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Guidance for Developing Ecological Soil Screening Levels

OSWER Directive 92857-55

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MAY 1 2 2004
By ER

U.S. Environmental Protection Agency
Office of Solid Waste and Emergency Response
1200 Pennsylvania Avenue, N.W.
Washington, DC 20460

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EXECUTIVE SUMMARY

This document describes the process used to derive a set of risk-based ecological soil screening levels (Eco-SSLs) for many of the soil contaminants that are frequently of ecological concern for plants and animals at hazardous waste sites and provides guidance for their use. The Eco-SSL derivation process represents the group effort of a multi-stakeholder workgroup consisting of federal, state, consulting, industry, and academic participants led by the U.S. Environmental Protection Agency Office of Superfund Remediation and Technology Innovation (OSRTI). The Eco-SSLs are concentrations of contaminants in soil that are protective of ecological receptors that commonly come into contact with soil or ingest biota that live in or on soil. These values can be used to identify those contaminants of potential concern in soils requiring further evaluation in a baseline ecological risk assessment. The Eco-SSLs should be used during Step 2 of the Superfund Ecological Risk Assessment process, the screening-level risk calculation. The Eco-SSLs are not designed to be used as cleanup levels and EPA emphasizes that it is inappropriate to adopt or modify these Eco-SSLs as cleanup standards.

EPA derived the Eco-SSLs in order to conserve resources by limiting the need for EPA and other risk assessors to perform repetitious toxicity data literature searches and data evaluations for the same contaminants at every site. This effort should also allow risk assessors to focus their resources on key site-specific studies needed for critical decision-making. EPA also expects that the Eco-SSLs will increase consistency among screening risk analyses and decrease the possibility that potential risks from soil contamination to ecological receptors will be overlooked.

EPA prepared a list of twenty-four (24) contaminants to be addressed initially by the Eco-SSL guidance. This list was based on a review of the contaminants of concern reported in recent Record of Decisions at Superfund National Priority List sites. The Eco-SSL contaminant list also included contaminants nominated by the EPA regional Biological Technical Assistance Group Coordinators. The list of 24 Eco-SSL contaminants contained 17 metals including aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, selenium, silver, vanadium, and zinc. The organic contaminants on the list were dieldrin, Hexahydro -1,3,5-trinitro-1,3,5-triazine (RDX), trinitrotoluene (TNT), 1,1,1-Trichloro-2,2-bis (p-chlorophenyl)ethane (DDT) and metabolites (DDE and DDD), pentachlorophenol, polycyclic aromatic hydrocarbons (PAHs), and polychlorinated biphenyls (PCBs).

The omission of other contaminants, such as phthalates, cyanides, dioxins and mercury, does not imply that these contaminants can be excluded from the ERA screening process for soil contamination. The processes and procedures established here for developing the Eco-SSLs were intended to be sufficiently transparent to allow others to derive values for additional contaminants, as needed. PCBs were included by the workgroup in the original Eco-SSL contaminant list. However, it became apparent early in the process, that development of a PCB soil screening value was not warranted. Because of the known high persistence and toxicity of PCBs, and the conservative nature of the Eco-SSLs, it was acknowledged that soil screening

levels derived for PCBs would normally be lower than the soil analyses detection limits. EPA believes that if PCBs are detected in soil above background levels, the PCBs are probably site-related and therefore should be included as a contaminant of potential concern in the baseline risk assessment.

The approach developed for deriving the Eco-SSLs for plants and soil invertebrates was similar to the approach taken for deriving the wildlife Eco-SSLs (specifically the toxicity reference values). The general approach included four steps: (1) conduct literature searches, (2) screen identified literature with exclusion and acceptability criteria, (3) extract, evaluate, and score test results for applicability in deriving an Eco-SSL, and (4) derive the value. These procedures were finalized as standard operating procedures prior to initiating any work to derive the actual values.

Chapter 3 provides a description of the procedures used for deriving plant and soil invertebrate Eco-SSL values. The values were derived directly after an evaluation of all available plant and soil invertebrate chronic toxicity test data (measured toxicity related to soil contaminant concentrations). Chapter 4 provides a description of the procedures for deriving the wildlife Eco-SSLs. The wildlife Eco-SSLs were the result of back-calculations from a hazard quotient of 1.0. The hazard quotient is equal to the estimated exposure dose divided by the toxicity reference value (TRV). An HQ of 1.0 is the condition where the exposure and the dose associated with no adverse chronic effects are equal, indicating adverse effects at or below this soil concentration are unlikely. A generic food-chain model was used to estimate the relationship between the concentration of the contaminant in soil and the dose for the receptor (mg per kg body weight per day). The TRV represents a receptor-class specific estimate of a no-observed adverse effect level (dose) for the respective contaminant for chronic exposure.

The Eco-SSLs apply to sites where terrestrial receptors may be exposed directly or indirectly to contaminated soil. Seven groups of ecological receptors were initially considered in the development of the Eco-SSLs. These included mammals, birds, reptiles, amphibians, soil invertebrates, plants, and soil microbes and their processes. After investigation, the toxicity data for amphibians and reptiles were deemed insufficient to derive Eco-SSLs. EPA recognizes that the Eco-SSL may not be protective of these receptor groups. Eco-SSLs protective of microbes and soil microbial processes were also not derived. Like amphibians and reptiles, EPA recognizes their importance within terrestrial systems, but concurs with the workgroup that data are insufficient and the interpretation of test results too uncertain for establishing risk-based thresholds.

Eco-SSLs are appropriate to all sites where key soil parameters fall within a certain range of chemical and physical parameters. The Eco-SSLs for plants and soil invertebrates were derived to apply to soils where the pH is greater than or equal to 4.0 and less than or equal to 8.5, and the organic matter content is less than or equal to 10%. Based on these stated parameters, it is expected that there are certain soils and situations to which Eco-SSLs do not apply. These situations include (but may not be limited to) wetland soils that are regularly flooded (i.e., sediments), sewage sludge amended soils where the organic matter content is > 10%, and waste types where the pH is < 4.0.

Because of the diversity of the workgroup scientists, the process developed to derive the Eco-SSLs underwent constant peer review. There were also two external peer reviews performed during the development process. The first was a consultation requested by EPA's Office of Solid Waste and Emergency Response of EPA's Science Advisory Board (SAB). This consultation was held on April 6, 1999. At this meeting, the SAB provided verbal comments to the presenters which were subsequently addressed, as appropriate, by the workgroup as they prepared the guidance. A peer review of the draft guidance document was also performed. The peer review workshop was held on July 26 and 27, 2000 and was open to the public. Each of the comments received was carefully considered by the workgroup Steering Committee and appropriate changes were made to both the procedures for establishing Eco-SSLs and to the guidance document.

After developing the procedures and completing the peer review process, the workgroup focused primarily on deriving Eco-SSL values for the list of contaminants. The results of the application of the derivation procedures reported in this document are provided as separate contaminant-specific documents. In cases where data were limited or not available and Eco-SSL values could not be derived for specific contaminants and receptor groups, EPA may at some point in the future revise the contaminant-specific documents or add contaminants as appropriate.

ACKNOWLEDGMENTS

The development of this guidance was a team effort led by the U.S. Environmental Protection Agency Office of Superfund Remediation and Technology Innovation (OSRTI). A Steering Committee coordinated the activities of four task groups. A team of scientists from Syracuse Research Corporation (SRC) managed by Janet Burris provided technical and administrative support in the development of this guidance. Listed below are the members of the Steering Committee and each task group.

Steering Committee
Steve Ells, U.S. EPA OSRTI, Co-Chair
Ralph Stahl, DuPont, Co-chair
Randy Wentsel, U.S. EPA ORD, Co-chair

Bill Adams	Rio Tinto
Doris Anders	U.S. Air Force Center for Environmental Excellence (AFCEE)
John Bascietto	U.S. Department of Energy (DOE)
David Charters	U.S. EPA OSRTI
Ron Checkai	U.S. Army Edgewood Chemical Biological Center (ECBC)
Stiven Foster	U.S. EPA, Office of Research and Development (ORD)
Dale Hoff	U.S. EPA, Region 8
Charlie Menzie	Menzie-Cura & Associates
Chris Russom	U.S. EPA, ORD
Brad Sample	CH2MHill
Jason Speicher	North Division of the Naval Facilities Engineering Command
Mike Swindoll	Exxon Mobile Biomedical Sciences, Inc.

Task Group on Soil Chemistry
Randy Wentsel, U.S. EPA, Co-Chair
Charlie Menzie, Menzie-Cura & Associates, Co-Chair

Bill Berti	DuPont
Ron Checkai	U.S. Army Edgewood Chemical Biological Center (ECBC)
Mary Goldade	U.S. EPA, Region 8
Roman Lanno	Oklahoma State University
Charles R. Lee	U.S. Army Corps of Engineers, Waterways Experiment Station
Linda Lee	Purdue University
Mike Ruby	Exponent
John Samuelian	OGDEN Environmental and Energy Services

Task Group on Eco-SSLs for Soil Invertebrates and Plants
Ron Checkai, U.S. Army ECBC, Co-Chair
Mike Swindoll, Exxon Mobile Biomedical Sciences, Inc., Co-Chair

David Barclift	North Division of the Naval Facilities Engineering Command
Ron Checkai	U.S. Army ECBC
William Desmond	Tetra Tech EM, Inc.
Steve Ells	U.S. EPA, OSRTI
Charlene Falco	Illinois EPA
Stiven Foster	U.S. EPA, ORD.
Dave Gannon	Zeneca Corp.
Andrew Green	International Lead Zinc Research Org. (ILZRO)
Larry Kapustka	ecological, planning & toxicology, Inc.
Roman Kuperman	U.S. Army ECBC
Les Morrow	Illinois EPA
Daniel Mazur	U.S. EPA, Region 5
Chris Russom	U.S. EPA, ORD
Jason Speicher	North Division of the Naval Facilities Engineering Command
Gladys Stephenson	ESG International, Ltd. / University of Guelph

Task Group on Wildlife Toxicity Reference Values
Dale Hoff, U.S. EPA, Co-Chair
Doris Anders, U.S. Air Force, Co-Chair

Nelson Beyer	U.S. Geological Survey
David Charters	U.S. EPA OSRTI
David Cozzie	U.S. EPA Office of Solid Waste
Dave Cragin	Elf-Atochem North America
Steve Dole	Exponent
Anne Fairbrother	U.S. EPA, ORD, Corvallis, Oregon
Bob Fares	Environmental Standards, Inc.
Gary Friday	Westinghouse Savannah River Co.
Kinzie Gordon	Parsons Engineering Science, Inc.
Gerry Henningsen	U.S. EPA, Region 8 (retired)
Mark Johnson	U.S. Army Center for Health Promotion and Preventative Medicine
Paul Kuhlmeier	Dames & Moore
Jackie Little	TN & Assoc.
Patricia Newell	Environmental Health Associates, Inc.
Drew Rak	U.S. Army Corps of Engineers, Baltimore District
Linda Schmeising	Exponent

Task Group on Exposure Models for Wildlife Species
John Bascietto, U.S. Department of Energy (DOE), Co-Chair
Brad Sample, CH2M Hill, Co-Chair

Amber Brenzikofer	Parsons Engineering Science
Bridgette Deshields	Harding Lawson Associates
Will Gala	Chevron
Tracy Hammon	Colorado Department of Health and Environmental Protection
Rob Pastorok	Exponent
Phillip Rury	Arthur D. Little, Inc.
Randy Ryti	Neptune and Co.
William Schew	Environmental Standards, Inc.
Ralph Stahl	DuPont
Jeff Yurk	U.S. EPA, Region 6

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Due to the length of many of these Attachments, they are only available on the EPA Superfund web site at www.epa.gov/superfund/programs/risk/tooleco.htm

LIST OF ACRONYMS AND ABBREVIATIONS

AEC	Anion exchange capacity
ASTM	American Society of Testing and Materials
AUF	Area use factor
AF_{ij}	Absorbed fraction of contaminant (j) from biota type (i)
AF_{sj}	Absorbed fraction of contaminant (j) from soil (s)
B_i	Contaminant concentration in biota type (i)
$B0_{ij}$	Intercept from log-linear bioaccumulation model for contaminant (j) for biota type (i)
$B1_{ij}$	Slope from log-linear bioaccumulation model for contaminant (j) for biota type (i)
BAF	Bioaccumulation factor
BEH	Behavior
BIO	Biochemical
BTAG	Biological Technical Assistance Group
BW	Body weight
C_{soil}	Concentration of contaminant in soil
CCME	Canadian Council of Ministers of the Environment
CEC	Cation exchange capacity
CI	Confidence interval
COC	Contaminant of concern
COPC	Contaminant of potential concern
DDT	1,1,1-Trichloro-2,2-bis(p-chlorophenyl)ethane
DQO	Data quality objective
dw	Dry weight
EC_{xx}	Effect concentration for the xx% of the test population
Eco-SSL	Ecological soil screening level
EPA	U.S. Environmental Protection Agency
ERA	Ecological risk assessment
ERAGS	Ecological Risk Assessment Guidance for Superfund
ERE	Ecologically relevant endpoint
f_{oc}	fraction organic carbon content
FBRC	Federal Biology Research Cooperative
FIR	Food ingestion rate
g	Grams
GRO	Growth
HQ	Hazard quotient
HQ_j	Hazard quotient for contaminant (j)
HSDB	Hazardous Substance Data Bank
ISO	International Standards Organization
kg	Kilogram
K_{oc}	Organic carbon-normalized partition coefficient
K_{ow}	Octanol water partition coefficient
LC_{50}	Concentration lethal to 50 percent of test population
LOAEC	Lowest-observed adverse effect concentration
LOAEL	Lowest-observed adverse effect level

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

MATC	Maximum acceptable toxicant concentration
mg	Milligram
mmol	Millimole
MOR	Mortality
MPA	Maximum permissible addition
MPC	Maximum permissible concentration
NC	Negligible concentration
NOAEL	No-observed adverse effect level
NOAEC	No-observed adverse effect concentration
NOC	Non ionic organic compounds
OC	Organic carbon
OECD	Organization for Economic Cooperation and Development
OM	Organic matter
ORNL	Oak Ridge National Laboratory
OSRTI	Office of Superfund Remediation and Technology Innovation
P_i	Proportion of biota type (i) in diet
P_s	Soil ingestion as proportion of diet
pKa	Acid dissociation constant
PAH	Polycyclic aromatic hydrocarbon
PCB	Polychlorinated biphenyl
PCP	Pentachlorophenol
PHY	Physiology
PTH	Pathology
QA	Quality assurance
QSAR	Quantitative Structure Activity Relationship
RDX	Hexahydro-1,3,5-trinitro-1,3,5-triazine
REP	Reproduction
RIVM	Dutch National Institute of Public Health and the Environment
ROD	Record of decision
SAB	Science Advisory Board
SMDP	Scientific Management Decision Point
$Soil_j$	the Eco-SSL for contaminant j for wildlife
SOP	Standard operating procedure
SQG	Soil quality guideline
T_{ij}	Soil-to-biota bioaccumulation factor for contaminant (j) for biota type (i)
T_{ver}	diet-to-biota BAF
TNT	Trinitrotoluene
TRV	Toxicity reference value
TRV_j	Toxicity reference value for contaminant (j)
UCL	Upper confidence limit
U.S.	United States
µm	micrometer

LIST OF ACRONYMS AND ABBREVIATIONS
(Continued)

VOC	Volatile organic compound
ww	Wet weight

1.0 INTRODUCTION

This guidance describes the process used to derive a set of risk-based ecological soil screening levels (Eco-SSLs) for many of the soil contaminants that are frequently of ecological concern for plants and animals at hazardous waste sites and further provides guidance on using Eco-SSLs. The specific Eco-SSL values and the data upon which they were derived are described in separate contaminant specific Eco-SSL documents. The Eco-SSL derivation process represents the group effort of a multi-stakeholder workgroup consisting of federal, state, consulting, industry, and academic participants led by the U.S. Environmental Protection Agency (EPA) Office of Superfund Remediation and Technology Innovation (OSRTI). The workgroup developed the following mission statement at the initiation of the Eco-SSL project:

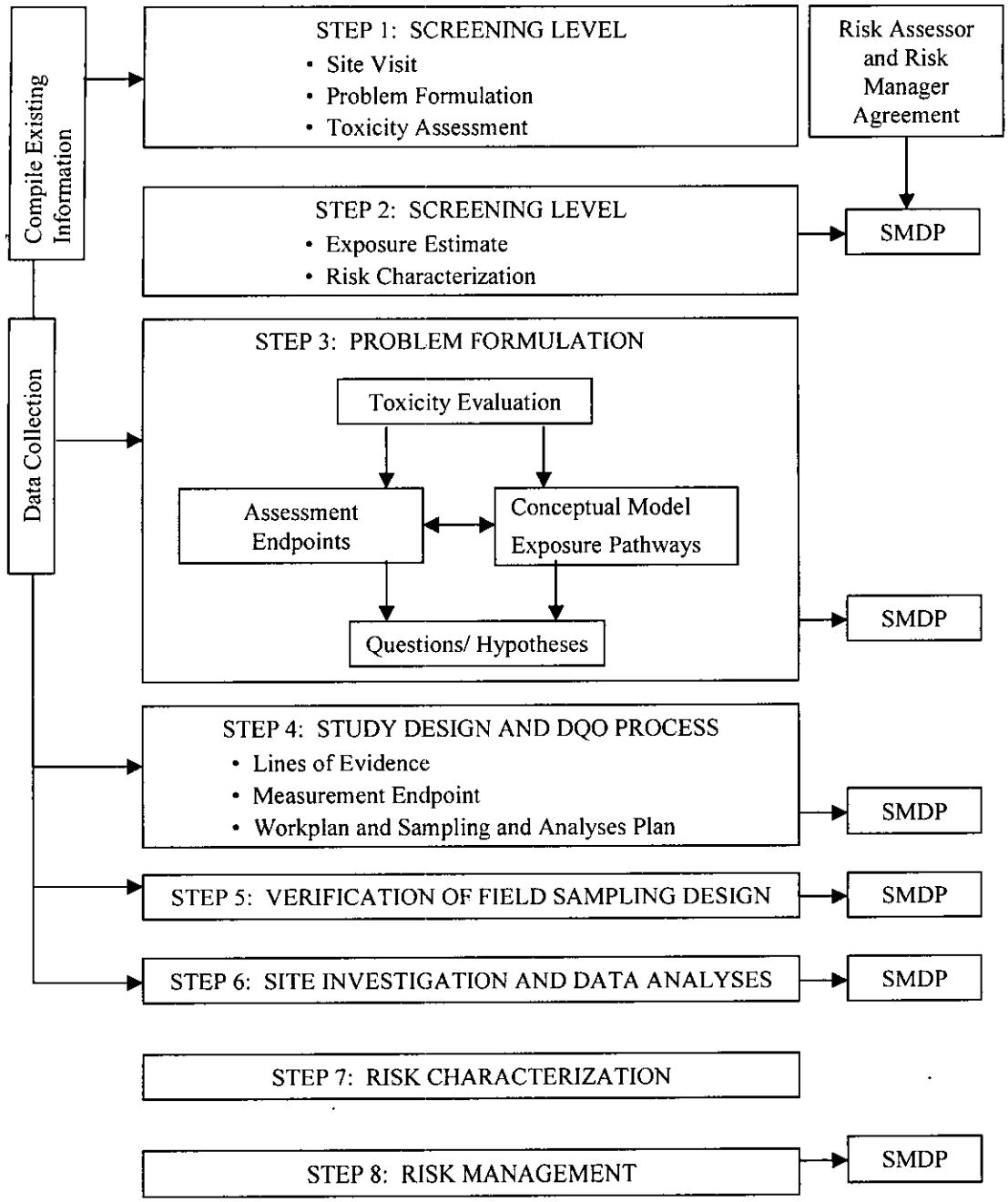
> *Develop a set of generic, scientifically sound, ecologically based, soil screening levels that are protective of the terrestrial environment for up to 24 contaminants of concern; and methodologies and models that use site-specific exposure data to modify these screening levels. The screening levels and methodologies should be sufficiently specific and transparent to allow for consistent implementation by EPA and other Federal Agencies, States, and private parties at all Superfund sites.*

The Eco-SSLs are screening values that can be used routinely to identify those contaminants of potential concern (COPCs) in soils requiring further evaluation in a baseline ecological risk assessment (ERA). Although these screening levels were developed specifically to be used during Step 2 of the Superfund ecological risk assessment process, EPA envisions that any federal, state, or private environment assessment or cleanup program could use these values to screen soil contaminants and sites in order to determine if additional ecological site study was warranted. **The Eco-SSLs were not designed to be used as cleanup levels and EPA emphasizes that it would be inappropriate to adopt or modify these Eco-SSLs as cleanup standards.**

This document provides guidance and is designed to communicate national policy on identifying contaminants 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 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 guidance and the appropriateness of the application of this document to a particular situation. EPA welcomes public comments on this guidance at any time and may consider such comments in future revisions of this guidance.

What are Eco-SSLs?

Eco-SSLs are concentrations of contaminants in soil that are protective of ecological receptors that commonly come into contact with soil or ingest biota that live in or on soil. Eco-SSLs are derived separately for four groups of ecological receptors: plants, soil invertebrates, birds, and mammals.



SMDP = Sample Management Decision Point

DQO = Data Quality Objective

Figure 1.1 Eight Step Process Recommended in Ecological Risk Assessment Guidance for Superfund (ERAGs) (U.S. EPA, 1997)

Protection of Rare, Endangered and Threatened Species

Eco-SSLs should be protective of rare, endangered, and threatened species. However, the final decision should be made on a site-specific basis in consultation with the United States Fish and Wildlife Service and other natural resource trustees.

As such, these values are presumed to provide adequate protection of terrestrial ecosystems. Eco-SSLs for wildlife are derived to be protective of the representative of the conservative end of the distribution in order to make estimates for local populations. The Eco-SSLs are conservative and are intended to be applied at the screening stage of the assessment. These screening levels should be used in the ERA process to identify the COPCs that require further evaluation in the site-specific baseline risk assessment. This Eco-SSL guidance was written with the assumption that the reader is familiar with Superfund's guidance on performing ERAs (Ecological Risk Assessment Guidance for Superfund (ERAGS)), U.S. EPA, 1997, Figure 1.1), with Superfund's ecological risk assessment and risk management principles (U.S. EPA, 1999) and with EPA's risk assessment guidelines (U.S. EPA, 1998).

The Eco-SSLs should be used during Step 2 of the Superfund ERA process, the screening-level risk calculation. This step normally is completed at a time when limited soil concentration data are available, and other site-specific data (e.g., contaminant bioavailability information, area use factors) are not available. It is expected that the Eco-SSLs will be used to screen the site soil data to identify those contaminants that are not of potential ecological concern and do not need to be considered in the subsequent baseline ERA. The Eco-SSLs are intentionally conservative in order to provide confidence that contaminants which could present an unacceptable risk are not screened out early in the ERA process. EPA believes that the Eco-SSLs generally provide an appropriate balance of protectiveness and reasonableness.

Why are Eco-SSLs Needed?

EPA derived the Eco-SSLs with the intent to conserve resources by limiting the need for EPA, state, contractor, and other federal risk assessors to perform repetitious toxicity data literature searches and toxicity data evaluations for the same contaminants at every site. These Eco-SSLs are also intended to increase consistency among screening risk analyses, decrease the possibility that potential risks from soil contamination to ecological receptors will be overlooked, and allow risk assessors to focus their resources on identifying key site studies needed for critical decision-making.

In the process of deriving the Eco-SSLs, the workgroup examined currently available soil screening guidelines (see text box) for their potential use within the Superfund process.

Some Other Available Soil Screening Guidelines

Canadian Council of Ministers of the Environment (CCME) Canadian Soil Quality Guidelines (SQGs). The CCME guidelines are numerical limits for contaminants intended to maintain, improve, or protect environmental quality and human health. They are intended for use in the assessment and remediation of contaminants at sites in Canada (CCME, 1997).

The Dutch National Institute of Public Health and the Environment (RIVM). Maximum permissible concentrations (MPCs), maximum permissible additions (MPAs), and negligible concentrations (NCs) were developed in a series of reports for soils, sediments, and water for metals and pesticides (RIVM, 1997a and 1997b).

Oak Ridge National Laboratory (ORNL). A series of reports have been issued from ORNL that provide screening levels for plants (Efroymson et al., 1997a), soil invertebrates and microbial processes (Efroymson et al., 1997b), wildlife (Sample et al., 1996), and sediments (Jones et al., 1997).

Because these existing guidelines were developed in response to country-specific legislation and/or included policies not totally consistent with current EPA policies, EPA believes use of these guidelines may not be appropriate. A summary and evaluation of the available guidelines was completed and provided as Attachment 1-1.

How Are the Eco-SSLs Derived?

Eco-SSLs were derived using standardized procedures for literature review, toxicity data selection, and data evaluation. Where acceptable data were judged to be adequate, four Eco-SSLs were derived for each contaminant: one each for plants, soil invertebrates, birds, and mammals.

Plant and soil invertebrate Eco-SSL values were derived directly from an evaluation of available plant and soil invertebrate toxicity test data (measured toxicity related to soil contaminant concentrations), as described in Chapter 3. The process for deriving mammalian and avian Eco-SSLs is described in Chapter 4. The wildlife Eco-SSLs were the result of back-calculations from a Hazard Quotient (HQ) of 1.0. The HQ is equal to the estimated exposure dose divided by a toxicity reference value (TRV). An HQ of 1.0 is the condition where the exposure and the dose associated with no adverse effects are equal, indicating adverse effects at or below this soil concentration are unlikely. A generic food-chain model was used to estimate the relationship between the concentration of the contaminant in soil and the dose for the receptor (milligrams per kilogram body weight per day (mg/kg bw/d)). The TRV represents a receptor-class specific estimate of a no-observed adverse effect level (NOAEL) (dose) for the respective contaminant.

1.1 Scope of the Eco-SSLs

Contaminants Considered

EPA prepared a list of twenty-four (24) contaminants to be addressed initially by the Eco-SSL guidance. This list was based on a review of the contaminants of concern reported to be the subject of soil remediation in recent Record of Decisions (ROD) at Superfund National Priority List sites. The Eco-SSL contaminant list also included contaminants nominated by the EPA regional Biological Technical Assistance Group (BTAG) Coordinators. The list of 24 Eco-SSL contaminants contained seven organics and17 metals (see Figure 1.2).

Figure 1.2 Eco-SSL Contaminants

Organics

- Dieldrin
- Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)
- Trinitrotoluene (TNT)
- 1,1,1-Trichloro-2,2-bis (p-chlorophenyl)ethane (DDT) and metabolites DDE and DDD.
- Pentachlorophenol (PCP)
- Polycyclic Aromatic Hydrocarbons (PAHs)
- Polychlorinated biphenyls (PCBs)

Metals

- Aluminum
- Antimony
- Arsenic
- Barium
- Beryllium
- Cadmium
- Chromium
- Cobalt
- Copper
- Iron
- Lead
- Manganese
- Nickel
- Selenium
- Silver
- Vanadium
- Zinc

The omission of other contaminants, such as phthalates, cyanides, dioxin, and mercury, does not imply that these contaminants can be excluded from the ERA screening process for soil contamination, only that these 24 contaminants have historically been of greatest ecological concern in soil. The process and procedures

established here for developing the Eco-SSLs are intended to be sufficiently transparent to allow others to derive values for additional contaminants, as needed. Polychlorinated biphenyls (PCBs) were included by the workgroup in the original 24 identified Eco-SSL contaminants. However, it became apparent early in the process that development of a screening value would not be appropriate. Because of the known persistence and toxicity of PCBs, and the conservative nature of the Eco-SSLs, any soil screening level derived for PCBs would often be lower than the detection limits used in a screen. EPA recommends that if PCBs are detected in soil above background levels, then they should be considered site-related and therefore should be included as a COPC in a baseline ERA.

Ecological Receptors of Concern

The Eco-SSLs generally apply to sites where terrestrial receptors may be exposed directly or indirectly to contaminated soil. Seven groups of ecological receptors were initially considered in the development of the Eco-SSLs. These initial groups included mammals, birds, reptiles, amphibians, soil invertebrates, plants, and soil microbes and their processes. After further investigation, the toxicity data for amphibians and reptiles were deemed insufficient to derive Eco-SSLs. EPA recognizes that the Eco-SSL values do not address possible risks for reptiles and amphibians and may not be protective of these receptor groups. The user should consider including these receptors in the site-conceptual model for the site-specific risk assessment.

Eco-SSLs protective of microbes and soil microbial processes were also not derived. Like amphibians and reptiles, EPA recognized their importance within terrestrial systems, but believes that data are insufficient and the interpretation of test results too uncertain for establishing risk-based thresholds for risk screening purposes. While Eco-SSLs for microbes and soil microbial processes were not established at this time, they may be considered in the future as the science develops and appropriate studies are completed. A summary of the task group discussion concerning establishing Eco-SSLs for soil microbes and their processes was documented as Attachment 1-2.

Eco-SSLs were derived for four general groups of ecological receptors: mammals, birds, plants, and soil invertebrates. By deriving conservative soil screening values considered protective of these groups, it is assumed that these receptor groups are protected from possible adverse effects associated with soil contamination. This assumption is consistent with the use of "generic assessment endpoints" as discussed in Section 1.2.5 of ERAGS.

Exposure Pathways for Ecological Receptors

A complete exposure pathway is defined in ERAGS as "one in which the contaminant can be traced or expected to travel from the source to a receptor that can be affected by the contaminant." Exposure pathways can be classified as incomplete, complete, or potentially complete. An exposure pathway is not considered complete if natural habitat for ecological receptors is not present and is not expected to be present in the future.

The Eco-SSLs for plants considered direct contact of contaminants in soils. The Eco-SSLs for soil invertebrates considered ingestion of soil and direct contact exposures with a preference for conditions of high bioavailability (refer to Chapters 2 and 3).

The Eco-SSLs for birds and mammals considered two potentially complete exposure pathways: 1) incidental ingestion of soils during feeding, grooming and preening; and 2) ingestion of food contaminated as a result of the uptake of soil contaminants. Two potentially complete exposure pathways (dermal contact and inhalation) were not considered in the derivation of wildlife Eco-SSLs. The rationale for this decision included the following:

What is a Complete Ecological Exposure Pathway for Contaminants in Soil?

For an exposure pathway to be complete, a contaminant must be able to travel from the source to ecological receptors and be taken up by the receptors via one or more exposure routes (U.S. EPA, 1997).

Exposure pathways may not be complete for ecological receptors if:

✓ Soil contamination exists only below the root zone, and deep burrowing mammalian species are not identified as potential receptors in the site conceptual model.

✓ The site is within urban and/or industrialized areas where natural habitat and receptors are absent.*

*Urban settings may in some cases be used by protected species. The appropriate trustees should be consulted.

- Burrowing animals could be exposed to relatively high concentrations of volatile organic compounds (VOCs) in their burrows via inhalation. However, with the exception of some of the polynuclear aromatic hydrocarbons (PAHs), none of the Eco-SSL contaminants were VOCs. At sites with high VOC and/or certain PAH concentrations in soils with burrowing mammals present, the inhalation exposure pathway should be considered in the baseline ERA. In this case, the contaminants would not be excluded in the screening step.

Exposure Pathways Considered in Eco-SSLs

Birds and Mammals

- Ingestion of soils during grooming, feeding, and preening
- Ingestion of food contaminated as a result of uptake of soil contaminant

Plants

- Direct contact

Soil Invertebrates

- Direct contact
- Soil ingestion

- Soil particles containing non-VOC contaminants (by either adsorption or absorption) could also be inhaled by wildlife. Respirable particles (greater than five μm) are, however, most likely ingested as a result of mucocilliary clearance rather than being inhaled (Witschi and Last, 1996). At equal exposure concentrations, inhalation of contaminants associated with dust particles is expected to contribute less than 0.1 % of total risk compared to oral exposures (Attachment 1-3).

- Birds and mammals may also be exposed to contaminants in soils via dermal contact. Studies investigating dermal exposures to birds from the application of pesticides by spray to tree branches have shown this exposure route to be significant relative to oral exposures for some substances; e.g. organophosphate pesticides, (Abou-Donia and Graham 1978, Driver et al. 1991, and Henderson et al. 1994). However, current information is

insufficient to evaluate dermal exposure for the 24 selected Eco-SSL contaminants in various soil matrices, or to predict possible rates of absorption for many species. For most contaminants, the dermal exposure is expected to contribute less than one percent to 11 % of the total risk (Attachment 1-3) compared to oral exposures.

This approach is consistent with Section 9.2.4 of ERAGS (U.S. EPA, 1997), which states that the ingestion route is most important for terrestrial animals and that "although other exposure routes can be important, more assumptions are needed to estimate exposure levels for these routes, and the results are less certain". Exclusion of dermal and inhalation exposure routes for the Eco-SSLs does not preclude their inclusion in the site-specific baseline ERA. If it is expected that receptors may be more exposed to contaminant(s) via dermal and/or inhalation exposures relative to oral exposures due to site-specific conditions, these exposure routes should be evaluated as part of the baseline ERA.

Soils for Which Eco-SSLs are Applicable

It is recommended that Eco-SSLs be considered at sites where key soil parameters fall within a certain range of chemical and physical parameters. The Eco-SSLs for plants and soil invertebrates are usually appropriate for application to soils where: the pH is greater than or equal to 4.0 and less than or equal to 8.5 and the organic matter content is less than or equal to 10 %.

The Eco-SSLs are intended for use in upland soils. However, they may also be useful for screening wetland soils. The wildlife Eco-SSLs are derived for several general receptor groups that are likely to be representative of wildlife found in wetlands. A major caveat, however, is the omission of the amphibians and reptiles from derivation of the wildlife Eco-SSLs. These groups could be especially important in wetlands. The Eco-SSLs for plants and soil invertebrates are expected to be broadly applicable (i.e., conservative enough for most soils) as preference was given to studies with high bioavailability of the contaminants in soils. For this reason, the Eco-SSLs for plants and soil invertebrates may be useful for screening for contaminants in wetland soils. In general, wetland soils are expected to exhibit a lower bioavailability (compared to those used to derive Eco-SSLs) as a result of the high organic content.

Based on these stated parameters, it is expected that there are certain soils and situations to which Eco-SSLs may not be appropriate. These situations include (but may not be limited to):

- Wetland soils that are regularly flooded (i.e., sediments).
- Sewage sludge amended soils where the organic matter (OM) content is > 10 %.
- Waste types where the pH is < 4.0.

1.2 The General Process for Establishing Eco-SSLs

Four separate task groups were formed to develop the procedures for establishing Eco-SSLs and to accomplish the work necessary to derive the Eco-SSL values for the 24 listed contaminants. The task groups were composed of a cross-section of the stakeholders represented in the larger work

Eco-SSL Task Groups

Soil Chemistry. This task group provided information on the factors that influence bioavailability of contaminants from soils. The task group developed the soils matrix used to select studies for establishing plant and soil invertebrate Eco-SSLs, the background soils database, and Chapter 2 of this guidance document.

Plant and Soil Invertebrate Eco-SSLs. This task group developed the procedures for establishing plant and soil invertebrate Eco-SSLs (Chapter 3). The task group derived the plant and soil invertebrate Eco-SSL values according to these procedures.

Wildlife Eco-SSLs. The wildlife Eco-SSLs were developed by the combined efforts of two separate task groups:

Wildlife Toxicity Reference Values (TRVs). This task group developed the procedures for establishing the wildlife toxicity reference values as presented in Chapter 4.

Wildlife Exposure Model. This task group developed the equations, assumptions, and factors for establishing the exposure model for wildlife. The model is presented in Chapter 4. The model estimates the soil contaminant concentration associated with no adverse effects to representative wildlife species.

group with efforts directed by a steering committee. One task group focused on information related to the factors that influence the bioavailiblity of contaminants from soils. A second task group focused on deriving the Eco-SSLs protective of plants and soil invertebrates. The third and fourth task groups focused on deriving Eco-SSLs protective of wildlife. One group developed the procedures for deriving wildlife TRVs (mammalian and avian receptors) while the other group developed the models necessary for estimating contaminant transfer from soils to the terrestrial food chain and for deriving exposures for wildlife.

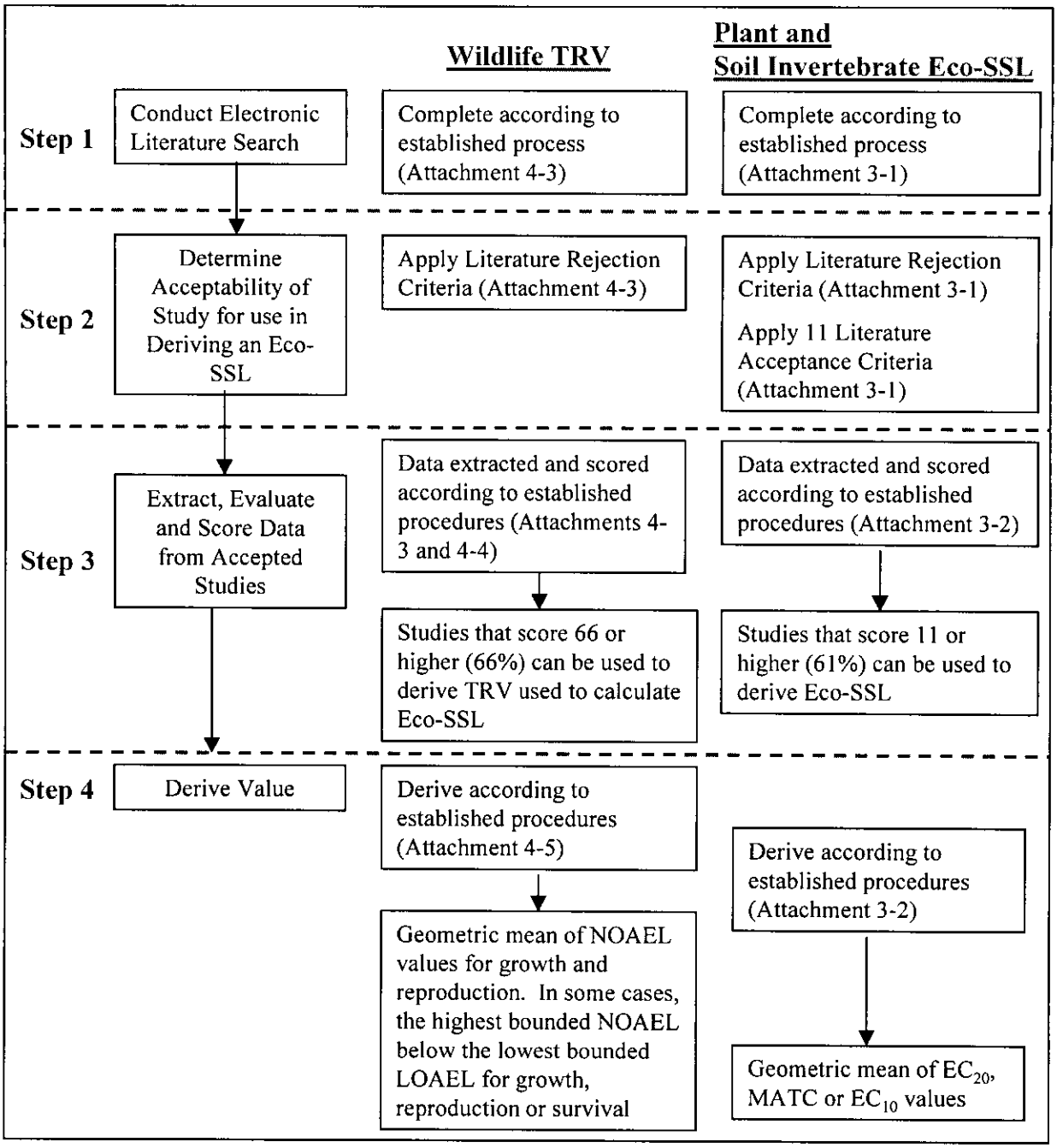
Although the task groups worked independently, the approach taken for deriving the Eco-SSLs for plants and soil invertebrates was similar (see Figure 1.3) to the approach taken for deriving the wildlife Eco-SSLs (specifically the TRVs). The general approach included four steps (1) conduct literature searches, (2) screen identified literature with exclusion and acceptability criteria, (3) extract, evaluate, and score test results for applicability in deriving an Eco-SSL, and (4) derive the value.

Step 1: Literature Search

For all receptors, potentially relevant publications were identified through literature searches of computerized abstracting databases combined with the examination of citations associated with published literature review articles. The literature searches for avian and mammalian species included all publication years, while those for plants and soil invertebrates included only publications after 1987 (Table 1.1). The task group theorized that most of the pre-1988 publications would be identified through the review bibliographies, and this was confirmed in subsequent analysis of the literature search results with approximately 40 % of potentially applicable papers identified through non-computerized search techniques. In cases where contaminant/receptor pairings had less than 20 potentially applicable articles, searches were completed for all publication years.

Step 2: Determine Acceptability of Study for Use in Deriving Eco-SSL

Both task groups used similar exclusion criteria to assess the potential applicability of publications identified through the literature searches. Publications were excluded for similar reasons as



NOAEL = No-Observed Adverse Effect Level
LOAEL = Lowest-Observed Adverse Effect Level
EC_{20} = Effect Concentration 20%
EC_{10} = Effect Concentration 10%
MATC = Maximum Acceptable Toxicant Concentration

Figure 1.3 Comparison of Eco-SSL Derivation Procedures for Wildlife and Plant and Soil Invertebrates

Table 1.1. Comparison of Eco-SSL Derivation Procedures

Step in Eco-SSL Process	Common to Both Approaches	Unique to Wildlife Approach	Unique to Plant and Soil Invertebrate Approach
Step 1: Conduct electronic literature search	Searches were conducted with appropriate abstracting databases finding the intersection of contaminant, species and toxicological terms. The final electronic search result was reviewed to determine potentially applicable studies. Bibliographies of review articles were skimmed to identify additional publications.	All publication years were searched.	Searches were limited to 1988 to present. For limited data sets, searches included literature published prior to 1988. Holdings of U. S. EPA MED-Duluth library were searched.
Step 2: Determine acceptability of study for use in deriving an Eco-SSL	• Must be the primary source of the data • Exposure to single contaminant • Control must be included • Duration of exposure must be reported • Effects must be reported for relevant endpoints • Dose or concentration must be reported • Laboratory or field studies accepted • Beneficial effects not considered • Species must be reported • Percent metal or purity used to calculate nominal concentrations	• Oral route of exposure • At least two exposures: 1 control and 1 contaminant • Endpoints are behavioral, biochemical, growth, mortality, pathology, population, physiology, and reproduction • Chronic studies only (> 3 days exposure duration)	• Application rates not used • Natural or artificial soils • At least three exposures: 1 control and 2 contaminant • Test media must have: % organic matter (OM) content ≤ 10 %; pH ≥ 4 and ≤ 8.5 • Endpoints are growth , physiology (plants only), population, and reproduction • Priority given to chronic studies, but acute studies with sublethal effects or plant emergence as an endpoint were used
Step 3: Extract, evaluate and score data from accepted studies	Papers were reviewed and the results were extracted according to established guidelines.	Separate results were used if any of the following varied: test organism (species or strains), contaminant form, test location, control type, doses, application frequency, or route of exposure.	Separate results were used if any of the following parameters varied: test species (not strain), contaminant (not form), soil (natural vs. artificial), pH, or % OM content.
	Each result was scored according to established guidelines.	All endpoints were scored in order of preference based on: source of data; chemical form, measurement or no measurement in substrate; ability to calculate a dose; bounded vs unbounded NOAEL/LOAEL, route of exposure, endpoint type, duration of exposure, statistical power, and adherence to test guidelines. Studies that scoreed > 65 % were used to derive a TRV.	Within a study with multiple endpoints only one was used in the following order of preference: reproduction > population > growth > physiology. Score was based on soil bioavailability score; experimental design (i.e.,adherence to ideal test guidelines); reporting of chemical concentration; use of appropriate controls; duration of exposure; NOAEC and LOAEC or EC_{10},EC_{20} reported (or can be estimated); statistical analysis; and origin of test organism. Studies that scored ≥ 11 out of 18 (≥ 61 %) were used to derive an Eco-SSL.
Step 4: Calculation of value	Results that scored above a cutoff were used in and established approach to determine value.	The TRV was equal to the geometric mean of NOAEL values for growth and reproduction or the highest bounded NOAEL below the lowest bounded LOAEL for growth, reproduction or survival. The process considered NOAEL and LOAEL endpoints and included unbounded NOAEL values, but not unbounded LOAEL values.	The Eco-SSL was equal to geometric mean of EC_{20}, MATC or EC_{10} values. Only EC_{20}, MATC and EC_{10} values were considered. NOAEC and LOAEC values were used to calculate the MATC. Unbounded NOAECs and LOAECs were not used. When a study reported multiple endpoints, the selection followed the following order of preference: EC_{20} > MATC > EC_{10}

specified later in Chapters 3 and 4 and summarized in Table 1.1. Acceptable plant and soil invertebrate studies were further restricted to those that followed state-of-the-art soil testing requirements (e.g., 4.0 ≤ pH ≤ 8.5, organic matter content ≤ 10 %, use of natural or artificial soil). Both task groups agreed that three or more treatment levels (including the control) were preferred, but a substantial portion of the avian and mammalian studies would have been excluded if this requirement was applied. Therefore only two treatment levels were required for mammalian and avian receptors and five were required for plants and soil invertebrates. Only chronic toxicity studies (greater than a three-day exposure) were accepted for mammalian and avian studies. Although acute studies were not excluded for plants and soil invertebrates, the exposure duration was considered later in the process for selecting the most appropriate test results for deriving the Eco-SSL.

Step 3: Extract, Evaluate and Score Data

The extraction of toxicity data from the acceptable literature, evaluation of test methods and results, and scoring of each test result also followed similar processes. When the methods diverged, it was due mainly to inherent differences in study designs (e.g., direct exposures to soils versus exposures in the diet or drinking water). Both task groups determined a cutoff for acceptable results for use in deriving the wildlife TRV or plant or soil invertebrate Eco-SSL by plotting data for various data sets and identifying logical breaks. For mammalian and avian species this break occurred at an evaluation score of 66 out of a possible 100 (i.e., studies with a score greater than or equal to 66 % were used to derive the TRV), while the break for plants and soil invertebrates occurred with a score of 11 out of 18.

Step 4: Select Value

For both task groups, only the results from studies scoring above the respective cutoffs were used to determine the value. For mammals and birds the TRV was equal to the geometric mean of NOAEL values for growth and reproduction, or the highest bounded NOAEL (NOAEL with paired LOAEL) below the lowest bounded lowest-observed adverse effect level (LOAEL) for growth, reproduction or survival (whichever was lower). For contaminants with no growth, reproduction, or survival data, the TRV was derived from biochemical, behavioral, pathology and physiology results. The methodology considered both NOAEL and LOAEL endpoints including unbounded NOAEL values but not unbounded LOAEL values.

For plants and soil invertebrates, the Eco-SSL was equal to the geometric mean of values for the maximum acceptable toxicant concentration (MATC), the effective concentration that affects 20 % of the test population (EC_{20}), or the effective concentration that affects 10 % of the test population (EC_{10}). When a study reported multiple endpoints, the selection of endpoints for use in deriving the Eco-SSL followed an order of preference of the EC_{20}, then the MATC, then the EC_{10}. The MATC was either reported in the study or was calculated from the geometric mean of the no-observed adverse effect concentration (NOAEC) and the lowest-observed adverse effect concentration (LOAEC).

1.3 Peer Review Process

The Eco-SSL procedures received both internal and external peer review. Because of the diversity of the workgroup scientists, the process developed to derive the Eco-SSLs underwent constant peer review. There were also two external peer reviews performed during the development of the Eco-SSLs. The first was a consultation requested by EPA's Office of Solid Waste and Emergency Response of EPA's Science Advisory Board (SAB). This consultation was held April 6, 1999. At this meeting the SAB provided verbal comments to presenters at the SAB review, which were passed on to the workgroup and incorporated into the guidance as appropriate. A formal external peer review of the draft guidance document was also performed. The peer review workshop was held on July 26 and 27, 2000 and was open to the public. The results of this peer review are provided in separate documentation on the Eco-SSL website. Each of the comments received was carefully considered by the Steering Committee and the individual work groups and appropriate changes were made to both the procedures for establishing Eco-SSLs and the associated guidance document.

1.4 Quality, Objectivity, Utility, and Integrity of Information

The EPA is committed to a policy of ensuring that the information it provides to the public, and uses to make its decisions, maintain a basic standard of quality, which includes objectivity, utility, and integrity. The Eco-SSLs are primarily derived from information the EPA obtained from external sources that may not have used the same standards, guidelines, and controls that EPA imposes on itself, and those who gather data on behalf of the agency. The agency has recently proposed five assessment factors for evaluating the quality of information it obtains from external sources (67 FR 57225, September 9, 2002):

- Soundness The extent to which the procedures, measures, methods, or models employed to generate the information are reasonable for, and consistent with, the intended application and are scientifically/technically appropriate.

- Applicability and Utility The extent to which the information is applicable and appropriate for the Agency's intended use.

- Clarity and Completeness The degree of clarity and completeness with which the data, assumptions, methods, quality controls, and analyses employed to generate the information are documented.

- Uncertainty and Variability The extent to which the variability and uncertainty in the information or in the procedures, measures, methods, or models are evaluated or characterized.

- Evaluation and Review The extent of independent application, replication, evaluation, validation, and peer review of the information or of the procedures, measures, methods, or models.

Because these five assessment factors were developed after this guidance document was prepared, they are not addressed by name. However, all five of these principles were embedded in the standardized procedures for literature review, toxicity data selection, and data evaluation that were used to derive the Eco-SSLs.

1.5 Using Eco-SSLs to Screen Contaminated Soils

The Eco-SSLs are intended for use in identifying soil contaminants (i.e., COPCs) and/or areas of soil contamination that warrant further consideration in a baseline ERA. Screening is typically completed during Step 2 of the 8-step Superfund ERA process, as depicted in Figure 1.1. Prior to using the Eco-SSLs, it is assumed that the risk assessor has completed Step 1, including the site visit and initial problem formulation. With the information gathered in Step 1, it is recommended that the risk assessor completes a screening of soils data using the Eco-SSLs in the risk calculation performed during Step 2.

Comparing the Site Conceptual Model to the General Eco-SSL Model

The user should compare the preliminary site conceptual model developed for their site during Step 1, with the assumptions and limitations inherent in the Eco-SSLs to determine if additional or more detailed assessments are needed for any exposure pathways or contaminants. Early identification of areas, conditions, or receptors where Eco-SSLs are not appropriate is important for adequate planning and sampling strategies for the ERA.

Are There Soil Exposure Pathways for Ecological Receptors?

The Eco-SSLs are designed for use at sites where terrestrial receptors may be exposed directly or indirectly to contaminated soil. Therefore, generally the first step in determining whether use of the Eco-SSLs is appropriate is to identify all complete and potentially complete soil pathways present at the site. The following are the receptor group-specific pathways of exposure to soil contaminants considered in deriving the Eco-SSLs:

Mammals and Birds

- Incidental ingestion of soil
- Ingestion of food (soil invertebrates and plants)

Soil Invertebrates and Plants

- Direct contact
- Ingestion of soil (by soil invertebrates)
- Uptake (by plants)

For surface soils (i.e., those soils within the root zone at the specific site), all the above pathways were considered. Ecological risks from potential exposure to contaminated subsurface soils were generally not considered. In some site-specific cases, however, there may be risks to animals that

burrow beneath the root zone. It should also be noted that, for some plants, the root zone can extend several feet.

As part of Step 1 of the ERAGS process, the site manager and risk assessor generally need to know enough about the site to answer at least the following questions:

- What contaminants are known or suspected to exist at the site?
- What complete exposure pathways might exist at the site?
- What habitat types located on or near the site are potentially contaminated?

If it is determined that there are no complete soil exposure pathways (e.g., the current and future land-use is industrial and there are no terrestrial habitats, or the only soil contamination is well below both the root zone and the burrow zone at the site), then additional screening for soil effects on ecological receptors is generally not needed.

Are There Exposure Pathways at the Site Not Addressed by the Eco-SSLs?

In some cases, the site-specific conceptual model may identify complete or potentially complete ecological soil exposure pathways that are not considered in the derivation of the Eco-SSLs. In these instances, the additional pathways should be considered in a separate screening analysis or as part of the baseline ERA. Examples of such instances include:

- The contaminated soil is near a surface water body or wetland where there is potential for contamination of surface water and/or sediments by transport during rain events.

- There are other likely ecological exposure routes not considered in the derivation of the Eco-SSLs. For example, inhalation of VOCs may be of concern for burrowing animals.

- Some site conditions may be a source of contamination to groundwater. For example, contaminants from soils may leach to groundwater, which could result in exposures for ecological receptors upon discharge to surface waters.

Comparing Site Soil Concentrations to the Eco-SSLs

Comparisons of site soil concentrations to the Eco-SSLs during Step 2 of the ERAGS process may be used to answer the following questions:

- Are there any potential ecological risks associated with soil contamination, and is it necessary to proceed with a baseline ERA (Steps 3 to 8 of ERAGS)?

- Which contaminants in soil can be dropped from further consideration and which ones should be the focus of the baseline ERA?

- Which geographic areas of soil contamination may result in ecological risks?

- Which receptors/functional groups (e.g., birds or soil invertebrates) appear to be at most risk and should be the focus of the baseline ERA?

Are the Existing Site Soil Contaminant Data Adequate?

At this point of the process, the user should make a decision concerning the adequacy of the available contaminant concentration data for soils for use in completing a screening level analysis. This decision, typically made by the site manager and risk assessor, usually considers the following:

- Are all expected areas of soil contamination sampled, or are there other areas of potential exposure for ecological receptors for which soil data are not available?

- Are the parameters of the soil analyses sufficient to identify the possible contaminants deposited as part of known waste disposal processes and practices? For example, if DDT is suspected as part of the deposited waste, are soil analyses available for DDT? Or are data only available for metals?

- Are the quantification limits adequate to measure the contaminants at the Eco-SSL levels?

How do you Calculate the Concentration Term for Comparison to the Eco-SSLs?

The appropriate soil contaminant concentration for comparison to the Eco-SSL is dependent on a number of factors, including the size of the site, the nature and extent of the contamination, and the level of confidence in the site sampling data. In most cases, there are limited soil data available at Step 2 of the ERAGS process; therefore, it is recommended that the maximum soil contaminant concentrations be compared to the Eco-SSLs. However, if the data set is large, the 95 % upper confidence limit (UCL) of the arithmetic mean may be the appropriate value to use. Decisions concerning concentration terms used for comparisons should be made in consultation with the site manager, site risk assessor, and the regional BTAG (as applied in Superfund).

Which Eco-SSL Should be Used?

Assuming there is a complete exposure pathway, the lowest of the four reported Eco-SSLs should generally be used to compare to the site soil concentrations. The ERA process assumes that complete exposure pathways exist for each of the four receptor groups; i.e., every terrestrial habitat at or near a hazardous waste site is, or should be, suitable for mammals, birds, plants, and soil invertebrates.

What if Soil Contaminant Concentrations Exceed Eco-SSLs?

If the appropriate site soil contaminant concentration exceeds an Eco-SSL, then the user should retain that contaminant as a COPC for further consideration in the baseline ERA. If soil concentrations exceed some receptor-specific Eco-SSLs and not others, then it is recommended that the contaminant be retained as a COPC only for those receptor groups where Eco-SSLs are exceeded.

What if Soil Contaminant Concentrations Do Not Exceed Eco-SSLs?

Contaminants in soils with concentrations lower than Eco-SSLs can be excluded as COPCs in the subsequent ERA. However, the user should recognize that new information may become available during the baseline ERA which may show that initial assumptions are no longer valid (e.g., site contaminant levels are higher than reported earlier). In this case, contaminants may be placed back on the list of COPCs. If there are no soil contaminant concentrations that exceed the Eco-SSLs, a baseline ERA for soils is generally not needed for that site.

What if There is No Eco-SSL?

At this time, Eco-SSLs are not available for all four receptor groups and for all 24 soil contaminants. For some of the Eco-SSL contaminants, there was an insufficient number of acceptable toxicity studies to establish an Eco-SSL. For some contaminants, EPA had not completed the review of toxicity data for derivation of Eco-SSLs. The current Eco-SSLs are available on the EPA Eco-SSL website http://www.epa.gov/superfund/programs/risk/tooleco.htm. The user should consult this source for the current values.

For those contaminants with an insufficient number of acceptable toxicity studies to establish an Eco-SSL, a summary of the toxicity studies evaluated in the Eco-SSL process was made available in the contaminant specific Eco-SSL documents. The information from these studies can be used according to the process described in Section 1.3.1 of ERAGS to derive screening values. As more toxicity information becomes available, EPA may use these processes to revise existing Eco-SSLs or to develop new ones.

Can I Use Site-specific Data to Modify an Eco-SSL or Should I Proceed to a Baseline Risk Assessment?

If one or more Eco-SSL values are exceeded it is recommended that the user proceed to a baseline ERA. The Eco-SSLs are intended to be conservative values used to identify those contaminants that should be the focus of a baseline ERA and as such they should not be modified as part of the screening step. During the baseline ERA, it will be possible for the user to collect and use site-specific data as part of development of the site-specific exposure and toxicity assessments in the baseline ERA.

Consideration of Background Soil Concentrations

Due to conservative modeling assumptions (e.g., metal exists in most toxic form or highly bioavailable form, high food ingestion rate, high soil ingestion rate) which are common to screening processes, several Eco-SSLs are derived below the average background soil concentration for a particular contaminant as presented in Attachment 1-4. Since Eco-SSLs are not designed to be used as clean-up levels, EPA is not promoting clean-up to below background concentrations. It is EPA's policy to not screen against background levels. Background concentrations, the speciation of metals, and the effects of conservative modeling assumptions are generally taken into account in the initial steps of the baseline risk assessment. Specific procedures for comparing risk information to site specific background levels is addressed in the Office of Solid Waste and Emergency Response document *Role of Background in the CERCLA Cleanup Program* (OSWER 9285.6-07P) (U.S. EPA, 2002). However, if a specific exposure parameter or toxicity endpoint is found to consistently produce an Eco-SSL that is below background concentrations (taking into account natural species of metals), EPA may reevaluate specific Eco-SSL values as they are updated.

Information on background concentrations of contaminants in soils was collected and reviewed during the Eco-SSL derivation process to examine how the Eco-SSL values compare to natural soil conditions. These comparisons were used to guide the process and are presented as Attachment 1-4. The review indicated that there are regions of the country where natural background levels for some metals exceed Eco-SSLs. For these regions and for specific local areas, the acquisition of adequate data on background soil concentrations is an important step toward evaluating, on a site-specific basis, if observed concentrations are related to releases or are naturally occurring. Background concentrations are further discussed in each of the contaminant-specific Eco-SSL documents.

Definitions

Contaminants of concern (COCs) are the contaminants that, at the completion of the risk assessment, are found to pose unacceptable human or ecological risks. The COCs drive the need for a remedial action.

Contaminants of potential concern (COPCs) generally comprise the contaminants that are investigated during the baseline risk assessment that may or may not pose unacceptable risks.

Screening is a common approach used by risk assessors to refine the list of COPCs to those hazardous substances, pollutants and contaminants that may pose substantial risks to health and the environment.

Background refers to constituents or locations that are not influenced by the releases from a site, and is usually described as naturally occurring or anthropogenic (US EPA, 2002)

- **Anthropogenic** -natural and human-made substances present in the environment as a result of human activities (not specifically related to the release in question); and,
- **Naturally occurring** - substances present in the environment in forms that have not been influenced by human activity.

2.0 SOIL PROPERTIES

2.1 Introduction

Soil properties influence the toxicity of contaminants to invertebrates, plants, and wildlife. Therefore, they are generally important to consider in the development of Eco-SSLs and provide a basis for guiding site-specific evaluations that may follow application of Eco-SSLs. This chapter discusses the primary soil parameters that influence bioavailability of contaminants from soils. This soil property information provides the rationale for defining a set of soil parameters used in the selection of the most appropriate studies for deriving Eco-SSLs for plants and soil invertebrates and specific recommendations for screening soils for aluminum and iron.

This chapter focuses primarily on the relationship between soil chemistry factors that influence the toxicity to and accumulation of contaminants in soils to plants and soil invertebrates. The absorption of contaminants bound to incidentally ingested soil particles in the animal gut is influenced by other parameters including gut residence time as well as toxicokinetic and physiological factors that may affect the uptake of contaminants in wildlife. Because wildlife species vary in the anatomy and physiology of their digestive systems (e.g., herbivores vs. carnivores), generalizations can not and should not be made concerning bioavailability of contaminants on soil incidentally ingested by wildlife at the screening level.

2.2 Soil Properties Influencing Contaminant Bioavailability

Bioavailability is a measure of the potential for entry of the contaminant into ecological or human receptors and is specific to the receptor, the route of entry, time of exposure, and the soil matrix containing the contaminant (Anderson et al., 1999). In order to ensure that Eco-SSLs are adequately conservative for a broad range of soils, an effort is made in the procedures developed to select studies that favor the bioavailability of the selected contaminants. To accomplish this, it is first necessary to develop a basic understanding of how various soil properties may influence bioavailability. Several authors stress the importance of physical and chemical properties of contaminants that influence the bioavailability in soils and thus exposure and toxicity (Alexander, 1995; Allen et al., 1999; Linz and Nakles, 1997; and Loehr and Webster, 1996). The behavior and bioavailability of contaminants are greatly influenced by their interactions with soil parameters, such that not all contaminants are equally available to biota. However, estimating the availability of metals and organic contaminants in soil to soil biota and plant toxicity is not a straightforward process.

The bioavailability of contaminants depends on their chemical properties and the specific physical and geochemical binding mechanisms that vary among contaminants and soil types. Contaminants interact with soil through interactions with the surface of particulate material in soils (adsorption), by penetration through the particulate surfaces where the contaminant becomes associated with the internal material (absorption or partitioning), and through specific contaminant reactions sometimes referred to as chemisorption. Also some contaminants, in particular metals, can associate with inorganic ligands and precipitate. The affinity of a

contaminant to be removed from solution and become associated with soil particulates irrespective of mechanism, is generally referred to as "sorption". The exception are precipitation reactions, which are often discussed independently from sorption processes. Contaminants are generally considered to be bioavailable when they are released from interactions with the soil and soil constituents and released into the soil pore-water. The exception to this rule is the direct ingestion of soil by terrestrial wildlife.

Identifying and quantifying soil properties that control the distribution of a contaminant in soil/water systems at equilibrium are useful for exposure situations where time is sufficient for equilibrium conditions to develop. For exposure situations that are dominated by discrete events often of short duration (e.g., incidental ingestion of soil), the kinetics of contaminant release from soils into another medium (i.e., the amount released per unit time) and residence time (i.e., time allowed for transfer to occur) controls the fraction of a contaminant that would be labile to target biota. Both adsorption and absorption partitioning processes are considered reversible, although mass transfer from the particle to the pore-water can be constrained. In the case of interactions within a particle, a contaminant can become sequestered or trapped through various physical and contaminant alterations that occur over time, such that contaminant release is completely constrained. The decline of the availability of many organic contaminants in soil over months or years has been well-documented (Alexander, 1995; Loehr and Webster, 1996). For chemisorption, the binding mechanism is considered irreversible under most environmental conditions. For precipitation reactions, release to pore-water is controlled by the factors affecting the stability or solubility of the contaminant precipitate. Overall, bioavailability of a contaminant in soil strongly depends on its physical and chemical properties, the characteristics of the soil, the interactions between the contaminant and the medium, including time of exposure, and the physiological and biochemical conditions of the receptor.

Contaminant Characteristics Impacting Lability

The soil parameters important in affecting sorption and precipitation reactions and the extent of their influence and thus contaminant bioavailability, are dependent on the intrinsic properties of the contaminants. The 24 contaminants considered in this guidance include both metals and organic contaminants. Metals can exist as either cations or anions in the soil environment, which significantly affects their sorption, mobility, and solubility in soils. For example, soil is primarily negatively charged, thus, metal cations have a higher propensity to be sorbed by soil particles relative to metal anions. For organics, lipophilicity and persistence alter their availability, as well as ionic potential in the case of organic contaminants with ionizable functional groups. Collectively, the 24 contaminants are classified into the four groups (Table 2.1).

Metals. Metals occur naturally in soils primarily as amorphous oxides and hydroxides, and to a lesser extent as carbonates, phosphates, sulfates, and sulfides, which are relatively insoluble. The same is generally true for metal-contaminated soils, because metals quickly undergo precipitation and coprecipitation reactions forming relatively insoluble solid phases, and/or are strongly complexed by soil minerals or organic matter (Lindsay, 1979). Toxicity testing on the

other hand usually employs very soluble metals not commonly found in any appreciable amounts in soils relative to total metal concentrations.

Table 2.1 General Contaminant Classification	
Contaminant Class	**Eco-SSL Contaminant**
Metal Cations	aluminum, antimony, barium, beryllium, cadmium, cobalt, copper, iron, lead, manganese, nickel, silver, and zinc
Metal Anions	arsenic, chromium, selenium, and vanadium
Nonionic Organics	PCBs, DDT and metabolites, dieldrin, PAHs, TNT, and RDX
Ionizable Organics	PCP

As identified in Table 2.1, most of the 24 contaminants considered for Eco-SSLs are metals that typically exist as cationic species. These metals can complex with inorganic soil constituents, e.g., carbonates, sulfates, hydroxides, sulfides, to form either precipitates or positively charged complexes. Both complexation and precipitation reactions are pH dependant. Therefore, although these metals can form complexes with a net negative charge, under most environmentally relevant scenarios (pH = 4 to 8.5), these metals either precipitate or exist as cations.

Arsenic, chromium, selenium, and vanadium complex with oxygen and typically exist as anionic species under most environmentally relevant scenarios (Bohn et al., 1985; Lindsay, 1979). The most common forms of arsenic are arsenate (arsenic V) and arsenite (arsenic III), which are present in soil solution in the form of AsO_4^{3-} and AsO^{2-}, respectively. The chemistry of arsenic resembles that of phosphate (Barber, 1995; Bohn et al., 1985). Chromium can exist as chromate (chromium VI or CrO_4^{2-}), which is usually considered more soluble, mobile and bioavailable than the sparingly soluble chromite (chromium (III)), which is normally present in soil as the precipitate $Cr(OH)_3$ (Barnhart, 1997; James et al., 1997). Similarly, selenium can be present as selenates (SeO_4^{2-}) and selenites (SeO_3^{2-}). For vanadium, vanadate (VO_4^{3-}) is the most common form.

Metals in their various forms can exist in the pore-water as charged species, as soluble complexes, or precipitate out of solution. Retention by soil is usually electrostatic with cationic species and anionic species being associated with negatively and positively charged sites on the soil, respectively. For most soils in the United States, negatively charged sites are more plentiful with less than 5% of the total available charge on the soil surface being positively charged. Therefore, metals existing as cationic species have a greater propensity to associate with the soil and are less bioavailable, whereas, distribution of anionic metals is generally more towards the pore-water for most soil/water systems. The soil pH and availability of charged sites on soil surfaces are the primary soil factors controlling their release to the pore-water, and subsequently, bioavailability.

Organic Contaminants. Of the seven organic contaminants identified in Table 2.1, DDT and metabolites, dieldrin and PCBs are very hydrophobic, highly lipophilic, and persistent nonionic organic contaminants. These contaminants are highly sorbed to soil surfaces and organic matter and tend to bioaccumulate and biomagnify in the food chain. The structure and degree of chlorination of PCBs and associated congeners directly impacts their behavior, persistence, and bioavailability (e.g., see citations in Hansen et al., 1999). As solubility decreases, sorption increases, and bioavailability generally decreases with increasing chlorination. However, uptake, degradability, and toxicity are also impacted by placement of the chlorines in the biphenyl structure. The remaining nonionic organic contaminants, PAHs and explosives (TNT and RDX) are generally considered less persistent and more bioavailable than pesticides or PCBs under identical soil conditions. PAHs are compounds with two or more aromatic rings in their structure and consist of only carbon and hydrogen. PAHs can be highly retained by soil in a similar manner as pesticides or PCBs, but are considered less persistent due to their higher affinity to be degraded microbially. TNT and RDX, a trinitro aromatic and trinitro nitrogen-heterocyclic respectively, are explosive materials and are more polar than PCBs or PAHs. The only ionizable organic contaminant being considered at this time in the development of Eco-SSLs, is the organic acid pentachlorophenol (PCP). Organic acids can exist as either a nonionic species or as an organic anion, which is dependent on the acid dissociation constant (pKa) and pH. In the pH range relevant to most environmental scenarios, PCP can exist as both a neutral species and as an anionic species; however, the majority will exist as the organic anion (Lee et al., 1990).

For all nonionic organic compounds (NOC) and the neutral form of PCP, sorption by soil is primarily related to their hydrophobicity and the amount of organic matter present in the soil (Lagrega, 1994; Lee et al., 1990), with the exception of the more polar, nitro-substituted organic contaminants (i.e., the explosives). Differences in the distribution of several NOCs in diverse soil-water and sediment-water systems have been minimized by normalization to organic matter or more specifically organic carbon (OC) with OC-normalized distribution coefficients, referred to as K_{oc} values (e.g., Gertsl, 1990; Lyman et al., 1990;). The greater the affinity of a contaminant for organic matter, the larger the organic carbon-normalized partition coefficient (K_{oc}), and a soil with higher amounts of organic matter has a higher propensity to sorb NOCs. The hydrophobicity and K_{oc}, of organic compounds increases with the size of the compound and with increasing chlorine content, as in the case of chlorinated organics. Therefore, sorption of PAHs by soils increases with the number of aromatic rings. For compounds like PCBs, sorption increases with increasing chlorination. Increasing compound hydrophobicity also reflects increasing lipophilicity, which will result in a greater propensity to bioaccumulate in the lipid fraction of biota. For PCP, an ionic contaminant, the anionic species has a greater tendency relative to the neutral PCP to remain in the pore-water similar to metal anions. Therefore, pH-dependent speciation drastically modifies the solubility, sorption, transport, and bioavailability of PCP. Although organic matter is the primary sorption domain in soils, all contaminants have some affinity to be associated with any surface through weak physical forces (Schwarzenbach et al., 1993). In addition, the nitro-substituted NOCs are known to have specific interactions with clay surfaces that are impacted by the inorganic cations present and

clay charge density, and less so by the amount of organic matter present (Weissmahr et al., 1998; 1999).

A common contaminant index representing the degree of hydrophobicity and lipophilicity of an organic contaminant is the octanol-water partition coefficient (K_{ow}), which is the contaminant distribution between octanol and water phases. K_{ow} values are positively correlated to both K_{oc} values and bioconcentration factors (Lyman et al., 1990). For reference, log K_{ow} values for selected organic contaminants are summarized in Table 2.2.

Table 2.2. Log K_{ow} Values for Organic Contaminants

Analyte	CAS no.	log K_{ow}	Source
RDX	121824	0.87	Syracuse Research Corporation (SRC)
TNT	118967	1.6	SRC
DDT	50293	6.53	U.S. EPA (1996)
DDD	72548	6.1	U.S. EPA (1996)
DDE	72559	6.76	U.S. EPA (1996)
Dieldrin	60571	5.37	U.S. EPA (1996)
Pentachlorophenol (PCP)	87865	5.09	U.S. EPA (1996)
PCBs		4.5 (1 chlorine) >8 (10 chlorines)	Verschueren (1996) Schwarzenbach et al. (1993)
PAHs			
Naphthalene (2 rings)	91203	3.36	U.S. EPA (1996)
Acenaphthene (3 rings)	83329	3.92	U.S. EPA (1996)
Phenanthrene (3 rings)	85018	4.55	U.S. EPA (1995)
Anthracene (3 rings)	120127	4.55	U.S. EPA (1996)
Chrysene (4 rings)	218019	5.7	U.S. EPA (1996)
Benzo(a)anthracene (4 rings)	56553	5.7	U.S. EPA (1996)
Benzo(a)pyrene (5 rings)	50328	6.11	U.S. EPA (1996)
Dibenzo(ah)anthracene (5 rings)	53703	6.69	U.S. EPA (1996)
Benzo(b)fluoranthene (5 rings)	92240	6.2	U.S. EPA (1996)
Benzo(k)fluoranthene (5 rings)	207089	6.2	U.S. EPA (1996)
Benzo(ghi)perylene (6 rings)	191242	6.7	U.S. EPA (1995)

Key Soil Parameters Affecting Contaminant Bioavailability in Soils

From the preceding overview of how contaminants interact with soil constituents, it is clear that soil plays a very significant role in reducing the potential bioavailability of contaminants in the environment. Given the types of contaminant-soil interactions presented, the primary soil factors controlling the potential bioavailability of all contaminants are identified as soil pH, available charged sites on soil surfaces, clay content, and soil organic matter. Below is a discussion

briefly detailing the key soil parameters affecting the various contaminants' availability to the pore-water, thus bioavailability.

Soil pH. Soil pH is often termed the master soil variable because it controls virtually all aspects of contaminant and biological processes in soil. These processes include solubility, precipitation, speciation, and sorption processes as well as microbial activity. Soil pH controls the speciation of both ionizable organic contaminants such as PCP, and metals. For metals, the net charge of the metal complexes and their precipitation/dissolution reactions are directly impacted by soil pH. For organic acids such as PCP, the fraction of contaminant existing as an anion increases with increasing pH. The anion has a lower affinity for the soil relative to the neutral species. Increasing soil pH also results in an increase in the number of negatively charged soil sites with a concomitant decrease in the positively charged sites. Therefore, increasing the soil pH directly impacts the sorption and removal from the pore-water of metal or organic ions (Bohn et al., 1985). The impact of pH on the behavior and bioavailability of nonionic organic contaminants is less marked and is generally achieved through its influence on organic matter and on microbial activity.

Cation and Anion Exchange Capacities. The available charges on soil surfaces are quantified in the soil parameters known as cation exchange capacity (CEC) and anion exchange capacity (AEC). CEC is a measure of the soil's ability to adsorb and release cations, which is directly proportional to the number of available, negatively charged sites. Likewise, AEC is a measure of the soil's ability to adsorb and release anions. As a result, the AEC is a measure of available positively-charged surface sites. CEC is directly related to the clay mineral content and type, organic matter and soil pH. CEC is greater for 2:1 clays such as montmorillonite (600 to 1,000 millimole (mmol)/kg) compared to 1:1 clays such as kaolinite (20 to 160 mmol/kg). CEC in organic matter ranges from 2,000 to 4,000 mmol/kg; however, the organic matter fraction of a soil is usually much less than the clay fraction. CEC arising from pH-dependent charge, which includes organic matter contributions to CEC, increases with increasing pH. CEC in soil ranges from values as low as 10 millimole (mmol) per kg for extremely coarse-textured soil to as much as 600 mmol/kg for fine textured soil, containing large amounts of 2:1 clays and organic matter (Bohn et al., 1985). AEC, which is primarily associated with amorphous oxides, decreases with increasing soil pH. As previously mentioned, the number of positively charged sites (i.e., AEC) on the majority of soil types is very small, and in environmentally-relevant pH ranges, is usually negligible. Therefore, AEC is not generally considered an important parameter in assessing contaminant availability at most sites in the United States.

Clay Minerals. Clays, by definition, are soil particles less than 2 microns in size (Miller and Gardiner, 1998); therefore, high clay soils have higher surface areas relative to sandy soils (sand particle size ranges from: 20 microns to 2 millimeters (mm)). For nonionic organic contaminants, the primary sorption domain is organic matter; however, soils with high surface area will result in enhanced sorption of organic contaminants through weak physical interactions, as well. Much of the CEC of a soil comes from the negatively charges sites on clay surfaces. Therefore, high clay soils will have a higher affinity to sorb cationic species whether organic or

inorganic due to CEC, and to sorb nonionic organic contaminants due to high surface areas, thus making contaminants less bioavailable relative to sandy soils. In addition to charged sites available in clays, siloxane oxygens present in clays can interact specifically with contaminants such as the nitro-substituted explosives. Metals can form precipitates with inorganic soil constituents, such as carbonate and phosphate minerals under certain soil conditions. Carbonate- and phosphate-metal complexes have varying degrees of solubility and reactivity depending on the metal, its oxidation state, the ligand to which it is bound, and pH. Precipitation removes a contaminant from the pore-water, thus decreasing bioavailability.

Organic Matter (Organic Carbon) Content. Organic matter includes plant and animal remains in various stages of decomposition (e.g., cells and tissues, of soil organisms and substances from plant roots and soil microbes) (Sumner, 2000). Organic matter is primarily composed of carbon, oxygen, and nitrogen. Organic matter is often reported or analytically determined on a carbon basis. On average, approximately 58% of organic matter is organic carbon. Soils encompass a range in organic matter from <1% for a sandy soil to almost 100% for a peat soil, with most soils having organic matter contents <10% (Bohn et al., 1985). Also, organic matter content is usually higher in surface soils or in the root zone and decreases with depth in the soil profile.

Organic matter has a high affinity to bind organic compounds as well as some metals in soils thereby, reducing their availability. Organic contaminants preferentially partition to organic matter relative to the polar aqueous phase, while the organic acid functional groups typically present in organic matter have a high affinity to attract metal cations. For nonpolar or neutral organic contaminants at equilibrium, sorption is positively correlated to the amount of organic matter, usually reported as the fraction of organic carbon (f_{oc}), and inversely proportional to aqueous solubility. Sorption of organic contaminants increases with increasing amounts of soil organic matter. The greater the hydrophobicity or lipophilicity of an organic contaminant, the greater potential it has to be sorbed onto organic matter. The latter has led to the use of K_{oc} for estimating contaminant sorption with the soil-specific distribution coefficient estimated by K_{oc} multiplied by f_{oc}. Another indirect effect of soil organic matter is its role on limiting contaminant mass-transfer. The rate of mass-transfer of an organic contaminant from soil particles to the surrounding pore-water is inversely proportional to the contaminant's soil-water distribution coefficient (Pignatello, 2000). Therefore, with increasing organic matter content, retention of an organic contaminant increases and rates of release decrease, thereby, decreasing overall contaminant bioavailability.

Other Factors

Background. Background refers to constituents or locations that are not influenced by the releases from a site, and is usually described as naturally occurring or anthropogenic background (US EPA, 2002). Background contaminant concentrations can vary due to soil type, depth, and region of the country. Due to this variation, background metal levels in soils are addressed on a

site-specific basis in the baseline ERA. As part of the development of Eco-SSLs, background metal concentrations from the literature were compiled to provide a general comparison of the screening levels with current available information. Background metal concentrations were reviewed and compiled in Attachment 1-4. For reference, background levels by state are provided in Table 2.3. In the contaminant specific Eco-SSL documents, the Eco-SSL values are compared to a summary box-and-whisker chart depicting background concentrations in eastern and western United States soils. A discussion on the quality of available toxicity data and the reasonableness of the Eco-SSL values when compared to background concentrations is presented. Background data is site-specific and should be derived for each site investigated.

Aging. The issue of adsorption, complexation, lability of contaminants in soils, and the corresponding reduction in toxicity over time is an important issue in understanding the fate of contaminants in soils. In the evaluation of the available toxicological literature for plants and soil biota, few studies incorporated a step to age or weather spiked contaminants in soils. The use of contaminated soils from the field in laboratory tests is a viable option; however, due to the common presence of mixtures and the specific soil chemistry parameters, the use of field contaminated soils is primarily useful only for site-specific studies. While no standard setting organization has established methods for aging contaminants in soils, an aging step has been added by some investigators in plant and soil invertebrate test methods that involves several cycles of wetting and drying of a freshly spiked soil (Kuperman et al., 2002 and Phillips et al., 2002).

2.3 Using Soil Properties to Guide Eco-SSL Derivation

In identifying a set of soil parameters for use in selecting studies for deriving Eco-SSLs for plants and soil invertebrates, four soil parameters were selected: soil pH, CEC, clay content, and organic matter. However, when the plant and soil invertebrate task group evaluated the current literature, they observed that CEC and clay content were not routinely reported. Thus, these parameters were not used and the matrices were constructed using only pH and organic matter content as the primary soil parameters affecting bio-availability and toxicity. For these soil parameters, ranges were within that typically found in soils. Tests that used soils with characteristics that fell outside the selected ranges were not considered. Although other soil factors can be significant, combinations of these two soil parameters are sufficient for use in this screening process as a qualitative guide to address how most soils across the United States may influence bioavailability of contaminants. Qualitative rankings of high, medium, and low bioavailability were used to categorize each combination of the soil parameters and their ranges. Information on bioavailability was used to help select and score studies to include in the derivation of the Eco-SSL values. Greater weight was given to those studies that had higher bioavailability. Using the selected soil parameters and defining ranges that correspond qualitatively to the soil's affinity for the contaminant and thus for bioavailability, Tables 2.4a and 2.4b, 2.5, and 2.6 are provided for metal cations, nonionic organics, and anionic species, respectively. For each of the soil parameters, the values typically found in soils were divided into three ranges. For example, most environmentally relevant scenarios fall between pH values

Table 2.3. Mean Reported Soil Metal Background Concentrations (mg/kg dry weight) by State*																	
	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Chromium	Cobalt	Copper	Iron	Manganese	Nickel	Lead	Selenium	Silver	Vanadium	Zinc
Alabama	23100	3.6	4.7	200	0.6		30.6	4.4	9.6	11950	420	11	9.3	0.3		38	26
Arkansas	33429	1.2	9.7	336	0.9		53.1	12	17	19857	731	18	21	0.7		52	39
Arizona	32933	1.4	9.6	364	1.0	0.4	37.3	9.9	23	20787	447	23	16	0.4	0.5	42	51
California	75633	0.8	5.1	598	1.1	0.4	119.9	14	39	36867	640	48	26	0.2	0.8	118	113
Colorado	61557	1.1	6.7	662	1.4		41.7	6.8	21	23048	343	13	31	0.4		74	87
Connecticut	85000		4.1	400	0.5		40.0	7.5	15	17500	450	13	5.0	0.8		60	40
Delaware	22500	1.0	1.4	400	0.5		30.0	3.3	5.0	7500	85	6.0	15	0.3		20	23
Florida	9944	0.9	3.0	48	0.6	0.1	15.4	1.6	5.6	3705	86	8.5	12	0.3	0.5	11	12
Georgia	38250	1.0	5.0	232	0.6		32.4	6.9	21	16976	252	17	19	0.4		43	47
Iowa	64667	1.0	7.3	617	1.3		64.7	11	31	23278	603	26	19	0.4		97	57
Idaho	58500	1.0	6.4	757	1.1		52.1	12	28	32000	580	22	22	0.3		90	83
Illinois	48714	1.1	7.1	551	0.7		48.4	9.8	24	19159	646	19	39	0.5		62	67
Indiana	50000	1.0	7.5	500	0.7		46.8	10	27	21364	518	18	18	0.4		74	56
Kansas	61818	1.1	6.8	694	1.0		49.0	8.9	25	18788	452	17	32	0.4		77	67
Kentucky	54123	1.0	7.8	349	1.1		79.8	11	17	30432	483	23	16	0.5		66	35
Louisiana	42188	1.0	7.6	441	0.6		60.8	8.6	33	19688	470	33	16	0.7		76	55
Massachusetts	34083	1.0	8.6	203	1.3	0.2	39.5	7.8	16	19000	439	13	13	1.9		87	54
Maryland	39167	1.2	3.8	393	1.3		47.9	7.5	20	28571	291	13	22	0.2		63	39
Maine	65385	1.0	9.4	319	1.6		71.2	10	28	45385	581	30	19	0.7		98	80
Michigan	10964	1.3	4.2	127	0.7	0.9	13.8	4.6	12	10520	230	12	9.2	0.3	0.5	44	33
Minnesota	49457	1.0	5.5	571	0.7	0.3	25.4	7.2	20	19581	583	14	9.9	0.3		72	38
Missouri	42094	1.0	10	499	1.0		50.0	12	19	24733	940	20	23	0.5		72	53
Mississippi	45368	1.0	8.8	390	0.9		53.2	12	20	19684	471	21	18	0.5		68	45
Montana	70938	1.1	8.8	739	1.1		63.3	7.5	29	27766	366	20	14	0.4		101	69
Nebraska	59474	1.0	5.5	711	1.1		32.5	5.9	15	16000	306	15	16	0.4		62	54
North Carolina	60105	1.0	4.8	356	0.6		64.8	15	34	37053	563	24	17	0.4		107	56
North Dakota	62857	1.0	7.0	682	0.9		53.2	6.9	23	25357	530	20	13	0.4		83	64
New Hampshire	66667		4.4	500	2.3	0.6	18.4	5.3	12	33333	633	10	28	0.3		57	23
New Jersey	10075	1.4	7.0	54	0.3	0.3	13.9	1.7	14	11632	221	3.8	35	0.9		30	22
New Mexico	54423	1.0	5.9	727	1.0		55.5	8.8	21	20898	367	28	18	0.3		72	44
Nevada	66078	1.0	9.0	822	1.3		36.8	8.4	25	22725	481	15	25	0.3		78	69
New York	58800	1.0	6.4	666	1.4	0.2	66.9	9.1	36	38900	418	21	20	0.3		132	82
Ohio	54615		12	469	1.0		55.0	13	28	27308	550	25	23	0.6		88	69
Oklahoma	39200	1.0	7.0	430	1.1		46.0	7.1	16	19320	465	15	18	0.3		50	50
Oregon	94412	1.2	5.1	682	0.9		121.6	16	53	50147	725	23	15	0.3		168	70
Pennsylvania	63438	1.0	13	366	1.4		52.8	15	37	36063	609	24	23	0.5		80	81
Rhode Island	100000		3.5	500	0.5		50.0	10	15	30000	500	15	15	0.9		70	30
South Carolina	39143		3.9	151	1.4		21.4	3.5	16	12500	87.1	7.8	5.0	0.3		45	25
South Dakota	74333	1.3	8.5	1043	1.4		58.7	7.7	29	25667	1013	28	16	0.5		108	75
Tennessee	31894	0.7	16	193	0.8	0.2	40.3	14	17	28479	1112	18	23	0.6	1.2	49	57
Texas	41958	1.1	6.4	404	0.9		39.6	5.3	15	16328	303	12	14	0.3		52	39
Utah	45638	1.1	8.0	493	0.9		45.6	6.6	26	18830	371	13	35	0.3		70	96
Virginia	60438	1.2	5.1	436	0.9		54.3	9.7	33	27750	441	17	36	0.4		77	233
Vermont	56667		3.6	333	1.7		66.7	12	18	30000	800	25	20	0.4		70	43
Washington	66834	1.0	4.5	606	0.9	0.8	49.9	18	31	42635	760	23	14	0.3	0.7	160	78
Wisconsin	48000	1.0	4.4	543	2.0		40.3	7.7	12	15667	365	14	12	0.3		48	44
West Virginia	67000	1.3	8.6	360	1.0		46.0	14	22	28500	770	23	17	0.5		65	60
Wyoming	56125	1.1	6.5	756	0.7		47.9	8.3	21	25250	416	16	17	0.5		84	57

* Summary of background soil concentration data provided as Attachment 1-4.

of 4.0 and 8.5. This pH range was divided into the following sub-ranges: 4.0 to 5.5, 5.5 to 7.0, and 7.0 to 8.5. Qualitative bioavailability indices of very high, high, medium, low, and very low were assigned for each combination of soil parameters within each class of the contaminants (Tables 2.4a, 2.4b, 2.5, and 2.6). For example, a soil with a pH between 5.5 to 7.0, and organic matter content between 2 and 6%, would bind metal cations to a moderate extent. Therefore, a bioavailability index of 'medium' for metal cations was assigned (see Table 2.4a and 2.4b).

These tables simplified and facilitated the use of soil chemistry information in the derivation of Eco-SSLs for plants and soil invertebrates. The ranges given in these tables were used in selecting the most appropriate plant and soil invertebrates toxicity data for deriving Eco-SSLs (Chapter 3).

Table 2.4a.
Qualitative Bioavailability of Metal Cations in Natural Soils to Plants

Soil Type	Soil pH		
	Low Organic Matter (< 2%)	Medium Organic Matter (2 to < 6%)	High Organic Matter (6 to 10%)
4 ≤ Soil pH ≤ 5.5	Very High	High	Medium
5.5 < Soil pH < 7	High	Medium	Low
7 ≤ Soil pH ≤ 8.5	Medium	Low	Very Low

Table 2.4b.
Qualitative Bioavailability of Metal Cations in Natural Soils to Soil Invertebrates

Soil Type	Soil pH		
	Low Organic Matter (< 2%)	Medium Organic Matter (2 to <6%)	High Organic Matter (6 to 10%)
4 ≤ Soil pH ≤5.5	Very High	High	Medium
5.5 < Soil pH < 7	High	Medium	Low
7 ≤ Soil pH ≤ 8.5	Medium	Medium	Very Low

Table 2.5 Qualitative Bioavailability of Non-Ionizing Organic Contaminants in Natural Soils				
Soil Type	**Log K_{ow}**	**Organic Matter (%)**		
		< 2	**2 to <6**	**6 to 10**
4 ≤ Soil pH ≤5.5	Log K_{ow} > 3.5	High	Medium	Low
	Log K_{ow} < 3.5	Very High	High	Medium
5.5 < Soil pH < 7	Log K_{ow} > 3.5	Medium	Low	Low
	Log K_{ow} < 3.5	High	Medium	Low
7 ≤ Soil pH ≤ 8 .5	Log K_{ow} > 3.5	Low	Low	Low
	Log K_{ow} < 3.5	Medium	Low	Low

Table 2.6 Qualitative Bioavailability of Metal Anions in Natural Soils			
Soil Type	**Soil pH**		
	Low Organic Matter (< 2%)	**Medium Organic Matter (2 to <6%)**	**High Organic Matter (6 to 10%)**
4 ≤ Soil pH ≤5.5	Medium	Low	Very Low
5.5 < Soil pH < 7	High	Medium	Low
7 ≤ Soil pH ≤ 8.5	Very High	High	Medium

3.0 DERIVATION OF PLANT AND SOIL INVERTEBRATE ECO-SSLs

Eco-SSLs for plants and soil invertebrates were derived using a four-step process. These procedures built upon previous efforts (CCME, 1997; Efroymson *et al.*, 1997 a,b), and established a process for evaluating published studies and selecting relevant data from the literature. The process (Figure 3.1) was guided by a set of standard operating procedures (SOPs) that specified the steps for identifying and evaluating data for appropriateness in deriving an Eco-SSL as well as the actual calculation of the screening values (Attachments 3-1 and 3-2). The process was intended to ensure that the Eco-SSLs for plants and soil invertebrates were based on sound science. The process required data from ecotoxicity studies that met prescribed requisites including but not limited to a thorough experimental design, appropriate quality control, and specific soil boundary conditions.

When appropriate and sufficient data were available for a specific contaminant, Eco-SSLs for plants and soil invertebrates generally could be derived using the prescribed process. Alternatively, if sufficient data does not exist, then toxicity testing could be completed under the preferred Eco-SSL experimental conditions (refer to Section 3.5) to generate the data needed to derive an Eco-SSL for the contaminant of interest.

Eco-SSLs for plants and soil invertebrates were derived using data from tests performed within soil boundary conditions favoring relatively high bioavailability for upland aerobic soils (refer to Tables 2.4 - 2.6 of Chapter 2). The soil chemistry conditions of relatively high bioavailability were defined by low soil pH and organic matter. These parameters were frequently found to be the predominant factors affecting contaminant bioavailability to plants and soil invertebrates in aerobic soils. Extreme pH values (< 4 and > 8.5) will substantially affect the solubility, precipitation, speciation, and sorption processes of contaminants, and therefore were not appropriate for use in Eco-SSL derivation. Similarly, organic matter, composed primarily of carbon, oxygen, and nitrogen, at elevated levels in the soils (i e. >10%) has a high affinity to bind organic compounds as well as some metals, thereby reducing their bioavailability.

Figure 3.1 The Four-Step Process for Deriving Eco-SSLs for Plants and Soil Invertebrates

Step 1. Literature search, acquisition, and screening (Attachment 3-1). Apply 22 Literature Exclusion Criteria.

Step 2. Identify acceptable literature by applying eleven Study Acceptance Criteria to retrieved papers (Attachment 3-1).

Step 3. Extract and score data from acceptable literature according to nine Study Evaluation Criteria (Attachment 3-2).

Step 4. Derive soil invertebrate and plant Eco-SSLs according to specified procedures (Attachment 3-2).

- Sort study data by bioavailability score
- Complete QA review
- Calculate value

3.1 Literature Search, Acquisition, and Screening

The first step in the process of developing Eco-SSLs for plants and soil invertebrates was to identify, retrieve, and screen published papers that reported data for soil toxicity to terrestrial plants or soil invertebrates. The procedures used to complete the literature search, retrieval and review are provided as Attachment 3-1.

The literature search included both paper-based searches and searches of computerized abstracting databases. The paper-based literature search process consisted primarily of the manual review of bibliographies, guidance documents, and review articles. This manual search was not limited by publication year. Searches of computerized abstracting databases included the use of DIALOG, SilverPlatter and Ovid commercial database vendors. Within DIALOG, the targeted databases included AGRICOLA, BIOSIS and ChemAbstracts. The searches were supplemented with other electronic databases including Toxline, PolTox1, Toxnet, and Current Contents. Searches of computerized abstracting databases were limited to papers published after 1988, except in cases when fewer than 20 publications were identified for a contaminant- receptor pairing (e.g., cadmium- plants). In these cases, the electronic search was expanded to include all publication years in the databases. It was assumed that relevant studies prior to 1988 would be identified in the bibliographies of review articles. A list of 22 Literature Exclusion Criteria (see Figure 3.2) was then used to screen out those studies not appropriate for use in deriving Eco-SSLs. These Literature Exclusion Criteria were applied to retrieved abstracts, or to the entire publication if the needed information was not available in the abstract.

Figure 3.2 Literature Exclusion Criteria

Biological Product	Biological toxins (venoms, etc.)
Chemical Methods	Methods for measuring contaminants
Drug	Testing for drug effects
Effluent	Effluent, sewage, polluted run-off
Contaminant Fate	Fate and transport of substance in the environment (only)
Human Health	Human or primate subjects
In Vitro	In vitro studies, including cell cultures and excised tissues
Methods	Methods reported but no usable specific toxicity test results
Mixture	Combinations of chemicals in laboratory testing
Modeling	Only modeling results reported
No Conc	No dose or concentration reported, or not able to calculate from information given
No Duration	No exposure duration reported
No Effect	No effect reported for a biological test species
No Species	No viable plant or animal present or tested
No Toxicant	No toxicant used
No Tox Data	Toxicant used, but no results reported that had a negative impact
Nutrient	Nutrition studies reporting no concentration-related negative impact
Oil	Oil and petroleum products
Publ As	Author states information is published in another source
QSAR	Data developed only from quantitative-structure activity relationships
Review	Data reported are not primary data
Survey	Assessment of toxicity in the field over a period of time

QSAR = Quantitative Structure Activity Relationship

For the 24 contaminants listed in the Chapter 1, EPA completed the literature searches according to the SOP (Attachment 3-1). The searches identified more than 7,600 papers. These publication abstracts and titles were screened to determine if they were likely to meet the Eco-SSL requirements using the 22 Literature Exclusion Criteria. This process resulted in the acquisition of more than 5,200 papers.

Figure 3.3 Eleven Study Acceptance Criteria

1. The document is the primary source of the test result.
2. Adverse effects are caused by an identified chemical stressor (i.e., no mixture testing in laboratory studies).
3. The chemical form (e.g., metal salt used) and concentration are reported by the author(s).
4. The test medium used in the study is a natural or artificial soil.
5. The study reports the organic matter content and it is ≤ 10 % of the composition of the soil; or equivalent concentration reported on the basis of organic carbon.
6. Except for studies on non-ionizing substances (e.g., PCP), the study reports the pH of the soil, and the soil pH is within the range 4.0 ≤ soil pH ≤ 8.5.
7. The study includes at least one control treatment.
8. The duration of the exposure is reported, or a standard study method with a defined duration is used.
9. For studies conducted in a laboratory setting, at least three treatment levels are used (i.e., control plus two chemical exposures).
10. Biological effects are reported for ecologically relevant endpoints (ERE).
11. Either the test species' scientific name, common name, variety, or strain is reported.

3.2 Identification of Potentially-Acceptable Literature

The second step of the process identified which publications acquired through Step 1 included at least the minimum information necessary for deriving an Eco-SSL. Eleven Study Acceptance Criteria (see Figure 3.3) were applied to each of the acquired publications. Publications that meet all 11 Study Acceptance Criteria were further evaluated in Step 3. Detailed descriptions of the Study Acceptance Criteria are presented in Attachment 3.1. Approximately seven percent of the plant and soil invertebrate publications reviewed by EPA (identified during Step 1) met all 11 Study Acceptance Criteria.

3.3 Extraction of Data and Scoring Studies

In Step 3, each of the publications that met all 11 Study Acceptance Criteria were reviewed and study data extracted and scored. If a publication contained more than one study, each study was evaluated and scored separately. For each study reviewed, a set of critical notes were recorded in a spreadsheet. A separate "study" was defined if any of the following parameters varied: test species (not strain), contaminant (not form), soil (natural vs. artificial), pH or percent organic matter (% OM) content. The specific procedures used to extract and record study data are provided as Attachment 3-2.

Ecologically Relevant Endpoints

For each of the studies reviewed, the measures of toxic effects to either plants or soil invertebrates were grouped into one of four ecologically relevant endpoints (EREs) (see Table 3.1). If a study reported toxic effects for multiple EREs, only the preferred ERE and corresponding contaminant concentration were recorded in the critical notes. For soil invertebrates, the preferred ERE followed the order: reproduction > population > growth. For soil invertebrates, reproduction was the preferred ERE because it is necessary for sustaining populations, and reproductive endpoints are good indicators of longer term (i.e., chronic) exposure. Although population endpoints were considered less robust than reproductive endpoints, they were next in preference because screening ecological risk assessments focus on protection at the population level. Growth measurements on individuals were the traditional measurement endpoints, and are frequently extrapolated to represent impact at the population level.

For plants, the preferred ERE was biomass production as it is normally the most sensitive measurement. If no measurement of biomass production was reported, some physiological endpoints were accepted as there were established linkages between certain measures of photosynthesis and productivity (refer to Table 3.1).

Table 3.1 Ecologically Relevant Endpoints (EREs) for Soil Invertebrate Eco-SSLs

Ecologically Relevant Endpoint	Definition
Reproduction	Measures of the effect of toxicants on offspring production. Examples of EREs associated with reproduction included changes in fecundity, number of progeny produced (eggs, cocoons, etc.), rate of reproduction (hatching rates, etc.), rate of maturation, sexual development, change in sex expression, and sterility number or proportion of abnormal progeny.
Population	Measurements and endpoints regarding a group of soil invertebrates of the same species occupying the same area at a given time. Measurement included population dynamics. Examples of EREs associated with population included changes in size and age class structures, changes in sex ratio, intrinsic population growth rate, survivability of subsequent generations, diversity, evenness, index to population size (count, number, abundance), life table data, population density (number/area).
Growth	Broad category which encompassed measures of weight/mass and length. EREs associated with growth and development included responses such as a change in body weight.

Table 3.2 Ecologically Relevant Endpoints (EREs) for Plant Eco-SSLs	
Ecologically Relevant Endpoint	**Definition**
Growth (Biomass)	Measurement of plant products including standing crop biomass, seedling emergence, shoot length/growth, root elongation/growth, fresh or dry mass, yield or production (e.g., seed production).
Physiology	For the purposes of developing Eco-SSLs, plant studies reporting EREs associated with physiological responses were used. Physiological endpoints for plants included net photosynthesis (CO_2 uptake, oxygen release), decrease in chlorophyll content or chlorophyll fluorescence, increased deformation, membrane damage, desiccation/decrease in water content, detrimental changes in dormancy measures, decreased flowering, and increased senescence.

Toxicity Parameters

For each study, a toxicity parameter was recorded. The toxicity parameter was the concentration-response measurement associating the adverse effect with the contaminant exposure. Toxicity parameters considered acceptable for deriving Eco-SSLs were the EC_{20} (effective concentration that affects 20% of the test population), the MATC and the EC_{10} (effective concentration that affects 10% of the test population). The MATC was equal to the geometric mean of the NOAEC and the LOAEC. Some toxicity data were not used to derive Eco-SSLs including acute toxicity data such as the concentration lethal to 50% of the test population (LC_{50}) or the effective concentrations affecting more than 50% of the test population (EC_{50}). Effect concentrations affecting less than 5% of the test population (EC_x <5) were also not considered acceptable for deriving Eco-SSLs. The LC_{50} and EC_{50} values were not considered sufficiently protective of ecological resources, while EC_5 values have low levels of confidence due to natural variability.

When NOAEC and LOAEC values were reported, these data were used to calculate an MATC. A bounded value was a study result with both a NOAEC and LOAEC reported (other than control). Unbounded NOAEC or LOAEC values do not describe a dose-response curve and thus were not used due to the high uncertainty over where the real threshold of toxicity lies. If a study reported multiple toxicity parameters, a single preferred toxicity parameter was selected. Selection of the preferred toxicity parameter followed the order:

$$\mathbf{EC_{20} > MATC > EC_{10}}$$

If a study reported more than one adverse effect concentration with the "preferred" ERE and toxicity parameter, the lowest effect concentration was then selected. If a publication did not report an EC_{20}, MATC or EC_{10}, but sufficient data were provided, the reviewer calculated and recorded the toxicity value under the appropriate toxicity parameter. Toxicity data were reported as mg/kg of the chemical on the critical notes form (Attachment 3-2). Data not reported in these units were converted to mg/kg or converted from formulation to active ingredient. When metal

concentrations were reported, these were converted to an elemental basis. The only data extracted were for results where an adverse effect was significantly different from the control.

Scoring Each Study

Each study was scored according to nine specific Study Evaluation Criteria (Table 3.3) and the results documented in the critical notes. If a single publication contained data for multiple studies (e.g., reports toxicity data for more than one species or soil type, etc.), each study within the publication was scored separately. The information recorded for each study included test species, soil characteristics (e.g., pH, %OM), relative bioavailability score, the ERE, toxicity parameter, and toxicity value (Attachment 3.2). The specific procedures used to score studies and document the results are provided as Attachment 3-2.

Scoring for each Study Evaluation Criterion used a three-point scale (i.e., 0, 1, or 2). The maximum score for a study was 18. Studies were deemed inappropriate for deriving Eco-SSLs for plants and soil invertebrates if they did not score above ten. Studies with an evaluation score of 10 or less were presumed to lack sufficient detail about the study to enable reviewers to assess the quality of the data. These studies results were not included in the pool of data considered for deriving the Eco-SSL values.

3.4 Derivation of Eco-SSLs

Sorting Data by Bioavailability Score

The first step in deriving an Eco-SSL was to sort the studies accepted at Step 3 (receiving a Study Evaluation Score greater than ten out of 18 possible points) by their bioavailability score. The bioavailability score was determined as part of the scoring process in Step 3 (Table 3.3). This score was based on the soil matrix tables presented in Chapter 2 (Tables 2.4 to 2.6), the type of soil (natural versus artificial), pH and OM content. A score of two was applied to natural soils with relatively high or very high bioavailability, a score of one was applied to natural soil with medium bioavailability and to standard artificial soil, and a score of zero was applied for natural soil with low or very low relative bioavailability.

Quality Control Review

A quality assurance review of the sorted data was preformed by a panel of experts. The reviewers verified that all studies used to derive the Eco-SSLs were correctly evaluated and scored. All studies were reviewed by at least two individuals (other than the original reviewer). The quality control review provided a forum for confirming that the appropriate data were identified and documented, resolving any comments or concerns, and ensuring consensus on data selection. For example, in cases where a study reported data for multiple test species and for several endpoints, the quality control review provided a forum to reach a consensus that the most

Table 3.3 Summary of Nine Study Evaluation Criteria for Plant and Soil Invertebrate Eco-SSLs		
Criteria Title	**Rationale**	**Scoring**
#1: Testing was Done Under Conditions of High Bioavailability	Bioavailability of metals and polar organic compounds is influenced by pH and soil organic matter, cationic exchange capacity, and clay content. The scoring is intended to favor relatively high bioavailability.	Scores were based on the bioavailability matrix (see Chapter 2). Scored 2 if bioavailability of natural soil was high or very high. Scored 1 for natural soil with medium bioavailability or standard artificial soil. Scored 0 for natural soil with low and very low bioavailability.
#2A (laboratory) and **#2B** (field): Experimental Designs for Studies are Documented and Appropriate	Experimental design can significantly influence the quality of a study. Higher quality studies will use an experimental design sufficiently robust to allow analysis of the test variables and discriminate non-treatment effects.	Scored based on experimental design and methods used for statistical analyses. Scored 2, 1 or 0. Specific criteria used provided in Attachment 3-2.
#3: Concentration of Test Substance in Soil is Reported	The concentration of the contaminant tested must be reported unambiguously.	Scored 2 if measured concentrations were reported. Scored 1 for nominal concentrations and scored 0 in all other cases.
#4: Control Responses are Acceptable	Negative controls are critical to distinguish treatment effects from non-treatment effects.	Scored 2 if a standardized procedure were used and control values were within procedural guidelines or acceptable range (if non-standard procedure used). Scored 1 if results of control were not reported or were ambiguous. Score d0 if control results were not within an acceptable range.
#5: Chronic or Life Cycle Test was Used	Chronic toxicity tests assessing long-term adverse sub-lethal impacts on the life-cycle phases of an organism are considered superior to acute toxicity tests.	Scored 2 if chronic exposures were used. Scored 1 if acute tests were used. Scored 0 if very short term exposures were used.
#6: Contaminant Dosing Procedure is Reported and Appropriate for Contaminant and Test	Contaminant dosing procedure may affect the outcome of a test. Dosing procedure should include: (A) the form of the contaminant; (B) the carrier or vehicle (e.g., solvent, water, etc.); (C) how the carrier was dealt with following dosing (i.e., allowed to volatilize, controls, etc.); (D) procedure for mixing of soil with contaminant (homogeneity).	Score applied based on how well the study reports the four contaminant dosing procedures (A to D). Scored 2 if study reported all. Scored 1 if information for items A and B, but not C or D; Scored 0 if details were not provided and could not be inferred.
#7: A Dose-Response Relationship is Reported or can be Established from Reported Data	Two methodologies can be used to identify this benchmark concentration. The first method generates a no observed adverse effect concentration (NOAEC) and a lowest observed adverse effect concentration (LOAEC). The second method uses a statistical model to calculate a dose response curve and estimate an effect concentration for some percentage of the population (EC_x), usually between an EC_5 and an EC_{50}.	Scored 2 if an EC_{10}- EC_{20}; or a NOEC and LOEC were within a factor of 3. Scored 1 if the difference between the NOEC and LOEC was > 3x but < 10x. Scored 0 if an EC_x was not reported or the difference between the NOEC and LOEC was > 10, or only a NOEC or LOEC was reported.
#8: The Statistical Tests used to Calculate the Benchmark and the Level of Significance were Described	Statistical tests and results reported in the study should be sufficient to determine the significance of the results.	Scored 2 if ANOVA or statistical method were based on a P = 0.05; or the 95% CI of the EC_x. Scored 1 if an ANOVA was completed but P level not provided or > 0.05; or if EC data did not include the 95% CI or used a 90% CI. Scored 0 if a NOEC, LOEC, or EC/LC_x were not reported, or were reported without a description of the method used to calculate the values.
#9: The Origin of the Test Organisms is Described	The results of a toxicity test can be influenced by the condition of the test organisms. Culture conditions should be maintained such that the organisms are healthy and have had no exposure above background to contamination prior to testing (inverts) or detailed information is provided about the seed stock (plants).	Scored 2 if the source and condition of the test organisms were known and described. Scored 1 for a non-commercial source not adequately described, or if insufficient information was provided about a commercial source. Scored 0 if organisms were from a known contaminated site, or insufficient information was provided on the a commercial source.

appropriate data were used to derive the Eco-SSL. The quality assurance review consisted of verifying the following information:

- Adherence to all eleven Study Acceptance Criteria
- Accuracy of study evaluation scores
- Accuracy of soil pH, OM, and relative bioavailability score for each study
- Selection of preferred EREs, toxicity parameter(s), and toxicity results
- Units of the toxicity result (wet weight/dry weight, contaminant form)

Calculation of the Eco-SSL Values

The Eco-SSL was calculated as the geometric mean of all the toxicity values at the highest relative bioavailability score for which sufficient data existed (i.e., ≥ three data points). If less than three data values were available at the highest relative bioavailability level, data from the next highest bioavailability level were included in that Eco-SSL data set. This process proceeded until a combined data set of three or more data values were identified for calculating the Eco-SSL. For example, if there were only two toxicity values from studies using soils with relatively high bioavailability (i.e., score = two), but there were data from four medium bioavailability studies (i.e., score = one), then an Eco-SSL was calculated using the combined six data values. If there were less than three acceptable studies (score > ten) an Eco-SSL was not calculated.

3.5 Soil Toxicity Test Methods

If sufficient data for deriving an Eco-SSL were not available from the published literature, additional plant or soil invertebrate data could be generated through completion of appropriately designed soil toxicity studies. The Agency recommends that such studies be designed with consideration of the nine Study Evaluation Criteria (Table 3.3) to generate the highest quality data to derive an Eco-SSL. For example, the ideal studies would be conducted using natural soils within the specified soil chemistry conditions, have the highest relative bioavailability (i.e., score = two), and satisfy the other evaluation criteria.

Several standardized soil test procedures are available that can be used to generate the data for deriving Eco-SSLs. Alternative test methods or designs could also be used if they use the appropriate EREs. Whether standardized or other methods are used, experimental design options should be selected that best fit the Study Evaluation Criteria outlined in Table 3.3. To obtain data that best represent natural conditions, investigators are encouraged to incorporate aging/weathering of contaminated soil into their study design. Examples of standard procedures that may be used are described in the following subsections and are listed in Table 3.4.

Soil Invertebrate Toxicity Testing

Several internationally standardized soil invertebrate toxicity tests may be used to generate data for Eco-SSLs. Specifically, three soil toxicity tests are identified as generally appropriate: 1) a 21-day chronic earthworm reproduction (cocoon production) toxicity test (ISO/11268-2:1998),

2) the enchytraeid reproduction test (ISO/16387:2001), and 3) the collembolan reproduction test (ISO/11267:1998) (Table 3.4). These specific tests are recommended as they measure contaminant toxicity during chronic assays, and include at least one reproductive component among the measurement endpoints. Guidelines for these methods have been approved by the International Standards Organization (ISO), and similar efforts are in the final stages of review or approval by one of several national and international organizations (e.g., the Organization for Economic Cooperation and Development (OECD), the American Society for Testing and Materials (ASTM), the European Community, and the Federal Biology Research Cooperative (FBRC)).

Plant Toxicity Testing

There are relatively few standardized plant toxicity test procedures that EPA expects would generate data acceptable for deriving Eco-SSLs (Table 3.4). The EPA guidelines for the early seedling growth and vigor plant test may be used, as well as similar ASTM methods (e.g., ASTM E 1963-98). The use of these procedures may require a modified design to best meet the nine Study Evaluation Criteria.

Table 3.4 Standard Methods Appropriate for use in Generating Data for the Derivation of Plant or Soil Invertebrate Eco-SSLs

Species	Citation
Eisenia fetida	ISO (International Standardization Organization). 1998. Soil Quality – Effects of Pollutants on Earthworms (*Eisenia fetida*) – Part 2: Determination of Effects on Reproduction. ISO 11268-2:1998
Enchytraeus sp.	ISO (International Standardization Organization) (2001). Soil Quality – Effects of Pollutants on Enchytraeidae (*Enchytraeus sp.*) – Determinations of effects on reproduction and survival. ISO/CD 16387.
Folsomia candida	ISO (International Standardization Organization) (1999). Soil Quality – Inhibition of Reproduction of Collembola (*Folsomia candida*) by Soil. ISO 11267:1999.
Terrestrial Plants	ASTM (American Society for Testing and Materials). 2002. Standard Guide for Conducting Terrestrial Plant Toxicity Tests. Designation: E 1963-98 Annual Book of Standards. American Society for Testing and Materials. West Conshohocken, PA.
Terrestrial plants	U.S. EPA (U.S. Environmental Protection Agency). 1996. Ecological effects test guidelines. OPPTS 850.4230: Early seedling growth toxicity test. Report Number EPA 712–C–96–347. Office of Prevention, Pesticides and Toxic Substances, Washington, DC.
Terrestrial plants	U.S. EPA (U.S. Environmental Protection Agency). 1996. *Ecological effects test guidelines. OPPTS 850.4250. Vegetative vigor, Tier II.* Report Number EPA 712–C–96–364. Office of Prevention, Pesticides and Toxic Substances, Washington, DC.
Terrestrial plants	U.S. EPA (U.S. Environmental Protection Agency). 1996. *Ecological effects test guidelines. OPPTS 850.4150. Terrestrial Plant Toxicity, Tier 1: Vegetative vigor.* Report Number EPA 712–C–96–163. Office of Prevention, Pesticides and Toxic Substances, Washington, DC.

4.0 DERIVATION OF WILDLIFE ECO-SSLs

Eco-SSLs for wildlife were derived using a five-part process that included: selecting a wildlife risk model, selecting a surrogate species, estimating an exposure dose model, deriving the TRVs, and calculating the Eco-SSL. Wildlife Eco-SSLs were derived for two groups of receptors: mammals and birds. Eco-SSLs were not derived for amphibians or reptiles at this time, as described in Chapter 1.

4.1 The Wildlife Risk Model for Eco-SSLs

The basic equation that was used for estimating potential risks to wildlife was:

$$\text{Hazard Quotient (HQ)} = \frac{\text{Exposure Dose (mg / kg bw / day)}}{\text{No Effect Dose (mg / kg bw / day)}}$$

Contaminant exposure for terrestrial wildlife was expressed as an Exposure Dose in mg/kg bw/day, and the No Effect Dose was represented by a TRV for no adverse effects expressed in the same units.

Steps for Establishing a Wildlife Eco-SSL

1. **Identify the Wildlife Risk Model** - Equation relates the contaminant soil concentration to an acceptable threshold based on a food-chain exposure model.
2. **Select Surrogate Wildlife Species** - Specific indicator species were identified for parameterization of the exposure model.
3. **Estimate Exposure Dose** - Parameterization of the exposure dose model for the estimation of exposure doses for each contaminant.
4. **Derive the Effects Dose or TRV**- Identification of an acceptable dose.
5. **Calculate the Eco-SSL** - Calculation of the Eco-SSLs by solving equation for an HQ=1.

The Eco-SSL is the soil concentration that results in an HQ=1, that is, when the No Effect Dose (TRV) and the Exposure Dose are equal. The Exposure Dose for wildlife was equal to the amount of contaminant in the diet that is taken up or transferred from the soil. Therefore, it was necessary to model the contaminant specific soil concentration that would result in a dietary concentration equal to the Exposure Dose that was equal to the TRV. Estimation of the Exposure Dose is described in Section 4.3. Derivation of the Effect Dose or TRV is described in Section 4.4. Calculation of the Eco-SSLs to solve for an HQ =1 is described in Section 4.5. The full HQ equation is provided in Figure 4.1. In this model, incidental oral soil exposure was added to the total dietary (food-based) exposure, making the total oral exposure greater than 100%. This equation also included terms for the absorbed fraction of the contaminant from soil and the diet as well as an area use factor (AUF) (representing the fraction of time an animal would be exposed). For the purposes of establishing Eco-SSLs, which are conservative screening values, these terms were set equal to one.

Figure 4.1. The Wildlife Risk Model for Eco-SSLs (Equation 4-1)

$$HQ_j = \frac{\left([Soil_j * P_s * FIR * AF_{js}] + [\sum_{i=1}^{N} B_i * P_i * FIR * AF_{ij}] \right) * AUF}{TRV_j}$$

where:

HQ_j	=	Hazard quotient for contaminant (j) (unitless),
$Soil_j$	=	Contaminant concentration for contaminant (j) in soil (mg/kg dry weight),
N	=	Number of different biota types in diet,
B_i	=	Contaminant concentration in biota type (i) (mg/kg dry weight),
P_i	=	Proportion of biota type (i) in diet,
FIR	=	Food ingestion rate (kg food [dry weight]/ kg BW [wet weight] /day),
AF_{ij}	=	Absorbed fraction of contaminant (j) from biota type (i) (for screening purposes set equal to 1).
AF_{sj}	=	Absorbed fraction of contaminant (j) from soil (s) (for screening purposes set equal to 1).,
TRV_j	=	The no adverse effect dose (mg/kg BW/day) (Section 4.4),
P_s	=	Soil ingestion as proportion of diet,
AUF	=	Area use factor (for screening purposes set equal to 1).

4.2 Selection of Surrogate Wildlife Species

It was neither feasible nor necessary to derive an Eco-SSL for each and every wildlife species potentially present at a hazardous waste site; therefore, surrogate species were used to derive wildlife Eco-SSLs. In this approach, specific species were selected as "representatives" for other species within the same class (mammalian or avian) with similar diets. The advantages of focusing Eco-SSLs on representatives within generic trophic groups included, but were not limited to, the following:

- This approach provided generic screening values that could be applied to any site, regardless of the presence or absence of a particular species. The trophic groups selected were expected to be present or potentially present at all sites across the nation.

- This approach provided results that could be used to examine comparative risks associated with different exposure routes (e.g., ingestion of food versus ingestion of soil) representing different contaminant transport pathways (e.g., soil to herbivore, soil to ground insectivore, soil to soil invertebrate, and soil to plant) versus direct soil ingestion.

- This approach was consistent with ERAGS which states: "for the screening-level ERA, assessment endpoints are any adverse effects on ecological receptors, where receptors are plant and animal populations and communities, habitats, and sensitive environments." (p. 1-7; U.S. EPA, 1997)

Criteria for Selection of Surrogate Taxa

Three general trophic groups (e.g., herbivore, ground insectivore, and carnivore) for both mammals and birds were used for the Eco-SSL wildlife exposure model. Within each of these trophic groups, a specific species was identified as a "surrogate" species. Surrogate species were selected to provide a conservative representation of their respective trophic groups. Selected species were generally small in size relative to other species within their respective trophic groups (e.g., weasels and voles vs. foxes and coyotes or rabbits and deer). Because small size was considered to be associated with higher metabolic rates (Nagy et al., 1999) and smaller home ranges (McNab, 1963), exposure for small receptors was assumed to be high. Eco-SSLs based on these species were therefore likely to be protective of other, larger species in their trophic group.

Selection of specific surrogate species was necessary for parameterizing the Eco-SSL wildlife model, which required estimates of body weights, food ingestion rates, and soil ingestion rates. The following criteria were used to guide the selection of surrogate species for each trophic group:

1) **Exposure pathway link to soil.** Each surrogate species had to have a clear direct or indirect exposure pathway link to soil. Direct exposure pathways to soil included ingestion of soil dwelling biota (e.g., plants or soil invertebrates) and incidental ingestion of soil as a result of foraging at the soil surface (as opposed to from plants). Species with direct exposure pathways to soil were assumed to be the most highly exposed to soil contamination with the exception of contaminants that biomagnify. Indirect exposure included ingestion by carnivores of prey that have direct contact with soil.

2) **Diet Composition.** The selected, surrogate species must forage in terrestrial, upland habitats. This criteria ensured that only potential exposures related to soil contamination were considered and consumption of aquatic prey items (exposures to the aquatic environment) were not considered.

3) **Diet composition can be simplistically classified.** The dietary composition of each surrogate species had to be easily classified into one of the three selected trophic groups (herbivore, ground insectivore, carnivore). Clear classification of diet served to

What Wildlife Groups are not Considered Appropriate for Eco-SSLs?

Some specific wildlife groups were not considered suitable for deriving wildlife Eco-SSLs. These groups include:

- ✕ **Generalist species (e.g., raccoons, jays)** were excluded due to difficulty in defining diet and, therefore, exposure. These species forage opportunistically and are likely to consume different foods in different parts of their range.
- ✕ **Piscivores (e.g., herons, otter)** were excluded due to the lack of a direct exposure pathway to soil.
- ✕ **Aerial Insectivores (e.g., swallows) and Arboreal Insectivores (e.g., warblers)** were excluded as they do not forage primarily from terrestrial environments.

simplify the exposure assumptions related to dietary composition into three classes: plants, invertebrates and animals. Further, the dietary composition for the surrogate species needed to be realistically assumed to consist of a single food type. This assumption allowed for the evaluation of the potential maximum exposure and risk from that dietary pathway. Evaluation of the maximum risk that may be presented by a given pathway (i.e., plants, invertebrates, or vertebrates) produced results that are protective of species with more varied diets. Omnivorous species were assumed to be more likely to consume foods with differing contaminant concentrations. As a result, their total exposure would be less than that for species whose diets that consisted of the single most contaminated food type. By selecting surrogate species that foraged exclusively on a specific food type (plants, invertebrates, or vertebrates), maximum risks were expressed for any given contaminant. This helped to ensure protectiveness of all other species.

4) **Mammalian and avian species identified.** Because toxic responses for the same contaminant could differ among wildlife taxa, surrogate species were selected for both mammals and birds. Based upon the above factors, three mammalian and three avian species (listed in Table 4.1) were selected to represent some of the most highly exposed species. It was assumed that the use of these six species also protected other herbivores, ground insectivores, and carnivores.

4.3 The Exposure Dose

Estimation of the exposure dose associated with contaminant concentrations in soil required parameterization of the general model provided as Equation 4-1.

Reduced Wildlife Risk Model for Screening

The Eco-SSLs are intended to be conservative screening values that can be used to eliminate contaminants clearly not associated with unacceptable risks. Therefore, several simplifying, conservative assumptions were made in the parameterization of the general wildlife risk model (Equation 4-1). These assumptions included:

- Surrogate species were assumed to reside and forage exclusively on and within the contaminated site. Therefore, the area use factor (AUF) was set equal to 1.

- Bioavailability of the contaminant in both soil and food was assumed to be comparable to the bioavailability of the contaminant in the laboratory studies used to establish the TRVs. Therefore, the absorbed fraction from soil (AF_{sj}) and absorbed fraction from biota type i (AF_{ij}) were both equal to 1.

- The surrogate species' diet consisted of just one food type. Therefore, the proportion of biota type in the diet (P_i) was equal to 100% and the number of biota types (N) in diet was equal to 1.

Based on these assumptions, the equation in Figure 4.1 (Equation 4-1) was reduced to:

$$HQ_j = \frac{\left([Soil_j * P_s * FIR] + [\sum_{i=1}^{N} B_i * P_i * FIR] \right)}{TRV_j} \qquad \text{Equation 4-2}$$

Parameterizing the Model for Estimating the Exposure Dose

Parameterization of the model included using exposure factors related to the surrogate species (see Table 4.1) and estimating the contaminant concentrations in biota items (B_i) consumed in the diet. The exposure factors identified and derived for surrogate species-specific exposure factors are described in Attachment 4-1. The food and soil ingestion rates used in the exposure model were represented by the 90th percentiles from their respective distributions. Use of exposure parameter values from the upper tails of the distributions ensures the protectiveness of the Eco-SSLs for other wildlife species.

Table 4.1. Parameterization of the Eco-SSL Wildlife Exposure Model

Receptor Group (Surrogate Species)	Body Weight (kg) [1]	Food Ingestion Rate (kg dw/kg bw day) [2]	Soil Ingestion (P_s) [3]	Assumed Diet
Mammalian Herbivore (Meadow Vole)	0.039	0.28	0.029	100% foliage
Mammalian Ground Insectivore (Short-tailed shrew)	0.018	0.20	0.03	100% earthworms
Mammalian Carnivore (Long-tailed weasel)	0.202	0.10	0.04	100% small mammals
Avian Grainivore (Mourning dove)	0.115	0.23	0.16	100% seeds
Avian Ground Insectivore (American woodcock)	0.159	0.17	0.12	100% earthworms
Avian Carnivore (Red-tailed hawk)	1.076	0.12	0.05	100% small mammals

Parameterization details provided in Attachment 4-1.
[1] Mean value for both males and females. Derivation of mean presented in Attachment 4-1.
[2] Mean value is presented but the full distribution of body weights (not a conservatively skewed value) was used to derive the food ingestion distributions.
[3] Soil ingestion as proportion of diet.
dw = dry weight

Estimating Contaminant Concentrations in Biota (Dietary Items)

The contaminant concentrations in biota types (B_i) composing the wildlife diets were estimated by assuming that the concentration of the contaminant in the food type could be predicted from the concentration of the contaminant in the soil (C_{soil}) by using a bioaccumulation factor (BAF). The function that typically relates B_i to C_{soil} is a constant, which is referred to as the BAF:

$$B_i = BAF * C_{soil}$$

However, the concentration of the contaminant in the food item may be better described by linear or nonlinear functions that predict bioaccumulation, such as:

$B_i = a * C_{soil} + b$ (linear)
$\ln(B_i) = a * \ln(C_{soil}) + b$ (logarithmic)
$B_i = a + b * (1 - \exp(-c * C_{soil}))$ (exponential)

where a, b, and c are the parameters of the best-fit equation through the paired data (soil versus soil organism or plant). These are referred to as regression models. A hierarchy was established for decision-making concerning the use of available data to estimate contaminant concentrations in biota types (B_i). The following values were used in order of preference:

1) **Existing Regression (R).** If regression models were available and the r-square values were > 0.2, then these were preferentially used. The primary sources of existing regression models were: Sample et al. (1999) for earthworms; Sample et al. (1998a) for small mammals; and Bechtel-Jacobs (1998) for plants.

2) **New Regression (R).** If paired data (contaminant concentrations in soil organism or plant versus soil) were sufficient to establish regression models and these models were significant with r-square values > 0.2, then these regression models were developed and used.

3) **Ratio (BAF).** BAFs (or ratios of the contaminant in soil to the contaminant in the food item) were available from the scientific literature. If reported ratios were not available, then paired data (contaminant in soil versus contaminant in food item) were collected from the literature to derive these ratios.

4) **Estimating BAFs or B_i (M for modeled).** If BAFs were not available in the literature or the paired data were not available to derive the BAF, then the B_i was estimated using existing relationships that estimated B_i based on the physical or chemical parameters of the COC. Existing or new models associating contaminant parameters of the contaminant with the potential for accumulation in biota or plant tissue were used to estimate B_i. These estimation models that were evaluated and reviewed are provided in Attachment 4-1.

5) **Assumptions (A)**. In instances where data were not available to complete any of the previously listed options in the hierarchy (1 to 4) then it was necessary to make assumptions concerning the bioaccumulation of contaminants for soil into B_i. These assumptions are discussed in following subsections.

Figure 4.2 summarizes the method (based on the hierarchy) used for estimating contaminant concentrations in biota types (dietary items) for each of the Eco-SSL contaminants. The following subsections describe how contaminant concentrations were estimated in each of the dietary items including plants and soil invertebrates and small mammals.

How Contaminant Concentrations Are Estimated for Plants and Soil Invertebrates as Dietary Items (B_i)

The specific information concerning how contaminant concentrations were estimated for the plant and soil invertebrate components (B_i) of the diets of the surrogate species is provided as Attachment 4-1. Regressions (R), BAFs, models (M) and assumptions (A) were all used (Figure 4.2).

The existing models for plants produce estimated contaminant concentrations in foliage. Although these data are suitable for receptors that consume foliage (e.g., meadow vole), their suitability for receptors whose diets consist of seeds (e.g., mourning dove) is unknown. To address this issue, a literature search was performed to locate studies in which contaminant concentrations in seeds and in soil were evaluated. The few data located (limited to metals) were plotted over reported soil-to-plant foliage bioaccumulation data (Figure 4.3).

Figure 4.2 Summary of Method Used for Estimation of Contaminant Concentrations in Biota Types (B_i)

COC	Soil to Plant	Soil to Earthworm	Diet to Mammal	Soil to Mammal
Antimony	R	BAF	BAF	NA
Arsenic	BAF	R	NA	R
Barium	BAF	BAF	BAF	NA
Beryllium	BAF	BAF	BAF	NA
Cadmium	R	R	NA	R
Chromium	BAF	BAF	NA	R
Cobalt	BAF	BAF	NA	R
Copper	R	BAF	NA	R
Lead	R	R	NA	R
Manganese	BAF	R	NA	R
Nickel	R	BAF	NA	R
Selenium	R	R	NA	R
Silver	BAF	BAF	NA	BAF
Vanadium	A	A	A	NA
Zinc	R	R	NA	R
Dieldrin	R	M	BAF	NA
DDT	BAF	M	BAF	NA
DDD	BAF	M	BAF	NA
DDE	BAF	M	BAF	NA
PCP	BAF	M	R	NA
PAHs		Specific to Individual PAH		
TNT	M	M	A	NA
RDX	M	M	A	NA

A = Assumption (see text).

BAF = Bioaccumulation Factor.

M = Estimated based on equation relating physical-chemical factor to bioaccumulationl (model).

NA = Not applicable. Only one method is needed for estimating tissue concentrations in mammals based on either diet or soil concentrations.

R = Either existing or new regression uptake model (Attachment 4-1)

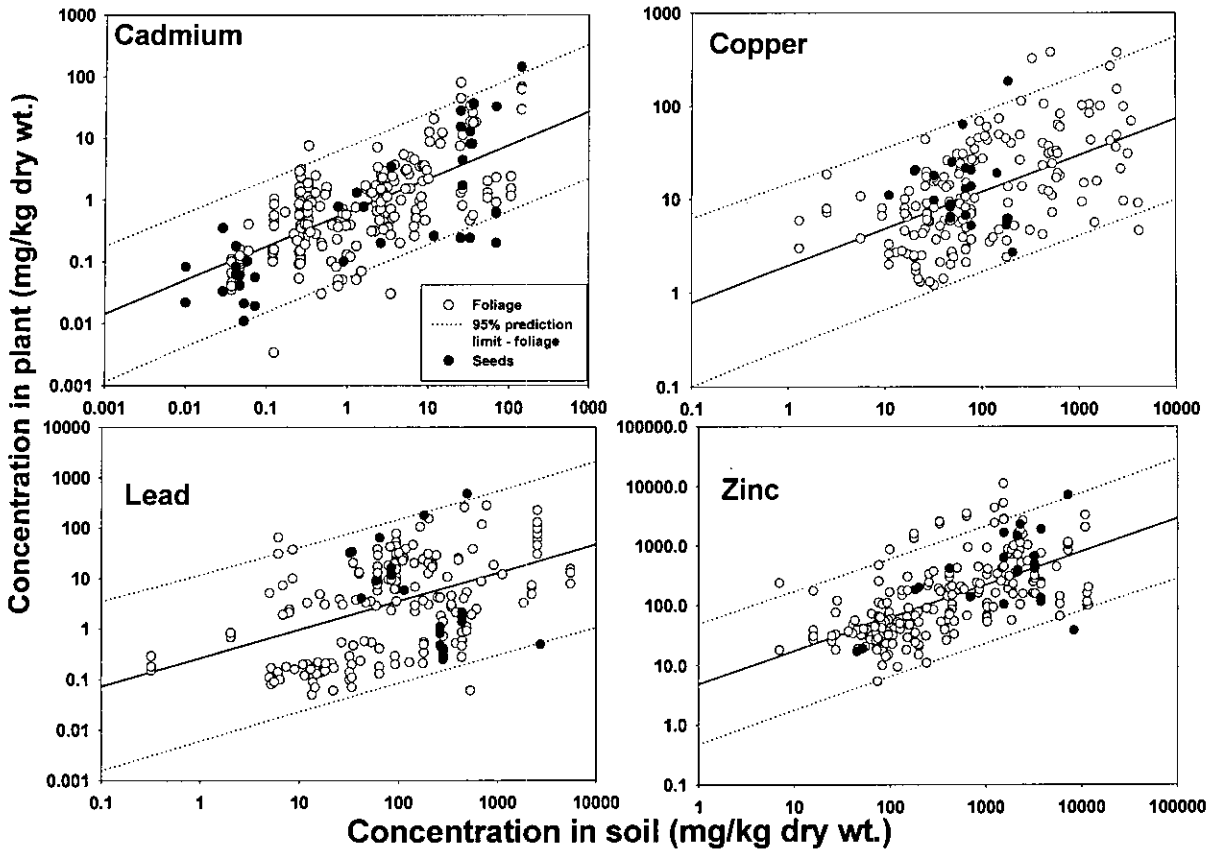


Figure 4.3 Comparison of Soil-to-Foilage and Soil-to-Seed Bioaccumulation for Cadmium, Copper, Lead and Zinc

For cadmium, copper, lead, and zinc soil-to-seed bioaccumulation mirrors the pattern observed for soil-to-foliage bioaccumulation. The degree of spread in the seed bioaccumulation data was comparable to that for foliage data. Based on these data, the models estimating contaminant concentrations in foliage were assumed to be suitable surrogates (at least for metals) for estimating contaminant concentrations in seeds.

How Contaminant Concentrations Are Estimated for Mammals as Dietary Items (B_j)

Empirical soil-whole body log-linear regression models and BAFs were available from Sample et al. (1998a) for 11 of the 24 contaminants. For the remaining organic contaminants for which empirical regression models or BAFs were not available, diet-to-tissue BAFs were estimated using the methods presented in Attachment 4-1.

Although many species of predatory wildlife consume both birds and mammals as prey, few data were available to estimate bioaccumulation of contaminants into birds. As a consequence, the bioaccumulation models for mammals were assumed to produce estimates that adequately represent concentrations in birds. The validity of this assumption was supported by data presented in Beyer et al. (1985). Birds (representing multiple species), white-footed mice, and short-tailed shrews were collected from two locations in the vicinity of a zinc smelter in Pennsylvania. Analyses were available for carcasses (tissue remaining after removal of the gastrointestinal tract, skin, feet, and beaks) for lead, zinc, cadmium, and copper. Mean analyte concentrations (and 95% confidence limits) in birds and mammals from both locations are presented in Figure 4.4. Based on these data, concentrations in birds appear to be approximately equivalent to or less than those found in omnivorous or insectivorous small mammals.

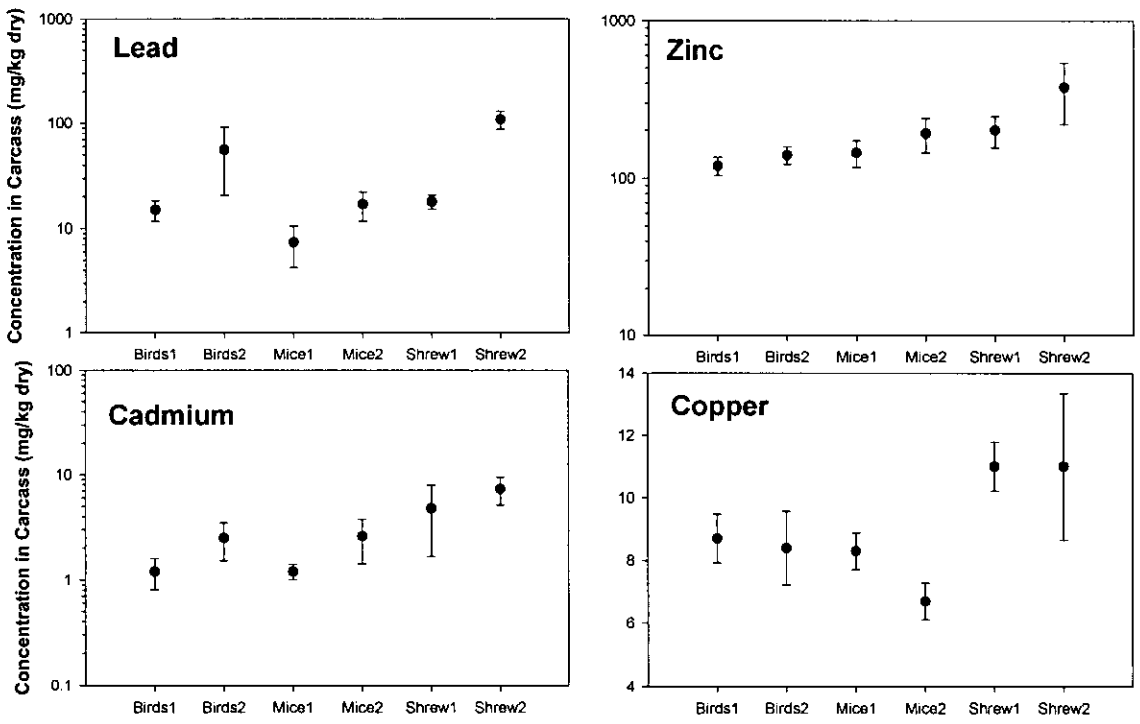


Figure 4.4 Comparison of Mean Concentrations in Multiple Species near a Smelter

What if Data are not Available to Estimate Concentrations in Dietary Items (B_j)?

For some contaminants and biota types (i.e., earthworms and small mammals for antimony, plants and small mammals for beryllium, and earthworms for chromium), data were not available to derive BAFs (as described in Attachment 4-1). For these contaminants, an assumption or default BAF of 1 was used. This assumption was supported by analyses of BAFs for plants, earthworms, and small mammals from Bechtel Jacobs (1998), Sample et al. (1998b), and Sample et al. (1998a), respectively (refer to Table 4.2). Approximately 90% of plant BAFs, 68% of earthworm BAFs and 83% of small mammal BAFs were less than one. Assuming BAFs for inorganic contaminants when data are absent generally over-estimate uptake and are, therefore, suitable for screening purposes only. A default BAF of 1 was also used for organic compounds.

Table 4.2 Cases where the Median of the BAF Distribution for Metals is Greater or Less than One

Biota Type	Total Number of Contaminants	BAFs < 1	BAFs > 1
Plants	21	19	2
Earthworms	31	21	10
Small Mammals	24	20	4

Validation of the Food Ingestion Model

To verify that the food ingestion model was generating realistic values, the modeled food ingestion distributions used in calculating the Eco-SSLs were compared to observed food ingestion rates for each of the six surrogate species. Because the modeled values were expressed as dry weight and food ingestion rates in the literature were generally reported as fresh or wet weight, the modeled food ingestion values were converted to wet weight using water content data for dietary items as reported in U. S. EPA (1993) where assumed water content for plant foliage, earthworms, seeds, and small mammals are 85%, 84%, 9.3%, and 68%, respectively.

The estimated wet-weight (ww) food ingestion rates (and corresponding dry weight (dw) estimates) were calculated for each species (Table 4.3). For all surrogate species the estimated food ingestion rates were within the ranges reported in the literature for actual food consumption by each species. A more detailed discussion and the literature consulted is provided in Attachment 4-1.

Table 4.3 Summary of Estimated Wet and Dry Weight Food Ingestion Rates for Surrogate Wildlife Species.							
Surrogate Species	**Food Intake Units**	**Used in Eco-SSL Calculation (90th percentile)**	**Minimum**	**25th percentile**	**Median**	**75th percentile**	**Maximum**
Meadow Vole	g dw/g bw/d	0.28	0.03	0.1	0.14	0.2	0.70
	g ww/g bw/d (85% moisture)	1.87	0.20	0.67	0.93	1.33	4.67
Mourning Dove	g dw/g bw/d	0.23	0.05	0.11	0.14	0.18	0.52
	g ww/g bw/d (9.3% moisture)	0.25	0.06	0.12	0.15	0.20	0.57
Short-tailed Shrew	g dw/g bw/d	0.20	0.02	0.08	0.11	0.15	0.65
	g ww/g bw/d (84% moisture)	1.25	0.13	0.50	0.69	0.94	4.06
American Woodcock	g dw/g bw/d	0.17	0.05	0.1	0.12	0.14	0.26
	g ww/g bw/d (84% moisture)	1.06	0.31	0.63	0.75	0.88	1.63
Long-tailed Weasel	g dw/g bw/d	0.10	0.01	0.04	0.05	0.07	0.24
	g ww/g bw/d (68% moisture)	0.31	0.03	0.13	0.16	0.22	0.75
Red-tailed Hawk	g dw/g bw/d	0.12	0.03	0.06	0.08	0.1	0.24
	g ww/g bw/d (68% moisture)	0.38	0.09	0.19	0.25	0.31	0.75

4.4 Derivation of Toxicity Reference Values (TRVs)

The wildlife TRV is defined as:

> *Dose above which ecologically relevant effects might occur to wildlife species following chronic dietary exposure and below which it is reasonably expected that such effects will not occur.*

As presented in Figure 4.5, a four-step process was used to select TRVs appropriate for calculating wildlife Eco-SSLs. The four steps included: 1) conduct a literature search, 2) complete a review of the literature and extract data, 3) complete an evaluation of the extracted data and score data, and 4) derive a TRV.

Figure 4.5. Steps of the Wildlife TRV Derivation Process

The wildlife TRV derivation process is composed of four general steps that are documented as separate standard operating procedures (SOPs):

- **Literature Search and Retrieval**
  Wildlife TRV Literature Search and Retrieval (Attachment 4-2). A literature search identifies dose-response literature for retrieval.
- **Literature Review and Data Extraction**
  Wildlife TRV Literature Review, Data Extraction and Coding (Attachment 4-3). The retrieved literature studies are reviewed and data are extracted according to an established coding system. Data are entered into an electronic data base.
- **Data Evaluation**
  Wildlife TRV Data Evaluation (Attachment 4-4). Each of the results identified in the reviewed literature is scored for quality and applicability for TRV derivation.
- **TRV Derivation**
  Wildlife TRV Derivation (Attachment 4-5). This procedure plots the collective dose-response information and establishes the process for estimating the TRV.

Literature Search and Retrieval

The first step in deriving the TRVs was to conduct a literature search to identify toxicological studies for mammals and birds for retrieval and review. The search procedure was described in detail in Attachment 4-2. EPA completed a literature search for 23 of the Eco-SSL contaminants (PCBs were excluded). The search process identified over 44,000 records for review. The literature search process was documented in sufficient detail that others may use it to identify relevant data for additional contaminants not completed by EPA.

Literature Review and Data Extraction

The toxicological literature identified from the literature search was next reviewed for usefulness in establishing wildlife TRVs. Literature exclusion criteria (similar to those discussed in Chapter 3 for plants and soil invertebrates) and listed in detail in Attachment 4-3 were applied to the identified literature. Additional types of studies excluded specifically for wildlife included those that only report genotoxic, mutagenic, or carcinogenic effects, acute or non-oral exposures (inhalation, injection, dermal, etc.), or studies unrelated to the contaminant and receptor groups of interest. Where possible, the literature exclusion criteria were applied to identified titles and abstracts prior to

retrieval of the paper. For retrieved studies that passed the literature exclusion criteria, the relevant toxicological data were extracted and entered into an electronic database according to established extraction and coding procedures detailed as Attachment 4-3. These extraction and coding procedures were consistent with EPA's EcoTox database (USEPA, 2003).

The primary purpose of the data extraction process was to identify two values associated with each study result:

- A no-observed adverse effect level (NOAEL), which is the highest dose that does not cause a statistically significant adverse effect; and
- A lowest-observed adverse effect level (LOAEL), which is the lowest dose that caused a statistically significant adverse effect.

In theory, the threshold for the particular adverse effect lies between the NOAEL and the LOAEL.

Data Evaluation

Each test result extracted during the literature review process was scored for quality and applicability for TRV derivation. The data evaluation process was provided as Attachment 4-4. In instances where more than one "experiment" (i.e., different combinations of test organism (species or strains), contaminant form, test location, control type, doses, application frequency, or route of exposure) were reported in a paper, the individual "experiments" were scored separately. In cases of more than one experiment, the scoring system was applied independently to each experimental result. The scoring system was based on the evaluation of ten attributes of the toxicological study (Figure 4.6) assigning a score for each attribute, ranging from zero (no merit in setting a TRV) to 10 (extremely valuable and relevant to setting a TRV). Note that a low score does not necessarily imply the study itself is poor, only that the study design is not the most appropriate for deriving an oral TRV. The

Figure 4.6 Ten Attributes Scored as Part of the Wildlife Toxicological Data Evaluation

1. **Data Source**
   Primary sources only considered.
2. **Dose Route**
   Dietary studies scored higher than gavage, capsule and liquid. Non oral exposures are excluded.
3. **Test Substance Concentrations**
   Studies with measured exposures scored higher than nominal exposures.
4. **Contaminant Form**
   Contaminant forms similar to soil forms scored higher compared to dissimilar forms.
5. **Dose Quantification**
   Exposures reported as doses scored higher than those reported as concentrations.
6. **Endpoint**
   Reproductive effects scored higher than lethality and growth. Physiology, behavioral, biochemical and pathology changes are scored lower and biomarkers scored lowest.
7. **Dose Range**
   Studies with both NOAEL and LOAEL values scored higher than studies which report only one value. Narrower ranges between NOAEL and LOAEL scored higher.
8. **Statistical Power**
   The statistical power of a NOAEL is scored.
9. **Exposure Duration**
   Exposure durations encompassing multiple generations and critical life stages scored higher than chronic, subchronic, and acute.
10. **Test Conditions**
    Studies that report standard exposure conditions scored higher then those that report fewer or none.

total score was calculated by adding the results of the evaluation of each attribute. The use of total Data Evaluation Score was interpreted as follows:

80 to 100	High confidence
71 to 79	Medium confidence
66 to 70	Low confidence
0 to 65	Not used in Eco-SSL derivation

A web-based data entry system and database was created by EPA as a tool to facilitate efficient, accurate, and consistent data extraction from individual reviewed toxicological studies as well as data evaluation scoring. Extraction of the data directly into an electronic database facilitated necessary sorting, searching and presentation of the data for the purposes of TRV derivation. The TRV database was focused on extracting the NOAEL and LOAEL doses from each of the toxicological studies.

TRV Derivation

The dose-response information for mammals and birds was plotted separately, and a TRV was derived for each class using an established procedure. The process used was documented in Attachment 4-5. The following general steps were completed to derive the TRVs:

Data Sorted. The toxicity data (effect doses) were downloaded from the database into spreadsheet files for each contaminant using a consistent tabular format. One table was constructed for avian data and a second for mammalian data. The tables provided the essential information concerning each of the toxicity testing results. Table 4.4 provides an example using the results for mammals and cobalt. The results were numbered sequentially and sorted by general effect group, then by effect measure.

Data Plotted. Summary plots were constructed depicting the NOAELs and LOAELs for each contaminant. Separate plots were completed for mammalian and avian data. The data plots (example provided as Figure 4.7) were organized by General Effect Group in order from left to right as: biochemical (BIO), behavior (BEH), physiology (PHY), pathology (PTH), reproduction (REP), growth (GRO), and mortality (MOR). Within each toxicological study there may be several effect measures reported that have the same NOAEL and/or LOAEL values. Inclusion of the NOAEL and LOAEL values for all endpoint measures would result in repetitive values on the plots. To avoid the inclusion of repetitive and duplicative data, the results for only one Effect Measure per Effect Group were recorded on the plots. For example a study may report more the one adverse reproductive effect such as reduced progeny weight and also progeny survival and also reduced number of litters. In this case only one effect was coded for the most conservative "worst case" result.

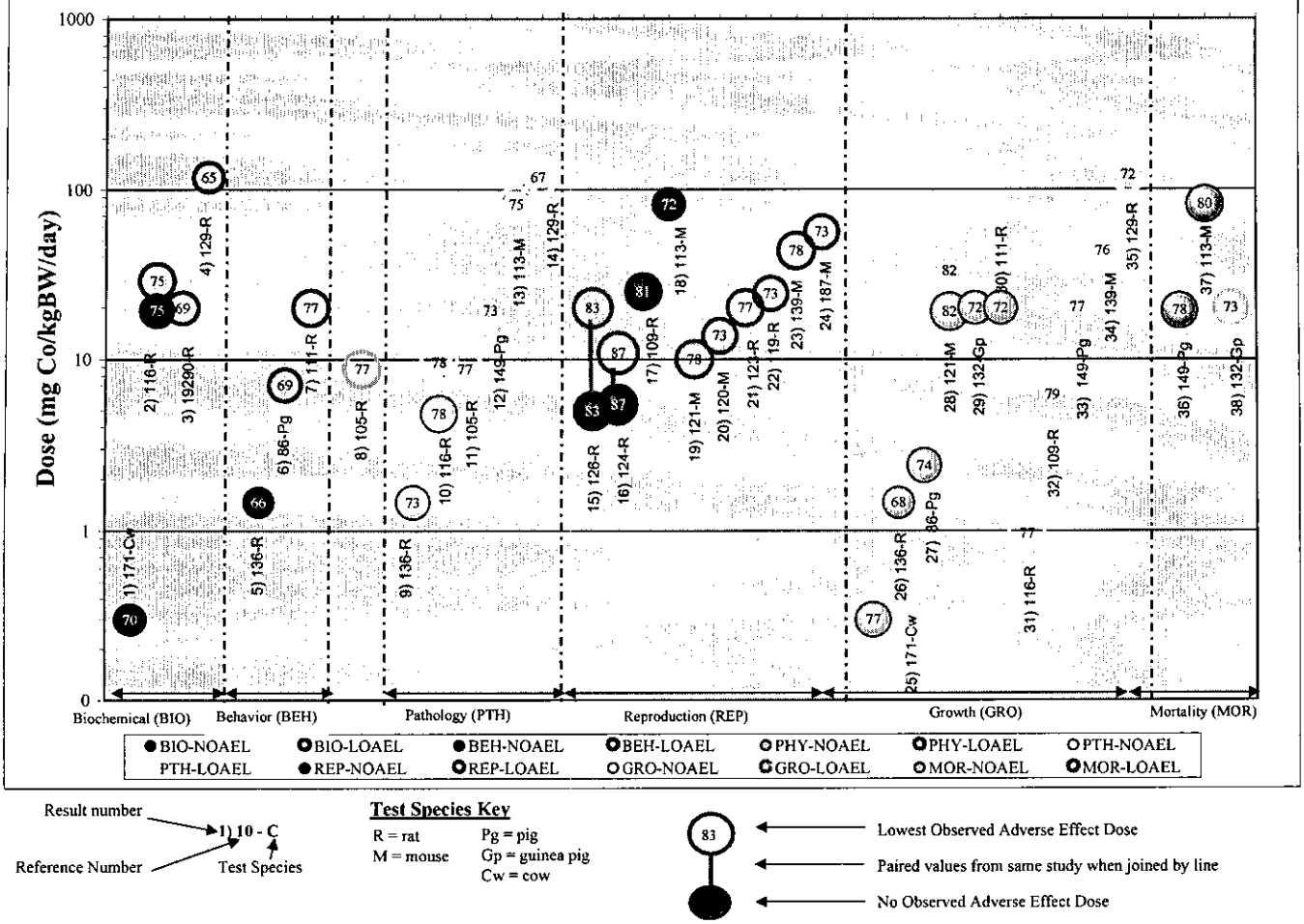
Exclusion of Data with Limited Utility in Establishing an Eco-SSL. Each NOAEL and LOAEL result was evaluated according to the Data Evaluation process (Attachment

Table 4.4. Example of Extracted and Sorted Data for Wildlife TRV Derivation (Cobalt)

Result #	Reference	Ref No.	Test Organism	# of Conc/ Doses	Method of Analyses	Route of Exposure	Exposure Duration	Duration Units	Age	Age Units	Lifestage	Sex	General Effect Group	Effect Measure	Response Site	NOAEL Dose (mg/kg/day)	LOAEL Dose (mg/kg/day)	Data Evaluation Score
Biochemical Effects																		
1	Maro et al., 1980	171	Cow (*Bos taurus*)	2	M	FD	45	d	7	mo	JV	F	BIO	HMGL	BL	0.30		70
2	Chetty et al., 1979	115	Rat (*Rattus norvegicus*)	6	U	FD	4	w	NR	NR	NR	B	BIO	HMGL	BL	19	29	75
3	Kadiiska et al., 1985	19290	Rat (*R. norvegicus*)	2	U	DR	30	d	NR	NR	JV	M	BIO	P450	LI		20	69
4	Derr et al., 1970	129	Rat (*R. norvegicus*)	2	U	DR	35	d	NR	NR	JV	M	BIO	HMCT	BL		118	65
Behavioral Effects																		
5	Gershbein et al., 1983	136	Rat (*R. norvegicus*)	2	U	FD	80	d	44	d	JV	M	BEH	NMVM	WO	1.5		66
6	Huck and Clawson, 1976	86	Pig (*Sus scrofa*)	4	U	FD	28	d	NR	NR	NR	NR	BEH	FCNS	WO		7.1	69
7	Bourg et al., 1985	111	Rat (*R. norvegicus*)	2	M	DR	57	d	80	d	JV	M	BEH	ACTP	WO		20	77
Physiology Effects																		
8	Haga et al., 1996	105	Rat (*R. norvegicus*)	2	U	FD	16	w	NR	NR	NR	M	PHY	Other	HE		8.8	77
Pathology Effects																		
9	Gershbein et al., 1983	136	Rat (*R. norvegicus*)	2	U	FD	80	d	44	d	JV	M	PTH	GHIS	NR	1.5		73
10	Chetty et al., 1979	116	Rat (*R. norvegicus*)	6	U	FD	4	w	NR	NR	NR	B	PTH	SMIX	TS	4.8	9.6	78
11	Haga et al., 1996	105	Rat (*R. norvegicus*)	2	U	FD	16	w	NR	NR	NR	M	PTH	BDWT	WO		8.8	77
12	Van Vleet et al., 1981	149	Pig (*S. scrofa*)	2	U	FD	10	w	NR	NR	JV	M	PTH	GLSN	HE		19	73
13	Seidenberg et al., 1986	113	Mouse (*Mus musculus*)	2	U	GV	5	d	NR	NR	GE	F	PTH	BDWT	WO		82	75
14	Derr et al., 1970	129	Rat (*R. norvegicus*)	2	U	DR	35	d	NR	NR	JV	M	PTH	SMIX	HE		118	67
Reproductive Effects																		
15	Nation et al., 1983	126	Rat (*R. norvegicus*)	3	U	FD	69	d	80	d	MA	M	REP	TEWT	TE	5.0	20	83
16	Domingo et al., 1985	124	Rat (*R. norvegicus*)	4	U	GV	28	d	NR	NR	MA	F	REP	PRWT	WO	5.4	11	87
17	Paternain et al., 1988	109	Rat (*R. norvegicus*)	4	U	GV	9	d	NR	NR	GE	F	REP	PRWT	WO	25		81
18	Seidenberg et al., 1986	113	Mouse (*M. musculus*)	2	U	GV	5	d	NR	NR	GE	F	REP	PROG	WO	82		72
19	Pedigo et al., 1988	121	Mouse (*M. musculus*)	4	U	DR	13	w	10	w	MA	B	REP	RSUC	WO		10	78
20	Anderson et al., 1992	120	Mouse (*M. musculus*)	2	U	DR	9	w	12	w	MA	M	REP	TEWT	TE		14	73
21	Corrier et al., 1985	123	Rat (*R. norvegicus*)	2	U	FD	70	d	100	d	SM	M	REP	TEDG	TE		20	77
22	Mollenhauer et al., 1985	119	Rat (*R. norvegicus*)	2	U	FD	98	d	100	d	MA	M	REP	TEWT	TE		24	73
23	Anderson et al., 1993	139	Mouse (*M. musculus*)	2	U	DR	13	w	12	w	MA	M	REP	TEWT	TE		43	78
24	Pedigo et al., 1993	187	Mouse (*M. musculus*)	2	U	DR	10	w	8 to 10	w	JV	M	REP	PRFM	WO		56	73
Growth Effects																		
25	Maro et al., 1980	171	Cow (*Bos taurus*)	2	M	FD	45	d	7	mo	JV	F	GRO	BDWT	WO	0.30		77
26	Gershbein et al., 1983	136	Rat (*R. norvegicus*)	2	U	FD	80	d	44	d	JV	M	GRO	BDWT	WO	1.5		68
27	Huck and Clawson, 1976	86	Pig (*S. scrofa*)	4	U	FD	16	w	NR	NR	NR	NR	GRO	BDWT	WO	2.4		74
28	Pedigo et al., 1988	121	Mouse (*M. musculus*)	4	U	DR	5	w	6 to 7	w	SM	M	GRO	BDWT	WO	19	33	82
29	Mohiuddin et al., 1970	132	Guinea pig (*Cavia porcellus*)	2	U	OR	5	w	NR	NR	MA	M	GRO	BDWT	WO	20		72
30	Bourg et al., 1985	111	Rat (*R. norvegicus*)	2	M	DR	57	d	80	d	JV	M	GRO	BDWT	WO	20		72
31	Chetty et al., 1979	116	Rat (*R. norvegicus*)	6	U	FD	4	w	NR	NR	NR	B	GRO	BDWT	WO		0.96	77
32	Paternain et al., 1988	109	Rat (*R. norvegicus*)	4	U	GV	9	d	NR	NR	GE	F	GRO	BDWT	WO		6.2	79
33	Van Vleet et al., 1981	149	Pig (*Sus scrofa*)	2	U	FD	5	w	NR	NR	JV	M	GRO	BDWT	WO		20	77
34	Anderson et al., 1993	139	Mouse (*M. musculus*)	2	U	DR	13	w	12	w	MA	M	GRO	BDWT	WO		43	76
35	Derr et al., 1970	129	Rat (*R. norvegicus*)	2	U	DR	24	d	NR	NR	JV	M	GRO	BDWT	WO		122	72
Mortality Data																		
36	Van Vleet et al., 1981	149	Pig (*S. scrofa*)	2	U	FD	10	w	NR	NR	JV	M	MOR	MORT	NR	19		78
37	Seidenberg et al., 1986	113	Mouse (*M. musculus*)	2	U	GV	5	d	NR	NR	GE	F	MOR	MORT	NR	82		80
38	Mohiuddin et al., 1970	132	Guinea pig (*Cavia porcellus*)	2	U	OR	5	w	NR	NR	MA	M	MOR	SURV	WO		20	73

ACTP = activity level; B = both; BIO = biochemical; BL = blood; d = days; BDWT = body weight changes; BEH = behavior; DR = Drinking water; F = female; FCNS = food consumption; FD = food; GE = gestation; GRO = growth; GLSN = gross lesions; GV = gavage; HE = heart; HMCT = hematocrit; HMGL = hemoglobin; JV = juvenile; LI = liver; MA = mature; M = male; M = measured; m = months; MOR = mortality, NMVM = number of movements; NR = Not reported; OR = other oral; PHY = physiology; PTH = pathology; PRFM = sexual performance; REP = reproduction; SM = sexually mature; SMIX = weight relative to body weight; SURV = survival; TE = testes; TEDG = testes degeneration; TEWT = testes weight; U = unmeasured; w = weeks; WO = whole organism

Figure 4.7 Example of a Toxicological Plot for the TRV Derivation Process (Cobalt)



Result number → 1) 10 - C ← Test Species
Reference Number

Test Species Key

R = rat
M = mouse
Pg = pig
Gp = guinea pig
Cw = cow

83 — Lowest Observed Adverse Effect Dose
Paired values from same study when joined by line
No Observed Adverse Effect Dose

4-4) and scored within a range of 0 to 100 (worst to best) for usefulness in establishing an oral TRV. Data with limited utility were defined as study endpoints receiving a Total Data Evaluation Score of 65 or less. These data points were excluded from the plots. The purpose of the exclusion was to ensure that the TRV derivation used the most suitable data.

TRV Selected. The general steps and conditional statements of the derivation process are outlined in Figure 4.8. These steps are an a priori framework for selection of the TRV value based on the results of the toxicological plots. The flow chart (Figure 4.8) is used with the toxicity data plots to derive the TRV according to the described steps. The TRV is equal to the geometric mean of the NOAEL values for growth (GRO) and reproductive (REP) effects. In cases where the geometric mean NOAEL is higher than the lowest bounded LOAEL (bounded refers to a LOAEL that has a paired NOAEL) for either, GRO, REP or mortality (MOR), the TRV is equal to the highest bounded NOAEL below the lowest bounded LOAEL. An example is provided using the mammalian cobalt plot depicted as Figure 4.9.

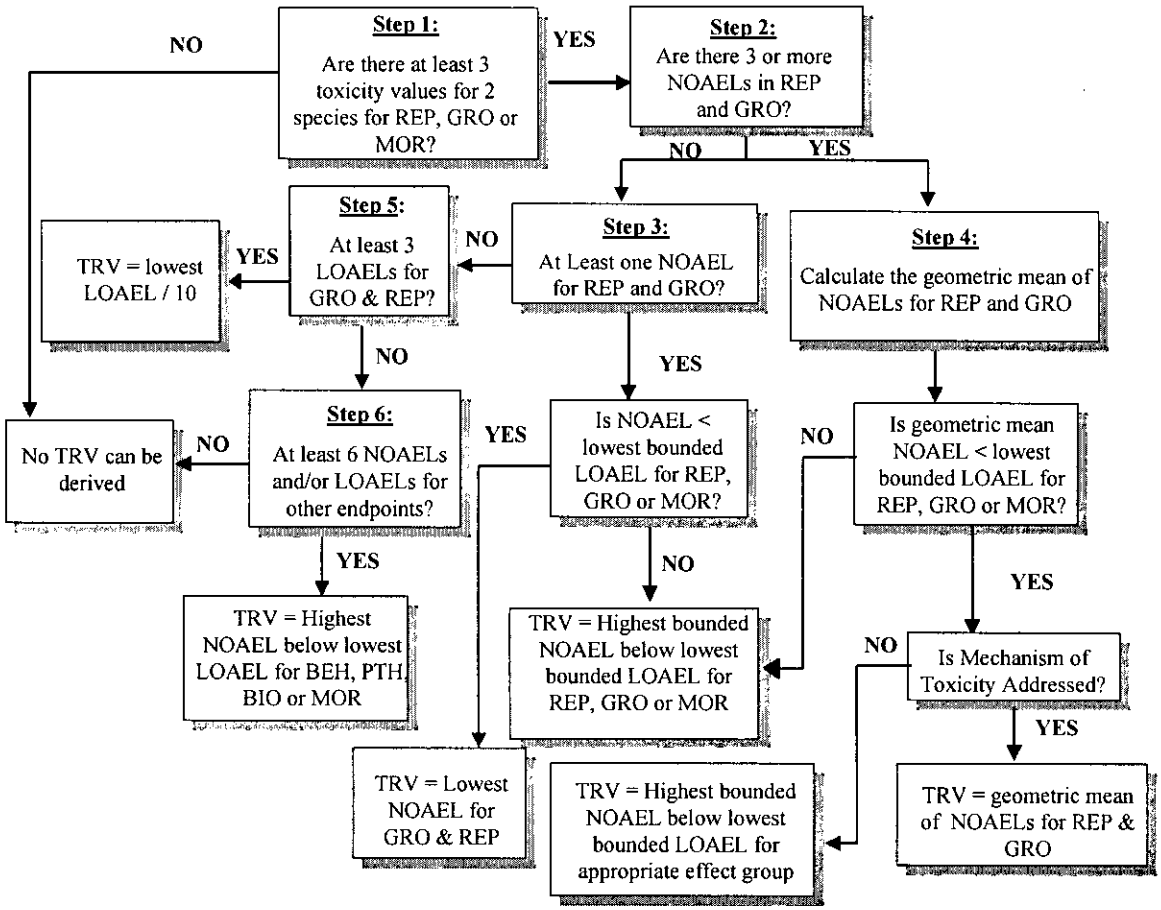
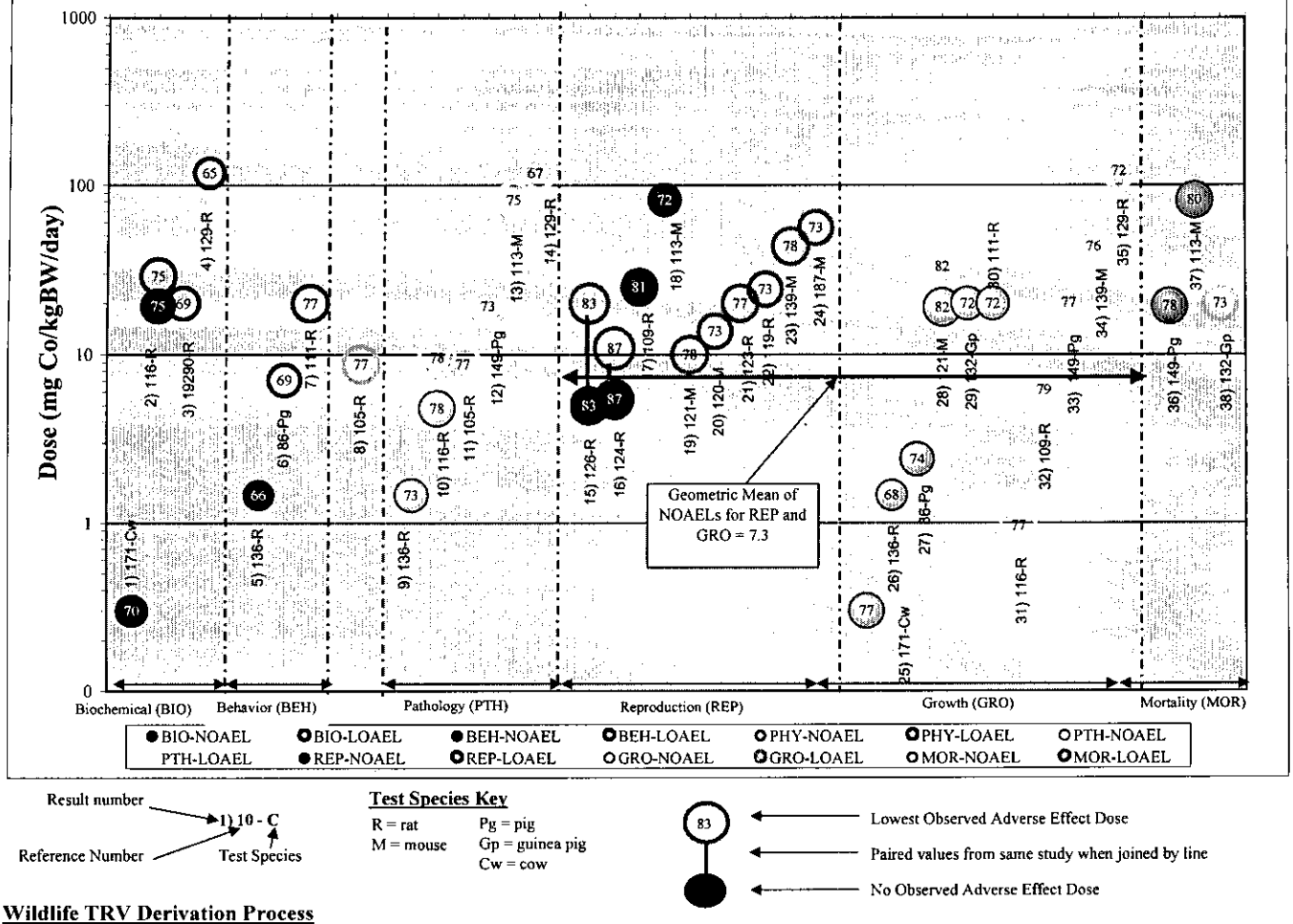


Figure 4.8 Procedure for Deriving the Wildlife Toxicity Reference Value (TRV)

Figure 4.9 Example of a TRV Derivation (Cobalt)



Wildlife TRV Derivation Process

1) There are at least three results available for two test species within the GRO, REP and MOR effect groups. There is enough data to derive TRV.

2) There are are at least three NOAEL results available for calculation of a geometric mean.

3) The geometric mean of the NOAEL values for GRO and REP equals 7.3 mg Co/kg BW/day.

4) The geometric mean NOAEL value is less than the lowest bounded LOAEL for REP, GRO or MOR.

5) The mammalian wildlife TRV for cobalt is equal to 7.3 mg Co/kg BW/day.

4.5 Calculation of Wildlife Eco-SSLs

The Eco-SSL wildlife risk model (Equation 4-2) was expressed in two forms, depending on the method used to estimate contaminant concentrations in food items (B_i).

1) If a BAF was used to estimate the contaminant concentrations in food items leave, then the equation was:

where:

T_{ij} = soil-to-biota BAF (units- dry weight to dry weight) for contaminant (j) for food type (i)

$$HQ_j = \frac{\left([Soil_j * P_s * FIR] + [\sum_{i=1}^{N} (Soil_j * T_{ij}) * P_i * FIR]\right)}{TRV_j} \qquad \textit{(Equation 4-3)}$$

2) If regression models were used, then the equation was:

$$HQ_j = \frac{\left([Soil_j * P_s * FIR] + [\sum_{i=1}^{N} e^{B0_{ij} + \ln(Soil_j) * B1_{ij}} * P_i * FIR]\right)}{TRV_j} \qquad \textit{(Equation 4-4)}$$

where:

e = Napierian constant (2.7182818),

$B0_{ij}$ = Intercept from log-linear bioaccumulation model for contaminant (j) for biota type (i), and

$B1_{ij}$ = slope from log-linear bioaccumulation model for contaminant (j) for biota type (i)

The general procedure for calculating the wildlife Eco-SSL involved inverting the BAF or log-linear forms of the exposure models (Equations 4-3 and 4-4, respectively) to determine the contaminant concentration in soil that was equivalent to an HQ = 1. The exposure models that employed BAFs were a simple linear function of the soil concentration and were inverted algebraically. However, when the exposure model incorporated the log-linear bioaccumulation models, numerical methods were required. The solution of the Eco-SSL exposure model when a simple BAF was used is outlined in the following steps. Equation 4-3 was rewritten as:

$$HQ_j = \frac{\left([P_s * FIR] + [\sum_{i=1}^{N} (T_{ij}) * P_i * FIR]\right) * Soil_j}{TRV_j} \qquad \textit{(Equation 4-5)}$$

Multiplication of both sides of Equation 4-5 by $\frac{1}{Soil_j}$ and $\frac{1}{HQ_j}$ produced:

$$\frac{1}{Soil_j} = \frac{\left([P_s * FIR] + [\sum_{i=1}^{N} (T_{ij}) * P_i * FIR]\right)}{TRV_j * HQ_j} \qquad \textit{(Equation 4-6)}$$

Inversion of Equation 4-6 produced:

$$Soil_j = \frac{TRV_j * HQ_j}{\left([P_s * FIR] + [\sum_{i=1}^{N} (T_{ij}) * P_i * FIR]\right)} \qquad \textit{(Equation 4-7)}$$

where:

$Soil_j$ = the Eco-SSL for contaminant j for wildlife and TRV_j was equal to a no-effect level.

Solution of the log-linear form of the wildlife Eco-SSL model was more complex than the BAF-based model. Solution of the log-linear form of the model was accomplished by solving Equation 4-4 where the HQ = 1 using a computer spreadsheet program.

Wildlife Eco-SSLs. In order to calculate wildlife Eco-SSLs, Equation 4-7 was rearranged, with the removal of all parameters that were set to 1, resulting in the following simplified model:

$$Soil_j = \frac{TRV_j}{FIR*[P_s + T_{ij}]} \qquad \textit{(Equation 4-8)}$$

where:

$Soil_j$ = Contaminant concentration for contaminant (j) in soil (mg/kg dry weight),
FIR = Food ingestion rate (kg food [dry weight]/ kg bw [wet weight] / d),
P_s = Soil ingestion as proportion of diet,
TRV_j = Toxicity reference value for contaminant (j) (mg [dry weight]/kg bw [wet weight] /d),
T_{ij} = Soil-to-biota BAF for contaminant (j) for biota type (i).

In some cases where soil-to-biota BAFs were not available it was necessary to use a string of BAFs (for example: (BAF for soil to earthworm + BAF for earthworm to shrew) in which case the equation was reduced to:

$$Eco-SSL_{pred} = \frac{TRV_j}{FIR*[P_s + (T_{ij} * T_{ver})]} \qquad \textit{(Equation 4-9)}$$

where:

T_{ver} = diet-to-biota BAF

Conservatism of Model Parameterization

The purpose of the Eco-SSLs is to identify concentrations of contaminants in soil that may present a risk, from those concentrations that clearly do not. As a screening tool, the Eco-SSLs should be conservative, but not so much so that no concentrations pass the screen. To this end, the wildlife Eco-SSL model was parameterized using a combination of conservatively skewed and non-conservatively skewed parameter values. The level of conservatism associated with the model parameter values is summarized in Table 4.5. Whereas the TRVs, food and soil ingestion rates, diet composition, area use, and bioavailability were all conservatively skewed, all bioaccumulation values were based on central tendency estimates.

Sensitivity Analysis of the Wildlife Eco-SSL Model

Parameterization of the final wildlife EcoSSL model was accomplished by selecting a combination of conservative and central tendency values from distributions for the different parameters. For example, whereas food and soil ingestion rates were defined as the 90th percentile from their respective distributions, bioaccumulation was defined by central tendency values (median values for T_{ij} and T_{ver}, least -squares regression output for log-linear bioaccumulation estimates). To evaluate the relative influence of parameter values to the final Eco-SSL value, nominal range sensitivity analyses (Cullen and Frey 1999) were performed. The results of the sensitivity analyses were included in Attachment 4-1.

Table 4.5 Summary of Conservatism Associated with the Wildlife Eco-SSL Risk Model Parameters.			
Parameter	**Value selected for use in calculation of Eco-SSL**	**Conservatism of Value**	**Rationale**
Toxicity Reference Value (TRV)	highest bounded NOAEL below the lowest bounded LOAEL or the geometric mean of NOAELs for REP or GRO	moderate	Represents highest dose that did not cause any adverse effects in any test species
Food Ingestion Rate (FIR)	90th percentile	high	Conservatively-skewed value selected to represent majority of individuals within population without being over protective.
Soil Ingestion Rate (P_s)	90th percentile	high	Conservatively-skewed value selected to represent majority of individuals within population without being over protective.
Soil-Biota Bioaccumulation Factor (T_{ij})	median	neither conservative nor anti-conservative	Lowest uncertainty - not expected to over-predict concentrations
Diet-Biota Bioaccumulation Factor (T_{ver})	median	neither conservative nor anti-conservative	Lowest uncertainty - not expected to over-predict concentrations
log-linear regression models for bioaccumulation	Best-fit least-squares model	neither conservative nor anti-conservative	Lowest uncertainty - not expected to over-predict concentrations
Diet composition (P_i)	100% plant, small mammal, or soil invertebrate (depending on trophic group)	high	Maximum pathway-specific exposure to allow screening of risks by pathway. Consistent with Superfund Ecological Risk Assessment Guidance (EPA 1997)
Area Use Factor (AUF)	100%	high	Consistent with Superfund Ecological Risk Assessment Guidance (EPA 1997)
Bioavailability (Af_{ij}, AF_{sj})	Equivalent to that for the chemical form used to develop the TRV	high	Consistent with Superfund Ecological Risk Assessment Guidance (EPA 1997)

5.0 ECO-SSL DOCUMENTS

Presented in this chapter is a description of the format and content of the Eco-SSL documents which report the results of the Eco-SSL derivation procedures as described in the previous chapters. Each document is structured with the following standard sections. However, the structure is not followed for iron and aluminum where the documents specifically review the chemistry, bioavailability, and toxicity in soils instead of providing numeric screening levels. EPA is continuing to evaluate existing toxicity studies (primarily for birds and mammals) and intends to issue additional Eco-SSL documents in the future. These documents will be posted on the afore mentioned website as they become available. The following subsections describe the basic components of each of the documents.

Introduction

The introduction to each contaminant summary provides a brief review of the contaminant including environmental forms, sources, background concentrations, mechanisms of toxicity, and essential elemental status if applicable. These summaries are intended to provide the reader with a general introduction only and do not represent an exhaustive review of the environmental fate and effects of the contaminant. It is recommended that the user of the Eco-SSL values review site-specific data concerning contaminant sources and possible fate and transport processes to evaluate as necessary the site-specific properties of the contaminant in soils. The general introductory material is based on a review of literature obtained during the search process for plants and soil invertebrates and wildlife. Some review material is based on information available from the Hazardous Substances Databank (HSDB), a database of the National Library of Medicine's TOXNET system (http://toxnet.nlm.nih.gov). Some Eco-SSLs for metals are within the range of reported background concentrations that may occur at sites without any contaminant release due to hazardous waste management activities. As part of the Eco-SSL project, available data for the background concentrations of metals are summarized in Table 2.3 (see Chapter 2) and Attachment 1-4.

Summary Table

This subsection of each document contains a summary table of the Eco-SSL values calculated for each receptor group expressed as mg contaminant per kg dw soil. If an Eco-SSL could not be calculated for a receptor group then "NC" is noted for not calculated. In some cases, the Eco-SSL is pending further review of toxicity information. In these cases, "pending" is noted. The Eco-SSL values are rounded to two significant digits.

Eco-SSL for Plants

This subsection describes the results of the derivation of an Eco-SSL value for terrestrial plants completed according to the procedures describe in Chapter 3 and appropriate Attachments.

Eco-SSL for Soil Invertebrates

This subsection describes the results of the derivation of an Eco-SSL value for soil invertebrates completed according to the procedures described in Chapter 3 and Attachments.

Eco-SSL for Avian Wildlife

This subsection describes the results of the derivation of an Eco-SSL value for avian wildlife. The subsection provides only the data used to derive the Eco-SSL according to the procedures described in Chapter 4 and Attachments. The results are provided as two parts.

- Toxicity Reference Value
- Estimation of Dose and Calculation of the Eco-SSL

Eco-SSL for Mammalian Wildlife

This subsection describes the results of the derivation of an Eco-SSL value for mammalian wildlife. The subsection provides only the data used to derive the Eco-SSL according to the procedures described in Chapter 4 and Attachments. The results are provided as two parts.

- Toxicity Reference Value
- Estimation of Dose and Calculation of the Eco-SSL.

References

The references are provided as the last subsection of each document. The references are segregated by receptor with separate lists for plants and soil invertebrates and wildlife. The references for each receptor are further segregated into two lists. The first list provides the papers used to derive the Eco-SSL and the second list provides the papers that were rejected for use. For each of the papers rejected the reason for the rejection is listed.

Appendices

A complete tabulation of the toxicity data used to derive the wildlife toxicity reference values (TRVs) is provided as an appendix.

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Attachment 1-1

Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs)

Review of Existing Soil Screening Benchmarks

OSWER Directive 92857-55

November 2003

A Critical Review of Methods

for

Developing Ecological Soil Quality

Guidelines and Criteria

Prepared for

American Petroleum Institute

Biomonitoring Task Force

1220 L Street, Northwest

Washington, DC 20005-4070

Prepared by

ecological planning and toxicology, inc.

5010 S.W. Hout Street

Corvallis, OR 97333-9540

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EXECUTIVE SUMMARY

In support of the U.S. Environmental Protection Agency (USEPA) development of soil criteria referred to as Ecological Soil Screening Level to screen contaminated sites, methods used elsewhere to develop similar criteria were reviewed. Technical guidance documents from Europe (most notably, The Netherlands), Australia, Canada (Federal), British Columbia, and Oak Ridge National Laboratory were examined. None of the U.S. states have distinct methods. Technical staff in each of the countries were also consulted. In addition, USEPA methods for development of water and sediment criteria were reviewed.

Three generic methods have been used to set protective soil concentrations throughout the world.

- Type 1 selects the lowest reported toxicity value and divides by an assessment (safety) factor.
- Type 2 arrays all reported values in a statistical distribution and selects a particular percentile.
- Type 3 ranks all reported soil concentrations from lowest to highest and chooses the upper boundary such that no toxic effects are known to occur at lower concentrations; however, higher concentrations do not always cause toxicity.

The final goal of all environmental protection values, regardless of media, is protection while being reasonable. How issues such as level of protection, use of assessment factors, background levels, and minimum data requirements are addressed varies with jurisdictions, which in turn affects the final values. Compilation of soil protection values revealed substantial differences among the various jurisdictions. Generally, the different values were drawn from the same world-wide body scientific studies. Therefore the differences among these jurisdictions primarily reflect differences in policy, rather than technical rigor or quality of the underlying science.

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ABBREVIATIONS

ACR	**A**cute to **C**hronic **R**atio
BCF	**B**ioconcentration **F**actor
BCME	**B**ritish **C**olumbia **M**inistry of **E**nvironment, **L**ands, and **P**arks
BW	**B**ody **W**eight
CCME	**C**anadian **C**ouncil of **M**inisters of the **E**nvironment
EC	**E**uropean **C**ommunity
EC_{10}	**E**ffect **C**oncentration for **10**% of the test organisms
EC_{50}	**E**ffect **C**oncentration for **50**% of the test organisms
Eco-SSL	**E**cological **S**oil **S**creening **L**evel
EIL	**E**nvironmental **I**mpact **L**evel
ER-H	**E**ffects **R**ange – **H**igh
ER-L	**E**ffects **R**ange **- L**ow
ER-M	**E**ffects **R**ange - **M**edium
LC_{50}	**L**ethal **C**oncentration for **50**% of the test animals
LOAEC	**L**owest **O**bservable **A**dverse **E**ffect **C**oncentration
MOEE	**M**inistry of **E**nvironment and **E**nergy (Ontario)
MPC	**M**aximum **P**ermissible **C**oncentration
NOAA	**N**ational **O**ceanographic and **A**tmospheric **A**dministration
NOAEC	**N**o **O**bservable **A**dverse **E**ffect **C**oncentration
NPER	**N**o **P**otential **E**ffects **R**ange
ORNL	**O**ak **R**idge **N**ational **L**aboratory
PNEC	**P**redicted **N**o **E**ffect **C**oncentration
QSAR	**Q**uantitative **S**tructure **A**ctivity **R**elationship
SETAC	**S**ociety of **E**nvironmental **T**oxicology and **C**hemistry
TEC	**T**hreshold **E**ffects **C**oncentration
USEPA	**U**nited **S**tates **E**nvironmental **P**rotection **A**gency

GLOSSARY

Acute Toxicity: A short-term exposure to a contaminant in a medium and usually at concentrations high enough to induce an effect rapidly.[1]

Assessment Factors: A number applied to the toxicity value of a chemical in a situation with little data to provide an assumed safe value in the ecosystem. Also called: application factors, uncertainty factors, or safety factors.

Background Concentration: A representative ambient level for a chemical in soil or water.[1]

Benchmark Values: Concentrations related to thresholds sometimes used in Risk Quotients.

Bioaccumulation: Defined by the USEPA to be terrestrial rates of uptake of contaminants from the environment.

Bioconcentration Factor (BCF): The ratio of the chemical concentration in an organisms to the concentration in the media. However, the USEPA defines bioconcentration as only a concentration of chemical absorbed through gills from an aquatic environment.

Biomagnification: As tissue concentrations of accumulated chemical compounds are passed up trophic levels, the tissue residue concentrations increase systematically as trophic level increases.[1]

Chronic Continuous Criterion: A USEPA water quality value that is the highest concentration of a pollutant that can be continuously maintained in a water body without unacceptably affecting aquatic organisms or beneficial uses.

Chronic Maximum Concentration: A value for the USEPA that my be exceeded for a few hours once every three years, set at half of the Final Acute Value.

Chronic Toxicity: Long-term exposure (weeks to years) to a contaminant in a medium, often includes reproduction or the full life cycle of the organism.[1]

Cofauna: Australian term for animals not directly associated with an area of contamination, but may be affected by impact (i.e., indirect effects) or by offsite migration of the contaminant.

[1] Adapted from CCME 1996(a)

Criteria: Concentrations of contaminants in environmental media that may not be exceeded; legally enforceable and subject to fine or other regulatory action should exceedences occur.

Critical Limits: A threshold value where harmful effects occur used in RIVM (The Netherlands) Guidelines. Also called: Maximum Permissible Concentration or Maximum Allowable Concentration.

Critical Loads: A threshold amount of material that can be present without causing harm to terrestrial organisms within the context of the specific soil chemistry that is used in RIVM (The Netherlands) Guidelines.

Ecological Soil Screening Level (Eco-SSL): Soil concentrations protective of terrestrial organisms; unacceptable adverse effects should not occur to ecological receptors at or below this value. Also called: critical loads, precautionary soil values, or soil quality objectives.

Ecotox Thresholds: A screening value set by the USEPA Superfund to determine if a risk assessment is necessary at a particular site.

Effect Concentration (EC_x): The concentration of a chemical in the medium that results in some *sublethal effect* to x% of the test organisms.[1]

Effects Range- High (ER-H): NOAA's definition of the sediment concentration above, which effects are always seen and below which they sometimes occur.

Effects Range- Low (ER-L): The 10^{th} percentile of the distribution of toxic effects (LOAEC values) thresholds for organisms in soil. The USEPA defines it as the sediment concentration below which measured effects have never been seen and above which measured effects are sometimes seen.

Effects Range- Median (ER-M): The midpoint between the ER-H and the ER-L.

Environmental Impact Level (EIL): Australia's level for protecting ecological values. It is the concentration of a contaminant that does not cause an adverse effect on specified biota.

Epifauna: Australian term for animals that live in general contact with soil.

Equilibrium Partitioning Theory: The relationship between the concentration of a substance bound to the soil particles and the concentration in soil solution when the system is at equilibrium.

Final Acute Value: Acute water quality criteria developed by the USEPA for a group of organisms. Using the mean data from available genus and species tests, the 5th percentile of the lowest four values is calculated.

Infauna: Australian term for fauna that live within and in contact with soil.

Intervention Values: A soil concentration defined in The Netherlands as a level indicating serious contamination and requiring immediate remediation.

Lethal Concentration (LC_x): The concentration of chemical in the medium that results in *mortality* to x% of the test organisms.[1]

Lowest Effect Level: The State of New York's level of contamination that can be tolerated by the majority of organisms, but still causes a toxicity to a few species.

Lowest Observable Adverse Effect Concentration (LOAEC): The lowest concentration of a chemical used in a toxicity test that has a statistically adverse effect on test organisms relative to a control.[1]

Matrix Standard: A standard developed by British Columbia for substances with a larger database with separate numbers for human health and ecological receptors.

No Observable Adverse Effect Concentration (NOAEC): The highest concentration of a contaminant used in a toxicity test that has no statistically adverse effect on the exposed population of test organisms relative to a control.[1]

No Potential Effects Range (NPER): A Canadian point estimate in the distribution of LOAEC/NOAEC and EC_{50}/LC_{50} below which the proportion of definitive effects data does not exceed "acceptable levels."

Numerical Soil Standard: Standards developed by British Columbia for each land use category for substances with a limited toxicity database, intended to be protective of both human health and ecological receptors.

Precautionary Soil Value: The German term for the soil concentration above which the responsible party has to reduce or avoid future input of these substances onto the site or in the vicinity of the site.

Predicted No Effect Concentration (PNEC): The European value or the concentration below which unacceptable effects on organisms will most likely not occur. This is derived from the No Observable Effect Concentration.

Preliminary Soil Quality Guidelines: Canadian developed generic numerical concentrations of a contaminant considered safe for a broad range of conditions and regions.

Quantitative Structure Activity Relationship (QSAR): A prediction of how a molecule will react in and effect the environment based on its molecular structure.

Severe Effect Level: The State of New York's level of contamination at which pronounced disturbance of the sediment community can be expected.

Soil Protection Value: A general term used in this report to encompass all soil concentration values derived to protect all or part of the terrestrial system from unacceptable effects due to contamination. It includes screening level values, criteria, and clean-up target levels.

Soil Quality Remediation Objectives: Canadian developed numerical concentrations selected or derived to define acceptable residual contamination at a specific site.

Target Values: Clean-up goals.

Threshold Effects Concentration (TEC): The concentration of a chemical below which no adverse effect is expected to occur.

1. INTRODUCTION

Many jurisdictions around the world have begun developing Soil Protection Values (SPVs), variously known as "critical loads," "precautionary soil values," "soil criteria," ecological soil screening levels, or "soil quality objectives." These soil concentrations (based on total recoverable concentrations of chemical measured from bulk soils) are to be protective for terrestrial organisms. At the SPV or below, there is no reason to believe that adverse effects will occur to ecological receptors. At concentrations above the SPV, there may be adverse effects depending upon local conditions. Soil Protection Values are used to screen potentially contaminated sites for priority pollutants or, in some countries, as clean up goals or targets for allowable discharge rates. In screening sites, substances with concentrations below the particular SPV would be eliminated from further consideration, allowing the site-specific ecological risk assessment to focus only on those substances that may cause adverse effects.

Development of SPVs is a two-step process. The first is a data gathering and qualification exercise. Typically, this involves search of the peer reviewed and government literature on toxicological response and exposure relationships for terrestrial plants and animals. This is followed by a quality control screen to select only those studies that meet relatively stringent criteria for inclusion in the final database. This type of quality control screen is followed for all regulatory criteria development (e.g., water quality criteria, human health reference doses), as most of the studies reported in the literature were conducted with other objectives in mind. It therefore is necessary to screen such work carefully to find only those that are applicable to the regulatory effort, as well as those that embody sound, quality scientific approaches.

The next step in the SPV development process is determining how to use the retrieved data to set the final value. Differences in measurement endpoints and species sensitivity, as well as in test design and laboratory practices result in relatively large variability in reported toxicity threshold values. How all these values are integrated into final SPV is of great importance. The final value is intended to be protective of terrestrial species and critical ecological functions, but must also be reasonable and not so low that even at trivial concentrations (i.e., well below biological effects thresholds) no chemical is ever screened out from further risk analysis. Certainly, values for metals should not be significantly below natural background levels. Those metals that are essential micronutrients need to be present at minimal levels to sustain plants and invertebrate communities and microbial functions. Acceptable levels of either natural or

synthetic organic substances must account for organismal mechanisms that protect against toxic insults as well as acknowledging the assimilative capacity of ecological systems.

Development of SPVs requires a review of the toxicology literature. Soil concentrations related to toxicity effects are used to set a soil concentration that will be protective of terrestrial species. In setting SPVs, regulatory agencies generally will err on the side of protection while not being unreasonably lower than known biological response levels. Achieving this balance between what is protective and reasonable has been the subject of much debate in many countries as SPVs are being developed. A blend of toxicology and ecology, as well as public interest and policies regarding species protection are required to attain protectiveness and reasonableness. In the United States, this means that the single screening value must be protective across such diverse regions as the New England forests, Rocky Mountain forests, Central Plains grasslands, and Great Basin desert scrublands.

Countries that currently are developing SPVs would benefit greatly from a critical review of the approaches used by other jurisdictions, with a particular emphasis on understanding where a scientific understanding of ecotoxicological principles can provide guidance and where regulatory policy should take precedence. This will enable regulatory agencies to build on what has been learned from the work by other jurisdictions. This report reviews all the approaches currently in use for establishing SPVs. It includes as well a review of water and sediment criteria development (as practiced in the U.S.) as these processes have addressed the same issues currently confronting soil evaluations. Final sections critically review some of the common issues associated with criteria development and highlight where particular approaches have had difficulty.

1.1. INFORMATION SOURCES

The U.S. Environmental Protection Agency has tabulated information on SPVs methods used by other jurisdictions as it began to develop Ecological Soil Screening Levels (EcoSSLs) for use in the Superfund program. The information was prepared by DynCorp and submitted to the USEPA on 16 March 1998 (DynCorp, 1998). The DynCorp report did not include information from European countries or Australia and, for many of the jurisdictions, it lacked information about methods used to calculate the soil values once the toxicity data have been retrieved. Information from Europe and Australia have been included in this report and have focused on

the methods to convert toxicity data to soil criteria (Table 1-1). Where sufficient information was provided by DynCorp, it has been abstracted and incorporated into this report.

Table 1-1. Documents and other information sources reviewed

Technical guidance documents

Australian Environmental Protection Authority
(Environmental Australia, 1997)

British Columbia Ministry of Environment, Lands and Parks
(BCME 1995)

Canadian Council of Ministers of the Environment
(CCME 1996a) -- Protocol for the derivation of environmental and human health soil quality guidelines
(CCME 1996b) - Guidance manual for developing site-specific soil quality remediation objectives for contaminated sites in Canada

European Commission
(EC 1996)

Netherlands Ministry of Housing, Spatial Planning, and the Environment
(De Vries and Bakker, 1998)

Oak Ridge National Laboratory
(Efroymson *et al.*, 1997a,b; Sample *et al.*, 1996).

Washington River Site
(WSRS 1998)

DiToro *et al.* (1991)

Long and Morgan (1991)

Stephan *et al.*, (1985)

Review articles

Beyer, N. (1990)

Cowan *et al.*, (1995)

Kimerle *et al.*, (1995)

Internet

http://ci.mond.org/9513/951306.html

Other

personal discussions between the authors and scientists involved in regulatory agencies in Germany, Denmark, Belgium, and Spain
(personal communications 1999 at SETAC Pellston workshop on Hazard Assessment of Metals in Soil, San Lorenzo de El Escorial, Spain).

ECO Update bulletin (USEPA, 1989).

2. APPROACHES FOR ECO-SSL DEVELOPMENT

Derivation of criteria for protection of organisms against potential adverse effects of chemical exposure requires information about the concentration-response relationship (i.e., hazard) in media representative of that found in the natural environment. Additional information about the relative sensitivity of species is required, to select a concentration that is "protective" of all (or most) species. Thus, all criteria setting, whether in water, sediment, or soil, follows the same basic principles: develop a dataset of hazard information and then apply some extrapolation method to determine the "safe" value (Kimerle *et al.*, 1995).

Ideally, hazard information would be available for *all* species, thus allowing an accurate determination of the toxicity threshold, (i.e., that concentration below which effects never occur in any species and above which effects sometimes occur in one or more species). However, this can never be achieved, given the thousands of currently extant species. Therefore, tests are performed on a range of representative species and extrapolations are made to account for differences in species sensitivity. In aquatic and human toxicology, these extrapolations to non-tested species may be based on scientific knowledge of chemical-organism relationships through the use of comparative physiology and Quantitative Structure Activity Relationships (QSARs) (Enslein, 1988; Zeeman, 1995). However, QSARs for terrestrial organisms have not been developed. Therefore, determination of the range of species sensitivity becomes more difficult and derivation of a "safe" concentration may rely more on policy than science through the application of "assessment" or "safety factors" when there are very few data [but see Chapman *et al.* (1998) for a discussion of the drawbacks to this approach]. When more data are available, alternative approaches are used. These include using geometric mean toxicity values within or among trophic levels, or arranging the toxicity values in a frequency distribution and selecting a pre-specified lower percentile (Kimerle *et al.*, 1995).

Wildlife soil criteria have been particularly problematic, as these animals generally have limited direct exposure to soil. Toxicological relationships are expressed in terms of dietary exposures, followed by a variety of methods to estimate a corresponding soil concentration. Many jurisdictions discussed below have chosen to leave out wildlife, focusing only on the soil infauna, to set soil criteria. Others have not set generic wildlife standards, but have chosen instead to derive values for individual species. These will be discussed in detail when describing methods for the respective jurisdictions.

While each of the jurisdictions described below differ to some degree in how the final soil values are derived, they all share a common struggle to use data that were not produced under standardized systems and in many cases, not intended for this purpose. They have grappled with issues arising from lack of information on some organism groups, and of desiring a value that is protective and reasonable. The following sections review each of the approaches currently in use. The intended use or purpose for developing the method (e.g., contaminated site clean up levels, discharge allocations, etc.) is provided. Terminology is explained and summarized in the Glossary (page viii), as each jurisdiction refers to the soil values differently. Issues associated with the various methods are critiqued in Section 4 of this report. Summary tables of the various approaches currently in use are provided in Appendix A.

2.1. EUROPEAN

The methods described here are contained in the European Community Technical Guidance Document for Environmental Risk Assessment (European Community, 1996). These methods have been used to derive Probable No Effect Concentrations (PNECs) values for local, regional, and continental scale risk assessments for substances in commerce (e.g., metals, plasticizers) as well as for derivation of critical loads of pollutants (particularly metals) in soils. The Netherlands provided extended discussions on the derivations of PNECs and soil values (De Vries and Bakker, 1998), and uses these numbers for ecological risk assessment (generic and site-specific), identification of seriously contaminated sites requiring intervention and target values for regulation for discharges (Ministry of Housing Spatial Planning and Environment, 1994; Soil Protection Act, 1998). Germany currently has no Federal legislation for contaminated soil issues, so each state is responsible for preparing their own values although there is no formal written documentation for how this is to be done. Bachmann *et al.* (1997) of the German Federal Environmental Agency, Section on Soil Protection compiled the available information for discussion at a European Community workshop. The German approach is conceptually similar to that used by The Netherlands and other European Community countries. Denmark also has been working to develop soil assessment and clean-up values for contaminated sites, but still has no formal documentation. Great Britain has documentation on allowable amounts of contaminants for sludge applications, but no similar documents for contaminated sites.

The information described here is the general approach followed by all the European Community countries, as embodied in the Technical Guidance document and further described by The Netherlands. The only major difference among countries is whether they have different

intervention and target values and whether or not different values are used depending upon land use (Table 2-1). For the Netherlands, "intervention values" are indicative of seriously contaminated sites that require immediate clean-up action. "Target values" are protective levels intended to achieve desired soil quality. Land use is defined as industrial, residential, agricultural, or natural lands, requiring more protective (i.e., lower) values in the order listed.

Table 2-1. Contaminated sites soil criteria in Europe

Criteria levels	Land use dependent	Land use independent
Single value	Denmark	Germany (draft) Norway Sweden United Kingdom
Two values	Switzerland The Netherlands	Belgium Finland France

The Netherlands has developed methods for deriving *critical loads* of metals and persistent organic pollutants in soils, which is defined as the amount of material that can be present without causing harm to terrestrial organisms within the context of the specific soil chemistry (e.g., pH, organic matter, and cation exchange capacity). This includes derivation of *critical limits* of exposure for the organisms, which is the value where "unacceptable harmful effects" (De Vries and Bakker, 1998) occurs. This also is called the Maximum Permissible Concentration or the Maximum Allowable Concentration.

Germany uses the term *precautionary soil values* to denote the soil concentration above which the responsible party has to reduce or avoid future input of these substances onto the site or in the vicinity of the site (Bachmann *et al.*, 1997). Site-specific permits may allow additional input of substances, but no guidance has been provided on how the annual allowable loading will be calculated.

Austria, Belgium, and Switzerland have developed laws and regulations for dealing with contaminated sites and soil protection. France, Norway, Finland, Denmark, and the United Kingdom have general pollution regulations that cover issues related to soil protection, but

currently do not have contaminated lands legislation. These countries have, or are developing, *soil quality criteria* that can be used as guidelines for site-specific risk assessments.

The soil values developed by the Europeans are validated to some extent, particularly for metals. De Vries and Bakker (1998) includes an uncertainty analysis in the guidance for calculating critical soil loads, including a sensitivity analysis of which parameters contribute the most uncertainty to the final soil value. All jurisdictions recognize the concept of "natural background" levels for metals, but disagree on how these are defined. This concept is discussed further in Section 4 of this report.

The following sections describe three methods used by the European Community for deriving soil values, depending upon how much toxicity data are available. The distribution method is the preferred method, but can only be used with robust data sets. If fewer toxicity data are available, the factor method is used. If no toxicity data are available form terrestrial organisms, a proposal has been made to use the Equilibrium Partitioning method where information from aquatic studies, extrapolated to soil systems through pore water analysis. The numbers generated by these methods have, so far, relied only on toxicity data from soil organisms; wildlife information has not been included. However, the approach suggested by The Netherlands for deriving wildlife values also is reviewed. Regardless of the method used, a single number is derived that is meant to be protective of all organisms in the terrestrial ecosystem.

2.1.1. Distribution Based Method

This method has been used when there are an acceptable number of reported toxicity threshold values (i.e., four or more values), representing a wide spectrum of genera. It is assumed that the varying sensitivities of soil organisms follow a predictable statistical distribution with most genera having approximately the same sensitivity and fewer being more sensitive or less sensitive. The frequency distribution of species (or genera) sensitivities generally is assumed to follow a log-normal distribution (Figure 2-1). The 5^{th} percentile (i.e., low end) of the toxicity threshold values is then estimated and is used as the final criterion value (Van Straalen and Denneman, 1989; Wagner and Løkke, 1991).

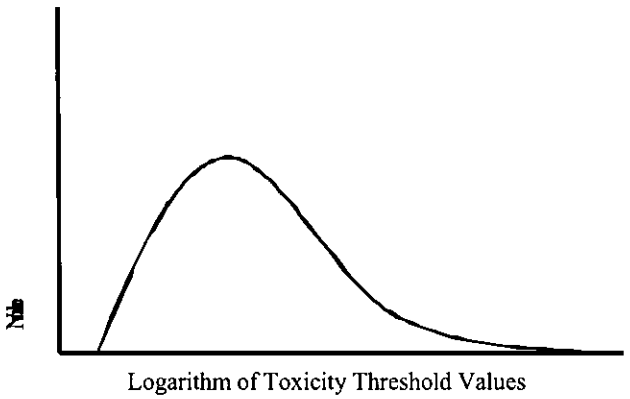

Figure 2-1. Frequency distribution of toxicity threshold (hypothetical).

2.1.2. Factor Application Method

The Factor Applications Method is used when there is little information available about the hazard of the chemical of concern to terrestrial organisms. It generally is applied if the data set is small (fewer than four studies) or when only acute data are available. Acute toxicity data, arise from short-term ecotoxicological experiments (defined by the European Union as less than one day in duration) and generally are expressed as an LC_{50} (lethal concentration for 50% of the test animals), but also may be a non-lethal response at the 50% or lower level. The lowest reported value is chosen, and then assessment factors (also known as "application factors," "uncertainty factors," or "safety factors") are applied. Generally, this entails dividing the toxicity value by 100 or 1,000 (Table 2-2). If chronic data (from studies one day to one month in duration) are available, but the number of tests or genera represented are still small, the lowest value is selected and divided by ten (Table 2-2). Chronic data are reported as the No Observable Adverse Effect Concentration (NOAEC). Note that the lowest reported toxicity number always is divided by at least ten. This is to account for uncertainties in the data, potential for additive or synergistic interactions among chemicals occurring in the environment, unknown differences in species sensitivity that may not be captured in the existing data set, and differences in laboratory methods as well as lab-to-field extrapolations. Data also are adjusted to standardize pH and organic matter according to algorithms developed from background conditions of uncontaminated sites (Table 2-2).

Table 2–2. Assessment factors for determination of soil quality criteria (Europe)

Information available	Assessment Factor
Only acute LC_{50} data are available and the data set is small or represents only a few genera (<3)	1,000
Only acute LC_{50} data are available, but there is an extensive phylogenetic range represented (≥3)	100
Chronic test data are available but from a limited data set (<4)	10

2.1.3. Equilibrium Partitioning Method

For the equilibrium partitioning method, the assumption is made that toxicity to soil organisms is due to the amount of chemical in the soil pore water (for metals, this would be the free ion activity in the pore water). Thus, The Netherlands would prefer to set allowable amounts of chemicals in the soil as equivalent to the amount that would move into the pore water plus the amount that remains bound to soil particles. They propose that critical soil values can be set based on toxicity to standard aquatic organisms (daphnia and algae) and an estimation of soil pore water concentration using equilibrium partitioning theory (assuming reversible adsorption processes that can be described by linear sorption isotherms). The critical soil concentration is determined by multiplying the aquatic toxicity threshold value by the linear partition coefficient.

2.1.4. Wildlife

In general, vertebrate wildlife are not considered by European countries when setting soil criteria. However, The Netherlands provides directives for both a general and a food chain-specific method for calculating critical soil levels for the protection of wildlife from bioaccumulative contaminants. This is derived as:

$$MPC_{soil} = \frac{NOAEC_{wildlife}}{BCF_{food}}$$

(Equation 2-1)

Where:

MPC_{soil} = maximum permissible concentration of a chemical in dry soil (mg/kg)

$NOAEC_{wildlife}$ = No observable adverse effect concentration for either all wildlife (derived by the extrapolation method described above) or species of concern

BCF_{food} = bioconcentration factor representing the ratio between the concentration in the food (wet weight) and the concentration in the soil (dry weight).

Up to three BCFs can be concatenated to determine the exposure to a particular trophic level of wildlife (soil to plants or invertebrates, then to birds or mammals, and then to predators). The Netherlands used field collected data to determine BCFs empirically for the wildlife food chain, applying a Monte Carlo analysis of all BCF data for each trophic level and selecting the 95th percentile (i.e., a high BCF to develop a conservative estimate). Species-specific food chains can be derived as well following this same model.

2.2. CANADIAN

2.2.1. Canadian Council of Ministers of the Environment

The Canadian Council of Ministers of the Environment (CCME) provides guidance for deriving *preliminary soil quality guidelines* (CCME, 1996a) and site specific *soil quality remediation objectives* (CCME, 1996b) for use in assessing risk at contaminated sites, clean-up goals, and monitoring remediation efforts. The recommended approaches were based (at least in part) from a review prepared by MacDonald and Sobolewski (1993) for CCME of approaches existing at that time. The guiding principle under which CCME operated in developing the soil numbers was to "provide a healthy functioning ecosystem capable of sustaining the current and likely future uses of the site by ecological receptors and humans." (CCME, 1996a). The CCME further describes the basis for their approach (CCME, 1996b) as needing to be practical, applicable to the objectives of the contaminated site program, and scientifically defensible. They listed 14 additional guiding principles for the derivation of site-specific soil remediation objectives (Appendix B) and conducted an uncertainty and sensitivity analysis of all the input parameters (CCME, 1996a).

Soil quality guidelines and remediation goals for receptors in direct contact with the soil (i.e., plants and invertebrates) are derived using one of several approaches, depending upon the quantity and type of toxicological data available and the specified land use. A single value is derived for each chemical under each land use that is assumed to be protective of all soil organisms, based on the lowest value derived for invertebrates, wildlife, and microorganisms (see Section 2.2.1.6 for details). Land use categories (listed here from most to least protective) are: agricultural lands, residential/parkland, commercial land, and industrial land. Differences in

protection levels result from consideration of different receptors and different exposure pathways.

Ambient background levels of contaminants may be higher than the effects-based derived generic soil quality guidelines. In this instance, the CCME recognizes that background levels will take precedence over the derived values. Therefore, the final clean-up criterion will be the derived value or background, whichever is the highest. Background levels are based on regional or provincial limits and may be determined on a site-specific basis.

2.2.1.1. Weight of Evidence Approach

The Canadians prefer the "weight-of-evidence" approach where sufficient numbers of chronic studies are conducted from which Lowest Observable Adverse Effect Concentrations (LOAECs) and NOAECs have been derived. Studies that calculated EC_{50} or LC_{50} values also are included in this data set. The data set then is examined to determine if it is biased by excessive numbers of NOAEC or LOAEC values or if EC_{50} or LC_{50} values predominate. If one or the other type of study is over-represented, then this approach would not be used (determination of "over-represented" is based on "expert judgment"). If the data set is balanced, the 25^{th} percentile of the frequency distribution is calculated and assumed to represent the "No Potential Effects Range" (NPER). The Threshold Effects Concentration (TEC) is then derived by dividing the NPER by an uncertainty factor between 1 and 5 (Table 2-3). An uncertainty factor need not always be applied and the magnitude of any factor used is left to expert judgment.

Table 2-3. Uncertainty factors for determination of soil quality criteria using the weight of evidence approach (Canada)

Information available	Suggested Uncertainty Factor
Only the minimum of 3 studies is available	5
> 3 studies are available, but <3 taxonomic groups are represented	3
> 25% of the data below the 25^{th} percentile are definitive effects data (i.e., not LOAECs)	1

2.2.1.2. Lowest Observed Effect Concentration Method

When there are insufficient data to apply the weight of evidence method, the TEC is derived by dividing the lowest available LOAEC by an uncertainty factor. A minimum of three studies including at least one terrestrial plant and one soil invertebrate study must be available for

application of this approach. The uncertainty factor is again between 1 and 5, dependent upon expert judgement (Table 2-4).

Table 2-4. Uncertainty factors for determination of soil quality criteria using the LOAEC method (Canada)

Information available	Suggested Uncertainty Factor
The LOAEC is "biologically significant" and not just statistically different from controls	1
The LOAEC is taken from an acute study	3
Only 3 studies were available and/or <3 taxonomic groups are represented	5

2.2.1.3. Median Effects Method

If only acute toxicity study data are available (EC_{50} or LC_{50} data), then neither of the above methods can be used. In this case, the TEC is estimated using the Median Effects Method. Here, the TEC is the lowest reported EC_{50} or LC_{50}, divided by an uncertainty factor. A minimum of three studies is required, including one terrestrial plant and one soil invertebrate study. If the lowest datum is an EC_{50} value, the uncertainty factor of five should be used. If the lowest datum is an LC_{50}, then an uncertainty factor of ten should be applied. An additional uncertainty factor between one and five may be applied if the factors listed in Table 2-4 are incurred as well. The use of uncertainty factors of five and ten applied to the EC_{50} and LC_{50} data, respectively, were selected after examination of acute versus chronic (NOAEC) data for 38 inorganic and organic contaminants for soil-dependent organisms.

2.2.1.4. Microbial Processes

Effect threshold concentrations for microbial processes (nutrient and energy cycling) are calculated in parallel with determination of the TEC for plants and soil invertebrates. Data on effects of chemicals on nitrification and denitrification are gathered and a TEC for microbial processes is derived by one of the above methods. If insufficient data are available, then decomposition, soil respiration, and nitrogen mineralization rate data are gathered as well, and the TEC derivation process is followed as above. If the minimum number of data sets are not available, no value is generated.

2.2.1.5. Wildlife

Critical values for wildlife are limited to those related to soil and food ingestion and further limited to herbivorous animals (using a livestock model). A minimum of three studies is required, one of which must be an oral mammalian study, and one must be an oral avian study. Only one laboratory rodent study may be used to fulfill the data requirements for mammalian species. The daily threshold effect dose is estimated using the lowest reported LOAEL divided by an uncertainty factor between one and five (Table 2-4). This value is converted to a soil concentration using the body weight, food ingestion rate, and soil ingestion rate of the species from which the LOAEL was determined. Bioconcentration factors (BCFs) are derived from the literature using "best professional judgement," with no guidance provided for how to select among the available BCFs or which one(s) to use in the final calculation. Additionally, it is assumed that 20% of the animal's estimated daily intake is from water, and apportionment of exposure estimates are made accordingly.

2.2.1.6. Final Soil Criteria

Once the TEC has been derived, it is compared with microbial process data (nutrient and energy cycling) and wildlife data. For agricultural lands, the lowest of the TEC, the microbial value, or the wildlife value is used as the criteria. For residential and park lands, the lowest of the TEC or the microbial values is used. For commercial and industrial land use, the TEC is used if it is below the microbial value. If the microbial value is lower, then the geometric mean of the microbial value and the TEC is calculated and used as the final criterion.

2.2.2. British Columbia

British Columbia also derives separate soil standards for soil organisms (plants and invertebrates), microbial functions, and livestock for five categories of land use (the same uses as defined by CCME, but residential and urban parklands are in separate categories). Single generic *numerical soil standard* are developed for each land use category for substances with a limited toxicity database. These standards are intended to be protective of both human health and environmental receptors. *Matrix standards* are provided for substances with a larger amount of data. For these, separate numbers are generated for human health (one based on contaminated soil intake and another based on protection of groundwater for drinking) and ecological receptors (soil invertebrates, plants, livestock, and microbial functions). The lowest matrix standard is used for purposes of defining a contaminated site or establishing remediation

goals. The contaminated sites regulations state that clean-up below background will not be required for metals or other naturally occurring substances. Background levels may be determined on site-specific basis with approval of the protocol for doing so given by the Director of the Ministry of Environment, Lands, and Parks. Furthermore, for the few cases where the toxicologically-based standards are below current analytical detection limits, the value will be raised to the detection limit. Should better analytical chemistry techniques become available in the future, the standard may be lowered to the toxicologically-derived value.

2.2.2.1. Soil organisms

For soil organisms (plants and invertebrates) or microbial functions, all acceptable toxicity data are examined. Data are sorted into two data sets of either lethality endpoints (LCx values) or non-lethal endpoints (ECx values). Studies that report NOAEC or LOAEC values are used only if sufficient data are reported in the study for calculation of an ECx or LCx value. Within the lethal and non-lethal data sets, if multiple studies exist that report the same percent response (e.g., an LC_{50}), then the concentration causing that response is averaged to obtain a single value. For the non-lethal data, these responses represent a variety of measured endpoints, although reproduction studies are preferred. These revised data sets (one for lethality studies and one for the non-lethal endpoints) are then used to calculate the regression line representing the soil concentration as a function of the reported percent response (Figure 2-2). The predicted soil concentration where a 50% non-lethal response (EC_{50}) or a 20% lethal response (LC_{20}) occurs is then determined from the regression lines or equations. For Agricultural, Residential, or Park land uses, the lesser of the EC_{50} (non-lethal) or LC_{20} (lethal) soil concentration values is used as the criterion. For Commercial or Industrial land uses, the greater of the EC_{50} (non-lethal) or LC_{20} (lethal) soil concentration values is used. If insufficient data are available for the application of this method, an estimation of the EC_{50} or LC_{20} concentrations is made using best professional judgment (no guidance is provided on what constitutes a "sufficient" data set nor how this determination should be carried out).

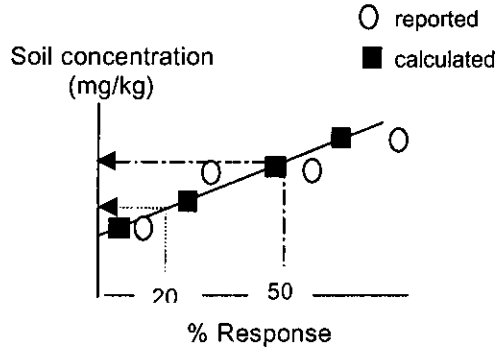

Figure 2-2. Example calculation of effects distribution for derivation of critical soil values by British Columbia

2.2.2.2. Microbial Function

British Columbia has adopted the CCME methods for derivation of criteria protective of soil microbial processes.

2.2.2.3. Wildlife

British Columbia soil matrix standards do not address wildlife. The Agriculture land use standards address livestock exposure through ingestion of soil and fodder. Development of these soil criteria are equivalent to those described above for CCME and European soil criteria.

2.2.3. Ontario

The Ontario Ministry of Environment and Energy (MOEE) has published guidelines containing both generic and site-specific approaches to clean up of contaminated sites (MOEE 1996). These criteria are meant to "protect against adverse effects to human health, ecological health and the natural environment" (MOEE, 1996). The guidance and associated criteria contain both human health and ecological effects information. The single soil criterion for each chemical is the lowest number from human health and ecological effects analyses. Human health criteria are derived from the lowest value from the following exposure routes: dermal exposure, incidental soil ingestion, groundwater contamination, or soil vapor to indoor air. Wildlife are considered for agricultural lands and residential/parklands, but only the herbivore food chain is

evaluated. Unlike CCME and British Columbia, Ontario groups industrial and commercial uses together into a single category of land use. The guideline document (MOEE, 1996) does not describe how Ontario derives ecological effects criteria (other than to state that conservative exposure values are used), but does state that the Netherlands' numbers will be used whenever Ontario does not promulgate a specific number. As in British Columbia, the MOEE provides that soil criteria will be at or above background levels (for naturally occurring substances) or analytical detection limits. Province-wide background levels are published by the MOEE, but site-specific background numbers may be developed with MOEE approval.

2.2.4. Other provinces

None of the other Canadian provinces have developed soil criteria or guidance for contaminated sites, although Alberta is in the process of development of such documentation (personal communication, Ted Nason, Environment Canada,).

2.3. AUSTRALIA

Soil values are developed separately for two multi-exposure pathways: plants plus animals that live within soil (e.g., soil invertebrates, called "infauna" by the Australian EPA) and animals that live above ground having direct soil contact (called "epifauna" by the Australian EPA) plus potentially affected animals impacted indirectly or via off-site movement of contaminants (i.e., "cofauna" as used by the Australian EPA). The lowest of these values is then selected as the *Environmental Impact Level* for soil (EIL_{soil}) (Environment Australia, 1997). The aim of setting an EIL_{soil} is "to protect ecological values." These values include ecological processes, community systems, and populations or biota of particular value. The values and species differ for land uses, which include: residential, urban parkland, commercial, industrial, agricultural, rural parkland, and nature reserves. The EIL_{soil} should be the concentration of a contaminant that may persist in the soil without causing an adverse effect on specified biota. Where assumptions are made in deriving EILs, they should be conservative in nature. The technical guidance document for derivation of $EILs_{soil}$ (Environment Australia, 1997) includes an appendix with criteria for assessing the quality and applicability of ecotoxicological data in the literature for use in the derivation process. For substances with insufficient or low quality toxicity data, EILs should be based on background concentrations or chemical detection limits. Toxicologically-based EILs should not be below the background or detection concentrations. The EIL_{soil} are meant to be used a screening tools for assessing whether or not a site may be considered

contaminated, and are also referred to as *Investigation Levels*. Soils that exceed these levels may require further assessment of actual risk through the derivation of site-specific $EILs_{soil}$.

The Australian method for derivation of EIL_{soil} are part of the *National Framework for Ecological Risk Assessment of Contaminated Sites (Parts B and C).* This document is in draft form, and is available for public review and comment at: *http://www.environment.gov.au/epg/contam/documents.html.* Because the Framework is only in draft form, soil ecological impact levels have not been published at this time.

2.3.1.1. Soil Organisms

The $EIL_{in\ \&\ f}$ (EIL for infauna and flora) is developed by selecting the lowest reported NOAEC from studies of plants or animals that live within the soil. The guidelines go into great detail describing how to evaluate toxicity studies for quality of the data, but very little detail on what to do with the information once it has been retrieved. There is a suggestion that NOAEC data should be used (i.e., from chronic studies), with the lowest reported value selected as the final value. However, this is not stated explicitly, nor are there rules for the application of assessment factors (if any).

2.3.1.2. Wildlife

The Australian approach focuses wildlife protection on a species-specific basis. The overall $EIL_{epi\ \&\ co}$ is obtained by selecting the lowest calculated wildlife value. The process used to determine critical soil values for Australian wildlife is fundamentally the same as that used in Europe (See Wildlife, Page 2-6) although specific guidance is provided for incorporation of exposures from inhalation and drinking water routes. Toxicity data are derived from studies where NOAECs are reported or can be calculated. For derivation of biomagnification factors (equivalent to the BCF), data from studies that pass the quality screen are pooled for each chemical. The "best estimate" for the BCF is the median value while a "conservative estimate" is the upper 95% confidence limit. This designation of "best" and "conservative" estimate applies to any of the input parameters for which a distribution of values is available (e.g., body weight, food ingestion rate, etc.). The lowest reported NOAEC for the species of interest is selected, if available. If not, surrogate species data may be used as well as EC_{50} data or data from acute studies (LC_{50}s), adjusted by assessment factors (Table 2-5).

Table 2-5. Assessment factors for determination of soil quality criteria (Australia)

Information available	Assessment Factor
Acute to chronic extrapolation	1,000
EC_{50} to LOAEL	10
LOAEL to NOAEL	10
Extrapolation across species within a Family	10
Extrapolation across Families within a Class	10
Extrapolation across Classes within a Phylum	10

2.4. OAK RIDGE NATIONAL LABORATORY (ORNL)

Oak Ridge National Laboratory (ORNL) developed a set of soil *benchmark* values for plants, invertebrates, microorganisms, and wildlife for use in their site-specific risk assessments. These values were used as screening values for soils at the Oak Ridge Department of Energy site to determine areas where more ecological risk assessments would be required. If the toxicologically-derived values were below background (as determined for ORNL soils), then background values were used instead. The benchmark values were posted on the Internet and were made available through published documents. These values have been adopted by various states and USEPA Regions in the absence of any alternative values. ORNL has since removed the tabulated information from the Internet, as they recognized the difficulty of maintaining quality control and updating information, although their technical guidance documents (with associated tables of benchmark values) are still available on the ORNL web site.

2.4.1. Microorganisms, Invertebrates and Plants

Soil benchmarks for microorganisms, invertebrates and plants proposed by ORNL were derived using a method similar to that developed by the National Oceanographic and Atmospheric Administration (NOAA) for calculating the Effects Range Low (ER-L) in sediments (Long and Morgan 1991). This approach has been recommended as a sediment screening benchmark by USEPA Region IV. The ER-L is the 10^{th} percentile of the distribution of toxic effects thresholds for organisms in soil, using LOAEC values. If less than ten values were available for a chemical, the lowest LOAEC was used. For studies where a LC_{50} was reported instead of a LOAEC, the concentration was divided by five in the hope of approximating the more sensitive

endpoints of growth and reproduction, prior to inclusion in the LOAEC data set. No other assessment factors are used. Invertebrates are represented only by earthworms; no other species were included in the assessment. The assessment endpoints for microorganisms are related to community function (e.g., carbon mineralization, nitrogen transformation, and enzyme activities). Plant toxicity benchmarks derived by this method for metals generally are lower than those for soil invertebrates or microbial processes, and the reverse is true for organic compounds.

2.4.2. Wildlife

ORNL did not develop single soil criteria protective of all wildlife for each chemical. Rather, they developed animal-specific benchmark concentrations in a manner similar to that used by the Australians. In the event that a single mammalian or single avian soil benchmark value is needed for site screening purposes, ORNL uses the short-tailed shrew (*Blarina brevicauda*) and the American woodcock (*Philohela minor)* as representative species, respectively.

ORNL differs from the Australian approach by looking for the single best study that represented chronic effects (preferably reproductive endpoints) in a species as closely related to the species of interest as possible, rather than using all acceptable toxicity study data from any species and selecting the lowest value. Only mammalian studies were used to represent mammalian wildlife and only avian studies were used for birds. However, the same study often was used to model all birds (or all mammals), so differences in soil benchmarks became a function only of the exposure factors (food consumption rates, body weights, dietary BCFs, etc.). Furthermore, ORNL extrapolated among species using dose on a mg/kg-body weight (BW) basis, with the body weight modified to reflect differences in metabolic rates. Because the initial assumption that dose differences are related to metabolic rates expressed as $(BW)^{0.75}$ has since been proven to not be a universal characteristic of all species and chemicals, ORNL has realized that their wildlife benchmarks may not have been calculated correctly (personal communication, B. Sample). ORNL has not published revised values, however, as the appropriate algorithm has not been determined. Most other jurisdictions that develop species-specific wildlife benchmarks (e.g., CCME, Australia) have followed the ORNL approach to cross-species extrapolations and so suffer from the same inaccuracies.

2.5. SAVANNAH RIVER SITE

The Savannah River Site is another Department of Energy facility faced with environmental contamination issues. To support the preparation of ecological risk assessments at the Savannah River Site, Friday (1998) compiled ecological screening values for soil, sediment, and surface water. The report explicitly states that the screening values are "inappropriate for setting remedial action cleanup levels." The recommended soil screening levels, which were reviewed and adopted by the U.S. Environmental Protection Agency Region IV (http://www.epa.gov/region4/wastepgs/oftecser/epatab4.pdf), were selected from benchmarks published by the U.S. Fish and Wildlife Service (Beyer 1990), Oak Ridge National Laboratory (Efroymson et al. 1997a, b), Canadian Council of Ministers of the Environment (CCME 1997), and The Netherlands (MHSPE 1994, Crommentuijn et al. 1997). Generally, the most conservative and recently published value cited in these references was recommended as the ecological soil screening value. Dutch values comprised 60% of the recommended values; ORNL values comprised 38% whereas Canadian values comprised 2%. The report states that "no attempt is made to endorse a source or to evaluate the derivation process," thus implying that no validation procedure took place. Unless the recommended values are to be used to support a preliminary ecological screening assessment, the investigator must ultimately determine which values are most appropriate

2.6. U.S. FISH AND WILDLIFE SERVICE

In 1990, the U.S. Fish and Wildlife Service published a compilation of the soil screening level values available at that time (Beyer, 1990). There was little to no information provided about how the various numbers were chosen; rather, the reader is referred to the original guidance documents for further details. Summaries are provided from ten jurisdictions, including two states (New Jersey and California) whose numbers were developed for groundwater protection. Canada, and both the Federal and provincial levels, had five different sets of numbers. The remaining three sets of values were from Japan (although these numbers were developed for human health purposes only), The Netherlands, and the former Soviet Union. All of the ecological values, with the exception of the former Soviet Union, have been superceded by the newer methods described in the above sections of this report.

2.7. STATES AND PROVINCES

DynCorp (1998) surveyed the various U.S. states to determine which ones have generic soil screening benchmarks for ecological receptors. Washington, Texas, and Delaware have adopted the ORNL values for use at the state level. Texas, however, is re-evaluating the ORNL benchmarks as they may not be as conservative as the state would like. Many other states have developed guidance for conducting site-specific ecological risk assessments, without including any specific soil benchmarks. For example, Michigan states that "the published literature ... is not of sufficient quality to allow a clear-cut, quantitative approach in developing criteria" for aesthetics, terrestrial flora, fauna, food chain or other impacts (Michigan DEQ, 1998). The Michigan state guidance goes on to say that statewide, regional, or site-specific soil background levels will become default cleanup criteria where applicable risk-based criteria are lower than the background level.

2.8. USEPA

In January 1996, the USEPA Superfund program published an issue of the *Eco Update* bulletin devoted to *Ecotox Thresholds*. This discussed the use of thresholds to screen soil, sediment, or water chemical concentrations to determine if a risk assessment would be necessary at a particular site. Methods for calculating the Ecotox Thresholds are given for water (Ambient Water Quality Criteria) and sediment (USEPA's Sediment Quality Criteria). For soil, they state that "Methods to address toxicity in soils have not been sufficiently developed... The Superfund program is currently evaluating options in this area..."

USEPA Region IV provides guidance suggesting that soil screening values can be submitted by investigators based on information about potential direct toxicity to soil invertebrates and plants. For those contaminants that biomagnify, Region IV suggests that soil values can be determined by back-calculations from acceptable levels in prey items through two trophic levels to the soil. Furthermore, Region IV disallows the use of area or regional background levels, preferring instead to develop screening level concentrations based on data showing associations with "ecological" effects. Published soil screening level criteria available from Region IV are derived directly from the Westinghouse Savannah River Site documentation.

None of the other EPA regions have published soil values or guidance for their use in screening ecological risks at sites although internally Region VIII, for example, has applied soil screening levels at Superfund sites (personal communication, Gerry Henningsen). Region IX has

Preliminary Remediation Goals, but these were developed for human health assessments only. The other regions had no available guidance posted on their web sites.

2.9. USEPA WATER QUALITY CRITERIA

Although water quality criteria are not applicable to the derivation of soil criteria, it is instructive to examine how the USEPA develops water quality criteria. Once toxicity threshold information is generated for appropriate species in a particular media, the derivation process to set the final criterion value could be similar for water, soil, and sediment. The final goal of protection while being reasonable is the same in all media. How this is achieved is mostly a matter of policy rather than scientific rigor.

Development of a water quality criterion requires at least eight acute toxicity tests (LC_{50} values), including animal species from eight different families, as well as three animal chronic tests (one fish, one invertebrate, and one additional species), one algal test, and one test to determine the BCF (Stephen *et al.*, 1985). Nearly all the water quality criteria are based on studies conducted specifically for the purposes of criteria setting, following standard protocols. Nevertheless, even these studies are subject to data quality review. If more than one result is available for any species, the geometric mean value is calculated. This value can then be used to calculate a Species Mean Acute Value in the same manner as the Genus Mean Acute Value is calculated as described when more than one species in a genus were tested.

The Genus (or Species) Mean Acute Values for each group of organisms tested are plotted to determine the four lowest values. These four values are used to calculate the 5^{th} percentile. A triangular distribution is used to extrapolate this concentration known as the Final Acute Value. Using only the lowest four values, and assuming a triangular distribution, ensures that the extrapolation to the 5^{th} percentile will not result in unrealistically low numbers. Nevertheless, if data are available that show a species-specific toxicity threshold below the calculated value, the measured value is used as the criterion.

Because acute tests are conducted for short intervals of exposure, chronic criteria (based on NOAECs) also are derived. The Chronic Maximum Concentration criteria (a value that may be exceeded for a few hours only once every three years) is set at one-half the Final Acute Value, to have a built-in safety factor.

The Chronic Continuous Criterion (the most environmentally relevant number) is derived by multiplying the Chronic Maximum Concentration by the ratio of the acute effect and the chronic

effect levels. The USEPA recognizes that chronic studies are expensive and time-consuming, and thus requires a lower minimum number of studies. For those species with chronic studies, the ratio of the acute values to the chronic values is derived (acute-to-chronic ratio; ACR). Because organisms usually are more sensitive to long-term exposures than to very short ones, the chronic values are almost always lower than acute values, and so the acute-to-chronic ratio is greater than one. As with the acute values, any measured data that are below the calculated criterion take precedence and used as the final value.

2.10. SEDIMENT QUALITY CRITERIA

Sediment quality criteria have been proposed by the USEPA (Di Toro *et al.*, 1991) for nonpolar organic substances, by the province of Ontario (Persaud *et al.*, 1992) for metals, and by the NOAA (Long and Morgan, 1991) for a variety of substances. The USEPA approach differs from the other two, which use a similar method but rely on a different database.

2.10.1. Equilibrium Partitioning Method

Nonpolar organic substances partition between the sediment particles and the interstitial pore water in a relatively predictable fashion. The USEPA proposed setting sediment quality standards using toxicity data developed for aquatic organisms (e.g., daphnia, fish, and algae). Aquatic toxicity thresholds would be determined for these organisms and set equivalent to the maximum allowable concentration in pore water. Using equilibrium partitioning theory, the total amount of chemical in the sediment (pore water plus particulate) could then be calculated. This bulk sediment concentration would be the established sediment criteria.

2.10.2. Effects Range Method

Both NOAA and Ontario proposed basing sediment criteria on empirical relationships between organism effects and sediment concentrations as determined by field measurements. Ontario only used information from the Great Lakes (which are oligotrophic systems) to develop criteria for metals, while NOAA incorporated data from a wide variety of freshwater and saline sites throughout the U.S. and developed criteria for both organic compounds and metals. In this method, the measured field concentrations are arrayed in ascending order and identified as to whether or not measured effects on benthic biota were noted (Figure 2-3). The Effects Range-Low (ER-L) is the sediment concentration below which measured effects have never been observed and above which measured effects are sometimes seen. Similarly, the Effects

Range-High (ER-H) is the sediment concentration above, which effects are always seen and below which they sometimes (but not always) occur. The Effects Range-Median (ER-M) is the midpoint between the ER-L and ER-H. Comparison of the Ontario and NOAA values for metals shows a significantly lower ER-L for metals using the Ontario data set. This is attributable to the low organic matter (and thus increasing the bioavailability of the metals to aquatic organisms) in Great Lakes water as compared to the larger set of data used by NOAA.

The state of New York, like Ontario, set two sediment levels of protection: the Lowest Effect Level and the Severe Effect Level. The Lowest Effect Level indicates a level of contamination that can be tolerated by the majority of organisms, but may be toxic to a few species. This was derived as the lowest value between the NOAA and Ontario data sets. The Severe Effect Level [adopted from the Ontario values (equivalent to the ER-H of NOAA)] indicates the concentration at which pronounced disturbance of the sediment community can be expected and was. Contamination in between these two levels is considered moderate.

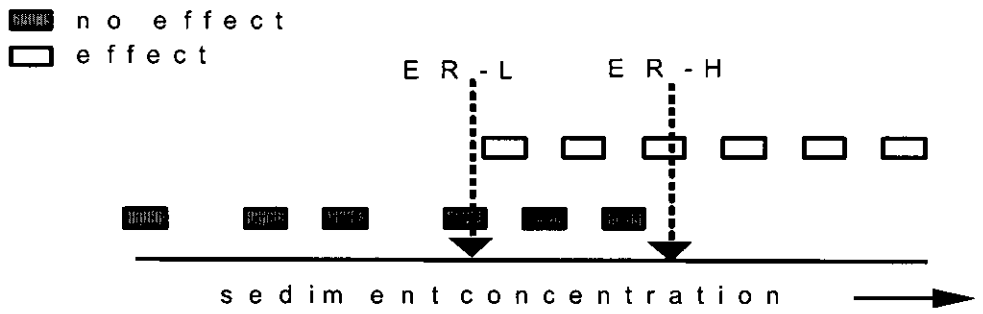

Figure 2-3. Sediment quality criteria derivation by Effects Range determination (Long and Morgan, 1991)

3. SOIL CRITERIA VALUES

A comparison of ecological soil criteria for selected metals from various jurisdictions (Table 3-1)shows that criteria for most metals (except for mercury) are less than an order of magnitude among the different methods employed by various countries. This suggests that the differences in approaches may be relatively minor. However, the fact that mercury, which acts more like an organic substance than a metal, has criteria spanning a 20-fold range, suggests that it may be harder to develop consistent criteria for organic substances. A compilation of all published soil screening or criteria values is in Appendix A.

Table 3-1. Critical limits for heavy metals in soils in several countries[1]

Country	Critical limits (mg/kg)[2]						
	Pb	Cd	Cu	Zn	Ni	Cr	Hg
Denmark	40	0.3	30	100	10	50	0.1
Sweden[3]	30-60	--	--	--	--	--	0.2-0.3
Finland	38	0.3	32	90	40	80	0.2
Netherlands	85	0.8	36	140	35	100	0.3
Germany[3]	40-100	0.4-1.5	20-60	60-200	15-70	30-100	0.1-1.0
Switzerland	50	0.8	50	200	50	75	0.8
Czech Republic	70	0.4	70	150	60	130	0.4
Eastern Europe[4]	32	2	55	100	85	90	2.1
Ireland	50	1.0	50	150	30	100	1.0
Canada	25	0.5	30	50	20	20	0.1

[1] From De Vries and Bakker, 1998
[2] Values are for protection of all land uses
[3] The first value is for sandy soils; second value for clay soils
[4] Eastern Europe includes Russia, Ukraine, Moldavia and Belarus

4. CRITICAL REVIEW

This section critically examines issues associated with the approaches that currently are in use to derive soil protection values. Significant issues include: intended application of the values, minimum data requirements, toxicity endpoints, data extrapolations, bioavailability, assessment factors, and validation. Some of these issues are common to all the methods; others are specific to only one. Where different methods use variations on the same theme, both are reviewed in relation to each other to highlight the relative strengths and weaknesses of the alternative approaches.

4.1. APPLICATION

Soil protection values have been derived for various intended applications by the different jurisdictions. Soil concentration levels may be established to either screen a particular site for contaminants that may cause potential ecological dysfunction, or they may be used as cleanup targets. The Netherlands is the only jurisdiction that explicitly acknowledges that these two goals may require different degrees of conservatism. They have two sets of values: a higher concentration that defines seriously contaminated sites requiring immediate cleanup (called the "intervention value"), and a lower value that will be used as a target for desired soil quality (called the "target value"), which is also used as the maximum amount allowable for release into the environment. If a value is between the intervention level and the target value, then further investigations are required to determine whether adverse effects are occurring, but remediation may or may not be necessary.

At both the federal and provincial level, Canada recognizes that their published soil values are most useful as screening tools. However, they require that sites be cleaned up to this level unless a site specific assessment is done to show that 1) local background values are higher than the published soil numbers or 2) a risk-based approach demonstrates no ecological concern. This puts the burden of proof on the principle responsible party to demonstrate lack of harm. For small sites, it generally is less expensive to clean up to the published levels, whereas at wide area, complex sites the risk assessment option may be more attractive. The Canadian numbers tend to be less conservative than those used by the Netherlands (certainly less so than The Netherlands target values). Additionally, the Canadians are more judicious about the use of assessment factors than are the other jurisdictions, preferring to use none, but never

more than a factor of five (see Section 4.6 for a further critique of the use of assessment factors).

The other jurisdictions explicitly state that their values are developed for screening purposes only and should not be used as remediation goals. This requires that additional site-specific assessments *always* be conducted in instances where soil concentrations exceed the screening value. In order to refute the presumption of risk that has been established in these cases, it is most likely that bioassays or field studies would be required. Development of the screening values relied on a literature review and desktop models of trophic transfers, generic exposure pathways, and assumptions about bioavailability with very conservative exposure assumptions. For example, 100% bioavailability is assumed, wildlife are estimated to consume 100% of their diet from material containing the substance of concern, and invertebrates are assumed to be stationary in the contaminated portion of the soil. Most of the jurisdictions recognize the conservative nature of these values, and consider them to be *protective* rather than *predictive*. That is, the goal is to make sure that no contaminated sites are mistakenly screened out and declared "clean" when they really are not. Thus, they are willing to accept false positives (i.e., declaring a site "contaminated" when it is not), and to rely on the Tier 2 process to exonerate parties in such cases.

States and provinces are developing guidance for Tier 2 assessment of sites that do not pass the screening phase. British Columbia, Washington state, Oregon, Michigan, and Massachusetts, for example, all have simple, easy to follow guidance for Tier 1 and Tier 2 assessments (see websites for Departments of Environmental Quality for the various states or the British Columbia Ministry of Environment, Lands, and Parks to access specific guidance documents). Tier 2 relies on development of site-specific bioavailability and trophic transfer factors, either through relationships established from tissue analysis of field-collected biota or in laboratory bioassays. Further refutation of the presumption of risk requires site-specific field studies of ecological effects.

Experience has shown that the screening values generally are quite conservative and below site-specific risk levels, with the exception of values for bioaccumulative compounds that did not have wildlife values included in their derivation. However, for small sites (less than 5 hectares), or sites located within urban or industrial areas, it generally is not cost-effective to conduct a site-specific assessment. Thus, the conservative screening values often become *de facto* cleanup goals for these sites.

4.2. MINIMUM DATA SET REQUIREMENTS

All of the approaches for deriving soil protection values rely on published studies. The CCME has a minimum data set requirement for substances having only acute data. In those instances, at least three studies must be used, including at least one terrestrial plant and one soil invertebrate study. For all other jurisdictions and derivation methods, the implicit assumption is that even a single acceptable datum point is sufficient to set an SPV, albeit generally requiring the use of an assessment factor. In contrast to the relatively stringent data requirements for derivation of water quality criteria (a minimum of eight acute toxicity tests representing species from eight different families plus at least three chronic tests including one fish and one invertebrate and an algal assay), minimum data requirements are not included in soil protection value approaches. Recommendations from the recently convened SETAC-sponsored workshop on Methods for Hazard Assessment of Metals in Soils (Madrid, Spain, June 1999) include a minimum data set of three soil invertebrates (an earthworm, a collembola, and an enchytrid) and three plants (lettuce, radish, and a grass). This minimum dataset reduces uncertainty regarding the distribution of species sensitivity that would exist with smaller datasets.

4.3. TOXICITY ENDPOINT

All of the methods currently in use for soil protection value derivation rely on NOAEC or LOAEC values from chronic studies, except for British Columbia, which prefers EC20, or LC_{50} values. The CCME preferred method includes both NOAEC and LOAEC endpoints, chronic ECx, and acute LC_{50}s. Scientists have concluded that NOAECs do not accurately reflect a toxicity threshold, as they are more a function of test design than an actual dose-response relationship (e.g., Chapman *et al.*, 1996). In fact, by only slightly changing the spacing of the test concentrations, Chapman *et al.* (1996) were able to change the calculated NOAEC in an aquatic toxicity test by nine-fold. Of even greater importance in NOAEC determination is the number of replicates at each treatment level relative to the amount of variability in a measured endpoint. An endpoint that is highly variable will return a NOAEC at a higher concentration than one with low variability, given the same number of replicates at each treatment level. Thus, the NOAEC (or corresponding LOAEC) becomes more an artifact of statistical design and acuity than an actual measure of toxicity.

Moreover, the use of a hypothesis test design to determine if one treatment is statistically similar to another is not an appropriate statistic to use in a regulatory context such as determination of toxicity thresholds. What is needed is a complete description of the dose-response relationship, so threshold concentrations can be determined, but only within relationship to the form of the remainder of the response function. If the concentration-response curve is very steep, this would suggest more protective levels might be required than for a chemical with a very shallow response function. In the first case, only a small addition of more chemical into the environment could potentially to cause a large response, while in the latter case a substantial amount of chemical could be added before an adverse effect would occur. Thus, in the ideal case, information would be available about the slope of the response function, as well as values close to the true toxicity threshold.

In human health risk assessments, this issue has been dealt with by using the Benchmark Dose (Rees and Hattis, 1994). The Benchmark Dose is calculated as the concentration at the upper 95th confidence interval of the EC_{10}. (Figure 4-1). The Reference Dose (RfD) is then calculated as the Benchmark Dose divided by appropriate assessment factors to provide a large "margin of safety." The Benchmark Dose has intuitive appeal, as it relies on calculation of the entire dose-response function, rather than a NOAEC derived from hypothesis testing.

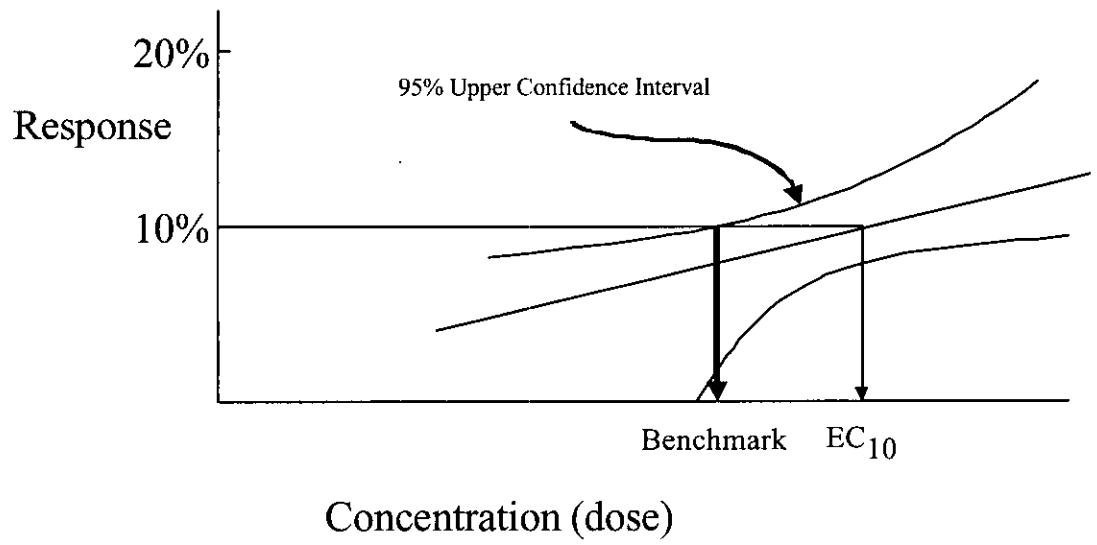

Figure 4-1. Derivation of the Benchmark Dose for human health risk assessment

The test design required for determination of point estimates differs slightly from that used in hypothesis testing in that it requires fewer replicates, but more test concentrations. Several researchers have concluded independently that most of the NOAEC values determined in terrestrial toxicity tests following standard protocols such as the ASTM early seedling growth (ASTM, 1994) are equivalent to an EC_{20} (personal communications, Brad Sample, CH2M Hill and Gladys Stephenson, ESG International). Therefore, using a Benchmark Dose approach at the EC_{10} or EC_{20} is equally protective, but more consistent among laboratories (Chapman *et al.* 1996), than the use of a NOAEC.

4.4. EXTRAPOLATIONS

Most jurisdictions use extrapolation methods to estimate a single soil protection value from the array of reported toxicity threshold endpoints. The Europeans assume that all species responses lie within a log normal distribution and calculate the 5^{th} percentile. The CCME uses the 25^{th} percentile. British Columbia deviates from this approach by arraying the ECx or LCx values along a straight line to estimate the "true" EC_{20} and LC_{50}. All of these approaches have drawbacks identified by Hopkin (1993).

Hopkin (1993) argues that there are four main objections for adopting the 5^{th} percentile of species toxicity values as the soil criteria. First, this assumes that the most sensitive 5% of the species are not important ecologically and can be killed by the pollution. This may be in violation of other laws, such as the Endangered Species Act. Second, this method provides no means of making sure that ecosystem functions are protected, only that species diversity is considered. Third, the value may not be sufficiently protective to include reasonable worse case scenarios. And fourth, the toxicity values relate to individual effects and it is not known how these translate into population level consequences.

However, Hopkin's first argument that 5% of the species would not be protected probably is not true. Using a function such as the log normal distribution to represent the range of possible species sensitivities can result in unrealistically low values at the 5^{th} percentile (i.e., generate value substantially lower than the most sensitive species response measured) as a result of a large number of very insensitive species. Insensitive species increase the spread of the distribution and stretch the lower, sensitive end of the assumed distribution. Other functions such as the Weibull function may not be as sensitive to this effect, but still are affected to some degree by highly insensitive species. Most importantly, there is no *scientific* basis on which to

choose which function to use to represent the distribution of species sensitivities. Hopkin (1993) and Scott-Fordsmand *et al.* (1996) both independently concluded that the use of the log-normal distribution and 5th percentile calculations nearly always result in soil protection values for metals that are significantly below normal background concentrations. Therefore, they both conclude that the method is not feasible for use with metals. While similarly calculated values for synthetic organic substances cannot be compared to background concentrations, it is likely that they, too, are well below the assimilative capacity of the environment as the consequences of statistical artifact forcing the criteria value below any response likely to occur with these compounds as well.

The USEPA water quality criteria approach attempts to accommodate the shortcomings of the extrapolation method by using only the four most sensitive (measured) genera and applying a triangular distribution to derive the 5th percentile. Thus, addition of new, less sensitive species to the data set does not change the derived endpoint as it would in the log normal functions. This method does not "lose" information, as critics claim, but rather derives a protective value that is not unduly influenced by a large number of insensitive species.

4.5. BIOAVAILABILITY ADJUSTMENTS

The toxicity of a contaminant is influenced by its bioavailability. Both pH and organic matter content can influence the bioavailability of chemicals. In the derivation of soil protection values, bioavailability of the contaminant to biota is not considered by any jurisdiction, with the exception of The Netherlands. The Netherlands has developed algorithms for some metals to standardize toxicity values in terms of pH and organic matter. The algorithms were derived from analyses of soil parameters from uncontaminated sites. Their data are standardized to 10% organic matter. It is not clear whether these adjustments would work outside of the specialized conditions of the region, nor is it clear how much uncertainty is introduced with these adjustments.

4.6. ASSESSMENT FACTORS

Because of the apparent shortcomings of the extrapolation method, particularly the requirement for a relatively large data set, many jurisdictions provide the alternative approach of selection of a low value and division by appropriate assessment factors (also called uncertainty factors or safety factors). Cowan *et al.* (1995) suggest that this should be the preferred approach for setting values protective of terrestrial systems. Assessment factors range from three to 1,000,

depending upon the jurisdiction and degree of desired conservatism. CCME is the least conservative of the jurisdictions using assessment factors, considering that the data themselves contain a large amount of conservative assumptions and therefore recommending that assessment factors should never exceed five. Most other jurisdictions apply orders of magnitude assessment factors in sequence, to account for interlaboratory variability, interspecific differences, and laboratory-to-field extrapolations.

For metals, dividing the lowest reported LOAEC by more than a factor of 10 often results in values that are below background concentrations (e.g., Scott-Fordsmand *et al.*, 1996). Certainly, division of the lowest reported NOAEC (or any reported NOAEC, for that matter) by 100 or 1,000 will result in values so low as to be meaningless for screening out chemicals of little environmental concern. Therefore, for this reason alone, the assessment factor approach should be viewed with caution. Chapman *et al.* (1998) point out that applications of assessment factors are a matter of policy, not science, and grew out of human health risk assessments where a true margin of safety was desired to make sure that regulatory action levels were well below the predicted no effect level.

There is, however, sufficient knowledge about differences in measured endpoints among species, laboratories, and test conditions for ecological receptors to make some science-based generalizations. For plants, species differ in sensitivity by about 300-fold, and results obtained in glasshouse studies are not consistently higher or lower than those obtained in field studies (Fletcher, *et. al*, 1990; Kapustka and Reporter, 1993; Chapman *et al.*, 1998). Examination of chemical data sets with information on animal species sensitivity differences has shown that all species are within an order of magnitude of each other (Chapman *et al.*, 1998; Baril *et al.*, 1994). Therefore, in situations where policy dictates that assessment factors should be used to accommodate uncertainty for protection of untested species under field conditions, the CCME approach of dividing by no more than five is supported by this information. Application of any additional safety factors will be a matter of policy and not a science-based approach. However, it is likely that this will result in criteria that are well below background concentrations for metals and ambient concentrations for organic substances (ambient concentrations are defined as an anthropogenically derived background resulting from diffuse nonpoint source applications such as atmospheric deposition).

4.7. EQUILIBRIUM PARTITIONING

The equilibrium partitioning approach is based on three assumptions. First, this method assumes that toxicity to terrestrial organisms results from exposure to chemicals in the interstitial pore water. Further, it assumes that chemicals in soil are in equilibrium between partitioning into the solid matrix and into the pore water. Further, this method assumes that sensitivity of terrestrial organisms to exposures through an aquatic medium is no different than that of terrestrial organisms. However, none of these assumptions are true.

Exposure to chemicals by soil-dwelling organisms is through uptake from the pore water and off of soil particles. Most plants accumulate virtually all nutrients and water through mycorrhizal fungi. The zone surrounding roots, known as the rhizosphere, is populated by microorganisms. Plant roots, along with symbiotic and associative microorganisms in the rhizosphere, alter their microenvironment in ways that facilitates extraction of substances not represented in pore water fractions. Furthermore, plants can restrict root growth into contaminated micro-zones or suspend uptake processes in roots exposed to harmful substances. Of the soil invertebrates, only enchytrids live wholly within the soil pore water. Many of the other families actually are exposed to soil contaminants through the intra-soil food chain, by consuming microorganisms, fungi, decaying plant material, or other invertebrates. Some organisms, such as the earthworm, actively ingest soil particles and may have some chemical exposure from removal of materials within the gastrointestinal tract.

The assumption of chemical equilibrium in the soil also is not met. As discussed above, the presence of soil organisms themselves disrupts any stable equilibrium through the active processes of nutrient uptake, decomposition, and energy cycling. Furthermore, physical-chemical processes leading to equilibrium are slow acting and may be disrupted by chaotic environmental processes such as leaching following rain events.

Finally, there is no scientific basis for the assumption that aquatic and terrestrial organisms respond similarly to chemical exposures. In point of fact, mechanistic toxicology suggests otherwise. For metals, for example, aquatic animals are exposed primarily through competitive binding of the cations to the gill membrane. This results in disruption of blood oxygenation. Terrestrial plants, on the other hand, are exposed by uptake through root surface or cortical membranes, which may be active or passive events and depend upon cell membrane channels or ion pumps. Terrestrial animal exposure is through similar mechanisms in gut wall epithelial cells. Mode of action and detoxification mechanisms for metals and organic substances also

differ to a significant extent between aquatic and terrestrial organisms. Terrestrial animals rely more heavily on metallothioneins for metal sequestration and elimination than do aquatic animals, have significantly different metabolic partitioning of chemicals within the body, and have significant differences in kidney and liver physiology relating to detoxification and elimination rates. The significance of these differences is substantiated by comparison of results from daphnia testing with tests of the same chemicals in earthworms that show no predictable relationship (Clausen, 1999).

4.8. VALIDATION

An essential step in establishing soil protection values, whether for screening or as cleanup goals, is verification of protectiveness and reasonableness. Most jurisdictions state that the values should not be below background (for naturally occurring substances) or below analytical detection limits for xenobiotics. National or regional average background levels generally are provided in the guidance documents. Guidance documents further suggest that site-specific background levels can be derived, but only with oversight from the regulatory body. USEPA Region IV is the only jurisdiction that explicitly states that toxicologically-derived numbers are to be used for screening values in all cases, regardless of whether or not they were lower than background. However, regional guidance is silent on the subject of cleanup target values (i.e., whether cleanup would be required below background concentrations).

While most of the guidance documents tabulate regional or national background levels together with their toxicologically derived values, all the values still are presented, even if the derived values are below background. ORNL also published site-specific background numbers derived from uncontaminated areas on the Oak Ridge reservation, but likewise included all of the toxicologically-derived values. Thus, the user must be cognizant of the need to compare all screening values with the appropriate background concentrations prior to making a final determination of whether or not a substance is listed as a concern at a site.

The methods used to set soil protection values often yield values below background concentrations. This raises questions about the appropriateness of the extrapolation methods, but also begs for an ecotoxicological explanation. The ecological foundation of the problem lies in the fact that organisms evolved or adapted to great ranges of soil concentration of naturally occurring substances (Fairbrother and Kapustka, 1997). Organisms exhibit different levels of required nutrients and varying degrees of tolerance to soil concentrations of naturally occurring

substances. Assemblages of plants, soil invertebrates, microorganisms, and to some extent birds and mammals reflect niche preferences aligned with local or regional patterns of background concentrations. Levels that are toxic to some organisms are optimal for others organisms and deficient for yet another suite of organisms. The procedures for developing SPVs generally search for the lowest concentrations that affect the most sensitive species. Such efforts generally are independent of regional differences in background concentrations, therefore, when applied over large geographic areas they may be unreasonable for screening purposes. As such values often are misused as cleanup targets, they may also fail in terms of being protective; if the clean up goals fall below the nutrient requirement levels for the regional biota deficiency conditions would occur.

Furthermore, the design of laboratory toxicity studies conducted to derive the toxicity threshold values have not addressed the need to use organisms acclimated to normal background levels of metals and minerals and frequently produce values much lower than would ever be found in natural systems. This problem has been recognized in the European approach to setting PNEC values for regional or large-scale risk assessments (Dutch National Health Council, 1998).

There has been no systematic examination of spatial distribution of background concentrations to determine how much of an area within a state, province, or country has naturally occurring levels above toxicologically-derived values. If large areas have background levels higher than the screening values, then the toxicologically-derived values are of little use. Either no sites would pass the screens or regional background concentrations would become the default screening level. There also has been no evaluation of how site-specific ecological risk assessments and cleanup goals compare to SPVs. Reports of literature reviews, field studies, and regulatory assessment documents (e.g., USEPA Superfund Records of Decision) could be reviewed to determine if significant ecological risks have been detected at soil concentrations comparable to the screening values. If such analysis documented adverse ecological effects within an order of magnitude or so of toxicologically-based SPVs, there would be justification for the process. However, if adverse effects are not demonstrated until much higher concentrations are present, then the process should be revisited. Until such validation steps are taken, the published soil protection values remain as "best guess" toxicological targets that may or may not relate to significant ecological consequences at the population, community, or systems level.

4.9. PEER REVIEW

Most of the soil protection values have not undergone peer review. The USEPA requires peer review and public comment on all policy and regulatory requirements prior to implementation. Not all jurisdictions have such a policy. The CCME and British Columbia guidelines for soil criteria derivation both underwent considerable scientific and public review prior to adoption. The ORNL approach has not received such a review, nor has the European approach. The European numbers are being reviewed and challenged during the current EU process of risk assessment of chemicals in commerce, providing an opportunity for comment and revision during the application process (similar to the notion of adaptive management by the U.S. resource management agencies). Australia requires some level of public review, but it is not known to what extent this occurred for the ecological risk assessment guidelines.

5. CONCLUSIONS

As development pressures from an expanding human population increase, requirements for cleanup of contaminated sites will continue to grow. Natural areas must be of sufficient quality to maintain desired species on diminishing acreage. Managed lands will provide a greater proportion of refugia for wild plants and animals and should not become a population sink because of excessive contamination. Therefore, regulatory bodies will be faced with an increasing need to provide soil screening values and, ultimately, cleanup goals and discharge targets. This review of the methods currently in use by various jurisdictions for derivation of such values highlights the inadequacy of our current knowledge for setting realistic numbers. We continue to be faced with the necessity of using highly conservative exposure assessments and deriving information from laboratory toxicity studies that frequently were designed for other purposes. Added to this is the desire of regulatory bodies to be precautionary during a screening level assessment to ensure that all contaminated sites are given further consideration. For these reasons, the final values derived by most of the methods reviewed here tend to include the use of assessment factors to provide a "margin of safety." Given the conservative nature of the final values, a systematic validation process needs to be done to determine 1) what proportion of the jurisdictions to which the various values apply would default to background levels (for naturally occurring substances) as the toxicologically-derived values are too low and 2) what proportion of tested sites have been screened out by this procedure. If the development of toxicologically-based soil screening values fails to screen out sites, or only screens those out that are at background, then the need for such conservative values becomes questionable.

All jurisdictions use the same base of toxicological and exposure information to derive their soil values. Final numbers differ primarily in how the literature is qualified for use, what measurement endpoints are acceptable (e.g., only reproduction endpoints; NOAEC/LOAEC vs. ECx), how interspecific differences are treated, and what type of assessment factors are applied. Ecological procedures differ most from human health criteria development due to the vast array of species under consideration and the ecotoxicological differences among the species. Ecological assessments are concerned with protection of a wide variety of species. There is often an expressed desire to develop screening values that are protective of "the most sensitive species," even when it is not known which species this is or how sensitive they might be. This has lead to the various approaches using statistical distributions, arrays, or single

study effects data from toxicological tests. In aquatic systems, procedures for development of water quality criteria and sediment quality screening levels have been debated extensively. Difficulties with the distributional approach stem from a lack of knowledge about the shape of the distribution of species sensitivities and, even more, from insensitive species broadening the potential range of the distribution. The water quality criteria derivation solved this issue by using only the lower end of the species sensitivity curve to derive threshold values. This should be reviewed critically for terrestrial species as well. The approach for setting sediment screening values follows that suggested by CCME (when few data exist) and ORNL (for soil organisms) by setting a value between the concentrations at reported NOAEC and LOAEC values from all studies. The sediment screening values went one step further, however, by basing the exercise on field-collected data (relating benthic invertebrate community structure to sediment concentration), rather than relying on laboratory toxicity tests as is done for derivation of soil values.

Several regulatory bodies have been working towards development of soil protection values for nearly a decade. While a lot of thought has gone into the derivation of each of the methods, there obviously is no consensus about the best approach. All of the methods have a large degree of built in conservatism, although some jurisdictions recognize that different land uses may not need to support the same diversity of ecological services and functions and allow less conservative numbers to be used for commercial, industrial, or residential lands. Regardless of the methods chosen, all numbers are toxicologically based and do not incorporate many ecological considerations.

Although the process for derivation of soil screening values is based on ecotoxicological principles, regulatory policy has a significant influence on the outcome. How issues such as level of protection, use of assessment factors, background levels, and minimum data requirements are addressed varies with jurisdictions, which in turn affects the final values. It is important the users of these values recognize that both science and policy contribute to the derivation of soil protection values.

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Appendix A. Summary tables of methods for derivation of ecologically protective soil values

Table A- 1.

Jurisdiction	European Community
Technical Guidance Document	Technical guidance on environmental risk assessment of existing substances in the context of Regulation 94
Date	1996
Application	Screening, clean-up, and risk assessment
Approach	The Europeans use the Factor Application Method when there is little data. This applies an assessment factor to the lowest LC50 or NOAEL. When there have been numerous studies on different species, the Distribution Based Approach is used. This assumes that the frequency distribution follows a log-normal distribution, and calculates the final criterion values as the 5th percentile of the distribution.
Trophic Levels	Soil invertebrates, plants
Validation	Mostly just for metals
Soil Values Available	No
Other Comments	

Table A- 2

Jurisdiction	The Netherlands
Technical Guidance Document	Manual for calculating loads of heavy metals for terrestrial ecosystem: Guidelines for critical limits, calculation methods and input data
Date	1998
Application	Clean-up, screening
Approach	The Netherlands adds to the approach of the rest of the European Community. In the absence of soil toxicity data, the Dutch propose that soil pore water concentration be estimated through equilibrium partitioning. The critical soil concentration is derived using aquatic toxicity threshold values and the equilibrium partitioning theory. They also calculate critical soil levels for wildlife that takes into account BCFs derived from field-collected data.
Trophic Levels	soil invertebrates to wildlife predators
Validation	Yes for background concentrations of metals
Soil Values Available	Yes
Other Comments	

Table A- 3

Jurisdiction	Canadian Council of Ministers of the Environment
Technical Guidance Document	Recommended Canadian Soil Quality Guidelines
Date	1997
Application	Screening, clean-up goals
Approach	If there have been sufficient chronic studies, the Weight of Evidence approach is used. This takes a percentile of the NOAEC and LOAEC numbers, and divides by an uncertainty factor to get the Threshold Effect Concentration (TEC). If there are not enough data for this method, the LOAEC approach is used. This arrives at the TEC by dividing the lowest LOAEC by an uncertainty factor. If there are only acute toxicity data, The TEC is estimated by the Median Effects Method. By this method, the lowest reported EC50 or LC50 is divided by an uncertainty factor. Effects on microbial processes and wildlife are included. Land use determines which value is used for the final environmental guideline.
Trophic Levels	soil microbes, soil invertebrates, plants, terrestrial wildlife (mammalian and avian)
Validation	Gives regional or provincial background limits, may be site-specific. Detection limits for organics.
Soil Values Available	Yes
Other Comments	

Table A- 4

Jurisdiction	British Columbia Ministry of Environment, Lands, and Parks
Technical Guidance Document	A protocol for the derivation of environmental and human health soil quality guidelines
Date	1996
Application	Contaminated soils clean-up goals
Approach	For soil organisms, all toxicity data are examined. The lethal and non-lethal studies are compared and if multiple studies report the same percent age response, the concentrations that caused the response are averaged. This new data set is used to calculate a regression line to determine predicted soil concentrations. Land use determines whether the EC50 or LC20 soil concentration value is used.
Trophic Levels	soil invertebrates, plants, livestock
Validation	Background levels may be analyzed on a site-specific basis with protocol approval
Soil Values Available	Yes
Other Comments	

Table A- 5

Jurisdiction	Ontario Ministry of Environment and Energy
Technical Guidance Document	Guideline for use at Contaminated Sites in Ontario
Date	1996
Application	Soil clean-up
Approach	The soil criterion is the lowest number from human health and ecological effects analysis. No documentation was found on how the ecological effects analysis is conducted.
Trophic Levels	Soil microbes, herbivores, humans
Validation	Site-specific background may be developed
Soil Values Available	Yes
Other Comments	

Table A- 6

Jurisdiction	Australia
Technical Guidance Document	Draft national framework for ecological risk assessment of contaminated sites. Part B: Derivation of ecological impact levels for soils
Date	1997
Application	Screening
Approach	The available literature is studied, and the lowest reported NOAEC from soil organisms and wildlife is taken as the Environmental Impact Level. Extrapolation is allowed with use of appropriate assessment factors. The BCFs also are estimated from past studies.
Trophic Levels	Soil microorganisms, soil invertebrates, plants, wildlife
Validation	Yes, background or detection limits
Soil Values Available	No
Other Comments	

Table A- 7

Jurisdiction	Oak Ridge National Laboratory
Technical Guidance Document	Toxicological Benchmarks for Wildlife, Toxicological Benchmarks for Screening Contaminants of Concern for Effects on Terrestrial Plants, Benchmarks for Potential Contaminants of Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process
Date	1996, 1997, 1995
Application	Remediation goal
Approach	For invertebrates and plants, ORNL derived the soil benchmark from LOAEC values by calculating the 10th percentile of the distribution of toxic effects thresholds for soil organisms. For wildlife, they developed animal-specific benchmarks. Instead of averaging the values of many species studies, they looked for the single best chronic study that most closely related the species of interest.
Trophic Levels	Soil microorganisms, invertebrates, plants, wildlife
Validation	Regional and site-specific background concentrations
Soil Values Available	Yes
Other Comments	The wildlife benchmarks may have been incorrectly calculated since the extrapolation of data between species used an assumption that the ratio of body weight to metabolic rates was constant for all species and chemicals.

Table A- 8

Jurisdiction	United States Environmental Protection Agency
Technical Guidance Document	Guidelines for deriving numerical national water quality criteria for the protection of aquatic organisms and their uses
Date	1985
Application	Discharge
Approach	Water Quality Criteria: The USEPA mandates that at least eight acute toxicity tests, three chronic animal tests, one algal test, and one test to determine a BCF be used to develop a water quality criterion. A Species Mean Acute Value is calculated from the different tests. Mathematical extrapolation is performed on the four lowest values to estimate the 5th percentile. This is the Final Acute Value. The Chronic Continuous Criterion is half of the Final Acute Value multiplied by the ratio of the acute and chronic effect levels.
Trophic Levels	Algae, invertebrate, vertebrate
Validation	Site specific adjustments are encouraged
Soil Values Available	No
Other Comments	

Table A- 9

Jurisdiction	United States Environmental Protection Agency
Technical Guidance Document	Technical basis for establishing sediment quality criteria for nonionic organic chemicals by using equilibrium partitioning. Guidelines for the protection and management of aquatic sediment quality in Ontario. The potential for biological effects of sediment-sorbed contaminants tested in the National Status and Trends Program
Date	1991, 1992, 1991
Application	Site screening, clean-up goals
Approach	Sediment Quality Criteria: For non-polar organics, standards using aquatic toxicity data are suitable for concentrations in the pore water. The total amount of chemical in the sediment can be calculated using the equilibrium partitioning theory. The effects-range method is a compilation of results from NOAA, which studies many different marine environments, and Ontario, which only used the Great Lakes. A graph of the results gives an Effects Range-High, Low and Median.
Trophic Levels	Algae, invertebrate, vertebrate
Validation	Site specific adjustments are encouraged
Soil Values Available	No
Other Comments	

Appendix B. Guiding principles used by the Canadian Council of Ministers of the Environment for deriving soil protection values

The following guiding principles for the development of numerical soil quality remediation objectives for contaminated sites in Canada are based on the philosophy established by CCME (1991a; 1995a):

1. Site specific soil quality remediation objectives should be protective of human health and the environment.

2. Site specific soil quality remediation objectives should be protective of the appropriate land use at a contaminated site.

3. The land uses to be considered for protection include agricultural, residential/parkland, commercial, and industrial.

4. It is the philosophy of the CCME to encourage remediation to the lowest level practicable, considering the intended land use and other factors, such as technological limitations. Environmental quality guidelines are not intended to establish maximum levels of contamination acceptable at contaminated sites. Where the quality of site conditions is considered superior to the Canadian environmental quality guidelines, degradation of existing site conditions should be avoided.

5. Generic soil quality guidelines for a substance may be adopted directly (Method 1) as the recommended soil quality remediation objective for the intended or likely future use of a remediated contaminated site in Canada. Where it can be demonstrated that the guidelines are not applicable or appropriate to the specific site in question using the evaluation guidelines that follow, the guidelines may be modified within the limits prescribed in this guidance manual (Method 2). In some circumstances, the risk-based approach (Method 3) may be deemed more appropriate to determine site-specific remediation objectives.

6. If generic soil quality guidelines for the designated land use at a contaminated site are not available, the proponent should consult the jurisdictional authority. Options for guidelines development may include, but are not limited to, using risk assessment to develop remediation objectives, using the *Protocol* (CCME, 1995a) to develop remediation objectives, adopting appropriate background levels as remediation objectives, or adopting guidelines from other jurisdictions as remediation objectives.

7. The Explanations in this chapter specify the recommended conditions and procedures under which it is appropriate to modify generic guidelines or to develop risk-based remediation objectives.

8. The approach used to modify soil quality guidelines should adhere to the guidance documents relating to the guideline-based (this document) and risk-based approaches (CCME, 1995b and HC, 1995).

9. Generic soil quality guidelines were developed using information on defined exposure scenarios in Canada. Limited modification may be allowed to the parameters in three equations, and management check procedures may or may not be applicable. Apart from the equation and management check procedures specified in this guidance manual, the exposure scenario assumptions should not be altered without permission from the jurisdictional authority when using the guideline-based approach. However, these assumptions may be altered if the recommended soil quality remediation objective was modified using the risk-based approach.

10. Recommended soil quality remediation objectives may be modified within limits by omitting toxicological data on terrestrial organisms (e.g., annelids, arthropods) if it can be demonstrated by the proponent that specific toxicity data used to derive the national generic guidelines may be modified by recalculating them based on an adjusted data set derived by eliminating toxicological information not relevant to the site under investigation, provided that

    - The minimum data requirements for deriving generic soil quality guidelines in the *Protocol* (CCME, 1995a) are met; and
    - The administrative rules set out in Explanation 19 are followed.

11. Recommended soil quality remediation objectives (RSQRO) should normally be protective of the most sensitive water use associated with the groundwater at or near the contaminated site.

12. Each decision to accept or reject modification of the RSQROs should be carefully documented and justified.

13. In general, the Subcommittee recommends that socioeconomic and technical feasibility factors be considered in detail in developing a risk management strategy. The framework presented in this guidance manual provides for consideration of

socioeconomic and technological factors after an RSQRO has been developed, using either the guideline-based or risk-based approach. Guidance on socioeconomic and technical feasibility factors is, however, outside the scope of the Subcommittee.

14. Continued contamination of the site from readily identifiable sources (pits, ponds, lagoons, leaking storage tanks, etc.) should be prevented while detailed site investigations are conducted to support the development of site-specific soil quality remediation objectives using either the guide-based or risk-based approach. Under these circumstances, the generic soil quality guidelines, modified using the available information, may be used to guide the remedial action.

Appendix C. Comparison of methods for deriving ecologically protective soil values

	Europe	CCME	British Columbia	Ontario
Factor method	Yes	Yes	No	Yes
Assessment factors applied	10 to 1,000	1 to 5		10 to 1,000
When used		"small" data set		
Median effects method	No	Yes	No	No
Assessment factors applied		5 or 10		
When used		Only acute data		
Extrapolation approach	Yes	Yes	Yes	Yes
Type of distribution	Log normal	Not stated	Meta analysis	Log normal
Percentile used	5^{th}	25^{th}	LC_{50}/EC_{20}	5^{th}
Assessment factors applied	No	1 to 5	No	No
Endpoints preferred	NOAEC	LOAEC	LC_{50}, EC_{50}	NOAEC
Equilibrium partitioning	Proposed for metals (Dutch)	No	No	No
Effects range method	No	No	No	No
Wildlife included	No	No	Livestock	No
BCF calculation			Measured	
Microbes included	Yes	Yes	Yes	Yes
Endpoints	Function and numbers	Functional endpoints	(uses CCME approach)	(uses CCME approach)

	Australia	ORNL	Water quality	Sediment quality

Factor method	Yes	Yes	No	No
Assessment factors applied	10 to 1,000	5		
When used	Acute data; only LOACs	Acute data only		
Median effects method	No	No	No	No
Assessment factors applied				
When used				
Extrapolation approach	No	No	Yes	No
Type of distribution			Triangular	
Percentile used			5^{th} of lowest 4 values	
Assessment factors applied			2	
Endpoints preferred	NOAEC	LOAEC	NOAEC	NOAEC & LOAEC
Equilibrium partitioning	No	No	No	Yes
Effects range method	No	Yes	No	Yes
Wildlife included	Yes	Yes	No	
BCF calculation	Median	Measured		
Microbes included	No	No		No
Endpoints				

Appendix D. Published soil values for use in screening, cleanup, or monitoring contaminated sites.

All values taken from the Technical Guidance Documents referenced in this report

JURISDICTIONAL ABBREVIATIONS

ORNL-E.....Oak Ridge National Laboratory-Earthworms
ORNL-M.....Oak Ridge National Laboratory-Microbes
ORNL-P.....Oak Ridge National Laboratory-Plants
WSR.....Westinghouse Savannah River Site
WSR-FN.....Westinghouse Savannah River Site-Footnotes
BC Ag.....British Columbia Agricultural
BC AG-FN.....British Columbia Agricultural-Footnote
BC UP.....British Columbia Urban Park
BC UP-FN.....British Columbia Urban Park-Footnote
BC R.....British Columbia Residential
BC R-FN.....British Columbia Residential-Footnote
BC C.....British Columbia Commercial
BC C-FN.....British Columbia Commercial-Footnote
BC I.....British Columbia Industrial
BC I-FN.....British Columbia Industrial-Footnote
CCME Ag.....Canadian Council of Ministers of the Environment Agricultural
CCME Ag-FN.....Canadian Council of Ministers of the Environment Agricultural-Footnote
CCME RP.....Canadian Council of Ministers of the Environment Residential/Parkland
CCME RP-FN.....Canadian Council of Ministers of the Environment Residential/Parkland-Footnote
CCME C.....Canadian Council of Ministers of the Environment Commercial
CCME C-FN.....Canadian Council of Ministers of the Environment Commercial-Footnote
CCME I.....Canadian Council of Ministers of the Environment Industrial
CCME I-FN.....Canadian Council of Ministers of the Environment Industrial-Footnote
Ont Ag (M/F).....Ontario Agricultural (Medium and fine textured soils-ug/g)
Ont AG (M/F).....Ontario Agricultural land use (medium and fine textured soils-ug/g)
Ont Ag (C).....Ontario Agricultural land use (coarse-ug/g)
Ont Ag-FN.....Ontario Agricultural -Footnote
Ont RP (M/F).....Ontario Residential/Parkland land use (medium and fine textured soils-ug/g)
Ont RP (C).....Ontario Residential/Parkland land use (coarse-ug/g)
Ont RP-FN.....Ontario Residential/Parkland land use-Footnote
Ont IC (M/F).....Ontario Industrial/Commercial land use (medium and fine textured soils-ug/g)
Ont IC (C).....Ontario Industrial/Commercial land use (coarse-ug/g)
Ont IC-FN.....Ontario Industrial/Commercial land use-Footnote
RIVM TV.....The Netherlands soil/sediment (mg/kg dry material) target value
RIVM-FN.....The Netherlands-Footnote
USSR MAC.....USSR (Maximum allowable concentration)
USSR FN.....USSR Footnote
USSR TAC.....USSR (Tentative allowable concentration)

pound Name	Sub category	ORNL-E	ORNL-M	ORNL-P	WSR	WSR-FN	BC Ag	BC Ag-FN	BC UP	BC UP-FN	BC R	BC R-FN	BC C	BC C-FN	BC I	BC I-FN	CCME Ag	CCME Ag-FN	CCME RP	CCME RP-FN	CCME C	CCME C-FN	CCME I	CCME I-FN	Ont Ag (M/F)	Ont Ag (C)	Ont Ag-FN	Ont RP (M/F)	Ont RP (C)	Ont R/P-FN	Ont IC (M/F)	Ont IC (C)	Ont IC-FN	RIVM MPC	RIVM MPC-FN	RIVM TV	RhVM-FN	USSR MACa	USSR FN	USSR TACa.	Min	Max	G
carbons																																											
hloromethane																										0.12			0.12			0.12									0.12	0.12	
ed hydrocarbons		30			0.1	a																																		0.1	30	
henols (total)																																			0.003					0.003	0.003	
				600	600	b																																			600	600	
rophenols (total)																																			0.0025					0.0025	0.0025	
orinated (each)					0.1	a																																		0.1	0.1	
lorinted (total)					0.1	a																																		0.1	0.1	
al)				40	0.02	d											0.3	k	0.3	k	33	kj	33	kj													d			0.02	40	
	groundwater used for livestock watering							q		p																																
	livestock ingesting soil and fodder							b		b																																
	major microbial functional impairment							b		b																																
	toxicity to soil invertebrates and plants						0.5		5		5		50		50																										0.5	50	
nated biphenyls																										0.5			5			25									0.5	25	
nated Dioxons and CDDs and PCDFs)	groundwater used for livestock watering							q,r																																		
nated Dioxons and CDDs and PCDFs)	livestock ingesting soil and fodder							br																																		
nated Dioxons and CDDs and PCDFs)	major microbial functional impairment							br																																		
nated Dioxons and CDDs and PCDFs)	toxicity to soil invertebrates and plants						1E-05	r,s	0.001	r	0.001	r	0.003	r	0.003	r	0.00001	s	0.001	s		p		p																		0.00001	0.0025	
chlorinated ons (total)					0.1	a																																		0.1	0.1	
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ofuran					0.1	s,d																													0.12					0.1	0.12	
thene																																			0.001					0.001	0.001	
nethane																																			0.001					0.001	0.001	
henols (total)																																			0.001					0.001	0.001	
ophenols																																			0.001					0.001	0.001	
d																																											
			600	50	50	b																																			50	600	
				5	3.5	c	20		20		20		40		40		20		20		40		40			13			13		44	40		3.5	cb			4.5			3.5	44	
							60	a																																	60	60	
							20																																			20	20	
								b																																			
							35		35		35		150		150																											35	150	
		60	100	10	10	b											12	a	12	a	12	a	12	a	25	20		25	20		50	40		34	ca	29		2			2	100	
			3000	500	165	c	750		500		500		2000		2000		750	b	500	b	2000	b	2000	b	1000	750		1000	750		2000	1500		165	cb	200					165	3000	
				10	1.1	c	4		4		4		8		8		4		4		8		8			1.2		1.2	1.2			1.2		1.1	fg						1.1	10	
			20	0.5	0.5	b	2										2	o		p		p		p																	0.5	20	
vailable)																										1.5	a		1.5	a		1.5	a								1.5	1.5	
				10	10	b																																			10	10	
		20	20	4	1.6	c											1.4	a	10	c	22	c	22	c	4	3			12			12		1.6	ca	0.8					0.8	22	
							1.5	e,f																																		1.5	1.5	
							4500	e,f																																		4500	4500	
							2.5	e,f																																		2.5	2.5	
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							250		250		250		700		700																											250	700	

pound Name	Sub category	ORNL-E	ORNL-M	ORNL-P	WSR	WSR-FN	BC Ag	BC Ag-FN	BC UP	BC UP-FN	BC R	BC R-FN	BC C	BC C-FN	BC I	BC I-FN	CCME Ag	CCME Ag-FN	CCME RP	CCME RP-FN	CCME C	CCME C-FN	CCME I	CCME I-FN	Ont Ag (M/F)	Ont Ag (C)	Ont Ag-FN	Ont RP (M/F)	Ont RP (C)	Ont R/P-FN	Ont IC (M/F)	Ont IC (C)	Ont IC-FN	RIVM MPC	RIVM MPC-FN	RIVM TV	RhVM-FN	USSR MACa	USSR FN	USSR TACa	Min	Max	Gu
							150	ab																			d			d											150	150	
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		0.4	10	1	0.4	b,c											64	a	64	a	87	a	87	a	1000	750		1000	750		1000	750		100	e,g	100		0.05			0.05	1000	
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							150		150		150		250		250																											150	250	
		50	100	100	40	e											63	a	63	a	91	a	91	a	200	150		300	225		300	225		40	e,g	36		3	b		3	300	
free)																	0.9	b	0.9	a	8	b	8	a		100			100			100				1				0.9	100	
SAD)							5	l	50	l	50	l	500	l	500	l																									5	500	
WAD)							0.5	m	10	m	10	m	100	m	100	m																									0.5	100	
mplex (pH<5)																																				5	a				5	5	
omplex (pH>5)																																				5					5	5	
omplex (total)					5	a																																			5	5	
ree (total)					0.9	c																																				0.9	0.9	
							200		400		400		2000		2000		200		400		2000		2000																		200	2000	
			30	200																																					30	200	
				4																																					4	4	
			200		200	b																																			200	200	
					50	b																																			50	50	
							150	a,n																																	150	150	
							30000	e,n																																	30000	30000	3
							250	e,n																																	250	250	
							1500	e,n																																	1500	1500	1
							350																																		350	350	
								h																																		
							1000		1000		1000		2000		2000																											1000	2000	1
		500	900	50	50	a,b											70	a	140	a	260	a	600	a		200			200			1000		140	e,g	85		20			20	1000	
			10	2	2	b																																			2	10	
e			100	500	100	b																																			100	1500	
		0.1	30	0.3			0.8		2		2		10		10											10			10			10					0.3		2.1		0.1	30	
Inorganic)					0.1	b											6.6	a	6.6	a	24	a	50	a										2.2	a						0.1	50	
Methyl)					0.67	c																				6.8	b		6.8	b		10	b	0.67	e,g						0.67	10	
um			200	2	2	b	5		10		10		40		40		5		10		40		40			5			40			40		254	f,h	10					2	254	
		200	90	30	30	b	150		100		100		500		500		50	k	50	k	50	k	50	k	200	150		200	150		200	150		38	c	35		4	e		4	500	
																											d			d			d									
																																								130			130	130	
																											d			d			d									
s pentoxide																																								200			200	200	
		70	100	1	0.81	c	2		3		3		10		10		2		3		10		10			2			10			10		0.81	f,h						0.81	100	
			50	2	2	b	20		20		20		40		40		20		20		40		40		25	20		25	20		50	40									2	50	
																											d			d			d									
lemental)							500										500				P		P		P																	500	500	
n				0.2	0.2	b																																				0.2	0.2	
				1	1	b	2	d									1	l	1	m	1	m	1	m		4.1			4.1			32		1.3	f,h						1	32	
ites					2	d																																			2	2	
ites Total)																																											
			2000	50	53	e	5		50		50		300		300		5		50		300		30											53	f,h						5	2000	
			1000		1000	b																																			1000	1000	1
			400		400	b																																			400	400	
				5	5	b																																			5	5	
			20	2	2	b	200		200		200						130	k	130	k	130	n	130	n	250	200		250	200		250	200		43	f,h			150			2	250	
							450	e,i																																	450	450	
							550	e,i																																	550	550	
							1500	e,i																																	1500	1500	1
							9000	e,i																																	9000	9000	5
							70000	e,i																																	70000	70000	7

pound Name	Sub category	ORNL-E	ORNL-M	ORNL-P	WSR	WSR-FN	BC Ag	BC Ag-FN	BC UP	BC UP-FN	BC R	BC R-FN	BC C	BC C-FN	BC I	BC I-FN	CCME Ag	CCME Ag-FN	CCME RP	CCME RP-FN	CCME C	CCME C-FN	CCME I	CCME I-FN	Ont Ag (M/F)	Ont Ag (C)	Ont Ag-FN	Ont RP (M/F)	Ont RP (C)	Ont R/P-FN	Ont IC (M/F)	Ont IC (C)	Ont IC-FN	RIVM MPC	RIVM MPC-FN	RIVM TV	RhVM-FN	USSR MACa	USSR FN	USSR TACa.	Min	Max	Gr
							150000	wj																																	150000	150000	15
							200																																		200	200	
								h																																			
							450		450		450		600		600																										450	600	
		200	100	50	50	b											200	k	200	k	360	k	360	k	800	600		800	600		800	600		160	a,g	140		23	d		23	800	
um)																	200		200		360	q	360	q																200	360	
ound																																											
n																										0.11			0.11			0.11								0.11	0.11	
																																								0.6	0.6	0.6	
thexylphthalate							30																																		30	30	
thalate (DBP)							30																																		30	30	
henol, 2,4-							0.1		1		1		10		10		0.1		1		10		10			0.94			0.94			0.94								0.1	10	
lycol					97	c											960	j	960	j	960	j	960	j																	97	960	
lycol (erratum)																	103	q	103	q	428	q	428	q																	103	428	
					20	b																																			20	20	
			50																																						50	50	
ils					50	d																														50	i				50	50	
us phase liquids								x		x		x		x		x																												
substances								x		x		x		x		x																												
Hydrocarbons l)																										100			100			100								100	100	
Hydrocarbons s)																										1000			1000			1000								1000	1000	1
																																									0.6	0.6	0.6	
					0.0025	d																				0.05			0.05			0.05			0.0025					0.0025	0.05	
																																								0.5	0.5	0.5	
					5E-05	d																													0.05	xxx	0.5			0.00005	0.5	
																																					0.2			0.2	0.2	
s																																							0.4	0.4	0.4	
					0.5	d																															0.05			0.05	0.5	
n					0.2	d																															2			0.2	0.2	
s																																								2	2	
					20	d																															0.05			20	20	
																																								0.05	0.05	
																										0.29			0.29			0.29								0.29	0.29	
s																																					0.5			0.5	0.5	
																																					0.5			0.5	0.5	
																																							0.4	0.4	0.4	
																																					0.8			0.8	0.8	
																																					0.1			0.1	0.1	
um salt, 2,4-																																					0.25			0.25	0.25	
																																							0.1	0.1	0.1	
odium, Salt																																					0.5			0.5	0.5	
																										2.2			2.2			3.5								2.2	3.5	
																										1.6			1.6			2.4								1.6	2.4	
																	0.7	h	0.7	h	12	h,l	12	h,l		1.6			1.6			2					0.1			0.1	12	
DDD (total)					0.0025	d																														0.0025	e				0.0025	0.0025	
																																								0.6	0.6	0.6	
s																																					0.25			0.25	0.25	
																																							0.1	0.1	0.1	
					0.0005	d																				0.05			0.05			0.05			0.0005					0.0005	0.05	
ptachlor																																					0.5			0.5	0.5	
e																																					0.3			0.3	0.3	
																																					1			1	1	
ran (ng TEQ/g																										0.01		1	1			1								0.01	1	
																																							0.6	0.6	0.6	
																																				f						
n																										0.18			0.18			0.18								0.18	0.18	
n					0.001	d																				0.05			0.05			0.05			0.001					0.001	0.05	
																																							0.9			0.9	0.9	
																																							0.1	0.1	0.1	
ibromide																									0.01	0.006		0.01	0.006		0.012	0.0056								0.0056	0.012	

pound Name	Sub category	ORNL-E	ORNL-M	ORNL-P	WSR	WSR-FN	BC Ag	BC Ag-FN	BC UP	BC UP-FN	BC R	BC R-FN	BC C	BC C-FN	BC I	BC I-FN	CCME Ag	CCME Ag-FN	CCME RP	CCME RP-FN	CCME C	CCME C-FN	CCME I	CCME I-FN	Ont Ag (M/F)	Ont Ag (C)	Ont Ag-FN	Ont RP (M/F)	Ont RP (C)	Ont R/P-FN	Ont IC (M/F)	Ont IC (C)	Ont IC-FN	RIVM MPC	RIVM MPC-FN	RIVM TV	RbVM-FN	USSR MACa	USSR FN	USSR TACa	Min	Max	G
																																					1.8			1.8	1.8	
																																							0.3	0.3	0.3	
e																																				1.4			1.4	1.4	
pounds																																				0.5			0.5	0.5	
					0.0025	d																														g						
					0.001	d																													0.0025					0.0025	0.0025	
Lindane)					5E-05	d																													0.001					0.001	0.001	
r																									0.12	0.084		0.12	0.084		0.15	0.084				0.05			0.00005	0.05	
r Epoxide																										0.06			0.06			0.09							0.05	0.15	
																																							0.06	0.09	
s																																							0.7	0.7	0.7	
on					1	d																														0.05			0.05	0.05	
																																							1	1	
																																			1			1	1	
																																						0.1	0.1	0.1	
																																			0.1			0.1	0.1	
					3.5	d																														1			1	1	
																																							3.5	3.5	
s																																							1	1	
hlor																										4			4			4					0.1			0.1	0.1	
robenzene							0.1		1		1		10		10																						m				4	4	
on																																							0.1	10	
																																						0.7	0.7	0.7	
																																						0.6	0.6	0.6	
																																						0.6	0.6	0.6	
																																						0.05	0.05	0.05	
																																						0.7	0.7	0.7	
																																						0.4	0.4	0.4	
																																					0.5			0.5	0.5	
os																																					0.1			0.1	0.1	
-methyl																																					0.05			0.05	0.05	
																																					0.5			0.5	0.5	
-methyl (soil																																					0.3			0.3	0.3	
																																					0.1			0.1	0.1	
apinewe																																					0.5			0.5	0.5	
(mixture of imazine, and)																																					0.01			0.01	0.01	
																																					0.5			0.5	0.5	
																																					1.5			1.5	1.5	
																	0.1			P		P		P																0.1	0.1	
l					1	d																																		1	1	
																																					0.2			0.2	0.2	
																																							0.6	0.6	0.6	
																																							0.4	0.4	0.4	
																																							0.4	0.4	0.4	
thiophene					0.1	a,d																														0.1					0.1	0.1	
																	0.1			P		P		P																0.1	0.1	
icides					0.1	a																																			0.1	0.1	
																																					0.5			0.5	0.5	
																																					0.5			0.5	0.5	
																																							0.1	0.1	0.1	
																																							0.9	0.9	0.9	
																																					1.8			1.8	1.8	
c Compound																																										
ene				20																						15			15			15							15	20	
ylene																										100			100			130							100	130	
Chlorinated ons (each)					0.1	a																																	0.1	0.1	
Chlorinated ons (total)					0.1	a																																	0.1	0.1	
e																										28			28			28							28	28	
nthracene							0.1		1		1		10		10		0.1		1		10		10			6.6			6.6			6.6							0.1	10	
yrene																	0.1	d	0.7	e	0.7	a	0.7	a		1.2			1.2			1.9					0.02		0.02	1.9	
luoranthene							0.1		1		1		10		10		0.1		1		10		10			12			12			18							0.1	18	
,Dperylene																										40			40			40							40	40	

pound Name	Sub category	ORNL-E	ORNL-M	ORNL-P	WSR	WSR-FN	BC Ag	BC Ag-FN	BC UP	BC UP-FN	BC R	BC R-FN	BC C	BC C-FN	BC I	BC I-FN	CCME Ag	CCME Ag-FN	CCME RP	CCME RP-FN	CCME C	CCME C-FN	CCME I	CCME I-FN	Ont Ag (M/F)	Ont Ag (C)	Ont Ag-FN	Ont RP (M/F)	Ont RP (C)	Ont R/P-FN	Ont IC (M/F)	Ont IC (C)	Ont IC-FN	RIVM MPC	RIVM MPC-FN	RIVM TV	RbVM-FN	USSR MACa	USSR FN	USSR TACa	Min	Max	G
aoranthene							0.1		1		1		10		10		0.1		1		10		10			12			12			18									0.1	18	
yrene								c		c		c																														
yrene								b																																		
yrene								d																																		
yrene							0.1		1		1		10		10																												
				60																																					0.1	10	
1,1-																																									60	60	
oroethyl)ether																										0.89			0.89			0.89									0.89	0.89	
lhexyl)phthalate																										0.66			0.66			0.66									0.66	0.66	
, Nonchlorinated																										100			100			100									100	100	
																	0.3			P		P		P																	0.3	0.3	
tamide		2			2	b																																			2	2	
line, 3-				20	20	b																																			20	20	
line, p-																										1.3			1.3			1.3									1.3	1.3	
zene		40															0.1		1		10		10			2.4			2.4			2.4									0.1	40	
zene (each)					0.05	a											0.05	e	2	f	10	g	10	g																	0.05	10	
zene (total)					0.05	a																																			0.05	0.05	
nol, 2-																										0.1			0.1			0.1									0.1	0.1	
nol, 3-		10		7																																					7	10	
nol, 4-																																											
nol, meta							0.05		0.5		0.5		5		5		0.05		0.5		5		5																			0.05	5	
nol, ortho							0.05		0.5		0.5		5		5		0.05		0.5		5		5																			0.05	5	
nol, para							0.05		0.5		0.5		5		5		0.05		0.5		5		5																			0.05	5	
																										12			12			17									12	17	
)anthuracene							0.1		1		1		10		10		0.1		1		10		10			1.2			1.2			1.9									0.1	10	
2-butene, 1,4-			1000		1000	b																																			1000	1000	1
2-butene, 1-4-			1000		1000	b																																			1000	1000	1
niline, 2,4-		100			100	b																																			100	100	
niline, 3,4-		20			20	b																																				20	20	
enzene					0.01	d																																				0.01	0.01	
enzene (total)																																				0.01					0.01	0.01	
enzene, 1,2-							0.1		1		1		10		10		0.1		1		10		10																			0.1	10	
enzene, 1,2- (o-																										0.88			0.88			0.88									0.88	0.88	
enzene, 1,3-							0.1		1		2		10		10		0.1		1		10		10																			0.1	10	
enzene, 1,3- (m-																										30			30			30									30	30	
enzene, 1,4-		20					0.1		1		2		10		10		0.1		1		10		10																			0.1	20	
enzene, 1,4- (p-																										0.32			0.32			0.32									0.32	0.32	
enzidine, 3,3-																										1.3			1.3			1.3									1.3	1.3	
henol, 2,3-							0.05		0.5		0.5		5		5		0.05		0.5		5		5																			0.05	5	
henol, 2,4-							0.05		0.5		0.5		5		5		0.05		0.5		5		5			0.3			0.3			0.3						0.05			0.05	5	
henol, 2,5-							0.05		0.5		0.5		5		5		0.05		0.5		5		5																			0.05	5	
henol, 2,6-							0.05		0.5		0.5		5		5		0.05		0.5		5		5																			0.05	5	
henol, 3,4-		20		20			0.05		0.5		0.5		5		5		0.05		0.5		5		5																			0.05	5	
henol, 3,5-							0.05		0.5		0.5		5		5		0.05		0.5		5		5																			0.05	20	
halate				100	100	b																																				0.05	5	
hthalate		200			200	b																				0.71			0.71			0.71									0.71	100	
phthalate				200	200	b																				0.7			0.7			0.7									0.7	200	
nol, 2,4-				20			0.1		1		1		10		10		0.1		1		10		10			0.2			0.2			0.2									200	200	
nol, 4,6- 2-methyl							0.1		1		1		10		10		0.1		1		10		10																			0.1	20	
ene, 2,4-																										0.66			0.66			0.66									0.1	10	
ne																										40			40			40									0.66	0.66	
		30																								340			340			340									40	40	
							1000	w	1000	w	1000	w	5000	w	5000	w																										30	340	
obenzene			1000		0.0025	d											0.05		2		10		10																			1000	5000	1
obenzene							0.05		2		2		10		10																											0.0025	1000	
obutadiene																										0.46			0.46			0.76									0.05	10	
ocyclohexane							0.01										0.01			P		P		P	2.2	0.38		2.2	0.38		2.2	0.38						0.5			0.38	2.2	
ocyclohexane,																										0.41			0.41			0.49						0.1			0.01	0.1	
ocyclopentadiene				10	10	b																																			0.41	0.49	
,3-c,d)pyrene							0.1		1		1		10		10		0.1		1		10		10			12			12			19									10	10	
							1000	w	1000	w	1000	w	2000	w	2000	w																											0.1	19	
hthalene, 2-(*1-)																										1.2	c		1.2	c		1.2	c									1000	2000	1
																																										1.2	1.2	

pound Name	Sub category	ORNL-E	ORNL-M	ORNL-P	WSR	WSR-FN	BC Ag	BC Ag-FN	BC UP	BC UP-FN	BC R	BC R-FN	BC C	BC C-FN	BC I	BC I-FN	CCME Ag	CCME Ag-FN	CCME RP	CCME RP-FN	CCME C	CCME C-FN	CCME I	CCME I-FN	Ont Ag (M/F)	Ont Ag (C)	Ont Ag-FN	Ont RP (M/F)	Ont RP (C)	Ont R/P-FN	Ont IC (M/F)	Ont IC (C)	Ont IC-FN	RIVM MPC	RIVM MPC-FN	RIVM TV	RbVM-FN	USSR MACa	USSR FN	USSR TACa	Min	Max	Ge
ne							0.1		5		5		50		50		0.1	c	0.6	g	22	g	22	g		4.6			4.6			4.6									0.1	50	
ene		40	1000		40	b																																		40	1000	
																																							0.2	0.2	0.2	
ol, 2-							0.1		1		1		10		10		0.1		1		10		10																	0.1	10	
ol, 4-		7					0.1		1		1		10		10		0.1		1		10		10																	0.1	10	
henylamine, N-		20			20	b																																		20	20	
of 10)																																				1	b,j			1	1	
oaniline		100			100	b																														0.0025				100	100	
obenzene		20			0.0025	d	0.05		2		2		10		10		0.05		2		10		10																	0.0025	20	
ophenol							750000	c																																750000	750000	75
ophenol							450000	c																																450000	450000	45
ophenol							4000	c																																4000	4000	4
ophenol							70	c																																70	70	
ophenol							6.5	c																																6.5	6.5	
ophenol							2	c																																2	2	
ophenol							1.5	c																																1.5	1.5	
ophenol							1	c																																1	1	
ophenol								b																																		
ophenol								b																																		
ophenol							20		20		20		50		50																										20	50	
ophenol		6	400	3													7.6	a	7.6	a	7.6	a	7.6	a		5			5			5				0.002				0.002	400	
ne							0.1		5		5		50		50		0.1		5		50		50			40			40			40								0.1	50	
		30	100	70			0.1		1		1		10		10		3.8	a	3.8	a	3.8	a	3.8	a		40			40			40				0.05	k			0.05	100	
(total)					0.1	d																														0.01	h			0.01	0.1	
cid esters (each)																	30			p		p		p																	30	30	
							0.1		10		10		100		100		0.1		10		100		100			250			250			250								0.1	250	
					0.1	nd																														0.01				0.01	0.1	
oaniline, 2,3,5,6-		20		20	20	b																																		20	20	
obenzene					0.01	d	0.05		2		2		10		10																										0.01	10	
obenzene (total)																																				0.01				0.01	0.01	
obenzene, 1,2,3,4-		10																																						10	10	
ethane, 1,1,2,2-																	0.1		5		50		50																	0.1	50	
ophenol, 2,3,4,5-		20					0.05		0.5		0.5		5		5		0.05		0.5		5		5																	0.05	20	
ophenol, 2,3,4,6-							0.05		0.5		0.5		5		5		0.05		0.5		5		5																	0.05	5	
ophenol, 2,3,5,6-							0.05		0.5		0.5		5		5		0.05		0.5		5		5																	0.05	5	
niline 2,4,5-		20		20	20	b																																		20	20	
niline, 2,4,5-		20																																						20	20	
enzene					0.01	d	0.05		2		2		10		10																										0.01	10	
enzene (total)																																				0.01				0.01	0.01	
enzene, 1,2,3-		20																																						20	20	
enzene, 1,2,4-		20																								30			30			30								20	30	
thane, 1,1,1-							0.1		5		5		50		50		0.1		5		50		50		34	26		34	26		34	26							0.1	50	
henol, 2,3,4-							0.05		0.5		0.5		5		5		0.05		0.5		5		5																	0.05	5	
henol, 2,3,5-							0.05		0.5		0.5		5		5																										0.05	5	
henol, 2,3,6-							0.05		0.5		0.5		5		5		0.05		0.5		5		5																	0.05	5	
henol, 2,4,5-		9		4			0.05		0.5		0.5		5		5		0.05		0.5		5		5			3.2			3.2			3.2								0.05	9	
henol, 2,4,6-		10					0.05		0.5		0.5		5		5		0.05		0.5		5		5			0.66			0.66			0.66								0.05	10	
henol, 3,4,5-							0.05		0.5		0.5		5		5		0.05		0.5		5		5																	0.05	5	
mpound																																							10			10	10	
yde																																											
																										3.5			3.5			3.5								3.5	3.5	
ile			1000		1000	b																																		1000	1000	
								c																																		
								b																																			
								b																																			
							80		80		80		150		150																										80	150	
																	0.05	c	0.5	c	5	c	5	c		0.24			0.24			0.24				0.05	k	0.3			0.05	5	
roisopropyl)ether																				e						0.66			0.66			0.66								0.66	0.66	
hane																									0.38	0.061		0.38	0.061		0.38	0.061								0.061	0.38	
trachloride			1000		1000	b	0.1		5		5		50		50		0.1		5		50		50		0.64	0.1		0.64	0.1		0.64	0.1								0.1	1000	
m					0.001	d	0.1		5		5		50		50		0.1		5		50		50			0.13			0.13			0.13								0.001	50	
					0.5	d	0.1		1		1		10		10		0.01		1		10		10																	0.01	10	
otal)																																											
ne					0.1	a																																				0.1	0.1	
none					0.1	d																														0.01						0.01	0.1	

pound Name	Sub category	ORNL-E	ORNL-M	ORNL-P	WSR	WSR-FN	BC Ag	BC Ag-FN	BC UP	BC UP-FN	BC R	BC R-FN	BC C	BC C-FN	BC I	BC I-FN	CCME Ag	CCME Ag-FN	CCME RP	CCME RP-FN	CCME C	CCME C-FN	CCME I	CCME I-FN	Ont Ag (M/F)	Ont Ag (C)	Ont Ag-FN	Ont RP (M/F)	Ont RP (C)	Ont R/P-FN	Ont IC (M/F)	Ont IC (C)	Ont IC-FN	RIVM MPC	RIVM MPC-FN	RIVM TV	RhVM-FN	USSR MACa	USSR FN	USSR TACa	Min	Max	Gr
hloromethane																										0.09			0.09			0.09									0.09	0.09	
thane							0.1		5		5		50		50																										0.1	50	
thane, 1,1-							0.1		5		5		50		50		0.1		5		50		50			3			3			3								0.1	50	
thane, 1,2-					0.04	c	0.1		5		5		50		50		0.1		5		50		50		0.05	0.022		0.05	0.022		0.05	0.022								0.022	50	
thene, 1,1-																	0.1		5		50		50																	0.1	50	
thene, 1,2-																	0.1		5		50		50																	0.1	50	
thylene, 1,1-							0.1		5		5		50		50										0.015	0.002		0.015	0.002		0.015	0.0024								0.0024	50	
thylene, 1,2-							0.1		5		5		50		50											2.3			2.3			2.3								0.1	50	
thylene, Cis-1,2-																										2.3			2.3			2.3								2.3	2.3	
thylene, Trans-1,2-																										4.1			4.1			4.1								4.1	4.1	
ethane					2	d	0.1		5		5		50		50		0.1		5		50		50														k				0.1	50	
ropane, 1,2-		700			700	b	0.1		5		5		50		50		0.1		5		50		50		0.12	0.019		0.12	0.019		0.12	0.019								0.019	700	
ropane, 1,3-																									0.04	0.007		0.04	0.007		0.04	0.0066								0.0066	0.04	
ropane, 1,3- cis							0.1		5		5		50		50																										0.1	50	
ropane, 1,3- trans							0.1		5		5		50		50																										0.1	50	
ropene, 1-2 (cis)																	0.1		5		50		50																	0.1	50	
ropene, 1-2 (trans)																	0.1		5		50		50																	0.1	50	
ne								c																																		
ne								b																																		
ne								b																																		
ne							0.1	d	5		5		50		50																										0.1	50	
ene																	0.1	c	1.2	g	20	g	20	g		0.28			0.28			0.28				0.05	k				0.05	20	
yde																																						7			7	7	
oethane																									6.3	3.8		6.3	3.8		8.5	3.8									3.8	8.5	
yl ketone																										0.27			0.27			0.27									0.27	0.27	
butyl ketone																										0.48			0.48			0.48									0.48	0.48	
t butyl ether																										5.7			5.7			5.7									5.7	5.7	
chloride																										1.1			1.1			1.1									1.1	1.1	
				300	0.1	cd	0.1		5		5		50		50		0.1		5		50		50		1.7	1.2		1.7	1.2		1.7	1.2				0.1					0.1	300	
oethene					0.01	d																														0.01					0.01	0.01	
oethene, 1,1,1,2-																									0.12	0.019		0.12	0.019		0.12	0.019									0.019	0.12	
oethene, 1,1,2,2-							0.1		5		5		50		50											0.01			0.01			0.01									0.01	50	
oethylene																	0.1	d	0.2	e	0.5	e	0.6	e		0.45			0.45			0.45									0.1	0.6	
oethylene (PERC)								c																																		
oethylene (PERC)								b																																		
oethylene (PERC)								b																																		
oethylene (PERC)							0.1	d	5		5		50		50																										0.1	50	
omethane					0.001	d											0.1		5		50		50														0.001				0.001	50	
omethane, 1,1,1-							0.1		5		5		50		50																										0.1	50	
omethane, 1,1,2-							0.1		5		5		50		50																										0.1	50	
								c																																		
								b																																		
								b																																		
							0.1	d	3		3		30		30																										0.1	30	
				200													0.1	d	0.8	e	0.8	e	0.8	e		2.1			2.1			2.1				0.05	k	0.3			0.05	200	
thane, 1,1,2-							0.1		5		5		50		50		0.1		5		50		50			0.28			0.28			0.28									0.1	50	
thylene																	1	c	3	g	31	g	31	g	3.9	1.1		3.9	1.1		3.9	1.1								1	31	
thylene (TCE)							0.15																																		0.15	0.15	
thylene (TCE)								b																																		
thylene (TCE)								b																																		
thylene (TCE)							0.1	d	5		5		50		50																										0.1	50	
ride					0.01	d																			0.0075	0.003		0.0075	0.003		0.0075	0.003								0.003	0.01	
							200	a	200	a	200	a	200	a	200	a																									200	200	
								c																																		
								b																																		
								b																																		
							0.1	d	5		5		50		50																										0.1	50	
																	0.1	d	1	e	17	a	20	a		25			25			25				0.05	k				0.05	25	

FOOTNOTES

Footnotes for BC Screening Level Figures

All values in µg/g unless otherwise stated. Substances shall be analyzed using methods in protocols approved under section 50 or methods acceptable to the Director.

1	Standard has been adjusted based on a reference provincial background soil concentration. Standard represents the rounded sum of the toxicologically-based value plus the reference provincial background soil concentration. For all land uses, the reference provincial background soil concentration is 14.9 µg/g.
2	No standard. Insufficient acceptable scientific data exists, so no standard is calculated.
3	No standard. No appropriate standard, guideline, or criterion exists to use to develop a soil quality standard.
4	No standard. Insufficient acceptable environmental data exists, so standards are set equal to the Canadian Council of Ministers of the Environment Interim soil quality criteria.
5	The pH is the pH of the soil at a site.
6	Standard has been adjusted based on a reference provincial background soil concentration. Standard represents the rounded sum of the toxicologically-based value plus the reference provincial background soil concentration. For all land uses, the reference provincial background soil concentration is 1.3 µg/g.
7	Standard is for chromium (total).
8	Standard has been adjusted based on a reference provincial background soil concentration. Standard represents the rounded sum of the toxicologically-based value plus the reference provincial background soil concentration. For all land uses, the reference provincial background soil concentration is 58.9 µg/g.
9	Standard is for chromium+6.
10	Standard has been adjusted based on a reference provincial background soil concentration. Standard represents the rounded sum of the toxicologically-based value plus the reference provincial background soil concentration. For all land uses, the reference provincial background soil concentration is 74.0 µg/g.
11	Standard varies. If sheep are the livestock of concern, standard is 40 µg/g. For all other livestock the standard is 150 µg/g.
12	WAD means weak acid dissociable.
13	SAD means strong acid dissociable.
14	Standard has been adjusted based on a reference provincial background soil concentration. Standard represents the rounded sum of the toxicologically-based value plus the reference provincial background soil concentration. For all land uses, the reference provincial background soil concentration is 108.6 µg/g.

15	Polychlorinated biphenyls (PCBs) include Arochlor mixtures 1242, 1248, 1254, and 1260.
16	No standard. No appropriate model to calculate data exists, so no standard is calculated.
17	Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) expressed in 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) toxicity equivalents. NATO International Toxicity Equivalency Factor (I-TEFs) for congeners and Isomers of PCDDs and PCDFs are as follows:

	PCDD Congener	I-TEF	PCDF Congener	I-TEF
	2,3,7,8,-T_4CDD	1.0	2,3,7,8-T_4CDF	0.1
	1,2,3,7,8-P_5CDD	0.5	2,3,4,7,8-P_5CDF	0.5
	1,2,3,4,7,8-H_6CCD	0.1	1,2,3,7,8-P_5CDF	0.05
	1,2,3,7,8,9-H_6CDD	0.1	1,2,3,4,7,8-H_6CDF	0.1
	1,2,3,4,6,7,8-H_7CDD	0.1	1,2,3,7,8,9-H_6CDF	0.1
	1,2,3,4,6,7,8-H_7CDD	0.01	1,2,3,6,7,8-H_6CDF	0.1
	O_8CDD	0.001	2,3,4,6,7,8-H_6CDF	0.1
			1,2,3,4,6,7,8-H_7CDF	0.01
			1,2,3,4,7,8,9-H_7CDF	0.01
			O_8CDF	0.001

18	Insufficient acceptable environmental data exists, so AL, PL, and RL standards are set equal to the Canadian Council of Ministers of the Environment interim soil quality criteria.
19	Standard has been adjusted based on a reference provincial background soil concentration. Standard represents the rounded sum of the toxicologically-based value plus the reference provincial background soil concentration. For all land uses, the reference provincial background soil concentration is 138.1 µg/g.
20	Volatile petroleum hydrocarbons with the exception of benzene, toluene, ethylbenzene and xylenes.
21	Light extractable petroleum hydrocarbons with the exception of benzo(a)anthrancene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene and pyrene.
22	Heavy extractable petroleum hydrocarbons with the exception of benz(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenz(a,h)anthrancene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene and pyrene.
23	Soil must be remediated so that substances are not present in quantities in excess of that acceptable to a manager.

API Footnotes RE: Canadian Soil Quality Guidelines for the Protection of Environmental and Human Health.

a	Data are sufficient and adequate to calculate an SQG_{HH} and an SQG_E. Therefore the soil quality guideline is the lower of the two and represents a fully integrated de novo guideline for this land use, derived in accordance with the soil protocol (CCME 1996). The corresponding interim soil quality criterion (CCME 1991) is superseded by the soil quality guideline.

b	Data are insufficient/inadequate to calculate an SQG_{HH}, an SQG_E, or a provisional SQG_E. Therefore the interim soil quality criterion (CCME 1991) is retained as the soil quality guideline for this land use.
e	Data are sufficient and adequate to calculate only a provisional SQG_E. It is greater than the corresponding interim soil quality criterion (CCME 1991). Therefore, in consideration of receptors and/or pathways not examined, the interim soil quality criterion is retained as the soil quality guideline for this land use.
c	Data are sufficient and adequate to calculate an SQG_{HH} and a provisional SQG_E. Both are greater than the corresponding interim soil quality criterion (CCME 1991). Therefore, in consideration of receptors and/or pathways not examined, the interim soil quality criterion is retained as the soil quality guideline for this land use.
e	Data are sufficient and adequate to calculate an SQG_{HH} and a provisional SQG_E. Both are less than corresponding interim soil quality criterion (CCME 1991). Therefore, the soil quality guideline supersedes the interim soil quality criterion for this land use.
f	The soil-plant-human pathway was not considered in the guideline derivation. If produce gardens are present or planned, a site-specific objective must be derived to take into account the bioaccumulation potential (e.g., adopt the agricultural guideline as objective). The off-site migration check should be recalculated accordingly.
g	Data are sufficient and adequate to calculate only a provisional SQG_E, which is less than the existing interim soil quality criterion (CCME 1991). Therefore, the soil quality guideline supersedes the interim soil quality criterion for this land use.
h	Data are sufficient and adequate to calculate only an SQG_E. An interim soil quality criterion (CCME 1991) was not established for this land use, therefore the SQG_E becomes the soil quality guideline.
i	In site-specific situations where the size and/or the location of commercial and industrial land uses may impact primary, secondary, or tertiary consumers, the soil and food ingestion guideline is recommended as the SQG_E.
j	Data are sufficient and adequate to calculate only a provisional SQG_E.
k	Data are sufficient and adequate to calculate only an SQG_E, which is less than the interim soil quality criterion (CCME 1991) for this land use. Therefore the SQG_E becomes the soil quality guideline, which supersedes the interim soil quality criterion for this land use.
l	Data are sufficient and adequate to calculate only an SQG_{HH} and an SQG_E. The provisional SQG_{HH} is equal to the SQG_E and to the existing interim soil quality criterion (CCME 1991) and thus becomes the soil quality guideline, which supersedes the interim soil quality criterion for this land use.
m	Data are sufficient and adequate to calculate a provisional SQG_{HH} and an SQG_E. The provisional SQG_{HH} is less than the SQG_E and thus becomes the soil quality guideline for this land use.
n	Data are sufficient and adequate to calculate only an SQG_E. An interim soil quality criterion (CCME 1991) was not established for this land use, therefore the SQG_E becomes the soil quality guideline.
o	Hot water soluble.

p	Values not estimated.
q	An erratum with this change was issued in the technical supporting document for this substance (dated December 1996).
r	Chlorobenzenes include all trichlorobenzene isomers, all tetrachlorobenzene isomers, pentachlorobenzene
s	Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) expressed in 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) toxicity equivalents. NATO International Toxicity Equivalency Factor (I-TEFs) for congeners and Isomers of PCDDs and PCDFs are as follows:

	PCDD Congener	I-TEF	PCDF Congener	I-TEF
	2,3,7,8,-T_4CDD	1.0	2,3,7,8-T_4CDF	0.1
	1,2,3,7,8-P_5CDD	0.5	2,3,4,7,8-P_5CDF	0.5
	1,2,3,4,7,8-H_6CCD	0.1	1,2,3,7,8-P_5CDF	0.05
	1,2,3,7,8,9-H_6CDD	0.1	1,2,3,4,7,8-H_6CDF	0.1
	1,2,3,4,6,7,8-H_7CDD	0.1	1,2,3,7,8,9-H_6CDF	0.1
	1,2,3,4,6,7,8-H_7CDD	0.01	1,2,3,6,7,8-H_6CDF	0.1
	O_8CDD	0.001	2,3,4,6,7,8-H_6CDF	0.1
			1,2,3,4,6,7,8-H_7CDF	0.01
			1,2,3,4,7,8,9-H_7CDF	0.01
			O_8CDF	0.001

The Netherlands Footnotes:

a. Acidity: pH (0.01 M $CaCl_2$). In order to determine whether pH is greater than or equal to 5, or less than 5, the 90 percentile of the measured values is taken.

b. "PAH (total of 10)" here means the total of anthracene, benzo(a)anthracene, benzo(k)fluoroanthene, benzo(a)pyrene, chrysene, phenantrene, fluoroanthene, indeno(1,2,3-cd)pyrene, naphthalene and benzo(ghi)perylene.

c. "Chlorobenzenes (total)" here means the total of all chlorobenzenes (mono-, di-, tri-, penta- and hexachlorobenzene).

d. In the case of the intervention value, "polychlorobiphenyls" (total) means the total of PCB, 28, 52, 101, 118, 138, 153, and 180. For the target value it refers to the total excluding PCB 118.

e. "DDT/DDD/DDE" means the total of DDT, DDD and DDE.

f. "Drins" means the total of aldrin, dieldrin, and endrin.

g. "HCH compounds" means the total of α-HCH, β-HCH, γ-HCH and δ-HCH.

h. "Phathalates (total)" means the total of all phthalates.

i. "Mineral oil means" the sum of all the alkanes, both straight-chain and branched-chain. Where the contamination is due to mixtures (e.g., gasoline or domestic heating oil), then

not only the alkane content but also the content of aromatic and/or polycyclic aromatic hydrocarbons must be determined. This aggregate parameter has been adopted for practical reasons. Further toxicological and chemical disaggregation is under study.

j. The values for total polycyclic aromatic hydrocarbons, total chlorophenols and total chlorobenzenes in soil/sediment apply to the total concentration of the compounds belonging to the relevant category. If the contamination is due to only one compound of a category, the value used is the intervention value for the compound, where there are two or more compounds the value for the total of these compounds applies, etc. For soil/sediment, effects are directly additive (i.e., 1 mg of substance A has the same effect as 1 meg of substance B) and can be checked/compared against an aggregate standard by summing the concentrations of the substances involved. For further information about this additivity see, for example, the Technical Committee for Soil Protection (1989)[1].

m. Detection threshold

MPC (Maximum Permissible Concentrations Footnotes

a. MPA based on statistical extrapolation, toxicity data follow a long-logistic distribution.

c. MPA based on modified EPA-method, applying a factor 10 on the lowest NOEC

f. MPA based on equilibrium partioning

g. Van de Meent *et al.*, (1990)

h. Van de Plassche and De Bruijn (1992)

Westinghouse Savannah River Site Footnotes

1. Beyer (1990)
2. Oak Ridge National Laboratory (Efroymson et al. 1997a,b)
3. CCME (1997)
4. Ministry of Housing, Spatial Planning and Environment (1994)
5. Crommentuijn et al. (1997)

USSR Footnote:

1. Maximum allowable concentration (MAC) and tentative allowable concentrations (TAC) of pesticides and other substances in soil in the Soviet Union (from USSR State Committee for Science and Technology, 1984).

[1] Technical Committee for Soil Protection (1989). *Advies beoordeling van bodemverontreiniging met polycyclische aromate* (Advice regarding the assessment of soil contaminated with polycyclic aromatics) TCB A89-03

Attachment 1-2

Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs)

Assessment of Whether to Develop Ecological Soil Screening Levels for Microbes and Microbial Processes

OSWER Directive 92857-55

November 2003

Assessment of Whether to Develop Ecological Soil Screening Levels for Microbes and Microbial Processes

Executive Summary

Bacteria and fungi (i.e., microbes) are essential components of soil systems and the importance of microbial processes in terrestrial systems is well recognized. The Eco-SSL workgroup had lengthy discussions as to the merits of deriving microbial Eco-SSLs, and the potential significance of either having or not having Eco-SSLs for microbes in this guidance. As an outcome of these discussions, the Eco-SSL Steering Committee decided that Eco-SSLs for microbes would not be developed at this time for this guidance. The decision to not include microbial Eco-SSLs in this guidance should not be interpreted as any indication as to the perceived importance (or lack of) of microbes to soil ecosystems, or that microbes and microbial processes do not merit protection. Instead, it is the Steering Committee's recommendation that evaluation of risks to microbes and microbial processes at a Superfund site not be conducted at the screening level, but rather decisions as to the appropriate actions be discussed and decided among the decision makers (e.g., risk managers, risk assessors, responsible parties) as part of the baseline risk assessment. If determinations are made that microbes are appropriate assessment endpoints for a Superfund site, problem formulation and workplans should be developed to specifically address issues associated with scale and uncertainty for these sites.

Introduction

Microbes are essential components of soil systems. Microbes comprises nearly 90% of global biomass and biodiversity in ecosystems. In soil, microbial decomposition of organic material governs the rate of mineralization and the cycling of essential nutrients, and is an important determinant of soil fertility. Without the microbial biomass and the functions it performs, plants are not self-sustaining. The diversity of microbial taxa involved in various nutrient cycling processes can be related to the ubiquitous nature of certain substances. For example, relatively large numbers of microbial taxa can catabolize simple sugars and simple proteins, but substantially fewer taxa catabolize complex molecules such as lignin, keratin, or chlorinated biphenyls.

In non-agricultural settings, the importance of associations between plant roots and microbes (mycorrhizae) has gained recognition over the past twenty years. In particular, mutualism achieved between a host plant species and one or more fungal species is essential for certain plant species to flourish. Indeed, estimates are that more than 95% of all plant species and 99% of all plant individuals are mycorrhizal dependent - that is to say that elimination of mycorrhizal associations leads to dramatic shifts in the composition of the plant community. Even so, most associations are facultative and because there is great taxonomic diversity among fungal symbiots, the loss of one mycorrhizal species would not translate to a meaningful shift in primary production or structural shift in plant community composition. This is because

individual plants often are colonized simultaneously by a few to several genera of mycorrhizae.

Although microbes are recognized as essential components of soil ecosystems, Eco-SSLs for microbes and microbial processes have not been included in this EPA Eco-SSL guidance. The decision not to provide these Eco-SSLs in this guidance was made following lengthy discussions among workgroup members that included both scientific and non-technical (e.g., policy) considerations. In support of these discussions, draft position papers on the subject were developed by the workgroup; one paper represented the merits for microbial Eco-SSLs for inclusion in this guidance, and the other paper presented reasoning for not deriving microbial Eco-SSLs for this guidance. In addition, a debate on this issue was conducted at the 20th Annual Meeting of the Society of Environmental Toxicology and Chemistry (SETAC 1999).

Considerations and Rationale for Not Deriving Microbial Eco-SSLs for this Guidance
The considerations and rationale for the Eco-SSL Steering Committee's decision not to derive EcoSSLs for microbes or microbial processes can be summarized as:

- This Eco-SSL guidance has been developed to support risk-management decisions for Superfund sites. As Superfund sites, these sites are identified as having significant contamination potentially present for many years or even decades. Contaminant risks of significance to the environment can be reasonably expected to be manifested to higher organisms (i.e., plants, invertebrates, wildlife). Therefore, the risk assessment should quantify risks for higher organisms. The absence of unacceptable risk to higher organisms would indicate that risks to microbes are not of a magnitude or significance to the ecosystem to warrant separate risk management considerations. There was a consensus within the Steering Committee that it is unlikely that site conditions would pose unacceptable risk only to microbes and not be reflected as unacceptable risk to plants, soil invertebrates, or wildlife. However, it may be important to develop endpoints in the baseline risk assessment to evaluate microbial processes. In the baseline risk assessment, attention can be focused on microbial processes as a further explanation of expected risks for plants, soil invertebrates, or wildlife, to address those situations where sustained dysfunction of microbial functions can be documented.

- There are a considerable number of published laboratory investigations that demonstrate contaminant effects to microbes or microbial processes, however, the actual significance and relevance of much of these data to Superfund sites is uncertain. Uncertainties exist as to whether laboratory microbial ecotoxicological studies are good surrogates for natural environments due to differences in factors such as scale, functional redundancies, and complexities. Based on the potential uncertainties associated with these data, the Steering Committee concludes that risk management would be better served by not making screening-level decisions based on these data; instead, assessments of potential risk to microbial communities and functions should be based on the baseline risk assessment that utilizes site-specific information rather than generic, screening-level data.

- The scale and dynamic nature of microbes presents a challenge to defining conditions that indicate actual or potential adverse conditions for microbes. Measurements of microbial function and community structure are subject to great spatial (across millimeter distances) and temporal (within minutes to hours) variation, which makes an evaluation of ecological consequence of any measured change challenging. Of the endpoints typical used in microbial ecology and toxicology, (e.g., population, diversity, respiration, enzyme activity, substrate use, mutation rate) each is modified substantially during testing. Microbial endpoints tend to be highly responsive to fluxes of temperature, moisture, oxygen and many other non-contaminant factors. While threshold response levels for plants, soil invertebrates, and terrestrial wildlife among different high quality studies are generally in good agreement (i.e., typically within an order of magnitude), microbial responses which can be dramatically influenced by testing conditions often range across several orders of magnitude among studies (e.g., from <10 ppm to >1,000 ppm) for a given chemical with no apparent explanation for the differences. Functional redundancy across broad taxonomic groups enables swings in community composition without remarkable change in rates of decomposition or community respiration. Consequently, it is exceedingly difficult to relate specific microbial activities with indications of adverse and unacceptable environmental conditions. For the most common microbial activities, functional redundancy easily masks population shifts.

Attachment 1-3

Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs)

Evaluation of Dermal Contact and Inhalation Exposure Pathways for the Purpose of Setting Eco-SSLs

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EVALUATING THE DERMAL CONTACT AND INHALATION EXPOSURE PATHWAYS FOR THE PURPOSE OF SETTING ECO-SSLs

1.0 POTENTIAL EXPOSURE PATHWAYS

Pursuant to USEPA guidance, a complete exposure pathway consists of the following four elements: 1) sources and release mechanisms, 2) retention and transport media, 3) exposure points, and 4) exposure routes (USEPA, 1989). If any of these elements are missing, the pathway is considered to be incomplete. Exposure pathways can be characterized as incomplete, complete, or potentially complete. The risks from some complete or potentially complete pathways may be considered insignificant due to 1) low levels of contaminants, 2) low exposure frequency, or 3) because they are insignificant as compared to other "risk-driving" pathways. According to USEPA guidance (1997), complete or potentially complete exposure pathways should be evaluated quantitatively. However, pathways considered less significant may not warrant further quantitative evaluation for an ERA. Complete, but insignificant exposure pathways should be qualitatively evaluated and identified as a source of uncertainty.

The sections below discuss the dermal contact and inhalation exposure routes and present both dose and risk information for the 24 Eco-SSL contaminants. The analyses supports the conclusion that these pathways are generally less significant when compared to the ingestion pathways and do not warrant inclusion in the derivation of the Eco-SSLs. However, the site manager and/or risk assessor should not automatically dismiss these pathways on a site-by-site basis.

1.1 Dermal Contact with Contaminants in Soil

Potential receptors for which Eco-SSLs were derived included plants, soil invertebrates, birds and mammals. Although dermal exposure through direct contact with soil can be considered a complete exposure pathway for birds and mammals, this exposure pathway is usually considered to be incidental due to low frequency and/or duration of exposure and the relative contribution to risk compared to oral exposures. While methods are available to quantitatively assess dermal exposure to humans (USEPA, 1992), the data necessary to estimate dermal exposures for wildlife are generally not available (USEPA, 1993; Sample et al., 1997). Feathers of birds, fur on mammals, and scales on reptiles are believed to reduce dermal exposure by limiting the contact of the skin surface with the contaminated media. Studies assessing the toxicity of dermal exposures for wildlife species are limited. Available studies generally report results for laboratory rodents and are performed by shaving the fur and applying the contaminant directly to the exposed skin. This type of exposure rarely occurs in the environment.

Classes of chemicals known or suspected to be of concern via dermal absorption include volatile organic compounds (VOCs), pesticides, and petroleum compounds. Petroleum compounds are more likely to cause physical disruption and impairment in wildlife (e.g. oiling feathers, disabling flight, or interfering with temperature regulation) rather than chemical effects.

Conditions under which dermal pathways may need to be considered on a site-specific basis include:

- Species with little or no fur or feathers
- Species that spend a lot of time exposed to soil (i.e., in burrows)
- Where the contaminants of concern may be significantly more toxic via the dermal pathway compared to the oral pathway.
- Where dermal exposures may be substantially higher compared to oral exposures (i.e., pesticides applied directly to trees or soil surfaces).

Metals

Even though information is limited on the rate and extent of dermal absorption of metals in soil across the skin, most scientists consider that this pathway to be minor in comparison to exposures resulting from direct soil ingestion. This view is based on the following concepts: 1) most metals tend to bind to soils thus reducing the likelihood they would dissociate from the soil and cross the skin; and, 2) ionic species, such as metals, have a relatively low tendency to cross the skin, even when contact does occur. Based on these considerations, along with a lack of data to allow reliable estimation of dermal uptake of metals from soil, USEPA Region VIII generally recommends that dermal exposure to metals in soils not be evaluated quantitatively (USEPA, 1995).

VOCs

Since VOCs rapidly volatilize from surface soil, dermal contact by terrestrial wildlife to these contaminants in surface soils is expected to be minimal. However, this exposure pathway could be important for burrowing animals and may need further consideration on a site-specific basis if burrowing receptors and substantial VOC are identified.

Pesticides

There is some evidence to suggest that organophosphate (OP) pesticides are more toxic by dermal uptake compared to oral exposure. Driver et al. (1990) studied the uptake of agricultural chemicals to avian wildlife and found that routes of uptake in order of contribution to toxicological response were: dermal > preening >= oral > inhalation. They concluded that "thin avian skin may be even more conductive to OP uptake compared to mammalian skin" and "the principal barrier layer (*stratum corneum*) of the skin is greatly reduced in birds".

Henderson et al. (1993) evaluated oral and dermal exposures for the domestic pigeon (*Columba livia*) by applying treatments to the feet. The order of oral toxicity was the same as that for dermal toxicity: parathion > diazinon > methidathion. The data from this study suggests that dermally-applied pesticides were stored in the body, gradually appearing in the blood stream. Abou-Donia and Graham (1978) observed a similar toxic response to leptophos in hens dosed by long term application of the pesticide onto the comb compared to oral administration.

Each of these studies reports toxicity via dermal exposure to OP pesticides resulting from either direct application of the pesticide to the skin or spray application onto branches (perches). For avian wildlife, exposure to contaminants in soils is not expected to occur in a similar manner. There could however be site-specific conditions that result in dermal exposures to pesticides and these may need to be considered in a site-specific ERA.

1.2 Inhalation

Inhalation exposure pathways related to soil contamination generally consist of :

- Inhalation of volatile organic chemicals (VOCs) in ambient air (volatilization from soil)
- Inhalation of soil dust particles.

VOCs

VOCs are defined by USEPA (1998) as chemicals with Henry's Law constants greater than 10^{-5} atm-m^3/mol and molecular weights less than 200 grams/mol. Cal/EPA (1994) guidance defines a VOC as a chemical with a Henry's Law constant greater than 10^{-5} atm-m^3/mol and a vapor pressure greater than 10^{-3} mm Hg. VOCs are expected to disperse very rapidly in air following volatilization from soil or groundwater. This dispersion, caused by wind and advection, is likely to result in very low exposure point concentrations of VOCs in ambient air. Additionally, because VOCs have log Kow values less than 3.5, they are unlikely to be taken up and bioaccumulated in plant and animal tissues at significant levels (USEPA and USACE, 1998).

Additionally, most VOCs are generally not highly toxic to wildlife species. For humans, VOCs are mostly a concern because of their carcinogenic effects and the non-cancer effects of these chemicals seldom drive human health risk results. For derivation of wildlife Eco-SSLs, carcinogenic endpoints were not considered in the derivation of toxicity reference values (TRVs) (Appendix 4-3).

Since VOCs rapidly volatilize from surface soil, inhalation of VOCs from surface soil by wildlife species should be insignificant. However, this pathway may be significant for burrowing species and may need to be evaluated further based on site-specific conditions.

Metals and SVOCs

Metals and semi-volatile organic compounds (SVOCs) can sorb to dust particles and potentially be inhaled by ecological receptors. The fraction of dust that cannot be inhaled is considered non-respirable. Non-respirable dust can potentially be ingested and is, in fact, accounted for in published incidental soil ingestion values for wildlife species (USEPA, 1993). The fraction of dust that is respirable differs from species to species and little data exist to determine exact respirable fractions for individual ecological receptors. When the dust inhalation exposure pathway is evaluated for human receptors, it generally makes up a relatively insignificant fraction of the total multi-pathway risk (less than 5 percent, based on best professional judgement and the results presented by Carlsen, 1996).

Conditions under which inhalation pathways may need to be considered include:

- Sites where significant levels of VOCs are detected in soil gas within soil depths where wildlife species of concern may burrow.
- Sites with extensive VOC contamination in soils and/or groundwater.
- Sites with special-status species that occupy burrows and where any one of the above conditions is found.
- Where the contaminants of concern being evaluated are more toxic by the inhalation pathway compared to the oral pathway.

2.0 EXAMPLE DOSE ESTIMATES

To further demonstrate the relative contribution of the dermal and inhalation pathways to overall risk estimates compared to oral, the following analyses was completed. The following tables present examples of doses, toxicity and risk estimated for the oral, dermal, and inhalation pathways for different classes of chemicals at the same exposure concentration.

Exposure (Dose)

Very conservative assumptions and models were used in the dose estimation. The exposure and modeling assumptions, as well as a discussion of the conservatism of these values, are presented in an attachment and are summarized in Table 1.

The meadow vole was selected for this example because: (1) exposure assumptions are readily available (USEPA, 1993); (2) the small body weight of the meadow vole tends to maximize dose; and. (3) the meadow vole is an herbivore (simple diet). The use of a simplified diet decreased the number of dietary exposure pathways and allows for a more conservative evaluation of percent contribution of the dermal and inhalation pathways. The ingestion of invertebrates generally results in a higher dose compared to plant ingestion, which would decrease the relative contribution of the other pathways.

Table 1. Relative Dose Contributions for Meadow Vole[a]

Chemical	Dose (mg/kg-day) and Percent Contribution			
	Soil Ingestion	Plant Ingestion	Dermal Contact	Inhalation
Lead	0.78 38%	1.3 63%	4.1E-04 0.02%	7.9E-08 <0.001%
Fluoranthene	0.78 37%	1.3 63%	5.3E-03 0.2%	7.9E-08 <0.001%
DDT	0.78 79%	0.21 21%	1.2E-03 0.1%	7.9E-08 <0.001%

[a] Based on soil concentrations of 100 mg/kg and using standard exposure assumptions from USEPA, 1993, 1996, 1998. See attachment.

As shown in Table 1, the oral pathways (i.e., soil and biota ingestion) are the primary contributors to exposure (dose). For species ingesting invertebrates the primary exposure would be attributed to the invertebrate ingestion and the percent contribution of the dermal and inhalation pathways to the total dose would be even lower. Regardless, the contribution to the total dose associated with the dermal exposure pathway is 0.5% or less. The inhalation pathway contribution is very low at less than 0.01% for particulates and less than 1% for volatiles.

Absorption Factors

A comparison of dermal absorption factors against oral absorption factors indicates that 70% of the Eco-SSL COCs have a dermal absorption factor ranging from 1 to 33% of the oral absorption factor. Of the 21 COCs for which both dermal and oral absorption factors are available, 80% have a dermal absorption factor ranging from 1 to 33% of the oral absorption factor (see Table 2). Based on these findings, it can be assumed that, in general, the absorbed dermal dose is much lower than the absorbed oral dose for most COCs and the dermal exposure pathway is much less significant compared to the oral exposure pathway.

Toxicity

Comparison of the oral toxicity values (slope factor and reference dose) with respective dermal and inhalation toxicity values for each of the 24 Eco-SSL contaminants reveals little difference between the two values. If there is a difference, it is due to the conversion of oral toxicity values to dermal values using the oral absorption fraction (RAGS, Appendix A).

$$\text{Dermal RfD} = \text{Oral RfD} \times \text{Oral Absorption Factor}$$
$$\text{Dermal SF} = \text{Oral SF} / \text{Oral Absorption Factor}$$

This may result in a slightly greater dermal toxicity than oral toxicity since most oral absorption fractions are less than 100%.

A similar comparison of oral versus inhalation toxicity values reveals that for many of the Eco-SSL contaminants, the inhalation toxicity may be greater than the oral toxicity. These contaminants include hexavalent chromium, aluminum, barium, beryllium, cadmium, and manganese.

Risk Comparison

Table 3 presents a summary of oral, dermal and inhalation risk values from exposure to 1 ppm in soil for each of the 24 Eco-SSL contaminants (where toxicity information is available). In addition, ratios of risk values for dermal:oral and inhalation:oral are presented for each contaminant and summarized for all the contaminants. In general, the dermal risks ranged from less than 1% to 11% of the oral risks, and averaged 2.5% of oral risks. The inhalation risks ranged from 0.0001% to 0.1022% of the oral risks, and averaged 0.0172% of oral risks. These comparisons clearly indicate that dermal and inhalation risks from soil are much less significant than risks from ingesting soil for the Eco-SSL COCs.

3.0 CONCLUSIONS AND RECOMMENDATIONS

The Eco-SSL Task Group characterizing exposure pathways for terrestrial wildlife decided not to include the dermal or inhalation pathways in the Eco-SSL wildlife exposure model based on best professional judgement. The discussion presented here provides a conceptual basis for this decision. It is anticipated that the contribution of the dermal and inhalation pathways will be negligible for most sites. However, a site-specific evaluation of the complete and potentially complete exposure pathways for terrestrial wildlife should be completed for each site. If this evaluation concludes that receptors may be more highly exposed to contaminants through the dermal and/or inhalation pathways because of site-specific conditions, then these pathways would need to be evaluated in the baseline risk assessment or a screening analyses separate from the use of Eco-SSLs.

Table 2
Summary of Eco-SSL Contaminant Relative Toxicity Values

Chemical	Oral RfD mg/kg-d		Oral Absrptn Fraction %	Source	Dermal Absrptn Fraction %	Source	Dermal [1] RfD mg/kg-d		Inhalation RfD mg/kg-d		RfD Comparison Oral/Dermal --	RfD Comparison Oral/Inh --	Dermal Abs/ Oral Abs %	Abs < 1?
Dieldrin	5.00E-05	IRIS	100.0%	cons assm	10.0%	EPA, 1995	5.00E-05	IRIS	--	--	1	--	10%	YES
Total PCBs	--	--	96.0%	ATSDR (McLachlan 1993)	6.0%	EPA, 1995	--	--	--	--	--	--	6%	YES
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	3.00E-03	IRIS	100.0%	cons assm	100.0%	cons assm	3.00E-03	IRIS	--	--	1	--	100%	NO
Trinitrotoluene (TNT)	5.00E-04	IRIS	94.0%	ATSDR (Army 1981d)	100.0%	cons assm	4.70E-04	IRIS	--	--	1.1	--	106%	NO
DDT & metabolites	5.00E-04	IRIS	70.0%	ATSDR (70-90 %, Keller & Yearny 1980)	10.0%	EPA, 1995	3.50E-04	IRIS	--	--	1.4	--	14%	YES
Pentachlorophenol (PCP)	3.00E-02	IRIS	90.0%	ATSDR (Braun et al, 1979)	24.4%	EPA, 1995	2.70E-02	IRIS	--	--	1.1	--	27%	YES
Polycyclic Aromatic Hydrocarbons (PAHs)	--	--	40.0%	ATSDR (Foth et al 1988a for BAP)	10.0%	EPA, 1995	--	--	--	--	--	--	25%	YES
Aluminum	1.00E+00	NCEA	27.0%	ATSDR (Gupta et al 1986)	1.0%	EPA, 1995	2.70E-01	NCEA	1.00E-03	NCEA	4	1000	4%	YES
Antimony	4.00E-04	IRIS	100.0%	cons assm	1.0%	EPA, 1995	4.00E-04	IRIS	--	--	1.0	--	1%	YES
Arsenic	3.00E-04	IRIS	95.0%	ATSDR (Bettley & O'Shea 1975)	3.2%	EPA, 1995	2.85E-04	IRIS	--	--	1.1	--	3%	YES
Barium	7.00E-02	IRIS	5.0%	ATSDR (ICRP 1973)	1.0%	EPA, 1995	3.50E-03	IRIS	1.40E-04	H-Alt	20	500	20%	YES
Beryllium	2.00E-03	IRIS	1.0%	ATSDR (Morgareidge et al, 1975)	1.0%	EPA, 1995	2.00E-05	IRIS	5.70E-06	IRIS	100	351	100%	NO
Cadmium-water	5.00E-04	IRIS	4.6%	ATSDR (McLellan et al 1978)	1.0%	EPA, 1995	2.30E-05	IRIS	5.70E-05	NCEA	22	8.8	22%	YES
Cadmium-food	1.00E-03	IRIS	25.0%	ATSDR (Rahola et al 1973)	1.0%	EPA, 1995	2.50E-04	IRIS	5.70E-05	NCEA	4	18	4%	YES
Chromium III	1.50E+00	IRIS	0.5%	ATSDR (0.5 - 2%, Anderson 1986)	1.0%	EPA, 1995	7.50E-03	IRIS	--	--	200	--	200%	NO
Chromium VI	3.00E-03	IRIS	0.5%	ATSDR (0.5 - 2%, Anderson 1986)	1.0%	EPA, 1995	1.50E-05	IRIS	3.00E-05	IRIS	200	100	200%	NO
Cobalt	6.00E-02	NCEA	18.0%	ATSDR 18-97%(Sorbie et al 1971; Valberg et al 1969)	1.0%	EPA, 1995	1.08E-02	NCEA	--	--	6	--	6%	YES
Copper	4.00E-02	H	60.0%	ATSDR (Weber et al, 1969; Strickland et al 1972)	1.0%	EPA, 1995	2.40E-02	H	--	--	1.7	--	2%	YES
Iron	3.00E-01	NCEA	100.0%	cons assm	1.0%	EPA, 1995	3.00E-01	NCEA	--	--	1.0	--	1%	YES
Lead	--	--	50.0%	ATSDR (Chamberlain et al,1978)	1.0%	EPA, 1995	--	--	--	--	--	--	2%	YES
Manganese-Nonfood	2.00E-02	IRIS	3.0%	ATSDR 3-5%(Davidsson et al 1988; 1989; Mena et al 1969)	1.0%	EPA, 1995	6.00E-04	IRIS	1.43E-05	IRIS	33	1399	33%	YES
Nickel	2.00E-02	IRIS	1.0%	ATSDR 1-10%(Ambrose et al 1976; Ho & Furst 1973; Tedeschi & Sunderman 1957)	1.0%	EPA, 1995	2.00E-04	IRIS	--	--	100	--	100%	NO
Selenium	5.00E-03	IRIS	90.0%	ATSDR 90-95% (Griffiths et al 1976; Thomson 1974; Thomson & Steward 1974; Thomson et al 1978)	1.0%	EPA, 1995	4.50E-03	IRIS	--	--	1.1	--	1%	YES
Silver	5.00E-03	IRIS	21.0%	ATSDR (East et al, 1980; MacIntyre et al 1978)	1.0%	EPA, 1995	1.05E-03	IRIS	--	--	5	--	5%	YES
Vanadium	7.00E-03	H	1.0%	ATSDR (Roshchin et al 1980)	1.0%	EPA, 1995	7.00E-05	H	--	--	100	--	100%	NO
Zinc	3.00E-01	IRIS	20.0%	ATSDR 20-30%	1.0%	EPA, 1995	6.00E-02	IRIS	--	--	5	--	5%	YES
													# YES	20
													Total	27
													% where derm abs factor less than oral abs factor	74.07%

Notes:

[1] Dermal toxicity values are adjusted from oral toxicity values based on oral absorption fractions and the following equations (RAGS, Appendix A: Dermal RfD = Oral RfD x Oral Absorption Efficiency; Dermal SF = Oral FS /Oral Absorption Efficiency

cons ass = Conservative assumption

Table 3
Summary of Risks and Risk Comparisons

Chemical	Soil Conc (mg/kg)	BW (kg)	Soil Ingest rate (kg/day)	$Intake_{soil\ ing}$ (mg/kg-day)	Skin Surface Area (cm2/day)	Soil-skin Adher factor (kg/cm2)	Dermal Abs Factor (unitless)	$Intake_{soil\ derm}$ (mg/kg-day)	PEF (kg/m3)	Inhal rate (m3/day)	$Intake_{soil\ part\ inh}$ (mg/kg-day)	RfD Oral mg/kg-d	RfD Dermal mg/kg-d	RfD Inhal mg/kg-d	Noncancer Risk Oral	Noncancer Risk Dermal	Noncancer Risk Inhal	Risk Ratio Dermal:Oral	Risk Ratio Inhal:Oral
Dieldrin	1	0.0373	0.000283	**7.59E-03**	15.2	1.00E-06	0.1	**4.08E-05**	7.58E-10	3.90E-02	**7.92E-10**	5.00E-05	5.00E-05	--	**1.52E+02**	**8.15E-01**	--	0.5371%	--
Total PCBs	1	0.0373	0.000283	**7.59E-03**	15.2	1.00E-06	0.06	**2.45E-05**	7.58E-10	3.90E-02	**7.92E-10**	--	--	--	--	--	--	--	--
Hexahydro-1,3,5-trinitro-1,3,5-triazine (RDX)	1	0.0373	0.000283	**7.59E-03**	15.2	1.00E-06	1	**4.08E-04**	7.58E-10	3.90E-02	**7.92E-10**	3.00E-03	3.00E-03	--	**2.53E+00**	**1.36E-01**	--	5.3710%	--
Trinitrotoluene (TNT)	1	0.0373	0.000283	**7.59E-03**	15.2	1.00E-06	1	**4.08E-04**	7.58E-10	3.90E-02	**7.92E-10**	5.00E-04	4.70E-04	--	**1.52E+01**	**8.67E-01**	--	5.7139%	--
DDT & metabolites	1	0.0373	0.000283	**7.59E-03**	15.2	1.00E-06	0.1	**4.08E-05**	7.58E-10	3.90E-02	**7.92E-10**	5.00E-04	3.50E-04	--	**1.52E+01**	**1.16E-01**	--	0.7673%	--
Pentachlorophenol (PCP)	1	0.0373	0.000283	**7.59E-03**	15.2	1.00E-06	0.244	**9.94E-05**	7.58E-10	3.90E-02	**7.92E-10**	3.00E-02	2.70E-02	--	**2.53E-01**	**3.68E-03**	--	1.4561%	--
Polycyclic Aromatic Hydrocarbons (PAHs)	1	0.0373	0.000283	**7.59E-03**	15.2	1.00E-06	0.1	**4.08E-05**	7.58E-10	3.90E-02	**7.92E-10**	--	--	--	--	--	--	--	--
Aluminum	1	0.0373	0.000283	**7.59E-03**	15.2	1.00E-06	0.01	**4.08E-06**	7.58E-10	3.90E-02	**7.92E-10**	1.00E+00	2.70E-01	1.00E-03	**7.59E-03**	**1.51E-05**	**7.92E-07**	0.1989%	0.0104%
Antimony	1	0.0373	0.000283	**7.59E-03**	15.2	1.00E-06	0.01	**4.08E-06**	7.58E-10	3.90E-02	**7.92E-10**	4.00E-04	4.00E-04	--	**1.90E+01**	**1.02E-02**	--	0.0537%	--
Arsenic	1	0.0373	0.000283	**7.59E-03**	15.2	1.00E-06	0.032	**1.30E-05**	7.58E-10	3.90E-02	**7.92E-10**	3.00E-04	2.85E-04	--	**2.53E+01**	**4.58E-02**	--	0.1809%	--
Barium	1	0.0373	0.000283	**7.59E-03**	15.2	1.00E-06	0.01	**4.08E-06**	7.58E-10	3.90E-02	**7.92E-10**	7.00E-02	3.50E-03	1.40E-04	**1.08E-01**	**1.16E-03**	**5.66E-06**	1.0742%	0.0052%
Beryllium	1	0.0373	0.000283	**7.59E-03**	15.2	1.00E-06	0.01	**4.08E-06**	7.58E-10	3.90E-02	**7.92E-10**	2.00E-03	2.00E-05	5.70E-06	**3.79E+00**	**2.04E-01**	**1.39E-04**	5.3710%	0.0037%
Cadmium-water	1	0.0373	0.000283	**7.59E-03**	15.2	1.00E-06	0.01	**4.08E-06**	7.58E-10	3.90E-02	**7.92E-10**	5.00E-04	2.30E-05	5.70E-05	**1.52E+01**	**1.77E-01**	**1.39E-05**	1.1676%	0.0001%
Cadmium-food	1	0.0373	0.000283	**7.59E-03**	15.2	1.00E-06	0.01	**4.08E-06**	7.58E-10	3.90E-02	**7.92E-10**	1.00E-03	2.50E-04	5.70E-05	**7.59E+00**	**1.63E-02**	**1.39E-05**	0.2148%	0.0002%
Chromium III	1	0.0373	0.000283	**7.59E-03**	15.2	1.00E-06	0.01	**4.08E-06**	7.58E-10	3.90E-02	**7.92E-10**	1.50E+00	7.50E-03	--	**5.06E-03**	**5.43E-04**	--	10.7420%	--
Chromium VI	1	0.0373	0.000283	**7.59E-03**	15.2	1.00E-06	0.01	**4.08E-06**	7.58E-10	3.90E-02	**7.92E-10**	3.00E-03	1.50E-05	3.00E-05	**2.53E+00**	**2.72E-01**	**2.64E-05**	10.7420%	0.0010%
Cobalt	1	0.0373	0.000283	**7.59E-03**	15.2	1.00E-06	0.01	**4.08E-06**	7.58E-10	3.90E-02	**7.92E-10**	6.00E-02	1.08E-02	--	**1.26E-01**	**3.77E-04**	--	0.2984%	--
Copper	1	0.0373	0.000283	**7.59E-03**	15.2	1.00E-06	0.01	**4.08E-06**	7.58E-10	3.90E-02	**7.92E-10**	4.00E-02	2.40E-02	--	**1.90E-01**	**1.70E-04**	--	0.0895%	--
Iron	1	0.0373	0.000283	**7.59E-03**	15.2	1.00E-06	0.01	**4.08E-06**	7.58E-10	3.90E-02	**7.92E-10**	3.00E-01	3.00E-01	--	**2.53E-02**	**1.36E-05**	--	0.0537%	--
Lead	1	0.0373	0.000283	**7.59E-03**	15.2	1.00E-06	0.01	**4.08E-06**	7.58E-10	3.90E-02	**7.92E-10**	--	--	--	--	--	--	--	--
Manganese-Nonfood	1	0.0373	0.000283	**7.59E-03**	15.2	1.00E-06	0.01	**4.08E-06**	7.58E-10	3.90E-02	**7.92E-10**	2.00E-02	6.00E-04	1.43E-05	**3.79E-01**	**6.79E-03**	**5.54E-05**	1.7903%	0.0146%
Nickel	1	0.0373	0.000283	**7.59E-03**	15.2	1.00E-06	0.01	**4.08E-06**	7.58E-10	3.90E-02	**7.92E-10**	2.00E-02	2.00E-04	--	**3.79E-01**	**2.04E-02**	--	5.3710%	--
Selenium	1	0.0373	0.000283	**7.59E-03**	15.2	1.00E-06	0.01	**4.08E-06**	7.58E-10	3.90E-02	**7.92E-10**	5.00E-03	4.50E-03	--	**1.52E+00**	**9.06E-04**	--	0.0597%	--
Silver	1	0.0373	0.000283	**7.59E-03**	15.2	1.00E-06	0.01	**4.08E-06**	7.58E-10	3.90E-02	**7.92E-10**	5.00E-03	1.05E-03	--	**1.52E+00**	**3.88E-03**	--	0.2558%	--
Vanadium	1	0.0373	0.000283	**7.59E-03**	15.2	1.00E-06	0.01	**4.08E-06**	7.58E-10	3.90E-02	**7.92E-10**	7.00E-03	7.00E-05	--	**1.08E+00**	**5.82E-02**	--	5.3710%	--
Zinc	1	0.0373	0.000283	**7.59E-03**	15.2	1.00E-06	0.01	**4.08E-06**	7.58E-10	3.90E-02	**7.92E-10**	3.00E-01	6.00E-02	--	**2.53E-02**	**6.79E-05**	--	0.2686%	--
																	Max ratio	**10.7420%**	**0.1022%**
																	Min ratio	**0.0537%**	**0.0001%**
																	Mean ratio	**2.4558%**	**0.0172%**

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ATTACHMENT

ASSUMPTIONS USED IN THE DOSE CALCULATIONS

The following presents the equations and assumptions used to estimate doses for the meadow vole.

Table A1. Chemical Dose via Soil Ingestion

A. Intake Equation:

$$Dose_{soil}\ (mg/kg\text{-}day) = \frac{Cs \times IRs}{BW}$$

B. Variables and Assumptions:

Variable	*Value*	*Units*	*Description*	*Source*
Cs	100	milligrams per kilogram	Chemical concentration in soil	Assumption
IRs	0.000283	Kilograms per day	Soil ingestion rate	2.4 percent of food ingestion (USEPA, 1993); total soil ingestion, includes incidental ingestion during grooming, etc.
BW	0.0373	kilograms	Body weight	Average of males and females, year-round (USEPA, 1993)

Table A2. Chemical Dose via Plant Ingestion

A. Intake Equation:

$$Dose_{plant}\,(mg/kg\text{-}day) = \frac{Cp \times IRp}{BW}$$

B. Variables and Assumptions:

Variable	*Value*	*Units*	*Description*	*Source*
Cp	Cs x PUF [a]	milligrams per kilogram	Chemical concentration in plant tissue	Chemical-specific [a]
IRp	0.0118	kilograms/day	Plant ingestion rate	Median of range of values (USEPA, 1993)
BW	0.0373	kilograms	Body weight	Average of males and females, year-round (USEPA, 1993)

[a] Plant uptake factors (PUFs): lead, 0.0412; fluoranthene, 0.0425; and DDT, 0.0065. From Baes et al., 1984 for inorganics and Travis and Arms, 1988 for organics. Models incorporate site-specific factors such as percent moisture in the food items and the percentage of reproductive and vegetative portions ingested. Values above are taken from previously conducted agency-approved ERAs for the meadow vole.

Table A3. Chemical Dose via Dermal Contact

A. Intake Equation:

$$Dose_{dermal}\ (mg/kg\text{-}day) = \frac{Cs \times SA \times AF \times ABS}{BW}$$

B. Variables and Assumptions:

Variable	*Value*	*Units*	*Description*	*Source*
Cs	100	milligrams per kilogram	Chemical concentration in soil	Assumption
SA	15.2	square centimeters per day	Surface area	10 percent of total surface area (USEPA, 1993); V. Hayssen *pers. comm.* (March, 1993)
AF	0.000001	kilograms per square centimeter	Soil-to-skin adherence factor	Upper end of range of values for naked human skin (USEPA, 1992)
ABS	lead, 0.01; fluoranthene, 0.13; DDT, 0.03	unitless	Absorption fraction of chemical from soil	USEPA, 1998
BW	0.0373	kilograms	Body weight	Average of males and females, year-round (USEPA, 1993)

Table A4. Chemical Dose via Inhalation

A. Intake Equation:

$$Dose_{inhal}\ (mg/kg\text{-}day) = \frac{Ca \times IRa}{BW}$$

B. Variables and Assumptions:

Variable	*Value*	*Units*	*Description*	*Source*
Ca	Chemical-specific	milligrams per cubic meter	Chemical concentration in air	Cs x PEF (non-volatiles) Cs / VF (volatiles) (see below)
IRa	0.039	Cubic meters per day	Inhalation rate	by allometric equation; USEPA, 1993
BW	0.0373	kilograms	Body weight	Average of males and females, year-round (USEPA, 1993)

The following modeling and chemical-specific factors were used:

Calculation of Ca for non-VOCs – Cs x (7.6×10^{-10} kg/m^3). Particulate emission factor (PEF) from USEPA, 1996.

Calculation of Ca for VOCs – Cs divided by VF, where VF (Volatilization factor) for 1,1,1-TCA (only chemical meeting definition of a VOC) is 15,000 m^3/kg. From USEPA, 1998 (consistent with emission and dispersion models presented in USEPA's Soil Screening Guidance [USEPA, 1996]; default site factors and chemical-specific factors used in the derivation, as specified by USEPA, 1998). The VF value is highly conservative for use with ecological receptors because the equation assumes no dispersion. This is a highly unlikely scenario for ecological receptors because they are unlikely to spend 24 hours/day in a burrow or other enclosed air space.

Dose Estimation

The attached table (Table 5) presents the dose estimation using the equations and assumptions presented above.

Uncertainties

The assumptions presented above were developed to be conservative in nature. Conservative assumptions include the following:

- The AF (soil-to-skin adherence factor) is based on 1992 USEPA guidance which has since been updated and recommends lower AFs. This guidance is still in *Interim Draft* form and not yet accepted in all states and regions. Also, the AFs presented are for naked human skin. These values are likely overly conservative for adult/juvenile wildlife species, which have fur and feathers that would tend to prevent dermal contact of soil directly with underlying skin. These values may be applicable for evaluating exposures to hairless young. (Note that ingestion of soil by preening of feathers and grooming of fur is included in the soil ingestion rate.)

- The air models used in the above evaluation are those developed by USEPA for evaluating human health exposures. These values may be overly conservative for many wildlife species. Additionally, the use of site-specific soil parameters and other site-specific factors tend to results in lower air concentrations (i.e., the models use the most conservative assumptions). However, the models may underestimate exposures for species that spend a lot of time in underground burrows in areas of VOC contamination (Carlsen, 1996). Exposure time considerations and more site-specific modeling assumptions may be needed to evaluate some wildlife receptors.

- To be conservative and provide a generic evaluation, no area use factors or other weighting factors were used.

Table A5. Dose Estimation for the Meadow Vole

Chemical	Soil Concentration (mg/kg)	Air Concentration (mg/m^3)[a]	Plant Uptake Factor (unitless)	Dermal Absorption Factor (unitless)	Meadow Intakes (mg/kg bw-day)[d] Soil Ingestion	Plant Ingestion	Dermal Contact	Inhalation
Inorganics								
Lead	100	7.6.E-08	0.041	0.010	7.6E-01	1.3E+00	4.1E-04	7.9E-08
Semivolatile Organics								
Fluoranthene	100	7.6.E-08	0.043	0.13	7.6E-01	1.3E+00	5.3E-03	7.9E-08
4,4'-DDT	100	7.6.E-08	0.007	0.03	7.6E-01	2.1E-01	1.2E-03	7.9E-08
Volatile Organics								
1,1,1-TCA	100	6.7.E-03	NA	0.10	7.6E-01	NA	4.1E-03	7.0E-03

mg/kg	Milligrams per kilogram.
mg/m^3	Milligrams per cubic meter.
mg/kg bw-day	Milligrams per kilogram body weight - day.
NA	Not applicable.

[a] Based on soil concentration / PEF for non-volatiles and soil concentration / VF for volatiles.
[b] Seet text for intake equations, input parameters, and assumptions.

Attachment 1-4

Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs)

Review of Background Concentrations for Metals

OSWER Directive 92857-55

November 2003

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Appendix A Background Soil Concentration Database (electronic only)

1.0 INTRODUCTION

Many metals of concern commonly found at Superfund sites are also found in non-impacted areas. Background refers to constituents or locations that are not influenced by the releases from a site, and is usually described as naturally occurring or anthropogenic (US EPA, 2002). Naturally occurring metals are present in the environment in forms that are not influenced by human activity while anthropogenic refers to natural and human-made substances present as a result of human activities (not specifically related to a Superfund release) (US EPA, 2002). Understanding typical background concentrations of metals in soil is important to interpreting the toxicity-derived ecological soil screening levels (Eco-SSLs).

Ideally, this document would provide discrete contaminant concentrations that define the background concentrations for each metal applicable to soils across the United States. Unfortunately, this cannot be accomplished since soil characteristics are highly variable from state to state and from region to region (Connor and Shacklette, 1975; Shacklette and Boerngen, 1984). This document instead provides a summary of the data available on background concentrations in soil for the metals for which ecological soil screening levels (Eco-SSLs) were developed. The purpose is to provide a range of background concentrations that are expected in soils across the United States that can be used to:

Definition of Background

Background refers to constituents or locations that are not influenced by the releases from a site, and is usually described as naturally occurring or anthropogenic (US EPA, 2002)

1) **Anthropogenic** -natural and human-made substances present in the environment as a result of human activities (not specifically related to the CERCLA release in question); and,

2) **Naturally occurring** - substances present in the environment in forms that have not been influenced by human activity.

- Identify if the Eco-SSLs are near or below typical background soil concentrations; and
- Illustrate the importance of performing investigations to quantify site-specific background concentrations.

Little adequate and reliable data were found concerning background concentrations of organics in soils therefore the scope has been limited to inorganics. Metals and metalloids are consistently found as components of soil in uncontaminated areas. Over 50 inorganic elements can be found in native soils; however, only 17 of these are considered for the development of Eco-SSLs. (Table 1.1). The subsequent sections summarize the methods used to obtain appropriate data and the compile that data into a database of background concentrations. The data is then subsequently used to describe typical background concentrations of metals found in soils across the United States.

Table 1.1 Metals Considered in Developing Ecological Soil Screening Levels		
Aluminum	Chromium	Nickel
Antimony	Cobalt	Selenium
Arsenic	Copper	Silver
Barium	Iron	Vanadium
Beryllium	Lead	Zinc
Cadmium	Manganese	

2.0 DATA REQUIREMENTS AND RETRIEVAL

When compiling information from a variety of data sets, it is important to realize that no single data set will contain all the information that is desired. Therefore, it is important to describe the scope of desirable data from which all potential data sources may be measured. This section summarizes both the list of identified data requirements and data retrieval processes.

2.1 Data Requirements

Ideally, each data source contains the same information and meets all of the requirements for inclusion in the background database. However, this is not a realistic expectation given the fact that studies are performed across different soil types, sampling conditions and for a variety of study objectives. Therefore, a list of data characteristics to be reviewed for each data source was compiled (Table 2.1) and segregated into two classifications: 1) mandatory; and 2) optional. Data characteristics that must be included in the data source are classified as mandatory, whereas data characteristics that are useful but not essential are classified as optional.

Table 2.1 Data Characteristics for the Review of Data Sources Reporting Metal Background Concentrations in Soil

Classification	Data Characteristic
Mandatory	Contains data on soils for an Eco-SSL metal of concern
	The data is representative of natural conditions (e.g., not impacted by site releases)
	Statistics (arithmetic or geometric mean) clearly differentiated or raw data available to calculate statistics
Optional	Soil type or classification
	Wet-weight or dry-weight concentration
	Soil depth
	Geographic or regional location of soil
	Sample preparation and analysis methods
	Raw data reported

2.2 Data Retrieval

A literature review was performed to identify sources of information on background concentrations in soil for metals. The data retrieval consisted of a review of published data, a review of references from published literature, and an on-line (Internet) search to find additional state or federal publications. Data were retrieved from the following sources:

- United States Geological Survey (USGS) reports;
- Reports from State and other agencies; and
- Published literature.
- CERCLIS-3 records associated with Superfund sites;

The review of each study and its respective data characteristics are recorded in Table 2.1. As was anticipated, the number of data characteristics reported varied significantly among the data sources. The studies that contained the mandatory data characteristics were included in the database and are listed in Table 2.2.

2.3 Source Documents

The source documents obtained could be divided into three general categories: CERCLIS-3 database, USGS nationwide studies, and state and other independent surveys. Each of the source documents for which data were included in the background soil concentration database are discussed in the following subsections.

2.3.1 Data from USGS Nationwide Soil Studies

Two large data sets were obtained from the USGS. The findings in these two publications were considered natural background concentrations because environmental samples were intentionally excluded in locations where metals concentrations were expected to be affected due to anthropogenic activities. Connor and Shacklette (1975) compiled the results of 25 different studies carried out to collect background samples of rock, soil, and plant material through out the United States. Of the 25 studies identified, ten provided information on background levels of metals in soil by state or by region. Connor and Shacklette (1975) provided geometric mean, minimum and maximum values for both cultivated and uncultivated lands. Only data for uncultivated soils were included in the Background Soil Concentration Database.

Shacklette and Boerngen (1984) summarized background concentrations of metals present in surficial soil samples collected at a depth of 20 cm across the United States. Raw analytical data were downloaded electronically in a spreadsheet format provided by the USGS website (*http://minerals.usgs.gov/sddp/mrdata/sddpftp.shtml* - "Soil Chemistry" category) and summary statistics for each analyte were calculated for each state. Calculated arithmetic means and standard deviations for each analyte grouped by state were incorporated into the Background Soil Concentration Database from Shacklette and Boerngen (1984). A more recent publication reprocessed this same dataset to provide full-color maps for seven major elements (Al, Ca, Fe, K, Mg, Na and Ti) and 15 trace elements (As, Ba, Cr, Cu, Hg, Li, Mn, Ni, Pb, Se, Sr, V, Y, Zn and Zr) (USGS, 2001).

Table 2.2 Summary of Documents Reviewed for the Background Soil Database

Citation	Geographic		Depth	Soil Type	Basis (ww or dw)*	Date	Description	Description of Data Used for Database	Data and Statistics Provided by Study			
	Region	State (s)							Raw Data	Minimum/ Maximum	Mean	Std Dev
Ames and Hawkins, 1997	West	WA	soil horizons (A=2-6 in.; B=24-30 in)	primarily alluvium	dry weight	1991	Sampling was conducted in Clark County, WA in April and May 1991. Four methods were used to analyze metals including : total, total recoverable, TCLP and ASTM. 55 soil samples were collected from 26 sites and analyzed using the total method.	Table 3 data for total method analyses added to database.	Yes - (appendix A)	Yes (table 3)	Yes (table 3)	Yes (table 3)
Arizona Department of Environmental Quality (ADEQ), 1991	West	AZ	0.25 to 9 ft	NR	NR	NR	62 samples collected from 10 sites from areas without known site contamination (Tuscon and Phoenix areas only) Study also presents Arixona data from USGS (Borengen and Shacklette 1981)	ADEQ samples included in the database but not the USGS data as it was incorporated from the primary source.	Yes - (appendix B)	Yes (table 3-1)	Yes (table 3-1)	Yes (table 3-1)
Barringer, et. al 1998	East	NJ	soil horizon (O,E,A,B,C)	sand and clay	NR	1995	Uncultivated, cultivated and residential sites.	Statistics calculated from undeveloped forest areas and entered in database. Mean for each soil horizon included.	Yes - (appendix 1)	No (calculated)	No (calculated)	No (caclulated)
Bradford, et. al 1996	West	CA	Approx 50cm	22 different soil types	NR	1967	Sampling was conducted across 22 soil types and were collected in 1967. Sampling was conducted across 22 soil types (50 samples) across California.	Table 3 data added to database	Yes (table 2)	Yes (table 3)	Yes arithmetic & geometric (table 3)	Yes (table 3)
Breckenridge and Crockett 1995	US	NR	NR	15 different soil types	dry weight	NR	Guidance document for determining background soil concentrations at hazardous waste sites. Presents data from Kabata-Pendias & Pendias (1984).	Table 3 data added to database	No	Yes (table 1)	Yes (table 1)	No
Chen et al., 1999	East	FL	NR	sandy soils from uncultivated or minimally cultivated sites	dry weight	NR	448 soil samples collected by the Florida Cooperative Soil Survey Program (FCSSP) selected as representative of Florida soils.	Table 3 data added to database	No	Yes (table 2)	Yes (table 2)	Yes (table 2)
Conner and Shacklette 1975	West and East	MO, CO, CA, NV, ID, MT, WY, SD, NE, NM, GA, KY, AR, KA, OK, WI	A, B, C soil horizons	cultivated and uncultivated soils	NR	see text	25 different field studies across the US. Soil data from 10 different primary sources		No	Yes (as a %)	Yes geometric unless noted	Yes geometric unless noted
Holmgren et al., 1993	US	multiple	surface to 50 cm	major agricultural production areas	dry weight	1978	Study conducted by USDA, FDA, and USEPA at 3,045 agricultural sites across the US.	Table 4 data added to database.	No	Yes (table 4)	Yes- geometric & arithmetic (table 4)	Yes geometric & arithmetic (table 4)
McGovern, 1998	East	NY, MA, NJ	NR	See text	dry weight	see text	Literature values of elements from uncontaminated/unidsturbed areas or areas far from pollution sources.		No	Yes	Yes geometric for regional, arithmetic for others	No
Michigan Dept of Environmental Quality (MDEQ) 1991	East	MI	NR	topsoil/ clay/ silt/ sand/ swamp-peat (swamp-peat excluded b/c sediment)	NR	1987 to 1991	Local unimpacted background conditions data from hazardous waste sites. 348 samples. State background sampling continuous since 1987 (176 samples) and data from closure documents reviewed by MI WMD.	Means and standard deviations are reported for soil type and then sub-divided geographically to account for different glacial sheet areas in the state.	Yes as attachment	Yes as attachment	Yes as attachment	Yes as attachment

Table 2.2 Summary of Documents Reviewed for the Background Soil Database

Citation	Geographic		Depth	Soil Type	Basis (ww or dw)*	Date	Description	Description of Data Used for Database	Data and Statistics Provided by Study			
	Region	State (s)							Raw Data	Minimum/ Maximum	Mean	Std Dev
New Hampshire Division of Public Health Services 1991	East	NH	0 to 6 inches	NR	NR	1989	Sampling was conducted at public schools in New Hampshire. Four composite soils were collected at each school.		Yes - (appendix A)	Yes (table 2)	Yes (table 2)	Yes (table 2)
Pierce et al., 1982	West	MN	Surface,subsurface, till	representative of 7 major parent materials with a range of soil properties. Surface (0-15 cm) Subsoil (15cm-top of C), Parent Material (top of C to depth)	dry weight	NR	Seven "parent soil materials" were sampled at locations determined by the USDA Soil Conservation Service and area soil scientists. Weighted mean total metals and total extractable metals (weighted by metal concentration, depth, and bulk density of each horizon within each layer) for 16 surface, subsurface and till samples representative of 7 parent materials.	The weighted mean HNO_3 extractable metals summary statistics for all surface and subsurface soils were incorporated into the Background Soil Concentration database.	No	Yes total metals (Table 2)	Yes weighted mean for total metals (Table 2)	Yes weighted stedev for total metals (Table 2)
Shacklette and Boerngen 1984	East and West	multiple	Approx 20 cm (8 in)	NR	NR	1961-1975	In 1961 sampling program started to estimate ranges of element abundances in unaltered/minimally altered surficial materials. 1318 sampling sites--samples taken at depths of 20cm approximately .8km apart throughout the US	1,318 sampling stations across the US and analyzed for 50 analytes. Raw data obtained electronically in spreadsheet format from website.	Yes electronic from website	Yes (table 1) calculated from raw data	Yes (table 1) calculated from raw data	No calculated
Washington State Department of Ecology 1994	West	WA	Mostly from B & C soil horizons (2 to 5 ft)	NR	NR	1987-1993	USGS and Washington Dept. of Ecology 7 year study--on natural background concentrations of metals in surficial soils. Six different study results used to determine background concentrations. 490 smaples from 166 sites.	Total recoverable metals; 90th percentile value is used to calculate natural background levels.	Yes (section 11)	Yes (section 11)	Yes arithmetic & geometric (section 11)	Yes (section 11)
Watkins, et. al 1993	East	TN-Oak Ridge Reservation	Stratified by soil horizons A, B, C	Soil types are described by the site locations, not for the individual samples taken	NR	1992	Sampling conducted at various sites on ORNL Reservation lands.	Composited samples for inorganics from sites within 5 different geologic groups. Field operations and sampling conducted by: BSCP-SOP-01 (May 1992) and BSCP-SOP-02 (Aug 1992)	Yes (appendix D)	Yes	No calculated	No calculated

NR= not reported
ASTM = American Society for Testing and Materials
TCLP = Toxic Characteristic Leaching Procedure

2.3.2 Data from State, Federal or Other Independent Surveys

Additional background information was obtained from the following state or federal agencies and from literature searches:

- Ames and Hawkins (1997)
- Arizona Department of Environmental Quality (ADEQ 1991)
- USGS Water Resources - New Jersey (Barringer et al., 1998)
- University of California-Division of Agriculture (Bradford et al. 1996)
- Breckenridge and Crockett (1995)
- Florida Cooperative Soil Survey Program (Chen et al., 1999)
- US agricultural soils (Holmgren et al., 1993)
- New York State Department of Environmental Conservation (McGovern, 1988)
- Michigan Department of Natural Resources (MDNR, 1991)
- New Hampshire Bureau of Health Risk Assessment (NHDPHS, 1991)
- State of Minnesota (Pierce et al,. 1982)
- Washington State Department of Ecology (WSDOE, 1994)
- Oak Ridge National Laboratory (Watkins et al. 1993)
- Delaware Department of Natural Resources and Environmental Control (Delaware DNR & EC 1998)
- Massachusetts Department of Environmental Protection (MADEP 1995)
- Illinois Environmental Protection Agency (ILEPA 1997)

Ames and Hawkins (1997). Ames and Hawkins (1997) collected background soil data from Clark County, Washington, to determine if soil concentrations from sites of suspected contamination were elevated above background. Seventy-nine samples were randomly collected from 11 different soil types from areas that were relatively undisturbed by human activity. Concentrations for 17 metals, including 13 inorganic priority pollutants listed by the EPA, were analyzed for all soil samples. Analyses by four methods examined including: total method, total recoverable method, an ASTM leaching method, and TCLP. Summary statistics calculated include detection frequency, arithmetic mean, median, standard deviation, minimum, maximum, and the 90th percentile. The The summary statistics for analyses of 55 soil samples using the total method from Ames and Hawkins (1997) were incorporated into the Background Soil Concentration Database.

Arizona Department of Environmental Quality. The Arizona Department of Environmental Quality (ADEQ) compiled approximately 62 data points on background soil concentrations obtained from the USGS survey and from independent statewide soil surveys. All samples were taken at depths ranging from 3 inches to 9 feet. The analytical raw data were provided in an appendix and the arithmetic mean, maximum, minimum and standard deviation values for each analyte are presented in Table 3-1 in document. This document also summarizes data from Shacklette and Boerngen (1984) for soils collected in Arizona. These data were obtained from

the primary source and were not included from in the Background Soil Concentration Database. Summary statistics for ADEQ samples were incorporated into the Background Soil Concentration Database.

USGS Water Resources - New Jersey. USGS Water Resources of New Jersey conducted a study on the background soil concentrations of 23 metals in the vicinity of the Imperial Oil Company National Priority List (NPL) site (Barringer et al. 1998). This study singled out uncultivated, cultivated and residential sites outside the boundaries of the NPL site. Various soil types were collected including sand, silt and clay were included in the investigation and samples from 5 soil horizons (O, A, E, B and C). Summary statistics are not provided within the document, however the raw data is provided as an attachment. Summary statistics were calculated from the raw data for each of the soil horizons for each metal and entered into the Background Soil Concentration Database. For values reported as less than the detection limit, the detection limit was used to calculate the summary statistics. The calculated arithmetic mean, standard deviation, minimum detected concentration and maximum detected concentration for the undeveloped forest samples were incorporated into the Background Soil Concentration Database.

University of California-Division of Agriculture. The University of California Division of Agriculture conducted a large-scale investigation in 1967 to determine the background concentrations of metals in surficial soils (at approximately a 50 cm depth) for 22 different soil types. Bradford et al. (1998) report both the raw analytical data and the arithmetic and geometric means, standard deviation, minimum and maximum for each of 46 metals (Tables 2 and 3 in document). The arithmetic and geometric means, standard deviations, minimum and maximum detected concentrations were incorporated into the Background Soil Concentration Database.

Breckenridge and Crockett (1995). Breckenridge and Crockett (1995) published a report providing remedial project managers (RPMs) and others investigating hazardous waste sites with a summary of technical issues that should be considered when determining if a site has elevated concentrations of inorganics relative to local background soil and/or sediment concentrations. Background is defined as the concentration of inorganics found in soils or sediments surrounding a waste site, but which are not influenced by site activities or releases. The background data they provide as concentration ranges (minimum to maximum) and arithmetic mean values in selected surface soils for several United States soil types are taken from Kabata-Pendias and Pendias (1984). Background cadmium concentrations are not presented because its mobility is dependant upon soil pH and organic carbon content. The arithmetic mean soil concentrations reported by Breckenridge and Crockett (1995) were incorporated into the Background Soil Concentration Database.

Florida Cooperative Soil Survey Program. Chen et al. (1999) established background soil concentrations for 15 different trace elements in the state of Florida. Surface soil samples (n=448) were collected as part of the Florida Cooperative Soil Survey Program (FCSSP)

conducted jointly by the University of Florida Soil and Water Science Department and the United States Department of Agriculture (USDA) Natural Resources Conservation Service to establish baseline levels. Summary statistics (range, median, arithmetic and geometric means and standard deviations) are presented for each metal (Table 2 in the source document). These data were incorporated into the Background Soil Concentration Database.

US Agricultural Soils. As part of an investigation of trace element uptake by major agricultural crops, Holmgren et al. (1993) collected 3,045 soil samples across the United States in agricultural production regions. Samples were analyzed for lead, cadmium, zinc, copper and nickel. For each metal, summary statistics were calculated across all samples. Arithmetic and geometric means and standard deviations along with concentration percentiles are summarized in Table 4 of the source document. The summary statistics presented in Holmgren et al. (1993) were incorporated into the Background Soil Concentration Database.

New York State Department of Environmental Conservation. The New York State Department of Environmental Conservation (NYDEC) prepared an unpublished report by McGovern (1988) that summarizes concentrations of 20 elements for New York and other East Coast states. These values were based on previously published literature from undisturbed and uncontaminated areas. The background concentrations were provided in a combination of geometric and arithmetic statistics. When possible, primary literature sources were obtained to verify and supplement the data cited in this document. Generally, arithmetic means were provided for most data sources for New York, Maine and New Jersey. Geometric means were typically provided for data generated for the eastern United States. The arithmetic and geometric mean values were incorporated into the Background Soil Concentration database.

Michigan Department of Natural Resources. The Michigan Department of Natural Resources (MDNR) has collected 348 soil samples from various hazardous waste sites since 1987. Background concentrations are available for 16 metals from soil samples collected from geographically distinct areas within the state of Michigan (MDNR 1991). Five types of soil samples were collected, topsoil, sand, silt, clay, and swamp-peat. MDNR (1991) provides the number of samples, arithmetic mean, standard deviation, minimum and maximum values for each soil type. Samples identified as swamp-peat were excluded because these are likely to be representative of sediments not soils. For values reported as less than the detection limit, one-half the detection limit was used to calculate summary statistics. These summary statistics were incorporated into the Background Soil Concentration Database.

New Hampshire Division of Public Health Services (NHDPHS). The New Hampshire Division of Public Health Services (NHDPHS) and the US Fish and Wildlife Service (USFWS) conducted a study to determine baseline concentrations of metals in soils throughout New Hampshire (NHDPHS 1991). Public schools from each state county were selected randomly and composite surface soil samples were collected in May and June of 1989. Raw data results are provided for arsenic, cadmium, chromium, mercury, nickel, and lead for each sample. After outliers were

excluded, the arithmetic mean, standard deviation, varience, and concentration range of all samples were calculated (Table 2 in document). These data were incorporated into the Background Soil Concentration Database.

State of Minnesota. Soil background concentrations were retrieved from a paper published by Pierce et al. (1982) in which concentrations of six metals in some major Minnesota soils were reported. These soil types include the: Loess, Superior Lobe Till, Rainy Lobe Till, Lacustrine, Wadena Lobe Till, Percy Till, Des Moines Lobe Till (prairie), Des Moines Lobe Till (forest). Weighted mean total metals, weighted mean extractable metals and weighted standard deviations are reported (Tables 2, 3, and 4 in document). The weighted mean HNO_3 extractable metals summary statistics for all surface and subsurface soils were incorporated into the Background Soil Concentration database.

Washington State Department of Ecology. The Washington State Department of Ecology (WSDOE) published natural background concentrations for 12 metals in surficial soils throughout the state. A total of 490 soil samples were collected from 166 locations. The samples were collected across varying depths from undisturbed and undeveloped areas (WSDOE 1994). WSDOE (1994) provides the raw data in addition to providing geometric and arithmetic means, minimum, maximum and standard deviation values (1 record per metal - Section 11 in document). These summary statistics were incorporated into the Background Soil Concentration Database.

Oak Ridge National Laboratory (ORNL). The Oak Ridge National Laboratory (ORNL) conducted a study on the background soil concentrations of organics, metals and radionuclides in natural soil on the Oak Ridge Reservation. This study, known as the Background Soil Characterization Project, was part of the environmental restoration efforts undertaken by the ORNL (Watkins et al. 1993). Statistical data in the document includes median and upper confidence concentrations. Raw analytical data are included as an appendix. The arithmetic mean, standard deviation, minimum and maximum values were calculated from the raw data and incorporated into the Background Soil Concentration Database.

Delaware Department of Natural Resources and Environmental Control. The Delaware Department of Natural Resources and Environmental Control (DNR & EC) published "default" background standards to be used for remediation purposes. These default values for 20 metals are the upper value of the concentration range in soil samples collected at background locations at remediation sites across the state (Delaware DNR& EC 1998). The Delaware DNR & EC (1998) did not provide information on the type of mean value (arithmetic or geometric) presented. However, an agency representative was contacted and confirmed that the mean values represented are the arithmetic means. As a result of time and resource constraints these results were not incorporated into the Background Soil Concentration Database.

Massachusetts Department of Environmental Protection. The Massachusetts Department of Environmental Protection has published background soil concentrations for 20 metals that reportedly represent non-urban (suburban and rural) areas. These concentrations may be used in lieu of site-specific background concentrations for risk assessments in Massachusetts (MADEP1995). MADEP (1995) provides both the arithmetic and geometric mean background value. The background concentrations were collected from "counties within metropolitan statistical areas". Therefore, samples used to represent background concentration values could have the following biases [excerpted from MADEP 1995, page 2-44]:

1) the samples were taken in the vicinity of disposal sites and may in fact have been affected by the contamination at the sites;

2) background samples are more likely to be taken (and reported to MADEP) in areas with relatively high background concentrations; samples are less likely to be taken if the concentrations at the site are so low that they are "obviously" background;

3) it is possible that some samples taken as background at sites were not included in reports submitted to MADEP;

4) high background samples at sites may have been mistaken for contaminated samples and not identified as "background".

Given the uncertainty in the accuracy of this data set to represent natural background concentrations, these data were not incorporated into the Background Soil Concentration Database.

Illinois Environmental Protection Agency. The Illinois Environmental Protection Agency (ILEPA) has published background concentrations for 26 metals as part of the guidance for corrective action objectives (Section 742.405, Appendix A). These values were used for the development of remedial action objectives for public health risks as required under the State environmental regulations. The background concentrations as defined under these regulations, however, do not necessarily represent concentrations present under undisturbed conditions (ILEPA 1997). An agency representative was contacted to clarify the criteria used to define background conditions for the study. The representative stated that samples were collected from undisturbed and unimpacted sites within and outside of metropolitan areas. As a result of time and resource constraints these results were not incorporated into the Background Soil Concentration Database.

Other Studies. Upon review, several other studies were found either to not contain any background soil data or they provided data for chemicals or regions outside of the scope of the Eco-SSL effort. These studies are identified below.

Efroymson, R.A., M.E. Will, G.W. Suter, and A.C. Wooten. 1997. *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision.* Oak Ridge National Laboratory ES/ER/TM-85/R3. November 1997.

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

Miesch, A.T. 1967. *Methods of Computation for Estimating Geochemical Abundances.* US Geological Survey Professional Paper 574-B.

Ontario Ministry of Environment and Energy. 1993. *Ontario Typical Range of Chemical Parameters in Soil, Vegetation, Moss Bags and Snow, Version 1.0a.* Ministry of Environment and Energy. December 1993.

Sell, J.L., F.D. Deitz, and M.L. Buchanan. 1975. Concentration of Mercury in Animal Products and Soils of North Dakota. *Archives of Environmental Contamination.* 3:278-288.

Additional studies of background concentrations of metal in soil may continue to be identified, reviewed, and incorporated into the Background Soil Concentration Database at a later date. Currently, several publications are identified but have not been added to the database. These include:

Fields, T.W., T.F. McNevin, and R.A. Harkov. 1993. *A summary of Selected Soil Constituents and Contaminants at Background Locations in New Jersey.* New Jersey Department Environmental Protection and Energy. September 1993.

Gough, L.P., R.C. Severson, and H.T. Shacklette. 1988. *Element Concentrations in Soils and Other Surficial Materials of Alaska.* US Geological Survey Professional Paper 1458.

Markert, B. and Z.D. Li. 1991. Natural Background Concentrations of Rare-Earth Elements in a Forest Ecosystem. *The Science of the Total Environment.* 103:27-35.

New Hampshire Department of Environmental Services. 1998. *Contaminated Sites Risk Characterization and Management Policy.* January 1998.

Walsh, L.M., M.E. Sumner, and D.R. Keeney. 1977. Occurrence and Distribution of Arsenic in Soils and Plants. *Environmental Health Perspectives* 19:67-71.

Wright, J.R., R. Levick, and H.J. Atkinson. 1955. Trace Element Distribution in Virgin Profiles Representing Four Great Soil Groups. *Soil Science Society Proceedings* 19(3):340-344.

2.3.3 Background Concentrations from CERCLIS-3 Records

The CERCLIS-3 database stores quantitative site data from each record of decision (ROD) that has been signed, generally since 1996. Although the CERCLIS-3 database is structured for easy retrieval of site-specific data, it was not possible to filter the background data set for surficial soils only. Therefore, all background concentrations in soil for the Eco-SSL metals were extracted. An EPA employee queried the CERCLIS-3 database yielding records reporting background concentrations in soil from 60 sites across the United States. The query output included the following information: EPA Region, state, site name, operable unit number, date the ROD was signed, metal name, metal background concentration, units of measure and the method used to determine the background concentration (e.g., 95% UCL, arithmetic mean, etc.). The data for each Superfund site are reported using a variety of descriptive statistics including the arithmetic mean, geometric mean, standard deviation, minimum or maximum concentrations.

For each of the metals, the 5th, 25th, 50th (median), 75th and 95th percentiles of the arithmetic means were plotted as a "box-and-whisker" plot. Box-and-whisker plots provide a visual summary of where the bulk of background data are concentrated and the shapes of each distribution. These plots display data under four quartiles with each quartile corresponding to four equal sized sets based on their rank. Figure 2.1 provides a key to the box and whisker data

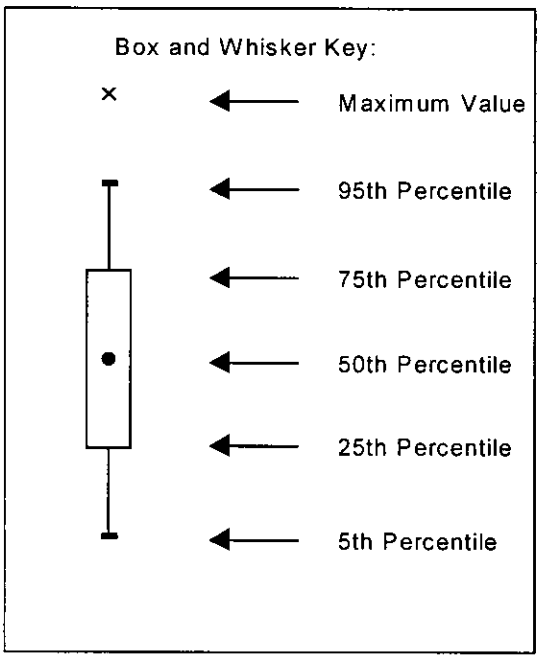
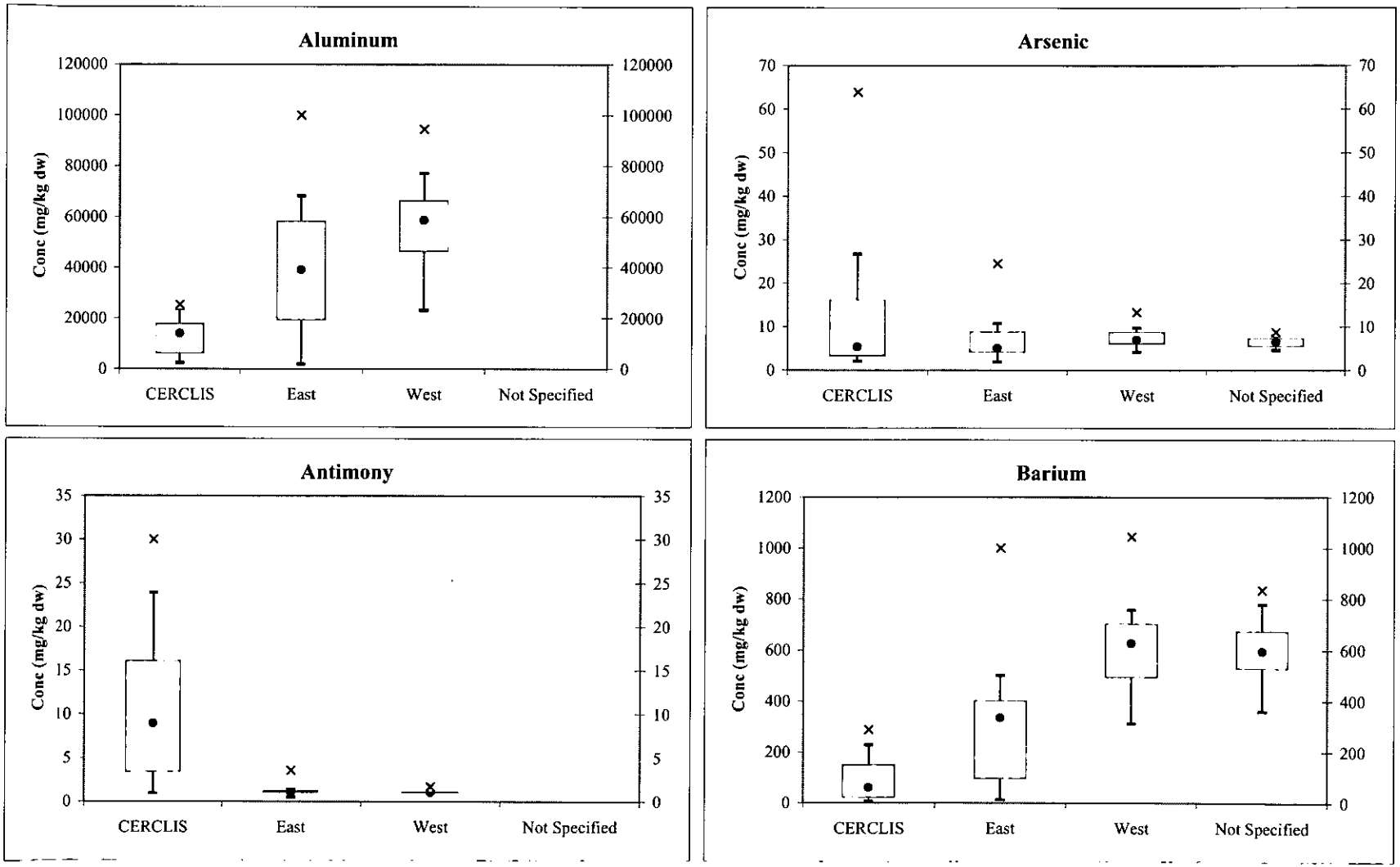


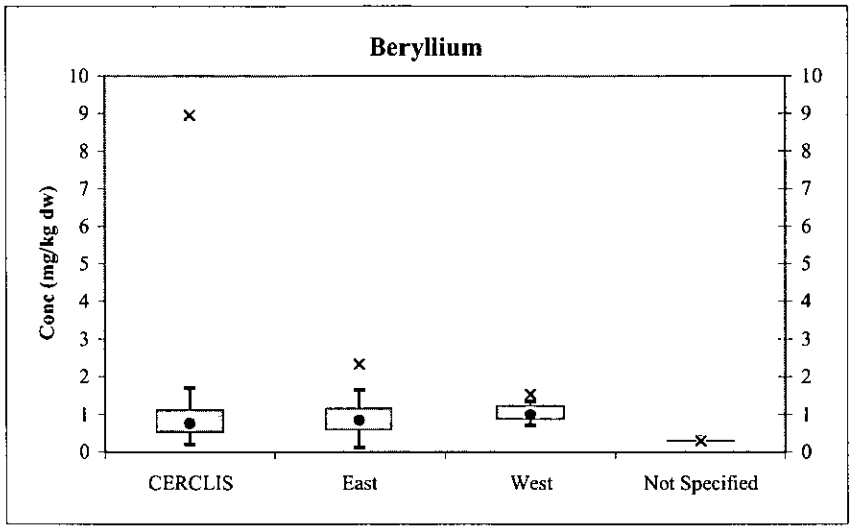
Figure 2.1 Key to Box and Whisker Plots

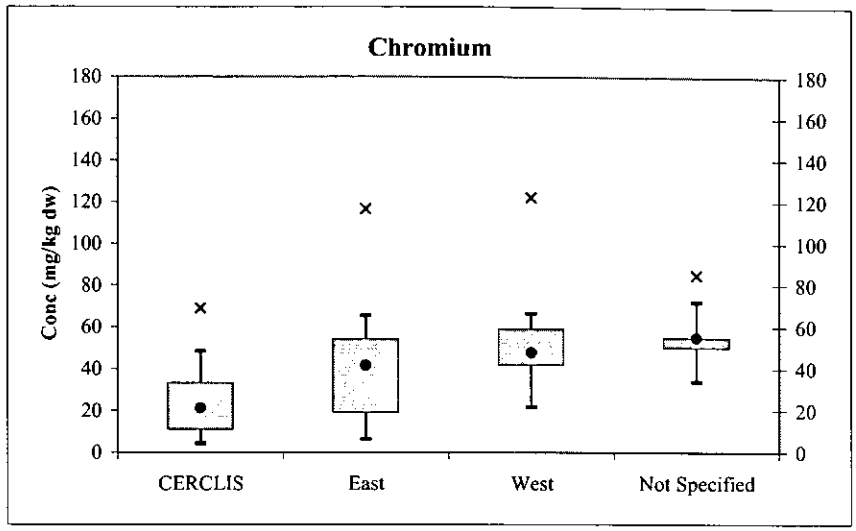
Figure 2.2 presents box-and-whisker plots of background metal concentrations in soil as reported by geographic region (eastern and western US) to discern relative differences in the distributional characteristics. The background data from CERCLIS-3 is plotted separately against the other eastern and western US data from the datasets discussed in the previous section (summarized in Table 2.2).

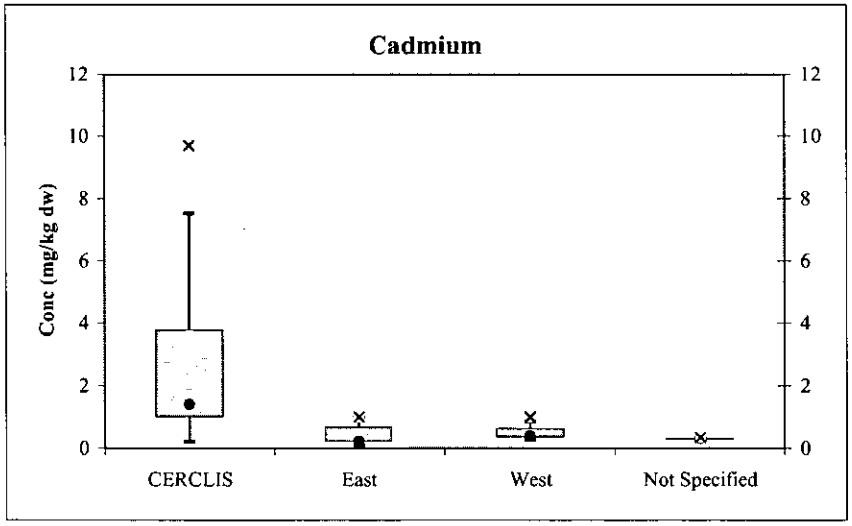
Due to the large number of maximum values higher than those reported by others, it is apparent from these plots that CERCLIS-3 captures data that may not be representative of background concentrations. Consequently, the CERCLIS-3 data was not incorporated into the Background Soil database.

Figure 2.2 Box and Whisker Plots of Background Metals Concentrations




Beryllium
Conc (mg/kg dw)
0
1
2
3
4
5
6
7
8
9
10
CERCLIS
East
West
Not Specified


Chromium
Conc (mg/kg dw)
0
20
40
60
80
100
120
140
160
180
CERCLIS
East
West
Not Specified


Cadmium
Conc (mg/kg dw)
0
2
4
6
8
10
12
CERCLIS
East
West
Not Specified

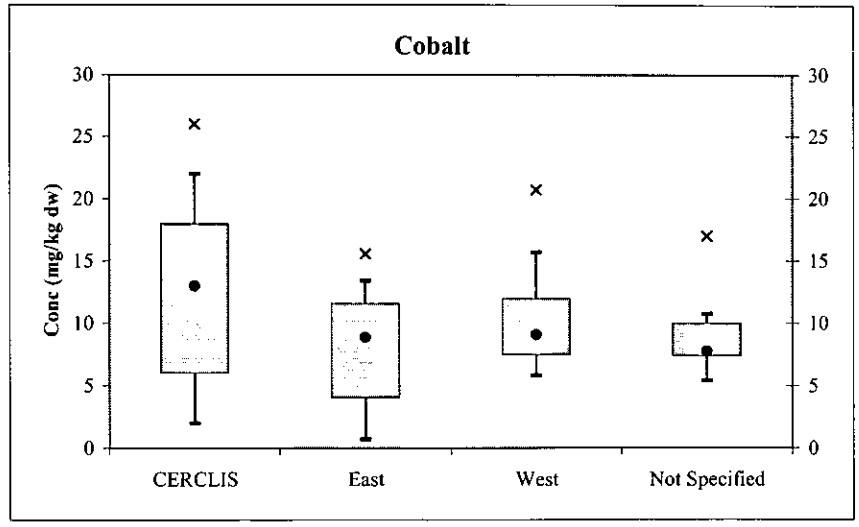

Cobalt
Conc (mg/kg dw)
0
5
10
15
20
25
30
CERCLIS
East
West
Not Specified

Figure 2.2 Box and Whisker Plots of Background Metals Concentrations

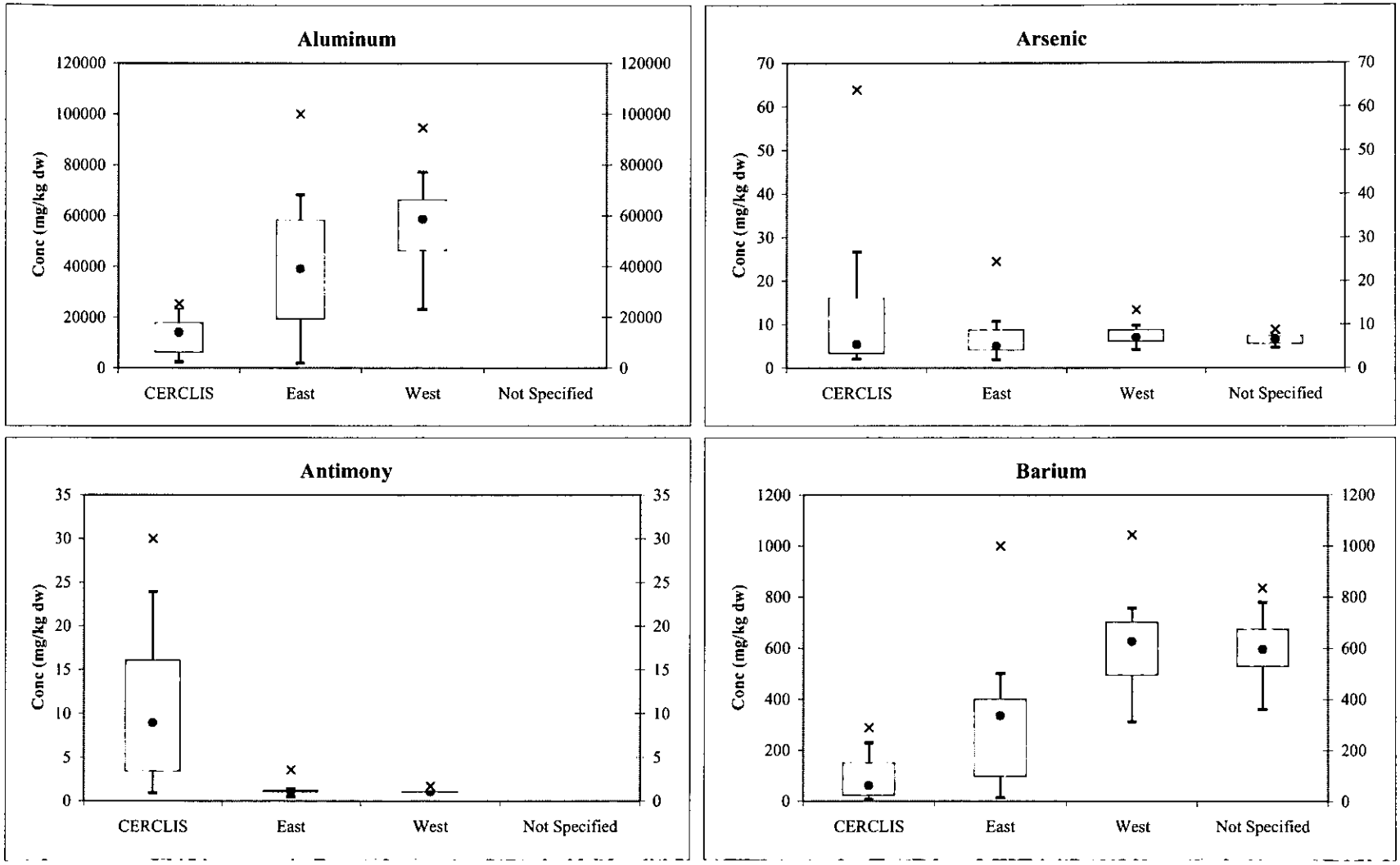


Figure 2.2 Box and Whisker Plots of Background Metals Concentrations

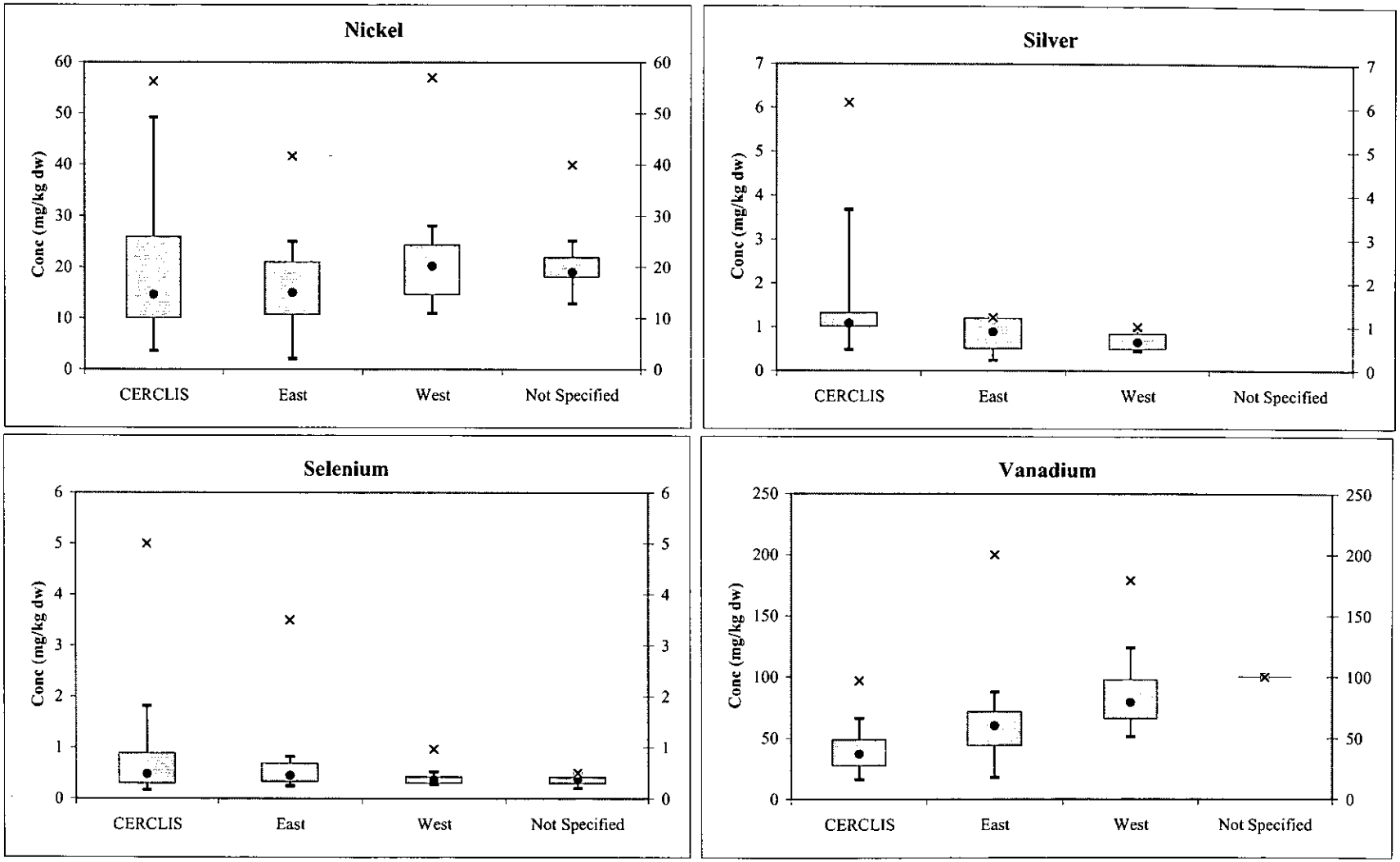
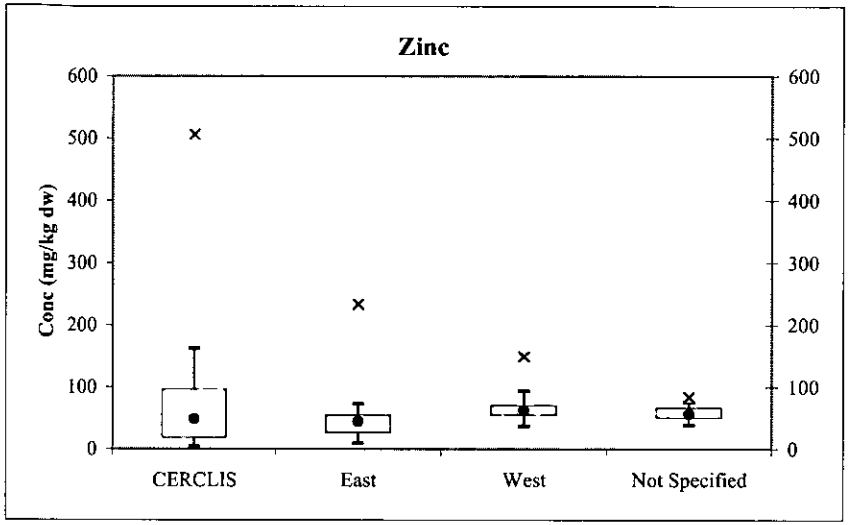


Figure 2.2 Box and Whisker Plots of Background Metals Concentrations



3.0 DATABASE DEVELOPMENT

A Microsoft Access® database was structured such that records for each Eco-SSL metal could be stored and retrieved by the soil type, geographic region, source document and statistics. The datasets included met all of the mandatory requirements. The database is provided in Appendix A as an electronic deliverable.

3.1 Data Evaluation

Table 3.1 provides a summary of the source data used in the database. Wherever soil depth was specified, only the soils samples closest to the surface were retained in the Background Soil Concentration Database. As seen in Table 3.1, information concerning optional data characteristics such as soil type, wet-weight versus dry-weight, sample preparation and analysis methods were often not available.

Because data incorporated into the Background Soil Concentration Database are mean values, these data (specifically non-detects) are already censored. In some cases, non-detect values were reported at one-half the detection limit. This is the standard approach used in risk assessments. In other cases, the non-detect values may have been reported at the detection limit. Unfortunately, most data sources are silent as to how non-detects were handled in the calculation of statistics. The few raw data points reported as non-detects in the database were evaluated at the detection limit.

The topic of unreported detection limits was an issue during database development. In instances where a publication reported non-detect values as "ND" and did not report the associated detection limit, the data point was removed from the database, since a numerical replacement could not be determined. As a result, the remaining data points may characterize a misleadingly high data set.

3.2 Transformation of Data

Most of the data sources used to compile data into the Background Soil Concentration Database provide arithmetic statistics only or both arithmetic and geometric statistics. However, in some cases a report may only present geometric statistics. This combination of different reported statistical data make meaningful comparisons across data sets difficult. Therefore, the source data was normalized in the Background Soil Concentration Database. Data for which geometric mean and standard deviation were available were transformed to arithmetic mean values using the following equation:

$$AM = \exp [\ln GM + (\ln GSD^2/2)]$$

A data set normalized to arithmetic mean (as opposed to geometric mean) was selected for two

reasons. First, the source data primarily reports arithmetic means. Second, the arithmetic mean is historically used in risk assessment calculations such as determination of the 95% upper confidence limit, for example.

3.3 Distributional Characteristics

For each of the metals, the 5th, 25th, 50th (median), 75th and 95th percentiles of the arithmetic means were determined and plotted as a "box-and-whisker" plot. Box-and-whisker plots provide a visual summary of where the bulk of background data are concentrated and the shapes of each distribution. These plots display data under four quartiles with each quartile corresponding to four equal sized sets based on their rank.

Figure 3.1 presents box-and-whisker plots of background metal concentrations in soil as reported by geographic region (eastern and western US) to discern relative differences in the distributional characteristics. Figure 3.2 provides a key to the box and whisker data.

Figure 3.1 Box and Whisker Plots of Background Metals Concentrations

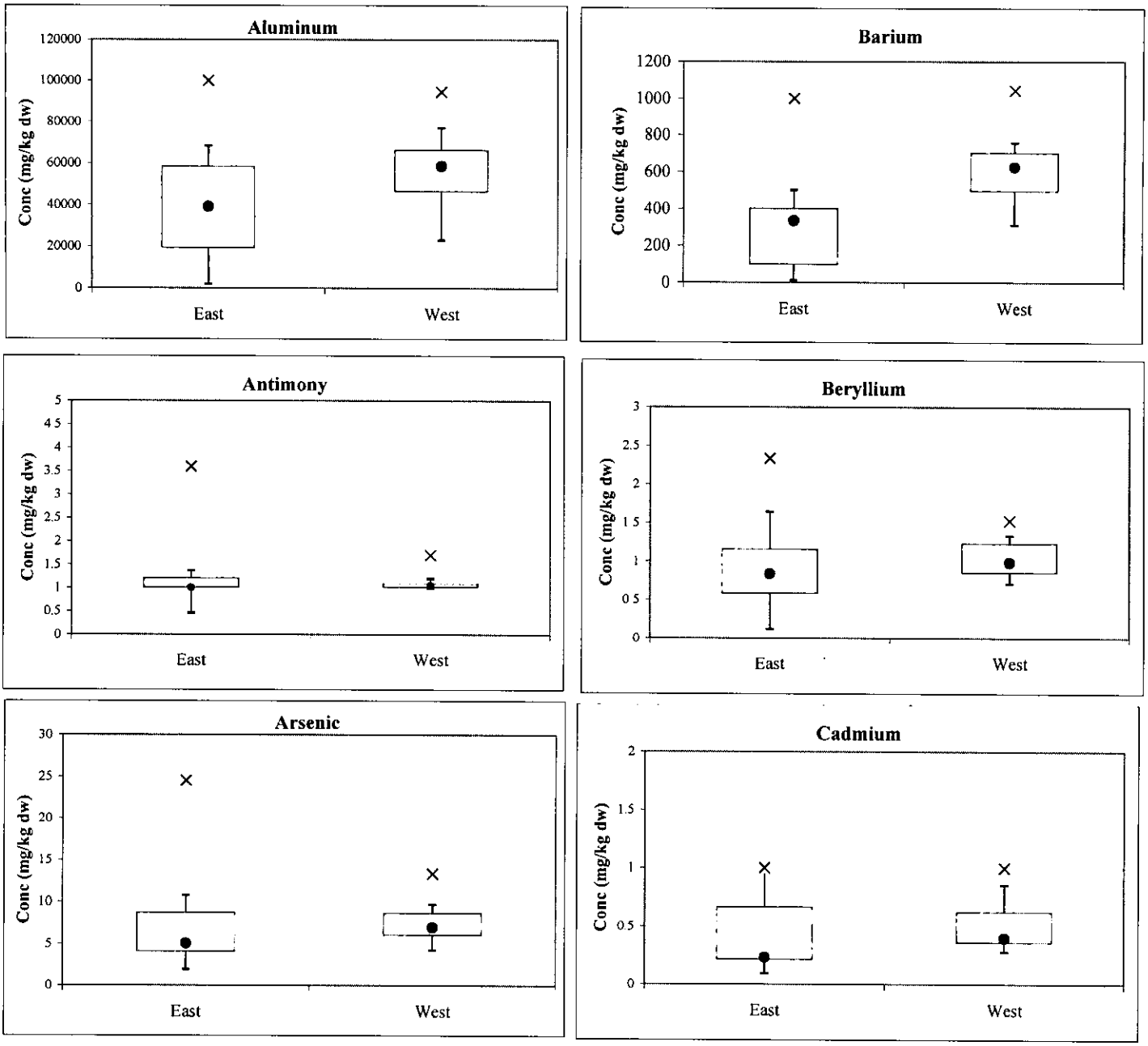


Figure 3.1 Box and Whisker Plots of Background Metals Concentrations

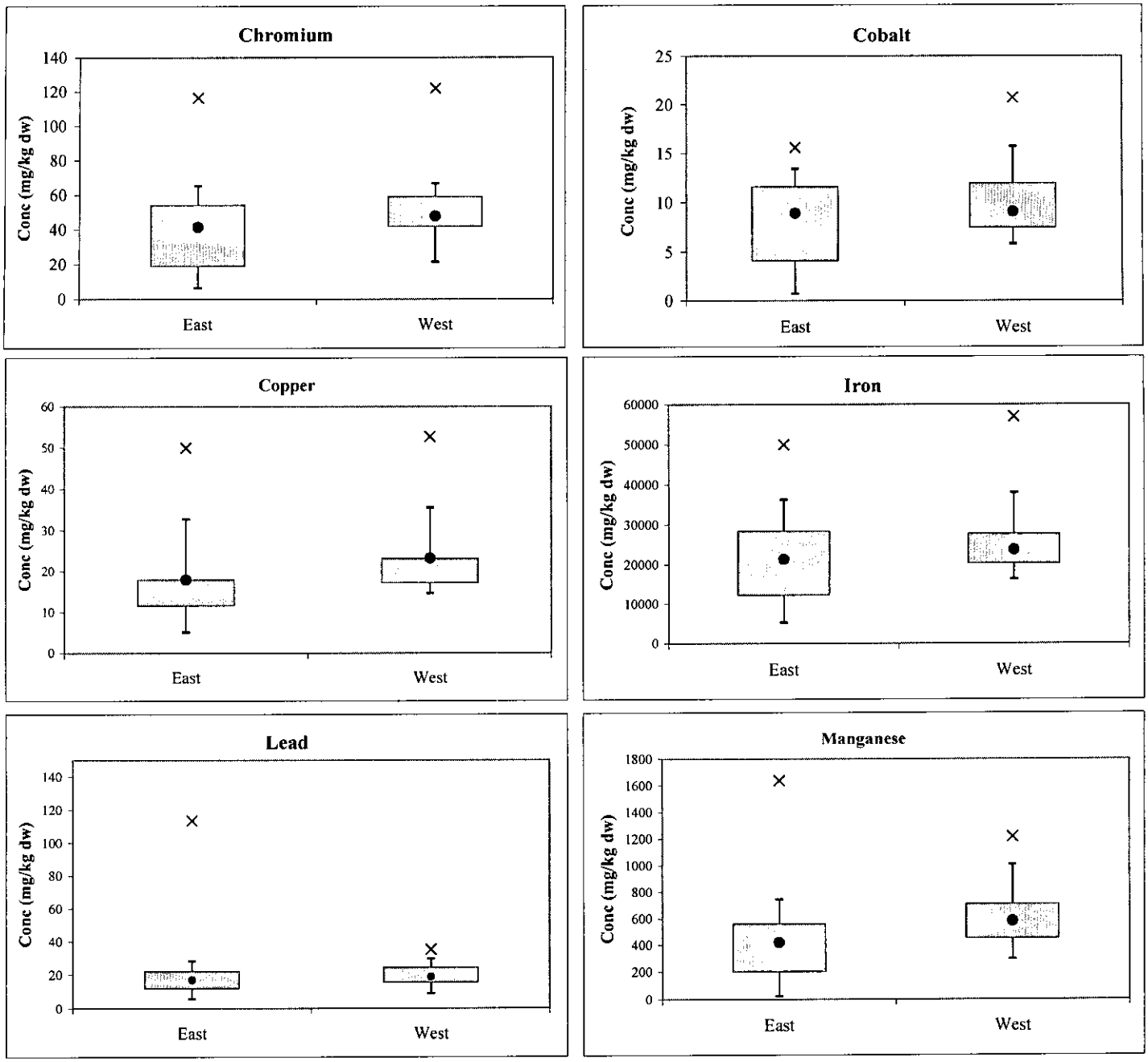
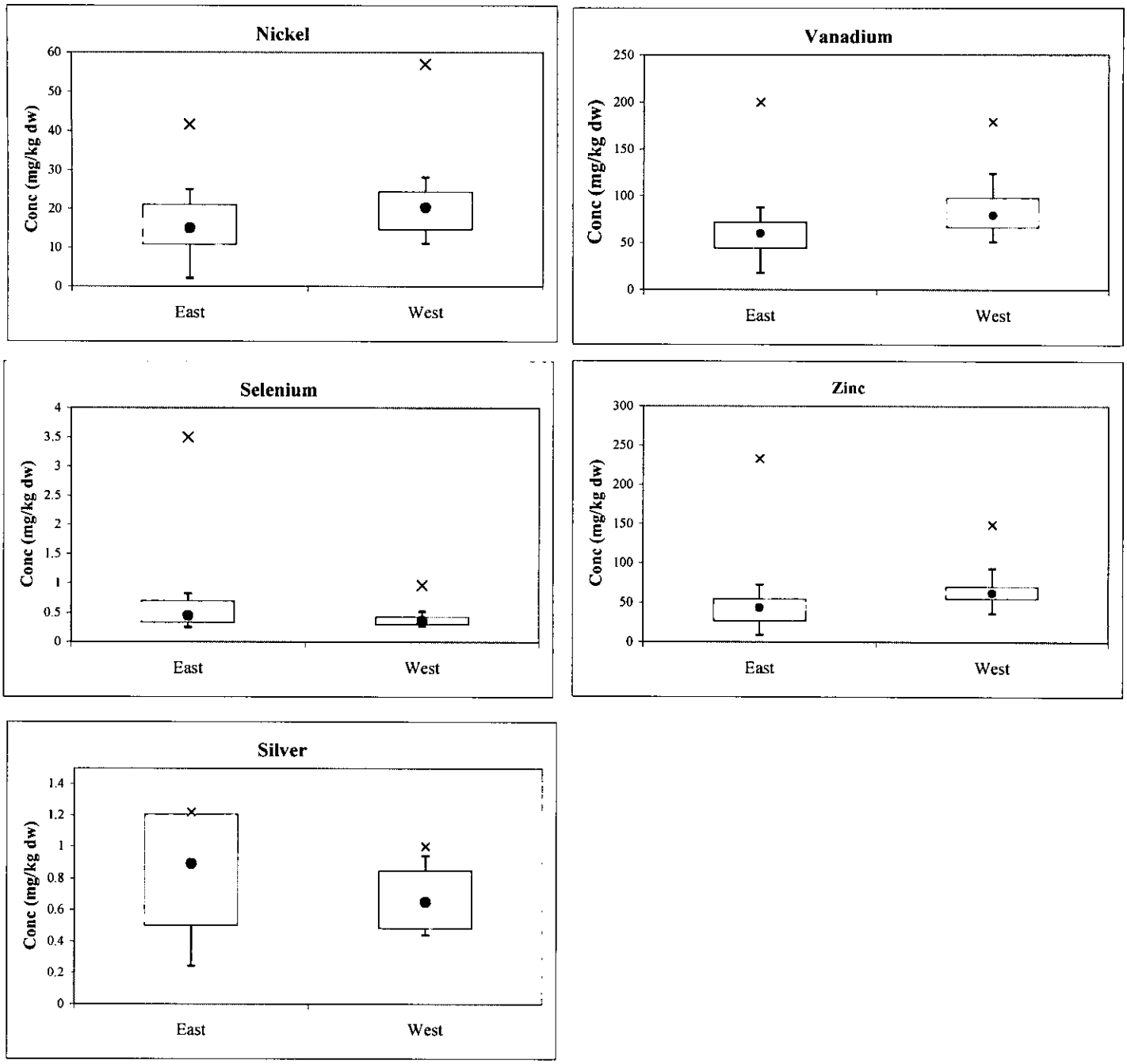


Figure 3.1 Box and Whisker Plots of Background Metals Concentrations



4.0 CONCLUSIONS

The box-and-whisker plots (Figure 3-1) provide an at-glance statistical summary for the background soil concentration data. These appear to indicate that:

- The median values generally reflect the central tendencies in the background data.
- Metals such as aluminum and iron were reported from all data sources and are consistently reported at very high concentrations (typically over 10,000 ppm).
- Metals such as aluminum, barium, iron and manganese display a wide concentration range. The wide range appears to be consistent across data sources and, therefore, represents the variability observed across the United States for these metals.
- Background concentrations of toxic heavy metals such as arsenic, beryllium, cadmium, copper, lead, and zinc fall are reported from most data sources within a relatively narrow concentration range.
- For a selected group of metals there is considerable regional variation (eastern versus western US) which likely reflects natural variation in the geochemical composition of soils.

5.0 REFERENCES

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Barringer, J.L. Z. Szabo and T.H. Barringer. 1998. *Arsenic and Metals in Soils in the Vacinity of the Imperial Oil Company Superfund Site, Marlboro Township, Monmouth County, New Jersey.* USGS Water-Resources Investigations Report 98-4016. West Trenton, NJ. 1998.

Bradford, G.R., A.C. Chang, A.L. Page, D. Bakhtar, J.A. Frampton, and H. Wright. 1996. *Background Concentrations of Trace and Major Elements in California Soils.* University of California, Division of Agriculture and Natural Resources. March 1996.

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Connor, J.J., and H.T. Shacklette. 1975. *Background Geochemistry of Some Rocks, Soils, Plants, and Vegetables in the Conterminous United States.* United States Government Printing Office, Washington DC.

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Attachment 3-1

Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs)

Eco-SSL Standard Operating Procedure (SOP # 1): Plant and Soil Invertebrate Literature Search and Acquisition

OSWER Directive 92857-55

November 2003

OVERVIEW

Currently, there is a lack of clear guidance in setting terrestrial effect thresholds when conducting risk assessments. Without an EPA-approved, peer-reviewed, ecologically-based terrestrial effect database, the process to develop thresholds is problematic both to EPA, other federal agencies, states, and concerned private parties. Identification of published toxicity studies on invertebrates, microbial processes and plants is a key step in the derivation of benchmarks. The purpose of the Task Group 4, Standard Operating Procedure Number 1: Literature Search and Acquisition (referred to as TG4-SOP#1) is to document procedures used to identify and acquire potentially relevant toxicology literature for use in setting ecological soil screening levels. The literature search strategy is designed to locate worldwide terrestrial toxicity literature that includes the effects of chemicals of concern on terrestrial soil-dwelling invertebrates and plants. The literature acquisition process is designed to ensure timely acquisition of relevant publications.

LITERATURE IDENTIFICATION

Potentially relevant literature for developing ecological soil screening levels (Eco-SSLs) is identified by examining hard copies of relevant journals, bibliographies and guidance publications and through the use of a comprehensive computerized literature search strategy. These procedures are designed to locate worldwide terrestrial toxicology literature that includes the effects of specific toxic substances with an emphasis on exposure via soil.

Paper-based Literature Identification

The paper-based literature identification process includes the scanning of relevant review article bibliographies and key journals held in the U.S. EPA, National Health and Ecological Effects Research Laboratory (NHEERL), Mid-Continent Ecology Division-Duluth (MED-Duluth) library holdings. Identification of literature from review bibliographies and guidance documents is not limited by publication year. If the citation includes a chemical of concern and an identified species group, the publication is acquired.

Review Articles

The following review articles, specifically dealing with developing soil screening levels were identified by Task Group 4:

> Efroymson, R. A., M. E. Will, G. W. Suter II, and A. C. Wooten (1997) Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision. ES/ER/TM-85/R3, Oak Ridge National Laboratory, Oak Ridge, TN: 128 p.
>
> Efroymson, R. A., M. E. Will, and G. W. Suter II (1997) Toxicological Benchmarks for Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision. ES/ER/TM-126/R2, Oak Ridge National Laboratory, Oak Ridge, TN: 34 p.

Canadian Council of Ministers of the Environment (1997) Canadian Soil Quality Guidelines for Copper: Environmental and Human Health. CCME Documents, Winnipeg, Manitoba: 82 p.

Canadian Council of Ministers of the Environment (CCME) (1997) Canadian Soil Quality Guidelines for Pentachlorophenol: Environmental and Human Health. CCME Documents, Winnipeg, Manitoba: 52 p.

Canadian Council of Ministers of the Environment (CCME) (1997) Recommended Canadian Soil Quality Guidelines. CCME Documents, Winnipeg, Manitoba: 185 p.

Gibson, E., D. Strudwick, and P. Walker (1997) National Framework for Ecological Risk Assessment of Contaminated Sites. Victorian EPA for Environment Australia, Kingston, Australia: 45 p.

Crommentuijn, T., M. D. Polder, and E. J. Van de Plassche (1997) Maximum Permissible Concentrations and Negligible Concentrations for Metals, Taking Background Concentrations into Account. Rep. No. 601501 001, National Institute of Public Health and the Environment, Bilthoven, The Netherlands: 260 p.

The initial focus of the paper-based literature identification effort will be on these guidance publications, but any bibliography articles identified in literature searches will be acquired and placed in the queue for identification of potentially relevant literature.

The following steps will be undertaken when identifying potentially relevant literature from manual searches of review publications:

- Bibliographies will be reviewed and potentially applicable literature will be marked for acquisition. All markings will be placed on the original publication.
- The citations for all potentially applicable articles are data entered into an electronic reference database (ECOTOX InProcess - a ProCite bibliographic database) using procedures outlined in Attachment A.
- The review article which was the source of the citation is noted in the InProcess database (see Attachment A).

MED-Duluth Library Journal Holdings

Selected journals in the MED-Duluth library are searched quarterly for articles relevant to any MED-Duluth database. *The focus of the MED-Duluth library is aquatic toxicology, but some of the journals do present results from terrestrial toxicology studies.*

The following steps will be undertaken when identifying potentially relevant literature from manual searches of MED-Duluth library holdings:

- The journal issues that have been scanned for applicable literature will be marked with an "EC" in the upper right hand corner of the cover page.
- All applicable citations are entered into the InProcess file and duplicate citations are

deleted. All remaining citations are marked for Copy Request with date and forwarded to EPA for photocopying.

- After articles are photocopied, they are skimmed using Eco-SSL acceptance criteria (See 'Eco-SSL Acceptance Criteria' section below) and entered into the InProcess bibliographic database using procedures outlined in Attachment A.

The following journals are examined (NOTE: *not all of these journals are relevant to terrestrial toxicology but they are routinely scanned as part of the ECOTOX effort*):

Aquatic Toxicology
Archives of Environmental Contamination and Toxicology
Bulletin of Environmental Contamination and Toxicology
Canadian Journal of Fisheries and Aquatic Sciences
Chemosphere (added 1989)
Ecotoxicology and Environmental Safety
Environmental Biology of Fishes (added 1994)
Environmental Pollution
Environmental Toxicology and Chemistry
Freshwater Biology (added 1994)
Journal of Environmental Biology
Journal of Environmental Quality (added 1997)
Journal of Fish Biology (added 1989)
Journal of Freshwater Ecology (added 1994)
Journal of Great Lakes Research (added 1994)
Journal of the North American Benthological Society (added 1994)
Limnology and Oceanography (added 1994)
Water Air and Soil Pollution
Water Research

Computerized Literature Searches

Online searches are performed using the DIALOG, SilverPlatter or Ovid commercial database vendors. Task Group 4 has identified several databases that will be the focus of Eco-SSL literature searches.

- AGRICOLA database (http://www.nal.usda.gov) provides a strong agricultural focus that has strict indexing codes for both toxicity and soil organisms.

- BIOSIS database (http://www.biosis.org/) provides a strict taxonomical indexing system. BIOSIS recently (1998) began adding Chemical Abstract Service (CAS) Registry numbers.

- CA Search database (http://www.cas.org/) provides a strict chemical indexing system, but lacks a taxonomical indexing system.

In addition, the searches will be supplemented using the following literature abstracting databases:

- Toxline database, provided through SilverPlatter PolTox1 is available on CD-ROM at MED-Duluth. Used in searches performed prior to 9/30/99. DIALOG databases (Pollution Abstracts, Toxline and NTIS) are used for searches performed after 10/1/99

- Toxnet (http://igm.nlm.nih.gov/) provides a free web browser interface system, but has a limit to the number of search terms allowed (current version allows nine search terms).

- Current Contents: Agriculture, Biology & Environmental Sciences, using OVID, Version 3.0 software at MED-Duluth provides timely supplemental citations for publication years 1995 to present.

Development of Literature Search Strategy

Literature search strategies are developed iteratively with each section of terms examined using different criteria. The search strategies may include the following: category codes, chemical terms, species specific terms, publication years, and exclusion terms. Attachment B provides detailed summary of the literature search strategy.

Category Codes

Category codes are used within DIALOG databases to group documents by subject or topic. By specifically selecting category codes relevant to the Eco-SSL effort, the literature search output should result in a more focused data set. The Eco-SSL literature search strategy (Attachment B) includes a summary of category codes for each DIALOG database selected.

Chemical Terms

The Eco-SSL Steering Committee identified a list of chemicals (Table 1) as the initial focus of the Eco-SSL effort.

Table 1: Eco-SSL Chemical List

Organics	Metals	
DDT and metabolites	Aluminum	Iron
Dieldrin	Antimony	Lead
Pentachlorophenol	Arsenic	Manganese

Table 1: Eco-SSL Chemical List		
Organics	**Metals**	
TNT	Barium	Nickel
total PAHs	Beryllium	Selenium
total PCBs	Cadmium	Silver
TPHs	Chromium	Vanadium
RDX	Cobalt	Zinc
	Copper	

- A comprehensive list of chemical terms and CAS Registry numbers was developed by evaluating various standard reference manuals (See Attachment C).

- Task Group 4 recommended that the chemical list focus on soluble salts, but that it include the generic metal form. Task Group 4 also recommended that the chemical search list not include oxides.

- Task Group 4 recommended that PCBs and TPHs be placed on hold until further notice.

A complete listing of chemical terms defined for use in Eco-SSL literature searches is provided in Attachment B.

Species Specific Terms

The effort under TG4-SOP#1 covers two major terrestrial species groups: soil invertebrates and plants. Search terms were defined by species grouping (see Attachment B) using the following procedures.

- Initial terms were provided to Task Group 4 and modifications were made based on their input.

- A test search of the organism specific terms intersected with the chemical terms and category codes was conducted. Brief outputs of citations were downloaded to examine effectiveness of the search strategy. If a large percentage (>60%) of non-applicable citations were identified, Task Group 4 was consulted on additional terms to include or terms that could be used to exclude non-applicable hits.

- All search terms are documented as to testing that was conducted and results observed.

- All exclusion terms are documented as to the testing that was conducted and the number of potentially applicable citations that would be excluded if the term is used. If a high percentage of applicable citations (>10%) would be missed by using the exclusion term,

the term is not included in the search strategy. (NOTE: *exclusion terms are those that are added at the end of the search as a NOT term*; e.g., ((Zn AND plant) NOT aquatic)).

Publication Year

The Eco-SSL Task Group 4 computerized literature searches will focus on publications years 1988 to present. Using these search results, for each chemical and species group (plant or invertebrates) citation results were analyzed, and additional expanded literature searches (all pre-1988 publication years) were conducted for all chemical and species groups for which less than twenty citations had been identified to-date. Table 2 identifies the chemical and species groups meeting this criteria.

Table 2

Chemical	Species Group
Aluminum	invertebrate
Antimony	invertebrate and plant
Arsenic	invertebrate
Barium	invertebrate and plant
Beryllium	invertebrate and plant
Chromium	invertebrate
Cobalt	invertebrate
Iron	invertebrate
Manganese	invertebrate
Nickel	invertebrate
Selenium	invertebrate
Silver	invertebrate
Vanadium	invertebrate and plant
Dieldrin	plant
DDT/DDD/DDE	plant
PCP	plant
RDX	invertebrate and plant
TNT	invertebrate and plant

Conducting the Literature Search

Instructions for performing searches and defining BIBLIOLINKS output format for DIALOG, SilverPlatter and Ovid are found in Attachments D, E and F respectively. The following procedures are to be followed when conducting the literature search using an electronic abstracting database system.

- All chemicals will be searched within a single search strategy.
- An attempt will be made to search all databases at the same time, allowing for removal of duplicate entries across the various databases prior to downloading citations.
- Each species term grouping (invertebrate, plant) will be conducted as a separate search to reduce the number of records downloaded in a single search and to allow for the use of more specific search strategies.
- Task Group 4 must approve any modification to the search strategy prior to conducting a search.
- The strategies used for all searches are saved and downloaded electronically to avoid the possibility of typographical errors.
- Any modifications to the literature search strategy are examined by a second person before conducting the search.
- Copies of all search strategies and results (number of hits) are saved to be included in the report to EPA (see 'Analysis of Search Results' section below).
- All data retrieved from a computerized literature search are transferred to a temporary ProCite database file using BIBLIOLINKS software and procedures according to the specifications provided for each commercial database.

Identification of Potentially Applicable Publications

The temporary ProCite bibliographic file containing the computerized search results is given to a reviewer for identification of publications to be ordered. Each citation is marked with appropriate codes denoting potential applicability. Potentially applicable Eco-SSL citations are marked as "P" (plant - PHYTOTOX database), or "T" (invertebrate - TERRETOX database). Items applicable to other MED-Duluth database efforts are so noted, even if not the focus of the search. Some items may be applicable to more than one database, or there may not be sufficient information to determine applicability. In these instances, all applicable initials are marked on the search result. All potentially applicable articles are ordered through photocopy or interlibrary loan requests. The following procedures are used to determine applicability for

ordering of the literature:

- Items marked as applicable for the Eco-SSL effort must at least have the potential for meeting the basic requirements for coding; i.e., paper includes a chemical stressor identified in Table 1, appears to report toxic effects associated with the chemical stressor, and affected species/process is a terrestrial plant or invertebrate.

- Review articles and publications that document study methods are marked for acquisition.

- Many studies are not relevant to the Eco-SSL efforts. The reject categories presented in Attachment G are used to assist in making decisions of applicability.

- When a determination of potential applicability is questionable (i.e., cannot be determined from the information provided), the article should be marked for ordering. The determination of applicability will be made once the paper is received.

- The first author of each clearly applicable and possibly applicable citation is highlighted to indicate publications to be ordered.

- Field studies using chemical mixtures are marked as potentially relevant.

- All citations that have been marked by the reviewer as potentially applicable are electronically transferred from the temporary ProCite file to the InProcess ProCite file.

LITERATURE ACQUISITION

To expedite literature acquisition, potentially applicable citations are either photocopied from the MED-Duluth library holdings or ordered through the MED-Duluth Library using the OCLC Interlibrary Loan procedures. Prior to acquiring publications, a check is made of all ECOTOX bibliographic files to ensure that the paper is not already available in the ECOTOX filing system. Once all duplicates have been eliminated, the acquisition process is initiated.

Photocopying of MED-Duluth Journal Articles

Articles identified as held in the MED-Duluth library holdings, either through the scanning of MED-Duluth journals holdings as described above, or identified through the scanning of review bibliographies or computerized literature searches, are photocopied in order to expedite acquisition. In addition, publications acquired through the MED-Duluth OCLC Interlibrary Loan procedures may need to be photocopied and returned to the lending library. Prior to photocopying articles, MED-Duluth library staff are contacted to ensure compliance with existing copyright laws.

Ordering Publications using OCLC/Interlibrary Loan (ILL)

If the publication is not available to be photocopied through the MED-Duluth library holdings, it is ordered through the MED-Duluth library using the OCLC/ILL procedures. Relevant publications are downloaded from the InProcess ProCite database file and provided to the MED-Duluth library staff in an electronic file format. Attachment H summarizes the procedures used to create the electronic OCLC/ILL request. The InProcess bibliographic file is updated with information regarding the order status following procedures outlined in Attachment A.

ANALYSIS OF SEARCH RESULTS

After the publications have been ordered, a summary is prepared for each manual and electronic search to provide an estimate of the effectiveness of the procedures used. In addition to analyzing the results, the search terms are evaluated as to their effectiveness in identifying potentially relevant literature. The extent of analysis following a search is determined by need for changes (success rate) and EPA requests. Some keywords from appropriate literature are added to the list of keywords for possible inclusion in future searches, and some keywords from inappropriate literature are added to the list of keywords for possible exclusion from future searches. Analysis of reject categories may be used to help determine possible exclusion terms or search terms which are too broad and should be omitted. Possible changes of terms are further analyzed by the Eco-SSL Task Group 4, and may or may not be included in future searches.

The report to EPA following each search should include the following:

- date of search
- database or journal searched
- dates covered: CD-ROM date and/or publication years specified
- total number of hits
- number of applicable hits
- percentage of applicable hits
- number and percentage of applicable hits which are new, after elimination of duplications
- results of any changes tested: number of hits added or subtracted compared to the search without the change, and number of those hits which are applicable
- recommendation of whether to add or change terms in the search strategy
- a copy of the search strategy with numbers of hits shown

Searches should be summarized using the forms are provided in Attachment I. Attachment I contains a list of frequently cited journals that contain data for soil invertebrate and plant toxicity. This journal listing was used to determine the journals that should be used in the Current Contents search strategy.

Between searches further analysis is performed to determine:

- the best databases to search
- how frequently searches should be performed
- the most effective search strategy

It is important to remember that a search will not likely result in 100% precision. And, despite the searcher's best efforts, a search may not produce 100% retrieval. Development of the most effective search strategy is an on-going effort and care must be taken to document procedures and results as they are attempted and completed.

ECO-SSL ACCEPTANCE CRITERIA

As publications are received via the ILL/OCLC and photocopying processes, they are screened for general acceptability for use in developing soil screening levels. The purpose of applying acceptance criteria is to exclude test results that are incompatible with the intended purpose of setting soil screening levels. In Attachment 3-2, evaluation criteria will be applied to each test record in order to assess the level of confidence associated with using the data in developing Eco-SSLs. The acceptance criteria should exclude test results that are not likely to be useful, but potentially useful test results should not be excluded. Therefore, the acceptance screening process should ensure that the minimal data requirements needed to set Eco-SSLs are included in the publication, but is not an evaluation as to the quality of test procedures or appropriateness of the publication for use in setting soil screening levels.

The following procedures are used in evaluating papers based on acceptance criteria defined by Task Group 4:

- Each paper is individually evaluated. The publication is skimmed, and specific questions associated with the acceptance criteria (see Attachment J) are answered.

- On the "Literature Acceptance Criteria Checklist" form (Attachment J), enter the unique InProcess location number in the box marked "InProcess Reference Number".

- If multiple "Literature Acceptance Criteria Checklist" forms are required for a publication, identify unique experimental design characteristics in the "Experimental Design" box provided in Attachment J.

- For each acceptance criterion, an appropriate answer is entered on the "Literature Acceptance Criteria Checklist" form (Attachment J):

- Enter a 'Y' (yes) if the author(s) presents sufficient information in the paper to conclude that the answer is positive.

- Enter an 'N' (no) if the author(s) presents sufficient information in the paper to conclude that the answer is negative.

- Enter a 'U' (unknown) if the author(s) did not present sufficient information to answer either affirmatively or negatively. This instance will occur when the authors have (a) referred to a method for details regarding the criteria or (b) the authors do not directly address the issue in the paper.

- "OK" is entered into the InProcess database EcoSSL Status data field (line #30) if all acceptance criteria have a positive response.

- If one or more acceptance criteria have a negative response, a NO is placed in the InProcess file under EcoSSL Status data field (line #30), the code(s) associated with each negative criteria (see Attachment A; Table 5) and a corresponding note is data entered into the InProcess database. For example, if the exposure is carried out on filter paper, a NO is placed in line #30 with a note media: filter paper. If there is more than one reason for rejecting the publication, each reason will be noted.

- If there are no negative responses to the acceptance criteria, but the answer to one or more criteria is unknown, the code "UNKN" is entered into the InProcess database file under EcoSSL Status data field (line #30) .

- The appropriate code(s) (see Attachment A; Table 2) identifying the applicable database(s) (e.g., PHYTOTOX or TERRETOX) is entered into the InProcess bibliographic file DATABASE field.

- A copy of the completed Literature Acceptance Criteria Checklist form(s) is attached to the back of the publication.

- Papers with affirmative answers to all acceptance criteria questions are forwarded to reviewing staff for immediate data abstraction and encoding.

- Papers with responses of 'N' or 'U' to any of the acceptance criteria questions are filed in the ECOTOX file room. These papers may be useful to other MED-Duluth database efforts.

ATTACHMENT A: Instructions for BIBLIOLINKS, Formatting and Data Entry in ECOTOX ProCite InProcess File

I. Access Bibliolinks II software to transfer records to ProCite.

A. Select "File", "Open Download File".

1. Select the drive and directory that contains the search output file.
2. Select the correct file.
3. Click on "OK".

B. After the search output file has been loaded into Bibliolinks II, select the destination ProCite database. Choose one of the following:

1. "Create New Database"
2. "Select Existing Database" (This will prompt you to a list of existing database; select one.)
3. A list of recently used databases may be displayed, if this includes your database you may select it using this list.

C. Select a "Configuration File" to direct the transfer of records. Use the following transfer configurations for these databases:

Database	Configuration (database format, if needed)
DIALOG	DIALOG.CFG
OVID	REPRINTOVD.CFG (MEDLINE)
SILVERPLATTER	DIALOG.CFG (MEDLINE)

D. Click on "Start Transfer".

1. If necessary Bibliolinks II will ask you to once again select a destination database. If this occurs verify database selection and continue.

E. For a clean transfer, provide a search output file with only the citation information, no search headers or summaries. Once the transfer has begun, Bibliolinks II may ask you what to do with certain fields it does not recognize in the download file. You may target the information to a specific field in the ProCite database. Or you may choose to ignore the unrecognizable fields and continue downloading.

F. When the transfer is complete, you will see the Transfer Complete dialog box.

1. You may view the transfer log.
    a. Click in "Show Log".
    b. The transfer log will be displayed.
2. To keep a copy if the Transfer Results log, click on "Save As" on the Transfer log screen.
    a. The Choose Directory and Name for New File dialog box will appear; select directory.
    b. Name the file in the "File Name" text box.
    c. Click "OK". You will return to the Transfer Results Screen.
3. If you don't want to view or save the log, click OK on the Transfer Complete screen.
4. To finish, click "Done".

G. You may now exit Bibliolinks II by using the File Menu.

1. To leave Bibliolinks II without starting ProCite, select "Exit".
2. To leave Bibliolinks II and start ProCite, select "Exit to ProCite". This will transfer you to the destination database you identified.

H. To combine search outputs from various databases into the primary bibliographic data file, copy the applicable records from the searches into the primary file. The new records are inserted at the end of the existing file so as to not disrupt the record numbering of existing records.

Use the Duplicate Records feature in ProCite to eliminate duplicate citations. However, the Duplicate Records feature is only partially successful in identifying duplicates. Additional verification of duplicate records is conducted by sorting the records first by Author Field and conducting a visual review of duplicate authors, checking to see if the titles and/or sources are the same. A second verification is conducted by a Citation Field sort. Even after the verification process, duplicates may exist due to the variable database citation source format. A final check for duplicates is conducted during the applicability review, data review and filing processes.

The final editing steps include: 1) globally change the citation entries to the "ECOTOX workform"; 2) move any misplaced fields to correct locations; and 3) globally enter the search database name and date (e.g., POLTOX 2-99) in the Source (ProCite field number 44).

II. To open the InProcess (ECOTOX *in process file*) Database in ProCite 3.4:

a. Double click on the *ProCite Icon*. ProCite will open to the most recently used file. If this is not the InProcess file, click on *File* and *Open*.

b. Double click on:
    i. *PROCITE3*
    ii. *INPROCES*
    iii. *INPROCES.DAT*

c. Every personal computer will need a one time set up for viewing standard entry screens and workforms.

i. Select *view*, click on *configure record list* , mark to show records and click on *OK*.

ii. Select *edit*, click on *preferences*, click on *directories*. Detail the following directories:

DATABASE FILE PATH:	N:\procite3
WORKFORM PATH:	N:\procite3\forms
OUTPUT STYLE FILE PATH:	N:\procite3\styles
LISTS FILES PATH:	N:\procite3\lists

iii. Highlight a record. Select *view*, click on *configure edit record*, mark to show all *fields* and *toolbars* are selected.

d. Select *'N:\PROCITE3\STYLES\ECOTOX.OUT'* for an Output Style.

2. To enter InProcess Data:

a. Click on *Database* and *New Record (F9)*.

b. Select the *"ECOTOX"* workform.

c. Enter data in the applicable fields:

i. Write the RECORD # in GREEN ink on the lower right corner of the citation card.

ii. Use the TAB key to move between fields.

iii. To enter *author information (01)*, enter last name followed by comma and initials. The author names are separated by forward slashes (//). Example(s):

Felsot,A.S.//Bhatti,M.A.//Mink,G.I.
Felsot,A. S. =Jr.//Bhatti,M.A.=Jr.
Felsot,A.S.=Jr.//
Felsot III,A.S.//

iv. *Titles (04)* should be entered using the bibliographic format standard

v. To select a *journal name (09)*,

(1) Click on *Edit*, Click on *Insert Term*, Select journal list from the *(N:\PROCITE\LISTS\AQDL1JRN.LST)* file.

(2) Enter the first letter of the journal name and use the pg/up and pg/down keys and arrow keys to locate.

(3) Double click on *Insert Term* and *Close*.

vi. To add a journal name to the journal list ,

(1) Select *File* and *Open*.

(2) Open file: *N:\PROCITE3\LISTS\AQDL1JRN.LST*.

(3) Click on *Add* and enter the abbreviated journal name (without periods). Follow the BIOSIS standard to determine the correct abbreviation.

(4) Click on *OK* and *Close* the file.

vii. To enter a book or report use the *journal name (09)* field.

viii. Enter the *year (20)*, *volume (22)*, *issue identification (24)* and *page numbers (25)* in the next fields.

ix. Enter *status: order date/ data file (38)* information. This information includes a code and date information and should be entered using the following format: Auth/10-9-97//

The status and data file drop menu can be found on *N:\procite3\lists\status.lst*, see Table 1.

Table 1. Status codes and descriptions

STATUS CODES	STATUS CODE DESCRIPTIONS
$/date	Ordered from commercial source
$ (no date)	To be sent as commercial order
ARCHIVE	Paper will not be obtained
Auth/date	Ordered as author request card
Auth (no date)	To be sent as author request
Copy Request/date	Ordered as photocopy request
Copy Request (no date)	To be sent as photocopy request
EVAL /date	Citations that need evaluation (for citation verification, locating full publication, citation or source)
HOLD-P /date	PHYTOTOX (P) paper not being ordered
HOLD-T /date	TERRETOX (T) paper not being ordered
LITBIB	Literature Bibliography datafile
METHFILE	Methods datafile
NON-APPLICABLE	Rejected paper, not retained
OL/date	Ordered as Interlibrary Loan (ILL) request
OL (no date)	To be sent as ILL request
SKIMMED	Skimmed for all applicable citations
STATUS CHECK /date	Library check on status of receiving publication

x. To select a *database descriptor (39) and database (40)*,

(1) Click on *Edit*, Click on *Insert Term*, Select database code file *(N:\PROCITE\LISTS\DATABASE.LST)*, see Table 4.

(2) Select the appropriate database for the database field (40) This data field will only contain AQ, P, or T.

(3) Double click on *Insert Term* and *Close*.

(4) Follow the above instructions for the database desciptor field (39) if descriptor is known. Use the descriptors that are noted for IP field number 39 as noted in Table 2.

Table 2. Database codes and descriptions.

IP FIELD	DATABASE CODES	DATABASE CODE DESCRIPTIONS
40	AQ	AQUIRE
40	P	PHYTOTOX
40	T	TERRETOX
39	L	LITBIB
39	M	METHFILE
39	T-AVIAN	TERRETOX BIRDS
39	T-BEES	TERRETOX BEES
39	T-DOM	TERRETOX DOMESTIC
39	T-FLY	TERRETOX LABORATORY FLY
39	T-FORE	TERRETOX FOREIGN PAPER
39	T-HERP	TERRETOX HERPS
39	T-MAMMAL	TERRETOX MAMMALS
39	T-MONKEY	TERRETOX MONKEY
39	T-OIL	TERRETOX OIL
39	T-PUBELS	TERRETOX PUBLISHED ELSEWHERE
39	T-RODE	TERRETOX LABORATORY RODENT

xi. Enter *Notes (42)* information. This information may include information about duplicate data or tracking of the publication.

xii. To select *source of citation (44)*,

(1) Click on *Edit*, Click on *Insert Term*, Select source of citation code file from the *(N:\PROCITE\LISTS\SOURCE.LST)*, see Table 3.

(2) Select the appropriate database and in the case of LITBIB's add the LITBIB citation after the LITBIB number.

(3) Double click on *Insert Term* and *Close*.

Table 3. Source codes and descriptions.

SOURCE CODES	SOURCE CODE DESCRIPTIONS
L#	LITBIB #
AGRIS	AGRIS International
Agricola	Agricola

SOURCE CODES	SOURCE CODE DESCRIPTIONS
ASFA	ASFA
BIOSIS	BIOSIS
CAB	CAB
CAS	CA Search
CC	Current Contents
Life Sciences	Life Sciences
MEDLINE	MEDLINE
P #	PHYTOTOX #
Pascal	Pascal
POLTOX	POLTOX
RETOX #	RETOX #
T #	TERREF #
TOXLINE	TOXLINE
TOXNET	TOXNET
WEB Search	WEB Search

xiii. To select *keyword (45)*,

(1) Click on *Edit*, Click on *Insert Term*, Select keyword codes from the appropriate keyword list files including *(N:\PROCITE\LISTS\ARCHIVE.LST* archive lists, and N:*\PROCITE\LISTS\NONAPDSC.LSt* for Non-Applicable lists), see Table 4 and 5.
(2) Select the appropriate keyword.
(3) Double click on *Insert Term* and *Close*.

Table 4. Archive codes and descriptions

ARCHIVE CODES	DESCRIPTION
ATTACHED	If an abstract or other second source is attached to the paper it refers to, assign "Archive" status to the citation of the abstract or second source with the keyword "Attached". Include in the note field the Reference number of the main publication.
INCORRECT CITATION	For citations being retained in IP after being found not to be correct, assign "Archive" status with the keyword "Incorrect Citation". Place paperwork documenting correct citation and/or attempts to verify into the Archive file.

ARCHIVE CODES	DESCRIPTION
NOT PURSUING	For a citation which is being terminated as unavailable or not worth additional effort or expense to locate, assign the keyword "Not Pursuing". Additional information may be included in the note field, such as "No source located", or "Likely survey". Guidelines for decisions of when to suspend efforts to locate a publication are as follows: (a) If a publication of any type has a marginal possibility of being applicable, do not pursue beyond author request and ILL, (b) Publications identified as containing endpoint data are given higher priority, (c) Peer-reviewed journals are the preferred source; other reports of the same study should not be pursued if journal articles are available, (d) older publications (pre-1980) are given lower priority for commercial order, (e) documents listed in the CAD bibliographies and items ordered as replacements for missing publications already reviewed are given priority and are not terminated without trying all possible resources.
PUBLISHED ELSEWHERE	If a citation is found which clearly duplicates material already held and not a preferred source (e.g., a peer-reviewed journal article would be ordered even if a technical report covering the same material was already held), assign "Archive" status with the keyword "Published Elsewhere". Include the Reference File number of the other item(s) in the note field in IP.

xiv. Papers related to the EcoSSL effort:

(1) If papers meet the accepted criteria an OK is placed in the In Process file under EcoSSL Status (line #30)

(2) The date that the publication is forwarded to an EcoSSL team member for evaluation is noted after the OK.

(3) If the publication does not meet the accepted criteria a NO is placed in the In Process file under EcoSSL Status with one of the InProcess abbreviations and a note (e.g., media: filter paper).

(4) Enter the TERRETOX three letter major effect grouping code in EcoSSL MJR Efct Group (line #31)

Table 5. InProcess Codes for Papers Processed for EcoSSL Acceptance Criteria

CRITERIA FOR ACCEPTABILITY	IP Abbreviation
Criteria 1	Source
Criteria 2	Toxicant
Criteria 3	Chemical
Criteria 4	Media
Criteria 5	Organic Matter
Criteria 6	pH
Criteria 7	Control

CRITERIA FOR ACCEPTABILITY	IP Abbreviation
Criteria 8	Duration
Criteria 9	Concentration
Criteria 10	Ecologically Relevant Endpoint
Criteria 11	Species

3. To Search Data:
   a. Select *View.*
   b. Select *Search.*
   c. Click the *'Fields'* button.
   d. Highlight the field to search (i.e. RECORD #) and click twice or click 'OK.'
   e. Type or select an operator ; use '=' for most searches, and type a record number or name for search and click the *'Search'* button, or press *Enter.*
   f. To Exit, click on *View,* click on *Quick Search.*

4. To Edit *InProcess* Data:
   a. Double-click on the appropriate reference.
   b. Use the mouse or tab key to get to the fields for editing.

5. To View Records:
   a. Click View.
   b. Click Formatted References.
   c. To Exit this:
      i. Click View.
      ii. Click Quick Search.

6. To Print Data:
   a. Select Records by highlighting and marking (x).
   b. Select Bibliography and Print Bibliography.
   c. Select Marked Records.
   d. Change Reference List title or Reference List Order, (optional)
   e. Click 'OK'.

ATTACHMENT B: Literature Search Strategy

The commercial computerized literature databases proposed for use include:

- AGRICOLA database (http://www.nal.usda.gov) provides a strong agricultural focus that has strict indexing codes for both toxicity and soil organisms.

- BIOSIS database (http://www.biosis.org/) provides a strict taxonomical indexing system. They recently (1993) began adding chemical registry numbers.

- CA Search database (http://www.cas.org/) provides a strict chemical indexing system, but lacks a taxonomical indexing system.

- PolTox/Toxline database, provided through SilverPlatter PolTox1 CD-ROM available at MED-Duluth. Ceased using PolTox in searches performed after 10/1/99. DIALOG databases (Pollution Abstracts, Toxline and NTIS) are used for searches performed after 10/1/99.

- Toxnet/Toxline database (http://igm.nlm.nih.gov/) provides a free web browser interface system, but has a limited search terms/strategy available. In the current version, the system is limited to nine terms. This search will be used to supplement the BIOSIS database search as needed. For example, only the BIOSIS subfile of TOXNET was searched to locate additional earthwork and collembola citations for the invertebrate search. The abbreviated search strategy is provided below.

- Current Contents: Agriculture, Biology & Environmental Sciences CD-ROM, using OVID, Version 3.0 software at MED-Duluth provides supplemental citations greater or equal to publication year 1998. The focus of this search is to locate citations for literature published after the databases listed above were updated and ECOSSL searches were performed.

AGRICOLA, BIOSIS, CA Search andToxline databases provide an index code for toxic effects data (see detailed search strategies below). The basic search will intersect four areas:

- soil species terms in the title, descriptor and abstract fields only
- priority chemicals terms in the title, descriptor and abstract fields only
- toxic effects indexing codes
- publication year $\geq$1988 or all publication years (see Chemical List for specific details on publication year searching)

Exclusion terms may also be used to further reduce the number of non-applicable citations located by a search strategy.

AGRICOLA Search

Species Terms (See Species List)

Chemical Names

alumin*, antimon*, arsen*, barium, barite, beryllium, cadmium, chromate, chromic, chromium, cobalt, copper, cupr*, iron or ferr*, lead, manganese, nickel*, seleno*, selenate, seleni*, silver, vanad*, zinc, dieldrin*, alvit, dieldrex, heod, illoxol, octalox, panoram, quintox, dimethanonaphthalene*, DDT, agritan, anofex, arkotine, azotox, bosan, bovidermol, chlorophenothan*, citox, clofenotane, dedelo, deoval, detox, detoxan, dibovan, dichlorodiphenyltrichloroethane, dicophane, didigam, didimac, diphenyltrichloroethane, dodat, dykol, estonate, genitox, gesafid, gesapon, gesarex, gesarol, guesapon, guesarol, byron, havero*, hildit, ivoran, ixodex, kopsol, mutoxin, neocide, parachlorocidum, pentachlorin, pentech, rukseam, santobane, ze*dane, DDD, dichlorodiphenyl(w)dichloroethane, dilene, rhothane, TDE, DDE, dichlorodiphenyl(w)dichloroethylene, pentachlorophen*, PCP, acutox, chem-penta, chem-tol, chlorophen, cryptogil, dowcide, crotox, fungifen, lauxtol, liroprem, nci, penchlorol, pentachlorofen*, pentacon, penta-kil, pentasol, penwar, peratox, permite, pervenol, priltox, santo*, weedone, witophen, RDX, hexolite, cyclonite, cyclotrimethylene*, trinitro(w)triazine, hexogen, pbx*, trimethylenetrinitramine, trinitrocyclotrimethylene, TNT, trinitrotoluene, tolit*, entosufon, tritol, triton, trotyl, trinitrotoluol, acenaphthene, acenaphth?lene, albocarbon, anthrac?n, anthrac?ne , benz*(w) (acephenanthrylene or anthracene or chrysene or fluoranthene, or fluorene or peryleneor phenanthrene or pyrene or pyrilene), benzacenaphthene, benzanthracene, benzanthrazen, benzanthrene, benzfluoranthene, benzindene, benzoanthracene, benzochrysene, benzofluoranthene, benzofluorene, benzoperylene, benzophenanthrene, benzopyrene, benzopyrilene, benzperylene, benzphenanthrene, benzpyrene, benzypyrene, beta-pyren*, binaphthylene, biphenylenemethane, biphenylmethane, bis-alkylamino(w)anthracene, camphor(n1)tar, chrysene, coal(w)tar(w)pitch, cyclopenta(w)naphthalene, dezodorator, dibenz(w)antracene, dibenz*(w)anthracene, dibenz*(w)fluorene, dibenzanthracene, dibenzoanthracene, dibenzofluorene, dibenzonaphthalene, dihydroacenaphthylene, diphenylenemethane, ethylenenaphthalene, fluoranthene, fluorene, green(w)oil, ,idryl, inden*(w)pyrene, indenopyrene, methylenebiphenyl, mighty(w)(150 or rd1), naphthal?n, naphthal?ne, naphthalenediylbenzene, naphthanthracene, naphthene, naphthalenebenzene, naphthylenebenzene, naphthyleneethylene, ortho-phenylenepyrene, paranaphthalene, peri-ethyl?nenaphthalene, phenanthr?n*, phenantrin, phenylenepyrene, pyrene, ravatite, tetra(w)olive, tetraphene, white(w)tar, (polynuclear or polycyclic(w) arom*(w)hydrocarbon*)

Category Codes

(W000 Pollution and (K100 Forestry Production-General or F110 Plant Production-Horticultural Crops or J100 Soil Biology or L600 Animal Physiology or F831 Plant Diseases-Fungal or F840 Plant Diseases-Physiological)) or (F600 Plant Physiology and Biochemistry and (uptake/de or phytotoxic?/de)) or F841 (Miscellaneous Plant Disorders)

BIOSIS Search

Species Codes

BC Bacteria or BC Microorganisms or BC Fungi
BC Plants
BC Invertebrates

Species Terms Use species terms from Species List

Category Codes

CC=22501 Toxicology-general; Methods And Experimental
CC=22506 Toxicology-Environmental And Industrial Toxicology

CC=51504 Plant Physiology, Biochemistry and Biophysics (Nutrition) and uptake*
CC=51520 Plant Physiology, Biochemistry and Biophysics (Metabolism) and uptake*

and

CC=37015 Public Health: Air, Water or Soil Pollution
CC=40000 Soil Microbiology
CC=52502 Agronomy-Miscellaneous and Mixed Crops
CC=52504 Agronomy-Grain Crops
CC=52506 Agronomy-Forage Crops and Fodder
CC=53008 Horticulture-Vegetables
CC=53010 Horticulture-Flowers and Ornamental
CC=53012 Horticulture-General, Miscellaneous and Mixed Crops
CC=53500 Forestry and Forest Products

Chemical name/CAS#

alumin*, antimon*, arsen*, barium, barite, beryllium, cadmium, chromium, chromate, chromic, cobalt, copper, cupr*, iron or ferr*, lead, manganese, nickel*, seleno*, selenate, seleni*, silver, vanad*, zinc, dieldrin*, alvit, dieldrex, heod, illoxol, octalox, panoram, quintox, dimethanonaphthalene*, DDT, agritan, anofex, arkotine, azotox, bosan, bovidermol, chlorophenothan*, citox, clofenotane, dedelo, deoval, detox, detoxan, dibovan, dichlorodiphenyltrichloroethane, dicophane, didigam, didimac, diphenyltrichloroethane, dodat, dykol, estonate, genitox, gesafid, gesapon, gesarex, gesarol, guesapon, guesarol, byron, havero*, hildit, ivoran, ixodex, kopsol, mutoxin, neocide, parachlorocidum, pentachlorin, pentech, rukseam, santobane, ze*dane, DDD, dichlorodiphenyl(w)dichloroethane, dilene, rhothane, TDE, DDE, dichlorodiphenyl(w)dichloroethylene, pentachlorophen*, PCP, acutox, chem-penta, chem-tol, chlorophen, cryptogil, dowcide, crotox, fungifen, lauxtol, liroprem, nci, penchlorol, pentachlorofen*, pentacon, penta-kil, pentasol, penwar, peratox, permite, pervenol, priltox, santo*, weedone, witophen, RDX, hexolite, cyclonite, cyclotrimethylene*, trinitro(w)triazine, hexogen, pbx*, trimethylenetrinitramine, trinitrocyclotrimethylene TNT, trinitrotoluene, tolit*, entosufon, tritol, triton, trotyl, trinitrotoluol, acenaphthene, acenaphth?lene, albocarbon, anthrac?n, anthrac?ne , benz*(w) (acephenanthrylene or anthracene or chrysene or fluoranthene, or fluorene or peryleneor phenanthrene or pyrene or pyrilene), benzacenaphthene, benzanthracene, benzanthrazen, benzanthrene, benzfluoranthene, benzindene, benzoanthracene, benzochrysene, benzofluoranthene, benzofluorene, benzoperylene, benzophenanthrene, benzopyrene, benzopyrilene, benzperylene, benzphenanthrene, benzpyrene, benzypyrene, beta-pyren*, binaphthylene, biphenylenemethane, biphenylmethane, bis-alkylamino(w)anthracene, camphor(n1)tar, chrysene, coal(w)tar(w)pitch, cyclopenta(w)naphthalene, dezodorator, dibenz(w)antracene, dibenz*(w)anthracene, dibenz*(w)fluorene, dibenzanthracene, dibenzoanthracene, dibenzofluorene, dibenzonaphthalene, dihydroacenaphthylene, diphenylenemethane, ethylenenaphthalene, fluoranthene, fluorene, green(w)oil, , idryl, inden*(w)pyrene, indenopyrene, methylenebiphenyl, mighty(w)(150 or rd1), naphthal?n, naphthal?ne, naphthalenediylbenzene, naphthanthracene, naphthene, naphthalenebenzene, naphthylenebenzene, naphthyleneethylene, ortho-phenylenepyrene, paranaphthalene, peri-ethyl?nenaphthalene, phenanthr?n*, phenantrin, phenylenepyrene, pyrene, ravatite, tetra(w)olive, tetraphene, white(w)tar, (polynuclear or polycyclic(w) arom*(w)hydrocarbon*)

and

All CAS numbers from chemical list will be used.

CA Search Terms

Species Terms

Use species terms from Species List

Category Codes

SC=CA?04* (Toxicology) or ((SC=CA?05* (Agrochemicals) or SC=CA?19* Fertilizers, Soils and Plant Nutrition) and effect*(w)on) or ((CA?11* Plant Biochemistry) and uptake*) and soil*

CAS#

Use CAS# only from chemical list

PolTox/Toxline Search Search using Toxline, Pollution Abstracts, NTIS to be developed. [12/14/99]

Species terms

Use species terms from Species List

Chemical names

alumin*, antimon*, arsen*, barium, barite, beryllium, cadmium, chromate, chromic, chromium, cobalt, copper, cupr*, iron or ferr*, lead, manganese, nickel*, seleno*, selenate, seleni*, silver, vanad*, zinc, dieldrin*, alvit, dieldrex, heod, illoxol, octalox, panoram, quintox, dimethanonaphthalene*, DDT, agritan, anofex, arkotine, azotox, bosan, bovidermol, chlorophenothan*, citox, clofenotane, dedelo, deoval, detox, detoxan, dibovan, dichlorodiphenyltrichloroethane, dicophane, didigam, didimac, diphenyltrichloroethane, dodat, dykol, estonate, genitox, gesafid, gesapon, gesarex, gesarol, guesapon, guesarol, byron, havero*, hildit, ivoran, ixodex, kopsol, mutoxin, neocide, parachlorocidum, pentachlorin, pentech, rukseam, santobane, ze*dane, DDD, dichlorodiphenyl(w)dichloroethane, dilene, rhothane, TDE, DDE, dichlorodiphenyl(w)dichloroethylene, pentachlorophen*, PCP, acutox, chem-penta, chem-tol, chlorophen, cryptogil, dowcide, crotox, fungifen, lauxtol, liroprem, nci, penchlorol, pentachlorofen*, pentacon, penta-kil, pentasol, penwar, peratox, permite, pervenol, priltox, santo*, weedone, witophen, RDX, hexolite, cyclonite, cyclotrimethylene*, trinitro(w)triazine, hexogen, pbx*, trimethylenetrinitramine, trinitrocyclotrimethylene, TNT, trinitrotoluene, tolit*, entosufon, tritol, triton, trotyl, trinitrotoluol, acenaphthene, acenaphth?lene, albocarbon, anthrac?n, anthrac?ne , benz*(w) (acephenanthrylene or anthracene or chrysene or fluoranthene, or fluorene or peryleneor phenanthrene or pyrene or pyrilene), benzacenaphthene, benzanthracene, benzanthrazen, benzanthrene, benzfluoranthene, benzindene, benzoanthracene, benzochrysene, benzofluoranthene, benzofluorene, benzoperylene, benzophenanthrene, benzopyrene, benzopyrilene, benzperylene, benzphenanthrene, benzpyrene, benzypyrene, beta-pyren*, binaphthylene, biphenylenemethane, biphenylmethane, bis-alkylamino(w)anthracene, camphor(n1)tar, chrysene, coal(w)tar(w)pitch, cyclopenta(w)naphthalene, dezodorator, dibenz(w)antracene, dibenz*(w)anthracene, dibenz*(w)fluorene, dibenzanthracene, dibenzoanthracene, dibenzofluorene, dibenzonaphthalene, dihydroacenaphthylene, diphenylenemethane, ethylenenaphthalene, fluoranthene, fluorene, green(w)oil , idryl, inden*(w)pyrene, indenopyrene, methylenebiphenyl, mighty(w)(150 or rd1), naphthal?n, naphthal?ne, naphthalenediylbenzene, naphthanthracene, naphthene, naphthalenebenzene, naphthylenebenzene, naphthyleneethylene, ortho-phenylenepyrene, paranaphthalene, peri-ethyl?nenaphthalene, phenanthr?n*, phenantrin, phenylenepyrene, pyrene, ravatite, tetra(w)olive, tetraphene, white(w)tar, (polynuclear or polycyclic(w) arom*(w)hydrocarbon*)

Descriptor Code: soil*

Inclusion Database: Toxline (DB=TOX)
Exclusion Database: Riskline (only online data and lacks a bibliography (similar to RTECS)).

TOXNET/BIOSIS SEARCH

Species: earthworm or collembola

Chemicals: cadmium, cobalt, barium, aluminum, antimony, arsenic, beryllium, chromium, copper, iron, lead, manganese, nickel, selenium, silver, vanadium, zinc, dieldrin, ddt, dde, ddd, pentachlorophenol, pcp, trinitrotoluene, tnt, rdx

Database: Toxline: Subfile = Toxicological Aspects of Environmental Health (BIOSIS)

Publication Year: 1981 to present (Note: only selections available are 1965 or 1981 to present)

CURRENT CONTENTS SEARCH: Standard Search

Species terms

Use species terms from Species List

Chemical names

alumin*, antimon*, arsen*, barium, barite, beryllium, cadmium, chromate, chromic, chromium, cobalt, copper, cupr*, iron or ferr*, lead, manganese, nickel*, seleno*, selenate, seleni*, silver, vanad*, zinc, dieldrin*, alvit, dieldrex, heod, illoxol, octalox, panoram, quintox, dimethanonaphthalene*, DDT, agritan, anofex, arkotine, azotox, bosan, bovidermol, chlorophenothan*, citox, clofenotane, dedelo, deoval, detox, detoxan, dibovan, dichlorodiphenyltrichloroethane, dicophane, didigam, didimac, diphenyltrichloroethane, dodat, dykol, estonate, genitox, gesafid, gesapon, gesarex, gesarol, guesapon, guesarol, byron, havero*, hildit, ivoran, ixodex, kopsol, mutoxin, neocide, parachlorocidum, pentachlorin, pentech, rukseam, santobane, ze*dane, DDD, dichlorodiphenyl(w)dichloroethane, dilene, rhothane, TDE, DDE, dichlorodiphenyl(w)dichloroethylene, pentachlorophen*, PCP, acutox, chem-penta, chem-tol, chlorophen, cryptogil, dowcide, crotox, fungifen, lauxtol, liroprem, nci, penchlorol, pentachlorofen*, pentacon, penta-kil, pentasol, penwar, peratox, permite, pervenol, priltox, santo*, weedone, witophen, RDX, hexolite, cyclonite, cyclotrimethylene*, trinitro(w)triazine, hexogen, pbx*, trimethylenetrinitramine, trinitrocyclotrimethylene, TNT, trinitrotoluene, tolit*, entosufon, tritol, triton, trotyl, trinitrotoluol, acenaphthene, acenaphth?lene, albocarbon, anthrac?n, anthrac?ne , benz*(w) (acephenanthrylene or anthracene or chrysene or fluoranthene, or fluorene or peryleneor phenanthrene or pyrene or pyrilene), benzacenaphthene, benzanthracene, benzanthrazen, benzanthrene, benzfluoranthene, benzindene, benzoanthracene, benzochrysene, benzofluoranthene, benzofluorene, benzoperylene, benzophenanthrene, benzopyrene, benzopyrilene, benzperylene, benzphenanthrene, benzpyrene, benzypyrene, beta-pyren*, binaphthylene, biphenylenemethane, biphenylmethane, bis-alkylamino(w)anthracene, camphor(n1)tar, chrysene, coal(w)tar(w)pitch, cyclopenta(w)naphthalene, dezodorator, dibenz(w)antracene, dibenz*(w)anthracene, dibenz*(w)fluorene, dibenzanthracene, dibenzoanthracene, dibenzofluorene, dibenzonaphthalene, dihydroacenaphthylene, diphenylenemethane, ethylenenaphthalene, fluoranthene, fluorene, green(w)oil, idryl, inden*(w)pyrene, indenopyrene, methylenebiphenyl, mighty(w)(150 or rd1), naphthal?n, naphthal?ne, naphthalenediylbenzene, naphthanthracene, naphthene, naphthalenebenzene, naphthylenebenzene, naphthyleneethylene, ortho-phenylenepyrene, paranaphthalene, peri-ethyl?nenaphthalene, phenanthr?n*, phenantrin, phenylenepyrene, pyrene, ravatite, tetra(w)olive, tetraphene, white(w)tar, (polynuclear or polycyclic(w) arom*(w)hydrocarbon*)

Descriptor Code: soil*

Publication Year: 1998 to present. The search will be performed quarterly in conjunction with the MED hand search using the CDROM update date, since the last search was performed. No plant exclusion terms are used in this search.

Current Contents: Journal Issue Search

Journal issues will be screened within the software and applicable citations will be downloaded into ProCite for acquisition. This search strategy will focus on developing the literature search terms that may be missed in the standard search term list.

Publication Year: 1998 to present. The search will be performed quarterly in conjunction withe MED hand search using the CDROM update date, since the last search was performed.

Journals:

Acta Agriculturae Scandinavica Section B - Soil and Plant Science
Agriculture Ecosystems & Environment
Ambio
Applied and Environmental Microbiology
Applied Soil Ecology
Australian Journal of Agricultural Research
Biodegradation
Biology and Fertility of Soils
Bioresource Technology
Bioscience Biotechnology and Biochemistry
Communications in Soil Science and Plant Analysis
FEMS Microbiology Ecology
Geoderma
Journal of Industrial Microbiology Biotechnology
Journal of Plant Nutrition
Journal of Soil Contamination
Mycological Research
Mycopathologia
Mycorrhiza
New Phytologist
Pedobiologia
Plant and Soil
Plant Physiology
Science of the Total Environment
Soil & Tillage Research
Soil Biology & Biochemistry
Soil Science
Soil Science and Plant Nutrition
Soil Science Society of America Journal
Zeitschrift fuer Pflanzenernaehrung und Bodenkunde

SPECIES LIST

Invertebrates	Plants
annelid*	bean* or phaseolus
caenorhabditis	bluegrass or poa
collembol*	bluestem
dendrobaena	carrot* or daucus
earthworm*	brassica
eisenia	clover
insect(3n)larva*	corn or maize
lumbricus or lumbricid*	cotton
metal* and invertebrat*	crop(w)yield*
mite*	cucumber* or cucumis
potworm*	fescue
scud*	foliage
springtail*	leaf
soil*(3n)arthropod* or microarthropod* or macroarthropod*	leaves
soil*(3n)biota or microbiota or macrobiota	legum*
soil*(3n)animal*	lettuce* or lactuca
soil*(3n)fauna or microfauna or macrofauna	oak* or quercus
soil*(3n)invertebrat* or microinvertebrat* or macroinvertebrat*	oat or oats or avena
soil*(3n)nematod*	pea or peas
worm*	phytotoxic*
	pine* or pinus
	plant*(3n)grow*
	plant*(w)yield
	radish* or raphanus
	rice
	root*
	ryegrass*
	seed*(3n)germinat*
	seedling*
	soil*(3n)emergence
	soil*(3n)germinat*
	soybean*
	spinach*
	stem*
	tree*
	vascular (w)plant*
	wheat
	Exclusion Terms:
	acid*(w)rain
	mining(w)waste*[1]
	sewage(w)sludge*
	smelter*
	trace(w)element*
	wastewater* or waste(w)water*

** All species terms are intersected with all effect/process terms.

NOTE: 3n= the second term is within three terms either before or after the first term;
w = the second term is adjacent to the first word

[1] Based on the SAB review (April 1999) the term "mining(w)waste" will be removed from the list of Exclusion Terms for the next time a search is conducted.

CHEMICAL LIST

ALUMINUM (alumin*)
Publication Year: Invert = All years/ Plants ≥1988
7429905 Aluminum
7446700 Aluminum chloride
7784181 Aluminum fluoride
7784250 Sulfuric acid, Aluminum ammonium salt (2:1:1)
10043013 Sulfuric acid, Aluminum salt (3:2)
10043671 Sulfuric acid, Aluminum potassium salt
13473900 Aluminum nitrate (Al(NO3)3)
10043671 Aluminum potassium sulfate (AlK(SO4)2)
10043013 Aluminum sulfate
17927650 Aluminum sulfate hydrate
7784272 Aluminum nitrate nonahydrate
7784136 Aluminum chloride hexahydrate
15098870 Aluminum fluoride trihydrate
10124273 Aluminum chloride hydrate
7784318 Aluminum sulfate octahydrate
32287653 Aluminum fluoride dihydrate
16828118 Aluminum sulfate hydrate

ANTIMONY (antimon*)
Publication year = All years
7440360 Antimony III
1333784 Potassium antimonate
28300745 Antimony potassium tartrate
10025919 Antimony trichloride
7783564 Antimony trifluoride
1345046 Antimony trisulfide
11071151 L-Antimony potassium tartrate
12208138 Potassium hexahydroantimonate
33908666 Sodium hexahydroxy antimonate
63994332 Hexahydroxyantimonate (1-) potassium

ARSENIC (arsen*)
Publication Year: Invert = All years/ Plants ≥1988
7440382 Arsenic
7631892 Arsenic acid, Sodium salt
7645252 Arsenic acid, Lead salt
7778394 Arsenic acid (H3AsO4)
7778430 Arsenic acid, Disodium salt
7784341 Arsenous trichloride
7784409 Arsenic acid, Lead(2+) salt (1:1)
7784443 Arsenic acid, Diammonium salt
7784465 Arsenenous acid, Sodium salt
10048950 Arsenic acid, Disodium salt, Heptahydrate (Na2AsH3o4.7H2O
15120179 Sodium arsenate (NaAsO3)
13464385 Sodium arsenate (Na3AsO4)
7631892 Sodium arsenate (generic form)
13466063 Sodium arsenite (Na2HAsO3)
13464374 Sodium arsenite (Na3AsO3)

BARIUM (barium or barite)
Publication year = All years
513779 Barium carbonate
543806 Barium acetate
115216778 Barium nitrate hydrate
10326279 Barium chloride hydrate
7440393 Barium
7727437 Barium sulfate
10022318 Barium nitrate
10361372 Barium chloride
13462867 Barite (barium sulfate)
21109955 Barium sulfide

BERYLLIUM (beryllium)
Publication year = All years
7440417 Beryllium
7787475 Beryllium chloride
7787497 Beryllium fluoride
13327327 Beryllium hydroxide
7787555 Beryllium nitrate (Be(NO3)2.3H20)
13597994 Beryllium nitrate (BeN2O6)
12161829 Beryllium silicate
13510491 Beryllium sulfate
7787566 Beryllium sulfate tetrahydrate

CADMIUM (cadmium)
Publication year = ≥1988
7440439 Cadmium
543908 Cadmium acetate
7789426 Cadmium bromide
10108642 Cadmium chloride
7790809 Cadmium iodide (CdCI2)
10022681 Nitric acid, Cadmium salt tetrahydrate
10325947 Cadmium nitrate
10124364 Cadmium sulfate
7790785 Cadmium chloride hydrate
7790843 Cadmium sulfate 8/3H2O
89759808 Cadmium acetate hydrate
34330648 Cadmium chloride hydrate

CHROMIUM (chromium, chromate, chromic)
Publication Year: Invert = All years/ Plants ≥1988
1066304 Acetic acid, Chromium(3+) salt
7440473 Chromium
7738945 Chromic acid (+6)
7775113 Sodium chromate (+6)
7778509 Chromic acid, Dipotassium salt (+6)
7788978 Chromium fluoride (+3)
7788989 Chromic acid, Diammonium salt (+6)
7789006 Chromic acid, Dipotassium salt (+6)
10025737 Chromium chloride (+3)
10101538 Sulfuric acid, Chromium (3+) salt (3:2)
10141001 Chromium potassium sulfate (+3)
10588019 Sodium dichromate (+6)
12680487 Sodium chromate (unknown formula)
13530682 Chromic acid (+6)
13548384 Chromium(III) nitrate (+3)
13907454 Chromate (CrO4) (+6)

13907476 Chromate (+6)
15244389 Chromium sulfate pentahydrate (+3)
18540299 Hexavalent chromium
7789028 Chromium nitrate nonahydrate

COBALT (cobalt)
Publication Year: Invert = All years/ Plants ≥1988
7440484 Cobalt
71487 Cobalt acetate
7646799 Cobalt chloride
10141056 Cobalt nitrate
10124433 Cobalt sulfate
544183 Cobalt(2)formate
60459087 Cobalt sulfate hydrate
69098142 Cobalt chloride hydrate

COPPER (copper, cupr*)
Publication year = ≥1988
7440508 Copper
1344678 Copper chloride
1333228 Copper sulfate
7758987 Copper sulfate
598549 Copper acetate
1332656 Copper chloride hydroxide
4180125 Copper acetate
6046931 Acetic acid, Copper 2+ salt monohydrate
7758998 Sulfuric acid copper (2+) salt (1:1), Pentahydrate
142712 Cupric acetate
3251238 Cupric nitrate
3251294 Cuprous nitrate
7447394 Cupric chloride
7758896 Cuprous chloride
13770188 Cupric perchlorate
66923668 Copper acetate hydrate
13468854 Cupric chloride hydrate
19004194 Cupric nitrate hydrate
10125130 Copper chloride dihydrate

IRON (iron, ferr*)
Publication Year: Invert = All years/ Plants ≥1988
563713 Carbonic acid, Iron(2+)salt (1:1)
7439896 Iron
7705080 Iron chloride
7758943 Iron chloride FeCl2
10124499 Iron sulfates
10421484 Nitric acid, Iron(3+) salt
11113669 Iron hydroxide
12040572 Iron chloride
26273461 Carbonic acid, Iron (3+) salt
1309337 Ferric hydroxide
1317379 Ferrous sulfide
7720787 Ferrous sulfate
10028225 Ferric sulfate
18624447 Ferrous hydroxide
10028225 Ferric sulfate hydrate
7705080 Iron trichloride hexahydrate
13478109 Iron dichloride tetrahydrate

LEAD (lead)
Publication year = ≥1988
7439921 Lead
301042 Lead acetate
7758954 Lead chloride
10099748 Lead nitrate
7446142 Lead sulfate
546678 Acetic acid, Lead (4+) salt
13826658 Nitrous acid, Lead (2+) salt

MANGANESE (manganese)
Publication Year: Invert = All years/ Plants ≥1988
7439965 Manganese
13444729 Manganese (III) sulfate
11132788 Manganese chloride
7773015 Manganese chloride (MnCl2)
10377669 Manganese nitrate
15710664 Manganese nitrate hydrate
15244367 Manganese sulfate hydrate

NICKEL (nickel*)
Publication Year: Invert = All years/ Plants ≥1988
373024 Acetic acid, Nickel (2+) salt
7791200 Nickel chloride hexahydrate
69098153 Nickel chloride hydrate
15060625 Nickel (II) selenate
7440020 Nickel
7718549 Nickelous chloride
13138459 Nickelous nitrate
7786814 Sulfuric acid, nickel(2+)salt (1:1)
10101970 Nickel sulfate hexahydrate
373024 Nickelous acetate tetrahydrate
13478007 Nickel (II) chloride hydrate

SELENIUM (seleno*, seleni*, selenate)
Publication Year: Invert = All years/ Plants ≥1988
7446084 Selenium dioxide
7790592 Potassium selenate
10431147 Potassium selenite
7783075 Hydrogen selenide
7782492 Selenium
7783008 Selenous acid
13410010 Sodium selenate
10102188 Sodium selinite

SILVER (silver)
Publication Year: Invert = All years/ Plants ≥1988
506649 Silver cyanide
563633 Acetic acid, Silver (1+) salt
7440224 Silver
7761888 Silver nitrate
7783906 Silver chloride
7783962 Silver iodide
10294265 Silver sulfate

VANADIUM (vanad*)
Publication year = All years
7440622 Vanadium

7718981 Vanadium chloride
7727186 Vanadyl chloride
7803556 Vanadic acid, Ammonium salt
13718268 Sodium vanadate
13721396 Vanadic acid, Trisodium salt
14333187 o-Vanadate

ZINC (zinc)
Publication year = ≥1988
7440666 Zinc
7646857 Zinc chloride
7779886 Zinc nitrate
7733020 Zinc sulfate
557346 Zinc acetate
1314223 Zinc peroxide
1314847 Zinc phosphide
7446200 Zinc sulfate heptahydrate
7699458 Zinc bromide
10139476 Zinc iodide
13597449 Sulfurous acid, Zinc salt (1:1)
10196186 Zinc nitrate hydrate
5970456 Zinc acetate dihydrate

DIELDRIN
Publication Year: Invert ≥1988 / Plant = All years
60571 dieldrin*, alvit, dieldrex, heod, illoxol, octalox, panoram, quintox, dimethanonaphthalene*

DDT Group
Publication Year: Invert ≥1988 / Plant = All years
50293 DDT, agritan, anofex, arkotine, azotox, bosan, bovidermol, chlorophenothan*, citox, clofenotane, dedelo, deoval, detox, detoxan, dibovan, dichlorodiphenyltrichloroethane, dicophane, didigam, didimac, diphenyltrichloroethane, dodat, dykol, estonate, genitox, gesafid, gesapon, gesarex, gesarol, guesapon, guesarol, byron, havero*, hildit, ivoran, ixodex, kopsol, mutoxin, neocide, parachlorocidum, pentachlorin, pentech, rukseam, santobane, ze*dane
72548 DDD, dichlorodiphenyl(w)dichloroethane, dilene, rhothane, TDE
72559 DDE, dichlorodiphenyl(w)dichloroethylene

PENTACHLOROPHENOL
Publication Year: Invert ≥1988 / Plant = All years
87865 Pentachlorophen*, PCP, acutox, chem-penta, chem-tol, chlorophen, cryptogil, dowcide, crotox, fungifen, lauxtol, liroprem, nci, penchlorol, pentachlorofen*, pentacon, pentakil, pentasol, penwar, peratox, permite, pervenol, priltox, santo*, weedone, witophen

RDX
Publication year = All years
121824 RDX, hexolite, cyclonite, cyclotrimethylene*, trinitro(w)triazine, hexogen, pbx*, trimethylenetrinitramine, trinitrocyclotrimethylene

TNT
Publication year = All years
118967 TNT, trinitrotoluene, tolit*, entosufon, tritol, triton, trotyl, trinitrotoluol

PAH Group
Publication year = All years

83329, 208968, 120127 56553, 50328, 205992, 191242, 207089, 218019, 53703, 206440, 86737, 193395, 91203, 85018 , 129000, 130498292
acenaphthene, acenaphth?lene, albocarbon, anthrac?n, anthrac?ne , benz*(w) (acephenanthrylene or anthracene or chrysene or fluoranthene, or fluorene or peryleneor phenanthrene or pyrene or pyrilene), benzacenaphthene, benzanthracene, benzanthrazen, benzanthrene, benzfluoranthene, benzindene, benzoanthracene, benzochrysene, benzofluoranthene, benzofluorene, benzoperylene, benzophenanthrene, benzopyrene, benzopyrilene, benzperylene, benzphenanthrene, benzpyrene, benzypyrene, beta-pyren*, binaphthylene, biphenylenemethane, biphenylmethane, bis-alkylamino(w)anthracene, camphor(n1)tar, chrysene, coal(w)tar(w)pitch, cyclopenta(w)naphthalene, dezodorator, dibenz(w)antracene, dibenz*(w)anthracene, dibenz*(w)fluorene, dibenzanthracene, dibenzoanthracene, dibenzofluorene, dibenzonaphthalene, dihydroacenaphthylene, diphenylenemethane, ethylenenaphthalene, fluoranthene, fluorene, green(w)oil, idryl, inden*(w)pyrene, indenopyrene, methylenebiphenyl, mighty(w)(150 or rd1), naphthal?n, naphthal?ne, naphthalenediylbenzene, naphthanthracene, naphthene, naphthalenebenzene, naphthylenebenzene, naphthyleneethylene, ortho-phenylenepyrene, paranaphthalene, peri-ethyl?nenaphthalene, phenanthr?n*, phenantrin, phenylenepyrene, pyrene, ravatite, tetra(w)olive, tetraphene, white(w)tar, (polynuclear or polycyclic(w) arom*(w)hydrocarbon*)

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ATTACHMENT D: Instructions for DIALOG Online

Introduction

The DIALOGLINK software interacts with the DIALOG server. It holds the search strategy and the information you retrieve. In addition, it has an accounting tool to track the search costs. The instructions in this SOP are for using DIALOGLINK software, version 2.20. The software can be downloaded directly from the DIALOG web site (http://www.dialog.com/).

Configuring DIALOGLINK

After you load the software, under the Configuration menu and Service Setup, you must set up your communication method. For example, for an internet connection, the configuration should be set to Port = TCP/IP and Hostname = dialog.com. Enter your account number and password in the configuration and the software will automate your account and password login service each time you access DIALOG. Set your preferences for service to Maximum Buffer Size = MAX and to warn you when this is 80% full.

DIALOGLINK should operating with a Type-Ahead buffer. If a service is configured with a Type-Ahead buffer, the session window will have two independent scrolling regions. The top region is the Retrieve buffer for the online session, the bottom region is the Type-Ahead buffer, where commands can be typed or loaded before going online or while the host is still processing earlier commands.

Accessing DIALOGLINK

To get into **DIALOGLINK**, click on the DLINK icon. The icon should be created when you download and execute the DIALOGLINK software. Turn on modem or phone line, if necessary. There is a menu bar with DIALOGLINK features and a status bar on the top of the screen contains messages regarding buffer, accounting, on-line/off-line status.

Creating/Editing Search Terms

The search terms can be created and edited in either the DIALOGLINK Type-Ahead buffer or in WordPerfect. To edit the search terms in **WordPerfect**:

- Always save the text as DOS text with an extension, *.SRC for search terms.
- The WP commands may be saved for the DIALOG search in landscape format if the text wraps around in portrait format. The text must not **wrap** in DOS or **DIALOGLINK** will not read the search correctly.
- Use landscape (w/ 0.3,0.3 margins) in WP to be sure the text doesn't wrap.
- Save the file as an ASCI text format.

To use the type-ahead buffer
Enter search strategy on the search session screen. Click on "Save Copy as", then select **Type-Ahead Buffer** . Save the strategy as a new file, using a filename up to 8 characters long (the program automatically assigns the .SRC extension), and press **<enter>**. To load a .SRC file from a saved file to the type-ahead buffer, click "Load Type Ahead Buffer", chance directory if necessary, to view the desired set of files. Default is usually c:\dlinkwin\searches.

After a file is loaded into the Type-Ahead buffer, the file may be edited using **DIALOGLINK** editing options. The search is not case sensitive. Spelling needs to be checked. Each search term line should start with an S (select). The command lines need to be checked for accuracy in logic using a practice database (see on-tap instructions below).

To connect to DIALOG Server
DIALOGLINK has been configured to automatically dial the phone number and present the user number and password. Remember to save all your search term edits prior to connecting or you will lose them. Click on "Connect" and the software will automatically connect you to the DIALOG server.

Remember that DIALOG will only search on search terms that are shown prior to the cursor (i.e., if your carriage return is placed above the line to be searched, DIALOG will wait until <enter> is pressed. This allows the user to edit terms while running a search).

Output
After the search is completed, the search and results (buffer) can be saved to the C:\dlinkwin\output drive (or a diskette), printed off-line by DIALOG or by E-mail. See DIALOG basics (below) for specific examples of output commands. If you retrieve the output to the buffer (using the Type command), use mark feature to download specific sections of either the search or results DIALOGLINK will save this on the c: drive with an extension of *.REF. If you want all results (buffer) to be saved or printed, you do not use the mark option. The print command will automatically delay the printing for 30 minutes to allow you to cancel the printing, if desired. After 30 minutes, the print command will begin and forward a hard copy output to you via surface mail. If you select to Email the output to an E-mail address, you have 30 minutes to cancel your output. Remember when E-mailing the output, the file must be under 3 mb (a warning will be displayed by DIALOG, it is greater than 3 mb). If is it greater than 3 mb, divide the search output into smaller sections thereby receiving several Email output files.

For compatibility with ProCite software, you must select FORMAT 4 (tagged field header output) as the output format. Select records to download from your search output using **FORMAT 4.** An output that consists of citations only, without search summary information, will provide a clean transfer. Additional information may be included in the files if necessary, see Section II.E.

If you are using the DIALOGLINK software, mark only citation information (not the search term text). Save your captured output by selecting "File", "Save copy as".

- Save the search output by naming the drive and filename.
- Double check (using WordPerfect) that the output file was saved properly before you exit DIALOGLINK.

DIALOG Search Basics

Refer to the full search documentation on the DIALOG web site (http://www.dialog.com) for basic DIALOGLINK instructions and additional DIALOG commands. A brief synopsis is presented below.

- To select a database to search, use Begin command (e.g. **B41** or **B44**)
- Terms are searched by using the Select command (e.g. **S wetland)**
- Use the displays sets command, **ds**, to display the terms searched so far
- To display records, you use the terms **type** or **print .** Example output commands are:

  Print S7/4/1-2
  where S7 = desired search output set number
  4 = format number
  1-2 = number of records to display (i.e., ALL, 1-10, etc.)

  Print S60/4/1-999/addr acdelore (Sends to email address selected for this account)

  Type S7/6/ALL (to type records on-line to Retrieve buffer)

  Print Cancel p0008 (to cancel off-line or Email print command)

- **LOGOFF** disconnects you from DIALOG

Connectors for search terms:

S S1 and S2 --> combines two sets of terms
S S1:s16 --> joins a numeric range of sets selected (e.g., s1 or s2 or s3, etc.)
S pesticide? --> "?" is the truncation symbol to retrieve variable word endings
E pesticide --> expand term locate all variable ending for the term
OR --> pesticide or wetland
AND --> pesticide and wetland
NOT --> pesticide not wetland
To select adjacent words in the selected order --> **pesticide(w)wetland** or **pesticide()wetland**

More adjacent word tips:

(2W) means up to two words separate the selected terms.
(3W) means up to 3 words separate the selected terms.
(F) means searching for two terms within a field like the title, abstract, or descriptors.
(N) means two words are adjacent, but in either order.

More advanced searching techniques:

Year search --> **S1 and PY = 1982:1993**
Search Update -- > UD = 9401:9999 will search records entered into the database between 1/94 and present (99/99).
Saving searches --> **Save temp** (e.g. "TB001" stored, remember the displayed number)
Recall searches --> **exs TB001**
Release TB001 will delete the saved search
Logoff hold --> will hold the search strategy for 30 minutes. DIALOG needs to be accessed again, but the search will begin where the user left off. (There is no on-line charge during this 30 minutes.)
Pause --> will hold the search strategy for 10 minutes. (However, there is an on-line charge for this time.)
From [datafile number]--> e.g., s 1 from 5, means only search the BIOSIS datafile. This is very useful for unique category codes and descriptors only found in one datafile. Also can be used to locate number of hits for individual databases in a Onesearch strategy.

Selecting Applicable Databases
DIALINDEX is a feature which allows the user to search a group of related databases simultaneously to determine which database(s) contain the most appropriate literature. This features is used prior to selecting databases for searching. An example to finding the most appropriate data bases.

b 411 (DIALINDEX database) use ALLSCIENCE
S pesticide? and wetland?

You can rank the most applicable databases.

Practice Searching
OnTap is a subset of databases to help the user refine or correct a search prior to the performance of the final search, using a subset of the entire database and at a much cheaper or free rate. The account numbers and passwords are available on the DIALOG web site (http://www.dialog.com/) or contact the DIALOG HELP desk (800-334-2564). The passwords change every few months.

Searching Multiple Databases
DIALOG can perform two or more searches simultaneously, called a OneSearch (e.g., AFSA and Pollution Abstracts). You will be charged for both online costs during the search, but

combining searches can reduce total online time. OneSearch can be cross checked for duplicates using DIALOG commands, prior to printing. Remember to type in the databases selected from least to most cost. DIALOG will remove duplicates according to the order you selected the databases.

ATTACHMENT E: Instructions For Using SilverPlatter Software

Accessing WinSPIRS

SilverPlatter, Version 4, produces the WinSPIRS software used to access and search literature databases on CDROM. The WinSPIRS software can be accessed through any MED networked computer which has Windows 95. The computer used for a full search for one of the ECOTOX databases must have a large operating memory, since these searches are very complicated. Before running a new search, the search histories should be transferred to the C: drive from the floppy disk, and the search should be run from the C: drive. The icon for WinSPIRS in the MED LAN Scientific Applications window. More detailed instructions can be found in the WinSPIRS User Manual or on their web site (http://www.silverplatter.com/).

Selecting Databases:

To get into **WinSPIRS**, click on the SilverPlatter icon within the MED-LAN Scientific Applications window. The first screen displays the databases you may select. Click the databases you want to search over to the right-hand column. The system will display an error message if the databases are unavailable (in use by other MED staff). If the databases are available, a database copyright message will display. The database searched is Toxline, which is a subfile of PolToxI.

Creating/Editing Search Terms

The search terms can be created within WinSPIRS. The search files are saved, by clicking on the File menu, under Save Search History, with the ".his" extension. Large searches should be parsed into smaller groups of terms to save time in editing saved files. You cannot add or delete terms within search history file. You need to retype the entire portion within WinSPIRS and save the file again. However, you can edit typographical errors outside of the WinSPIRS software. Editing typographical errors can be performed using Microsoft WordPad and saved.

You do not need to type anything the search line other than the search terms. The software is not case sensitive. Logic and spelling need to be checked. Search terms are highlighted in the output. You can toggle between brief and full citations output.

Running a Saved Search

Enter search strategy on the search session screen. Click on "Load and Run Searches". Saved parsed searches can be run within WinSPIRS in any order. The search lines will be automatically renumbered.

Output

When the citation results are displayed, sort them by author name. The "Sort" option is in the Records menu. Make sure you select "Download Search History" in the download option menu. The "Print Search History" option must be selected, so the search terms can be proofed and evaluated by second person. For compatibility with ProCite software, you must select "Short Field Names" (tagged field header output) as the output format. See instructions for Bibliolinks

software below, if you want to transfer the citations to a ProCite file. Make any necessary changes and rerun any sections needed before proceeding with the final citation download. After the search is completed and formatted with the above modifications, the search and results can be saved to the C: drive (you cannot save to a disk or network drive from WinSPIRS).

Saving and Transferring Results for use with ProCite Bibliolinks Software:
In order to ensure compatibility with ProCite/Bibliolinks software, request records from the bibliographic databases in a tagged output format (output that uses field identifiers/ headers). An output that consists of citations only, without the search summary information, will provide a clean transfer. Additional information may be included in the files if necessary, see Section II.E.

Select records from your search output to download using a tagged format.

a. Select "File," "Download records".
b. Select the drive and directory to save the download file.
c. Save the download file in an ASCII format. Select "short field name headers" for your output.
d. Name the download file.
e. Select range of records to save to download file (eg., all marked records, 1-10).

WinSPIRS Search Basics
Refer to the full search documentation on the SilverPlatter web site, (http://www.silverplatter.com) for basic WinSPIRS instructions and additional Boolean commands. A brief synopsis is presented below.

Connectors for search terms:

#1 and #2 --> combines two sets of terms
#1 or #2 or #36 --> joins a numeric range of sets selected (e.g., s1 or s2 or s3, etc.)
pesticide* --> "*" is the truncation symbol to retrieve variable word endings
Use the "thesaurus" feature to locate all variable ending for the term
OR --> pesticide or wetland
AND --> pesticide and wetland
NOT --> pesticide not wetland
To select adjacent words in the selected order --> **aquatic toxicity**

More adjacent word tips:

(near2) means up to two words separate the selected terms.
(near3) means up to three words separate the selected terms.
(with) means searching for two terms within a field like the title, abstract, or descriptors.
(near) means two words are in the same sentence.

Other searching techniques:

The Limit feature creates search strategy for you by years and databases within PolTox. Use the strategy of limiting the terms to the abstract, descriptor and title fields. WinSpirs searches the affiliation field (i.e., the author address) which can include false hits, if not eliminated.

ATTACHMENT F: Instructions For Using Ovid Software (Current Contents)

Accessing Ovid

Ovid for Windows, Version 3.0, provides access to the CDROM Current Contents literature databases. The OVID software can only be accessed via the MED-Duluth library computer. Before running a new search, insert the appropriate Current Contents CD into the E: drive. The Current Contents disks are located in a carousel on top of the library PC tower. Detailed instructions can be found in the Ovid User Manual (in the MED-Duluth library) or on the web site http://www.ovid.com/.

Selecting Databases:

To access Ovid, click on the library PC "OVID" icon. The first screen displays the databases you may select from. Click on the database publication date that identifies the CDROM you have inserted into the computer's E: drive.

To change databases or publication year CDROMS, click on the "Database" button and insert the new disk. If you have previously entered a search strategy, you will have the option to save and reuse the same search strategy at this point. Select the new disk text within Ovid that matches the new CDROM disk.

Creating/Editing Search Terms

The initial search terms must be created within the Ovid software. The search files are saved, by clicking on the File menu under, "Save", then "Save Search Strategy" with the ".sav" (e.g., C:\ovid\users*.sav) file name extension. Large searches (n >) should be parsed into smaller groups of terms (eg., n =) to save time in editing saved files. You cannot add or delete search **lines** within search history file. You need to retype the entire portion within Ovid and save the file again. However, you can edit typographical errors and add/delete terms within the created search line outside of the OVID software. Editing typographical errors can be performed using Microsoft WordPad and saved.

When typing in a new search, you do not need to type anything at the beginning of the search line other than the search terms. The software is not case sensitive. Logic and spelling must be checked.

Running a Saved Search

From the File menu, click on "Open", then "Open Strategy". Select the search file name, then click on "Execute". Saved parsed searches can be run within OVID in any order. The search lines will be automatically renumbered.

Output

When the citation results are displayed, you can save search strategy results by selecting "Print" in the File menu. From the Print menu, select "Print Strategy" to print a copy of the search history with the number of citations found in the current search (Note: The search strategy

history cannot be electronically saved and truncates long search lines). Search terms can be proofed and evaluated by second person, using the search term file (*.sav).)

To print citations, select "Save" options in the File menu. Then click on "Save Documents". Type in the filename and drive you want the citation output to be stored. Click on the "Include Search Strategy" (but this has not saved the search strategy). The maximum citations that can be saved to one file is 500. Click on the "Options" button and modify the "Output Format" to "Reprint". For compatibility with ProCite software, you must select "Reprint" (tagged field header output) as the output format. See instructions for Bibliolinks software below, if you want to transfer the citations to a ProCite file. Make any necessary changes and rerun any sections needed before proceeding with the final citation download.

In order to ensure compatibility with ProCite/Bibliolinks software, request records from the bibliographic databases in a tagged output (output that uses field identifiers/ headers). An output that consists of citations only, without the search summary information, will provide a clean transfer. Additional information may be included in the files if necessary, see Section II.E.

Select records from your search output to download using a tagged format.

a. From File menu, Select , "Save Documents".
b. Select the drive to save the download file.
c. Select "Reprint" for your output format.
d. Name the download file.
e. Select range of records to save to download file (e.g., all records).

Ovid Search Basics

Refer to the full search documentation on the world-wide web (http://www.ovid.com/) for basic Ovid for Windows instructions and additional Boolean commands. A brief synopsis is presented below.

Connectors for search terms:

1 and 2 --> combines two sets of terms
1 or 2 or 3 --> joins a numeric range of sets selected (e.g., s1 or s2 or s3, etc.)
**pesticide$** --> "$" is the truncation symbol to retrieve variable word endings
OR --> pesticide or wetland
AND --> pesticide and wetland
NOT --> pesticide not wetland
To select adjacent words in the selected order --> **aquatic adj toxicity**

More adjacent word tips:

(adj2) means up to two words separate the selected terms.
(adj3) means up to three words separate the selected terms.

(with) means searching for two terms within a field like the title, abstract, or descriptors.
(adj) means two words are in the same sentence.

Other searching techniques:

Ovid automatically includes prefixes for truncated terms (e.g., water$ will locate freshwater and saltwater)

Journal searches can be done by clicking on the "Journal" button and typing in the journal name. This will move you to a journal index.

ATTACHMENT G: ECOTOX Rejection Categories

Categories considered unsuitable for the ECOTOX database effort.

Categories	Description
BIOLOGICAL PRODUCT	Biological toxicants, including venoms, fungal toxins, Bacillus thuringiensis, other plant, animal, or microbial extracts or toxins. Biological products being commercially produced and purified chemicals may be codable; may need to order paper to determine.
CHEMICAL METHODS	Chemical methods only--methods for determination of chemicals, purification of chemicals, etc.
DRUG	Testing for drug effects and side-effects. Drugs are coded when tested for environmental toxicity, including non-target organisms.
EFFLUENT	Effluent, sewage, polluted runoff. Studies involving caged organisms in field situations are coded if a concentration of any specific chemical component of the effluent is given. In identification, watch for comparison tests of single chemicals reported in the same publication.
CHEMICAL FATE/METABOLISM	Studies of what happens to the chemical, not what happens to the organism.
HUMAN HEALTH	Human health effects; studies with human subjects or with animal subjects as surrogates for human health risk assessment. Animal surrogates codable if testing environmental toxicants rather than medical applications.
IN VITRO	In Vitro studies, including exposure of cell cultures and excised tissues. In identification, watch for: In Vitro used for embryo and algae studies (codable); whole organisms exposed and an effect quantified using an In Vitro form (probably codable); and studies which also report results of whole-organism tests for comparison.
METHODS	Methods, no usable specific toxicity tests. Some papers presenting modifications of methods do report results of trial toxicity tests; order the paper if this seems likely. Some methods papers are also selected to be ordered for the ECOTOX Methods file.
MIXTURE	Publications that report data from aquatic laboratory and field studies for combinations of single toxicants are excluded; for example aquatic mixtures of copper and cadmium. Terrestrial publications reporting data for laboratory studies for mixtures are excluded while exposure in a field setting from contaminated natural soils or waste application to soil may be included.
MODELING	Modeling only, no new organism exposure data. Some publications may report toxicity tests performed as comparisons.
NO CONC	No usable dose or concentration reported--identified after examination of full paper. Includes lead-shot studies which lack dose information or give only number of pellets, etc., not a useable concentration.
NO DURATION	No duration--identified after examination of full paper. AQUIRE–acceptable to code NR for duration for abstract only or foreign-language papers; paper not coded entered as ND if an experimental method is reported. TERRETOX and PHYTOTOX–some studies without duration are coded if there is a quantifiable dose or concentration.
NO EFFECT	No effect reported for a biological test species.
NO SPECIES	No viable plant or organism present or tested.

Categories	Description
NO TOXICANT	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.
NO TOX DATA	Toxicant used but no toxicity effects reported. The publication may report genetic changes or effects on media chemistry; this type of endpoint is not included in the ECOTOX system.
NUTRIENT	Nutrient studies. Sometimes difficult to determine whether added chemicals are for the purpose of testing toxicity or benefit to the organism as a nutrient; order papers which are not clear from the abstract. Toxic effects of trace metals and specific chemical fertilizers (with CAS numbers available) are coded.
OIL	Oil and petroleum products. Not coded for AQUIRE or PHYTOTOX, a set-aside category for TERRETOX. In identification, watch for dispersants or other single chemicals reported in the same publication.
PUBL AS	The author states that the information in this report has been published in another source. The data is recorded from only one source; the second citation is noted as Publ As.
QSAR	Quantitative Structure-Activity Relationships; a form of modeling. Publications are rejected if raw toxicity data is not reported or if the toxicity data reported is a secondary form, ie., citing published data.
REVIEW	The data reported in the article not primary data from research conducted by the author; the publication is a compilation of data published elsewhere.
SEDIMENT CONC	The only exposure concentration reported is for the level of toxicant in the sediment.
SURVEY	Assessment of toxicity in the field over a period of time; often a duration nor an exposure concentration is not reported. Studies are primarily residue studies.

ATTACHMENT H: Creation of OCLC/ILL Order Form

To Open File(s) in ProCite:

a.. Press File and Open. (Screen will automatically display the last data screen used in ProCite.)

b. Select filename: C:\PROCITE3\MINITEX\MINITEX.DAT.

1. To Insert Data:
   a. Select Database and New Record to enter record (or press F9.)
   b. Select Minitex Workform with the arrow in the upper left corner of the 'New Record' table.
   c. Enter data and use the TAB key to jump to alternate fields.
   d Select Database and Save Record to save data (or press F10.)

2. To View Records:
   a Press View and Formatted Reference.
   b. Select the output style by pressing the arrow above the 'Minitex Info' window.
   c. Select filename: C:\PROCITE3\STYLES\MINITEX.OUT.
   d. Exit screen:
      i. Press View
      ii. Press Quick Search

3. To Search Records:
   a. Press View and Search.
   b. Select Field to search by pressing the 'Field' button.
   c. Highlight the field name to be searched and press okay. (i.e. RECORD #)
   d. After displaying the field name, type "=" and the data to be searched (i.e. RECORD "=100"), and press enter.
   e. Double-click on the highlighted record to view or edit record.

4. Use mouse to move curser to specified fields and press F10 to save changes.

5. To Sort Data by Title (Field #19):
   a. Select View and Sort by.
   b. Select 'Configure Available Sorts.'
   c. Select 'Define Custom Sort...'
   d. Select Sort by field option (i.e. Field #19) and press 'OK.'
   e. Select View, Sort by, and select Custom.

6. To Print Interlibrary Loan Journals Information List:
   a. Select Bibliography and Print Bibliography.
   b. Change the Reference List Title (i.e. Minitex List.)
   c. Select Reference List Order and change to 'Custom.'
   d. Select Destination: Word Processor File.
   e. Press 'OK.'
   f. Give a filename with the extension ".rtf" and press 'OK.'
   g. Go into WordPerfect 6.1 and then format in columns, etc.

EXAMPLE ILL/OCLC ORDER OUTPUT FROM InProcess DATABASE:

Rec #364 - Nekrasova, L. S. (1993)

Title: Effect of copper-smelting production on soil mesofauna.

Journal: EKOLOGIYA (MOSCOW) :83-85

Periodical

Title:_____

Order Source /Date :OL

Source of Citation: //BIOSIS 1/99//

OCLC # : 23278318

ISB(S)N: 0235-7224

EPA: _____

OTHER: AGL

MULS: _____

ATTACHMENT I: Summary of Searches

I. ECOSSL Search Results

Database/Date search performed	Total Hits	Hits after Duplicates Removed*	Applicable ECOSSL Hits (% Applicable Hits)	New Applic. ECOSSL Hits (% Applicable Hits)	Additional Applicable Citations Identified				Non-Applicable Citations**
					AQ	P	T	M/L	
TOTAL									

* The overlap between the databases search

x duplicate citations between Agricola and BIOSIS

x duplicate citations between BIOSIS and PolTox/Toxline

x duplicate citations between Agricola and PolTox/Toxline

** Non-applicable citation categories are:

No toxicant (n=x)

Biological toxicant (n=x)

Survey (no conc or duration) (n=x)

Human health (n=x)

Sediment/Effluent (AQUIRE rejects) (n=x)

Aquatic bacteria (n=x)

Modelling (n=x)

Mixture (laboratory study) (n=x)

No species (n=x)

Review, no toxicity data (n=)

II. ECOSSL Journal Listing

The Table 1 journal listing was compiled by ranking journal frequency from all computerized literature searches for plants and invertebrates. Journals with an 'x' in the column labeled 'other' were identified by EPA as potentially useful for identifying literature. The invertebrate journal rank was determined for any journal that listed ten or more citations. The plant journal rank was determined for any journal that listed twenty-five or more citations.

Table 1. ECOSSL Commonly Cited Journals (n=42)

Journal Name	Location*	Invert	Plant	Other
Acta Agriculturae Scandinavica Sect B - Soil and Plant Science	CC			x
Acta Zoologica Fennica	-	12		-
Agriculture Ecosystems & Environment	CC			x
Agrokhimiya	-		8	
Ambio	CC			x
Applied and Environmental Microbiology	CC			x
Applied Soil Ecology	CC	13		x
Archives of Environmental Contamination and Toxicology	MED	6		x
Australian Journal of Agricultural Research	CC		16	-
Biodegradation	CC			x
Biology and Fertility of Soils	CC	10		x
Bioresource Technology	CC			x
Bioscience Biotechnology and Biochemistry	CC			x
Bulletin of Environmental Contamination and Toxicology	MED	3	17	-
Chemosphere	MED	9	21	-
Communications in Soil Science and Plant Analysis	CC		3	x
Development of Plant and Soil Science (may only be a limited series)	-		4	
Ecotoxicology and Environmental Safety	MED	2		x
Environmental Toxicology and Chemistry	MED	1		x
Environmental Pollution	MED	7	10	x
FEMS Microbiology Ecology	CC			x
Geoderma	CC			x
Journal of Environmental Quality	MED		7	x
Journal of Industrial Microbiology Biotechnology	CC			x
Journal of Indian Society of Soil Science	-		6	-

Journal Name	Location*	Invert	Plant	Other
Journal of Plant Nutrition	CC		2	x
Journal of Soil Contamination	CC			x
Mycological Research	CC			x
Mycopathologia	CC			x
Mycorrhiza	CC			x
New Phytologist	CC		11	-
Pedobiologia	CC	4		x
Plant and Soil	CC		1	x
Plant Physiology	CC		9	-
Science of the Total Environment	CC	8	12	x
Soil & Tillage Research	CC			x
Soil Biology & Biochemistry	CC	5	18	x
Soil Science	CC		19	x
Soil Science and Plant Nutrition	CC		13	x
Soil Science Society of America Journal	CC		14	x
Water Air and Soil Pollution	MED	11	5	x
Zeitschrift fuer Pflanzenernaehrung und Bodenkunde	CC		15	x

* CC = Available in Current Contents (Agriculture, Biology & Environmental Science)

MED = Available MED Library (hand search)

"-" = not available in either source

III. ECOTOX Journal Search Tracking Form

Date of Search:									
Journal Title	Last Issue Previously Searched	Issues Searched in Current Search	Type of Search*	Number Applic. Citations**					
				A	P	T	APT	M R	Total
Aquat. Toxicol.									
Arch. Environ. Contam. Toxicol.									
Bull. Environ. Contam. Tox.									
Can. J. Fish. Aquat. Sci.									
Comp. Biochem. Physiol. C									
Chemosphere									
Ecotoxicol. Environ. Saf.									
Environ. Biol. Fish.									
Environ. Pollut.									
Freshwater Biol.									
J. Environ. Biol.									
J. Environ. Qual.									
J. Fish Biol.									
J. Freshwater Ecol.									
J. Gr. Lakes Res.									
J. N. Am. Benthol. Soc.									
Limnol. Oceanog.									
Water Air Soil Pollut.									
Water Res.									
Totals		# of issues:							
Environ. Toxicol. Chem. (Issues searched on arrival)									
Environ. Ecol. (Issues searched on arrival)									
Totals									
Overall Totals									

**Applicable citation types: ECO=Eco-SSL, A=AQUIRE, P=PHYTOTOX, T=TERRETOX, APT=Applicable to more than one ECOTOX database, MR=Methods and Reviews

ATTACHMENT J

LITERATURE ACCEPTANCE CRITERIA CHECKLIST

InProcess Reference Number _____

Study Type (Field/Laboratory) _____

Experimental design description (optional): If more than one experimental design is used in the study, multiple Literature Acceptance Criteria Checklist forms may be required. If more than one checklist is being used for this reference, briefly describe the characteristics of the study design (e.g., chemical, species, exposure location) that can be used to differentiate this checklist from the others.

No.	Criteria / *Detailed explanation of criteria*	Y/N/U*
1.	Is the document a primary source for the test result?	
	A document is considered a primary source only if at least one of the investigators who conducted the toxicity test is an author, and the authors do not cite another publication as the original source of the data.	
2.	Were the adverse effects caused by a single stressor?	
	The focus of the Eco-SSL effort is to present results from toxicity tests involving a single stressor. Tests concerning synergism, additivity, potentiation, or antagonism, whether it involves two or more chemical stressors or a combination of chemical and non-chemical stressors are not acceptable studies under this criteria. Effluents, leachates, drilling muds, fly ashes, sediments, and sludges are not considered single chemicals. In addition, the single chemical cannot be introduced as a component of an effluent, etc. Emulsifiable concentrates and wettable powders are considered single chemicals because they can provide very high quality results in some cases, which will be determined using the Task Group 4 Evaluation criteria (TG4-SOP#3). Chemicals such as toxaphene are considered single chemicals because they are mixtures of structurally similar organic chemicals that only exist in large quantities as commercial mixtures of the various chemicals and apparently have similar biological, chemical, physical, and toxicological properties.	

* Y = yes; N = no; U = unknown

No.	Criteria / *Detailed explanation of criteria*	Y/N/U*
3.	Was the chemical form (i.e., metal salt vs. metal) and concentration reported by the author(s)?	
	If the authors provide sufficient information to determine the concentration and units associated with the observed or calculated result(s), and clearly identify what form of the chemical the concentration is based on (e.g., metal salt vs metal form only) the answer is 'Y'.	
4.	Is the test media used in the study a natural or artificial soil?	
	Authors must report that the study was conducted using a natural or artificial soil. Studies conducted in pore water or any other aqueous phase (e.g., hydroponic studies), filter paper, petri dishes, manure, organic or histosoils (e.g., peat, muck, humus), are not considered suitable for use in defining soil screening levels.	
5.	Does the study report the organic matter content as ≤ 10% of the composition of the soil?	
	If the authors report that a standard (e.g., OECD) or commercially available artificial soil is used, but do not present the organic matter content, the answer should be 'Y' for the accepted artificial soil types listed in Table 1. *If the authors report that an EPA or OECD standard artificial soil is used, but do not present the organic matter content, the answer should be 'Y'* (OMC = 10%). **OR** *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); see Table 1 for conversions;* **OR** *If the carbon and/or nitrogen content of the soils is reported by the author the response should be 'Y', because the organic matter content can be estimated; see Table 1 for conversions.*	
6.	With the exception of studies on non-ionizing substances, does the study report the pH of the soil, and is the soil pH within the range of ≥4and ≤ 8.5?	
	If the authors report that an EPA or OECD standard soil is used, the answer should be 'Y' (pH = 6).	

* Y = yes; N = no; U = unknown

No.	Criteria / *Detailed explanation of criteria*	Y/N/U*
7.	Does the study include control treatment(s)?	
	The control treatment must be comparable to the other treatments, and must be free of the chemical stressor. Appropriate controls include baseline or background control - parameters of actual or representative test species measured before and after administration of test chemical, though not as part of the same test scenario; negative control - organisms maintained under conditions identical to exposed organisms except for the absence of the test substance; positive controls - organisms maintained under conditions identical to the exposed organisms except the test substance is replaced with a substance known to elicit a consistent toxic response, and solvent controls - organisms exposed to carrier or solvent that is used as a vehicle for administrating the test substance to exposed organisms.	
8.	Was the duration of exposure reported, or was a standard study method indicating duration referenced?	
	If the authors report an exposure duration or refer to a standard references for details on duration used in the exposure (e.g., ASTM procedures, OECD guidelines) the response should be 'Y'. *If the authors do not present a duration for the exposure, but do refer to another reference as the source of the information, the answer should be 'U'.*	
9.	If the study was conducted in a laboratory setting, were at least three (i.e., control + two chemical exposure) treatment levels used in the study? If the study was conducted in a field setting, were at least two (i.e., control + one chemical exposure) treatment levels used in the study?	
	The authors must clearly state that a control and the appropriate number of treatments were used in the study or refer to a standard method that requires this exposure scenario as a minimum.	
10.	Are biological effects reported for ecologically relevant endpoints (ERE) (see Table 2)?	
	A calculated or statistically derived value must be presented by the authors, and the value must be associated with an ERE. This would include concentration response data associated with an ERE.	
11.	Is the scientific name, common name and/or variety or strain of the test species reported by the author(s)?	
	If the authors provide sufficient information to determine the species scientific name the answer is 'Y'.	

Table 1a: List of the pH and OM content of standard soils.

OECD 1984	Organization for Economic Cooperation and Development 1984
OECD 1993	Organization for Economic Cooperation and Development 1993
EEC	Council of European Communities
ISO 1994	International Standard Organization 1994

Standard Artificial Soil Characteristics		
Soil Type	**Organic Matter**	**pH**
OECD 1984	10 % peat	6.0
OECD 1993	10 % peat	6.0
EEC	10 % peat	6.0
ISO 1994	10 % peat	6.0

Table 1b: List of the conversions for OM in soils

Organic Matter Type	Conversion
Total Organic Carbon (TOC)	Multiply by a factor of 1.72 gives the content of organic matter (6/99)
Particulate Organic Carbon (POC)	Multiply by a factor of 1.72 gives the content of organic matter (6/99)
Organic Carbon (OC)	Multiply by a factor of 1.72 gives the content of organic matter (6/99)
Carbon (C)	Multiply by a factor of 1.72 gives the content of organic matter (6/99)
Nitrogen (N) (Must have C:N ratio)	Convert ratio to %OC & Multiply by a factor of 1.72 to get the content of organic matter (6/99)
Carbon Particulate Organic Matter (CPOM)	Equivalent to OM
Particulate Organic Matter (POM)	Equivalent to OM
Loss on Ignition (LOI)	Equivalent to OM if reported as %, if not multiply by 100 for % OM
% Peat	Equivalent to OM, only for synthetic soils
Ash Free Dry Weight/Mass	Roman will send

Table 2: Ecologically-Relevant Endpoints

Effect Group Codes and Definitions for EcoSSL Tests

Ecologically Relevant Effects	DEFINITION
BEH	**Beh**avior: a general term characterizing overt activity of an organism. represented by three general categories: avoidance, general behavior, and feeding behavior Examples of ERE's associated with behavioral responses include avoidance to food, chemical, stimulus, light and/or water and changes in food consumption rates.
GRO/DVP, GRO	**Gro**wth: a broad category which encompasses measures of weight and length and includes effects on development and growth. Examples of ERE's associated with growth and development responses include change in body weight/length, developmental changes such as emergence to adult stages, emergence from cases, maturation plant curvature, loss of canopy, deformation, membrane damage, desiccation/change in water content, dormancy measures, change in flowering, injury, seed emergence, changes in senescence, shoot length/growth, root elongation/growth, fresh mass, and yield.
BCM/BCM ENZ, HRM	**Bio**chemical: measurement of biotransformation or metabolism of chemical compounds, modes of toxic action, and biochemical responses in plants and animals including three effect groups - chemical, enzyme and hormone effects. For the purposes of developing Eco-SSLs, only plant studies will have ERE's associated with biochemical responses. Examples include changes in photosynthesis, changes in chlorophyll content, changes in fluorescence, chlorosis, and change in carotene content.
MOR	**Mor**tality: measurements and endpoints where the cause of death is by direct action of the chemical. *Effect* measurements of death include an actual count of the number dead or the percentage reduction within a population as a result of the exposure while an *endpoint* such as the LD50 estimates the effects to the population. Examples of ERE's associated with mortality include time to death studies, counts of mortality/surivorship, and immobility.
POP	**Pop**ulation: measurements and endpoints regarding a group of organisms or plants of the same species occupying the same area at a given time. Measurement includes population dynamics - changes over time. Examples of ERE's associated with population include changes in size and age class structures, changes in sex ratio, population change over time, population growth rate, survivability of subsequent generations, biomass or weight for total population, live mass, diversity, evenness, index to population size (count, number, abundance), life table data, number of animals per population, and population density (number/area), primary productivity, standing crop biomass, CO_2 uptake, oxygen release, germination rates, population growth, intrinsic rate of increase, and biomass / abundance in relation to time.

Ecologically Relevant Effects	DEFINITION
REP	**Rep**roduction: measurements and endpoints to track the effect of toxicants on the reproductive cycle. Examples of ERE's associated with reproduction include changes in reproductive behavior, abnormal progeny, fecundity, number of offspring produced, hatching rates/success/viability, reproductive success/capacity (e.g., offspring/adult/week), change in pupation, change in cocoon production, number of cocoons produced, clitella development, sexual development, dormancy measures, germination, parthenocarpy, seed mass, change in sex expression, and sterility.

Endpoint Codes and Definitions for EcoSSL Tests (note that BAF/BCF reviewed by TG3)

ATCN **A**symptotic **t**hreshold **c**oncentration: The concentration of a chemical at which some percentage of a population of test organisms is in a state of approximate homeostasis for some prolonged period of time.

ECxx xx% **E**ffective **C**oncentration: Effective concentration for xx% of tested organisms.

EDxx xx% **E**ffective **D**ose: Effective dose for xx% of tested organisms.

ET50 Median **E**ffective **T**ime: Median time to effect or estimated mean survival time.

ICxx **I**nhibition **c**oncentration: concentration of the inhibitor required to give xx% inhibition of enzyme activity under specific conditions

LCxx **L**ethal **c**oncentration to xx% of test animals

LDxx **L**ethal **d**ose to xx% of test animals

LETC **L**ethal **T**hreshold **C**oncentration: Toxicity curve asymptotic concentration indicating an incipient LC50 value. Acute lethal action has essentially ceased.

LOEL **L**owest-**o**bservable-**e**ffect-**l**evel: lowest dose (concentration) producing effects that were significantly different (as reported by authors) from responses of controls

LTxx **L**ethal **t**ime, median: time required for xx% of a population to die from a given dose; also reported as "STxx" - survival time for xx% of a population

NOEL **N**o-**o**bservable-**e**ffect-**l**evel: highest dose (concentration) producing effects not significantly different from responses of controls according to author's reported statistical test

EcoSSL Ecologically Relevant Group Effect, Effect and Measurement Codes and Definitions
These are the currently available effect measurement codes that apply to the above defined ERE's. As new codes are defined, this list will increase.

BEH Behavior

AVO Avoidance effects

Measurements

CHEM	chemical avoidance	STIM	stimulus avoidance
FOOD	food avoidance	WATR	water avoidance

FDB Feeding behavior effects

Measurements

FDNG	feeding behavior	FCNS	food consumption
FEFF	feeding efficiency	WCON	water consumption
FTIM	feeding time		

BCM Biochemical (plants only)

BCM Biochemical effects

Measurements

CARO	Carotene	CLRS	Chlorosis

GRO Growth

GRO Growth effects - specific to invertebrates

Measurements

LGTH	Length changes (SITE=BOD)	(SITE=BOD)
WGHT	Weight changes	

DVP Developmental effects - specific to invertebrates

Measurements

GDVP	Development, general
EMRG	Emergence

GRO/DVP: Growth and development effects - specific to plants

Measurements

DFRM	Deformation	NPOD	Pods, number of
BMAS	Dry or Fresh mass,yield		
HGHT	Height	**under PHY:**	
LGTH	Length	SENI	Senescence induced
MATR	Maturation	SENR	Senescence retarded
SIZE	Size		

MOR Mortality or Survivorship

MOR Mortality effects

Measurements

HTCH	Hatch	SURV	Survival
MORT	Mortality		

POP Population

POP Population effects

Measurements

ABND	abundance (number of org/area)	NCHG	population change (change in N/change in time)
BMAS	biomass or weight for total population	PGRT	population growth rate
CVER	Cover - loss of canopy		
DVRS	diversity		
INDX	index to population size; count, number, abundance		

REP Reproduction

REP Reproductive effects - specific to invertebrates

Measurements

ABNM	Abnormal	RPRD	Reproductive capacity
PROG	Progeny counts/numbers	RSUC	Reproductive success (general)
WGHT	Progeny weight SITE=PRG		
RBEH	Reproductive behavior changes	TPRD	Total production

REP **Reproductive effects - specific to plants**

Measurements

FLOR	Floral Induction	SEXE	Sex expression Change
GERM	Germination		
PRTH	Parthenocarpy	**under PHY:**	
SEED	Seed Mass/Number/Yield	DORI	Dormancy Induction
STRL	Sterility	DORB	Dormancy Break Increase

Attachment 3-2

Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs)

Eco-SSL Standard Operating Procedure (SOP) #2: Plant and Soil Invertebrate Literature Evaluation, Data Extraction, and Eco-SSL Calculation

OSWER Directive 92857-55

November 2003

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1.0 INTRODUCTION

This standard operating procedure (SOP) describes how nine criteria are used for assessing the applicability of published studies for deriving a terrestrial plant or soil invertebrate Ecological Soil Screening Level (Eco-SSL), provides a set of rules for extracting and reporting the most appropriate study data, and presents the method for calculating an Eco-SSL. Only those studies that meet the study acceptance criteria in SOP #1 (Appendix 3-1) should be evaluated and scored using this SOP. This SOP is intended to ensure that the data most appropriate for deriving an Eco-SSL are selected and used.

2.0 EVALUATION AND SCORING OF STUDY ATTRIBUTES

Nine study evaluation criteria are used to score each reported study (Attachment A). Scoring is based on a three-point scale (i.e., 0, 1, or 2) with a score of "2" being the highest score. The scores for each study evaluation criteria are recorded in a Score Sheet spreadsheet (Attachment B) and summed to generate a total evaluation score for each study. A study must receive a total evaluation score greater than ten to be considered for deriving an Eco-SSL.

Users of this SOP should recognize that toxicity studies reported in published literature were generally not conducted or intended for the purpose of deriving Eco-SSLs. Therefore, the specific information addressed by each criterion may not be reported for each study. Scoring should be objective, however, in some instances professional judgement may be needed to ascertain the appropriate score for a criterion.

Some publications will contain the results of several different experimental designs, or studies, each of which should be scored separately. When a publication reports toxicity data for more than one test species, chemical, or soil type (defined below) these should be considered different studies for the purpose of deriving an Eco-SSL. Studies that vary in other parameters, such as temperature, photoperiod, or species life stage (e.g., immature versus mature), should not be considered different studies for the purpose of deriving an Eco-SSL. Distinct artificial soil types are defined as having different bioavailability scores as determined with study evaluation criteria #1, which is based on pH and percent organic matter. Natural soils from two different sampling locations are considered distinct soils regardless of their bioavailability scores.

When multiple studies are presented in a paper, the reviewer should assign a unique identification code to each study, and document information for each study separately on the Score Sheet. For example, a publication by Jones et al. (Publication No.1022) contains results for three separate experimental designs. In this example, results of each experimental design (i.e., study) should be evaluated and scored separately, and identified on the Score Sheets with an unique experiment identification code such as a, b, and c for the respective publication number (e.g., 1022a, 1022b, 1022c).

A publication may include some studies that do not pass the study acceptance criteria. The reviewer should only score those individual studies that meet the requirements of the study

acceptance criteria (see Appendix 3-1). For example, if a study reports the results of both a topical application and artificial soil study, the topical application study (which does not meet the study acceptance criteria) would not be scored. Reviewers should provide comments on which studies were scored and which were excluded. These comments should be entered in the "comment" field of the Critical Notes spreadsheet (see Section 3.0).

3.0 DATA EXTRACTION

For each study reviewed, a set of Critical Notes (Figure 1) are recorded in a spreadsheet (Attachment C). As with the Study Evaluation Criteria Score Sheet, individual studies are assigned separate experiment identification codes.

Details on the soil parameters including soil pH and percent organic matter (%OM) are recorded. If a study reports the pH at both test initiation and completion only the initial pH should be recorded. If a pH range is reported the arithmetic mean of the minimum and maximum should be calculated and reported. However, if a range is reported and it includes a pH value that is outside of the acceptable soil parameters (i.e., pH < 4 or > 8.5), this study should be rejected and this information should be noted in the comment field of the Critical Notes. Likewise, if %OM is reported as a range for a single soil type and the range extends outside of the acceptable range (i.e., >10%), the study should be rejected and not used for deriving an Eco-SSL. This information should be noted in the comment field of the Critical Notes.

Figure 1. Critical Notes

- Paper identification code
- Study identification code
- First author and year of publication
- Chemical
- Receptor
- Common name
- Species name
- Soil pH
- Percent organic matter (OM)
- Bioavailability score
- Total evaluation score
- Ecologically relevant endpoint (ERE)
- Preferred toxicity parameter
- Preferred toxicity value
- Secondary toxicity parameter
- Secondary toxicity value
- Other available toxicity parameters and concentrations
- Preference level
- Comments

Toxicity values are reported in the Critical Notes spreadsheet. Toxicity values are chemical concentrations related to measurements of a defined ecologically relevant endpoint (ERE). The EREs are presented in Table 1. Toxicity values should be reported as milligram per kilogram (mg/kg) dry weight of the chemical in soil. If the concentrations are reported in units other than mg/kg, or are reported as the concentration of a salt, the reviewer should convert these values to mg/kg of the chemical. If the concentrations are reported as wet weight of the chemical in soil, they should be converted to dry weight concentration based on the percent soil moisture reported in the publication. Any calculations or assumptions by the reviewer must be noted in the comment field of the Critical Notes. If the toxicity value is reported as a range of concentrations rather than a point estimate, no value should be recorded on the Critical Notes and a notation should be made in the comment field.

Table 1. Ecologically Relevant Endpoints (ERE) for Deriving Eco-SSLs	
Ecologically Relevant Endpoint	**Definition**
Reproduction	Measures of the effect of toxicants on offspring production. Examples of EREs associated with reproduction include changes in fecundity, number of progeny produced (eggs, cocoons, etc.), rate of reproduction (hatching rates, etc.), rate of maturation, sexual development, change in sex expression, and sterility number or proportion of abnormal progeny.
Population	Measurements and endpoints regarding a group of soil invertebrates of the same species occupying the same area at a given time. Measurement includes population dynamics. Examples of EREs associated with population include changes in size and age class structures, changes in sex ratio, intrinsic population growth rate, survivability of subsequent generations, diversity, evenness, index to population size (count, number, abundance), life table data, population density (number/area).
Growth	Broad category which encompasses measures of weight/mass and length. EREs associated with growth and development responses such as a change in body weight.
Biomass (plants only)	Measurement of plant products including seed production, standing corp biomass, seedling emergence, shoot length/growth, root elongation/growth, fresh or dry mass, or yield.
Physiology (plants only)	For the purposes of developing Eco-SSLs, only plant studies reporting EREs associated with physiological responses will be used. Physiological endpoints for plants include net photosynthesis (CO_2 uptake, oxygen release), decrease in chlorophyll content or chlorophyll fluorescence, increased deformation, membrane damage, desiccation/decrease in water content, detrimental changes in dormancy measures, decreased flowering, and increased senescence.

Toxicity values are categorized in the Critical Notes by standard measurements of dose-response relationships, or toxicity parameters. Acceptable toxicity parameters include No Observed Adverse Effect Concentrations (NOAEC), Lowest Observed Adverse Effect Concentrations (LOAEC), or Effect Concentrations for 10 - 20% of the population (EC_{10} and EC_{20}). Acute toxicity data (e.g., LC_x) and, $EC_{<10}$ or $EC_{>20}$ are not considered acceptable toxicity parameters for deriving Eco-SSLs. If these are the only parameters reported for a study this information should be recorded in the comment field.

If a publication does not identify acceptable toxicity parameters, but sufficient data are provided, the reviewer should determine and record the toxicity value under the appropriate toxicity parameter. For example, if a study does not identify LOAECs and NOAECs but treatments with and without significant adverse effects are reported, the reviewer should record these toxicity values as LOAECs and NOAECs and note in the comment field that these toxicity parameters were assigned by the reviewer, instead of reported in the publication.

When a study provides NOAEC and LOAEC values, these data are used to calculate a Maximum Acceptable Threshold Concentration (MATC). The MATC is the geometric mean of the NOAEC and LOAEC values:

$$\mathbf{GM = exp(average(LnY_1, Y_2, Y_3 \ldots Y_n))}$$

If data for more than one toxicity parameter are reported for a study (e.g., EC_{20} and EC_{10}), all acceptable toxicity data are reported on the Critical Notes Form and a single preferred toxicity parameter is selected for Eco-SSL derivation based on the following hierarchy:

$$\mathbf{EC_{20} > MATC > EC_{10}}$$

If a study reports more than one toxicity value for the same type of toxicity parameter, a preferred toxicity value for invertebrates is selected according to the following hierarchy of EREs:

Reproduction > Population > Growth

For plants the most sensitive measurement of biomass production is selected. If no measurement of biomass production is reported some physiological endpoints are acceptable EREs for plants. If a publication reports multiple "preferred" toxicity values for the same study (e.g., two reproductive EC_{20} values), the lowest value is recorded on the Critical Notes.

4.0 ECO-SSL DERIVATION

The first step in deriving an Eco-SSL is to sort the studies by their literature evaluation score. Studies with a total evaluation score $\leq$10 (out of 18 possible points) are removed from further consideration for deriving an Eco-SSL. Studies that receive an evaluation score >10 are then ranked by bioavailability score. The Eco-SSL is calculated as the geometric mean of the toxicity values at the highest bioavailability score for which sufficient data exists ($\geq$3 data points). For example, if there are two high bioavailability data points (score = 2) and five medium bioavailability data points (score = 1) the Eco-SSL would be calculated as at the medium bioavailability score using all seven data points. If there are less than three acceptable data points an Eco-SSL can not be calculated.

An Eco-SSL is calculated by taking the geometric mean (GM) of the preferred toxicity values (where N $\geq$ 3) with the highest bioavailability scores:

$$\mathbf{GM = exp(average(LnY_1\ Y_2))}$$

Where Y_1 = NOAEC and Y_2 = LOAEC

5.0 QUALITY ASSURANCE REVIEW

A quality assurance review of the data in studies used to derive an Eco-SSL must be preformed by a panel of experts. The reviewers must verify that all of the studies that will be used to derive an Eco-SSL were correctly evaluated and scored. All publications are checked by at least two individuals, and then reported to the panel of experts for final quality assurance evaluation. The Quality Assurance review consists of the following multi-step process:

- The Literature Acceptance Criteria Checklist (SOP# 1) are reviewed to verify that all of the Acceptance Criteria were met.
- The study evaluation scores are checked to verify that only studies that scored greater than 10 are considered for deriving Eco-SSLs.
- Each publication is reviewed to ensure that toxicity data for all of the available studies are reported on the Critical Notes.
- The soil pH, OM and bioavailability score for each study is verified.
- Selection of the appropriate ecological endpoints, toxicity parameter(s) and toxicity values are verified.
- The preferred toxicity parameter and toxicity value for each study are verified.
- The units of the toxicity value (wet weight/dry weight, chemical form) are verified.
- Calculations (e.g., converting organic carbon to organic matter) and any assumptions made by the reviewer (e.g., assigning toxicity values where values are not reported) documented in the comment field are verified.

ATTACHMENT A
STUDY EVALUATION CRITERIA

Criteria #1 Testing was Done Under Conditions of High Bioavailability

Bioavailability of metals and polar organic compounds is influenced by pH and soil organic matter. The scoring is intended to favor relatively high bioavailability. If the authors do not present the organic matter content, but present another measure of organic content (total organic carbon, particulate organic carbon, or organic carbon) these measurements are converted to organic matter content by multiplying them by a factor of 1.72. If neither the percent organic matter nor the organic carbon content is provided in the publication but this information is available from the United States Department of Agriculture (USDA) National Cooperative Soil Survey (NRCS) database, the data reported in the soil database may be used.

Natural Soils

Natural soils are scored using one of the three Bioavailability Tables provided below. These tables are the same as those reported in Chapter 2 where very high or high = 2, medium = 1, and low or very low = 0.

QUANTITATIVE BIOAVAILABILITY FOR CATIONIC METALS IN NATURAL SOILS

	Low OM (< 2%)	Medium OM (2 - 6%)	High OM (> 6 -10%)
4 ≤ Soil pH ≤ 5.5	V. High (score = 2)	High (score = 2)	Medium (score = 1)
5.5 < Soil pH < 7	High (score = 2)	Medium (score = 1)	Low (score = 0)
7 ≤ Soil pH ≤ 8.5	Medium (score = 1)	Low (score = 0)	V. Low (score = 0)

QUANTITATIVE BIOAVAILABILITY FOR ANIONIC METALS IN NATURAL SOILS

	Low OM (< 2%)	Medium OM (2 - 6%)	High OM (> 6 - 10%)
4 ≤ Soil pH ≤ 5.5	Medium (score = 1)	Low (score = 0)	V. Low (score = 0)
5.5 < Soil pH < 7	High (score = 2)	Medium (score = 1)	Low (score = 0)
7 ≤ Soil pH ≤ 8.5	V. High (score = 2)	High (score = 2)	Medium (score = 1)

QUANTITATIVE BIOAVAILABILITY FOR ORGANIC CHEMICALS IN NATURAL SOILS

Soil Type	Chemical Type	Organic Matter (%)		
		< 2	2 - 6	> 6 - 10
4 ≤ Soil pH ≤ 5.5	Pesticides/PCBS (Log Koc > 3.5)	High (score = 2)	Medium (score = 1)	Low (score = 0)
	Other Organics (Log Koc < 3.5)	V. High (score = 2)	High (score = 2)	Medium (score = 1)
5.5 < Soil pH < 7	Pesticides/PCBS (Log Koc > 3.5)	Medium (score = 1)	Low (score = 0)	Low (score = 0)
	Other Organics (Log Koc < 3.5)	High (score = 2)	Medium (score = 1)	Low (score = 0)
7 ≤ Soil pH ≤ 8.5	Pesticides/PCBS (Log Koc > 3.5)	Low (score = 0)	Low (score = 0)	Low (score = 0)
	Other Organics (Log Koc < 3.5)	Medium (score = 1)	Low (score = 0)	Low (score = 0)

Standard Artificial Soils

Standard artificial soils (i.e., ASTM, ISO, OECD, i.e., 10% OM, 20% Kaolinite, 69% sand, 1% $CaCO_3$) with pH of 4.0 to 8.5 are assigned a medium bioavailability score of 1. All other artificial soils are scored according to the Bioavailability Tables for natural soils.

Criteria #2 Experimental Designs for Laboratory and Field Studies are Documented and Appropriate

There are two sections that may apply for this criterion. Apply the criteria in 2A when the paper describes laboratory studies. Criteria 2A is used for laboratory studies and Criteria 2B are used when a field study is described. Experimental design can significantly influence the quality of a study. Higher quality studies use experimental design(s) sufficiently robust to allow analysis of the test variables and discriminate non-treatment effects.

Criteria #2A: Experimental Designs for Laboratory Studies

The following scores are applied to laboratory studies. A **Score of 2** is assigned if a standard method or protocol is cited (e.g., US EPA, OECD, ASTM, ISO), or if a standard method is not cited but the study includes a description of the experimental design, the test conditions, and the nature of the test units, as indicated in the following subsections.

Experimental Design. The number of exposure concentrations must be ≥6 including a control, the exposure concentrations (nominal or measured), the number of test organisms per test unit (i.e., loading rate), and the time of observations must be reported in the publication. In addition, if an ANOVA or factorial design was used, there must be at least 3 replicate test units per exposure concentration; or if the study used a regression design, there must be at least two replicates and the toxicity estimate must encompass the range of responses needed to describe the dose-response (e.g., interpolation).

Test Conditions. Test conditions reported in the publication should include, at a minimum: exposure temperature. If it is a plant study, it must also report photoperiod (or conditions, e.g., natural light June-August), and type (e.g. sunlight) or intensity of light.

Test Units. Volume or dimensions, and material comprising the test unit, amount/type of soil in each test unit.

A **Score of 1** is assigned if an analysis of variance (ANOVA) or factorial design is used and the number of exposure concentrations is 4 or 5 including a control, or if number of replicate test units are 2 (duplicates). A Score of 1 is also assigned in the following instances:

- the study uses a regression design and the number of exposure concentrations is 4 or 5 including a control, or ≥6 without replication (i.e., only one test unit per exposure concentration); or
- the reported toxicity estimate (e.g., effect concentration or ECx) encompasses the range of responses needed to describe the dose-response,
- the extrapolation does not exceed 10% of the highest test concentration.
- the conditions described in the preceeding experimental design are met but those in either Test Conditions and/or Test Units are not met.

A **Score of 0** is assigned in all other cases.

Criteria #2B: Experimental Designs for Field Studies

A **Score of 2** is assigned if the study includes a description of the experimental design, the test conditions, and the nature of the test plots, as described in the following subsections.

Experimental Design.. If experimental plots are used, the study should report the number of exposure concentrations, the number of replicate plots per exposure concentration, the location or method of selecting the sampling locations, and the time of

sampling or number of sampling times. If transects are used, the method for selecting the location of the transects, the number of transects, the location or method of selecting the sampling locations along the transects, and the time of sampling, or number of sampling times, should be reported.

Test Conditions. Information on the physico-chemical characteristics of the soil should be reported and, at a minimum, include: soil texture or particle size description (sand, silt, or clay, or some combination thereof), pH, and organic matter content.

Test Plots. The size of the test plots, or length of transects should be reported or they can be cited elsewhere.

A Score of 1 is assigned in the following instances:

- the experimental design is an ANOVA design and has 5 exposure concentrations including controls
- less than 3 replicate test units per exposure concentration are reported,
- a regression design is used with <6 treatments, including a control and no replication,
- the test conditions, the test units, or the test plots, are only partially described or are not reported and are not cited elsewhere.

A Score of 0 is assigned in all other cases.

Criteria #3: Concentration of Test Substance in Soil is Reported

The concentration of the chemical tested must be reported unambiguously. It is unacceptable, for instance to report application rates (e.g., lbs./acre, to 500 ppm in sludge applied at 10 tons per acre). Studies that only report application rates are not accepted and should not be used to derive an Eco-SSL. In some cases, greenhouse studies may report soil mass of pots that would make it possible to convert an application rate to a concentration, however, this is rare. Pot volume alone is not be an adequate parameter to calculate concentrations as one would have to approximate the mass. If the concentrations are reported on a wet weight or fresh weight basis, this is recorded in the Comments field, along with any information that allows conversion to dry weight.

A **Score of 2** is assigned if the measured concentrations are reported. A Score of 1 is assigned if the toxicity values are based on nominal concentrations and are used in calculating toxicity values. A **Score of 0** is assigned in all other cases.

Criteria #4: Control Responses are Acceptable

Negative controls are a crucial part of toxicity tests in order to distinguish treatment effects from non-treatments effects. A **Score of 2** is assigned if a standardized procedure is followed and negative control values are within procedural guidelines of the standard procedure cited. A Score of 2 is also assigned if non-standardized procedure are used and the control values are within an acceptable range (e.g., earthworms mortality <10%, plants germination < 20%). A **Score = 1** is assigned f results of control are not reported or are ambiguous. A **Score of 0** is assigned if control results are not within an acceptable range.

Criteria #5: Chronic or Life Cycle Test

Chronic toxicity tests, or those assessing long-term adverse sub-lethal impacts on the life-cycle phases of an organism, are considered superior to acute toxicity tests. **A Score of 2** is applied if chronic exposures, or life-cycle phase studies are used. A **Score of 1** is applied if acute tests are used and a **Score of 0** if very short term exposures are used (i.e., for physiological measurements).

Criteria #6: **Chemical Dosing Procedure is Reported and Appropriate for Chemical and Test**

Chemical dosing procedure may affect the outcome of a test. The type of chemical dosing procedure depends on the chemical and the type of test. Typically dosing procedure should include:

(A) The form or species of the chemical used in the test,
(B) The carrier or vehicle used to deliver the chemical (e.g., solvent, water, etc.)
(C) How the carrier is handled following dosing (i.e., allowed to volatilize, controls, etc.),
(D) How the soil and chemical are mixed to ensure homogeneity.

A Score of 2 is assigned if a study includes information for the dosing procedure including items items A to D (above). A Score of 1 is assigned if information for items A and B are included but not information for items C or D. A **Score of 0** is assigned if the study does not specify details of the dosing procedure, the dosing procedures cannot be inferred, or it does not meet the other scoring criteria.

The evaluator should exercise judgement regarding technical details of all four components (A thru D above), and if questionable or unacceptable methods are used, the scores should be lowered by 1 (i.e., the score becomes either 1 or 0) and the rationale for scoring should be stated in the comment section.

Criteria #7: Dose-Response Relationship is Reported or can be Established from Reported Data

A benchmark concentration is intended to represent the location on the dose-response curve that is the threshold between absence and presence of the effects of concern for a relevant ecological endpoint. Two methodologies can be used to identify this benckmark concentration. The first is a method that generates a no observed effect concentration (NOEC) and a lowest observed effect concentration (LOEC). The NOEC is the concentration that did not cause statistically significant effects when compared to controls. The LOEC is the lowest concentration that resulted in statistically significant effects when compared to controls. The threshold lies somewhere between these two values. The second method involves a statistical model to calculate a dose response curve and estimate an effect concentration for some percentage of the population (EC_{xx}), usually between an EC_5 and an EC_{20}. Lethal concentration (LC_{xx}) and $EC_{<10}$ or $EC_{>20}$ are not used for calculating an Eco-SSL and are not scored but the information is recorded on the Critical Notes form. Tests with relatively small upper and lower confidence limits around the NOEC or LOEC and ECx values are preferred. Studies where at least two test concentrations produced adverse effects < 100% are also preferred.

A **Score of 2** is applied if an EC_{10}- EC_{20}; are reported or a NOEC and LOEC within 3x of each other. A **Score of 1** is applied if the difference between the NOEC or LOEC is > 3x but < 10x. A **Score of 0** is applied if a study does not report an ECx; or the difference between the NOEC and LOEC > 10, or only a NOEC *or* LOEC.

Criteria # 8: The Statistical Tests used to Calculate the Benchmark and the Level of Significance were Described

When no observed effect concentrations (NOECs) and lowest observed effect concentrations (LOECs) are reported, an ANOVA or other statistical test should be conducted to determine that the NOEC is the highest test concentration that did not produce a statistically significant effect and the LOEC is the lowest concentration tested that did produce a significant effect when compared to the control. When EC values are reported, the confidence levels around these values should be reported and should be based on a 95% probability level.

A **Score of 2** is applied if the results of the ANOVA or statistical method based on a P = 0.05; or the 95% CI of the ECx are presented. A **Score of 1** is applied if the ANOVA was completed but a P level is not provided, or the P level is > 0.05. If EC data are presented, a **Score of 1** is applied if the 95% CI is not reported or a CI of 90% is used. A **Score of 0** is applied if no

NOEC, LOEC, or EC/LCx data are reported, or if they are reported but no description of the methods used for their calculation are provided.

Criteria #9: The Origin of the Test Organisms is Described

The results of a toxicity test can be influenced by the condition of the test organisms. Test organisms should be healthy and have had no exposure above background to contamination prior to testing.

A Score = 2 is applied if the source and condition of the test organisms are known and described (for seeds unambiguous information should be provided on species identity), and the organisms come from a non-contaminated or commercial source. A **Score of 1** is assigned if the organisms are obtained from a non-commercial source that is not adequately described, or sufficient information is not provided about either the seed stock or the commercial source. A **Score of 0** is applied if organisms are from a known contaminated site, or adequate information is not provided about the seed stock nor the commercial source.

ATTACHMENT B
STUDY EVALUATION CRITERIA SCORE SHEET

Criterion	Title	IP#	IP#	IP#	IP#	IP#	IP#
1	Testing was Done Under Conditions of High Bioavailability (See Soil Evaluation Matrix).						
2	Experimental Designs were Documented and Appropriate.						
3	Concentration of Substance of Interest in Soil was Reported.						
4	Control Measures were Applied.						
5	Chronic or Life Cycle Test was Used.						
6	Chemical Dosing Procedure was Reported and Appropriate for Chemical and Test.						
7	A Dose-Response Relationship is Reported or can be Estimated from Reported Data.						
8	The Statistical Tests used to Calculate the Benchmark and the Levels of Significance were Described.						
9	The Origin of the Test Organisms were Described.						
Total Score							

ATTACHMENT C
CRITICAL NOTES SPREADSHEET

Chemical	Receptor	IP Number	Study ID	First Author, Pub. Year	Species Common Name	Total Eval. Score	Bioavailability Score Soi	pH	OM	ERE	EC20	NOAEC	LOAEC	MATC	EC10	EC50	Level	COMMENTS

Attachment 4-1

Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs)

Exposure Factors and Bioaccumulation Models for Derivation of Wildlife Eco-SSL

OSWER Directive 92857-55

November 2003

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1.0 INTRODUCTION

Historically and in accordance with EPA guidance (U.S. EPA, 1997), soil screening values are derived using deterministic methods. Although simple and easy to perform, these methods do not take into account the variability or uncertainty associated with the data from which soil screening values are derived. To better represent the variability and uncertainty of the underlying data, and to better quantify both biases and potential protectiveness of resulting values, Monte Carlo methods were incorporated into the parameterization of the wildlife Eco-SSLs. These methods allowed the development and definition of distributions for input parameters in the wildlife Eco-SSL model.

Because the wildlife Eco-SSLs are intended for screening and data to differentiate variability from uncertainty were lacking, one-dimensional Monte Carlo analyses were performed. Distribution shapes were assigned to parameters based on a combination of professional judgement or as defined by the available data.

2.0 DERIVATION OF PARAMETER DISTRIBUTIONS FOR WILDLIFE ECO-SSLs

2.1 Body Weight

Body weight data for receptor species from various locations in North America were identified in published literature (Table 1). Distributions were assigned to data from each location based upon the nature of the data; for example normal distributions were assumed for data presented as means and standard deviations, triangular distributions were assumed for data presented as means (or medians), minimum and maximum values, and uniform distributions were assumed for data presented only as minimum and maximum values. Standard errors were converted to standard deviations by multiplying by the square-root of the sample size (if reported). Monte Carlo analyses were performed on the average of the body weight data over all data sources. The resulting distribution (Table 2) was used to represent the distribution of body weights for each receptor species.

2.2 Food Ingestion Rates

Food ingestion rates (FIR) for all receptors were estimated using allometric relationships between body weight and field metabolic rates as reported by Nagy et al. (1999). The relationship is described by a power model of the form:

$$\log(\text{FMR}) = a + b^{*}\log(\text{BW}) + e$$

where:

FMR = field metabolic rate (kJ/d)
BW = receptor body weight (g)
a = point estimate of regression intercept
b = point estimate of regression slope

e = error term: normal(0, s)
s = the variance of log(FIR) around the point log(BW)

In an earlier work, Nagy (1987), applied average metabolizable energy efficiency values (kJ/g dry weight) to the FMR values to estimate daily food ingestion rates (FIR g/d dry weight) for birds and mammals. Regression analyses were then performed to determine how food ingestion varied with body weight. Although conversion of FMR to FIR was not performed as part of the Nagy et al. (1999) paper, data are presented to perform the conversion. FIR-based allometric regression models were developed using the FMR, body weight, and average metabolizable energy efficiency values reported in Nagy et al. (1999). These models are presented in Table 3.

In order to reconstruct the variation in the data on which the linear regression model is based (as is needed in Monte Carlo simulation), one needs to apply Nagy's model (or any linear regression model, in general) as follows (Sokal and Rohlf 1981, p. 459):

$$\log(FIR) = a + b^{*}\log(BW) + e$$

where:

FIR = food intake rate (g/d dry weight)
BW = body weight: normal(mean, std.dev.)
a = point estimate of regression intercept
b = point estimate of regression slope
e = error term: normal(0, s)
s = the variance of log(FIR) around the point log(BW)

The value s is derived from the regression analyses and is the square-root mean square error (root MSE; Table 3). Regression error is defined as being normally distributed with a mean of zero and variance equal to five.

Using the models in Table 3 and the information outlined above, Monte Carlo analyses were used to generate FIR distributions for each receptor species (Table 4). The full form of the model used to derive FIR (g/g/d dry weight) was:

$$FIR = \left[10^{[a + b^{*}\log(BW) + e]}\right] / BW$$

To verify that the food ingestion model was generating realistic values, the modeled food ingestion distributions were compared to observed food ingestion rates for each of the six surrogate species. Because modeled values were expressed as dry weight and food ingestion rates in the literature were generally in fresh or wet weight, modeled food ingestion values were converted to wet weight using water content data for dietary items as reported in U.S. EPA (1993):

Plant Foliage	85% water
Earthworms	84% water
Seeds	9.3% water
Small Mammals	68% water

Estimated wet-weight food ingestion values (and corresponding dry weight estimates) for each species are presented in Table 5. Ingestion of a dry laboratory diet by meadow voles when exposed to 14 hour days was 0.095 ± 0.002 (mean ± SE) g/g/d; intake by individuals exposed to 10 hour days was 0.085 ± 0.005 g/g/d (Dark et al., 1983). Dice (1922) observed ingestion of a diet consisting of oats and dry grass (water content of 10% or less) by adults of a related vole species, prairie voles (*Microtus ochrogaster*), was 0.13-0.14 g/g-day at 21 °C, but dropped to 0.09-0.10 g/g-day at 28°C. For comparison, dry weight ingestion rates for meadow voles estimated for use in the Eco-SSLs ranged from 0.03 to 0.7 g/g/d, with a median of 0.14 g/g/d (Table 4), encompassing the range of observed values.

Barrett and Stuek (1976) maintained male and female short-tailed shrews on a diet of mealworms (estimated 2.33 Kcal/g live weight) at temperatures between 22 and 23 °C. The mean food ingestion rate was 7.95 ± 0.17 g/d (0.47 g/g-day at a body weight of 16.8 g reported in the study). Lab studies using beef liver diets found that shrews (average body weight 21 g) had food ingestion rates between 0.49 g/g-day and 0.62 g/g-day at 25 °C (Morrison et al., 1957). Median wet-weight food ingestion estimated for short-tailed shrews the Eco-SSLs was 0.69 g/g/d (Table 5), comparable to that observed among shrews in the laboratory.

Food ingestion rates for long-tailed weasels modeled for use in the Eco-SSLs ranged from 0.03 to 0.75 g/g/d wet weight with a median of 0.16 g/g/d (Table 5). Observations of three long-tailed weasels (sex not reported) indicate that four mice/day would "sustain them in apparent health" (Quick, 1951). Brown and Lasiewski (1972) report the mean (± STD) metabolism of male and female long-tailed weasels to be 1.36 ± 0.2 and 0.84 ± 0.12 kcal/hr, respectively. Assuming that male and female weasels weigh 0.297 kg and 0.153 kg (Brown and Lasiewski, 1972), respectively, the diet consists exclusively of small mammals with an energy content of 5,163 kcal/kg dry weight (Golley, 1961), and the water content of small mammals is 68 % (U.S. EPA 1993), male and female weasels consume 0.067 and 0.080 g/g/d. In a review of weasel life histories, Fagerstone (1987) reports that captive weasels may consume 17 to 33 % of their body weight per day, with some individuals consuming 40 % to almost 70 % of their body weight daily. Our modeled values are consistent with these observations.

A range for the food consumption rate of 7-17 g/day was estimated for the mourning dove (Hanson and Kossack, 1957a). In general, daily food intake equals about 16 % of the body mass though it fluctuates during different seasons (Taber, 1928). Food ingestion rates estimated for

mourning doves for the EcoSSLs were comparable to these reported values, ranging from 0.06 to 0.57 g/g/d wet weight (median=0.25; Table 5).

Modeled food ingestion for American woodcock ranged from 0.31 to 1.63 g/g/d fresh weight (median=0.75 g/g/d; Table 5). These estimates were virtually identical to the observations in Stickel et al. (1965); captive woodcocks eating an earthworm diet during the winter in Louisiana had a mean food ingestion rate of 0.77 g/g/d (range, 0.11-1.43 g/g/d).

Craighead and Craighead (1956) observed that food consumption rate of adult female red-tailed hawks housed outdoors in winter in Michigan was 0.11 g/g BW/day. Adult males were reported to consume 0.10 g/g /d in winter and 0.086 g/g /d in summer. These few observed values for food ingestion by red-tailed hawks fall within the modeled wet-weight ingestion distribution for this species (Table 5).

2.3 Soil Ingestion Rates

Distributions for soil ingestion rates for all receptor species were derived based on the model presented in Beyer et al. (1994):

$$x = (b-y+ay)/(ay-c+b)$$

where:

- x = fraction of soil in diet (dry mass)
- a = digestibility of food (dry mass)
- b = concentration of acid-insoluble ash in food (dry mass)
- c = concentration of acid-insoluble ash in soil (dry mass)
- y = concentration of acid-insoluble ash in scat (dry mass)

Values for each parameter for each receptor species are summarized in Table 6. Correlations among parameters in the soil ingestion model are possible. For example, the concentration of acid-insoluble ash in scat is likely to be positively correlated with both ash in soil and ash in food. Similarly, digestibility of food is likely to be inversely related to both ash in food and ash in scat. Potential biases that may result from correlations of model parameters were investigated by performing Monte Carlo analyses with and without correlations among variable. Specific data for the correlations were lacking. Therefore, correlations were assumed as follows:

assumed correlations

Pair	r
a and b	-0.8
a and c	0
a and y	-0.6
b and c	0
b and y	0.6

assumed correlations	
Pair	r
c and y	0.8

Correlations between digestibility of food and ash content of food were presumed to be greater than digestibility and ash in scat. Similarly, ash in soil was presumed to be more highly correlated with ash in scat than ash in food. Digestibility of food and ash in scat, and ash in food and soil were assumed to be unrelated.

Comparison of distributions resulting from Monte Carlo analyses with correlated and uncorrelated variables indicated no significant differences. Consequently, soil ingestion distributions resulting from the uncorrelated Monte Carlo analyses were used (Table 7).

3.0 BIOACCUMULATION MODELS

A summary of all bioaccumulation models selected or derived for application in the Eco-SSLs are presented in Table 8. Discussion of derivation and selection of these models is presented below.

3.1 Inorganics and Earthworms, Plants, and Small Mammals

Soil-to-biota bioaccumulation models, both as simple BAFs or as regression models, have recently been developed from published data for earthworms, terrestrial plants, and small mammals (e.g., Sample et al. 1999, Sample et al. 1998a, Sample et al. 1998b, and Bechtel-Jacobs 1998). Bioaccumulation models presented in these reports were selected as the primary means for estimation of concentrations of inorganic contaminants in wildlife foods. If a both BAFs and regression models were available for a given contaminant, the regression model was selected for application provided the model was significant (i.e., the slope differed significantly [$p \leq 0.05$] from 0) and the coefficient of determination (r^2) was greater than or equal to 0.2. If neither of these criteria were met, the median BAF was used to estimate bioaccumulation (Table 8).

Soil-to-biota bioaccumulation models were available for all inorganics placed on the initial Eco-SSL list except for antimony for plants, earthworms, and small mammals, and barium and beryllium for small mammals. Based on limited data presented in Bechtel-Jacobs (1998) and a recently published study (Baroni et al.2000), BAFs and a log-linear regression model were developed for antimony in plants (Table 8, Figure 1).

Diet-to-tissue BAFs from Baes et al. (1984) were used to estimate concentrations of antimony, barium, and beryllium in tissue of prey consumed by vertebrate predators. Because no earthworm bioaccumulation data were located for antimony, a default BAF of 1 was assumed.

3.2 Organics and Earthworms

Concentrations of organic contaminants in earthworms are assumed to be a function of partitioning between of soil water and the earthworm tissues (Connell and Markwell 1990, Sample et al. 1997, Jager 1998):

$$C_{worm} = K_{BW}C_w$$

where:

C_{worm} = concentration in worm (mg/kg dry weight)
K_{BW} = biota/soil water partitioning coefficient
C_w = concentration in soil water (mg/L)

K_{BW} was estimated by Connell and Markwell (1990) based on data for 32 lipophilic chemicals in earthworms:

$$\log K_{bw} = \log K_{ow} - 0.6$$

To reconstruct the variation in the data on which the linear regression model for K_{BW} is based, regression analyses were redone using the data presented in Connell and Markwell (1990), resulting in the following:

$$\log K_{bw} = 1.001*[\log K_{ow}] - 0.553 + e \quad (n=100, r^2=0.83)$$

where:

e = regression error (normal distribution, mean=0, STD=s)
s = square root mean square error from the regression = 0.63566

The conventional formula for estimation of the concentration of a chemical in water (C_w) based on concentrations in soil is:

$$C_w = C_s/K_d$$

where:

C_s = concentration in soil (mg/kg dry weight)
K_d = soil(or sediment)/water partitioning coefficient

For non-ionic organic compounds, K_d may be estimated as:

$$K_d = f_{oc}K_{oc}$$

where

f_{oc} = fraction of organic carbon in soil
K_{oc} = water/ soil organic carbon partitioning coefficient

Specific values of K_{OC} may not be available for all possible chemicals. Therefore, a family of models for estimation of K_{OC} from K_{OW} for different classes of chemicals was developed based on data presented in Gerstl (1990):

PCBs:

$\log K_{OC} = 0.890*(\log K_{OW}) - 0.732 + e$ (root MSE=0.56569, n=15, r^2=0.70)

Nonpolar PAHs:

$\log K_{OC} = 0.890*(\log K_{OW}) + 0.279 + e$ (root MSE=0.32984, n=14, r^2=0.90)

Aromatic Halogenated Hydrocarbons:

$\log K_{OC} = 0.974*(\log Kow) - 0.224 + e$ (root MSE=0.34944, n=26, r^2=0.88)

Aromatic Non-halogenated Hydrocarbons:

$\log K_{OC} = 0.529*(\log K_{OW}) + 0.918 + e$ (root MSE=0.37489, n=37, r^2=0.66)

Chlorophenols:

$\log K_{OC} = 1.076*(\log K_{OW}) - 0.801 + e$ (root MSE=0.23701, n=8, r^2=0.91)

Triazines:

$\log K_{OC} = 0.586*(\log K_{OW}) + 0.826 + e$ (root MSE=0.18291, n=12, r^2=0.89)

The set of models outlined above for estimating K_{BW}, K_d, K_{OC}, and C_w were combined as follows to produce an overall model for estimation of BAFs for earthworms:

Original model:

$$C_{worm} = K_{BW} \times C_w$$

substitute C_s/K_d for C_w:

$$C_{worm} = K_{BW} \times C_s/K_d$$

multiple both sides of equation by $1/C_s$:

$$C_{worm}/C_s = K_{BW} / K_d$$

Because the BAF is the ratio between concentrations in biota and that in the media they reside in, C_{worm}/C_s = BAF, and the previous equation is equivalent to:

$$BAF = K_{BW} / K_d$$

Substitute for K_{BW} and K_d:

$$BAF = 10^{(\log Kow - 0.6)} / [f_{oc} \times 10^{(0.983 \log Kow + 0.00028)}]$$

To be conservative, f_{oc} for Tier 1 calculations is set to 1 % (0.01).

Distributions of earthworm BAFs for organic contaminants were generated based using the model outlined above and parameters summarized in Table 9. Regression errors were all assumed to be normally distributed. Distributions for measured K_{OC} values were assigned triangular distributions. Resulting distributions for earthworm BAFs for organic contaminants are presented in Table 10.

3.3 Organics and Plants

Models to estimate chemical-specific soil-to-plant foliage BAFs based on K_{OW} have previously been developed and reported in Travis and Arms (1988). As part of the model verification process of undertaken for the Eco-SSLs, selected data used by Travis and Arms were chosen for verification. Because the data values could not be verified or were found to be erroneous, all literature cited in Travis and Arms (1988) was acquired, and with additional more recent data, a new model to estimate chemical-specific soil-to-plant foliage BAFs based on K_{OW} was developed. This new model is: $\log(BAF) = -0.4965(\log K_{OW}) + 2.53$ ($n=263$, $p<0.0001$, $r^2=0.62$) and is presented in Figure 2. The model specific to PAHs is presented in Figure 3.

In the process of developing data to derive the K_{OW}-based model for plant foliage BAFs, bioaccumulation data for chemicals on the initial Eco-SSL list was obtained. These data were used to develop chemical-specific BAFs or regression models as appropriate. Newly developed chemical-specific BAFs or regression models are presented in Table 8. Use of the K_{OW}-based model for estimation of plant foliage BAFs was necessary for only for one chemical, pentachorophenol. The resulting distribution for plant BAFs for pentachlorophenol are presented in Table 11, with summary values presented in Table 8.

3.4 Organics and Small Mammals

Similar to plants, models to estimate chemical-specific diet-to-mammal BAFs based on K_{OW} have previously been developed and reported in Travis and Arms (1988). Because most of these data values also could not be verified or were found to be erroneous, all literature cited in Travis and Arms (1988) was acquired, and with additional more recent data, a new model to estimate chemical-specific diet-to-mammal BAFs based on K_{OW} was developed. This new model is: $\log_{10}BAF=0.338-0.145(\log_{10}K_{OW})$($n=55$, $p=0.38$, $r^2=0.015$) and is presented in Figure 4. Results of these analyses indicates that diet-to-mammal BAFs cannot be accurately estimated based on K_{OW}.

In the process of developing data to derive the K_{OW}-based model for mammal BAFs, bioaccumulation data for chemicals on the initial Eco-SSL list was obtained. These data were used to develop chemical-specific BAFs or regression models as appropriate. Newly developed chemical-specific BAFs or regression models are presented in Table 8. In addition, a literature-based model for dietary accumulation of pentachorophenol by chickens was obtained (Stedman et al. 1980; Table 8). No suitable vertebrate bioaccumulation data has been located thus far for PAHs, RDX or TNT. However, due to the rapid metabolism these compounds experience upon ingestion by birds and mammals, bioaccumulation is expected to be minimal.

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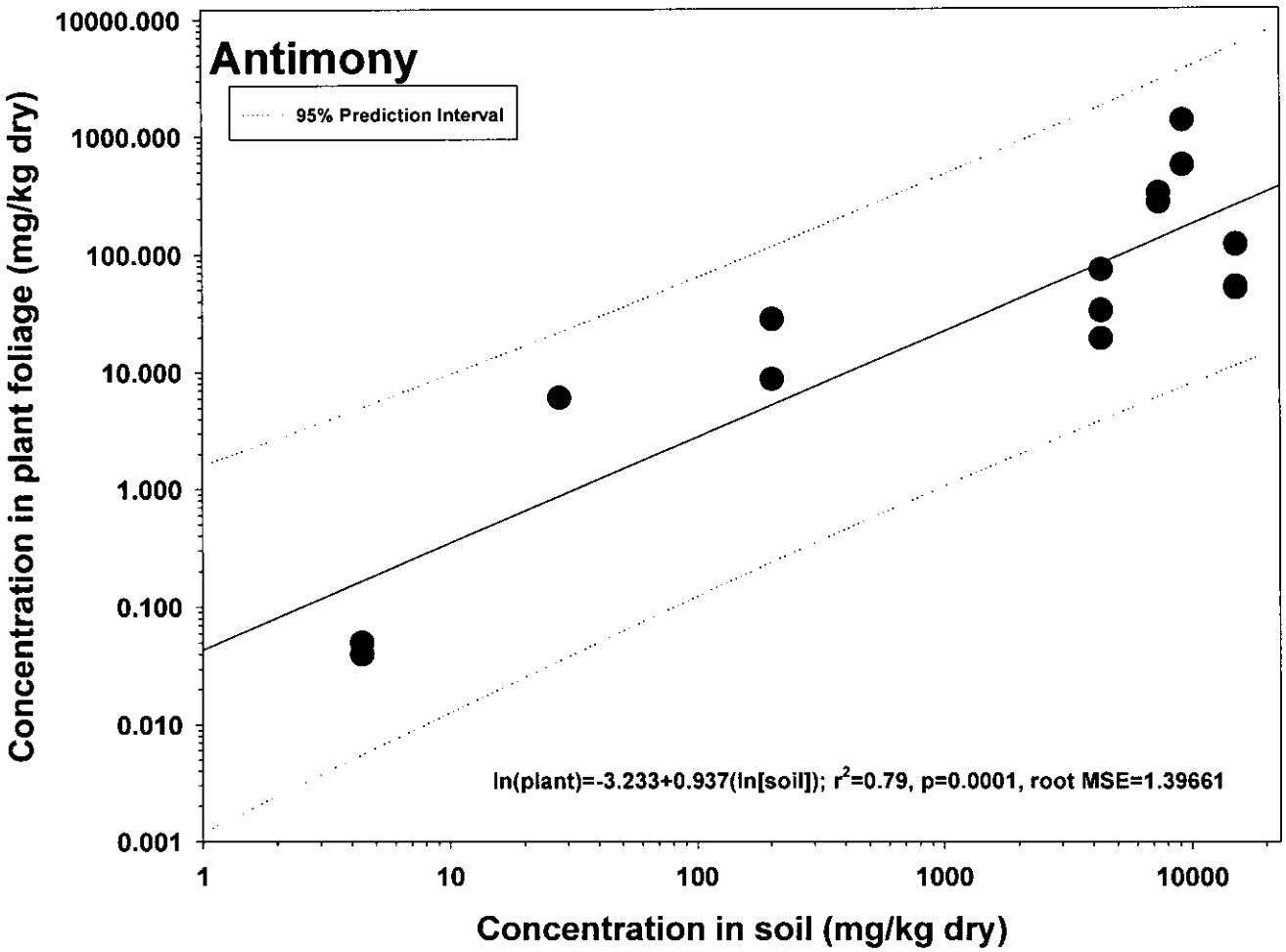

Figure 1. Analysis of bioaccumulation of antimony from soil by plants.

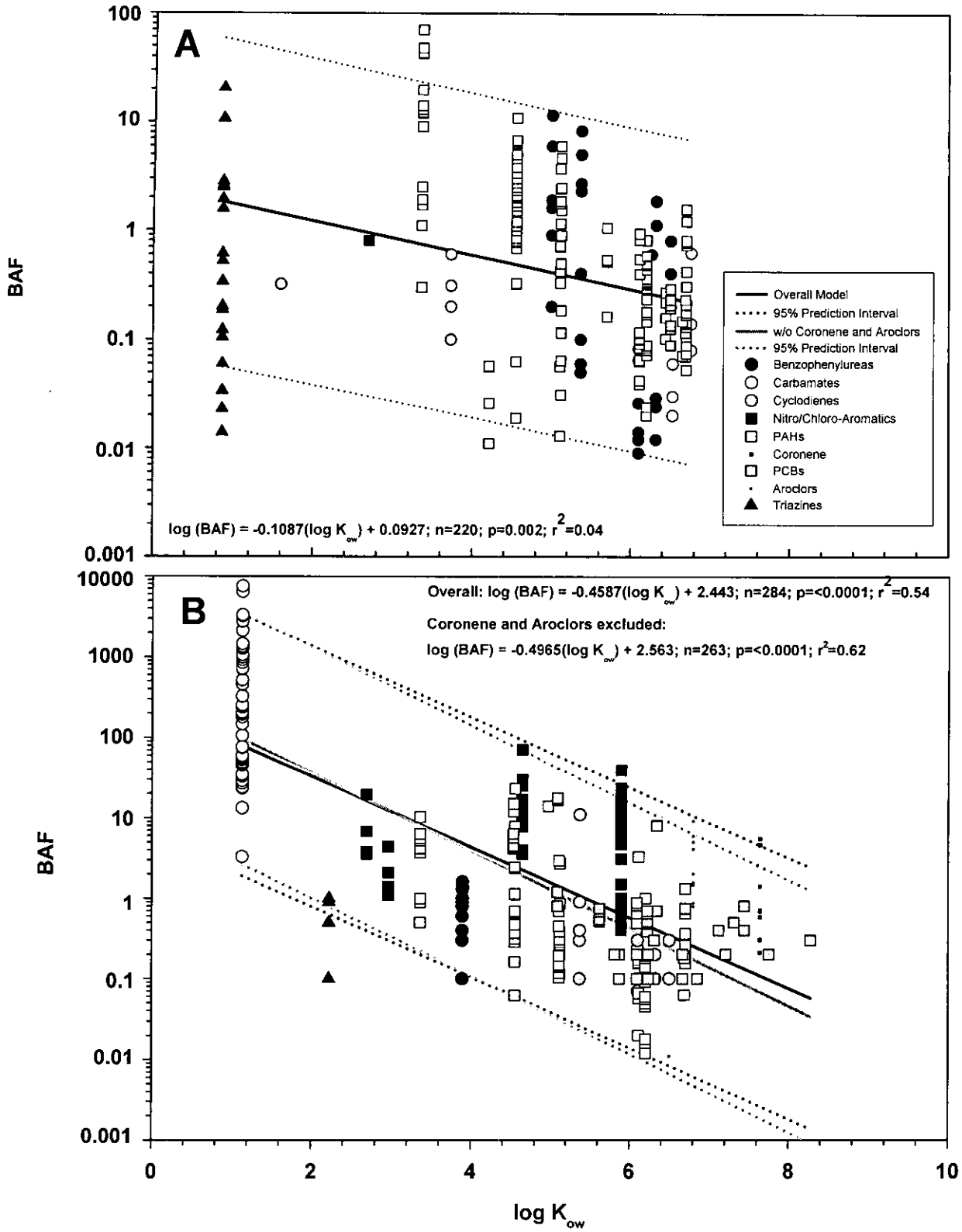

Figure 2. Scatterplot of log K_{ow} versus log BAF for organic contaminants in rinsed (A) and unrinsed (B) plant foliage.

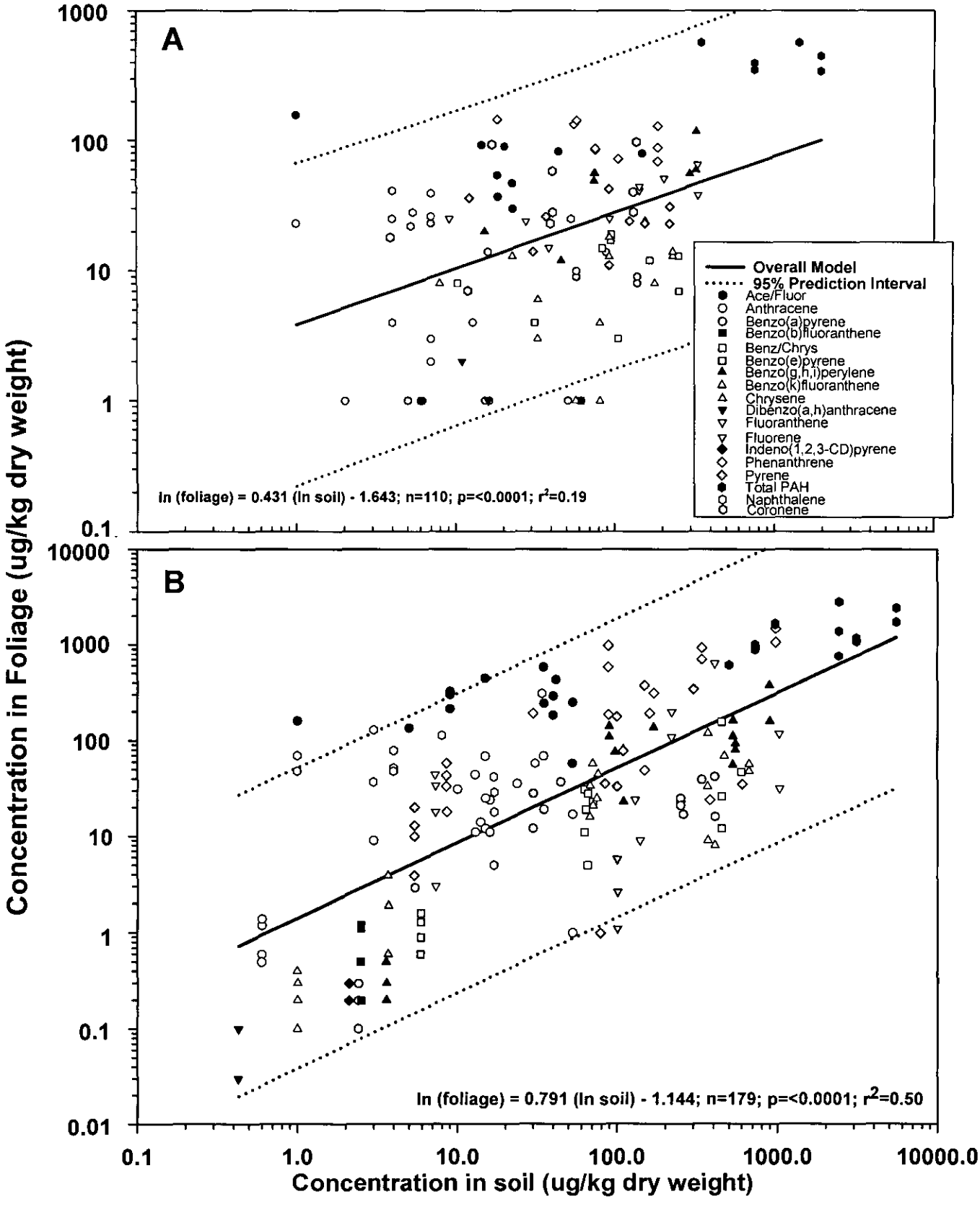

Figure 3. Scatterplot of unrinsed (A) and rinsed (B) foliage versus concentrations of PAHs in soil.

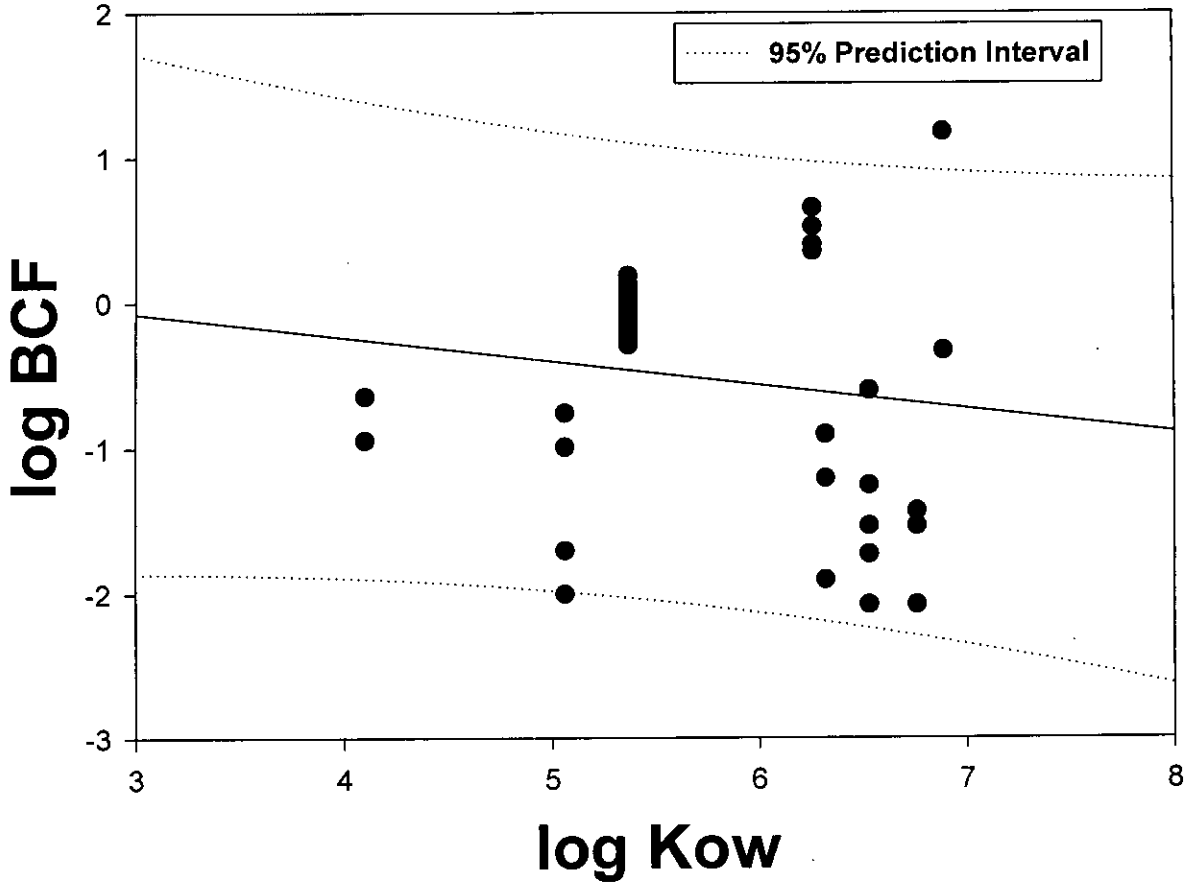

Figure 4. Relationship between Kow and BCF for organics in beef tissue.

Table 1. Summary of Literature-Derived Body Weight (g) Data for Representative Wildlife Receptor Species.

Species	n	mean	SD	SE	Min	Max	Sex	Location	Season	Reference	Assumed Distribution
Meadow vole	39	29.4	4.4	0.7			f	Manitoba		Innes and Millar, 1981	normal
		44.2	6.3				m	.	.	Reich, 1981	normal
		44.0	10.3				f	.	.	Reich, 1981	normal
		32.5			20.4	48.5	b	Alberta	.	Silva and Downing, 1995	triangular
		35.6			29.2	47.2	b	Indiana	.	Silva and Downing, 1995	triangular
		38.2			25.1	62.7	m	Indiana	.	Silva and Downing, 1995	triangular
		38.8			24.4	63.2	f	Indiana	.	Silva and Downing, 1995	triangular
					34.2	46.5	b	New Jersey	.	Silva and Downing, 1995	uniform
		36.8			28.0	56.0	f	Virginia	.	Silva and Downing, 1995	triangular
		48.8			32.0	71.0	m	Virginia	.	Silva and Downing, 1995	triangular
					25.0	45.0	b	Wyoming	.	Silva and Downing, 1995	uniform
Short-tailed Shrew	4	16.4	2.5				b	Ohio	.	Barrett and Steuck, 1976	normal
	50	19.8	3.1		16.0	28.6	b	Canada	.	vanZyll de Jong, 1983	normal
	6	15.9	1.0	0.4			b	Pennsylvania	sept	Merritt, 1986	normal
	14	22.2	2.4	0.7			b	Pennsylvania	April	Merritt, 1986	normal
		22.0			15.0	29.0	b	Manitoba	.	Silva and Downing, 1995	triangular
		17.5			11.0	26.3	m	Indiana	.	Silva and Downing, 1995	triangular
		14.1			9.9	19.9	b	Indiana	.	Silva and Downing, 1995	triangular
		16.3			11.4	24.8	f	Indiana	.	Silva and Downing, 1995	triangular
					9.0	18.5	b	New Jersey		Silva and Downing, 1995	uniform
Long-tailed Weasel		297.0	36.0				m	Nevada	.	Brown and Lasiewski, 1972	normal
		153.0	3.0				f	Nevada	.	Brown and Lasiewski, 1972	normal
		200.0	54.0				m	Indiana	.	Mumford and Whitaker, 1982	normal
		94.0	10.0				f	Indiana	.	Mumford and Whitaker, 1982	normal
					160.0	450.0	m	.	.	Sheffield and Thomas, 1997	uniform
					80.0	250.0	f	.	.	Sheffield and Thomas, 1997	uniform
					196.0	267.0	m	Virginia	.	Virginia Dept. of Game & Inland Fisheries (1999)	uniform
					101.0	126.0	f	Virginia	.	Virginia Dept. of Game & Inland Fisheries (1999)	uniform
					300.0	500.0	.	Texas	.	Texas Parks & Wildlife (1999)	uniform
		199.2	35.0				m	Idaho		Johnson, 1991	normal
		98.9	14.4				f	Idaho		Johnson, 1991	normal
					85.0	250.0	b	Arkansas		Silva and Downing, 1995	uniform
Mourning Dove		130.0			110.0	170.0	m	.	.	Mirarchi and Baskett, 1994	triangular
		116.0			96.0	143.0	m	.	.	Mirarchi and Baskett, 1994	triangular
		123.0			100.0	156.0	f	.	.	Mirarchi and Baskett, 1994	triangular
		108.0			86.0	142.0	f	.	.	Mirarchi and Baskett, 1994	triangular
	140	123.0	1.9				m	Illinois	.	Dunning, 1993	normal
	95	115.0	1.8				f	Illinois	.	Dunning, 1993	normal
Red-tailed Hawk					690.0	1300.0	m	.	.	Preston and Beane, 1993	uniform
					900.0	1460.0	f	.	.	Preston and Beane, 1993	uniform
		945.3			698.0	1296.0	m	Wisconsin	.	Preston and Beane, 1993	triangular
		1222.0			904.0	1455.0	f	Wisconsin	.	Preston and Beane, 1993	triangular
American Woodcock		145.9			127.0	165.0	m	Massachussets	summer	U.S. EPA, 1993	triangular
		182.9			162.0	216.0	f	Massachussets	summer	U.S. EPA, 1993	triangular
					116.0	219.0	m	.	.	Keppie and Whiting, 1994	uniform
					151.0	279.0	f	.	.	Keppie and Whiting, 1994	uniform
		186.6			161.0	214.0	f	Maine	breeding	Keppie and Whiting, 1994	triangular
		211.5			163.0	276.0	f	.	nonbreeding	Keppie and Whiting, 1994	triangular
		134.9	11.1		116.0	160.0	m	Maine	breeding	Keppie and Whiting, 1994	normal
		136.2	4.4				m	New Brunswick	spring	Keppie and Redmond, 1985	normal
		135.4	8.1				m	New Brunswick	spring	Keppie and Redmond, 1985	normal
		134.1	7.3				m	New Brunswick	spring	Keppie and Redmond, 1985	normal
		134.4	8.4				m	New Brunswick	spring	Keppie and Redmond, 1985	normal
		133.7	6.7				m	New Brunswick	spring	Keppie and Redmond, 1985	normal
		136.1	9.5				m	New Brunswick	spring	Keppie and Redmond, 1985	normal

Table 2. Body Weight (g) Distributions for Representative Wildlife Receptors as Generated from Monte Carlo Analyses of Literature-Derived Data

	Vole	Shrew	Weasel	Dove	Hawk	Woodcock
Mean	39.86	17.94	202.31	122.04	1076.09	159.01
Std Deviation	1.97	0.80	12.31	3.87	70.34	4.61
Iterations	400.00	200.00	800.00	600.00	400.00	800.00
Minimum	35.38	15.88	168.30	111.56	910.58	144.93
5th Percentile	36.66	16.59	181.78	115.86	965.97	151.14
10th Percentile	37.32	16.90	186.71	116.90	980.76	153.11
15th Percentile	37.80	17.12	189.42	117.87	997.24	154.05
20th Percentile	38.14	17.24	192.06	118.70	1009.46	155.10
25th Percentile	38.39	17.39	193.79	119.42	1027.08	155.91
30th Percentile	38.70	17.49	195.14	120.00	1034.96	156.69
35th Percentile	38.95	17.61	197.24	120.47	1047.50	157.32
40th Percentile	39.31	17.72	198.88	120.97	1057.63	157.74
45th Percentile	39.57	17.82	200.79	121.56	1067.66	158.34
50th Percentile	39.78	17.95	202.18	122.06	1077.80	159.00
55th Percentile	40.06	18.06	204.02	122.62	1086.50	159.77
60th Percentile	40.38	18.19	205.88	123.16	1095.40	160.34
65th Percentile	40.61	18.26	207.40	123.57	1104.02	160.84
70th Percentile	40.87	18.36	209.17	124.08	1112.77	161.50
75th Percentile	41.21	18.44	211.02	124.59	1125.04	162.19
80th Percentile	41.58	18.54	212.95	125.10	1140.95	162.97
85th Percentile	41.91	18.71	215.10	125.92	1151.51	163.73
90th Percentile	42.36	18.88	217.50	126.90	1164.34	164.89
95th Percentile	43.17	19.29	222.44	128.50	1192.10	166.43
Maximum	47.55	20.27	242.50	135.70	1289.53	172.88

Table 3. Summary of Regression Results Based on Conversion of Nagy et al. (1999) Field Metabolic Rate (FMR) Data to Food Ingestion Rate (FIR)

Class	Subclass	Order	Trophic Group	n	slope	intercept	root MSE	P	r-square
Birds	.	.	.	95	0.688	-0.2057	0.15909	0.0001	0.94
Mammals	Eutheria	.	.	58	0.744	-0.4889	0.25861	0.0001	0.94
Birds	.	Passeriformes	.	40	0.717	-0.2525	0.11325	0.0001	0.74
Mammals	Eutheria	Rodentia	.	30	0.774	-0.4793	0.2165	0.0001	0.79
Mammals	Eutheria	.	carnivore	12	0.873	-0.9871	0.20937	0.0001	0.93
Mammals	Eutheria	.	herbivore	15	0.579	0.0752	0.28089	0.0001	0.87
Mammals	Eutheria	.	insectivore	10	0.640	-0.5102	0.21193	0.0001	0.89
Mammals	Eutheria	.	omnivore	14	0.696	-0.4007	0.16075	0.0001	0.79
Birds	.	.	carnivore	38	0.664	-0.0758	0.14499	0.0001	0.92
Birds	.	.	granivore	3	0.679	-0.4153	0.31517	0.0001	0.91
Birds	.	.	insectivore	26	0.705	-0.2681	0.1112	0.0001	0.75
Birds	.	.	omnivore	18	0.627	-0.1743	0.17576	0.0001	0.91

model: log10(FIR)=intercept + slope*(log10[BW]) + root MSE

Table 4. Food Ingestion Rate Distributions Generated by Monte Carlo Simulation of Allometric Model Derived from Nagy et al. (1999).

	Vole[1]	Shrew[2]	Weasel[3]	Dove[4]	Hawk[5]	Woodcock[6]
Mean	0.16	0.12	0.06	0.15	0.08	0.13
Std Deviation	0.09	0.06	0.03	0.06	0.03	0.03
Iterations	700	1600	1600	1600	1600	1600
Minimum	0.03	0.02	0.01	0.05	0.03	0.05
5th Percentile	0.06	0.05	0.02	0.07	0.05	0.08
10th Percentile	0.07	0.06	0.03	0.09	0.05	0.09
15th Percentile	0.08	0.07	0.03	0.09	0.06	0.09
20th Percentile	0.09	0.07	0.03	0.10	0.06	0.10
25th Percentile	0.10	0.08	0.04	0.11	0.06	0.10
30th Percentile	0.11	0.08	0.04	0.12	0.07	0.11
35th Percentile	0.12	0.09	0.04	0.12	0.07	0.11
40th Percentile	0.12	0.09	0.05	0.13	0.07	0.11
45th Percentile	0.13	0.10	0.05	0.13	0.08	0.12
50th Percentile	0.14	0.11	0.05	0.14	0.08	0.12
55th Percentile	0.16	0.11	0.06	0.15	0.08	0.13
60th Percentile	0.17	0.12	0.06	0.15	0.09	0.13
65th Percentile	0.18	0.13	0.06	0.16	0.09	0.13
70th Percentile	0.19	0.14	0.07	0.17	0.10	0.14
75th Percentile	0.20	0.15	0.07	0.18	0.10	0.14
80th Percentile	0.22	0.16	0.08	0.19	0.11	0.15
85th Percentile	0.24	0.18	0.09	0.21	0.11	0.16
90th Percentile	0.28	0.20	0.10	0.23	0.12	0.17
95th Percentile	0.34	0.24	0.11	0.26	0.14	0.18
Maximum	0.70	0.65	0.24	0.52	0.24	0.26

[1] FIR distribution calculated using eutherian rodent model.

[2] FIR distribution calculated using eutherian insectivore model.

[3] FIR distribution calculated using eutherian carnivore model.

[4] FIR distribution calculated using general avian model.

[5] FIR distribution calculated using avian insectivore model.

[6] FIR distribution calculated using avian carnivore model.

Table 5. Summary of Estimated Wet and Dry Weight Food Ingestion Rates for Surrogate Wildlife Species.

	Meadow Vole		Mourning Dove		Short-tailed Shrew		American Woodcock		Long-tailed Weasel		Red-tailed Hawk	
	g/g/d dry	g/g/d wet (85% water content)	g/g/d dry	g/g/d wet (9.3% water content)	g/g/d dry	g/g/d wet (84% water content)	g/g/d dry	g/g/d wet (84% water content)	g/g/d dry	g/g/d wet (68% water content)	g/g/d dry	g/g/d wet (68% water content)
Value used in EcoSSL calculation	0.28	1.87	0.23	0.25	0.20	1.25	0.17	1.06	0.10	0.31	0.12	0.38
minumum	0.03	0.20	0.05	0.06	0.02	0.13	0.05	0.31	0.01	0.03	0.03	0.09
25th percentile	0.1	0.67	0.11	0.12	0.08	0.50	0.1	0.63	0.04	0.13	0.06	0.19
median	0.14	0.93	0.14	0.15	0.11	0.69	0.12	0.75	0.05	0.16	0.08	0.25
75th percentile	0.2	1.33	0.18	0.20	0.15	0.94	0.14	0.88	0.07	0.22	0.1	0.31
maximum	0.70	4.67	0.52	0.57	0.65	4.06	0.26	1.63	0.24	0.75	0.24	0.75

Table 6. Summary of Parameter Values for Estimation of Soil Ingestion Rates.

Parameter	vole	shrew[1]	weasel[2]	dove[3]	hawk[4]	woodcock	Assumed Distribution	Notes
b	0 to 0.02	0 to 0.02	0 to 0.02	0 to 0.02	0 to 0.02	0 to 0.02	Uniform	Assumed based on Beyer et al., 1994
a	0.76(0.076)	0.82(0.048)	0.84(0.065)	0.59(0.13)	0.78(0.052)	0.72(0.051)	Normal	Mean (STD) digestibility values presented in Table 4-3 in U.S. EPA, 1993, except shrew which is from Randolph (1973)
c	0.9 to 1	0.9 to 1	0.9 to 1	0.9 to 1	0.9 to 1	0.9 to 1	Uniform	Assumed based on Beyer et al., 1994
y	0.089 (0.012-0.14)	0.104 (0.067-0.173)	0.14 (0.048-0.25)	0.16 (0.084-0.39)	0.14 (0.048-0.25)	0.22 (0.063-0.40)	Triangular	Mean (range) reported in Beyer et al., 1994 except for shrew.

[1] acid insoluble ash in GI tracts from unpubl. data from C. Garten, Oak Ridge National Laboratory.

[2] Soil ingestion data for weasel assumed to be comparable to that for red fox reported in Beyer et al., 1994.

[3] Soil ingestion data for dove assumed to be comparable to that for wild turkey reported in Beyer et al., 1994.

[4] Soil ingestion data for red-tailed hawk assumed to be comparable to that for red fox reported in Beyer et al., 1994.

Table 7. Soil Ingestion Rate Distributions Generated by Monte Carlo Simulation of Model Derived from Beyer et al. (1994). No Correlations Among Variables Assumed. Total Iterations=3200.

	Vole	Shrew	Woodcock	Weasel	Dove	Hawk
Mean	0.0138	0.0156	0.0707	0.0165	0.0956	0.0270
Std Deviation	0.0122	0.0112	0.0345	0.0166	0.0505	0.0170
Minimum	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
5th Percentile	0.0000	0.0000	0.0208	0.0000	0.0279	0.0022
10th Percentile	0.0000	0.0013	0.0289	0.0000	0.0386	0.0063
15th Percentile	0.0009	0.0039	0.0350	0.0000	0.0459	0.0094
20th Percentile	0.0032	0.0058	0.0400	0.0024	0.0523	0.0121
25th Percentile	0.0051	0.0077	0.0452	0.0046	0.0578	0.0147
30th Percentile	0.0069	0.0094	0.0497	0.0068	0.0638	0.0169
35th Percentile	0.0087	0.0108	0.0536	0.0090	0.0695	0.0192
40th Percentile	0.0102	0.0124	0.0581	0.0111	0.0746	0.0212
45th Percentile	0.0116	0.0138	0.0624	0.0131	0.0807	0.0232
50th Percentile	0.0134	0.0153	0.0668	0.0151	0.0877	0.0255
55th Percentile	0.0149	0.0168	0.0715	0.0172	0.0944	0.0279
60th Percentile	0.0165	0.0182	0.0765	0.0194	0.1008	0.0300
65th Percentile	0.0180	0.0198	0.0814	0.0215	0.1089	0.0324
70th Percentile	0.0196	0.0213	0.0871	0.0238	0.1162	0.0348
75th Percentile	0.0217	0.0230	0.0922	0.0266	0.1255	0.0375
80th Percentile	0.0237	0.0253	0.0987	0.0299	0.1354	0.0407
85th Percentile	0.0262	0.0275	0.1079	0.0333	0.1474	0.0445
90th Percentile	0.0298	0.0301	0.1174	0.0390	0.1644	0.0493
95th Percentile	0.0347	0.0344	0.1326	0.0466	0.1918	0.0573
Maximum	0.0595	0.0629	0.2041	0.0761	0.3306	0.0968

Table 8. Summary of Bioaccumulation Models for Food Types Included in the Eco-SSL Wildlife Model. Highlighted Values Represent Recommended Bioaccumulation Data.

Taxa	Analyte	Trophic Group	Transfer type	Summary Statistics for BAFs N	Minimum	Median	Maximum	Trophic Group	Parameters for log-linear uptake model[1] N	Slope	Intercept	r-square	p (model)	Reference
Plants	Antimony	NA	soil-to-biota	17	0.003	0.037	0.22	NA	17	0.937	-3.233	0.79	0.0001	newly developed for Eco-SSLs
Plants	Arsenic	NA	soil-to-biota	122	0.00006	0.03752	9.0741	NA	122	0.564	-1.991	0.15	0.0001	Bechtel-Jacobs 1998
Plants	Barium	NA	soil-to-biota	28	0.036	0.156	0.92	NA	.	.	.	.	.	Bechtel-Jacobs 1998
Plants	Beryllium	NA	soil-to-biota			0.01								Baes et al. 1984
Plants	Cadmium	NA	soil-to-biota	207	0.0087	0.58571	22.8788	NA	207	0.546	-0.475	0.45	0.0001	Bechtel-Jacobs 1998
Plants	Chromium	NA	soil-to-biota	28	0.021	0.041	0.48	NA	.	.	.	.	.	Bechtel-Jacobs 1998
Plants	Cobalt	NA	soil-to-biota	28	0.0019	0.0075	0.045	NA	.	.	.	.	.	Bechtel-Jacobs 1998
Plants	Copper	NA	soil-to-biota	180	0.0011	0.12432	7.4	NA	180	0.394	0.668	0.31	0.0001	Bechtel-Jacobs 1998
Plants	Lead	NA	soil-to-biota	189	0.00011	0.0388	10.6011	NA	189	0.561	-1.328	0.24	0.0001	Bechtel-Jacobs 1998
Plants	Manganese	NA	soil-to-biota	28	0.0199	0.079	0.433	NA	.	.	.	.	.	Bechtel-Jacobs 1998
Plants	Nickel	NA	soil-to-biota	111	0.00217	0.01786	22.2143	NA	111	0.748	-2.223	0.37	0.0001	Bechtel-Jacobs 1998
Plants	Selenium	NA	soil-to-biota	158	0.02	0.67189	77	NA	158	1.104	-0.677	0.63	0.0001	Bechtel-Jacobs 1998
Plants	Silver	NA	soil-to-biota	10	0.0029	0.014	0.04	NA	.	.	.	.	.	Bechtel-Jacobs 1998
Plants	Zinc	NA	soil-to-biota	220	0.00855	0.36616	34.2857	NA	220	0.554	1.575	0.4	0.0001	Bechtel-Jacobs 1998
Plants	Dieldrin	NA	soil-to-biota	41	0.00855	0.024	1.64	NA	41	0.841	-3.271	0.24	0.001	newly developed for Eco-SSLs
Plants	DDT	NA	soil-to-biota	7	0.00035	0.028	0.08	NA						newly developed for Eco-SSLs
Plants	DDD	NA	soil-to-biota	7	0.00035	0.028	0.08	NA						see footnote 3
Plants	DDE	NA	soil-to-biota	3	0.075	0.136	0.62	NA						newly developed for Eco-SSLs
Plants	Pentachlorophenol	NA	soil-to-biota	3600	4.70E-03	9.615071	25277.54	NA						Modeled from K_{ow}, see Table 10
Plants	PAHs													
	Anthracene	NA	soil-to-biota	8	0.16292	1	3.1	NA	8	0.867	0.079	0.62	0.02	newly developed for Eco-SSLs
	Benzo(a)anthracene	NA	soil-to-biota	1	0.53704	0.537	0.54							newly developed for Eco-SSLs
	Benzo(a)pyrene	NA	soil-to-biota	7	0.01964	0.066	0.2	NA	7	0.635	-2.053	0.61	0.04	newly developed for Eco-SSLs
	Benzo(b)fluoranthene	NA	soil-to-biota	6	0.01627	0.173	0.48							newly developed for Eco-SSLs
	Benzo(e)pyrene	NA	soil-to-biota	4	0.10169	0.19	0.27							newly developed for Eco-SSLs
	Benzo(ghi)perylene	NA	soil-to-biota	7	0.05278	0.131	1.31	NA	7	1.299	-2.565	0.81	0.006	newly developed for Eco-SSLs
	Benzo(k)fluoranthene	NA	soil-to-biota	4	0.08	0.255	0.36							newly developed for Eco-SSLs
	Chrysene	NA	soil-to-biota	4	0.16216	0.784	1.05							newly developed for Eco-SSLs
	Coronene	NA	soil-to-biota	3	0.5787	0.588	4.61							newly developed for Eco-SSLs
	Dibenz(ah)anthracene	NA	soil-to-biota	4	0.06977	0.128	0.23							newly developed for Eco-SSLs
	Fluoranthene	NA	soil-to-biota	7	0.26838	2.466	6.03							newly developed for Eco-SSLs
	Fluorene	NA	soil-to-biota	4	0.01089	0.041	0.06							newly developed for Eco-SSLs
	Indeno(123 cd)pyrene	NA	soil-to-biota	2	0.07143	0.11	0.15							newly developed for Eco-SSLs
	Naphthlene	NA	soil-to-biota	7	0.29412	1.059	4.19							newly developed for Eco-SSLs
	Phenanthrene	NA	soil-to-biota	7	0.69243	3.837	7.92							newly developed for Eco-SSLs
	Pyrene	NA	soil-to-biota	7	0.19324	1.852	3.7							newly developed for Eco-SSLs
Plants	TNT	NA	soil-to-biota	2	7.00E-05	0.1595	0.32	NA						newly developed for Eco-SSLs
Plants	RDX	NA	soil-to-biota	18	1.44E-02	0.4296	20.48	NA						newly developed for Eco-SSLs

Table 8. Summary of Bioaccumulation Models for Food Types Included in the Eco-SSL Wildlife Model. Highlighted Values Represent Recommended Bioaccumulation Data.

				Summary Statistics for BAFs					Parameters for log-linear uptake model[1]					
Taxa	Analyte	Trophic Group	Transfer type	N	Minimum	Median	Maximum	Trophic Group	N	Slope	Intercept	r-square	p (model)	Reference
Earthworms	Antimony	NA		.	.	.	.	NA	.	.	.	.	.	
Earthworms	Arsenic	NA	soil-to-biota	53	0.006	0.224	0.925	NA	53	0.706	-1.421	0.26	0.0001	Sample et al. 1999
Earthworms	Barium	NA	soil-to-biota	20	0.005	0.091	0.31	NA	.	.	.	.	.	Sample et al. 1998a
Earthworms	Beryllium	NA	soil-to-biota	12	0	0.045	1.429	NA	.	.	.	.	.	Sample et al. 1998a
Earthworms	Cadmium	NA	soil-to-biota	226	0.253	7.708	190	NA	226	0.795	2.114	0.67	0.0001	Sample et al. 1999
Earthworms	Chromium	NA	soil-to-biota	67	0.021	0.306	11.416	NA	67	-0.067	2.481	0.0026	0.68	Sample et al. 1999
Earthworms	Cobalt	NA	soil-to-biota	17	0.031	0.122	0.321	NA	.	.	.	.	.	Sample et al. 1998a
Earthworms	Copper	NA	soil-to-biota	197	0.002	0.515	5.492	NA	197	0.264	1.675	0.18	0.0001	Sample et al. 1999
Earthworms	Lead	NA	soil-to-biota	245	0	0.266	228.261	NA	245	0.807	-0.218	0.58	0.0001	Sample et al. 1999
Earthworms	Manganese	NA	soil-to-biota	36	0.012	0.054	0.228	NA	36	0.682	-0.809	0.34	0.0002	Sample et al. 1999
Earthworms	Nickel	NA	soil-to-biota	31	0.033	1.059	7.802	NA	31	-0.26	3.677	0.06	0.19	Sample et al. 1999
Earthworms	Selenium	NA	soil-to-biota	14	0.3	0.985	13.733	NA	13	0.733	-0.075	0.43	0.016	Sample et al. 1999
Earthworms	Silver	NA	soil-to-biota	10	0.001	2.045	19.5	NA	.	.	.	.	.	Sample et al. 1998a
Earthworms	Zinc	NA	soil-to-biota	244	0.025	3.201	49.51	NA	244	0.328	4.449	0.45	0.0001	Sample et al. 1999
Earthworms	Dieldrin	NA	soil-to-biota	6300	1.73	267.08	7.70E+05	NA	.	.	.	.	.	Modeled from K_{ow}, see Table 9
Earthworms	DDT	NA	soil-to-biota	6300	0.59	116.61	3.70E+04	NA	.	.	.	.	.	Modeled from K_{ow}, see Table 9
Earthworms	DDD	NA	soil-to-biota	6300	0.27	67.55	4.00E+04	NA	.	.	.	.	.	Modeled from K_{ow}, see Table 9
Earthworms	DDE	NA	soil-to-biota	6300	0.12	73.04	3.80E+04	NA	.	.	.	.	.	Modeled from K_{ow}, see Table 9
Earthworms	Pentachlorophenol	NA	soil-to-biota	6300	0.23	74.68	4.90E+04	NA	.	.	.	.	.	Modeled from K_{ow}, see Table 9
Earthworms	PAHs	NA	soil-to-biota	6300	0.08	50.61	5.30E+04	NA	.	.	.	.	.	Modeled from K_{ow}, see Table 9
	Acenaphthene	NA	soil-to-biota	6300	0.08	38.75	10997.33	NA	.	.	.	.	.	Modeled from K_{ow}, see Table 9
	Anthracene	NA	soil-to-biota	6300	0.14	44.00	6535.99	NA	.	.	.	.	.	Modeled from K_{ow}, see Table 9
	Benzo(a)anthracene	NA	soil-to-biota	6300	0.03	34.45	28284.23	NA	.	.	.	.	.	Modeled from K_{ow}, see Table 9
	Benzo(b)fluoranthene	NA	soil-to-biota	6300	0.10	72.78	52905.02	NA	.	.	.	.	.	Modeled from K_{ow}, see Table 9
	Benzo(k)fluoranthene	NA	soil-to-biota	6300	0.08	71.30	27972.71	NA	.	.	.	.	.	Modeled from K_{ow}, see Table 9
	Benzo(ghi)perylene	NA	soil-to-biota	6300	0.35	81.08	24226.89	NA	.	.	.	.	.	Modeled from K_{ow}, see Table 9
	Benzo(a)pyrene	NA	soil-to-biota	6300	0.14	31.47	11628.95	NA	.	.	.	.	.	Modeled from K_{ow}, see Table 9
	Chrysene	NA	soil-to-biota	6300	0.10	61.78	15876.65	NA	.	.	.	.	.	Modeled from K_{ow}, see Table 9
	Dibenzo(ah)anthracene	NA	soil-to-biota	6300	0.21	78.71	11605.75	NA	.	.	.	.	.	Modeled from K_{ow}, see Table 9
	Naphthalene	NA	soil-to-biota	6300	0.14	50.61	15394.11	NA	.	.	.	.	.	Modeled from K_{ow}, see Table 9
	Phenanthrene	NA	soil-to-biota	6300	0.08	45.49	11607.82	NA	.	.	.	.	.	Modeled from K_{ow}, see Table 9
Earthworms	TNT	NA	soil-to-biota	6300	0.02	19.57	5424	NA	.	.	.	.	.	Modeled from K_{ow}, see Table 9
Earthworms	RDX	NA	soil-to-biota	6300	0.04	9.91	2570	NA	.	.	.	.	.	Modeled from K_{ow}, see Table 9

Table 8. Summary of Bioaccumulation Models for Food Types Included in the Eco-SSL Wildlife Model. Highlighted Values Represent Recommended Bioaccumulation Data.

				Summary Statistics for BAFs					Parameters for log-linear uptake model[1]				
Taxa	Analyte	Trophic Group	Transfer type	N	Minimum	Median	Maximum	Trophic Group	N	Slope	Intercept	r-square	p (model)	Reference
Small Mammals	Antimony	.	diet-to-biota	.	.	0.001	.	.	.	.	.	.	.	Baes et al. 1984
Small Mammals	Arsenic	General	soil-to-biota	72	0	0.0025	0.071	General	60	0.8188	-4.8471	0.52	0.0001	Sample et al. 1998b
Small Mammals	Barium	.	diet-to-biota	.	.	0.001	.	.	.	.	.	.	.	Baes et al. 1984
Small Mammals	Beryllium	.	diet-to-biota	.	.	0.00015	.	.	.	.	.	.	.	Baes et al. 1984
Small Mammals	Cadmium	Herbivore	soil-to-biota	28	0.0153	0.1258	1	Herbivore	28	0.4723	-1.2571	0.64	0.0001	Sample et al. 1998b
Small Mammals	Chromium	General	soil-to-biota	38	0.0314	0.0846	0.8	General	38	0.7338	-1.4599	0.42	0.0001	Sample et al. 1998b
Small Mammals	Cobalt	General	soil-to-biota	15	0.0101	0.0205	0.18	General	15	1.307	-4.4669	0.41	0.01	Sample et al. 1998b
Small Mammals	Copper	General	soil-to-biota	76	0.0044	0.1963	1.398	General	76	0.1444	2.042	0.26	0.0001	Sample et al. 1998b
Small Mammals	Lead	General	soil-to-biota	138	0.0031	0.1054	2.659	General	138	0.4422	0.0761	0.37	0.0001	Sample et al. 1998b
Small Mammals	Manganese	General	soil-to-biota	12	0.0114	0.0205	0.079	.	.	.	.	.	.	Sample et al. 1998b
Small Mammals	Nickel	General	soil-to-biota	43	0	0.2488	1.143	General	36	0.4658	-0.2462	0.55	0.0001	Sample et al. 1998b
Small Mammals	Selenium	General	soil-to-biota	35	0	0.1619	1.754	General	27	0.3764	-0.4158	0.31	0.0026	Sample et al. 1998b
Small Mammals	Silver	General	soil-to-biota	10	0	0.004	0.81	.	.	.	.	.	.	Sample et al. 1998b
Small Mammals	Zinc	Herbivore	soil-to-biota	30	0.00511	0.504	16.3636	Herbivore	30	0.0706	4.3632	0.31	0.0013	Sample et al. 1998b
Small Mammals	Dieldrin	Beef	diet-to-biota	29	0.35088	0.9091	1.4035							newly developed for Eco-SSLs
Small Mammals	DDT	Beef	diet-to-biota	2	0.0188	0.1344	0.25							newly developed for Eco-SSLs
Small Mammals	DDD	Beef	diet-to-biota	*2*	*0.0188*	*0.1344*	*0.25*							see footnote 4
Small Mammals	DDE	Beef	diet-to-biota	3	0.0084	0.0294	0.0372							newly developed for Eco-SSLs
Small Mammals	Pentachlorophenol	NA	diet-to-biota	NA	.	.	.	chickens[2]		0.00452	0.198	0.837		Stedman et al. 1980
Small Mammals	PAHs													
Small Mammals	TNT													
Small Mammals	RDX													

[1] model is of the form: ln (tissue [dry wt.]) = slope*(ln[soil])+ intercept

[2] model is for bioaccumulation into breast muscle and is of the form: tissue [dry wt.] = slope*(diet)+ intercept

3 Plant bioaccumulation data were unavailable; bioaccumulation data for DDE is assumed to be representative.

4 Beef bioaccumulation data were unavailable; bioaccumulation data for DDT is assumed to be representative.

Table 9. Summary of Parameter Values for Estimation of Bioaccumulation of Organic Contaminants from Soil by Earthworms.

				log Kbw model[1]					log Koc model[2]					
Analyte	log Kow	Source	foc	slope	intercept	root MSE	log Kbw	Kbw	Chemical Class/Source[3]	slope	intercept	root MSE	logKoc	Koc
RDX	0.87	SRC	0.01	1.001334	-0.5528	0.63566	0.32	2.08	Triazine	0.5865	0.8256	0.18291	1.34	21.67
TNT	1.6	SRC	0.01	1.001334	-0.5528	0.63566	1.05	11.20	Aromatic Nonhalogenated Hydrocarbons	0.5289	0.9182	0.37489	1.76	58.14
DDT	6.53	EPA 1996	0.01	1.001334	-0.5528	0.63566	5.99	968079.49	EPA 1996 (n=6)					min=258467 geomean= 677934 max=1741516
DDD	6.1	EPA 1996	0.01	1.001334	-0.5528	0.63566	5.56	359200.89	Aromatic Halogenated Hydrocarbons	0.9739	-0.2238	0.34944	5.72	521182.71
DDE	6.76	EPA 1996	0.01	1.001334	-0.5528	0.63566	6.22	1645196.74	Aromatic Halogenated Hydrocarbons	0.9739	-0.2238	0.34944	6.36	2289623.11
Dieldrin	5.37	EPA 1996	0.01	1.001334	-0.5528	0.63566	4.82	66736.52	EPA 1996 (n=3)					min=23308 geomean= 25546 max=27399
Pentachlorophenol	5.09	EPA 1996	0.01	1.001334	-0.5528	0.63566	4.54	34993.72	Chlorophenols	1.0757	-0.8006	0.23701	4.67	47283.87
Acenaphthene	3.92	EPA 1996	0.01	1.001334	-0.5528	0.63566	3.37	2357.38	Nonpolar PAHs	0.8903	0.2794	0.32984	3.77	5879.98
Anthracene	4.55	EPA 1996	0.01	1.001334	-0.5528	0.63566	4.00	10075.57	EPA 1996 (n=9)					min=14500 geomean= 23493 max=33884
Benzo(a)anthracene	5.7	EPA 1996	0.01	1.001334	-0.5528	0.63566	5.15	142824.86	EPA 1996 (n=4)					min=150000 geomean= 357537 max=840000
Benzo(b)fluoranthene	6.2	EPA 1996	0.01	1.001334	-0.5528	0.63566	5.66	452346.05	Nonpolar PAHs	0.8903	0.2794	0.32984	5.80	629883.16
Benzo(k)fluoranthene	6.2	EPA 1996	0.01	1.001334	-0.5528	0.63566	5.66	452346.05	Nonpolar PAHs	0.8903	0.2794	0.32984	5.80	629883.16
Benzo(ghi)perylene	6.7	EPA 1995	0.01	1.001334	-0.5528	0.63566	6.16	1432642.40	Nonpolar PAHs	0.8903	0.2794	0.32984	6.24	1755537.05
Benzo(a)pyrene	6.11	EPA 1996	0.01	1.001334	-0.5528	0.63566	5.57	367579.04	EPA 1996 (n=3)					min=487947 geomean= 968774 max=2130000
Chrysene	5.7	EPA 1996	0.01	1.001334	-0.5528	0.63566	5.15	142824.86	Nonpolar PAHs	0.8903	0.2794	0.32984	5.35	226000.81
Dibenzo(ah)anthracene	6.69	EPA 1996	0.01	1.001334	-0.5528	0.63566	6.15	1399988.47	EPA 1996 (n=14)					min=565014 geomean= 1789101 max=3059425
Naphthalene	3.36	EPA 1996	0.01	1.001334	-0.5528	0.63566	2.81	648.16	EPA 1996 (n=20)					min=830 geomean= 1191 max=1950
Phenanthrene	4.55	EPA 1995	0.01	1.001334	-0.5528	0.63566	4.00	10075.57	Nonpolar PAHs	0.8903	0.2794	0.32984	4.33	21392.67

w) + error [model from Connell and Markwell 1990 - data reanalyzed]
*log Kow) + error [model from Gerstl 1990 - data reanalyzed]
measure Koc available, values were modeled based on chemical class-specific models from Gerstl (1990).

Bs (Aroclor-1260, -1254, -1248, -1242, -1232, -1221, and -1016). ATSDR/TP-88/21
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Table 10. Summary of Distributions for Earthworm BAFs for Organic Contaminants. Total Number of Iterations= 6300.

	RDX	TNT	DDT	DDD	DDE	Dieldrin	Pentachlorophenol	Acenaphthene	Anthracene	Benzo(a)anthracene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Benzo(ghi)perylene	Benzo(a)pyrene	Chrysene	Dibenzo(ah)anthracene	Naphthalene	Phenanthrene
Mean	31.29	82.90	368.62	286.60	285.45	751.43	261.18	146.41	124.70	107.23	276.06	263.36	306.18	96.44	240.39	245.30	152.40	182.81
Std Deviation	83.17	263.11	1081.28	1088.32	989.61	1918.34	963.53	451.27	276.17	425.01	969.57	846.82	949.50	265.45	694.91	607.23	413.16	569.09
Minimum	0.04	0.02	0.59	0.27	0.12	1.73	0.23	0.08	0.14	0.03	0.10	0.08	0.35	0.14	0.10	0.21	0.14	0.08
5th Percentile	0.84	1.21	9.66	4.52	4.53	23.21	5.55	2.54	3.56	2.88	5.29	4.79	5.41	2.68	4.05	6.75	4.24	3.20
10th Percentile	1.45	2.18	16.20	7.74	8.42	40.18	10.22	4.52	6.19	5.04	9.34	8.80	9.52	4.62	7.66	11.65	7.36	5.82
15th Percentile	2.08	3.34	23.58	12.16	13.12	57.42	14.94	6.80	9.16	7.28	13.94	13.23	14.10	6.87	11.28	17.12	10.37	8.56
20th Percentile	2.78	4.62	32.13	16.61	18.24	77.70	20.23	9.48	12.29	9.77	18.77	18.36	19.63	9.10	15.45	23.11	14.26	11.67
25th Percentile	3.60	6.12	41.04	22.22	24.06	99.24	25.90	12.68	16.01	12.40	24.52	23.52	26.05	11.57	20.43	29.85	18.13	15.55
30th Percentile	4.43	7.84	52.34	27.86	31.36	123.33	32.69	16.24	20.19	15.79	31.10	29.98	33.49	14.58	26.48	37.46	22.57	19.56
35th Percentile	5.46	9.91	64.64	35.04	39.21	151.62	41.50	20.43	25.11	19.32	38.71	36.95	42.21	17.91	33.49	45.70	28.13	24.29
40th Percentile	6.68	12.56	79.52	43.87	47.83	185.85	51.69	25.37	30.70	23.52	47.98	46.18	52.63	21.48	41.02	55.31	34.57	29.85
45th Percentile	8.25	15.45	97.17	54.23	59.56	223.30	61.68	31.45	36.80	28.32	58.68	57.54	65.53	25.75	50.56	64.94	42.24	37.52
50th Percentile	9.91	19.57	116.61	67.55	73.04	267.08	74.68	38.75	44.00	34.45	72.78	71.30	81.08	31.47	61.78	78.71	50.61	45.49
55th Percentile	11.90	24.38	140.24	82.54	89.29	321.58	89.94	47.09	51.61	40.98	89.08	87.28	98.20	38.43	76.60	96.15	61.39	55.20
60th Percentile	14.43	29.83	170.09	101.70	109.52	382.78	109.86	57.46	63.66	49.66	108.85	108.05	121.22	46.45	94.68	118.83	73.62	68.56
65th Percentile	17.47	37.42	206.56	126.19	139.16	467.10	132.10	72.06	78.92	61.06	135.65	133.17	148.47	55.92	119.33	143.08	90.12	86.40
70th Percentile	21.43	48.18	256.59	163.95	178.46	572.28	163.86	90.93	96.88	76.19	173.09	166.91	183.42	68.85	150.57	179.92	109.69	109.73
75th Percentile	27.40	60.57	318.00	211.62	225.13	708.21	207.60	116.60	120.11	96.83	220.81	209.24	239.61	87.12	190.32	227.49	139.26	142.80
80th Percentile	35.52	78.52	409.19	285.54	294.82	911.78	269.56	153.75	156.06	125.25	287.66	275.45	311.80	111.04	248.16	287.04	175.70	187.71
85th Percentile	48.29	113.33	544.88	401.22	404.06	1183.23	362.30	208.73	208.58	165.69	395.42	381.36	433.30	147.68	332.34	377.79	237.12	257.29
90th Percentile	70.71	167.56	794.48	594.90	580.01	1731.26	529.58	328.54	296.07	236.28	585.06	556.57	665.23	214.66	528.80	556.42	334.25	380.18
95th Percentile	121.94	334.95	1359.72	1039.94	1057.72	2898.34	1004.57	578.37	502.27	412.59	1076.59	1032.45	1204.66	371.52	982.53	934.91	574.76	676.15
Maximum	2570.90	5424.10	36910.07	40189.34	37720.05	76769.38	48667.73	10997.33	6535.99	28284.23	52905.02	27972.71	24226.89	11628.95	15876.65	11605.75	15394.11	11607.82

Table 11. Summary of Distributions for Plant BAFs for Organic Contaminants. Total Number of Iterations= 3600.

	Pentachlorophenol
Mean	2.52
Std Deviation	15.29
Minimum	0.0001
5th Percentile	0.006
10th Percentile	0.01
15th Percentile	0.02
20th Percentile	0.04
25th Percentile	0.05
30th Percentile	0.07
35th Percentile	0.10
40th Percentile	0.14
45th Percentile	0.18
50th Percentile	0.24
55th Percentile	0.32
60th Percentile	0.43
65th Percentile	0.58
70th Percentile	0.80
75th Percentile	1.11
80th Percentile	1.58
85th Percentile	2.43
90th Percentile	4.10
95th Percentile	7.96
Maximum	553.37

Attachment 4-2

Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs)

Eco-SSL Standard Operating Procedure (SOP) # 3: Wildlife Toxicity Reference Value Literature Search and Retrieval

OSWER Directive 92857-55

November 2003

Attachment 4-2
Ecological Soil Screening Levels (Eco-SSLs)
Standard Operating Procedure (SOP) #3: Wildlife Toxicity Reference Value Literature Search

Version 1.2

Prepared for AFCEE

by

T N & Associates, Inc.
Oak Ridge, Tennessee
under contract HF41624-97-D-8201
Delivery Order #0004

FINAL DRAFT

Standard Operating Procedure 1

Acquisition of Literature to Support the Development of Toxicity Reference Values for Wildlife

Version 1.2

January 2000

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Doris Anders	US Air Force
Janet Burris	ISSI Consulting Group, Inc.
David Charters	USEPA Emergency Response Team (ERT)
June Crowe	T N & Associates
Anne Fairbrother	EP&T, Inc.
Kinzie Gordon	Parsons Engineering Science
Dale Hoff	USEPA
Rosemary Holdsworth	T N & Associates
Mark Johnson	US Army CHPPM
Jackie Little	T N & Associates
Drew Rak	US Army Corps of Engineers
Chris Russom	USEPA MED-Duluth
Brad Sample	CH2M Hill
Julie Yamamoto	California EPA- Office of Environ. Health Hazard Assessment

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ACRONYMS AND ABBREVIATIONS

AGRICOLA	Agricultural OnLine Access
ATSDR	Agency for Toxic Substances and Disease Registry
BIOSIS	Toxicological Aspects of Environmental Health
CARA	Chemical Assessments and Related Activities
CAS	Chemical Abstract Service
CD-ROM	Compact disk-read only memory
ChemID	Chemical Identification
CIS	Chemical Information Systems
CRISP	Toxicology Research Projects
EcoSSL	Ecological Soil Screening Level
EPA	U.S. Environmental Protection Agency
FEDRIP	Federal Research in Progress
FTP	File Transfer Protocol
FWS	U.S. Fish and Wildlife Service
HSDB	Hazardous Substance Databank
IGM	Internet Grateful Med
IRIS	Integrated Risk Information System
KWIC	Keywords in Context
MESH	Medical Subject Headings
NIEHS	National Institute of Environmental Health Sciences
NIOSH	National Institute for Occupational Safety and Health
NISC	National Information Services Corporation
NLM	National Library of Medicine
NTIS	National Technical Information Service
OERR	EPA Office of Emergency and Remedial Response
OHEA	Office of Health and Environmental Assessment
ORNL	Oak Ridge National Laboratory
RTECS	Registry of Toxic Effects of Chemical Substances
SIS	Specialized Information Services
SOP	Standard Operating Procedure
SSL	Soil Screening Level
TEHIP	Toxicology and Environmental Health Information Program
TRV	Toxicity Reference Value
Web	World Wide Web

1.0 SCOPE AND APPLICATION

This standard operating procedure (SOP), hereafter referred to as SOP1, *Acquisition of Literature to Support the Development of Toxicity Reference Values (TRVs) for Wildlife*, provides direction for the retrieval of toxicological literature. The toxicological literature will be used in the development of TRVs for birds, mammals, reptiles, and amphibians. However, the scope of this SOP is limited to toxicological literature retrieval from electronic databases and hardcopy sources.

2.0 OVERVIEW

The U.S. Environmental Protections Agency (EPA) developed *Soil Screening Guidance (EPA/540/R-96/018)* to accelerate and standardize the cleanup of contaminated soils at sites on the National Priorities List. This document describes a method for calculating soil screening levels (SSLs) for chemicals in soil. SSLs are site-specific risk-based concentrations that may be used to define areas of a site that do not require further study or action. SSLs are calculated to be protective of human health and do not address the protection of ecological receptors. To address the lack of SSLs protective of wildlife, the EPA Office of Emergency and Remedial Response (OERR) initiated the development of ecological SSLs (EcoSSLs), which are concentrations of chemicals in soil that are calculated to be protective of wildlife receptors. Initially, generic EcoSSLs will be developed and presented in an EPA guidance document as a reference table. Site-specific EcoSSLs will be developed at a later date. TRVs are derived from dose-response studies of the toxicity of chemicals to animal receptors and will be used as input to derive EcoSSL values.

A literature search is conducted to obtain information on contaminants of concern, their potential ecological effects, and species of concern (*Ecological Risk Assessment Guidance for Superfund*, EPA 1997). The literature search strategy presented in SOP1 is designed to facilitate the search, preliminary review, and acquisition of literature for developing TRVs. The flowchart in Appendix A summarizes this procedure.

3.0 PERSONNEL REQUIREMENTS

SOP1 presents the information necessary to perform a literature search and review the literature retrieved; however, specialists should be consulted regarding various aspects of the procedure. A research librarian with a specialization in technical information and experience in performing scientific literature searches should be consulted to develop the search strategy (see Section 5.3). A chemist should be consulted for review of specific chemical synonyms (see Section 5.1). A toxicologist should assess the abstracts and publications retrieved from the literature search for their suitability for TRV development (see Section 5.5.1).

4.0 DATABASE SELECTION

The following background information briefly describes the more commonly used electronic databases and nonelectronic sources of ecotoxicity data.

4.1 ELECTRONIC DATABASES AND PROVIDERS

The databases described in this section may be accessed via the World Wide Web (Web), dial-up modem, directly from the provider, and/or through a commercial information vendor. Some of the databases may be accessed without charge via the Web; however, there may be certain search limitations or restrictions. Individuals using these databases will need to obtain information and training concerning use of the various search systems.

The databases described below are grouped according to the information vendor, and instructions for obtaining access are provided. Database vendors include the DIALOG Corporation, the National Library of Medicine (NLM), EPA, Chemical Information Systems (CIS), and the National Information Services Corporation (NISC).

4.1.1 DIALOG

DIALOG offers more than 450 databases from a broad range of disciplines (e.g., chemistry, environment, science, technology, patents and trademarks, worldwide company information, and domestic and international news). See Appendix B for file descriptions and contents. File selection can be accomplished by using their Dialindex feature or by using a "OneSearch" strategy or a combination of these. Although much of the toxicological literature can be found in BIOSIS (File 5), MEDLINE (File 155), and TOXLINE (156), the following additional databases contain toxicological information:

- AGRICOLA (Agricultural OnLine Access) (File 10)
- AGRIS International (File 203)
- CAB Abstracts (File 50)
- CA Search (Chemical Abstracts) (File 399)
- CHEMTOX Online (File 337)
- Conference Papers Index (File 77)
- Dissertation Abstracts (File 35)
- Enviroline (File 40)
- Environmental Bibliography (File 68)
- Life Sciences Collection (File 76)
- NTIS (National Technical Information Service) (File 6)
- Pollution Abstracts (File 41)
- RTECS (Registry of Toxic Effects of Chemical Substances) (File 336)
- Science (File 370)
- Wilson Biological and Agricultural Index (File 143)
- Zoological Record (File 185)
- Pascal (File 144)
- SciSearch (File 434)

The OneSearch strategy in DIALOG allows up to 60 files to be searched simultaneously. This is advantageous because the "*remove duplicates*" command can be utilized to remove the majority of duplicate records from all the files. It is recommended that Files 68, 336, 337, 370, 143, and

144 not initially be used in the OneSearch strategy but rather be added as needed. Some chemical and receptor combinations do not have a large body of toxicological literature, and these files may be helpful in exhausting all the possible sources of information available on DIALOG. File 144 contains many foreign language publications, many of which have been translated from English originals. Therefore, the user should be aware that some of these records may be duplicates of English language papers retrieved from other files. File 336 is useful only as a source for background information on a particular chemical, not as a primary source of toxicological studies. Science Citation Index (File 434) is another database that could be used to expand the initial search. This source is further discussed in section 4.2.5.

DIALOG can be accessed via the Web at http://www.dialog.com and via modem using a telecommunications system. Additionally, selected databases are available on compact disk–read only memory (CD–ROM) through subscription. Information on pricing and access is available from the Web address or from The Dialog Corporation, U.S. Headquarters, 11000 Regency Parkway, Suite 400, Cary, NC 27511; telephone (919) 462-8600.

4.1.2 National Library of Medicine

The Specialized Information Services (SIS) Division of NLM is responsible for information coverage and services for several topics, including toxicology and environmental health, and directories to other information resources related to health and biomedicine. The SIS Division's Toxicology and Environmental Health Information Program (TEHIP) responds to information queries and develops interactive retrieval services in toxicology, environmental health, and other health-related areas. The SIS TEHIP online databases that contain toxicology information include TOXNET, TOXLINE, and Chemical Identification (ChemID). These databases are described below.

- TOXNET is a computerized system of files from which toxicological and related information may be obtained (see Appendix B for file descriptions and contents). TOXNET provides a free Web-based interface. The Hazardous Substances Databank (HSDB) and Integrated Risk Information System (IRIS) files in this system may be useful for their bibliographies. TOXNET files can be accessed without charge on the Web at http://sis.nlm.nih.gov. The Web interface provides an approach to searching files of varying formats and contents, and toxicology data and literature references on particular chemicals can be extracted from these files. Alternately, a search may be performed using subject terms to identify chemicals that cause certain effects. A variety of display options is available, including sending results by e-mail or FTP (File Transfer Protocol).

- The TOXLINE database produced by NLM contains more than 2 million bibliographic references including journal publications, letters to the editor, meeting abstracts, meeting papers, meeting reports, monographs, technical reports, theses, and research in progress. Subjects covered include pharmacological, biochemical, physiological, and toxicological effects of drugs, other chemicals, physical stressors, and biological agents. TOXLINE is updated monthly. Records in the Toxicology Research Projects (CRISP) and Federal Research in Progress (FEDRIP) subfiles in this system are not useful because they describe studies in progress and may not have been completed or peer reviewed.

TOXLINE can be accessed online without charge through NLM's Internet Grateful Med (IGM) search system (http://igm.nlm.nih.gov). TOXLINE searching through IGM is somewhat restricted in that search statements are limited by the number of terms that can be entered at one time. TOXLINE can be searched as a single file (File 156) (i.e., pre-1965–present) via DIALOG.

- ChemID is a database available from NLM via the IGM Web interface. ChemID is a chemical dictionary file of more than 339,000 compounds of biomedical and regulatory interest. Records include Chemical Abstract Service (CAS) registry numbers and other identifying numbers, molecular formulae, generic names, synonyms, MESH (Medical Subject Headings), and file locators that lead users to other files available through NLM.

4.1.3 Environmental Protection Agency

The ECOTOX Database System produced by EPA is a source of toxicity data for aquatic life, terrestrial plants, and wildlife. This system integrates three toxicology effects databases: AQUIRE (aquatic life), PHYTOTOX (terrestrial plants), and TERRETOX (terrestrial wildlife). TERRETOX contains 40,000 records related to the toxic effects of 1300 chemical substances on terrestrial animals, primarily mammals and birds. The subjects covered include chemical name identification, toxicology, test conditions, species identification, CAS numbers, assay results/analyses, and environmental effects.

The ACQUIRE database in ECOTOX can be accessed without charge at http://www.epa.gov/ecotox/. PHYTOTOX and TERRATOX are currently unavailable on the ECOTOX system; however, CIS, a commercial vendor, provides access to all three databases.

4.1.4 Chemical Information Systems

CIS is a commercial provider of the Oxford Molecular Group, Inc. CIS provides access to a number of databases including EPA's AQUIRE, PHYTOTOX, and TERRATOX. Access is available via dial-up modem. Questions regarding CIS should be directed to CIS User Support, Chemical Information Systems, 810 Gleneagle Court, Suite 300, Towson, MD 21286; telephone (800) CIS-USER. Product information may be accessed at http://www.oxmol.com/prods/cis/.

4.1.5 National Information Services Corporation

Wildlife Worldwide Index provides access to more than 345,000 records regarding wild mammals, birds, reptiles, and amphibians. Subject coverage includes all aspects of wildlife and wildlife management. This database can be accessed via BiblioLine, an online service at http://www.nisc.com, or by contacting NISC International, Inc., 3100 St. Paul Street, Baltimore, MD 21218; telephone (410) 243-1198.

4.2 OTHER DATABASES AND HARDCOPY SOURCES

The following sources may also be examined for toxicological information and references.

4.2.1 U.S. Fish and Wildlife Service

The U.S. Fish and Wildlife Service (FWS) has published several contaminant-specific documents listing toxicological data on terrestrial, avian, and aquatic wildlife (e.g., those studies produced by Eisler, R. 1985). The FWS maintains a bibliographic database that is available online at http://FA.R9.FWS.gov/R9fwrs/Dbinfo.htm.

4.2.2 Agency for Toxic Substances and Disease Registry

The Agency for Toxic Substances and Disease Registry (ATSDR) has produced toxicological profiles (e.g., *Toxicological Profile for RDX*) (ATSDR 1995) for hazardous substances that are most commonly found at Superfund sites (e.g., ATSDR 1993). ATSDR records are available online at http://atsdr.cdc.gov/toxpro2.html.

4.2.3 Oak Ridge National Laboratory

Oak Ridge National Laboratory (ORNL) provides toxicological information on wildlife receptors in *Toxicological Benchmarks for Wildlife: 1996 Revision* (ORNL 1996). ORNL records are available online at http://www.hsrd.gov/ecorisk/tm86r3.

4.2.4 Environmental Protection Agency

The *Wildlife Exposure Factors Handbook* (EPA 1993a,b) provides information and guidance for conducting exposure assessments for wildlife species exposed to toxic chemicals in the environment. Included is information on exposure factors (e.g., body weight, dietary composition, food ingestion rates, home range, etc.) for 34 selected wildlife species. The *Handbook* can be viewed at http://www.epa.gov/nceawww1/wefh.htm.

EPA-sponsored health effects documents are maintained in the *Chemical Assessments and Related Activities* (CARA) list (EPA 1994) produced by the Office of Health and Environmental Assessment (OHEA). CARA is an alphabetical file of chemicals and projects and lists the types of documents available, the OHEA offices responsible for producing the documents, the names of the client offices, and other publication information. CARA covers the period from 1980–1994. Documents listed in CARA include the following:

- Air Quality Criteria Documents
- Ambient Water Quality Criteria Documents
- Drinking Water Quality Criteria
- Exposure Assessments
- Health Assessment Documents
- Health Effects Assessments
- Health and Environmental Effects Documents
- Health and Environmental Effects Profiles
- Risk Assessments

4.2.5 Science Citation Index

The manual or electronic version of *Science Citation Index* is a useful resource, especially if more information for a particular chemical is needed to expand a search that has produced only a few retrievals. This database, produced by the Institute for Scientific Information, indexes 5300 major journals in science. The electronic version includes many minor journals and also includes abstracts. This tool is invaluable for updating searches.

4.2.6 Amphibian and Reptile Contamination and Toxicology Bibliography

The Amphibian and Reptile Contamination and Toxicology Bibliography is a useful Internet resource for amphibian and reptile toxicological literature. The file is located at http://www.cciw.ca/green-lane/herptox/ and is frequently updated.

5.0 LITERATURE SEARCH PROCEDURE

Sections 5.1 through 5.6 present the information required and the sequence of events necessary to execute a literature search and the subsequent screening process using the DIALOG system (refer to the flow chart in Appendix A). An example search is provided in Appendix C.

5.1 CHEMICAL NAME, SYNONYMS, AND CAS NUMBER IDENTIFICATION

The CAS registry number for the chemical of interest must be identified. Organic chemical nomenclature has undergone many revisions, and some compounds have several common names (synonyms), and in some instances many trade names, but the use of the CAS number provides positive identification for each particular chemical. CAS numbers appear in the format "nnnnn-nn-n," and the hyphens must be included when the DIALOG system is searched. Both CAS numbers and common names should be used to search DIALOG databases even though some files are not indexed by CAS number. Use of the root name of the parent compound captures most of the relevant publications. For example, use of the term "cadmium" captures "cadmium chloride," "cadmium acetate," etc. A list of recommended chemical terms, synonyms, and CAS numbers is presented in Appendix D.

Truncation of some terms is necessary to identify all variations of an element. For example, a search for copper should include "copper," its CAS number (7440-50-8), "cupr," and all of the CAS numbers listed for copper compounds listed in Appendix D. A search for an organic compound should include the common name, CAS number, and all synonyms. For example, a search for Dieldrin should include "dieldrin," its CAS number (60-57-1), and its synonyms (e.g., alvit, dieldrix, heod, etc.).

Searches containing truncations should be tested in a preliminary file before the search is performed because using the truncated term may retrieve more extraneous studies than if the term were actually spelled out in its various forms. For example, truncating chromium (chrom*) will retrieve numerous unrelated studies such as those for chromosome and chromatography.

CAS numbers and synonyms for chemicals not included in Appendix D may be obtained from printed sources such as *Sax's Dangerous Properties of Industrial Materials*, *The Merck Index*, *Patty's Industrial Hygiene & Toxicology*, *Handbook of Toxic & Hazardous Chemicals and Carcinogens*, the *Handbook of Environmental Data on Organic Chemicals*, the *Sigma* catalog of biochemicals and reagents, and the *Aldrich* catalog of fine chemicals. CAS numbers and synonyms can also be obtained from electronic databases available on the Web (e.g., ChemID) or from commercial vendors (e.g., DIALOG). The Internet is also an excellent source for the online versions of chemical catalogs and related chemical Web sites.

A chemist should review the results of the synonym search to ensure that it is fully inclusive and that the search queries for the metallic and other elements are constructed accurately. For example, the metallic element chromium may be identified in the literature as chromium, chromic, dichromate, chromate, chrome, Cr, Cr(III), or Cr(VI). The metallo-organic complexes, where they are known to exist (e.g., methylmercury) and all the valence states of metallic elements (e.g., "ferric" and "ferrous" for iron) should be included in a search. The CAS numbers of simple salts should be added to the search strategy for metallic elements [e.g., aluminum chloride (CAS No. 7446-70-0) and aluminum sulfate (CAS No. 16828-11-8)]. To retrieve all information for a compound such as phenol, incorporate CAS numbers for sodium phenate, potassium phenate, and phenol into the search strategy. It is essential that all synonyms in common usage for a chemical are used in the search strategy to provide an inclusive search.

5.2 RECOMMENDED RECEPTOR GROUPS

The terms in the recommended list presented below have proven to be the most useful in retrieving toxicological studies for both laboratory and wildlife receptors. Additional species-specific receptor terms can be added to address site-specific concerns. The recommended list for wild mammals includes all the major families found in the continental United States with the exception of bats, seals, and manatees. To avoid duplication of effort with the laboratory mammal search (which includes the terms rat, rats, mice, mouse), the family Muridae was omitted from the recommended list for the wild mammal receptors because most of the search results would come from the sub-family Murinae. Two sub-families, Sigmodontinae and Arvicolinae, and genera belonging to these sub-families, as well as some common names for members of the genera have been included in the recommended list for wild mammals. These terms will retrieve publications for the wildlife members of the family Muridae.

Common names have been included in the recommended list where testing has shown that their inclusion increased the number of literature retrievals for a family (e.g., *opossum, beaver*). When common names did not increase the total number of retrievals, they were not retained in the receptor list. The common names *cat* and *dog* were included in the recommended list for wild mammal receptors rather than in the laboratory mammal receptor list. The terms aves, avian, bird, waterfowl, waterbird, and songbird were included to broaden the strategy for the avian receptor search. Each of these terms was tested and resulted in more retrievals for wild birds.

Recommended Receptor List

Avian Receptors

chicken	quail	duck
duckling	ducks	mallard
Japanese quail	coturnix	gallus domesticus
platyrhyn*	anas	songbird
bobwhite	waterbird	waterfowl
aves	avian	bird

Laboratory Mammals

rat	rats	mouse
mice	hamster	guinea pig
monkey	rabbit	

Wild Mammals

Didelphidae	Soricidae	Talpidae
Dasypodidae	Ochotonidae	Leporidae
Aplodontidae	Sciuridae	Geomyidae
Heteromyidae	Castoridae	Arvicolinae
Dipodidae	Erethizontidae	Myocastoridae
Canidae	Ursidae	Procyonidae
Mustelidae	Felidae	Equidae
Suidae	Dicotylidae	Cervidae
Antilocapridae	Bovidae	Sigmodontinae
Harvest mice	Harvest mouse	Microtus
Peromyscus	Reithrodontomys	Onychomys
Sigmodon	vole	lemming
cat	dog	bear
opossum	beaver	weasel
skunk	marten	badger
ferret	mink	

Amphibians and Reptiles

amphibian	frog	salamander
newt	toad	reptile
crocodile	alligator	caiman
snake	lizard	turtle
tortoise	terrapin	

*Denotes the term is truncated

5.3 SEARCH STRATEGY DEVELOPMENT

When performing a literature search, it is important that the search be sufficiently broad to retrieve all relevant literature but not so broad that an undue number of unrelated records are retrieved. It is recommended that a preliminary search be performed in one or two database files for each chemical and receptor group combination before the strategy is executed in all files. Broad search strategies may need to be further refined to exclude as much irrelevant material as possible, whereas narrow search strategies may need to be expanded to capture more relevant studies. A review of the output of the preliminary search will indicate the necessity of using additional terms, exclusion terms, or truncations to focus the search.

The following search strategy example is constructed for use in the DIALOG search system.

Step 1: Identify and test the chemical name, synonyms, and CAS numbers and search the relevant databases in DIALOG listed in Section 4.1.1 to determine the total number of retrievals for the chemical. Appropriate synonyms should be included because not all files support CAS numbers. The proximity connector "***or***" should be used to connect search terms within a specific category of information, as illustrated below:

cobalt ***or*** RN=7740-48-4 ***or*** RN=7646-79-9

Step 2: Perform a preliminary test search. Test the terms and truncations in one or two files and remove those that do not retrieve any records. Files 5, 155 and 156 are suggested for this preliminary search.

Step 3: Combine the total number of chemical retrievals with a particular receptor group. The two categories are connected by the proximity connector "***and***". For example, combine the results of Step 1 with the following:

and(rat or rats or mouse or mice or hamster? or (guinea()pig?) or monkey? or rabbit?)

Step 4: Focus the search by combining the results of Step 3 with the following toxicological terms: Note that the asterisks denote where the word was truncated.

- reproduc*
- systemic
- development*
- histology
- growth
- neurological
- behav*
- mortal*
- lethal*
- diet

- dietary
- surviv*
- drinking()water

In DIALOG, the symbol for the question mark (?) is used to permit variations in word length or spelling. For example, "reproduction" when truncated to "reproduc?" will also capture terms such as "reproductive," "reproducing," "reproduce," or "reproduction." Combine the results of the previous searches with the toxicological terms as shown below:

and (reproduc? or diet or dietary or systemic or development? or histolog? or growth or neurological or behav? or mortal? or lethal? or surviv? or (drinking()water))

Step 5: Focus the search with exclusion terms. Exclusion statements must be carefully constructed to ensure that relevant papers are not excluded. For example, the exclusion statement *not tumo?* may exclude publications that contain information about non-cancer endpoints as well as the carcinogenic effect that is the main subject of the document. In DIALOG, the use of the limiting connector "***not***" will eliminate records that contain terms that are not desired. Some recommended general exclusion terms are:

- human*
- vitro
- culture*
- inhalation
- subcutaneous
- inject*
- gene
- carcin*
- cancer*
- tumo*

The use of the "***not***" connector for these searches is limited to the title and descriptor fields to ensure that relevant articles are not eliminated from the search. However, in an effort to eliminate all instances of literature retrieval associated with the terms *human, inhalation, subcutaneous,* the MESH (medical subject heading) may also be included in the "***not***" statement. The abstract field should not be included because of the possibility that relevant papers will not be captured. Note that not all database files in DIALOG support medical subject headings. Proximity operators [e.g., *near* (n), *with* (w)] can be used to focus the strategy more precisely by requesting that terms be adjacent to each other and in the order specified. They may also be used to request that terms be within a certain number of words of each other and in the order specified as well as many other combinations. For example, not(aluminum(w)garnet(2n)laser).

It is helpful to use limiting connectors one-by-one to evaluate the effect of each exclusion term, at least in the preliminary searches. However, it is also possible to nest the exclusion statement. Combine the results of the chemical, receptor, and toxicological end-point retrievals and apply the exclusion terms as shown below:

not human?/ti,de,mesh

Alternatively the exclusion terms can be nested as indicated below:

not (human? or culture? or subcutaneous or vitro or gene or inject? or tumo? or inhalation or carcin? or cancer?)/ti,de,mesh

For more information concerning the use of proximity connectors, please consult with the Dialog Corporation, which provides manuals and intensive training sessions.

Step 6: The removal of duplicate records is the final step in refining the search and may need to be done by date-delimited increments if the number of retrievals exceeds 5,000 (the upper limit of retrievals for which duplicate detection is supported in DIALOG). Duplicates can only be removed by grouping the results into year range segments of less than 5,000 hits [e.g., group one may contain records with the publication year greater than (PY >1990) and and group two would contain all records with the publication year less than 1991 (PY<1991)]. The duplicate detection command, which is supported in most DIALOG files, is a useful command but does not always remove duplicate records within files. Foreign language papers may have more than one translation of the title, and descriptors and cannot be identified as a duplicate by the remove duplicate (*RD*) command.

5.4 SUMMARY

Although the search strategy is presented in this SOP in a linear manner, literature searching is actually an iterative process and requires collaboration between information specialists, chemists, and toxicologists. An example of this iterative process and the close collaboration between the information specialist and the toxicologist is illustrated by the search for the chemical cobalt. Examination of preliminary search results indicated that the literature associated with cobalt-60 (radiotherapy) needed to be excluded [e.g., ***not*** (irradiation or radiation or fission)].

After the preliminary search has been completed and reviewed, all files should be searched as a "OneSearch." The results (which can be several thousand records) should be downloaded and printed in Format 6 (title and keywords in context (KWIC)) for review and coding by a toxicologist. Printing the titles with the KWIC makes the preliminary review much easier and eliminates the cost of printing full abstracts for records unrelated to the development of TRVs.

Recommended Strategies for Receptor Groups

The following strategies have been tested and are recommended for the various receptor groups. Note that in DIALOG-Link, the type-ahead buffer is limited to 240 characters, thus some of the larger receptor groups (e.g., wild mammals and avian receptors) must be divided into smaller sets and the results combined. For example, each of the avian receptor groups can be searched as a separate set and then the results of each search combined. This total can then be combined with the total results from the chemical search. Site-specific species can be added to the receptor terms as needed. Truncations of receptor terms should be used with caution and be tested to avoid the retrieval of unrelated records. For example if the term "*newt*" is truncated, records with the word "*newton*" will be retrieved.

Avian Receptors

- chemical term and CAS numbers
- ***and*** (chicken? or duck or duckling? or ducks or mallard? or quail? or (Japanese()quail?) or coturnix or (gallus()domesticus) or platyrhyn? or anas)
- ***or*** ((song()bird?) or bobwhite? or (water()bird?) or (water()fowl) or aves or avian or bird?)
- ***and*** (reproduc? or diet or dietary or systemic or development? or histolog? or growth or neurological or behav? or mortal? or lethal? or surviv? or (drinking()water))
- ***not*** (exclusion terms to be determined after initial review of search)
- ***rd*** (remove duplicates)

Laboratory Mammals

- chemical term and CAS numbers
- ***and*** (rat or rats or mouse or mice or hamster? or (guinea()pig?) or monkey? or rabbit?)
- ***and*** (reproduc? or diet or dietary or systemic or development? or histolog? or growth or neurological or behav? or mortal? or lethal? or surviv? or (drinking()water))
- ***not*** (exclusion terms to be determined after initial review of search)
- ***rd*** (remove duplicates)

Wild Mammals

- chemical term and CAS numbers

- ***and*** (didelphidae or opossum? or soricidae or shrew? or talpidae or armadillo? or dasypodidae or ochotonidae or leporidae)

- ***or*** canidae or ursidae or procyonidae or mustelidae or felidae or cat or cats or dog or dogs or bear or bears or weasel? or skunk? or marten or martens or badger? or ferret? or mink or minks?

- ***or*** aplodontidae or beaver? or sciuridae or geomyidae or heteromyidae or castoridae or equidae or suidae or dicotylidae or cervidae or antilocapridae or bovidae

- ***or*** arvicolinae or mycocastoridae or dipodidae or erethizontidae or sigmodon? or (harvest()mice) or (harvest()mouse) or microtus or peromyscus or reithrodontomys or onychomys or vole or voles or lemming?

- ***and*** (reproduc? or diet or dietary or systemic or development? or histolog? or growth or neurological or behav? or mortal? or lethal? or surviv? or (drinking()water))

- ***not*** (exclusion terms to be determined after initial review of search)

- ***rd*** (remove duplicates)

Amphibians and Reptiles

- chemical term and CAS numbers

- ***and*** (amphibi? or frog or frogs or salamander? or newt or newts or toad? or reptil? or crocodil? or alligator? or caiman? or snake? or lizard? or turtle? or tortoise? or terrapin?)

- ***and*** (reproduc? or diet or dietary or systemic or development? or histolog? or growth or neurological or behav? or mortal? or lethal? or surviv? or (drinking()water))

- ***not*** (exclusion terms to be determined after initial review of search)

- ***rd*** (remove duplicates)

5.5 ELECTRONIC LITERATURE SEARCH

The following instructions relate to performing a literature search of the DIALOG databases. It is recommended that the DIALOG databases be searched first because this is the provider most likely to identify the greatest number of applicable references. The relevant DIALOG files should be searched as a "OneSearch" following the strategy developed in Section 5.3. For a large number of records, print titles and KWIC to facilitate the selection of relevant abstracts. This format is the most cost effective method of reducing the total costs of the search. If only a few records are retrieved, print the full abstracts rather than titles and KWIC.

The steps for conducting the electronic search are as follows:

- Use the "OneSearch" option to search the recommended DIALOG files as described in Section 4.1.1.
- If using DIALOG-Link, type the search statement and proofread the statement to correct possible errors. Save the search statement in a file for reuse.
- Search for the chemical of interest using the nomenclature described in Section 5.1.
- Combine the results of the chemical search with each receptor group as described in Section 5.2 (common names and taxonomic nomenclature of mammalian wildlife receptors, laboratory mammals, etc.).
- Combine the results with all of the toxicological terms.
- Combine the results with the exclusion terms listed in Section 5.3, Step 5.
- Remove duplicate records.
- Download titles and KWIC for review by a toxicologist
- Download applicable abstracts and print them.

5.5.1 Review and Coding of the Electronic Search Results

The results of the electronic search are coded in two stages.

In the first stage, the toxicologist reviews and codes the appropriate titles from the initial Dialog search output using "**RA**" to indicate that the full abstract should be retrieved or using the codes described below to indicate why they did not meet the necessary criteria for further consideration. The codes are marked directly on the printed search. The DIALOG accession numbers are used to retrieve those titles selected for retrieval which are then downloaded and printed for the second stage of review by the toxicologist.

In the second stage, the toxicologist reviews and codes the full abstracts (which were marked for retrieval from the initial stage) using "**RP**" to indicate the retrieval of the paper or using the codes outlined in the following paragraphs to indicate the reason it was eliminated from further consideration. Both of the screening processes are necessary to determine the relevance of the publication for TRV development. The codes used for eliminating records from further consideration are the same for both stages. All abstracts identified for possible use in TRV development as well as those that were coded with the appropriate rejection code(s) are downloaded into a data management system.

The review and coding procedures are described below.

1. For the titles and KWIC or abstracts meeting one or more of the following criteria, code appropriate KWIC as "**RA**" (retrieve abstract) or abstracts as "**RP**" (for retrieval of the entire publication) directly on the printed search results:

    - studies with relevant titles but no abstracts
    - review articles (use bibliography to acquire primary citations)
    - field studies describing the effect of a chemical on a target population or ecosystem (potential use as modifying information for TRV values derived from laboratory studies)
    - studies that describe changes in the following:

- morphology or histology of target organs
- patterns of growth and development
- fetal weight, fetal re-absorption, fetal abnormalities, and neonatal survival
- behavior of the test organism
- survival of the test organism

2. Do not retrieve publications for titles and KWIC or abstracts that meet one or more of the following criteria. Use the codes provided in parentheses below to indicate directly on the printed search results the reason the publication was rejected:

   - genetic/mutagenicity studies (Gene)
   - carcinogenicity studies (Carcin)
   - physiology studies (Phys)
   - in vitro studies (In Vit)
   - human health effects studies (HHE)
   - acute studies (Acu)
   - analytical studies that describe the preparation and analysis of the chemical in the tissues of the receptor (Chem Meth)
   - studies that describe the intermediary metabolism of the chemical (e.g., radioactive tracer studies) (Fate)
   - studies that record the effects of two or more simultaneously administered chemicals (Simlt)
   - studies that record the effects of a stressor (e.g., radiation, heat, etc.) and the chemical (QAC)
   - studies that describe the effects of the chemical on surgically altered or chemically modified receptors (e.g., right nephrectomy, left renal artery ligature, hormone implant, etc.) (Alt)
   - bioaccumulation/survey studies only measuring amounts of chemical present in tissues (Surv)
   - studies using non-oral routes of chemical administration (i.e. injection, inhalation, skin absorption) (No Oral)
   - studies that are unrelated to the chemical/receptor group of interest (Unrel)
   - drug/therapeutic studies (Drug)
   - anatomical studies (Anat)
   - field studies (Field sur)
   - field studies (Field sur –aquatic)
   - field studies (Field sur – marine)
   - field studies (Field Sur-sediment)
   - mathematical model or model ecosystem (Model)
   - lipid studies (lipid study)
   - cardiovascular studies e.g. blood pressure changes (Cardiovas)
   - physiological deficiency e.g., dietary study designed to deplete receptor of an element (Phys Defic)
   - meeting poster/abstract (meeting poster/asbstract)
   - conference proceeding (Conf Proc)

- behavioral studies, either simple or complex (behav -simple)(behav-complex)
- primate studies (primate)
- isolated, perfused organ studies (iso)
- larval stage of amphibians (larv)
- lead shot studies of effects of lead weights/sinkers and lead shot (lead shot)
- epilepsy studies describing induction of epilepsy by chemical agent (epilep)
- sub-chronic, generally a study of less than 10% of the test organism's lifetime (sub chronic)
- ecological risk assessment (risk assess)
- drug administered by intraruminal pellet, glass bolus, etc. (bul)

3. Code abstracts with questionable applicability as "?" for evaluation by a second reviewer.

Enter the retrieved abstracts and codes are into an electronic database management system such as ProCite or Microsoft Access.

Additional electronic databases (e.g., TOXNET, TERRATOX, BiblioLine, etc.) should be searched according to the providers' instructions. Although search strategies vary, follow the basic outline provided in Section 5.3 where applicable.

5.5.2 Retrieve Selected Publications

Retrieve publications with abstracts that meet the preliminary screening criteria. Selected publications may be obtained from a technical library; a national laboratory library; or from a commercial vendor such as Carl Uncover, OCLC (Online Computer Library Center), Purdue's Technical Information Service, or other commercial vendors.

5.6 MANUAL LITERATURE SEARCH

The basic components of the manual search include (1) identification and retrieval of applicable publications identified in the bibliographies of reviews retrieved from the results of the electronic search, and (2) search of other recommended sources (see Section 4.2).

The following steps should be undertaken in the manual search:

Step 1: Evaluate the bibliographies of review articles retrieved from the electronic search to identify potentially useful publications.

Step 2: Make a copy of the bibliographies from the review articles retrieved from the search.

Step 3: Code the potentially useful citations as "RP" for retrieval.

Step 4: Mark publications with questionable applicability as "?" for a second reviewer to evaluate.

Step 5: Consult the resources listed in Section 4.2 (e.g., ATSDR profiles, FWS reviews, CARA, Science Citation Index, etc.).

Step 6: Enter literature citations for retrieved publications into an electronic database management system.

5.7 SEARCH RESULTS DOCUMENTATION

The search results should be managed electronically in an electronic database management system such as *ProCite* or *Microsoft Access*. The electronic database management system should contain all the bibliographic information necessary to retrieve the record, including the abstract code, database file number, the chemical symbol, and the receptor. A well-designed database management system can be used for tracking the search and screening procedure and generating various reports.

Documentation for each electronic and manual search should include the following information:

- date of search
- name of person conducting search
- name and version of database or source citation
- publication years searched
- documentation of the search strategy (i.e., search terms)
- complete citation of abstracts retrieved [i.e., title, author(s), date, primary source]
- abstract code (e.g., "RP", HHE, Acu, etc.)
- recommendations for future search strategy

The above information can be used to determine the most appropriate databases to search, the most effective search strategy, and thoroughness of the search.

6.0 QUALITY ASSURANCE

The literature search and preliminary screening procedure is designed to be transparent, credible, and reproducible; therefore, maintaining comprehensive, accurate, and timely records is important. Electronic and paper copies should be maintained of all files and data generated during the course of the search.

Someone other than the person performing the initial task should review all entries into the database management system for completeness and accuracy . A review of all records marked for retrieval in the initial search should be made by someone other than the searcher and toxicologist.

7.0 REFERENCES

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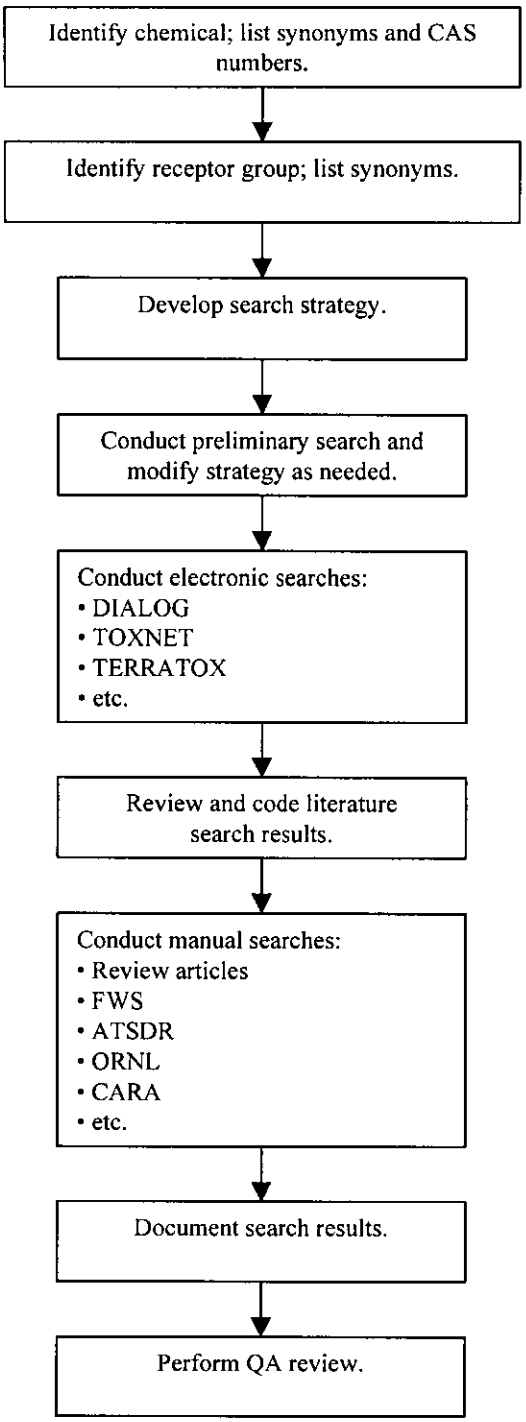
APPENDIX A
LITERATURE SEARCH FLOWCHART



APPENDIX B

ELECTRONIC DATABASE FILE DESCRIPTIONS

National Library of Medicine

TOXNET includes the following files:

- CCRIS (Chemical Carcinogenesis Research Information System) – CCRIS is sponsored by the National Cancer Institute and contains scientifically evaluated data derived from carcinogenicity, mutagenicity, tumor promotion, and tumor inhibition tests on approximately 8000 chemicals.

- DART (Development and Reproductive Toxicology) and ETICBACK (Environmental Teratology Information Center Backfile) – DART is a bibliographic database containing literature on teratology and other aspects of developmental toxicology. It is managed by NLM and funded by EPA, the National Institute of Environmental Health Sciences (NIEHS), and the National Center of Toxicology Research of the Food and Drug Administration. ETICBACK contains literature published from 1950–1989.

- EMIC (Environmental Mutagen Information Center) and EMICBACK (Environmental Mutagen Information Center Backfile) – EMIC is a bibliographic database containing literature on chemical, biological, and physical agents that have been tested for genotoxic activity. It is produced by Oak Ridge National Laboratory (ORNL) and funded by EPA and NIEHS. EMIC contains literature published since 1991. EMICBACK contains literature published from 1950–1990.

- GENE-TOX (Genetic Toxicology) – GENE-TOX, produced by EPA, contains genetic toxicology test results on more than 3000 chemicals. Selected mutagenicity assay systems and the source literature are reviewed by panels of scientific experts for each of the test systems under evaluation. Each test system in GENE-TOX has been peer reviewed and is referenced.

- HSDB (Hazardous Substance Data Bank) – HSDB is a factual database focusing on the toxicology of over 4500 potentially hazardous chemicals. The file also includes information regarding emergency handling procedures, environmental fate, human exposure, detection methods, and regulatory requirements. The data are fully referenced and peer reviewed by a panel of expert toxicologists and other scientists.

- IRIS (Integrated Risk Information Services) – IRIS is an online database maintained by EPA. It contains information regarding carcinogenic and non-carcinogenic health risks of more than 500 chemicals. The data have been scientifically reviewed by groups of EPA scientists and represent EPA consensus. The IRIS database is also available without charge on the Web at http://www.epa.gov/iris.

TOXLINE contains the following subfiles:

- ANEUPL (Aneuploidy File)
- BIOSIS (Toxicological Aspects of Environmental Health)
- CIS (International Labour Office)
- CRISP (Toxicology Research Projects)
- DART (Developmental & Reproductive Toxicology)
- EMIC (Environmental Mutagen Information Center)
- EPIDEM (Epidemiology Information System)
- ETIC (Environmental Teratology Information Center)
- FEDRIP (Federal Research in Progress)
- HMTC (Hazardous Materials Technical Center)
- IPA (International Pharmaceutical Abstracts)
- NIOSHTIC (National Institute for Occupational Safety and Health (NIOSH)
- NTIS (Toxicology Document and Data Depository)
- PESTAB (Pesticides Abstracts)
- PPBIB (Poisonous Plants Bibliography)
- RISKLINE (Swedish National Chemicals Inspectorate)
- TOXBIB/MEDLINE (Toxicity Bibliography)
- TSCATS (Toxic Substances Control Act Test Submissions)

DIALOG

The following DIALOG databases contain toxicological information:

- AGRICOLA (Agricultural OnLine Access) (File 10) is an extensive bibliographic database with subject coverage including chemistry, pesticides, pollution, veterinary medicine, wildlife, and zoology.

- AGRIS International (File 203) is an international information system for agricultural science and technology. It reflects research in all aspects of world food supply. Subject coverage includes animal production, forestry, pollution, plant production, and other topics related to food production.

- BIOSIS (File 5) provides worldwide coverage in the biological and biomedical sciences. Subject coverage includes agriculture, botany, clinical medicine, environmental biology, genetics, immunology, toxicology, veterinary science, zoology, and much more.

- CAB Abstracts (File 50) is a comprehensive file of agricultural information containing all records in the more than 50 abstract journals published by CAB International, a leading scientific information service in agriculture and related sciences. Subject coverage includes veterinary medicine, environmental degradation, conservation, and amelioration.

- CA Search (Chemical Abstracts) (File 399) includes over 13 million citations of the worldwide literature regarding chemistry and its applications from 1967 forward. Some of the principal areas of chemical applications and technologies of chemical substances included are environmental chemistry and toxicology.

- CHEMTOX Online (File 337) is a collection of environmental, health, and safety data for chemical substances that are addressed by legislation or regulation and substances that are potential candidates for legislation or regulation.

- Conference Papers Index (File 77) provides access to more than 100,000 scientific and technical papers presented at over 1000 major regional, national, and international meetings each year. Main subject areas include the life sciences, chemistry, physical sciences, geosciences, and engineering.

- Dissertation Abstracts (File 35) provides a definitive subject, title, and author guide for almost every American dissertation accepted at an accredited institution since 1861. Subject coverage includes agriculture, biological and environmental sciences, chemistry, and other topics.

- Enviroline (File 40) contains international environmental information. It indexes and abstracts more than 1000 primary and secondary publications reporting all aspects of the environment.

- Environmental Bibliography (File 68) provides access to the contents of periodicals regarding the environment. Subject coverage includes human and animal ecology, and wildlife conservation.

- Life Sciences Collection (File 76) includes abstracts from the worldwide literature of the life sciences, corresponding to the series of 17 abstracting journals from Cambridge Scientific Abstracts. Subject coverage includes biology, medicine, ecology, and some aspects of veterinary science.

- MEDLINE (File 155), produced by NLM, includes indexing to articles from more than 3700 journals.

- NTIS (National Technical Information Service) (File 6) NTIS contains summaries of U.S. government-sponsored research, development, and engineering, plus analyses prepared by federal agencies, their contractors, or grantees. Also included are the results of government-sponsored research and development from countries outside the United States. Some state and local government agencies also contribute summaries of their reports to the database. NTIS has a broad range of subject coverage including environmental pollution and control, agriculture and food, medicine, and biology.

- Pollution Abstracts (File 41) is a leading resource for references to environmentally related literature on pollution, its sources, and its control. Subject coverage includes, air pollution, environmental quality, pesticides, and water pollution.

- RTECS (Registry of Toxic Effects of Chemical Substances) (File 336) is a non-bibliographic databank focusing upon the acute and chronic effects of potentially toxic chemicals, data on skin/eye irritation, carcinogenicity, mutagenicity, and reproductive consequences. References are available for all data. Toxicology and carcinogenic reviews, when available are cited. RTECS is built and maintained by NIOSH. This file is updated quarterly and contains toxicity information on more than 100,000 chemicals.

- Science (File 370) is published by the American Association for the Advancement of Science and covers the physical, biological, and social sciences.

- SCISEARCH (Files 34, 434, 294) is an international, multidisciplinary index to the literature of science, technology, biomedicine, and related disciplines, and is produced by the Institute for Scientific Information. It contains all of the records published in the Science Citation Index , plus additional records from the Current Contents publications. This file is useful for searching for specific authors and keeping abreast of current publications in the field of toxicology. It is not recommended for inclusion in standard searches.

- TOXLINE (File 156) is international in coverage and comprises several subfiles covering toxicological, pharmacological, biochemical, and physiological effects of chemicals and drugs. TOXLINE is updated monthly and contains more than 2,400,000 records.

- Wilson Biological and Agricultural Index (File 143) indexes approximately 258 periodicals that pertain to biology and agriculture. Subject coverage includes agricultural chemicals, biology, botany, ecology, environmental science, fishery sciences, genetics, and other topics.

- Zoological Record (File 185) provides extensive coverage of the world's zoological literature and includes a unique systematics field that provides complete taxonomic hierarchy information. Subject coverage includes ecology, genetics, habitat, histology, life cycle and development, and related topics.

- Pascal (File 144) is a multidisciplinary database including literature from international sources. Subjects include life sciences, biology, medicine, chemistry, food and agricultural sciences.

APPENDIX C

COBALT SEARCH EXAMPLE FOR LABORATORY MAMMALS

Cover Sheet

Date of Search 6/4/99
Performed By Carmen Diaz
Results Examined By Diego Reviera

Summary of Strategy

The following files in Dialog were searched:
154, 155, 156, 5, 10, 203, 399, 337, 77, 35, 40, 68, 76, 41, 336, 370, 143, 185, 6, 50, 144 with no year restrictions. File 154 was included in the example search but was dropped from subsequent searches because it overlaps with the information in File 155, the more comprehensive file in Medline. Please note that the term "*drinking water*" was not in the list of toxicological terms. Subsequent searches included this term.

The detailed search strategy from DIALOG is appended to this cover sheet. Included is a summarized version of the Cobalt search strategies for each receptor. Examination of preliminary searches for cobalt and laboratory mammal receptors indicated the need to add many exclusion terms specific to cobalt. It became apparent that the literature associated with the use of cobalt 60 as a radiotherapeutic agent would need to be excluded. Therefore, exclusion terms such as not *cobalt 60, irridation, co60, 60co* were used to focus the search. Similarly the large number of literature retrievals related to the use of cobalt alloys in surgical implants were excluded by using exclusion terms such as *prosthesis, implant, alloy*, and *cobalt samarium* were used. Retrieved abstracts were coded and downloaded into ProCite.

DIALOG Example of Cobalt Search for Laboratory Mammals
(Note that the bold and italicized wording is not system supplied.)

Enter an option number to view information or to connect to an online service. Enter a BEGIN command plus a file number to search a database (e.g., B1 for ERIC).

?b154,155,156,5,10,203,399,337,77,35,40,68,76,41,336,370,143,185,6,50,144

SYSTEM:OS - DIALOG OneSearch

File 154:MEDLINE(R) 1993-1999/Jul W4
(c) format only 1999 Dialog Corporation
*File 154: reloaded, note accession numbers changed.
File 155:MEDLINE(R) 1966-1999/Jul W4
(c) format only 1999 Dialog Corporation
*File 155: reloaded, note accession numbers changed.
File 156:Toxline(R) 1965-1999/May
(c) format only 1999 The Dialog Corporation
*File 156: reloaded, note accession numbers changed.
File 5:Biosis Previews(R) 1969-1999/May W4
(c) 1999 BIOSIS
File 10:AGRICOLA 70-1999/May
(c) format only 1999 The Dialog Corporation
File 203:AGRIS 1974-1999/Apr
Dist by NAL, Intl Copr. All rights reserved
File 399:CA SEARCH(R) 1967-1999/UD=13023
(c) 1999 American Chemical Society
*File 399: Use is subject to the terms of your user/customer agreement.
RANK charge added; see HELP RATES 399.
File 337:CHEMTOX (R) Online 1998/Q3
(c) 1998 MDL Info Systems
File 77:Conference Papers Index 1973-1999/May
(c) 1999 Cambridge Sci Abs
File 35:Dissertation Abstracts Online 1861-1999/Jun
(c) 1999 UMI
File 40:Enviroline(R) 1975-1999/Mar
(c) 1999 Congressional Information Service
File 68:Env.Bib. 1974-1999/May
(c) 1999 Internl Academy at Santa Barbara
File 76:Life Sciences Collection 1982-1999/Mar
(c) 1999 Cambridge Sci Abs
File 41:Pollution Abs 1970-1999/Jun
(c) 1999 Cambridge Scientific Abstracts
File 336:RTECS 1999/Q2
Comp & dist by NIOSH, Intl Copyright All Rights Res
File 370:Science 1996-1999/Apr W3
(c) 1999 AAAS
File 143:Biol. & Agric. Index 1983-1999/Apr
(c) 1999 The HW Wilson Co

File 185:Zoological Record Online(R) 1978-1999/V135P26
(c) 1999 BIOSIS
File 6:NTIS 64-1999/Jun W4
Comp&distr 1998 NTIS, Intl Copyright All Rights Res
File 50:CAB Abstracts 1972-1999/May
(c) 1999 CAB International
File 144:Pascal 1973-1999/May
(c) 1999 INIST/CNRS

STEP 1 Search the chemical name, synonyms, CAS numbers

Set Items Description
--- ----- -----------

?s cobalt? or RN=7440-48-4 or rn=71-48-7 or rn=7646-79-9 or rn=10141-05-6 or rn=10124-43-3 or rn=544-18-3 or rn=60459-08-7 or rn=69098-14-2

>>>One or more prefixes are unsupported
>>> or undefined in one or more files.
332504 COBALT?
126866 RN=7440-48-4
2513 RN=71-48-7
7238 RN=7646-79-9
2003 RN=10141-05-6
2295 RN=10124-43-3
103 RN=544-18-3
6 RN=60459-08-7
10 RN=69098-14-2
S1 399089 COBALT? OR RN=7440-48-4 OR RN=71-48-7 OR RN=7646-79-9 OR RN=10141-05-6 OR RN=10124-43-3 OR RN=544-18-3 OR RN=60459-08-7 OR RN=69098-14-2

TOTAL HITS FOR SET 1 = 399,089

STEP 2 Combine set 1 hits with receptors

?s ***s1 and (rat or rats or mice or mouse or hamster? or (guinea()pig?) or rabbit? or monkey?)***

Processing
Processing
Processed 10 of 21 files ...
Processing
Processed 20 of 21 files ...
Processing
Completed processing all files
399089 S1
2965989 RAT
2588600 RATS
1575461 MICE
1454660 MOUSE
308385 HAMSTER?
456112 GUINEA

1310041 PIG?
408460 GUINEA(W)PIG?
958907 RABBIT?
252393 MONKEY?
S2 18205 S1 AND (RAT OR RATS OR MICE OR MOUSE OR HAMSTER? OR (GUINEA()PIG?) OR RABBIT? OR MONKEY?)

TOTAL HITS FOR SET 2 =18,205

STEP 3 Combine set 2 hits with toxicological terms

?s s2 and (reproduc? or diet or dietary or systemic or development? or histolog? or growth or neurological or behav? or mortal? or lethal? or surviv?)
Processing
Processing
Processed 10 of 21 files ...
Processing
Processing
Processed 20 of 21 files ...
Processing
Completed processing all files
18205 S2
1451016 REPRODUC?
801329 DIET
511117 DIETARY
473838 SYSTEMIC
4531328 DEVELOPMENT?
879511 HISTOLOG?
3464725 GROWTH
163753 NEUROLOGICAL
2562160 BEHAV?
857457 MORTAL?
229774 LETHAL?
1062016 SURVIV?
S3 4622 S2 AND (REPRODUC? OR DIET OR DIETARY OR SYSTEMIC OR DEVELOPMENT? OR HISTOLOG? OR GROWTH OR NEUROLOGICAL OR BEHAV? OR MORTAL? OR LETHAL? OR SURVIV?)

Total Hits for SET 3 = 4,622

?s s3 not human/ti,de,mesh
>>>Term "MESH" is not defined in one or more files
Processing
>>>Term "TI" is not defined in one or more files
>>>Term "DE" is not defined in one or more files
Processed 10 of 21 files ...
Completed processing all files
4622 S3
8984086 HUMAN/TI,DE,MESH
S4 4401 S3 NOT HUMAN/TI,DE,MESH

?***s s4 not vitro/ti,de***
>>>Term "TI" is not defined in one or more files
>>>Term "DE" is not defined in one or more files
4401 S4
1035942 VITRO/TI,DE
S5 4231 S4 NOT VITRO/TI,DE
?***s s5 not culture?/ti,de***
>>>Term "TI" is not defined in one or more files
>>>Term "DE" is not defined in one or more files
Processing
Processed 20 of 21 files ...
Completed processing all files
4231 S5
2025762 CULTURE?/TI,DE
S6 3817 S5 NOT CULTURE?/TI,DE
?***s s6 not inhalation/ti,de,mesh***
>>>Term "MESH" is not defined in one or more files
>>>Term "TI" is not defined in one or more files
>>>Term "DE" is not defined in one or more files
3817 S6
128292 INHALATION/TI,DE,MESH
S7 3768 S6 NOT INHALATION/TI,DE,MESH
?***s s7 not subcutaneous/ti,de,mesh***
>>>Term "MESH" is not defined in one or more files
>>>Term "TI" is not defined in one or more files
>>>Term "DE" is not defined in one or more files
3768 S7
88182 SUBCUTANEOUS/TI,DE,MESH
S8 3742 S7 NOT SUBCUTANEOUS/TI,DE,MESH
?***s s8 not inject?/ti,de***
>>>Term "TI" is not defined in one or more files
>>>Term "DE" is not defined in one or more files
3742 S8
501953 INJECT?/TI,DE
S9 3638 S8 NOT INJECT?/TI,DE
?***s s9 not gene/ti,de***
>>>Term "TI" is not defined in one or more files
>>>Term "DE" is not defined in one or more files
3638 S9
1853901 GENE/TI,DE
S10 3549 S9 NOT GENE/TI,DE
?***s s10 not tumo?/ti,de***
>>>Term "TI" is not defined in one or more files
>>>Term "DE" is not defined in one or more files
Processing
Processed 20 of 21 files ...
Completed processing all files
3549 S10
1541887 TUMO?/TI,DE
S11 3330 S10 NOT TUMO?/TI,DE

?***s s11 not carcin?/ti,de***
>>>Term "TI" is not defined in one or more files
>>>Term "DE" is not defined in one or more files
3330 S11
1110313 CARCIN?/TI,DE
S12 3233 S11 NOT CARCIN?/TI,DE
?***s s12 not cancer?/ti,de***
>>>Term "TI" is not defined in one or more files
>>>Term "DE" is not defined in one or more files
3233 S12
830864 CANCER?/TI,DE
S13 3212 S12 NOT CANCER?/TI,DE
?***s s13 not (60co or co60 or (cobalt()60) or irradiat? or (gamma()ray?) or neutron? or (gamma()irradiat?) or radiation or (x()ray?) or (fission) or alloy?)***
Processing
Processing
Processed 10 of 21 files ...
Processing
Processed 20 of 21 files ...
Processing
Processing
Completed processing all files
3212 S13
11936 60CO
1210 CO60
326867 COBALT
1117638 60
15594 COBALT(W)60
614534 IRRADIAT?
942297 GAMMA
1563886 RAY?
196437 GAMMA(W)RAY?
297005 NEUTRON?
942297 GAMMA
614534 IRRADIAT?
57791 GAMMA(W)IRRADIAT?
1853870 RADIATION
2068374 X
1563886 RAY?
927158 X(W)RAY?
76200 FISSION
1283639 ALLOY?
S14 1527 S13 NOT (60CO OR CO60 OR (COBALT()60) OR IRRADIAT? OR (GAMMA()RAY?) OR NEUTRON? OR (GAMMA()IRRADIAT?) OR RADIATION OR (X()RAY?) OR (FISSION) OR ALLOY?)
?***s s14 not (radiotherap? or prosthes? or implant? or radioiso? or (samarium()cobalt) or patient? or worker? or child? or epileps? or epilept?)***
Processing
Processing
Processed 10 of 21 files ...

Processing
Processed 20 of 21 files ...
Completed processing all files
1527 S14
276877 RADIOTHERAP?
36145 PROSTHES?
443740 IMPLANT?
306004 RADIOISO?
29125 SAMARIUM
326867 COBALT
2126 SAMARIUM(W)COBALT
5104818 PATIENT?
316132 WORKER?
2165976 CHILD?
137760 EPILEPS?
70125 EPILEPT?
S15 1245 S14 NOT (RADIOTHERAP? OR PROSTHES? OR IMPLANT? OR RADIOISO? OR (SAMARIUM()COBALT) OR PATIENT? OR WORKER? OR CHILD? OR EPILEPS? OR EPILEPT?)

STEP 5 Remove duplicates
?rd
>>>Duplicate detection is not supported for File 337.
>>>Duplicate detection is not supported for File 336.

>>>Records from unsupported files will be retained in the RD set.
...examined 50 records (50)
...examined 50 records (100)
...examined 50 records (150)
...examined 50 records (200)
...examined 50 records (250)
...examined 50 records (300)
...examined 50 records (350)
...examined 50 records (400)
...examined 50 records (450)
...examined 50 records (500)
...examined 50 records (550)
...examined 50 records (600)
...examined 50 records (650)
...examined 50 records (700)
...examined 50 records (750)
...examined 50 records (800)
...examined 50 records (850)
...examined 50 records (900)
...examined 50 records (950)
...examined 50 records (1000)
...examined 50 records (1050)
...examined 50 records (1100)
...examined 50 records (1150)
...examined 50 records (1200)

...completed examining records
S16 760 RD (unique items)

TOTAL HITS USING ALL EXCLUSION TERMS = 760

EXAMPLE OF TITLES FROM THIS SEARCH WITH KEY WORDS IN CONTEXT
?t s16/6,k/378-384

>>>KWIC option is not available in file(s): 41, 77, 399
16/6,K/378 (Item 61 from file: 156)
DIALOG(R)File 156:(c) format only 1999 The Dialog Corporation. All rts. reserv.

01972309 Subfile: ETIC-35645
The influence of zinc and cobalt on the deoxyribonucleic acid biosynthesis and on the genetic information transmission in experimental animals. 2. Effect on the serum protein biosynthesis and on embryonic development
Publication Year: 1984

The influence of zinc and cobalt on the deoxyribonucleic acid biosynthesis and on the genetic information transmission in experimental animals. 2. Effect on the serum protein biosynthesis and on embryonic development
Descriptors/Keywords: RATTUS; MAMMAL, RAT; FEMALE; VIABILITY, FERTILITY AND MORTALITY ; GROWTH ; EXTRA-EMBRYONIC STRUCTURES; HEMIC AND LYMPHATIC SYSTEMS; CARDIOVASCULAR SYSTEM; ZINC CHLORIDE; COBALT CHLORIDE

16/6,K/379 (Item 62 from file: 156)
DIALOG(R)File 156:(c) format only 1999 The Dialog Corporation. All rts. reserv.

01971449 Subfile: ETIC-34372
The action of zn and co upon DNA synthesis and serum proteins during prenatal development of albino rats
Publication Year: 1984

The action of zn and co upon DNA synthesis and serum proteins during prenatal development of albino rats
Descriptors/Keywords: RATTUS, ALBINO; MAMMAL, RAT ; FEMALE; VIABILITY, FERTILITY AND MORTALITY ; GROWTH ; GENETICS; BIOCHEMISTRY AND METABOLISM; DIGESTIVE SYSTEM; ZINC CHLORIDE; COBALT CHLORIDE

16/6,K/380 (Item 63 from file: 156)
DIALOG(R)File 156:(c) format only 1999 The Dialog Corporation. All rts. reserv.

01970572 Subfile: ETIC-32560
Effect of short-term exposure to five industrial metals on the embryonic and fetal development of the mouse
Publication Year: 1984

Effect of short-term exposure to five industrial metals on the embryonic and fetal development of the mouse
Descriptors/Keywords: MUS, NMRI; MAMMAL, MOUSE ; FEMALE; VIABILITY, FERTILITY AND MORTALITY ; HEMIC AND LYMPHATIC SYSTEMS; GROWTH ; MUSCULOSKELETAL SYSTEM; NERVOUS SYSTEM; CRANIUM AND FACE; ALUMINUM CHLORIDE; COBALT DICHLORIDE; SODIUM MOLYBDATE; SODIUM TUNGSTATE; VANADIUM PENTOXIDE
CAS Registry No.: 7446-70-0; 7646-79-9 ; 7631-95-0; 13472-45-2; 1314-62-1

16/6,K/381 (Item 64 from file: 156)
DIALOG(R)File 156:(c) format only 1999 The Dialog Corporation. All rts. reserv.

01903739 Subfile: NTIS-PB83-209841
Development of a Toxicity Test System Using Primary Rat Liver Cells.
Publication Year: 1981

Development of a Toxicity Test System Using Primary Rat Liver Cells.
TD3: A model in vitro rat liver parenchymal cellular toxicity system employing cells obtained by the in situ collagenase perfusion technique...

... toxicants. The initial evaluation of this test system was accomplished using cadmium chloride, chromium chloride, cobalt chloride, mercuric chloride, nickelous chloride, sodium arsenite, sodium selenite, and ammonium vanadate. Linear regression analysis...

16/6,K/382 (Item 65 from file: 156)
DIALOG(R)File 156:(c) format only 1999 The Dialog Corporation. All rts. reserv.

01898117 Subfile: HEEP-82-13891
Cobaltous chloride effects on hexa chloro butadiene nephro toxicity
HEEP COPYRIGHT: BIOL ABS.
Publication Year: 1982

Cobaltous chloride effects on hexa chloro butadiene nephro toxicity
ABSTRACT RAT MORTALITY PROTEIN SYNERGISM
CAS Registry No.: 7646-79-9 ; 87-68-3

16/6,K/383 (Item 66 from file: 156)
DIALOG(R)File 156:(c) format only 1999 The Dialog Corporation. All rts. reserv.

01891217 Subfile: HEEP-82-06474
Serum lipoprotein patterns in rats and the effects of some pollutants.
HEEP COPYRIGHT: BIOL ABS.
Publication Year: 1981

Serum lipoprotein patterns in rats and the effects of some pollutants.
Serum tissue lipids were analyzed to determine the suspected role of dietary oils in combination with some chemicals on induced hyperlipidemia in rats. Mustard and rapeseed oils increased triglyceride levels of tissues and blood. Trace elements (V) and...
CAS Registry No.: 8002-13-9; 7440-62-2; 7440-48-4 ; 57-06-7; 50-29-3

16/6,K/384 (Item 67 from file: 156)
DIALOG(R)File 156:(c) format only 1999 The Dialog Corporation. All rts. reserv.

01884542 Subfile: HEEP-81-08151
Iron, lead and cobalt absorption: Similarities and dissimilarities.
HEEP COPYRIGHT: BIOL ABS.
Publication Year: 1981

Iron, lead and cobalt absorption: Similarities and dissimilarities.
Using isolated intestinal segments in rats , the absorption of Fe, Pb and Co was increased in Fe deficiency and decreased in...

... i.v. Fe injection and after parenteral endotoxin injection. Acute bleeding or abbreviated intervals of dietary Fe deprivation resulted in increased Fe absorption from isolated intestinal segments and in intact animals...

... absorptive mechanism apparently is selectively enhanced for Fe absorption by phlebotomy or brief periods of dietary Fe deprivation, or 2 or more mucosal pathways for Fe absorption may exist.
CAS Registry No.: 7440-48-4 ; 7439-92-1; 7439-89-6

Summarized version of Cobalt Search Strategies by Receptor

(Note that the term "drinking water" should be added to list of toxicological endpoints for future searches)

Cobalt Laboratory Mammal Search

b 155,156,5,10,203,399,337,77,35,40,68,76,41,336,370,143,185,6,50,144

s cobalt? or rn=7440-48-4 or rn=71-48-7 or rn=7646-79-9 or rn=10141-05-6 or rn=10124-43-3 or rn=544-18-3 or rn=60459-08-7 or rn=69098-14-2

and (rat or rats or mice or mouse or hamster? or (guinea()pig?) or rabbit? or monkey?)

and (reproduc? or diet or dietary or systemic or development? or histolog? or growth or neurological or behav? or mortal? or lethal? or surviv?)

Not human/ti,de
Not vitro/ti,de
Not culture?/ti,de
Not inhalation/ti,de
Not subcutaneous/ti,de
Not gene/ti,de
Not inject?/ti,de
Not tumo?/ti,de
Not carcin?/ti,de
Not cancer?/ti,de

Additonal exclusions:

Not (60c or co60 or (cobalt()60) or irradiat? Or (gamma()ray?) or neutron? Or (gamma()irradiat?) or radiation or (x()ray?) or fission or alloy?)

Not (radiotherap? Or prosthes? Or implant? Or radioiso? Or (samarium()cobalt) or patient? Or worker? Or child? Or epileps? or epilept?)

Rd

Cobalt Wild Mammal Search

b 155,156,5,10,203,399,337,77,35,40,68,76,41,336,370,143,185,6,50,144

s cobalt? or RN=7440-48-4 or rn=71-48-7 or rn=7646-79-9 or rn=10141-05-6 or rn=10124-43-3 or rn=544-18-3 or rn=60459-08-7 or rn=69098-14-2

and (didelphidae or opossum? or soricidae or shrew? or talpidae or armadillo? or dasypodidae or ochotonidae or leporidae)

or canidae or ursidae or procyonidae or mustelidae or felidae or cat or cats or dog or dogs or bear or bears or weasel? or skunk? or marten or martens or badger? or ferret? or mink?

or aplodontidae or beaver? or sciuridae or geomyidae or heteromyidae or castoridae or equidae or suidae or dicotylidae or cervidae or antilocapridae or bovidae

or arvicolinae or mycocastoridae or dipodidae or erethizontidae or sigmodon? or (harvest()mice) or (harvest()mouse) or microtus or peromyscus or reithrodontomys or onychomys or vole or voles or lemming?

and (reproduc? or diet or dietary or systemic or development? or histolog? or growth or neurological or behav? or mortal? or lethal? or surviv?)

Not human/ti,de
Not vitro/ti,de
Not culture?/ti,de
Not inhalation/ti,de
Not subcutaneous/ti,de

Not gene/ti,de
Not inject?/ti,de
Not tumo?/ti,de
Not carcin?/ti,de
Not cancer?/ti,de

Additonal exclusions:

Not (60c or co60 or (cobalt()60) or irradiat? Or (gamma()ray?) or neutron? Or (gamma()irradiat?) or radiation or (x()ray?) or fission or alloy?)

Not (radiotherap? Or prosthes? Or implant? Or radioiso? Or (samarium()cobalt) or patient? Or worker? Or child? Or epileps? or epilept?)

Rd

Cobalt Avian Receptor Search

b 155,156,5,10,203,399,337,77,35,40,68,76,41,336,370,143,185,6,50,144

s cobalt? or RN=7440-48-4 or rn=71-48-7 or rn=7646-79-9 or rn=10141-05-6 or rn=10124-43-3 or rn=544-18-3 or rn=60459-08-7 or rn=69098-14-2

and (chicken? or duck or duckling? or ducks or mallard? or quail? or (japanese()quail?) or coturnix or (gallus()domesticus) or platyrhyn? or anas or aves or avian or bird?)

or (song()bird?) or bobwhite? or (water()bird?) or (water()fowl)
and (reproduc? or diet or dietary or systemic or development? or histolog? or growth or neurological or behav? or mortal? or lethal? or surviv?)

Not Human/ti,de
Not vitro/ti,de
Not culture?/ti,de
Not inhalation/ti,de
Not subcutaneous/ti,de
Not gene/ti,de
Not inject?/ti,de
Not tumo?/ti,de
Not carcin?/ti,de
Not cancer?/ti,de

Additonal exclusions:

Not (60c or co60 or (cobalt()60) or irradiat? Or (gamma()ray?) or neutron? Or (gamma()irradiat?) or radiation or (x()ray?) or fission or alloy?)

Not (radiotherap? Or prosthes? Or implant? Or radioiso? Or (samarium()cobalt) or patient? Or worker? Or child? Or epileps? or epilept?)

Rd

Cobalt Amphibians & Reptiles Search

b 155,156,5,10,203,399,337,77,35,40,68,76,41,336,370,143,185,6,50,144

s cobalt? or RN=7440-48-4 or rn=71-48-7 or rn=7646-79-9 or rn=10141-05-6 or rn=10124-43-3 or rn=544-18-3 or rn=60459-08-7 or rn=69098-14-2

and (amphibi? or frog? or salamander? or newt or newts or toad? or reptil? or crocodil? or alligator? or caiman? snake? or lizard? or turtle? or tortoise? or terrapin?)

and (reproduc? or diet or dietary or systemic or development? or histolog? or growth or neurological or behav? or mortal? or lethal? or surviv?)

Not human/ti,de
Not vitro/ti,de
Not culture?/ti,de
Not inhalation/ti,de
Not subcutaneous/ti,de
Not gene/ti,de
Not inject?/ti,de
Not tumo?/ti,de
Not carcin?/ti,de
Not cancer?/ti,de

Additonal exclusions:

Not (60c or co60 or (cobalt()60) or irradiat? Or (gamma()ray?) or neutron? Or (gamma()irradiat?) or radiation or (x()ray?) or fission or alloy?)

Not (radiotherap? Or prosthes? Or implant? Or radioiso? Or (samarium()cobalt) or patient? Or worker? Or child? Or epileps? or epilept?)

Rd

APPENDIX D

CHEMICAL LIST

METALS: The names of salts marked with a bullet (•) are included as general information.

CHEMICAL	CAS #
ALUMINUM (alumin*)	
•Aluminum	7429-90-5
•Aluminum chloride	7446-70-0
•Aluminum fluoride	7784-18-1
•Sulfuric acid, Aluminum ammonium salt (2:1:1)	7784-25-0
•Sulfuric acid, Aluminum salt (3:2)	10043-01-3
•Sulfuric acid, Aluminum potassium salt	10043-67-1
•Aluminum nitrate (A1(NO3)3)	13473-90-0
•Aluminum potassium sulfate (A1K(SO4)2)	10043-67-1
•Aluminum sulfate	10043-01-3
•Aluminum sulfate hydrate	17927-65-0
•Aluminum nitrate nonahydrate	7784-27-2
•Aluminum chloride hexahydrate	7784-13-6
•Aluminum fluoride trihydrate	15098-87-0
•Aluminum chloride hydrate	10124-27-3
•Aluminum sulfate octahydrate	7784-31-8
•Aluminum fluoride dihydrate	32287-65-3
•Aluminum sulfate hydrate	16828-11-8

•These terms were not used in the search strategy. All references to these aluminum salts are retrieved by truncating alumin* and using the CAS numbers.

ANTIMONY (antimon*)	
•Antimony III	7440-36-0
•Potassium antimonate	1333-78-4
• Antimony potassium tartrate	28300-74-5
•Antimony trichloride	10025-91-9
•Antimony trifluoride	7783-56-4
•Antimony trisulfide	1345-04-6
•L-Antimony potassium tartrate	11071-15-1
•Potassium hexahydroantimonate	12208-13-8
•Sodium hexahydroxy antimonate	33908-66-6
•Hexahydroxyantimonate (1-) potassium	63994-33-2

•These terms were not used in the search strategy. All references to these antimony salts are retrieved by truncating antimon* and using the CAS numbers.

**ARSENIC (arsen*)	
Arsenic	7440-38-2
Arsenic acid, Sodium salt	7631-89-2
Arsenic acid (H3AsO4)	7778-39-4
Arsenic acid, Disodium salt	7778-43-0
Arsenous trichloride	7784-34-1
Arsenic acid, Lead (2+) salt (1:1)	7784-40-9
Arsenic acid, Diammonium salt	7784-44-3
Arsenenous acid, Sodium salt	7784-46-5
Arsenic acid, Disodium salt, Heptahydrate (Na2AsH3O4.7H2O)	10048-95-0
Sodium arsenate (NaAsO3)	15120-17-9
Sodium arsenate (NaAsO4)	13464-38-5
Sodium arsenate (generic form)	7631-89-2
Sodium arsenite (Na2HAsO3)	13466-06-3
Sodium arsenate (Na3AsO3)	13464-37-4

**BARIUM (barium/ barite)	
Barium carbonate	513-77-9
Barium acetate	543-80-6
Barium nitrate hydrate	115216-77-8
Barium chloride hydrate	10326-27-9
Barium	7440-39-3
Barium sulfate	7727-43-7
Barium nitrate	10022-31-8
Barium chloride	10361-37-2
Barite (barium sulfate)	13462-86-7
Barium sulfide	21109-95-5

**BERYLLIUM (beryllium)	
Beryllium	7440-41-7
Beryllium chloride	7787-47-5
Beryllium fluoride	7787-49-7
Beryllium hydroxide	13327-32-7
Beryllium nitrate (Be(NO3)2.3H20)	7787-55-5
Beryllium nitrate (BeN2O6)	13597-99-4
Beryllium silicate	12161-82-9
Beryllium sulfate	13510-49-1
Beryllium sulfate tetrahydrate	7787-56-6

CADMIUM (cadmium)	
Cadmium	7440-43-9
•Cadmium acetate	543-90-8
•Cadmium bromide	7789-42-6
•Cadmium chloride	10108-64-2
•Cadmium iodide (CdCI2)	7790-80-9
•Nitric acid, Cadmium salt tetrahydrate	10022-68-1
•Cadmium nitrate	10325-94-7
•Cadmium sulfate	10124-36-4
•Cadmium chloride hydrate	7790-78-5
•Cadmium sulfate 8/3H2O	7790-84-3
•Cadmium acetate hydrate	89759-80-8

•Cadmium chloride hydrate	34330-64-8

• These terms were not used in the search strategy. All references to these cadmium salts are retrieved by cadmium and the CAS numbers.

CHROMIUM (chromium, chromate, chromic, chrome, (chrome(n)6), (chromium(n)6), hexachrome, chromous)

•Acetic acid, Chromium (3+) salt	1066-30-4
Chromium	7440-47-3
•Chromic acid (+6)	7738-94-5
•Sodium chromate (+6)	7775-11-3
•Chromic acid, Dipotassium salt (+6)	7778-50-9
•Chromium fluoride (+3)	7788-97-8
•Chromic acid, Diammonium salt (+6)	7788-98-9
•Chromic acid, Dipotassium salt (+6)	7789-00-6
•Chromium chloride (+3)	10025-73-7
•Sulfuric acid, Chromium (3+) salt (3:2)	10101-53-8
•Chromium potassium sulfate (+3)	10141-00-1
•Sodium dichromate (+6)	10588-01-9
•Sodium chromate (unknown formula)	12680-48-7
•Chromic acid (+6)	13530-68-2
•Chromium (III) nitrate (+3)	13548-38-4
•Chromate (CrO4) (+6)	13907-45-4
•Chromate (+6)	13907-47-6
•Chromium sulfate pentahydrate (+3)	15244-38-9
Hexavalent chromium	18540-29-9
•Chromium nitrate nonahydrate	7789-02-8

• These terms were not used in the search strategy. All references to these chromium salts are retrieved by the use of the terms: chromium, chromate, chromic, chrome, (chrome(n)6), (chromium(n)6), hexachrome, chromous and the CAS numbers.

COBALT (cobalt*)

•Cobalt	7440-48-4
•Cobalt acetate	71-48-7
•Cobalt chloride	7646-79-9
•Cobalt nitrate	10141-05-6
•Cobalt sulfate	10124-43-3
•Cobalt(2)formate	544-18-3
•Cobalt sulfate hydrate	60459-08-7
•Cobalt chloride hydrate	690098-14-2

• These terms were not used in the search strategy. All references to these cobalt salts are retrieved by the truncation of cobalt* and the CAS numbers.

COPPER (copper, cupr*)

Copper	7440-50-8
•Copper chloride	1344-67-8
•Copper sulfate	1333-22-8
•Copper sulfate	7758-98-7
•Copper acetone	598-54-9
•Copper chloride hydroxide	1332-65-6
•Copper acetate	4180-12-5
•Acetic acid, Copper 2+ salt monohydrate	6046-93-1
•Sulfuric acid copper (2+) salt (1:1), Pentahydrate	7758-99-8
•Cupric acetate	142-71-2
•Cupric nitrate	3251-23-8
•Cuprous nitrate	3251-29-4
•Cupric chloride	7447-39-4
•Cuprous chloride	7758-89-6
•Cupric perchlorate	13770-18-8
•Copper acetate hydrate	66923-66-8
•Cupric chloride hydrate	13468-85-4
•Cupric nitrate hydrate	19004-19-4
•Copper chloride dihydrate	10125-13-0

• These terms were not used in the search stragegy. All references to these copper salts are retrieved by using the terms copper and truncating cupr* and the CAS number.

****IRON (iron, ferr*)**

Carbonic acid, Iron(2+)salt (1:1)	563-71-3
Iron	7439-89-6
Iron chloride	7705-08-0
Iron chloride FeC12	7758-94-3
Iron sulfates	10124-49-9
Nitric acid, Iron(3+) salt	10421-48-4
Iron hydroxide	11113-66-9
Iron chloride	12040-57-2
Carbonic acid, Iron (3+) salt	26273-46-1
Ferric hydroxide	1309-33-7
Ferrous sulfide	1317-37-9
Ferrous sulfate	7720-78-7
Ferric sulfate	10028-22-5
Ferrous hydroxide	18624-44-7
Ferric sulfate hydrate	10028-22-5
Iron trichloride hexahydrate	7705-08-0
Iron dichloride tetrahydrate	13478-10-9

•LEAD

The term "lead" cannot be used in a search strategy because the word is commonly used as a verb and noun. The following terms were developed to search this element and were used in combination with the CAS numbers listed below.

Lead level*	7439-92-1
Lead intake	301-04-2
Lead induce*	7758-95-4
Lead poison*	10099-74-8
Lead intoxi*	7446-14-2

Blood lead	546-67-8
Lead toxic*	13826-65-8
Lead metabol*	5224-23-7
Lead burden*	78-00-2
Dietary lead	7442-13-9
Lead emcephalopathy	15347-57-6
Lead expos*	
Trimethyl lead	
Trimethyllead	
Tributyl lead	
Tributyllead	
Lead tetraacetate	
Lead acetate	
Tetraethyl lead	
Trialkyl lead	
Inorganic lead	
Ambient lead	
Lead compound*	
Lead acetic	
TEL	
Pb	
Lead chloride	
Lead nitrate	
Lead sulfate	
Lead concentrat*	
Diethyl lead	
Plumbic	
Plumbous	

The term "*lead compound*" was used in the search strategy for this metal, but its use for future searches is not recommended. The pharmaceutical industry uses the term as a description for a particularly promising therapeutic agent from a group of structurally closely related compounds. Use of this term will retrieve many unrelated records.

****MANGANESE (manganese)**

Manganese	7439-96-5
Manganese (III) sulfate	13444-72-9
Manganese chloride	11132-78-8
Manganese chloride (MnC12)	7773-01-5
Manganese nitrate	10377-66-9
Manganese nitrate hydrate	15710-66-4
Manganese sulfate hydrate	15244-36-7

****NICKEL (nickel)**

Acetic acid, Nickel (2+) salt	373-02-4
Nickel chloride hexahydrate	7791-20-0
Nickel chloride hydrate	69098-15-3
Nickel (II) selenate	15060-62-5
Nickel	7440-02-0
Nickelous chloride	7718-54-9
Nickelous nitrate	13138-45-9
Sulfuric acid, nickel (2+) salt (1:1)	7786-81-4

Nickel sulfate hexahydrate	10101-97-0
Nickelous acetate tetrahydrate	373-02-4
Nickel (II) chloide hydrate	13478-00-7

SELENIUM (, seleni*, selenate, selenium)

•Selenium dioxide	7446-08-4
•Potassium selenate	7790-59-2
•Potassium selenite	10431-14-7
•Selenium	7782-49-2
•Selenous acid	7783-00-8
•Sodium selenate	13410-01-0
•Sodium selinite	10102-18-8

• These terms were not used in the search strategy. All references to these selenium salts are retrieved by using the terms seleni*, selenate, selenium and the CAS number.

****SILVER (silver)**

Acetic acid, Silver (1+)salt	563-63-3
Silver	7440-22-4
Silver nitrate	7761-88-8
Silver chloride	7783-90-6
Silver iodide	7783-96-2
Silver sulfate	10294-26-5

****VANADIUM (vanad*)**

Vanadium	7440-62-2
Vanadium chloride	7718-98-1
Vanadyl chloride	7727-18-6
Vanadic acid, Ammonium salt	7803-55-6
Sodium vanadate	13718-26-8
Vanadic acid, Trisodium salt	13721-39-6
o-Vanadate	14333-18-7

****ZINC (zinc)**

Zinc	7440-66-6
Zinc chloride	7646-85-7
Zinc nitrate	7779-88-6
Zinc sulfate	7733-02-0
Zinc acetate	557-34-6
Zinc peroxide	1314-22-3
Zinc phosphide	1314-84-7
Zinc sulfate heptahydrate	7446-20-0
Zinc bromide	7699-45-8
Zinc iodide	10139-47-6
Sulfurous acid, Zinc salt (1:1)	13597-44-9
Zinc nitrate hydrate	10196-18-6
Zinc acetate dihydrate	5970-45-6

ORGANICS

CHEMICAL	CAS #
DIELDRIN	60-57-1
dieldrin*	
alvit	
dieldrex	
heod	
panoram	
quintox	
dimethanonaphthalene	
****DDT GROUP**	50-29-3
DDT	
agritan	
anofex	
arkotine	
azotox	
bosan	
bovidermol	
chlorophenothan	
citox	
clofenotane	
dedelo	
deoval	
detox	
detoxan	
dibovan	
dichlorodiphenyltrichloroethane	
dicophane	
didigam	
didimac	
diphenyltrichloroethane	
dodat	
dykol	
estonate	
genitox	
gesafid	
gesapon	
gesarex	
gesarol	
guesapon	
guesarol	
byron	
havero*	
hildit	
ivoran	
ixodex	
kopsol	
mutoxin	
neocide	
parachlorocidum	
pentachlorin	

pentech
rukseam
santobane
ze*dane

****DDD** 72-54-8
dichlorodiphenyl(w)dichloroethane
dilene
rhothane
TDE

****DDE** 72-55-9
dichlorodiphenyl(w)dichloroethylene

****PENTACHLOROPHENOL** 87-86-5
pentachlorophen*
PCP
acutox
chem-penta
chem-tol
chlorophen
cryptogil
dowcide
crotox
fungifen
lauxtol
liroprem
nci
penchlorol
pentachlorofen*
pentacon
penta-kil
pentasol
penwar
peratox
permite
pervenol
priltox
santo*
weedone
witophen

RDX 121-82-4
RDX
hexolite
cyclonite
cyclotrimethylene*
trinitro(w)triazine
hexogen
pbx
trimethylenetrinitramine
trinitrocyclotrimethylene
triaza(n)trinitro(n)cycloc(n)hexane
trinitro(n)hexahydro(n)triazine

hexahydro(n)trinitro()triazine

Note: The term PBX was used in the search strategy for 121-82-4 but its use is not recommended. PBX is an acronym for several organic chemicals, e.g. piperonyl butoxide and the use of the term will retrieve unrelated records.

**TNT	118-96-7
TNT	
trinitrotoluene	
tolit*	
entosufon	
tritol	
triton	
trotyl	
trinitrotoluol	

**These chemicals terms have not been tested in a search strategy.

Wildlife PAH Literature Search and Acquisition

OVERVIEW

This Standard Operating Procedure (SOP) documents the procedure for used for polycyclic aromatic hydrocarbon (PAH) wildlife toxicological literature acquisition. The literature search and acquisition was completed by EPA MED-Duluth. These procedures were developed from Eco-SSL Standard Operating Procedure (SOP #3): *Acquisition of Literature to Support the Development of Toxicity Reference Values (TRVs) for Wildlife* , which provides direction for the retrieval of wildlife (birds, mammals, reptiles and amphibians) toxicological literature. Additional procedures for chemical terms, search strategy, literature tracking and acquisition were incorporated from the *Attachment 3-1 Eco-SSL SOP #1: Plant and Soil Invertebrate Literature Search and Acquisition*

LITERATURE IDENTIFICATION

Literature Identification in MED-Duluth Files

The literature identification process includes the scanning the terrestrial toxicity reference file for PAH citations. This reference file is located at the U.S. EPA, National Health and Ecological Effects Research Laboratory (NHEERL), Mid-Continent Ecology Division-Duluth (MED-Duluth). If the citation includes a PAH chemical and an identified species group, the citation was forwarded to the appropriate party for review of applicability.

Computerized Literature Searches

Online searches were performed using the DIALOG or SilverPlatter commercial database vendors. The search terms used for each database are listed in Attachment A. The first group of databases that were the focus of Eco-SSL literature searches were:

- AGRICOLA database (http://www.nal.usda.gov) provides a strong U.S. agricultural focus that has strict indexing codes for both toxicity and soil organisms.
- AGRIS International (http://www.icpa.ro/AgroWeb/AIC/RACC/Agris.htm) provides a strong international agricultural focus that has toxicity indexing codes.
- BIOSIS database (http://www.biosis.org/) provides a strict taxonomical indexing system. BIOSIS recently (1998) began adding Chemical Abstract Service (CAS) Registry numbers.
- CA Search database (http://www.cas.org/) provides a strict chemical indexing system, but lacks a taxonomical indexing system.

- Life Sciences Abstracts (http://www.csa.com/) provides toxicology abstracts. Some portions are already included in PolTox.

- PolTox database includes Toxline, NTIS and Pollution Abstracts, provided through SilverPlatter is available on CD-ROM at MED-Duluth.

DEVELOPMENT OF LITERATURE SEARCH STRATEGY

Literature search strategies were developed iteratively with each section of terms examined using different criteria. The search strategies included category codes, chemical terms, species specific terms, publication years, and exclusion terms. Attachment B provides a detailed summary of the literature search strategy development documentation.

Category Codes

Category codes are used within DIALOG databases to group documents by subject or topic. By specifically selecting category codes relevant to the Eco-SSL effort, the literature search output should result in a more focused data set. The Eco-SSL literature search strategy documentation (Attachment B) includes a summary of the category codes selected to focus the search (if necessary) for each DIALOG database.

Chemical Terms

The Eco-SSL Steering Committee identified the following list of terms as the initial focus of the polycyclic aromatic hydrocarbon (PAH) Eco-SSL effort.

> *Chemical Abstract Registry Numbers:* 83329, 208968, 120127 56553, 50328, 205992, 191242, 207089, 218019, 53703, 206440, 86737, 193395, 91203, 85018 , 129000, 130498292
>
> *Chemical Name Terms:* acenaphthene, acenaphth?lene, albocarbon, anthrac?n, anthrac?ne , benz*(w) (acephenanthrylene or anthracene or chrysene or fluoranthene, or fluorene or perylene or phenanthrene or pyrene or pyrilene), benzacenaphthene, benzanthracene, benzanthrazen, benzanthrene, benzfluoranthene, benzindene, benzoanthracene, benzochrysene, benzofluoranthene, benzofluorene, benzoperylene, benzophenanthrene, benzopyrene, benzopyrilene, benzperylene, benzphenanthrene, benzpyrene, benzypyrene, beta-pyren*, binaphthylene, biphenylenemethane, biphenylmethane, bis-alkylamino(w)anthracene, camphor(n1)tar, chrysene, coal(w)tar(w)pitch, cyclopenta(w)naphthalene, dezodorator, dibenz(w)antracene, dibenz*(w)anthracene, dibenz*(w)fluorene, dibenzanthracene, dibenzoanthracene, dibenzofluorene, dibenzonaphthalene, dihydroacenaphthylene, diphenylenemethane, ethylenenaphthalene, fluoranthene, fluorene, green(w)oil, idryl, inden*(w)pyrene, indenopyrene, methylenebiphenyl, mighty(w)(150 or rd1), naphthal?n, naphthal?ne, naphthalenediylbenzene, naphthanthracene, naphthene, naphthalenebenzene, naphthylenebenzene, naphthyleneethylene, ortho-phenylenepyrene, paranaphthalene,

peri-ethyl?nenaphthalene, phenanthr?n*, phenantrin, phenylenepyrene, pyrene, ravatite, tetra(w)olive, tetraphene, white(w)tar, (polynuclear or polycyclic(w) arom*(w)hydrocarbon*)

Species Terms

For species terms, refer to Table 1

CONDUCTING THE LITERATURE SEARCH

Instructions for performing the searches and defining BIBLIOLINKS output format for DIALOG and SilverPlatter are found in Eco-SSL Attachment 3-1. The following procedures were followed when conducting the literature search using an electronic abstracting database system.

- All chemicals were searched within a single search strategy.
- An attempt was made to search all databases at the same time, allowing for removal of duplicate entries across the various databases prior to downloading citations.
- Each species term grouping (amphibian/reptile, avian, mammal) was conducted as a separate search to reduce the number of records downloaded in a single search and to allow for the use of more specific search strategies.
- The Eco-SSL task group responsible for development of the wildlife toxicity reference values (TRVs) approved any modification to the search strategy prior to conducting the search.
- The strategies used for all searches were saved and downloaded electronically to avoid the possibility of typographical errors.
- Any modifications to the literature search strategy was examined by a second person before conducting the search.
- Copies of all search strategies and results (number of hits) were saved and a report provided to EPA (see 'Analysis of Search Results' section below).
- All data retrieved from the computerized literature search were transferred to a temporary ProCite database file using BIBLIOLINKS software and procedures according to the specifications provided for each commercial database.

IDENTIFICATION OF POTENTIALLY APPLICABLE PUBLICATIONS

The temporary ProCite bibliographic file containing the computerized search results was provided to the staff (contractor) responsible for identification of publications to be physically retrieved.

ATTACHMENT A: Literature Search Strategy

AGRICOLA, AGRIS International, BIOSIS, CASearch, databases provide an index code(s) for toxic effects data (see detailed search strategies below). Life Sciences Abstracts and PolTox do not require category codes to refine the search. The basic search will intersect two or three areas:

- species terms in the title, descriptor and abstract fields only
- PAH chemical terms in the title, descriptor and abstract fields only
- toxic effects indexing codes, as needed

Exclusion terms may also be used to further reduce the number of non-applicable citations located by a search strategy and included in the species list.

AGRICOLA Search

Species Terms (See Species List)

Chemical Names

acenaphthene, acenaphth?lene, albocarbon, anthrac?n, anthrac?ne , benz*(w) (acephenanthrylene or anthracene or chrysene or fluoranthene, or fluorene or perylene or phenanthrene or pyrene or pyrilene), benzacenaphthene, benzanthracene, benzanthrazen, benzanthrene, benzfluoranthene, benzindene, benzoanthracene, benzochrysene, benzofluoranthene, benzofluorene, benzoperylene, benzophenanthrene, benzopyrene, benzopyrilene, benzperylene, benzphenanthrene, benzpyrene, benzypyrene, beta-pyren*, binaphthylene, biphenylenemethane, biphenylmethane, bis-alkylamino(w)anthracene, camphor(n1)tar, chrysene, coal(w)tar(w)pitch, cyclopenta(w)naphthalene, dezodorator, dibenz*(w)antracene, dibenz*(w)anthracene, dibenz*(w)fluorene, dibenzanthracene, dibenzoanthracene, dibenzofluorene, dibenzonaphthalene, dihydroacenaphthylene, diphenylenemethane, ethylenenaphthalene, fluoranthene, fluorene, green(w)oil, idryl, inden*(w)pyrene, indenopyrene, methylenebiphenyl, mighty(w)(150 or rd1), naphthal?n, naphthal?ne, naphthalenediylbenzene, naphthanthracene, naphthene, naphthalenebenzene, naphthylenebenzene, naphthyleneethylene, ortho-phenylenepyrene, paranaphthalene, peri-ethyl?nenaphthalene, phenanthr?n*, phenantrin, phenylenepyrene, pyrene, ravatite, tetra(w)olive, tetraphene, white(w)tar, (polynuclear or polycyclic(w) arom*(w)hydrocarbon*)

Category Codes

(SH=W000 Pollution or L600 Animal Physiology)

AGRIS International Search

Species Terms (See Species List)

Chemical Names

acenaphthene, acenaphth?lene, albocarbon, anthrac?n, anthrac?ne , benz*(w) (acephenanthrylene or anthracene or chrysene or fluoranthene, or fluorene or perylene or phenanthrene or pyrene or pyrilene), benzacenaphthene, benzanthracene, benzanthrazen, benzanthrene, benzfluoranthene, benzindene, benzoanthracene, benzochrysene, benzofluoranthene, benzofluorene, benzoperylene, benzophenanthrene, benzopyrene, benzopyrilene, benzperylene, benzphenanthrene, benzpyrene, benzypyrene, beta-pyren*, binaphthylene, biphenylenemethane, biphenylmethane,

bis-alkylamino(w)anthracene, camphor(n1)tar, chrysene, coal(w)tar(w)pitch, cyclopenta(w)naphthalene, dezodorator, dibenz*(w)antracene, dibenz*(w)anthracene, dibenz*(w)fluorene, dibenzanthracene, dibenzoanthracene, dibenzofluorene, dibenzonaphthalene, dihydroacenaphthylene, diphenylenemethane, ethylenenaphthalene, fluoranthene, fluorene, green(w)oil, idryl, inden*(w)pyrene, indenopyrene, methylenebiphenyl, mighty(w)(150 or rd1), naphthal?n, naphthal?ne, naphthalenediylbenzene, naphthanthracene, naphthene, naphthalenebenzene, naphthylenebenzene, naphthyleneethylene, ortho-phenylenepyrene, paranaphthalene, peri-ethyl?nenaphthalene, phenanthr?n*, phenantrin, phenylenepyrene, pyrene, ravatite, tetra(w)olive, tetraphene, white(w)tar, (polynuclear or polycyclic(w) arom*(w)hydrocarbon*)

Category Codes

(SC=T01 Pollution or L74 Animal Production (Miscellaneous Disorders of Animals)

BIOSIS Search

Species Terms

Use species terms from Species List

Category Codes

CC=22501	Toxicology-general; Methods and Experimental
CC=22506	Toxicology-Environmental And Industrial Toxicology
CC=37015	Public Health: Air, Water or Soil Pollution
	(add CC22508 Veterinary Toxicology for lab mammals)

Chemical name/CAS#

Chemical Abstract Registry Numbers: 83329, 208968, 120127 56553, 50328, 205992, 191242, 207089, 218019, 53703, 206440, 86737, 193395, 91203, 85018 , 129000, 130498292

acenaphthene, acenaphth?lene, albocarbon, anthrac?n, anthrac?ne , benz*(w) (acephenanthrylene or anthracene or chrysene or fluoranthene, or fluorene or perylene or phenanthrene or pyrene or pyrilene), benzacenaphthene, benzanthracene, benzanthrazen, benzanthrene, benzfluoranthene, benzindene, benzoanthracene, benzochrysene, benzofluoranthene, benzofluorene, benzoperylene, benzophenanthrene, benzopyrene, benzopyrilene, benzperylene, benzphenanthrene, benzpyrene, benzypyrene, beta-pyren*, binaphthylene, biphenylenemethane, biphenylmethane, bis-alkylamino(w)anthracene, camphor(n1)tar, chrysene, coal(w)tar(w)pitch, cyclopenta(w)naphthalene, dezodorator, dibenz*(w)antracene, dibenz*(w)anthracene, dibenz*(w)fluorene, dibenzanthracene, dibenzoanthracene, dibenzofluorene, dibenzonaphthalene, dihydroacenaphthylene, diphenylenemethane, ethylenenaphthalene, fluoranthene, fluorene, green(w)oil, , idryl, inden*(w)pyrene, indenopyrene, methylenebiphenyl, mighty(w)(150 or rd1), naphthal?n, naphthal?ne, naphthalenediylbenzene, naphthanthracene, naphthene, naphthalenebenzene, naphthylenebenzene, naphthyleneethylene, ortho-phenylenepyrene, paranaphthalene, peri-ethyl?nenaphthalene, phenanthr?n*, phenantrin, phenylenepyrene, pyrene, ravatite, tetra(w)olive, tetraphene, white(w)tar, (polynuclear or polycyclic(w) arom*(w)hydrocarbon*)

CA Search Terms

Species Terms

Use species terms from Species List

Category Codes

SC=CA?04* (Toxicology)

CAS#

Chemical Abstract Registry Numbers: 83329, 208968, 120127 56553, 50328, 205992, 191242, 207089, 218019, 53703, 206440, 86737, 193395, 91203, 85018 , 129000, 130498292

PolTox and LifeSciences Abstracts Search

Species Terms Use species terms from Species List

Chemical names

acenaphthene, acenaphth?lene, albocarbon, anthrac?n, anthrac?ne , benz*(w) (acephenanthrylene or anthracene or chrysene or fluoranthene, or fluorene or perylene or phenanthrene or pyrene or pyrilene), benzacenaphthene, benzanthracene, benzanthrazen, benzanthrene, benzfluoranthene, benzindene, benzoanthracene, benzochrysene, benzofluoranthene, benzofluorene, benzoperylene, benzophenanthrene, benzopyrene, benzopyrilene, benzperylene, benzphenanthrene, benzpyrene, benzypyrene, beta-pyren*, binaphthylene, biphenylenemethane, biphenylmethane, bis-alkylamino(w)anthracene, camphor(n1)tar, chrysene, coal(w)tar(w)pitch, cyclopenta(w)naphthalene, dezodorator, dibenz*(w)antracene, dibenz*(w)anthracene, dibenz*(w)fluorene, dibenzanthracene, dibenzoanthracene, dibenzofluorene, dibenzonaphthalene, dihydroacenaphthylene, diphenylenemethane, ethylenenaphthalene, fluoranthene, fluorene, green(w)oil , idryl, inden*(w)pyrene, indenopyrene, methylenebiphenyl, mighty(w)(150 or rd1), naphthal?n, naphthal?ne, naphthalenediylbenzene, naphthanthracene, naphthene, naphthalenebenzene, naphthylenebenzene, naphthyleneethylene, ortho-phenylenepyrene, paranaphthalene, peri-ethyl?nenaphthalene, phenanthr?n*, phenantrin, phenylenepyrene, pyrene, ravatite, tetra(w)olive, tetraphene, white(w)tar, (polynuclear or polycyclic(w) arom*(w)hydrocarbon*)

Category Codes: none

Table 1: Wildlife PAH Species List

Amphibian/Reptile	**Avian**	**Mammals**
alligator alligators amphibi* caiman crocodil* frog frogs lizard lizards newt newts reptil* salamander* snake snakes terrapin* toad toads tortoise* turtle turtles *Biosystemic Codes (BIOSIS only)#* BC= Amphibians or Reptiles *Exclusion Terms* human (in descriptor field) venom*	aves avian* bird birds bobwhite* chicken chickens gallus duck ducks duckling* mallard* or anas quail or coturnix quails songbird* turkey turkeys waterbird* waterfowl *Biosystemic Codes (BIOSIS only)#* BC Birds *Exclusion Terms:* human (in descriptor field) food* (in descriptor field) cooking (in descriptor field)	***To Be Developed* *Species Terms:* *Effect/Toxicity Terms#:* *Biosystemic Codes (BIOSIS only)#* BC= nonhuman mammals *Exclusion Terms:*

All species terms are intersected with all effect/process terms and biosystemic codes.
NOTE: 3n= the second term is within three terms either before or after the first term;
w = the second term is adjacent to the first word

Attachment B: Search Development Documentation

The Task Group 1 SOP1 listing of applicable wildlife toxicity databases are listed in Table 1. This table is annotated with additional information to recommending the use in PAH searches. The recommendation is noted in Table 1:

Yes = high confidence that database will yield applicable citations and will be searched in the initial literature search strategy

? = unsure of confidence that the database will yield applicable citations or may only use for laboratory animals. These databases will be tested to determine a recommendation

No = low confidence that database will yield applicable citations and will not be tested further.

Tables 2 and 3 contain the amphibian/reptile and bird species term testing, respectively.

Table 1: Wildlife Search Database Listing from Task Group 1, SOP 1

Wildlife SOP Database	Cost*	Notes	Recommendation
Agricola (File 10)	DU: $2.50 PR: $1.20	Mostly oriented toward plants and soil organisms, but has useful toxicity data.	Yes
AGRIS International	DU:$2.25 PR:$1.25	International companion to Agricola (which is U.S. only)	Yes
BIOSIS (File 50)	DU:$5.25 PR:$1.55	Good categorization of toxicity, species and chemical terms that should be used in a large database.	Yes
CAB Abstracts (File 55)	DU:$2.75 PR:$1.60		?
CA Search (File 399)	DU:$11.75 PR:$2.45		Yes
CHEMTOX	DU:$3.00 PR:$12.90	Substance list, but has RTECS file imbedded it it.	?
Conference Papers Index (File 77)	DU:$2.75 PR:$1.80	Not useful, since we want fully completed research publications	No
Dissertation Abstracts	DU:$4.00 PR:$2.10	? Find in PolTox and other sources.	No
Enviroline	DU:$6.50 PR:$1.10	Few toxicity tests	No
Environmental Bibliography	DU:$2.25 PR:$1.05	Few toxicity tests	No
Life Science Collection (SilverPlatter)	DU:$4.75 PR:$1.65	Would not generally recommend, but can since we have the CDROM disks at MED. Overlaps with PolTox databases.	Yes

Wildlife SOP Database	Cost*	Notes	Recommend ation
MEDLINE	DU:$3.00 PR:$0.20	Only for laboratory animal tests?	Lab mammals only ?
NTIS (SilverPlatter)	DU:$5.50 PR:$1.70	Toxicity related dissertations included in PolTox/Toxline	Yes, within PolTox database
Pascal	DU:$3.25 PR:$1.45		?
Pollution Abstracts (SilverPlatter)	DU:$4.50 PR:$1.65		Yes, within PolTox database
RTECS	DU:$2.75 PR:$2.65	Search within CHEMTOX?	?
Science	DU:$3.25 PR:$2.10	Large database that does not specifically categorize toxicity data.	No
Toxline (SilverPlatter)	DU:$2.50 PR:$0.75		Yes
Wilson Biological and Agricultural Index	DU:$2.25 PR:$1.05		?
Zoological Record	DU:$5.75 PR:$2.05	Very few toxicity tests. Mostly related to ecological and taxonomic research.	No

* DU= Dialog Unit prices for online time, PR= Print cost per citation in DIALOG

Agricola

Documents cataloged and indexed in the AGRICOLA database are selected from current acquisitions of NAL and cooperating institutions. More than 2,000 serial titles are reviewed for indexing. Books, pamphlets, conference proceedings, translations, book chapters, research reports, government documents, in both English and many non-English languages, are included in the database. For additional coverage of non-U.S. agricultural materials, see AGRIS INTERNATIONAL, File 203. AGRICOLA includes audio-visual and microform media, and some computer software. Specific source information is indexed in the Subfile field, which contains codes for access of USDA, State Experiment Station, Cooperative Extension Service, and other U.S. publications. Subfile codes are also useful in searching non-U.S. imprints. Past use of subfile tags for subject specific sources has varied over the life of the database.

AGRIS International

AGRIS International is the international information system for agricultural sciences and technology. The AGRIS International database serves as a comprehensive inventory of worldwide agricultural literature which reflects research results, food production, and rural development to help users identify problems involved in all aspects of world food supply. Emphasis in AGRIS International is non-U.S. This file corresponds in part to the printed publication, Agrindex, published monthly by the Food and Agriculture Organization (FAO) of the United Nations.

AGRIS is a cooperative, decentralized system in which over 100 national and multinational centers take part. It collects and makes available current information on the agricultural literature of the world appearing in journals, books, reports, and conference papers. Each country which participates in AGRIS

does so by submitting information about documents published within its own territories. All contributing sources are of non-U.S. origin. FAO acts as a coordinating agency within this global information system, facilitating the exchange of agricultural information to its member countries.

BIOSIS Previews

BIOSIS Previews® contains citations from Biological Abstracts® (BA), and Biological Abstracts/ Reports, Reviews, and Meetings® (BA/RRM) (formerly BioResearch Index®), the major publications of BIOSIS®. Together, these publications constitute the major English-language service providing comprehensive worldwide coverage of research in the biological and biomedical sciences. Biological Abstracts includes approximately 350,000 accounts of original research yearly from nearly 6,000 primary journal and monograph titles. Biological Abstracts/RRM includes an additional 200,000+ citations a year from meeting abstracts, reviews, books, book chapters, notes, letters, selected institutional and government reports, and research communications. U.S. patents are included from 1986 through 1989.

Abstracts are available for records from the Biological Abstracts portion of the database starting in mid-1976 and for book synopses in BA/RRM starting in 1985. Most BA/RRM records do not contain abstracts.

CA SEARCH

The CA SEARCH®: Chemical Abstracts® database includes over 13 million citations to the worldwide literature of chemistry and its applications from 1967 forward. CA SEARCH corresponds to the bibliographic information and complete indexing found in the print Chemical Abstracts® published by CAS® (Chemical Abstracts Service). The controlled vocabulary CA General Subject Index Headings, related general subject terminology from the CA Index Guide, and CAS® Registry Numbers, each with its modifying phrase are included. Chemical substances are represented by CAS® Registry Numbers, unique numbers assigned to each specific chemical compound: corresponding substance information may be searched in the DIALOG chemical substance files such as CHEMSEARCHTM (File 398). All records from the 8th Collective Index Period forward are contained in File 399; Files 308-314 contain records from the individual Collective Index (CI) Periods as indicated in the File Data.

CAB Abstracts

CAB Abstracts is a comprehensive file of agricultural information containing all records in the more than 50 abstract journals published by CAB INTERNATIONAL (CABI). CABI has long been recognized as a leading scientific information service in agriculture and related sciences. Of particular note are sections in the database comprehensively covering literature in the fields of veterinary medicine, human nutrition, developing countries, leisure, recreation, and tourism. Over 14,000 serial journals in over 50 languages are scanned, as well as books, reports, and other publications. About 150,000 items per year are selected for inclusion in CAB Abstracts; over 95 percent of the literature is abstracted, while less important works are reported with bibliographic details only. An online thesaurus is available as an aid in locating broader, narrower, and related subject terms. File 250, ONTAP CAB Abstracts, is available for ONline Training And Practice; it contains approximately 38,000 CAB Abstracts records from early 1993.

CHEMTOX

The CHEMTOX® Online database is a collection of environmental, health, and safety data for chemical substances that have properties that either cause them to be addressed by legislation or regulation, or make them potential candidates for legislation or regulation. Currently, CHEMTOX includes information on chemicals identified and regulated by the U.S. Environmental Protection Agency (EPA) under regulations such as the Resource Conservation and Recovery Act (RCRA), the Clean Air Act (CAA), the Clean Water Act (CWA), the Toxic Substances Control Act (TSCA), Superfund Amendments and Reauthorization Act (SARA), and Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA); the U.S. Department of Transportation (DOT) under the Hazardous Materials Transport Act; and the U.S. Occupational Safety and Health Administration (OSHA) under the Occupational Safety and Health Act. In addition, chemicals listed by the U.S. National Institute for Occupational Safety and Health (NIOSH)

as workplace safety hazards and chemicals in the NIOSH Registry of Toxic Effects of Chemical Substances (RTECS) are included in CHEMTOX. Various lists of chemicals maintained by various agencies and governments are included in the CHEMTOX database. These lists include the carcinogens listed by the U.S. National Toxicology Program (NTP), the International Agency for Research on Cancer (IARC), and state lists provided by New Jersey, Pennsylvania, and California (Proposition 65). Chemicals listed under Canada's Workplace Hazardous Materials Information System (WHMIS) are also included in CHEMTOX.

Conference Papers Index

Conference Papers Index (CPI) provides access to records of the more than 100,000 scientific and technical papers presented at over 1,000 major regional, national, and international meetings each year. Conference Papers Index provides a centralized source of information on reports of current research and development from papers presented at conferences and meetings; it provides titles of the papers as well as the names and addresses (when available) of the authors of these papers. Also included in this database are announcements of any publications issued from the meetings, in addition to available preprints, reprints, abstract booklets, and proceedings volumes, including dates of availability, costs and ordering information. Primary subject areas covered include the life sciences, chemistry, physical sciences, geosciences, and engineering.

Dissertations Abstracts Online

Dissertation Abstracts Online is a definitive subject, title, and author guide to virtually every American dissertation accepted at an accredited institution since 1861. Selected Masters theses have been included since 1962. In addition, since 1988, the database includes citations for dissertations from 50 British universities that have been collected by and filmed at The British Document Supply Centre. Beginning with DAIC Volume 49, Number 2 (Spring 1988), citations and abstracts from Section C, Worldwide Dissertations (formerly European Dissertations), have been included in the file.

Abstracts are included for doctoral records from July 1980 (Dissertation Abstracts International, Volume 41, Number 1) to the present. Abstracts are included for masters theses from Spring 1988 (Masters Abstracts, Volume 26, Number 1) to the present.

DOSE

The Dictionary of Substances and their Effects (DOSE) is a unique guide to the impact of chemicals on organisms and the environment. DOSE contains detailed records for more than 4000 chemicals. These chemicals have been selected from sources such as Europe's Black List and Grey List of dangerous substances, the UK's Red List, priority pollutant lists from the USA and Canada, and the pollutant list from Germany. Other chemicals which are reported to have adverse effects on the environment are also covered.

Enviroline

Enviroline® covers the world's environmental related information. It provides indexing and abstracting coverage of more than 1,000 international primary and secondary publications reporting on all aspects of the environment. These publications highlight such fields as management, technology, planning, law, political science, economics, geology, biology, and chemistry as they relate to environmental issues. Enviroline corresponds to the print Environment Abstracts.

Environmental Bibliography

Environmental Bibliography provides access to the contents of periodicals dealing with the environment. Coverage includes periodicals on water, air, soil, and noise pollution; solid waste management; health hazards; urban planning; global warming; and many other specialized subjects of environmental consequence. The print equivalent is Environmental Periodicals Bibliography. More than 400 of the world's journals concerning the environment are scanned to create Environmental Bibliography. Journals represented are from the world's major publishers in science and technology (e.g., Elsevier/Pergamon, Kluwer Academic, John Wiley & Sons, Blackwell, Plenum, and Springer), as well as from smaller

publishers from many parts of the world. Many university press, society, and private publications are covered as well, some of which are available only on the Internet . (Availability of the Web publications is noted in the Notes field, along with the relevant URL.)

Environmental Bibliography covers conference papers and journal articles dating from 1973. Author abstracts appear in the file from July 1997 onward. Descriptors provide excellent indexing for scientific and common names, chemical compounds, geographic designations, computer model names, dates, trademark names, company names, and court cases.

Life Sciences Collection

Life Sciences Collection contains abstracts and bibliographic citations from recent worldwide research literature in major areas of biology, medicine, biochemistry, biotechnology, ecology, and microbiology, and some aspects of agriculture and veterinary science. Life Sciences Collection is produced by Cambridge Scientific Abstracts and corresponds to print series of more than 20 abstracting journals.

MEDLINE

MEDLINE (MEDLARS® onLINE), produced by the U.S. National Library of Medicine (NLM), is one of the major sources for biomedical literature. MEDLINE corresponds to three print indexes: Index Medicus TM, Index to Dental Literature, and International Nursing Index. Additional materials not published in Index Medicus are included in the MEDLINE database in the areas of communication disorders, and population and reproductive biology. MEDLINE is indexed using NLM's controlled vocabulary, MeSH® (Medical Subject Headings). An online thesaurus is available to aid in locating MeSH descriptors.

Abstracts, which are taken directly from the published articles, are included for over 59% of the records added from 1975 forward. Records added before 1975 do not contain abstracts; records added from 1985 to the present have abstracts for about 69% of the records. Approximately 400,000 records are added per year, of which more than 85% are in English.

NTIS

The NTIS: National Technical Information Service database consists of summaries of U.S. government-sponsored research, development, and engineering, plus analyses prepared by federal agencies, their contractors, or grantees. It is the means through which unclassified, publicly available, unlimited distribution reports are made available for sale from agencies such as NASA, DOD, DOE, HUD, DOT, Department of Commerce, and some 240 other agencies. Additionally, some state and local government agencies now contribute summaries of their reports to the database. NTIS also provides access to the results of government-sponsored research and development from countries outside the U.S. Organizations that currently contribute to the NTIS database include: the Japan Ministry of International Trade and Industry (MITI); laboratories administered by the United Kingdom Department of Industry; the German Federal Ministry of Research and Technology (BMFT); the French National Center for Scientific Research (CNRS); and many more. ONTAP® NTIS, File 206, is available for ONline Training And Practice; it contains records from January through June 1987 from File 6.

PASCAL

PASCAL is produced by the Institut de l'Information Scientifique et Technique (INIST) of the French National Research Council (CNRS). It provides access to the world's scientific and technical literature and includes about 450,000 new citations per year. Available in machine-readable form since 1973, PASCAL corresponds to the print publication Bibliographie internationale (previously Bulletin signaletique).

Each citation includes the article's original title, and, in most cases, a French translated title; for material since 1973, an English translated title is also provided. Most abstracts are in French. Analyzed documents come from all over the world, in 100 different languages. French journals are particularly well

represented. The file's breakdown by language is as follows: English 63%, French 12%, Russian 10%, German 8%, and other languages 7%.

Controlled descriptors from a vocabulary of over 80,000 terms are provided in English, French, and, in some cases, Spanish; German descriptors are also provided in the area of metallurgy.

Pollution Abstracts
Pollution Abstracts is a leading resource for references to environmentally related literature on pollution, its sources, and its control. The following subjects are covered by the Pollution Abstracts database: air pollution, environmental quality, noise pollution, pesticides, radiation, solid wastes, and water pollution.

RTECS
The Registry of Toxic Effects of Chemical Substances (RTECS®) is a comprehensive database of basic toxicity information for over 100,000 chemical substances including: prescription and non-prescription drugs, food additives, pesticides, fungicides, herbicides, solvents, diluents, chemical wastes, reaction products of chemical waste, and substances used in both industrial and household situations. Reports of the toxic effects of each compound are cited. In addition to toxic effects and general toxicology reviews, data on skin and/or eye irritation, mutation, reproductive consequences and tumorigenicity are provided. Federal standards and regulations, NIOSH recommended exposure limits and information on the activities of the EPA, NIOSH, NTP, and OSHA regarding the substance are also included. The toxic effects are linked to literature citations from both published and unpublished governmental reports, and published articles from the scientific literature. The database corresponds to the print version of the Registry of Toxic Effects of Chemical Substances, formerly known as the Toxic Substances List started in 1971, and is prepared by the National Institute for Occupational Safety and Health (NIOSH).

Toxicity information appearing in RTECS is derived form reports of acute, chronic, lethal and non-lethal effects of chemical substances. The reviewed information from the scientific literature and published governmental reports plus unpublished test data from the EPA TSCA test submissions database (TSCATS) are included in the file.

Science
Science, published by the American Association for the Advancement of Science (AAAS), serves its readers as a forum for the presentation and discussion of important issues related to the advancement of science. Emphasis is on material pertaining to the interactions among science, technology, government, and society. The peer-reviewed section of the journal presents cutting-edge research of either interdisciplinary interest or unusual significance to the specialist. Topical coverage reflects the range of AAAS's interest across the physical, biological, and social sciences. Major sections of the journal are This Week in Science, News and Comments, Research News, Articles, Research Articles, and Reports. Science also includes book reviews, editorial and letters sections, policy forums, perspectives, and information about new techniques
and instrumentation.

TOXLINE
TOXLINE covers the toxicological, pharmacological, biochemical, and physiological effects of drugs and other chemicals. It is composed of a number of subfiles, several of which are unique to TOXLINE. About 45% of the approximately 120,000 records added per year are from the TOXBIB subfile, which is derived from MEDLINE. The TOXBIB and BIOSIS (since August 1985) subfiles may be searched using the U.S. National Library of Medicine's Medical Subject Headings (MeSH). The records in these two subfiles are updated annually with the current version of MeSH headings. An Online thesaurus is available to aid in locating MeSH descriptors.

Wilson Biological and Agricultural Index
Biological & Agricultural Index provides thorough, reliable indexing of 258 periodicals common to most libraries. Periodical coverage includes a wide range of scientific journals, from popular to professional,

that pertain to biology and agriculture. About 45% of the focus is on agriculture. Types of materials indexed include feature articles, biographical sketches, reports of symposia and conferences, review articles, abstracts and summaries of papers, selected letters to the editor, special issues or monographic supplements, and book reviews.

Zoological Record

Zoological Record Online®, produced by BIOSIS, provides extensive coverage of the world's zoological literature, with particular emphasis on systematic/taxonomic information. The database corresponds closely to the printed index, Zoological Record. The database includes thorough subject indexing in both controlled- and natural-language format. It also includes a unique systematics field, which gives complete taxonomic hierarchy information for most organisms discussed.

Zoological Record Online indexes articles from over 6,000 international serial publications. Theses, monographs, conference proceedings, and special reports are also scanned for relevant information.

Table 2: Amphibian Search Term Testing (PolTox Database 7/99)

SOP Term	SOP Term Example hits/Notes	Recommended Term(s)
alligator*	alligator(s) alligatorweed alligatorfish	alligator alligators
amphibi*	amphibiotic amphibious (sometimes get amphibious plants) amphibia(n)(s)	amphibi*
caiman	caiman	caiman
crocodil*	crocodile(s)	crocodil*
frog*	froglegs frogmen *froggahimyia* (parasite specific name) *froggatti* (insect specific name)	frog frogs
lizard*	lizard lizards lizardfish lizardite (rock) lizardo	lizard lizards
newt*	newt newts newtech (new technology name for wastewater management) newton	newt newts
reptil*	reptile reptiles reptillia	reptil*
salamander*	salamander(s)	salamander*
snake*	snake snakes snakehead snakeroot snakeweed	snake snakes
terrapin*	terrapin terrapins	terrapin*
toad*	toad toads toadfish(es)	toad toads
tortoise*	tortoise tortoises	tortoise*

turtle*	turtle turtles turtledove turtlegrass turtleplant	turtle turtles

Table 3 Bird Search Term Testing (PolTox Database 7/99)

SOP Term	SOP Term Example hits/Notes	Recommended Term(s)
bird	bird birds birdcage birders birding birdlife birdsville birdwatcher	bird birds
chicken gallus domesticus	chicken chickens chickenpox gallus domesticus	chicken chickens gallus
duck or ducks	duck ducks duckling ducklings duckweed duckbill	duck ducks duckling*
mallard or anas or pltyrhyn	mallard mallards anas	mallard* anas
quail or coturnix Japanese quail	quail quails quaility	quail quails coturnix
songbird	songbird songbirds	songbird*
bobwhite	bobwhite bobwhites	bobwhite*
turkey	turkey (country or organism) turkey turkeyfish	turkey turkeys
aves or avian	aves avian avians	aves avian*
waterfowl	waterfowl	waterfowl

waterbird	waterbird waterbirds	waterbird*

Superfund/Oil Program Implementation Manual FY 02/03
Appendix A: Site Assessment/NPL Listing

Appendix A
Site Assessment/NPL Listing Targets and Measures

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Site Assessment/NPL Listing
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APPENDIX A
A.A. Site Assessment/NPL Listing
FY 02/03TARGETS AND MEASURES

A.A.1 SITE ASSESSMENT PROGRAM AND NPL LISTING PRIORITIES

The site assessment annual performance goal for FY 2002 is 475 final site assessment decisions. Assessing the worst sites first continues as a national priority. The regions should identify the sites posing the highest risk or potential risk and develop a strategy to assess those sites in a timely manner, while balancing their other site assessment needs. While assessing the worst sites first, the regions also need to ensure that the backlog of sites needing Preliminary Assessments (PAs), Site Inspections (SIs), or Expanded Site Inspections (ESIs) does not grow unacceptably. The regions should consider integrating assessments to reduce cost and time to assess sites. Regions should continue the use of pre-CERCLIS screening to assure only appropriate sites are placed in CERCLIS/WasteLAN. The regions should also ensure the appropriate investigations of sites of Tribal concern that are on or near Indian Country.

To better accomplish the national priorities, the regions should continue negotiating work share agreements with individual States (and Tribes if applicable). This will help divide up the site assessment work and potentially enhance relations with the States and Tribes. This process will also serve to identify the current lead agency for the public.

Given sizeable workloads and constrained resources, regions are encouraged to fund special projects designed to reduce the time and/or costs of assessing sites without compromising the integrity of the site assessment decisions. Regions must obtain concurrence from OERR if more than 10 percent of annual site assessment funding is used for special projects. Regions performing special projects are responsible for communicating the scope of these projects to other EPA regional and headquarters (HQ) site assessment staff.

HQ and regions should continue the streamlined process for listing sites on the National Priority List (NPL) and evaluate alternatives to listing sites while providing NPL quality cleanups.

A.A.2 SITE ASSESSMENT BACKLOGS

A key function of HQ is to report national progress in the site assessment program. Workload estimates are critical indicators of future program needs. HQ captures these workload estimates by identifying the number of sites at various stages in the site assessment pipeline. These stages are commonly referred to as "backlogs™ For example, sites needing completion of a CERCLA PA are collectively termed the "PA Backlog™ Throughout this appendix, the procedures HQ uses to derive backlog is provided for each step in the site assessment process.

A.A.3 OVERVIEW OF FY 02/03 SITE ASSESSMENT/NPL LISTING TARGETS AND MEASURES

The Superfund Comprehensive Accomplishments Plan (SCAP) is used by the Assistant Administrator for the Office of Solid Waste and Emergency Response (AA OSWER), Assistant Administrator for the Office of Enforcement and Compliance Assurance (AA OECA), and senior Superfund managers to monitor the progress each region is making towards achieving the Government Performance and Results Act (GPRA) annual performance goals. In addition, SCAP will continue to be used as an internal management tool to project and track activities that contribute to these GPRA goals and support resource allocation. The program will set national goals based on historical performance and performance expectations within a limited budget for the performance goals in GPRA and track accomplishments in the activities contributing to those goals. Regions should continue to plan and report accomplishments in WasteLAN as they have traditionally.

To more clearly reflect the relationship between GPRA and the SCAP process, GPRA annual performance goals and measures and program targets and measures are defined as follows:

- **GPRA Annual Performance Goals (APG) and GPRA Annual Performance Measures (APM)** - The Agency~~'s~~ Annual Plan describes the specific annual performance goals, annual measures of outputs and outcomes, and activities aimed at achieving the performance goals that will be carried out during the year. APGs are the specific activities that the Agency plans to conduct during the fiscal year in an effort towards achieving its long-term strategic goals and objectives. APMs are used by managers to determine how well a program or activity is doing in achieving milestones that have been set for the year. The annual performance goals will inform Congress and Agency stakeholders of the expected level of achievement for the significant activities covered by the GPRA objective. The goals are a subset of the overall planning and budgeting information that has traditionally been tracked by the Superfund program offices.

- **Program Targets and Measures** are activities deemed essential to tracking overall program progress. Program targets are used to identify and track the number of actions that each region is expected to perform during the year and to evaluate program progress. Program measures are used to show progress made in achieving program priorities.

The following pages contain, in pipeline order, the definitions of the FY 02/03 Superfund site assessment/Brownfields targets and measures. Exhibit A.1 displays the full list of site assessment and Brownfields activities defined in this Appendix. Exhibit A.2, at the end of this Appendix, identifies the Subject Matter Experts (SMEs).

A.A.4 GPRA AND SITE ASSESSMENT

Goal 5, Objective 1, Subobjective 2 contains the GPRA subobjective for Superfund assessment work. This subobjective states:

> "By 2005, EPA and its State, Tribal, and Federal partners will reduce the risks that Superfund sites pose to public health and the environment by....
>
> *...determining if Superfund cleanup is needed at 85% of the sites entered into the Superfund site data base (CERCLIS)...*
>
> ...EPA will collaborate with States and Tribes to enhance the Federal, State, and Tribal Superfund program, reduce overlap among the programs, and leverage public and private resources to promote cost-effective, efficient cleanups of Superfund sites.™

The assessment component of this subobjective focuses on the percent of sites brought to the attention of the Superfund program where Final Assessment Decisions (FADs) have been made. The formula to derive this measure is:

$$\frac{\text{No. sites with a final assessment decision}}{\text{Total sites in the CERCLIS and Archive site inventories}}$$

EPA Regions are responsible for maintaining FAD designations in WasteLAN. FAD status is captured in WasteLAN by selecting "Yes" in the "Final Assessment Decision" field on the Site Description/Operable Units screen. The WasteLAN application system populates the related "Final Assessment Decision Date:" field with the current date. Regions can accept or edit this date. The percentage of sites with FADS and the number of current fiscal year and cumulative FAD designations is captured on the GPRA SCAP-15 report available through WasteLAN.

Regions may assign a FAD designation to a site if any of the following conditions are met:

- The site has been proposed to or placed on the National Priorities List (NPL);
- The site has been removed from proposal to the NPL and no further assessment is needed;
- The decision made at the last completed assessment at the site is either:
  - → No further remedial action planned (NFRAP);
  - → Referred to Removal-NFRAP
  - → Deferred to RCRA or NRC; or
  - → Addressed as part of an NPL or non-NPL site;
- The site is being remediated under a formal state deferral agreement;
- The site is being remediated as a Superfund Alternative Site;
- The site is being remediated under a State, Local, Tribal, or other Federal government cleanup program as supported by written documentation between the lead party and EPA (e.g., Voluntary Cleanup Program Memorandum of Agreement or other work sharing type of agreement, site specific reports or fact sheets submitted by the lead party, etc.), and the site file contains documentation supporting the decision that Superfund assessment work is complete;
- The site has been properly archived from the active CERCLIS site inventory.

Regions must delete the FADs designation should conditions change such that the site no longer meets any of the above conditions.

EXHIBIT A.1
SITE ASSESSMENT/NPL LISTING ACTIVITIES

ACTIVITY	GPRA		PROGRAM	
	APG	APM	TARGET	MEASURE
Targeted Brownfields Assessment				✓
Pre-CERCLIS Screening Assessment				✓
Non-NPL Site Status				✓
Site Discovery				✓
Sites Archived				✓
Preliminary Assessment (PA) at Non-Federal Facility Sites				✓
Federal Facility PA Review				✓

EXHIBIT A.1
SITE ASSESSMENT/NPL LISTING ACTIVITIES

ACTIVITY	GPRA		PROGRAM	
	APG	APM	TARGET	MEASURE
Site Inspection (SI) at Non-Federal Facility Sites				✓
Federal Facility SI Review				✓
Combined PA/SI Assessment at Non-Federal Facilities				✓
Site Inspection Prioritization (SIP) at Non-Federal Facility Sites				✓
Site Reassessment				✓
Expanded Site Inspection (ESI) at Non-Federal Facility Sites				✓
Federal Facility ESI Review				✓
Integrated ESI/RI at Non-Federal Facility Sites				✓
State Deferral of Non-Federal Facility Sites				✓
Hazard Ranking System (HRS) Package (Non-Federal Facility and Federal Facility)				✓
Integrated Removal Assessment & PA at Non-Federal Facility Sites				✓
Integrated Removal Assessment & SI at Non-Federal Facility Sites				✓
Integrated Removal Assessment & Combined PA/SI at Non-Federal Facility Sites				✓
Integrated Removal Assessments and Expanded Site Inspection (ESI)				✓
Integrated Removal Assessments and Site Inspection Prioritizations (SIPs)				✓
Integrated Removal Assessments and Hazard Ranking System (HRS)				✓
Integrated Removal Assessments and Expanded Site Inspection and Remedial Investigation (ESI/RI)				✓
NPL Listing	✓			
No. of Final Assessment Decisions *	✓			

NOTE:
Accomplishments are pulled from WasteLAN on a semi-annual basis.

* *Italic* text indicates that this activity is a goal or measure that is not specifically defined in the Appendices to the Manual. Data to support reporting of this goals are already included in existing definitions.

A.A.5 SITE ASSESSMENT/NPL LISTING DEFINITIONS

a. TARGETED BROWNFIELDS ASSESSMENT

Definition:

"EPA's Targeted Brownfields Assessment (TBA) program is designed to help States, Tribes, and local governments - especially those without EPA Brownfields Assessment Demonstration pilots - minimize the uncertainties of contamination often associated with brownfields. EPA generally will not fund TBAs at sites where the owner could be responsible for the contamination on the site unless there is a clear means of recovering EPA expenditures and there is significant public benefit. Due to the passage of the new Brownfields law (Public Law 107-118) and the new 03 funding structure, EPA will have authority under CERCLA 104(k)(2)(A)(ii) to perform Federal-administered TBA's via contract with funding from one of the earmarks in the STAG appropriation. The Agency can also fund states and tribes to perform State or Tribal-administered TBA's under CERCLA 128(a) with STAG appropriations from the other STAG earmark, if the States and tribes choose to use their CERCLA 128(a) grant for that purpose.

Under the TBA program, EPA provides funding and/or technical assistance for environmental assessments at brownfields sites throughout the country. A TBA may encompass one or more of the following activities:

§ A screening (ASTM Phase I* or equivalent) assessment, including a background and historical investigation and a preliminary site inspection;
§ A full (ASTM Phase II* or equivalent) site assessment, including sampling activities to identify the types and concentrations of contaminants and the areas of contamination to be cleaned; and
§ Establishment of cleanup options and cost estimates based on future uses and redevelopment plans."™

(Source: "Targeted Brownfields Assessments"™ Quick Reference Fact Sheet (EPA 500-F-98-251, November 1998) available on the EPA Internet at http://www.epa.gov/swerosps/bf/html-doc/tba.htm

*ASTM (American Society for Testing and Materials) Standards:
E1527-00 Standard Practice for Environmental Site Assessments: Phase I Environmental Site Assessment Process
E1903-97 Standard Guide for Environmental Site Assessments: Phase II Environmental Site Assessment Process)
Additional ASTM information available at: www.astm.org.

Definition of Accomplishment:

Regions can get accomplishment credit both "Targeted Brownfields Assessments"™ and "Number of Brownfields Properties Addressed by TBAs."™ A Brownfields Properties Addressed by TBAs is only counted once when the first TBA is completed at the property.

To get credit for TBA accomplishments, the Regions are required to enter and reconcile the data in WasteLAN in two different modules: in the Accomplishments Tracking Screens and in the Brownfields Module. (Dual module entry is required because the definition of properties assessed requires property-specific information on all historical TBAs (conducted since 1987) and many Regions have not yet entered this historical information. This requirement will be reviewed when all the Regions input their historic data).

Reporting TBAs and Properties on a Non-Property Specific Basis in the Accomplishments Tracking Screens.

Regions can get accomplishment credit for completed quarterly accomplishment information for both "Targeted Brownfields Assessments"™ and "Number of Brownfields Properties Addressed by TBAs"™ through the Non-site Accomplishments Screens.

Reporting TBAs and Properties on a Property Specific Basis in the Brownfields Module.

The WasteLAN Brownfields module provides the Regions with a centralized database for directly entering and tracking Targeted Brownfields Assessments (TBAs) information on a property-specific basis. Currently, the WasteLAN Brownfields module allows Regions to enter and track the following information about TBAs and the properties addressed by TBAs.

A TBA is complete when a particular site characterization activity undertaken has concluded (an Actual Completion Date exists for the Targeted Brownfields Assessment action ~~-ON-~~). The TBA must be identified as either Phase I, Phase II, or Cleanup Opt/Cost Est. using the Indicator field on the SCAP Information screen in WasteLAN.

Credit for a property assessed by a TBA is given for the first TBA which is performed at a specific Brownfields Property (rat_code = ON and Actual Completion Date exists and is "first-at-site™).

Changes in Definition FY 01 - FY 02/03:

Due to the passage of the new Brownfields law (Public Law 107-118) and the new 03 funding structure, EPA will have authority under CERCLA 104(k)(2) (A)(ii) to perform Federal-administered TBA's via contract with funding from one of the earmarks in the STAG appropriation. The Agency can also fund states and tribes to perform State or Tribal-administered TBA's under CERCLA 128(a) with STAG appropriations from the other STAG earmark, if the States and tribes choose to use their CERCLA 128(a) grant for that purpose. Designating the TBA lead as Federal or State is required and will indicate the source of the TBA funding.

Special Planning/Reporting Requirements:

Entering Data on TBAs and Properties on a Non-Property Specific Basis in the Accomplishments Tracking Screens.

TBA information is tracked in WasteLAN on a non-property specific basis, using the system ~~s~~ Accomplishments Tracking screens. You must enter quarterly planning data prior to entering completed quarterly accomplishment information for "Targeted Brownfields Assessments™and "Number of Brownfields Properties Addressed by TBAs.™ Annual planning data should be entered in October of each fiscal year. It may be updated at any time.

Detailed data entry instructions for Non-Property information can be found in Quick Reference Guide entitled "Tracking Brownfields Assessments.™This document is available on EPA ~~s~~ Intranet at http://intranet.epa.gov/swerbrnf/pdf/bfa_qrg.pdf

Entering Data on TBAs and Properties on a Property Specific Basis in the Brownfields Module.

A Brownfields module was designed and incorporated into WasteLAN during fiscal year 1999. The WasteLAN Brownfields module provides the Regions with a centralized database for directly entering and tracking Targeted Brownfields Assessments (TBAs) information on a property-specific basis. Currently, the WasteLAN Brownfields module allows Regions to enter and track information about TBAs and the properties addressed by TBAs.

EPA has developed several guidance documents that provide directions for entering property- specific TBA information in WasteLAN.

These documents are available on EPA ~~s~~ Intranet Web site (http://intranet.epa.gov/swerbrnf/wl_bfmod.htm).

Reconciling TBA Data on a Property Specific and Non-Property Specific Basis

Each Region is expected to reconcile the Property Specific Numbers and Non-Property Specific Numbers using the SCAP-13 Brownfields Report. The report shows official accomplishments of Targeted Brownfields Assessments (TBAs) completed and the Number of Properties Addressed by TBAs in the columns on the left of the report from the Accomplishments Tracking module of WasteLAN, without property-specific detail. For comparison, the columns on the right of the SCAP-13 Brownfields Report shows the TBAs and Properties that have property-specific details from the Brownfields Module. These two sets of numbers should be closely comparable. The number of "Targeted Brownfields Assessments™ in both modules should always be the same. Because Properties Addressed are only counted once, the properties will only match, if all historical TBAs are entered. Otherwise, a manual count of the Properties Addressed must be entered in the Accomplishment Screens, which counts the properties once in the first quarter and year that they are assessed.

b. PRE-CERCLIS SCREENING ASSESSMENTS

Definition:

Pre-CERCLIS screening is the process of reviewing data on a potential site to determine whether it should be entered into the CERCLIS inventory for further evaluation. The process can be initiated through the use of several mechanisms, such as a phone call or referral by a State or other Federal agency. The information/collection process is normally limited to one or two days. A site should not be entered into CERCLIS if:

- It is currently in CERCLIS or has been removed from CERCLIS and no new data warrants re-entry into CERCLIS;
- The site or contaminants found on the site are subject to certain limitations based on definitions in CERCLA;
- A State or Tribal remediation program is involved in response at the site and it is in the process of a final cleanup;
- The hazardous substance release at the site is regulated under a statutory exclusion (e.g., petroleum, natural gas, natural gas liquids, synthetic gas usable for fuel, normal application of fertilizer, release located in a workplace, naturally occurring, or covered by the Nuclear Regulatory Commission (NRC), or Uranium Mill Tailings Radiation Control Act (UMTRCA), [see CERCLA section 101(22)];
- The hazardous substance release at the site is deferred by policy considerations (e.g., RCRA Corrective Action);
- Site data are insufficient to determine if CERCLIS entry is warranted (i.e., based on potentially unreliable sources or with no information to support the presence of hazardous substances or CERCLA eligible pollutants or contaminants); or
- Documentation clearly demonstrates that there is no potential for a release that could cause adverse environmental or human health impacts.

For more information on pre-CERCLIS screening please refer to Pre-CERCLIS Screening Assessments fact sheet (OSWER 9375.2-11FS). This fact sheet provides the minimum requirements for conducting these type of assessments.

Definition of Accomplishment:

Pre-Screening Starts - A pre-screening (Action Name = Pre-CERCLIS Screening) is started when the region begins collecting data and performing other tasks related to completion of the Pre-CERCLIS Screening Assessment Checklist; and WasteLAN contains the actual pre-screening start date (Actual Start) and an action lead of: "Fund-Financed (F)™ "EPA-In House (EP).™ Pre-CERCLIS screening start dates are not required.

Pre-Screening Completions - A pre-screening (Action Name = Pre-CERCLIS Screening) is completed when:

- A Pre-CERCLIS Screening Assessment Checklist has been developed by EPA to document the decision and placed in the site file. The Pre-CERCLIS Screening actual completion date is the date the Checklist is finalized; and

- WasteLAN contains the actual Pre-CERCLIS Screening completion date (Actual Complete), a valid lead (Lead), and appropriate values in the NPL and Non-NPL Status fields.

In addition to the pre-screening action, entry of the following information is required:

Sites that require NPL assessment work, or both NPL assessment and removal work
- A Discovery Date on the Add Site screen, which corresponds to the actual completion date of the pre-screening action;
- An NPL Status of "Not on the NPL" on the Add Site screen;
- A Non-NPL Status of "PA Start Needed", "Combined PA/SI Start Needed", or "Integrated Removal Assessment PA Start Needed" on the Site Description/Operable Unit screen.

Sites that require only removal work
- An Initiation Date on the Add Site screen, which corresponds to the actual completion date of the pre-screening action;
- An NPL Status of "Not on the NPL" on the Add Site screen;
- A Non-NPL Status of "Removal Only" on the Site Description/Operable Unit screen.

Sites that require no further evaluation beyond the pre-screening
- An NPL Status of "Not a Valid Site or Incident" on the Add Site screen;
- A Non-NPL Status of "Not a Valid Site or Incident", "Not a Valid Site - RCRA Lead", "Not a Valid Site - NRC Lead", "Not a Valid Site - State Lead", or "Not a Valid Site - Tribal Lead."

For more information on tracking Pre-CERCLIS Screening activities, please refer to the March 2002 guidance document entitled "Data Entry for Pre-Screening Sites."

Changes in Definition FY 01 - FY 02/03:

Pre-screening activities are now being tracked site-specifically.

Special Planning/Reporting Requirements:

All pre-CERCLIS screening activities should be tracked in WasteLAN, including activities at sites not found to be CERCLA-eligible. Sites that are screened out of CERCLIS will be tracked in WasteLAN through the "Not a Valid Site or Incident™ values in the NPL and Non-NPL status field. If the decision is made that the site requires NPL assessment and potential cleanup under CERCLA authority, it should be added to the CERCLIS inventory by entering a Discovery Date and valid NPL and Non-NPL Statuses. A Discovery action or date should not be entered into WasteLAN if the site only needs a removal assessment/action and no NPL assessment work is necessary. For these sites with "removal-only™ interest, the Site Initiation Date on the Add Site screen needs to be entered for these sites to be considered part of the CERCLIS inventory. Sites that are screened out of the CERCLIS inventory should be entered on the Add Site screen with no Discovery or Initiation date, and the NPL status "Not a Valid Site or Incident". The region will maintain a record based on a pre-screening action. This is a program measure.

Regions are responsible for maintaining the accuracy of the non-NPL status for every non-NPL site in the CERCLIS inventory. As new actions and new dates are entered into WasteLAN, the system automatically calculates a new value for this field based on the traditional sequence of site assessment work. Regions must confirm or change this value as appropriate.

c. NON-NPL STATUS

Definition:

Non-NPL Status is the status assigned to a non-NPL site as it moves through the site assessment/removal pipeline. It is used to determine current regional and national assessment workloads (i.e., "backlogs™") and for reporting Superfund progress at non-NPL sites.

Definition of Accomplishment:

This measure tracks the progress EPA and its State and Tribal partners are making in addressing non-NPL sites under the Federal Superfund program. As site assessment and removal start and complete dates are entered into WasteLAN for non-NPL sites, the system automatically assigns a new Non-NPL Status value and a message is displayed stating the new value. Regions can change this value via the Site Description/Operable Units screen.

All non-NPL sites in both the CERCLIS and Archive site inventories must be assigned a valid Non-NPL status value. When the user selects or changes the Non-NPL Status, the system generates the date of the change in the Non-NPL Status Date field. Users may edit this date. For further details, including valid values, please refer to two January 2002 factsheets, *Reporting Non-NPL Status Quick Reference Guide* and *Understanding NPL and Non-NPL Status Code Relationships*. Both of these documents are available on the CERCLIS 3 Document database under Training and Documentation Section in the Quick Reference Guide folder.

Changes in Definition FY 01 - FY 02/03:

None.

Special Planning/Reporting Requirements:

EPA will utilize the Non-NPL Status field for site inventory management and reporting site assessment backlogs and progress.

The progress of each non-NPL site, as it moves through the site assessment/removal pipeline is tracked in WasteLAN. The "Non-NPL Status™" field, located on the Site Description/Operable Unit screen, contains this information. Regions are responsible for maintaining the accuracy of this field for every non-NPL site in the CERCLIS and Archive site inventories. As new actions and dates are entered and saved in WasteLAN, the system automatically generates a new value for this field. The generated value is based on the traditional sequence of site assessment work. Regions can change this value via the Site Description/Operable Units screen.

A user can edit the system-generated non-NPL Status value by going to the Site Description/Operable Unit screen and selecting a new value from the drop down list. Regions may want to do this if a different non-NPL Status value more closely reflects the actual status of a site. For example, the system may generate an "HRS Start Needed™" non-NPL Status value after completion of a Site Inspection action is recorded in WasteLAN. Site specific information may show that an "Other Cleanup Activity: State-Lead Cleanup™" value is more accurate. The list of values available in the Non-NPL Status drop down will depend upon the NPL status of each site, in order to prevent conflicting values from being entered in the two fields. Please refer to the January 2002 Quick Reference Guide *Understanding NPL and Non-NPL Status Code Relationships* for a list of valid combinations.

Users can protect the non-NPL Status value from being changed as new data are entered. To do this, the user must click on the "Protect Status™" check box. As long as this box is checked, the non-NPL Status value will not change even if the site assessment/removal data on the Site Schedule are updated. However, the system will notify users in these cases that another non-NPL Status value may be more appropriate based on traditional pipeline select logic. Users may decide to deselect the "Protect Status™" check box, thereby allowing WasteLAN to automatically generate the system-proposed value in this field. The Non-NPL Status value is only required for sites with an NPL Status of "Not on the NPL" or "Not a Valid Site or Incident." However a limited number of Non-NPL Status options are available for these sites.

d. SITE DISCOVERY

Definition:

Site discovery is the process by which a potential hazardous waste site is entered into the CERCLIS inventory for NPL assessment activities. All sites moving through the NPL assessment process must have a Discovery action and actual completion date documented in WasteLAN. Entry of the site discovery date initiates the NPL assessment process and places the site on the Preliminary Assessment backlog.

Definition of Accomplishment:

Site discovery of non-Federal facilities is the date the region completes the pre-CERCLIS screening activities, and documents the decision that the site warrants Superfund NPL assessment and potential cleanup attention. The site discovery date for Federal facilities is the date the site is formally added to the Federal Facilities Hazardous Waste Compliance Docket indicating Superfund involvement is required. The Site Name and Discovery Date must be entered into WasteLAN for both Federal and non-Federal sites. Valid leads for site discovery actions include: ˜Fund-Financed (F)™˜EPA-In House (EP)™˜State (S)™˜Tribal (TR)™and ˜Federal Facility (FF).™

Changes in Definition 01 - FY 02/03:

None.

Special Planning/Reporting Requirements:

Actual start and planning dates are not required for the Discovery action. The Discovery date is entered through the Add Site screen. The Discovery date will automatically populate the actual completion date for the Discovery action. Regions are now required to enter information on site type at the time of discovery on the Add Site or Site Discovery/Initiation screen. Multiple discovery actions are not allowed. Site discovery is a program measure.

Note: A separate field has been added to WasteLAN to record site initiation dates for removal-only sites. Sites that are subject only to removal interest generally do not require a discovery date. An exception is where a large scale removal action has been completed and the region seeks credit for a non-NPL site completion. Non-NPL site completions require site assessment review indicating the site has no further remedial actions planned. The discovery date for sites referred from removal to assessment should be the date the referral decision is made.

Regions are responsible for maintaining the accuracy of the non-NPL status for every non-NPL site in the CERCLIS inventory. As new actions and new dates are entered into WasteLAN, the system automatically calculates a new value for this field based on the traditional sequence of site assessment work. Regions must confirm or change this value as appropriate.

e. SITES ARCHIVED

Definition:

Archiving represents a site-wide decision that no further interest exists at the site under the Federal Superfund program based on available information. It is a comprehensive decision indicating there is no further Superfund site assessment, remedial, removal, enforcement, cost recovery, or oversight activities being planned or conducted at the site. Regions may perform re-evaluation work at a site while it is archived if site conditions change and/or new information becomes available. Sites re-evaluated and determined to need substantial site characterization and/or cleanup work under the Federal Superfund program must be returned to the CERCLIS inventory. Regions may also record general enforcement related activities (e.g. issuance of comfort letter or prospective purchaser agreements) and Brownfields activities (e.g. Targeted Brownfields Assessments) at archived sites.

Backlogs
The Archive site backlog consists of the potential archive candidate sites described below.

Definition of Accomplishment:

An archive decision is recorded in WasteLAN at the site level. To receive credit for an archive decision, the Archive Indicator (Archive IND) must be checked, and the "Archive Date" entered on the Site Description/Operable Units screen. A note must be prepared and placed in the site file explaining that no further Federal Superfund interest exists at the site based on available information. Since archiving is a comprehensive decision, the note must represent the interests of the appropriate regional business units (e.g., site assessment, removal, etc.), including the regional RCRA program for archive designations based on site deferral to RCRA. Regions should also consult with State and/or Tribal partners prior to making an archive designation to ensure any issues related to archiving are considered and handled appropriately. The date of the note is the Archive Date and entering this date automatically generates the Archive Indicator in WasteLAN.

Although the underlying basis for archiving a CERCLIS site is whether or not Federal Superfund interest exists, several categories of sites are used to generate lists of potential archive candidate sites. Based on review of sites in these categories, regions should update the "Archive IND" and "Archive Date" field as appropriate in a timely fashion. These categories are:

- Sites that have only completed the site assessment process and have either been given a No Further Remedial Action Planned (NFRAP) or Deferred decision at the conclusion of the last completed site assessment action, and no other Federal Superfund activity is anticipated;
- Sites that have completed both the removal and site assessment process, or have completed the removal process and require no site assessment work (removal-only sites), and which have completed all related oversight, cost recovery/other enforcement work, and have no further Federal Superfund activity anticipated;
- Sites that have successfully completed State Deferral as described in the May, 1995 OSWER Directive 9375.6-11 titled "Guidance on Deferral of NPL Listing Determinations While States Oversee Response Actions" and no further Federal Superfund activity is anticipated;
- Sites removed from the proposed NPL or final NPL (e.g., as a result of a lawsuit) that have no further Federal Superfund activity anticipated;
- Child sites addressed as part of a parent NPL or non-NPL site, provided there is no further Federal Superfund interest at the area represented by the child site. Parent non-NPL sites should not be archived until all related child sites have been archived;
- Sites that have been entered into the CERCLIS inventory via entry of a site discovery and/or site initiation date which have not had any work started and, based on review, do not warrant any type of additional Superfund activity. An abbreviated preliminary assessment (PA) should be completed for these sites prior to designating archive status.

As appropriate, sites can be returned to the CERCLIS inventory by deleting the date in the Archive Date field. The Archive Indicator will automatically be deleted. A note explaining why the site was returned to the CERCLIS inventory must be prepared and placed in the site file.

Changes in Definition FY 01 - FY 02/03:

Clarified certain actions can be recorded at sites while they are archived. Added reminder that the note to the site file must represent the interests of all relevant Superfund business units given the comprehensive nature of the archive designation. Added reminder to consult with State/Tribal partners on archive decisions. Added child sites as eligible candidates for archiving (with conditions). Removed Deleted NPL sites as eligible candidates for archiving.

Special Planning/Reporting Requirements:

The Archive Indicator field in WasteLAN is used as a filter on Superfund reports and data sets to delineate whether a site is still in, or has been removed from, the CERCLIS inventory. Planning dates for archiving sites are not available. It is important to note that an archive decision is not the same as no further remedial action planned (NFRAP) decision. A NFRAP decision is recorded as an Action Qualifier, is made only at the conclusion of a site assessment action, and does not take into account any other Superfund programmatic activity that may be going on at a site such as removals or cost recovery. Archived sites is a program measure for both non-Federal and Federal facilities.

The WasteLAN application will prevent adding certain assessment, removal, remedial, and enforcement actions at archived sites. The CERCLIS-Archive Quick Reference Guide lists the prohibited actions. Prohibited actions can be added to a site by either: 1) returning the site to CERCLIS (e.g., substantial site characterization and/or cleanup is needed); or 2) requesting a database revision through Headquarters (e.g., entry of historical data). The restriction will not prevent users from entering action-related data such as start/completion dates, leads, qualifiers, etc., at existing actions. WasteLAN will also prevent the archival of NPL sites (Proposed, Final, and Deleted) and sites having a start and no completion date at an archive-prohibited action.

Archive designations need to be made in a timely fashion to accurately portray the status of sites to all users of Superfund Program information. The site assessment program area within WasteLAN ~~s~~ reports module contains reports to help EPA regions maintain the integrity of archive data. The Potential Archive Site Inventory Report lists sites that may be eligible for archival. The Archived-To-Be-Reviewed Site Inventory Report lists sites that may warrant data corrections/updates or return to the active CERCLIS site inventory.

The WasteLAN application now captures archive designations by automatically generating an archive action and completion date when the Archive Date field is populated.

f. PRELIMINARY ASSESSMENTS (PA) AT NON-FEDERAL FACILITY SITES

Definition:

A Preliminary Assessment (Action Name = Preliminary Assessment) is often the first phase of the NPL assessment process following site discovery. The PA is used to determine what steps, if any, need to occur next at the site. Federal, State, and local government files, geological and hydrological data, and data concerning site practices are reviewed to complete the PA report. An on- or off-site reconnaissance also may be conducted, although it is not required.

Regions may combine PA and SI activities where warranted by site conditions to reduce repetitive tasks and ultimately costs. The combining of PA and SI activities is known as a "Combined PA/SI Assessment™" and is discussed in a separate measure below. The decision to perform a "Combined PA/SI Assessment™" is made when site assessment activities are initiated.

Regions also have been encouraged to furtherreduce repetitive tasks and costs by combining site assessment and removal evaluation activities where warranted by site conditions. This integrated removal/remedial evaluation is further discussed in a separate measure, below.

There are instances when an Abbreviated Preliminary Assessment (APA), as opposed to a full PA, is warranted. Examples include, but are not limited to the following: 1) A site has been inappropriately listed in CERCLIS because it is either not eligible or it could be deferred to another response program; 2) Available information allows EPA to make an early decision to undertake a combined PA/SI, an SI, or another Superfund investigation; or 3) A no further remedial action planned (NFRAP) designation can be made without completing a full PA. An abbreviated PA should be conducted for sites entered into the CERCLIS inventory via a site discovery at which no work has started and, based on review, do not warrant any type of additional Superfund activity. For such sites, the typical PA reporting requirements are abbreviated. The APA Checklist or an APA report must address the requirements set forth in the Oil and Hazardous Substances National Contingency Plan (NCP).

For more information on Abbreviated Preliminary Assessments please refer to Abbreviated Preliminary Assessment fact sheet (OSWER 9375.2-09FS) This fact sheet provides the minimum requirements for conducting this type of assessment.

Backlogs
The Preliminary Assessment backlog consists of sites with a Non-NPL Status of either "PA start needed™or "PA ongoing™

Definition of Accomplishment:

PA Starts - A PA (Action Name = Preliminary Assessment) is started when the region begins collecting data and performing other tasks related to development of the PA report; or when the region signs a letter, form, memo, or issues a Technical Direction Document (TDD) to the EPA contractor or State/Tribal government (where applicable), requesting performance of a PA at a specific site or group of sites; or when EPA receives written confirmation from a State/Tribal government that the State/Tribal government will conduct the PA; and WasteLAN contains the actual PA start date (Actual Start) and an action lead of: "Fund-Financed (F)™;"EPA-In House (EP)™;"State (S)™or "Tribal (TR)™ PA start dates are required and are used by HQ as a program measure.

APA Starts - An Abbreviated PA is started when the region begins collecting data and performing other tasks related to development of the PA report; or when the region signs a letter, form, memo, or issues a Technical Direction Document (TDD) to the EPA contractor or State/Tribal government (where applicable), requesting performance of a PA at a specific site or group of sites; or when EPA receives written confirmation from a State/Tribal government that the State/Tribal government will conduct the PA.

PA Completions - A Preliminary Assessment (Action Name = Preliminary Assessment) is completed when:

- A PA Report has been developed by EPA; or received by the region from the Federal contractor or State/Tribal government; and the appropriate Regional official signs a letter, form, or memo approving the PA report. The PA actual completion date is the date the PA report is approved; and

- WasteLAN contains the actual PA completion date (Actual Complete), a valid lead (Lead), and a "decision™on whether further activities are necessary in the Qualifier field; and

- The decision is documented by completing the Site Decision Form 9100-3 in WasteLAN or an equivalent document. The decision document must be printed, signed by the appropriate Regional official, and placed in the file.

Valid decisions to be recorded in WasteLAN upon completion of the PA include:

(H) High - Higher priority for further assessment Note: The next stage of assessment would typically be an SI (Action Name = Site Inspection); or

(L) Low - Lower priority for further assessment; or

(N) - No further *remedial* action planned; or

(D) - Deferred to RCRA (Subtitle C); or

(DN) - Deferred to NRC; or

(A) - Site is being addressed as part of a NPL site. The site should also have an NPL Status Indicator (Site NPL Status) of –A– and a valid value in the Parent Site ID field; or

(B) - Site is being addressed as part of another non-NPL site. The site should also have a Non-NPL Status of –Addressed as part of another non-NPL site– (AX) and a valid value in the Parent Site ID field; or

(F) - Referred to the removal program with further remedial assessment needed; or

(W) - Referred to the removal program with *no* further remedial assessment needed.

APA Completions - An Abbreviated Preliminary Assessment is completed when an APA checklist or equivalent report has been completed by EPA; or received by the region from the Federal contractor or State/Tribal government; and the appropriate Regional official signs a letter, form, or memo approving the APA report. The APA actual completion date is the date the APA report is approved.

Changes in Definition FY 01 - FY 02/03:

Added qualifier "Site is being addressed as part of another non-NPL site.™

Special Planning/Reporting Requirements:

Regions should attempt to complete PAs at non-Federal Facility sites listed in WasteLAN within one year of the site discovery completion date.

If a region decides to perform an Abbreviated Preliminary Assessment (APA) rather than a Preliminary Assessment, it needs to be indicated on the SCAP Information screen. Once an APA is selected on the SCAP Information screen, the definition, documentation, and special notes changes will be reflected on the screen. PA starts and completions (Actual Start and Complete) are reported site-specifically in WasteLAN. Preliminary Assessment completions at non-Federal Facility sites is a program measure.

Regions are responsible for maintaining the accuracy of the non-NPL status for every non-NPL site in the CERCLIS inventory. As new actions and new dates are entered into WasteLAN, the system automatically calculates a new value for this field based on the traditional sequence of site assessment work. Regions must confirm or change this value as appropriate.

g. FEDERAL FACILITY PRELIMINARY ASSESSMENT REVIEWS

Definition:

Federal Facility Preliminary Assessment Review is a quality assurance review of a PA report submitted by another Federal Agency. EPA=s involvement in PAs at Federal facilities differs from that at non-Federal facilities. While EPA conducts or funds development of PAs at non-Federal facilities, EPA=s role at Federal facilities is limited to reviewing PA reports developed and submitted by the Federal agencies responsible for a given Federal facility. Upon reviewing the PA for completeness, and working with the other Federal agency to address any deficiencies, EPA then determines what next steps are appropriate with respect to NPL listing.

Backlogs

The Federal Facility PA Review backlog consists of Federal facility sites with a Non-NPL Status of "FF-PA review needed™or "FF-PA review ongoing.™

Definition of Accomplishment:

Federal Facility PA Review Starts - A Federal Facility PA Review (Action Name = Federal Facility Preliminary Assessment Review) is started when the EPA starts an in-house review of the Federal facility PA or sends a letter, form, or memo to the EPA contractor requesting review of the Federal facility PA report, and WasteLAN contains the actual PA start date (Actual Start) and a valid action lead of "Fund-Financed (F)™;"EPA-In House (EP)™;"State (S)™;or "Tribal (TR)™

Federal Facility PA Review Completions - A Federal Facility PA Review (Action Name = Federal Facility Preliminary Assessment Review) is completed when:

- The appropriate Regional official signs a letter, form, or memo approving the PA report. The Federal Facility Preliminary Assessment Review actual completion date is the date the Federal facility PA report is approved;
- WasteLAN contains the actual Federal Facility Preliminary Assessment Review completion date (Actual Complete) a lead and a "decision™on whether further activities are necessary in the Qualifier field; and
- The decision is documented by completing the Site Decision Form 9100-3 in WasteLAN or an equivalent document. The decision document must be printed, signed by the appropriate Regional official, and placed in the file.

Valid decisions to be recorded in WasteLAN upon completion of a Federal facility PA Review include:

(H) - High - Higher priority for further assessment Note: The next stage of assessment would typically be an SI (Action Name = Site Inspection); or

(L) - Low - Lower priority for further assessment; or

(N) - No further *remedial* action planned; or

(A) - Site is being addressed as part of a NPL site. The site should also have an NPL Status Indicator (Site NPL Status) of =A= and a valid value in the Parent Site ID field; or

(B) - Site is being addressed as part of another non-NPL site. The site should also have a Non-NPL Status of =Addressed as part of another non-NPL site=(B) and a valid value in the Parent Site ID field; or

(D) - Deferred to RCRA (Subtitle C); or

(DN) - Deferred to NRC.

Changes in Definition FY 01 - FY 02/03:

Added qualifier "Site is being addressed as part of another non-NPL site."

Special Planning/Reporting Requirements:

Regions should attempt to complete PA reviews at Federal facility sites listed in the CERCLIS inventory within 18 months of the site discovery completion date. Federal facility PA review starts and completions are reported site-specifically in WasteLAN. Federal Facility Preliminary Assessment Review starts and completions are program measures.

If the Federal facility PA report does not provide sufficient information to make a NPL assessment decision, the report should be referred back to the Federal facility (SubAction Name = Referred back to Fed Fac). The date the report is referred back to the Federal facility is entered into WasteLAN as the actual completion date (Actual Complete). The actual completion date and qualifier for the Federal Facility Preliminary Assessment Review should not be entered until all the report deficiencies have been addressed.

Regions are responsible for maintaining the accuracy of the non-NPL status for every non-NPL site in the CERCLIS inventory. As new actions and new dates are entered into WasteLAN, the system automatically calculates a new value for this field based on the traditional sequence of site assessment work. Regions must confirm or change this value as appropriate.

h. SITE INSPECTIONS (SI) AT NON-FEDERAL FACILITY SITES

Definition:

The SI (Action Name = Site Inspection) involves the collection of field data from a suspected hazardous waste site to confirm or deny the presence of contamination and to further characterize contaminants, migration pathways, and background contaminant levels. The SI serves as a further screening activity to determine what steps, if any, need to occur next at the site. Regions should employ Field Analytical Sampling (FAS) techniques wherever practical during conduct of SI activities.

Regions may combine PA and SI activities where warranted by site conditions to reduce repetitive tasks and, ultimately costs. The combining of PA and SI activities is known as a "Combined PA/SI Assessment" and is discussed in a separate measure. The decision to perform a "Combined PA/SI Assessment" is made during initial PA activities or even before a PA is conducted.

Regions have also been encouraged to further reduce repetitive tasks and costs by combining site assessment and removal evaluation activities where warranted by site conditions. This "Integrated Removal/Remedial Evaluation" activity is discussed in a separate measure.

Backlogs

The Site Inspection backlog consists of sites with a Non-NPL Status of either "SI start needed" or "SI ongoing"

Definition of Accomplishment:

SI Starts - A SI (Action Name = Site Inspection) start date at a non-Federal facility site is defined as the date when EPA or the State/Tribal government signs a letter, memo or form approving the site-specific SI work plan, or a Technical Direction Document (TDD) is issued to the contractor at a site (refer to OSWER Publication #9345.1-03 FS for further guidance on defining SI starts) and WasteLAN contains the actual SI start date (Actual Start) and an action lead of: "Fund-Financed (F)", "EPA-In House (EP)", "State (S)", or "Tribal (TR)" SI start dates are required.

SI Completions - A SI (Action Name = Site Inspection) is completed when:

- A SI Report has been generated by EPA; or received by the region from the Federal contractor or State/Tribal government; and the appropriate Regional official signs a letter, form, or memo approving the SI report. The SI actual completion date is the date the SI report is approved; and

- WasteLAN contains the actual SI completion date (Actual Complete), a valid lead (Lead), and a "decision" on whether further activities are necessary in the Qualifier field; and

- The decision is documented by completing the Site Decision Form 9100-3 in WasteLAN or an equivalent document. The decision document must be printed, signed by the appropriate Regional official, and placed in the file.

Valid decisions to be recorded upon completion of a SI include:

(H) - High - Higher priority for further assessment Note: The next stage of assessment could be an ESI (Action Name = Expanded Site Inspection), an integrated ESI/RI (Action Name = ESI/RI), or preparation of an HRS package (Action Name = HRS Package); or

(L) - Low - Lower priority for further assessment; or

(N) - No further *remedial* action planned; or

(D) - Deferred to RCRA (Subtitle C); or

(DN) - Deferred to NRC; or

(A) - Site is being addressed as part of a NPL site. The site should also have an NPL Status Indicator (Site NPL Status) of "A" and a valid value in the Parent Site ID field; or

(B) - Site is being addressed as part of another non-NPL site. The site should also have a Non-NPL Status of "Addressed as part of another non-NPL site" (B) and a valid value in the Parent Site ID field; or

(F) - Referred to the removal program with further remedial assessment needed; or

(W) - Referred to the removal program with no further remedial assessment needed.

Changes in Definition FY 01 - FY 02/03:

Added qualifier "Site is being addressed as part of another non-NPL site."

Special Planning/Reporting Requirements:

Planning dates are not required for SIs. Actual start and completion dates are required for SIs. SI starts (Actual Start) and completions (Actual Complete) are reported site-specifically in WasteLAN. Site Inspection starts and completions at non-Federal Facility sites are program measures.

Regions are responsible for maintaining the accuracy of the non-NPL status for every non-NPL site in the CERCLIS inventory. As new actions and new dates are entered into WasteLAN, the system automatically calculates a new value for this field based on the traditional sequence of site assessment work. Regions must confirm or change this value as appropriate.

i. COMBINED PA/SI ASSESSMENTS AT NON-FEDERAL FACILITY SITES

Definition:

Regions are encouraged to combine PA and SI activities where warranted by site conditions to reduce repetitive tasks and, ultimately, costs. The combining of PA and SI activities is known as a "Combined PA/SI Assessment." The results of combined PA/SI assessment can be documented in one physical report, as long as the report contains all of the elements that would have been addressed under separate PA and SI reports. The report should state specifically that it covers both the PA and SI. The decision to conduct an SI as part of a combined assessment is made either prior to initiation of the PA or during initial phases of the PA and is documented in the initial task assignment provided to the contractor, by correspondence between EPA and the State, or by a form or memo to the file. As is the case with its individual components, a combined PA/SI is performed to determine what steps, if any, need to occur next at a site. Regions should employ FAS techniques wherever practical during PA/SI activities.

Regions are also encouraged to further reduce repetitive tasks and costs by combining site assessment and removal evaluation activities where warranted by site conditions. Combined PA/SI assessments may be applied in an integrated removal/remedial evaluation approach. Integrated Removal Assessment and Combined PA/SI (Action Name = Int. Rmvl Assess and Combined PA/SI) activities are entered as one action in WasteLAN and tracked as an internal planning measure.

Backlogs

The Combined PA/SI Assessment backlog consists of sites having a non-NPL status value of either "Combined PA/SI start needed" or "Combined PA/SI ongoing."

Definition of Accomplishment:

Combined PA/SI Assessment Starts - A Combined PA/SI Assessment (Action Name = Combined PA/SI) starts when the region begins collecting data and performing other tasks related to development of the combined PA/SI assessment report; or when the region signs a letter, form, or memo to the EPA contractor or State/Tribal government (where applicable) requesting performance of a combined PA/SI assessment at a specific site or group of sites; or when EPA receives written confirmation from State/Tribal government that the State/Tribal government will conduct the combined PA/SI assessment. The actual start date (Actual Start) of the Combined PA/SI and a valid lead of: "Fund-Financed (F)", "EPA-In House (EP)", "State (S)" or "Tribal (TR)" Start dates are required.

Combined PA/SI Assessment Completions - A Combined PA/SI Assessment is completed when:

- A Combined PA/SI Report has been developed by EPA; or received by the region from the Federal contractor or State/Tribal government; and the appropriate Regional official signs a letter, form, or memo approving the Combined PA/SI report. The date the Combined PA/SI report is approved is entered into WasteLAN as the actual completion date of the Combined PA/SI; and

- The decision is documented by completing the Site Decision Form 9100-3 in WasteLAN, or an equivalent document. The decision document must be printed, signed by the appropriate Regional official, and placed in the file.

Valid decisions to be recorded in WasteLAN upon completion of the Combined PA/SI Assessment include:

(H) - High - Higher priority for further assessment Note: The next stage of assessment could be an ESI (Action Name = Expanded Site Inspection), an integrated ESI/RI (Action Name = ESI/RI), or preparation of an HRS package (Action Name = HRS Package); or

(L) - Low - Lower priority for further assessment; or

(N) - No further *remedial* action planned; or

(D) - Deferred to RCRA (Subtitle C); or

(DN) - Deferred to NRC; or

(A) - Site is being addressed as part of a NPL site. The site should also have an NPL Status Indicator (Site NPL Status) of "A" and a valid value in the Parent Site ID field; or

(B) - Site is being addressed as part of another non-NPL site. The site should also have a Non-NPL Status of "Addressed as part of another non-NPL site" (B) and a valid value in the Parent Site ID field; or

(F) - Referred to the removal program with further remedial assessment needed; or

(W) - Referred to the removal program with *no* further remedial assessment needed.

Changes in Definition FY 01 - FY 02/03:

Added qualifier "Site is being addressed as part of another non-NPL site."

Special Planning/Reporting Requirements:

Actual start and completion dates are required for combined PA/SIs. Combined PA/SI Starts (Actual start) and completions (Actual Complete) are reported site-specifically in WasteLAN. Combined PA/SI Assessment starts and completions at non-Federal Facility sites are program measures.

Regions are responsible for maintaining the accuracy of the non-NPL status for every non-NPL site in the CERCLIS inventory. As new actions and new dates are entered into WasteLAN, the system automatically calculates a new value for this field based on the traditional sequence of site assessment work. Regions must confirm or change this value as appropriate.

j. SITE INSPECTION PRIORITIZATIONS (SIPS) AT NON-FEDERAL FACILITY SITES

Definition:

SIPs (SubAction Name = Site Inspection Prioritization) require the gathering of additional information to update site inspections performed under the original Hazard Ranking System (HRS). SIPs are performed only at sites where the last SI was completed prior to August 1, 1992, and further evaluation is required to determine what steps, if any, need to occur next at the site. For most regions, the original SIP backlogs have been completed although a few still remain. SIPs are currently recorded in WasteLAN as SubActions (SubAction Name = Site Inspection Prioritization) to the last completed site inspection event (Action Name = Site Inspection).

In general, a finite number of sites were originally identified as needing SIPs and EPA has completed SIPs at nearly all of these sites. Nonetheless, EPA anticipates that a number of older sites addressed under the original HRS, which were not part of the original universe of sites needing SIPs, may now require SIPs based on new information received by EPA. This would apply to sites that were evaluated and assigned a NFRAP or Deferred decision under the original HRS prior to August 1, 1992, for which new information has been provided to EPA indicating further Superfund evaluation of the site is warranted.

Regions should employ FAS techniques wherever practical during SIP activities.

Backlogs

The Site Inspection Prioritization backlog consists of sites having a non-NPL status value of either "SIP start needed" or "SIP ongoing."

Definition of Accomplishment:

SIP Starts - A SIP start is defined as the date the region signs a letter, form, or memo requesting a SIP be performed at a specific site. The date should be entered into WasteLAN as the actual start date (Actual Start) of the SIP SubAction. alid leads for SIPs include: ˜Fund-Financed (F)™;˜EPA In-House (EP)™;˜State (S)™or ˜Tribal (TR)™ SIP start dates are required, and are used by HQ as a program measure.

SIP Completions - A SIP (SubAction Name = Site Inspection Prioritizations) is complete when:

- A SIP Report has been developed by EPA; or received by the region from the Federal contractor or State/Tribal government; and the appropriate Regional official signs a letter, form, or memo approving the SIP report. The SIP actual completion date is the date the SIP report is approved; and

- WasteLAN contains the actual SIP completion date (Actual Complete), and a ˜decision™on whether further activities are necessary is recorded in the Qualifier field for the SubAction; and

- The decision is documented by completing the Site Decision Form 9100-3 in WasteLAN or an equivalent document. The decision,document must be printed, signed by the appropriate Regional official, and placed in the file.

Valid decisions at the conclusion of a SIP include:

(H) - High - Higher priority for further assessment Note: The next stage of assessment could be an expanded site inspection (Action Name = Expanded Site Inspection), an integrated ESI/RI (Action Name = ESI/RI), or preparation of an HRS package (Action Name = HRS Package); or

(L) - Low - Lower priority for further assessment; or

(N) - No further *remedial* action planned; or

(D) - Deferred to RCRA (Subtitle C); or

(DN) - Deferred to NRC; or

(A) - Site is being addressed as part of a NPL site. The site should also have an NPL Status Indicator (Site NPL Status) of ~~A~~ and a valid value in the Parent Site ID field; or

(B) - Site is being addressed as part of another non-NPL site. The site should also have a Non-NPL Status of ~~Addressed as part of another non-NPL site~~ (B) and a valid value in the Parent Site ID field; or

(F) - Referred to the removal program with further remedial assessment needed; or

(W) - Referred to the removal program with *no* further remedial assessment needed.

Changes in Definition FY 01 - FY 02/03:

Added qualifier ˜Site is being addressed as part of another non-NPL site.™

Special Planning/Reporting Requirements:

Actual start and completion dates are required for SIPs. SIP starts (Actual Start) and completions (Actual Complete) are reported site-specifically in WasteLAN. Decisions reached at the conclusion of SIP activities must be recorded with the SIP SubAction. Site Inspection Prioritization starts and completions at non-Federal facility sites are program measures.

Regions are responsible for maintaining the accuracy of the non-NPL status for every non-NPL site in the CERCLIS inventory. As new actions and new dates are entered into WasteLAN, the system automatically calculates a new value for this field based on the traditional sequence of site assessment work. Regions must confirm or change this value as appropriate.

k. SITE REASSESSMENT

Definition:

A Site Reassessment represents the gathering and evaluation of new information on a site previously assessed under the Federal Superfund Program to determine whether further Superfund attention is needed. A Site Reassessment serves as a supplement to previous assessment work, and not as a replacement for traditional assessment activities (e.g., Preliminary Assessment, Site Inspection). The scope of work for a Site Reassessment activity is flexible, but will usually represent a component of a traditional site assessment action. The intent of the Site Reassessment action is to document the expenditure of Superfund resources on older sites where EPA has received new information or learned that site conditions have changed. This action is also used to record further assessment decisions made after reviewing this new site information. A brief summary of work performed as part of the Site Reassessment action and the related site decision as a result of this work must be documented by completing the Site Decision Form 9100-3 in WasteLAN, or an equivalent document. Correction of site disposition decisions (i.e., action qualifiers) based solely on file reviews should be documented using the historical lockout feature in WasteLAN and not as a new Site Reassessment action.

Definition of Accomplishment:

Site Reassessment Starts - A Site Reassessment (Action Name = Site Reassessment) start is defined as the date when EPA or State/Tribal government signs a letter, memo or form approving the site-specific Site Reassessment work plan or a TDD is issued to the contractor at a site and WasteLAN contains the actual Site Reassessment start date (Actual Start) and an action lead (Lead) of: ˜Fund-Financed (F)™;˜EPA-In House (EP)™;˜State (S)™; or ˜Tribal (TR)™

Site Reassessments Completions - A Site Reassessment (Action Name = Site Reassessment) is complete when:

- A Site Reassessment report has been developed by EPA, or received by the region from the Federal contractor, or the State/Tribal government, and the appropriate Regional official signs a letter, form, or memo approving the Site Reassessment report. The Site Reassessment actual completion date is the date the Site Reassessment report is approved, and

- WasteLAN contains the actual Site Reassessment completion date (Actual Complete), a valid lead (Lead), and a valid ˜decision™on whether further activities are necessary in the Qualifier field; and

- The decision is documented by completing the Site Decision Form 9100-3 in WasteLAN or an equivalent document. The decision document must be printed, signed by the appropriate Regional official, and placed in the file.

Valid decisions to be recorded upon completion of the Site Reassessment include:

(H) - High - High priority for further assessment; or

(L) - Low - Lower priority for further assessment; or

(N) - No further *remedial* action planned; or

(D) - Deferred to RCRA (Subtitle C); or

(DN) - Deferred to NRC; or

(A) - Site is being addressed as part of a NPL site. The site should also have an NPL Status Indicator (Site NPL Status) of "A" and a valid value in the Parent Site ID field; or

(B) - Site is being addressed as part of another non-NPL site. The site should also have a Non-NPL Status of "Addressed as part of another non-NPL site" (B) and a valid value in the Parent Site ID field; or

(F) - Referred to the removal program with further remedial assessment needed; or

(W) - Referred to the removal program with *no* further remedial assessment needed.

Changes in Definition FY 01 - FY 02/03:

Added qualifier "Site is being addressed as part of another non-NPL site."

Special Planning/Reporting Requirements:

Planning dates are not required for Site Reassessment. Actual start and completion dates are required for Site Reassessment. Site Reassessment starts (Actual Start) and completions (Actual Complete) are reported site-specifically in WasteLAN. Site Reassessment starts and completions are program measures for non-Federal facilities.

Regions are responsible for maintaining the accuracy of the non-NPL status for every non-NPL site in the CERCLIS inventory. As new actions and new dates are entered into WasteLAN, the system automatically calculates a new value for this field based on the traditional sequence of site assessment work. Regions must confirm or change this value as appropriate.

l. EXPANDED SITE INSPECTIONS (ESI) AT NON-FEDERAL FACILITY SITES

Definition:

The ESI (Action Name = Expanded Site Inspection) collects additional data beyond that collected in the SI to evaluate the site for HRS scoring. ESIs are reserved for more complex sites that cannot be adequately characterized using standard SI methodologies. Installation of groundwater monitoring wells is typical of activities performed under the ESI.

Regions also have been encouraged to further reduce repetitive tasks and costs by combining site assessment and removal evaluation activities where warranted by site conditions. This is called an integrated removal/remedial evaluation (Action Name = Int. Rmvl Assess and Expanded Site Inspection).

Regions should employ FAS techniques wherever practical during ESI activities.

Backlogs

The Expanded Site Inspection backlog consists of sites where the Non-NPL Status is either "ESI start needed" or "ESI ongoing"

Definition of Accomplishment:

ESI Starts - An ESI (Action Name = Expanded Site Inspection) start is defined as the date when EPA or State/Tribal government signs a letter, memo or form approving the site specific ESI work plan or a Technical Direction Document is issued to the contractor at a site and WasteLAN contains the actual ESI start date (Actual Start) and an action lead (Lead) of: "Fund-Financed (F)", "EPA-In House (EP)", "State (S)" or "Tribal (TR)"

ESI Completions - An ESI (Action Name = Expanded Site Inspection) is complete when:

- An ESI Report has been developed by EPA; or received by the region from the Federal contractor; or the State/Tribal government; and the appropriate Regional official signs a letter, form, or memo approving the ESI report; the ESI actual completion date is the date the ESI report is approved; and

- WasteLAN contains the actual ESI completion date (Actual Complete), a valid lead (Lead), and a valid "decision™ on whether further activities are necessary in the Qualifier field; and

- The decision is documented by completing the Site Decision Form 9100-3 in WasteLAN or an equivalent document. The decision document must be printed, signed by the appropriate Regional official, and placed in the file.

Valid decisions to be recorded upon completion of the ESI include:

(G) - Recommended for HRS Scoring (i.e., development of HRS package, Action Name = HRS Package); or

(L) - Low - Lower priority for further assessment; or

(N) - No further *remedial* action planned; or

(D) - Deferred to RCRA (Subtitle C); or

(DN) - Deferred to NRC; or

(A) - Site is being addressed as part of a NPL site. The site should also have an NPL Status Indicator (Site NPL Status) of A and a valid value in the Parent Site ID field; or

(B) - Site is being addressed as part of another non-NPL site. The site should also have a Non-NPL Status of Addressed as part of another non-NPL site (B) and a valid value in the Parent Site ID field; or

(F) - Referred to the removal program with further remedial assessment needed; or

(W) - Referred to the removal program with *no* further remedial assessment needed.

Changes in Definition FY 01 - FY 02/03:

Added qualifier "Site is being addressed as part of another non-NPL site.™

Special Planning/Reporting Requirements:

Planning dates are not required for ESIs. Actual start and completion dates are required for ESIs. ESI starts (Actual Start) and completions (Actual Complete) are reported site-specifically in WasteLAN. ESI starts and completions are program measures for non-Federal facilities.

Regions are responsible for maintaining the accuracy of the non-NPL status for every non-NPL site in the CERCLIS inventory. As new actions and new dates are entered into WasteLAN, the system automatically calculates a new value for this field based on the traditional sequence of site assessment work. Regions must confirm or change this value as appropriate.

m. FEDERAL FACILITY SI REVIEWS

Definition:

A Federal facility SI Review (Action Name = Federal Facility SI Review) is an EPA quality assurance review of a SI report submitted by another Federal agency. EPA's involvement in SI activities at Federal facilities differs from that at non-Federal facilities. While EPA conducts or funds development of SIs at non-Federal facilities, EPA's role at Federal

facilities is limited to reviewing SI reports developed and submitted by the Federal agencies responsible for a given Federal facility. Upon reviewing the SI for completeness, and working with the other Federal agency to address any deficiencies, EPA then determines what next steps are appropriate with respect to NPL listing.

Backlogs

The Federal Facility SI Review backlog consists of sites with a Non-NPL Status of "FF-SI review needed™or "FF-SI review ongoing.™

Definition of Accomplishment:

Federal Facility SI Review Starts - A Federal facility SI review (Action Name = Federal Facility SI Review) is started when EPA starts in-house review of the Federal Facility SI report, or sends a letter, form, or memo to the EPA contractor requesting review of the Federal facility SI report; and WasteLAN contains the actual Federal Facility SI Review start date (Actual Start) and a valid action lead of "Fund-Financed (F)™;"EPA-In House (EP)™;"State (S)™;or "Tribal (TR)™

Federal Facility SI Review Completions - A Federal facility SI Review (Action Name = Federal Facility SI Review) is completed when:

- The appropriate Regional official signs a letter, form, or memo approving the Federal facility SI report. The date the Federal facility SI report is approved is entered into WasteLAN as the actual completion date of the Federal facility SI report; and

- WasteLAN contains the actual completion date (Actual Complete) of the Federal Facility SI Review, a lead and a valid "decision™on whether further activities are necessary in the Qualifier field; and

- The decision is documented by completing the Site Decision Form 9100-3 in WasteLAN or an equivalent document. The decision document must be printed, signed by the appropriate Regional official, and placed in the file.

Valid decisions to be recorded upon completion of Federal facility SI reviews include:

(H) - High - Higher priority for further evaluation/HRS Scoring; or

(L) - Low - Lower priority for further assessment; or

(N) - No further *remedial* action planned; or

(A) - Site is being addressed as part of a NPL site. The site should also have an NPL Status Indicator (Site NPL Status) of –A–and a valid value in the Parent Site ID field; or

(B) - Site is being addressed as part of another non-NPL site. The site should also have a Non-NPL Status of –Addressed as part of another non-NPL site–(B) and a valid value in the Parent Site ID field; or

(D) - Deferred to RCRA; or

(DN) - Deferred to NRC.

Changes in Definition FY 01 - FY 02/03:

Added qualifier "Site is being addressed as part of another non-NPL site.™

Special Planning/Reporting Requirements:

Planning dates are not required for Federal facility SI reviews. Actual start and completion dates are required for Federal facility SI reviews. Federal facility SI Review starts (Actual Start) and completions (Actual Complete) are reported site-specifically in WasteLAN. Federal facility SI Review starts and completions are program measures.

If the Federal facility SI report does not provide sufficient information to make a NPL assessment decision, the report should be referred back to the Federal facility (SubAction Name = Referred back to Fed Fac). The date the report is referred back to the Federal facility is entered into WasteLAN as the actual completion date (Actual Complete). The actual completion date and qualifier for the Federal Facility Site Inspection Review should not be entered until all the report deficiencies have been addressed.

Regions are responsible for maintaining the accuracy of the non-NPL status for every non-NPL site in the CERCLIS inventory. As new actions and new dates are entered into WasteLAN, the system automatically calculates a new value for this field based on the traditional sequence of site assessment work. Regions must confirm or change this value as appropriate.

n. FEDERAL FACILITY ESI REVIEWS

Definition:

A Federal facility ESI Review (Action Name = Federal Facility ESI Review) is an EPA quality assurance review of an ESI report submitted by another Federal agency. EPA-s involvement in ESI activities at Federal facilities differs from that at non-Federal facilities. While EPA conducts or funds development of ESIs at non-Federal facilities, EPA-s role at Federal facilities is limited to reviewing ESI reports developed and submitted by the Federal agencies responsible for a given Federal facility. Upon reviewing the ESI for completeness, and working with the other Federal agency to address any deficiencies, EPA then determines what next steps are appropriate with respect to NPL listing.

Backlogs

The Federal Facility ESI Review backlog consists of sites having a Non-NPL Status of ~FF-ESI review needed™ or FF-ESI review ongoing™

Definition of Accomplishment:

Federal Facility ESI Review Starts - A Federal facility ESI review (Action Name = Federal Facility ESI Review) is started when EPA starts in-house review of the Federal Facility ESI report, or sends a letter, form, or memo to the EPA contractor requesting review of the Federal Facility ESI report; and WasteLAN contains the actual Federal Facility ESI Review start date (Actual Start) and a valid action lead of ~Fund-Financed (F)™; ~EPA-In House (EP)™; ~State (S)™; or ~Tribal (TR)™

Federal Facility ESI Review Completions - A Federal Facility ESI Review (Action Name = Federal Facility ESI Review) is completed when:

- The appropriate Regional official signs a letter, form, or memo approving the Federal facility ESI report. The date the Federal facility ESI report is approved is entered into WasteLAN as the actual completion date of the Federal Facility, ESI report; and
- WasteLAN contains the actual completion date (Actual Complete) of the Federal Facility ESI Review, a lead (Lead), and a valid ~decision™ on whether further activities are necessary in the Qualifier field; and
- The decision is documented by completing the Site Decision Form 9100-3 in WasteLAN or an equivalent document. The decision document must be printed, signed by the appropriate Regional official, and placed in the file.

Valid decisions to be recorded upon completion of Federal facility ESI reviews include:

(G) - Recommended for HRS Scoring; or

(L) - Low - Lower priority for further assessment; or

(N) - No further *remedial* action planned; or

(A) - Site is being addressed as part of a NPL site. The site should also have an NPL Status Indicator (Site NPL Status) of -A- and a valid value in the Parent Site ID field; or

(B) - Site is being addressed as part of another non-NPL site. The site should also have a Non-NPL Status of -Addressed as part of another non-NPL site- (B) and a valid value in the Parent Site ID field; or

(D) - Deferred to RCRA; or

(DN) - Deferred to NRC.

Changes in Definition FY 01 - FY 02/03:

Added qualifier "Site is being addressed as part of another non-NPL site.™

Special Planning/Reporting Requirements:

Planning dates are not required for Federal facility ESI reviews. Actual start and completion dates are required for Federal facility ESI reviews. Federal Facility ESI Review starts (Actual Start) and completions (Actual Complete) are reported site-specifically in WasteLAN. Federal Facility ESI Review starts and completions are program measures.

If the Federal facility ESI report does not provide sufficient information to make a NPL assessment decision, the report should be referred back to the Federal facility (SubAction Name = Referred back to Fed Fac). The date the report is referred back to the Federal facility is entered into WasteLAN as the actual completion date (Actual Complete). The actual completion date and qualifier for the Federal Facility Expanded Site Inspection Review should not be entered until all the report deficiencies have been addressed.

Regions are responsible for maintaining the accuracy of the non-NPL status for every non-NPL site in the CERCLIS inventory. As new actions and new dates are entered into WasteLAN, the system automatically calculates a new value for this field based on the traditional sequence of site assessment work. Regions must confirm or change this value as appropriate.

o. INTEGRATED EXPANDED SITE INSPECTION/REMEDIAL INVESTIGATION (ESI/RI) AT NON-FEDERAL FACILITY SITES

Definition:

The integrated ESI/RI (Action Name = ESI/RI) is an assessment consisting of an ESI and a RI. The ESI/RI is used to expedite remedial response by gathering site characterization data common to both ESI and RI activities in one step, thereby expediting the later collection of data when comprehensive RI activities are perfomed. The goal of ESI/RIs is to save time and costs characterizing sites when compared to the traditional, sequential ESI-NPL Listing-RI process. ESI/RIs facilitate but do not replace RIs, and are recommended at sites where conditions indicate that the HRS score will be above 28.5 and a remedial response will be needed. The RI portion of an ESI/RI is intended to be a site-wide activity. ESI/RIs actions should be entered into WasteLAN at operable unit -00-.

ESI/RIs may not always be feasible given known site conditions and activities completed to date. In some cases, it may be more prudent to conduct a separate ESI and RI. The definitions for RI/FS Completion and RI Completion (see

definitions in Appendix B) are different from the definition for ESI/RI Completion. The definition of an ESI/RI Completion is the same as that of an ESI Completion. If an ESI/RI action is recorded in WasteLAN, a stand-alone ESI event (Action Name = Expanded Site Inspection) should not be recorded at that site.

Regions are also encouraged to further reduce repetitive tasks and costs by combining site assessment and removal evaluation activities where warranted by site conditions. This is called an integrated removal/remedial evaluation (Action Name = Int Rmvl Assess and ESI/RI) and is further discussed in a separate section below.

Backlogs
The ESI/RI backlog consists of sites with a Non-NPL Status of either "Integrated ESI/RI start needed" or "Integrated ESI/RI ongoing"

Definition of Accomplishment:

***ESI/RI* Starts** - ESI/RI (Action Name = ESI/RI) start date is defined as the date when EPA approves the site-specific ESI/RI work plan and WasteLAN contains the actual ESI/RI start date (Actual Start) and an action lead of: "Fund-Financed (F)"; "EPA-In House (EP)"; "State (S)"; or "Tribal (TR)"

ESI/RI Completions - An ESI/RI (Action Name =ESI/RI) is complete when:

- An ESI/RI Report has been reviewed and accepted by the region and the appropriate Regional official signs a letter, form, or memo approving the ESI/RI report. The ESI/RI actual completion date is the date the ESI/RI report is approved; and

- The following has been recorded in WasteLAN: the actual ESI/RI completion date (Actual Complete); a valid lead (Lead); and a "decision" on whether further activities are necessary in the Qualifier field; and

- The decision is documented by completing the Site Decision Form 9100-3 in WasteLAN or an equivalent document. The decision document must be printed, signed by the appropriate Regional official, and placed in the file.

Valid decisions to be recorded upon completion of the ESI/RI include:

(G) - Recommended for HRS Scoring (i.e., development of HRS package, Action Name =HRS Package); or

(L) - Low - Lower priority for further assessment; or

(N) - No further *remedial* action planned; or

(A) - Site is being addressed as part of a NPL site. The site should also have an NPL Status Indicator (Site NPL Status) of –A– and a valid value in the Parent Site ID field; or

(B) - Site is being addressed as part of another non-NPL site. The site should also have a Non-NPL Status of –Addressed as part of another non-NPL site– (B) and a valid value in the Parent Site ID field; or

(F) - Referred to the removal program with further remedial assessment needed; or

(W) - Referred to the removal program with *no* further remedial assessment needed; or

(D) - Deferred to RCRA; or

(DN) - Deferred to NRC.

Changes in Definition FY 01 - FY 02/03:

Added qualifier "Site is being addressed as part of another non-NPL site."

Special Planning/Reporting Requirements:

Planned start and completion dates are not required for ESI/RIs. Actual start and completion dates are required for ESI/RIs. ESI actions (Action Name = Expanded Site Inspection) should not be recorded separately in WasteLAN if they are conducted as part of an ESI/RI. ESI/RI starts and completions at non-Federal Facility sites are program measures.

Regions are responsible for maintaining the accuracy of the non-NPL status for every non-NPL site in the CERCLIS inventory. As new actions and new dates are entered into WasteLAN, the system automatically calculates a new value for this field based on the traditional sequence of site assessment work. Regions must confirm or change this value as appropriate.

p. STATE DEFERRAL OF NON-FEDERAL FACILITY SITES

Definition:

State Deferral (Action Name = State Deferral) is an administrative mechanism enabling States and Tribes, under their own laws, to respond at sites in the CERCLIS inventory that EPA would otherwise not soon address. Under the State Deferral program, EPA anticipates that responses may be quick and efficient, yet still be protective of the environment and of communities—rights to participate in the decision-making process. Refer to the "Guidance on Deferral of NPL Listing Determinations While States Oversee Response Actions"(OSWER Directive 9375.6-11, May 1995) for additional information on this program.

Backlogs

The State Deferral backlog consists of CERCLIS sites with a Non-NPL Status of "Deferral of NPL listing decision while States oversee response"

Definition of Accomplishment:

State Deferral Starts - The State Deferral (Action Name = State Deferral) process start is defined as the date when the Regional Superfund program director and the State program director sign a document deferring the site to the State under the terms established in the deferral guidance. A State Deferral action must be recorded in WasteLAN with an action lead (Lead) of "State Deferral (SD)" State deferrals are applicable only to non-Federal facility sites that are not on the NPL.

State Deferral Completions The State Deferral (Action Name = State Deferral) completion date is defined as either: 1) the signature date of a formal regional document confirming that the deferral has been completed successfully, or terminating the deferral agreement; or 2) 90 days after the date EPA receives State certification that the deferral has been completed. The outcome (Qualifier) of the State deferral must be entered with the completion date.

Valid outcomes (Qualifiers) to be recorded upon completion of the State Deferral include:

(RS) - Region confirmed successful deferral completion; or

(RT) - Region terminated deferral.

Changes in Definition FY 01 - FY 02/03:

None.

Special Planning/Reporting Requirements:

Six SubActions can be entered for the State Deferral action to generically capture the different cleanup phases a site may be undergoing. These SubActions include:

1. Comprehensive Site Investigation (SubAction Name = Comprehensive Site Investigation)
2. Remedy Selection (SubAction Name = Remedy Selection);
3. Design (SubAction Name = Design);
4. Construction (SubAction Name = Construction); and
5. Post-Construction Maintenance (SubAction Name = Post Construction Maintenance)
6. Short Term Cleanup (SubAction Name = Short Term Cleanup)

SubAction start and completion dates and SubAction lead codes are available for documenting the start and completion of the different cleanup phases being conducted at non-NPL sites by non-EPA parties.

Planned start and completion dates are not required for State Deferral actions. Actual start and completion dates are required. Sites successfully completing the deferral process are eligible for archiving (removal) from the CERCLIS inventory. State Deferral starts and completions are program measures.

Regions are responsible for maintaining the accuracy of the non-NPL status for every non-NPL site in the CERCLIS inventory. As new actions and new dates are entered into WasteLAN, the system automatically calculates a new value for this field based on the traditional sequence of site assessment work. Regions must confirm or change this value as appropriate.

q. HAZARD RANKING SYSTEM PACKAGE (HRS)

Definition:

The HRS Package (Action Name = HRS Package) documents a numeric score of the relative severity of a hazardous substance release or potential release based on: (1) the relative potential of substances to cause hazardous situations; (2) the likelihood and rate at which the substances may affect human and environmental receptors; and (3) the severity and magnitude of potential effects. The HRS Package also includes references and documentation in support of the score. The score is computed using the revised Hazard Ranking System (HRS). Regions are responsible for preparing HRS packages for both Federal and non-Federal facility sites. Regions submit a draft version of the HRS package to HQ for quality assurance review. Regions and HQ work together to address issues and agree on a final version of the HRS package. Based on results of the completed HRS package and other factors, regions determine what the next steps, if any, are appropriate for a site (e.g., NPL listing, NFRAP, etc.)

Backlogs

The HRS backlog consists of sites having Non-NPL Status of either ˜HRS start needed™ or ˜HRS ongoing™

Definition of Accomplishment:

HRS Package Starts - An HRS Package (Action Name = HRS Package) start is defined as the date when EPA signs a memo, form, or letter requesting development of a HRS Package for a specific site and WasteLAN contains the actual HRS Package start date (Actual Start) and a valid action lead of ˜Fund-Financed (F)™, ˜EPA-In House (EP)™, ˜State (S)™, or ˜Tribal (TR)™ HRS Package start dates are required for both Federal and non-Federal facility sites, and are used to identify the status of sites in the site assessment pipeline and to measure activity durations. Due to the pre-decisional nature of HRS packages, regions may postpone entry of HRS start dates until after the HRS package has gone through HQ quality assurance review or after the site has been proposed to the NPL.

HRS Package Completions - An HRS Package (Action Name = HRS Package) is complete when:

- An HRS Package has completed HQ quality assurance review and HQ and the region agree to a final version; and
- The following has been recorded in WasteLAN: the approval date for the final version of the HRS Package date as the actual HRS Package completion date (Actual Complete), a lead (Lead), and a "decision™on whether further activities are necessary in the Qualifier field. Since HRS packages are pre-decisional, entry of HRS Package completion dates in WasteLAN may be delayed until after the site is proposed to the NPL, if applicable; and
- The decision is documented by completing the Site Decision Form 9100-3 in WasteLAN or an equivalent document. The decision document must be printed, signed by the appropriate Regional official, and placed in the file.

Note: Submission of HRS Packages to HQ for technical assistance does not represent an HRS Package completion.

Valid decisions to be recorded upon completion of the HRS Package include:

(O) - Site is being considered for proposal to the NPL; or

(N) - No further *remedial* action planned; or

(W) - Referred to the removal program with *no* further remedial assessment needed; or

(F) - Referred to the removal program with further remedial assessment needed; or

(D) - Deferred to RCRA; or

(DN) - Deferred to NRC.

Changes in Definition FY 01 - FY 02/03:

None.

Special Planning/Reporting Requirements:

Planned start and completion dates are not required for HRS Packages. Actual start and completion dates are required for HRS Packages. HRS Package starts and completions at both Federal and non-Federal Facilities are program measures.

Regions are responsible for maintaining the accuracy of the non-NPL status for every non-NPL site in the CERCLIS inventory. As new actions and new dates are entered into WasteLAN, the system automatically calculates a new value for this field based on the traditional sequence of site assessment work. Regions must confirm or change this value as appropriate.

r. INTEGRATED REMOVAL/REMEDIAL EVALUATION

Definition:

Integrated Removal/Remedial Evaluations are actions integrating both site assessment (e.g., Preliminary Assessment, Site Inspection) and removal assessment activities to reduce the overall time and money spent characterizing site conditions. The scope of the Integrated Removal/Remedial Evaluation will depend on which activities are being jointly conducted. Seven specific types of Integrated Removal/Remedial Evaluations will be tracked:

- Integrated Removal Assessments and Preliminary Assessments (Action Name = Int Rmvl Assess and Preliminary Assessment);
- Integrated Removal Assessments and Site Inspections (Action Name = Int Rmvl Assess and Site Inspection);
- Integrated Removal Assessments and Combined PA/SI (Action Name = Int Rmvl Assess and Combined PA/SI);
- Integrated Removal Assessments and Expanded Site Inspections (Action Name - Int. Rmvl Assess and Expanded Site Inspection);
- Integrated Removal Assessments and Hazard Ranking System (Action Name = Int. Rmvl Assess and HRS Package);
- Integrated Removal Assessments and ESI/RI (Action Name = Int. Rmvl Assess and ESI/RI); and
- Integrated Removal Assessments and Site Inspection Prioritizations (SubAction Name = Int Rmvl Assess and Site Inspection Prioritization).

Regions are encouraged to make use of integrated assessment approaches wherever appropriate. Requirements of site assessment actions (e.g., PA, SI) and removal assessments must still be met, even though they are conducted in an integrated fashion. Refer to appropriate sections of the SPIM and Superfund assessment guidance documents for further requirements of stand-alone assessment activities. The definitions and special planning/reporting requirements for all seven types of Integrated Removal/Remedial Evaluations listed above follow the same general concept. Generic definitions and requirements are provided below.

For more information on Integrated Removal/Remedial Assessments, please see OERR's Quick Reference Guidance Series document titled: "Improving Site Assessment: Integrated Removal and Remedial Site Evaluations™ OSWER 9360.0-39FS, PB99-963314; dated April 2000.

Regions should employ FAS techniques wherever practical during Integrated Removal/Remedial Evaluation activities.

Backlogs
The Integrated Removal/Remedial Evaluation backlog consists of sites having a Non-NPL Status of "Integrated Removal/Remedial evaluation needed™ or "Integrated Removal/Remedial evaluation ongoing™

Definition of Accomplishment:

Starts - An Integrated Removal/Remedial Evaluation (Action Name = Int. Rmvl Assess and Preliminary Assessment, Int. Rmvl Assess and Site Inspection, Int. Rmvl Assess and Expanded Site Inspection, Int. Rmvl Assess and Combined PA/SI, Int. Rmvl Assess and ESI/RI, and Int. Rmvl Assess and HRS Package) and (Subaction Name = Int. Rmvl Assess and Site Inspection Prioritization) start date is defined as the date when EPA approves the site-specific Integrated Removal/Remedial Evaluation work plan (e.g., Removal Assessment and SI work plan) and WasteLAN contains:

- The actual Integrated Removal/Remedial Assessment start date (Actual Start) and an action lead (Lead) of: "Fund-Financed (F)™; "EPA-In House (EP)™; "State (S)™; or "Tribal (TR)™; and

Completions - An Integrated Removal/Remedial Evaluation (Action Name = Int. Rmvl Assess and Preliminary Assessment, Int. Rmvl Assess and Site Inspection, Int. Rmvl Assess and Expanded Site Inspection, Int. Rmvl Assess and Combined PA/SI, Int. Rmvl Assess and ESI/RI, and Int. Rmvl Assess and HRS Package) and (Subaction Name = Int. Rmvl Assess and Site Inspection Prioritization) is complete when:

- The Integrated Removal/Remedial Evaluation report has been reviewed and accepted by the region and an appropriate Regional official signs a letter, form, or memo approving the report. The report must contain all of the information required for the related site assessment and must document the completion of a Removal Assessment to determine whether a removal action is necessary. A note to the site file must also be prepared indicating that the Integrated Removal/Remedial Evaluation report meets all the requirements for the related assessment activities; and

- The Integrated Removal/Remedial Evaluation report approval date is entered into WasteLAN as the actual Integrated Removal/Remedial Assessment completion date (Actual Complete) with a valid lead (Lead); and

- The decision is documented by completing the Site Decision Form 9100-3 in WasteLAN or an equivalent document. The decision document must be printed, signed by the appropriate Regional official, and placed in the file.

A "decision™on whether further activities are necessary is entered into WasteLAN in the Action Qualifier field.

Valid Integrated Assessment action qualifiers include:

(H) - High - Higher priority for further assessment. Note: The next stage of assessment could be an SI (Action Name= Site Inspection), expanded site inspection (Action Name =Expanded Site Inspection), an integrated ESI/RI (Action Name =ESI/RI), or preparation of an HRS package (Action Name = HRS Package), or consideration for proposal to the NPL; or

(L) - Low - Lower priority for further assessment; or

(N) - No further *remedial* action planned; or

(D) - Deferred to RCRA (Subtitle C); or

(DN) - Deferred to NRC; or

(A) - Site is being addressed as part of a NPL site. The site should also have an NPL Status Indicator (Site NPL Status) of –A–and a valid value in the Parent Site ID field; or

(B) - Site is being addressed as part of another non-NPL site. The site should also have a Non-NPL Status of–Addressed as part of another non-NPL site–(B) and a valid value in the Parent Site ID field; or

(F) - Referred to the removal program with further remedial assessment needed; or

(W) - Referred to the removal program with *no* further remedial assessment needed; or

(G) - Recommended for HRS scoring. This qualifier should be used only for Int. Rmvl Assess and ESI or Int. Rmvl Assess and ESI/RI.

Changes in Definition FY 01 - FY 02/03:

Added qualifier "Site is being addressed as part of another non-NPL site.™Added separate actions/subaction for each integrated assessment. The data entry will be reduced from adding three actions (Removal Assessment, Integrated Assessment and the corresponding Site Assessment action) to one action or subaction.

Special Planning/Reporting Requirements:

Planning dates are not required for Integrated Assessments. Actual start and completion dates are required for Integrated Assessments. Integrated Assessment action qualifiers are required. Integrated Removal Assessment and PA, Integrated Removal Assessment and Site Inspection, Integrated Removal Assessment and Combined PA/SI , Integrated Removal Assessment and Expanded Site Inspection, Integrated Removal Assessment and Site Inspection Prioritization, Integrated Removal Assessment and ESI/RI and Integrated Removal Assessment and HRS Package starts and completions at non-Federal facilities are program measures.

Regions are responsible for maintaining the accuracy of the non-NPL status for every non-NPL site in the CERCLIS inventory. As new actions and new dates are entered into WasteLAN, the system automatically calculates a new value for this field based on the traditional sequence of site assessment work. Regions must confirm or change this value as appropriate.

s. NPL LISTING

Definition:

The NPL is a list of national priorities among the known or threatened releases of hazardous substances, pollutants, or contaminants throughout the United States and trust territories. There are three mechanisms for placing sites on the NPL for possible remedial action:

- A site may be included on the NPL if it scores sufficiently high on the Hazard Ranking System (HRS). The HRS serves as a screening device to evaluate the relative threat that uncontrolled hazardous substances pose to human health or the environment. As a matter of Agency policy, those sites that score 28.50 or greater on the HRS are eligible for the NPL.

- Each State may designate a single site as its top priority to be listed on the NPL, regardless of the HRS score.

- Certain sites may be listed regardless of their HRS score, if all of the following conditions are met:

  - The Agency for Toxic Substances and Disease Registry (ATSDR) of the U.S. Public Health Service has issued a health advisory that recommends dissociation of individuals from the release; and

  - EPA determines that the release poses a significant threat to public health; and

  - EPA anticipates that it will be more cost-effective to use its remedial authority than to use its removal authority to respond to the release.

Backlogs

In general, the backlog for proposing sites to the NPL consists of sites having a Non-NPL Status of "HRS Package Completed - Further Evaluation Needed™

Definition of Accomplishment:

Proposed NPL Listing - The process of proposing a site for placement on the NPL is complete (Actual Complete date) when a Proposed Rule proposing the site to the NPL [Action Name = Proposal to NPL] is published in the *Federal Register.*

Removal of Proposed NPL Listing - The process of removing a site from the list of proposed NPL sites starts (Actual Start date) when a proposal to remove the site is published in the *Federal Register* and is complete (Actual Complete date) when final notice of the removal is published in the *Federal Register* [Action Name = Removed from the Proposed NPL].

Final NPL Listing - The listing process for a site is complete (Actual Complete date) when a Final Rule adding the site to the NPL [Action Name = Final Listing on NPL] is published in the *Federal Register.*

Withdrawn from the Final NPL - The process of withdrawing a site is complete (Actual Complete date) when a Final Rule withdrawing the site [Action Name - Withdrawn from the NPL] is published in the Federal Register.

Changes in Definition FY 01 - FY 02/03:

Added Federal Register dates as HQ responsibility.

Special Planning/Reporting Requirements:

The following data are to be entered into WasteLAN:

Regional Responsibility

Regions are responsible for entering the following site-related information.

- Site name (Listing Site Name will not be editable)
- EPA Site ID
- Street Address
- City
- County
- State
- Zip Code
- Region
- Congressional district
- Regional Latitude and Longitude

HQ Responsibility

š The NPL listing Actions (Proposal to NPL, Removed from Proposed NPL, Final Listing on NPL, Withdrawn from the NPL, and Deleted from the NPL);

š The actual completion date for these actions;

š An action lead of Fund-financed (F);

š The NPL Status of ˜Proposed for NPL (P)™;Removed from list of proposed NPL sites (R)™;˜Currently on Final NPL (F)™; ˜Withdrawn from NPL (W)™;and ˜Deleted from the NPL (D)™;

š The *Federal Register* citation;

š The Federal facility status; and

š *Federal Register* dates.

NOTE:
Further information on Deletion and Partial Deletion from the NPL can be found in Appendix B of this Manual. NPL Listing is a program measure.

t. OTHER CLEANUP ACTIVITY

Definition:

This action is used to document cleanup work at non-NPL sites being conducted by non-EPA parties without EPA enforcement or oversight.

Definition of Accomplishment:

Other Cleanup Activity Starts - An Other Cleanup Activity (Action Name = Other Cleanup Activity) start date is defined as the date the non-EPA party begins cleanup work at a non-NPL site. Valid leads for Other Cleanup Activity are: State Enforcement (SE), PRP Lead Under State (SR), State (S), No Fund Money (SN), Tribal (TR), Federal Facility (FF), PRP Response Under State (PS), and PRP (RP).

Other Cleanup Activity Completions - An Other Cleanup Activity (Action Name = Other Cleanup Activity) complete date is defined as the date the non-EPA party completes/completed cleanup work at a non-NPL site. The following action qualifiers are available for this action:

(H) - High - Higher priority; and

(L) - Low - Lower priority; and

(Blank) - No qualifier specified.

Changes in Definition FY 01 - FY 02/03:

None.

Special Planning/Reporting Requirements:

The following six SubActions should be entered under the Other Cleanup Activity Action to generically capture the different cleanup phases a site may be undergoing.

1. Comprehensive Site Investigation (SubAction Name = Comprehensive Site Investigation)
2. Remedy Selection (SubAction Name = Remedy Selection);
3. Design (SubAction Name = Design);
4. Construction (SubAction Name = Construction);
5. Post-Construction Maintenance (SubAction Name = Post Construction Maintenance); and
6. Short Term Cleanup (SubAction Name = Short Term Cleanup).

SubAction start and completion dates and SubAction lead codes are available for documenting the start and completion of the different cleanup phases being conducted at non-NPL sites by non-EPA parties.

The following action qualifiers are available for these SubActions:

(H) - High - Higher priority; and

(L) - Low - Lower priority; and

(Blank) - No qualifier specified.

Regions are responsible for maintaining the accuracy of the non-NPL status for every non-NPL site in the CERCLIS inventory. As new actions and new dates are entered into WasteLAN, the system automatically calculates a new value for this field based on the traditional sequence of site assessment work. Regions must confirm or change this value as appropriate.

A.B. SUBJECT MATTER EXPERTS

The following table identifies the subject matter experts for Appendix A: Site Assessment and NPL Listing Decisions.

EXHIBIT A.2 SUBJECT MATTER EXPERTS

Subject Matter Expert	Subject Area	Phone #
Terry Jeng	Site Assessment/NPL Listing	(703) 603-8852
Jennifer Griesert	Site Assessment	(703) 603-8888
Randy Hippen	Site Assessment	(703) 603-8829
Angelo Carasea	Site Assessment/SCAP-13	(703) 603-8828

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Attachment 4-3

Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs)

Eco-SSL Standard Operating Procedure (SOP) #4: Wildlife Toxicity Reference Value Literature Review, Data Extraction and Coding

OSWER Directive 92857-55

November 2003

Attachment 4-3

Standard Operating Procedure (SOP) #4: Wildlife Toxicity Reference Value Literature Review, Data Extraction and Coding

for

Ecological Soil Screening Levels (Eco-SSLs)
OSWER Directive 92857-55

November 2003

Prepared for USEPA Region 8 by
Syracuse Research Corporation
Denver, Colorado 80123

maintained by
Computer Sciences Corporation
Duluth, Minnesota 55804

Contract 68-W01-032, Task Order No. 24

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1.0 INTRODUCTION

1.1 Purpose

The United States Environmental Protection Agency (USEPA) Office of Emergency and Remedial Response (OERR) with a multi-stakeholder workgroup has developed risk-based soil screening levels (Eco-SSLs). Eco-SSLs are concentrations of contaminants in soils that are protective of ecological receptors that commonly come into contact with soil or ingest biota that live in or on soil. Eco-SSLs are derived separately for four groups of ecological receptors: mammals, birds, plants, and soil invertebrates. As such, these values are presumed to provide adequate protection of terrestrial ecosystems.

The Eco-SSLs should be used in the baseline ERA process to identify the contaminants that need to be evaluated further in the characterization of exposure, effects and risk characterization. The Eco-SSLs should be used during Step 2 of the Superfund ERA process, the screening-level risk calculation. This step normally is completed at a time when limited soil concentration data are available, and other site-specific data (e.g., contaminant bioavailability information, area use factors) are not available. It is expected that the Eco-SSLs will be used to screen the site soil data to identify those contaminants that are not of potential ecological concern and do not need to be considered in the subsequent baseline ERA.

Plant and soil biota Eco-SSLs are developed from available plant, soil invertebrate and microbial toxicity data. The mammal and bird Eco-SSLs are the result of back-calculations from a Hazard Quotient (HQ) of 1.0. The HQ is equal to the dose (associated with the contaminant concentration in soil) divided by a toxicity reference value (TRV). Generic food chain models are used to estimate the relationship between the concentration of the contaminant in soil and the dose for the receptor (mg per kg body weight per day). The TRV represents a numerical estimate of a no adverse effect level (dose) for the respective contaminant.

The methods for deriving the oral TRVs needed for calculation of Eco-SSLs for mammals and birds are contained within four standard operating procedures (SOPs):

Eco-SSL SOP #3	Literature Search and Retrieval (Attachment 4-2)
Eco-SSL SOP #4	Literature Review, Data Extraction and Coding (Attachment 4-3)
Eco-SSL SOP #5	Data Evaluation (Attachment 4-4)
Eco-SSL SOP #6	Derivation of the Oral TRV (Attachment 4-5)

This document serves as SOP #4 which is Attachment 4-4 of the Eco-SSL guidance document. It describes the procedures used for review and extraction of data from toxicological studies identified as a result of SOP #3 (Attachment 4-2) and also serves as a user's manual for the web-

based data entry system used to guide the data extraction process. The extracted data are evaluated (scored) for their usefulness in establishing an oral TRV according to procedures provided in SOP #5 (Attachment 4-4). The extracted and scored data are then used to derive TRVs for mammals and birds, according to the procedures outlined in SOP #6 (Attachment 4-5).

1.2 Wildlife TRV Database

The Wildlife TRV database is a tool designed to facilitate efficient and accurate data extraction from reviewed toxicological studies. Importing the data directly into an electronic database facilitates the necessary sorting, searching and presentation of the data for the purposes of TRV derivation. The original database was designed using Microsoft Access and included a series of data entry forms. It was envisioned that each of the parties responsible for data entry would receive a copy of the Access database on disk. After all toxicity studies had been entered and coded by individual parties, each remote database would then be transferred and merged into a master Access database., The use of the Access-based data entry system was reevaluated as a result of changes in the data entry process and the addition of USEPA regional users. Several issues were identified, including: 1) how to update future changes to the database after the initial distribution, 2) how to effectively merge and incorporate all remote databases into the master database, 3) how to distribute the completed master database to all interested parties after the data entry process has been completed, and 4) how to distribute the database for review by external parties.

A web-based data entry system was proposed to resolve these issues. The web-based data entry system allows for remote access from any computer with Internet capabilities. Entry to the site is password-protected and limited to only those individuals responsible for data entry. All information entered is sent directly to a master database, avoiding quality assurance problems associated with merging multiple sources into one database. This system provides immediate access to entered data. Any changes to the data entry process or scoring are immediately reflected on the website. The website also allows users to view summaries of entered information in a format designed for quality assurance (QA) review. Information in the system can be downloaded into Microsoft Access format.

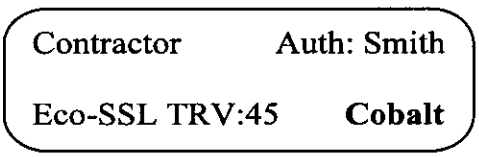
The results of the Eco-SSL coding effort are transferred to EPA, Mid-Continent Ecology Division, Duluth, MN for incorporation into the ECOTOX database. The coding guidelines used here for the Wildlife TRV effort follow the same basic structure as those used by EPA for TERRETOX. There are, however, some necessary additions and exclusions from the TERRETOX coding system. The TRV database is focused on identifying the no observed adverse effect level (NOAEL) and lowest observed adverse effect level (LOAEL) doses in relevant toxicological studies. Experimental data for toxicological endpoints are not entered into the TRV database.

2.0 REVIEW OF LITERATURE AND REJECTION CRITERIA

At this point in the Wildlife TRV derivation process, hard copies of literature identified as a result of SOP #5 are available to the User. A unique reference number is assigned to each article identified as a result of the literature search process. This reference number serves as a key to the full citation which is recorded in a commercially available bibliographic software program (ProCite or Reference Manager, ISI Researchsoft). The hard copies of the literature are housed at the EPA Region 8 offices in Denver, Colorado and at the EPA Mid-Continent Ecology Division in Duluth, MN.

The bibliographic reference file contains information on the article title, authors, journal or report title, date, volume, issue, page numbers, abstract, keywords, and article retrieval status. A unique Eco-SSL/TRV identification number provides the link between the data entered on the website and the article information identified in the literature search and recorded in the bibliographic reference file. This number is located in the upper-right corner of the article on a small white label. Additional information provided on this label includes the first author of the article and the identity of the contaminant of concern.

Example label:



A preliminary review is conducted on each article to determine whether the study contains data suitable for Wildlife TRV derivation. Table 1 provides a category listing of the types of publications and studies that are not included in the effort. These categories are referred to as rejection categories or criteria.

Table 1. Literature Rejection Categories

Rejection Criteria	Description	Basis
ABSTRACT (Abstract)	Abstracts of journal publications or conference presentations	Reference type
ACUTE STUDIES (Acu)	Single oral dose or exposure duration of three days or less.	Exposure
AIR POLLUTION (Air P)	Studies describing the results for air pollution studies.	Exposure
ALTERED RECEPTOR (Alt)	Studies that describe the effects of the contaminant on surgically-altered or chemically-modified receptors (e.g., right nephrectomy, left renal artery ligature, hormone implant, etc.).	Experimental design
AQUATIC STUDIES (Aquatic)	Studies that investigate toxicity in aquatic organisms	Experimental design

Table 1. Literature Rejection Categories		
Rejection Criteria	**Description**	**Basis**
ANATOMICAL STUDIES (Anat)	Studies of anatomy. Instance where the contaminant is used in physical studies (e.g., silver nitrate staining for histology).	Experimental design
BACTERIA (Bact)	Studies on bacteria or susceptibility to bacterial infection	Toxicant type
BIOACCUMULATION SURVEY (Bio Acc)	Studies reporting the measurement of the concentration of the contaminant in tissues.	Experimental design
BIOLOGICAL TOXICANT (BioX)	Studies of biological toxicants, including venoms, fungal toxins, *Bacillus thuringiensis*, other plant, animal, or microbial extracts or toxins.	Toxicant type
BIOMARKER (Biom)	Studies reporting results for a biomarker having no reported association with an adverse effect and an exposure dose (or concentration).	Endpoint
CARCINOGENICITY STUDIES (Carcin)	Studies that report data only for carcinogenic endpoints such as tumor induction. Papers that report systemic toxicity data are retained for coding of appropriate endpoints.	Endpoint
CHEMICAL METHODS (Chem Meth)	Studies reporting methods for determination of contaminants, purification of chemicals, etc. Studies describing the preparation and analysis of the contaminant in the tissues of the receptor.	Experimental design
CONFERENCE PROCEEDINGS (CP)	Studies reported in conference and symposium proceedings.	Data source
DEAD (Dead)	Studies reporting results for dead organisms. Studies. reporting field mortalities with necropsy data where it is not possible to establish the dose to the organism.	Exposure
DISSERTATIONS (Diss)	Dissertations are excluded. However, dissertations should be flagged for possible future use.	Data source
DRUG (Drug)	Studies reporting results for testing of drug and therapeutic effects and side-effects. Therapeutic drugs include vitamins and minerals. Studies of some minerals may be included if there is potential for adverse effects.	Endpoint
DUPLICATE DATA (Dup)	Studies reporting results that are duplicated in a separate publication. The publication with the earlier year is used.	
ECOLOGICAL INTERACTIONS (Ecol)	Studies of ecological processes that do not investigate effects of contaminant exposure (e.g., studies of "silver" fox natural history; studies on ferrets identified in iron search).	Experimental design
EFFLUENT (Effl)	Studies reporting effects of effluent, sewage, or polluted runoff.	Exposure
CHEMICAL FATE/METABOLISM (Fate)	Studies reporting what happens to the contaminant, rather than what happens to the organism. Studies describing the intermediary metabolism of the contaminant (e.g., radioactive tracer studies) without description of adverse effects.	Effect
FOREIGN LANGUAGE (FL)	Studies in languages other than English	Foreign Language

Table 1. Literature Rejection Categories		
Rejection Criteria	**Description**	**Basis**
FOOD STUDIES (Food)	Food science studies conducted to improve production of food for human consumption.	Effect
FUNGUS (Fungus)	Studies on fungus	Receptor
GENE (Gene)	Studies of genotoxicity (chromosomal aberrations and mutagenicity).	Endpoint
HUMAN HEALTH (HHE)	Studies with human subjects.	Receptor
IMMUNOLOGY (IMM)	Studies on the effects of contaminants on immunological endpoints.	Endpoint
INVERTEBRATE (Invert)	Studies that investigate the effects of contaminants on terrestrial invertebrates are excluded.	Receptor
IN VITRO (In Vit)	*In vitro* studies, including exposure of cell cultures, excised tissues and/or excised organs.	Effect
LEAD SHOT (Lead shot)	Studies administering lead shot as the exposure form. These studies are labeled separately for possible later retrieval and review.	Exposure
METHODS (Meth)	Studies reporting methods or methods development without usable toxicity test results for specific endpoints.	Experimental design
MINERAL REQUIREMENTS (Mineral)	Studies examining the minerals required for better production of animals for human consumption, unless there is potential for adverse effects.	Effect
MIXTURE (Mix)	Studies that report data for combinations of single toxicants (e.g. cadmium and copper) are excluded. Exposure in a field setting from contaminated natural soils or waste application to soil may be coded as Field Survey.	Exposure
MODELING (Model)	Studies reporting the use of existing data for modeling, i.e., no new organism toxicity data are reported. Studies which extrapolate effects based on known relationships between parameters and adverse effects.	Modeling/Existing data
NO CONTAMINANT OF CONCERN (No COC)	Studies that do not examine the toxicity of Eco-SSL contaminants of concern	Exposure
NO CONTROL (No Control)	Studies which lack a control or which have a control that is classified as invalid for derivation of TRVs.	Experimental design
NO DATA (No Data)	Studies for which results are stated in text but no data is provided. Also refers to studies with insufficient data where results are reported for only one organism per exposure concentration or dose.	Experimental design
NO DOSE or CONC (No Dose)	Studies with no usable dose or concentration reported. 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 lacation by doses to parents and then after weaning to similar concentrations as their parents. Dose cannot be determined.	Exposure
NO DURATION (No Dur)	Studies with no exposure duration. These are usually identified after examination of full paper.	Exposure
NO EFFECT (No Efct)	Studies with no relevant effect evaluated in a biological test species or data not reported for effect discussed.	Effect

Table 1. Literature Rejection Categories		
Rejection Criteria	**Description**	**Basis**
NO ORAL (No Oral)	Studies using non-oral routes of contaminant administration including intraperitoneal injection, other injection, inhalation, and dermal exposures.	Exposure
NO ORGANISM (No Org)	Studies that do not examine or test a viable organism (also see in vitro rejection category).	Receptor
NOT AVAILABLE (Not Avail)	Papers that could not be located. Citation from electronic searches may be incorrect or the source is not readily available.	Data source
NOT PRIMARY (Not Prim)	Papers that are not the original compilation and/or publication of the experimental data.	Data source
NO TOXICANT (No Tox)	No toxicant used. Publications often report responses to changes in water or soil chemistry variables, e.g., pH or temperature. Such publications are not included.	Exposure
NUTRIENT DEFICIENCY (Nut def)	Studies of the effects of nutrient deficiencies. Nutritional deficient diet is identified by the author. If reviewer is uncertain then the administrator should be consulted. Effects associated with added nutrients are coded.	Exposure
NUTRITION (Nut)	Studies examining the best or minimum level of a chemical in the diet for improvement of health or maintenance of animals in captivity.	Exposure
OTHER AMBIENT CONDITIONS (OAC)	Studies which examine other ambient conditions: pH, salinity, DO, UV, radiation, etc.	Toxicant
OIL (Oil)	Studies which examine the effects of oil and petroleum products.	Toxicant
ORGANIC METAL (Org Met)	Studies which examine the effects of organic metals. This includes tetraethyl lead, triethyl lead, chromium picolinate, phenylarsonic acid, roxarsone, 3-nitro-4-phenylarsonic acid,, zinc phosphide, monomethylarsonic acid (MMA), dimethylarsinic acid (DMA), trimethylarsine oxide (TMAO), or arsenobetaine (AsBe) and other organo metallic fungicides. Metal acetates and methionines are not rejected and are evaluated.	Exposure
LEAD BEHAVIOR OR HIGH DOSE MODELS (Pb Behav)	There are a high number of studies in the literature that expose rats or mice to high concentrations of lead in drinking water (0.1, 1 to 2% solutions) and then observe behavior in offspring, and/or pathology changes in the brain of the exposed dam and/or the progeny. Only a representative subset of these studies were coded. Behavior studies examining complex behavior (learned tasks) were also not coded.	Exposure and endpoint
PHYSIOLOGY STUDIES (Phys)	Physiology studies where adverse effects are not associated with exposure to contaminants of concern.	Effects
PLANT (Plant)	Studies of terrestrial plants are excluded.	Receptor
PRIMATE (Prim)	Primate studies are excluded.	Receptor

Table 1. Literature Rejection Categories		
Rejection Criteria	**Description**	**Basis**
PUBL AS (Publ as)	The author states that the information in this report has been published in another source. Data are recorded from only one source. The secondary citation is noted as Publ As.	Data source
QSAR (QSAR)	Derivation of Quantitative Structure-Activity Relationships 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.	Model
REGULATIONS (Reg)	Regulations and related publications that are not a primary source of data.	Data source
REVIEW (Rev)	Studies in which the data reported in the article are not primary data from research conducted by the author. The publication is a compilation of data published elsewhere. These publications are reviewed manually to identify other relevant literature.	Data source
SEDIMENT CONC (Sed)	Studies in which the only exposure concentration/dose reported is for the level of a toxicant in sediment.	Exposure
SLUDGE	Studies on the effects of ingestion of soils amended with sewage sludge	Exposure
SOIL CONC (Soil)	Studies in which the only exposure concentration/dose reported is for the level of a toxicant in soil.	Exposure
STRESSOR (QAC)	Studies examining the interaction of a stressor (e.g., radiation, heat, etc.) and the contaminant, where the effect of the contaminant alone cannot be isolated.	Exposure
SURVEY (Surv)	Studies reporting the toxicity of a contaminant in the field over a period of time. Often neither a duration nor an exposure concentration is reported.	Exposure
REPTILE OR AMPHIBIAN (Herp)	Studies on reptiles and amphibians. These papers flagged for possible later review.	Receptor
UNRELATED (Unrel)	Studies that are unrelated to contaminant exposure and response and/or the receptor groups of interest.	Relevance
WATER QUALITY STUDY (Wqual)	Studies of water quality	Relevance
YEAST (Yeast)	Studies of yeast	Receptor

If a retrieved article is rejected after review, the user records the reason for rejection in the bibliographic reference file and the article is not considered further in the process. The results of the literature review and the application of rejection criteria are described for each contaminant of concern.. SOP #6 (Attachment 4-5) describes the process for deriving the Wildlife TRV.

3.0 WILDLIFE TRV DATABASE WEBSITE

3.1 Location and Log-On

The Wildlife TRV Database is located in Duluth, MN and maintained by the USEPA Mid-Continent Division. For quality assurance purposes, the Eco-SSL Wildlife TRV Database is accessible only to authorized users. It is important that users not give their log on information to others.

The Wildlife TRV Database website is accessed from the Explorer or Netscape browsers by typing http://trv.ecodev.com/ in the address bar. The TRV Homepage will appear and display a prompt to log on. The User clicks on "log" to access the Log On page. The User enters a username and password as directed and clicks "Log On" to access the database.

3.2 Navigation

The TRV Database contains a sidebar for navigation among the database functions. Navigation choices include Home, Log Out, Admin, Data Entry, and Password. Most features needed by TRV Database users are located under the Data Entry feature. A brief description of each function is provided below.

Home

Clicking on the Home option will return the User to the log on, which prompts the User for username and password.

Logout

The Logout option is used to exit the Wildlife TRV Database.

Admin

The Admin feature allows users with administrative authorization (Administrative Users) to permanently delete articles or alter database features such as data entry codes or programming code for calculations.

Data Entry

The Data Entry option displays the main menu for data entry navigation. Six options are available for this feature:

1. Add Article
2. Article List
3. A Targeted Article List
4. QA'd Article List

5. Reports
6. Download database

A brief description of each option is provided below.

Add Article: This option allows the User to add information from a new article. This function is discussed in more detail in Section 4.

Article List: This option displays all articles currently in the TRV system. The User may View/Edit Articles, Add Phases to an article, Delete Articles, access the Exposures/Endpoint edit screens, or access the QA report (a printable version of the information entered for the article), by clicking on the appropriate column. Listed articles may be changed by any user if they have not been locked by the QA approval process (see Section 6). When an article has been approved following a QA review, the Add Phase, Delete Article and Exposures edit options are disabled. Article Approval information is then displayed on the QA report, along with any QA comments.

A Targeted Article List: This option allows the User to create a list of articles for a specific SSL#, chemical, or author. The retrieved list displays the selected articles in the same manner, and offers the same QA functionality, as the full Article List.

QA'd Article List: This option displays a list of articles that have received QA approval. The display information includes Record #, Chemical, Author, Reviewer, Date reviewed, Approver, Date Approved, an Edit Article function, and QA report display. Articles that have passed QA are locked for editing by users without Administrative User status. Locking means that the Edit Article feature in this list does not allow reviewers to change the QA status of an article. However, a reviewer who disagrees with a QA revision may provide an explanation in the comment box.

If an approved article is unlocked by an Administrative User (i.e., the Article Approved field is changed to "No" or "Not Checked"), the article disappears from the QA'd Article List, and all editing functionality is restored.

Reports: Three types of reports are available under this function:

QA Modifications: This report displays a list of articles that have been quality assured, but not necessarily approved. The display includes contaminant of concern, SSL (Record) #, Ecoref # (i.e., the number used to identify the article in the ECOTOX database), Author, Reviewer, Review date, Approver, QA date, Last change date, and whether or not the article has been approved (Apr?). This report allows reviewers could keep track of quality assurance revisions and to maintain consistency of coding.

Article Counts: This report provides information on all contaminants of concern, the total articles reviewed for each chemical, which articles were reviewed by Duluth Offsite, how many articles were approved, and the number of articles with at least one score of greater than 65.

Article Information: Information on contaminant of concern, SSL#, Ecoref#, Author, Reviewer, Review date, High Score, and approval status (Apr?) is provided for each chemical. This report function provides a "sort by" window, which allows the User to sort by each parameter.

Password

The password option allows individual users to change their password.

4.0 CODING GUIDELINES AND DATA ENTRY

Entry of study-specific toxicological information into the TRV Database is facilitated by data entry screens which prompt the User for required information. This interface helps ensure that relevant data from each study is completely and consistently entered. Required information is divided into five categories with a corresponding data entry screen for each: Article Information, Study Information, Exposure Information, Endpoint Information, and Score Information. A navigation bar, which summarizes the specific article, phase, and endpoint which is currently being scored, is provided at the top of each data entry screen to identify the User's location throughout the data entry process.

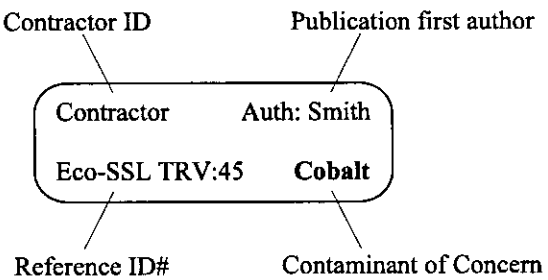
The data entry process is initiated by clicking on the Data Entry option located in the navigation bar. The User selects Complete Entry to begin entering information from a selected article or report. Once data entry has begun for a specific article or report, continue to enter information until *all endpoints* have been scored. This "start-to-finish" process ensures fewer errors resulting from incomplete entries. In addition, there is a time limit for data entry. The User is automatically logged out if no data entry activity is registered for a period of one hour.

4.1 Article Information

Record Number

The Record Number is a unique number assigned to an article identified in the literature search. The Record Number provides the link between the data entered on the website and the article information in the bibliographic reference file (e.g., ProCite or Reference Manager). This number is located on a small white label placed in the upper-right corner of the article. The User enters the number in the numeric field provided for the Record Number (eg.: 45 in the example below).

Example label:



Contaminant of Concern (COC)

The contaminant form tested in the reviewed study is entered at the "Exposure Information" screen. To ensure quality and consistency, a pull down list is provided for all contaminants which are to be reviewed for the Eco-SSL effort. This list is presented in Table 2. The User

selects the contaminant from the pull down list for entry into the database record. If results for several contaminants of concern (COCs) are available in a single article, separate results are entered for each COC.

Special cases for COC data entry are DDT and its metabolites and the polycyclic aromatic hydrocarbons (PAHs). Data for DDT metabolites (DDE, DDD, DDA, and DDMU) are entered as chemical forms of Total DDT. If an article contains experimental data for multiple forms, data for the parent compound and/or individual metabolites are entered as separate phases.

The PAHs of concern are listed individually in Table 2. The specific approach to evaluation of PAH toxicity and derivation of PAH TRVs is currently under review by EPA. The procedures for entering data on this class of contaminants will be added to this SOP in a future update.

Table 2. Contaminants of Concern

Contaminant Code	Contaminant Name	Contaminant Code	Contaminant Name
Chlorinated Organics		**Polycyclic Aromatic Hydrocarbons (PAHs)****	
Dld	Dieldrin	Dmg	3,3'-Dimethylbenzidine
PCB	Total PCBs	Dma	7,12-Dimethylbenz(a)-anthracene
DDT	Total DDT - DDT	Ace	Acenaphthene
DDD*	Total DDT - DDD	Acy	Acenaphthylene
DDE*	Total DDT - DDE	Ani	Aniline
DDA*	Total DDT - DDA	Ant	Anthracene
DDMU*	Total DDT - DDMU	Baa	Benz(a)anthracene
PCP	PCP (Pentachlorophenol)	Bap	Benzo(a)pyrene
Other Organics		Bkf	Benzo(k)fluoranthene
RDX	RDX (Hexahydro-1,3,5-trinitro-1,3,5-triazine)	Bghip	Benzo(g,h,I)perylene
TNT	TNT (Trinitrotoluene)	Bbf	Benzo(b)fluoranthene
Metals		Chr	Chrysene
Al	Aluminum	Dbaha	Dibenz(a,h)anthracene
Ba	Barium	Dbaep	Dibenzo(a,e)pyrene
Sb	Antimony	Dbf	Dibenzofuran
As	Arsenic	Fla	Fluoranthene
Be	Beryllium	Fl	Fluorene
Cd	Cadmium	Ind	Indeno(1,2,3-cd)pyrene
Cr	Chromium	Nap	Naphthalene
Co	Cobalt	Phe	Phenanthrene
Cu	Copper	Pyr	Pyrene
Fe	Iron		
Pb	Lead		
Mn	Manganese		
Ni	Nickel		
Se	Selenium		
Ag	Silver		
V	Vanadium		
Zn	Zinc		

* Considered a chemical form of DDT and is coded as a separate phase under the COC of Total DDT

** The specific approach to grouping of PAHs and derivation of TRVs is under consideration by USEPA and has not yet been finalized

Author Key

The Author Key is a text field designed to provide a citation for the article entered. This citation is used to verify the record number and is incorporated into the navigation bar at the top of each page. Author information is entered in the same way the article would be cited in a scientific document, with the author's last name(s) separated by a comma and the year. If there is one author, the citation appears as "Smith, 1997"; if there are two authors, the citation appears as "Smith and Jones, 1997"; if there are three or more authors, the citation appears as "Smith et al., 1997". The first or middle name initials are not used in the Author Key.

Primary Source

The toxicity data used for the Eco-SSL Wildlife TRVs are taken from primary sources only. A primary source is the original compilation and/or publication of the experimental data. Secondary sources are defined as studies where the data reported is not from research conducted by the author and/or the publication is a compilation of data published elsewhere. Secondary sources are coded as reviews ("Rev"; see Table 1) and are rejected for use (i.e., toxicological data from these sources are not entered into the TRV Database). However, secondary sources are examined to identify other relevant literature. This process is referred to as a manual review. The User selects "Yes" or "No" for primary source by checking the appropriate box. If "No" is selected, the information entered to this point is saved and the program exits to the "Data Entry" screen.

Results Reported for Exposure to a Single Contaminant

The Wildlife TRV database compiles data from experiments which examine exposure to a single contaminant. Studies that report results for concurrent exposure to multiple contaminants are rejected for use as a mixture ("mix"; see Table 1). The User selects "Yes" or "No" for exposure to a single contaminant by checking the appropriate box. If "No" is selected, the information entered to this point is saved and the program exits to the "Data Entry" screen.

When the "Article Information" screen is completed, the User verifies that all data entered are correct and then clicks on "Next" at the bottom of the screen to continue. The User **should not** use the browser back arrow to return to a previous data entry screen to correct errors, because use of this key results in a deletion of information.

4.2 Study Information

Study Phase determination

The study phase is the basic unit of experimental design for the Wildlife TRV Database. Multiple study phases are present if the study reports different results for any of the following parameters: test organism (different species /strain or lifestage), chemical form (e.g. DDE and p,p'DDT, Cadmium chloride and Cadmium sulfate, etc.), range of chemical doses or concentrations, test location, exposure type, control type, total number of doses, application frequency, or route of exposure. The User enters a description of each phase, including the basis for selection and differences in parameters, in the text box (remarks field) provided. The following is an example of data that would be coded as separate phases:

Example: Phase 1 - oral exposure to Cadmium chloride in food to rats for 10 weeks
Phase 2 - oral exposure to Cadmium chloride in food to mice for 10 weeks

The following cases would not be coded as multiple phases: 1) Experiments that perform interim measurements at intermediate time points in addition to terminal measurements; 2) Studies on metals where the dose is expressed as the metal (note: this is the only instance in which contaminant form does not trigger a new phase); 3) Results for male and female exposure groups within the same experiment. Results for males and females are not coded as separate phases because this could potentially create replicate NOAEL and LOAEL values. The User should select and enter the results for the most sensitive gender. Results for the opposite gender should be recorded in the NOAEL/LOAEL comment fields. In cases, where the male and female organisms have different exposure concentrations or doses, then they should be entered as separate phases.

If multiple phases of a study report the same NOAEL and LOAEL concentrations (or doses) for the same endpoint and test species, the User enters results for only one of the Phases. The phase entered should be the one that will give the highest total score. Replicate tests are generally considered one phase. Typically, the results for the shortest exposure duration that reports the most conservative results (lowest NOAEL or LOAEL) should be entered (see detailed comments on identification of the NOAEL and LOAEL below). The rationale for data entry decisions is recorded in the comments field.

When the "Study Information" screen is completed, the User verifies that all data entered are correct and then clicks on "Next" at the bottom of the screen to continue. The newly entered data are recorded in the database at this time. The User **should not** use the browser back arrow to return to a previous data entry screen to correct errors, as use of this key results in deletion of information.

When data entry for an individual phase is completed, the database will ask the User if another phase is required. At the end of data entry, the database will automatically calculate the number of phases for each article. This value is included in the QA report.

4.3 Exposure Information

Phase Number

The phase number is automatically generated by the application and corresponds to the phases briefly described in the "Study Information" section. The User should verify that the phase number is correct. If there are any discrepancies, the User should record the specific information and contact a database administrator.

Contaminant Form

The form of contaminant used in the exposure is recorded by the User in the text box provided. The form can be entered as a name or as a contaminant formula (eg.: Cadmium Chloride or $CdCl_2$). If a specific contaminant form is not provided in the article, the User enters the general name for the contaminant (e.g., cadmium). Organic forms of metals are not used for derivation of Wildlife TRVs and should not be coded (with the exception of acetate forms which readily dissociate in solution).

Administered Amount of a Contaminant (% Molecular Weight)

Toxicological studies administer metals using compounds which contain various amounts of the metal by weight. Some studies report concentrations (or doses) as units of metal per amount of exposure medium (water or diet) (e.g., mg of Co per kg of diet), while others report concentrations (or doses) based on the compound used (e.g., mg of cobalt chloride per kg of diet). For example, if the administered compound is cadmium chloride, then only 61.32 percent by weight was delivered as cadmium (based on the molecular weight (MW) for cadmium chloride ($CdCl_2$) of 183.32 g/mol and the MW for cadmium of 112.41 g/mol). A dose of cadmium chloride of 5 mg/kg is therefore equal to 3.1 mg of cadmium/kg (i.e., 5 mg/kg * 61.32% = 3.1 mg/kg). Table 3 provides a list of contaminant forms and the respective percentages of metal by weight. The User enters the listed percent in the numeric field provided. If the exposure is reported as pure contaminant, the User enters the number 100.

It is important to examine and enter data for metals accurately, as failure to do so may introduce errors into the calculation of the NOAEL and LOAEL. If, for example, the authors give the chemical form as lead acetate, but report the chemical concentration as 50 mg Pb/kg, then it should be assumed that the concentration is based on lead, not lead acetate, and the percentage of MW would be 100. However, if the chemical concentration had been 50 mg/kg, the percentage of MW would be 54.61. In another case, if the paper using a chemical form reports the concentration or dose based on a portion of the form, e.g., reports the concentration based on selenite for sodium selenite, the chemical should be reported as the portion of the form (selenite), and the percentage of MW would be the amount of selenium in selenite.

For organic chemicals, the study should be reviewed for information on the purity of the tested material. The purity of an organic chemical (including DDT and metabolites) is assumed to be

100%, unless the paper specifically reports material of lesser purity was used (e. g. 80% technical grade DDT). If a lesser purity is reported the user should enter the appropriate amount.

Table 3. Percentages of Metal and Occurrence in Soil					
Contaminant	**Compound**	**CAS #**	**% of MW as Metal**	**Could be Found in Soil Environment**	**Reference**
Aluminum	Aluminum chloride ($AlCl_3$)	7446-70-0	20.23	No	2
Aluminum	Aluminum fluoride (AlF_3)	7784-18-1	32.13	Yes	3
Aluminum	Aluminum nitrate (AlN_3O_9)	13473-90-0	12.67	Yes	
Aluminum	Aluminum potassium sulfate ($AlKO_8S_2$)	10043-67-1	10.45	No	
Aluminum	Aluminum sulfate ($Al(SO_4)_3$)	10043-01-3	15.77	Yes	2, 3
Aluminum	Aluminum sulfate hydrate ($Al(SO_4)_3H_20$	57292-32-7	14.98	Yes	2, 3
Aluminum	Aluminum nitrate nonahydrate ($AlH_{18}N_3O_{18}$)	7784-27-2	7.19	Yes	
Aluminum	Aluminum chloride hexahydrate ($AlCl_3H_{12}O_6$)	7784-13-6	11.18	No	2
Aluminum	Aluminum trihydrate (AlH_3O_3)	21645-51-2	34.59	Yes	
Aluminum	Aluminum sulfate octahydrate ($Al_2H_{36}O_{30}S_3$)	7784-31-8	8.10	Yes	3
Aluminum	Aluminum fluoride dihydrate ($AlF_3H_6O_3$)	15098-87-0	19.55	Yes	3
Aluminum	Aluminum sulfate hexadecahydrate ($Al_2H_{28}O_{26}S_3$)	16828-11-8	9.08	Yes	3
Antimony	Potassium antimonate (pyro) ($K_4O_7Sb_2$)	29638-69-5	47.05	No	
Antimony	Potassium antimonate (pyro) tetrathydrate ($K_2H_2Sb_2O_7$).	10090-54-7	46.31	No	
Antimony	Potassium antimonate hydrate ($KSbO_3$)	10090-54-7	46.31	No	
Antimony	Antimony potassium tartrate ($Sb_2H_4K_2O_{12}$)	11071-15-1	39.67	No	
Antimony	Antimony trichloride ($SbCl_3$)	10025-91-9	53.38	Yes	2
Antimony	Antimony trifluoride (SbF_3)	7783-56-4	68.11	No	
Antimony	Antimony trioxide (Sb_2O_3)	1309-64-4	83.53	Yes	2
Antimony	Antimony trisulfide (Sb_2S_3)	1345-04-6	71.69	Yes	2
Antimony	Potassium hexahydroxoantimonate (H_6KO_6Sb)	12208-13-8	46.32	No	
Arsenic	Sodium arsenate ($NaAsO_4$)	13464-38-5	36.04	Yes	1
Arsenic	Sodium arsenite ($NaAsO_2$)	7784-46-5	56.5	Yes	
Arsenic	Sodium arsenate (generic form) (AsH_2NaO_4)	7631-89-2	45.71	Yes	1
Barium	Barium carbonate (Ba CO_3)	513-77-9	69.59	Yes	2
Barium	Barium acetate (Ba $(C_2H_8O_2)_2$	543-80-6	53.77	No	
Barium	Barium chloride dihydrate ($BaCl_2H_40_2$)	10326-27-9	56.22	Yes	3
Barium	Barium sulfate (BaO_4S)	7727-43-7	58.84	Yes	2
Barium	Barium nitrate (BaN_2O_6)	10022-31-8	52.55	Yes	3
Barium	Barium chloride ($BaCl_2$)	10361-37-2	65.95	Yes	3
Barium	Barite (barium sulfate) (BaO_4S)	13462-86-7	58.84	Yes	2
Barium	Barium sulfide (BaS)	21109-95-5	81.07	No	2
Beryllium	Beryllium chloride ($BeCl_2$)	7787-47-5	11.27	Yes	3
Beryllium	Beryllium fluoride (BeF_2)	7787-49-7	19.17	No	
Beryllium	Beryllium hydroxide (BeH_2O_2)	13327-32-7	20.94	Yes	3
Beryllium	Beryllium nitrate trihydrate ($Be(NO_3)_2 \cdot 3H_2O$)	7787-55-5	4.82	Yes	
Beryllium	Beryllium nitrate ($Be(NO_3)_2$)	13597-99-4	6.77	Yes	

Table 3. Percentages of Metal and Occurrence in Soil					
Contaminant	**Compound**	**CAS #**	**% of MW as Metal**	**Could be Found in Soil Environment**	**Reference**
Beryllium	Beryllium silicate (Be_2O_4Si)	15191-85-2	16.37	Yes	3
Beryllium	Beryllium sulfate (BeO_4S)	13510-49-1	8.58	Yes	3
Beryllium	Beryllium sulfate tetrahydrate (BeH_8O_8S)	7787-56-6	5.09	Yes	3
Cadmium	Cadmium acetate ($C_4H_6CdO_4$)	543-90-8	48.77	No	
Cadmium	Cadmium bromide ($CdBr_2$)	7789-42-6	41.29	No	
Cadmium	Cadmium chloride ($CdCl_2$)	10108-64-2	61.32	Yes	1
Cadmium	Cadmium iodide (CdI_2)	7790-80-9	30.69	No	
Cadmium	Cadmium nitrate (CdN_2O_6)	10325-94-7	47.55	Yes	
Cadmium	Cadmium sulfate ($CdSO_4$)	10124-36-4	53.92	Yes	1
Cadmium	Cadmium chloride hydrate ($Cd_2Cl_4H_{10}O_5$)	7790-78-5	49.23	Yes	1
Cadmium	Cadmium sulfate hydrate ($CdH_{16}O_{12}S$)	7790-84-3	31.88	Yes	1
Chromium	Chromium (Cr)	7440-47-3	100	Yes	1
Chromium	Chromic acid (VI) (CrH_2O_4)	7738-94-5	44.06	No	
Chromium	Sodium chromate (VI) ($CrNa_2O_4$)	7775-11-3	32.10	Yes	1
Chromium	Chromium fluoride (III) (CrF_3)	7788-97-8	47.71	No	
Chromium	Chromium chloride ($CrCl_3$)	10025-73-7	32.83	Yes	
Chromium	Chromium potassium sulfate (III) ($CrKO_8S_2$)	10141-00-1	18.36	Yes	3
Chromium	Sodium dichromate (VI) ($Cr_2Na_2O_7$)	10588-01-9	39.70	Yes	1
Chromium	Chromium (III) nitrate (CrN_3O_9)	13548-38-4	21.85		
Chromium	Chromate (CrO_4)	11104-59-9	44.83	Yes	1
Chromium	Chromium sulfate pentahydrate (III) ($Cr_2O_{12}S_3$)	15244-38-9	26.52	Yes	3
Chromium	Hexavalent chromium ion (Cr^{+6}+6)	18540-29-9	100	Yes	3
Chromium	Chromium nitrate nonahydrate ($CrH_{18}N_3O_{18}$)	7789-02-8	13.00	Yes	
Chromium	Potassium chromate (CrK_2O_4)	7789-00-6	26.78	Yes	3
Chromium	Potassium dichromate ($Cr_2K_2O_7$)	7778-50-9	35.35	Yes	3
Cobalt	Cobalt acetate ($CoO_4C_4H_6$)	71-48-7	33.29	No	
Cobalt	Cobalt chloride ($CoCl_2$)	7646-79-9	45.39	Yes	
Cobalt	Cobalt chloride hexahydrate ($CoCl_2$+6H_20)	7791-13-1	24.9	Yes	
Cobalt	Cobalt nitrate $Co(NO_3)_2$	10141-05-6	32.22	Yes	
Cobalt	Cobalt sulfate ($CoSO_4$)	10124-43-3	38.02	Yes	2
Cobalt	Cobalt sulfate heptahydrate ($CoSO_4x7H^20$)	10026-24-1	21.91	Yes	2
Cobalt	Cobalt (II) formate ($CoO_4C_2H_2$)	544-18-3	39.55	No	
Copper	Copper chloride ($CuCl_2$)	1344-67-8	47.27	Yes	1
Copper	Copper (II) sulfate ($CuSO_4$)	7758-98-7	39.81	Yes	1
Copper	Copper (I) acetate ($C_2H_3CuO_2$)	598-54-9	51.84	No	
Copper	Copper oxychloride ($Cu_2Cl(OH)_3$)	1332-65-6	59.51	No	
Copper	Copper acetate ($CuO_4C_4H_6$)	4180-12-5	51.84	No	
Copper	Cupric acetate ($CuO_4C_4H_6$)	142-71-2	34.99	No	
Copper	Cupric nitrate $Cu(NO_3)_2$	3251-23-8	33.88	Yes	
Copper	Cupric chloride ($CuCl_2$)	7447-39-4	47.27	Yes	1
Copper	Cuprous chloride (CuCl)	7758-89-6	64.19	Yes	1
Copper	Cupric perchlorate hexahydrate ($Cl_2CuH_{12}O_{14}$)	13770-18-8	17.15	No	

Table 3. Percentages of Metal and Occurrence in Soil					
Contaminant	**Compound**	**CAS #**	**% of MW as Metal**	**Could be Found in Soil Environment**	**Reference**
Copper	Cupric nitrate hemipentahydrate ($Cu_2H_{10}N_4O_{19}$)	19004-19-4	27.32	Yes	
Copper	Copper chloride dihydrate ($Cl_2CuH_4O_2$)	10125-13-0	37.28	Yes	1
Iron	Ferric chloride (Cl_3Fe)	7705-08-0	34.43	Yes	2
Iron	Ferrous chloride (Cl_2Fe)	7758-94-3	44.06	Yes	2
Iron	Sulfonic acid, iron salt ($Fe_2O_{12}S_3$)	10124-49-9	27.93	No	
Iron	Ferric hydroxide (H_3FeO_3)	1309-33-7	52.26		
Iron	Ferrous sulfide (FeS)	1317-37-9	63.53	Yes	2
Iron	Ferrous sulfate (FeO_4S)	7720-78-7	36.77		
Iron	Ferric sulfate ($Fe_2O_{12}S_3$)	10028-22-5	27.93		
Iron	Ferrous hydroxide ($Fe_2H_3O_3$)	18624-44-7	52.26	Yes	
Iron	Ferric sulfate hydrate ($Fe_2O_{12}S_3$)	10028-22-5	27.93		
Iron	Iron trichloride ($FeCl_3$)	7705-08-0	34.43		
Iron	Iron (II) dichloride tetrahydrate ($FeCl_2H_8O_4$)	13478-10-9	28.09		
Lead	Lead acetate ($C_4H_6O_4Pb$)	301-04-2	54.61	No	
Lead	Lead carbonate ($PbCO_3$)	598-63-0	77.55	Yes	1
Lead	Lead chloride ($PbCl_2$)	7758-95-4	74.50	Yes	2
Lead	Lead nitrate ($Pb(NO_3)_2$	10099-74-8	62.56	Yes	
Lead	Lead oxide (Pb0)	1317-36-8	92.83	Yes	
Lead	Lead powder (Pb)	7439-92-1	100	Yes	
Lead	Lead sulfate ($PbSO_4$)	7446-14-2	68.32	Yes	2
Manganese	Manganese (II) chloride (Cl_2Mn)	7773-01-5	43.66	Yes	
Manganese	Manganese (II) nitrate (MnN_2O_6)	10377-66-9	30.70	Yes	
Manganese	Manganese (II) nitrate hydrate ($H_2MnN_2O_7$)	15710-66-4	27.89	Yes	
Nickel	Nickel chloride hexahydrate ($Cl_2H_{12}NiO_6$)	7791-20-0	24.69	Yes	
Nickel	Nickelous chloride (Cl_2Ni)	7718-54-9	45.29	Yes	
Nickel	Nickelous nitrate (N_2NiO_6)	13138-45-9	32.12	Yes	
Nickel	Nickel sulfate hexahydrate ($H_{12}NiO_{10}S$)	10101-97-0	22.33	Yes	1
Nickel	Nickelous acetate tetrahydrate ($C_4H_6NiO_4$)	373-02-4	33.20	No	
Nickel	Nickel (II) chloride hydrate ($H_{12}N_2NiO_{12}$)	13478-00-7	20.18	Yes	
Selenium	Selenium dioxide (O_2Se)	7446-08-4	71.16	No	4
Selenium	Potassium selenate (K_2O_4Se)	7790-59-2	35.71	Yes	4
Selenium	Potassium selenite (K_2O_3Se)	10431-47-7	38.49	Yes	4
Selenium	Hydrogen selenide (H_2Se)	7783-07-5	97.51	Yes	4
Selenium	Selenious acid (H_2O_3Se)	7783-00-8	61.22	Yes	4
Selenium	Sodium selenate (Na_2O_4Se)	13410-01-0	41.79	Yes	4
Selenium	Sodium selenite (Na_2O_3Se)	10102-18-8	45.66	Yes	4
Selenium	Sodium selenide (Na_2Se)	1313-85-5	63.20	Yes	4
Selenium	Selenium sulfide (S_2Se)	7488-56-4	55.19	No	
Selenium	Selenocystine ($C_6H_{12}N_2O_4Se_2$)	1464-43-3	47.27	Yes	2
Selenium	Selenomethionine (environmental form) ($C_5H_{11}NO_2Se$)	1464-42-2	40.26	Yes	4
Vanadium	Vanadium (III) chloride (Cl_3V)	7718-98-1	32.38	Yes	1

Table 3. Percentages of Metal and Occurrence in Soil					
Contaminant	**Compound**	**CAS #**	**% of MW as Metal**	**Could be Found in Soil Environment**	**Reference**
Vanadium	Vanadyl trichloride (Cl_3OV)	7727-18-6	29.39	Yes	1
Vanadium	Vanadic acid, Ammonium salt (H_4NO_3V)	7803-55-6	43.55	Yes	1
Vanadium	Sodium vanadate ($NaVO_3$)	13718-26-8	41.78	Yes	1
Vanadium	Vanadic acid, Trisodium salt (Na_3O_4V)	13721-39-6	26.70	Yes	1
Zinc	Zinc chloride (Cl_2Zn)	7646-85-7	47.98	Yes	1
Zinc	Zinc nitrate (N_2O_6Zn)	7779-88-6	34.52	Yes	
Zinc	Zinc sulfate ($Zn SO_4$)	7733-02-0	40.50	Yes	1
Zinc	Zinc acetate ($C_4H_6O_4Zn$)	557-34-6	35.64	No	
Zinc	Zinc peroxide (O_2Zn)	1314-22-3	67.14	No	
Zinc	Zinc phosphide (Zn_3P_2)	1314-84-7	76.00	No	
Zinc	Zinc sulfate heptahydrate ($H_{14}O_{11}SZn$)	7446-20-0	22.74	Yes	1
Zinc	Zinc bromide ($Zn Br_2$)	7699-45-8	29.04	No	
Zinc	Zinc iodide ($Zn I_2$)	10139-47-6	20.49	No	
Zinc	Zinc nitrate hexahydrate ($H_{12}N_2O_{12}Zn$)	10196-18-6	21.98	Yes	
Zinc	Zinc acetate dihydrate ($C_4H_{10}O_6Zn$)	5970-45-6	29.79	No	

[1]Alloway (1990)
[2]Merck Index
[3]Bodek et al. (1988)
[4]Shamberger (1983)

Species Common Name/Laboratory Strain

The common name or laboratory strain of the test organism is entered in the text box provided. Common name examples include: mouse, rat, dog, chicken, etc. Experiments testing different strains if the same species should be coded as different phases.

Genus and Species

The scientific name (genus and species) of the test organism is entered in the text box provided. If the genus and species are not reported in the article, use the Species Lookup Table next to the Species text box to find the correct scientific name.

Table 4a. Order, Family, and Common Name for Avian Test Species				
Common Name	**Order**	**Family**	**Genus**	**Species**
Bobwhite, northern	Galliformes	Odontophoridae	*Colinus*	*virginianus*
Chicken	Galliformes	Phasianidae	*Gallus*	*gallus*
Chicken	Galliformes	Phasianidae	*Gallus*	*domesticus*
Chicken	Galliformes	Phasianidae	*Gallus*	*sp.*
Cormorant, double-	Ciconiiformes	Phalacrocoracidae	*Phalacrocorax*	*auritus*
Cowbird, brown-headed	Passeriformes	Fringillidae	*Molothrus*	*ater*

Table 4a. Order, Family, and Common Name for Avian Test Species				
Common Name	**Order**	**Family**	**Genus**	**Species**
Dove, Ringed turtle-	Columbiformes	Columbidae	*Streptopelia*	*risoria*
Dove, rock	Columbiformes	Columbidae	*Columba*	*livia*
Duck, dabbling	Anseriformes	Anatidae	*Anas*	*sp.*
Duck, American black	Anseriformes	Anatidae	*Anas*	*rubripes*
Duck, mallard	Anseriformes	Anatidae	*Anas*	*platyrhynchos*
Duck, wood	Anseriformes	Anatidae	*Aix*	*sponsa*
Eagle, bald	Ciconiiformes	Accipitridae	*Haliaeetus*	*leucocephalus*
Finch, striated	Passeriformes	Passeridae	*Lonchura*	*striata*
Finch, zebra	Passeriformes	Estrildidae	*Poephila*	*guttata*
Goose, swan	Anseriformes	Anatidae	*Anser*	*cygnoides*
Guineafowl, helmeted	Galliformes	Numididae	*Numida*	*meleagris*
Hawk, red-tailed	Ciconiiformes	Accipitridae	*Buteo*	*jamaicensis*
Heron, black-crowned	Ciconiiformes	Ardeidae	*Nycticorax*	*nycticorax*
House sparrow	Passeriformes	Passeridae	*Passer*	*domesticus*
Kestrel, American	Ciconiiformes	Falconidae	*Falco*	*sparverius*
Owl, common barn	Strigiformes	Tytonidae	*Tyto*	*alba*
Owl eastern screech	Strigiformes	Strigidae	*Otus*	*asio*
Pheasant, ring-necked	Galliformes	Phasianidae	*Phasianus*	*colchicus*
Pigeon	Columbiformes	Columbidae	*Columba*	*sp.*
Quail	Galliformes	Phasianidae	*Coturnix*	*coturnix*
Quail, Japanese	Galliformes	Phasianidae	*Coturnix*	*japonica*
Robin, American	Passeriformes	Muscicapidae	*Turdus*	*migratorius*
Shrike, loggerhead	Passeriformes	Laniidae	*Lanius*	*ludovicianus*
Starling, European	Passeriformes	Sturnidae	*Sturnus*	*vulgaris*
Titmouse, tufted	Passeriformes	Paridae	*Parus*	*bicolor*
Turkey	Galliformes	Phasianidae	*Meleagris*	*gallopavo*

Table 4b. Order, Family, and Common Name for Mammalian Test Species				
Common Name	**Order**	**Family**	**Genus**	**Species**
Bank vole	Rodentia	Muridae	*Clethrionomys*	*glareolus*
Bat, little brown	Chiroptera	Vespertilionidae	*Myotis*	*lucifugus*
Blesbok	Artiodactyla	Bovidae	*Damaliscus*	*pygargus*
Cattle	Artiodactyla	Bovidae	*Bos*	*taurus*
Dog	Carnivora	Canidae	*Canis*	*familiaris*
Goat	Artiodactyla	Bovidae	*Capra*	*hircus*
Guinea pig	Rodentia	Caviidae	*Cavia*	*porcellus*
Hamster, golden	Rodentia	Muridae	*Mesocricetus*	*auratus*

Table 4b. Order, Family, and Common Name for Mammalian Test Species				
Common Name	**Order**	**Family**	**Genus**	**Species**
Mink	Carnivora	Mustelidae	*Mustela*	*vison*
Mouse	Rodentia	Muridae	*Mus*	*sp.*
Mouse, white-footed	Rodentia	Muridae	*Peromyscus*	*leucopus*
Mouse, house	Rodentia	Muridae	*Mus*	*musculus*
Mouse, oldfield	Rodentia	Muridae	*Peromyscus*	*polionotus*
Pig	Artiodactyla	Suidae	*Sus*	*sp.*
Pig, domestic/feral	Artiodactyla	Suidae	*Sus*	*scrofa*
Pronghorn	Artiodactyla	Antilocapridae	*Antilocapra*	*americana*
Rabbit, European	Lagomorpha	Leporidae	*Oryctolagus*	*cuniculus*
Rat, black	Rodentia	Muridae	*Rattus*	*rattus*
Rat	Rodentia	Muridae	*Rattus*	*sp.*
Rat, cotton	Rodentia	Muridae	*Sigmodon*	*hispidus*
Rat, Norway	Rodentia	Muridae	*Rattus*	*norvegicus*
Sheep, Dall	Artiodactyla	Bovidae	*Ovis*	*dalli*
Sheep	Artiodactyla	Bovidae	*Ovis*	*aries*
Shrew, short-tailed	Insectivora	Soricidae	*Blarina*	*brevicauda*
Shrew, common	Insectivora	Soricidae	*Sorex*	*araneus*
Vole, short-tailed	Rodentia	Muridae	*Microtus*	*agrestis*
Vole, meadow	Rodentia	Muridae	*Microtus*	*pennsylvanicus*
Wapiti	Artiodactyla	Cervidae	*Cervus*	*elaphus*
Whitetail deer	Artiodactyla	Cervidae	*Odocoileus*	*virginianus*

Organism Source

The source of the test organism is selected from the pull down list. A detailed description of each organism source is available under the description link to the right of the pull down list. The list of available organism sources is provided in Table 5. The User should use the code for COM to denote if laboratory species was obtained from an outside source. Confusion occurs when a laboratory rat strain is from a commercial source. In this case the code COM should be used. If there is no mention of source for laboratory strains the User should assign the LAB code.

Table 5. Organism Source Code	
Code	**Organism Source Description**
CBC	Captive Breeding Colony
COM	Commercial Source
DOM	Domestic Strain
GAM	Game Farm Strain
GOV	Government Agency Source
LAB	Laboratory Strain
NR	Not Reported

Table 5. Organism Source Code	
Code	**Organism Source Description**
WLD	Wild Strain

Control Type

The effects of contaminant exposure are evaluated by comparing groups of exposed organisms to one or more groups of untreated organisms. These untreated organisms are designated as the controls. The User selects the type of test control(s) used in the study from the Control Type pull down list. Detailed descriptions of each available control type are available under the description link to the right of the pull down list. The list of available control types is provided in Table 6. If the study reports multiple controls, select "M" for Multiple and briefly describe the control types in the comments text box provided. If the authors report that the control had a background level of the contaminant, this should be entered in the control comment field. Studies which use control types coded as historical B, H, K, P, Z and NR lack an acceptable control group and are not used for the derivation of Wildlife TRVs.

Table 6. Control Type Code Descriptions		
Code	**Validity of Control**	**Description**
B	Invalid	**Baseline or Background Control**: parameters of actual or representative test species measured either before or after administration of test contaminant, though not as part of the same test scenario.
C	Valid	**Concurrent Control:** controls are run simultaneously with the contaminant exposure, e.g. in the laboratory where a contaminant free test chamber is used or in field studies where the control data are obtained upstream from the exposure data; also includes field tests where the controls are run in a separate system, i.e., pond A and pond B or field A and field B.
H	Invalid	**Historical Control:** applicable to natural field system testing, data collected prior to exposure often during an independent long-term survey of the area; see also B - Baseline Control. In laboratory studies, the term historical control refers to compilation of data for a specific endpoint in multiple experiments over time.
K	Invalid	**Insufficient Information:** Data for control are presented, but without accompanying methodology to identify procedures used
M	Valid, if one control type is valid.	**Multiple:** multiple controls were reported, e.g. historic and concurrent
P	Invalid	**Positive control**: employs a test substance known to give a positive response for a specific endpoint in the test organism.
V	Valid	**Carrier, vehicle, or solvent control**: test organisms are concurrently exposed to the carrier or solvent (the "vehicle") used to administer the contaminant
Z	Invalid	**No Control:** no controls were used in the study

Table 6. Control Type Code Descriptions		
NR	Invalid	**Not Reported:** there is no information about presence or absence of controls provided in the publication

For some elements it may be necessary to establish if a control diet is provided or potentially toxic exposures are administered. Table 7 provides a list of the elements that are considered to be essential elements and nutrient requirements for domestic species. These ranges of essential nutrient requirements should be used to establish if exposures are nutritionally deficient, sufficient or potentially toxic (higher than nutrient requirements).

Table 7. Nutrition Requirements

Element	Amount (mg/kg diet dw)	Species	Reference
Copper	8	Chicken	NRC (1994); Underwood and Suttle (1999)
	4	Chicken (growing)	Underwood and Suttle (1999)
	4 to 5	Chicken (immature leg-horn)	NRC (1994); Underwood and Suttle (1999)
	5	Chicken (juvenile)	Underwood and Suttle (1999)
	8 to 25	Horse (foal)	Underwood and Suttle (1999)
	5	Japanese Quail	NRC (1994); Underwood and Suttle (1999)
	4	Pig (growing)	Underwood and Suttle (1999)
	6	Pig (juvenile)	Underwood and Suttle (1999)
	8 to 10	Ruminants	NAS (1980)
	4 to 5	Swine and poultry	NAS (1980)
	6 to 8	Turkey	NRC, 1994
		Turkey (breeding)	Underwood and Suttle (1999)
		Turkey (growing)	Underwood and Suttle (1999)
		Turkey (poults)	Underwood and Suttle (1999)
Chromium	5	Mice and rats	NAS (1980)
	10	Chicken (laying)	NAS (1980)
	20	Chicken	NRC (1997)
Cobalt	0.05 to 0.08	Sheep	Underwood and Suttle (1999)
	0.11	Sheep (growing)	Underwood and Suttle (1999)
	0.04 to 0.06	Cow, deer, and goat	Underwood and Suttle (1999)
	10 to 18	Pig	Underwood and Suttle (1999)
	3 to 10	Poultry	Underwood and Suttle (1999)
	0.07 to 0.11	Cow, sheep, goat	McDowell (1985)
	0.1	Ruminants	NAS (1980)
Iron	40 to 80	Chicken	NRC (1994)
		Chicken	NRC (1994)
		Chicken	NRC (1994)
		Chicken	NRC (1994)
	80	Chicken (up to 8 weeks of age)	Underwood and Suttle (1999)
	50	Cattle	McDowell (1985)
	30 to 60	Cattle (juvenile)	Underwood and Suttle (1999)
	80	Pig (adult female)	Underwood and Suttle (1999)
	60	Pig (up to 20 kg body weight)	Underwood and Suttle (1999)
	40 to 80	Poultry (first 4 weeks of life)	Underwood and Suttle (1999)
	30 to 50	Sheep	McDowell (1985)
	25 to 40	Sheep (juvenile)	Underwood and Suttle (1999)
	80 to 50	Turkey	Underwood and Suttle (1999)

Table 7. Nutrition Requirements			
Element	**Amount (mg/kg diet dw)**	**Species**	**Reference**
Manganese	4.5	Dog	NAS (1980)
	8.5	Rabbit	NAS (1980)
	10	Pig (female)	Underwood and Suttle (1999)
	10 to 25	Cattle	Underwood and Suttle (1999)
	1 to 16	Sheep and goat	Underwood and Suttle (1999)
	17 to 25	Chicken (laying)	Underwood and Suttle (1999)
	30	Chicken (growing)	Underwood and Suttle (1999)
	30	Sheep	NAS (1980)
	33	Chicken (breeding)	Underwood and Suttle (1999)
	60	Chicken (starting)	Underwood and Suttle (1999)
	55	Chicken	NAS (1980)
	4	Pig (growing) and adult	Underwood and Suttle (1999); NAS (1980)
	40	Cattle (calf)	NAS (1980)
	50	Rat	NAS (1980)
	55	Turkey	NAS (1980)
Nickel	<0.50	Ruminants	McDowell (1985)
Selenium	0.036 to 0.2	Cattle (beef)	Underwood and Suttle (1999); McDowell (1985)
	0.044 to 0.1	Cow (dairy)	Underwood and Suttle (1999); McDowell (1985)
	0.1	Sheep	McDowell (1985)
	0.028 to 0.043	Sheep (female)	Underwood and Suttle (1999)
	0.031 to 0.055	Sheep (juvenile)	Underwood and Suttle (1999)
	0.1 to 0.3	Domestic animals (general)	Underwood and Suttle (1999)
Vanadium	50	Cattle and sheep (maximum)	NAS (1980)
	25	Chicken (juvenile)	NAS (1980)
	0.05 to 0.5	Chicken (juvenile) and rat	McDowell (1985)
	10	Poultry (maximum)	NAS (1980)
	20	Rat (weanling)	NAS (1980)
	0.1	Rats	Hoekstra et al. (1973)
	200	Sheep (juvenile)	NAS (1980)
Zinc	35 to 40	Chicken	NRC (1994)
	65	Chicken (breeding)	Underwood and Suttle (1999)
	35	Chicken (juvenile growing)	Underwood and Suttle (1999)
	40	Chicken (juvenile starting)	Underwood and Suttle (1999)
	35 to 40	Chicken (juvenile)	Underwood and Suttle (1999)
	50	Chicken (laying)	Underwood and Suttle (1999)
	500	Cow (beef)	McDowell (1985)
	10 to 14	Cow (calf)	Underwood and Suttle (1999)
	500	Cow (dairy)	McDowell (1985)
	40 to 100	domestic animals and fowl	NAS (1980)
	1000	Goat	McDowell (1985)
	25 to 50	Japanese Quail	NRC (1994)
	60	Ring-Necked Pheasants	NRC (1994)
	1000	Sheep	McDowell (1985)
	18 to 33	Sheep (lambs)	Underwood and Suttle (1999)
	17	Sheep (lambs)	Underwood and Suttle (1999)

Number of Concentrations or Doses Tested

The total number of different concentrations or doses administered to the test organism is entered for the specific phase in the numeric field provided. The total number of concentrations (or doses) includes the control(s). For example, for a study which has four exposure groups of 5, 10, 20, 50 mg/kg and a valid control, the number 5 would be entered. A study must have at least two concentrations or doses (i.e., a valid control and one exposure group) to be used for derivation of Wildlife TRVs.

If a diet deficiency dose is reported for the chemical of concern (e.g. 0/0.2/1/2 mg/kg Selenium and 0.2 level is identified as the normal diet level), then code the normal diet (e.g., 0.2 mg/kg) as the control value (e.g., 0/1/2 mg/kg Se) and note the normal diet level (e.g., 0.2 mg/kg Se) in the control comments as the background level. The User should not include the diet deficient level in the number of total doses.

Test Concentrations or Test Doses with Units

The test ***concentration*** is the amount of contaminant to which the test organism is exposed per unit of exposure medium (water, diet or other medium). The test ***dose*** is the amount of contaminant administered to the test organism per unit of body weight in a specified period of time. Doses are preferred over concentrations for the purpose of establishing a wildlife TRV, but they are not reported in many toxicological studies.

If both dry and wet weight concentrations or doses are provided in the study, use the dry weight values, as this is the more conservative measurement. Tests in which doses varied over the exposure period after the initial dose level are coded only if the result is reported before a change in dose.

Information from gavage and capsule studies needs to be carefully examined to determine whether the contaminant was administered on a mg/kg body weight or mg/organism basis. In either case, the administered amount is a dose, and **should not** be entered as a concentration.

In cases where nursing offspring are exposed via the mother's milk, the concentration of contaminant in milk must be reported in order for the results to be coded as a juvenile lifestage effect. In most developmental and reproductive studies, exposure concentrations or doses are reported only for the mother and are not specifically estimated or reported for the offspring.

If only exposure concentrations are reported in the study, the User **should not** calculate the respective dose. The application is designed to calculate the dose automatically based on the reported concentrations and User-supplied body weight and ingestion rate parameters. The User should enter either the reported exposure concentrations **OR** doses, but not both, in the field. The concentrations or doses are separated by a forward-slash in the text box provided. The control(s) should be included as the first in the series (eg.: 0 / 5 / 10 / 20 / 50), and should always be zero. If a background level of contaminant is reported for the control, that information should be entered in the control comment field.

There is an exception to the rule to allow the system to calculate the dose. For studies that report different ingestion and body weights for each of the exposure levels, it is more accurate to calculate the doses for each exposure level and enter these in the system.

A separate data entry field allows the User to select the appropriate units for concentration (or dose) from the pull down list. The list of available concentration units and conversions to dose is shown in Table 7. The list of available dose units and conversion to standard units of mg/kg/day is shown in Table 8. A detailed description of the available units is provided under the description link to the right of the pull down list. The application assumes that doses which do not specify a unit of time (e.g., g/org or g/kg BW) are in or have been converted to units of **per day** prior to entry.

Table 8. Concentration Units and Conversions to Dose

Concentration Fields		Conversion to Concentration (C) as mg/kg or mg/L	Conversion to Dose as mg/kg BW/day
% in diet	percent in diet	multiply by 10000	Multiply C by the IR (kg/day) and divide by BW in kg
g/g	grams per g	multiply by 1,000,000	Multiply C by IR (kg/day) and divide by BW in kg
g/kg	grams per kilogram	multiply by 1,000	Multiply C by IR (kg/day) and divide by BW in kg
g/kg/d	grams per kilogram per day	multiply by 1,000	Multiply C by IR (kg/day) and divide by BW in kg
g/L	grams per liter	multiply by 1,000	Multiply C by IR (L/day) and divide by BW in kg
mg/g	milligrams per gram	multiply by 1,000	Multiply C by IR (kg/day) and divide by BW in kg
mg/kg	milligrams per kilogram	multiply by 1	Multiply C IR (kg/day) and divide by BW in kg
mg/kg/d	milligrams per kilogram per day	multiply by 1	Multiply C by IR (kg/day) and divide by BW in kg
mg/l	milligrams per liter	multiply by 1	Multiply C by IR (L/day) and divide by BW in kg
mg/ml	milligrams per milliliter	multiply by 1000	Multiply C by IR (L/day) and divide by BW in kg
ng/g	nanograms per gram	multiply by 0.001	Multiply C by IR (kg/day) and divide by BW in kg
ng/kg	nanograms per kilogram	multiply by 0.000001	Multiply C by IR (kg/day) and divide by BW in kg
ng/l	nanograms per liter	multiply by 0.000001	Multiply C by IR (L/day) and divide by BW in kg
ng/mg	nanograms per milligram	multiply by 1	Multiply C by IR (kg/day) and divide by BW in kg
ppb	parts per billion	multiply by 0.001	Multiply C by IR (kg/day) and divide by BW in kg
ppm	parts per million	multiply by 1	Multiply C IR (kg/day) and divide by BW in kg
ug/g	micrograms per gram	multiply by 1	Multiply C by IR (kg/day) and divide by BW in kg
ug/kg	micrograms per kilogram	multiply by 0.001	Multiply C by IR (kg/day) and divide by BW in kg
ug/l	micrograms per liter	multiply by 0.001	Multiply C by IR (L/day) and divide by BW in kg
ug/mg	micrograms per milligram	multiply by 1000	Multiply C by IR (kg/day) and divide by BW in kg
mg%	milligram percent by weight in diet or drinking water (i.e., mg/100 g diet or mg/100 mL drinking water)	multiply by 10	Multiply C by IR (L or kg/day) and divide by BW in kg
g%	gram percent by weight in diet or drinking water (i.e., g/100g diet or g/100mL drinking water)	multiply by 10,000	Multiply C by IR (L or kg/day) and divide by BW in kg

Table 9. Dose Units and Conversion to mg/kg BW/day		
Dose Fields*		Conversion to mg/kg BW/day
g/d	grams per day	multiply by 1,000 then divide by BW in kg
g/g BW	grams per gram body weight	multiply by 1,000,000
g/kg BW	grams per kilogram body weight	multiply by 1,000
g/kg BW /d	grams per kilogram body weight per day	multiply by 1,000
g/org	grams per organism	multiply by 1,000, divide by BW in kg
g/org/d	grams per organism per day	multiply by 1,000 then divide by BW in kg
kg/d	kilograms per day	multiply by 1,000,000 and divide by BW in kg
kg/org	kilograms per organism	multiply by 1,000,000, divide by BW in kg
kg/org/d	kilograms per organism per day	multiply by 1,000,000 and divide by BW in kg
mg/d	milligrams per day	divide by BW in kg
mg/g BW	milligrams per gram body weight	multiply by 1000
mg/g BW/d	milligrams per gram body weight per day	multiply by 1000
mg/kg BW	milligrams per kilogram body weight	multiply by 1
mg/kg BW/d	milligrams per kilogram body weight per day	multiply by 1
mg/org	milligrams per organism	divide by BW in kg
mg/org/d	milligrams per organism per day	divide by BW in kg
ng/g bw	nanograms per gram body weight	multiply by 0.001
ng/g bw/d	nanograms per gram body weight per day	multiply by 0.001
ng/kg BW	nanograms per kilogram body weight	multiply by 0.000001
ng/kg BW/d	nanograms per kilogram body weight per day	multiply by 0.000001
ng/org	nanograms per organism	multiply by 0.000001, divide by BW in kg
ug/org	micrograms per organism	multiply by 0.001, divide by BW in kg
ug/org/d	micrograms per organism per day	multiply by 0.001, divide by BW in kg
ug/kg BW	micrograms per kilogram body weight	multiply by 0.001
ug/kg BW/d	micrograms per kilogram body weight per day	multiply by 0.001

*The application assumes that doses which do not specify a unit of time (e.g., g/org or g/kg BW) are in or have been converted to units of **per day** prior to entry

In cases where the dose is not reported on a per day basis, the User must manually adjust the NOAEL and/or LOAEL for the duration between administered doses. For example, this conversion would be required in a study that administered the test material every other day or only on five out of seven days per week. An example of adjustment for duration is provided in the text box to the right. In cases where the reported concentration or dose units are not provided in the pull down list, the User must convert the reported results to one of the units available for selection.

Example for Conversion to Duration-Adjusted Concentration or Dose Units

A study reports a NOAEL dose administered as 10 ug per animal every two days. The User needs to convert this dose to any set of units that can be entered into the application. The User chooses to convert the dose to mg per day by multiplying the dose by a conversion factor for ug to mg of 0.001 and dividing by 2 to achieve an administered concentration of 0.005 mg **per day**. The User can now enter this result and select the mg per day units from the dose fields. The User should enter the conversions in detail in the comment field provided.

Are Absorbed Doses Reported?

An absorbed dose is defined as the amount of the exposure dose which is absorbed into the bloodstream. For example, if 80 percent of an exposure dose of 10 mg/kg BW/day is absorbed, the absorbed dose is 8 mg/kg BW/day. Absorbed doses are most often reported in toxicokinetic studies. They are not typically reported in the type of toxicity studies reviewed for inclusion in the TRV database.

The User selects "Yes" or "No" by checking the appropriate box. If "Yes" is selected, the User enters a brief description of how the absorbed doses were measured and reported in the text box provided. For example, the absorbed dose is estimated in some studies as the difference between administered dose or intake of the contaminant and the amount of contaminant or metabolite(s) excreted in feces and/or urine. When blood residue levels are reported, the User should select "No" for the Absorbed Doses check box, but enter the code "BL-RSDE" in the Absorbed Doses comments field.

Method of Contaminant Analysis

This field enables the User to indicate whether the tested concentrations (or doses) were quantified or if nominal (target) values are reported. The User selects the method of contaminant analysis from the pull down list provided. A detailed description of each method of analysis is available under the "Description" link to the right of the pull down list. The list of available contaminant analysis methods is shown in Table 10. The User selects "M" if the test concentrations (or doses) are quantified and the results are reported. The User selects "U" if nominal (target) values are reported or the method of contaminant analysis is not clear from the information provided in the study. To complete data entry for this field, the User needs to read the text of the paper carefully to determine whether exposure concentrations in the diet or drinking water are verified by contaminant analysis. Some studies that verify or measure the concentration or doses administered indicate in the text of the paper that analysis was performed, but do not report data for the measured dose levels. The method of contaminant analysis in this case is coded as unmeasured but verified (UX).

Table 10. Method of Contaminant Analysis Code Descriptions

Code	Method of Contaminant Analysis Description
Measured (M)	Exposure and/or observation concentrations or doses are verified by analytical methods and are reported as quantitative measured values.
Unmeasured (U)	Exposure and/or observation concentrations or doses are clearly identified as nominal values; or when the author does not report any information about whether the concentrations were measured or nominal, i.e. unmeasured is used as a default value when there is no information provided about the contaminant concentrations.
Unmeasured but Verified (UX)	Unmeasured exposure concentrations or doses are clearly identified as nominal values. The author reports that contaminant analysis was done to verify the nominal values, but analytical results are not reported in the article.

Measured Concentrations/Measured Doses with Units

The measured *concentration* is the amount of the contaminant in the exposure medium as determined by analysis. The measured *dose* is the amount of contaminant in the exposure vehicle as determined by analysis, expressed per unit of organism (amount of contaminant per unit body weight or per organism), and administered in a specified period of time. Doses are preferred over concentrations for derivation of Wildlife TRVs. If only concentrations are reported in the study, the User **does not** calculate the respective dose. The application is designed to calculate the dose automatically. The User enters either the measured concentrations **OR** doses (not both) for each of the treatment groups separated by a forward-slash in the text box provided. The control(s) are included first in the series. (eg.: 0 / 4.8 / 10.2 / 18.9 / 51.1). The User next selects the appropriate units associated with the measured concentrations or doses reported in the study from the pull down list. A detailed description of available units is provided under the description link to the right of the pull down list. The list of available units is shown in Table 8.

If both measured and nominal doses or concentrations are reported, the User enters the measured data only.

Application Frequency

The frequency of the exposure application is selected from the pull down list. For exposures in which there are "X" applications per a given time period, the User enters the number of applications in the numerical field provided. A detailed description of the selections available for application frequency is available under the description link to the right of the pull down list. The list of available application frequency selections is shown in Table 11a.

The User should note that this feature is NOT used to automatically calculate duration-adjusted doses (e.g. for doses administered every other day or five days per week). Duration-adjusted dose conversion must be performed manually by the User as described above.

Table 11a. Application Frequency Code Descriptions

ADL	Ad libitum; without limit or restraint
CON	Continual; non-pulsed
DLY	Daily; dosing regime not specified
EOD	Every other day
X	Dosed x time(s) per study period; e.g. 1 time = 1X
X per h	X times per hour
X per d	X times per day
X per w	X times per week
X per mo	X times per month
NR	Not Reported

Exposure Type

The exposure type represents the method by which the contaminant is administered to the test organism. Studies reporting results for oral exposures (diet, gavage, capsule and drinking water) are used exclusively for the purpose of establishing the Wildlife TRVs. Studies reporting an exposure type other than oral should have been excluded earlier in the process by application of the Literature Rejection Criteria described in Section 2. If the User discovers a study reporting results for non-oral exposures at this point of the data entry process, the information entered to this point is saved and the program exits to the "Data Entry" screen.

The following are special cases that might be encountered in coding exposure type and route. If the publication only indicates "diet" as an exposure, the User should choose "FD" (contaminant incorporated into the food) for the exposure route. If the exposure route changes within a test, the data are entered as a separate phase. Dosing of progeny via the mother's milk in reproductive and/or developmental studies is considered a food (FD) route, not a drinking water route. The User should note that the concentration of the contaminant of concern in mother's milk must be reported in order to code data for juvenile animals exposed via lactation.

Table 11b. Exposure Type Code Descriptions

Code	Description
FD	contaminant incorporated into the food
DR	contaminant incorporated into the drinking water
CH	choice of treated or untreated food or drinking water
GV	gavage
OR	other oral (e.g. capsule)

Route of Exposure

The route of exposure is directly related to the "Exposure Type" as described in Table 11b. Because the Wildlife TRVs are based on data from oral exposure studies, only codes specific to oral exposures are available in the pull down list.

Test Location

The User selects the appropriate location or setting in which the experiment is reported to be conducted from the pull down list. The list of test locations and definitions is provided in Table 12. The listed options are based on Rand (1995). If the test location is not specified, the User is instructed to select "NR" for Not Reported.

Table 12. Test Location Code Descriptions	
FieldA*	**Field, Artificial** - a simulated or artificial field study is conducted in "an artificially bounded system that is a simplification of a specific ecosystem", e.g., aviaries, pens, enclosures
FieldN*	**Field, Natural** - a natural field study is one "in which both the test system [...] and exposure to the stressor are "naturally" derived"; e.g., sprayed agricultural field or orchard plots, field surveys
FieldU*	**Field - Unable** to determine whether natural or artificial setting
Lab*	**Laboratory** indoor setting
NR*	**Not Reported** - unable to determine if laboratory or field

* Rand (1995)

Experimental Design

The purpose of the experimental design field is to capture information on the overall purpose and design of the study and to record important information that is not entered elsewhere. The User enters a statement on the objective of the experiment and a brief description of the experimental design in the text box provided. Care should also be taken to enter information on reproductive stages in this section. The experimental design should include, but is not limited to, information specific to the number of experiments conducted, dosing design, types of endpoints recorded, exposure durations (including the full duration of the experiment and interim time points), and statistical methods used to analyze the results. In studies with multiple phases this information may overlap information entered in the remarks field. In this case, enter "see remarks" for information that would be otherwise duplicated. An example of an experimental design entry is provided in the text box . Six main points to capture in this section: (1) Purpose of study; (2) Brief description of exposure (species, initial age, chemical, and duration of exposure); (3) time intervals when food consumption was monitored and dosing design; (4) time intervals when effect measurements were taken; (5) brief summary of effect groups that were measured during the study; (6) statistical analysis

If test methods are not reported in the current paper, but are reported in another paper being used for TRV, the User should enter the SSL-ID number for the paper containing the full description of test methods.

Experimental Design - Example Text

Purpose of study was to assess the effect of cadmium on energy metabolism and tissue metal concentrations. Juvenile mallard drakes were exposed to cadmium in feed for 41 to 43 days. Food consumption was monitored for 3 day periods at biweekly intervals. Body weights were determined on days 0, 21, and 42. Terminal endpoints included selected organ weights; concentration of cadmium, copper, and zinc in liver and kidney; biochemical measurements in liver, blodd, kidney, blood, and urine. One-way ANOVA was used to test for significant effects. Duncan's multiple range test was used to test for significant effects in pair-wise comparisons among variables significantly affected by treatment.

Test Conditions

A checklist of representative USEPA (2002) and ASTM (2001a-d) standard guidelines and reporting parameters for toxicological studies is provided as Table 13. Comparable toxicology study guidelines are also published by the U.S. Food and Drug Administration (USFDA, 2002) and the Organisation for Economic Development and Cooperation (OECD, 2002). These guidelines provide detailed descriptions of acceptable methodology for specific types of toxicity tests and are designed to generate consistently acceptable data for regulatory purposes. Studies conducted by the National Toxicology Program follow procedures comparable to those described in the USEPA guidelines, and should be considered guideline studies for purposes of deriving Wildlife TRVs..

For derivation of Wildlife TRVs, the objective in reviewing studies for guideline compliance is to determine whether the study authors used acceptable general methodology and animal husbandry procedures. A comparison of reporting parameters for 16 standard toxicological test protocols in Table 13 indicates that descriptions of procurement, animal care, characterization of the material tested are common to many standard guidelines. Therefore, reporting of information on these parameters in a study under evaluation for derivation of a TRV is considered a good indication that an acceptable approach to testing was used. The User evaluates the test conditions reported in the study by comparison to the parameters in Table 13. The User then chooses the appropriate description from the pull down list based on the test conditions and parameters reported in the study. If the test conditions are not reported in the current paper, but are reported in a separate paper being used for TRV, the User records the SSL-ID number for the source of the test methods in the Experimental Design comment field.

Experiment Sample Size

The experiment sample size should be summarized within this field. The user should denote the number of experimental animals per exposure dose or concentration as well as the controls. Any reduction in animal numbers during the experiment for reasons other than contaminant exposure should be denoted (losses from disease, handling, etc.,).

Table 13. Standard Study Guidelines and Reporting Parameters								
Test Conditions	**Test Protocols**							
	Avian Dietary	**Avian Reproduction**	**90 day Oral Study in Rats**	**Chronic Oral Study in Rats**	**Subacute Dietary with Avian Species**	**Reproductive Studies with Avian Species**	**Developmental Toxicity in Rats and Rabbits**	**Reproduction and Fertility Study in Rats**
	OPPTS 850.2200	**OPPTS 850.2300***	**ASTM E 1372-95**	**ASTM E 1619-95**	**ASTM E 857-87**	**ASTM E 1062-86**	**ASTM E 1483-92**	**ASTM E 1062-86***
Source of Test Animals	X	X	X	X	X	X	X	X
Health of Test Animals	X	X	X	X	X	X	X	X
Age of Test Animals	X	X	X	X	X	X	X	X
Acclimation procedures	X	X	X	X	X	X	X	X
Assignment of animals to housing	X	X	X	X	X	X	X	X
Description of basal diet (including source, diluents and supplements)	X	X	X	X	X	X	X	X
Nutrient content of diet	X	X	X	X	X	X	X	X
Water	X	X	X	X	X	X	X	X
Description of housing conditions (including size, type, material)	X	X	X	X	X	X	X	X
Temperature	X	X	X	X	X	X	X	X
Photoperiod	X	X	X	X	X	X	X	X
Lighting intensity	X	X	X	X	X	X	X	X
Humidity	X	X	X	X	X	X	X	X
Frequency, duration and methods of observation	X	X	X	X	X	X	X	X
General description of facilities	X	X	X	X	X	X	X	X
Description of test substance (including CAS number, purity, source, solvent or carrier, if used.)	X	X	X	X	X	X	X	X

* These test guidelines have recently been withdrawn without designation of replacement guidelines. Information on replacement guidelines will be included in future updates of this SOP as it becomes available.

The "Exposure Information" screen is now complete. The User now verifies that all data entered are correct and click on "Next" at the bottom of the screen to continue. The User **should not** use the browser back arrow to return to a previous data entry screen to correct errors. Using the back arrow results in deletion of information.

4.4 Endpoint Information

Exposure Duration and Units

The exposure duration for a specific endpoint is entered in the numeric field provided. For example, if contaminant exposure lasts for ten weeks, the User enters the number 10. For studies that report dosages (or concentrations) that are varied during the period of exposure, the User evaluates each unique dosage duration as a separate endpoint. The units associated with the exposure duration are selected from the pull down list provided. The list of available units is shown in Table 14. Studies of three days or less are considered acute and are not coded. Results reported for recovery periods (i.e., after exposure to the contaminant ceases) longer than one day post-exposure are not coded. In the comment field the User should also record the exposure durations at which measurements of the endpoint was made (e.g. 1, 14 and 28 days).

Coding Gestational and Lactation Exposure Studies

Gestational Exposures

- Enter results for gestational exposures as Phases for the mother not the progeny
- Effects to the progeny are coded as reproductive endpoints (REP)
- Enter the exposure duration as the time chemical was administered during gestation. If exact time is not reported estimate based on gestation of test animal.

Lactation Exposures

- Enter results for lactation exposures as Phases separate for the mother and the progeny
- For the Phase for the mother effects to the progeny are coded as reproductive endpoints (REP)
- Enter the exposure duration as the time chemical was administered during lactation. If exact time is not reported estimate based on lactation time for the test animal.
- If it is possible to quantify exposures for progeny during lactation (i.e. the concentration of contaminant is measured in the mother's milk) then enter exposure duration as the time during lactation that the progeny was exposed.

The general rules for determining the exposure duration for each LOAEL/NOAEL are as follows:

1. The exposure duration coded should be for the first occurrence of an adverse effect. If no clear dose response exists at the shortest exposure duration, the User should move to the next exposure duration and reassess the dose-response relationship.

2.. The first (shortest) exposure duration reporting an adverse should be coded, as long as a clear dose response relationship is evident in the data collected at this time point. The User should record in the exposure duration comment field the exposure durations at which further (later) measurements are reported.

3. If none of the exposure durations are associated with an adverse effect, the longest exposure duration is selected.

Table 14. Exposure Duration and Age Units	
s	second
mi	minute
h	hour
d	day
w	week
mo	month
yr	year
lf	lifetime
NR	Not Reported

Age with Units

The User enters the age of the test organism at the beginning of the study in the numeric field provided. For example, if the study reports that two-week-old ducklings are exposed at the start of the study, the User enters the number 2. The appropriate units are selected from the pull down list provided. The list of available age units is shown in Table 14. For designation between adult, juvenile, sexually mature, sexually immature, the user should assign the terms juvenile, adult and sexually mature according to the guidelines in Table 20. If the author identifies the test organisms as sexually mature or sexually immature this should be preferentially assigned.

Sex

The User selects the sex of the test organism from the pull down list provided. "M" is selected for male organisms. "F" is selected for female organisms. If organisms of both sexes are tested, "BH" is selected for "Both Male and Female". "NR" is selected for Not Reported if the sex of the test organisms is not specified.

Lifestage

The lifestage of the test organism is selected from the pull down list provided. The list of available lifestages is shown as Table 15. If the lifestage of the test organism is not reported then it can be estimated based on the reported body weight of the organism using the default body weight table. If the lifestage is not evident from the study, then "NR" is selected for Not Reported. The lifestage in which the result is reported is used when an organism is dosed through multiple lifestages. For example, if a female is exposed before mating, through gestation, and into lactation, the lactation (LC) lifestage is used.

The User should note that the pull down list for lifestage includes larvae (LV), nauplii (NU) and pupa (PU) lifestages for terrestrial insects. These are included for possible future applications and do not apply to the coding process for Wildlife TRVs.

Is This a Critical Lifestage?

A lifestage is defined as "critical" if it is critical to the survival and reproduction of the species. These lifestages may or may not be more sensitive to contaminant exposure. Exposures during

these critical lifestages are preferred in the derivation of wildlife TRVs. Table 15 identifies the lifestages from the pull down list considered to be "critical". The User selects "Yes" or "No" by checking the appropriate box. If the lifestage is not specified, the User should check "NR" for Not Reported. There may be some cases where the User must use professional judgement to classify certain exposures as critical; these cases should be documented by comments. Critical exposure periods include those during lactation and gestation. When reproductive effects are reported for adult males or females, the lifestage is identified as critical.

Determination of whether a lifestage in avian studies is critical is done in the following way. The lifestage code LB is used for birds that are producing eggs during the study period. This is by definition a critical lifestage that applies to all measured endpoints. The AD lifestage code is assigned to adult birds that are not laying eggs during the study period. The User should note that the relevant lifestage code for birds that stop producing eggs as a result of treatment is LB.

Table 15. Lifestage Code Descriptions

Code	Lifestage	Critical (Yes or No)
AD	adult	No
EG	egg	Yes
EM	embryo	Yes
IM	immature	Yes
JV	juvenile; includes yearling, fledgling, hatchling, weanling	Yes
LB	egg laying bird	Yes
MA	mature	No
NR	not reported	No
SA	subadult	No
SI	sexually immature	No
SM	sexually mature	No
YO	young	Yes
YY	young of year	Yes
GE	Gestational Exposures	Yes
LC	Lactation	Yes

Effect Group

Exposure of test organisms to contaminants can result in both positive and adverse effects. The reviewer should code only potentially adverse effects. Possible adverse effects that may be reported in toxicological studies are divided into nine Effect Groups. These groups were developed as part of the coding system devised for ECOTOX by EPA Duluth. The nine Effect Groups are accumulation (ACC), behavior (BEH), biochemistry (BIO), growth (GRO), mortality (MOR), pathology (PTH), physiology (PHY), population (POP), and reproduction (REP). A brief description of each effect group is provided under the description link to the right of the pull down list. The list of available Effect Groups is shown and described in Table 16.

The User selects the appropriate effect group from the pull down list provided. The User should consult both Tables 16 and 17, which provide the Effect Types and Measures that are specific to the Effect Groups to identify the appropriate Effect Group for the endpoint described in the study under review.

Table 16. Effect Group Descriptions

Code	Description
ACC	**Accumulation**: a general term describing the process (bioaccumulation) by which contaminants are taken into and stored in plants or animals; bioaccumulation occurs when the rate of contaminant uptake exceeds the rate of elimination of the same contaminant; therefore accumulation measurements include uptake (UPTK) and elimination (ELIM) rates as well as actual tissue concentrations (RSDE); accumulation endpoints include the asymptotic threshold concentration (ATCN), bioconcentration factor (BCF) and bioaccumulation factor (BAF).
BEH	**Behavior:** a general term characterizing overt activity of an organism represented by three effect groups - avoidance (AVO), general behavior (BEH), and feeding behavior (FDB). Examples of behavioral measurements include stimulus avoidance (STIM), feeding changes (FDNG), general reproductive success (RSUC), and general activity levels (ACTV).
BIO	**Biochemical:** measurement of biotransformation or metabolism of chemical compounds, modes of toxic action, and biochemical responses in animals including three effect groups - chemical (CHM), enzyme (ENZ) and hormone (HRM) effects. Examples of biochemical measurements include chemical parameters such as cell (CCHG) or amino acid (AMAC) changes, enzyme parameters such as transferase, oxidase or hydrolase reactions, and measurements of hormone response levels. NOTE: Biochemical responses associated with heavy metal accumulation (e.g., zinc content) should not be coded. Responses that are indicative of a target tissue response (e.g., calcium content in bone) should be coded.
GRO	**Growth**: a broad category which encompasses measures of weight and length and includes effects on development (DVP), growth (GRO) and morphology (MPH). Morphology: measurements and endpoints which address the structure (bones) and form (organ/tissue development) of an organism, at any stage of its life history.
MOR	**Mortality:** measurements and endpoints where the cause of death is by direct action of the contaminant; e.g. an endpoint such as the LD50 estimates the lethal dose to 50% of the exposed population whereas measurements count the actual number dead or the percentage reduction within a population as a result of the exposure.
PTH	**Pathology:** measurements and endpoints regarding the causes, nature and effects of diseases and other abnormalities; the four effect groups include histology (HIS), immunotoxicity (IMM), intoxication (ITX), and gross wasting effects (GRS). Immunotoxicity, intoxication, parasites and tumor effects are not coded for TRVs for the Eco-SSLs.
POP	**Population:** measurements and endpoints regarding a group of organisms or plants of the same species occupying the same area at a given time. Measurements include abundance, biomass, size and age class structures.
PHY	**Physiology:** measurements and endpoints regarding changes and activity in cells and tissues of plants or animals.
REP	**Reproduction:** measurements and endpoints to track the effect of toxicants on the reproductive cycle.

Effect Type

The available Effect Types are provided in a pull down list. The listed Effect Types are specific to the Effect Group previously selected by the User. The appropriate Effect Type for the endpoint is selected from the pull down list provided. The available selections are listed in Table 17.

Effect Measure

The effect measure is a variable used to determine organism response to contaminant exposure. The available Effect Measures in the pull down list correspond to the previously selected Effect Type. The User selects the Effect Measure from the pull down list. The measurement code "XXXX" denotes a temporary code that needs to be validated and assigned an acronym. The list of available selections is provided in Table 17. To avoid repetitive entries of NOAEL and LOAEL values and to make the coding process more efficient, the User is instructed to record only **one result** per Effect Group. The most conservative result (lowest NOAEL or LOAEL) should be recorded.

Table 17. Effect Groups, Types and Measures	
BEHAVIOR EFFECT GROUP (BEH)	
(AVO) Avoidance Effect Type Measurement Code and Definition	
CHEM	contaminant avoidance
FOOD	food avoidance
STIM	stimulus avoidance
WATR	water avoidance
(BEH) General Behavior Effect Type Measurement Code and Definition	
ACTP	accuracy of learned behavior
ACTV	activity, general
AGGT	aggression
AMBU	ambulatory/circadian rhythm
EQUL	balance and equilibrium
GBHV	behavioral changes
LOCO	distance
DPLY	displaying behavior
DRMT	dormant, adverse condition
FRZG	freezing behavior
GBHV	general behavior
GPRD	general production
INST	induced sleeping time
NMVM	number of movements
NVOC	number of vocalizations
RRSP	righting response
RSPT	response time to stimulus
VCLF	visual cliff
(FDB) Feeding Behavior Effect Type Measurement Code and Definition	
BGNB	begging behavior
CAIN	caloric intake
FCNS	food consumption
FDNG	feeding behavior
FEFF	feeding efficiency
FSTR	food storage
FTIM	feeding time
GFDB	general feeding behavior

WCON	water consumption
BIOCHEMISTRY EFFECT GROUP (BIO)	
(CHM) Biochemical Effect Type Measurement Code and Definition	
5HAA	5-hydroxyindole acetic acid
AABA	alpha-aminobutyric acid
ALAN	alanine
ALBM	albumins
ALBE	albumen energy
AMAC	amino acids, general term
AMMO	ammonia
AMNH	p-amino hippurate
ANBC	aniline binding capability
ARGI	arginine
ASCA	ascorbic acid
ASHC	ash content
ASIS	amyloidosis
ASPA	apartate
ATPT	adenosine triphosphate
B2MG	beta2-microglobulin
BASO	basophil
BIOT	biotin content
BUNT	blood urea nitrogen
CALC	calcium
CAPH	calcium/phosphorus ratio
CCHG	cell changes
CHLN	choline
CHLR	chloride
CHOL	cholesterol
CREA	creatinine
DISC	dethylsuccinate hdyrolysis
DTBL	direct bilirubin (conjugated)
EOSN	eosinophil
ERTH	erythoroblasts
ESAA	amino acids, essential
FECO	iron content (do not code)
FEPR	free erythrocyte protoporphyrins
FFTA	fatty acids, free
GBCM	general biochemical
GLCN	glycine
GLTH	glutathione
GLUC	glucose
GLYC	glycogen
GMIN	glutamine
HEME	heme content
HEMT	general hematology
HIST	histidine
HMCT	hematocrit (anemia)
HMGL	hemoglobin
IBIL	indirect bilirubin (free)

(CHM) Biochemical Effect Type Measurement Code and Definition	
ILEU	isoleucine
LACT	lactate
LCTA	lactic acid
LEUC	leucine
LEUK	leukocytes
LIPD	lipid
LMPH	lymphocyte
LPSA	lipid soluble antioxidants
LYSI	lysine
MCHC	mean corpuscular hemoglobin
MCPR	microsomal proteins
MCPV	mean corpuscular volume
METH	methionine
MONO	monocyte
NADP	nicatinamide-adenine dinucleotide phosphate, reduced
NEAA	amino acides, nonessential
NEFA	fatty acids, nonesterified
NEUT	neutrophil
ORNI	ornithine
OSRS	osmotic resistance/RBC
PCLV	packed cell volume
PHPH	pH
PHEN	phenyalanine
PPHT	phosphate
PHSP	phosphatide phosphorus
PCON	phosphorus
PHST	phospholipid content, total
PORP	porphyrin
KCON	potassium
PRTO	protoporhyrin
PYRV	pyruvate
RGSH	reduced gluthione
NPSH	nonprotein sulfhydryl
RBCE	red blood cell
RBVL	relative blood volume (volume/100g body weight)
RETI	reticulocytes
SERI	serine
NACO	sodium
SOMC	somatomedin C
SPLO	splenocytes
SRTN	serotonin
TEAM	tetraethylammonium
TFAA	amino acids, total free
THBA	thiobarbituric acid
THIA	thiamine
THRE	threonine
THRM	thrombocytes
TLBL	bilirubin, total

(CHM) Biochemical Effect Type Measurement Code and Definition	
PRTL	protein, total
TRIB	tributyrin
TRIG	triglycerides
TYRO	tyrosine
TRYP	tryptophan
TTAA	amino acids, total
TWBC	white blood cell count, total
UBWB	white blood cell, undifferentiated blasts
UREA	urea
URIC	uric acid
VALI	valine
VTD3	vitamin D3
VTMA	vitamin A
ZNPR	zinc protoporphyrin
(ENZ) Enzyme Effect Type Measurement Code and Definition	
20HB	2-OH biphenyl hydroxylase
40HB	4-OH biphenyl hydroxylase
450R	Cyt P450 reductase
DHYD	NADPH dehydrogenase
AATT	alanine aminotransferase
ACHE	acetylcholinesterase
ACPH	acid phosphatase
AEPX	aldrin epoxidase
AHHD	aryl hydrocarbon hydrolase
AHDX	aniline hydroxylase
ALAD	(delta) -aminolevulinic acid dehydrogenase
ALAS	(gamma) y-ALA synthetase
ALDO	aldolase
ALPH	alkaline phosphatase
ANAE	alpha naphthyl acetat esterase
APND	aminopyin n-demethylase
ATRP	alanine transpeptidase
ASAT	aspartate aminotransferase
BAPH	benzo(a)pyrene hydroxylase
BCHE	buterylcholinesterase
BCOD	butoxycoumurin O-dealkylase
BHXA	benzpyrene hydroxylase
BPND	benzphetamine-n-demethylase
BROD	benzylresorufin O-deethylase
CAAH	carbonic anhydrase
CACA	choline acetyltransferase
CATP	calcium ATPase
CYB5	cytochrome B-5
CCOX	cytochrome C-oxidase
CEST\	chloinesterase
CRKI	creatine kinase
NCCR	NADPH cytochrome C reductase
EPHY	epoxide hydrase

(ENZ) Enzyme Effect Type Measurement Code and Definition	
ECOD	ethoxycoumurin O-deethylase
EROD	7-ethoxyresorufin O-deethylase
ESTE	esterase
FDPA	fructos-diphosphate aldolase
GENZ	general enzyme
G6PD	glucose-6-phosphate dehydrogenase
GGTR	(gamma) Y-glutamyltransferase
GLAD	glutamic acid dehydrogenase
GLPX	gluathione peroxidase
GLRE	gluthione reductase
GLTR	glucouronyl transferase
GOTR	glutamic-oxaloacetic transaminase
GPTR	glutamic pyruvic transaminase
GSTR	glutathione S-transferase
HXBH	hexobarbital hydroxylase
LADH	lactate dehydrogenase
LDMD	lactate dehydrogenase/malic dehydrogenase ratio
MADH	malic dehydrogenase
MCOD	methoxycoumarin O-dealkylase
MG6P	microsomal glucose 6-phosphatase
MAOA	mono amino oxidase
MGAT	magnesium ATPase
NKAT	sodium potassium ATPase
ORCT	ornithine carbamoyl transferase
P450	cytochrome P450 proteins
PBES	phenyl benzoate esterase
PBHD	pentobarbital hydroxylase
PCOD	propoxycoumarin O-dealkylase
PNAD	p-nitroanisole demethylase
PROD	pentylresorufin O-deethylase
SBDH	sorbitol dehydrogenase
SCDH	succinate dehydrogenase
SGOT	serum glutamate oxalo aetate transaminase
SGPT	serum glutamic pyruvic transaminase
THTR	thiotransferase
TRIE	triacetin esterase
(HRM) Hormone Effect Type Measurement Code and Definition	
ANDR	androgen
CORT	corticosterone
CRTS	cortisol
DOPA	dopamine
EPIN	epinephirine
ESDL	17-beta estradiol
ESTR	estrogen
FOSH	follicle stimulating hormone
GHRM	general hormone
GTHH	growth hormone
GHRM	hormone, changes in

LUTH	luteinizing hormone
NORE	norephinephrine
PRGS	progesterone
TSTR	testosterone
THYR	thyroxine
TRII	tridothyronine
Growth Effect Group (GRO)	
(DVP) Development Effect Type Measurement Code and Definition	
EMDV	embryo development
FLDG	fledged/female or /brood
GDPV	general development
LRGN	limb regeneration
WEAN	weaned
(GRO) Growth Effect Type Measurement Code and Definition	
BODL	body length changes - non-adult organisms only (see PTH GRS for adults)
BDWT	body weight changes - non-adult organisms only (see PTH GRS for adults)
GGRO	general growth
(MPH) Morphology Effect Type Measurement Code and Definition	
COSC	caudal ossification center
CRLT	crown-rump length
FRLT	feather length
GMPH	general morphological changes
HULT	humerus length
MOSC	metacarpal ossification center
MUSC	muscle changes
OVLT	oviduct length
RULT	radius-ulna length
SOSC	sternal ossification center
SRIB	supernumerary ribs
TRLT	tarsus length
TELT	testis length
TTLT	tibiotarsus length
MORTALITY (MOR) EFFECT GROUP	
(MOR) Mortality Effect Type Measurement Code and Definition	
GMOR	general mortality
LFSP	lifespan
MDTH	mean time of death
MORT	mortality
SURV	survival
TDTH	time to death
TKNO	knockdown
PATHOLOGY (PTH) EFFECT GROUP	
(GRS) Gross Wasting Effect Type Measurement Code and Definition	
BODL	body length changes - adult organisms only (see GRO GRO for non-adults (jv, ma, sm, etc.)
BDWT	body weight changes - adult organisms only (see GRO GRO for non-adults (jv, ma, sm, etc.)
(ORW) Organ Weight Effect Type Measurement Code and Definition	
ORWT	organ weight changes
SMIX	organ weight in relationship to body weight

(HIS) Histology Effect Type Measurement Code and Definition	
ARTS	arteriosclerosis
CTYP	percent cell type
EDMA	edema
ENCP	encephalopathy
GHIS	histological changes, general
GLBM	glomerular basement membrane
GLSN	gross lesions
HEMR	hemorrhage
HYPL	hyperplasia
IIBD	intranuclear inclusion bodies
NCRO	necrosis
NPHR	nephrosis
TFLR	tissue fluorescence in UV light
USTR	ultrastructural changes
(ITX) Intoxication Effect Type Measurement Code and Definition	
ANOR	anorexia
ATAX	ataxia
CONV	convulsions
GITX	general intoxication
IMBL	immobile
INCO	incoordination
GITX	intoxication, general
PARL	paralysis
TINT	time to signs of intoxication
TREM	tremors
POPULATION (POP) EFFECT GROUP	
(POP) Population Effect Type Measurement Code and Definition	
PBMS	biomass or weight for total population
DVRS	diversity and evenness
GPOP	general population effect
INDX	index to population size, count, number
ABND	number of animals/population and population density (N/area)
NCHG	population change (change in N/change in time)
RCPR	recapture ratio
SEXR	sex ratio
TRAP	trappability
PHYSIOLOGY (PHY) EFFECT GROUP	
(PHY) Physiology Effect Type Measurement Code and Definition	
ADPO	oxidative phosphorylation
BLPR	blood pressure
BTMP	body temperature
CRDY	crop dysfunction
DIFD	digestibility of food
BDVL	blood volume
EECG	electroencephalogram
EXCR	excretion rate

PHYSIOLOGY (PHY) EFFECT GROUP	
(PHY) Physiology Effect Type Measurement Code and Definition	
FDCV	food conversion efficiency
GPHY	general physiology
GLFR	glomular filtration rate
HTRT	heart rate
HYDR	hydration
NRGM	metabolizable energy
META	metabolic rate
RPRT	respiratory rate
OSMO	serum/plasma osmolality
PRIN	PR intervals
IRRI	skin irritation
THRG	thermoregulation
PROT	Prothrombin time
REPRODUCTION (REP) EFFECT GROUP	
(REP) Reproduction Effect Type Measurement Code and Definition	
ABNM	abnormal
BEFF	breeding efficiency
BNDG	pair bonding nesting behavior
COUR	courtship behavior
CYNG	care of young, nest attentiveness
DEYO	death of young
EGPN	eggs per nest
FERT	fertility
GREP	general reproduction
GIDX	gestation index
GSTT	gestation time
HTCH	hatch
LACG	lactating
NANT	nests abandoned
NCLU	corpus lutea, number of
NDAY	number of days between eggs laid
NINC	number of nests incubated
NOPN	number of organisms per nest
NSNT	successful nests
NSTI	nest initiation
NSTS	number of active nests
NTSZ	nest size
NUNT	unsuccessful nests
OBRD	open brood
ODVP	offspring development
OEGP	onset of egg production
OHIS	offspring histology
ORWT	reproductive organ weight
OTHR	other; use this to code any effects (pathology, biochemistry, etc.) reported in offspring of contaminant-exposed mothers
OVRT	ovulation rate

REPRODUCTION (REP) EFFECT GROUP	
(REP) Reproduction Effect Type Measurement Code and Definition	
PBEH	progeny behavior
PIPD	pipped
PLBR	pairs with litter or brood
PRFM	pregnant females in a population
PROG	progeny counts/numbers
PRWT	progeny weight (TBWT, LTWT)
PVOP	premature or delayed vaginal opening
RBEH	reproductive behavior changes
SBRD	sealed brood
RHIS	reproductive organ histology
RPRD	reproductive capacity
RSEM	resorbed embryos
RSUC	reproductive success (general)
SPCL	sperm cell counts
SPCV	sperm cell viability
TEDG	testes degeneration
TERA	teratogenic measurements
TEWT	testes weight
TPRD	total production
(EGG) EGG Effect Type Measurement Code and Definition	
ALWT	albumen weight
CRAK	cracked eggs
EGVL	egg volume
EGWT	egg weight
ESIN	eggshell index
ESLT	eggshell length
ESQU	eggshell quality
ESTH	eggshell thickness
ESWD	eggshell width
ESWT	eggshell weight
FTEG	fertile egg
SHLL	percent shell
SHSZ	shell size
SFYK	soft yolk
YOLK	yolk, percent
YKWT	yolk weight

Response Site

The response site is the specific location (e.g., organ or tissue) where an effect is observed. The response site for mortality (MOR) or behavioral (BEH) effects is not applicable and whole organism should be selected. The response site that is specific to the endpoint is selected from the pull down list. The list of available selections is shown in Table 18. If the response site is not reported, "NR" is selected for Not Reported.

Table 18. Response Sites and Codes			
Code	**Response Site**	**Code**	**Response Site**
AG	Accessory Gland	MS	Mesenteric Lymph Node
AD	Adipose Tissue	MC	Microsome
AR	Adrenal Gland	MK	Milk, lactating females
AS	Air Sac	MT	Multiple Tissue/Organs
AL	Albumen (egg white)	MU	Muscle
AT	Alimentary Tract	MB	Muscle+Bone
AF	Amniotic Fluid	MO	Mucous
AP	Appendages	NG	Nasal Gland
BI	Bile	NE	Nervous Tissue
BL	Blood	NK	Neck
BV	Blood Vessel	NR	Not Reported
BO	Bone	OL	Olfactory
BM	Bone Marrow	OV	Ovaries
BR	Brain	OD	Oviduct
BT	Breast	PS	Pancreas
BU	Bursa	PE	Penis
CA	Cartilage	PI	Pituitary Gland
CH	Cord, spinal	PC	Placenta
CL	Claw	PL	Plasma
CG	Cloacal gland	PG	Prostate Gland
CO	Collagen	PR	Proventriculus
CR	Crop	PY	Progeny
DG	Digestive Gland	RC	Rectum
DT	Digestive Tract	RT	Reproductive Tissue
EG	Egg	SV	Seminal Vesicle
EU	Egg Cuticle	SE	Sensory Organs
EM	Embryo	SR	Serum
EN	Entrails	SN	Skeleton
ER	Erythrocyte	SK	Skin, Epidermis
ES	Esophagus	SG	Shell Gland
EY	Eye	SL	Shell
FE	Feathers	SM	Sperm
FM	Femur	SP	Spleen
FO	Foot	SH	Stomach
FT	Fetus	ST	Soft Tissue
GB	Gall Bladder	SX	Submaxillary Gland
GT	Gastrointestinal Tract	TA	Tail
GZ	Gizzard	TE	Testes
GO	Gonads	TG	Thigh muscle
HA	Hair	TB	Tibia
HD	Head	TI	Tissue
HE	Heart	TS	Thymus
HM	Humerus	TY	Thyroid
HG	Harderian Gland	UB	Urinary Bladder
HY	Hypothalamus	UR	Urine
IN	Intestinal Tract	UT	Uterus
KI	Kidney	VD	Vas Deferens
LD	Lipid, Fat	VE	Vertebra
LG	Leg	VI	Viscera

Table 18. Response Sites and Codes			
Code	**Response Site**	**Code**	**Response Site**
LI	Liver	WI	Wings
LU	Lungs	WO	Whole Organism
MM	Mammary Tissue	YO	Yolk
		XX	Temporary code, requires validation

Endpoint Comments

The endpoint comment field allows the User to enter specific notes concerning the selected endpoint. In cases where multiple effect types are reported, the User records only one measurement and response site. The User enters the rationale for selection of a particular endpoint for data entry in the comments field. The comment field is also used to record other effect types, measurements, and/or response sites in the same effect group that are not chosen for coding. Abbreviations are used as much as possible in the comment field.

Identify the NOAEL and or LOAEL

The User is required to review each toxicological study and to identify No Observed Adverse Effect Level (NOAEL) and/or Lowest Observed Adverse Effect Level (LOAEL) values. The NOAEL is defined as the highest concentration (or dose) used in a study for which there is no statistically significant adverse effect observed in the test organism. The LOAEL is defined as the lowest concentration (or dose) at which a statistically significant adverse effect is observed in contaminant-exposed organisms when compared to controls. The identification of the NOAEL and LOAEL is the most critical step in the data entry process, as these values will be ultimately be used to derive the Wildlife TRVs.

It is important to note that the NOAEL and LOAEL are endpoint specific. For example, the selected LOAEL for a growth endpoint may be 5.7 mg/kg BW/day whereas the LOAEL for a pathological endpoint may be 2.3 mg/kg BW/day.

Publications or documents which report studies of interest to the regulatory community may identify both a NOAEL and a LOAEL, only a NOAEL, or only a LOAEL. In cases where values are identified by the study author, this fact should be noted in the NOAEL/LOAEL comments field. The User should note NOAEL and LOAEL values are often reported only for the most sensitive endpoint in the study. If NOAEL and/or LOAEL values are identified by the study authors, these are considered to be the default values for entry into the TRV database. However, NOAEL and LOAEL values identified by the study authors should be carefully reviewed by the User for consistency with TRV coding guidelines.

Many publications, particularly those reporting basic toxicological research, do not identify NOAEL or LOAEL values. In these cases, the User must determine whether there are sufficient data available to determine NOAEL and/or LOAEL values. Four general cases are possible for data adequacy:

- The data have been analyzed using appropriate statistical methods
- The data have been analyzed, but the statistical methods are not appropriate
- No statistical analysis was performed, but sufficient data are available to perform an independent analysis
- No statistical analysis was reported and insufficient data are available to perform an independent analysis

The process of identifying a NOAEL and/or LOAEL begins by determining whether statistical analysis of the data was performed. This may be obvious from presentation of data in summary tables. However, the User should be prepared to carefully examine the text in the methods section, text of the results section, and footnotes in data tables for information on statistical analysis and results. In cases were no statistically significant results were observed, the only indication that statistical analysis was performed may be a description provided in the methods section. If an appropriate statistical analysis has been performed, the User applies the general rules below to identify NOAEL and/or LOAEL values.

The general rules for determining each LOAEL/NOAEL and their exposure durations are as follows:

1. The User identifies a NOAEL in the following cases where: 1) there are sporadic, statistically significant differences, but no clear dose response (e.g., a statistically significant difference is reported at a low or mid dose but not at higher doses); and/or 2) there is anecdotal information to suggest that the apparent difference is a statistical artifact rather than a real effect.

2. In individual studies which report results at multiple time points, the exposure duration coded should be the first (earliest) occurrence of an adverse effect. The concentration or dose at which the adverse effect occurs is the LOAEL. If a clear dose-response relationship is not evident at the shortest exposure duration, the User examines data for the subsequent exposure durations in a stepwise manner to identify the LOAEL.

3. When selecting among multiple effect measures for the same effect type, the first (shortest) exposure duration resulting in the lowest LOAEL should be coded, provided a clear dose response relationship is evident.

4. If there is no adverse effect reported and/or a dose-response relationship is not evident, the User selects the highest dose (or concentration) at the longest duration as a NOAEL value.

The User should carefully review the methods and results sections and footnotes of the data summary tables before making a determination that statistical analysis was not conducted.

The following examples are provided to assist reviewers in properly assigning NOAEL and LOAEL values and the corresponding exposure durations:

Example 1

Duration\Doses	10 mg/kg/d	20 mg/kg/d	30 mg/kg/d	TRV Duration NOAEL/LOAEL
1 week	no	no	no	2 week LOAEL 10
2 weeks	sig	sig	sig	
3 weeks	no	no	no	

Example 2

Duration\Doses	10 mg/kg/d	20 mg/kg/d	30 mg/kg/d	TRV Duration NOAEL/LOAEL:
1 week	no	no	sig	1 week NOAEL 20; LOAEL 30
2 weeks	no	sig	no	
3 weeks	no	no	sig	

Example 3

Duration\Doses	10 mg/kg/d	20 mg/kg/d	30 mg/kg/d	TRV Duration NOAEL/LOAEL:
1 week	no	sig	no	2 week NOAEL 20 LOAEL 30
2 weeks	no	no	sig	
3 weeks	no	sig	no	

Example 4

Duration\Doses	10 mg/kg/d	20 mg/kg/d	30 mg/kg/d	TRV Duration NOAEL/LOAEL:
1 week	sig	no	no	3 week NOAEL 20 LOAEL 30
2 weeks	no	sig	no	
3 weeks	no	no	sig	

Example 5

Duration\Doses	10 mg/kg/d	20 mg/kg/d	30 mg/kg/d	TRV Duration NOAEL/LOAEL:

1 week	no	no	sig	1 week NOAEL 20 LOAEL 30
2 weeks	no	sig	no	
3 weeks	sig	no	no	

Example 6

Duration\Doses	10 mg/kg/d	20 mg/kg/d	30 mg/kg/d	TRV Duration NOAEL/LOAEL:
1 week	no	no	no	3 week NOAEL 30
2 weeks	no	no	no	
3 weeks	no	no	no	

Example 7

Duration/Doses	10 mg/kg/d	20 mg/kg/d	30 mg/kg/d	TRV Duration NOAEL/LOAEL:
1 week	no	sig	no	3 week NOAEL 30 (No dose response)
2 weeks	no	sig	no	
3 weeks	sig	no	no	

Example 8

Duration\Doses	10 mg/kg/d	20 mg/kg/d	30 mg/kg/d	TRV Duration NOAEL/LOAEL:
1 week	no	sig	no	3 week NOAEL 30 (No dose response)
2 weeks	no	sig	no	
3 weeks	no	no	no	

Example 9

Duration\Doses	10 mg/kg/d	20 mg/kg/d	30 mg/kg/d	TRV Duration NOAEL/LOAEL:
1 week	no	sig	no	3 week NOAEL 30 (No dose response)
2 weeks	no	sig	no	
3 weeks	no	sig	no	

The User should take special care in identifying NOAEL and LOAEL values for nutrients. In some cases, contaminants that are also nutrients may give a biphasic dose-response curve, with the lower doses eliciting a positive effect and higher doses causing a negative response. The User selects the NOAEL and LOAEL for the second (adverse) phase of the dose response curve in these instances. For purposes of the Wildlife TRV effort, only data for no effects or adverse effects are recorded.

A nutrient study that examines a relevant endpoint (i.e., one with the potential for adverse effects) is coded, even in the absence of observed adverse effects. In this case, the User selects the highest dose as a NOAEL. Beneficial effects are not coded.

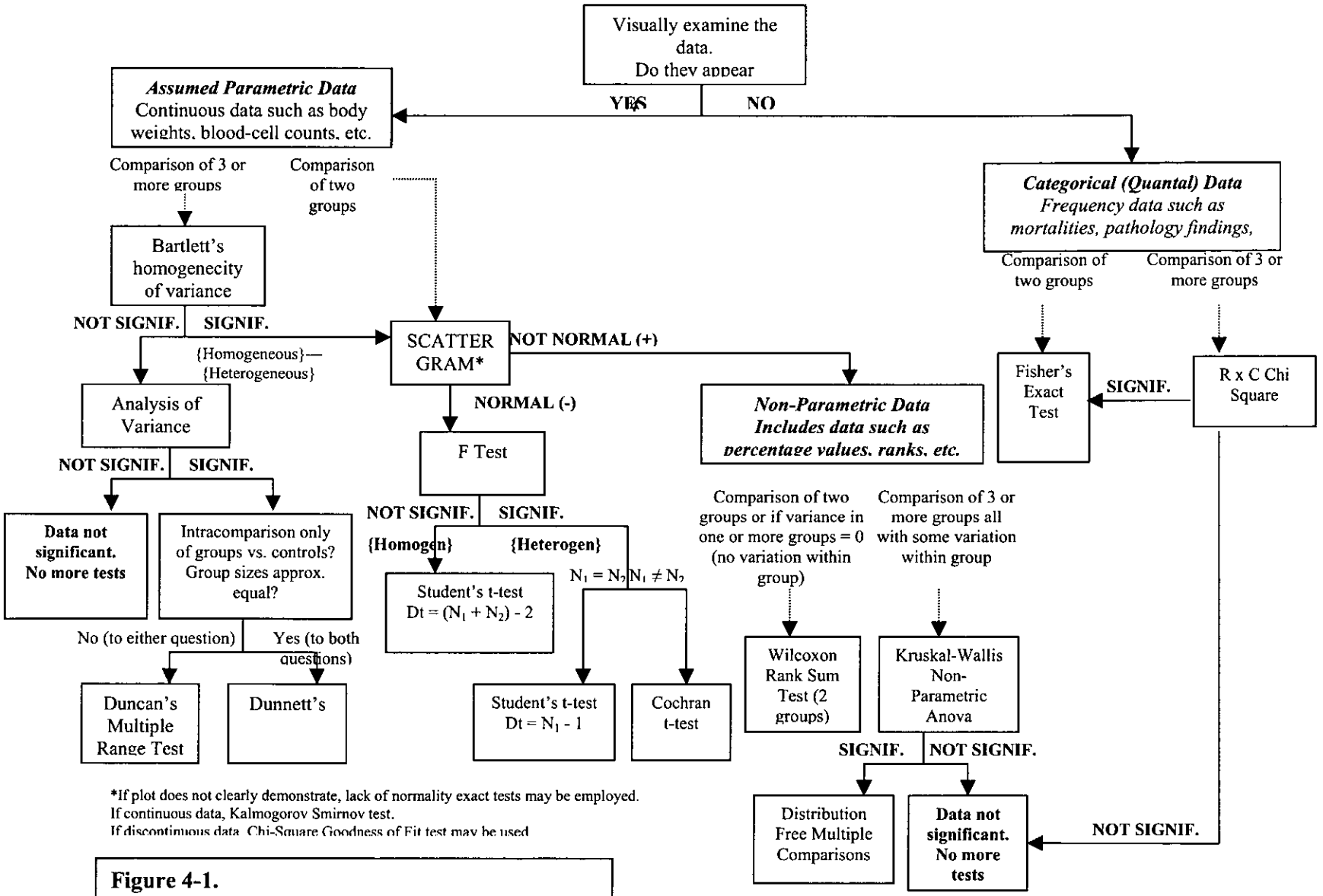
In some cases, the statistical analyses used in a study may not be appropriate or adequate for the particular study design. Alternatively, the study authors may not have performed a statistical analysis of the data. In either case, the User has three options. The first option is to analyze or re-analyze the data using appropriate statistical procedures and record the results (Figure 4-1) (Gad, 1998). The second option is to determine a NOAEL or LOAEL based on the preponderance of the data. The third option is rejection of the study and assignment of a data evaluation score of 0. In this case, the study result would be rejected and not used in the derivation of wildlife TRVs. In most cases a statistical analyses of the data will be completed in cases where the study does not use any statistics. There are expected to be very few instances where statistical analyses is recalculated by the User because the original method was inadequate. The statistical re-analyses or application of these three options can be completed by the user but will more often be the responsibility of the quality assurance reviewer.

If no statistical analysis was performed in a study and insufficient data are available to perform an independent analysis, the User should reject the study and assign a data evaluation score of zero. In this case, the study result would be rejected and not used in the derivation of wildlife TRVs. This action is based on a low degree of confidence in studies which do not adequately report the details of experimental design and results.

In theory, the threshold for the particular adverse effect lies between the NOAEL and the LOAEL. Recent publications have reviewed the weaknesses of the use of NOAELs in risk assessments (e.g., USEPA, 1995). Some analyses of acute toxicity data have shown that NOAELs can represent as much as a 30% or 40% difference from control (as a result of low statistical power), while other studies have identified LOAELs that are incorrectly low as a result of statistical artifacts. While it is hoped that NOAELs and LOAELs bracket the threshold concentration, their determination is a function of the spacing of dietary concentration and the statistical power of the test.

NOAEL and LOAEL Units

The units associated with the NOAEL and LOAEL are automatically assigned by the application based upon the units previously selected when describing the exposure concentrations or doses (see the Exposure Information section). If measured concentrations are entered, these units are preferentially returned as the units for the NOAEL field.



*If plot does not clearly demonstrate, lack of normality exact tests may be employed.
If continuous data, Kalmogorov Smirnov test.
If discontinuous data, Chi-Square Goodness of Fit test may be used

Figure 4-1.
Decision tree for selecting hypothesis-testing procedures (from Gad, 1998)

Is the NOAEL or LOAEL Reported by the Author?

If the NOAEL and/or the LOAEL are identified and reported by the author, the User selects "Yes" by checking the appropriate box. If the NOAEL and/or LOAEL are assigned by the reviewer, based on information provided in text, tables or figures, the User selects "No" by checking the appropriate box.

NOAEL and LOAEL Comments

The NOAEL/LOAEL comment field is used to record any specific information pertaining to the selection of NOAEL and/or LOAEL. Statistical analysis information, including p-values (when applicable), is entered in this field. Any information regarding lack of statistical significance at different exposure durations during the test is noted here (i.e, no significance). The specific location of the NOAEL and LOAEL results in the paper, including references to the text page number and table or figure numbers, is recorded by the User in this comment field.

Is Wet Weight Reported?

The Eco-SSL for wildlife is reported as a "safe concentration" in soil on a dry weight basis. The estimation (or back calculation) from a safe dose to an associated safe soil concentration requires the TRV to be expressed on a dry weight basis. The requires that the estimation of a dose (mg of contaminant per kg BW of the test organism per day) from dietary exposure concentrations be based on units per dry weight diet.

If the study reports that the dietary exposure concentrations are expressed on a wet weight basis, then the User should select "Yes" by checking the appropriate box. If the dietary concentration units are reported as dry weight, select "No" by checking the appropriate box. If the dietary concentration units are not specified as wet weight or dry weight, select "NR" for Not Reported. Also select "NR" if a drinking water, gavage or other oral study is being entered. For studies where NR is entered, the entered results are assumed to be reported in dry weight and are not converted by the application. This is assumed to be conservative as conversion to dry-weight results in higher LOAEL and NOAEL dose values.

If Wet Weight is Reported, Is the Percent Moisture Reported?

If the dietary concentration level units are reported as wet weight and the percent moisture is also reported, the User selects "Yes" by checking the appropriate box. If percent moisture is not reported, the User selects "No" by checking the appropriate box. For drinking water studies, the User selects "NR" by checking the appropriate box.

Percent Moisture (%)

If the percent moisture in the exposure media is reported, the User enters the percent moisture in the numeric field provided. For example, if the percent moisture for laboratory rat chow is

reported as 3 percent, the number 3 is entered. The number 100 should be entered for drinking water studies. If the percent moisture is not report the application assumes 5%.

Is the Body Weight Reported?

The User should review the study to determine if the test organism body weights are reported. If body weights are reported, the User selects "Yes" by checking the appropriate box. If body weights are not reported, the User selects "No" by checking the appropriate box.

Body Weight with Units

If body weight data are reported in the study, the User selects an appropriate value to be used by the application to calculate either a NOAEL or LOAEL dose. The User should select the body weight reported for the appropriate NOAEL or LOAEL exposure level group. The highest body weight should be used if both NOAEL and LOAEL exposure level groups are identified. If results are reported for both male and female organisms, the User should record the highest body weight for the appropriate NOAEL or LOAEL exposure (body weights are not averaged). If authors report total weight gain, that amount is used to adjust the appropriate initial weight to the approximate body weight at the time the endpoint was evaluated. This calculation should be documented in the body weight comments section. The body weight is entered in the numeric field provided. The User then selects the appropriate units for the reported body weight from the pull down list. The list of available units and conversion factors is provided in Table 19.

In cases where the study reports an initial weight, but does not report body weight or body weight gain for interim or terminal time points in the study, the User enters the initial body weight. Use of this data represents a conservative approach to calculation of the intake rate of the medium and subsequent calculation of the NOAEL and/or LOAEL value.

Table 19. Body Weight Units and Conversions

Body Weight Fields		Conversion to BW in kg
ng bw	nanograms body weight	multiply by 0.000000000001
ug bw	micrograms body weight	multiply by 0.000000001
mg bw	milligrams body weight	multiply by 0.000001
g bw	grams body weight	multiply by 0.001
kg bw	kilograms body weight	none
lb bw	pounds body weight	multiply by 0.4535924

If body weight data are not reported in the study, the User must select an appropriate default body weight. Table 20 provides a summary of default body weight values that are organism-, sex- and age-specific. The User selects the appropriate default body weight and enters the result in the numeric field provided. The largest body weight corresponding to the lifestage(s) used in the experiment should be used. Default body weight units are reported in kilograms (kg). If a default body weight value is not available in Table 20, the User may enter an appropriate value identified

from another source. If an alternate value is entered, the User should enter the value in units of kg and provide a description of the value and reference in the body weight comment field.

Body Weight Comments

The User enters information specific to any of the following in the comment field provided for the body weights:

1) A description of the body weight selected or calculated from the study for entry. The description should include the rationale for selection, sex of the organism, any calculations and appropriate references to study table (including dose or concentration, exposure duration if relevant, figure and page numbers).

2) A description of any value selected from the default table and rationale for selection.

3) A description of any alternative value selected from additional sources and the appropriate reference.

Table 20. Default Body Weights

General Organism Type	Specific Organism Type	Sex	Age	Lifestage	Default BW (kg)	Reference
cat	unspecified	M	weaning to 90 days	juvenile	1.72	USEPA, 1987
cat	unspecified	M	90 days to 1 year	sexually mature	3.66	USEPA, 1987
cat	unspecified	M	1 year or older	adult	4	USEPA, 1987
cat	unspecified	F	weaning to 90 days	juvenile	1.49	USEPA, 1987
cat	unspecified	F	90 days to 1 year	sexually mature	2.96	USEPA, 1987
cat	unspecified	F	1 year or older	adult	3.1	USEPA, 1987
cattle	unspecified	BH	Adult	adult	272	Osweiler et al., 1976
chicken	unspecified	M	Older than 30 days	adult	1.3	USEPA, 1987
chicken	unspecified	F	Older than 30 days	adult	1.6	USEPA, 1987
chicken	domestic	BH	1 day	juvenile	0.0397	Diaz et al 1994
chicken	domestic	BH	3 days	juvenile	0.0543	Franson and Custer, 1982
chicken	domestic	BH	7 days	juvenile	0.084	Southern and Baker, 1981
chicken	domestic	BH	14 days	juvenile	0.328	Southern and Baker, 1981
chicken	domestic	BH	20 days	juvenile	0.564	Donaldson and McGowan, 1989
chicken	domestic	BH	28 days	juvenile	1.042	Diaz et al., 1994
dog	unspecified	M	weaning to 90 days	juvenile	2.4	USEPA, 1987
dog	unspecified	M	90 days to 1 year	sexually mature	10.8	USEPA, 1987
dog	unspecified	M	1 year or older	adult	14	USEPA, 1987
dog	unspecified	F	weaning to 90 days	juvenile	1.97	USEPA, 1987
dog	unspecified	F	90 days to 1 year	sexually mature	10.1	USEPA, 1987

Table 20. Default Body Weights						
General Organism Type	Specific Organism Type	Sex	Age	Lifestage	Default BW (kg)	Reference
dog	unspecified	F	1 year or older	adult	14	USEPA, 1987
dove	ringed turtle	B	0 days	juvenile	0.010	Carriere et al., 1986
dove	ringed turtle	B	7 days	juvenile	0.057	Carriere et al., 1986; Kendall and Scanlon, 1981
dove	ringed turtle	B	14 days	juvenile	0.092	Carriere et al., 1986; Kendall and Scanlon, 1981
dove	ringed turtle	B	21 days	juvenile	0.117	Carriere et al., 1986; Kendall and Scanlon, 1981
dove	ringed turtle	B	28 days	juvenile	0.134	Carriere et al., 1986
dove	ringed turtle	B	Adult	adult	0.144	Carriere et al., 1986; Kendall and Scanlon, 1981; Keith and Mitchell, 1993
duck	mallard	F	Adult	adult	1.1	USEPA, 1993
duck	mallard	M	Adult	adult	1.2	USEPA, 1993
duck	mallard	JV	10 days	juvenile	0.092	USEPA, 1993
duck	mallard	JV	30 days	juvenile	0.46	USEPA, 1993
gerbil	unspecified	M	weaning to 90 days	juvenile	0.048	USEPA, 1987
gerbil	unspecified	M	90 days to 1 year	sexually mature	0.084	USEPA, 1987
gerbil	unspecified	M	1 year or older	adult	0.1	USEPA, 1987
gerbil	unspecified	F	weaning to 90 days	juvenile	0.04	USEPA, 1987
gerbil	unspecified	F	90 days to 1 year	sexually mature	0.073	USEPA, 1987
gerbil	unspecified	F	1 year or older	adult	0.09	USEPA, 1987
guinea pig	unspecified	M	weaning to 90 days	juvenile	0.48	USEPA, 1987
guinea pig	unspecified	M	90 days to 1 year	sexually mature	0.89	USEPA, 1987
guinea pig	unspecified	M	1 year or older	adult	1	USEPA, 1987
guinea pig	unspecified	F	weaning to 90 days	juvenile	0.39	USEPA, 1987
guinea pig	unspecified	F	90 days to 1 year	sexually mature	0.86	USEPA, 1987
guinea pig	unspecified	F	1 year or older	adult	0.9	USEPA, 1987
hamster	golden Syrian	M	weaning to 90 days	juvenile	0.097	USEPA, 1987
hamster	golden Syrian	M	90 days to 1 year	sexually mature	0.134	USEPA, 1987
hamster	golden Syrian	M	1 year or older	adult	0.15	USEPA, 1987
hamster	golden Syrian	F	weaning to 90 days	juvenile	0.095	USEPA, 1987
hamster	golden Syrian	F	90 days to 1 year	sexually mature	0.145	USEPA, 1987
hamster	golden Syrian	F	1 year or older	adult	0.16	USEPA, 1987
hamster	Chinese & Djungarain	M	weaning to 90 days	juvenile	0.03	USEPA, 1987
hamster	Chinese & Djungarain	M	90 days to 1 year	sexually mature	0.041	USEPA, 1987
hamster	Chinese & Djungarain	M	1 year or older	adult	0.04	USEPA, 1987

Table 20. Default Body Weights						
General Organism Type	**Specific Organism Type**	**Sex**	**Age**	**Lifestage**	**Default BW (kg)**	**Reference**
hamster	Chinese & Djungarain	F	weaning to 90 days	juvenile	0.025	USEPA, 1987
hamster	Chinese & Djungarain	F	90 days to 1 year	sexually mature	0.038	USEPA, 1987
hamster	Chinese & Djungarain	F	1 year or older	adult	0.035	USEPA, 1987
hamster	unspecified	M	weaning to 90 days	juvenile	0.0635	USEPA, 1987
hamster	unspecified	M	90 days to 1 year	sexually mature	0.0875	USEPA, 1987
hamster	unspecified	M	1 year or older	adult	0.095	USEPA, 1987
hamster	unspecified	F	weaning to 90 days	juvenile	0.2425	USEPA, 1987
hamster	unspecified	F	90 days to 1 year	sexually mature	0.5025	USEPA, 1987
hamster	unspecified	F	1 year or older	adult	1.03	USEPA, 1987
mink	unspecified	M	weaning to 49 days	juvenile	1.02	USEPA 1993
mink	unspecified	F	weaning to 49 days	juvenile	0.583	USEPA 1993
mink	unspecified	M	> 1 year	adult	1.18	USEPA 1993
mink	unspecified	F	> 1 year	adult	0.596	USEPA 1993
mouse	BAF1	M	weaning to 90 days	juvenile	0.0223	USEPA, 1987
mouse	BAF1	M	90 days to 1 year	sexually mature	0.0261	USEPA, 1987
mouse	BAF1	M	1 year or older	adult	0.035	USEPA, 1987
mouse	BAF1	F	weaning to 90 days	juvenile	0.0204	USEPA, 1987
mouse	BAF1	F	90 days to 1 year	sexually mature	0.0222	USEPA, 1987
mouse	BAF1	F	1 year or older	adult	0.03	USEPA, 1987
mouse	B6C3F1	M	weaning to 90 days	juvenile	0.0316	USEPA, 1987
mouse	B6C3F1	M	90 days to 1 year	sexually mature	0.0373	USEPA, 1987
mouse	B6C3F1	M	1 year or older	adult	0.04	USEPA, 1987
mouse	B6C3F1	F	weaning to 90 days	juvenile	0.0246	USEPA, 1987
mouse	B6C3F1	F	90 days to 1 year	sexually mature	0.0353	USEPA, 1987
mouse	B6C3F1	F	1 year or older	adult	0.035	USEPA, 1987
mouse	deer mouse	M	Adult	adult	0.02	USEPA, 1993
mouse	deer mouse	F	Adult	adult	0.019	USEPA, 1993
mouse	unspecified	M	weaning to 90 days	juvenile	0.02695	USEPA, 1987
mouse	unspecified	M	90 days to 1 year	sexually mature	0.0317	USEPA, 1987
mouse	unspecified	M	1 year or older	adult	0.0375	USEPA, 1987
mouse	unspecified	F	weaning to 90 days	juvenile	0.0225	USEPA, 1987
mouse	unspecified	F	90 days to 1 year	sexually mature	0.02875	USEPA, 1987
mouse	unspecified	F	1 year or older	adult	0.0325	USEPA, 1987
pheasant	ring-necked	F	Adult	adult	0.95	Dunning, 1993
pheasant	ring-necked	M	Adult	adult	1.3	Dunning, 1993
owl	barn owl	M	Adult	adult	0.479	Dunning, 1993
owl	barn owl	F	Adult	adult	0.568	Dunning, 1993
pig	domestic	M	Adult	adult	225	USEPA, 1987
pig	domestic	F	Adult	adult	225	USEPA, 1987
pig	miniature	M	Adult	adult	72.5	USEPA, 1987
pig	miniature	F	Adult	adult	72.5	USEPA, 1987

Table 20. Default Body Weights						
General Organism Type	Specific Organism Type	Sex	Age	Lifestage	Default BW (kg)	Reference
quail	Japanese	F	Adult	adult	0.1	Dunning, 1993
quail	Japanese	M	Adult	adult	0.09	Dunning, 1993
quail	bobwhite	F	Adult	adult	0.17	USEPA, 1993
quail	bobwhite	M	Adult	adult	0.16	USEPA, 1993
quail	bobwhite	JV	10 days	juvenile	0.012	USEPA, 1993
quail	bobwhite	JV	30 days	juvenile	0.04	USEPA, 1993
rabbit	unspecified	M	weaning to 90 days	juvenile	2.86	USEPA, 1987
rabbit	unspecified	M	90 days to 1 year	sexually mature	3.76	USEPA, 1987
rabbit	unspecified	M	1 year or older	adult	4	USEPA, 1987
rabbit	unspecified	F	weaning to 90 days	juvenile	3.1	USEPA, 1987
rabbit	unspecified	F	90 days to 1 year	sexually mature	3.93	USEPA, 1987
rabbit	unspecified	F	1 year or older	adult	4.1	USEPA, 1987
rat	Fischer 344	M	weaning to 90 days	juvenile	0.18	USEPA, 1987
rat	Fischer 344	M	90 days to 1 year	sexually mature	0.38	USEPA, 1987
rat	Fischer 344	M	1 year or older	adult	0.4	USEPA, 1987
rat	Fischer 344	F	weaning to 90 days	juvenile	0.124	USEPA, 1987
rat	Fischer 344	F	90 days to 1 year	sexually mature	0.229	USEPA, 1987
rat	Fischer 344	F	1 year or older	adult	0.25	USEPA, 1987
rat	Long-Evans	M	weaning to 90 days	juvenile	0.248	USEPA, 1987
rat	Long-Evans	M	90 days to 1 year	sexually mature	0.472	USEPA, 1987
rat	Long-Evans	M	1 year or older	adult	0.5	USEPA, 1987
rat	Long-Evans	F	weaning to 90 days	juvenile	0.179	USEPA, 1987
rat	Long-Evans	F	90 days to 1 year	sexually mature	0.344	USEPA, 1987
rat	Long-Evans	F	1 year or older	adult	0.35	USEPA, 1987
rat	Osborne-Mendel	M	weaning to 90 days	juvenile	0.263	USEPA, 1987
rat	Osborne-Mendel	M	90 days to 1 year	sexually mature	0.514	USEPA, 1987
rat	Osborne-Mendel	M	1 year or older	adult	0.55	USEPA, 1987
rat	Osborne-Mendel	F	weaning to 90 days	juvenile	0.201	USEPA, 1987
rat	Osborne-Mendel	F	90 days to 1 year	sexually mature	0.389	USEPA, 1987
rat	Osborne-Mendel	F	1 year or older	adult	0.4	USEPA, 1987
rat	Sprague-Dawley	M	weaning to 90 days	juvenile	0.267	USEPA, 1987
rat	Sprague-Dawley	M	90 days to 1 year	sexually mature	0.523	USEPA, 1987
rat	Sprague-Dawley	M	1 year or older	adult	0.6	USEPA, 1987
rat	Sprague-Dawley	F	weaning to 90 days	juvenile	0.204	USEPA, 1987
rat	Sprague-Dawley	F	90 days to 1 year	sexually mature	0.338	USEPA, 1987
rat	Sprague-Dawley	F	1 year or older	adult	0.35	USEPA, 1987
rat	Wistar	M	weaning to 90 days	juvenile	0.217	USEPA, 1987
rat	Wistar	M	90 days to 1 year	sexually mature	0.462	USEPA, 1987
rat	Wistar	M	1 year or older	adult	0.5	USEPA, 1987
rat	Wistar	F	weaning to 90 days	juvenile	0.156	USEPA, 1987
rat	Wistar	F	90 days to 1 year	sexually mature	0.297	USEPA, 1987
rat	Wistar	F	1 year or older	adult	0.32	USEPA, 1987
rat	unspecified	M	weaning to 90 days	juvenile	0.235	USEPA, 1987

Table 20. Default Body Weights						
General Organism Type	Specific Organism Type	Sex	Age	Lifestage	Default BW (kg)	Reference
rat	unspecified	M	90 days to 1 year	sexually mature	0.4702	USEPA, 1987
rat	unspecified	M	1 year or older	adult	0.51	USEPA, 1987
rat	unspecified	F	weaning to 90 days	juvenile	0.2024	USEPA, 1987
rat	unspecified	F	90 days to 1 year	sexually mature	0.3846	USEPA, 1987
rat	unspecified	F	1 year or older	adult	0.4	USEPA, 1987
sheep	Old Norse	M	Adult	adult	43	www.ansi.okstate.edu/breeds/sheep/
sheep	Old Norse	F	Adult	adult	32	www.ansi.okstate.edu/breeds/sheep/
sheep	Dala	M	Adult	adult	115	Geertman, 2001
sheep	Dala	F	Adult	adult	80	Geertman, 2001
sheep	Chun forest	BH	Juvenile	Juvenile	24	www.ansi.okstate.edu/breeds/sheep/ based on data for related strain (Kerry Hill)
sheep	Chun forest	M	Adult	Adult	91.5	www.ansi.okstate.edu/breeds/sheep/ based on data for related strain (mean of Kerry Hill and Shropshire)
sheep	Chun forest	F	Adult	Adult	73	www.ansi.okstate.edu/breeds/sheep/ based on data for related strain (mean of Kerry Hill and Shropshire)
sheep	domestic	B	1 week	juvenile		
shrew	short-tailed	M	Adult	adult	0.017	USEPA, 1993
shrew	short-tailed	F	Adult	adult	0.017	USEPA, 1993
starling	starling	M	Adult	adult	0.0847	Dunning, 1993
starling	starling	F	Adult	adult	0.0799	Dunning, 1993
turkey	domestic	M	20 w	juvenile	14.3	NRC, 1994
turkey	domestic	F	20 w	juvenile	8.4	NRC, 1994
turkey	domestic	M	25 w	juvenile	16.4	NRC, 1994
turkey	domestic	F	25 w	juvenile	9.8	NRC, 1994
turkey	domestic	M	30 w	juvenile	19.1	NRC, 1994
turkey	domestic	F	30 w	juvenile	11.1	NRC, 1994
turkey	domestic	M	35 w	juvenile	20.7	NRC, 1994
turkey	domestic	F	35 w	juvenile	11.1	NRC, 1994
turkey	domestic	M	40 w	juvenile	21.8	NRC, 1994
turkey	domestic	F	40 w	juvenile	10.8	NRC, 1994
turkey	domestic	M	45 w	juvenile	22.5	NRC, 1994
turkey	domestic	F	45 w	juvenile	10.5	NRC, 1994
turkey	domestic	M	50 w	juvenile	23.2	NRC, 1994
turkey	domestic	F	50 w	juvenile	10.5	NRC, 1994
turkey	domestic	M	55 w	adult	23.9	NRC, 1994
turkey	domestic	F	55 w	adult	10.5	NRC, 1994

Table 20. Default Body Weights						
General Organism Type	Specific Organism Type	Sex	Age	Lifestage	Default BW (kg)	Reference
turkey	domestic	M	60 w	adult	24.5	NRC, 1994
turkey	domestic	F	60 w	adult	10.6	NRC, 1994
vole	prairie vole	BH	Adult	adult	0.042	USEPA, 1993
vole	meadow vole	M	Adult	adult	0.043	USEPA, 1993
vole	meadow vole	F	Adult	adult	0.039	USEPA, 1993
finch	zebra finch	B	Adult	adult	12	Dunning, 1993

Is the Intake Rate Reported?

The Intake Rate fields refer to the intake rate of the exposure medium (diet or drinking water), not the contaminant. The intake rate is used to convert contaminant concentration data to a contaminant dose. If intake rates are reported, the User selects "Yes" by checking the appropriate box. If intake rates are not reported, the User selects "No" by checking the appropriate box. In gavage or other oral exposures (capsule), the User selects "No" by checking the appropriate box, but overrides the dose quantification score to reflect that intake rate was "reported."

Intake Rate with Units

If the intake rate is reported in the study, the User selects the appropriate value to be used by the application to calculate either a NOAEL or LOAEL dose. If the study reports doses, the intake rate does not need to be entered. If the intake rate for a treatment group is variable over the course of the experiment, enter the average rate and note this in the comments field. The User should select the intake rate reported for the appropriate NOAEL or LOAEL exposure level group. The highest intake rate should be used if both NOAEL and LOAEL exposure level groups are identified. The intake rate is entered in the numeric field provided. The application assumes that the intake rate entered (for dietary studies) is dry weight-based. If the User gathers information from the study that reports otherwise, then the User should convert the intake rate to a dry weight basis and report in detail the necessary conversion in the Intake Rate Comment Field. Next the User selects the appropriate units associated with the intake rate from the pull down list. The list of intake rate units is provided in Table 21.

If the intake rate is not reported. The User does not enter an intake rate, the application calculates the intake rate automatically using allometric equations based on the body weight, specific class and exposure route for the test organism. The intake rate is calculated and reported in the Score Information Screen in units of kg bw per day or L per day (see Appendix A).

Table 21. Units and Conversions for Intake Rate of Medium		
Intake Rate Fields		Conversion to kg/day or L/day
kg/d (or L/d)	kilograms or liters per day	multiply by 1
kg/kg BW/day or L/kg BW/day	kilograms or liters per kilogram BW per day	multiply by BW in kg

Table 21. Units and Conversions for Intake Rate of Medium		
Intake Rate Fields		Conversion to kg/day or L/day
kg/org/d or L/org/d	kilograms or liters per organism per day	multiply by 1
g/d or ml/day	grams per day	multiply by 0.001
g/kg BW/d or ml/kg BW/d	grams per kilogram BW per day	multiply by 0.001 then multiply by BW in kg
g/org/d or ml/org/d	grams per organism per day	multiply by 0.001
mg/d or ul/d	milligrams per day	multiply by 0.000001
mg/kg BW/d or ul/kg BW/d	milligrams per kilogram BW per day	multiply by 0.000001 then multiply by BW in kg
mg/org/d or ul/org/d	milligrams per organism per day	multiply by 0.000001
ug/d	micrograms per day	multiply by 0.000000001
ug/kg bw/d	micrograms per kilogram BW per day	multiply by 0.000000001 then multiply by BW in kg
ug/org/d	micrograms per organism per day	multiply by 0.000000001
ng/d	nanograms per day	multiply by 0.000000000001
ng/kg bw/d	nanograms per kilogram BW per day	multiply by 0.000000000001 then multiply by BW in kg
ng/org/d	nanograms per organism per day	multiply by 0.000000000001

Intake Rate Comments

In the comment field provided for the body weights, the User enters information specific to any of the following:

- A description of the intake rate selected or calculated from the study for entry. The description should include the rationale for selection, any calculations and appropriate references to study table, figure and page numbers.
- A description of any value selected from the default table and rationale.
- A description of any alternative value selected from additional sources and the appropriate reference.

Endpoint Sample Size

The user enters information in this field on the number of experimental animals for the specific endpoint entered for each exposure concentration or dose. Any specific reasons for loss of experimental animals not associated with exposure to the contaminant should be noted.

Results for the NOAEL

These fields allow the User to enter information concerning the experimental results for the NOAEL exposure (dose) level. The User enters information here in instances where ONLY A NOAEL is reported and no LOAEL is reported. In these instances, it is important to evaluate the

power of a study design to detect an adverse effect, if it were present. A detailed description of the power calculation is provided as Appendix B. Statistical power is calculated using the number of test organisms, the mean endpoint response for control and treated organisms, and the standard deviations of the means as inputs. If the distribution of values in the control group and the exposed group are both approximately normal and the variance is similar for both, the power of the study can be estimated from the information entered below. The numeric fields provided for power calculation data entry cannot be blank. If any of the required input data are missing (i.e., because they are not reported for the endpoint), the study power is not calculated and the application reports "not calculated".

The User should note that data from figures are not used to calculate power.

Number of Exposed Organisms. The User enters the total number of organisms exposed in the numeric field provided. If the total number of exposed organisms is not reported, the User leaves the numeric field blank. A blank field is evaluated as null and power is not calculated.

Number of Control Organisms. The User enters the total number of control organisms exposed at the NOAEL dose in the numeric field provided. If the total number of control organisms is not reported, the field is left blank. The blank field is evaluated as null and power is not calculated by the application.

Mean of Endpoint in Exposed Organisms. The User enters the mean of the NOAEL result for the exposed organisms in the numeric field provided. If a mean value is not reported, -99 is entered in the field. This value is evaluated as null and power is not calculated.

Mean of Endpoint in Control Organisms. The User enters the mean for the control group in the numeric field provided. If a mean value is not reported, -99 is entered in the field. This value is evaluated by the system as null and power is not calculated.

Standard Deviation of Endpoint in Exposed Organisms. The standard deviation is required for calculation of statistical power. The database permits entry of either the standard deviation or the standard error of the mean for the endpoint of interest. The User selects the appropriate data type and enters the value in the numeric field provided. If a standard error is entered, the database automatically estimates the standard deviation as the product of the standard error multiplied by the square root of the sample size *n*. If neither a standard deviation nor standard error value is provided, -99 is entered in the field. The field is evaluated as null and power is not calculated.

Standard Deviation of Endpoint in Control Organisms.

The standard deviation is required for calculation of statistical power. The database permits entry of either the standard deviation or the standard error of the control mean for

the endpoint of interest. The User selects the appropriate data type and enters the value in the numeric field provided. If a standard error is entered, the database automatically estimates the standard deviation as the product of the standard error multiplied by the square root of the sample size *n*. If neither a standard deviation nor standard error value is provided, -99 is entered in the field. The field is evaluated as null and power is not calculated.

Confidence Alpha. This is the statistical significance level chosen to declare a treatment response as significantly different different from the control response. **The default value of alpha is 0.05.** However, the system allows the User to select other statistical significance levels from the pull-down list provided. The User should seek approval from an Administrator before using alpha values other than the default of 0.05.

At this point in the data entry process, the "Endpoint Information" screen is now complete. The User verifies that all entered data are correct and clicks on the "Next" button at the bottom of the screen to continue. The User **should not** use the browser back arrow to return to a previous data entry screen to correct errors, as deletion of data results.

4.5 Data Evaluation Score

For the convenience of the User, the Data Evaluation screen provides a summary of the information required to determine a data evaluation score for each endpoint entered. This summary is provided at the top of the Score Information screen. The Data Evaluation Scoring system is described in SOP #7 (Attachment 4-5).

For this summary screen, the data previously entered for body weight, intake rate, and the NOAEL and/or LOAEL are converted to the appropriate units for calculation of a final NOAEL and/or LOAEL value expressed as mg/kg-day. Each of these conversions are described in detail below:

- **Body Weight**. The application automatically converts body weights and units entered by the User to units of kilograms. The equations used for the conversion of body weight data are presented in Table 19.

- **Intake Rate.** The application converts the exposure medium intake rate entered by the user to units of kilograms of food or liters of drinking water per organism per day. The equations that are used for this conversion are presented in Table 21. If the intake rate is assigned by the application, based on the default allometric equations for food and water ingestion, no conversion is required as the equations estimate intake rates in the appropriate units.

- **Conversion to Dose.** The application converts the entered NOAEL and/or LOAEL concentration or dose values to the appropriate units of mg of contaminant per kg BW per day. The equations used for these conversions are provided in Table 9. If the NOAEL and/or LOAEL concentrations are expressed on a wet weight basis in the study, the

application makes the appropriate conversion to dry weight based on the moisture content entered by the User.

The final data evaluation score assigned to the NOAEL and/or LOAEL is based on the addition of individual scores for ten study attributes. These ten attribute scores are described in the following subsection and are summarized in Table 22. For each attribute, a score is assigned ranging from 0 (no merit for derivation of a TRV) to 10 (extremely valuable and relevant for derivation of a TRV). It is important to note that a low score does not imply that the study is poor, only that it is not optimal for deriving a TRV.

To determine the final data evaluation score, the User selects the appropriate score from the pull down list provided for each of the study attributes. The application defaults to the appropriate score based on the information entered. The User can, however, alter the default scores under special circumstances. If any of the individual attribute scores are equal to 0 the total score is equal to 0 and the study is not used for the derivation of Wildlife TRVs.

Table 22. Summary of Data Evaluation Scoring System

Attribute	Description	Score
1. Data source "Source Score"	Primary	10
	Secondary	0
2. Contaminant Form "Chemical Form Score"	Contaminant form is known and is the same or similar to the of medium of concern	10
	Contaminant form is irrelevant to absorption or biological activity	10
	Contaminant form is known and is different from that found in the medium of concern	5
	Contaminant form is not reported (this includes situations when the contaminant is just listed as "Lead" or "Selenium")	4
3. Test Substrate "Test Substrate Score"	Test substance concentrations reported as actual measured values (M), verified nominal (UX) and/or doses administered by gavage	10
	Test substance concentrations reported as nominal values (U)	5
	Test substance concentrations not reported	0
4. Dose Quantification "Dose Quantification Score"	Administered doses reported as mg/kg-BW (includes gavage doses reported in these units)	10
	Administered doses need to be calculated and intake rates and body weights provided	7
	Administered doses need to be calculated and only one value (intake or body weight) provided (if study is gavage or other capsule, intake is "provided")	6
	Administered doses need to be calculated based on estimated intake rates and body weights	5
	Administered doses cannot be calculated from the information provided	0
5. Dose Range "Dose Range Score"	Both a NOAEL and a LOAEL are identified; values are within a factor of 3	10
	Both a NOAEL and a LOAEL are identified; values are within a factor of 10	8
	Both a NOAEL and a LOAEL are identified; values are not within a factor of 10	6
	Only a NOAEL or a LOAEL is identified	4
	Study lacks a suitable control group	0
6. Dose Route "Dose Route Score"	Chemical incorporated into food (including mother's milk)	10
	Other oral (gavage, capsule)	8
	Chemical incorporated into drinking water	5
	Not dietary, other oral, or drinking water or not reported or choice of treated and non treated food or water	0
7. Endpoint "Endpoint Score"	Reported endpoint is a reproductive or population effect (REP) (POP)	10
	Reported endpoint is lethality (chronic or subchronic exposures (MOR)	9
	Reported endpoint is reduction in growth (GRO)	8
	Reported endpoint is sublethal change in organ function, behavior or neurological function (BEH, PHY, PTH)	4
	Reported endpoint is a biomarker of exposure with unknown relationship to fitness (BIO)	1
8. Exposure Duration	Exposure duration encompasses multiple lifestages of test species	10
	Exposure duration is at least 0.1 times the expected life span of the test species or occurs	10

Table 22. Summary of Data Evaluation Scoring System		
Attribute	**Description**	**Score**
"Exposure Duration Score"	during a critical life phase	6
	Exposure duration is shorter than 0.1 times the expected life span of the test species and multiple doses or concentrations are administered	3
	Exposure duration is shorter than 0.1 times the expected life span of the test species and only a single dose or concentration is administered.	0
	Exposure duration is acute or not reported	
9. Statistical Power "Power Score"	At least 90% chance of seeing a difference that is biologically significant	10
	NOAEL and LOAEL available or LOAEL only available	10
	At least 75% chance of seeing a difference that is biologically significant	8
	At least 50% chance of seeing a difference that is biologically significant	6
	Less than a 50% chance of detecting a difference that is biologically significant	3
	Only NOAEL available; insufficient data reported to determine statistical power of study	1
10. Test Conditions "Test Parameter Score"	Follows a standard guideline and reports all test parameters	10
	Does not follow a standard guideline, but does report all test parameters	10
	Follows a standard guideline but does not report test parameters	7
	Does not follow a standard guideline and reports some, but not all of the test parameters	4
	Does not report any test parameters	2

1. Data Source Score

All studies considered for TRV derivation are from primary sources. Secondary sources of data are not used to derive Wildlife TRVs. The application automatically assigns a Source score based on the Primary Source entry. If the "No" box is selected, the application exits completely from the program. Since the User has progressed to this point of the data entry process, the application assumes that the study is a primary source and a score of 10 is assigned.

2. Contaminant Form Score

The wildlife TRVs are expressed in units of ingested dose (mg/kg BW/day or mg/L/day). Expression as units of ingested dose implicitly assumes that absorption of the contaminant from the test medium is the same as for the site medium. This assumption may be reasonable when the two media are the same (e.g., both water or both similar food items), but may not be true if the two media are different (e.g., test medium = water, site medium = soil). To account for the potential difference in absorption between different media, it is necessary to convert both the ingested dose and the TRV to units of absorbed dose:

Site Dose (absorbed) = Site Dose (ingested) * Absorption fraction from site medium

TRV(absorbed dose) = TRV(ingested dose)* Absorption fraction in test medium

Some contaminants are better absorbed and more biologically active than others. The best known examples are differences between inorganic and organic mercury, and inorganic and organic arsenic. Studies reporting oral absorption fraction from the test medium are preferred to those where the absorption fraction is unknown. In the absence of oral absorption data, the assumption of equal absorption of the contaminant from the test and site medium is reasonable when the form of the contaminant is the same in the test medium versus the site medium. Therefore, studies

which use the same chemical form of a contaminant in the exposure medium as that typically found on a waste site are preferred.

The User assigns a Contaminant Form score based upon the similarity of the contaminant form used in the study to contaminant forms found in environmental media. A summary of common contaminant forms found in environmental media is provided in Table 3. If the contaminant form used in the study is the same or similar to that in environmental media, a score of 10 is selected by the User. If the contaminant form is not relevant to absorption or biological activity, a score of 10 is selected. If the contaminant form is different from that in environmental media, a score of 5 is selected. If the contaminant form is not reported (NR), a score of 4 is selected by the User.

3. Test Substrate Score

Studies that report contaminant exposure concentrations or doses in the diet or drinking water confirmed by analytical measurement - "measured"- are preferred compared to those that do not measure or verify the exposure doses or concentrations.

The application automatically assigns a Test Substance score based on the value the User entered under "Method of Contaminant Analysis". If the method of contaminant analysis is measured (M) or unmeasured but analytically verified (UX), a score of 10 is assigned. If unmeasured (U) is entered, a score of 5 is assigned. If calculated (C) is entered, a score of 1 is assigned. Gavage studies are considered measured, and are scored as a 10.

4. Dose Quantification Score

Some toxicological studies report contaminant exposures in terms of dose (mg of contaminant per unit of body weight), but some only report the concentration of the contaminant in the exposure medium (food or drinking water). In these cases, it is necessary to convert the concentrations to a dose using an intake rate (food or water) and a body weight. Studies that report results as doses are preferred over those that report concentrations and the application automatically assigns these studies a Dose Quantification Score of 10. Studies that report exposure on a concentration basis are scored in the following manner according to preference:

- If both body weight and intake rates are reported for the test organisms in the study (the User is prompted to enter this information earlier in the data entry process), the study endpoint receives a score of 7. The application automatically uses the body weight and intake rate values entered previously to convert the exposure concentrations to doses.

- If only one value (intake rate or body weight) is provided for the test organisms, a score of 6 is assigned.

- If the study does not report either body weights or intake rates for the test organism, the application assigns a score of 5. Doses are automatically calculated based on the default body weight and intake rate values previously entered by the User.

- If the administered doses cannot be calculated from the information provided, a score of 0 is assigned by the User from the pull down menu.

If the study uses an exposure method of gavage, capsule or other oral exposure where the administered amount is known, the User selects the dose quantification score from the provided pull down list as follows:

- If the amount administered by gavage or capsule is reported in units of mg/kg body weight, a score of 10 is assigned.

- If the amount administered is in units of mg/organism, it must be divided by body weight to convert to dose units of mg/kg/day. If the body weight is reported in the study, a score of 7 is assigned.

- If the body weight is not reported and the value needs to be estimated based on a default, a score of 5 is assigned.

5. Dose Range Score

The TRV represents a threshold on the dose-response curve between the absence and presence of the adverse effect of concern. Establishing this threshold involves identification of two values from the toxicological study: a no observed adverse effect level (NOAEL) and a lowest observed adverse effect level (LOAEL). The NOAEL is defined as the highest administered dose that does not cause a significant adverse effect. The LOAEL is defined as the lowest administered dose that causes a significant adverse effect. Experimentally, the threshold value is estimated by assuming it lies between the NOAEL and the LOAEL. Therefore, a study which identifies both a NOAEL and a LOAEL is more valuable than a study that identifies only a NOAEL or LOAEL. Studies which use a larger number and/or more closely spaced doses may provide a more refined estimate of the NOAEL and LOAEL and are preferred.

The application automatically assigns a Dose Range score based upon the NOAEL and/or LOAEL values entered previously by the User. This assignment appears in the pull down menu on the score sheet. The User, however, may assign a different score from among the choices provided.

If both a NOAEL and a LOAEL are identified and the values are within a factor of 3, a score of 10 is assigned. If both a NOAEL and a LOAEL are identified and the values are within a factor of 10, a score of 8 is assigned. If both a NOAEL and a LOAEL are identified, but the values are not within a factor of 10, a score of 6 is assigned. If only a NOAEL or a LOAEL is identified, a score of 4 is assigned. If the study lacks a suitable control group, a score of 0 is assigned by the User. Unsuitable control groups include: Historical (H), No Methodology (K), and Positive (P). If the control type is not reported (NR), a score of 0 is assigned.

6. Dose Route Score

The Eco-SSLs reflect the concentrations of contaminants in soil protective of oral exposure via ingestion of soil or food items. Therefore, toxicological studies that use oral exposure (food, water, gavage, or capsule) are considered to be relevant compared to studies that use other non-oral methods of administration (inhalation, dermal, and injection routes). Studies that report results for non-oral exposures are not used to establish TRVs and should be labeled as "non oral" using the literature rejection criteria discussed in Section 2.0.

Dietary studies are preferred to oral exposure via gavage or capsule because they represent the closest approximation of the intake route under natural conditions. Gavage and capsule studies are less desirable because they do not generally reflect natural feeding behaviors and the vehicle used to deliver the gavage dose can alter the kinetics of absorption. Drinking water is the least desirable among the acceptable routes of administration because the Wildlife TRVs are derived for use in assessments conducted in terrestrial rather than aquatic environments.

The application automatically assigns a Dose Route score based upon the Exposure Type and Route of Exposure information previously entered by the User. If the Route of Exposure is via food (FD), a score of 10 is assigned. If the route of exposure is via other oral routes (OR) or gavage (GV), a score of 8 is assigned. If the route of exposure is via drinking water (DW), a score of 5 is assigned. If the route of exposure is a choice between contaminated and non contaminated media (CH), a score of 0 is assigned. If the route of exposure is not reported (NR), a score of 0 is assigned.

7. Endpoint Score

In most ecological risk assessments (ERAs), assessment endpoints focus on the effects of long term exposures of contaminants on population sustainability. The specific toxicological endpoints used as measurements of population sustainability in ERAs are site-specific. For the purposes of identification and derivation of a TRV for calculation of an Eco-SSL, the endpoints are predefined. The following endpoints are selected in order of preference for derivation of TRVs.

- Studies measuring reproductive endpoints are considered the most appropriate and are preferred. Reproductive endpoints are assigned a score of 10. Within the coding system, this includes any endpoint within the reproduction (REP) effect group (Table 17).

- Studies measuring mortality or survival (chronic) as an endpoint are also considered appropriate but are less preferable to reproductive endpoints. These study endpoints are assigned a score of 9. Within the coding system, this includes any endpoint within the mortality (MOR) effect group (Table 17).

- Studies measuring growth are also considered appropriate for establishing TRVs. These study endpoints are assigned a score of 8. Within the coding system, this includes any endpoint within the (GRO) effect group (Table 17).

- Studies measuring organ function, behavior or neurological function are considered less useful in establishing TRVs. This applies to endpoints within the pathology (PTH), behavior (BEH) or physiology (PHY) effect groups in the TRV coding system. These study endpoints are assigned a score of 4. The User may elect to score such studies lower if it is decided that the effect does not have an adverse effect on organism "fitness" or health (Table 17).

- Studies measuring biochemical effects or changes that are either hormonal, chemical or enzymatic in nature are considered the least useful in establishing TRVs. These study endpoints are assigned a score of 1. This evaluation includes any endpoint in the biochemical (BIO) effect group of the Wildlife TRV coding system. The User may elect to score such study measures higher if it is decided that the measure can be related to organism "fitness" or health. Biomarkers of exposure should always be scored as a 1.

8. Exposure Duration Score

The usefulness of a study result for derivation of a TRV is partially dependent on the duration of the exposure. Chronic and multiple generation exposures are preferred to subchronic or acute exposures. Chronic exposures are generally more representative of the type of exposure which may occur at a contaminated site.

The User assigns an Exposure Duration score based upon the duration of the study exposure and the life span of the test organism. A summary of typical laboratory test organism life spans is provided in Table 23. Data for representative species of wildlife are also included. In some cases, a range of values has been presented for the longevity of wildlife species. The User should preferentially select the average life span, if given, and secondarily select the minimum value from that range if the exposure occurs also at a critical lifestage.

To assess if the exposure duration is representative of the expected lifespan, the User multiplies the test organism lifespan by 0.1 and compares the result to information in Table 23. For example, if the test organism is a gerbil with an assumed lifespan of 2.5 years (2.5 years * 0.1 = 0.25 years or 12 weeks), an exposure duration of 9 weeks is less than 0.1 times the expected lifespan. If the duration of the study exposure encompasses multiple generations of the test organism, a score of 10 is selected. If the duration of exposure is at least 0.1 times the expected lifespan of the test organism or occurs during a critical lifestage, a score of 10 is selected. If the duration of exposure is less that 0.1 times the expected lifespan of the test organism and multiple dose or concentration groups are included in the study, a score of 6 is selected. If the duration of exposure is less that 0.1 times the expected lifespan and only a single dose or concentration group is used in addition to controls, a score of 3 is assigned. If the exposure duration is acute (a single oral dose), a score of 0 is selected.

Table 23. Default Weaning, Puberty, and Lifespan Values for TRV Species					
Group	**Species**	**Weaning (days)**	**Puberty (days)**	**Lifespan (years)**	**Reference**
Laboratory Rodents	Mice	21	50	2*	USEPA, 1987
	Rats	21	56	2*	USEPA, 1987
	Guinea Pigs	14	70	6	USEPA, 1987
	Hamsters	21	60	2.5	USEPA, 1987
	Gerbils	21	70	3	USEPA, 1987
Other Laboratory Mammals	Cats	49	240	15	USEPA, 1987
	Dogs, Beagles	42	240	15	USEPA, 1987
	Rabbits, New Zealand	56	190	6	USEPA, 1987
Other Tested Animals	Vole, meadow	21	>21 (male) >42 (female)	0.1-0.25 (mean) Use 0.25	Golley, 1962 Johnson and Johnson, 1982 Beer and Mcleod, 1961
	Shrew, short-tailed	25-30	≥65 (male, lab) ≥83 (male) <365 (female)	0.37-0.38 (lab) Use 1.04 <1.7	Blus, 1971 Pearson, 1944 French, 1984 Dapson, 1968
	Pig	NR	150	27	
	Mink	56	300	7 (mean) 10-11 (max) Use 9	Enders (1952) Ewer (1973)
	Pheasant	7-12[a]	330	<3	Giudice and Ratti, 2001
	Mallard	52-60 56	330	23	Clapp et al., 1982 Bellrose, 1976 Loekmoen et al., 1990 Krapu and Doty, 1979
	Chicken	NA	NA	24	USEPA, 1987
	Dove, mourning	15	80(males) 90 (females)	31 (max) 1.5 (mean) Use 1.5	Clapp et al. 1983 White et al., 1987 Mirarchi and Basket, 1994
	Quail, bobwhite	14	330	6.5 (max)	Rosene, 1969
	Quail, Japanese	NR	NR	3	Porter and Terril, 1986

* Substantial strain variability
NA = Not Applicable
NR = Not Reported
a Pheasant chicks can first take flight at 7 to 12 days; broodomg by hen is important for the first two weeks after hatching. Broods remain intact with hen for an indefinite period.

9. Power Score

A NOAEL is defined as the highest dose that does not cause a significant effect in the selected endpoint when compared to the control. However, the ability to detect an effect (i.e., the reliability of the NOAEL) depends on a number of factors. The most important are:

1) the variability of the measurement endpoint in both the control and the dosed groups
2) the number of animals in each group

That is, as variability in the measurement endpoint goes up and the number of experimental animals goes down, the ability to detect an effect becomes very poor, and a dose which actually causes an effect may be incorrectly identified as a NOAEL.

Statistical power is a measure of the ability to detect an effect. There are a number of standard statistical procedures available for calculating the power of a study to detect an effect which can be used to evaluate the reliability of NOAEL values. The statistical power test used for the toxicological Data Evaluation process for establishing Wildlife TRVs is described in Appendix B.

If both a NOAEL and a LOAEL are reported or if only a LOAEL is reported, the power calculation is not used and a score of 10 is assigned by the application. In cases where only a NOAEL is reported, scores are assigned as follows. If the calculated power is greater than or equal to 90 percent, a score of 10 is assigned. If the calculated power is greater than or equal to 75 percent, a score of 8 is assigned. If the calculated power is greater than or equal to 50 percent, a score of 6 is assigned. If the calculated power is less than 50 percent, a score of 3 is assigned. If the power cannot be calculated because one or more of the required fields is null, a score of 1 is assigned. In cases where the endpoint reported is mortality and the result is 0, the User should assign a score of 10 as power cannot be calculated.

10. Test Condition Score

The User is prompted earlier in the data entry process to identify if the study follows a standard guideline for toxicity testing and if not how many of the parameters the study reports. The standard guidelines and test parameters are provided in Table 13. If the study follows a standard guideline and reports all measurement parameters, then a score of 10 is assigned. If the study does not follow standard guidelines but reports all parameters, a score of 10 is also assigned. If the study follows a standard guideline but does not report all test parameters, then a score of 7 is assigned. If the study does not follow a standard guideline, but reports some but not all of the test parameters, then a score of 4 is assigned. If the study does not report any parameters, a score of 2 is assigned.

Final Total Score

The "Score Information" screen is now complete. The User verifies that all data entered are correct and clicks on the "Calculate Score" button at the bottom of the screen to calculate the final total score. The User should not use the browser back arrow to return to a previous data entry screen to correct errors, this action results in a duplication of information.

The total score is based upon the evaluation of each of the ten attribute scores identified above. The total score is calculated for a specific endpoint by taking the sum of all ten study attribute scores (a "perfect" study is given a score of 100). However, if any one study attribute is given a score of 0, the final score is also be set to equal 0. This ensures minimum standards for study

results that are used to derive wildlife TRVs. Studies without appropriate controls, of acute exposure duration, without reported test substance concentrations, and non-oral exposures are excluded from the TRV derivation process.

Several scoring examples are provided below:

Lowest Possible Total Score (all attribute scores are the minimum score without defaulting to 0:

Study Attribute	Score
Source Score:	10
Dose Route Score:	5
Test Substrate Score:	5
Contaminant Form Score:	4
Dose Quantification Score:	5
Endpoint Score:	1
Dose Range Score:	4
Power Score:	1
Exposure Duration Score:	3
Test Parameter Score:	2
Total Score	**40**

Case Where Individual Attribute Score = 0

Study Attribute	Score
Source Score:	10
Dose Route Score:	5
Test Substrate Score:	1
Contaminant Form Score:	4
Dose Quantification Score:	0
Endpoint Score:	1
Dose Range Score:	4
Power Score:	1
Exposure Duration Score:	3
Test Parameter Score:	2
Total Score	**0**

Final Score set to zero, due to Dose Quantification Score

Highest Possible Total Score available (all attribute scores are the maximum score):

Study Attribute	Score
Source Score:	10
Dose Route Score:	10
Test Substrate Score:	10
Contaminant Form Score:	10
Dose Quantification Score:	10
Endpoint Score:	10
Dose Range Score:	10
Power Score:	10
Exposure Duration Score:	10
Test Parameter Score:	10
Total Score	**100**

At this point of the data entry process, the User completes data entry and scoring for the selected endpoint and clicks on "Finish this Endpoint" to proceed. The User **should not** use the browser back arrow to return to a previous data entry screen to correct errors as this would result in a duplication of information.

If there is another endpoint associated with the selected phase (the selected phase is provided in the navigation bar at the top of the screen), the User selects "Yes" when prompted for another endpoint and begins entry of that endpoint at the Endpoint Information screen. If there are no other endpoints associated with the selected phase, then the User selects "No".

When the data entry process is completed, the endpoint scores are used to derive TRVs as described in Attachments 4-5 and 4-6. Papers with a total score of 66 or higher are included in the data set used for derivation of Wildlife TRVs. Papers with a score of 65 or less are not used for the derivation of TRVs.

5.0 QUALITY ASSURANCE AND QA REPORTS

Entered data are reviewed and approved for accuracy and completeness prior to use in derivation of Wildlife TRVs. The database provides a QA report option for manual review. Coded data are compiled on a printable screen form. The coded data are cross-checked against the source publication for accuracy and against the TRV coding guidelines for consistency by an administrative user. Any errors noted are corrected in the database prior to QA approval. The database program automatically records the date that changes were made to the TRV database as a result of QA review, but does not track specific edits.

To perform an QA review, an Administrative User accesses the QA report for a given article. If errors are found on the report, the User uses the editing functions available in the TRV database to make corrections (see Section 4 for more information regarding data entry and edits). When the correct data has been entered, the Administrative User chooses View/Edit Articles to approve the article by choosing the "Yes" radio button located beside the text "Article Approved?". A comment must be entered at this time, to signal to the system that the article has been approved. This feature protects against errant clicks that may accidently change the status of the Article Approved? radio button.

6.0 DOWNLOADS

Data contained in the TRV database can be downloaded from the TRV database to a User's computer in Microsoft Access format. To perform a download, select the "Download" function from the Data Entry menu of the TRV database.

APPENDIX A

ALLOMETRIC EQUATIONS FOR DEFAULT INTAKE RATES

Food Ingestion Rates

Where food ingestion rates are not reported in the individual respective toxicological studies, the food ingestion rates are estimated using the allometric equations of Nagy (1987). Nagy (1987) derived equations to estimate dry-weight-based food ingestion rates for mammals and birds based on body mass. Food ingestion rates are derived using the following equations:

For mammals:

$$IR_{food} = 0.0687 x BW^{0.822} \quad (1)$$

where:

IR_{food}	=	Ingestion rate of food, wet weight basis (Kg/day);
0.0687	=	Mathematical constant derived by Nagy (1987);
BW	=	Body weight of the ROI (Kg); and
0.822	=	Mathematical constant derived by Nagy (1987).

For birds:

$$IR_{food} = 0.0582 x BW^{0.651} \quad (2)$$

where:

IR_{food}	=	Ingestion rate of food, wet weight basis (Kg/day);
0.0582	=	Mathematical constant derived by Nagy (1987);
BW	=	Body weight of the ROI (Kg);
0.651	=	Mathematical constant derived by Nagy (1987); and

Water Ingestion Rates

If the water ingestion rate for the test species is not reported in the respective toxicological study under review then the water ingestion rate for the test species is estimated used an allometric equation. For avian species, Calder and Braun (1983) developed an equation for estimation of drinking water ingestion (IRwater) based on the body weight of the bird where:

$$IR_{water} = 0.059 x BW^{0.67} \quad (3)$$

where:

IR_{water}	=	Ingestion rate of water, (L/day);
0.059	=	Mathematical constant derived by Calder and Braun (1983);
BW	=	Body weight of the test species (kg); and
0.67	=	Mathematical constant derived by Calder and Braun (1983).

Calder and Braun (1983) also developed an allometric equation for drinking water ingestion by mammals.

$$IR_{water} = 0.099 x BW^{0.90} \quad (4)$$

where:

IRwater	=	Ingestion rate of water, (L/day);
0.099	=	Mathematical constant derived by Calder and Braun (1983);
BW	=	Body weight of the test species (kg); and
0.90	=	Mathematical constant derived by Calder and Braun (1983).

APPENDIX B

STATISTICAL POWER TEST

(Source: Rosner 1995. Fundamentals of Biostatistics)

The NOAEL is normally defined at the highest exposure level in a study that did not cause a statistically significant difference in mean response from the control group. The test for statistical significance that is most often used to compare the control group and an exposed group is the one-sided t-test assuming equal variance:

$$t = \frac{m_2 - m_1}{s_p\sqrt{1/n_1 + 1/n_2}}$$

$$s_p = \sqrt{\frac{(n_1 - 1)\cdot s_1^{\,2} + (n_2 - 1)\cdot s_2^{\,2}}{n_1 + n_2 - 2}}$$

where:

m = mean response of control group (m_1) or test group (m_2)
s = standard deviation of control group (s_1) or test group (s_2)
s_p = pooled standard deviation
n = number of animals in control group (n_1) or test group (n_2)

Power is the ability of a particular experimental study to detect a statistically significant difference between the control group and the exposed group, if the true difference in the means is some specified value (Δ). The method used to calculate power for the difference in the means of two normal distributions with equal variance in a one-tailed test is as follows:

$$Power = \Phi\left(Z_\beta\right) = \Phi\left(\frac{\Delta}{s_p\sqrt{1/n_1 + 1/n_2}} - Z_{1-\alpha}\right)$$

where:

ϕ = Standard normal distribution function

Δ = Assumed difference between the means of the exposed and control groups (i.e., the difference that is of concern to you as a biologically significant effect). Choosing the value of Δ to use is this calculation is subjective. For the purposes of evaluating toxicological studies as candidates for derivation of TRVs, **a default value of 20% of control is used as Δ.** This is based on the assumption that most experimental studies cannot detect smaller changes with acceptable power, and that changes of 20% or less will often not result in population level impacts, at least for many endpoints.

α = Statistical significance level used to declare an effect different from control. **The default value of α is 0.05.**

If it is not convenient to calculate the standard normal distribution function of Z_β exactly, the approximate power of a study can be determined using the following table of critical values:

Z_b (Critical)	Power
-0.674	25%
0.000	50%
0.674	75%
0.842	80%
1.282	90%
1.645	95%

For example, if the calculated value of Z_β is 0.93, then the power of the study to detect a difference of size Δ at the 0.05% confidence level is greater than 80% but less than 90%. A similar approach has been used in the Wildlife TRV database to evaluate the results of the power calculation and assign a power score.

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Attachment 4-4

Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs)

Eco-SSL Standard Operating Procedure (SOP) # 5: Wildlife TRV Data Evaluation

OSWER Directive 92857-55

November 2003

Attachment 4-4

Standard Operating Procedure (SOP) #5: Wildlife Toxicity Reference Value Data Evaluation for

Ecological Soil Screening Levels (Eco-SSLs)

OSWER Directive 92857-55

November 2003

Prepared for USEPA Region 8

by

Syracuse Research Corporation
999 18th Street, Suite 1975 North Tower
Denver, CO 80202

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5.0 EVALUATION AND SCORING OF STUDY ATTRIBUTES 3

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1.0 INTRODUCTION

The United States Environmental Protection Agency (USEPA) Office of Emergency and Remedial Response (OERR) with a multi-stakeholder workgroup developed risk-based based soil screening levels (Eco-SSLs). Eco-SSLs are concentrations of contaminants in soils that are protective of ecological receptors that commonly come into contact with soil or ingest biota that live in or on soil. Eco-SSLs are derived separately for four groups of ecological receptors: mammals, birds, plants, and soil invertebrates. As such, these values are presumed to provide adequate protection of terrestrial ecosystems.

The Eco-SSLs are used in the baseline ERA process to identify the contaminants that need to be evaluated further in the characterization of exposure, effects and risk characterization. The Eco-SSLs are used during Step 2 of the Superfund ERA process, the screening-level risk calculation. This step normally is completed at a time when limited soil concentration data are available, and other site-specific data (e.g., contaminant bioavailability information, area use factors) are not available. It is expected that the Eco-SSLs will be used to screen the site soil data to identify those contaminants that are not of potential ecological concern and do not need to be considered in the subsequent baseline ERA.

Plant and soil biota Eco-SSLs were developed from available plant, soil invertebrate and microbial toxicity data. The mammal and bird Eco-SSLs were the result of back-calculations from a Hazard Quotient (HQ) of 1.0. The HQ is equal to the dose (associated with the contaminant concentration in soil) divided by a toxicity reference value (TRV). Generic food chain models were used to estimate the relationship between the concentration of the contaminant in soil and the dose for the receptor (mg per kg body weight per day). The TRV represents a numerical estimate of a no adverse level (dose) for the respective contaminant.

The procedure(s) for deriving the oral TRVs needed for calculation of Eco-SSLs for mammals and birds are contained within four standard operating procedures (SOPs) that are sequentially numbered with those used to derive plant and soil invertebrate Eco-SSLs:

- Eco-SSL SOP #3 Wildlife TRV Literature Search and Retrieval (Attachment 4-2)
- Eco-SSL SOP #4 Wildlife TRV Literature Review, Data Extraction and Coding (Attachment 4-3)
- Eco- SSL SOP #5 Wildlife TRV Data Evaluation (Attachment 4-4)
- Eco-SSL SOP #6 Derivation of the Oral TRV (Attachment 4-5)

This document serves as SOP #5 (Attachment 4-4) and describes the procedure for evaluation of data extracted from toxicological studies for applicability in the derivation of wildlife TRVs.

The scored data is then used to derive TRVs for mammals and birds, according to the procedures outlined in SOP #6 (Attachment 4-5).

2.0 PURPOSE

TRVs are derived from the available literature reporting the toxicity of a contaminant to different mammalian and avian species. The toxicological study results (there may be more than one result reported within a study) are identified for each contaminant based on the results of literature reviews implemented as described in Attachment 4-2. Not all studies resulting from the literature search process are equally relevant to the derivation of oral TRVs.

The purpose of this SOP is to describe the procedure used for the review of attributes of a toxicological study that tend to increase or decrease their respective usefulness for the derivation of wildlife TRVs. The SOP establishes a standard system for scoring the relevance and reliability of the findings of each toxicological study result.

3.0 THE SCORING SYSTEM

Each study result with attributes extracted as described in Attachment 4-3 is evaluated and scored according to the following described system. In instances within one paper where more than one "experiment" (i.e., different combinations of receptor, dose, exposure route, exposure duration, and endpoint) is reported, the individual "experiments"are scored separately so that each may be evaluated.

The scoring system assigns an "attribute" score ranging from zero (no merit in setting a TRV) to 10 (extremely valuable and relevant to setting a TRV) to each of 10 toxicological study attributes. The ten attributes of the toxicological study include data source, dose route, test substrate, the contaminant form, dose quantification, endpoint, dose range, statistical power, exposure duration and test conditions. The evaluation of each attribute is described in Section 4.0. Note that a low score does not necessarily imply the study itself was poor, only that the study design was not optimal for the narrow goal of developing an oral TRV.

The total score is calculated by adding the results of the evaluation of each attribute. The total score may range from a minimum of 36 to a maximum of 100. The total scores are interpreted as follows:

80 to 100	High confidence
71 to 79	Medium confidence
66 to 70	Low confidence
0 to 65	Not Used in Eco-SSL Derivation

4.0 EVALUATION AND SCORING OF STUDY ATTRIBUTES

4.1 Data Source

The source of the toxicological study (e.g., peer reviewed vs. non-peer reviewed) is not expected to be an indication of the quality of the study nor its applicability in use as part of the data set to derive a TRV. Many peer reviewed studies in the toxicological literature may have little or no merit in setting oral TRVs, and some non-peer reviewed studies may be excellent sources of data for the derivation of oral TRVs. It is a requirement, however, that all studies being considered for the derivation of a TRV must be acquired and reviewed in primary form. That is, secondary descriptions of a study should not be used. Secondary reports often contain errors of fact, include only a subset of all of the data and findings, and may contain interpretations or judgements not supported by the primary data.

Scoring factors:

10 = Primary source is acquired and reviewed

0 = Primary source is not acquired and reviewed

4.2 Consideration of Absorption Fraction and Contaminant Form

Oral TRVs are expressed in units of ingested dose (mg/kg-day). It is important to recognize that the use of a TRV expressed as units of ingested dose implicitly assumes that absorption of the contaminant from the test medium is the same as for the site medium. This assumption may be reasonable when the two media are the same (e.g., both water, both similar food items), but may not be true if the two media are different (e.g., test medium = water, site medium = soil). To account for the potential difference in absorption between different media, it is necessary to convert both the ingested dose and the TRV to units of absorbed dose:

Site Dose (absorbed) = Site Dose (ingested) · Absorption fraction from site medium

TRV(absorbed dose) = TRV(ingested dose) · Absorption fraction in test medium

For this reason toxicological studies reporting the known oral absorption fraction from the test medium are preferred to those where the absorption fraction is not known. If the absorption fraction is known (either from the TRV study itself or from other studies in the same test medium), then the TRV can be used to evaluate hazard from any other medium with a known or estimated absorption fraction. For the Eco-SSLs it is conservatively assumed that absorption (bioavailabilty of the contaminant from the soil) is 100%.

The assumption of equal absorption of the contaminant from the test and site medium is reasonable when the form of the contaminant is the same in the test medium versus the site

medium. Some contaminants are more absorbed and more biologically active than others. The preferred toxicological studies use the same form of contaminant in the exposure medium compared to that found in the site medium. Table 3 in Attachment 4-3 provides a list of the contaminant forms considered for the wildlife TRVs and identifies if the are expected to occur in soils (site medium). For example, the acetate forms of metals are not expected to occur as such in the soil matrix and are scored lower than those that are expected (chlorides, oxides, etc...,). Most organic forms of metals are excluded from consideration including organic forms of arsenic used as herbicides, triethyl and tetraethyl lead, and chromium picolinate. Mixtures of contaminants are also excluded (e.g., lead chromate and mixtures of lead and arsenic). Lead shot studies are also excluded (although these were identified and labeled for further special consideration) as this metal form represents metal alloys with different combinations of metals. Acetate forms of metals are retained for use as these forms are used most often in water and quickly dissociate.

The contaminant form is considered in evaluation of the toxicological study according to the following scoring factors:

10	=	Contaminant form is known and is the same or similar to that found in the medium of concern
5	=	Contaminant form is irrelevant to absorption or biological activity
4	=	Contaminant form is not reported

4.3 Test Substrate Concentrations

An important issue in evaluation of the quality of a toxicological study for use in wildlife TRV derivation is if nominal or measured concentrations of the contaminant in the exposure medium (diet in particular) are reported and used in the determination of the dose-response relationship in the study. Using only nominal concentrations can introduce a large error into the determination of a toxicity "threshold". Studies that do not report measured concentrations are given less weight than those that provide measured concentrations. Gavage studies are considered measured, and are scored as a 10.

The following scoring factors are applied:

10	=	Test substance concentrations reported as actual measured values or unmeasured but analytically verified
5	=	Test substance concentrations reported as nominal values
1	=	Test substance concentrations calculated

0 = Test substance concentrations not reported

4.4 Dose Quantification

Knowledge of the actual doses ingested by animals in a laboratory study (or field study) can often be imprecise, especially when the exposure route is via food or water. Many studies measure the amount of water or food consumed (water and food intake rates), and hence the average ingested dose (assuming there has been no loss of contaminant) can be calculated. However, some studies do not measure and do not report water or food intake rates. This can cause errors in dose estimation, especially in cases where the presence of the test contaminant in the water or food causes a direct reduction in intake due to taste aversion, odor aversion or illness. For wildlife TRV derivation studies which report actual doses are preferred over those where the doses need to be estimated based on reported intake rates and body weights. The following scoring factors are applied:

10 = Administered doses reported as mg per kg-BW

7 = Administered doses need to be calculated and intake rates and body weights provided.

6 = Administered doses need to be calculated and only one value (intake or body weight provided)

5 = Administered doses need to be calculated based on estimated intake rates and body weights.

0 = Administered doses cannot be calculated from the information provided and the study is rejected. This includes studies where the exact dose or concentrations units or amount administered is not reported clearly or is obviously incorrect.

If the study uses an exposure method of gavage, capsule or other oral exposure where the administered amount is known then some more specific rules for scoring apply as follows:

- If the amount administered by gavage or capsule is reported in units of mg/kg body weight, a score of 10 is assigned.
- If the amount administered is in units of mg/organism, it must be divided by body weight to convert to dose units of mg/kg/day. If the body weight is reported in the study, a score of 7 is assigned.
- If the body weight is not reported and the value needs to be estimated based on a default, a score of 6 is assigned.

4.5 Dose Range

By definition, a TRV is intended to represent the location on the dose-response curve that is the threshold between absence and presence of the effect of concern (i.e., the toxicological endpoint selected as most relevant). There were two methodologies considered for establishing this threshold.

The first methodology involves identification of two values from the toxicological study including a no observed adverse effect level (NOAEL) and a lowest observed adverse effect level (LOAEL). The LOAEL is defined as the lowest administered dose that did cause a statistically significant adverse effect and the NOAEL as the lowest administered dose that did not cause a statistically significant adverse effect. Experimentally, the value of the threshold is estimated by assuming that it lies between the NOAEL and the LOAEL. Therefore, studies that use a series of doses that span the threshold region and which identify both a NOAEL and a LOAEL are much more valuable in estimating the threshold than a study which uses only one dose, or which uses multiple doses that do not bracket the threshold.

The second methodology involves the use of a modeling approach derived from the benchmark dose methodology being evaluated by EPA for use in human health risk assessment. This model estimates an exposure-response distribution. The dose level (and 95% confidence limits) are then identified from the distribution (e.g., ED_5 to ED_{50}). This method was considered in the development of the wildlife TRVs for Eco-SSLs but was not used due to limitations in the dose-response data available for wildlife. This methodology may be considered further in future revisions of the wildlife TRV procedures.

In the case of both methodologies, the same type of scoring system for evaluation of dose-range applies as it is desirable to have the "threshold" bracketed. Any study that does not contain a suitable control group cannot be used to establish a dose-response value as the TRV for calculation of an Eco-SSL.

Scoring factors:

10 = Both a NOAEL and a LOAEL are identified; values are within a factor of 3

8 = Both a NOAEL and a LOAEL are identified; values are within a factor of 10

6 = Both a NOAEL and a LOAEL are identified; values are not within a factor of 10

4 = Only a NOAEL or a LOAEL is identified

0 = Study lacks a suitable control group

4.6 Dose Route

The Eco-SSLs reflect the concentrations of contaminants in soil protective of oral exposure via ingestion of soil or food items. Dietary studies are preferred to oral exposure via gavage or capsule because they represent the closest approximation of the intake route under natural conditions. Gavage and capsule studies are less desirable because they do not generally reflect natural feeding behaviors and the vehicle used to deliver the gavage dose can alter the kinetics of absorption. Drinking water is the least desirable among the acceptable routes of administration because the Wildlife TRVs are derived for use to evaluate ingestion of soil or food items rather than drinking water.

Studies that report results for non-oral exposures (inhalation, interperitoneal injections, dermal, intravenous, subcutaneous) are not used to establish TRVs and are rejected as "not oral" using the literature rejection criteria discussed in Attachment 4-3.

The following scoring factors are applied to evaluate dose route:

10	=	Dietary
8	=	Other oral, solid exposures (gavage, capsule)
5	=	Other oral, liquid exposures
0	=	Not oral (inhalation, intravenous, subcutaneous, dermal); or choice between contaminated and non-contaminated media; or dose route not reported.

4.7 Endpoint

In most ecological risk assessments (ERAs), assessment endpoints focus on the effects of long term exposures of contaminants on population sustainability. The specific toxicological endpoints used as measurements of population sustainability in ERAs are site-specific. For the purposes of the identification and derivation of a TRV for calculation of an Eco-SSL, the endpoints are predefined. The following endpoints are selected in order of preference for derivation of TRVs.

- Studies measuring reproductive endpoints are considered the most appropriate and are preferred. Reproductive endpoints are assigned a score of 10. Within the coding system, this includes any endpoint within the reproduction (REP) effect group (Attachment 4-3; Table 16).

- Studies measuring mortality or survival (chronic) as an endpoint are also considered appropriate but are less preferable to reproductive endpoints. These study endpoints are assigned a score of 9. Within the coding system, this includes any endpoint within the mortality (MOR) effect group (Attachment 4-3; Table 16).

- Studies measuring growth are also considered appropriate for establishing TRVs. These study endpoints are assigned a score of 8. Within the coding system, this includes any endpoint within the (GRO) effect group (Attachment 4-3; Table 16).

- Studies measuring organ function, behavior or neurological function are considered less useful in establishing TRVs. This applies to endpoints within the pathology (PTH), behavior (BEH) or physiology (PHY) effect groups in the TRV coding system (Attachment 4-3; Table 16). These study endpoints are assigned a score of 4. The User may elect to score such studies lower if it is decided that the effect does not have an adverse effect on organism "fitness" or health.

- Studies measuring biochemical effects or changes that are either hormonal, chemical or enzymatic in nature are considered the least useful in establishing TRVs. These study endpoints are assigned a score of 1. This evaluation includes any endpoint in the biochemical (BIO) effect group of the Wildlife TRV coding system (Attachment 4-3; Table 16). The User may elect to score such study measures higher if it is decided that the measure can be related to organism "fitness" or health. Biomarkers of exposure are always scored as a 1.

4.8 Exposure Duration

The usefulness of a study result for derivation of a TRV is partially dependent on the duration of the exposure. Chronic and multiple generation exposures are preferred to subchronic exposures. Acute exposures are defined as single oral exposures and other exposures of less than 14 days. Chronic exposures are generally more representative of the type of exposure which may occur at a contaminated site.

The Exposure Duration score is based on the duration of the study exposure and the lifespan of the test organism. A summary of typical laboratory test organism's lifespan is provided in Table 22 of Attachment 4-3. If the exposure duration encompasses multiple generations of the test organism, a score of 10 is selected. If the duration of exposure is at least 0.1 times the expected lifespan of the test organism or occurs during a critical lifestage, a score of 10 is selected.

A lifestage is defined as critical if it is critical to the survival and reproduction of the species. These lifestages may or may not be more sensitive to contaminant exposure. Critical lifestages are listed in the following table. There may be some cases where professional judgement is used to classify certain exposures as critical outside of these listed.

Lifestage Code Descriptions	
Lifestage	**Critical (Yes or No)**
adult	No

Lifestage Code Descriptions	
Lifestage	**Critical (Yes or No)**
egg	Yes
embryo	Yes
immature	Yes
juvenile; includes yearling,	Yes
mature	No
multiple	Yes
not reported, unknown	No
subadult	No
sexually immature	No
sexually mature	No
young	Yes
young of year	Yes
Gestational Exposures	Yes
Lactation	Yes

To assess if the exposure duration is representative of the expected lifespan, the test organism lifespan is multiplied by 0.1. For example, if the test organism is a gerbil with an assumed lifespan of 2.5 years (2.5 years * 0.1 = 0.25 years or 12 weeks), an exposure duration of 9 weeks is less than 0.1 times the expected lifespan. If the duration of exposure is less that 0.1 times the expected lifespan of the test organism and multiple dosing intervals occur, a score of 6 is selected. If the duration of exposure is less that 0.1 times the expected lifespan and only a single dose interval occurs, a score of 3 is assigned. If the exposure duration is acute (a single oral dose), a score of 0 is selected.

Scoring:

10 = Exposure duration encompasses multiple generations of test species

10 = Exposure duration is at least 0.1 times the expected life span of the test species or occurs during a critical life phase.

6 = Exposure duration is shorter than 0.1 times the expected life span of the test species but multiple dosing intervals occur

3 = Exposure duration is shorter than 0.1 times the expected life span of the test species and only one dose interval occurs.

0 = Acute exposure or single oral dose.

4.9 Statistical Power

A NOAEL is defined as the highest dose that does not cause a significant effect in the selected endpoint when compared to the control. However, the ability to detect an effect (i.e., the reliability of the NOAEL) depends on a number of factors. The most important are:

1) the variability of the measurement endpoint in both the control and the dosed groups
2) the number of animals in each group

That is, as variability in the measurement endpoint goes up and the number of experimental animals goes down, the ability to detect an effect becomes very poor, and a dose which actually causes an effect may be incorrectly identified as a NOAEL. There are a number of standard statistical procedures available for calculating the power of a study to detect an effect which can be used to evaluate the reliability of NOAEL values. The statistical power test used for the toxicological Data Evaluation process for establishing Wildlife TRVs is based on Rosner (1995) and is described in detail in Appendix B of Attachment 4-3.

The NOAEL is normally defined at the highest exposure level in a study that did not cause a statistically significant difference in mean response from the control group. The test for statistical significance that is most often used to compare the control group and an exposed group is the one-sided t-test assuming equal variance:

$$t = \frac{m_2 - m_1}{s_p\sqrt{1/n_1 + 1/n_2}}$$

$$s_p = \sqrt{\frac{(n_1 - 1)\cdot s_1^{\,2} + (n_2 - 1)\cdot s_2^{\,2}}{n_1 + n_2 - 2}}$$

where:

m = mean response of control group (m_1) or test group (m_2)
s = standard deviation of control group (s_1) or test group (s_2)
s_p = pooled standard deviation
n = number of animals in control group (n_1) or test group (n_2)

Power is the ability of a particular experimental study to detect a statistically significant difference between the control group and the exposed group, if the true difference in the means is some specified value (Δ). The method used to calculate power for the difference in the means of two normal distributions with equal variance in a one-tailed test is as follows:

$$Power = \Phi\left(Z_\beta\right) = \Phi\left(\frac{\Delta}{s_p\sqrt{1/n_1 + 1/n_2}} - Z_{1-\alpha}\right)$$

where:

ϕ = Standard normal distribution function

Δ = Assumed difference between the means of the exposed and control groups (i.e., the difference that is of concern to you as a biologically significant effect). Choosing the value of Δ to use is this calculation is subjective. For the purposes of evaluating toxicological studies as candidates for derivation of TRVs, **a default value of 20% of control is used as Δ.** This is based on the assumption that most experimental studies cannot detect smaller changes with acceptable power, and that changes of 20% or less will often not result in population level impacts, at least for many endpoints.

α = Statistical significance level used to declare an effect different from control. **The default value of α is 0.05.**

If it is not convenient to calculate the standard normal distribution function of Z_β exactly, the approximate power of a study can be determined using the following table of critical values:

Z_b (Critical)	Power
-0.674	25%
0.000	50%
0.674	75%
0.842	80%
1.282	90%
1.645	95%

For example, if the calculated value of Z_β is 0.93, then the power of the study to detect a difference of size Δ at the 0.05% confidence level is greater than 80% but less than 90%. A similar approach has been used in the Wildlife TRV database to evaluate the results of the power calculation and assign a power score.

Choosing the value of Δ to use is this calculation is difficult. For example, for some receptors and some endpoints, rather large effects (e.g., 30 to 40% of control) might not be of biological significance, while for other endpoints and other receptors, even small differences (e.g., 5-10%, or even less) might be of concern. For the purposes of evaluating toxicological studies as candidates for derivation of TRVs, a default value of 20% of control is used for Δ. This is based on the assumption that most experimental studies cannot detect smaller changes with acceptable power, and that changes of 20% or less will often not result in population level impacts, at least for many endpoints.

Scoring factors:

10 = At least 90% chance of seeing a difference that is biologically significant

8 = At least 75% chance of seeing a difference that is biologically significant

6 = At least 50% chance of seeing a difference that is biologically significant

3 = Less than a 50% chance of detecting a difference that is biologically significant

1 = STDEV and/or N not reported; the power of the NOAEL cannot be determined.

4.10 Test Conditions

Many aspects of the conditions under which animals are subject to toxicity tests may affect the outcome of the endpoints being measured. Testing conditions including ambient or incubator temperature, lighting regime, food presentation and composition, age of test species and source of test species have all been shown to influence toxicity results. Therefore, it is important that these parameters be reported in the study so the potential for confounding effects can be evaluated. If studies are reported as having been conducted following standard test protocols (e.g., avian reproduction test method), and if the measured conditions are reported and meet target values, they can be considered as the highest quality study. Equally of high quality are studies that did not explicitly follow a standard protocol, but reported all test conditions. Studies that followed standard protocols but did not report the measured conditions are of secondary quality. Studies that report only some of the key test conditions are of lower quality while those that do not report any of the test conditions should not be used. Standard study protocols and test condition parameters are discussed in Attachment 4-3 as part of the coding guidelines. Table 12 of Attachment 4-3 provides a summary of the standard avian and mammalian testing protocols and the parameters measured for each. The following Scoring factors are applied:

10 = Follows standard guideline and reports all measurement parameters

10 = Does not follow a standard guideline, but reports all test parameters

7 = Follows a standard guideline but does not report test parameters

4 = Does not follow a standard guideline and reports some, but not all of the test parameters

2 = Does not report any test parameters

Summary of Data Evaluation Scoring System		
Attribute	**Description**	**Score**
1. Data source	Primary	10
	Secondary	0
2. Contaminant Form	Contaminant form is known and is the same or similar to the of medium of concern	10
	Contaminant form is irrelevant to absorption or biological activity	10
	Contaminant form is known and is different from that found in the medium of concern	5
	Contaminant form is not reported (this includes situations when the contaminant is just listed as "Lead" or "Selenium")	4
3. Test Substrate	Test substance concentrations reported as actual measured values (M), verified nominal (UX) and/or doses administered by gavage	10
	Test substance concentrations reported as nominal values (U)	5
	Test substance concentrations not reported	0
4. Dose Quantification	Administered doses reported as mg/kg-BW (includes gavage doses reported in these units)	10
	Administered doses need to be calculated and intake rates and body weights provided	7
	Administered doses need to be calculated and only one value (intake or body weight) provided (if study is gavage or other capsule, intake is "provided")	6
	Administered doses need to be calculated based on estimated intake rates and body weights	5
	Administered doses cannot be calculated from the information provided	0
5. Dose Range	Both a NOAEL and a LOAEL are identified; values are within a factor of 3	10
	Both a NOAEL and a LOAEL are identified; values are within a factor of 10	8
	Both a NOAEL and a LOAEL are identified; values are not within a factor of 10	6
	Only a NOAEL or a LOAEL is identified	4
	Study lacks a suitable control group	0
6. Dose Route	Chemical incorporated into food (including mother's milk)	10
	Other oral (gavage, capsule)	8
	Chemical incorporated into drinking water	5
	Not dietary, other oral, or drinking water or not reported or choice of treated and non treated food or water	0
7. Endpoint	Reported endpoint is a reproductive or population effect (REP) (POP)	10
	Reported endpoint is lethality (chronic or subchronic exposures (MOR)	9
	Reported endpoint is reduction in growth (GRO)	8
	Reported endpoint is sublethal change in organ function, behavior or neurological function (BEH, PHY, PTH)	4
	Reported endpoint is a biomarker of exposure with unknown relationship to fitness (BIO)	1

Summary of Data Evaluation Scoring System		
Attribute	**Description**	**Score**
8. Exposure Duration	Exposure duration encompasses multiple lifestages of test species	10
	Exposure duration is at least 0.1 times the expected life span of the test species or occurs during a critical life phase	10
	Exposure duration is shorter than 0.1 times the expected life span of the test species and multiple doses or concentrations are administered	6
	Exposure duration is shorter than 0.1 times the expected life span of the test species and only a single dose or concentration is administered.	3
	Exposure duration is acute or not reported	0
9. Statistical Power	At least 90% chance of seeing a difference that is biologically significant	10
	NOAEL and LOAEL available or LOAEL only available	10
	At least 75% chance of seeing a difference that is biologically significant	8
	At least 50% chance of seeing a difference that is biologically significant	6
	Less than a 50% chance of detecting a difference that is biologically significant	3
	Only NOAEL available; insufficient data reported to determine statistical power of study	1
10. Test Conditions	Follows a standard guideline and reports all test parameters	10
	Does not follow a standard guideline, but does report all test parameters	10
	Follows a standard guideline but does not report test parameters	7
	Does not follow a standard guideline and reports some, but not all of the test parameters	4
	Does not report any test parameters	2

5.0 EXAMPLES

Both of the examples below are hypothetical and are intended to illustrate the basic approach that is recommended to assessing the relevance of toxicological data as the basis for deriving wildlife TRVs for use in establishing Eco-SSLs for wildlife.

5.1 Example 1

Study Summary

Smith and Jones (1984) performed a study on the effects of ingestion of dieldrin on reproduction of rats. Male and female Sprague-Dawley rats (10 per dose group) were provided with drinking water (*ad lib.*) that contained 0, 3, 10, 30, or 100 ug/L of dieldrin. Exposure began when the rats were three weeks old. At sexual maturity, males and females were randomly selected from within each dose group and were allowed to breed. After breeding, exposure of the females continued throughout gestation and lactation. The number of pups in each litter that survived to weaning was measured. Results are summarized below. Shaded cells are statistically different than control ($p < 0.05$). This result is being considered for use for derivation of the TRV for the cottontail.

Dose Group (ug/L)	Viable pups per dam (mean ± stdev)
0	7.1 ± 2.1
30	7.3 ± 2.2
100	6.8 ± 1.9
300	6.0 ± 2.4
1000	3.1 ± 1.7

Evaluation of Study Attributes

Attribute	Description	Score
Data source	Primary report was obtained and reviewed	10
Dose Route	Oral (water)	5
Test Substance	Measured concentrations are reported	10
Contaminant Form	Contaminant form in exposure medium is the same as site medium.	10
Dose Quantification	Administered doses not quantified. Ingestion rate nor body weights reported. Some effects might be due to decreased water intake by dam due to taste aversion.	5
Endpoint	Reported endpoint is a reproductive effect	10

Attribute	Description	Score
Dose Range	Both a NOAEL and a LOAEL are identified; values are within a factor of 3	10
Statistical Power	NOAEL and LOAEL reported.	10
Study Duration	Exposure duration is at least 0.1 times the expected life span of the test species and occurs during a critical life phase.	10
Test Conditions	Follows standard guideline and reports all measurement parameters	10
	Total Score	90

5.2 Example 2

Study Summary

Adams and Baker (1993) performed a study on the effects of ingestion of cadmium on renal function in dogs. Male or female animals (3 per dose group) were provided with cadmium chloride in the diet at added concentration levels of 0, 100, or 1000 mg/kg. Based on measured dietary intake, dose levels were reported to be 0, 5.2, and 41.1 mg/kg-BW per day, respectively. Urinalysis was performed for urine samples collected at days 30, 60 and 90. At day 90, animals were sacrificed and the kidneys were examined histologically. The results are summarized below.

Dose Group	Study	Urinalysis	Histopathology
5.2	30	No effect	--
	60	Mild proteinurea	–
	90	Moderate proteinurea	7% focal necrosis of renal tubule
41.1	30	Mild proteinurea	–
	60	Moderate proteinurea	–
	90	Severe proteinurea	Widespread necrosis of renal tubule

Based on these data, the authors stated that doses of 5.2 to 41.1 mg/kg-day for 90 days caused moderate to severe renal injury in dogs.

Evaluation of Study Attributes

Attribute	Description	Score
Data source	Primary report was obtained and reviewed	10
Dose Route	Oral (diet)	10
Test Substrate	Measured concentrations are reported	10
Contaminant Form	The contaminant form is the same or similar as the medium of concern.	10
Dose Quantification	Administered doses are reported as mg/kg-BW.	10
Endpoint	Reported endpoint is a sublethal change in organ function	4
Dose Range	Only a LOAEL was identified. No NOAEL can be estimated	4
Statistical Power	No NOAEL was identified; therefore this factor is not applicable	10
Exposure Duration	Exposure duration is shorter than 0.1 times the expected life span of the test species	6
Test Conditions	Does not follow a standard guideline and reports some, but not all of the test parameters	4
	Total Score	78

Attachment 4-5

Guidance for Developing Ecological Soil Screening Levels (Eco-SSLs)

Eco-SSL Standard Operating Procedure (SOP) # 6: Derivation of Wildlife Toxicity Reference Value (TRV)

OSWER Directive 92857-55

November 2003

Attachment 4-5

Ecological Soil Screening Levels (Eco-SSLs) Standard Operating Procedure (SOP) #4: Derivation of Wildlife Toxicity Reference Value (TRV)

OSWER Directive 92857-55

November 2003

Prepared for USEPA Region 8

by

Syracuse Research Corporation
999 18th Street, Suite 1975, North Tower
Denver, CO 80202

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1.0 INTRODUCTION

The United States Environmental Protection Agency (USEPA) Office of Emergency and Remedial Response (OERR) with the assistance of a multi-stakeholder workgroup developed risk-based ecological soil screening levels (Eco-SSLs). Eco-SSLs are concentrations of contaminants in soils protective of ecological receptors that commonly come into contact with soil or ingest biota that live in, or on soil. Eco-SSLs are derived separately for four groups of ecological receptors: plants, soil invertebrates, birds and mammals.

Plant and soil invertebrate Eco-SSLs are developed from available plant and soil invertebrate toxicity data. The mammalian and avian Eco-SSLs are the result of back-calculations from a Hazard Quotient (HQ) of 1.0. The HQ is equal to the dose (associated with the contaminant concentration in soil) divided by a toxicity reference value (TRV). Generic food chain models are used to estimate the relationship between the concentration of the contaminant in soil and the dose for the receptor (mg/kg body weight/day). The TRV represents a numerical estimate of a no observable adverse effect level (dose) for the respective contaminant primarily for the endponts of growth, reproduction and survival.

The procedure(s) for deriving the mammalian and avian oral TRVs for calculation of Eco-SSLs are contained within four standard operating procedures (SOPs):

- Eco-SSL SOP #3 Wildlife TRV Literature Search and Retrieval (Attachment 4-2)
- Eco-SSL SOP #4 Wildlife TRV Literature Review, Data Extraction and Coding (Attachment 4-3)
- Eco- SSL SOP #5 Wildlife TRV Data Evaluation (Attachment 4-4)
- Eco-SSL SOP #6 Derivation of the Oral TRV (Attachment 4-5)

This document serves as SOP #6 and describes the procedure for derivation of the wildlife TRVs.

1.1 Purpose

The purpose of the SOP is to provide a clear written description of the procedures for derivation of the wildlife TRVs used for the calculation of the Eco-SSLs. The document is written with two primary objectives:

1) To allow the users of the Eco-SSL values to fully understand how the wildlife TRVs are derived including the basis for any assumptions used in the derivation process.

2) To allow users of the guidance to derive wildlife TRVs for additional contaminants for

which Eco-SSLs are not available at this time. This provides for reproducible and consistent results.

1.2 Scope

The second section of this SOP discusses how the results from the preceding SOPs (literature search, data extraction and data evaluation) are to be presented. Section 3 describes the process for plotting the toxicological data (NOAEL and LOAEL values). Section 4 describes the process for derivation of the wildlife TRV based on the results of Sections 2 and 3. Section 5 provides references.

This SOP is written as the fourth part of the wildlife TRV derivation process and it is assumed that the reader is familiar with the preceding three portions of the process. Some results are used in this SOP for illustration purposes.

Wildlife TRV Derivation Process

The wildlife TRV derivation process is composed of four general steps:

- **Literature Search and Retrieval**
  Eco-SSL SOP #3: Wildlife Literature Search and Retrieval (Attachment 4-2) . A literature search identifies dose-response literature for retrieval.

- **Literature Review and Data Extraction**
  Eco-SSL SOP#4: Wildlife TRV Literature Review, Data Extraction and Coding (Attachment 4-3).
  The retrieved literature studies are reviewed and data are extracted according to an established coding system. Data are entered into an electronic data base

- **Data Evaluation**
  Eco-SSL SOP#5: Wildlife TRV Data Evaluation (Attachment 4-3). Each of the results identified in the reviewed literature is scored for quality and applicability for TRV derivation.

- **TRV Derivation**
  Eco-SSL SOP#5: Wildlife TRV Derivation (Attachment 4-5). This procedure plots the collective dose-response information and establishes the process for estimating the TRV.

2.0 PRESENTATION AND REVIEW OF THE TOXICOLOGICAL DATA

2.1 Reporting the Results of the Literature Search

The literature search and review results for each contaminant are reported as three separate categories:

1) Literature from which useful toxicological data is identified and extracted (literature coded);

2) Literature rejected for use; and,

3) Literature that is pending review.

Each of the citations on these lists are identified with a unique record number assigned as part of the data extraction process as described in Attachment 4-3. Citations on the "literature rejected" list are labeled with respective literature rejection criteria as described in Attachment 4-3.

2.2 Reporting the Results of Data Review and Evaluation

An electronic database was created to facilitate efficient and accurate data extraction from individual reviewed toxicological studies. This database is fully described as Attachment 4-3. Extraction of the data directly into an electronic database facilitates the necessary sorting, searching and presentation of the data for the purposes of TRV derivation. A web-based data entry system is used allowing remote access by multiple reviewers from any computer with Internet capabilities. Entry to the site is password-protected and limited to only those individuals responsible for data entry and quality assurance. All information entered is sent directly to the master database (housed with the ECOTOX database by the EPA Office of Research and Development (ORD) National Health and Ecological Effects Research Laboratory (NHEERL), Mid-Continent Ecology Division-Duluth (MED-Duluth)) avoiding any quality assurance problems associated with merging multiple sources of information into one database. The web-based system provides for immediate access to the entered data with any changes to the database or data entry process being immediately reflected on the website.

The coding guidelines used for the Eco-SSL Wildlife TRV effort follow the same basic structure as that used by EPA Duluth for ECOTOX. There are, however, some necessary additions and exclusions from the TRV coding system. The TRV database is focused on extracting the no observed adverse effect level (NOAEL) and lowest observed adverse effect level (LOAEL) doses from each of the toxicological studies while the TERRETOX system is designed to record all toxicological results from the studies.

2.3 Organizing and Presenting the Data and Data Evaluation Scores

The toxicity data is downloaded from the database into excel spreadsheet files for each contaminant using the tabular format provided in Table 2.1. One table is constructed for avian data and a second for mammalian data. The tables provide the essential information concerning each of the toxicity testing results. Table 2.1 provides an example of the output for mammals and cobalt. The results are numbered sequentially and then sorted by general effect group, effect type and effect measure.

Exposure													Effects						Conversion to mg/kg bw/day Dose								
Test Organism	Phase #	# of Conc/ Doses	Conc or Doses	Study Conc or Dose Units (Units for NOAEL and LOAEL)	Method of Analyses	Route of Exposure	Exposure Duration	Duration Units	Age	Age Units	Lifestage	Sex	Effect Group	Effect Type	Effect Measure	Response Site	Study NOAEL	Study LOAEL	bw Reported	Body Weight	Body Weight Units	Body Weight (kg)	Ingestion Rate Reported?	Ingestion Rate	Ingestion Rate Unite	Ingestion Rate (kg/day)	
Cow (*Bos taurus*)	1	2	0/0.3	mg/kg bw/d	M	FD	45	d	7	mo	JV	F	BIO	CHM	HMGL	BL	0.3		Y	99	kg bw	99	N	na	na	3.00	0.
Rat (*Rattus norvegicus*)	1	6	0/10/50/100/200/300	ppm in mg/kg	U	FD	4	w	NR	NR	NR	B	BIO	CHM	HMGL	BL	200	300	Y	150	g bw	0.15	N	na	na	0.014	1
Rat (*R. norvegicus*)	1	2	0/20	mg/kg bw/d	U	DR	30	d	NR	NR	JV	M	BIO	ENZ	P450	LI		20	Y	175	g bw	0.175	N	na	na	0.020	
Rat (*R. norvegicus*)	1	2	1	mg/ml	U	DR	35	d	NR	NR	JV	M	BIO	CHM	HMCT	BL		1	Y	169.7	g bw	0.1697	N	na	na	0.020	
													...														
Rat (*R. norvegicus*)	1	2	0/75	ppm in mg/kg	U	FD	80	d	44	d	JV	M	BEH	BEH	NMVM	WO	75		Y	470	g bw	0.47	N	na	na	0.037	1.
Pig (*Sus scrofa*)	2	4	0/200/400/600	mg/kg	U	FD	28	d	NR	NR	NR	NR	BEH	FDB	FCNS	WO		200	Y	41.58	kg bw	41.58	N	1.896	na	1.47	
Rat (*R. norvegicus*)	1	2	0/20	mg/kg bw/d	M	DR	57	d	80	d	JV	M	BEH	BEH	ACTP	WO		20	Y	347	g bw	0.347	Y	34.96	g/d	0.035	
Rat (*R. norvegicus*)	1	2	0/40	mg/kg bw/d	U	FD	16	w	NR	NR	NR	M	PHY	PHY	Other	HE		40	Y	0.387	kg bw	0.387	N	na	na	0.031	
Rat (*R. norvegicus*)	1	2	0/75	ppm in mg/kg	U	FD	80	d	44	d	JV	M	PTH	HIS	GHIS	NR	75		Y	470	g bw	0.47	N	na	na	0.037	1.
Rat (*R. norvegicus*)	1	6	0/10/50/100/200/300	ppm in mg/kg	U	FD	4	w	NR	NR	NR	B	PTH	ORW	SMIX	TS	50	100	Y	150	g bw	0.15	N	na	na	0.014	4.
Rat (*R. norvegicus*)	1	2	0/40	mg/kg bw/d	U	FD	16	w	NR	NR	NR	M	PTH	GRS	BDWT	WO		40	Y	0.387	kg bw	0.387	N	na	na	0.031	
Pig (*S. scrofa*)	1	2	0/500	ppm in mg/kg	U	FD	10	w	NR	NR	JV	M	PTH	HIS	GLSN	HE		500	Y	25.8	kg bw	25.8	N	na	na	0.99	
Mouse (*Mus musculus*)	1	2	0/180	mg/kg bw/d	U	GV	5	d	NR	NR	GE	F	PTH	GRS	BDWT	WO		180	N	36	g bw	0.036	N	na	na	0.0045	
Rat (*R. norvegicus*)	1	2	1	mg/ml	U	DR	35	d	NR	NR	JV	M	PTH	ORW	SMIX	HE		1	N	169.7	g bw	0.1697	N	na	na	0.020	
Rat (*R. norvegicus*)	1	3	0/5/20	mg/kg bw/d	U	FD	69	d	80	d	MA	M	REP	REP	TEWT	TE	5	20	N	0.21	g bw	0.00021	N	na	na	0.000065	5.
Rat (*R. norvegicus*)	1	4	0/12/24/48	mg/kg bw/d	U	GV	28	d	NR	NR	MA	F	REP	REP	PRWT	WO	12	24	Y	0.3	kg bw	0.3	N	na	na	0.026	5.
Rat (*R. norvegicus*)	1	4	0/25/50/100	mg/kg bw/d	U	GV	9	d	NR	NR	GE	F	REP	REP	PRWT	WO	100		Y	280	g bw	0.28	N	na	na	0.024	2
Mouse (*M. musculus*)	1	2	0/180	mg/kg bw/d	U	GV	5	d	NR	NR	GE	F	REP	REP	PROG	WO	180		Y	36	g bw	0.036	N	na	na	0.0045	8
Mouse (*M. musculus*)	1	4	0/23/42/72	mg/kg bw/d	U	DR	13	w	12	w	SM	M	REP	REP	RSUC	WO		23	Y	0.0375	kg bw	0.0375	N	6.32	na	0.0052	
Mouse (*M. musculus*)	1	2	0/400	mg/l	U	DR	9	w	12	w	MA	M	REP	REP	TEWT	TE		400	N	0.037	kg bw	0.037	N	na	na	0.0051	
Rat (*R. norvegicus*)	1	2	0/20	mg/kg bw/d	U	FD	70	d	100	d	SM	M	REP	REP	TEDG	TE		20	N	0.523	kg bw	0.523	N	na	na	0.040	
Rat (*R. norvegicus*)	1	2	0/265	ppm in mg/kg	U	FD	98	d	100	d	MA	M	REP	REP	TEWT	TE		265	Y	200	g bw	0.2	N	na	na	0.018	
Mouse (*M. musculus*)	1	2	0/43.4	mg/kg bw/d	U	DR	13	w	12	w	MA	M	REP	REP	TEWT	TE		43.4	Y	0.045	kg bw	0.045	N	na	na	0.0061	
Mouse (*M. musculus*)	1	2	0/400	mg/l	U	DR	10	w	8 to 10	w	JV	M	REP	REP	PRFM	WO		400	N	0.0316	kg bw	0.0316	N	na	na	0.0044	
Cow (*Bos taurus*)	1	2	0/0.3	mg/kg bw/d	M	FD	45	d	7	mo	JV	F	GRO	GRO	BDWT	WO	0.3		Y	99	kg bw	99	N	na	na	3.00	0.
Rat (*R. norvegicus*)	1	2	0/75	ppm in mg/kg	U	FD	80	d	44	d	JV	M	GRO	GRO	BDWT	WO	75		Y	470	g bw	0.47	N	na	na	0.037	1.
Pig (*S. scrofa*)	1	4	0/25/50/100	mg/kg	U	FD	16	w	NR	NR	NR	NR	GRO	GRO	BDWT	WO	100		Y	97.5	kg bw	97.5	Y	2.35	kg/d	2.35	2.
Mouse (*M. musculus*)	1	4	0/23/42/72	mg/kg bw/d	U	DR	5	w	12	w	SM	M	GRO	GRO	BDWT	WO	42	72	Y	0.0375	kg bw	0.0375	Y	7.8	g/d	0.0078	1
Guinea pig (*Cavia porcellus*)	1	2	0/20	mg/kg bw/d	U	OR	5	w	NR	NR	MA	M	GRO	GRO	BDWT	WO	20		Y	0.478	kg bw	0.478	N	na	na	0.037	2
Rat (*R. norvegicus*)	1	2	0/20	mg/kg bw/d	M	DR	57	d	80	d	JV	M	GRO	GRO	BDWT	WO	20		Y	347	g bw	0.347	Y	34.96	g/d	0.035	2
Rat (*R. norvegicus*)	1	6	0/10/50/100/200/300	ppm in mg/kg	U	FD	4	w	NR	NR	NR	B	GRO	GRO	BDWT	WO		10	Y	150	g bw	0.15	N	na	na	0.014	
Rat (*R. norvegicus*)	1	4	0/25/50/100	mg/kg bw/d	U	GV	9	d	NR	NR	GE	F	GRO	GRO	BDWT	WO		25	Y	280	g bw	0.28	N	na	na	0.024	
Pig (*Sus scrofa*)	1	2	0/500	ppm in mg/kg	U	FD	5	w	NR	NR	JV	M	GRO	GRO	BDWT	WO		500	Y	19.8	kg bw	19.8	N	na	na	0.80	
Mouse (*M. musculus*)	1	2	0/43.4	mg/kg bw/d	U	DR	13	w	12	w	MA	M	GRO	GRO	BDWT	WO		43.4	Y	0.045	kg bw	0.045	N	na	na	0.0061	
Rat (*R. norvegicus*)	1	2	1	mg/ml	U	DR	24	d	NR	NR	JV	M	GRO	GRO	BDWT	WO		1	Y	126.2	g bw	0.1262	N	na	na	0.015	
Pig (*S. scrofa*)	1	2	0/500	ppm in mg/kg	U	FD	10	w	NR	NR	JV	M	MOR	MOR	MORT	NR	500		Y	25.8	kg bw	25.8	N	na	na	0.99	1
Mouse (*M. musculus*)	1	2	0/180	mg/kg bw/d	U	GV	5	d	NR	NR	GE	F	MOR	MOR	MORT	NR	180		Y	36	g bw	0.036	N	na	na	0.0045	8
Guinea pig (*Cavia porcellus*)	1	2	0/20	mg/kg bw/d	U	OR	5	w	NR	NR	MA	M	MOR	MOR	SURV	WO		20	Y	0.478	kg bw	0.478	N	na	na	0.037	
Pig (*S. scrofa*)	1	4	0/25/50/100	mg/kg	U	FD	16	w	NR	NR	NR	M	BIO	CHM	HMGL	BL	100		Y	97.5	kg bw	97.5	Y	2.35	kg/d	2.35	2.
Pig (*S. scrofa*)	1	2	0/500	ppm in mg/kg	U	FD	10	w	NR	NR	JV	M	BIO	ENZ	GLPX	BL	500		Y	25.8	kg bw	25.8	N	na	na	0.99	1
Mouse (*M. musculus*)	1	4	0/23/42/72	mg/kg bw/d	U	DR	12	w	12	w	SM	M	BIO	CHM	HMCT	BL	72		Y	0.038	kg bw	0.038	Y	6.4	g/d	0.0064	3
Pig (*S. scrofa*)	3	2	0/400	mg/kg	U	FD	2	w	NR	NR	NR	NR	BIO	CHM	HMGL	BL		400	Y	23.62	kg bw	23.62	Y	0.968	kg/d	0.97	

L = blood; d = days; BDWT = body weight changes; BEH = behavior; bw = body weight; CHM = chemical changes; DR = Drinking water; ENZ = enyzme level changes; F = female; FCNS = food consumption; FD = food; FDB = feeding behavior; g = grams; GE = vage; HE = heart; HIS = histological changes; HMCT = hematocrit; HMGL = hemoglobin; JV = juvenile; kg = kilograms; LI = liver; LOAEL = lowest observed adverse effect level; m = months; M = male; M = measured; MA = mature; mg = milligrams; MOR = el

3.0 SUMMARY PLOTS OF TOXICOLOGICAL DATA

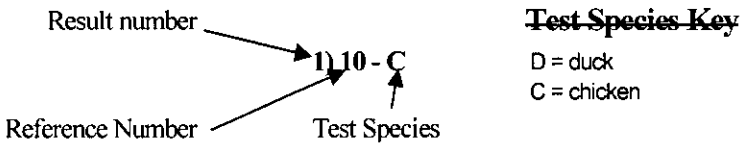
The data downloaded from the database into Excel spreadsheets is used to produce summary plots depicting the toxicological data (NOAEL and LOAEL results) for each contaminant Summary plots are constructed separately for mammalian and avian toxicological data.

3.1 Sorting by Endpoint

The data plots are organized by General Effect Group (described in Attachment 4-3) in order from left to right as:

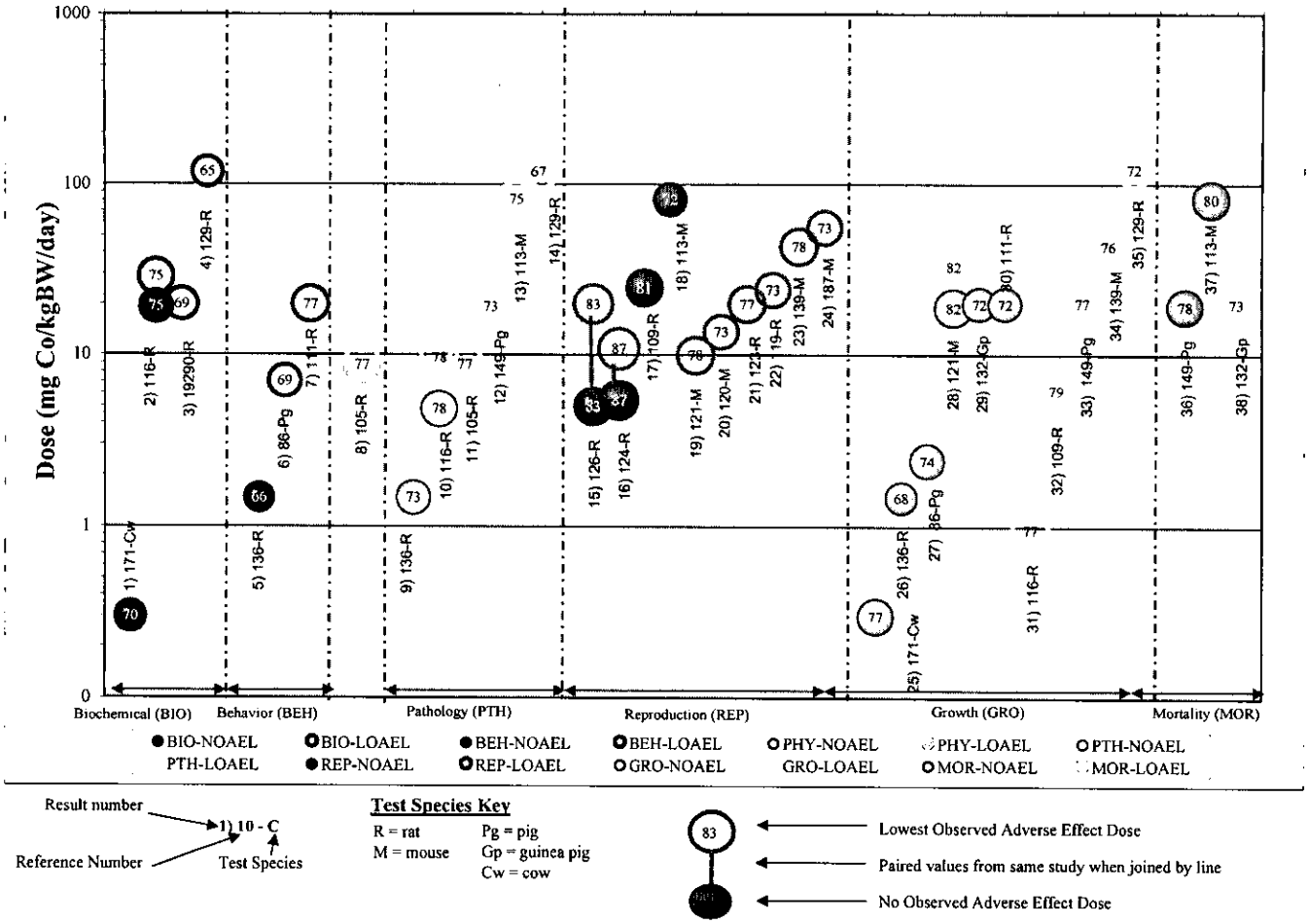
- Biochemical (BIO)
- Behavior (BEH)
- Physiology (PHY)
- Pathology (PTH)
- Reproduction (REP)
- Growth (GRO)
- Mortality (MOR)

Figure 3.1 provides an example plot showing the mammalian toxicity data for cobalt. The toxicity data associated with the plot is provided earlier as Table 2.1. The plot shows each study NOAEL and LOAEL result. NOAEL results are shown as closed circles while the LOAEL results are shown as open circles. Paired NOAEL and LOAEL values are connected by a vertical line. Within each of the circles the data evaluation score is shown and to the right of each circle the following label is shown:



The labels allow the reader to examine the plotted data and identify the relative results for different species as well as results that come from the same study. The result number allows the reader to associate that data point back to the associated toxicity data table describing more specific information for that test result.

Figure 3.1 Example Summary Plot of NOAEL and LOAEL Values



Result number → 1) 10 - C ← Test Species

Reference Number

Test Species Key

R = rat	Pg = pig
M = mouse	Gp = guinea pig
	Cw = cow

83 ← Lowest Observed Adverse Effect Dose

Paired values from same study when joined by line

No Observed Adverse Effect Dose

3.2 Exclusion of Data Considered Less Applicable for Deriving a TRV

Each test result extracted during the literature review process is scored for quality and applicability for TRV derivation according to a data evaluation process as described in Attachment 4-4. In instances where more than one "experiment" (i.e., different combinations of receptor, dose, exposure route, exposure duration, and endpoint) are reported in a study, the individual "experiments" are scored separately. In cases of more than one experiment, the scoring system is applied independently to each experimental result.

The scoring system is based on evaluation of ten attributes of the toxicological study and assigns a score for each attribute, ranging from zero (no merit in setting a TRV) to 10 (extremely valuable and relevant to setting a TRV). Note that a low score does not necessarily imply the study itself is poor, only that the study design is not optimal for the narrow goal of deriving an oral TRV. The total score is calculated by adding the results of the evaluation of each attribute. Data not used for TRV derivation are defined as study endpoints receiving a Total Data Evaluation Score of 65 or less. These data points are excluded from the plots. The purpose of the exclusion is to ensure that TRV derivation uses the most suitable data. The data evaluation process and rationale is provided as Attachment 4-4.

3.3 Exclusion of Repetitive Values

Within each toxicological study there may be several effect measures reported that have the same NOAEL and/or LOAEL values. Inclusion of the NOAEL and LOAEL results for all endpoint measures may result in repetitive values. To avoid the inclusion of repetitive and duplicative data, the results for only one Effect Measure per Effect Group are recorded in the plots. As described previously there are seven possible General Effect Groups so a unique study may yield up to seven results each that are extracted and plotted.

For example a study provides the following results:

General Effect Group	Effect Type	Effect Measure	NOAEL	LOAEL
BIO	CHM	TRIG	5	10
BIO	CHM	GLUC		5
BIO	ENZ	ACHE	5	10

There are results for three effect measures reported within the general effect group biochemical (BIO). In this instance, the most conservative result is recorded for BIO/CHM/GLUC with a LOAEL of 5 and the other effects are noted in the comment fields of the TRV database as instruction in Attachment 4-3.

4.0 PROCESS FOR DERIVATION OF WILDLIFE TRVs

4.1 TRV Definition

For the purposes of establishing the Eco-SSLs, the wildlife TRVs are defined by the workgroup as:

> *Doses above which ecologically relevant effects might occur to wildlife species following chronic dietary exposure and below which it is reasonably expected that such effects will not occur.*

4.2 Goals and Assumptions

The following underlying goals and assumptions guided the development of the TRV derivation process.

Use Chronic Exposure Data

The Wildlife TRV should be based on chronic effects data and not acute or subacute toxicity information (exposures of 3 days or less in duration). The purpose for exclusion of acute toxicity data was to focus efforts on establishing a dose protective of most species from adverse effects associated with long term exposures and sublethal reproductive and growth effects. A chronic exposure duration is that of sufficient length to reveal most adverse effects that will occur, or would be expected to occur, over the lifetime of an exposed organism (NAS, 1980; USEPA, 1985).

Consider All Toxicological Information.

The TRV should be based on the examination of all toxicological data extracted. These data are plotted and examined in a weight-of-evidence fashion as described in Section 4.4. The TRVs should not be based on the selection of a single "critical" study.

Consider Only Results for Dietary or Other Oral Exposures.

The wildlife TRVs should consider only oral dose response data. These data are considered the most relevant to establishing soil screening levels that are protective of potential oral exposures (ingestion of soil or food). Toxicological data for non-oral exposure routes are excluded from the literature search and literature evaluation processes as described in Attachments 4-2 and 4-3.

4.3 Methods Considered for TRV Derivation

The task group responsible for derivation of wildlife TRVs considered many different approaches for establishing these values. Some, but not all, of the methods considered are discussed here to provide context for the method developed for TRV derivation.

Critical Study Approach

One method considered was the selection of a critical study result for each contaminant for mammals and birds. The study result would then be used as the TRV or a series of extrapolation and/or uncertainty factors would be applied to the critical study result to achieve the TRV. Factors are typically applied for "normalization" of the data such as approximating the chronic result from either acute or subchronic exposure data or approximating the NOAEL from the LOAEL. Other factors can be applied to the critical study result to account for "uncertainty" and ensure the protectiveness of the value and this would include factors for interspecies sensitivity. The critical study approach is currently used by EPA for human health risk assessments with toxicity values made available in the Integrated Risk Information System (IRIS). The critical study approach was also used in the derivation of wildlife criteria for the Great Lakes Water Quality Initiative (GLI) (USEPA, 1995); by Sample et al. (1996) for the derivation of wildlife screening benchmarks for the Oak Ridge National Laboratory Reservation; and by the Canadian Council of Ministers of the Environment (CCME) for soil quality guidelines for livestock and wildlife (CCME, 1997).

The Eco-SSL task group chose to use a broader "weight-of-evidence approach"(further described in Sections 4.4 and 4.5) that considered all of the extracted toxicological data in place of the selection of one critical study. The use of the critical study approach would require considerable professional judgement thereby decreasing the transparency and reproducibility of the wildlife TRV derivation process. To avoid foreseen conflicts over selection of "one" result; to prevent the need for "committee" selection and to attain transparency and reproducibility this method was not selected.

Benchmark Dose Approach

In recent years, the benchmark dose approach has been examined for use in human health risk assessments in place of NOAEL and LOAEL approaches (Rees and Hattis, 1994; USEPA, 1995). The benchmark dose is defined by EPA as the statistical lower confidence limit for a dose that produces a predetermined change in response rate of an adverse effect (called benchmark response) compared to background (USEPA, 1995).

Use of a benchmark dose method requires not only the selection of a critical study but also the critical or benchmark response within that study that would be modeled. It is also necessary to select the appropriate model or model(s) for the experimental data to derive the benchmark dose. The benchmark dose approach has not been adopted for use by the ecological risk community and a margin of safety or the acceptable "predetermined change in response rate"has not been identified by the regulatory community. With these limitations as well as those discussed for the critical study approach, the benchmark dose approach was not selected for derivation of the wildlife TRVs for Eco-SSLs.

Distribution Approaches

Using distributions to represent the species sensitivities to contaminants is commonly used. The approach assumes that "...sensitivity of species is a stochastic variable that can be characterized by fitting a probability density function to test endpoints (e.g., LD50's LC50's for several species (Suter, 1993). This approach is used to establish soil standards in the Netherlands (Van Straalen and Denneman, 1989). Uncertainty is incorporated in the determination of confidence limits for thresholds protective of a fixed percentage of species (Van Straalen and Denneman, 1989; Aldenberg and Slob, 1993). As the sample size of the number of species tested increases, the protection threshold also increases.

Forbes and Forbes (1993) provides a review of the limitations of the distribution-based extrapolation models. The authors question the underlying assumptions of these models including: 1)"the distribution of species sensitivities in natural ecosystems closely approximates the threshold distribution"; 2) "the sensitivity of species used in laboratory tests provide an unbiased measure of the variance and mean of the sensitivity distribution of species in natural communities"; 3) "by protecting species composition, community function is also protected"; and 4) "interactions among species in communities and ecosystems can be ignored".

Within the ECOFRAM guidelines a distribution based approach is used to predict the 5^{th} percentile of the species sensitivity distribution based on the oral LD50 or LC50. With birds the minimum number of species required to use the distributional approach for species sensitivity is established by Luttik and Aldenberg (1995) at four. When N is equal to 4 or more species the parameters of the distribution are determined by the use of extrapolation factors from Aldenberg and Slob (1993). In cases, where n is less than four, then the 5^{th} percentile is predicted based on pre-determined extrapolation constants that compensate for small sample size (ECOFRAM, 1999).

The distributional methods recommended for use in ECOFRAM are not however recommended for use with the avian reproduction study (a 14 day exposure) as the toxic mechanisms are different from the ones involved with acute toxicity. In a review of reproduction studies done with the Mallard and Bobwhite Quail by Mineau, Boersma and Collins (1994) the developmental effects differed significantly between the two species and there was greater similarity between the rat and bird results than between that of the two bird species. This suggests a limited ability to extend the results of the avian reproductive test or any other chronic test that identifies no-effect and low-effect values to other bird species.

The use of distributional approaches is also limited by the non-comparability of the results reported for chronic exposures in the literature. The literature available reporting chronic toxicity of contaminants to laboratory test animals and wildlife reflects a wide range of endpoints, exposure durations, test species, exposure routes, test conditions and all (most) using different non standardized testing protocols. The chronic testing results are consequently non-comparable and inappropriate for plotting as a distribution. The distributional approach advocated for use within ECOFRAM and others is dependant upon the availability of

comparable results (LD_{50} values) from a standard toxicity testing protocol with the same toxicity endpoint, exposure duration, test species, exposure route and test conditions.

As a result of the earlier stated deficiencies and concerns with distributional approaches, and primarily the lack of an adequate toxicological database, the distributional approach was not selected for use.

Weight-of-Evidence Approach

In a weight-of-evidence approach the TRV is selected based on the preponderance of the data. With this approach, all toxicological data (NOAELs and LOAELs) extracted (Attachment 4-3) from the studies identified in the literature review (Attachment 4-1) and determined to be appropriate in establishing a TRV (as described in Attachment 4-4) would be plotted and the relative magnitude of the results examined to identify a threshold that would be protective. Examination of the dose-response data replaces the use of extrapolation factors as recommended by Chapman et al. (1998). The use of this method avoids the problems previously discussed with regard to the critical study approach.

4.4 Derivation Method Selected

The specific method selected for use in the derivation of TRVs is a "weight-of-evidence" approach that includes the use of some factors (adjustments) to account for uncertainties. All NOAEL and LOAEL values extracted (Attachment 4-3) from studies identified in the literature review (Attachment 4-2) and scored according to the data evaluation scoring procedure (Attachment 4-4) are plotted as described in Section 3.0. The resulting relative magnitude of the NOAEL and LOAEL values by effect type (biochemical, behavioral, physiological, pathology, growth, reproduction and mortality) are examined in a relative manner to identify or calculate a threshold value as the TRV according to the specific procedure described in Section 4.5. In most cases the TRV is equal to the geometric mean of NOAELs for GRO and REP effects. The use of NOAEL and LOAEL values as the basis of the wildlife TRV derivation process is deemed a reasonable and effective approach when these values are presented across multiple studies, species, and endpoints as depicted in the toxicological plots (Figure 3.1).

The LOAEL is defined as the lowest concentration (or dose) at which statistically significant adverse effects are observed in the test organism compared to controls. The No-observed adverse effect level (NOAEL) is defined as the highest experimental dose that is not associated with significant adverse effects in the test organism compared to controls.

The process developed for derivation of the wildlife TRVs is designed specifically to address some of the stated limitations and concerns in using NOAEL and LOAEL results for establishing threshold dose-response values. These limitations and concerns are previously discussed in several publications (Chapman et al., 1998; USEPA, 1995; Hoekstra and Van Ewijk, 1993; Chapman et al., 1996; Dhaliwal et al., 1997; and Chapman and Chapman, 1997). Some of the stated concerns and how they are addressed by the process are discussed as the following bullets:

2) The experimental dose referred to as the NOAEL is often based on judgement. The process developed for extraction of toxicity data (the NOAEL) (Attachment 4-3) and the data evaluation score (Attachment 4-4) include clear guidance on how to choose or select the NOAEL value from the toxicological study. The NOAEL and LOAEL results are examined to ensure they are accurately represented by the author. Primarily, the adequacy of the statistics used and the absence or presence of a dose dependant response are evaluated and considered in the identification of the NOAEL.

   The evaluation of the experimental design includes the dose ranges and statistical power. NOAELs with lower statistical power and wider or fewer dose ranges are given lower data evaluation scores. NOAELs with a data evaluation score of 65 (out of 100) or less are not used in the derivation of the TRV.

3) Experiments involving fewer animals tend to produce higher NOAELs and thus higher TRVs. The statistical power of the NOAEL is determined in part by the number of experimental animals. In the TRV derivation process, NOAELs with lower statistical power are given lower data evaluation scores. Also, the examination and use of NOAELs from multiple studies and multiple endpoints (in place of one study result) reduces the influence of any one study design in the calculation of the TRV.

4) The slope of the dose response curve plays little role in determining the NOAEL. The goal of the wildlife TRV derivation process is to identify a "no effect" concentration for purposes of deriving a soil screening value. Ideally, this "no effect" level should be close to the threshold for effects but this may not be true and the NOAEL consequently may be too low. As the wildlife TRV is based on multiple NOAELs across many studies, endpoints, and species this type of error for any individual study result is considered to be of little consequence.

5) The NOAEL cannot be used to characterize the magnitude of effects. The NOAEL value cannot be used to characterize the magnitude of any adverse effects. This is why LOAEL values are also included in the wildlife TRV process as a point of comparison with NOAELs and are also used to identify the TRV.

6) The NOAEL is affected by study design including the number and spacing of doses, endpoints measured and the number of replicates in each dose. The dose-response curve is also influenced by the study design. The examination and use of NOAELs from multiple studies and multiple endpoints (in place of one study result) reduces the influence of any one study design in the calculation of the TRV.

The use of NOAEL and LOAEL values as the basis of the wildlife TRV derivation process is deemed a reasonable and effective approach when these values are presented across multiple studies, species, and endpoints as depicted in the toxicological plots (Figure 3.1). These results are examined in a relative manner to identify or calculate a threshold value as the TRV according to the specific procedure described in Section 4.5. The minimum data sets required for the

procedure as well as the consideration of interspecies sensitivity are described in the following subsections.

4.4.1 Minimum Data Set Required to Derive a Wildlife TRV

The task group identified a minimum data set required for derivation of either the mammalian or avian TRV. This minimum data set is based on discussions within the workgroup and best professional judgment. Once the toxicological study data is reviewed and input into the wildlife TRV database (Attachment 4-3) the data will be examined to evaluate intraspecific sensitivity. This analysis may result in changes to the minimum data set. The required data set consists of three NOAEL or LOAEL results for at least two test species for either growth (GRO); reproduction (REP) or survival (MOR) effects.

The minimum data set is generally consistent with minimum data sets established for other soil and risk guidelines. The Canadian Soil Quality Guidelines (CCME, 1997) requires a minimum of three studies for calculation of soil quality guidelines for soil and food ingestion for livestock and wildlife. There is a further requirement that at least two of these studies be oral mammalian studies and one must be an oral avian study. A maximum of one laboratory rodent study may be used to fulfill the data requirements for mammalian species if needed. Toxicity testing of pesticides prior to registration generally requires only one or two standard test species (ECOFRAM, 1999). However, the minimum number of avian species required to use the distributional approach for species sensitivity is established by Luttik and Aldenberg (1995) at four.

4.4.2 Interspecies Sensitivity

For technical and fiscal reasons only a few species of wildlife can be tested for toxicity of contaminants. Only rarely are test species the same as those likely to be exposed under field conditions. This fact implies that test results from standard test species need to be extrapolated to most field species.

Several investigators have examined the inter-species sensitivity of avian species to pesticides. The interspecies extrapolation methods recommended by ECOFRAM as part of the FIFRA risk assessment methods are based on analyses of 20 years of acute oral toxicity studies (LD50 study) on pesticides. The oral LD50 data reflects a large number of tests completed for many species for numerous compounds using only one well established test protocol. Analysis of this data by Baril et al. (1994) resulted in the following observations:

(1) Ranking of species sensitivities tends to persist across chemicals

(2) Red-winged blackbirds are the most sensitive followed as a group by the Common Grackle, the House Sparrow, the Mallard and the Rock Dove. A second group including the Pheasant, Japanese Quail and the Starling are the least sensitive.

Other authors (Joermann, 1991; Schafer and Brunton, 1979; and Tucker and Haegele, 1971) have also evaluated phylogenetic patterns in sensitivity of avian species to pesticides. These studies have demonstrated some patterns of sensitivity between some families of birds across pesticides. However, each species shows a wide range of sensitivity among the same pesticides. ECOFRAM concludes that there are probably enough exceptions to prevent the development of a predictive approach based on phylogenetic relationships. They did conclude that two groupings of species (based on taxonomic relationships) could be separated according to sensitivity (acute) to cholinesterase-inhibiting chemicals (ECOFRAM, 1999).

As more data becomes available in the Wildlife TRV database, interspecies sensitivity will be further examined by comparison of bounded LOAEL values between species by contaminant. This approach is similar to that used to examine the use of uncertainty factors for wildlife criteria in the GLWQI. If the current minimum data set is deemed underprotective then the minimum data set and the use of additional uncertainty factors will be re-evaluated.

4.5 Specific Procedure for Derivation

The general steps and conditional statements of the derivation process are outlined in Figure 4.1. These steps are an a priori framework for selection or calculation of the TRV value based on the results of the NOAEL and LOAEL data plots. The flow chart is used with the toxicological data plots to derive the TRV according to the following described steps.

Step 1: Are there at least 3 results and 2 species tested for reproduction (REP), growth (GRO) or mortality (MOR) general effect groups?

The minimum data set required to derive either a mammalian or avian TRV consists of three results (NOAEL or LOAEL values) for REP, GRO or MOR for at least two mammalian or avian species. If these minimum results are not available then a TRV is not derived.

Step 2: Are there 3 or More NOAELs in REP and GRO Effect Groups?

Calculation of the geometric mean NOAEL for REP and GRO requires at least three NOAEL results from either of the GRO, REP or MOR effect groups. If three or more NOAEL results are available then the user proceeds to Step 4. If there are less than three NOAEL results, then the user proceeds to Step 3.

Step 3: Is there at least one NOAEL for REP and GRO?

If there is at least one NOAEL result available for the REP and GRO effect groups, then the TRV is equal to the lowest reported NOAEL for either effect group (GRO or REP). In cases where this NOAEL is higher than the lowest LOAEL for the MOR effect group then the TRV is equal to the highest NOAEL below the lowest LOAEL for the MOR effect group or the lowest LOAEL which ever is lower.

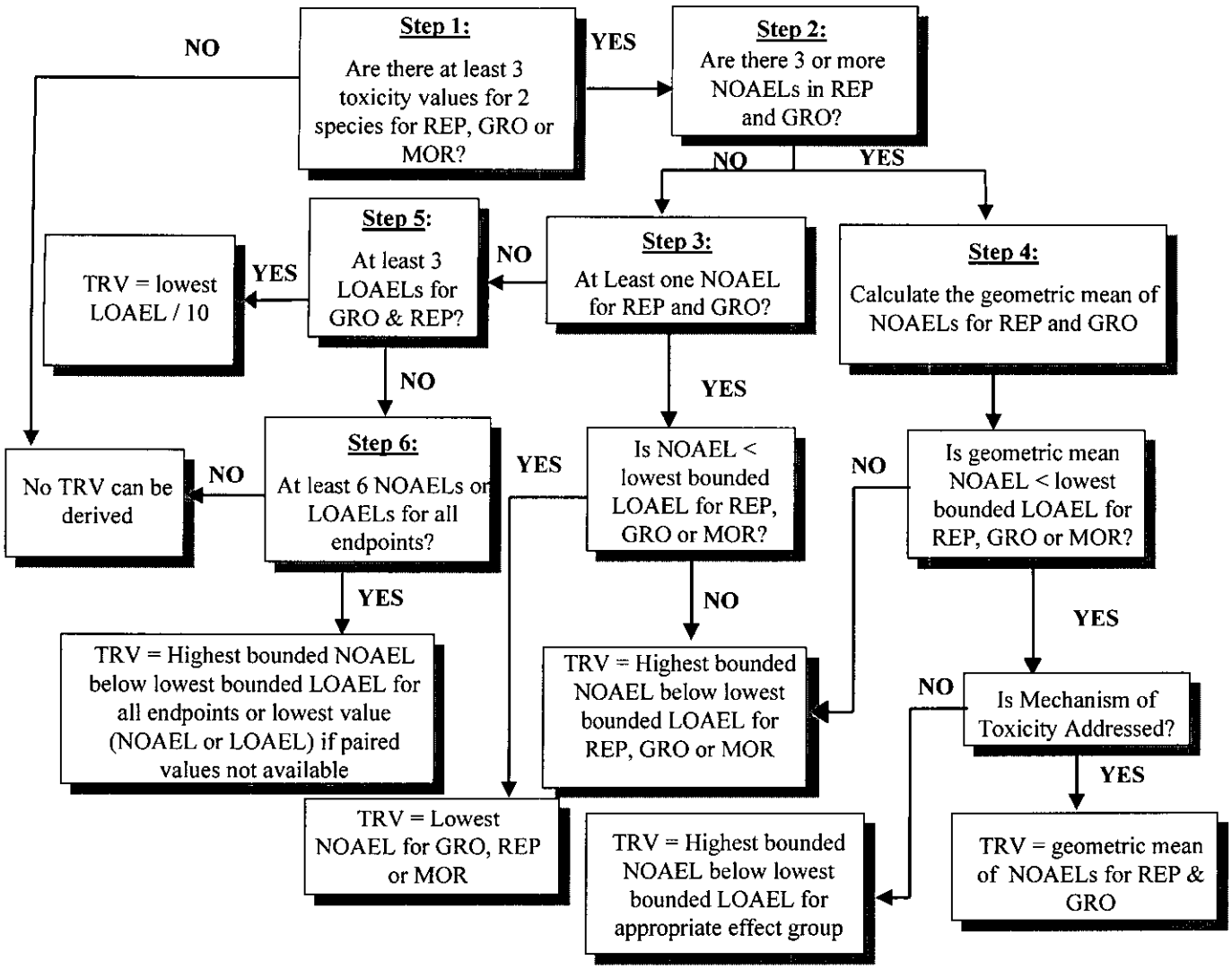


Figure 4.1 TRV Derivation Procedure

Step 4: Calculate a geometric mean of NOAELs for GRO and REP Effect groups.

The TRV is equal to the geometric mean of the NOAEL values in the REP and GRO Effect Groups with the following exceptions.

Is the Geometric Mean NOAEL greater than the highest bounded NOAEL below the Lowest bounded LOAEL for REP, GRO or MOR?

In some cases the geometric mean NOAEL (REP and GRO) may be higher than the highest bound NOAEL (paired NOAEL and LOAEL values) below the lowest bound LOAEL value for results within the REP, GRO or MOR effect groups. In other words, the geometric mean NOAEL value may not be sufficiently protect all tested species and represent the threshold of REP, GRO, and MOR effects. In these instances, the TRV is equal to the highest bound NOAEL below the lowest bound LOAEL value for results within the GRO, REP and MOR effect groups.

Is the mechanism or mode-of action of toxicity addressed by the Effect Measures in the GRO, REP and MOR Effect Groups?

If the mechanism, or mode-of-action of toxicity, is not addressed by the Effect Measures in the GRO, REP and MOR Effect Groups then the TRV is equal to the highest bound NOAEL below the lowest bound LOAEL for the appropriate effect group. This possible pathway for TRV derivation is included to allow the toxicologist to set a TRV based on the data most appropriate for the particular contaminant.

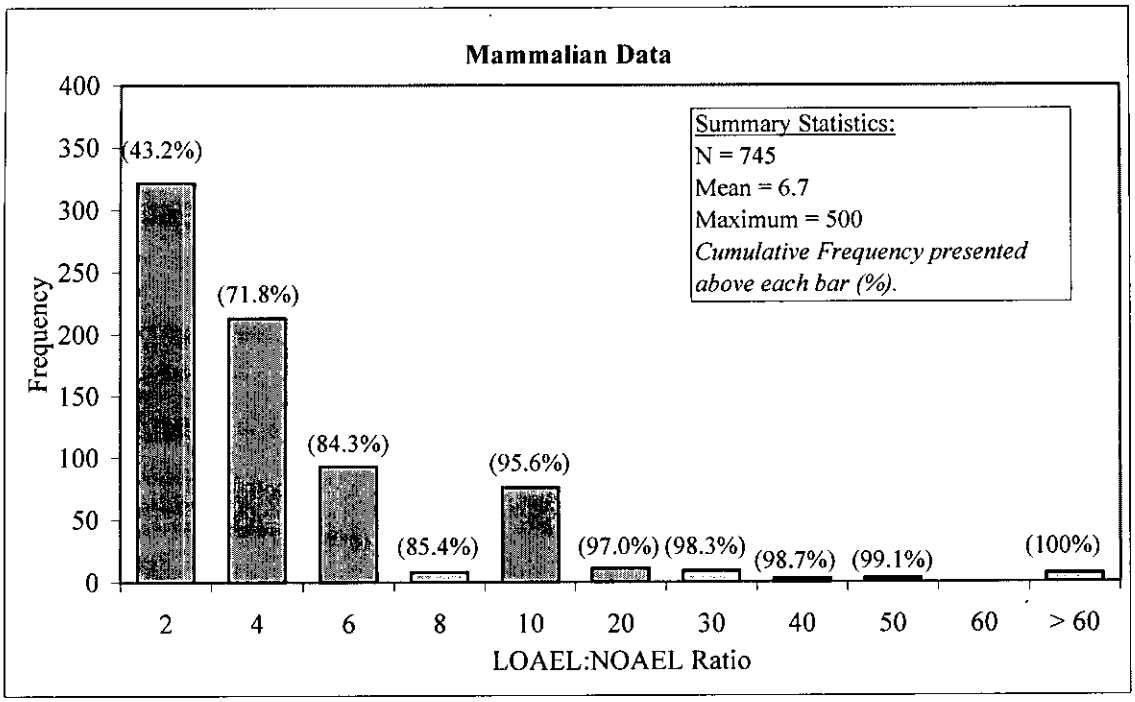
Step 5: Are there at least 3 LOAELs for GRO & REP?

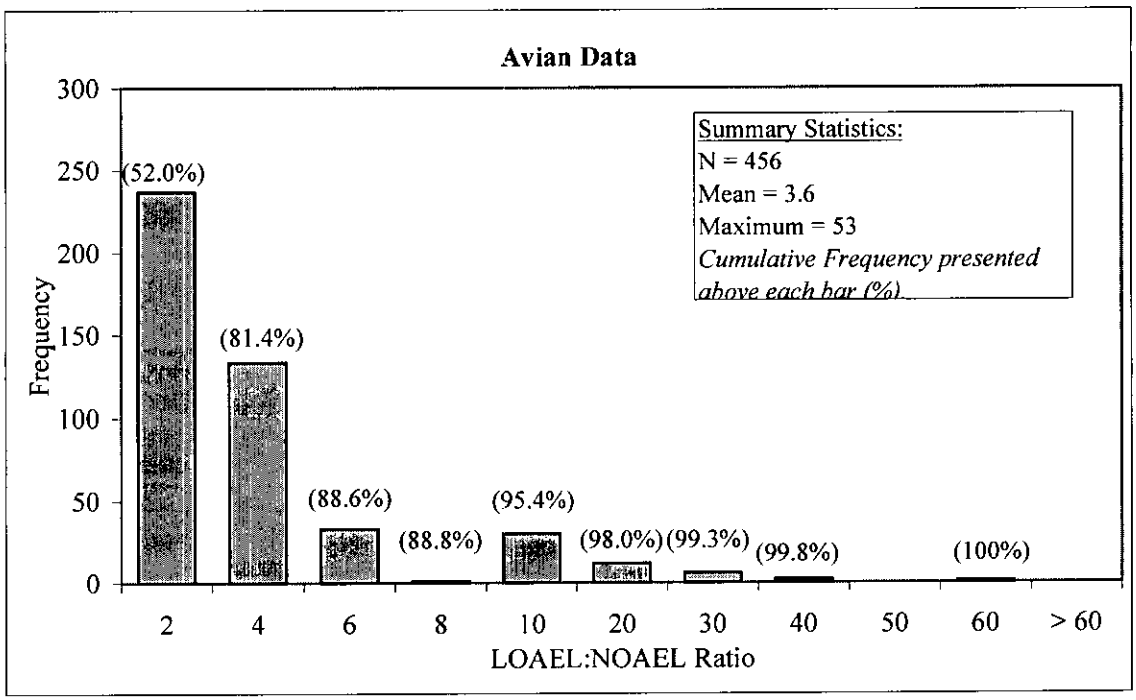
If there are at least 3 LOAELs for GRO and REP then the TRV is equal to the lowest LOAEL divided by an uncertainty factor. If there are less than 3 LOAELs then the user goes to Step 6.

The uncertainty factor is intended to extrapolate from the LOAEL (lowest observed effect) to a NOAEL (no observed effect) value. In order to derive an UF to approximate the NOAEL from the LOAEL, the LOAEL to NOAEL ratios (bounded) in the Wildlife TRV database were examined (Figure 4.2). To date there are 456 paired LOAEL/NOAEL values in the database for avian species and 745 for mammalian species. With this data the ratios of bounded LOAELs NOAELs are described in Figure 4.2.

Approximately 84.3% of the LOAEL values for mammals and 88.6% for birds are within a factor of 5 of the respective paired NOAEL value (Figure 4.2). Approximately 96% and 95% of the values are within a factor of 10 for mammals and birds, respectively. As the purpose of the TRV is for calculation of (conservative) soil screening values, a value of 10 was chosen as the UF as 97% of the cases within the wildlife TRV database, the NOAEL is within a factor of 10 of the LOAEL. This quantitative result is not surprising. Dosing studies are commonly designed with order of magnitude increased in dose (e.g., 1, 10, 100, 1000).

Figure 4.2
LOAEL to NOAEL Ratios in Wildlife TRV Database





Therefore, threshold approaches will consequently most likely end up with a factor of 10 between NOAEL and LOAEL values.

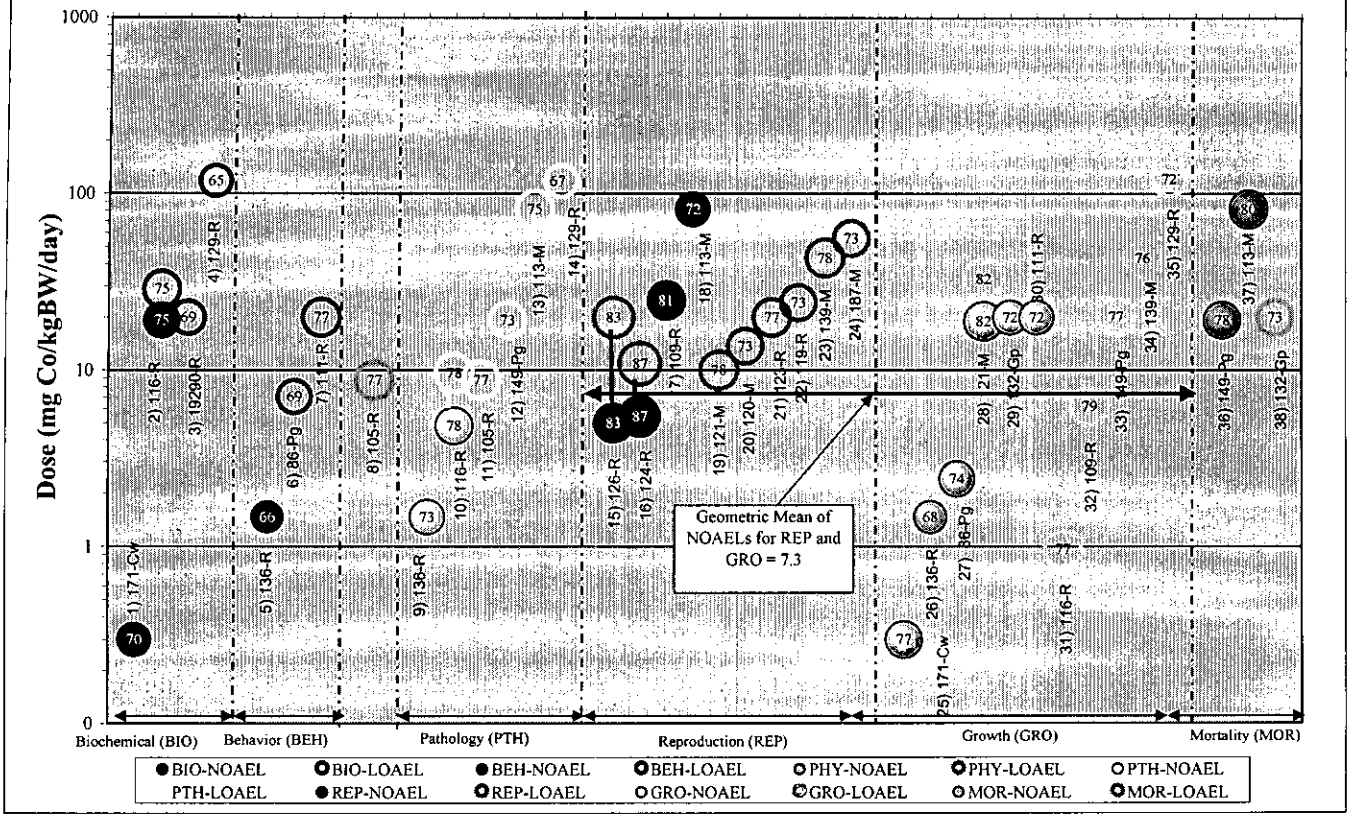
Chapman et al (1998) and e,p&t (1996) criticize the use of the LOAEL in approximating a NOAEL dose. They argue that LOAEL determination is a function of the spacing of dietary concentrations and statistical power of the test and that LOAELs are often incorrectly low due to statistical artifacts and that these uncertainties are compounded when the LOAEL is divided by an uncertainty factor. While it is true that NOAEL and LOAEL determination is function of study design, it is hoped that the NOAEL and LOAEL brackets the threshold. As many LOAELs may be incorrectly low it is assumed that the use of an UF equal to10 will successfully bracket the lower range of the possible threshold (NOAEL). This UF value will be updated as more toxicological data becomes available within the TRV wildlife database.

For the contaminants for which TRVs have been derived to date, there has not been an instance where this step was used to derive a TRV. All contaminants examined to date have either had sufficient data to derive a TRV based on NOAEL values or data is not available at all (e.g., antimony, barium and beryllium for birds).

Step 6: Are there at least 6 LOAEL values available for other endpoints?

In cases where there are less than three LOAEL values available for all GRO or REP Effect groups, the TRV can be derived based on the available LOAEL values for other Effect Groups (BEH, PTH, BIO, PHY, MOR). As this type of dose-response data is considered to be less useful for establishing a TRV twice the number of data points are required as a minimum to derive a TRV (compared to data for GRO, REP and MOR). The highest NOAEL below the lowest LOAEL for all effect Groups are identified and the lowest of these is identified as the TRV. If bounded values are not available, then the TRV equals the lowest NOAEL or LOAEL for all endpoints. If less than six total NOAEL or LOAEL values are available then a TRV cannot be derived.

Figure 4.3 Example of TRV Derivation



Wildlife TRV Derivation Process

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

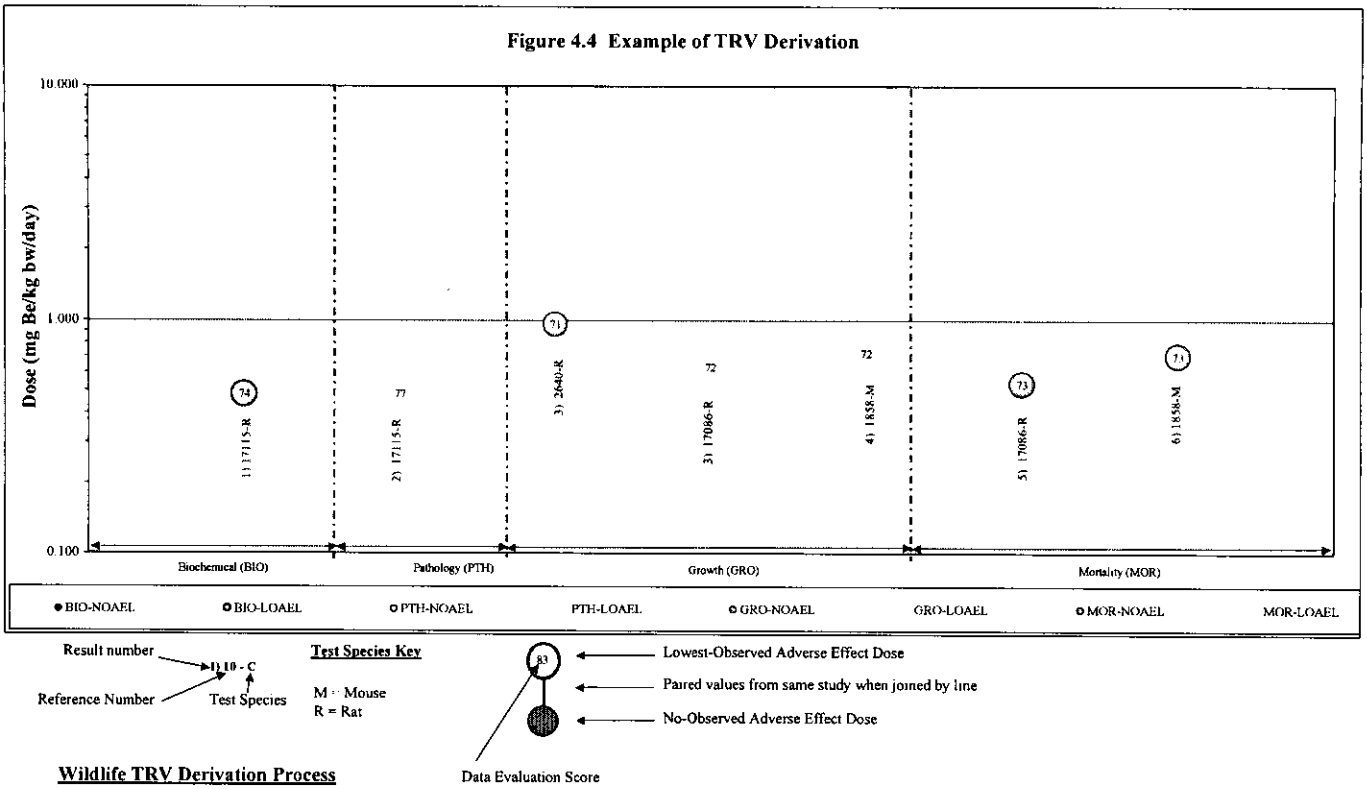
2) There are are at least three NOAEL results available for calculation of a geometric mean.

3) The geometric mean of the NOAEL values for growth and reproduction equals 7.3 mg Co/kg BW/day.

4) The geometric mean NOAEL value is less than the lowest bounded LOAEL for reproduction, growth or survival.

5) The mammalian wildlife TRV for cobalt is equal to 7.3 mg Co/kg BW/day.

Figure 4.4 Example of TRV Derivation



Result number
Reference Number
Test Species
Test Species Key
M = Mouse
R = Rat
Lowest-Observed Adverse Effect Dose
Paired values from same study when joined by line
No-Observed Adverse Effect Dose
Data Evaluation Score

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 is enough data to derive a TRV

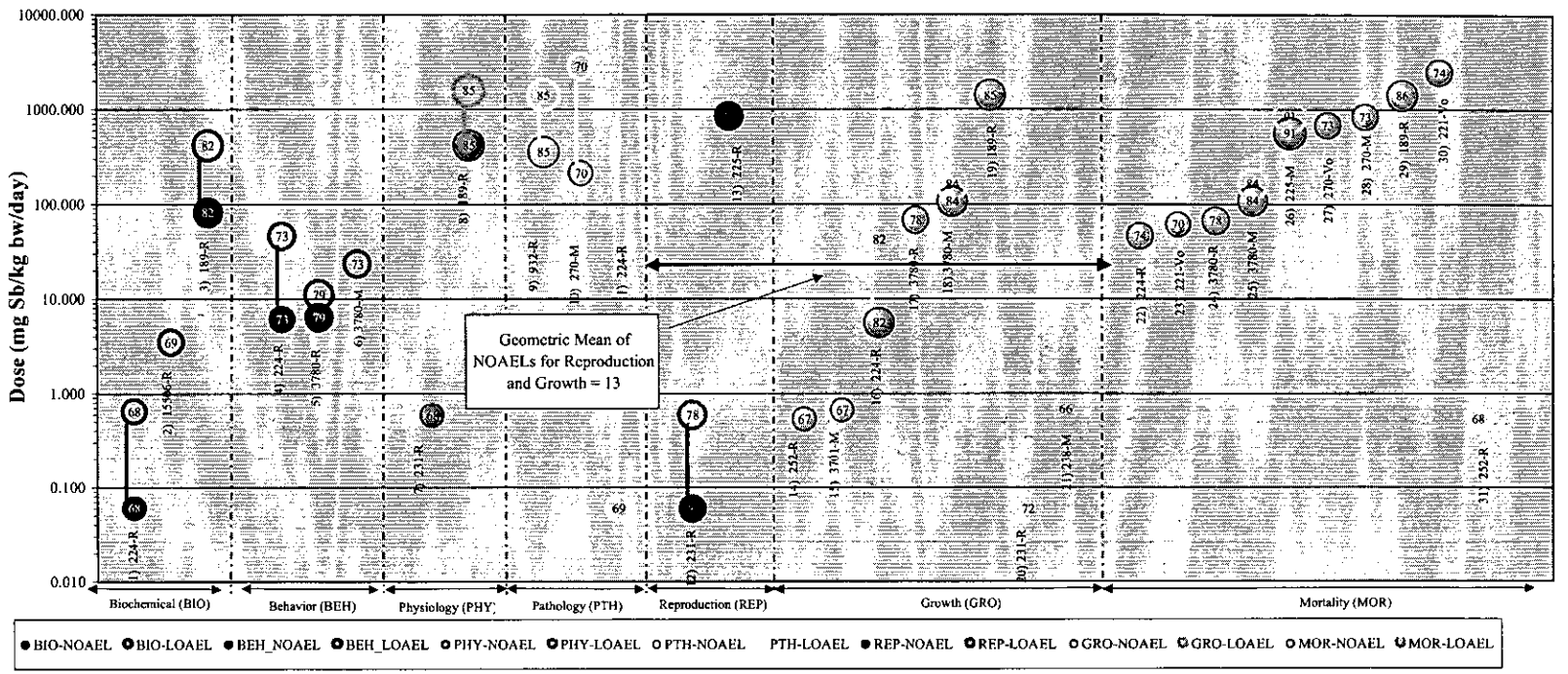
2) There are not three NOAEL results available for calculation of a geometric mean

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

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

6) The mammalian wildlife TRV for beryllium is equal to 0.48 mg Be/kg bw/day which is the lowest NOAEL for effects on growth, reproduction and survi

Figure 4.5 Example of TRV Derivation



Result number → 1) 10 - C ← Test Species

Reference Number

Test Species Key

Vo = Short-tailed field vole
M = Mouse
R = Rat

83 ← Data Evaluation Score

Lowest-Observed Adverse Effect Dose

Paired values from same study when joined by line

No-Observed Adverse Effect Dose

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 is enough data to derive a TRV.

2) There are 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 13 mg Sb/kg BW/day.

4) The geometric mean NOAEL value is higher than the lowest bounded LOAEL for reproduction, growth, or mortality effects

5) The mammalian wildlife TRV for antimony is equal to 0.059 mg Sb/kg BW/day which is the highest bounded NOAEL below the lowest bounded LOAEL for reproduction, growth or mortality effects.

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