher than the lowest bounded LOAEL for results within the reproduction, growth, and survival (MOR) effect groups.

The mammalian wildlife TRV for HMW - PAHs is equal to 0.615 mg/kg bw/day which is the highest bounded NOAEL lower than the lowest bounded LOAEL value for reproduction, growth or survi

## 7.0 REFERENCES

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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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## Appendix 2-1

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*Summary of Peer Review*

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*June 2007*

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## Summary of Peer Review of Draft Eco-SSL Document for PAHs

### Introduction

The methodology for deriving Eco-SSLs was primarily designed for deriving soil concentrations for single compounds and not a group of compounds with multiple forms. When the current Eco-SSL methods are applied to polycyclic aromatic hydrocarbons (PAHs) as a group with data for all individual compounds considered together, the results for derivation of a wildlife toxicity reference value (TRV) is a focus on the most toxic PAH compound. There is no consideration of the relative toxicity of less toxic compounds. For plants and soil, the focus is on the geometric mean of values across all PAH compounds.

In August of 2006, EPA sought a peer-review of the Eco-SSL methodology as to its applicability for derivation of values for PAHs as group of compounds with multiple forms. Five peer reviewers were identified who are experienced with either the toxicity of PAHs and/or risk assessment of these substances. The peer reviewers were provided with a package for review that included the draft Eco-SSL document for PAHs, an overview description of the Eco-SSL effort, internet links to the Eco-SSL guidance documents, a brief description of the literature review method and results and a list of the PAHs considered in the Eco-SSL effort. The peer reviewers were provided with a list of five charge questions to consider in their review of the Eco-SSL PAH document. The questions as stated were:

- 1) *Is it reasonable for EPA to use the most toxic PAH compounds in the derivation of a TRV (used to derive the Eco-SSL) for screening purposes? Or should TRVs (and Eco-SSLs) be derived for individual PAH compounds? If so, what would be the recommendation(s) for addressing individual PAH compounds for which toxicity data are not available?*
- 2) *Are the methods used for human health risk assessment in the use of toxicity equivalency factors for carcinogenicity developed sufficiently that they can be used in some manner for the derivation of TRVs for wildlife? Are there possible alternative methods for relative toxicity? If so, are the toxicity data available for PAHs (Tables 5.1 and 6.1 in the document) sufficient to implement a relative toxicity approach?*
- 3) *Is it reasonable for EPA to average across endpoints for individual PAH compounds in the derivation of an Eco-SSL for plants and/or soil invertebrates? Or should values be calculated for individual PAH compounds?*
- 4) *Modeling PAH exposure and comparing the estimated dose to a TRV is problematic in the calculation of the Eco-SSL in that the TRV may reflect a different mixture of PAH compounds than the estimated dose. For example, the TRV may reflect pyrene (the most toxic) and the modeled dose is an uptake factor or equation using data for several PAH compounds (including pyrene). Is it appropriate to have different congeners in the exposure and effects sides of the HQ equations that generate the Eco-SSL.*

- 5) *In the derivation of the Eco-SSLs for PAHs, EPA considered data for PAHs and PAH derivatives but did not include data for halogenated PAHs or heterocyclic PAHs. Are these inclusions and limitations appropriate?*

The peer review packages were delivered to reviewers in August of 2006 and four of the five reviewers returned comments in August and September of 2006. A Summary Report of the peer review and results was issued in September of 2006. The purpose of this memorandum is to make recommendations concerning changes to the draft Eco-SSL document for PAHs based on the results of the peer review. The memorandum is divided into two parts. The first summarizes the peer review results and the second lists the changes made to the draft document as a result of the peer review. The full report on the peer review process and results (USEPA, 2006) is available on the Eco-SSL web site at [www.epa.gov/ecotox/ecossl](http://www.epa.gov/ecotox/ecossl).

### **Summary of the Peer Review Results**

- *Use the Most Toxic PAH Compounds to Derive a TRV.* The reviewers were divided on the use of all PAH data to derive one toxicity reference value (TRV) versus derivation of values for individual PAHs. Half considered the current approach reasonable based on the limited amount of toxicity information available and the need to be conservative and use of the values as screening levels. However, segregation of data into low and high molecular weights was suggested as an alternative approach. The other half considered the approach not acceptable and were concerned that the values would be too conservative. Another concern was grouping all PAHs together when they vary widely in physical/chemical properties which indicates different environmental and biological behaviors. This second half advocated derivation of values for each individual PAH or groups of PAHs based on boiling point fractions.
- *Use of Toxicity Equivalency Approach.* Most reviewers agreed, in general, that the use of toxicity equivalency factors (TEFs) of some sort would be appropriate. However, most agreed that application of this approach would be prohibitive due to a lack of available data. Some provided datasets as examples however these were limited to the aquatic environment and in-vitro effects. One reviewer did not recommend the use of TEFs for a screening value and believed they should be considered later in the risk assessment process.
- *Average Across Individual PAHs for Plant and Soil Invertebrate Eco-SSL.* Most reviewers agreed it was appropriate to average across results for individual PAHs. However, segregation of data into low and high molecular weights was suggested as an alternative approach.
- *Modeling PAH Exposure.* The reviewers response to this issue was the same as that for derivation of wildlife TRVs. One half agreed it was appropriate to group PAHs together

even though the mixture may or may not be equal to that reflected in the TRV. The other half advocated derivation of Eco-SSLs for individual PAHs.

- *Should Data be included for Halogenated PAHs or Heterocyclic PAHs.* In general, the reviewers agreed it was reasonable to exclude halogenated PAHs but it may be appropriate to include heterocyclic PAHs.
- *Additional Comment.* An additional comment outside the framed questions was received from one reviewer. The comment concerned the assumption that bioaccumulation of PAHs in small mammal tissues is zero (diet for carnivores). The reviewer states that mammals and other vertebrates metabolize PAHs very efficiently but can bioaccumulate free (unmetabolized) PAHs in muscle, particularly under conditions of chronic exposure and could contribute to carnivore exposure. The reviewer points to a reference that shows PAH accumulation in the muscle of fish and shellfish. The reviewer suggests that the data supporting this assumption be briefly described.

### **Apparent Consensus**

The apparent consensus among the peer review comments is that grouping both toxicity and exposure data into two classes based on molecular weight is a reasonable approach. Although it would be ideal to use a toxicity equivalency approach in developing values, this is not possible due to limitations of the existing data. Grouping PAHs into the two classes (low and high molecular weight) is an apparent means to address the differences in physical/chemical properties of individual PAHs which influence toxicity and environmental fate.

### **Changes to the Draft Eco-SSL Document for PAHs**

- The introduction was expanded to describe the peer review process and results and to also describe the relative strength of the TRV and Eco-SSLs. The revised introduction acknowledges that PAHs are group of individual chemicals and that the approach taken to derive Eco-SSLs for them was different. The approach used is contrasted with the approach used for other chemicals.
- This peer review summary report was added to the document as an Appendix. The full report was provided on the web site.
- The data included remained limited to only PAHs and PAH derivatives. PAHs (CASRN: 130498-29-2) are defined as a class of organic substances made up of carbon and hydrogen atoms grouped into at least two condensed aromatic ring structures. PAH derivatives are PAHs having an alkyl or other radical attached to a ring. Heterocyclic aromatic compounds (HACs) will not be included. Although the peer reviewers suggest that it is appropriate to include these chemicals, the literature search procedures used for identification of both plant and soil invertebrate and wildlife toxicity data for PAHs were

not inclusive of HACs. HACs include PAHs having any one carbon atom in a ring replaced by a nitrogen, oxygen, or sulfur atom (<http://toxnet.nlm.nih.gov>).

- Eco-SSLs were calculated for two classes of PAHs (high and low molecular weights). Low molecular weight compounds are defined as PAHs and PAH derivatives composed of fewer than four rings and high molecular weight compounds are defined as those with four or more rings. Similarly, wildlife TRVs were also derived separately for the two classes. The current regression model used to predict the transfer of PAHs from soils to plant foliage was also segregated into two classes (Attachment 4-1 of the Eco-SSL guidance).

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## Appendix 5-1

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*Avian Toxicity Data Extracted and Reviewed for Wildlife Toxicity  
Reference Value (TRV) - LMW PAHs*

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*June 2007*

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**Appendix 5.1 Avian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)  
Low Molecular Weight Polynuclear Aromatic Hydrocarbons (LMW - PAHs)**

Result #	Ref	Reference	Chemical Form	MW%	Test Species	Exposure														Effects						Conversion to mg/kg bw/day			Result		Data Evaluation Score													
						# of Conc/ Doses	Conc/ Doses	Conc/Dose Units	Wet Weight Reported?	Percent Moisture	Application Frequency	Method of Analyses	Route of Exposure	Exposure Duration	Duration Units	Age	Age Units	Lifestage	Sex	Control Type	Test Location	General Effect Group	Effect Type	Effect Measure	Response Site	Study NOAEL	Study LOAEL	Body Weight Reported?	Body Weight in kg	Ingestion Rate Reported?	Ingestion Rate in kg/day 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
<b>Behavior</b>																																												
1	27393	Landis Assoc.Inc, 1985	Naphthalene	100	Bobwhite ( <i>Colinus virginianus</i> )	7	0/316/562/1000/1780/3160/5620	mg/kg diet	N	na	ADL	U	FD	5	d	13	d	JV	B	V	Lab	BEH	FDB	FCNS	WO	5620		Y	0.03400	Y	0.01000	1653		10	10	5	10	7	4	4	1	10	7	68
<b>Growth</b>																																												
2	27393	Landis Assoc.Inc, 1985	Naphthalene	100	Bobwhite ( <i>Colinus virginianus</i> )	7	0/316/562/1000/1780/3160/5620	mg/kg diet	N	na	ADL	U	FD	5	d	13	d	JV	B	V	Lab	GRO	GRO	BDWT	WO	5620		Y	0.03400	Y	0.01000	1653		10	10	5	10	7	8	4	1	10	7	72
<b>Survival</b>																																												
3	27393	Landis Assoc.Inc, 1985	Naphthalene	100	Bobwhite ( <i>Colinus virginianus</i> )	7	0/316/562/1000/1780/3160/5620	mg/kg diet	N	na	ADL	U	FD	5	d	13	d	JV	B	V	Lab	MOR	MOR	MORT	WO	5620		Y	0.03400	Y	0.01000	1653		10	10	5	10	7	9	4	10	10	7	82

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

Duplicate values for NOAELs and LOAELs for the same reference represent results from different experimental designs.





## Appendix 5-2

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*Avian Toxicity Data Extracted and Reviewed for Wildlife Toxicity  
Reference Value (TRV) - HMW - PAHs*

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*June 2007*

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**Appendix 5.2 Avian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)  
High Molecular Weight Polynuclear Aromatic Hydrocarbons (HMW - PAHs)**

Result #	Ref	Reference	Chemical Form	MW%	Test Species	Exposure																Effects						Conversion to mg/kg bw/day		Result		Data Evaluation Score													
						# of Conc/ Doses	Conc/ Doses	Conc/Dose Units	Wet Weight Reported?	Percent Moisture	Application Frequency	Method of Analyses	Route of Exposure	Exposure Duration	Duration Units	Age	Age Units	Lifestage	Sex	Control Type	Test Location	General Effect Group	Effect Type	Effect Measure	Response Site	Study NOAEL	Study LOAEL	Body Weight Reported?	Body Weight in kg	Ingestion Rate Reported?	Ingestion Rate in kg/day 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	
<b>Biochemical</b>																																													
1	27747	Trust et al, 1994	7,12- Dimethylbenz(a)anthracene	100	European Starling ( <i>Sturnus vulgaris</i> )	4	0/10/25/60	mg/kg bw/d	N	na	DLY	U	GV	5	d	NR	NR	AD	B	C	Lab	BIO	CHM	PRTL	PL	60		N	0.08470	N	0.011667	60.0		10	8	10	10	10	10	1	4	10	6	4	73
2	27747	Trust et al, 1994	7,12- Dimethylbenz(a)anthracene	100	European Starling ( <i>Sturnus vulgaris</i> )	3	0/2/20	mg/kg bw/d	N	na	DLY	U	GV	5	d	9	d	JV	B	C	NR	BIO	ENZ	AATT	PL	2	20	Y	0.05500	N	0.00881	2.0	20.0	10	8	10	10	10	10	1	8	10	10	4	81
<b>Pathology</b>																																													
5	27747	Trust et al, 1994	7,12- Dimethylbenz(a)anthracene	100	European Starling ( <i>Sturnus vulgaris</i> )	3	0/2/20	mg/kg bw/d	N	na	DLY	U	GV	5	d	9	d	JV	B	C	NR	PTH	ORW	ORWT	BU	2	20	N	0.05500	N	0.00881	2.0	20.0	10	8	10	10	10	4	8	10	10	4	84	
<b>Growth</b>																																													
7	27747	Trust et al, 1994	7,12- Dimethylbenz(a)anthracene	100	European Starling ( <i>Sturnus vulgaris</i> )	3	0/2/20	mg/kg bw/d	N	na	DLY	U	GV	5	d	9	d	JV	B	C	NR	GRO	GRO	BDWT	WO	2	20	Y	0.05500	N	0.00881	2.0	20.0	10	8	10	10	10	8	8	10	10	4	88	

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

Duplicate values for NOAELs and LOAELs for the same reference represent results from different experimental designs.





## Appendix 6-1

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

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*June 2007*

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## Appendix 6.1 Mammalian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV) Low Molecular Weight Polynuclear Aromatic Hydrocarbons (LMW-PAHs)

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Result #	Ref No.	Ref	Chemical Form	MW %	Test Species	Phase #	# of Conc/ Doses	Exposure											Effects						Conversion to mg/kg bw/day			Result		Data Evaluation Score															
								Conc/ Doses	Conc/Dose Units	Wet Weight Reported?	Percent Moisture	Application Frequency	Method of Analyses	Route of Exposure	Exposure Duration	Duration Units	Age	Age Units	Lifestage	Sex	Control Type	Test Location	General Effect Group	Effect Type	Effect Measure	Response Site	Study NOAEL	Study LOAEL	Body Weight Reported?	Body Weight in kg	Ingestion Rate Reported?	Ingestion Rate in 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
<b>Biochemical</b>																																													
1	30980	Shopp et al, 1984	Naphthalene	100	Mouse ( <i>Mus musculus</i> )	1	4	0/27/53/267	mg/kg bw/d	NR	na	DLY	U	GV	14	d	6-7	w	JV	B	V	Lab	BIO	CHM	GBCM	SR	27	53	Y	0.0335	N	0.0042125	27.0	53.0	10	8	10	10	10	1	10	10	10	4	83
2	29744	Verschuuren et al., 1976	1-Naphthaleneacetic acid	100	Rat ( <i>Rattus norvegicus</i> )	1	4	0/200/1000/5000	mg/kg	NR	na	ADL	U	FD	6	w	NR	NR	JV	M	C	Lab	BIO	ENZ	AHHD	LI	1000	5000	Y	0.247	Y	0.065	66.8	334	10	10	5	5	7	1	8	10	10	4	70
3	48537	Knuckles et al., 2004	Fluoranthene	98	Rat ( <i>Rattus norvegicus</i> )	1	4	0/150/750/1500	mg/kg bw/d	NR	na	ADL	UX	FD	90	d	9	w	JV	M	C	Lab	BIO	CHM	HEMT	BL	150	750	Y	0.16	N	0.0152315	147	735	10	10	10	10	10	1	8	10	10	4	83
4	26157	Poole and Buckley, 1989	1-Naphthol	100	Mouse ( <i>Mus musculus</i> )	1	4	0/50/100/200	mg/kg bw/d	NR	na	DLY	U	GV	90	d	6-7	w	JV	B	V	Lab	BIO	CHM	HMGL	BL	200		N	0.02695	N	0.0035227	200		10	8	10	10	10	1	4	6	10	4	73
5	30980	Shopp et al, 1984	Naphthalene	100	Mouse ( <i>Mus musculus</i> )	2	4	0/5.3/53/133	mg/kg bw/d	NR	na	DLY	U	GV	90	d	6-7	w	JV	F	V	Lab	BIO	CHM	CREA	SR	5.3		Y	0.0279	N	0.0036245		5.30	10	8	10	10	10	1	4	10	10	4	77
6	32253	Ramesh et. al, 2000	Fluoranthene	98	Rat ( <i>Rattus norvegicus</i> )	4	4	0/160/750/1490	mg/kg bw/d	NR	na	ADL	U	FD	90	d	6-7	w	JV	M	C	Lab	BIO	ENZ	AHHD	WO	160		N	0.180	N	0.016780		157	10	8	10	10	10	1	4	10	10	4	74
7	28360	Tao et al, 1991	Naphthalene	100	Rat ( <i>Rattus norvegicus</i> )	1	2	0/0.7	g/kg bw/d	NR	na	DLY	U	GV	20	d	NR	NR	JV	F	V	Lab	BIO	CHM	PRTL	EY	0.70		Y	0.164	N	0.015544		700	10	8	10	10	10	1	4	10	10	4	77
8	30470	Yamauchi et al, 1986	Naphthalene	100	Rat ( <i>Rattus norvegicus</i> )	1	2	0/1	g/kg bw/d	NR	na	DLY	U	GV	4	d	NR	NR	JV	M	V	Lab	BIO	CHM	GBCM	SR	1		Y	0.170	N	0.016010		1000	10	8	10	10	10	1	4	10	10	4	77
9	29132	Rao and Pandya, 1981	Naphthalene	100	Rat ( <i>Rattus norvegicus</i> )	1	2	0/1	g/kg bw/d	NR	na	DLY	U	OR	10	d	NR	NR	JV	M	V	Lab	BIO	ENZ	GENZ	LI	1		Y	0.125	N	0.012434		1000	10	8	10	10	10	1	4	10	10	4	77
10	31138	Kodama et al, 1974	Naphthalene	100	Rabbit ( <i>Oryctolagus cuniculus</i> )	1	2	0/3	g/d	NR	na	DLY	U	GV	3	w	NR	NR	JV	NR	C	Lab	BIO	ENZ	GENZ	LI	3		Y	2.5	N	0.14590		1200	10	8	10	10	6	1	4	10	10	4	73
11	30130	Srivastava and Nath, 1969	Naphthalene	100	Rabbit ( <i>Oryctolagus cuniculus</i> )	1	2	0/2	g/kg bw/d	NR	na	NR	U	FD	5	d	NR	NR	NR	NR	V	Lab	BIO	ENZ	LADH	EY	2		Y	2.0	N	0.12145		2000	10	10	5	10	10	1	4	10	3	4	67
<b>Behavior</b>																																													
12	28943	Navarro, et al, 1991	Naphthalene	100	Rat ( <i>Rattus norvegicus</i> )	1	4	0/50/150/450	mg/kg bw/d	NR	na	DLY	U	GV	9	d	8-10	w	GE	F	V	Lab	BEH	FDB	WCEN	WO	50	150	Y	0.3301	Y	0.22569	50.0	150	10	8	10	10	10	4	10	10	10	4	86
13	26048	Borzelleca, 1982	Naphthalene	100	Mouse ( <i>Mus musculus</i> )	1	4	0/5.3/53/133	mg/kg bw/d	NR	na	DLY	U	GV	60	d	NR	NR	AD	B	V	Lab	BEH	FDB	FCNS	WO	53	133	N	0.0375	N	0.0046218	53.0	133	10	8	10	10	10	4	10	10	6	4	82
14	29744	Verschuuren et al., 1976	1-Naphthaleneacetic acid	100	Rat ( <i>Rattus norvegicus</i> )	1	4	0/200/1000/5000	mg/kg	NR	na	ADL	U	FD	6	w	NR	NR	JV	M	C	Lab	BEH	FDB	FCNS	WO	1000	5000	Y	0.247	Y	0.065	66.8	334	10	10	5	5	7	4	8	10	10	4	73
15	28813	Navarro et al, 1992	Naphthalene	100	Rabbit ( <i>Oryctolagus cuniculus</i> )	1	4	0/20/80/120	mg/kg bw/d	NR	na	DLY	U	GV	13	d	6	mo	GE	F	V	Lab	BEH	FDB	FCNS	WO	120		Y	3.581	Y	0.0065903	120		10	8	10	10	10	4	4	3	10	4	73
16	32253	Ramesh et. al, 2000	Fluoranthene	98	Rat ( <i>Rattus norvegicus</i> )	4	4	0/160/750/1490	mg/kg bw/d	NR	na	ADL	U	FD	90	d	6-7	w	JV	M	C	Lab	BEH	FDB	FCNS	WO	160	750	N	0.180	N	0.016780	157	735	10	10	5	10	10	4	8	10	10	4	81
17	26017	Pharmakon Resesarch, 1986	Naphthalene	100	Rabbit ( <i>Oryctolagus cuniculus</i> )	1	4	0/40/200/400	mg/kg bw/d	NR	na	DLY	U	GV	4	d	>=24	d	GE	F	V	Lab	BEH	FDB	FCNS	WO	200	400	Y	3.97	Y	0.0000715	200	400	10	8	10	10	10	4	10	10	10	4	86
18	26016	Pharmakon Research, 1985	Naphthalene	100	Rabbit ( <i>Oryctolagus cuniculus</i> )	1	5	0/50/250/630/1000	mg/kg bw/d	NR	na	DLY	U	GV	7	d	>=24	w	GE	F	V	Lab	BEH	FDB	FCNS	WO	250	630	Y	4.530	Y	0.001250	250	630	10	8	10	10	10	4	10	10	10	4	86
19	26028	Anonymous, 1992	Naphthalene	100	Rat ( <i>Rattus norvegicus</i> )	1	4	0/24.5/88.3/294.1	mg/kg bw/d	NR	na	NR	U	FD	4	w	NR	NR	JV	NR	C	Lab	BEH	FDB	FCNS	WO	294		Y	0.307	Y	0.02070	294		10	10	5	10	10	4	4	1	10	4	68
20	48537	Knuckles et al., 2004	Fluoranthene	98	Rat ( <i>Rattus norvegicus</i> )	1	4	0/150/750/1500	mg/kg bw/d	NR	na	ADL	UX	FD	90	d	9	w	JV	M	C	Lab	BEH	FDB	FCNS	WO	750	1500	Y	0.16	N	0.0152315	735	1470	10	10	10	10	10	4	10	10	10	4	88
<b>Physiology</b>																																													
21	26028	Anonymous, 1992	Naphthalene	100	Rat ( <i>Rattus norvegicus</i> )	1	4	0/24.5/88.3/294.1	mg/kg bw/d	NR	na	NR	U	FD	4	w	NR	NR	JV	NR	C	Lab	PHY	PHY	FDCV	WO	294		Y	0.3070	Y	0.02070	294		10	10	5	10	10	4	4	1	10	4	68
<b>Pathology</b>																																													
22	26028	Anonymous, 1992	Naphthalene	100	Rat ( <i>Rattus norvegicus</i> )	1	4	0/24.5/88.3/294.1	mg/kg bw/d	NR	na	NR	U	FD	4	w	NR	NR	JV	NR	C	Lab	PTH	ORW	SMIX	AR	24.5	88.3	Y	0.3290	Y	0.02040	24.5	88.3	10	10	5	10	10	4	8	10	10	4	81
23	30980	Shopp et al, 1984	Naphthalene	100	Mouse ( <i>Mus musculus</i> )	2	4	0/5.3/53/133	mg/kg bw/d	NR	na	DLY	U	GV	90	d	6-7	w	JV	F	V	Lab	PTH	ORW	ORWT	LI	53	133	Y	0.02710	N	0.00353881	53.0	133	10	8	10	10	10	4	10	10	10	4	86
24	30980	Shopp et al, 1984	Naphthalene	100	Mouse ( <i>Mus musculus</i> )	1	4	0/27/53/267	mg/kg bw/d	NR	na	DLY	U	GV	14	d	6-7	w	JV	M	V	Lab	PTH	ORW	ORWT	TS	53	267	Y	0.03270	N	0.00412967	53.0	267	10	8	10	10	10	4	8	10	10	4	84
25	29744	Verschuuren et al., 1976	1-Naphthaleneacetic acid	100	Rat ( <i>Rattus norvegicus</i> )	1	4	0/200/1000/5000	mg/kg	NR	na	ADL	U	FD	6	w	NR	NR	JV	M	C	Lab	PTH	ORW	SMIX	TY	1000	5000	Y	0.247	Y	0.065	66.8	334	10	10	5	5	7	4	8	10	10	4	73
26	26157	Poole and Buckley, 1989	1-Naphthol	100	Mouse ( <i>Mus musculus</i> )	1	4	0/50/100/200	mg/kg bw/d	NR	na	DLY	U	GV	30	d	6-7	w	JV	M	V	Lab	PTH	HIS	GHIS	GI	100	200	N	0.02695	N	0.0035227	100	200	10	8	10	10	10	4	10	10	10	4	86
27	28813	Navarro et al, 1992	Naphthalene	100	Rabbit ( <i>Oryctolagus cuniculus</i> )	1	4	0/20/80/120	mg/kg bw/d	NR	na	DLY	U	GV	13	d	6	mo	GE	F	V	Lab	PTH	ORW	SMIX	LI	120		Y	3.5810001	Y	0.00659034	120		10	8	10	10	10	4	4	10	10	4	80
28	28943	Navarro, et al, 1991	Naphthalene	100	Rat ( <i>Rattus norvegicus</i> )	1	4	0/50/150/450	mg/kg bw/d	NR	na	DLY	U	GV	9	d	8-10	w	GE	F	V	Lab	PTH	ORW	ORWT	LI	450		Y	0.30460	Y	0.25345	450		10	8	10	10	10	4	4	10	10	4	80
29	26113	Koch et al, 1977	Naphthalene	100	Rat ( <i>Rattus norvegicus</i> )	2	2	0/0.5	g/kg bw/d	NR	na	EOD	U	GV	75	d	NR	NR	NR	NR	V	Lab	PTH	ORW	ORWT	EY	0.5		N	0.039498	N	0.039498	500		10	8	10	10	10	4	4	10	3	4	73
30	26113	Koch et al, 1977	Naphthalene	100	Rat ( <i>Rattus norvegicus</i> )	2	2	0/0.5	g/kg bw/d	NR	na	EOD	U	GV	75	d	NR	NR	NR	NR	V	Lab	PTH	ORW	ORWT	EY	0.5		N	0.510	N	0.039498	500		10	8	10	10	10	4	4	10	3	4	73
31	27906	Tao, et al, 1991	Naphthalene	100	Rat ( <i>Rattus norvegicus</i> )	1	2	0/0.7	g/kg bw/d	NR	na	DLY	U	GV	90	d	NR	NR	JV	NR	V	Lab	PTH	HIS	GHIS	EY	0.70		Y	0.160	N	0.015232	700		10	8	10	10	10	4	4	1	10	4	71
32	48424	Murata et al., 1997	3-Methylnaphthalene	97	Mouse ( <i>Mus musculus</i> )	2	3	0/54.3/113.8	mg/kg bw/d	NR	na	ADL	U	FD	81	w	6	w	JV	F	V	Lab	PTH	ORW	SMIX	KI	54.3		Y	0.0420	N	0.0050730		52.7	10	10	5	10	10	4	4	10	10	4	77
33	48537	Knuckles et al., 2004	Fluoranthene	98	Rat ( <i>Rattus norvegicus</i> )	1	4	0/150/750/1500	mg/kg bw/d	NR	na	ADL	UX	FD	90	d	9	w	JV	M	C	Lab	PTH	HIS	USTR	KI	150		Y	0.16	N	0.0152315		147	10	10	10	10	10	4	4	1	10	4	82
34	28756	Orzalesi, et al, 1994	Naphthalene	99	Rabbit ( <i>Oryctolagus cuniculus</i> )	1	2	0/0.5	g/kg bw/d	NR	na	EOD	U	GV	3	w																													

**Appendix 6.1 Mammalian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)  
Low Molecular Weight Polynuclear Aromatic Hydrocarbons (LMW-PAHs)  
Page 2 of 2**

Result #	Ref No.	Chemical Form	MW%	Test Species	Exposure														Effects					Conversion to mg/kg bw/day				Result		Data Evaluation Score															
					Phase #	# of Conc/ Doses	Conc/ Doses	Conc/Dose Units	Wet Weight Reported?	Percent Moisture	Application Frequency	Method of Analyses	Route of Exposure	Exposure Duration	Duration Units	Age	Age Units	Lifestage	Sex	Control Type	Test Location	General Effect Group	Effect Type	Effect Measure	Response Site	Study NOAEL	Study LOAEL	Body Weight Reported?	Body Weight in kg	Ingestion Rate Reported?	Ingestion Rate in 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	
<b>Growth</b>																																													
49	28943	Navarro, et al, 1991	Naphthalene	100	Rat ( <i>Rattus norvegicus</i> )	1	4	0/50/150/450	mg/kg bw/d	NR	na	DLY	U	GV	9	d	8-10	w	GE	F	V	Lab	GRO	GRO	BDWT	WO	50	150	Y	0.33010	Y	0.22569	50.0	150	10	8	10	10	10	8	10	10	10	4	90
50	28793	Germansky and Jamall, 1988	Naphthalene	100	Rat ( <i>Rattus norvegicus</i> )	1	2	0/50	mg/kg bw/d	NR	na	EOD	U	GV	2	w	NR	NR	JV	M	V	Lab	GRO	GRO	BDWT	WO	50		Y	0.1250	N	0.01243417	50.0		10	8	10	10	10	8	4	1	10	4	75
51	48424	Murata et al., 1997	2-Methylnaphthalene	97	Mouse ( <i>Mus musculus</i> )	2	3	0/54.3/113.8	mg/kg bw/d	NR	na	ADL	U	FD	81	w	6	w	JV	M	V	Lab	GRO	GRO	BDWT	WO	54.3	114	Y	0.0400	N	0.0048736	52.7	110	10	10	5	10	10	8	10	10	10	4	68
52	30980	Shopp et al, 1984	Naphthalene	100	Mouse ( <i>Mus musculus</i> )	1	4	0/27/53/267	mg/kg bw/d	NR	na	DLY	U	GV	14	d	6-7	w	JV	M	V	Lab	GRO	GRO	BDWT	WO	53	267	Y	0.03270	N	0.00412967	53.0	267	10	8	10	10	10	8	8	10	10	4	88
53	29744	Verschuuren et al., 1976	1-Naphthaleneacetic acid	100	Rat ( <i>Rattus norvegicus</i> )	1	4	0/200/1000/5000	mg/kg	NR	na	ADL	U	FD	6	w	NR	NR	JV	M	C	Lab	GRO	GRO	BDWT	WO	1000	5000	Y	0.247	Y	0.0162	65.6	328	10	10	5	5	7	8	8	10	10	4	82
54	48424	Murata et al., 1997	3-Methylnaphthalene	97	Mouse ( <i>Mus musculus</i> )	1	3	0/50.3/107.6	mg/kg bw/d	NR	na	ADL	U	FD	81	w	6	w	JV	F	V	Lab	GRO	GRO	BDWT	WO	108		Y	0.044	N	0.0052708	104		10	10	5	10	10	8	4	1	10	4	72
55	28813	Navarro et al, 1992	Naphthalene	100	Rabbit ( <i>Oryctolagus cuniculus</i> )	1	4	0/20/80/120	mg/kg bw/d	NR	na	DLY	U	GV	13	d	6	mo	GE	F	V	Lab	GRO	GRO	BDWT	WO	120		Y	3.5810001	Y	0.00659034	120		10	8	10	10	10	8	4	10	10	4	84
56	30980	Shopp et al, 1984	Naphthalene	100	Mouse ( <i>Mus musculus</i> )	2	4	0/5.3/53/133	mg/kg bw/d	NR	na	DLY	U	GV	90	d	6-7	w	JV	B	V	Lab	GRO	GRO	BDWT	WO	133		Y	0.03680	N	0.00455076	133		10	8	10	10	10	8	4	10	10	4	84
57	26016	Pharmakon Research, 1985	Naphthalene	100	Rabbit ( <i>Oryctolagus cuniculus</i> )	1	5	0/50/250/630/1000	mg/kg bw/d	NR	na	DLY	U	GV	12	d	>=24	w	GE	F	V	Lab	GRO	GRO	BDWT	WO	250	630	Y	4.40	Y	0.0015	250	630	10	8	10	10	10	8	10	10	10	4	90
58	26028	Anonymous, 1992	Naphthalene	100	Rat ( <i>Rattus norvegicus</i> )	1	4	0/24.5/88.3/294.1	mg/kg bw/d	NR	na	NR	U	FD	4	w	NR	NR	JV	NR	C	Lab	GRO	GRO	BDWT	WO	294		Y	0.3070	Y	0.0207	294		10	10	5	10	10	8	4	10	10	4	81
59	1234	Booth et al, 1983	Naphthalene	100	Mouse ( <i>Mus musculus</i> )	2	2	0/300	mg/kg bw/d	NR	na	DLY	U	GV	8	d	61-71	d	GE	F	V	Lab	GRO	GRO	BDWT	WO	300		Y	0.028180	N	0.00365433	300		10	8	10	10	10	8	4	8	10	4	82
60	26017	Pharmakon Resesarch, 1986	Naphthalene	100	Rabbit ( <i>Oryctolagus cuniculus</i> )	1	4	0/40/200/400	mg/kg bw/d	NR	na	DLY	U	GV	12	d	>=24	w	GE	F	V	Lab	GRO	GRO	BDWT	WO	400		Y	3.830	Y	0.2120	400		10	8	10	10	10	8	4	10	10	4	84
61	32253	Ramesh et. al, 2000	Fluoranthene	98	Rat ( <i>Rattus norvegicus</i> )	3	4	0/160/740/1490	mg/kg bw/d	NR	na	ADL	U	FD	60	d	6-7	w	JV	M	C	Lab	GRO	GRO	BDWT	WO	740	1490	N	0.180	N	0.016780	725	1460	10	10	5	10	10	8	10	10	10	4	87
62	48537	Knuckles et al., 2004	Fluoranthene	98	Rat ( <i>Rattus norvegicus</i> )	1	4	0/150/750/1500	mg/kg bw/d	NR	na	ADL	UX	FD	90	d	9	w	JV	M	C	Lab	GRO	GRO	BDWT	WO	750	1500	Y	0.16	N	0.0152315	735	1470	10	10	10	10	10	8	10	10	10	4	92
63	26157	Poole and Buckley, 1989	1-Naphthol	100	Mouse ( <i>Mus musculus</i> )	1	4	0/50/100/200	mg/kg bw/d	NR	na	DLY	U	GV	30	d	6-7	w	JV	B	V	Lab	GRO	GRO	BDWT	WO		50	Y	0.026950	N	0.0035227		50.0	10	8	10	10	10	8	4	10	10	4	84
64	1335	Hardin, et al, 1987	Naphthalene	100	Mouse ( <i>Mus musculus</i> )	1	2	0/300	mg/kg bw/d	NR	na	DLY	U	GV	17	d	NR	NR	GE	F	V	Lab	GRO	GRO	BDWT	WO		300	N	0.02250	N	0.00303704		300	10	8	10	10	10	8	4	10	10	4	84
65	28360	Tao et al, 1991	Naphthalene	100	Rat ( <i>Rattus norvegicus</i> )	1	2	0/0.7	g/kg bw/d	NR	na	DLY	U	GV	60	d	NR	NR	JV	F	V	Lab	GRO	GRO	BDWT	WO		0.70	Y	0.159	N	0.01515323		700	10	8	10	10	10	8	4	10	10	4	84
<b>Survival</b>																																													
66	28793	Germansky and Jamall, 1988	Naphthalene	100	Rat ( <i>Rattus norvegicus</i> )	1	2	0/50	mg/kg bw/d	NR	na	EOD	U	GV	2	w	NR	NR	JV	M	V	LAB	MOR	MOR	MORT	WO	50		Y	0.125	N	0.012434	50.0		10	8	10	10	10	9	4	10	10	4	85
67	28813	Navarro et al, 1992	Naphthalene	100	Rabbit ( <i>Oryctolagus cuniculus</i> )	1	4	0/20/80/120	mg/kg bw/d	NR	na	DLY	U	GV	13	d	6	mo	GE	F	V	COM	MOR	MOR	MORT	WO	120		Y	3.5810001	Y	0.00659034	120		10	8	10	10	10	9	4	10	10	4	85
68	30980	Shopp et al, 1984	Naphthalene	100	Mouse ( <i>Mus musculus</i> )	2	4	0/5.3/53/133	mg/kg bw/d	NR	na	DLY	U	GV	90	d	6-7	w	JV	B	V	LAB	MOR	MOR	SURV	WO	133		Y	0.0368	N	0.00455076	133		10	8	10	10	10	9	4	10	10	4	85
69	1234	Booth et al, 1983	Naphthalene	100	Mouse ( <i>Mus musculus</i> )	1	6	0/125/250/500/1200/2000	mg/kg bw/d	NR	na	DLY	U	GV	8	d	61-71	d	JV	F	V	LAB	MOR	MOR	MORT	WO	250	500	Y	0.02712	N	0.0035410	250	500	10	8	10	10	10	9	10	10	10	4	91
70	26016	Pharmakon Research, 1985	Naphthalene	100	Rabbit ( <i>Oryctolagus cuniculus</i> )	1	5	0/50/250/630/1000	mg/kg bw/d	NR	na	DLY	U	GV	24	d	>=24	w	GE	F	V	COM	MOR	MOR	MORT	WO	250	630	Y	4.57	Y	0.0020	250	630	10	8	10	10	10	9	10	10	10	4	91
71	30980	Shopp et al, 1984	Naphthalene	100	Mouse ( <i>Mus musculus</i> )	1	4	0/27/53/267	mg/kg bw/d	NR	na	DLY	U	GV	14	d	6-7	w	JV	B	V	LAB	MOR	MOR	SURV	WO	267		Y	0.0302	N	0.00386832	267		10	8	10	10	10	9	4	1	10	4	76
72	26028	Anonymous, 1992	Naphthalene	100	Rat ( <i>Rattus norvegicus</i> )	1	4	0/24.5/88.3/294.1	mg/kg bw/d	NR	na	NR	U	FD	4	w	NR	NR	JV	NR	C	NR	MOR	MOR	MORT	WO	294		Y	0.307	Y	0.02070	294		10	10	5	10	10	9	4	10	10	4	82
73	26017	Pharmakon Resesarch, 1986	Naphthalene	100	Rabbit ( <i>Oryctolagus cuniculus</i> )	1	4	0/40/200/400	mg/kg bw/d	NR	na	DLY	U	GV	12	d	>=24	w	GE	F	V	COM	MOR	MOR	MORT	WO	400		Y	3.830	Y	0.2120	400		10	8	10	10	10	9	4	10	10	4	85
74	28943	Navarro, et al, 1991	Naphthalene	100	Rat ( <i>Rattus norvegicus</i> )	1	4	0/50/150/450	mg/kg bw/d	NR	na	DLY	U	GV	9	d	8-10	w	GE	F	V	COM	MOR	MOR	MORT	WO	450		Y	0.3046	Y	0.25345	450		10	8	10	10	10	9	4	10	10	4	85
75	1234	Booth et al, 1983	Naphthalene	100	Mouse ( <i>Mus musculus</i> )	2	2	0/300	mg/kg bw/d	NR	na	DLY	U	GV	8	d	61-71	d	GE	F	V	LAB	MOR	MOR	MORT	WO		300	Y	0.02818	N	0.003654		300	10	8	10	10	10	9	4	10	10	4	85
76	1335	Hardin, et al, 1987	Naphthalene	100	Mouse ( <i>Mus musculus</i> )	1	2	0/300	mg/kg bw/d	NR	na	DLY	U	GV	11	d	NR	mo	GE	F	V	LAB	MOR	MOR	MORT	WO		300	N	0.0225	N	0.0030370		300	10	8	10	10	10	9	4	10	10	4	85

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

Duplicate values for NOAELs and LOAELs for the same reference represent results from different experimental designs.



## Appendix 6-2

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

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*June 2007*

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**Appendix 6.2 Mammalian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)  
High Molecular Weight Polynuclear Aromatic Hydrocarbons (HMW-PAHs)  
Page 1 of 2**

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	Wet Weight Reported?	Percent Moisture	Application Frequency	Method of Analyses	Route of Exposure	Exposure Duration	Duration Units	Age	Age Units	Lifestage	Sex	Control Type	Test Location	General Effect Group	Effect Type	Effect Measure	Response Site	Study NOAEL	Study LOAEL	Body Weight Reported?	Body Weight in kg	Ingestion Rate Reported?	Ingestion Rate in 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				
<b>Biochemical</b>																																																
1	25983	De Jong et al, 1999		Benzo(a)pyrene	98.6	Rat ( <i>Rattus norvegicus</i> )	1	5	0/2.14/7.14/21.4/64.3	mg/kg bw/d	NR	na	5 per w	U	GV	5	w	6	w	JV	M	V	Lab	BIO	CHM	HMGL	BL	2.14	7.14	Y	0.300	N	0.025536	2.11	7.04	10	8	10	10	10	10	10	10	10	4	81		
2	25982	Knuckles et al, 2001		Benzo(a)pyrene	98	Rat ( <i>Rattus norvegicus</i> )	1	4	0/5/50/100	mg/kg bw/d	NR	na	ADL	UX	FD	60	d	9	w	JV	M	C	Lab	BIO	CHM	HMCT	BL	5	50	Y	0.160	N	0.015232	4.90	49.0	10	10	10	10	10	10	10	10	7	86			
3	28204	Yamauchi et al, 1991		Benzo(a)pyrene	100	Rat ( <i>Rattus norvegicus</i> )	1	3	0/5/50	mg/kg bw/d	NR	na	DLY	U	GV	10	d	5	w	JV	M	V	Lab	BIO	ENZ	GSTR	LI	5	50	Y	0.202	N	0.018501	5.0	50.0	10	8	10	10	10	10	10	10	10	4	81		
4	28439	Burchiel et al, 1990		7,12-Dimethylbenz(a)anthracene	97	Mouse ( <i>Mus musculus</i> )	1	4	0/0.1/1/14	mg/kg bw/d	NR	na	DLY	U	GV	14	d	10-11	w	JV	F	V	Lab	BIO	CHM	GBCM	SP		0.10	N	0.0246	N	0.0032682		0.0970	10	8	10	10	10	10	10	10	10	10	4	77	
5	32253	Ramesh et. al, 2000		Benzo(a)pyrene	98	Rat ( <i>Rattus norvegicus</i> )	2	4	0/5.5/55/92	mg/kg bw/d	NR	na	ADL	U	FD	90	d	6-7	w	JV	M	C	Lab	BIO	ENZ	AHHD	LI	5.5	N	0.180	N	0.016780		5.39	10	10	5	10	10	10	10	10	10	10	10	4	74	
6	48370	Hood et al., 2003		3-Methylcholanthrene	100	Mouse ( <i>Mus musculus</i> )	1	5	0/62.5/125/250/500	mg/kg diet	NR	na	ADL	U	FD	21	d	7	w	JV	M	V	Lab	BIO	HRM	TRII	SR	62.5	N	0.03160	N	0.004015		7.94	10	10	5	10	5	1	4	10	10	10	4	69		
7	27748	Bosveld, et al, 1996		Benzo(a)pyrene	100	White toothed shrew ( <i>Sorex araneus</i> )	1	3	0/10/100	mg/kg bw/d	NR	na	CON	U	FD	9	d	NR	NR	NR	F	V	Lab	BIO	ENZ	ECOD	LI	10.0	Y	0.00920	N	0.0014561		10.0	10	10	5	10	10	1	4	10	10	6	4	70		
8	30150	Reuber and Glover, 1969		7,12-Dimethylbenz(a)anthracene	100	Rat ( <i>Rattus norvegicus</i> )	1	2	0/0.025	% in diet	NR	na	ADL	U	FD	12	w	12	w	JV	M	C	Lab	BIO	CHM	GBCM	SR	0.025	Y	0.351	N	0.029054		20.7	10	10	5	10	6	1	4	10	10	10	4	70		
9	30641	Polidoro et al., 1985		3-Methylcholanthrene	100	Guinea pig ( <i>Cavia porcellus</i> )	1	2	0/30	mg/kg bw/d	NR	na	DLY	U	GV	14	d	NR	NR	JV	F	V	Lab	BIO	ENZ	GLPX	LI	30	Y	0.550	N	0.004209		30.0	10	8	10	10	10	1	4	10	10	10	4	77		
10	27335	Das et al, 1994		Benanthrone	100	Guinea pig ( <i>Cavia porcellus</i> )	1	2	0/50	mg/kg bw/d	NR	na	DLY	U	GV	4	w	NR	NR	JV	M	V	Lab	BIO	CHM	HMGL	BL	50	Y	0.297	N	0.025326		50.0	10	8	10	10	10	1	4	10	10	10	4	77		
<b>Behavior</b>																																																
11	25982	Knuckles et al, 2001		Benzo(a)pyrene	98	Rat ( <i>Rattus norvegicus</i> )	1	4	0/5/50/100	mg/kg bw/d	NR	na	ADL	UX	FD	90	d	9	w	JV	M	C	Lab	BEH	FDB	FCNS	WO	50	100	Y	0.160	N	0.015232	49.0	98.0	10	10	10	10	10	10	4	10	10	10	7	91	
12	32253	Ramesh et. al, 2000		Benzo(a)pyrene	98	Rat ( <i>Rattus norvegicus</i> )	2	4	0/5.5/55/92	mg/kg bw/d	NR	na	ADL	U	FD	90	d	6-7	w	JV	M	C	Lab	BEH	FDB	FCNS	WO	55	92	N	0.180	N	0.016780	53.9	90.2	10	10	5	10	10	4	10	10	10	4	83		
<b>Physiology</b>																																																
13	26033	Lambelin et al., 1967		6-Aminochrysene	100	Rat ( <i>Rattus norvegicus</i> )	1	3	0/11.8/24.0	mg/kg bw/d	NR	na	ADL	U	FD	360	d	1	mo	JV	M	C	Lab	PHY	PHY	PDCV	WO	24		Y	0.375	N	0.0175	24		10	10	5	10	10	4	4	1	10	4	68		
14	26033	Lambelin et al., 1967		6-Aminochrysene	100	Rat ( <i>Rattus norvegicus</i> )	1	3	0/13.3/26.4	mg/kg bw/d	NR	na	ADL	U	FD	360	d	1	mo	JV	F	C	Lab	PHY	PHY	FDCV	WO	26.4		Y	0.2330	N	0.01200	26.4		10	10	5	10	10	4	4	1	10	4	68		
<b>Pathology</b>																																																
15	25983	De Jong et al, 1999		Benzo(a)pyrene	98.6	Rat ( <i>Rattus norvegicus</i> )	1	5	0/2.14/7.14/21.4/64.3	mg/kg bw/d	NR	na	5 per w	U	GV	5	w	6	w	JV	M	V	Lab	PTH	ORW	ORWT	TS	2.14	7.14	Y	0.3000	N	0.025536	2.11	7.04	10	8	10	10	10	10	4	8	10	10	4	84	
16	48343	Gao et al., 2005		7,12-Dimethylbenz(a)anthracene	95	Mouse ( <i>Mus musculus</i> )	1	4	0/3.4/10/30	mg/kg bw/d	NR	na	DLY	U	GV	5	d	8-10	w	JV	M	V	Lab	PTH	ORW	SMIX	SP	3.4	10	Y	0.02040	N	0.002802	3.23	9.5	10	8	10	10	10	4	10	10	10	4	86		
17	28204	Yamauchi et al, 1991		Benzo(a)pyrene	100	Rat ( <i>Rattus norvegicus</i> )	1	3	0/5/50	mg/kg bw/d	NR	na	DLY	U	GV	10	d	5	w	JV	M	V	Lab	PTH	ORW	SMIX	LI	5	50	Y	0.2020	N	0.018501	5.0	50.0	10	8	10	10	10	10	10	4	8	10	10	4	84
18	27748	Bosveld, et al, 1996		Benzo(a)pyrene	100	White toothed shrew ( <i>Sorex araneus</i> )	1	3	0/10/100	mg/kg bw/d	NR	na	CON	U	FD	9	d	NR	NR	NR	F	V	Lab	PTH	GRS	BDWT	WO	10	100	Y	0.00920	N	0.0014561	10.0	100	10	10	5	10	10	4	8	10	10	6	4	77	
19	25982	Knuckles et al, 2001		Benzo(a)pyrene	98	Rat ( <i>Rattus norvegicus</i> )	1	4	0/5/50/100	mg/kg bw/d	NR	na	ADL	UX	FD	90	d	9	w	JV	M	C	Lab	PTH	ORW	SMIX	LI	50	100	Y	0.160	N	0.015232	49.0	98.0	10	10	10	10	10	10	10	10	10	10	7	91	
20	48539	Uno et al., 2006		Benzo(a)pyrene	100	Mouse ( <i>Mus musculus</i> )	1	4	0/1.25/12.5/125	mg/kg bw/d	NR	na	ADL	U	FD	18	d	NR	NR	JV	M	V	Lab	PTH	ORW	SMIX	LI	125		Y	0.024	N	0.0032025	125		10	10	5	10	10	4	4	1	10	4	68		
21	25987	Seidel, 1977		7,12-Dimethylbenz(a)anthracene	100	Mouse ( <i>Mus musculus</i> )	1	2	0/0.14	mg/kg bw/d	NR	na	1 per w	U	GV	2	w	8-10	w	JV	F	V	Lab	PTH	ORW	ORWT	TS		0.14	N	0.02250	N	0.0030370		0.140	10	8	10	10	10	4	4	10	10	10	4	80	
22	30150	Reuber and Glover, 1969		7,12-Dimethylbenz(a)anthracene	100	Rat ( <i>Rattus norvegicus</i> )	1	2	0/0.025	% in diet	NR	na	ADL	U	FD	12	w	12	w	JV	M	C	Lab	PTH	ORW	ORWT	TY	0.025	Y	0.3510	N	0.029054		20.7	10	10	5	10	6	4	4	10	10	10	4	73		
23	27335	Das et al, 1994		Benanthrone	100	Guinea pig ( <i>Cavia porcellus</i> )	1	2	0/50	mg/kg bw/d	NR	na	DLY	U	GV	4	w	NR	NR	JV	M	V	Lab	PTH	ORW	SMIX	LI	50	Y	0.2970	N	0.025326		50.0	10	8	10	10	10	4	4	10	10	10	4	80		
<b>Reproduction</b>																																																
24	26128	Mackenzie and Angevine, 1981		Benzo(a)pyrene	100	Mouse ( <i>Mus musculus</i> )	1	4	0/10/40/160	mg/kg bw/d	NR	na	DLY	U	GV	9	d	NR	NR	GE	F	V	Lab	REP	REP	PRWT	WO	10	40	N	0.028750	N	0.0037150	10.0	40.0	10	8	10	10	10	10	8	10	10	10	4	90	
25	26033	Lambelin et al., 1967		6-Aminochrysene	100	Rat ( <i>Rattus norvegicus</i> )	1	3	0/13.3/26.4	mg/kg bw/d	NR	na	ADL	U	FD	3	mo	1	mo	GE	F	C	Lab	REP	REP	PROG	WO	13.3	26.4	Y	0.2650	N	0.01370	13.3	26.4	10	10	5	10	10	10	10	10	10	10	4	89	
26	26164	Rigdon an d Neal, 1965		Benzo(a)pyrene	100	Mouse ( <i>Mus musculus</i> )	1	2	0/0.25	mg/g	NR	na	ADL	U	FD	17	d	NR	NR	LC	F	V	Lab	REP	REP	PRWT	WO		0.25	Y	0.0040	N	0.00073426		45.9	10	10	5	10	6	10	4	10	10	4	79		
<b>Growth</b>																																																
28	48317	Culp et al., 1998		Benzo(a)pyrene	100	Mouse ( <i>Mus musculus</i> )	1	4	0/5/25/100	mg/kg diet	NR	na	ADL	M	FD	55	w	5	w	JV	B	V	Lab	GRO	GRO	BDWT	WO	25	100	Y	0.037	N	0.0045711	3.09	12.4	10	10	10	10	6	8	8	10	10	10	4	86	
29	28204	Yamauchi et al, 1991		Benzo(a)pyrene	100	Rat ( <i>Rattus norvegicus</i> )	1	3	0/5/50	mg/kg bw/d	NR	na	DLY	U	GV	10	d	5	w	JV	M	V	Lab	GRO	GRO	BDWT	WO	5.0	50	Y	0.202	N	0.018501	5.0	50.0	10	8	10	10	10	8	8	10	10	10	4	88	
30	2743	Kristensen et al. 1995		Benzo(a)pyrene	100	Mouse ( <i>Mus musculus</i> )	1	2	0/10	mg/kg bw/d	NR	na	DLY	U	GV	9	d	9	w	GE	F	V	Lab	GRO	GRO	BDWT	WO	10.0		N	0.03710	N	0.00458123															

**Appendix 6.2 Mammalian Toxicity Data Extracted for Wildlife Toxicity Reference Value (TRV)  
High Molecular Weight Polynuclear Aromatic Hydrocarbons (HMW-PAHs)  
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Result #	Ref No.	Ref	Chemical Form	MW %	Test Species	Exposure																Effects					Conversion to mg/kg bw/day				Result		Data Evaluation Score												
						Phase #	# of Conc/ Doses	Conc/ Doses	Conc/Dose Units	Wet Weight Reported?	Percent Moisture	Application Frequency	Method of Analyses	Route of Exposure	Exposure Duration	Duration Units	Age	Age Units	Lifestage	Sex	Control Type	Test Location	General Effect Group	Effect Type	Effect Measure	Response Site	Study NOAEL	Study LOAEL	Body Weight Reported?	Body Weight in kg	Ingestion Rate Reported?	Ingestion Rate in 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
48	26164	Rigdon and Neal, 1965	Benzo(a)pyrene	100	Mouse ( <i>Mus musculus</i> )	2	2	0/0.25	mg/g	NR	na	ADL	U	FD	6	d	20	d	JV	M	V	Lab	BEH	FDB	FCNS	WO	0.25		Y	0.0110	Y	0.0012	27.3		10	10	5	10	7	4	4	1	10	4	65
49	48370	Hood et al., 2003	3-Methylcholanthrene	100	Mouse ( <i>Mus musculus</i> )	1	5	0/62.5/125/250/500	mg/kg diet	NR	na	ADL	U	FD	21	d	7	w	JV	M	V	Lab	PTH	ORW	ORWT	LI	500		Y	0.0316	N	0.004015	63.5		10	10	5	5	10	4	4	1	10	4	63
50	48539	Uno et al., 2006	Benzo(a)pyrene	100	Mouse ( <i>Mus musculus</i> )	1	4	0/1.25/12.5/125	mg/kg bw/d	NR	na	ADL	U	FD	18	d	NR	NR	JV	M	V	Lab	BIO	ENZ	AATT	BL	125		Y	0.024	N	0.0032025	125		10	10	5	10	10	1	4	1	10	4	65
27	28203	Holladay and Smith, 1994	Benzo(a)pyrene	100	Mouse ( <i>Mus musculus</i> )	1	4	0/50/100/150	mg/kg bw/d	NR	na	DLY	U	GV	5	d	NR	NR	GE	F	V	Lab	REP	REP	OHIS	PY		50	N	0.03530	N	0.00439772		50.0	10	8	10	10	10	10	4	10	10	4	86

All abbreviations and definitions used in coding studies are available from Attachment 4-3 of the Eco-SSL guidance (U.S. EPA 2003).  
Duplicate values for NOAELs and LOAELs for the same reference represent results from different experimental designs.