Guidance for Conducting RCRA Ecological Risk Assessments

"This Policy Does Not Have the Force of Law"

March 2003

State of Ohio
Environmental Protection Agency
Division of Hazardous Waste Management
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Forward:

Ohio EPA Division of Hazardous Waste Management (DHWM) utilizes guidance to aid regulators and the regulated community in meeting laws, rules, regulations, and policy. Guidance outlines the recommended practices and explains their rationale in an effort to achieve consistency in the regulation of hazardous waste. *It is important to note, however, that the term implies no enforcement authority.* The Agency may not require an entity to follow methods recommended by this or any other guidance document. It may, however, require an entity to demonstrate that an alternate method produces data and information that meet the pertinent requirements.

This Guidance for Conducting RCRA Ecological Risk Assessments is primarily designed to assist facility operators/owners in preparing an ecological risk assessment, and to assist technical staff of DHWM in reviewing these risk assessments. An ecological risk assessment may be performed for a RCRA closure or corrective action.

TABLE OF CONTENTS

		Page
Forward		ii
Ohio EPA Districts		vi
Acknowledgments		vii
Acronyms		viii
Chapter 1	**OVERVIEW**	1-1
	1.1 Overview of the Ecological Risk Assessment Process	1-1
	1.1.1 Level I - Scoping Ecological Risk Assessment	1-3
	1.1.2 Level II - Screening Ecological Risk Assessment	1-3
	1.1.3 Level III - Baseline Ecological Risk Assessment	1-4
	1.1.4 Level IV - Field Baseline Ecological Risk Assessment	1-4
Chapter 2	**Level I - Scoping Ecological Risk Assessment**	
	2.1 Objective	2-1
	2.2 Prerequisites	2-1
	2.3 Tasks	2-1
	2.3.1 Task 1: Assess Existing Data	2-1
	2.3.2 Task 2: Site Information and Identification of Important Ecological Resources	2-2
	2.3.3 Task 3: Identify Potential Chemical and Non-chemical Stressors	2-2
	2.3.4 Task 4: Level I Assessment	2-2
	2.3.5 Task 5: Submit Level I Deliverable	2-3
	ATTACHMENT A - Phase I Site Assessment	2-4
	ATTACHMENT B - Ecological Scoping Checklist	2-7
	ATTACHMENT C - Evaluation of Potential Ecological Harm	2-11
	ATTACHMENT D - Level I Deliverable Outline	2-12
	ATTACHMENT E - ODNR Species List	2-13
Chapter 3	**Level II - Screening Ecological Risk Assessment**	
	3.1 Objective	3-1
	3.2 Prerequisites	3-1
	3.3 Tasks	
	3.3.1 Task 1: Evaluate Existing Site Data	3-1
	3.3.2 Task 2: Site Characterization	3-2
	3.3.3 Task 3: Data/Media Evaluation	3-2
	Frequency of Detection	3-2
	Common Laboratory Contaminants	3-3
	Background Concentrations	3-3
	Ohio Sediment Reference Values (SRVs)	3-4
	3.3.4 Task 4: Scientific Management Decision Point	3-4
	3.3.5 Task 5: Screening	3-4
	Soil	3-5
	Surface Water	3-5
	Sediment	3-6
	Persistent, Bioaccumulative, and Toxic Pollutants	3-7
	Cumulative Effects	3-7
	Benchmark Availability	3-7
	State and/or Federal Listed Species	3-7

3.3.6 Task 6: PECOC Selection 3-7
3.3.7 Task 7: Conduct Site Survey 3-8
3.3.8 Task 8: Update Site Description 3-8
3.3.9 Task 9: Revise Conceptual Site Model 3-8
3.3.10 Task 10: Identify Ecological Receptors 3-9
State and/or Federal Listed Species 3-9
3.3.11 Task 11: Identify Complete Exposure Pathways 3-10
3.3.12 Task 12: Identify Candidate Assessment Endpoints 3-10
3.3.13 Task 13: Scientific Management Decision Point (SMDP) 3-11
3.3.14 Task 14: Submit Level II Report 3-12
ATTACHMENT A - Flowchart and Legend 3-13
ATTACHMENT B - Potential Ecological Contaminants of Concern . 3-20
ATTACHMENT C - Summary of Ecological Receptors 3-21
ATTACHMENT D - Exposure Routes for Ecological Receptors by Environmental Media 3-22
ATTACHMENT E - CSM Diagram 3-23
ATTACHMENT F - Level II Report 3-24
ATTACHMENT G - Point of Compliance 3-25
ATTACHMENT H - Ohio Specific Sediment Reference Values 3-26
ATTACHMENT I - Supplemental Guidance to RAGS: Calculating the Concentration Term 3-32
ATTACHMENT J - ECO Update: Ecological Significance and Selection of Candidate Assessment Endpoints . . 3-41
ATTACHMENT K- Generic Receptor Species List 3-47

Chapter 4 **Level III - Baseline Ecological Risk Assessment**
4.1 Objective 4-1
4.2 Prerequisites 4-1
4.3 Tasks
4.3.1 Task 1: Complete Problem Formulation 4-1
4.3.2 Task 2: Prepare Analysis Plan 4-2
4.3.3 Task 3: Perform Exposure Assessment 4-2
4.3.4 Task 4: Perform Toxicity Assessment 4-4
4.3.5 Task 5: Perform Risk Characterization 4-4
4.3.6 Task 6: Perform Uncertainty Analysis 4-6
4.3.7 Task 7: Scientific Management Decision Point (SMDP) . . . 4-7
4.3.8 Task 8: Submit Level III Deliverable 4-7
4.3.9 Task 9: Scientific Management Decision Point (SMDP) . . . 4-7
ATTACHMENT A - Generic Receptors 4-8
ATTACHMENT B - Exposure Assessment 4-13
ATTACHMENT C -Toxicity Assessment 4-22
ATTACHMENT D - Receptor Life History Data 4-32
ATTACHMENT E - Level III Report - Outline 4-43

Chapter 5 **Level IV - Field Baseline Ecological Risk Assessment**
5.1 Objective 5-1
5.2 Prerequisites 5-1
5.3 Tasks
5.3.1 Task 1: Refine Problem Formulation 5-1
Select ECOCs 5-1
Review/revise Establish Measures 5-1
5.3.2 Task 2: Select Assessment Tools 5-2
Tissue Analysis/Bioaccumulation Studies 5-2
Population/Community Evaluations/Toxicity Tests 5-2
Toxicity Tests (Bioassay) 5-3

5.3.3 Task 3: Prepare Field Ecological Sampling and Analysis Plan 5-3
5.3.4 Task 4: Conduct Field/Laboratory Work 5-3
5.3.5 Task 5: Perform Risk Characterization 5-4
5.3.6 Task 6: Perform Uncertainty Analysis 5-4
5.3.7 Task 7: Submit Level IV deliverable 5-4
ATTACHMENT A - Useful References 5-5

CHAPTER 6 **Definitions**
Definitions 6-1

CHAPTER 7 **Literature Cited**
Literature Cited 7-1

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ACRONYMS

ADD	Average Daily Dose ADD_A - Average Daily Dose by ingestion of Animal matter ADD_P - Average Daily Dose by ingestion of Plant matter ADD_S - Average Daily Dose by ingestion of Soil ADD_{Total} - Total Average Daily Dose
A_F	Fraction of the diet that is Animal matter
ARL	Acceptable Risk Level
AUF	Area Use Factor
BAF	Bioaccumulation Factor BAF_I - Bioaccumulation Factor for Invertebrates BAF_P - Bioaccumulation Factor for Prey Items
BCF	Bioconcentration Factor
BSAF	Biota-to-Sediment Accumulation Factor
BW	Body Weight
CF	Dry-weight to wet weight Conversion Factor
ECOC	Ecological Contaminant Of Concern
COI	Contaminant Of Interest
CSM	Conceptual Site Model
CV	Coefficient of Variation
DHWM	Division of Hazardous Waste Management
DO	Dissolved Oxygen
DQOs	Data Quality Objectives
dw	Dry Weight
EDQL	Ecological Data Quality Level
EHI	Environmental Hazard Index
EHQ	Environmental Hazard Quotient
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
ERAG	Ecological Risk Assessment Group
ERfD	Ecologically-Based Reference Dose
FESAP	Field Ecological Sampling and Analysis Plan
GIS	Geographic Information System
HEP	Habitat Evaluation Procedures
IBI	Index of Biological Integrity
ICI	Invertebrate Community Index
IRIS	Integrated Risk Information System
K_{ow}	Octanol-Water Partition Coefficient
LD_{50}	Lethal Dose to 50% of population

LOAEL	Lowest Observed Adverse Effect Level?
LRW	Limited Resource Water
MDC	Maximum Detected Concentration
MI_{wb}	Modified Index of Well-Being
NOAEL	No Observed Adverse Effect Level
	$NOAEL_{mc}$ - Modified Chronic No Observed Adverse Effect Level
NOEL	No Observed Effect Level
OAC	Ohio Administrative Code
OEPA	Ohio Environmental Protection Agency
Ohio EPA	Ohio Environmental Protection Agency
ODNR	Ohio Department of Natural Resources
ODW	Ohio Division of Wildlife, division of ODNR
PAHs	Polycyclic (or Polynuclear) Aromatic Hydrocarbons
PBT	Persistent, Bioaccumulative, and Toxic
PCBs	Polychlorinated Biphenyls
PECOC	Potential Ecological Contaminants of Concern
P_F	Fraction of the diet that is Plant matter
RAGS	Risk Assessment Guidance for Superfund
S_F	Fraction of the diet that is soil
SMDP	Scientific Management Decision Point
SRV	Sediment Reference Value
T&E	Threatened and Endangered
TAL	Target Analyte List
TCDD	Tetrachlorodibenzo-p-dioxin
TCL	Target Compound List
TDS	Total Dissolved Solids
TEC	Threshold Effect Concentration
TUF	Temporal Use Factor
UCL	Upper Confidence Limit
U.S. EPA	United States Environmental Protection Agency
U.S. FWS	United States Fish & Wildlife Service
USGS	United States Geological Society
ww	Wet Weight

CHAPTER 1
OVERVIEW

The Ohio EPA Division of Hazardous Waste Management (DHWM) ecological risk assessment (ERA) guidance document provides methodologies, supported by appropriate references, needed to conduct consistent and protective ecological risk assessments. It is hoped that, as discussed in the 13 August 1998, U.S. EPA Ecological Risk Management Guidance document, these ERA guidelines will aid in:

- planning and conducting ecological risk assessments of appropriate scope and complexity necessary to establish exposure levels that are protective of the environment;
- planning and conducting other environmental evaluations useful for developing and screening remedial alternatives. ; and,
- providing a body of information to enable rational risk management decision making.

ERA has been defined (U.S. EPA, 1992a) as a process that evaluates the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more ecological stressors. Typically, ERAs are developed within a risk management context to evaluate chemical and non-chemical stressors and support appropriate environmental decision making.

Ohio EPA DHWM stresses that, as stated in the 1998 U.S. EPA ERA guidance, all members of the site evaluation team, including risk assessors and risk managers, should discuss and agree upon:

- clearly established and articulated ecological risk management goals;
- characterization of the decisions to be made in the context of the ecological risk management goal; and,
- the scope, complexity and focus of the ecological risk assessment.

A critical initial component of the ecological risk assessment is problem formulation, the process for generating and evaluating preliminary hypotheses related to the ecological effects of chemical and non-chemical stressors. Ohio EPA recommends a flexible and phased approach to this problem formulation process, such that identified deficiencies can be rectified prior to relevant management decision points.

1.1 OVERVIEW OF THE ECOLOGICAL RISK ASSESSMENT PROCESS

The Ohio EPA DHWM ecological risk assessment process consists of the following four levels:

- Level I Scoping
- Level II Screening
- Level III Baseline
- Level IV Field Baseline

Figure #1 illustrates the various levels and sequence of the ERA process.

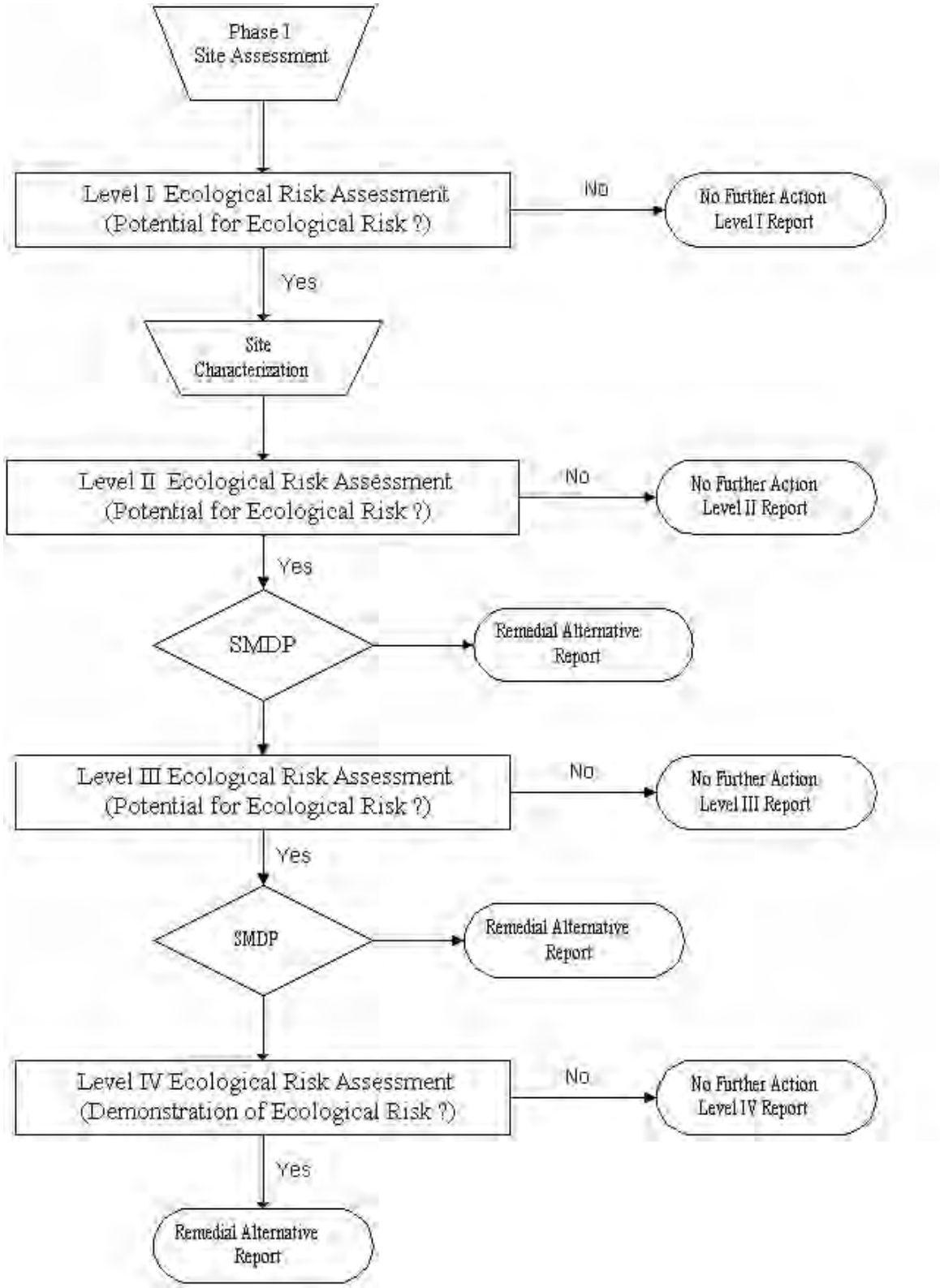
The levels in the ERA process are designed to streamline and focus any ecological investigations that are necessary, and, at each level, to eliminate sites that do not require further ecological assessments from the ecological risk assessment process. Sites enter the ERA process at Level I and may exit at the conclusion of any level provided the results indicate that minimal ecological risk exist at the site, a remedial alternative is chosen to reduce ecological risks to acceptable levels, or no further action has been approved by Ohio EPA DHWM.

Prior to beginning any ERA, the risk assessors should have read and be familiar with the terms, concepts, and approaches discussed in the following framework documents:

- Ohio EPA DHWM, Guidance for Conducting RCRA Ecological Risk Assessments;
- U.S. EPA, Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, Interim Final, June, 5 1997, EPA 540-R-97-006; and,
- U.S. EPA, Guidelines for Ecological Risk Assessment, Final, April 1998, EPA 630-R-95-002F.

The level of effort, detail, and quantity of site data that is required increases as a risk assessment advances from one level to the next. Below is an outline describing the purpose and requirements of each level of an ecological risk assessment:

Figure 1. Ecological Risk Assessment Process.



SMDP = Scientific Management Decision Point

1.1.1 Level I Scoping Ecological Risk Assessment

The purpose of a Level I ERA is to eliminate sites from further ecological risk evaluation that do not have the potential for a current or past release of contaminants of interest (COIs) and non-chemical stressors or, do not contain important ecological resources on or in the locality of the site. The Level I ERA is designed to efficiently determine whether further ecological risk should be evaluated at a particular site. The Level I assessment only requires the results of a Phase I Site Assessment and a site visit/limited field investigation to determine whether or not the site should be evaluated for ecological risks. The following questions are to be answered at the completion of the Level I ERA:

a) Are current or past releases at the site suspected (use Phase I Site Assessment methodology found in Level I Attachment A)?
b) Are important ecological resources present at or in the locality of the site?

If the answer to both questions is yes, then the site is subject to continued ecological investigation by completing a Level II ERA. If however, either of the two questions are answered no, then no further ecological evaluation is required.

1.1.2 Level II Screening Ecological Risk Assessment

The purpose of a Level II ERA is to screen the list of detected chemicals per media as appropriate, evaluate aquatic habitats potentially impacted by the site, and if necessary, revise the conceptual site model, complete a list of ecological receptors, identify potential ecological contaminants of concern (PECOCs) and non-chemical stressors, and other tasks required for further ecological evaluation of the site and impacted habitats. The Level II ERA is to be completed after the full nature and extent of the site contamination has been determined.

COIs and non-chemical stressors detected in terrestrial habitats (*e.g.*, soil) will be screened against the appropriate ecotoxicologically-based screening values in a Level II ERA. In addition, concentrations of chemicals in any medium detected on-site may be compared to concentrations representative of background conditions. Background values are to be determined from media samples taken from areas that have not been impacted by site related or other activities that may have negatively impacted the background locations. Aquatic habitats, may in addition to, or in place of background values, also compare sediment concentrations to the Ohio specific sediment reference values (SRVs) to demonstrate that surface waters have not been impacted by site-related contaminants. Aquatic habitats identified as being impacted by site-related COIs and/or non-chemical stressors, will need to be evaluated using appropriate chemical specific and biological criteria.

The COIs and non-chemical stressors are identified in the Level I ERA due to a history of their use/presence at the site and through the site characterization process following the completion of a Level II ERA. Potential ecological contaminants of concern (PECOCs) are simply the COIs and non-chemical stressors remaining after the screening and evaluation procedures of the Level II ERA are completed. PECOCs and non-chemical stressors may then be carried through a Level III or Level IV ERA, or a remedial action may be chosen for the site based on the results of the Level II ERA.

A scientific management decision point (SMDP) is offered at the completion of a Level II ERA and any of the following levels of the ERA process. The SMDPs are designed to allow those involved with a site to make a decision for remedial action in lieu of pursuing further ecological evaluations. This decision may provide a cost effective way of eliminating ecological risk and reduce unnecessary ecological evaluation, for instance, when only a limited area requires removal or remediation, or when ecological harm at a site is obvious. SMDPs are made to determine one of three following recommendations:

- Continuation of the ecological risk assessment process at the next level;
- Undertake a removal or remedial action after completion of site characterization and a Level II ERA, and necessary Agency approval has been obtained; or,
- No further action.

If ecological stressors in terrestrial habitats are above the screening values, or site-related ecological stressors have been identified in surface water and/or sediments, the following items are to be completed in a Level II ERA:

a) Identify impacted and exposure media (soil, sediment, soil, surface water, and tissue);
b) List PECOCs (contaminants remaining after the screening process) including non-chemical stressors;
c) Assess surface water and sediment quality using the Ohio EPA's chemical specific and biological criteria methodology as appropriate;
d) Revise the conceptual site model (CSM);
e) Identify/list important ecological resources/species (species that are potentially affected) and identify assessment endpoints; and,
f) Make one of the following scientific management (SMDP) decisions:
   1) remedy/remedial action, or,
   2) continue ecological assessment in a Level III (baseline ecological risk assessment).

1.1.3 Level III Baseline Ecological Risk Assessment

The purpose of a Level III ERA is to identify the potential for ecological harm at a site. Specifically, the level III ERA is a formal ecological risk assessment process that includes an exposure assessment, toxicity assessment, risk characterization, and an uncertainty analysis. Potential ecological hazards are evaluated by using the PECOCs and non-chemical stressors identified in a Level II ERA, generic receptors, direct contact evaluations, and food-web models that are provided in the guidance document. The food-web models are used to assess adverse effects caused by the ingestion of contaminated media on the various trophic (feeding) levels identified at the site. The direct contact evaluations are to estimate adverse effects on terrestrial plants and soil invertebrates. The required direct contact evaluations and food-web models are designed to evaluate the most probable exposures and significant effects that could appear at any site.

The hazard values for ecological receptors should be calculated one time only during the risk assessment process. Site-specific parameters are to be used in the hazard calculations to streamline the evaluation and to ensure that hazard quotient values generated from a Level III ERA reflect possible site conditions and are of such value to be used directly for risk management decisions.

At the conclusion of the Level III ERA three choices are given for a SMDP and include:

1) No further action (potential harm to ecological receptors are within the appropriate guidelines);
2) Remedy/remedial action, including risk management; or,
3) Continue ecological assessment in a Level IV (field baseline risk assessment) risk assessment.

1.1.4 Level IV Field Baseline Ecological Risk Assessment

The purpose of a Level IV ERA is to confirm or refute the findings of the Level III ERA through field and biological measurements. The results of a Level IV ERA are to be used to support a more robust weight-of-evidence determination of possible adverse ecological impacts of site-related ecological stressors.

The Level IV guidance document provides information on choosing the appropriate biological measurements that can aid in the determination of whether the Level III ERA results are consistent with field observations and measurements. Due to the complexity of a Level IV ERA and the variety of issues involved with field/population measurements and evaluation, the Level IV guidance consists of an overview of the process and references additional supporting and guidance documents. The Level IV ERA requires considerable over-sight and approval by Ohio EPA DHWM. It is recommended that the appropriate DHWM personnel be contacted once a decision has been made to conduct a Level IV ERA prior to the development of a Level IV work plan.

NOTE: The *Guidance for Conducting RCRA Ecological Risk Assessments* is a continuing work in progress and will be updated as needed to reflect major revisions or changes. It is strongly recommended that facilities/responsible parties contact and work closely with Ohio EPA throughout the ecological risk assessment process.

CHAPTER 2
LEVEL I - SCOPING

2.1 OBJECTIVE

The objective of a Level I (scoping) ecological risk assessment (ERA) is to determine whether there are any reasons to believe that an *important ecological resource* is present or potentially present at or *in the locality of the site*, and to investigate the potential of (a) release(s) of an *ecological stressor*. [Note: See definition section in Chapter 6 for all italicized terms.] Scoping is intended to identify sites that are obviously devoid of important ecological resources, and/or where the Phase I Site Assessment indicates that ecological stressors were not potentially released at the site.

Sites that:

- do not have an important ecological resource; or,
- for which there is no reason to believe a release of any ecological stressor has occurred,

will not be required to continue the ERA process.

A Level I ERA is intended to focus primarily on habitat and Phase I Site Assessment data (*i.e.*, chemical data from the appropriate media are not required for Level I, although adequately validated data may be factored into the decision-making process, as appropriate). Habitat evaluation is required to determine whether important ecological resources are found on or in the locality of the site.

Habitat is assessed to determine the quality and quantity of the environment, and the likelihood that important ecological resources could be affected by potential releases from a site. Phase I Site Assessment data are used to determine the potential for releases of ecological stressors that may have occurred at a site. Historical data are collected by performing a Phase I Site Assessment as described in Attachment A. The Phase I Site Assessment is designed to evaluate the potential of a release of ecological stressors at or in the locality of the site. In this context, special attention should be paid to the requirement to identify all above and below ground migration conduits associated with the suspected, actual or potential releases. Habitat type(s) and quality, and the potential existence of important ecological resources must also be evaluated and documented by using the Level I methods and checklists attached.

2.2 PREREQUISITE

The completion of a Phase I Site Assessment (Attachment A) is required to begin a Level I ERA.

2.3 TASKS

The following tasks are to be completed as part of a Level I ERA:

2.3.1 Task 1 Assess Existing Data

When possible, the following information should be obtained prior to the site visit:

a) Surface area of the site;
b) Present and historical uses of the site and nearby properties;
c) Current and potential future land and/or water use(s);
d) Important ecological resources at or in the locality of the site;
e) Known or suspected presence of threatened and/or endangered species, or any state or federal special status species, or their habitat at or in the locality of the site as evidenced by request and response letters from: U.S. Fish & Wildlife Service (U.S. FWS); the Ohio Department of Natural Resources (ODNR), Ohio Division of Wildlife (ODW) and Division of Natural Areas and Preserves (DNAP); the Ohio EPA Division of Surface Water (DSW) Ecological Assessment Section; local naturalists, or other information sources. See Attachment E for a list of State and Federally Listed Threatened and Endangered species;
f) Accurate site and regional maps showing structures, sampling locations (if available), land use, wetlands, surface water bodies, and *sensitive environments*;
g) Types of ecological stressors potentially released at the site; and,
h) Biological and Water Quality studies performed by Ohio EPA.

It is also recommended that the public be included where applicable during the initial stages of determining whether important ecological resources are present at or in the locality of the site. This will help ensure that public concerns

regarding what constitutes an important ecological resource have been considered.

2.3.2 Task 2 Site Information and Identification of Important Ecological Resources

A site visit is required to directly assess ecological features and conditions of the site and to determine the presence or absence of important ecological resources. An ecologist or biologist with risk assessment experience should be consulted and conduct the site inspection. The site visit should be conducted at a time of the year when ecological features are most apparent (*e.g.*, spring, summer). Visits during the winter months or periods of severe weather are more likely to produce evidence incorrectly indicating the absence of ecological receptors. The site, and if possible, areas in the locality of the site, should be visited. While at the site, or following the site visit, the following activities should be performed:

a) Look for any signs (*e.g.*, visual, olfactory) of a chemical release;
b) Produce a site map (derived from paper maps or from Geographic Information System (GIS) databases) identifying relevant surface features such as water and potential hazardous substances migration pathways, location of buildings, green space etc. Additional maps should be included such as United States Geological Survey (USGS) 7.5 minute quadrangle maps, National Wetland Inventory maps, and National Resource Conservation Service (NRCS) maps, if appropriate, or available;
c) Note any signs (*e.g.*, visual, olfactory) of hazardous substance migration within the site or offsite;
d) Look for signs of habitat within or in the locality of the site that could contain or be used by threatened and/or endangered species or other important ecological receptors;
e) As appropriate, note any signs for groundwater discharge (*e.g.*, seeps, springs) to the surface;
f) Note any natural or anthropogenic disturbances onsite;
g) Make a photographic record of the site with emphasis on ecological features and potential exposure pathways. Photographs should also be identified by time, direction, latitude and longitude and identified on a USGS quadrangle map; and,
h) Complete the Ecological Scoping Checklist (Attachment B), Parts 1-3.

2.3.3 Task 3 Identify Potential Chemical and Non-Chemical Stressors

Based on the Phase I Site Assessment, summarize any potential chemical and non-chemical stressors that may have been released at the site. Please note that identification of chemical and non-chemical stressors for ecological receptors may necessitate a separate identification process than that used for any human health evaluation, since a contaminant not generally considered a threat to human health may be a threat to *biota*. When gathering information on potential chemical and non-chemical stressors, the focus should not be solely on hazardous substances. The investigation should also consider whether or not non-chemical stressors, such as mechanical disturbances, abnormal soil/sediment conditions, or other water quality parameters (*e.g.*, elevated total dissolved solids (TDS), low dissolved oxygen (DO), temperature, extremes in pH, etc.), are potentially contributing to adverse ecological effects. These non-chemical stressors should be identified along with the chemical stressors to provide an insight into the general ecological health at and surrounding the site. The resuts of this evaluation are summarized by completing Attachment B, Part 4.

2.3.4 Task 4 Level I Assessment

Make an estimate, based on the site-specific information gathered in the previous three tasks and professional judgment, as to whether important ecological resources are, or potentially could be impacted by site related ecological stressors. The evaluation results are summarized by completing Attachment C.

Decision 1: Are Ecological Risks Suspected?

Based on information gathered in tasks 1 through 3, do important ecological resources exist at or in the locality of the site, and has there been a release or suspected release of ecological stressors? Specific criteria from Attachment C are as follows:

a) If "**Y**" or "**U**" boxes in Attachment C are checked for Question 2 <u>and</u> any row in Question 1, then a recommendation to move to Level II should be made for an assessment of the appropriate aquatic and/or terrestrial habitat. In completing this Attachment, a lack of knowledge, presence of high uncertainty, or any "unknown" circumstances should be tabulated as a "**U**".

b) If all of the "**No**" boxes in Attachment C are checked, or if only Question 2, or only rows **a** through **e** in Question 1 are checked **"No"**, then the site is highly unlikely to present significant risks to important ecological receptors and a recommendation for no further ecological investigations should be made.

2.3.5 Task 5 Submit Level I Deliverable

This deliverable is a report (see Attachment D, Level I (Scoping) Ecological Risk Assessment Report, for suggested format and content) detailing the results of the data review, the site visit, the evaluation of the presence or absence of important ecological resources, and the potential releases of ecobgical stressors. It should present information in sufficient depth to give risk managers confidence in determining whether important ecological resources and uncontrolled ecological stressors are or are not likely to exist at the site.

Attachment A
Phase I Site Assessment

Purpose:
The purpose of a Phase I Site Assessment is to determine whether any releases have or may have occurred from on or off-site activities. The Phase I Site Assessment is used to help complete Task 3 of the Level I Ecological Risk Assessment. At a minimum, the Phase I Site Assessment should include a review of the historic and current uses of the site, a review of the complete environmental site history, a review of the history of hazardous substances or petroleum release history, and a site inspection.

The Phase I Site Assessment Investigation:
Historic And Current Uses
The purpose of exploring the historic and current uses of the site is to establish a continuous site history from the first industrial or commercial use through the present use. A diligent inquiry of reasonably available historical sources should be made to determine this information. A chain of title investigation using deeds, mortgages, easements of record, and other similar documents that are reasonably available should help establish a history of previous ownerships. Interviews with people who were employed or resided near the site may help identify past uses of the site.

Environmental History Review
This section of the assessment should provide the environmental site history to determine areas suspected of hazardous substance or petroleum management, treatment, storage or disposal, and areas where a release may have occurred. This section should include any previous environmental assessments or studies, property or site assessments and/or geologic studies of the site.

An investigation of the environmental compliance history of the site should be made for both current and past owners or operators. This information can be obtained from U.S. EPA, Ohio EPA, the Ohio Department of Natural Resources (ODNR), and the Bureau of Underground Storage Tank Regulations (BUSTR). Specifically, the following sources may help locate information on environmental compliance history: Federal National Priorities List (NPL), Federal Comprehensive Environmental Response, Compensation, and Liability Information System list (CERCLIS), Federal Resource Conservation and Recovery Act (RCRA) treatment storage and disposal facility list, Federal RCRA generators list, Federal emergency release notification system list, RCRA Info data base (RCRIS), Ohio EPA Division of Hazardous Waste Management (DHWM) files, Ohio EPA Division of Emergency and Remedial Response (DERR) files, Ohio BUSTR registered Underground Storage Tank (UST) list, Ohio BUSTR leaking UST list, Ohio EPA spill data base, ODNR well log information, Community Right-to-Know inventory report records of the State Emergency Response Commission or the Local Emergency Planning Committee, local fire department records, and local health department records. Other federal, state and local agency records and databases, such as those referenced in ASTM Standard E 1527, paragraph 7.2.2, may also help locate additional information. Lastly, interviews with people who were employed or resided near the site may help identify areas that were used for hazardous substance or petroleum management, treatment, storage or disposal, and areas where releases occurred.

A review of these sources should also be conducted on areas surrounding the site to determine if releases from adjoining properties may have migrated onto the site. If information from this search indicates such releases may have occurred, then a "Site Hazardous Substance or Petroleum Release History" review should be performed for these sites as well, to the extent practicably reviewable.

Site Release History
The purpose of this portion of the Phase I Site Assessment is to identify all known or suspected contaminant releases that have or may have occurred on-site or off-site. Specifically, the Phase I Site Assessment should identify, to the extent known or suspected: the contaminant type, the quantity, the date of release, the areas of the site impacted by the release, the media impacted, and any measures taken to address the release, including the result of those measures.

Site Inspection
The purpose of a site inspection is to determine whether any releases have or may have occurred by a physical inspection of the site. A physical inspection of the interior and exterior of all buildings and structures on the site and an inspection of all other areas should be conducted. When conducting the site inspection

the following areas should be identified and documented: underground storage tanks, above-ground storage tanks, wells (including oil and gas wells and underground injection control wells), cans, boxes and other containers, pipes, drains, storm or sanitary sewers, electrical equipment, cables, fuel tanks, oil pans, lagoons, stacks, cooling systems, inventory, pits, piles, landfills, waste or process water treatment systems, equipment and associated structures that contain or previously contained any hazardous substances or petroleum, and areas used for the treatment, storage, management or disposal of any hazardous substances or petroleum.

If any of these sources are identified in the site inspection, the condition of the sources should be documented. Evidence of a release at these sources or any other areas of the site should be noted. Such evidence includes stressed vegetation, spilled materials, discolored soils, or a strong, pungent or noxious odor. Also, any identifiable migration conduits for hazardous substances or petroleum, such as basements, drains, tiles, wells, and utility lines should be documented. Evidence of current and past uses of adjoining properties which may be observed from the site or which are accessible from public rights of way should be included in this section.

Lastly, the general physical condition of the site and the general topographic conditions of the site and areas surrounding the site should be noted. Any physical obstructions which limit the visibility of conditions on the site, including but not limited to buildings, snow or leaf cover, rain, fill, asphalt, or pavement, should be included in this section.

The Phase I Site Assessment Report:

Introduction

The introduction should identify the site and include the legal description of the site. The introduction should also include the date that the Phase I Site Assessment and the written report were completed, the name and job title of each person conducting the investigation, and a summary of the current and intended use of the site.

Identified Areas

The Phase I Site Assessment should identify each area located on or underlying the site which has contained hazardous substances or petroleum at some point in the history of the site. In addition, this section should also identify any area where a release has or may have occurred. If there is reason to believe a release has or may have occurred, but it cannot be visually observed or otherwise defined, then it is necessary to designate as an identified area that portion of the site suspected to be affected by the hazardous substances or petroleum. If it is known that a release of hazardous substances or petroleum occurred on the site but there is no information on the location of the release, then the whole site may be designated as one identified area.

Conclusions

The conclusion section should discuss whether there is any reason to believe that any releases have or may have occurred. If there is any reason to believe that any releases have or may have occurred, the report should identify the hazardous substances or petroleum as Contaminants of Interest (COIs) and identify the areas where these COIs are known or suspected to be present. [Note: Any of the areas and/or COIs identified in the Phase I Site Assessment report may be redelineated or eliminated as a result of additional data collected during the Level I and/or Level II Ecological Risk Assessment.]

Maps

A number of maps should accompany the Phase I Site Assessment report, including: a site location map using the most currently available 7.5 minute USGS topographic map; a site map which identifies significant structures and features, including property lines; a site map which labels the identified areas, and the locations of all known or suspected releases on the site; and a map which identifies all areas surrounding the site which were identified in the "Environmental History Review" as areas that were used for hazardous substance or petroleum management, treatment, storage or disposal. The Phase I Site Assessment should provide latitude and longitude coordinates for the site, and a digitized map should be included, whenever possible.

Review Methodology

This section should include an explanation of all procedures used during the Phase I Site Assessment. This section should also include a summary of all relevant information used to meet the objectives of the Phase I Site Assessment investigation, including: historic and current uses of the site, adjoining properties, and areas

surrounding the site; the environmental history review; the release history on or adjoining the site; any interviews conducted and any site inspections performed.

Statement of Limitations
This section should include a statement of any limitations or qualifications which impacted the Phase I Site Assessment, including an identification and explanation of any sources of information which were not reviewed because they were not publically available, practicably reviewable or otherwise reasonably available.

Bibliography
The bibliography should include any references which identify, to the extent available, a description, date, source, and location of any document reviewed as part of the Phase I Site Assessment, including the name, address and telephone number of any persons interviewed.

Photographs
Sufficient color photograph documentation should establish the site's current condition, the season and weather conditions during the site inspection, and any significant findings discovered during the site inspection. Documentation should include the date that the photograph was taken and a description of the photograph, such as the specific location and direction.

Appendices
The appendices should include all appropriate supporting documentation.

Signed Statement
This section should include a signed statement by the owner/operator or duly authorized representative that performed the Phase I Site Assessment, verifying that: all information is complete and reliable; all of the items outlined in "Phase I Site Assessment Investigation" have been performed to the extent practicably reviewable; and all activities in the "Phase I Site Assessment Investigation" section have either been performed within 180 days prior to Ohio EPA DHWM receiving the assessment, or that subsequent time and/or investigation has not altered the conditions at the site since these activities were performed.

Definitions:
For the purposes of this appendix:

"Areas surrounding the site" means all areas located within one half-mile of the property boundaries.
"Diligent inquiry" means conducting a thorough search of all reasonably available information, and making reasonable efforts to interview people with knowledge about the current and past uses of the site, waste disposal practices, and environmental compliance history.
"Historical sources" means sources of information which help in identifying current or past uses or occupants of a site, such as: aerial photographs, fire insurance maps, property tax files, recorded land title records, United States Geological Survey (USGS) 7.5 minute topographic maps, local street directories, building department records, zoning or land use records.
"Practicably reviewable" means information provided in a form that, upon examination, yields information relevant to the site. Records that cannot feasibly be retrieved by reference to the site location, geographic area in which the site is located, or the name of the owner or operator of the site are not practicably reviewable.
"Publicly available" means the source of the information allows access to the information by anyone upon request.
"Release" means a release of hazardous substances and/or petroleum on, underlying, or emanating from a site including, but not limited to, any release from management, handling, treatment, storage, or disposal activities.

Attachment B
Ecological Scoping Checklist

Part 1			
SITE INFORMATION			
Site Name:		Date:	
Personnel:_____ _____ (Identify team leader)		Time Arrived: Time Departed:	
Site Address:			
Site Location:	Latitude:	Longitude:	
Site Size (acres):			
Weather Conditions (note any unusual conditions):			
Land uses at and adjacent to the site: (Circle all that apply and record at or adjacent)			
Residential	Commercial	Recreational	Industrial
Agricultural	Urban	Green-Space/ Undeveloped	Other:_____

*** Note: This checklist provides a suggested format. The format may be altered to fit the needs of the facility; however, all pertinent information should be presented.

Part 2

SPECIFIC EVALUATION OF ECOLOGICAL RECEPTORS/HABITAT

Terrestrial - Wooded ____% of site

Dominant vegetation (circle one):
Coniferous Deciduous Mixed

Dominant tree diameter at breast height (*dbh*): ____(in)

Evidence/observation of wildlife*: _____

Terrestrial - Shrub/scrub/grasses ____% of site

Dominant vegetation (circle one): Shrub/scrub Grasses

Vegetation density: Dense Patchy Sparse

Prominent height of shrub/scrub: (<2', 2' to 5', >5')

Prominent height of grasses/herbs: (<2', 2' to 5', >5')

Evidence/observation of wildlife*: _____

Terrestrial - Ruderal/Engineered ____% of site

Dominant vegetation/surfaces (circle one):
Landscaped Agricultural Bare ground
Parking lot Artificial surfaces

Dominant vegetation height (0', >0'-2', 2'-5', >5')

Vegetation density: Dense Patchy Sparse

Evidence/observation of wildlife*: _____

Aquatic - Non-Flowing (Lentic) ____% of site

Type: Lake Pond Vernal pool Lagoon
Engineered** Impoundment Reservoir

Water source: Surface water Industrial discharge
Ground water (seeps/springs) Storm water runoff

Discharge point: Surface water Ground water
Wetlands Impoundment

Bottom substrate***: _____

Vegetation: Submerged Emergent Floating

Evidence/observation of wildlife*: _____

Aquatic - Flowing (Lotic) ____% of site

Aquatic life use designation (if available):_____

Type: River Stream Intermittent stream Ditch

Water source: Surface water Industrial discharge
Ground water (seeps/springs) Storm water runoff

Discharge point: Surface water Ground water
Wetlands Impoundment

Bottom substrate***: _____

Vegetation: Submerged Emergent Floating

Evidence/observation of wildlife*: _____

Aquatic - Wetlands ____% of site

Size: _____(acres)

Obvious or designated wetland: Yes No

Water source: Surface water Industrial discharge
Ground water (seeps/springs) Storm water runoff

Discharge point: Surface water Ground water
Wetlands Impoundment

Bottom substrate***: _____

Vegetation: Submerged Emergent Floating

Evidence/observation of wildlife*: _____

* Wildlife includes: macroinvertebrates, reptiles, amphibians, birds, mammals and fish.
** Engineered can mean any surface water body that has been artificially created or significantly altered.
*** Bottom substrate types include but not limited to: cobble, gravel, sand, silt, clay, muck, artificial (*e.g.*, concrete).

Part 3
Ecologically Important Resources Observed

Part 4		
CONTAMINANTS OF INTEREST		
Contaminants of Interest and *Ecological Stressors* (Types, names including CASRN, classes, or specific *hazardous substances* and non-chemical stressors either known or suspected)	Onsite (O) or Adjacent (A) to the site	Media (soil, sediment, surface water, groundwater (seeps/springs))

Attachment C

EVALUATION OF POTENTIAL ECOLOGICAL HARM		**Y**	**N**	**U**
1) Are ecological stressors present or potentially present in:				
	a. Soil?			
	b. Surface Water?			
	c. Sediment?			
	d. Groundwater?			
	e. Other (biotic media)?			
2) Are important ecological resources located at or in the locality of the site?				

"Y" = yes; "N" = No, "U" = Unknown (counts as a "Y")

When answering the above questions, consider the following:

- Known or suspected presence of ecological stressors stored, used or manufactured at the site.
- Ability of ecological stressors to migrate from one medium to another.
- The mobility of the various media.
- Transfer of contaminants through food webs and uptake of chemicals by organisms.
- The presence of important ecological resources, including surface waters on or in the locality of the site.

(a) If "Y" or "U" boxes in Attachment C are checked for Question 2 <u>and</u> any row in Question 1, then a recommendation to move to Level II should be made for an assessment of the appropriate aquatic and/or terrestrial habitat. In completing this attachment, a lack of knowledge, presence of high uncertainty, or any "unknown" circumstances should be tabulated as a "U".

(b) If all of the "No" boxes in Attachment C are checked, or if <u>only</u> Question 2, or <u>only</u> rows a through e in Question 1 are checked "No", then the site is highly unlikely to present significant risks to important ecological receptors and a recommendation for no further ecological investigations should be made.

Attachment D
Level I Deliverable - Level 1 (Scoping) Ecological Risk Assessment Report
Outline

(1) EXISTING DATA SUMMARY
- (a) Site location (Part 1, Attachment B)
- (b) Site history (Summary from Phase 1 Site Assessment)
- (c) Site land and/or water use(s)
  - (i) Current
  - (ii) Future (list reasonable potential uses)
- (d) Known or suspected hazardous substance releases
- (e) Threatened and/or endangered species (USFWS/ODNR/DOW data)

(2) SITE VISIT SUMMARY
- (a) Ecological features (Part 2, Attachment B)
- (b) Ecologically important species/habitats (Part 3, Attachment B)
  - (i) Threatened and/or endangered species
  - (ii)Threatened and/or endangered species habitat
- (c) Contaminants of Interest (Part 4, Attachment B)
- (d) Exposure pathways (Attachment C)

(3) RECOMMENDATIONS

(4) ATTACHMENTS
- (a) Regional map showing location of site
- (b) Local map showing site in relation to adjacent property
- (c) Site map
- (d) Sketch/develop a map of ecological features as an overlay to the site map or as a separate map.
- (e) Sketch/develop a map of known or suspected extent of hazardous substances as an overlay to the site map or as a separate map
- (f) Summary of Phase I Site Assessment report
- (g) Site photograph(s)
- (h) Copies of letters to and from USFWS and ODNR, responding to queries about threatened and endangered species

(5) REFERENCES / DATA SOURCES

Attachment E

Division of Wildlife
Ohio Department of Natural Resources

Wildlife That are Considered to be Endangered,
Threatened, Species of Concern, Special Interest,
Extirpated, or Extinct
in Ohio

Inservice Note
May2002

The Division of Wildlife's mission is to conserve and improve the fish and wildlife resources and their habitats, and promote their use and appreciation by the public so that these resources continue to enhance the quality of life for all Ohioans. The Division has legal authority over Ohio's fish and wildlife, which includes about 56 species of mammals, 200 species of breeding birds, 84 species and subspecies of amphibians and reptiles, 170 species of fish, 100 species of mollusks and 20 species of crustaceans. In addition, there are thousands of species of insects and other invertebrates which fall under the Division's jurisdiction. Furthermore, Ohio law grants authority to the chief of the Division to adopt rules restricting the taking or possession of native wildlife threatened with statewide extirpation and to develop and periodically update a list of endangered species (Ohio Revised Code 1531.25).

The status of native wildlife species is very important to the Division. While the listing process identifies individual wildlife species needing protection, it also serves as a powerful tool in the Division's planning process. It provides direction for the allocation of personnel time and funds in the Division programs and projects.

The first list of Ohio's endangered species was adopted in 1974 and included 71 species. An extensive examination of the list is conducted every five years. The Division seeks input from our staff along with other noted professional and amateur wildlife experts across Ohio. In 2001, as part of our comprehensive management plan, the Division initiated a reevaluation of the endangered species list. During this process, the need for an additional state-list category was recognized and has been designated as "Special Interest". The name of the previous special interest category has been changed to "Species of Concern," but retains its original definition.

Therefore in addition to endangered, the Division uses five other categories, threatened, species of concern, special interest, extirpated, and extinct, to further define the status of selected wildlife. These categories and the species contained within them are dynamic and will be revised as our knowledge of the status of Ohio's wildlife evolves.

Definitions of these categories, a summary of the numbers of species and subspecies in each category, and the list of species and subspecies in each category follow:

ENDANGERED - A native species or subspecies threatened with extirpation from the state. The danger may result from one or more causes, such as habitat loss, pollution, predation, interspecific competition, or disease.

THREATENED - A species or subspecies whose survival in Ohio is not in immediate jeopardy, but to which a threat exists. Continued or increased stress will result in its becoming endangered.

SPECIES OF CONCERN - A species or subspecies which might become threatened in Ohio undercontinued or increased stress. Also, a species or subspecies for which there is some concern but forwhich information is insufficient to permit an adequate status evaluation. This category may contain species designated as furbearer or game species but whose statewide population is dependent on the quality and/or quantity of habitat and is not adversely impacted by regulated harvest.

SPECIAL INTEREST- A species that occurs periodically and is capable of breeding in Ohio. It is at the edge of a larger, contiguous range with viable population(s) within the core of its range. These species have no federal endangered or threatened status, are at low breeding densities in the state, and have not been recently released to enhance Ohio's wildlife diversity. With the exception of efforts to conserve occupied areas, minimal management efforts will be directed for these species because it is unlikely to result in significant increases in their populations within the state.

EXTIRPATED - A species or subspecies that occurred in Ohio at the time of European settlement and that has since disappeared from the state.

EXTINCT - A species or subspecies that occurred in Ohio at the time of European settlement and that has since disappeared from its entire range.

Number of Species in Major Taxa Classified as Endangered, Threatened, Species of Concern, Special Interest, Extirpated, or Extinct in Ohio, May 2002.

Taxon	Endangered	Threatened	Species of Concern	Special Interest	Extirpated	Extinct
Mammals	5	0	8	0	9	0
Birds	19	8	13	30	5	2
Reptiles	5	2	8	0	0	0
Amphibians	5	1	1	0	0	0
Fishes	24	13	9	0	5	2
Mollusks	24	4	9	0	14	5
Crayfishes	0	1	2	0	0	0
Isopods	0	0	2	0	0	0
Pseudoscorpions	0	0	1	0	0	0
Dragonflies	13	1	1	0	0	0
Damselflies	2	1	0	0	0	0
Caddisflies	3	6	3	0	0	0
Mayflies	2	0	1	0	0	0
Midges	1	3	1	0	0	0
Crickets	0	0	1	0	0	0
Butterflies	7	1	2	1	1	0
Moths	14	4	23	10	0	0
Beetles	3	2	6	0	0	0
Total	127	47	91	41	34	9

ENDANGERED

MAMMALS

Bobcat	*Felis rufus*
Snowshoe Hare	*Lepus americanus*
Indiana myotis *E	*Myotis sodalis*
Allegheny woodrat	*Neotoma magister*
Black bear	*Ursus americanus*

BIRDS

American bittern	*Botaurus lentiginosus*
Cattle Egret	*Bubulcus ibis*
Piping plover *E	*Charadrius melodus*
Black tern	*Chlidonias niger*
Lark sparrow	*Chondestes grammacus*
Northern harrier	*Circus cyaneus*
Trumpeter swan	*Cygnus buccinator*
Kirtland's warbler *E	*Dendroica kirtlandii*
Snowy egret	*Egretta thula*
Peregrine falcon	*Falco peregrinus*
Sandhill crane	*Grus canadensis*
Bald eagle *T	*Haliaeetus leucocephalus*
Loggerhead shrike	*Lanius ludovicianus*
Osprey	*Pandion haliaetus*
King rail	*Rallus elegans*
Yellow-bellied sapsucker	*Sphyrapicus varius*
Common tern	*Sterna hirundo*
Bewick's wren	*Thryomanes bewickii*
Golden-winged warbler	*Vermivora chrysoptera*

REPTILES

Timber rattlesnake	*Crotalus horridus horridus*
Copperbelly water snake *T	*Nerodia erythrogaster neglecta*
Lake Erie Water Snake *T	*Nerodia sipedon insularum*
Eastern massasauga *C	*Sistrurus catenatus*
Eastern plains garter snake	*Thamnophis radix radix*

AMPHIBIANS

Blue-spotted salamander	*Ambystoma laterale*
Green salamander	*Aneides aeneus*
Eastern hellbender *M	*Cryptobranchus a. alleganiensis*
Cave salamander	*Eurycea lucifuga*
Eastern spadefoot	*Scaphiopus holbrookii*

FISHES

Lake sturgeon	*Acipenser fulvescens*
Pirate perch	*Aphredoderus sayanus*
Longnose sucker	*Catostomus catostomus*
Cisco (or Lake herring)	*Coregonus artedi*
Blue sucker	*Cycleptus elongatus*
Spotted darter	*Etheostoma maculatum*
Western banded killifish	*Fundulus diaphanus menona*
Goldeye	*Hiodon alosoides*
Mississippi silvery minnow	*Hybognathus nuchalis*
Ohio lamprey	*Ichthyomyzon bdellium*
Northern brook lamprey	*Ichthyomyzon fossor*
Mountain brook lamprey	*Ichthyomyzon greeleyi*
Blue catfish	*Ictalurus furcatus*
Spotted gar	*Lepisosteus oculatus*
Shortnose gar	*Lepisosteus platostomus*
Speckled chub	*Macrhybopsis aestivalis*
Popeye shiner	*Notropis ariommus*
Mountain madtom	*Noturus eleutherus*
Blackchin shiner	*Notropis heterodon*
Blacknose shiner	*Notropis heterolepis*
Northern madtom	*Noturus stigmosus*
Scioto madtom *E	*Noturus trautmani*
Pugnose minnow	*Opsopoeodus emiliae*
Shovelnose sturgeon	*Scaphirhynchus platorynchus*

ENDANGERED

MOLLUSKS

Fanshell *E	*Cyprogenia stegaria*
Butterfly	*Ellipsaria lineolata*
Elephant-ear	*Elliptio crassidens crassidens*
Purple catspaw *E	*Epioblasma o. obliquata*
White catspaw *E	*Epioblasma obliquata perobliqua*
Northern riffleshell *E	*Epioblasma torulosa rangiana*
Snuffbox	*Epioblasma triquetra*
Ebonyshell	*Fusconaia ebena*
Long-solid	*Fusconaia maculata maculata*
Pink mucket *E	*Lampsilis orbiculata*
Sharp-ridged pocketbook	*Lampsilis ovata*
Yellow sandshell	*Lampsilis teres*
Eastern pondmussel	*Ligumia nasuta*
Washboard	*Megalonaias nervosa*
Sheepnose	*Plethobasus cyphyus*
Clubshell *E	*Pleurobema clava*
Ohio pigtoe	*Pleurobema cordatum*
Pyramid pigtoe	*Pleurobema rubrum*
Rabbitsfoot	*Quadrula cylindrica cylindrica*
Monkeyface	*Quadrula metanevra*
Wartyback	*Quadrula nodulata*
Purple lilliput	*Toxolasma lividus*
Rayed bean	*Villosa fabalis*
Little spectaclecase	*Villosa lienosa*

DRAGONFLIES

Canada darner	*Aeshna canadensis*
Mottled damer	*Aeshna clepsydra*
American emerald	*Cordulia shurtleffi*
Racket-tailed emerald	*Dorocordulia libera*
Plains clubtail	*Gomphurus externus*
Uhler's sundragon	*Helocordulia uhleri*
Blue corporal	*Ladona deplanata*
Chalk-fronted corporal	*Ladona julia*
Frosted whiteface	*Leucorrhinia frigida*
Yellow-sided skimmer	*Libellula flavida*
Elfin skimmer	*Nannothemis bella*
Hine's emerald *E	*Somatochlora hineana*
Brush-tipped emerald	*Somatochlora walshii*

DAMSELFLIES

Seepage dancer	*Argia bipunctulata*
Lilypad forktail	*Ischnura kellicotti*

CADDISFLIES

Chimarra socia
Oeceetis eddlestoni
Brachycentrus numerosus

MAYFLIES

Rhithrogena pellucida
Litobrancha recurvata

MIDGES

Rheopelopia acra

ENDANGERED

BUTTERFLIES

Swamp metalmark	*Calephelis muticum*
Persius dusky wing	*Erynnis persius*
Frosted elfin	*Incisalia irus*
Karner blue *E	*Lycaeides melissa samuelis*
Purplish copper	*Lycaena helloides*
Mitchell's satyr *E	*Neonympha mitchellii*
Regal fritillary	*Speyeria idalia*

MOTHS

Graceful underwing	*Catocala gracilis*
Unexpected cycnia	*Cycnia inopinatus*
Pointed sallow	*Epiglaea apiata*
Hebard's noctuid moth	*Erythroecia hebardi*
	Hypocoena enervata
	Lithophane semiusta
	Melanchra assimilis
	Papaipema silphii
	Papaipema beeriana
	Spartiniphaga inops
	Trichoclea artesta
	Tricholita notata
	Ufeus plicatus
	Ufeus satyricus

BEETLES

American burying beetle *E	*Nicrophorus americanus*
Kramer's cave beetle	*Pseudanophthalmus krameri*
Ohio cave beetle	*Pseudanophthalmus ohioensis*

THREATENED

BIRDS

Upland sandpiper	*Bartramia longicauda*
Hermit thrush	*Catharus guttatus*
Least flycatcher	*Empidonax minimus*
Least bittern	*Ixobrychus exilis*
Dark-eyed junco	*Junco hyemalis*
Yellow-crowned night-heron	*Nyctanassa violacea*
Black-crowned night-heron	*Nycticorax nycticorax*
Barn owl	*Tyto alba*

REPTILES

Kirtland's snake	*Clonophis kirtlandii*
Spotted Turtle	*Clemmys guttata*

AMPHIBIANS

Mud salamander	*Pseudotriton montanus*

FISHES

American eel	*Anguilla rostrata*
Rosyside dace	*Clinostomus funduloides*
Lake chubsucker	*Erimyzon sucetta*
Bluebreast darter	*Etheostoma camurum*
Tippecanoe darter	*Etheostoma tippecanoe*
Tonguetied minnow	*Exoglossum laurae*
Greater redhorse	*Moxostoma valenciennesi*
Bigeye shiner	*Notropis boops*
Bigmouth shiner	*Notropis dorsalis*
Channel darter	*Percina copelandi*
River darter	*Percina shumardi*
Paddlefish *M	*Polyodon spathula*
Brook trout	*Salvelinus fontinalis*

MOLLUSKS

Black sandshell	*Ligumia recta*
Threehorn wartyback	*Obliquaria reflexa*
Fawnsfoot	*Truncilla donaciformis*
Pondhorm	*Uniomerus tetralasmus*

DRAGONFLIES

Riffle snaketail	*Ophiogomphus carolus*

DAMSELFLIES

River jewelwing	*Calopteryx aequabilis*

CADDISFLIES

	Hydroptila albicornis
	Hydroptila artesa
	Hydroptila koryaki
	Hydroptila talledaga
	Hydroptila valhalla
	Psilotreta indecisa

MIDGES

	Apsectrotanypus johnsoni
	Bethbilbeckia floridensis
	Radotanypus florens

CRAYFISHES

Sloan's crayfish	*Orconectes sloanii*

BUTTERFLIES

Sliver-bordered fritillary	*Boloria selene*

THREATENED

MOTHS

Wayward nymph	*Catocala antinympha*
	Fagitana littera
The pink-streak	*Faronta rubripennis*
	Spartiniphaga panatela

BEETLES

	Cicindela hirticollis
Cobblestone tiger beetle	*Cicindela marginipennis*

SPECIES OF CONCERN

MAMMALS

Star-nosed mole	*Condylura cristata*
Rafinesque's big-eared bat	*Corynorhinus rafinesquii*
Southern red-backed vole	*Clethrionomys gapperi*
Ermine	*Mustela erminea*
Eastern small-footed bat	*Myotis subulatus*
Wooland jumping mouse	*Napaeozapus insignis*
Pygmy shrew	*Sorex hoyi*
Badger	*Taxidea taxus*

BIRDS

Sharp-shinned hawk	*Accipiter striatus*
Henslow's sparrow	*Ammodramus henslowii*
Great egret	*Casmerodius albus*
Marsh wren	*Cistothorus palustris*
Sedge wren	*Cistothorus platensis*
Northern bobwhite	*Colinus virginianus*
Black vulture	*Coragyps atratus*
Cerulean warbler	*Dendroica cerulea*
Bobolink	*Dolichonyx oryzivorous*
Common moorhen	*Gallinula chloropus*
Sora rail	*Porzana carolina*
Prothonotary warbler	*Protonotaria citrea*
Virginia rail	*Rallus limicola*

MOLLUSKS

Elktoe	*Alasmidonta marginata*
Flat floater	*Anodonta suborbiculata*
Purple wartyback	*Cyclonaias tuberculata*
Wavy-rayed lampmussel	*Lampsilis fasciola*
Creek helsplitter	*Lasmigona compressa*
Round pig-toe	*Pleurobema sintoxia*
Kidneyshell	*Ptychobranchus fasciolaris*
Salamander mussel	*Simpsonaias ambigua*
Deertoe	*Truncilla truncata*

REPTILES

Eastern fox snake	*Elaphe vulpina gloydi*
Blanding's turtle	*Emydoidea blandingi*
Coral skink	*Eumeces anthracinus*
False map turtle	*Graptemys pseudogeographica*
Black king snake	*Lampropeltis getula nigra*
Rough green snake	*Opheodrys aestivus*
Eastern box turtle	*Terrapene carolina*
Eastern garter snake (melanistic)	*Thamnophis sirtalis sirtalis*

AMPHIBIANS

Four-toed salamander	*Hemidactylium scutatum*

FISHES

Eastern sand darter	*Ammocrypta pellucida*
Lake whitefish	*Coregonus clupeaformis*
Spoonhead sculpin	*Cottus ricei*
Muskellunge	*Esox masquinongy*
Least darter	*Etheostoma microperca*
Iowa darter	*Etheostoma exile*
Burbot	*Lota lota*
River redhorse	*Moxostoma carinatum*
Lake trout	*Salvelinus namaycush*

CRAYFISHES

Great Lakes crayfish	*Orconectes propinquus*
Northern crayfish	*Orconectes virilis*

SPECIES OF CONCERN

DRAGONFLIES	
Tiger spiketail	*Cordulegaster erronea*
MAYFLIES	
	Stenonema ithica
MIDGES	
	Cantopelopia gesta
CADDISFLIES	
	Asynarchus montanus
	Hydroptila chattanooga
	Nemotaulius hostilis
BUTTERFLIES	
Two-spotted Skipper	*Euphyes bimacula*
Grizzled skipper	*Pyrgus cantaureae wyandot*
MOTHS	
	Agonopterix pteleae
	Agroperina lutosa
	Amolita roseola
	Apamea mixta
	Brachylomia algens
	Capis curvata
Precious underwing	*Catocala pertiosa*
	Chytonix sensilis
Looper moth	*Euchlaena milnei*
Buck moth	*Hemileuca maia*
Goat sallow	*Homoglaea hircina*
Scurfy quaker	*Homorthodes f. furfurata*
	Macrochilo bivittata
	Paectes abrostolella
Columbine borer	*Papaipema leucostigma*
Bracken borer moth	*Papaipema pterisii*
Osmunda borer moth	*Papaipema speciosissima*
	Phalaenostola hanhami
Purple arches	*Polia purpurissata*
One-eyed sphinx	*Smerinthus cerisyi*
	Tarachidia binocula
	Trichosilia manifesta
BEETLES	
	Cicindela ancocisconensis
	Cicindela cuprascens
	Cicindela cursitans
	Cicindela macra
	Cicindela splendida
Six-banded longhorn beetle	*Dryobius sexnotatus*
ISOPODS	
Fern cave isopod	*Caecidotea filicispeluncae*
Frost cave isopod	*Caecidotea rotunda*
PSEUDOSCORPIONS	
Buckskin cave pseudoscorpion	*Apochthonius hobbsi*
CRICKETS	
Laricis tree cricket	*Oecanthus laricis*

SPECIAL INTEREST

BIRDS	
Northern saw-whet owl	*Aegolius acadicus*
Northern pintail	*Anas acuta*
American widgeon	*Anas americana*
Northern shoveler	*Anas clypeata*
Green-winged teal	*Anas crecca*
Gadwall	*Anas strepera*
Short-eared owl	*Asio flammeus*
Long-eared owl	*Asio otus*
Redhead duck	*Aythya americana*
Chuck-will's-widow	*Caprimulgus carolinensis*
Pine siskin	*Carduelis pinus*
Purple finch	*Carpodacus purpureus*
Brown creeper	*Certhia americana*
Black-throated blue warbler	*Dendroica caerulescens*
Blackburnian warbler	*Dendroica fusca*
Magnolia warbler	*Dendroica magnolia*
Little blue heron	*Egretta caerulea*
Common snipe	*Gallinago gallinago*
Blue grosbeck	*Guiraca caerulea*
Black rail	*Laterallus jamaicensis*
Mourning warbler	*Oporornis philadelphia*
Ruddy duck	*Oxyura jamaicensis*
Wilson's phalarope	*Phalaropus tricolor*
Golden-crowned kinglet	*Regulus satrapa*
Northern waterthrush	*Seiurus noveboracensis*
Red-breasted nuthatch	*Sitta canadensis*
Western meadowlark	*Sturnella neglecta*
Winter wren	*Troglodytes troglodytes*
Bell's vireo	*Vireo bellii*
Canada warbler	*Wilsonia canadensis*
Yellow-headed blackbird	*Xanthocephalus xanthocephalus*
BUTTERFLIES	
Olympia marblewing	*Euchloe olympia*
MOTHS	
Subflava sedge borer moth	*Archanara subflava*
	Calophasia lunula
	Caradrina meralis
	Catocala marmorata
	Catocala maestosa
Slender clearwing	*Hemaris gracilis*
	Leucania insueta
	Protorthodes incincta
	Sphinx lucitiosa
	Tathoryhnchus exsiccatus

EXTIRPATED

MAMMALS

Bison	*Bison bison*
Timber wolf	*Canis lupus*
Wapiti	*Cervus canadensis*
Porcupine	*Erethizon dorsatum*
Lynx	*Felis canadensis*
Mountain lion [*E]	*Felis concolor*
Marten	*Martes americanus*
Fisher	*Martes pennanti*
Rice rat	*Oryzomys palustris*

BIRDS

Bachman's sparrow	*Aimophila aestivalis*
Ivory-billed woodpecker	*Campephilus principalis*
Common raven	*Corvus corax*
American swallow-tailed kite	*Elanoides forficatus*
Greater prairie chicken	*Tympanuchus cupido*

FISHES

Crystal darter	*Ammocrypta asprella*
Alligator gar	*Lepisosteus spatula*
Pugnose shiner	*Notropis anogenus*
Gilt darter	*Percina evides*
Longhead darter	*Percina macrocephala*

MOLLUSKS

Mucket	*Actinonaias ligamentina*
Rock pocketbook	*Arcidens confragosus*
Spectaclecase	*Cumberlandia monodonta*
Tubercled blossom	*Epioblasma t. torulosa*
Cracking pearly mussel *E	*Hemistena lata*
Western sand shell	*Ligumia subrostrata*
Hickorynut	*Obovaria olivaria*
Ring pink	*Obovaria retusa*
White wartyback	*Plethobesus cicatricosus*
Orange-footed pearly mussel *E	*Plethobasus cooperianus*
Rough pigtoe *E	*Pleurobema plenum*
Fat pocketbook *E	*Potamilus capax*
Winged mapleleaf *E	*Quadrula fragosa*
Ellipse	*Venustaconcha e. ellipsiformis*

BUTTERFLIES

Mustard white	*Pieris napi*

EXTINCT

MAMMALS

[Eastern Elk]	*[Cervus canadensis canadensis]*

BIRDS

Passenger pigeon	*Ectopistes migratorius*
Carolina parakeet	*Conuropis carolinensis*

FISHES

[Longjaw cisco]	*[Coregonus alpanae]*
Harelip sucker	*Lagochila lacera*
Blue pike	*Stizostedion vitreum glaucum*

MOLLUSKS

Leafshell	*Epioblasma flexuosa*
Forkshell	*Epioblasma lewisi*
Round snuffbox	*Epioblasma personata*
Cincinnati riffleshell	*Epioblasma phillipsi*
[Tennessee riffleshell]	*[Epioblasma propiqua]*
Scioto pigtoe	*Pleurobema bournianum*

Federal status codes:
E - Endangered
T - Threatened
C - Candidate
M - Monitored in Ohio
PT - Proposed to be listed as threatened
[ ] - Listed only by US FWS

Please see: Division of Wildlife, Ohio Department of Natural Resources at: http://www.dnr.state.oh.us/
for additional and current information about threatened and endangered animal species.

ENDANGERED

PLANTS

Striped maple	*Acer pensylvanicum*
Northern monkshood T*	*Aconitum noveboracense*
Southern monkshood	*Aconitum uncinatum*
Ear-leaf foxglove	*Agalinis auriculata*
Gattinger's foxglove	*Agalinis gattingeri*
Small purple foxglove	*Agalinis purpurea var. parviflora*
Skinner's foxglove	*Agalinis skinneriana*
Rock serviceberry	*Amelanchier sanguinea*
Common brome-grass	*Andropogon virginicus var. abbreviatus*
Long tail moss	*Anomodon viticulosus*
Limestone rock-cress	*Arabis divaricarpa*
Drummond's rock-cress	*Arabis drummondii*
Western hairy rock-cress	*Arabis hirsuta var. pycnocarpa*
Missouri rock-cress	*Arabis missouriensis*
Spreading rock-cress	*Arabis patens*
Bristly sarsaparilla	*Aralia hispida*
Bearberry	*Arctostaphylos uva-ursi*
Spreading sandwort	*Arenaria patula*
Dragon's-mouth	*Arethusa bulbosa*
False arrow-feather	*Aristida necopina*
Beach wormwood	*Artemisia campestris*
Bottomland aster	*Aster ontarionis*
Creeping aster	*Aster surculosus*
Cooper's milk-vetch	*Astragalus neglectus*
Prairie fern-leaf false foxglove	*Aureolaria pedicularia var. ambigens*
Woodland fern-leaf false foxglove	*Aureolaria pedicularia var. pedicularia*
Blue false indigo	*Baptisia australis*
Twisted teeth moss	*Barbula indica var. indica*
Triangle grape-fern	*Botrychium lanceolatum*
Least grape-fern	*Botrychium simplex*
Ethereal elf cap moss	*Buxbaumia minakatae*
Bartley's reed grass	*Calamagrostis porteri ssp. insperata*
Harebell	*Campanula rotundifolia*
Rock-loving swan-necked moss	*Campylostelium saxicola*
Texas shield lichen	*Canoparmelia texana*
American cuckoo-flower	*Cardamine pratensis var. palustris*
Northern fox sedge	*Carex alopecoidea*
Drooping wood sedge	*Carex arctata*
Bush's sedge	*Carex bushii*
Thin-leaved sedge	*Carex cephaloidea*
Short fringed sedge	*Carex crinita var. brevicrinis*
Cypress-knee sedge	*Carex decomposita*
Two-seeded sedge	*Carex disperma*
Little prickly sedge	*Carex echinata*
Garber's sedge	*Carex garberi*
Mud sedge	*Carex limosa*
Long's sedge	*Carex longii*
Louisiana sedge	*Carex louisianica*
Fire sedge	*Carex lucorum*
False hop sedge	*Carex lupuliformis*
Fernald's sedge	*Carex merritt-fernaldii*
Flat-spiked sedge	*Carex planispicata*
Northern bearded sedge	*Carex pseudocyperus*
Reflexed bladder sedge	*Carex retrorsa*
Hay sedge	*Carex siccata*
Lined sedge	*Carex striatula*
Silkgrass	*Chrysopsis graminifolia*
Northern wood-reed	*Cinna latifolia*
Bluebead-lily	*Clintonia borealis*
Long-bracted orchid	*Coeloglossum viride*

ENDANGERED

PLANTS

Dotted pulp lichen	*Collema conglomeratum*
Dusky jelly lichen	*Collema fuscovirens*
Early stoneroot	*Collinsonia verticillata*
Early coral-root	*Corallorhiza trifida*
Dwarf hawthorn	*Crataegus uniflora*
Hazel dodder	*Cuscuta coryli*
Five-angled dodder	*Cuscuta pentagona*
Pale umbrella-sedge	*Cyperus acuminatus*
Rough umbrella-sedge	*Cyperus dipsaciformis*
Many-flowered umbrella-sedge	*Cyperus lancastriensis*
Reflexed umbrella-sedge	*Cyperus refractus*
Small yellow lady's-slipper	*Cypripedium calceolus var parviflorum*
White lady's-slipper	*Cypripedium candidum*
Sessile tick-trefoil	*Desmodium sessilifolium*
Pink dot lichen	*Dibaesis absoluta*
Cumberland grain o' wheat moss	*Diphyscium cumberlandianum*
Little whitlow-grass	*Draba brachycarpa*
Spathulate-leaved sundew	*Drosera intermedia*
Log fern	*Dryopteris celsa*
Clinton's wood fern	*Dryopteris clintoniana*
Burhead	*Echinodorus rostratus*
Caribbean spikerush	*Eleocharis caribaea*
Engelmann's spikerush	*Eleocharis engelmannii*
Ovate spikerush	*Eleocharis ovata*
Least spikerush	*Eleocharis parvula*
Few-flowered spikerush	*Eleocharis pauciflora*
Robbins' spikerush	*Eleocharis robbinsii*
Wolf's spikerush	*Eleocharis wolfii*
Fireweed	*Epilobium angustifolium*
White-buttons	*Eriocaulon septangulare*
Western wallflower	*Erysimum arkansanum*
Goldenstar	*Erythronium rostratum*
Hyssop thoroughwort	*Eupatorium hyssopifolium*
Glade spurge	*Euphorbia purpurea*
Round-leaved spurge	*Euphorbia serpens*
Filmy fissidens	*Fissidens hyalinus*
Cottonweed	*Froelichia floridana*
Marsh bedstraw	*Galium palustre*
Prairie gentian	*Gentiana puberulenta*
Soapwort gentian	*Gentiana saponaria*
Sampson's snakeroot	*Gentiana villosa*
Bicknell's crane's-bill	*Geranium bicknellii*
Sharp-glumed manna grass	*Glyceria acutiflora*
Winged cudweed	*Gnaphalium viscosum*
Mud-plantain	*Heteranthera reniformis*
Long-bearded hawkweed	*Hieracium longipilum*
Navelwort	*Hydrocotyle umbellata*
Lakeside daisy T*	*Hymenoxys herbacea*
Canadian St. John's wort	*Hypericum canadense*
Coppery St. John's wort	*Hypericum denticulatum*
Few-flowered St. John's-wort	*Hypericum ellipticum*
Least St. John's wort	*Hypericum gymnanthum*
Wrinkled-leaved marsh hypnum	*Hypnum pratense*
Leafy blue flag	*Iris brevicaulis*
Appalachian quillwort	*Isoetes engelmannii*
Small whorled pogonia T*	*Isotria medeoloides*
Diffuse rush	*Juncus diffusissimus*
Greene's rush	*Juncus greenei*
Inland rush	*Juncus interior*
Flat-leaved rush	*Juncus platyphyllus*
Ground juniper	*Juniperus communis*
June grass	*Koeleria macrantha*
Hairy tall lettuce	*Lactuca hirsuta*
Wild pea	*Lathyrus venosus*

ENDANGERED

PLANTS

Labrador-tea	*Ledum groenlandicum*
Catchfly grass	*Leersia lenticularis*
Old-field toadflax	*Linaria canadensis*
Drummond's dwarf bulrush	*Lipocarpha drummondii*
Northern prostrate clubmoss	*Lycopodiella margueritae*
Northern appressed clubmoss	*Lycopodiella subappressa*
One-cone clubmoss	*Lycopodium lagopus*
Bigleaf magnolia	*Magnolia macrophylla*
Three-flowered melic	*Melica nitens*
Dotted horsemint	*Monarda punctata*
One-flowered wintergreen	*Moneses uniflora*
Plains muhlenbergia	*Muhlenbergia cuspidata*
Bayberry	*Myrica pensylvanica*
Two-leaved water-milfoil	*Myriophyllum heterophyllum*
Green water-milfoil	*Myriophyllum verticillatum*
Thread-like naiad	*Najas gracillima*
Bullhead-lily	*Nuphar variegata*
Cleland's evening-primrose	*Oenothera clelandii*
Limestone adder's-tongue	*Ophioglossum engelmannii*
Large-leaved mountain-rice	*Oryzopsis asperifolia*
Commons' panic-grass	*Panicum commonsianum*
Lindheimer's panic-grass	*Panicum lindheimeri*
Long-panicled panic-grass	*Panicum perlongum*
Early panic-grass	*Panicum praecocius*
Narrow-headed panic-grass	*Panicum spretum*
Tuckerman's panic-grass	*Panicum tuckermanii*
Warty panic-grass	*Panicum verrucosum*
Villous panic-grass	*Panicum villosissimum*
Spotted panic-grass	*Panicum yadkinense*
Madagascar shield lichen	*Parmotrema madagascariaceum*
Cliff-green	*Paxistima canbyi*
Smooth beard tongue	*Penstemon laevigatus*
Small-flowered scorpion-weed	*Phacelia dubia*
Blue scorpion-weed	*Phacelia ranunculacea*
Mountain phlox	*Phlox latifolia*
Carolina leaf-flower	*Phyllanthus caroliniensis*
Virginia ground-cherry	*Physalis virginiana*
Brown stipplecase	*Placidium lachneum*
Woolly plantain	*Plantago patagonica*
White fringed orchid	*Platanthera blephariglottis*
Small purple fringed orchid	*Platanthera psycodes*
Camphorweed	*Pluchea camphorata*
Pasture bluegrass	*Poa saltuensis*
Wolf's bluegrass	*Poa wolfii*
Riverweed	*Podostemum ceratophyllum*
Cross-leaved milkwort	*Polygala cruciata*
Curtiss' milkwort	*Polygala curtissii*
Gay-wings	*Polygala paucifolia*
Mountain bindweed	*Polygonum cilinode*
Bristly smartweed	*Polygonum setaceum var. interjectum*
Balsam poplar	*Populus balsamifera*
Fries' pondweed	*Potamogeton friesii*
Grass-like pondweed	*Potamogeton gramineus*
Hill's pondweed	*Potamogeton hillii*
White-stem pondweed	*Potamogeton praelongus*
Robbins' pondweed	*Potamogeton robbinsii*
Tennessee pondweed	*Potamogeton tennesseensis*
Tall cinquefoil	*Potentilla arguta*
Bushy cinquefoil	*Potentilla paradoxa*
Rough rattlesnake-root	*Prenanthes aspera*
Gall-of-the-earth	*Prenanthes trifoliolata*
Bigtree plum	*Prunus mexicana*
Tailed bracken	*Pteridium aquilinum var. pseudocaudatum*

ENDANGERED

PLANTS

Reticulate speckled shield lichen	*Punctelia perreticulata*
Hoary mountain-mint	*Pycnanthemum verticillatum var. pilosum*
Green-flowered wintergreen	*Pyrola chlorantha*
Rock ramalina	*Ramalina intermedia*
Chalky ramalina	*Ramalina pollinaria*
Water-plantain spearwort	*Ranunculus ambigens*
Low spearwort	*Ranunculus pusillus*
Flame azalea	*Rhododendron calendulaceum*
Tall grass-like beak-rush	*Rhynchospora recognita*
Missouri gooseberry	*Ribes missouriense*
Swamp red currant	*Ribes triste*
Smooth rose	*Rosa blanda*
Silver plume grass	*Saccharum alopecuroideum*
Grass-leaf arrowhead	*Sagittaria graminea*
Bog willow	*Salix pedicellaris*
Slender willow	*Salix petiolaris*
Scheuchzeria	*Scheuchzeria palustris*
False melic	*Schizachne purpurascens*
Coastal little bluestem	*Schizachyrium scoparium var. littorale*
Smith's bulrush	*Scirpus smithii*
Swaying rush	*Scirpus subterminalis*
Tubercled nut-rush	*Scleria oligantha*
Few-flowered nut-rush	*Scleria pauciflora*
Wherry's catchfly	*Silene caroliniana var. Wherryi*
Snowy campion	*Silene nivea*
Compass-plant	*Silphium laciniatum*
Atlantic blue-eyed-grass	*Sisyrinchium atlanticum*
Narrow-leaved blue-eyed-grass	*Sisyrinchium mucronatum*
Downy carrion-flower	*Smilax herbacea var. pulverulenta*
Dusty goldenrod	*Solidago puberula*
False goldenrod	*Solidago sphacelata*
Western mountain-ash	*Sorbus decora*
Small bur-reed	*Sparganium chlorocarpum*
Bartlett's peat moss	*Sphagnum bartlettianum*
Shore-growing peat moss	*Sphagnum riparium*
Appalachian spiraea T*	*Spiraea virginiana*
Fringed moon lichen	*Sticta beauvoisii*
Rose twisted-stalk	*Streptopus roseus*
Fuzzy hypnum moss	*Tomentypnum nitens*
Curved tortella	*Tortella inclinata*
Northern poison-ivy	*Toxicodendron rydbergii*
Walter's St. John's-wort	*Triadenum walteri*
Appalachian filmy fern	*Trichomanes boschianum*
Narrow-leaved bluecurls	*Trichostema dichotomum var. lineare*
Buffalo clover	*Trifolium reflexum*
Running buffalo clover E*	*Trifolium stoloniferum*
Painted trillium	*Trillium undulatum*
Spreading globe-flower	*Trollius laxus*
Spring nettle	*Urtica chamaedryoides*
Horned bladderwort	*Utricularia cornuta*
Two-scaped bladderwort	*Utricularia geminiscapa*
Prairie valerian	*Valeriana ciliata*
Yellow crownbeard	*Verbesina occidentalis*
Missouri ironweed	*Vernonia missurica*
Highbush-cranberry	*Viburnum opulus var. americanum*
Missouri violet	*Viola missouriensis*
Northern bog violet	*Viola nephrophylla*

ENDANGERED

PLANTS

Prairie violet	*Viola pedatifida*
Primrose-leaved violet	*Viola primulifolia*
Kidney-leaved violet	*Viola renifolia*
Wedge-leaved violet	*Viola tripartita var. glaberrima*
Walter's violet	*Viola walteri*
Sharp's green-cushioned moss	*Weissia sharpii*
Carolina yellow-eyed-grass	*Xyris difformis*
Twisted yellow-eyed-grass	*Xyris torta*

THREATENED

PLANTS

Deam's three-seeded mercury	*Acalypha virginica var. deamii*
Red baneberry	*Actaea rubra*
Mountain-fringe	*Adlumia fungosa*
American aloe	*Agave virginica*
American beach Ggrass	*Ammophila breviligulata*
Western rock-jasmine	*Androsace occidentalis*
Prairie thimbleweed	*Anemone cylindrica*
Shale barren pussy-toes	*Antennaria virginica*
Clasping-leaf dogbane	*Apocynum sibiricum*
Southern hairy rock-cress	*Arabis hirsuta var. adpressipilis*
Lyre-leaved rock-cress	*Arabis lyrata*
Lake cress	*Armoracia lacustris*
Bradley's spleenwort	*Asplenium bradleyi*
Wall-rue	*Asplenium ruta-muraria*
Drummond's aster	*Aster drummondii*
Bushy aster	*Aster dumosus*
Shale barren aster	*Aster oblongifolius*
Narrow-leaved aster	*Aster solidagineus*
Swamp birch	*Betula pumila*
Sparse-lobe grape-fern	*Botrychium biternatum*
Leathery grape-fern	*Botrychium multifidum*
Satin brome	*Bromus nottowayanus*
Bluehearts	*Buchnera americana*
Limestone savory	*Calamintha arkansana*
Wild calla	*Calla palustris*
Vernal water-starwort	*Callitriche verna*
Grass-pink	*Calopogon tuberosus*
Pale straw sedge	*Carex albolutescens*
Appalachian sedge	*Carex appalachica*
Bicknell's sedge	*Carex bicknellii*
Tufted fescue sedge	*Carex brevior*
Brownish sedge	*Carex brunnescens*
Field sedge	*Carex conoidea*
Raven-foot sedge	*Carex crus-corvi*
Midland sedge	*Carex mesochorea*
Few-seeded sedge	*Carex oligosperma*
Necklace sedge	*Carex projecta*
Purple wood sedge	*Carex purpurifera*
Reflexed sedge	*Carex retroflexa var. retroflexa*
Sprengel's sedge	*Carex sprengelii*
Dwarf hackberry	*Celtis tenuifolia*
Pipsissewa	*Chimaphila umbellata*
Fringe-tree	*Chionanthus virginicus*
Golden-knees	*Chrysogonum virginianum*
Carolina thistle	*Cirsium carolinianum*
Speckled wood-lily	*Clintonia umbellulata*
Sweet-fern	*Comptonia peregrina*
Bushy horseweed	*Conyza ramosissima*
Bunchberry	*Cornus canadensis*
Northern croton	*Croton glandulosus*
Glomerate dodder	*Cuscuta glomerata*
Schweinitz's umbrella-sedge	*Cyperus schweinitzii*
Showy lady's-slipper	*Cypripedium reginae*
Robin-run-away	*Dalibarda repens*
Crinkled hair grass	*Deschampsia flexuosa*
Tansy-mustard	*Descurainia pinnata*
Nodding mandarin	*Disporum maculatum*
Wedge-leaf whitlow-grass	*Draba cuneifolia*
Carolina whitlow-grass	*Draba reptans*
Flat-stem spikerush	*Eleocharis compressa*
Olivaceous spikerush	*Eleocharis olivacea*
Bearded wheat grass	*Elymus trachycaulus*
Simple willow-herb	*Epilobium strictum*
Woodland horsetail	*Equisetum sylvaticum*

THREATENED

PLANTS

Variegated scouring-rush	*Equisetum variegatum*
Rattlesnake-master	*Eryngium yuccifolium*
White thoroughwort	*Eupatorium album*
Small white snakeroot	*Eupatorium aromaticum*
Great lakes goldenrod	*Euthamia remota*
Milk-pea	*Galactia volubilis*
Bog bedstraw	*Galium labradoricum*
Yellowish gentian	*Gentiana alba*
Round-fruited hedge-hyssop	*Gratiola virginiana*
Short's hedge-hyssop	*Gratiola viscidula*
Common oak fern	*Gymnocarpium dryopteris*
Rough pennyroyal	*Hedeoma hispidum*
Plains frostweed	*Helianthemum bicknellii*
Canada frostweed	*Helianthenum canadense*
Ashy sunflower	*Helianthus mollis*
Small flowered alumroot	*Heuchera parviflora*
Hairy alumroot	*Heuchera villosa*
Crested coral-root	*Hexalectris spicata*
Canada hawkweed	*Hieracium canadense*
Northern St. John's-wort	*Hypericum boreale*
Kalm's St. John's-wort	*Hypericum kalmianum*
Dwarf iris	*Iris verna*
One-sided rush	*Juncus secundus*
Potato-dandelion	*Krigia dandelion*
Dwarf-dandelion	*Krigia virginica*
Inland beach-pea	*Lathyrus japonicus*
Yellow vetchling	*Lathyrus ochroleucus*
Michaux's leavenworthia	*Leavenworthia uniflora*
Thyme-leaf pinweed	*Lechea minor*
Leggett's pinweed	*Lechea pulchella*
Narrow-leaved pinweed	*Lechea tenuifolia*
Slender blazing-star	*Liatris cylindracea*
Wood lily	*Lilium philadelphicum*
Dwarf bulrush	*Lipocarpha micrantha*
Plains puccoon	*Lithospermum caroliniense*
Southern woodrush	*Luzula bulbosa*
Angle-pod	*Matelea obliqua*
Cow-wheat	*Melampyrum lineare*
Bunchflower	*Melanthium virginicum*
Buckbean	*Menyanthes trifoliata*
American water-milfoil	*Myriophyllum sibiricum*
False garlic	*Nothoscordum bivalve*
Oakes' evening-primrose	*Oenothera oakesiana*
Small-flowered evening-primrose	*Oenothera parviflora*
Mountain-rice	*Oryzopsis racemosa*
Bicknell's panic-grass	*Panicum bicknellii*
Northern panic-grass	*Panicum boreale*
Leiberg's panic-grass	*Panicum leibergii*
Southern hairy panic-grass	*Panicum meridionale*
Philadelphia panic-grass	*Panicum philadelphicum*
Maypop	*Passiflora incarnata*
Gray beard-tongue	*Penstemon canescens*
Downy white beard-tongue	*Penstemon pallidus*
Lurking leskea	*Plagiothecium latebricola*
Heart-leaved plantain	*Plantago cordata*
Yellow fringed orchid	*Platanthera ciliaris*
Prairie fringed orchid T*	*Platanthera leucophaea*
Marsh spear-grass	*Poa paludigena*
Rose pogonia	*Pogonia ophioglossoides*
Pink milkwort	*Polygala incarnata*
Racemed milkwort	*Polygala polygama*
Coarse smartweed	*Polygonum robustius*
Little gray polypody	*Polypodium polypodioides*
Spotted pondweed	*Potamogeton pulcher*
Sand cherry	*Prunus pumila var. cuneata*
Spanish oak	*Quercus falcata*
Blackjack oak	*Quercus marilandica*

THREATENED

PLANTS

Appalachian trail lichen	*Ramalina petrina*
Great rhododendron	*Rhododendron maximum*
Pinxter-flower	*Rhododendron nudiflorum var. nudiflorum*
Wapato	*Sagittaria cuneata*
Deer's-tongue arrowhead	*Sagittaria rigida*
Hoary willow	*Salix candida*
Midwest spikemoss	*Selaginella eclipes*
Balsam squaw-weed	*Senecio pauperculus*
Carolina catchfly	*Silene caroliniana var. pensylvanica*
Northern blue-eyed-grass	*Sisyrinchium montanum*
Sweet goldenrod	*Solidago odora*
Leafy goldenrod	*Solidago squarrosa*
Keeled bur-reed	*Sparganium androcladum*
Prairie wedgegrass	*Sphenopholis obtusata var. obtusata*
Hooded ladies'-tresses	*Spiranthes romanzoffiana*
Prairie dropseed	*Sporobolus heterolepis*
Feather-fells	*Stenanthium gramineum*
Porcupine grass	*Stipa spartea*
False asphodel	*Tofieldia glutinosa*
Large marsh St. John's-wort	*Triadenum tubulosum*
Seaside arrow-grass	*Triglochin maritimum*
Three-birds orchid	*Triphora trianthophora*
Rock elm	*Ulmus thomasii*
Flat-leaved bladderwort	*Utricularia intermedia*
Velvet-leaf blueberry	*Vaccinium myrtilloides*
Small cranberry	*Vaccinium oxycoccos*
Wood's hellebore	*Veratrum woodii*
Soft-leaved arrow-wood	*Viburnum molle*
Bird-foot violet	*Viola pedata*
Wolffiella	*Wolffiella gladiata*
Wild rice	*Zizania aquatica*

POTENTIALLY THREATENED

PLANTS

Grove sandwort	*Arenaria laterifolia*
Rock sandwort	*Arenaria stricta*
Purple triple-awned grass	*Aristida purpurascens*
Blunt-leaved milkweed	*Asclepias amplexicaulis*
White milkweed	*Asclepias variegata*
Green milkweed	*Asclepias viridiflora*
Spider milkweed	*Asclepias viridis*
Prairie false indigo	*Baptisia lactea*
Gray birch	*Betula populifolia*
Fen indian-plantain	*Cacalia plantaginea*
Inland sea-rocket	*Cakile edentula*
Narrow-leaved toothwort	*Cardamine dissecta*
Broad-winged sedge	*Carex alata*
Leafy tussock sedge	*Carex aquatilis*
Silvery sedge	*Carex argyrantha*
Wheat sedge	*Carex atherodes*
Howe's sedge	*Carex atlantica var. capillacea*
Golden-fruited sedge	*Carex aurea*
Bebb's sedge	*Carex bebbii*
Little yellow sedge	*Carex cryptolepis*
Cumberland sedge	*Carex cumberlandensis*
Lesser panicled sedge	*Carex diandra*
Yellow sedge	*Carex flava*
Juniper sedge	*Carex juniperorum*
Slender sedge	*Carex lasiocarpa*
Pale sedge	*Carex pallescens*
Straw sedge	*Carex straminea*
Little green sedge	*Carex viridula*
American chestnut	*Castanea dentata*
Leather-leaf	*Chamaedaphne calyculata*
Butterfly pea	*Clitoria mariana*
Spotted coral-root	*Corallorhiza maculata*
Spring coral-root	*Corallorhiza wisteriana*
Round-leaved dogwood	*Cornus rugosa*
Rock-harlequin	*Corydalis sempervirens*
Low umbrella-sedge	*Cyperus diandrus*
Tennessee bladder fern	*Cystopteris tennesseensis*
Tall larkspur	*Delphinium exaltatum*
Tufted hairgrass	*Deschampsia cespitosa*
Tawny cottongrass	*Eriophorum virginicum*
Green cottongrass	*Eriophorum viridicarinatum*
Pink thoroughwort	*Eupatorium incarnatum*
Seaside spurge	*Euphorbia polygonifolia*
Fringed gentian	*Gentianopsis crinita*
Small Fringed gentian	*Gentianopsis procera*
Water avens	*Geum rivale*
Narrow-leaved summer bluets	*Hedyotis nigricans*
Western sunflower	*Helianthus occidentalis*
Tall St. John's-wort	*Hypericum majus*
Butternut	*Juglans cinerea*
Alpine rush	*Juncus alpinus*
Baltic rush	*Juncus balticus*
Tamarack	*Larix laricina*
Round-fruited pinweed	*Lechea intermedia*
Hairy pinweed	*Lechea villosa*
Scaly blazing-star	*Liatris squarrosa*
Turk's-cap lily	*Lilium superbum*
Southern wapato	*Lophotocarpus calycinus*
Wild lupine	*Lupinus perennis*
Umbrella magnolia	*Magnolia tripetala*
Green adder's-mouth	*Malaxis unifolia*
Prickly pear	*Opuntia humifusa*
False scurf-pea	*Orbexilum pedunculatum*
Pale green panic-grass	*Panicum laxiflorum*
Riverbank paspalum	*Paspalum fluitans*
Fern-leaf scorpion-weed	*Phacelia bipinnatifida*
Wild kidney-bean	*Phaseolus polystachios*
Long beech-fern	*Phegopteris connectilis*

POTENTIALLY THREATENED

PLANTS

Tubercled rein-orchid	*Platanthera flava*
Weak spear-grass	*Poa languida*
Bowman's-root	*Porteranthus trifoliatus*
Floating pondweed	*Potamogeton natans*
Richardson's pondweed	*Potamogeton richardsonii*
Flat-stem pondweed	*Potamogeton zosteriformis*
March fivefinger	*Potentilla palustris*
Nodding rattlesnake-root	*Prenanthes crepidinea*
Prairie rattlesnake-root	*Prenanthes racemosa*
Early buttercup	*Ranunculus fascicularis*
Virginia meadow-beauty	*Rhexia virginica*
Northern rose azalea	*Rhododendron nudiflorum var. roseum*
White beak-rush	*Rhynchospora alba*
Carolina willow	*Salix caroliniana*
Blue-leaved willow	*Salix myricoides*
Autumn willow	*Salix serissima*
Pitcher-plant	*Sarracenia purpurea*
Woodland bulrush	*Scirpus expansus*
Pursh's bulrush	*Scirpus purshianus*
Tall nut-rush	*Scleria triglomerata*
Rock skullcap	*Scutellaria saxatilis*
Canadian buffalo-berry	*Shepherdia canadensis*
Virginia mallow	*Sida hermaphrodita*
Royal catchfly	*Silene regia*
Round-leaved catchfly	*Silene rotundifolia*
Pale carrion-flower	*Smilax herbacea var. lasioneura*
Smooth buttonweed	*Spermacoce glabra*
Swamp-oats	*Sphenopholis pensylvanica*
Shining ladies'-tresses	*Spiranthes lucida*
Great plains ladies'-tresses	*Spiranthes magnicamporum*
Lesser ladies'-tresses	*Spiranthes ovalis*
Arbor vitae	*Thuja occidentalis*
Marsh arrow-grass	*Triglochin palustre*
Prairie wake-robin	*Trillium recurvatum*
Purple sand-grass	*Triplasis purpurea*
Lesser bladderwort	*Utricularia minor*
Hairy wing-stem	*Verbesina helianthoides*
Prairie ironweed	*Vernonia fasciculata*
Hobblebush	*Viburnum alnifolium*
Southern black-haw	*Viburnum rufidulum*
Lance-leaved violet	*Viola lanceolata*
Pigeon grape	*Vitis cinerea*
Netted chain-fern	*Woodwardia areolata*
Wand-lily	*Zigadenus elegans var. glaucus*

ADDED (Not Designated)

PLANTS

American sweet-flag	*Acorus americanus*
Canada milk vetch	*Astragalus canadensis*
Timid sedge	*Carex timida*
Cuspidate dodder	*Cuscuta cuspidata*
Pretty dodder	*Cuscuta indecora*
Hairy tick-trefoil	*Desmodium glabellum*
Male fern	*Dryopteris filix-mas*
Tufted moisture-loving moss	*Philonotis fontana var. caespitosa*
Narrow-necked Pohl's moss	*Pohlia elongata var. elongata*
Elegant sunburst lichen	*Xanthoria elegans*

EXTIRPATED

PLANTS

Elliott's bent-grass	*Agrostis elliottiana*
Black rock moss	*Andreaea rupestris var. rupestris*
Bog-rosemary	*Andromeda glaucophylla*
Common silver moss	*Anomobryum filiforme*
Black-stem spleenwort	*Asplenium resiliens*
Mountain aster	*Aster acuminatus*
Besseya	*Besseya bullii*
Sweet shrub	*Calycanthus fertilis*
Dewey's sedge	*Carex deweyana*
Handsome sedge	*Carex formosa*
Hayden's sedge	*Carex haydenii*
Peck's sedge	*Carex peckii*
Richardson's sedge	*Carex richardsonii*
Lowland wood sedge	*Carex styloflexa*
Thin-flowered sedge	*Carex tenuiflora*
Prairie redroot	*Ceanothus herbaceus*
Chaffweed	*Centunculus minimus*
Strawberry-blite	*Chenopodium capitatum*
Slender goosefoot	*Chenopodium leptophyllum*
Purple virgin's-bower	*Clematis occidentalis*
Crinkled pulp lichen	*Collema crispum*
Beaked hazel	*Corylus cornuta*
Brainerd's hawthorn	*Crataegus brainerdii*
Sessile dodder	*Cuscuta compacta*
Northern wild comfrey	*Cynoglossum virginianum var. boreale*
Brittle fern	*Cystopteris fragilis*
Purple prairie-clover	*Dalea purpurea*
Prairie tick-trefoil	*Desmodium illinoense*
Slender finger-grass	*Digitaria filiformis*
Elatine	*Elatine triandra*
Slender cottongrass	*Eriophorum gracile*
Creeping snowberry	*Gaultheria hispidula*
Northern manna-grass	*Glyceria borealis*
Checkered rattlesnake-plantain	*Goodyera tesselata*
Appalachian oak fern	*Gymnocarpium appalachianum*
Beardgrass	*Gymnopogon ambiguus*
Northern stickseed	*Hackelia deflexa*
Silverbell	*Halesia carolina*
Long-flowered alumroot	*Heuchera longiflora*
Featherfoil	*Hottonia inflata*
Beach-heather	*Hudsonia tomentosa*
Spiny-spored quillwort	*Isoetes echinospora*
American lovage	*Ligusticum canadense*
American twinflower	*Linnaea borealis*
Heart-leaved twayblade	*Listera cordata*
Pale yellow honeysuckle	*Lonicera flava*
Swamp fly-honeysuckle	*Lonicera oblongifolia*
Mountain fly-honeysuckle	*Lonicera villosa*

EXTIRPATED

PLANTS

Maleberry	*Lyonia ligustrina*
Water-marigold	*Megalodonta beckii*
Hairgrass	*Muhlenbergia capillaris*
Louisiana broom-rape	*Orobanche ludoviciana*
One-sided wintergreen	*Orthilia secunda*
White wood-sorrel	*Oxalis montana*
Tall green panic-grass	*Panicum calliphyllum*
Long-leaved panic-grass	*Panicum longifolium*
White-wand beard-tongue	*Penstemon tubaeflorus*
Perideridia	*Perideridia americana*
Blackseed needle grass	*Piptochaetium avenaceum*
Large purple fringed orchid	*Platanthera grandiflora*
Hooker's orchid	*Platanthera hookeri*
Tall northern green orchid	*Platanthera hyperborea*
Carey's smartweed	*Polygonum careyi*
Filiform pondweed	*Potamogeton filiformis*
Red-head pondweed	*Potamogeton perfoliatus*
Spiral pondweed	*Potamogeton spirillus*
Straight-leaved pondweed	*Potamogeton strictifolius*
Vasey's pondweed	*Potamogeton vaseyi*
Canada plum	*Prunus nigra*
Great lakes sand cherry	*Prunus pumila var. pumila*
Drummond's ptychomitrium	*Ptychomitrium drummondii*
Narrow-leaved crab	*Pyrus angustifolia*
Dotted ramalina	*Ramalina farinacea*
Beach sumac	*Rhus aromatica var. arenaria*
Skunk currant	*Ribes glandulosum*
Prairie Wild Rose	*Rosa arkansana*
Southern pearlwort	*Sagina decumbens*
Elliptic-leaved arrowhead	*Sagittaria platyphylla*
Torrey's bulrush	*Scirpus torreyi*
Turgid brown worm moss	*Scorpidium scorpioides*
Rock spikemoss	*Selaginella rupestris*
Three-leaved false solomon's-seal	*Smilacina trifolia*
Cut-leaved goldenrod	*Solidago arguta*
White upland goldenrod	*Solidago ptarmicoides*
Bigleaf snowbell	*Styrax grandifolius*
Snowberry	*Symphoricarpos albus var. albus*
Allen's fern moss	*Thuidium allenii*
Nodding trillium	*Trillium cernuum*
Swamp valerian	*Valeriana uliginosa*
New York ironweed	*Vernonia noveboracensis*
Three-parted violet	*Viola tripartita var. tripartita*
Rusty woodsia	*Woodsia ilvensis*

Please see: Division of Natural Areas and Preserves, Ohio Department of Natural Resources at: http://www.ohiodnr.gov/dnap/heritage/tabid/2010/Default.aspx for additional and current information about threatened and endangered plant species.

CHAPTER 3
LEVEL II -SCREENING

3.1 OBJECTIVE

The objective of a Level II ERA is to compare site-specific data to the Ohio Water Quality Standards, Ohio sediment reference values (SRVs), and other values identified in this document to determine the need for further ecological evaluation of a site. If all concentrations of site-related ecological stressors are below the appropriate screening concentrations, in all relevant media, and surface waters are meeting applicable criteria, then the entire site is considered to have minimal impact on important ecological resources and no further ecological assessment is necessary. However, if any site-related ecological stressor concentration is not meeting the applicable value, then the site is required to continue the ecological assessment in a Level III ERA, or the information is used to complete a remedial or other risk management alternative.

Furthermore, the process of the Level II ERA is designed to:

a) evaluate site-specific chemical concentrations and attainment of Ohio Water Quality Standards (Tasks 3 and 5);
b) characterize wetlands at or in the locality of the site using Ohio EPA's Rapid Assessment Method (ORAM) for Wetlands;
c) identify potential ecological contaminants of concern (PECOCs) from among the contaminants of interest (COIs) associated with the site and identified during the Level I ERA and site characterization process;
d) update the site description based on information from site visits and/or surveys, the existing literature, any prior preliminary assessments, and site history (including past and present uses) (Task 8);
e) revise the conceptual site model (Task 9);
f) identify site-specific ecological receptors (Task 10);
g) identify relevant and complete exposure pathways between each source medium of concern and site-specific ecologically important receptors (Task 11);
h) define ecologically appropriate assessment endpoints (Task 12);
i) scientific management decision point (SMDP) (Task 13); and,
j) summarize the appropriate information in a Level II report (Task 14).

Activities b through i (Tasks 6 through 13) are only required after the screening process (Tasks 4 and 5) when chemicals are retained as PECOCs or non-attainment of the Ohio Water Quality Standards exist at, or in the locality of the site. All sites conducting a Level II ecological risk assessment are required to submit a Level II report (Task 14).

Level II Flowchart and Legend (Attachment A)
The Level II guidance includes a flowchart and legend (Attachment A) that outlines the appropriate methodologies for evaluating potentially contaminated media. The flowchart guides the reader through the procedures contained within the Level II guidance. The flowchart begins with site characterization which is completed in Task 2 of the Level II ecological risk assessments. The flowchart should be used in conjunction with the written text of the Level II guidance. The Level II guidance makes several references to the flowchart to help identify various steps of the flowchart with the corresponding sections of guidance text.

3.2 PREREQUISITES

A release or suspected release, of ecological stressors and the identification (completion of Level I ERA) of important ecological resources on or in the locality of the site is required to begin a Level II ERA. In addition, the determination of the full nature and extent of contamination *(i.e.,* site characterization) is required before Tasks 4-14 of the Level II ecological assessment can be completed.

3.3 TASKS

The following are to be completed as part of a Level II ERA:

3.3.1 Task 1 Evaluate Existing Site Data

If the results from the Level I (Scoping) ERA efforts indicate important ecological resources are associated with the site, and evidence exists that ecological stressors may have been released at the site, then site characterization is required.

If sufficient chemical data from ongoing activities exist to satisfy the site characterization data needs, further data collection may not be required for the completion of a Level II ERA. It should be noted that sites with impacted lotic surface water or sediment will generally be required to conduct biological criteria investigations to determine compliance with Ohio Surface Water Standards [Ohio Administrative Code (OAC) 3745-1]. The collection of data needed for conducting the biological evaluation has both technical and seasonal considerations that should be reviewed prior to conducting the site characterization process.

3.3.2 Task 2 Site Characterization

Site characterization must be completed prior to completing the remaining tasks of the Level II ERA process. The following information is provided to assist the development of the site characterization sampling plan.

A) Sampling

Sampling should be designed and conducted to determine the full nature and extent of potential contamination. Chemical sampling and analysis of non-chemical stressors, provides data concerning the presence or absence of COIs and their concentrations in abiotic media (*i.e.*, soil, surface water, ground water, and sediment). Sampling of aquatic organisms (*e.g.*, macroinvertebrates and fish) to document the attainment of the Water Quality Standards of Ohio may also be required. Non-chemical stressors should be evaluated when impacts caused by these stressors are expected (see Task 6). Sampling should cover all relevant media of ecological interest. Analytical detection levels are to be low enough to be of ecological significance (*e.g.*, lower than the screening values), as determined by the analysis plan (which includes Data Quality Objectives (DQOs) and a Quality Assurance/Quality Control (QA/QC) plan). [Note: A consistent sampling approach and methodology for site evaluation is envisioned for the site characterization process that will result in data sufficient for conducting both human health and ecological risk assessments.]

B) Calculate COI Concentration(s)

For the Level II screening assessment, maximum detected values of chemical concentrations in soils and sediment are to be used to compare to the appropriate screening values. Surface water COI concentrations, when used to compare to water quality criteria, are specified in OAC 3745-01.

It may be desirable to use a geographic information system (GIS) to overlay the spatial distribution of various habitat types with contaminant distributions. This information would be useful for identifying potential ecological receptor species and habitats if contamination is present at a site. GIS information and support may be available from the Ohio EPA DHWM. Please contact the DHWM to determine if data and support are available for the site of interest.

3.3.3 Task 3 Data/Media Evaluation

COIs (identified in Level I, site characterization, and quantified in Task 2 and 3 of Level II) in all appropriate media are evaluated on the basis of physicochemical properties and/or toxicity [see Step B of the flowchart (Attachment A)]. The Data/Media evaluation is comprised of two processes: a) Data Evaluation, a process used to screen chemicals from the risk assessment by using a frequency of detection screen and to eliminate common laboratory contamination, and b) Media Evaluation, which is a process to determine if site-related chemicals have impacted media associated with a site.

A) **Data Evaluation**

(i) Frequency of Detection

COIs that are detected infrequently may be artifacts in the data due to sampling, analytical, or other errors. COIs detected in five percent or less of the samples for a given medium need not be selected as PECOCs, assuming that the detection limits were low enough for ecological purposes and that adequate sampling has occurred in all relevant media. A detection frequency of five percent or less is usually considered grounds for eliminating a chemical from further consideration. A COI should be retained however, if it could cause an adverse impact. For example, a COI should be retained if it is exceptionally toxic (i.e. toxic at very low concentrations) to ecological receptors, measured at high concentrations, is a persistent, bioaccumulative, and toxic (PBT, see 3.3.5 (C)) compound, identified in multiple media, or located in sensitive environments.

(ii) Common Laboratory Contaminants
Blank data should be compared to the corresponding field samples from which the blanks are associated. This will provide a measure of contamination that has been introduced into the samples during sample preparation or analysis. Acetone, 2-butanone (or methyl ethyl ketone), carbon disulfide, methylene chloride, toluene, and phthalate esters are considered to be common laboratory contaminants. If blanks contain detectable levels of common laboratory contaminants, then the sample results should be considered as positive results only if the concentrations in the samples exceed ten times the maximum amount detected in any blank. For those chemicals which are not common laboratory contaminants, the chemical should be retained for further evaluation if the maximum sample concentration is greater than five times the corresponding blank concentration.

B) **Media Evaluation**

The media evaluation step is used to determine whether site-related stressors have impacted media associated with the site. The evaluation method is dependent upon the medium in question. Below are the acceptable methods for media evaluation.

(i) Background Concentration
Ecological stressors detected on-site may be compared to concentrations representing background levels. Background levels can be determined for soil, surface water, and sediment. Chemicals and media may be eliminated from further investigations provided on-site concentrations of ecological stressors are comparable to background conditions.

Background is defined as the quantity of naturally occurring chemical and non-chemical stressors at a site and areas surrounding a site, that have not been affected by any current or past activities involving the management, handling, treatment, storage or disposal of ecological stressors. If a site-related compound is comparable to the selected background concentration (*e.g.*, maximum detected concentration (MDC) of a COI is less than the concentration selected as a background value), then that COI need not be selected as a PECOC. [Please refer to Ohio EPA DHWM's *Closure Plan Review Guidance for RCRA Facilities* for information on determining background.] Furthermore, media samples for background concentrations are to be from environments that have not been impacted by site related or other contaminating activities. To help ensure media samples were taken from the appropriate background locations, background samples may be analyzed for target analyte list (TAL) and target compound list (TCL) chemicals. The results should indicate whether background locations have been impacted by site-related or other activities. Caution is recommended for anthropogenic compounds detected in locations considered to be background. Additional scrutiny of the data is recommended to ensure that background locations have not been impacted by site related activities.

Concentrations of ubiquitous anthropogenic organic chemicals can be determined and used in the Level II Report to discuss potential urban/industrial impacts to a site. Anthropogenic background concentrations are not to be used for screening chemicals from the risk assessment, but for discussion purposes in the Level II Report.

For surface water and sediment screening, the background evaluation is not intended to determine relative amounts or up-stream sources of contamination. The background screening step is intended to determine if sediment or surface waters have been impacted by site related stressors and to eliminate specific compounds or entire media if chemical concentrations are indicative of background conditions.

Background conditions for all surface water bodies can be measured on a site specific basis. Sediment background concentrations from lotic (flowing) surface water bodies may be derived from on-site sampling or selected from the appropriate Ohio specific sediment reference values (SRVs), (see 3.3.3 (B)(ii)). If chemical concentrations in depositional sediments indicate background conditions, then the sediments may be eliminated from further ERA procedures and the results are to be provided in the Level II report. If ecological stressors in sediment are detected above background or SRV concentrations, then the sediments are considered impacted or potentially impacted by site related compounds and are subject to the Ohio surface water statutes, which include chemical and biological criteria where appropriate. See

section 3.3.5 (B) for details regarding the evaluation of contaminated sediment and surface water bodies.

(ii) Ohio Specific Sediment Reference Values
Sediment concentrations from lotic (flowing) surface water systems may be compared to the Ohio specific sediment reference values. [Note: Sediments from lentic environments may be evaluated using SRVs upon approval.] The SRVs, found in Attachment H, can be used in lieu of site-specific background concentrations for sediments for determining whether sediments have been impacted by site related activities. If the on-site sediment concentrations approximate reference conditions (*e.g.*, the maximum detected concentration of a COI is less than the corresponding SRV), then sediment is not retained as an exposure medium in the Level II ERA. If SRVs do not exist for certain chemicals detected in sediment, then those chemicals can only be eliminated by being detected at concentrations less than or equal to site specific background values (see 3.3.3 (B)(i)). Sediment associated PECOCs can be narrowed further in tasks 5 and 6 where appropriate. Sediment associated PBT compounds cannot be eliminated by this process; see 3.3.5 (C) for conditions and information about PBT compounds.

The media evaluation step is designed so evidence may be gathered that reasonably demonstrates that specific media at a site may not have been impacted by site-related compounds. This evidence may include up-stream/background chemical concentrations, topographic and other information that demonstrates or explains why site-related compounds have not migrated from one medium to another. For example, if a site can demonstrate that no releases have occurred and there is little potential for future releases to surface water then, sediments and surface water can be eliminated as exposure media in the ecological risk assessment. The results of the sampling and the rationale used for eliminating any media in the ecological risk assessment is to be given in the Level II report. An example of how surface water and sediments may be dismissed from further evaluation is as follows:

> It was determined that a site has bcalized soil contamination, found only in the vicinity of a building, and that the contamination has not migrated to a nearby surface water body. Soils down-gradient and adjacent to the surface water body are not impacted. Site related compounds were not detected in sediments or were detected at or below the Ohio specific reference values or upstream concentrations.

3.3.4 Task 4 Scientific Management Decision Point (SMDP)(removal)

A scientific/management decision point (SMDP) is offered for sites with limited soil or sediment contamination of lentic or lotic water bodies designated as limited resource water (LRW) by the Ohio EPA, Division of Surface Water. A site may choose to remove contaminated media in lieu of completing an ecological risk assessment. If site contamination has been identified, important ecological resources are at or in the locality of the site, and a remedy other than contaminant removal is desired, then the ecological risk assessment process is to continue onto Task 5.

The SMDP (removal) option is offered to allow for removal of contaminated soil to background levels. Sediment contamination may also be removed for lentic or LRW designated surface water bodies, but the specifics on how the removal is to be completed and potential impacts to surface waters and important ecological resources are to be discussed/approved by Ohio EPA Division of Surface Water prior to the removal action. The SMDP (limited) option offered as part of Task 4 is only available for removal actions and would require the removal of contaminated media. The use and applications of the other SMDPs are discussed in Task 13 of the Level II guidance.

Task 4 (SMDP) is also the termination point of the ecological risk assessment process if all media concentrations of site-related chemical and non-chemical stressors are indicative of background conditions. If through the data and media evaluation step (Task 3) all compounds have been eliminated, then the Level II ERA can be completed by finalizing the Level II report.

3.3.5 Task 5 Media Screening

The media screening process is to be conducted if following the site characterization and data/media evaluation, a decision is made to continue with the ecological risk assessment process in stead of selecting a removal option (Task 4). The screening process is dependent on the media that have been retained due to the possibility of site-specific contamination. If

stressors detected in any media are below their appropriate and available screening values, then those stressors may be eliminated from further ecological risk evaluations. If all of the stressors detected in any given medium do not exceed the appropriate screening values, then the entire medium may be eliminated from future ecological risk evaluations. Chemicals detected in various media may be screened according to the following procedures:

A) Soils
Soil found to be potentially impacted (*e.g.,* ecological stressors were detected at concentrations greater than background) may be screened using toxicologically-based benchmark values (see steps E through H of the Level II flowchart, Attachment A). The maximum soil concentrations are to be used for the comparison of site related chemicals to benchmark values. Chemicals with maximum concentrations found to be greater than the benchmark values are to be retained as PECOCs (Task 6) and reported in the Level II Report (Task 14). Chemicals with maximum concentrations below the cited benchmark values may be eliminated from further ecological evaluation. If only minor exceedances are detected and other evidence can substantiate, a claim may be made that some or all of the site-associated soils have not been impacted and no additional ecological investigation of the soils are warranted. This information is to be presented in the Level II Report.

The soil screening value hierarchy is to be used in finding the appropriate screening values for soils, and is to be used in the order given in the guidance.

Soil Screening Hierarchy:

1) Preliminary Remediation Goals for Ecological Endpoints, Efroymson, R.A., G.W. Suter II, B.E. Sample, and D.S. Jones, August 1997, ES/ER/TM-162/R2, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831, http://www.esd.ornl.gov/programs/ecorisk/documents/tm162r2.pdf

2) Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Soil and Litter Invertebrates and Heterotrophic Process: 1997 Revision, Efoymson, R.A., M.E. Will, and G.W. Suter II, ES/ER/TM-126/R2, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831, http://www.esd.ornl.gov/programs/ecorisk/documents/tm126r21.pdf

3) Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision, Efoymson, R.A., M.E. Will, G.W. Suter II, and A.C. Wooten, ES/ER/TM-85/R3, Oak Ridge National Laboratory, Oak Ridge Tennessee, http://www.esd.ornl.gov/programs/ecorisk/documents/tm85r3.pdf

[Note: All benchmark values from this reference are incorporated into Preliminary Remediation Goals for Ecological Endpoints (Efroymson et al, 1997). This reference was included as an additional resource for screening terrestrial plants.]

4) Ecological Data Quality Levels (EDQL), U.S. EPA, Region 5, Final Technical Approach for Developing EDQLs for RCRA Appendix IX Constituents and Other Significant Contaminants of Ecological Concern, 1999. http://www.epa.gov/reg5rcra/ca/edql.htm

B) Surface Water and Sediment Evaluation
The evaluation of sediment and surface water is dependent on the type of surface water(s) that is affected. Surface water is classified as either lotic (flowing) or lentic (not flowing). The distinction between water bodies is based on the fact that biological criteria are not available for lentic waters in OAC 3745-1 or lotic waters designated as Limited Resource Waters (LRW) in accordance with section OAC 3745-1, found at http://www.epa.ohio.gov/dsw/rules/3745-1.aspx. Lotic water bodies designated warmwater, exceptional warmwater, and modified warmwater habitat have specific biological criteria associated with the designations (OAC 3745-1-07). Aquatic life habitat use designations for these designated water bodies are listed in OAC 3745-1-08 through 3745-1-30.

Lotic water bodies that have not been designated will need to be designated prior to completing the ecological evaluation. See 3.3.5 (B)(ii)(b) for the designation process for surface water bodies. In the Level II flowchart, step I is the beginning point for the evaluation of surface water and step M is the beginning point for sediment. The following procedures for evaluating surface waters and sediments for a Level II ERA are divided into lentic/LRW and lotic systems and are to be used accordingly:

(i) Surface Water
Surface water chemical concentrations are to be compared to the chemical criteria pursuant

to OAC 3745-1. The outside mixing zone average criteria for human health and aquatic life should be compared against ambient samples averaged over a 30-day period. Single ambient samples are not to exceed the outside the mixing zone maximum. If all chemical constituents are below their corresponding chemical criteria, then the surface water may be eliminated as an exposure medium. An updated summary of chemical criteria can be found at: http://www.epa.ohio.gov/dsw/wqs/criteria.aspx. Biological criteria corresponding to the aquatic life habitat designation of the water body are to be in full attainment (see 3.3.5 (B)(ii)(b) below).

(ii) Sediment

The sediment screening/evaluation process is specific for the type of water body being investigated. Sediment evaluation begins at step M of the Level II flowchart. Below are the procedures for evaluating sediments basedon the surface water type:

a) Lentic Surface Water/LRW Designated Lotic Surface Water

Sediment concentrations for lentic/LRW surface water bodies can be screened using the values prescribed in the sediment screening hierarchy listed in section 3.3.5 (B)(ii)(d). Maximum sediment concentrations are to be compared to the screening benchmark values. If sediment chemical concentrations are ator bebw the appropriate screening benchmark values, then the chemicals may be eliminated from further investigation. If all chemicals are at or below the appropriate screening benchmark values, and screening benchmark values exist for all chemicals, then sediment may be eliminated as an exposure medium in the ERA. Chemicals that exceed screening benchmark values, or where screening values are not available in the hierarchy, are to be retained as PECOCs (Task 6) and lsted in the Level II report (Task 14).

b) Lotic Surface Water

Lotic surface water must meet chemical and non-chemical specific criteria and be in full attainment of the aquatic life habitat use designation criteria listed in OAC 3745-1. If a lotic surface water system has not been designated in the OAC, the assessors are to contact Ohio EPA Division of Surface Water for information regarding the designation of the water body. It is possible that data and proposed designations are available on lotic surface water systems that have not been codified in the OAC. If a lotic surface water system has not been designated in the OAC and Ohio EPA has not recommended a use designation, then the criteria for warm water aquatic life habitat use designation apply. Site specific data may also be collected to determine the appropriate designation of the water body. Ohio EPA is to be contacted for specific procedures and the level of effort required to adequately designate a surface water body. Once a lotic stream has been designated, the attainment status of the biological criteria can be determined. Lotic surface water bodies are to be in full attainment of their aquatic life use designations. If only partial or non-attainment of the aquatic life use designation is met, then further evaluation may be required.

Pertinent information explaining the reasons why a site is not in full attainment can be given in the Level II report. If physical degradation of the aquatic habitat, urban development, or reasons other than site related contamination can adequately explain the failure of a site to be in full attainment of the aquatic life use designations, the further ecological evaluation (*i.e.*, Level III or greater ERA) may not be required. If however, a site is not in full attainment of the aquatic life use designation(s), and any site-related chemical contamination has been identified in sediment or surface waters, then continued ecological evaluation (Level III or greater ERA), remediation, or other remedial actions will be required.

Sediment contaminant concentrations from streams that are not in full attainment of the aquatic life habitat use designations, or do not exceed the non-significant departure of the aquatic life habitat use designation (see definitions section), are to be compared to the values cited in the sediment screening hierarchy in 3.3.5 (B)(ii)(d). Chemicals that exceed the sediment screening benchmark values are to be retained as PECOCs (Task 6) and listed in the Level II report (Task 14).

c) Wetlands

Wetlands at or in the locality of the site should be evaluated using Ohio EPA's Rapid Assessment Method for Wetlands, found at: http://www.epa.ohio.gov/portals/35/guidance/wetland1.pdf. Wetlands are to be treated as lentic/LRW surface water for the evaluation of

sediments. Sediment substrates are to be compared to the sediment screening values given in section 3.3.5 (B)(ii)(d).

Surface waters associated with wetlands are to meet the surface water chemical specific criteria where appropriate. Surface water chemical criteria are discussed in 3.3.5 (B)(i). Ohio EPA should be contacted with any specific questions regarding the evaluation wetland media (surface water or sediment/substrate).

d) Sediment Screening Hierarchy:
Below is the hierarchy for obtaining sediment screening values:

1) Consensus-based TEC values;
The TEC values are located in: Development and Evaluation of Consensus-based Sediment Quality Guidelines for Freshwater Ecosystems, D.D. MacDonald, C.G. Ingersoll, and T.A. Berger, Arch. Environ. Contam. Toxicol. 39, 20-31 (2000).

2) Ecological Data Quality Levels (EDQL);
U.S. EPA, Region5, Final Technical Approach for Developing EDQLs for RCRA Appendix IX Constituents and Other Significant Contaminants of Ecological Concern, April 1998.

C) Persistent, Bioaccumulative, and Toxic Pollutants
Persistent, bioaccumulative and toxic (PBT) compounds include but are not limited to the following substances; aldrin/dieldrin, chlordane, 1,1'- (2,2,2-trichloroethylidene)-bis[4-chlorobenzene] (DDT) and metabolites (DDD+DDE), hexachlorobenzene, hexachlorobutadiene (hexachloro-1,3-butadiene); hexachlorocyclohexanes (BHCs, alpha-BHC, beta-BHC, delta-BHC); lindane (gamma-hexachlorocyclohexane); alkyl-lead, mercury and its compounds, mirex, photomirex, octachlorostyrene, polychlorinated biphenyls (PCBs), 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD); dioxin; PCDF (furans), 1,2,3,4-tetrachlorobenzene, 1,2,4,5-tetrachlorobenzene; toxaphene, and other chemicals that are reasonably anticipated to bioaccumulate in animal tissues. Chemicals with Log K_{ow} values greater or equal to 3.0 which are not metabolized or metabolized slowly by ecological receptors are considered to bioaccumulate in animal tissue.

A PBT compound should not be screened from soil or sediment unless the method used to derive the screening value considered exposure to higher trophic level organisms in the development of the screening value. If a PBT is screened out of the assessment, then appropriate documentation should be provided in the Level II Report. If a SMDP is made to remediate the site without completing a Level III ERA, then the remediation goals are to be calculated using the appropriate bioaccumulation (BAF) and bioconcentration factors (BCF) for the detected PBT compounds. See Level III for determining the appropriate BAF and BCF values.

D) Cumulative Effects
Screening benchmarks values may be available for chemical classes (e.g. total PAHs). When a class specific screening benchmark value is available, a constituent must meet both the appropriate chemical-specific and class-specific screening benchmark before it can be eliminated from further evaluation. In addition, the potential for adverse effects associated with exposure to multiple contaminants (*i.e.*, all PECOCs, as well as COIs not selected as PECOCs) should be qualitatively evaluated and discussed in the Level II report. If evidence supports that the cumulative effects of COIs detected below benchmark values are potentially impacting important ecological receptors then the COIs should be considered as PECOCs for future evaluation.

E) Benchmarks Availability
If screening benchmark values do not exist for any specific COI, then the chemical is to be retained as a PECOC.

F) State and Federally Listed Threatened and Endangered Species
Toxicologically based benchmark screening values are not to be used for any medium utilized by State or Federally listed Threatened and Endangered (T&E) species that are present or potentially present at a site (see Attachment D in the Level I guidance). See section 3.3.9 (c)() for additional information on T&E species.

3.3.6 Task 6 PECOC Selection

PECOCs are the remaining chemicals, quantified or identified on-site that exceeded screening benchmark levels, background, chemical specific criteria, did not have screening values available, or were retained for other specific characteristics

(*e.g.*, PBT compounds, non-chemical stressors). Site-related non-chemical stressors that may be impacting important ecological receptors are also to be listed as PECOCs. Examples of potential non-chemical PECOCs include:

- Elevated total dissolved solids (TDS);
- Elevated or decreased pH concentrations in soils/surface waters;
- Low dissolved oxygen levels in surface waters;
- Cementation of surface water sediments;
- Physical habitat modification; and,
- Elevated temperatures in surface water.

The PECOCs should be presented in tabular format, with the table(s) clearly presenting all data from each medium used to determine whether a COI qualifies as a PECOC. The table(s) should include all stressors (*e.g.*, chemicals and identified nonchemical stressors) that were not chosen as PECOCs. Maximum detected and 95% UCL values (see Attachment I) should also be included in the table(s) when appropriate.

Chemicals and media may be eliminated from further ecological evaluation based on the screening results and compliance with appropriate water quality criteria. If all chemicals are below the screening values for soils and sediments where appropriate, and surface waters are in full attainment of all pertinent criteria, then the ecological assessment is to be completed by submitting the Level II report (Task 14). If any PECOCs were retained or a waterbody was not in full attainment of the appropriate criteria, then the ecological risk assessment is to continue to complete Tasks 7-13. For sites that had no PECOCs based on screening, but surface waters were not in full attainment of the appropriate criteria, see Task 14 for the use of the Level II report for discussions of a water body not being in full attainment of its aquatic life habitat use designation.

3.3.7 Task 7 Conduct Site Survey

A detailed site survey should be conducted following the screening step (Task 5) and PECOC selection (Task 6). The Level II site survey goes beyond the Level I site visit to gather site-specific qualitative and semi-quantitative data necessary for identifying relevant and complete contaminant-pathway-receptor (exposure pathway) relationships. The completion of the additional site survey and tasks 7-12 is contingent upon PECOCs being retained for further evaluation. Tasks 7-12 are also to be completed if a remedial alternative is chosen as part of a SMDP (Task 13). Techniques that may be employed to accomplish the Level II survey may include, but are not limited to, any or all of the following:

- Terrestrial receptor inventory (observation, night-lighting, live and snaptraps, nets, Emlen line transects, etc.);
- Geographic information system (GIS) mapping and analysis of survey data; and,
- Habitat/vegetation inventory (observation, line transects, quadrats, habitat evaluation procedures (HEP), etc.).

3.3.8 Task 8 Update Site Description

A narrative giving a description and analysis of the ecological conditions at and in the locality of the site is required in the Level II assessment. This narrative should provide greater depth and detail than that allowed for in the Level I checklists and should consider:

- Known and historical types, sources, and extent of contamination;
- Recorded or observed environmental problems, (*e.g.*, observed toxicity; mortality, fish kills, chlorosis in plants, etc.);
- Available results from any previous biological testing, such as data on acute or chronic toxicity or bioaccumulation phenomena;
- Physical and chemical characteristics of abiotic media in the area or climatic, physiographic, and/or geohydrologic features that could create contaminant pathways linking biota with contaminants;
- Location of any T&E species, or their potential habitats, or sensitive environmental areas, on or in the locality of the site;
- Common flora and fauna of the site and surrounding areas, *i.e.*, the most common species likely to be exposed to contaminants;
- Ecological information on biological assemblages or species important to site ecosystems;
- Specific mapping of the site to identify site-specific micro-habitats (areas of use); and,
- Results from any previous ecosystem modeling or geographic information system (GIS) based analyses.

3.3.9 Task 9 Revise Conceptual Site Model

The conceptual site model (CSM) establishes the complete exposure pathways that will be evaluated

in an ecological risk assessment and the relationship of the assessment endpoints to the measurement endpoints. The CSM can be used for a Level III ERA or may be used to help define receptors to be protected if a remedial alternative is chosen for the site.

In a conceptual site model, the possible exposure pathways are depicted in an exposure pathway diagram and must be linked directly to the assessment endpoints. Information on ecologically important receptors, assessment endpoints, PECOCs, exposure routes, and potential effects is integrated to create a preliminary CSM involving both text and graphics and should consist of:

A) A preliminary set of "risk hypotheses" that describe predicted relationships between PECOCs, exposure, and assessment endpoint response; *i.e.*, a statement of how each PECOC might affect important ecological receptors. The risk hypotheses should be written using the traditional null hypothesis format. Examples of risk hypotheses include, the following:

- The concentration of PCBs in the prey of predatory birds do not exceed levels known to impair reproduction in these birds;
- The environmental concentration of copper in sediments and surface water is not toxic to aquatic plants or animals;
- The benthic macroinvertebrate community is not affected by benzene; and,
- Food chain accumulation and transfer of DDT does not occur to a degree that allows egg shell thinning in piscivorous birds utilizing the site.

B) A simple box and arrow diagram (Attachment E), showing the relationship between exposure media and ecological receptors and all relevant exposure pathways is to be included as part of the CSM.

3.3.10 Task 10 Identify Ecological Receptors

Site-specific ecologically important receptors are identified using the criteria as follows:

a) Identify habitat types at and within the locality of the facility.

b) Identify the plant and animal species most likely to be associated with each habitat type identified in (a) above. Resources to be consulted include results of the initial site visit, the Level II site survey, a review of the available published literature, published government or scientific studies of the area, or information maintained by government agencies, resource conservation groups, or academic institutions.

c) Identify site-specific receptors for each habitat type. To the extent practicable, these receptors should be organisms that spend a significant portion of their lives or derive a significant portion of their diets or physiological needs from that habitat type. Species representing all appropriate feeding types (herbivore, carnivore, insectivore, invertivore, etc.) should be listed in the Level II report. Please see Attachment A of the Level III guidance document for information regarding the species to be used in the generic food web models. Please note that the presentation of long lists of species copied from regional or state-wide guide books without reference to observations made during the site visit or site survey, or that are not appropriate for the specific habitats found at or in the locality the site are not useful.

(i) <u>State/Federal Listed-Threatened and Endangered Species</u>
Any State or Federal-listed T&E species discovered to use or potentially use the site, for any reason (*e.g.*, nesting, roosting, feeding, etc.) is to be identified in the Level II report. Benchmark screening values are not protective of T&E species. A Level III ecological risk assessment will be required if any T&E species is identified to use the site or if the site is found to have suitable habitat to support T&E species. The Level III ERA will use each T&E species identified to use the site as an assessment endpoint in an appropriate food web model to identify possible adverse impacts. If a remedy is chosen for the site as part of a SMDP before the completion of a Level III or IV ERA, then the development of the remediation goals are to be in part calculated based on the pertinent parameters for the appropriate T&E species as well as any other assessment endpoints associated with the site. Attachment D of the Level 1 guidance contains a partial listing of state and federally-listed T&E species as provided by the Ohio Department of Natural Resources/Division of Wildlife. See: http://www.dnr.state.oh.us/endangered/default.htm and http://www.dnr.state.oh.us/

dnap/heritage for periodic updates to the species list.

d) Summarize the results of steps (a-c) above in the form of a table (Attachment C). The Level II Report should also contain text identifying and describing the T&E species present or potentially present at the site.

3.3.11 Task 11 Identify Complete Exposure Pathways

A thorough identification is to be made of relevant and complete exposure pathways that provide exposure of the identified important ecological resources to the PECOCs. An exposure route is the means in which a chemical or physical agent comes in contact with a receptor (*e.g.*, ingestion or absorption). Ecological receptors may be exposed to chemical contaminants either through direct (primary) and/or indirect (secondary) exposure routes. Only those pathways that are complete, and are expected to contribute substantially to exposures to ecologically important receptors should be addressed.

a) For an exposure to a contaminant to occur, a complete exposure pathway must exist, which requires:

(i) A source and mechanism for contaminant release;
(ii) A transport medium;
(iii) A point of environmental contact; and,
(iv) An exposure route at the exposure point.

If any of these four components is absent, a pathway is generally considered incomplete. However, the transport medium may be missing and the pathway still be complete if the contact point is directly at the contaminant release point. A pathway may also be complete if a source and mechanism for contaminant release appear to be absent but (ii), (iii), and (iv) exist, *i.e.*, direct ingestion of a contaminated transport medium.

b) Identify those pathways that have the greatest potential to bring receptors into contact with toxicologically significant quantities of a given ecological stressor. Some of the possible exposure pathways are listed below:

(i) Exposure to contaminated soil through incidental ingestion or direct contact;
(ii) Exposure to contaminated surface water through ingestion or direct contact;
(iii) Exposure to sediments through incidental ingestion or direct contact;
(iv) Exposure to ground water through ingestion or direct contact (requires a discharge to surface water by means of seeps, springs, wetlands, etc.); and,
(v) Exposure to contaminated tissues through ingestion. Receptors may be exposed to contaminants that are capable of bioaccumulation and/or bio-magnification or transfer within a food chain.

c) Select from one or more of the most typical exposure routes summarized (by environmental media) in Attachment D. Identification of typical exposure routes does not rule out the possibility that at certain sites, highly unique exposure routes could bring receptors in to contact with significant quantities of contaminants. However, unless demanded by unique site characteristics, it is usually not productive to identify particularly obscure exposure pathways and/or routes as these will ultimately be difficult or impossible to quantify.

3.3.12 Task 12 Identify Candidate Assessment Endpoints

Assessment endpoints are defined as "explicit expressions of the actual environmental value that is to be protected, operationally defined by an ecological entity and its attributes (U. S. EPA 1998)." Well-crafted assessment endpoints establish a clear logical connection between regulatory goals for a site, endpoint species, and the objectives of the ecological risk assessment. Assessment endpoints should be as specific as possible, rather than broad and all-inclusive, so as to bring focus to the assessment [see also EPA guidance ECO Update, vol. 3, number 1, January 1996, Ecological Significance and Selection of Candidate Assessment Endpoints, EPA 540/F-95/037, Attachment J].

a) The identification of "candidate" assessment endpoints is intended to begin focusing the ecological risk assessment on site-specific ecological features or resources of particular interest to risk managers. This is an opportunity for the risk manager and the risk assessor to begin a dialogue to translate the risk manager's higher-level decision criteria into a statement of assessment objectives.

b) Assessment endpoints are a required component of an ecological risk assessment.

Care must be taken to choose the appropriate assessment endpoints. If the results of an ecological risk assessment are to play a meaningful role in the remedial decision process, caution must be exercised when identifying assessment endpoints (and their associated endpoint species). When identifying assessment endpoints, consider whether there would be a willingness on the part of the risk managers to undertake a potentially costly and/or time-consuming remedial action to alleviate risk if an unacceptable hazard is demonstrated for an endpoint. Such identification works best with input from risk managers, all potential stakeholders, and risk assessors. Two elements are required to define an assessment endpoint: 1) an identification of the specific valued ecological entity; and 2) the characteristic about the entity of concern that is important to protect and potentially at risk.

c) Assessment end points do not represent a desired achievement (*i.e.*, goal). Instead they are ecological values defined by specific entities and their measurable attributes, providing a framework for measuring stress-response relationships. Examples of assessment endpoints include, but are not limited to, the following:

- Survival and growth of soil invertebrates;
- Survival and reproduction success of fish eating birds;
- Shrew populations and reproduction rates; and,
- Wetland benthic community abundance and diversity.

Of the set of ecologically important receptors (identified during Level II and/or Task (11) above), those that have substantial aesthetic, social, or economic value or are important in the biological functions or biodiversity of the system, may be selected for association with assessment endpoints. These ecological receptors linked to specific assessment endpoints are termed "endpoint species". Endpoint species are either themselves the object of protection or serve as surrogates for all other ecological receptors requiring protection.

d) Groups (guilds) of receptors that are examples of candidates for association with assessment endpoints include, but are not limited to: benthic or epibenthic aquatic invertebrates; small mammalian predators whose diets consists of soil invertebrates; small mammalian herbivores; ground-feeding avian predators; piscivorous avian predators; and omnivorous waterfowl whose diet includes aquatic macrophytes and invertebrates.

e) Any candidate endpoints identified at this point may be further refined in terms of receptors and potential effects during Task 1 of a Level III assessment. Also at that time, assessment endpoints will be linked to related measures of exposure and effects.

f) All State and/or Federally-listed T&E species located at or in the locality of the site must be included as assessment endpoints and endpoint species.

3.3.13 Task 13 SMDP: (Ecological Risk Probable?)

For a site to present a potential for hazard, it must exhibit the following three conditions: (a) contain PECOCs in media at detectable and biologically significant concentrations, (b) provide exposure pathways linking PECOCs to ecological receptors, and (c) have endpoint species that either utilize the site, are not observed to utilize the site but habitat is such that the endpoints species should be present, are present nearby, or can potentially come into contact with site-related PECOCs. Thus, the Level III deliverable should identify if PECOCs, endpoint species, and complete exposure pathways exist at or in the locality of the site.

a) Specific conditions are as follows:

(i) Are PECOCs in any medium present at the site?
(ii) Are surface waters meeting all applicable criteria?
(iii) Are ecological receptors present or potentially present at the site, or could be exposed to site related PECOCs?
(iv) Based on site-specific information gathered during the site visit and/or site survey, knowledge of PECOC characteristics, receptor behavior, and professional judgment, do there appear to be plausible links between ecological stressors and T&E or non-T&E endpoint species?
(v) Does the locality of the facility contain sufficient suitable habitat to support a local population of endpoint species?

a) If (i) is **"No"** and (ii) is **"Yes"**, then the site is highly unlikely to present ecological risks and a recommendation for no further ecological investigations should be made.

b) If (i), (iii), (iv), and (v) are **"Yes"**, then the site could present ecological risks and a recommendation to move to SMDP should be made.

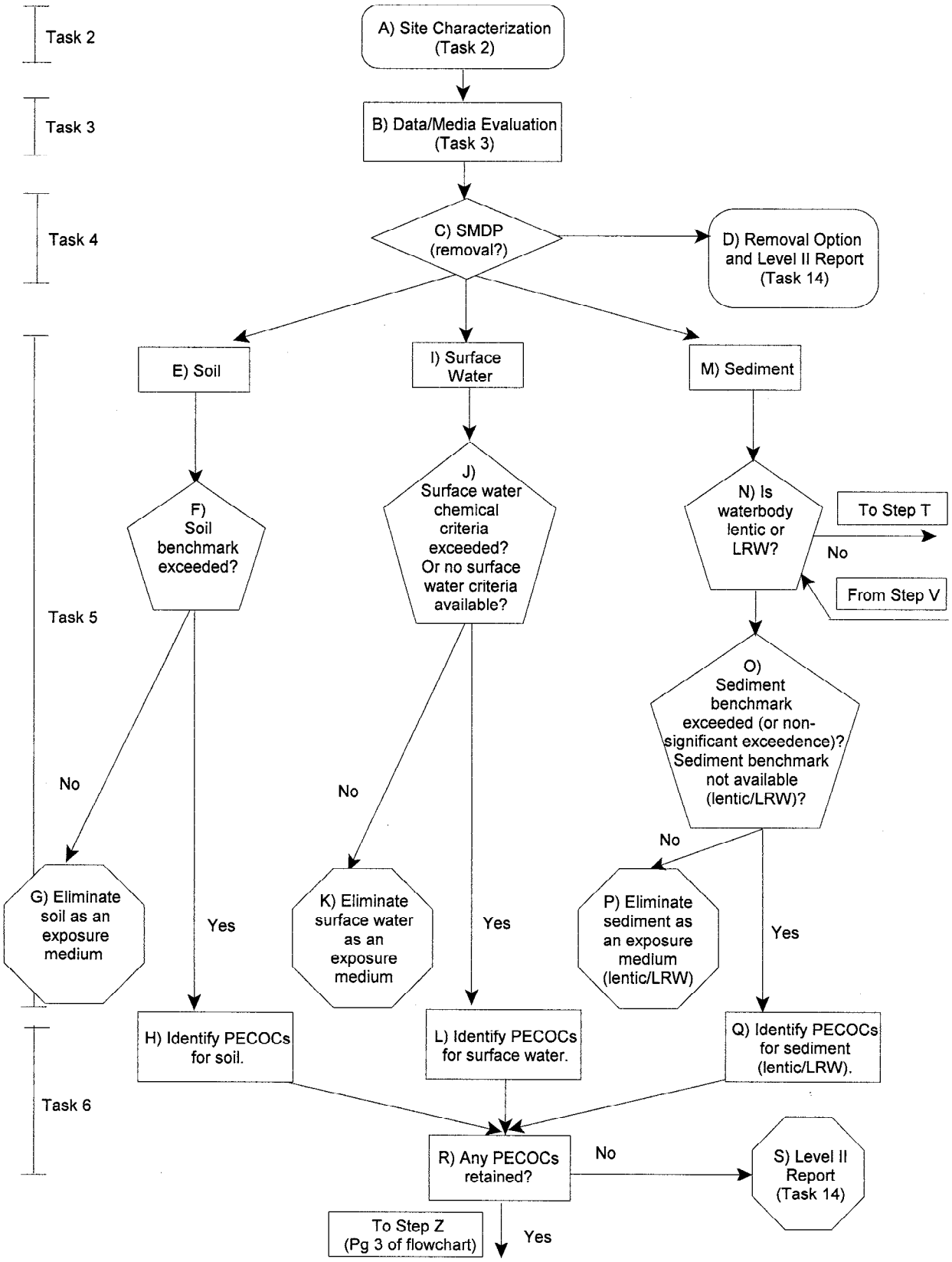
c) If (i) is **"Yes"** and (ii) is **"No"**, then the site could present ecological risks and a recommendation to move to SMDP should be made.

(Remedial Decision Possible?)
Are risk managers willing to make a response action decision with existing information and current levels of uncertainty? A decision for remedial action is possible anytime after step B of the flowchart. Key questions: Would cleanup be less costly than further investigation? Are data adequate to approve a removal action or to select or approve a remedy? If "**Yes**", then further ecological investigation is deferred in favor of a response action. Site-specific target cleanup levels may be calculated using the appropriate guidance (to be developed). If "**No**", then the assessment process proceeds to Level III for further evaluation of the ecological risks posed by site related PECOCs. A SMDP is offered at two different times throughout the Level II ERA. The Level II flow chart identifies the SMDPs and their appropriate times for use during the Level II ERA process.

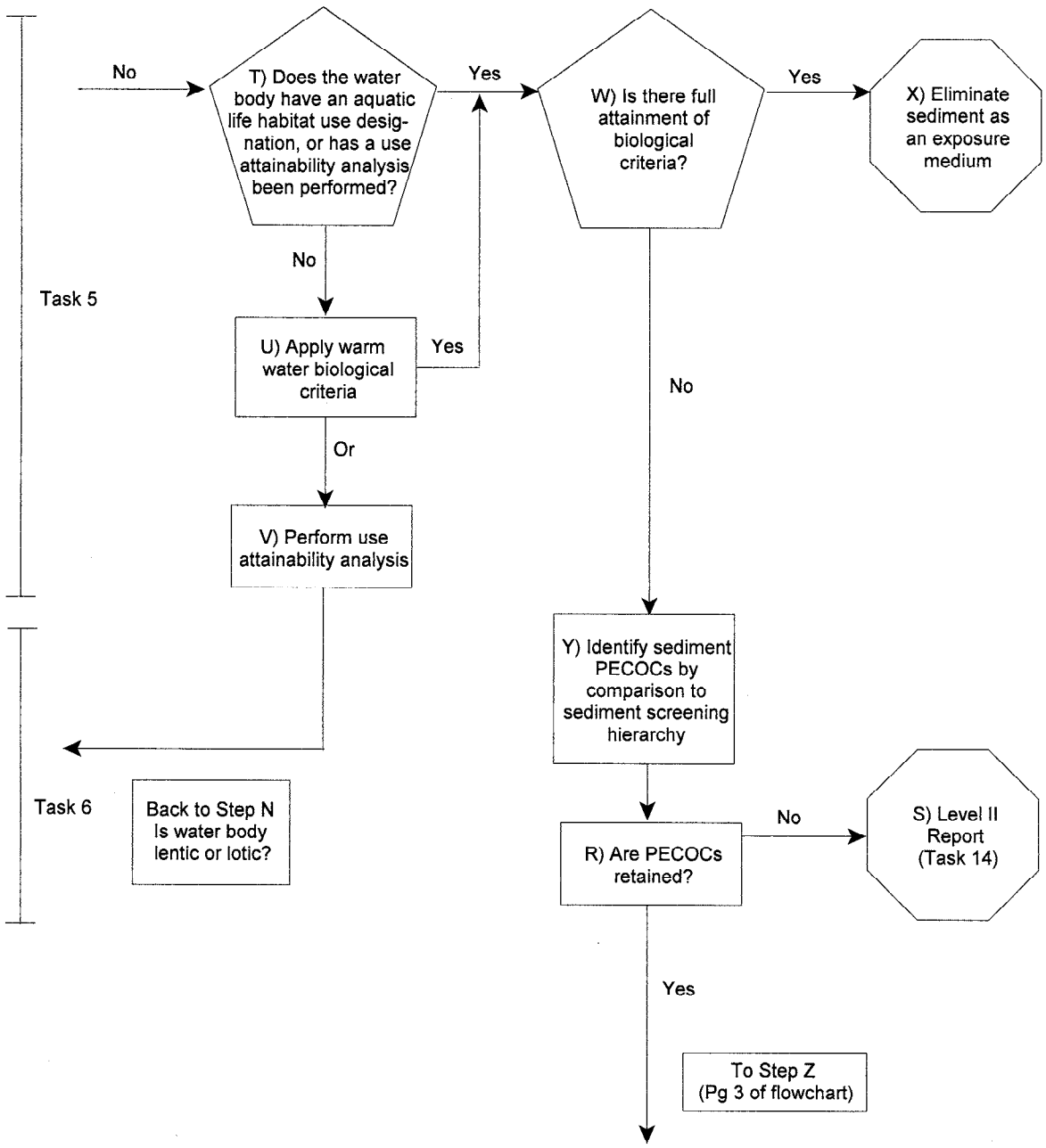
3.3.14 Task 14 Submit Level II Report

The Level II report is to summarize the results of all tasks that were completed during the Level II ERA in a concise and logical manner. The report will also summarize all investigations that have occurred and any relevant site information regarding the ecological habitat and health of the site. The Level II report is a deliverable which identifies PECOCs, site-specific receptors, relevant and complete exposure pathways, and other pertinent information for conducting a Level III ERA if a SMDP was chosen to continue the ecological assessment in a Level III ERA. If a remedy was chosen as the result of a SMDP, the Level II report is to discuss all results of each task completed and the remedy of choice. Approval of the remedial plan by Ohio EPA DHWM is required before beginning a remedy. The report may also discuss upstream sources of contamination in surface waters and anthropogenic compounds detected in all media during the site investigation process. Sites containing surface water that were not in full attainment of their appropriate aquatic life habitat use designation(s) may also use the report to summarize information regarding non-chemical impacts and reasons other than contamination that may be responsible for the water body not being in full attainment. See Attachment F for an outline of the Level II report and expected contents.

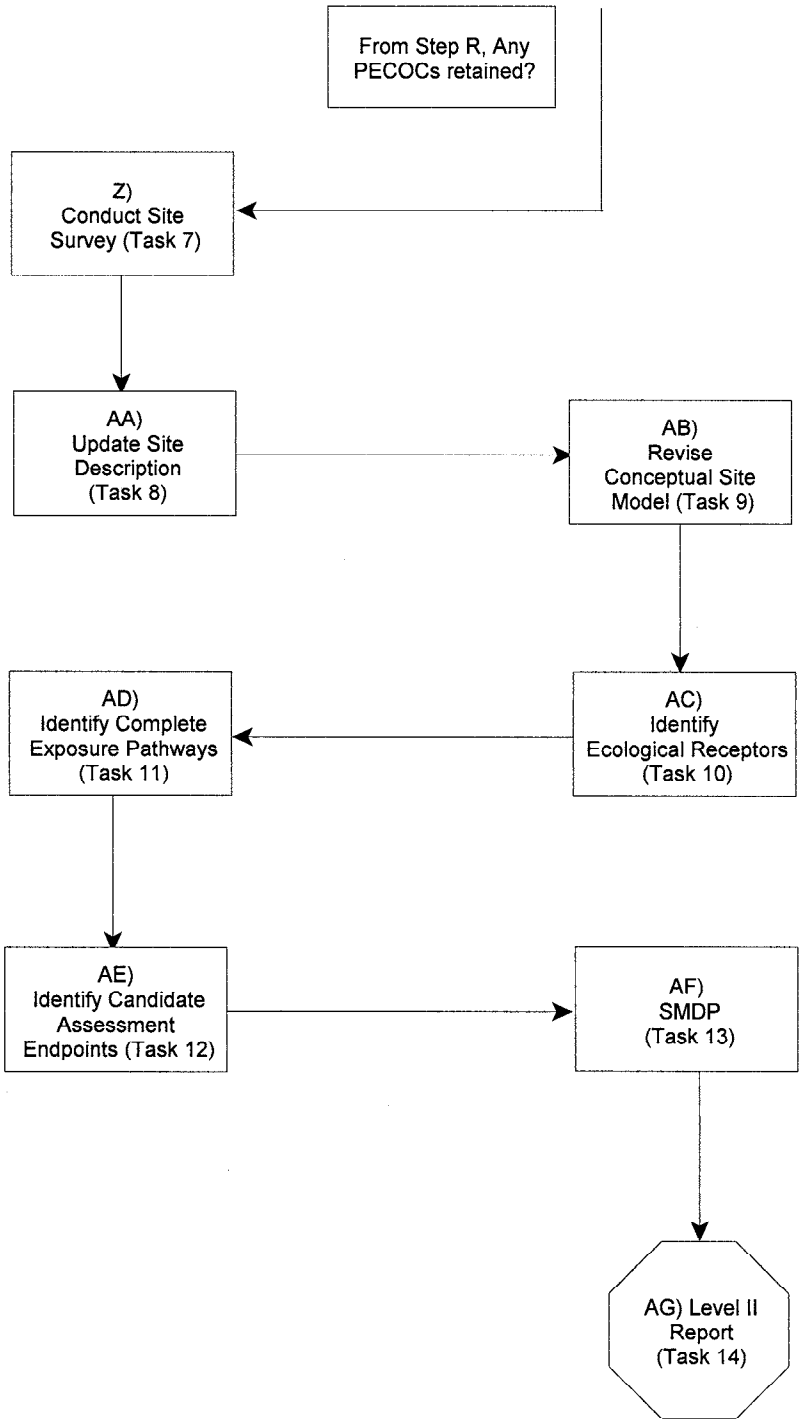
Attachment A
Level II Flowchart and Legend
(Tasks 2-6)



Level II Flowchart (continued)
(Tasks 5-6 continued)



Level II Flowchart (continued)
(Tasks 7- continued)



Flowchart Legend

A) Site Characterization (Task 2)

Site characterization is completed after a Level I ERA has been completed, and prior to beginning a Level II ERA. Site characterization consists of all necessary media sampling and investigations including biological criteria if necessary, that will adequately define the nature and extent of contamination, the attainment status of impacted surface water bodies, and if desired, the representative background conditions at or near the site.

B) Data/Media Evaluation (Task 3)

Data/Media evaluation is comprised of two processes: (I) Data Evaluation to determine if any chemicals can be eliminated from the risk assessment by a frequency of detection screen and (II) Media evaluation to determine if site-related chemicals have impacted media associated with the site.

I) *Data Evaluation*: Any chemical in any medium may be eliminated if it is detected at a frequency of less than 5 percent. Common laboratory contaminants may also be eliminated if appropriate.

II) *Media evaluation*: This evaluation is to determine whether or not site-related chemicals have impacted media associated with the site.

1) <u>Comparison to background concentrations</u>

2) <u>Ohio Specific Sediment Reference Values</u>

3) <u>Persistent, Bioaccumulative, and Toxic (PBT) Compounds</u>
PBT compounds detected in surface water, sediment, or soil are to be listed as PECOCs. PBT compounds are defined and discussed in 3.3.5 (C) of the Level II ERA guidance.

C) SMDP (removal) (Task 4)

SMDP (removal) is offered following the completion of the data/media evaluation step (Task 3). The only options available at this SMDP are either a removal of contaminated media or the exit of the Level II ERA process at this point as a result of soil, sediment, and surface waters being demonstrated to be consistent with background conditions of the site (*i.e.*, soil, sediment and surface water(s) are consistent with background conditions).

D) Removal Option (Task 4) and/or Level II Report (Task 14)

A complete removal is the only remedy offered with the removal SMDP. A description of the removal, confirmatory sampling results and the remainder of the required Level II information is to be submitted in a Level II report (Task 14) to the Ohio EPA DHWM. For sites exiting the Level II ERA process because soil, sediment and surface waters contained only inorganic compounds and the concentrations were consistent with background conditions, see step S of the flow chart and Task 14 for details on the Level II report.

E) Soil (Task 5)

Soil refers to terrestrial habitats at the site and can include any non-hydric soil. Hydric soils are considered under surface water and sediments where appropriate.

F) Soil Benchmark Exceeded? (Task 5)

This step refers to the comparison of chemicals detected in on-site soils to values cited in the soil screening benchmark hierarchy given in 3.3.5 (A). If the maximum soil concentrations are below or equal to the benchmark values, then they may be eliminated from the ecological risk assessment.

G) Eliminate Soil as an Exposure Medium (Task 5)

Soil may be eliminated as an exposure medium only if all detected chemicals carried through the flow chart process are below or equal to the soil benchmark values, or only minor exceedances are observed. If soil is to be eliminated as an exposure medium, then the results and rationale are to be given in the Level II report.

H) Identify PECOCs for Soil (Task 6)
The PECOCs identified for soil will be those chemicals detected in soil and not eliminated during steps B (Task 3) and F of the flowchart. Soil PECOCs are to be listed in the Level II report.

I) Surface Water (Task 5)
Surface Water refers to any surface waterbodies on-site.

J) Surface Water Chemical Criteria Exceeded? or, No Surface Water Criteria Available (Task 5)
Surface water concentrations of all water bodies are to be compared to the Ohio EPA Chemical Specific Water Quality Criteria found in OAC 3745. If all surface water chemicals detected in surface waters on-site are below their appropriate chemical criteria and chemical criteria exist for all detected compounds, then surface water can be eliminated as an exposure medium. If surface water chemicals exceed their chemical criteria, no chemical criteria are available, or PBT compounds (3.3.5 (C)) are present in surface water, then they are to be retained as surface water PECOCs.

K) Eliminate Surface Water as an exposure Medium (Task 5)
The elimination of surface water as an exposure medium is completed only if all detected chemicals are below their appropriate surface water criteria. The results and rationale are to be given in the Level II report to satisfy the exclusion of compounds and/or media from further ecological risk evaluation.

L) Identify PECOCs for Surface Water (Task 6)
The remaining chemicals, if any, from the comparison of compounds detected in surface waters to the Ohio Surface Water Criteria, described in step J are listed in the Level II report as PECOCs for surface waters. See 3.3.5 (C) regarding the inclusion of PBT compounds.

M) Sediment (Task 5)
Sediment underlying surface waters is to be evaluated under the sediment pathway, starting at step M of the flow chart. Materials underlying wetlands (sediments) are to be evaluated as sediments or soils, depending on the type of wetlands. See 3.3.5 (B)(ii)(c) of the Level II ERA guidance document for a discussion about wetland soils/sediments.

N) Is Water body Lentic or LRW? (Task 5)
This question asks if the water body(ies) on-site is lentic (non flowing systems such as lakes, ponds, wetlands, etc.), or if the flowing surface water body(ies) on site has been designated as Limited Resource Waters (LRW) by the State of Ohio. If the impacted surface water is lotic and has not been designated LRW, then continue to step T. Sediments associated with lentic or LRW designated water bodies, or wetlands where appropriate, are to continue to step O of the flow chart.

O) Sediment Benchmark Exceeded? (Or non significant exceedances), No Sediment Benchmark Available? (lentic/LRW) (Task 5)
Sediment concentrations are to be compared to the appropriate benchmark values given in the sediment screening hierarchy listed in 3.3.5 (B)(iii)(d). If the sediment concentrations exceed the sediment benchmark values, or if no sediment benchmarks are available, or PBT compounds are present in sediments and the benchmark values have not considered higher trophic level exposures in the derivation of the value (see 3.3.5 (C)) then, the chemicals are to be retained as sediment PECOCs ((Task 6) step Q of the flowchart).

P) Eliminate Sediment as an Exposure Medium (lentic/LRW) (Task 5)
The elimination of sediments as an exposure medium is completed only if all detected chemicals are below their appropriate benchmark values or only minor exceedances are observed. See 3.3.5 (C) regarding PBT compounds. All results and rationale are to be given in the Level II report for the exclusion of compounds and/or media from further ecological risk evaluation.

Q) Identify PECOCs for Sediment (lentic/LRW) (Task 6)
The PECOCs identified for lentic or LRW associated sediments will be the chemicals remaining after the comparison to the appropriate benchmark values (step O). The sediment PECOCs are to be listed in the Level II report.

R) Any PECOCs Retained?

Step R questions if there are any chemicals that exceed the appropriate screening values. If all chemicals are below the appropriate values and surface waters are in full attainment of all pertinent criteria, then the ecological assessment is to be completed by submitting the Level II report (Task 14). If any PECOCs are retained or a water body was not in full attainment of the appropriate criteria, the ecological risk assessment is to continue to complete Tasks 7-13. For sites that have no PECOCs but surface waters are not in full attainment of the appropriate criteria, see Task 14 for the use of the Level II report for discussions of a water body not being in full attainment of its aquatic life habitat use designation.

S) Level II Report (Task 14)

The Level II report is the terminal point for the Level II flowchart and the Level II ecological risk assessment. A report will summarize all of the results of the Level II investigation that will explain which media have been retained as exposure media and if and why media were eliminated from further evaluation. If a removal or other remedial action is chosen, then the pertinent information regarding the action and confirmatory results are also to be included in the Level II report. The report will list the PECOCs for each medium and the appropriate details required in the Level II report. If media and chemicals remain after the screening processes, then additional details may also be required in the Level II report. See Task 14 and Attachment F of the Level II ERA guidance document for the specific requirements.

T) Does the Water Body have an Aquatic Life Use Habitat Designation or has a Use Attainability Analysis been Performed? (Task 5)

This step is to determine whether or not the flowing surface water body has been designated by Ohio EPA as Warm water, Exceptional Warm Water, Modified Warm Water, Cold Water, or Seasonal Salmonid habitat, or if a use attainability analysis has been performed by Ohio EPA or other qualified investigator. Aquatic life habitat use designations are listed in OAC 3745-1-07 through 3745-1-30. If the flowing water body has not been designated, or is too distant from a designated stream or section of stream, then the water body will need to be designated.

U) Apply Warm Water Criteria (Task 5)

If a lotic surface water body on site has not been designated or is too distant from a designated section of a lotic water body, then the warm water aquatic life habitat use designation criteria apply, or a use attainability analysis is to be performed and the water body designated using the results from the analysis. Please refer to section 3.3.5 (B)(ii)(b) for a discussion regarding the water body designation process.

V) Perform Use Attainability Analysis (Task 5)

A use attainability analysis may be performed to determine the appropriate aquatic life habitat use designation for the lotic water body. This may be beneficial and/or cost effective when a lotic water body without an official use designation is believed to be a limited resource water or have a designation other than warm water habitat. The Ohio EPA Division of Surface Water should be contacted prior to planning a use attainability analysis. Following the use attainability analysis and confirmation of the results with the Ohio EPA Division of Surface Water, the ecological evaluation is to continue again at step N of the Level II flowchart.

W) Is there Full Attainment of the Biological Criteria? (Task 5)

Full attainment of the appropriate aquatic life habitat use designation is required for designated lotic water bodies other than limited resource waters, or lotic water bodies that are using the warm water habitat designation criteria, once sediment contamination has been identified (Task 3, step B in the flowchart). If the water body is not in full attainment of the appropriate aquatic life habitat use designation, then sediment associated PECOCs are identified in step Y of the Level II flowchart. The results of the biological/habitat evaluations are to be included in the Level II report regardless of the attainment status of the water bodies.

X) Eliminate Sediment as an Exposure Medium (Task 5)

The elimination of sediments as an exposure medium for a designated lotic water body other then LRW, or a lotic water body that is using the warm water habitat designation criteria, is completed only if the water body is in full attainment of its aquatic life habitat use designation and PBT compounds are not present in sediments.

Note: Steps Y-AD (Tasks 7-12) are only to be completed if PECOCs are retained for further evaluation.

Y) Identify Sediment PECOCs by Comparison to Sediment Benchmark Hierarchy (Task 5)

Sediment PECOCs are to be determined if the lotic water body does not fully attain its aquatic life use designation. The sediment chemical concentrations are to be compared to the appropriate sediment benchmark values from the sediment benchmark hierarchy given in section 3.3.5 (B)(ii)(d). Any chemical that exceeds its appropriate benchmark value or does not have an available benchmark is to be retained as a sediment PECOC and listed in the Level II report. Please see section 3.3.5 (C) for information regarding the elimination of PBT compounds in sediment.

Z) Conduct Site Survey (Task 7)

The Level II site survey is intended to identify habitats and organisms that are potentially exposed to site-related contaminants.

AA) Update Site Description (Task 8)

The site description given in the Level II report is to include all relevant information gathered during the Level II and previous ERAs regarding habitats and ecological receptors at or in the locality of the site.

AB) Revise Conceptual Site Model (Task 9)

A conceptual site model is to be developed for the site and given in the Level II report. The CSM is to consist of both a written description and a graphical representation of the completed contaminant migration/exposure pathways, receptors, and other relevant information that describes the flow of contaminants through the various habitats/receptors associated with the site.

AC) Identify Ecological Receptors (Task 10)

Site-specific ecological receptors identified on-site or receptors that have the potential to use the site are to be listed in the Level II report.

AD)Identify Complete Exposure Pathways (Task 11)

A list of relevant and complete exposure pathways are to be given in the Level II report.

AE) Identify Candidate Assessment Endpoints (Task 12)

Specific assessment endpoints are to be listed in the Level II report given the complete exposure pathways and receptors identified in Task 9.

AF) SMDP (Task 13)

The SMDP will be a decision that is documented in the Level II report. The following three decisions are possible for the SMDP:

a) no further ecological investigations are required;
b) continued ecological investigations will be pursued in a Level III or greater ERA; or,
c) a remedial alternative is selected for the site.

AG) Level II Report (Task 14)

The Level II report is to summarize the results of all tasks that were completed during the Level II ERA in a concise and logical manner and discuss any relevant site information regarding the ecological habitat(s) and health of the site.

Attachment B
Potential Ecological Contaminants of Concern
(example of spread sheet)

Contaminant of Interest	Minimum Detection Limit	Range of Detected Concentrations		Frequency of Detection	Exposure Point Concentration	Background Concentration	Toxicity Criteria	PECOC Decision
		Minimum	Maximum					

Attachment C
Summary of Ecological Receptors (by habitat)

Habitat Type (1)	Habitat Type (2)	Expected Species	Observed Species	Time Observed (am/pm)	Relative Occurrence	T&E Species

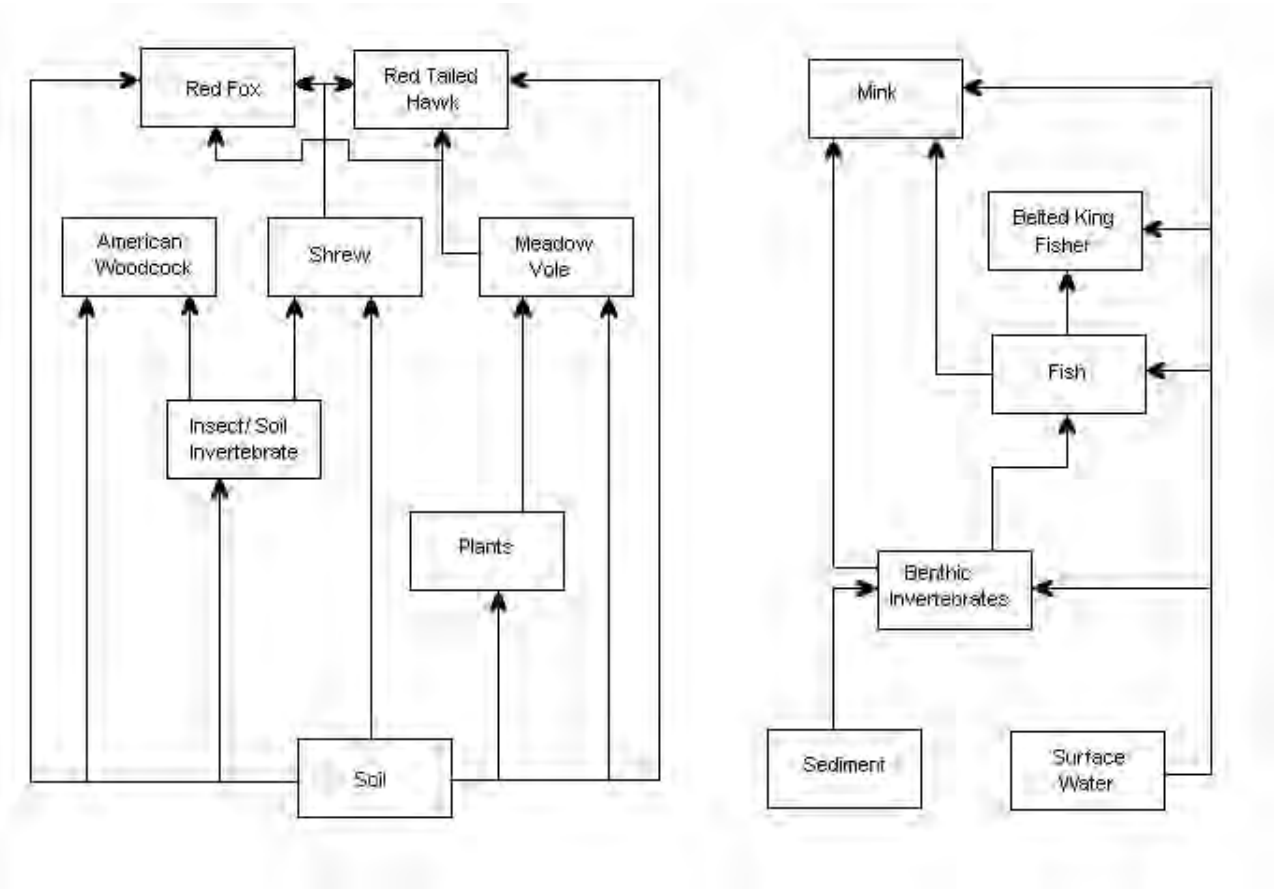
1) Habitat type may include: wooded, old field, oak/willow riparian, etc.
2) Percentage of habitat type (habitat type in acres/ total acres).

*** Note: This checklist provides a suggested format. The format may be altered to fit the needs of the facility; however, all requested information should be presented.

Attachment D
Exposure Routes for Ecological Receptors By Environmental Media (example)

Environmental Media	Exposure Route	Comments
Surface Water	Direct Contact	Terrestrial organisms may be exposed to water-borne contaminants via dermal contact as a result of wading or swimming in contaminated waters. Aquatic receptors may be exposed through osmotic exchange, respiration of surface waters.
	Root Contact	Contaminants may be taken-up by terrestrial plants whose roots are in contact with surface waters.
	Ingestion	Terrestrial receptors may ingest water-borne contaminants if contaminated surface waters are used as a drinking water source.
Ground Water	Root Contact	Contaminants may be taken-up by terrestrial plants whose roots are in contact with ground water present within the root zone (~1 m depth).
	Ingestion	Receptors generally will not contact ground water unless it is discharged to the surface, at which time it should be evaluated as surface water.
Sediment	Direct Contact	If sediments are present in an area that is only periodically inundated with water, terrestrial species may be exposed via dermal contact during dry periods; such sediment exposure would be evaluated as soil exposure. Aquatic receptors may be directly exposed to sediments or may be exposed through osmotic exchange, respiration or ventilation of sediment pore waters.
	Root Contact	Exposure of emergent aquatic plants rooted in contaminated sediment.
	Ingestion	If sediments are present in an area that is only periodically inundated with water, terrestrial species may have direct access to sediments for the purposes of incidental ingestion. In this instance, sediment exposure would be evaluated as soil exposure. Aquatic receptors while foraging.
Soil	Root Contact	Contaminants in bulk soil may partition into soil solution, making them available to roots.
	Ingestion	Incidental ingestion of contaminated soil could occur while animals search for food, reside in the soil, feed on plant matter covered with contaminated soil or groom themselves.
Food Web	Ingestion	Higher trophic level terrestrial and aquatic consumers and predators, not necessarily in direct contact with any contaminated media, may be exposed through consumption of contaminated food sources.

Attachment E
CSM Diagram (example)



Attachment F
Level II Report - Outline

(1) INTRODUCTION
- (a) Site History
- (b) Regulatory Status
- (c) Level I Report

(2) SITE SURVEY
- (a) Objectives and Scope
- (b) Methodology
- (c) Results

(3) RESULTS
- (a) Site Description
- (b) Site-specific Ecological Receptors*
- (c) T&E Species
- (d) Candidate Assessment Endpoints*
- (e) Potential Ecological Contaminants of Concern (PECOCs)*
- (f) Relevant and Complete Exposure Pathways*
- (g) Preliminary Conceptual Site Model*

(4) RECOMMENDATIONS

(5) ATTACHMENTS
- (a) Regional map showing location of site
- (b) Local map showing site in relation to adjacent property
- (c) Site map
- (d) Map of ecological habitats as overlay to site map
- (e) Map of known or suspected extent of PECOCs as overlay to site map

* Only applicable if the site progresses beyond Task 5

Attachment G
Point of Exposure

Medium	Depth	Rationale
Soil	0-1.2 m*	Based on burrowing animals
Sediment	0-15 cm*	Based on the depth of macroinvertebrate activities in sediment
Surface Water	All waters	
Tissue	Whole body concentrations	Based on the fact that most of the prey is consumed by the predator

* Site specific conditions need to be addressed including the nature and extent of contamination and the actual point of exposure needs to reflect the appropriate soil depth (*e.g.,* considering burrowing animals, site specific receptors) or sediment depth *(e.g*., as the result of scouring, depositional areas).

Attachment H

OHIO SPECIFIC SEDIMENT REFERENCE VALUES

2/11/03

Introduction

The decision to remediate potential contamination of an environmental medium (e.g. air, soil, ground or surface water, sediments) on the basis of potential impacts to ecological receptors is based in part, upon the concentration of the chemical(s) in the medium. In the case of evaluating impacts to sediments, one option is to demonstrate that the chemical concentrations may be acceptable using toxicological benchmark screening values. However, these are often not directly associated with ecological integrity.

The utility of these benchmarks is somewhat limited for several reasons. Generally, these benchmarks are developed based on potential adverse affects to a variety of organisms using bioassays, receptor intake modeling (exposure models using toxicity threshold criteria and hazard quotient methodologies), or, more rarely, measured responses in actual contaminated environments. If the benchmark values are based on bioassays, then often pollutant tolerant species were used due to their ability to survive and reproduce in captivity or laboratory environments. It is also likely that the organisms used in the development of the conservative benchmark values may not be associated with the site. In addition, many of these benchmark values are applied regardless of the specific media characteristics or regional differences associated with the development of the benchmark values.

A second option is to compare chemical concentrations in potentially impacted sediments to background levels derived from non- or minimally impacted locations. In the context of this communication, background is defined as the concentration of naturally occurring chemicals that are unaffected by any current or past activities involving the management, handling, treatment, storage, or disposal of chemicals. The use of background concentrations of chemicals in identifying potential contamination has been a common practice and, although most regulatory agencies allow the screening of potentially contaminated media based on background conditions, the development of site-specific background concentrations is limited due the number of samples and associated costs often required to permit a statistically relevant estimation of background.

As a potential resource and cost effective alternative to the latter approach, Ohio-specific Sediment Reference Values (SRVs) were developed to identify representative background sediment concentrations for lotic (flowing) water bodies. The SRVs will more conclusively identify whether a site has been contaminated, as reliable background values can be used to identify if sediments have concentrations of chemicals above a level considered to be representative of the area. The ability to develop background sediment concentrations including regional differences in Ohio were based on the sediment sampling conducted at biological reference sites. These reference sites were the same sites used in the development of biological criteria in Ohio.

Biological Criteria and Reference Areas

Biological criteria are narrative and measurable attributes of aquatic communities. These attributes include macroinvertebrate and fish community structure and function combined with habitat evaluations (Yoder and Rankin, 1996). In Ohio, numerical biological criteria were developed using a regional reference site approach (Ohio EPA 1987a,b; Ohio EPA 1989; Yoder 1989; Yoder and Rankin 1995). The development of the SRVs also used the same regional approach as the data used in the development of the biological criteria, with sediment and biological sites often co-occurring (Figure 1).

Sediment samples were taken from reference areas throughout the state that have been used historically to develop the biological criteria as part of the State of Ohio's water quality standards. These reference areas were selected as being representative of least impacted conditions in the watersheds for which they serve as models. In Ohio, parts of five ecoregions occur (Figure 1). An ecoregion is a relatively homogenous area where boundaries of several key geographic variables more or less coincide (Hughes et al. 1986). In using the ecoregion/reference site approach the reference sites serve as benchmarks for measuring the condition of other sites within the same ecoregion (Ohio EPA 1987b).

Materials and Methods

Sample collection
Sediment data was collected from lotic Ohio surface water bodies in all five ecoregions from approximately 1984 through 2001. Sediments were sampled in accordance with Ohio EPA sediment sampling guidelines (Ohio EPA 2001) which specify that samples be taken, when possible, in sediment deposition zones. A majority of these samples were taken as part of the Ohio EPA surface water program to assess water resource conditions in rivers and streams of Ohio. In addition, sediment samples collected as part of Division of Emergency and Remedial Response's site assessments (co-occurring at biological reference sites) and the Lake Erie watershed biological reference site sediment characterization project (Ohio EPA 1999a) were included. A total of 512 bulk sediment chemistry results were used in this analysis.

Laboratory analysis
Chemical analysis of the sediments was performed using methodologies summarized in Table 1. Specific analysis to determine metal speciation were not conducted.

Table 1: Summary of analytical methodologies[1]

Analytical technique	USEPA Methodology
Graphite furnace atomic absorption spectrometry (GFAA)	USEPA 7041, 7060A, 7131A, 7421, 7740, 7760A, 7841,
Cold vapor atomic absorption spectrophotometry - (CVAA)	USEPA 7471A, 245.5
Inductively coupled plasma-atomic emission spectrometry (ICP-AES)	USEPA 6110B
Stabilized temperature GFAA	USEPA 200.15

[1] All methods listed are SW-846 (excluding USEPA 245.5 and 200.15)

Sediment chemical concentrations were reported on a bulk dry-weight basis. Dry-weight data were used as previous studies regarding predictive toxicity -based values indicate that they predict effects as well or better than values that are based on carbon-normalized data. (Barrick et al. 1988; Long et al. 1995; Ingersoll et al. 1996; U.S. EPA 1996a; MacDonald 1997).

Data consisted of single discrete chemical samples and samples taken for quality assurance and quality control (QA/QC) purposes. Data from individual samples were used "as is." Data derived from field split samples were averaged between the splits. This was based on the fact that split samples were duplicate aliquots taken from the same mixed sample. Field split samples were collected to verify field compositing techniques and sediment homogeneity within a single collected sample (Ohio EPA 2001). In contrast, station replicate samples were completely separate QA/QC samples. However, these station replicates were taken in the same general vicinity as the sample of interest. Replicate samples can be collected to determine the variability of the concentrations of chemicals in the sediment at a specific site and/or as an assessment of a field sampling technique. Based on the above, replicate data points were considered as discrete values in the development of the SRVs.

Treatment of Detection Limits
In evaluating any environmental dataset the presence of numerous detection limits can complicate its statistical analysis, due to the clustering of single values often at or near the lower extreme of the data range. Because these data represent actual, albeit somewhat uncertain quantitative data, but also include, in general, the lowest sample concentrations, their inclusion in a complete analysis is critical. The usual approach to dealing with detection limits is to use either the detection limit itself, or some constant fraction (e.g. 0.5 or 0.1) of the detection limit. Because this approach does not relieve the issue of data clustering, an alternative approach to evaluating detection limits was employed.

Given that a detection limit represents the theoretical maximum concentration that could be measured in a specific sample, the true sample concentration is a value somewhere between 0 and the detection limit. The probability that the actual value approximates any specific value within that range is equal for all values in the range. That is, if a random number between 0 and the detection limit were chosen, the likelihood that it would be a better or worse representation of the actual value than 0, the detection limit itself, or any fraction of the detection limit is the same. The advantage in choosing a random number however, is that while it has the same level of uncertainty as choosing a value such as 0.5 times the detection limit to represent the true concentration, the likelihood of drawing the same number for each occurrence of a detection limit is quite small. Thus distributional issues due to clustering at a single value, as well as inappropriate statistical bias to a particular value as a better representation of the true value is eliminated. The importance of using this approach increases as the percentage of concentrations reported as detection limits increases.

A second issue regarding detection limits is related to samples in which high detection limits are reported. In these cases, it was assumed that sample conditions were such that an accurate measurement of a specific constituent could not be made. Therefore, as an initial screen, all detection limits were evaluated in the context of maximum measured concentrations for each constituent. In instances where the detection limit exceeded the maximum measured concentration for a specific analyte, the sample was excluded for that particular analyte. Detection limits passing this criterion were included in the evaluation as a random number between 0 and the detection limit.

Statistical Analysis

Once all detection limits had been adjusted as noted above, the data were first evaluated for underlying distributions (normal or lognormal) using probability plots of original and transformed data. Results of this analysis indicated that in most cases, the data were neither normally nor lognormally distributed. This was confirmed using a Komolgorov/Smirnov nonparametric test for normality.

Based upon this finding, individual constituents grouped by ecoregion were evaluated in order to determine whether significant differences existed between concentrations observed in each ecoregion. Because the data were not normally distributed a nonparametric Kruskal-Wallace test was used in lieu of a standard one-way analysis of variance. Based upon this evaluation, most constituents exhibited significant differences ($p < 0.05$) among concentrations observed at one or more ecoregions. In those cases where no significant differences were observed, a single statewide reference value was derived. In instances where a significant difference was observed, individual reference values were calculated for each ecoregion.

In some instances, insufficient data ($n<12$) precluded derivation of either an ecoregion-specific reference value, or determination of whether or not a statewide value would accurately reflect concentrations for a specific ecoregion. In those instances no value is provided and it is recommended that site-specific background concentrations for these specific constituents be developed on a case-by-case basis.

Derivation of SRVs

Once it was determined that a statewide or ecoregion value should be developed, the data were pooled for each constituent as appropriate and a representative value was derived. The derivation and use of an upper-bound confidence limit of a defined sample quantile (e.g. 90th percentile) as an appropriate representation of the background population was precluded because the data could not, in general, be fit to an underlying distribution. As an alternative approach, the value was derived as a cutoff value, above which a value would be considered an outlier (Ohio EPA1999b). Using this technique, the reference value was defined as the interquartile range (distance between the 25th and 75th percentile) multiplied by 1.5 and added to the upper quartile (75th percentile) value. This value is consistent with the upper inner fence on a standard box plot.

Results

The SRVs given in Table 2 may be used in conjunction with, or in lieu of, generating site-specific background concentrations to determine whether sediments have been potentially impacted by site-related activities. As mentioned above, it should be noted that the SRVs ***are not*** Ohio EPA standards or criteria. The values are to be used as a screening tool for sites that have identified potential sediment contamination in lotic waterbodies. Where indicated, ecoregion specific values are provided and are appropriate for sites within that ecoregion (see Figure 1 for ecoregion boundaries and abbreviations).

Table 2: Sediment Reference Values (mg/kg)

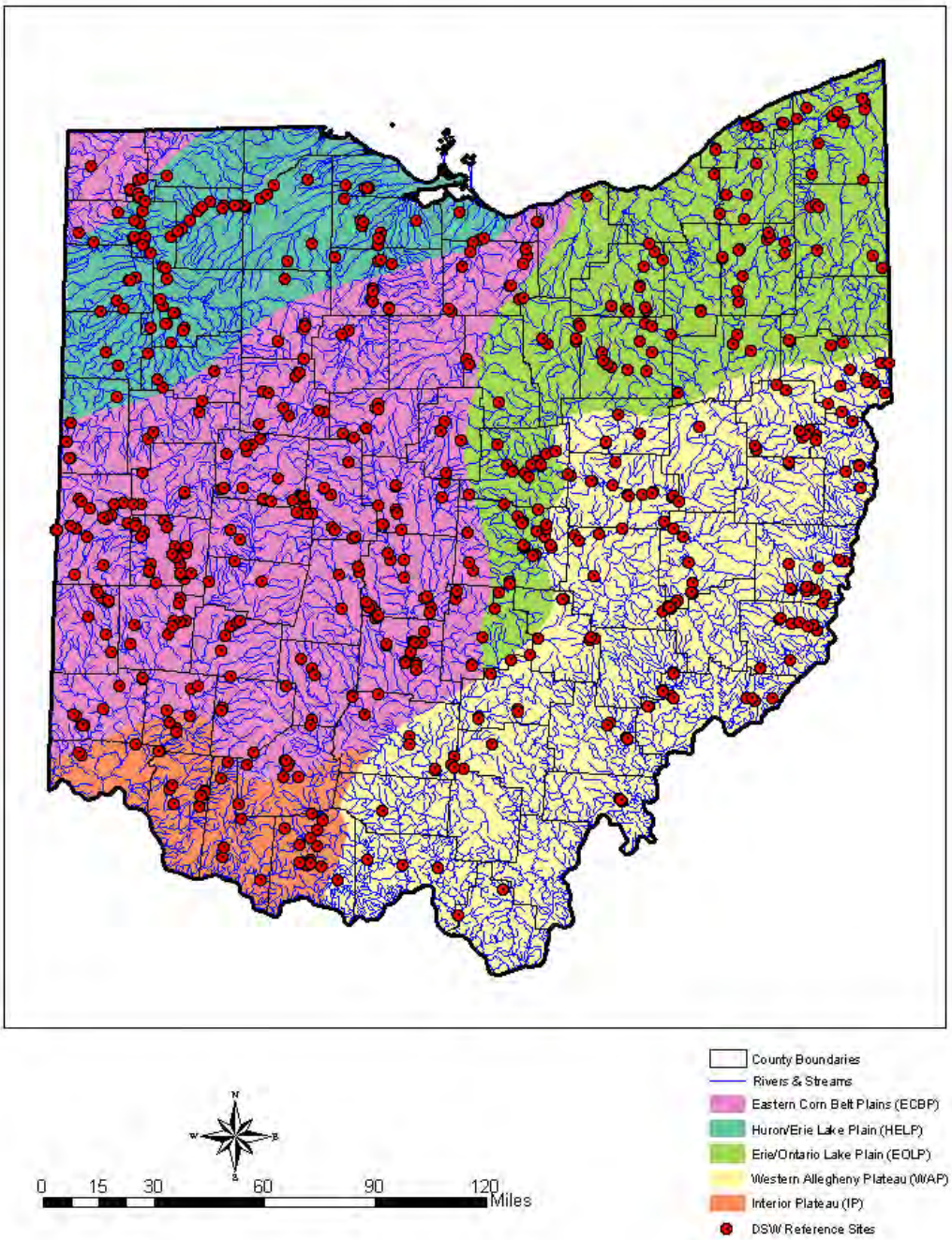
	ECBP	EOLP	HELP	IP	WAP	Statewide
aluminum	3.9E+04	2.9E+04	4.2E+04	2.8E+04	5.3E+04	
antimony	9.2E-01	1.3E+00	8.4E-01	**NA**[1]	**NA**	
arsenic	1.8E+01	2.5E+01	1.1E+01	1.1E+01	1.9E+01	
barium	2.4E+02	1.9E+02	2.1E+02	1.7E+02	3.6E+02	
beryllium				**NA**	**NA**	8.0E-01
cadmium	9.0E-01	7.9E-01	9.6E-01	3.0E-01	8.0E-01	
calcium	1.2E+05	2.1E+04	1.1E+05	9.4E+04	2.7E+04	
chromium	4.0E+01	2.9E+01	5.1E+01	3.0E+01	5.3E+01	
cobalt				**NA**	**NA**	1.2E+01
copper	3.4E+01	3.2E+01	4.2E+01	2.5E+01	3.3E+01	
iron	3.3E+04	4.1E+04	4.4E+04	3.1E+04	5.1E+04	
lead						4.7E+01
magnesium	3.5E+04	7.1E+03	2.9E+04	2.0E+04	9.9E+03	
manganese	7.8E+02	1.5E+03	1.0E+03	1.4E+03	3.0E+03	
mercury						1.2E-01
nickel	4.2E+01	3.3E+01	3.6E+01	3.3E+01	6.1E+01	
potassium	1.1E+04	6.8E+03	1.2E+04	5.9E+03	1.4E+04	
selenium	2.3E+00	1.7E+00	1.4E+00	1.6E+00	2.6E+00	
silver[2]					**NA**	4.3E-01
strontium	3.9E+02	6.2E+01	2.5E+02	**NA**	2.5E+02	
thallium				**NA**	**NA**	4.7E+00
vanadium				**NA**	**NA**	4.0E+01
zinc	1.6E+02	1.6E+02	1.9E+02	1.0E+02	1.7E+02	

[1]Not Applicable

[2]Value for silver was derived as indicated, however a judgement regarding the validity of the maximum concentration related to data from a single laboratory resulted in removal of the data point. As a result, several elevated detection limits from the same laboratory were removed based upon application of this decision rather than on the basis of exceeding the highest measured concentration.

The maximum sediment concentration value for each constituent detected in lotic sediments is to be compared to the appropriate SRV. If the maximum detected value is less than the SRV, then the constituent may be eliminated from further consideration in the aquatic ecological risk assessment. If all site-related constituents are below the appropriate SRVs, then it is considered that the site did not impact the sediments in question. Other qualitative evaluations (*e.g.*, site sediments approximate background conditions, lentic sediment evaluations) may also be made using the SRVs, however, these evaluations should be discussed and approved prior to the submission of any risk assessment reports. Constituents without SRVs are to be retained for further evaluation or compared to site-specific background values identified from upstream sediment concentrations.

Figure 1: Division of Surface Water Sampling Locations and Ohio Ecoregions



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Attachment I
Supplemental Guidance to RAGS: Calculating the Concentration Term

PB92-963373

United States Environmental Protection Agency

Office of Solid Waste and Emergency Response Washington, D.C. 20460

Publication 9285.7-08I May 1992

EPA

Supplemental Guidance to RAGS: Calculating the Concentration Term

Office of Emergency and Remedial Response
Hazardous Site Evaluation Division, OS-230

Intermittent Bulletin
Volume 1 Number 1

The overarching mandate of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) is to protect human health and the environment from current and potential threats posed by uncontrolled releases of hazardous substances. To help meet this mandate, the U.S. Environmental Protection Agency's (EPA's) Office of Emergency and Remedial Response has developed a human health risk assessment process as part of its remedial response program. This process is described in *Risk Assessment Guidance for Superfund: Volume I — Human Health Evaluation Manual* (RAGS/HHEM). Part A of RAGS/HHEM addresses the baseline risk assessment, and describes a general approach for estimating exposure to individuals from hazardous substance releases at Superfund sites.

This bulletin explains the concentration term in the exposure/intake equation to remedial project managers (RPMs), risk assessors, statisticians, and other personnel. This bulletin presents the general intake equation as presented in RAGS/HHEM Part A, discusses basic concepts concerning the concentration term, describes generally how to calculate the concentration term, presents examples to illustrate several important points, and, lastly, identifies where to get additional help.

THE CONCENTRATION TERM

How is the concentration term used?

RAGS/HHEM Part A presents the Superfund risk assessment process in four "steps": (1) data collection and evaluation; (2) exposure assessment; (3) toxicity assessment; and (4) risk characterization. The concentration term is calculated for use in the exposure assessment step. Highlight 1 presents the general equation Superfund uses for calculating exposure, and illustrates that the concentration term (C) is one of several parameters needed to estimate contaminant intake for an individual.

For Superfund assessments, the concentration term (C) in the intake equation is an estimate of the arithmetic average concentration for a contaminant based on a set of site sampling results. Because of the uncertainty associated with estimating the true average concentration at a site, the 95 percent upper confidence limit (UCL) of the arithmetic mean should be used for this variable. The 95 percent UCL provides reasonable confidence that the true site average will not be underestimated.

Why use an average value for the concentration term?

An estimate of average concentration is used because:

Supplemental Guidance to RAGS is a bulletin series on risk assessment of Superfund sites. These bulletins serve as supplements to *Risk Assessment Guidance for Superfund: Volume I — Human Health Evaluation Manual*. The information presented is intended as guidance to EPA and other government employees. It does not constitute rulemaking by the Agency, and may not be relied on to create a substantive or procedural right enforceable by any other person. The Government may take action that is at variance with these bulletins.

Highlight 1
GENERAL EQUATION FOR ESTIMATING EXPOSURE TO A SITE CONTAMINANT

$$I = C \times \frac{CR \times EFD}{BW} \times \frac{1}{AT}$$

where:

I = intake (i.e., the quantitative measure of exposure in RAGS/HHEM)
C = contaminant concentration
CR = contact (intake) rate
EFD = exposure frequency and duration
BW = body weight
AT = averaging time

(1) carcinogenic and chronic noncarcinogenic toxicity criteria[1] are based on lifetime average exposures; and

(2) average concentration is most representative of the concentration that would be contacted at a site over time.

For example, if you assume that an exposed individual moves randomly across an exposure area, then the spatially averaged soil concentration can be used to estimate the true average concentration contacted over time. In this example, the average concentration contacted over time would equal the spatially averaged concentration over the exposure area. While an individual may not actually exhibit a truly random pattern of movement across an exposure area, the assumption of equal time spent in different parts of the area is a simple but reasonable approach.

When should an average concentration be used?

The two types of exposure estimates now being required for Superfund risk assessments, a reasonable maximum exposure (RME) and an average, should both use an average concentration. To be protective, the overall estimate of intake (see Highlight 1) used as a basis for action at Superfund sites should be an estimate in the high end of the intake/dose distribution. One high-end option is the RME used in the Superfund program. The RME, which is defined as the highest exposure that could reasonably be expected to occur for a given exposure pathway at a site, is intended to account for both uncertainty in the contaminant concentration and variability in exposure parameters (e.g., exposure frequency, averaging time). For comparative purposes, Agency guidance (U.S. EPA, *Guidance on Risk Characterization for Risk Managers and Risk Assessors*, February 26, 1992) states that an average estimate of exposure also should be presented in risk assessments. For decision-making purposes in the Superfund program, however, RME is used to estimate risk.[2]

Why use an estimate of the arithmetic mean rather than the geometric mean?

The choice of the arithmetic mean concentration as the appropriate measure for estimating exposure derives from the need to estimate an individual's long-term average exposure. Most Agency health criteria are based on the long-term average daily dose, which is simply the sum of all daily doses divided by the total number of days in the averaging period. This is the definition of an arithmetic mean. The

[1] When acute toxicity is of most concern, a long-term average concentration generally should not be used for risk assessment purposes, as the focus should be to estimate short-term, peak concentrations.

[2] For additional information on RME, see RAGS/HHEM Part A and the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), 55 *Federal Register* 8710, March 8, 1990.

arithmetic mean is appropriate regardless of the pattern of daily exposures over time or the type of statistical distribution that might best describe the sampling data. The geometric mea. of a set of sampling results, however, bears no logical connection to the cumulative intake that would result from long-term contact with site contaminants, and it may differ appreciably from — and be much lower than — the arithmetic mean. Although the geometric mean is a convenient parameter for describing central tendencies of lognormal distributions, it is not an appropriate basis for estimating the concentration term used in Superfund exposure assessments. The following simple example may help clarify the difference between the arithmetic and geometric mean when used for an exposure assessment:

> Assume the daily exposure for a trespasser subject to random exposure at a site is 1.0, 0.01, 1.0, 0.01, 1.0, 0.01, 1.0, and 0.01 units/day over an 8-day period. Given these values, the cumulative exposure is simply their summation, or 4.04 units. Dividing this by 8 days of exposure results in an arithmetic mean of 0.505 units/day. This is the value we would want to use in a risk assessment for this individual, not the geometric mean of 0.1 units/day. Viewed another way, multiplication of the geometric mean by the number of days equals 0.8 units, considerably lower than the known cumulative exposure of 4.04 units.

UCL AS AN ESTIMATE OF THE AVERAGE CONCENTRATION

What is a 95 percent UCL?

The 95 percent UCL of a mean is defined as a value that, when calculated repeatedly for randomly drawn subsets of site data, equals or exceeds the true mean 95 percent of the time. Although the 95 percent UCL of the mean provides a conservative estimate of the average (or mean) concentration, it should not be confused with a 95th percentile of site concentration data (as shown in Highlight 2).

Why use the UCL as the average concentration?

Statistical confidence limits are the classical tool for addressing uncertainties of a distribution average. The 95 percent UCL of the arithmetic mean concentration is used as the average concentration because it is not possible to know the true mean. The 95 percent UCL therefore accounts for uncertainties due to limited sampling data at Superfund sites. As sampling data become less limited at a site, uncertainties decrease, the UCL moves closer to the true mean, and exposure evaluations using either the mean or the UCL produce similar results. This concept is illustrated in Highlight 2.

Should a value other than the 95 percent UCL be used for the concentration?

A value other than the 95 percent UCL can be used provided the risk assessor can document that high coverage of the true population mean occurs (i.e., the value equals or exceeds the true population mean with high probability). For exposure areas with limited amounts of data or extreme variability in measured or modeled data, the UCL can be greater than the highest measured or modeled concentration. In these cases, if additional data cannot practicably be obtained, the highest measured or modeled value could be used as the concentration term. Note, however, that the true mean still may be higher than this maximum value (i.e., the 95 percent UCL indicates a higher mean is possible), especially if the most contaminated portion of the site has not been sampled.

CALCULATING THE UCL

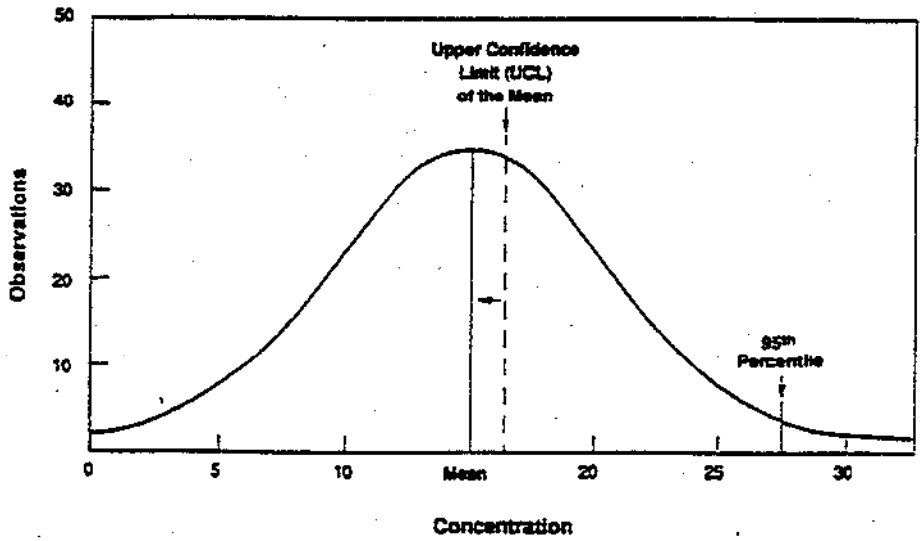
How many samples are necessary to calculate the 95 percent UCL?

Sampling data from Superfund sites have shown that data sets with fewer than 10 samples per exposure area provide poor estimates of the mean concentration (i.e., there is a large difference between the sample mean and the 95 percent UCL), while data sets with 10 to 20 samples per exposure area provide somewhat better estimates of the mean, and data sets with 20 to 30 samples provide fairly consistent estimates of the mean (i.e., the 95 percent UCL is close to the sample mean). Remember that, in general, the UCL approaches the true mean as more samples are included in the calculation.

Should the data be transformed?

EPA's experience shows that most large or "complete" environmental contaminant data sets

Highlight 2
COMPARISON OF UCL AND 95th PERCENTILE



As sample size increases, the UCL of the mean moves closer to the true mean, while the 95th percentile of the distribution remains at the upper end of the distribution.

from soil sampling are lognormally distributed rather than normally distributed (see Highlights 3 and 4 for illustrations of lognormal and normal distributions). In most cases, it is reasonable to assume that Superfund soil sampling data are lognormally distributed. Because transformation is a necessary step in calculating the UCL of the arithmetic mean for a lognormal distribution, the data should be transformed by using the natural logarithm function (i.e., calculate ln(x), where x is the value from the data set). However, in cases where there is a question about the distribution of the data set, a statistical test should be used to identify the best distributional assumption for the data set. The W-test (Gilbert 1987) is one statistical method that can be used to determine if a data set is consistent with a normal or lognormal distribution. In all cases, it is valuable to plot the data to better understand the contaminant distribution at the site.

How do you calculate the UCL for a lognormal distribution?

To calculate the 95 percent UCL of the arithmetic mean for a lognormally distributed data set, first transform the data using the natural logarithm function as discussed previously (i.e., calculate ln(x)). After transforming the data, determine the 95 percent UCL for the data set by completing the following four steps:

(1) Calculate the arithmetic mean of the transformed data (which is also the log of the geometric mean);

(2) Calculate the standard deviation of the transformed data;

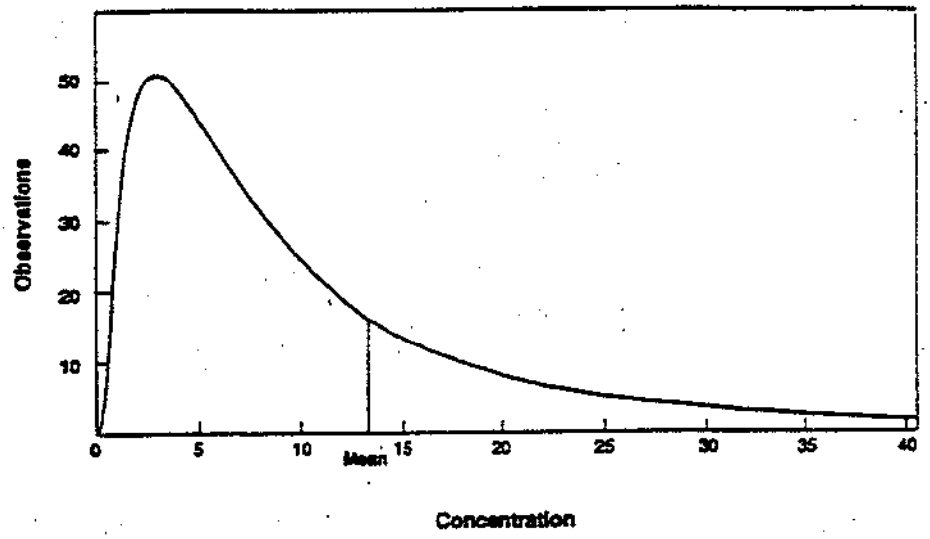
(3) Determine the H-statistic (e.g., see Gilbert 1987); and

(4) Calculate the UCL using the equation shown in Highlight 5.

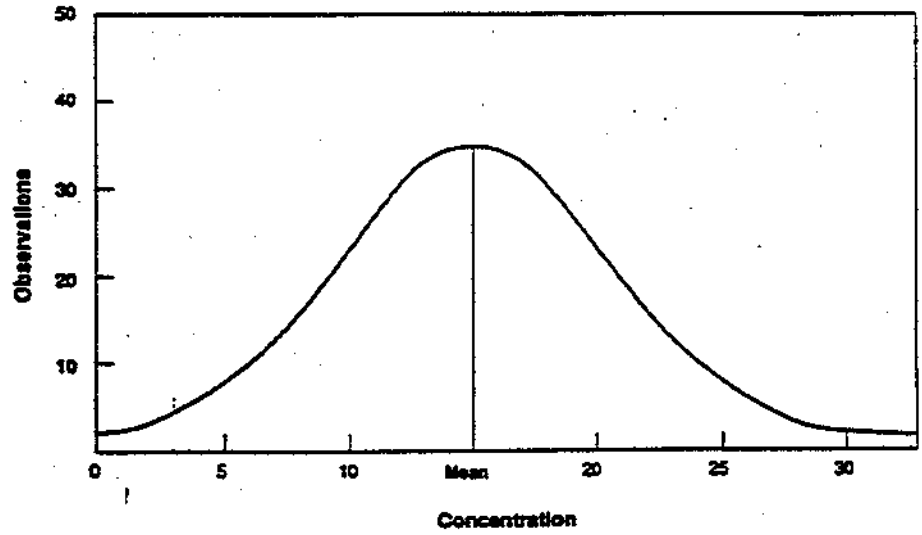
How do you calculate the UCL for a normal distribution?

If a statistical test supports the assumption that the data set is normally distributed, calculate the 95 percent UCL by completing the following four steps:

Highlight 3
EXAMPLE OF A LOGNORMAL DISTRIBUTION



Highlight 4
EXAMPLE OF A NORMAL DISTRIBUTION



Highlight 5
CALCULATING THE UCL OF THE ARITHMETIC MEAN FOR A LOGNORMAL DISTRIBUTION

$$UCL = e^{(\bar{x}+0.5s^2+sH/\sqrt{n-1})}$$

where:

UCL	=	upper confidence limit
e	=	constant (base of the natural log, equal to 2.718)
$\bar{x}$	=	mean of the transformed data
s	=	standard deviation of the transformed data
H	=	H-statistic (e.g., from table published in Gilbert 1987)
n	=	number of samples

Highlight 6
CALCULATING THE UCL OF THE ARITHMETIC MEAN FOR A NORMAL DISTRIBUTION

$$UCL = \bar{x} + t\,(s/\sqrt{n})$$

where:

UCL	=	upper confidence limit
$\bar{x}$	=	mean of the untransformed data
s	=	standard deviation of the untransformed data
t	=	Student-t statistic (e.g., from table published in Gilbert 1987)
n	=	number of samples

(1) Calculate the arithmetic mean of the untransformed data;

(2) Calculate the standard deviation of the untransformed data;

(3) Determine the one-tailed t-statistic (e.g., see Gilbert 1987); and

(4) Calculate the UCL using the equation presented in **Highlight 6**.

Use caution when applying normal distribution calculations if there is a possibility that heavily contaminated portions of the site have not been adequately sampled. In such cases, a UCL from normal distribution calculations could fall below the true mean, even if a limited data set at a site appears normally distributed.

EXAMPLES

The examples shown in **Highlights 7** and **8** address the exposure scenario where an individual at a Superfund site has equal opportunity to contact soil in any sector of the contaminated area over time. Even though the examples address only soil exposures, the UCL approach is applicable to all exposure pathways. Guidance and examples for other exposure pathways will be presented in forthcoming bulletins.

Highlight 7 presents a simple data set and provides a stepwise demonstration of transforming the data — assuming a lognormal distribution — and calculating the UCL. **Highlight 8** uses the same data set to show the difference between the UCLs that would result from assuming normal and lognormal distribution of the data. These

Highlight 7
EXAMPLE OF DATA TRANSFORMATION AND CALCULATION OF UCL

This example shows the calculation of a 95 percent UCL of the arithmetic mean concentration for chromium in soil at a Superfund site. This example is applicable only to a scenario in which a spatially random exposure pattern is assumed. The concentrations of chromium obtained from random sampling in soil at this site (in mg/kg) are 10, 13, 20, 36, 41, 59, 67, 110, 110, 136, 140, 160, 200, 230, and 1300. Using these data, the following steps are taken to calculate a concentration term for the intake equation:

(1) Plot the data and inspect the graph. (You may need the help of a statistician for this part [as well as other parts] of the calculation of the UCL.) The plot (not shown, but similar to **Highlight 3**) shows a skew to the right, consistent with a lognormal distribution.

(2) Transform the data by taking the natural log of the values (i.e., determine ln(x)). For this data set, the transformed values are: 2.30, 2.56, 3.00, 3.58, 3.71, 4.08, 4.20, 4.70, 4.70, 4.91, 4.94, 5.08, 5.30, 5.44, and 7.17.

(3) Apply the UCL equation in **Highlight 5**, where:

$\bar{x} = 4.38$
$s = 1.25$
$H = 3.163$ (based on 95 percent)
$n = 15$

The resulting 95 percent UCL of the arithmetic mean is thus found to equal $e^{(6.218)}$, or 502 mg/kg.

Highlight 8
COMPARING UCLS OF THE ARITHMETIC MEAN ASSUMING DIFFERENT DISTRIBUTIONS

In this example, the data presented in **Highlight 7** are used to demonstrate the difference in the UCL that is seen if the normal distribution approach were inappropriately applied to this data set (i.e., if, in this example, a normal distribution is assumed).

ASSUMED DISTRIBUTION:	Normal	Lognormal
TEST STATISTIC:	Student-t	H-statistic
95 PERCENT UCL (mg/kg):	325	502

examples demonstrate the importance of using the correct assumptions.

WHERE CAN I GET MORE HELP?

Additional information on Superfund's policy and approach to calculating the concentration term and estimating exposures at waste sites can be obtained in:

- U.S. EPA, *Risk Assessment Guidance for Superfund: Volume I — Human Health Evaluation Manual (Part A)*, EPA/540/1-89/002, December 1989.
- U.S. EPA, *Guidance for Data Useability in Risk Assessment*, EPA/540/G-90/008 (OSWER Directive 9285.7-05), October 1990.
- U.S. EPA, *Risk Assessment Guidance for Superfund (Part A — Baseline Risk Assessment) Supplemental Guidance/ Standard Exposure Factors*, OSWER Directive 9285.6-03, May 1991.

Useful statistical guidance can be found in many standard textbooks, including:

- Gilbert, R.O., *Statistical Methods for Environmental Pollution Monitoring*, Van Nostrand Reinhold, New York, New York, 1987.

Questions or comments concerning the concentration term can be directed to:

- Toxics Integration Branch
  Office of Emergency and Remedial Response
  401 M Street SW
  Washington, DC 20460
  Phone: 202-260-9486

EPA staff can obtain additional copies of this bulletin by calling EPA's Superfund Document Center at 202-260-9760. Others can obtain copies by contacting NTIS at 703-487-4650.

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Attachment J

ECO Update: Ecological Significance and the Selection of Candidate Assessment Endpoints

United States Environmental Protection Agency

Office of Solid Waste and Emergency Response

Publication 9345.0-11FSI
EPA 540/F-95/037
PB95-963323
January 1996

EPA

ECO Update

Office of Emergency and Remedial Response

Intermittent Bulletin
Volume 3, Number 1

Ecological Significance and Selection of Candidate Assessment Endpoints

This Bulletin provides guidance to Superfund risk assessors and risk managers on planning ecological risk assessments (ERAs) at Superfund sites. This guidance is based on the experience of the Regional Biological Technical Advisory Groups (BTAGs). Following the concepts advocated in this Bulletin should result in ERAs that will meet the needs of Superfund program.

IN THIS BULLETIN

Background 1

Ecological Significance and the Risk Assessment Process 2

Ecological Significance and Candidate Assessment Endpoint Selection 3

Conclusion 4

Reference 5

Glossary 5

Background

In a 1994 OSWER Directive (No. 9285.7-17), Assistant Administrator Elliott Laws stressed the importance of protecting ecological receptors at Superfund sites through the Ecological Risk Assessment (ERA) process. The purpose for conducting the ERA was described as characterizing threats from chemical contaminants to the environment and identifying clean-up levels that will protect the ecological receptors at risk. The information provided in the ERA and the Human Health Risk

ECO Update is a Bulletin series on ecological risk assessment of Superfund sites. These Bulletins serve as supplements to *Risk Assessment Guidance for Superfund, Volume II: Environmental Evaluation Manual* (EPA/540-1-89/001). The information presented is intended to provide technical information to EPA and other government employees. It does not constitute rulemaking by the Agency, and may not be relied on to create a substantive or procedural right enforceable by any other person. The Government may take action that is at variance with these Bulletins.

Assessment complete the Baseline Risk Assessment conducted during the Remedial Investigation. It is important to note that Superfund ERAs may be more focused than ERAs conducted by other programs, in that only chemical stressors are evaluated during the baseline risk assessment process. Superfund risk managers, however, do consider both chemical and non-chemical (e.g., habitat loss due to physical disturbances) stressors when selecting a remedial alternative that will be ecologically protective.

A critical element in the ERA process requires distinguishing important environmental responses to chemical releases from those that are inconsequential to the ecosystem in which the site resides: in other words, determining the ecological significance of past, current, or projected site-related effects. Failure to make this distinction may result in a risk assessment that brings little value to the decision-making process.

For the purpose of a Superfund ERA, investigations should focus on endpoints most likely to be affected given the fate and transport mechanisms of the contaminants involved, the ecotoxicological properties of the contaminants, the habitats at the site, and the potential ecological receptors. Additional endpoints may be added to assist in risk communication. The challenge then, for the risk assessor and the risk manager, is to structure the ERA in such a manner that potentially ecologically significant risks will be addressed.

Ecological Significance and The Ecological Risk Assessment Process

The Superfund program accepts the approach described in the *Framework for Ecological Risk Assessment* (EPA/630/R-92/001) as an appropriate conceptual model for the ERA process. Superfund-specific guidance is being prepared by both the Office of Emergency and Remedial Response (OERR) and some Regions that will complement this generic Agency Framework. However, the OERR guidance is a process document that does not address issues such as the ecological significance of an observed or expected effect. Due to inherent complexities in developing site-specific ERAs, risk managers (e.g., Remedial Project Managers and On-Scene Coordinators) should coordinate with Regional ecological risk assessment teams (BTAGs).

The issue of ecological significance must be addressed in at least two phases of the risk assessment process. First, during the Problem Formulation phase, the risk assessor and the risk manager should discuss and identify ecological attributes associated with the site that may function as *assessment endpoints*, which are defined as explicit expressions of the environmental value that is to be protected (EPA, 1992). During these planning discussions, it is important to keep in mind the objectives of the risk assessment and what it seeks to achieve. A pertinent question to ask at this juncture is how an assessment of the proposed ecological endpoints will help determine whether or not to remediate the site, and if so, to what level.

Ecological Significance must be addressed during two phases of a Superfund ERA:

- *Problem Formulation, and*
- *Risk Characterization.*

The issue of ecological significance arises again during the Risk Characterization step. At this time, the risk assessor presents the results of the assessment to the risk manager and the results are in turn presented to the general public. The risk assessor must provide an interpretation of the assessment in the context of the questions raised in the Problem Formulation: what is the nature of the risk (likelihood, duration and magnitude) to the receptor(s) represented by the assessment endpoint(s), what is the anticipated spatial/temporal extent of the threat(s), and at what chemical concentration would the contaminant(s) of concern no longer pose a threat.

Ecological Significance and Candidate Assessment Endpoint Selection

During Problem Formulation, the significance of adverse toxicological, biological, and ecological effects to receptors is considered as part of the process in the selection of assessment endpoints. The BTAG considers individual, population, and community level assessment endpoints appropriate at Superfund sites. Examples of receptors at these levels of organization include:

Individual Level

- **Endangered or threatened species known to be present (e.g., bald eagle, spotted owl, gopher tortoise)**

Population Level

- **A sensitive fish population**
- **Bird populations exposed to contaminants of concern**

Community Level -

- Distribution and abundance of:

  - fish and avian communities
  - benthic community
  - wetland plant community
  - soil invertebrate communities

This list does not encompass the complete array of potential ecological structural and functional attributes that could be assessed. Given the state of current ecosystem models and the relatively small physical size of most Superfund sites, however, the utility of ecosystem-type assessments is questionable for Superfund ERAs.

For Superfund ERAs, at the population level of organization, "life-table" parameters (e.g., mortality, fecundity, age class distributions) are recommended as appropriate measures of response. It is suggested that community assessment endpoints should focus on structural characteristics such as productivity and diversity.

Distinguishing potential and current adverse effects due to releases of contaminants from normal fluctuations in measurable population- and community-level parameters is the most contentious and complicating issue in the ERA. Natural variability (e.g., population fluctuations, changes in presence/absence of species, abundance, diversity, biomass) is a factor that must be addressed when selecting

During a Superfund ERA, natural variability inherent in the ecosystem at a site must be addressed as an uncertainty, and factored into the risk characterization.

assessment endpoints. Due to time constraints in the Superfund process, it is unlikely that site-specific studies will be conducted to determine natural variability inherent in populations associated with Superfund sites. Consideration of whether the observed or estimated effect is within the range of normal variability should be addressed as an uncertainty, and factored into the risk characterization.

Candidate assessment endpoints that are consistent with the Superfund ERA process include (but are not limited to) the following:

Population Level Assessment Endpoints

- Survival and reproduction of fish
- Survival, growth, and reproduction of fish-eating birds and mammals

Community Level Assessment Endpoints

- Stream benthic invertebrate species diversity and abundance
- Survival of soil invertebrates
- Productivity of wetland vegetation
- Maintenance of song-bird populations

Additionally, candidate assessment endpoints for endangered or threatened species, individuals, or populations should include impacts on the following:

- Physiological status
- Reproduction
- Growth
- Development
- Morbidity and mortality

Conclusion

Choosing from candidate endpoints is a challenging process that requires site-specific information on species, communities, and functions; the mode of action (both direct and indirect) of the released contaminants; and exposure and sensitivity of the response of the receptors. It is important that Superfund ERAs address risks that are ecologically significant and relevant to the site. Decisions to remediate sites based upon poorly-designed ERAs that do not clearly define site-specific needs are contradictory to the intent of CERCLA and compromise the integrity of the Superfund Program.

It may be argued that any discussion regarding the significance of an effect, the significance of a specific receptor, and the societal value of remediation all fall within the purview of risk management rather than risk assessment. While it is important to not allow the risk management process to force the assessment process in any predetermined direction (and thus compromise the integrity of the assessment), the risk assessor and risk manager must reach agreement on the issue of assessment endpoints prior to beginning any data collection activities to confirm the projected effects. When the results of the ERA are provided to the risk manager, the significance of the risks to the ecosystem should be discussed, and the role of societal value can then be weighed as an aspect of risk management. Without this coordination, there is no way to assure that the ERA will be useful to the risk management decision-making process.

Regional BTAG Coordinators can work with Superfund RPMs and other project managers to select appropriate assessment endpoints for ERAs. This process will increase the chance that the ERA will address risks that are ecologically significant and relevant to the site.

The Regional BTAG Coordinators can work with the project manager to select the appropriate assessment endpoints for the ERA. Establishing explicit assessment endpoints very early in the process greatly increases the likelihood that a successful ERA will be accomplished.

Reference

U.S. Environmental Protection Agency, 1992. *Framework for Ecological Risk Assessment*. EPA/630/R-92/001. Risk Assessment Forum, U.S. Environmental Protection Agency, Washington, DC.

Glossary (adapted from EPA, 1992)

assessment endpoint - An explicit expression of the environmental value that is to be protected.

community - An assemblage of populations of different species within a specified location in space or time.

direct effect - An effect where the stressor acts on the ecological component of interest itself, not through effects on other components of the ecosystem (compare with definition for **indirect effect**).

ecological risk assessment - The process that evaluates the likelihood that adverse ecological effects may occur or are occurring as a result of exposure to one or more stressors.

ecosystem - The biotic community and abiotic environment within a specified location in space and time.

exposure - Co-occurrence of or contact between a stressor and an ecological component.

indirect effect - An effect where the stressor acts on supporting components of the ecosystem, which in turn have an effect on the ecological component of interest.

measurement endpoint - A measurable ecological characteristic that is related to the valued characteristic chosen as the assessment endpoint. Measurement endpoints are often expressed as the statistical or arithmetic summaries of the observations that comprise the measurement.

population - An aggregate of individuals of a species within a specified location in space and time.

risk characterization - A phase of ecological risk assessment that integrates the results of the exposure and ecological effects analyses to evaluate the likelihood of adverse ecological effects associated with exposure to stressor. The ecological significance of the adverse effects is discussed, including consideration of the types and magnitudes of the effects, their spatial and temporal patterns, and the likelihood of recovery.

stressor - Any physical, chemical, or biological entity that can induce an adverse response.

xenobiotic - A chemical or other stressor that does not occur naturally in the environment. Xenobiotics occur as a result of anthropogenic activities such as the application of pesticides and the discharge of industrial chemicals to air, land, or water.

Attachment K
Generic Receptor Species List

Soil Associated Receptors

Direct Soil Contact	Herbivore	Carnivore	Invertivore
Plants	Meadow vole	Red-tailed hawk	Short-tailed shrew
Earthworms	Deer mouse	American kestrel	American woodcock
	Eastern cottontail	Red fox	American robin
	White-tailed deer*		

Surface Water and Wetland Associated Receptors

Direct Surface Water/ Sediment Contact	Herbivore	Piscivore	Invertivore
Aquatic Plants	Muskrat	Mink	Spotted sandpiper**
Macroinvertebrates	Mallard duck	Belted kingfisher	
Fish		Great blue heron	

* White-tailed deer are only to be evaluated when public concerns has been raised regarding white-tailed deer populations.

** Suggested invertivore for wetland habitats.

Note: See Level III ERA guidance document, attachment A, for specifics regarding the selection of receptors for use in a Level III ERA.

CHAPTER 4
LEVEL III - BASELINE

4.1 OBJECTIVE

The objective of a Level III baseline assessment is to estimate the potential hazards to representative endpoint species posed by chemical and nonchemical stressors identified at a site. The Level III ecological risk assessment (ERA) is designed to determine: (a) the potential and/or significant ecological effects occurring at a site as measured using a deterministic risk assessment procedure; (b) the probable stressors responsible for these effects; (c) the source of causal agents; and, (d) the basis for site-specific ecological risk management decisions. The Level III assessment provides the basis for determining the need for ecological risk mitigation and provides information necessary for the development of site-specific remedial alternatives and ecological risk management practices.

4.2 PREREQUISITES

Initiation of a Level III ERA requires completion of a Level I and Level II ERA coupled with a decision to proceed with further ecological investigation.

U.S. EPA has concluded that the strengths and weaknesses of ecological risk assessments in part, originate from the quality of decisions made during the problem formulation stage. It is especially important at this stage to identify and contact any stakeholders with responsibilities for and impacted by the resources being analyzed. If the affected parties do not participate in the early decisions about goals, endpoints, and measurements, the analysis is likely to fail to provide information useful for decision making. Therefore, it is strongly recommended that problem formulation (Tasks 1 and 2 below) be completed with stakeholder involvement during the initial stages of a Level III ecological assessment.

Completion of problem formulation in essence, requires the following: (a) assessment endpoints that link the risk assessment to management concerns, (b) a Conceptual Site Model (CSM) that describes key relationships between one or more potential ecological contaminant(s) of concern (PECOCs, identified in Level II) and the assessment endpoint(s); and, (c) finally, one or more risk hypotheses. All these inputs (a-c above) are factored into the analysis plan. The assessment endpoints and their associated endpoint species, preliminary risk hypotheses, conceptual site model(s), and other information developed in the Level II ERA (Tasks 7-12) should be reviewed and if necessary revised in the Level III ERA to reflect any new information or the results of further discussions among stakeholders.

The approach given in this guidance for the calculation of potential hazards to ecological receptors differs from the traditional process of iterative hazard quotient (HQ) calculations. HQ values are to be calculated once during the ecological risk assessment process using reasonable/site-specific assumptions and representative endpoint species as specified in this guidance document.

The following is a list of tasks required for the completion of a Level III-Baseline ecological risk assessment:

4.3 TASKS

The following tasks are to be completed as part of a Level III ERA:

4.3.1 Task 1 Complete Problem Formulation

Problem formulation is a systematic planning step that identifies the focus and scope of the risk assessment and results in the development of a problem statement that is addressed by the Analysis Plan (Task 2) step. Typically, problem formulation includes ecosystem characterization, pathway analysis, assessment endpoint evaluation, and, measurement endpoint identification. Exposure setting or habitat characterization is critical in delineating ecological receptors that may be potentially impacted by PECOCs. Evaluation of ecological receptors representative of the habitats provides the basis for selecting measurement endpoints, in addition to demonstrating the presence or absence of State or Federally-listed threatened or endangered species (T&E). This process is initiated in Level II (see Level II, Task 7, site survey; Task 8, site description; and Task 9, revise conceptual site model). Complete or potentially complete

exposure pathways are also identified in Task 3 of the Level III process. Ohio EPA recommends that, as a function of the evaluation of terrestrial and aquatic ecosystems identified in previous levels, generic receptors representative of the feeding habits and habitats are modeled as discussed in the Level III Attachments A and B.

Following the screening process described in Level II, there should be a limited number of PECOCs in one or more media to evaluate. Therefore, it should be possible to better ascertain the relationship between specific PECOCs, their likely pathway to specific ecological receptors, and the effect(s) they may induce in these receptors. This process should substantially lessen the chance of having inappropriate assessment endpoints and of having the assessment itself consider insignificant or implausible PECOCs-pathway-receptor relationships.

As a reminder, establishing clear assessment endpoints, risk hypotheses, and their associated measures is the goal of the problem formulation task, and should enable all stakeholders to decide and agree upon a common basis for understanding what is potentially at risk at a given site. Definition of the appropriate assessment endpoints avoids making remedial decisions on the basis of trivial or insignificant effects. Therefore, once these factors have been defined, all affected parties and stakeholders should agree as to their acceptability. The assessment endpoints, hypotheses, and measurements should be modified and refined until such an agreement is achieved; at which point an analysis plan can be prepared.

The Problem Formulation should consist of:

A) Review/revise assessment endpoints
Assessment endpoints are to be selected from the list of candidate assessment endpoints developed for Task 11 in the Level II ERA. The final list of assessment endpoints is to be completed as part of the problem formulation step. Additional assessment endpoints may be developed and used in the Level III ERA. Assessment endpoints identified by risk managers and/or stakeholders which have little or no anticipated concern should nonetheless be carried forward in the assessment process to address specific concerns raised by the public and/or other stakeholders. See attachment A for details regarding the selection of assessment and measurement endpoints and the required generic receptors to be used for a Level III ERA.

B) Review/revise the CSM
A revised/updated CSM should be completed and included in the Level III report.

C) Review/revise risk hypotheses
The preliminary risk hypotheses stated for Task 12 of the Level II assessment are reviewed and further focused prior to designing and performing any baseline investigations. This will limit generation of data that are of little use in assessing baseline risk or in making possible future risk management decisions. As a reminder, the risk hypothesis should be written using the traditional null hypothesis format.

4.3.2 Task 2 Prepare analysis plan

The analysis plan describes the assessment design, data needs, and methods for conducting the exposure and effects assessment components of the Level III ecological risk assessment. The analysis plan is to be completed prior to initiation of field and sampling activities. The analysis plan may be relatively brief or extensive depending on the nature of the assessment; however, it should be included as a component of the overall work plan and report for the site. The plan includes, but is not limited to, discussion of:

- Data Quality Objectives (DQOs) for the assessment, these are developed for and during the site assessment process;
- The data interpretation paradigm, *i.e.*, how measurements including sampling and analysis of biotic and abiotic material and associated data analyses will assist in the evaluation of the risk hypotheses;
- The risk characterization options that will be used, including any weight-of-evidence techniques involving a combination of qualitative and quantitative data;
- How uncertainties in the data and analyses will be addressed; and,
- How the results will be presented.

4.3.3 Task 3 Perform Exposure Assessment

Exposure assessment is the quantitative evaluation of the magnitude, frequency, duration, and route of exposure of ecological receptors to site-related environmental stressors that have

been identified in Level II and carried through the site characterization process. The exposure point concentration (EPC) is the concentration of a PECOC in a specfic environmental medium at the point of contact for the receptor. The point of contact is either at an outer membrane such as the dermal root membranes for plants, or through ingestion. Only exposures and therefore potential hazards through direct contact and ingestion are quantified in the Level III ERA process. Due to data limitations, exposures via inhalation and dermal contact (this is specific for most terrestrial receptors, as exposures to aquatic and terrestrial macroinvertebrates and fish are estimated holistically) are not evaluated.

For terrestrial receptors, the EPC is the soil PECOC concentration estimated using the 95% UCL of the arithmetic mean, capped at the maximum detected value. See U.S. EPA's 1992 guidance titled: Supplemental Guidance to RAGS: Calculating the Concentration Term, for specific equations for calculating the 95 % UCL of the arithmetic mean (Level II, Attachment I).

Alternative exposure values for mobile receptors may be estimated using more spatially-explicit estimations. These types of evaluations can be made in addition to the standard uptake equations. These types of exposure assessments can help better quantify the exposure to ecological receptors by taking into account "attractive" or unsuitable habitat. However, approval of the models and input assumptions should be reviewed and approved by Ohio EPA DHWM prior to the submission of a completed risk assessment report document.

The exposures to aquatic invertebrates and fish are evaluated using the chemical specific and biological criteria when appropriate. Aquatic macroinvertebrates and fish tissue PECOC concentrations are occasionally calculated using surface water and sediment EPCs or by direct tissue sampling, when adverse effects via food chain exposures are evaluated. See attachment B for details regarding estimation of fish tissue PECOC concentrations.

Exposure characterization of wildlife with large home ranges is based on the average daily dose (ADD) (*i.e.*, the dose of a chemical or PECOC ingested by an ecological receptor and expressed as the mass of a chemical ingested concentration per kilogram body weight of the receptor per day (mg $kg^{-1}day^{-1}$)). The ADD is analogous to the term "intake" used in human health risk assessments to estimate the dose of a compound to a human receptor.

The ADD and the EPC values for each receptor and PECOC are required to estimate risk during the risk characterization phase of the Level III ERA. Determining the EPC and ADD values requires taking into consideration a number of factors including, but not limited to, the spatial distribution of endpoint species, the distribution and concentration of PECOCs, and the transfer and accumulation of PECOCs in and through the various food chains. Calculating EPC or ADD values for any given ecological receptor involves the following processes:

A) Identify ecological receptors based on the generic receptor list (Attachment A) and the revised Level II conceptual site model (CSM). The chosen ecological receptors in the Level III ERA represent the assessment endpoints finalized in task 1(A) above. Attachment A details the selection of the ecological receptors based upon a set of generic receptors that are required for the completion of a Level III ERA. These receptors have been categorized on the basis of feeding habits and trophic level relationships. Receptors that are not included in the generic receptor list may be used in addition to the generic recptors if justification is given to support the rationale and benefits for using these receptors in the Level III ERA. If T&E species have been identified to be present at a site, or potentially impacted by site-related environmental stressors, each species should be used as an ecological receptor in the Level III ERA in addition to the required generic receptors.

B) Estimate the EPC and ADD values for each PECOC in all appropriate media. Attachment B details the exposure characterization process and gives specific methodologies for estimating EPC and ADD values. The calculation of EPC and ADD values generally requires the following information:

(i) Complete site characterization information. This includes concentrations of PECOCs in all affected abiotic media (*e.g.,* soil, sediment, and surface water) and biotic media (*e.g.*, the specific tissue PECOC concentrations of potential prey species) when trophic interactions are of concern. The concentrations of PECOCs in all relevant biotic media may be modeled or directly

measured in non-T&E species when greater certainty is required in the Level III ERA risk estimation. The Ohio Department of Natural Resources (ODNR), Division of Wildlife should be contacted at (614)265-6300 prior to animal collection to obtain any required permits or approval. The magnitude and extent of the contamination should have been defined during the site characterization process.

(ii) Receptor species life history parameters (dietary component fraction, weight, home range, etc.). The life history parameters for the generic receptors can be found in Attachment D of the Level III ERA guidance document. The life history parameters listed in attachment D have been developed based upon the average of literature values and represent reasonable values for use in the Level III ERA process.

(iii) Physicochemical properties of the identified PECOCs. This information is necessary to evaluate potential exposure routes, estimate bioconcentration and/or bioaccumulation factors, and assess the mobility and bioavailability of the identified PECOCs.

Attachment B gives specific instructions and methodologies for completing the exposure characterization process. Attachment B is to be used for the calculation of EPC and ADD values for the selected ecological receptors.

4.3.4 Task 4 Perform Toxicity Assessment

PECOCs that come into contact with endpoint species can induce acute or chronic adverse effects in individual organisms, or may indirectly affect their ability to survive and reproduce. Ecological effects may also be expressed as some impairment of a biological function or condition which may potentially effect populations.

The objective of the toxicity assessment (Task 4) is to evaluate the appropriate toxicity data for all PECOCs and to develop an ecologically-based reference dose (ERfD) for each PECOC to be used in assessing possible harm to ecological receptors. Specific information for the development of individual ERfD values is given in Attachment C of the Level III guidance document. The following information summarizes the toxicological criteria to be used for deriving the appropriate ERfD values for the receptors used in the risk characterization (Task 5) step of a Level III ERA:

For State or Federally-listed threatened or endangered species the ERfD = Modified Chronic No Adverse Effect Level ($NOAEL_{mc}$) ($mg\ kg_{bw}^{-1}\ d^{-1}$) adjusted to account for interspecies uncertainty and multiplied by an appropriate intraspecies uncertainty factor.

For receptors other than threatened or endangered species, the ERfD = $NOAEL_{mc}$ adjusted to account for interspecies uncertainty. Note that for aquatic habitats, the biological criteria when appropriate, is used in evaluating population level effects on aquatic organisms. See Level II ERA guidance for specific requirements for aquatic habitats. Also note that for plants and soil invertebrates, no interspecies adjustments of the ERfD values are required.

4.3.5 Task 5 Perform Risk Characterization

Risk characterization estimates the magnitude of potential hazard to endpoint species under a specific set of circumstances. It is the process of applying numerical methods and professional judgment to determine whether acceptable levels for endpoint species are or could be exceeded as a result of exposure to site-related PECOCs. Risk characterization involves two components: a quantitative, and when necessary qualitative, estimation of potential harm and a narrative risk description.

Risk characterization as a part of the ERA process, should be consistent with the values of "transparency, clarity, consistency, and reasonableness" (U.S. EPA 1995). Well-balanced risk characterizations present risk conclusions and information regarding the strengths and limitations of the risk assessment and its methods for other risk assessors, Ohio EPA DHWM, and the public. The risk characterization process and the Level III ERA report is not to include or imply any approval or Agency risk management decisions but simply provide the hazard estimations from the quantitative and qualitative assessments. The risk characterization process consists of a quantitative hazard estimations that should include the following procedures:

A) For all quantitative assessments, hazard is assessed with the use of a quotient methodology. The purpose of this calculation is to determine the level of the EPC or ADD relative to the ERfD. Thus, the environmental hazard quotient (EHQ) = (EPC or ADD)/ERfD. An environmental hazard index (EHI) is

derived by summing all appropriate EHQs (EHI) = ΣEHQ. Both EHQ and EHI values are rounded to one significant digit. An EHI should be calculated to determine the potential adverse effects caused by exposure to multiple PECOCs that have similar toxic endpoints (included as available, target organ, mode of action, or mechanism of action). Use of an EHI assumes simple additive effects of toxic responses, and does not consider other interactions such as synergism and antagonism. Tables 1-3, provide sample formats for listing toxicologic data, including toxic endpoints and the development of an EHI for toxicologically similar chemicals.

Table 1. Example Table Format for Toxicity Values.

Chemical	**CASRN**	**Exposure period**	**Response Measurement from Critical Study(ies) (mg kg^{-1} day^{-1})**	**Critical Effect/ target organ**	**Confidence**	**Source/ date**	**Uncertainty Factors Used (total)**	**ERfD**
Acenaphthene	83-32-9	subchronic	175 NOAEL	Hepatotoxicity	low	IRIS/November/ 1990	300	0.58
Aldrin	309-00-2	chronic	0.025 (LOAEL)	Liver toxicity	medium	IRIS/January/ 1991	10	0.0025
1,1-Biphenyl	92-52-4	chronic	50 (NOAEL)	Kidney damage	medium	IRIS/March/1991	30	1.7
Pentachlorophenol	87-86-5	chronic	3 (NOAEL)	Liver and kidney pathology	medium	IRIS/January/ 1987	scaled*	2.7
Vanadium (Vanadium pentoxide)	1314-62-1	chronic	0.89 (NOAEL)	Decreased hair cystine	low	IRIS/June/1988	scaled*	0.71

* allometric scaling was used instead of uncertainty factors.

Table 2. Example Format for Chronic Hazard (HQ) Estimates

Chemical	**CASRN**	**ADD (mg kg^{-1} day^{-1})**	**ERfD (mg kg^{-1} day^{-1})**	**EHQ**
Acenaphthene	83-32-9	0.91	0.58	2
Aldrin	309-00-2	0.002	0.0025	0.8
1,1-Biphenyl	92-52-4	0.13	1.7	0.08
Pentachlorophenol	87-86-5	1.6	2.7	0.6
Vanadium (Vanadium pentoxide)	1314-62-1	11.1	0.71	16

Table 3. Example Format for Hazard Index (HI) Estimates

Chemical	CASRN	Critical Effect/target organ(s)	EHQ	EHQ Liver	EHQ Kidney
Acenaphthene	83-32-9	Hepatotoxicity	2	2	
Aldrin	309-00-2	Liver toxicity	0.8	0.8	
1,1-Biphenyl	92-52-4	Kidney damage	0.08		0.08
Pentachlorophenol	87-86-5	Liver and kidney pathology	0.6	0.6	0.6
Vanadium (Vanadium pentoxide)	1314-62-1	Decreased hair cystine	16		
Total Hazard Index (EHI)				3	0.7

B) Risk description is a qualitative narrative discussion of the potential hazards presented by the site and must include a discussion of any toxicological and ecological factors beyond those embodied in the quantitative risk estimates. Risk must be described for <u>each</u> PECOC-pathway-receptor combination and each assessment endpoint.

C) If required, a Level IV field baseline assessment would use field investigations to further refine the risk estimate through acquisition of the additional types of field evidence. Because no one piece of information can adequately define risks to complex ecological systems, a formal "weight-of-evidence" approach might be needed to compile and integrate various types of evidence indicating the degree of risk present for each PECOC and assessment endpoint. The two general types of evidence gathered for a field baseline ERA consist of (a) toxicity testing using abiotic media from the site, (b) ecological survey data from the site. Site surveys and interpretation of site data is a difficult task and communication with Ohio EPA DHWM is required before site-specific field measurements are conducted. The field methods described above are generally associated with a Level IV ERA (field baseline ERA), however, if such information is available it should be included in the Level III report.

4.3.6 <u>Task 6</u> <u>Perform Uncertainty Analysis</u>

Quantitative estimates of the potential for adverse affects from exposure to PECOCs inherently contain the artifacts of uncertainty (*i.e.*, lack of knowledge or data gaps) and variability (*i.e.*, differential expression of attributes or characteristics in a population). The uncertainty analysis summarizes assumptions made for each element of the assessment and evaluates their validity, strengths and weaknesses of the analyses, and quantifies to the greatest extent possible the uncertainties associated with each identified potential hazard. This analysis addresses uncertainty associated with each component of the baseline assessment, including but not limited to: PECOC selection and quantification, receptor selection, exposure estimation, effects estimation, and risk characterization. It is important that data gaps that may have hindered or prevented the full determination of potential risk, and which may be addressed with a Level IV assessment, be identified at this time. The uncertainty analysis is the location in the Level III report where, if desired, alternate risk calculations may also be completed to discuss possible risk management decisions. The uncertainty analysis is to be completed as a stand alone section of the Level III report and should not attempt or promote risk management decisions; however information that could help in the selection of the appropriate site decision may be included.

4.3.7 Task 7 SMDP: Acceptable Ecological Risk Level Exceeded?

An SMDP made at this stage of the ecological evaluation may attempt to answer this question: Based on information presented in the Level III deliverable, are any of the following acceptable levels exceeded for individuals and/or populations of endpoint species associated with assessment endpoints? The SMDP would be based on the following information:

A) Determination of the Acceptable Risk Level (ARL):
The acceptable risk level is defined as the following:

(i) Environmental Hazard quotient (EHQ), or environmental hazard index (EHI) where appropriate of less than or equal to one (rounded to one significant figure); and,

(ii) No other observed significant adverse effects on the heath or viability of the bcal individuals or populations of species are identified.

B) Interpretation of the ARL:
If both criteria (i and ii above) are not exceeded, then the site is highly unlikely to present significant risks to endpoint species.

C) No Further Action:
If both criteria (i and ii above) are not exceeded then a recommendation for no further ecological investigations should be made.

D) Further action:
If any criterion (i or ii above) is exceeded, then the site could present significant risks to endpoint species and a recommendation to move to the next SMDP is made. In this instance, the Level III analyses should identify (1) the PECOCs that clearly pose risks below the ARL and thus require no further action, (2) the PECOCs that currently constitute risks above the ARL and thus should be subject to remediation, and (3) the PECOCs that may or may not pose a significant ecological risk but, because of elevated uncertainty, should also be subject to further investigation, monitoring, risk management and/or remediation. PECOCs in category (2) or (3) are termed ecological contaminants of concern (ECOCs) and are the focus of either further investigations or remedial actions.

4.3.8 Task 8 Submit Level III Deliverable

This deliverable is a document (see Attachment E, Baseline Risk Assessment Report, for suggested format and contents) which will provide detailed procedures regarding the basis for exposure assessment and toxicity assessment, and a thorough discussion of uncertainties inherent in the risk analyses. The results presented in this report provide the factual basis for evaluating the following SMDP. The risk assessment report should be easy to follow and understand, with all assumptions, defaults, uncertainties, professional judgments (with justifications) and any other inputs to the risk estimates clearly identified and referenced.

4.3.9 Task 9 SMDP: Remedial Action Decision Possible?

Based on the results of the Level III risk assessment, risk managers (and not risk assessors) will make a determination whether a response action is appropriate with existing information and current levels of uncertainty. Key questions: Would cleanup be less costly than further investigation? Are data adequate to approve a removal action or to select or approve no further action or a remedy? If "**Y**", then further ecological investigation is deferred in favor of a response action. If "**N**", then the assessment process proceeds to a Level IV ERA.

Attachment A
GENERIC RECEPTORS, FOOD-WEB CRITERIA, AND DIRECT CONTACT EVALUATIONS

(1) Introduction

The objective of using generic receptors, food-web models, and direct contact evaluations is to estimate the magnitude of exposure to potential ecological contaminants of concern (PECOCs) and the effect of those exposures on selected ecological receptors. Attachment A discusses the use, requirements, and the selection of receptors to be used in a Level III ecological risk assessment (ERA). U.S. EPA, 1996, ECO Update, Ecological Significance and Selection of Candidate Assessment Endpoints, and U.S. EPA, 1997, Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments, should also be reviewed before and during the selection of receptors to represent the various assessment endpoints chosen for the site. The food-web models/ direct contact evaluations (section 2) lists the minimum number of required receptors and exposure pathways that must be evaluated during a level III ERA.

Food-web models quantify the transfer of PECOCs from one medium to another including PECOCs that may be transferred from abiotic media such as soil and surface water to and through biotic media or tissues. The food-web criteria given in Attachment A have been developed for the basic feeding habits of terrestrial and aquatic receptors and in conjunction with Attachment B (Exposure Characterization), assist in the quantification of PECOC concentrations in biological tissues that may be consumed by ecological receptors.

Direct contact evaluations estimate the potential for adverse ecological impacts to specific organisms that are intimately associated with contaminated media. More specifically, direct contact evaluations estimate adverse effects to plants, soil/aquatic invertebrates, or other organisms caused by the exposure and uptake of PECOCs from contaminated media by means other than ingestion. Examples of direct contact exposures include but are not limited to; passive and active uptake of PECOCs by plants, or absorption of PECOCs through the outer-membranes of soil invertebrates or microorganisms. Earthworms are considered under the direct contact category even though they are exposed to soil PECOCs through both dermal contact and ingestion.

In practice, ecological risk assessments generally evaluate and choose similar ecological receptors to represent various feeding habits and trophic levels for use in estimating potential hazards. These receptors are often chosen based on the availability of toxicity information, the abundance of the receptors, their role as potential food sources for predators, their limited home ranges, and their specific feeding habits. The generic receptors and the food-web criteria given in Attachment A reflect the most commonly used and accepted approaches and receptors for estimating ecological impacts without extensive field evaluations and expense.

(2) Food-web Criteria/Direct Contact Evaluations

Food-web and direct contact evaluations are required for a Level III ERA and are dependent upon the type of contamination and the affected media. Terrestrial and aquatic systems are evaluated differently and require separate consideration in the Level III ERA and report. PECOCs identified in terrestrial systems are to be evaluated using both the appropriate food-web models and direct contact evaluations.

Persistent, bioaccumulative and toxic (PBT, see Level II ERA guidance) compounds are also to be evaluated using direct contact and food-web models; however, an additional level of effort is required for this classification of compounds. The additional level of effort includes the evaluation of two top food-chain predators, which is not required for non-PBT PECOCs. Because PBT compounds have the tendency to bioaccumulate or biomagnify, this additional quantification step is warranted. If multiple PECOCs are encountered at a site, then only the PBT stressors are required to be evaluated by modeling the top carnivorous receptors unless chemical specific data indicates sensitivity to top carnivores.

Ohio EPA recommends the use of empirical contaminant tissue concentration data when available or when a greater amount of certainty is required in a Level III ERA. Food-web models may also be used for estimating the dose of PECOCs to the generic receptors when necessary, or when a lesser amount of certainty is required for the ERA. Exposures to ecological receptors via ingestion of abiotic or biotic media are estimated by using various food-web models. Food-web models are the mathematical procedures used to quantitate the concentrations (dose) of PECOCs ingested by selected receptors. These models are to include all relevant media that are potentially consumed by a receptor. Consumed media may include: soil, surface water, sediment, and biological tissues.

The accepted methods for estimating contaminant concentrations in biological media are given in Attachment (B). Attachment (D) lists the life history data for each generic receptor that are to be used in the various uptake models given in Attachment B. The selection of the food-web models is based upon the habitat (aquatic or terrestrial) that is affected and the type of contaminant. These models are to be used for organic and inorganic PECOCs. Non-chemical stressors will need to be evaluated appropriately. Due to the variety of substances that can be considered as non-chemical stressors, no generic food-web models for non-chemical stressors can be developed. Instead, non-chemical stressors are to be evaluated on an as-needed basis. Discussions with risk assessment personnel from the Ohio EPA DHWM are strongly encouraged before a Level III ERA is completed and submitted for approval for sites assessing the effects caused by non-chemical stressors.

The food-web criteria and direct contact evaluations that are required when evaluating terrestrial and aquatic habitats that are potentially impacted by PBT and non-PBT PECOCs are given below:

A) Terrestrial Environments:
Terrestrial systems that do not contain PBT compounds are at a minimum, required to evaluate direct contact effects/toxicity on plants and earthworms (if sufficient information is available), and to use one herbivore and one invertivore receptor in assessing the potential impacts to ecological receptors by site-related PECOCs. If PBT compounds are present then, one mammalian and one avian top carnivorous receptor must also be evaluated in addition to the receptors listed for terrestrial environments with non-PBT compounds. The specific requirements for a Level III ERA for the evaluation of terrestrial environments include:

1) Non-PBT PECOCs
   a) Direct contact effects on plants (see Attachment B (2));
   b) Direct contact effects on soil dwelling invertebrates/microorganisms (see Attachment B (2));
   c) Effects on herbivorous mammals and birds (see table A-1 for list of receptors); and,
   d) Effects on invertivorous mammals and birds (see table A-1 for list of receptors).

2) PBT PECOCs
   a) All evaluations for Non-PBT PECOCs; and,
   b) Effects on two top terrestrial carnivores (one mammalian and one avian (see table A-1 for list of receptors)). The diets of the top carnivores should include herbivorous and invertivorous small mammals or birds depending on the type of contamination and feeding habits of the receptors. Generally, sites with organic PECOCs should evaluate top carnivorous receptors by estimating 100% of the diets as invertivorous mammals or birds. For sites with inorganic PECOCs, the top carnivores should be evaluated using 100% of the prey as herbivorous mammals or birds. For sites that have both organic and inorganic PBTs, a site-specific prey evaluation may be warranted to determine the appropriate proportion(s) of invertivorous and herbivorous prey items.

It should be noted that sites with active seeps or contaminated surface water may need to include the ingestion of surface water as a pathway for receptors in the Level III ERA. This pathway should only be considered when it is probable for ecological receptors to come into contact and

consume contaminated surface water. The appropriate Ohio EPA personnel should be contacted for additional information regarding the evaluation of contaminated surface water for terrestrial environments.

B) Aquatic Environments:
Surface waters are to meet all applicable water quality standards as given in OAC 3745-01 and discussed in the Level II ERA guidance document. A detailed description of the use of Ohio EPA water quality criteria in ecological risk assessment is given in the Level II ERA guidance document. It should be noted that much of the surface water evaluations are to be conducted or begun during the Level II ERA. The specific requirements for a level III surface water evaluation include:

1) Lotic water bodies (other than those designated as limited resource water (LRW):
   a) Non-PBT PECOCs:
      i) Lotic surface waters other than those designated as limited resource water (LRW) that do not list PBT compounds as PECOCs must meet the appropriate chemical specific and biological criteria given in OAC 3745-01.

   b) PBT PECOCs:
      i) Lotic surface waters other than those designated as limited resource water (LRW) that list PBT compounds as PECOCs must meet the appropriate chemical specific and the biological criteria given in OAC 3745-01; and,

      ii) A food-web analysis must be completed that evaluates the potential risks to one piscivorous bird and one piscivorous mammal from the specific PBT compounds identified as PECOCs.

2) Lentic and LRW surface water bodies:

   a) Non-PBT compounds:
      i) Lentic and LRW designated water bodies that do not list PBT compounds as PECOCs must meet the chemical specific criteria listed in OAC 3745-01.

      ii) Lentic or lotic water bodies designated LRW that flow into a lotic water body that is designated other than LRW must meet the appropriate chemical specific and biological criteria near or at the point of confluence;

      iii) A food-web analysis must be completed that evaluates the potential risks to one herbivorous bird and one herbivorous mammal from the specific non-PBT compounds identified as PECOCs.

      iv) Sediment toxicity tests are to be conducted to evaluate potential sediment toxicity to aquatic macroinvertebrates and/or fish. See task (2)(C) of the Level IV ERA guidance for a list of acceptable toxicity/bioassay tests.

   b) PBT compounds:

      i) Lentic and LRW designated water bodies that list PBT compounds as PECOCs must meet the chemical specific criteria listed in OAC 3745-01.

ii) Lentic or lotic water bodies designated LRW that flow into a lotic water body that is designated other than LRW must meet the appropriate chemical specific and biological criteria near or at the point of confluence;

iii) Sediment toxicity tests are to be conducted to evaluate potential sediment toxicity to aquatic macroinvertebrates and/or fish. See task (2)(C) of the Level IV ERA guidance for a list of acceptable toxicity tests; and,

iv) A food-web analysis must be completed that evaluates the potential risks to one piscivorous bird and one piscivorous mammal from the specific PBT compounds identified as PECOCs (surface water or sediment to fish to piscivorous bird and animal model).

(3) Generic Receptors

Table A-1 lists the generic receptors under their appropriate feeding habits to be used in a Level III ERA. The receptors are to be chosen based upon the assessment endpoints, the types of habitats that are associated with the site, and the feeding habits of the receptors required for Level III ERA. The actual choice of the specific receptors may vary based upon the toxicity information that is available for each PECOC receptor combination and site-specific information. Attachment C of the Level III ERA guidance document discusses the toxicity assessment and the implications of selecting a receptor with adequate toxicity information. Attachment C and the appropriate toxicological data bases should be reviewed before selecting the receptors for a Level III ERA. Attachment D provides that appropriate life history parameters for the generic receptors.

Table A-1
Generic Receptor List

Soil Associated Receptors

Direct Soil Contact	Herbivore	Carnivore***	Invertivore
Plants	Meadow vole	Red-tailed hawk	Short-tailed shrew
Earthworms	Deer mouse	American kestrel	American woodcock
	Eastern cottontail	Red fox	American robin
	White-tailed deer*		

Surface Water and Wetland Associated Receptors

Direct Surface Water/ Sediment Contact	Herbivore	Piscivore***	Invertivore
Aquatic Plants	Muskrat	Mink	Spotted sandpiper**
Macroinvertebrates	Mallard duck	Belted kingfisher	
Fish		Great blue heron	

* White-tailed deer are only to be evaluated when public concerns have been raised regarding white-tailed deer populations.
** Suggested invertivore for wetland habitats.
*** For use in evaluating PBT compounds.

It is recommended that the receptor with the smallest home range be selected for assessing ecological risk at a site. White-tailed deer are generally not used as ecological receptors due to their large home range unless there is a concern fom the public that is specific to deer population health. If white-tailed deer are to be included in a terrestrial risk assessment, then the assessment must also include a terrestrial herbivore with a smaller home range (*e.g.*, meadow vole). By using receptors with limited home ranges additional certainty is added to the risk assessment to ensure that a site is protective or does not pose unacceptable hazard to ecological receptors.

All terrestrial State and/or Federally-listed threatened and endangered species (T&E) identified to inhabit or be potentially impacted by the site are to be included as ecobgical receptors in the Level III ERA. If by using the identified T&E species in the Level III ERA one or more of the feeding habits are evaluated, then the generic receptors that represent those particular feeding habits would not be required. If for example a barn owl was identified on site and used to estimate potential adverse effects to top carnivorous birds, then an assessment using either the red-tailed hawk or the American kestrel would not be required.

Aquatic T&E species are to be evaluated using the biological criteria where appropriate. If the biological criteria cannot be used to evaluate the potential impacts to aquatic T&E species, the Ohio EPA DHWM is to be contacted to determine the appropriate methodology for the estimation of potential hazards to these receptors prior to completing the Level III ERA.

Attachment B
EXPOSURE ASSESSMENT

(1) Introduction

Exposure is defined as the co-occurrence or contact between a stressor and an ecological receptor. Exposure assessment is the process of estimating the magnitude, frequency and duration of a site-specific exposure and the dose of a chemical received by an ecological receptor. For relatively sessile organisms such as plants and soil invertebrates/microorganisms, the exposure characterization is based on exposure point concentrations (EPC) (*i.e.*, the concentration of a chemical in a specific environmental medium at the point of contact for the receptor) and potential harm is assessed as a direct contact evaluation. Because plants and soil invertebrates are relatively sessile, the concentration of a chemical at a given location is likely to be representative of the chronic exposure concentration for these organisms.

Mobile wildlife exposure characterizations are based on the average daily dose (ADD) (*i.e.*, the dose of a chemical or PECOC ingested by an ecological receptor and expressed as the mass of a chemical ingested concentration per kilogram body weight of the receptor per day (mg $kg_{bw}^{-1}day^{-1}$). Calculation of wildlife ADD_S incorporates exposure point concentrations derived from (1) modeled concentrations of chemicals in food items such as terrestrial plants, terrestrial invertebrates, terrestrial prey species, aquatic invertebrates, and fish, and (2) measured concentratons of chemicals in surface soil, surface water and biological media (tissues). If measured tissue concentrations are used to characterize exposure, sampling methodologies should be reviewed and approved by Ohio EPA DHWM prior to tissue collection and analysis. Direct sampling is recommended when greater certainty is required for the risk assessment.

The primary route of exposure of PECOCs to wildlife receptors is the ingestion of food and water which includes the ingestion of suface soil and sediment incidentally consumed during feeding and/or grooming. The following text summarizes the EPC and ADD methodologies for ecological receptors evaluated in an ecological risk assessment.

(2) Direct Contact Evaluation

Direct contact evaluations estimate potential impact to soil invertebrates and plants as the result of exposure to site-related PECOCs. Sites that contain potentially impacted soils are to evaluate possible adverse impacts to plants and soil invertebrates. This evaluation is performed by comparing measured concentrations of site-related PECOCs to the appropriate toxicological dose response data (see Attachment C (1)).

(3) Quantification of Exposure via Ingestion (Average Daily Dose)

The exposure of an ecological receptor to PECOCs in surface soil, sediment, tissues, and surface water are quantified as the average daily dose (ADD). The ADD is estimated using measured or modeled concentrations in environmental media and receptor life history parameters. The ADD equations account for both the transfer of constituents from abiotic media into food or prey items and for direct up-take of contaminated media by the ecological receptors.

The concentration of PECOCs used in the exposure calculations is defined as the exposure point concentration (EPC). The EPC is the lower of the 95 % upper confidence limit (UCL) on the arithmetic mean or maximum detected concentration of the PECOCs for all media in Level III.

The quantity of food ingested by a receptor is defined as the daily rate of food ingested (IR_f), given in units of g g_{bw}^{-1} d^{-1}. The IR_f is the combination of all intakes for the receptor. These intakes consist of the ingestion rate, or the quantity of food ingested that is plant matter (I_P), animal matter (I_A), and soil (I_S). These ingestion values are calculated by multiplying the IR_f by the fractions of the diet that are plant matter (P_F), animal matter (A_F) and soil (S_F). Life history parameters for the generic receptors are given in Attachment D.

Ecological receptors obtain all or a fraction of their diet from the exposure site. The amount of exposure a receptor would receive from the site is dependent upon the size of the site or area of contamination, and the home range of the receptor. Assuming that individual receptors are randomly

distributed over their home range and/or forage randomly over their home or foraging ranges, they obtain only a fraction of their diet from an exposure area that is smaller than their range. The area use factor (AUF) is the ratio of the size of the home range or foraging ranges to the size of the exposure area or site (see attachment D for generic receptor home range values).

The temporal use factor (TUF) is the time spent present at the site or the time spent foraging at the site. TUFs are used to estimate the time migratory species spend at the site, or to incorporate site specific factors that limit the time ecological receptors are expected to be present at the site. One example for using a TUF includes the duration a site is inundated by water due to annual river flooding events. Site-specific and/or receptor-specific information should be provided for calculated exposures using a TUF of less than one.

The general ADD equation is:

Exposure = Total Average Daily Dose = $ADD_P + ADD_A + ADD_S \times AUF \times TUF$

where:

ADD_P = Average daily dose by ingestion of plant matter (mg kg_{bw}^{-1} d^{-1});
ADD_A = Average daily dose by ingestion of animal matter (mg kg_{bw}^{-1} d^{-1});
ADD_S = Average daily dose by ingestion of soil (mg kg_{bw}^{-1} d^{-1});
AUF = Area use factor (unitless); and,
TUF = Temporal use factor (unitless).

The specific ADD(x) equations are divided into plant, animal, and soil categories for discussion and are as follows:

A) Ingestion of Plant Matter (*e.g.*, Meadow vole)

ADD_P = $EPC \times I_P \times UF_{r\ or\ v}$

EPC = Exposure point concentration in soil (mg kg_{soil}^{-1})
I_P = Ingestion rate of plant matter (kg kg_{bw}^{-1} d^{-1}), see below,
$UF_{r\ or\ v}$ = Soil-to-plant uptake factor (UF_r reproductive or storage parts, or UF_v vegetative parts depending on the contaminant and feeding habit of receptor) uptake factor (kg_{soil} kg_{plant}^{-1}), see section 4.0
I_P = $IR_F \times P_F$
IR_F = Ingestion rate of food (kg kg_{bw}^{-1} d^{-1}, IRf values for the generic receptors are given in Attachment D in units of (g g_{bw}^{-1} d^{-1}) which are equivalent)
P_F = Fraction of diet that is plant matter (unitless, P_F values for the generic receptors are given in Attachment D)

B) Ingestion of Animal Matter

1) Invertivore (*e.g.*, Short-tailed shrew, American robin, etc.)

ADD_A = $EPC \times I_A \times BAF_I$

EPC = Exposure point concentration in soil (mg kg_{soil}^{-1})
I_A = Ingestion rate of animal matter (kg kg_{bw}^{-1} d^{-1}), see below,
BAF_i = Soil-to-soil dwelling invertebrates uptake factor (kg_{soil} kg_{tissue}^{-1}, see section 5.0)
I_A = $IR_F \times A_F$
IR_F = Ingestion rate of food (kg kg_{bw}^{-1} d^{-1}, IR_F values for the generic receptors are given in Attachment D in units of (g g_{bw}^{-1} d^{-1}) which are equivalent)
A_F = Fraction of diet that is animal matter (unitless, A_F values for the generic receptors are given in Attachment D)

2) Terrestrial Carnivores (*e.g.*, Red tailed Hawk, Red Fox)
The ADD equations for terrestrial carnivores are simply the summation of the prey ADD equations with the appropriate BAF_P values to account for the uptake of PECOCs into prey tissues. Many terrestrial carnivores will prey upon both carnivorous and herbivorous small mammals and birds. It is generally assumed that all exposures to prey species are from contaminated locations year round (*i.e.*, AUF and TUF =1). There may be rare circumstances where limited amounts of contamination (by area) may justify the use of an AUF or TUF of less than one for the prey. The use of an AUF and TUF values of less than one for prey species should be approved by Ohio EPA DHWM prior to the completion of the Level III ERA.

ADD_A = (Concentration in prey, Cs) x $I_{a(predator)}$

Cs = Prey $_{ADDTotal}$ x BAF_P / IR_f
Prey $_{ADDTotal}$ = Prey ADD_P + Prey ADD_A + ADD_S
Prey ADD_P = EPC x $UF_{v\ or\ r}$ x I_P x AUF x TUF (see section 4.0)
Prey ADD_A = EPC x BAF_I x I_A x AUF x TUF (see section 6.0)
Prey ADD_S = EPC x I_S x AUF x TUF (see section (3.0)C))

Where:

$I_{a(predator)}$ = Ingestion rate of animal matter (kg kg_{bw}^{-1} d^{-1}); = IR_F x A_F
IR_F = Ingestion rate of food (kg kg_{bw}^{-1} d^{-1}, IR_F values for the generic receptors are given in Attachment D in units of (g g_{bw}^{-1} d^{-1}) which are equivalent) these values are species specific
A_F = Fraction of diet that is animal matter (unitless, A_F values for the generic receptors are given in Attachment D)
BAF_P = Food-to-tissue uptake factor in prey ($kg_{prey's\ food}$ kg_{tissue}^{-1})
IR_F = Ingestion rate of food for the prey species (kg kg_{bw}^{-1} d^{-1}, IR_F values for the generic receptors are given in Attachment D in units of (g g_{bw}^{-1} d^{-1}) which are equivalent to kg kg_{bw}^{-1} d^{-1})
EPC = Exposure point concentration in soil (mg_{PECOC} kg_{soil}^{-1})
$UF_{r\ or\ v}$ = Soil-to-plant uptake factor (UF_r reproductive or storage parts, or UF_v vegetative parts depending on the contaminant and feeding habit of receptor) uptake factor (kg_{soil} kg_{plant}^{-1})
I_P = Ingestion rate of plant matter by prey species (kg kg_{bw}^{-1} d^{-1})
AUF = Area use factor of the prey species (unitless)
TUF = Temporal use factor of the prey species (unitless)
BAF_i = Soil-to-soil dwelling invertebrates uptake factor (kg_{soil} kg_{tissue}^{-1}, see section 5.0)
I_A = Ingestion rate of animal matter by prey species (kg kg_{bw}^{-1} d^{-1})
I_S = Ingestion rate of soil by prey species (kg kg_{bw}^{-1} d^{-1})

3) Ingestion of tissues by Piscivorous Receptors
For piscivorous receptors, the diet is assumed to consist of 100% fish. Fish tissue concentrations collected in Level II should be measured directly when possible, or modeled when tissue concentration data are not available. The ADD equation below is for estimating the average daily dose to the avian piscivorous receptors. If a mammalian receptor is used the dose of the sediment/soil may be incorporated by adding the ADD_S term as discussed in the equation for the terrestrial carnivore (section (3)(B)(ii) above). The following ADD_A equation is to be used for estimating the ADD of fish tissue:

ADD_A = EPC x I_A x BAF (BAF, BSAF, or BCF)

Where:

EPC	=	Exposure point concentration in surface water (mg L^{-1}) or sediment (mg kg^{-1})
I_A	=	Ingestion rate of animal (fish) matter (kg kg_{bw}^{-1} d^{-1}), see below,
BAF	=	Surface water to fish (BCF, L kg^{-1}), or sediment to fish concentration factor (BAF, BSAF, L $kg_{fish\ tissue}^{-1}$)
I_A	=	IR_F x A_F
IR_F	=	Ingestion rate of food (kg kg_{bw}^{-1} d^{-1}, IRf values for the generic receptors are given in Attachment D in units of (g g_{bw}^{-1} d^{-1}) which are equivalent)
A_F	=	Fraction of diet that is animal (fish) matter (unitless, A_F values for the generic receptors are given in Attachment D)

If the recommended fish tissue data are available, then the EPC and the BAF variables are replaced with the fish tissue wet weight PECOC concentration data.

C) Ingestion of Soil

ADD_S	=	EPC x Is
EPC	=	Exposure point concentration in soil (mg_{PECOC} kg_{soil}^{-1})
I_S	=	Ingestion rate of soil (kg_{soil} kg_{bw}^{-1} d^{-1}); = IR_F x S_F
IR_F	=	Ingestion rate of food (kg kg_{bw}^{-1} d^{-1}, IR_F values for the generic receptors are given in Attachment D in units of (g g_{bw}^{-1} d^{-1}) which are equivalent)
S_F	=	Fraction of diet that is soil (unitless., S_F values for the generic receptors are given in Attachment D)

(4) Determination of Plant Tissue PECOC Concentration

Plant PECOC concentrations can be ether directly measured from plant tissue or be modeled using one of several uptake equations. Plant PECOC concentrations may be estimated by using the appropriate bioaccumulation factor for the type of PECOC and plant tissue. Bioaccumulation factors for plants ($BAF_{r\ or\ v}$) are used in the ADD_P equation for estimating the plant tissue PECOC concentrations and ultimately, the dose of PECOC received by an herbivore from consuming plant tissue.

In general, the soil-to-plant $BAF_{r\ or\ v}$ for inorganic compounds are derived from the literature (*e.g.*, Baes *et al.*, 1984) and organic BAF_v are derived by using a model based upon the octanol-water partition coefficient of the organic PECOC (Travis and Arms, 1988).

Baes *et al.* (1984) conducted an extensive literature review and identified soil-to-plant BAF values which represent the ratio of the dry weight concentration of elements in plant tissue to the dry weight concentration of elements in the root zone soils. These values are given for both vegetative and reproductive portions of plants. The appropriate uptake factors should be chosen based on the ecological receptors used in the assessment. If a receptor predominantly consumes vegetative portions of plants, then BAF_v values should be used to estimate the PECOC tissue concentrations. If a receptor consumes fruits and seeds, then the reproductive uptake factor, or BAF_r values should be used in estimating fruit and seed PECOC concentrations. If uptake values are not available in the listed sources, and are needed to conduct a Level III ERA, then Ohio EPA should be consulted for acceptable $BAF_{r\ or\ v}$ values or sources of information.

Organic chemicals may enter the plant by partitioning from contaminated soil to the roots and then translocated throughout the plant via the xylem tissue. Most bioaccumulative, lipophilic organic chemicals partition to the epidermis of the root or adhere to soil particles and are not drawn into the inner root or xylem (Paterson et al, 1990). Plant bioaccumulation factors for estimating concentration of hydrophilic organic chemicals can be derived from the following equation based on a linear regression of bioaccumulative factors for 29 organic chemicals (Travis and Arms, 1988), where:

$$B_v = 10^{1.588} / K_{ow}^{0.578}$$

or alternatively stated;

$$(\text{Log } B_v = 1.588 - 0.578 \text{ Log } K_{ow})$$

B_v	=	UF_v
UF_v	=	Plant uptake factor ($kg_{soil}\ kg_{plant}^{-1}$)
K_{ow}	=	Octanol water coefficient.

This methodology is expressed as a BAF_v for the vegetative portions of plants. It may be necessary to use this methodology to develop a BAF_r for estimating organic PECOC concentrations in reproductive and storage tissues if other information is not available.

It should be noted that most uptake factors are expressed in terms of dry weight of plant matter. The calculated plant tissue PECOC concentrations must therefore be converted to wet weights for use in the ADD_P equations by multiplying the results by the appropriate conversion factor (CF). See section 8 for information on converting dry weight to wet weight. The appropriate plant dry-weight-to-wet-weight CF is given below:

CF = Dry-weight to wet weight conversion factor for plants. Recommended value 0.15 kg plant dry weight per kg plant wet weight for vegetative portions, or approximately 85% moisture; for seed and grains, assume 10 % moisture (U.S. EPA, 1993).

(5) Determination of Earthworm Tissue PECOC Concentration

Earthworm tissue PECOC concentrations can be either directly measured from earthworm tissues, or be modeled using a bioaccumulation factor for soil invertebrates (BAF_I). During field sampling for earthworm tissue, it is recommended that co-located soil samples be taken to help in the determination of a site specific soil-to-earthworm bioaccumulation factor for use in potential soil remediation goals.

The following hierarchy of references are to be used for obtaining acceptable BAF_I values or methodologies for estimating BAF_I values:

1) Sample *et al.* 1999;
Sample *et al.*, 1999, lists BAF_I values for As, Cd, Cr, Cu, Hg, Mn, Ni, Pb, Zn, PCB, and TCDD.

2) Beyer and Stafford, 1993;
BAF_I values for Al, B, Ba, Be, Fe, Mg, Mo, Sr, and Vn and for 24 individual polycyclic aromatic hydrocarbons (PAHs) are given in Beyer and Stafford, 1993. When the BAF_I values from Beyer and Stafford 1993 are used, it is important to note that the uptake values were estimated with non-depurated earthworms. Therefore, the earthworm soil gut contents were included with the tissue analysis for the various inorganic and organic compounds. When these values are used in an ADD equation, the soil consumption term, I_S for the earthworm consuming predator only, should be eliminated.

3) Connell and Markwell, 1990;
The three phase model of Connell and Markwell is to be used to estimate BAF_I values for organic compounds not listed in the above references. The specific equation is as follows:

$$BF = (y_L / x f_{oc}) k_{ow}^{b-a}$$

Where:

BF = BAF_I
y_L = Organism lipid content (0.01 (earthworm), Rao and Davidson, 1980, Belfroid *et al.*, 1993)
x = Proportionality constant (0.66, Rao and Davidson, 1980)
f_{oc} = Fraction of organic carbon in soil
k_{ow} = Octanol to water partition coefficient for the organic PECOC
b-a = Non-linearity constant (0.07)

Additional methodologies may be used to estimate BAF_I with pre-approval from Ohio EPA DHWM ecological risk assessors.

Many of the BAF_I equations and values are expressed in terms of dry weight of earthworm tissue. The results of the earthworm tissue PECOC concentration estimations must be converted to wet weight or live weight for use in the ADD equations. See section 8 for information on converting dry weight to wet weight. The following CF is to be used for earthworm tissue dry-weight-to-wet-weight conversions:

CF = Dry-weight to wet-weight conversion factor for earthworms. The dry weight to wet weight conversion factor of 0.13 kg soil invertebrate, dw per kg soil invertebrate, ww (wet weight = 87% moisture, U.S. EPA 1993 Wildlife Exposure Handbook) was derived from Markwell et al., (1989).

(6) Determination of Prey Tissue PECOC Concentrations

Prey PECOC concentrations can be either directly measured from captured prey, or be modeled using the uptake equation described below. Bioaccumulation factors for prey (BAF_P) are used in the ADD_P equation for estimating the prey tissue PECOC concentrations and ultimately, the dose of PECOC received by a top predator from the consumption prey.

BAF values for inorganic compounds can be found in section 2.3 titled; Ingestion-to-Beef Parameter, F_f, in Baes *et al.* (1984). The transfer values are representative of the fraction of the daily elemental intake in feed which transferred to and remains in a kilogram of beef until slaughter.

One method for estimating BAF_P values has been described by Travis and Arms, 1988 based on the transfer of organic compounds in feed to beef. The equation is as follows:

$$\text{Log } Bb = -7.6 + \text{Log } k_{ow}$$

Where:

Bb = BAF_P
k_{ow} = Octanol to water partition coefficient for the organic PECOC

If empirically derived BAF_P values can be obtained, then they may be used in the ERA following approval from Ohio EPA DHWM.

It is important to note that the equation for determining BAF_P for organic compounds is based on a dry-weight intake of the prey species and the resulting estimate of tissue PECOC concentration is also based on a dry weight measurement. Therefore, dry-weight-to-wet weight conversions should not be performed until the prey tissue PECOC has been estimated in terms of dry-weight. The following CF is to be used to estimate the PECOC concentrations based on a wet or fresh weight of prey tissues:

CF = Dry-weight to wet weight conversion factor for small mammals. Recommended value 0.32 kg mammal tissue dry weight per kg mammal tissue wet weight, or approximately 68% moisture (EPA, 1993).

(7) Determination of Fish and Aquatic Macroinvertebrate Tissue PECOC Concentration

Tissue PECOC concentrations for fish and aquatic macroinvertebrates can be either directly measured from captured organisms, or be modeled using the methods described below. Direct sampling of tissues is recommended when greater certainty is required for the risk assessment. Given that sampling of macroinvertebrates and fish communities are required for lotic water bodies being evaluated for attainment of the appropriate aquatic life habitat use designation, tissue sampling is the recommended method for evaluating tissue PECOC concentrations of these organisms.

Fish and macroinvertebrate tissue PECOC concentrations may also be estimated using an appropriate bioaccumulation factor (BAF) multiplied by the appropriate sediment or surface water PECOC concentration. The methodologies for deriving the appropriate BAF values are those found in OAC 3745-1-37, and are consistent with the methods described in U.S. EPA's, Great Lakes Water Quality Initiative Technical Support Document for the Procedure to Determine Bioaccumulation Factors, March 1995, EPA-820-B-95-005, and in the Great Lakes Water Quality Initiative Technical Support Document for Wildlife Criteria, March 1995, EPA-820-B-95-009. These documents give explicit details for calculating bioconcentration, bioaccumulation, biota-sediment accumulation factors, and the use of food-chain multipliers. It should be noted that contaminant tissue concentrations estimated using these methods may be overestimated when compared to direct tissue sampling results.

U.S. EPA discusses that the BAF (Bioaccumulation Factor) is a better predictor of the concentration of a chemical within fish tissue in the Great Lakes System because it includes consideration of the uptake of contaminants from all routes of exposure. This is in contrast to the use of a BCF (Bioconcentration Factor) that only estimates uptake of chemical in surface water.

The cited guidance documents and OAC include a hierarchy of three methods for deriving BAFs for PECOCs:

1) field-measured BAFs;
2) predicted BAFs derived by multiplying a laboratory-measured BCF by a foodchain multiplier; and,
3) BAFs predicted by multiplying a BCF calculated from the log K_{ow} by a food-chain multiplier.

This hierarchy has been modified to include the methodology for predicting a BAF based on a BSAF as the second method. It is presumed that the BSAF will be multiplied by a food chain multiplier. This however is not directly stated in the U.S. EPA guidance documents.

Bioaccumulation values are also available in the U.S. EPA document: Screening Level Ecological Risk Assessment Protocol for Hazardous Waste Combustion Facilities, August 1999, EPA530-D-99-001A.

It is important to note that many of the BCF, BSAF, and BAF equations are based on dry-weight measurements of either sediment or tissue PECOC concentrations. Therefore, dry-weight to wet-weight conversions may need to be performed. The following CFs are to be used to estimate the PECOC concentrations based on a wet or fresh weight of prey tissues:

CF = Dry-weight to wet-weight conversion factor for aquatic invertebrates. Recommended value 0.21 kg aquatic invertebrate tissue dry weight per kg aquatic invertebrate wet weight, or approximately 79% moisture (EPA, 1993). Recommended value of 0.25 kg bony fish tissue dry weight per kg bony fish wet weight, or approximately 75% moisture (EPA, 1993).

(8) Dry-weight to wet-weight Conversions

Much of the environmental data that will be gathered from the site will be presented on a dry weight basis. Many analytical procedures require that all media samples be dried before the chemical extraction procedures can be completed. The result from these analytical processes is generally some expression of concentration of a PECOC in a medium based on a dry weight. Because the food intake rates of ecological receptors are based on wet weights of ingested materials, a dry weight

to wet weight conversion step is required before the ADD equations are completed. The equation for converting dry weight concentration to a wet weight concentration is presented below. Dry weight to wet weight conversion factors (CFs), are listed above in sections 5 through 7. The inverse of the formula may be used to estimate dry weights based on wet weight data.

Conversion of dry-weight to wet-weight:

$$\frac{\text{x mg PECOC}}{\text{kg medium}_{dw}} \times \text{CF} = \frac{\text{x mg PECOC}}{\text{kg medium}_{ww}}$$

where:

dw = dry weight
ww = wet weight
CF = dry weight to wet weight conversion factor = $\frac{\text{1kg medium}_{dw}}{\text{x kg medium}_{ww}}$

Example:

$$\frac{\text{0.8 mg PECOC}}{\text{kg plant tissue}_{dw}} \times \frac{\text{0.18 kg plant tissue}_{dw}}{\text{1 kg plant tissue}_{ww}} = \frac{\text{0.14 mg PECOC}}{\text{kg plant tissue}_{ww}}$$

Most BAF values and uptake factors are expressed in terms of dry weight of tissue and media (soil and sediment) concentrations . Therefore, the BAF and uptake values are to be used to estimate PECOC concentrations in the appropriate tissues based in terms of dry weight before the dry weight to wet weight conversions are completed. Once the concentration of the PECOCs in the appropriate tissues is expressed in terms of wet weights, then the values can be used in the ADD equations.

Literature Cited

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Attachment C
TOXICITY ASSESSMENT

(1) Introduction

The purpose of the toxicity assessment is to weigh available evidence regarding the potential for a particular contaminant to cause adverse effects in exposed individuals or populations of receptors, and to provide an estimate of the relationship between the extent of exposure to a contaminant and the likelihood and/or severity of adverse effects. As stated in Task 4 of the Level III ERA guidance document, an ecobgically-based reference dose (ERfD) is to be used in assessing possible hazards to ecological receptors from a potential ecological contaminant of concern (PECOC). Toxicobgical data characterizing adverse effects on ecologically relevant endpoints such as growth, seed germination, reproduction, and survival are to be used when deriving an ERfD. The following toxicological criteria are to be used for deriving an appropriate ERfD for each PECOC:

> For State or Federally-listed threatened or endangered species the ERfD = Modified Chronic No Observed Adverse Effect Level ($NOAEL_{mc}$) (mg kg_{bw}^{-1} d^{-1}) adjusted to account for interspecies uncertainty and multiplied by an appropriate intraspecies uncertainty factor.
>
> For receptors other than threatened or endangered species or direct contact evaluations, the ERfD = $NOAEL_{mc}$ adjusted to account for interspecies uncertainty.
>
> For direct contact evaluations for plant and soil invertebrates the ERfD = $NOAEL_{mc}$. A twenty percent reduction in survival, growth, activity, or yield (measured as plant or invertebrate mass) is used as the threshold for significant effects and is considered as a chronic LOAEL (Suter *et al.* 1995, Efroymson, *et al.* 1997a, Efroymson *et al.* 1997b). It should be noted that a direct contact evaluation is based on a medium concentration and is not a dose. However, for this guidance, the concentration at which a change in 20 percent of the measured attribute is considered a LOAEL. No interspecies uncertainty adjustments are required for direct contact evaluations. Screening values presented in Level II may be the basis for an ERfD if additional information is not available.
>
> Note that for aquatic habitats, the appropriate biological criteria is used in evaluating population level effects on aquatic organisms. See Attachment A for the specific criteria regarding the evaluation of aquatic habitats.

The terms lowest observed adverse effect level (LOAEL), no observed adverse effect level (NOAEL), and no observed effect level (NOEL) are used to designate the actual values generated from a toxicity study of the particular compound or stressor. The ERfD is defined as an estimate of daily intake of a specific compound or substance by an ecological receptor that is likely to be without an appreciable risk of deleterious effects. Often the ERfD is an extrapolated toxicity value generated from the specific dose-response toxicity study of the compound of interest that was initially reported as an acute, sub-acute, sub-chronic, or chronic, NOAEL, LOAEL, LD_{50}, or other value.

It should be noted that if toxicological information on a chemical is not available for the specific receptor being modeled, then the toxicity information is to be extrapolated using the methods given below. In some cases the appropriate toxicity information may not be available or a valid extrapolation of the toxicological data may not be possible for a particular receptor. In these circumstances, the appropriate food-web model will not be required as listed in Attachment A. A description and explanation is to be given in the Level III report for not completing any specific food-web models. If however a chemical is found in high concentrations and is site-related, then it may be warranted to establish a surrogate chemical that has sufficient toxicological information for use in a Level III ERA. The use of surrogate compounds should only be done following consultation with the appropriate Ohio EPA DHWM risk assessors.

(2) ERfD Derivation

The toxicological information shall be based, to the extent practicable, on studies in which the routes and duration of exposure were commensurate with the expected routes and duration of exposure for endpoint species of the receptor population considered in the risk assessment, or appropriate surrogate endpoint species for those receptors. If a chronic NOAEL or NOEL is not available for the endpoint species considered in the risk assessment, then the ERfD criterion may be derived from toxicity information gathered from various exposure periods, dosing regimes, and test species. Toxicological dose response data (*e.g.*, NOAEL, NOEL, LOAEL, etc.) based on exposure periods other than chronic, must be modified with uncertainty factors to derive a modified, chronic NOAEL ($NOAEL_{mc}$).

Interspecies uncertainty must also be evaluated when developing an ERfD. Interspecies variability can be evaluated using either the preferred allometric scaling method for mammalian species, or by applying the appropriate taxon-based uncertainty factors. For State or Federally-listed threatened or endangered species an additional intraspecies uncertainty factor must also be appled to account for variability and sensitive sub-populations.

The adjustment and modification of toxicological data is a fundamental step in the risk assessment process. Human Health Risk assessments routinely use toxicity data based on various dosing regimes (*i.e.*, single or multiple dose) and study subjects of another (*i.e.*, non-human) species. U.S. EPA has described procedures for the extrapolation of such data for use in human health risk assessments (Risk Assessment Guidance for Superfund Volume 1 Human Health Evaluation Manual, 1989 (Part A)). The following methodologies are to be used for deriving an ERfD from toxicity data for use in ecological risk assessments and were derived from a collaboration of multiple information sources (Dourson and Stara 1983, Barnes and Dourson 1988, Calabrese and Gilbert 1993, Dourson 2000, Calabrese and Baldwin 1993, U.S. EPA 1993, U.S. EPA 1992, U.S. EPA 1989, Wentsel *et al.* 1996, West *et al.* 1997, Ford *et al.* 1992).

A stepwise process (shown in Figure C-1 and summarized below) is used to extrapolate toxicological data based on various dosing regimes, exposure periods, taxonomic differences, and, when required, intraspecies uncertainty to develop an ERfD suitable for evaluating hazard to individuals or populations of selected receptor species. The ERfDs are developed using a two-tiered approach. The first tier requires that a $NOAEL_{mc}$ be developed from select toxicological data. The second tier adjusts the $NOAEL_{mc}$ for interspecies uncertainty and, when required, intraspecies uncertainty.

A) Developing a $NOAEL_{mc}$

Uncertainty factors are used to modify toxicity data to account for differences between the dosing regimes (*i.e.*, single, multiple, or continuous), exposure periods (*i.e.*, acute, sub-acute, sub-chronic, and chronic), and dose-response endpoints (*e.g.*, LOAEL, NOAEL, LD_{50} etc.) of the critical studies and the conditions of the environmental exposure addressed in the ecological risk assessment. Figure C-1 lists the appropriate uncertainty factors for the various exposure periods and study endpoints. Figure C-1 also lists uncertainty factors used to adjust the $NOAEL_{mc}$ to account for taxonomic differences between test animals and ecological endpoint species (see section 1(B)). It is recommended that acute NOAEL, acute LOAEL, or an LD_{50} not be used in deriving a $NOAEL_{mc}$. However, information was given in figure C-1 and below that gives the appropriate uncertainty factors for determining a $NOAEL_{mc}$ from data collected using these specific exposure periods and dose-response endpoints. These uncertainty factors should be used only when more appropriate toxicological data are not available. Irregular toxicity test data should also not be converted using this protocol; instead an Agency risk assessor should be contacted prior to completing the toxicity assessment of a Level III ERA. In some circumstances, it may be more appropriate to evaluate toxicity data from an appropriately selected surrogate compound rather than utilize a NOAEL or NOEL from an acute exposure study or an LD_{50} for the specific chemical or compound of interest. If a chemical surrogate is to be selected for the derivation of an ERfD, then an Agency risk assessor should be contacted prior to submitting a Level III report or continuing an ecological risk assessment.

(i) Chronic-NOAEL or NOEL to $NOAEL_{mc}$

No modifications are required (chronic-NOAEL = $NOAEL_{mc}$). In the case where several NOAELs are identified either from one or more studies, the regulatory focus is normally on the highest value. However, Ohio EPA DHWM recommends that NOAELs based on developmental or reproductive endpoints and studies with the greater number of test animals and therefore the greater power be considered as the preferred chronic-NOAEL values. If two or more NOAELs based on developmental or reproductive endpoints which used equivalent numbers of test animals are identified, then the chronic-NOAEL with the greatest value is to be used in the development of the ERfD.

(ii) Sub-chronic NOAEL to $NOAEL_{mc}$

Chronic toxicity data are the preferred data for use in ecological risk assessments. If only sub-chronic NOAEL studies are available in the literature, then an uncertainty factor of one-half order of magnitude based on a log scale (sub-chronic NOAEL multiplied by 1/3), or one order of magnitude (sub-chronic NOAEL multiplied by 1/10) should be used to modify the data for estimating a $NOAEL_{mc}$. If the exposure period of the sub-chronic NOAEL is more consistent with a chronic exposure period of the test organism, then the one-half order of magnitude uncertainty factor should be used to estimate a $NOAEL_{mc}$. If however, the exposure period is closer to a sub-acute or other short-term exposure period, then the one order of magnitude uncertainty factor should be applied to the data to estimate the $NOAEL_{mc}$.

(iii) Chronic LOAEL or LOEL to $NOAEL_{mc}$

U.S. EPA methodology (U.S. EPA 1997) provides a procedure for the conversion of a LOAEL to NOAEL. This methodology suggests that an uncertainty factor of up to 10 could be used to convert a LOAEL to a NOAEL. U.S. EPA (1989) recommends an uncertainty factor of up to 10 when LOAELs are converted to NOAELs for use in human health risk assessments. Critical studies citing a LOAEL may list a variety of adverse effects as the basis for the LOAEL. These effects range from gross effects, such as death, to more subtle biochemical, physiological, or pathologic changes. For this reason Ohio EPA DHWM employs either a one-half or one order of magnitude (based on a log scale) uncertainty factor to extrapolate a chronic-NOAEL from a chronic-LOAEL. For ecological risk assessments conducted for sites in Ohio, an uncertainty factor of one-half order of magnitude (chronic-LOAEL multiplied by 1/3) is to be used for estimating a $NOAEL_{mc}$ derived from a chronic-LOAEL or chronic-LOEL when the observed adverse effect on the test animal was minor, (*e.g.*, subtle biochemical effects, minor physiological changes, etc.), or was based on a reproductive endpoint. An uncertainty factor of one order of magnitude is to be used to estimate a $NOAEL_{mc}$ from a chronic-LOAEL (chronic-LOAEL multiplied by 1/10) if the critical effect was based on gross or severe effects (*e.g.*, substantial decrease in body or relative organ weights, an effect that would decrease survivability in a wild environment, etc.) or the number of test animals was low in the critical study and therefore, effects in a larger percent (*e.g.*, 50%) of the exposed animals were required to see a statistical difference from the control animals.

(iv) Sub-chronic LOAEL to $NOAEL_{mc}$

Chronic NOAEL toxicity data are the preferred data for use in ecological risk assessments. If only sub-chronic LOAEL studies are available in the literature, then an uncertainty factor of one order of magnitude (sub-chronic LOAEL multiplied by 1/10), one and one-half order of magnitude (sub-chronic LOAEL multiplied by 1/30), or two orders of magnitude (sub-chronic LOAEL multiplied by 1/100) may be used to extrapolate a $NOAEL_{mc}$ from a sub-chronic LOAEL value. The final uncertainty factor applied will be a combination of two factors that

account for the LOAEL to NOAEL conversion (see (2)(A)(iii) above) and the sub-chronic to chronic extrapolation (see (2)(A)(ii) above). The uncertainty factor is to be derived by using the following guidelines:

Sub-chronic LOAEL to chronic LOAEL
If the exposure period of the sub-chronic LOAEL is more consistent with a chronic exposure period, then a one-half order of magnitude uncertainty factor is selected to adjust the sub-chronic LOAEL to a chronic LOAEL (sub-chronic LOAEL multiplied by 1/3). If the exposure period is more consistent with a sub-acute or other short-term exposure period, then a one order of magnitude uncertainty factor is appropriate to convert the sub-chronic LOAEL to a chronic LOAEL (sub-chronic LOAEL multiplied by 1/10).

Chronic LOAEL to $NOAEL_{mc}$
The chronic LOAEL to $NOAEL_{mc}$ extrapolation is based on the severity and endpoint of the observed effect cited in the critical study. The uncertainty factors used are either a one-half order of magnitude (3), or a one order of magnitude (10) value. See section (2)(A)(iii) above for criteria for selecting the appropriate value for the uncertainty factor.

Final Sub-chronic LOAEL to $NOAEL_{mc}$ Uncertainty Factor
The final uncertainty factor used to extrapolate a $NOAEL_{mc}$ from a sub-chronic LOAEL is the product of the two previous uncertainty factors (sub-chronic to chronic and the LOAEL to NOAEL) and ranges from one order of magnitude to two orders of magnitude. Examples: a) If the sub-chronic to chronic uncertainty factor is one-half order of magnitude (3) and the chronic LOAEL to chronic NOAEL is also one-half order of magnitude (3), then the final uncertainty factor would equal one order of magnitude (3 x 3 ~ 10 = sub-chronic LOAEL multiplied by 1/10 = $NOAEL_{mc}$). b) If the sub-chronic to chronic uncertainty factor is one order of magnitude (10) and the chronic LOAEL to $NOAEL_{mc}$ uncertainty factor is one-half order of magnitude (3), then the final uncertainty factor would equal one and one-half order of magnitude (sub-chronic LOAEL multiplied by 1/30 = $NOAEL_{mc}$). c) If the sub-chronic to chronic uncertainty factor is one order of magnitude (10) and the chronic LOAEL to chronic NOAEL is also one order of magnitude (10), then the final uncertainty factor would equal two orders of magnitude (10 x 10 = 100 = sub-chronic LOAEL multiplied by 1/100 = $NOAEL_{mc}$).

(v) Acute NOAEL to $NOAEL_{mc}$
A $NOAEL_{mc}$ can be estimated from an acute-NOAEL only when necessary by multiplying the acute-NOAEL by an uncertainty factor of two orders of magnitude (acute-NOAEL x 1/100).

(vi) Acute LOAEL to $NOAEL_{mc}$
A $NOAEL_{mc}$ can be estimated from an acute-LOAEL only when necessary by multiplying the acute-LOAEL by an uncertainty factor of three orders of magnitude (acute-LOAEL x 1/1000).

(vii) LD_{50} to $NOAEL_{mc}$
A $NOAEL_{mc}$ can be estimated from an acute-LOAEL only when necessary by multiplying the LD_{50} by an uncertainty factor of four orders of magnitude (LD_{50} x 1/10,000).

Acute NOAEL, Acute LOAEL, or LD_{50} data should only be used when necessary. It may be more appropriate to use a surrogate chemical when only toxicological data of this type is available.

B) Interspecies Uncertainty Factors (Adjusting the $NOAEL_{mc}$);
The adjustments of the $NOAEL_{mc}$ for interspecies uncertainty and, when necessary, intraspecies uncertainty constitutes the second tier in the derivation of the ERfD. One of two alternative methodologies may be used to adjust a $NOAEL_{mc}$ that was developed from toxicity information gathered from a test species different from the selected endpoint species. It is recommended that this adjustment step only be used if toxicity data are not available for the specific selected endpoint species evaluated in the ecological risk assessment.

(i) Taxonomically-based Uncertainty Factors;
Taxonomically-based uncertainty factors may be selected to account for differences in interspecies sensitivity. Figure C-1 and the text below both describe the appropriate uncertainty factors to be applied in a taxonomically-based adjustment of a $NOAEL_{mc}$. If the toxicological study test species and the selected endpoint species in the ecological risk assessment are of the:

a) *Same Genus*
If the appropriate $NOAEL_{mc}$ was derived using a test organism within the same genus as the endpoint species in the ecological risk assessment then, no uncertainty factor is required and the $NOAEL_{mc}$ equals the ERfD.

b) *Same Family*
If the appropriate $NOAEL_{mc}$ was derived using a test species within the same family as the endpoint species in the ecological risk assessment then, an uncertainty factor of one-half order of magnitude (the $NOAEL_{mc}$ is multiplied by 1/3) is required to convert the $NOAEL_{mc}$ to the ERfD.

c) *Same Order*
If the appropriate $NOAEL_{mc}$ was derived using a test species of the same order as the endpoint species in the ecological risk assessment then, an uncertainty factor of one order of magnitude (the $NOAEL_{mc}$ is multiplied by 1/10) is required to convert the $NOAEL_{mc}$ to the ERfD. If the test species is not of the same order as the endpoint species in the ecological risk assessment then, an uncertainty factor of two orders of magnitude (the $NOAEL_{mc}$ is multiplied by 1/100) is required to convert the $NOAEL_{mc}$ to the ERfD. Taxonomically-based adjustments should not be performed between taxa in different classes (e.g. Aves, Mammalia).

(ii) Allometric scaling;
Allometric scaling is an alternative method to the taxonomically-based uncertainty factors that can be used to adjust a $NOAEL_{mc}$ in the derivation of an ERfD. NOAELs and LOAELs are daily dose levels normalized to the body weight of the test organisms (*e.g.*, milligrams of chemical per kilogram body weight per day). With toxicity data presented on a $mg\ kg_{bw}^{-1}\ d^{-1}$ basis, comparisons across species with consideration for body size is possible. Studies have shown that numerous physiological rates and activities are a function of body size. Smaller animals generally have greater metabolic rates than larger animals, and usually are more resistant to toxic effects because of the more rapid rates of detoxification.

However, many substances are activation-dependent and require bio-transformation to be converted into their active or toxic forms. If the compound for which the ERfD is being developed requires activation to the toxic form, or metabolites of the parent compound are produced that are also toxic, then the taxonomically-based adjustment is preferred over the allometric scaling method.

The allometric scaling method is only to be used for mammalian species. The modification of an $NOAEL_{mc}$ for avian receptors must be done by using the taxonomically-based interspecies uncertainty factors as given in section (1)(B)(i).

For mammals, it has been shown that this relationship is best expressed in terms of body weight (bw) raised to the 3/4 power ($bw^{3/4}$) (Travis and White 1988, Travis et al. 1990, and U.S. EPA 1992). If the dose (d) has been calculated in terms of unit body weight (*i.e.*, mg kg^{-1}) then the metabolic dose (D) equates to:

$$D = \frac{d \times bw}{bw^{3/4}} = d \times bw^{1/4} \qquad (1)$$

The assumption is that the dose per body surface area (eq. 1) for species "a" and "b" would be equivalent:

$$d_a \times bw^{1/4}_a = d_b \times bw^{1/4} \qquad (2)$$

Therefore, knowing the body weights of two species and the dose (d_b) producing a given effect in species "b," the dose (d_a) producing the same effect in species "a" can be determined:

$$da = db \times \frac{bw_b^{1/4}}{bw_a^{1/4}} \qquad (3)$$

If however a $NOAEL_{mc}$ is available for a mammalian test species (NOAELt), the process becomes less complicated and the equivalent $NOAEL_{mc}$ for a mammalian wildlife species (NOAELw) can be calculated by using the adjustment factor for the differences in body size:

$$NOAEL_w = NOAEL_t \times \frac{(bw_t)^{1/4}}{(bw_w)^{1/4}} \qquad (4)$$

For avians, research suggests that physiological scaling factors developed for mammals may not be appropriate for interspecies extrapolation. Mineau et al. (1996) developed body weight based scaling factors for birds using LC_{50} data for 37 pesticides. Scaling factors ranged from 0.63 to 1.55 with a mean of 1.15. However, scaling factors for the majority of the chemicals evaluated (29 of 37) were not significantly different from 1. A scaling factor of 1 was therefore considered most appropriate for interspecies extrapolation among birds. However, because the allometric scaling method for avians only considered data from toxicity studies with LC_{50} endpoints, this method is not recommended for estimating avian interspecies uncertainty for the derivation of an ERfD.

For interspecies extrapolation for mammalian species, the body weight scaling method, is recommended over the use of the uncertainty factors (section 1(B)), for converting $NOAEL_{mc}$ from test species to those that may be used for endpoint species in ecological risk assessments unless the chemical of interest is activation-dependent. If multiple conversions are required during the derivation of the $NOAEL_{mc}$, then it is suggested that the dosing regime conversions be completed prior to the use of the allometric scaling. This will insure that the proportional conservatism remains and is carried through the allometric scaling.

C) Intraspecies Uncertainty Factors;
If the endpoint species is a State or Federally-listed threatened or endangered species, then an additional uncertainty factor is required to account for variation within the endpoint species population. This intraspecies uncertainty factor is intended to protect sensitive sub-populations and individuals, and account for the individual effects to such populations, in addition to population effects. Figure C-1 lists the uncertainty factors to be applied to the adjusted $NOAEL_{mc}$ when State or Federally-listed organisms are modeled in the ecological risk assessment.

The intraspecies uncertainty factor is intended to be applied to a $NOAEL_{mc}$ after it has been adjusted using either the taxonomically-based uncertainty factors or the allometric approach to account for interspecies uncertainty. The intraspecies uncertainty factor is to be either one-half or one order of magnitude (adjusted $NOAEL_{mc}$ multiplied by 1/3 or 1/10 respectively) based upon whether the critical study effects (NOAEL or LOAEL) were closely related to effects on populations (*e.g.*, reproductive, growth, or developmental effects) rather than more subtle effects on individuals (*e.g.*, biochemical responses, behavioral changes). If the effects in the critical study or studies, were related to population effects, then the one order of magnitude uncertainty factor should be used to account for intraspecies uncertainty. If the effects in the critical study or studies were related to effects on individuals, then the one-half order of magnitude uncertainty factor should be used to account for intraspecies uncertainty.

(3) Toxicological Information Sources
Toxicological information is available from the following sources:

A) Integrated Risk Information System (IRIS)
It should be noted that the critical studies cited in IRIS that were used to generate the reference doses will need to be reviewed to obtain the appropriate data for developing an ERfD. IRIS can be accessed via the Internet (http://www.epa.gov/iris/index.html);

B) ECOTOX Database
The ECOTOXicology database is a source for locating single chemical toxicity data for aquatic life, terrestrial plants and wildlife. ECOTOX integrates three U.S. EPA, Office of Research and Development (ORD), National Health and Environmental Effects Research Laboratory (NHEERL), Mid- Continent Ecology Division, toxicology effects databases; AQUIRE (aquatic life), PHYTOTOX (terrestrial plants), and TERRETOX (terrestrial wildlife). This database can be accessed via the Internet (http://www.epa.gov/ecotox/);

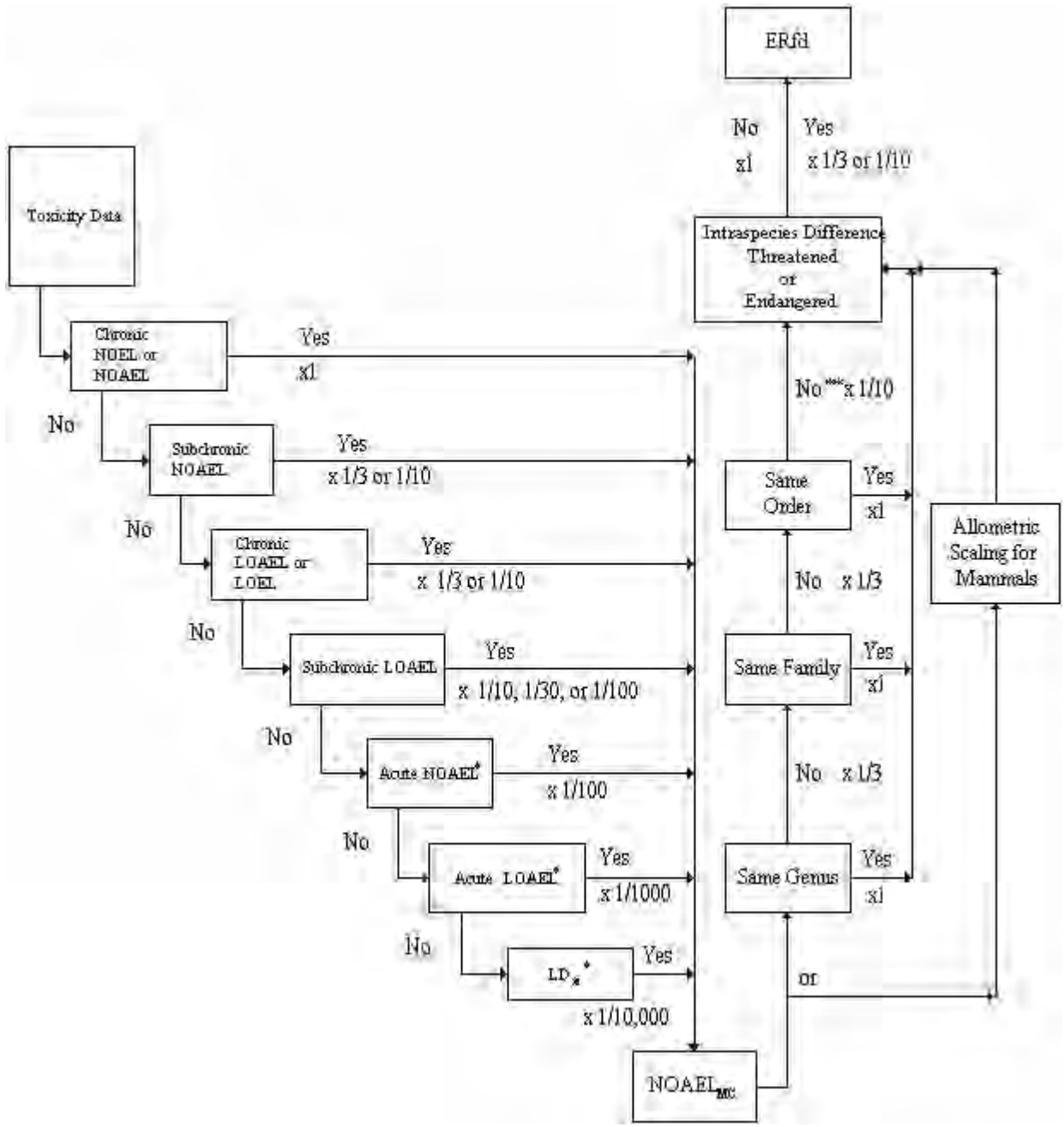
C) Agency for Toxic Substances and Disease Registry (ATSDR) Toxicity Profiles;

D) TOXLINE (National Library of Medicine);

E) Hazardous Substances Data Bank (National Library of Medicine); and,

F) Registry of Toxic Effects of Chemical Substances (RTECs).

Figure C-1, ERfD Derivation



*Acute NOAEL, Acute LOAEL, or LD_{50} data should only be used when necessary. It may be more appropriate to use a surrogate chemical when only toxicological data of this type is available. An agency toxicologist should be contacted before surrogates are selected or used in an ecological risk assessment.

** For toxicological test species and receptor species classified in the same taxonomic order, but found within the same class (*e.g.*, Mammalia, Aves). Taxonomically-based adjustments should not be performed between taxa in different classes.

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Attachment D
RECEPTOR LIFE HISTORY DATA

(1) Introduction

Attachment D presents life history information for specific species that are to be used in evaluating potential hazards to ecological receptors. In practice, ecological risk assessments generally evaluate and choose similar measurement endpoints for use in estimating risks to ecological receptors. These receptors are often chosen based on the availability of toxicity information, the abundance of the receptors, their role as potential food sources for predators, their limited home ranges, and their specific feeding habits. Ohio EPA DHWM has selected a list of "Generic Receptors" to be used in ecological risk assessments. The ERA process recommended by Ohio EPA DHWM lists specific criteria for selecting and using representative species in an ERA. The receptor criteria is given in Attachment A of the Level III ERA guidance.

Outside data sources (most notably the Wildlife Exposures Factor Handbook from U.S. EPA) have been coalesced to simplify and standardize the life history information for use in ecological risk assessments completed for Ohio EPA DHWM and are given in Table D-1. The species specific tables (section 2.0) following Table D-1 give the references for the cited information. A complete list of these references is found in section 2.

Table D-1. Generic Receptor Life History Information

				Dietary Composition (fraction by weight)			
Species/Feeding Habit	Body Weight (g)	Food Ingestion Rate (IR_F) ($g\ g_{bw}^{-1}d^{-1}$)	Water Intake ($g\ g_{bw}^{-1}d^{-1}$)	Plant (P_F)	Animal (A_F)	Incidental Soil (S_F)	Home Range (ha)
Plants							na
Earthworms							na
Herbivore							
Meadow vole	32.9	0.33	0.18	0.98	0	0.02	0.027
Deer mouse	21	0.27	0.22	0.5	0.46	0.02	0.059
Eastern cottontail	1220	0.2	0.097	0.94	0	0.063	3.1
White-tailed deer	56500	0.031	0.065	0.98	0	0.02	175
Muskrat	1174	0.3	0.98	1	0	0	0.13
Mallard duck	1162	0.063	0.057	0.98[1]	0	0.03[1]	435
Invertivore							
Short-tailed shrew	17	0.56	0.223	0.13[1]	0.87[1]	0.06[1]	0.39
American robin	81	1.2	0.14	0.5[1]	0.5[1]	0.05[1]	0.25
American woodcock	170	0.77	0.1	0	0.9	0.1	25
Spotted sandpiper	42.5	1.5	0.17	0	0.86	0.14	0.25
Carnivore							
Red-tailed hawk	1134	0.1	0.057	0	1	0	876
American kestrel	119	0.3	0.12	0	1	0	106
Red fox	4535	0.095	0.085	0.046[1]	0.95[1]	0.028[1]	504
Piscivore							
Mink	1020	0.16	0.079	0	1	0	470
Mink	1020	0.16	0.079	0	1	0	2.24[2]
Belted kingfisher	147	0.5	0.11	0	1	0	1.16[2]
Great blue heron	2336	0.18	0.045	0	1	0	0.6 3.1[2]

[1] Due to the data being from multiple sources the diets summations are greater than 100%.
[2] km of shoreline.
For citations, see tables below

(2) Species Specific Tables

Parameter	Definition	Receptor: **Meadow vole** (*Microtus pennsylvanicus*)	
		Value	**Reference / Notes**
BW	Body weight (g)	32.9	Arithmetic mean of means, adult, both sexes, all seasons (EPA 1993)
IR_F	Food ingestion rate (g g_{bw}^{-1} d^{-1})	0.33	EPA 1993
P_F	Plant fraction of diet	0.98	Arithmetic mean of all seasons, assumed to be vegetative p arts (EPA 1993), diet is assumed to be the vegetative portion of the plants
A_F	Animal fraction of diet	0	Assumed to be negligible
S_F	Soil fraction of diet	0.02	Beyer, Conner, and Gerould 1994
IR_w	Water ingestion rate (g g_{bw}^{-1} d^{-1})	0.18	Arithmetic mean of means, adult, both sexes, (EPA 1993)
HR	Home range (ha)	0.027	Arithmetic mean of means, adult both sexes (EPA 1993)
TUF	Temporal use factor	1	Assumed to be present year-round.

Parameter	Definition	Receptor: **Deer mouse** (*Peromyscus maniculatus)*	
		Value	**Reference / Notes**
BW	Body weight (g)	21	Arithmetic mean of means, adult, both sexes (EPA 1993)
IR_F	Food ingestion rate (g g_{bw}^{-1} d^{-1})	0.27	Arithmetic mean of means (EPA 1993)
P_F	Plant fraction of diet	0.5	Based on data from Wolff et al. 1985, Whitaker 1966, and Batz li 1977, die t i s considered to be the reproductive portions of the plants
A_F	Animal fraction of diet	0.46	Arthropods, based on data from Wolff et al. 1985, Whitaker 1966, and Batzli 1977
S_F	Soil fraction of diet	0.02	Beyer, Conner, and Gerould 1994
IR_w	Water ingestion rate (g g_{bw}^{-1} d^{-1})	0.22	Non-reproductive females, based on data from Oswald et al., 1994
HR	Home range (ha)	0.059	Mean of males and females, mixed deciduous forest, Wolff 1985
TUF	Temporal use factor	1	Assumed to be present year-round.

Parameter	Definition	Receptor: **Eastern cottontail** (*Sylvilagus floridanus*)	
		Value	**Reference / Notes**
BW	Body weight (g)	1220	Arithmetic mean of means,adult, both sexes, all seasons (EPA 1993)
IR_F	Food ingestion rate (g g_{bw}^{-1} d^{-1})	0.2	Dalke and Sime 1941
P_F	Plant fraction of diet	0.94	Exclusively herbivorous, assumed to be vegetative parts (EPA 1993)
A_F	Animal fraction of diet	0	Not stated in EPA (1993); assumed to be negligible
S_F	Soil fraction of diet	0.063	Assumed comparable to that for black-tailed jackrabbit (6.3%) (Arthur and Gates 1988)
IR_w	Water ingestion rate (g g_{bw}^{-1} d^{-1})	0.097	EPA 1993
HR	Home range (ha)	3.1	EPA 1993
TUF	Temporal use factor	1	Assumed to be present year-round

Parameter	Definition	Receptor: **White-tailed deer** (*Odocoileus virginianus*)	
		Value	**Reference / Notes**
BW	Body weight (g)	56500	Sample and Suter (1994)
IR_F	Food ingestion rate (g g_{bw}^{-1} d^{-1})	0.031	1.74 kg d^{-1} (Sample and Suter 1994) converted to g g_{bw}^{-1} d^{-1} by dividing by body weight of 56500 g
P_F	Plant fraction of diet	0.98	Exclusively herbivorous, assumed to be vegetative parts (Sample and Suter 1994)
A_F	Animal fraction of diet	0	Assumed to be negligible
S_F	Soil fraction of diet	0.02	Sample and Suter 1994
IR_w	Water ingestion rate (g g_{bw}^{-1} d^{-1})	0.065	3.7 L d-1 (Sample and Suter 1994) converted to g g_{bw}^{-1} d^{-1} by dividing by body weight of 56500 g
HR	Home range (ha)	175	Geometric mean of minimum (59) and maximum (520) reported in Sample and Suter 1994
TUF	Temporal use factor	1	Assumed to be present year-round

Parameter	Definition	Receptor: **Muskrat** (*Ondatra zibethicus*)	
		Value	**Reference / Notes**
BW	Body weight (g)	1174	Arithmetic mean of means,adult, both sexes, all seasons (EPA 1993)
IR_F	Food ingestion rate (g g_{bw}^{-1} d^{-1})	0.3	Arithmetic mean of means (EPA 1993)
P_F	Plant fraction of diet	1	Exclusively herbivorous, assumed to be vegetative parts (EPA 1993)
A_F	Animal fraction of diet	0	Assumed to be negligible
S_F	Soil fraction of diet	0	Assumed to be negligible
IR_w	Water ingestion rate (g g_{bw}^{-1} d^{-1})	0.98	Estimated (EPA 1993)
HR	Home range (ha)	0.13	Arithmetic mean of means (EPA 1993)
TUF	Temporal use factor	1	Assumed to be present year-round

Parameter	Definition	Receptor: **Mallard duck** (*Anas platyrhynchos*)	
		Value	**Reference / Notes**
BW	Body weight (g)	1162	Arithmetic mean of means, adult, both sexes, all seasons (EPA 1993)
IR_F	Food ingestion rate (g g_{bw}^{-1} d^{-1})	0.063	Estimated based on $F=0.648(bw)^{0.651}$, ingestion rate for birds, Opresko et al. (1994)
P_F	Plant fraction of diet	0.98	Assumed to be a 50% mixture of vegetation and fruit/seed
A_F	Animal fraction of diet	0	Assumed to be negligible
S_F	Soil fraction of diet	0.03	Beyer et al. 1994
IR_w	Water ingestion rate (g g_{bw}^{-1} d^{-1})	0.057	Estimated (EPA 1993)
HR	Home range (ha)	435	Arithmetic mean of means, adult, both sexes, spring (EPA 1993)
TUF	Temporal use factor	1	Assumed to be present year-round however site specific or other information may be used to estimate a site-specific TUF

Parameter	Definition	Receptor: **Short-tailed shrew** (*Blarina brevicauda*)	
		Value	**Reference / Notes**
BW	Body weight (g)	17	Arithmetic mean of means,adult, both sexes, summer and fall (EPA 1993)
IR_F	Food ingestion rate (g g_{bw}^{-1} d^{-1})	0.56	Arithmetic mean of adults, both sexes, 25^{0}C, Wisconsin (EPA 1993)
P_F	Plant fraction of diet	0.13	June through October, New York (EPA 1993); assuming vegetative parts and fungi
A_F	Animal fraction of diet	0.87	June through October, New York (EPA 1993); assuming 100% earthworms
S_F	Soil fraction of diet	0.06	EPA 1999
IR_w	Water ingestion rate (g g_{bw}^{-1} d^{-1})	0.223	Adult, both sexes, Illinois, lab (EPA 1993)
HR	Home range (ha)	0.39	EPA 1993
TUF	Temporal use factor	1	Assumed to be present year-round

Parameter	Definition	Receptor: **American robin** (*Turdus migratorius*)	
		Value	**Reference / Notes**
BW	Body weight (g)	81	Arithmetic mean of means, adult,both sexes, summer and fall (EPA 1993)
IR_F	Food ingestion rate (g g_{bw}^{-1} d^{-1})	1.2	Arithmetic mean of adults, both sexes, (EPA 1993)
P_F	Plant fraction of diet	0.5	Arithmetic mean, 4 seasons, central U.S., % of stomach contents that is animal material (EPA 1993); assumed to be plant fruit/seed
A_F	Animal fraction of diet	0.5	Arithmetic mean, 4 seasons, central U.S., % of stomach contents that is animal material (EPA 1993); assumed to be earthworm
S_F	Soil fraction of diet	0.05	Based on value for American woodcock (*Solopax minor*)(Beyer, Conner, and Gerould 1994) and adjusted for the proportion of earthworm in the robin diet
IR_w	Water ingestion rate (g g_{bw}^{-1} d^{-1})	0.14	Estimated, both sexes, adult (EPA 1993)
HR	Home range (ha)	0.25	Arithmetic mean of adults, both sexes, (EPA 1993)
TUF	Temporal use factor	1 0.58	Assumed to be present year-round however site specific or other information may be used to estimate a site-specific TUF, Migrate from northern breeding range in mid-October, return to northern breeding range in early-March (EPA 1993)

Parameter	Definition	Receptor: American woodcock (*Scolopax minor*)	
		Value	**Reference / Notes**
BW	Body weight (g)	170	Arithmetic mean of means,adult, both sexes, spring, summer and fall (EPA 1993)
IR_F	Food ingestion rate (g g_{bw}^{-1} d^{-1})	0.77	Mean, winter, captive study (EPA 1993)
P_F	Plant fraction of diet	0	Assumed to be negligible
A_F	Animal fraction of diet	0.9	EPA 1993
S_F	Soil fraction of diet	0.1	Beyer et al. 1994
IR_w	Water ingestion rate (g g_{bw}^{-1} d^{-1})	0.1	Estimated (EPA 1993)
HR	Home range (ha)	25	Arithmetic mean of means, adult, spring, and summer (EPA 1993)
TUF	Temporal use factor	1 0.58	Assumed to be present year-round however, site specific or otherinformation may be used to estimate a site-specific TUF. Mgrate from northern breeding range in November, return to northern b reeding range in late March (Sheldon 1971)

Parameter	Definition	Receptor: Spotted sandpiper (*Actitis macularia*)	
		Value	**Reference / Notes**
BW	Body weight (g)	42.5	Arithmetic mean of means, adult, both sexes (EPA 1993)
IR_F	Food ingestion rate (g g_{bw}^{-1} d^{-1})	1.5	Estimated using equation 3-3 (EPA 1993)
P_F	Plant fraction of diet	0	Not stated in EPA (1993); assumed to be negligible
A_F	Animal fraction of diet	0.86	Aquatic invertebrates (EPA 1993)
S_F	Soil fraction of diet	0.14	EPA (1993)
IR_w	Water ingestion rate (g g_{bw}^{-1} d^{-1})	0.17	Arithmetic mean of means, adult, both sexes (EPA 1993)
HR	Home range (ha)	0.25	(EPA 1993)
TUF	Temporal use factor	1	Assumed to be present year-round however, site specific or other information may be used to estimate a site-specific TUF

Parameter	Definition	Receptor: **Red-tailed hawk** (*Buteo jamaicensis*)	
		Value	**Reference / Notes**
BW	Body weight (g)	1134	Arithmetic mean of means, adult, both sexes (EPA 1993)
IR_F	Food ingestion rate (g g_{bw}^{-1} d^{-1})	0.1	Arithmetic mean of means, adult, both sexes, captive, outdoors (EPA 1993)
P_F	Plant fraction of diet	0	Not stated in EPA (1 993); assumed to be negligible
A_F	Animal fraction of diet	1	Prey brought to nests (EPA 1993)
S_F	Soil fraction of diet	0	Not stated in EPA (1993) and Beyer et al. (1994); assumed to be negligible
IR_w	Water ingestion rate (g g_{bw}^{-1} d^{-1})	0.057	Estimated (EPA 1993)
HR	Home range (ha)	876	Mean, adults, both sexes (EPA 1993)
TUF	Temporal use factor	1	Assumed to be present year-round however, site specific or other information may be used to estimate a site-specific TUF

Parameter	Definition	Receptor: **American kestrel** (*Falco sparverius*)	
		Value	**Reference / Notes**
BW	Body weight (g)	119	Arithmetic mean of means, adult, both sexes (EPA 1993)
IR_F	Food ingestion rate (g g_{bw}^{-1} d^{-1})	0.3	Arithmetic mean of means adult, both sexes (EPA 1993)
P_F	Plant fraction of diet	0	Assumed to be negligible
A_F	Animal fraction of diet	1	EPA 1993
S_F	Soil fraction of diet	0	Assumed to be negligible
IR_w	Water ingestion rate (g g_{bw}^{-1} d^{-1})	0.12	Estimated, both sexes, adult (EPA 1993)
HR	Home range (ha)	106	Arithmetic mean of means, adult, both sexes (EPA 1993)
TUF	Temporal use factor	1	Assumed to be present year-round however, site specific or other information may be used to estimate a site-specific TUF

Parameter	Definition	Receptor: **Red fox** (*Vulpes vulpes*)	
		Value	**Reference / Notes**
BW	Body weight (g)	4535	Arithmetic mean of means, adult, both sexes (EPA 1993)
IR_F	Food ingestion rate (g g_{bw}^{-1} d^{-1})	0.095	Adult non-breeding, North Dakota (EPA 1993)
P_F	Plant fraction of diet	0.046	Illinois farm/woods, spring, percent wet weight (EPA 1993); assumed to be reproductive parts
A_F	Animal fraction of diet	0.95	Illinois farm/woods, spring, percent wet weight (EPA 1993); assumed to be reproductive parts
S_F	Soil fraction of diet	0.028	Estimated percent soil in diet, dry weight (EPA 1993)
IR_w	Water ingestion rate (g g_{bw}^{-1} d^{-1})	0.085	Arithmetic mean, adult, both sexes (EPA 1993)
HR	Home range (ha)	504	Arithmetic mean, adult, both sexes, Minnesota and Wisconsin (EPA 1993)
TUF	Temporal use factor	1	Assumed to be present year-round however, site specific or other information may be used to estimate a site-specific TUF

Parameter	Definition	Receptor: **Great blue heron** (*Ardea herodias*)	
		Value	**Reference / Notes**
BW	Body weight (g)	2336	Arithmetic mean of means, adult, both sexes (EPA 1993)
IR_F	Food ingestion rate (g g_{bw}^{-1} d^{-1})	0.18	Mean, adult, both sexes (EPA 1993)
P_F	Plant fraction of diet	0	Assumed to be negligible
A_F	Animal fraction of diet	1	Assumed to be fish, may also include site specific prey items (EPA 1993)
S_F	Soil fraction of diet	0	Assumed to be negligible
IR_w	Water ingestion rate (g g_{bw}^{-1} d^{-1})	0.045	Estimated (EPA 1993)
HR	Home range (ha)	0.6 3.1(km)	Size of feeding area only (EPA 1993) or, forage area (length of shoreline, km)
TUF	Temporal use factor	1	Assumed to be present year-round however, site specific or other information may be used to estimate a site-specific TUF

Parameter	Definition	Receptor: **Mink** (*Mustela vison*)	
		Value	**Reference / Notes**
BW	Body weight (g)	1020	Arithmetic mean of means,adult, both sexes, Montana (EPA 1993)
IR_F	Food ingestion rate (g g_{bw}^{-1} d^{-1})	0.16	Arithmetic mean of means, adult, both sexes (EPA 1993)
P_F	Plant fraction of diet	0	Assumed to be negligible
A_F	Animal fraction of diet	1	Assumed to be fish, may also include site specific prey items (EPA 1993)
S_F	Soil fraction of diet	0	Assumed to be negligible
IR_w	Water ingestion rate (g g_{bw}^{-1} d^{-1})	0.079	Arithmetic mean of means, adult, both sexes (EPA 1993)
HR	Home range (ha)	470	Arithmetic mean of means, adult, both sexes (EPA 1993)
HR	Home range (km)	2.24	km of stream, mean of means, adult, both sexes (EPA 1993)
TUF	Temporal use factor	1	Assumed to be present year-round however, site specific or otherinformation maybe used to estimate a site-specific TUF

Parameter	Definition	Receptor: **Belted kingfisher** (*Ceryle alcyon*)	
		Value	**Reference / Notes**
BW	Body weight (g)	147	Arithmetic mean of means, adult, both sexes (EPA 1993)
IR_F	Food ingestion rate (g g_{bw}^{-1} d^{-1})	0.5	Mean, adult, both sexes Michigan (EPA 1993)
P_F	Plant fraction of diet	0	Assumed to be negligible
A_F	Animal fraction of diet	1	Assumed to be fish, may also include site specific prey items (EPA 1993)
S_F	Soil fraction of diet	0	Assumed to be negligible
IR_w	Water ingestion rate (g g_{bw}^{-1} d^{-1})	0.11	Estimated (EPA 1993)
HR	Home range (km shoreline)	1.16	Arithmetic mean of means, adult, both sexes (EPA 1993)
TUF	Temporal use factor	1	Assumed to be present year-round however, site specific or otherinformation maybe used to estimate a site-specific TUF

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Attachment E
Level III Report - Outline

(1) Introduction

(a) Site History
(b) Regulatory Status
(c) Summary of previous ecological evaluations (*e.g.*, summaries of the Level I and II reports)

(2) Results

The information in the results section should be adequate to reproduce pertinent calculations.

(a) Exposure assessment
(b) Toxicity assessment
(c) Risk characterization
(d) Uncertainty analysis

(3) Recommendations

The recommendations section should discuss the results of all ecological evaluations that have been conducted at the site. The focus of the discussion should be on the results of the Level III ERA. The information should be used to select one of the following three options: 1) No further action at the site due to no adverse ecological effects being estimated or identified as the result of the completion of the Level III and previous ERAs; 2) Continued ecological evaluation in a Level IV-Field baseline ecological risk assessment; or, 3) Risk management/remedy selection.

(4) Attachments

Attachments should include tables that list toxicity values and references, in-put parameters for all up-take calculations, chemical concentrations in all media that were evaluated in the Level III ERA, and any other information needed to reproduce the risk calculations.

CHAPTER 5
LEVEL IV - FIELD BASELINE

5.1 OBJECTIVE

The objective of a Level IV field baseline assessment is to quantify, based on field observation, adverse effects to populations of representative species that have been shown to be potentially impacted based upon the hazard calculation(s) developed in a Level III ecological risk assessment (ERA). The information derived by use of a Level IV assessment is to be used as additional lines of evidence to support a more robust weight-of-evidence conclusion regarding the potential adverse effects identified and quantified in the Level III risk assessment.

5.2 PREREQUISITES

The completion of a Level III ERA and a decision to continue the ecological evaluation using biological and other field-based measurements are the prerequisites for beginning a Level IV ERA. Prior to proceeding with a Level IV ERA, it must be cautioned that designing an acceptable field study to determine whether or not impacts are observed in field conditions is often difficult. The Level IV risk assessment differs from the previous ecological investigations in the amount of oversight that is required by the Ohio EPA. Due to the site-specific nature and technical expertise required for a field baseline risk assessment, approval of the sampling and analysis plan is required by the Ohio EPA DHWM prior to any field work.

The following is a list of tasks required for the completion of a Level IV field baseline ecological risk assessment:

5.3 TASKS

The following tasks are to be completed as part of a Level IV ERA:

5.3.1 Task 1 Refine Problem Formulation

Following the assessment process described in the Level III guidance, there should now be a limited number of ecological contaminants of concern (ECOCs) under consideration. Once again, the relationship between specific ECOCs, their toxicological characteristics, their likely pathway to specific ecological receptors, and the effect(s) they may induce in these receptors should be re-examined. This re-examination should substantially lessen the chance of engaging in field and/or laboratory investigations that do not provide information useful to risk managers.

The Problem Formulation should consist of:

A) Select ECOCs
The results of the Level III ERA will have identified ECOCs on the basis of risk characterization. Because the Level IV evaluation is focused on population studies and/or laboratory studies that use contaminated media taken from the actual site, the ECOCs will be assessed as a mixture in any given evaluation. The Level III ERA will have identified the ecological stressors most likely to be adversely impacting biological communities. These ECOCs should be discussed as the primary risk drivers in the Level IV ERA.

B) Review/Revise Established Measures
For a Level IV ERA, measures are expected to be numerical expressions of observations (*e.g.*, toxicity results, community diversity measures, tissue analysis, etc.) that are to be compared to reference locations or other controls to detect adverse responses in endpoint species resulting from exposure to site-related ECOCs. The first output of this comparison is the determination of whether adverse responses are occurring at site-related ECOC concentrations. For sites where adverse responses are identified, the second output may be the identification of the concentration level(s) where site-related ECOC's may be causing the adverse responses. The use of a concentration gradient is recommended to make determinations of the range of adverse effects and to aid in the selection of final remedial levels.

When defining measures for field and laboratory investigations, select those with as

strong of an association as possible between site-related ECOCs and responses in the selected measures and those that represent the same exposure pathway and toxic mechanism of action as the assessment endpoint with which they are associated. Development of empirical exposure-response relationships is important for evaluating remedial options, so selection of measures that incorporate a ECOC concentration gradient should be a goal whenever possible.

5.3.2 Task 2 Select Assessment Tools

Presently, there are a limited number of assessment tools for conducting site-specific field evaluations on adverse ecological effects induced by ecological stressors. The chosen methods will depend on site-specific factors and the risk hypotheses and measures chosen for the assessment. The basic categories of field-based ecological measures that should be evaluated for use in a Level IV field-baseline assessment are given below:

A) Tissue Analysis/Bioaccumulation Studies
Contaminant concentrations in tissues may have been quantified and used during the Level III ERA. It is important to mention that generally, hazard quotient calculations will not be repeated in the Level IV ERA. As discussed in Level III, HQ calculations are to be conducted one time only, using realistic and site-specific information, that may include empirically derived contaminant tissue concentrations for use in the exposure assessment. It has been demonstrated that reiterations of hazard calculations are not particularly useful. For example, if an initial hazard calculation exceeds the limit of unity by more than two orders of magnitude, then, rarely will additional recalculations result in hazard quotient values being reduced to below unity. Information gained through tissue analysis conducted following the Level III ERA, may be used for the development of site-specific remedial goals and will help determine the bioavailability of a ECOC.

Tissue analysis that may be useful in determining whether field impacts can be demonstrated in the field include:

(i) Chemical analysis of tissues (specific organs, tissues, whole body);
(ii) Laboratory bioaccumulation studies (uptake measured in a laboratory setting using contaminated media from the site);
(iii) Field measured bioaccumulation studies (receptor, animal or surrogate, placed on-site in proximity to contaminated media);
(iv) Gross morphology and/or histopathology;
(v) Biomarkers;
(vi) Results obtained with one or more of the above may be used to support the following analysis (to be used primarily for remedial goals determination, and not for generating additional hazard quotient values):

- Evaluating the degree to which ECOCs are transferred through the food chain;
- Measuring ECOC concentrations in foods consumed by endpoint species associated with an assessment endpoint; and,
- Providing site-specific estimates of exposure to higher trophic level organisms, that may include bioconcentration and/or bioaccumulation factors.

B) Population/Community Evaluations and Toxicity Tests
The populations to be evaluated or the appropriate toxicity test should be chosen based upon the results of the Level III ERA and discussions with the appropriate Ohio EPA DHWM personnel. The most relevant population studies or *in situ* toxicity studies should be chosen. Generally, the lowest trophic levels that have been identified with elevated hazard quotient values are to be investigated during a field baseline ERA. These include soil microbial studies, soil invertebrate assays, plant community analysis and, occasionally, small mammal investigations.

The following methods are useful for measuring and quantifying adverse ecological effects and responses to contaminants:

(i) Community metrics (measurements of species composition, abundance, community structure, trophic dynamics, seasonal patterns, age classes, etc.);
(ii) Population metrics (measurements of density patterns, growth, and survival, etc.) -study site vs. reference area differences related to the presence of ECOCs;
(iii) Physiological and behavioral measurements - respiration, photosynthesis, reproduction, predation, courtship, etc.; and,
(iv) Field experiments.

C) Toxicity Tests (Bioassay)
Toxicity tests are useful for measuring and quantifying both exposure and ecological responses to contaminants. These tests may be conducted in the laboratory, field, and *in situ*. They are appropriate measures for both lethal and/or sub-lethal responses and may be used to:

(i) Demonstrate and/or quantify the bioavailability of ECOCs;
(ii) Evaluate the aggregate toxic effects of all contaminants in a medium;
(iii) Evaluate the toxicity of substances whose biological effects may have not been well characterized;
(iv) Compare toxicity data generated at the site with that obtained in the laboratory or literature;
(v) Characterize the nature of a toxic effect;
(vi) Characterize the distribution of toxicity at a site;
(vii) Support a monitoring program;
(viii) Develop remedial goals; and,
(ix) Determine the post-remediation potential of the site to support viable communities.

5.3.3 Task 3 Prepare Field Ecological Sampling and Analysis Plan

The Level IV field ecological sampling and analysis plan (FESAP) describes details of the site-specific field and/or laboratory investigation(s). It addresses the field and/or laboratory collection and analysis of ecological data. The data collection and analysis must be consistent with, and achievable within, the scope of the analysis plan prepared for the Level IV ERA, as well as the overall remedial investigation work plan. The FESAP may also include the methods for determining site-specific remedial concentrations. Because field and/or laboratory investigations can be expensive, time-consuming, and result in ambiguous results, it is important to consider the types of studies that will provide the most expeditious and defensible (*i.e.,* supported by scientific literature, peer review, and statistical evaluations) tests of the stated risk hypotheses. The plan may include, but is not limited to:

A) A description of the study design, including its key assumptions and uncertainties. The design is guided by the conceptual site model and results of the Level III ERA. The study design should also take into account any new information that has been obtained regarding the site, receptors, or ECOCs.

B) A statement of data needs. These data needs are to be specific for testing the risk hypotheses (Is there, or, is there no appreciable harm to the selected ecological receptors?) and, if harm is demonstrated, to assist in the selection of a remedy. Basically, the discussion should focus on how each piece of data planned for collection will be used to answer the question of whether or not adverse impacts to pertinent ecological receptors or populations exists or can be quantified. The discussion may also include how site-specific remedial clean-up values will be generated if needed.

C) A detailed description of the assessment tools (see task (2) above) that will yield data of the type and qualty required for the Level IV ERA.

D) A statement of data quality objectives (DQOs) for all key components of the field and/or laboratory investigations, considering that DQOs should be used in conjunction with, not as a substitute for, a scientifically defensible experimental design.

The FESAP must be approved prior to initiating field and/or laboratory investigations. The approval of the FESAP will be given by the appropriate Ohio EPA DHWM personnel that is overseeing the site. If some time has elapsed since site surveys/visits were conducted, an additional site visit may be required to verify that the study design specified in the FESAP is still possible to implement, (*i.e.*, whether sampling and testing specified by the FESAP can actually be collected at the site). It may be necessary to modify the FESAP in response to changes in site conditions before approval to proceed with field or laboratory investigations.

5.3.4 Task 4 Conduct Field/laboratory Work

The site investigation involves implementation of the agreed upon FESAP and includes all of the field sampling and surveys that are conducted as part of the Level IV ERA.

5.3.5 Task 5 Perform Risk Characterization

Risk characterization is designed to evaluate the likelihood of an adverse effect in an endpoint species (associated with an assessment endpoint) from exposure to a site-related ECOCs. The risk characterization discusses the results and interpretation of the Level IV field evaluations. The risk characterization is also to be used to develop a comprehensive evaluation of the hazards being expressed at the site as the result of site-related ECOCs. This discussion should use information from the Level IV effort and the information obtained in the previous risk assessment efforts and is used to develop a weight-of-evidence approach to discuss the risk characterization. The lines of evidence that may be available in Level IV to construct a weight-of-evidence risk characterization include, but are not limited to:

A) Observations of adverse effects in potentially exposed habitats compared to reference sites, including mortality and morbidity, vegetation stress, habitat degradation, and, presence or absence of key species;

B) Presence of endangered species or sensitive habitat;

C) ECOC concentrations in surface water, soil, sediment, or tissues that exceed doses observed or estimated to cause chronic toxicity. This information is the part of the results of the Level III ERA including the appropriate HQ and HI values;

D) Detection of acute or chronic toxicity in surface waters, soil or sediment;

E) Tissue and/or bioaccumulation analysis provide evidence of ECOC availability in animals and plants;

F) Biomarkers which suggest that receptors have been exposed to ECOCs;

G) Observed changes in rates of physiological and/or behavioral processes (*e.g.*, respiration, photosynthesis, burrowing, or predation);and,

H) Observations from ecological field studies of communities or populations.

5.3.6 Task 6 Perform Uncertainty Analysis

Uncertainty analysis involves summarizing assumptions made in the Level IV assessment, evaluating their validity and sensitivity, identifying the strengths and weaknesses of the analyses (laboratory and field), and quantifying, to the extent possible, the uncertainty associated with each component of the Level IV assessment.

5.3.7 Task 7 Submit Level IV Deliverable

This deliverable is a document which will describe how the various field measurements were conducted, the results of all laboratory analyses, the assumptions employed by these analysis, the result of the weight-of evidence discussions, and a thorough evaluation of the uncertainties inherent in the Level IV risk assessment. The results presented in the Level IV report will provide a factual basis for the determination of whether a remedial activity is required. The results may also be used to quantify the remedial goals based on site-specific parameters, receptors, and conditions.

Attachment A
Useful References

General References:
Listed below are references that discuss or provide guidance on several topics that could be incorporated into a Level IV ERA. These references are not complete.

1) U.S. EPA. 1997. *Superfund Program Representative Sampling Guidance, Volume 3: Biological- DRAFT.* Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington DC. *In* US EPA. 1997. *Ecological Risk Assessment Guidance for Superfund: Process for Designing and Conducting Ecological Risk Assessments.* EPA/540/R-97/006. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington DC.
This reference includes information regarding:
– Standard field studies for ecological assessment (population/community response studies, toxicity tests).
– Collection methods.
– Quality assurance/ Quality control.

2) U.S. EPA. 1994. *Catalogue of Standard Toxicity Tests for Ecological Risk Assessment.* EPA/540/F-94/013. ECO Update, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington DC.
This reference includes information regarding:
- Aquatic, sediment, terrestrial and microbial toxicity test methods.

3) U.S. EPA. 1994. *Field Studies for Ecological Risk Assessment.* EPA/540/F-94/014. ECO Update, Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington DC.
This reference includes information regarding:
- Organism selection for field studies.
- Ecological field study design.
- Field study sampling and collection methods.

4) U.S. EPA. 1992. *Evaluation of Terrestrial Indicators for Use in Ecological Assessment at Hazardous Waste Sites.* EPA/600/R92/183. Office of Research and Development, U.S. Environmental Protection Agency, Washington DC.
This reference includes information regarding:
– Animal test methods for the assessment of soil contamination at hazardous waste sites.
– Plant test methods for the assessment of soil contamination at hazardous waste sites.
– Soil biota test methods for the assessment of soil contamination at hazardous waste sites.
– Field methods for the assessment of soil contamination at hazardous waste sites.

5) U.S. EPA. 1991. *Compendium of ERT Toxicity Testing Procedures.* EPA/540/P-91/009. Office of Solid Waste and Emergency Response, U.S. Environmental Protection Agency, Washington D.C.
This reference includes information regarding:
- Standard Operating Procedures for the ecological sampling methods of genera *Pimephales, Daphnia, Ceriodaphnia,* and *Selenastrum*.

6) U.S. EPA. 1989. *Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference.* EPA/600/3-89/013. Office of Research and Development, U.S. Environmental Protection Agency, Washington DC.
This reference includes information regarding:
– Field assessment methods for vegetation, terrestrial invertebrate and terrestrial vertebrate.
– Aquatic, terrestrial and microbial toxicity tests.
– Biomarkers.
– Sampling design.

7) Chapman, P.M., 1995, Extrapolating toxicity results to the field, Environ. Toxicol. Chem. 14:927-930.

Vegetation Measurement References:

1) ASTM (American Society of Testing and Materials), 1998, E-1598-94 Standard practice for conducting early seedling growth tests, 1998 Annual Book of ASTM Standards, Volume 11.05, ASTM, West Conshohocken, PA, pp. 994-1000.

2) Daubenmire, R.F., 1959, Canopy coverage method of vegetation analysis, Northwest Scientist, 33:43-64.

3) Diersing, V.E., R.B. Shaw, and D.J. Tazik, 1992, US Army Land Condition-Trend Analysis (LCTA) program, Environ. Mgmt. 16:405-414.

4) EPA, 1986, SW-846 Test Methods for Evaluating Solid Wastes Third Edition, U.S. Environmental Protection Agency, OSWER, Washington, DC.

5) Giovanetti, M. and B. Mosse, 1980, An evaluation technique for measuring vesicular-arbuscular mycorrhizal infection in roots, New Phytol. 84:489-500.

6) Hair, J.D., 1980, Measurement of Ecological Diversity, In: S.D. Schemnitz (Ed.), Wildlife Management Techniques Manual, 4th edition, The Wildlife Society, Washington, DC. pp. 269-276.

7) Kapustka, L.A., 1989, Vegetation Assessment, In: W. Warren-Hicks, B.R. Parkhurst, and S.S. Baker, Jr. (Eds.), Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference, EPA/600/3-89/013. U.S. Environmental Protection Agency, Environmental Research Laboratory, Corvallis, OR.

Microbiological Measurement References:

1) Parmelle, R.W., R.S. Wentsel, C.T. Phillips, M. Simini, and R.T. Checkai, 1993, Soil microcosm for testing the effects of chemical pollutants on soil fauna communities and trophic structure, Environ Toxicol Chem 12:1477-1486.

2) Giller, K.E., E. Witter, and S.P. McGrath, 1998, Toxicity of heavy metals to microorganisms and microbial processes in agricultural soils: a review, Soil Biol. Biochem 30:1389-1414.

3) Domsch, K.H. G.A. Jagnow, and T.H. Anderson, 1983, An ecological concept for assessment side-effects of agrochemicals on soil microorganisms, Residue Rev. 86:65-105.

4) Sunahara, G.I., S. Dodard, S. Sarrazin, M. Paquet, G. Ampleman, S. Thiboutot, J. Hawari, and A.Y. Renoux, 1998, Development of a soil extraction procedure for ecotoxicity characterization of energetic compounds, Ecotoxicol. Environ. Saf. 39:185-194.

5) Babich, H, and G. Stotzky, 1980, Environmental factors that influence the toxicity of heavy metals and gaseous pollutants to microorganisms, CRC Critical Rev Microbiol 8:99-145.

6) Van Beelen, P. and P. Doelman, 1997, Significance and application of microbiological toxicity tests in assessing ecotoxicological risks of contaminants in soil and sediment, Chemosphere, vol. 34 no. 3 455-499.

Soil Invertebrate Measurement References:

1) US EPA. 1992. *Guide to Site and Soil Description for Hazardous Waste Site Characterization, Volume 1: Metals.* EPA/600/4-91/029. Office of Research and Development, U.S. Environmental Protection Agency, Washington D.C.
This reference includes information about:
- Characterization of metal contamination by soil mesofauna and macrofauna density.
- Characterization of metal contamination by soil microbiota density.

2) Southwood, T.R.E., 1978, *Ecological Methods: With Particular Reference to the Study of Insect Populations,* Second Edition, John Wiley and Sons, New York, NY.
A reference in the ECO Update for field studies, this book provides detailed capture methods and statistical analyses for invertebrate sampling.

3) Bromenshenk, J.J., 1989, Terrestrial Invertebrate Sampling, *In* W. Warren-Hicks, B.R. Parkhurst, and S.S. Baker, Jr. (Eds.), Ecological Assessment of Hazardous Waste Sites: A Field and Laboratory Reference, EPA/600/3-89/013. U.S. Environmental Protection Agency, Environmental Research Laboratory, Corvallis, OR.

4) Schauff, M.E. (ed.) "Collecting and preserving insects and mites: Techniques and tools." Systematic Entomology Laboratory, U.S. Department of Agriculture, Washington D.C. (Available online at: http://www.ars.usda.gov/SP2UserFiles/ad_hoc/12754100CollectingandPreservingInsectsandMites/collpres.pdf.)

5) Luff M.L., 1975, Some features influencing the efficiency of pitfall traps, *Oecologia.* **19:** 345-357.

6) Greenslade, P.J.M., 1964, Pitfall trapping as a method for studying populations of Carabidae (Coleoptera), *Journal of Animal Ecology.* **33:** 301-310.

7) Handbook of Soil Invertebrate Toxicity Test, eds., H. Lokke and C.A.M. Van Gestel,1998, John Wiley and Sons.

8) Edwards, C.A., and J. Bohlen, 1992, The effects of toxic chemicals on earthworms, Reviews of Environmental Contamination and Toxicology. Vol.125,pp. 23-99.

9) Beyer, W.N., R.L. Chaney, and B.M. Mulhern, 1982, Heavy metal concentrations in earthworms from soil amended with sewage sludge, Journal of Environmental Quality 11:381-385.

Small Mammal Measurement References:

1) Day, G.I., S.D. Schemnitz, and R.D. Taber, 1980, Capturing and Marking Wild Animals, In: S.D. Schemnitz (Ed.), Wildlife Management Techniques Manual, 4th edition, The Wildlife Society, Washington, D.C. pp. 61-88.

2) Davis, D.E. and R.L. Winstead, 1980, Estimating the Numbers of Wildlife Populations, In: S.D. Schemnitz (Ed.), Wildlife Management Techniques Manual, 4th edition, The Wildlife Society, Washington, D.C. pp. 221-246.

3) Drowning, R.L. 1980, Vital Statistics of Animal Population, In: S.D. Schemnitz (Ed.), Wildlife Management Techniques Manual, 4th edition, The Wildlife Society, Washington, D.C. pp. 247-268.

Sediment and Wetland soil Bioassay/Measurement References:

In general, no population measurements of lotic aquatic environments should be taken in a Level IV ERA. Lotic environments will have already been assessed using population measurements as described by the biological criteria in Level II and III. Population evaluations of other aquatic environments are possible. However, standard measurements for these environments are not presently available. Therefore, methods designed for lotic environments must be adapted for use in lentic and wetland environments as well as wetland evaluation techniques that are under development. Any evaluation of wetlands is to be done in coordination with Ohio EPA personnel. Below is a list of references that may be useful in evaluating wetlands and other aquatic environments:

1) Biological Criteria for the Protection of Aquatic Life: Volume I: The Role of Biological Data in Water Quality Assessment, 24 July 1987 (updated 15 February 1988), Ohio Environmental Protection Agency.

2) Biological Criteria for the Protection of Aquatic Life: Volume II: Users Manual for Biological Field Assessment of Ohio Surface Waters, 30 October 1987 (Updated 1 January 1988), Ohio Environmental Protection Agency.

3) Addendum to: Biological Criteria for the Protection of Aquatic Life: Volume II: Users Manual for Biological Field Assessment of Ohio Surface Waters, 30 October 1987 (Updated 1 January 1988), Ohio Environmental Protection Agency.

4) Biological Criteria for the Protection of Aquatic Life: Volume III: Standardized Biological Field Sampling and Laboratory Methods for Assessing Fish and Macroinvertebrate Communities, First Update September 30, 1989, Ohio Environmental Protection Agency.

5) The Quality Habitat Evaluation Index [QHEI]: Rationale, Methods, and Application, 6 November 1989, Ohio Environmental Protection Agency.

6) Yoder, C.O. and E.T Rankin, 1995, Biological criteria program development and implementation in Ohio, pp. 109-144 (Chapter 9), *in* W.S. Davis and T. Simon (eds), *Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making*, Lewis Publishers, Boca Raton, FL.

7) Rankin, E.T., Habitat indices in water resource quality assessments, pp. 181-208 (Chapter 13), *in* W.S. Davis and T. Simon (eds), *Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making*, Lewis Publishers, Boca Raton, FL.

8) DeShon, J.E., 1995, Development and application of the Invertebrate Community Index (ICI), pp. 217-243 (Chapter 15), *in* W.S. Davis and T. Simon (eds), *Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making*, Lewis Publishers, Boca Raton, FL.

9) Yoder, C.O. and ET Rankin, 1995, Biological response signatures and the area of degradation value: new tools for interpreting multimetric data, pp. 263-286, (Chapter 17), *in* W.S. Davis and T. Simon (eds), *Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making*, Lewis Publishers, Boca Raton, FL.

10) Yoder, C.O., 1995, Policy issues and management applications of biological criteria, pp. 327-343 (Chapter 21), *in* W.S. Davis and T. Simon (eds), *Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making*, Lewis Publishers, Boca Raton, FL.

11) The Role of Biological Criteria in Water Quality Monitoring, Assessment, and Regulation, Ohio EPA Technical Report Series, 23 February 1995, Division of Surface Water, Ohio Environmental Protection Agency.

12) Rankin, E.T. and C.O. Yoder, The nature and sampling variability in the Index of Biotic Integrity (IBI) in Ohio streams, Division of Surface Water, Ohio Environmental Protection Agency.

13) Yoder, C.O., 1989, The development and use of biological criteria for Ohio surface waters, Water Quality Standards for the 21st Century, 139-145.

14) Yoder, C.O., 1989, Answering some concerns about biological criteria based on experiences in Ohio, Water Quality Standards for the 21st Century, 95-104.

15) Yoder, C.O., The integrated biosurvey as a tool for evaluation of aquatic life use attainment and impairment in Ohio surface waters, Division of Surface Water, Ohio Environmental Protection Agency.

16) Yoder, C.O. and E.T. Rankin, 1996, Assessing the condition and status of aquatic life designated uses in urban and suburban watersheds, pp. 201-227, in Roesneer, L.A., (ed), *Effects of Watershed Development and Management in Aquatic Ecosystems*, American Society of Civil Engineers, New York.

17) Boyle, T.P., G.M Smillie, J.C. Anderson and D.R. Beeson, 1990, A sensitivity analysis of nine diversity and seven similarity indices, Research Journal WPCF, vol. 62, number 6, 749-762.

18) Ohio EPA *Hyalella azteca* Solid Phase Sediment Toxicity Testing Procedure, Division of Environmental Services, May 1998.

19) Standard Operating Procedures for *Lumbriculus variegatus* 4-day Sediment Toxicity Screening Test, Bioassay Section, Division of Environmental Services, Ohio EPA.

20) Methods for Measuring the Toxicity and Bioaccumulation of Sediment-associated Contaminants with Freshwater Invertebrates, U.S. EPA, EPA/600/H-94/024, Office of Research and Development, Washington D.C. 20460.

21) Brinson, M.M., and R. Rheinhardt, 1996, The role of reference wetlands in functional assessment and mitigation, Ecological Applications, 6(1) 69-76.

22) Ohio Rapid Assessment Method (ORAM) for Wetlands, version 5.0, User's manual and Scoring Forms. 2001. Ohio EPA Technical Report Wet/2001-1. Division of Surface Water. http://www.epa.ohio.gov/dsw/wetlands/WetlandEcologySection.aspx#ORAM

Statistical Considerations and References:

General Statistical Information;
The purpose of the statistics used in a Level IV ERA is to determine whether ECOCs are negatively impacting populations of organisms. This is done by use of toxicity bioassays, comparing field measurements in reference areas to those in contaminated areas and identifying statistically significant differences, or other methods. A statistical test is the mathematical evaluation of the probability that a hypothesis is false. It is not the intent of this guidance to reproduce and/or reiterate the statistical work cited in the references below. It is the intent of this guidance to specify some general parameters and methodologies to ensure that biological measurements be taken in such a way to be scientifically defensible and be of such quality that meaningful risk management decisions can be made using the results of a Level IV evaluation. The following information should be used in discussions between the Ohio EPA and other stakeholders of the site under evaluation for developing a Level IV ERA:

1) Hypothesis Formulation:
Generally, the hypothesis should be written so that H_0 = Site attribute is not greater than reference area, or alternatively stated: the Site attribute is not different than the reference area. By stating the hypothesis

in this format, a Type I error would indicate that the site area is impacted or adversely effected by the ECOCs when in fact no effects are occurring.

2) Alpha Level:
Alpha level (a) is the probability that the test would indicate that the populations were different (impacted) when in reality they were not different (not impacted). This is equal to the Type I error rate. This value should be specified in the field sampling plan and approved before field measurements are taken. This will help in the estimation of the number of required samples to achieve the appropriate power level in the statistical analysis of the Level IV population measurements. The alpha level can vary, however, levels from 5% to 20 % are recommended. It should be noted that by increasing the alpha level, the number of required samples is reduced. However, the likely-hood or chance of calling a clean site dirty (Type I error) increases as the alpha level increases.

3) Power:
The power of the test is the probability that a difference between the reference populations and the on-site populations would be detected by the test if in reality there was a difference. Power is equal to 1-b where

b is the type II error rate. It is recommended that power levels should be as high as possible. Generally, a power level of 95% is suggested, however study design and cost limitations may require this value to be reduced to as low as 80%.

4) Significant Difference:
The significant difference is the difference of a characteristic between two populations that would be considered important. The significant difference is usually expressed as a percent relative to the mean of the characteristic being measured. Historically, field measurements and laboratory bioassays use a significant difference range of 10 -20% as being of importance. This value may be as high as 50%, however discussions between Ohio EPA and the stakeholders is required to finalize the statistical requirements.

5) Coefficient of Variation (CV):
The coefficient of variation (CV) is the standard deviation divided by the average expressed as a percent. This value is dependent on the variability of what is being measured. It cannot be predetermined. Biological measurements can have a CV that ranges from 10% to well over 100%. Because this value must be determined before the required number of samples can be esitmated for a given set of statistical parameters, it is recommended that a limited sampling event be planned on the measurement of interest before the FESAP is submitted to Ohio EPA DHWM for review and approval. This limited sampling should also be discussed with Ohio EPA DHWM before it is executed to minimize misunderstandings and to maximize the use and effectiveness of the results.

References:

A) Gilbert, R.O. and J. C. Simpson, 1992, Statistical Methods for the Attainment of Cleanup Standards. Volume 3: Reference-based Standards for Soils and Solid Media. Prepared for the U.S. Environmental Protection Agency by Pacific Northwest Laboratory. Richland Washington. December 1992. PNL-7409-vol.3-Rev.1.

B) Green, R.H., 1997, Sampling Design and Statistical Methods for Environmental Biologists, published by Wiley-Interscience Publication, John Wiley & Sons, New York, Chichester, Brisbane, Toronto.

C) Gilbert R.O., Statistical Methods for Environmental Pollution Monitoring, 1987, published by Van Nostrand Reindhold/Thomson Publishing company.

D) Osenberg, C.W., R.J. Schmitt, S.J. Holbrook, K.E. Abu-Saba, and A. R. Flegal, 1994, Detection of environmental impacts: natural variability, effects size, and power analysis, Ecological Applications, 4(1) 16-30.

CHAPTER 6
DEFINITIONS

"**Acute Exposure**" means one dose or multiple doses of short duration spanning less than or equal to 24 hours. Often, acute lethality tests are defined as the number of test animals that die in a 14-day period following a single dose exposure. Exposure durations may vary depending on the selected test organism.

"**Adverse Effect**" means a biochemical change, functional impairment, or pathologic lesion that affects the performance of the whole organism, or reduces an organisms's ability to respond to an additional environmental challenge.

"**Average Daily Dose (ADD)**" means a dose rate averaged over a pathway-specific period of exposure expressed as a daily dose on a per-unit-body-weight basis. The ADD is usually expressed in terms of mg kg^{-1} day^{-1} or other mass-time units.

"**Areas surrounding the property**" means all areas located within one half-mile of the property boundaries.

"**Benchmark Dose (BMD) or Concentration (BMC)**" means a statistical lower confidence limit on the dose that produces a predetermined change in the response rate of an adverse effect (called the benchmark response or BMR) compared to background.

"**Benchmark Response (BMR)**" means an adverse effect, used to define a benchmark dose from which an RfD (or RfC) can be developed. The change in response rate over the background of the BMR is usually in the range of 5-10 %, which is the limit of responses typically observed in well-conducted animal studies.

"**Biota**" means the animal or plant life of a particular region.

"**Contaminant of Interest (COI)**" means any chemical suspected to be present due to past use, storage, or disposal practices that may have occurred at a site.

"**Chronic Exposure**" means multiple exposures occurring over an extended period of time, or a significant fraction of the animal's life span (approximately 10% of the lifetime of an test organism). Exposure durations may vary depending on the selected test organism. Chronic exposures are associated with multiple administrations of the compound under investigation.

"**Critical Effect**" means the first adverse effect, or its known precursor, that occurs to the most sensitive species or life stage as the dose rate of an agent increases.

"**Critical Study**" means the study that contributes most significantly to the qualitative and quantitative assessment of risk. Also termed "Principal Study". Often, the critical study will be the one study that matches the route of expected exposure of the ecological receptor, has the greatest statistical power (largest number of test subjects per dosing concentration), identifies a toxic response (NOAEL, LOAEL), and the toxic response is not of trivial significance to the receptor.

"**dbh**" means diameter of a tree trunk measured at breast height.

"**Dose-Response Assessment**" means a determination of the relationship between the magnitude of an administered, applied, or internal dose and a specific biological response. Response can be expressed as measured or observed incidence, percent response in groups of subjects (or populations), or as the probability of occurrence within a population.

"**Ecological stressor**" means any physical, chemical (including hazardous substances and petroleum) or, biological entity that can induce an adverse response to an ecological receptor.

"**Ecologically-based Reference Dose (ERfD)**" means an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily oral exposure to the ecological receptor that is likely to be without an appreciable risk of deleterious effects during a lifetime. It can be derived from a NOAEL, LOAEL, or benchmark dose, with uncertainty factors generally applied to reflect limitations of the data used.

"Hazardous substance" includes all of the following;

(a) Any substance identified or listed in rules adopted under division (B)(1)(c) of secton 3750.02 of the Revised Code;

(b) Any product registered as a pesticide under section 921.02 of the Revised Code when the product is used in a manner inconsistent with its required labeling;

(c) Any product formerly registered as a pesticide under that section for which the registration was suspended or canceled under section 921.05 of the Revised Code;

(d) Any mixture of a substance described in paragraphs (A)(20)(a) to (A)(20)(c) of this Rule with radioactive material; and,

(e) Any pollution as defined under division (A) of section 6111.01 of the Revised Code.

"**Important Ecological Resource**" means any specific ecological community, population or individual organism protected by federal, state, or local laws and regulations, or ecological resources that provide important natural or economic resource functions or values. Important ecological resources include, but are not limited to: any surface water or wetland protected under federal law and the state of Ohio's water quality laws; any dedicated natural area or preserve; any federally-listed or state-listed threatened or endangered species and its associated habitat; any State of Ohio species of concern or potentially threatened species and its associated habitat; any State or National park; any designated Federal wilderness area; any National lakeshore recreational area; any National or State wildlife refuge; any federal, state, local, or private land designated for the protection of natural ecosystems; any federally-designated or state-designated scenic or wild river; any federal or state land designated for wildlife or game management; wildlife populations and their associated important nesting areas and food resources, taking into consideration land use and the quality and extent of habitat on and in the vicinity of the site.

The definition of important ecological resource is, however, meant to exclude terrestrial areas such as mowed or maintained green spaces (*e.g.*, manicured lawns), industrial, or other areas that do not exhibit, or exhibit only minimal natural functions. In addition, because they are not members of natural communities, any of the following should not be considered "ecologically important": any pest and opportunistic species that populates an area because of artificial or anthropogenic conditions; any domestic or once domesticated animal (*e.g.*, pets, livestock, or feral animals); any plant or animal whose existence is maintained by continuous human intervention (*e.g.*, agricultural crops).

Industrialized properties may have limited green space around buildings, roadways, parking lots, etc. and there may be a limited number of trees with nests but this type of situation generally would not be considered to be providing important nesting areas and food resources to wildlife populations. However, there may be situations where industrialized sites contain limited habitat capable of supporting populations or individuals of important receptors and therefore would require an ecological evaluation. For example, a small area (<0.5 acre) may be considered an important ecological resource if important functions are provided by the area (*e.g.*, a vernal pool that provides breeding habitat for a state declining species of amphibian).

Thus, the determination as to whether a particular site contains or could potentially impact an important ecological resource, requires an evaluation of habitat on and in the locality of the site. Habitat evaluation is the critical decision criterion for determining whether an important ecological resource is or is potentially associated with the site and therefore trigger the requirement for an ecological risk assessment.

"**Locality of the site**" means any point where an important ecological resource contacts, or is reasonably likely to come into contact with, site-related ecological stressors, considering:

(a) The chemical and physical characteristics of the hazardous substance;

(b) Physical, meteorological, and hydrogeological characteristics that govern the tendency for hazardous substances to migrate through environmental media or to move and accumulate through food webs;

(c) Any activity or biological process that governs the tendency for hazardous substances to move into and through environmental media or to move and accumulate through food webs; and,

(d) The time required for contaminant migration to occur based on factors described in subsections (a) through (c).

"**Lowest-Observed-Adverse-Effect Level (LOAEL)**" means the lowest exposure level at which there are statistically or biologically significant increases in frequency or severity of adverse effects between the exposed population and its appropriate control group. Also referred to as lowest-effect level (LEL).

"**Lowest-Observed Effect Level (LOEL or LEL)**" means in a study, the lowest dose or exposure level at which a statistically or biologically significant effect is observed in the exposed population compared with an appropriate unexposed control group.

"**Non-significant Departure**" means the lower range of biological index scores that are considered acceptable for determining the attainment status of a water body using a biological measurement. Data variability is an important consideration in any assessment of environmental risks to ecosystems stemming from a number of anthropogenic influences, *e.g.*, introduction of xenobiotics, alterations of habitats, the introduction of species, or most often a combination of these activities. This is as true for biosurvey data as for chemical or toxicological data. There are five important sources of variability in biosurvey data: 1) temporal variability (*e.g.*, seasonal, daily, and diurnal changes in community composition); 2) sampling variability (*e.g.*, related to gear, training, and effort); 3) spatial variability (*e.g.*, related to stream size or faunal changes); 4) analytical variability (*e.g.*, related to choice of the appropriate analytical tools); and 5) anthropogenic variability (*e.g.*, degradation of water quality or habitat and/or toxic impacts to aquatic communities) (Rankin and Yoder 1990; DeShon 1995). The objective is to distinguish impacts and variability from anthropogenic sources and minimize or partition temporal, sampling, spatial, and analytical variation.

Ohio EPA uses standardized sampling methods (for two organism groups: fish and macroinvertebrates), specified index periods (seasonal sampling), and standardized analytical tools (Ohio EPA 1987b and 1989) to minimize the sources of variation not under scrutiny (i.e., changes in community structure induced by human activities). Ohio EPA addresses the variability inherent in the biological data gathered in three general ways (Yoder and Rankin 1995):

1) Variability is **compressed** through the use of multimetric evaluation mechanisms such as the IBI and ICI.
2) Variability is **stratified** by the tiered use classification system, ecoregions, biological index calibration, and site type.
3) Variability is **controlled** through standardized sampling procedures that address seasonality, effort, replication, gear selectivity, and spatial concerns.

Ohio EPA used these sampling methods and analytical tools to develop numerical biological criteria (Invertebrate Community Index, ICI; Index of Biological Integrity, IBI; and the modified Index of Well-Being, MI_{wb}) (Ohio EPA 1987a, Yoder and Rankin 1995, and DeShon 1995) for evaluating the biological integrity of a stream segment measured against the ecoregional biological criteria. Biological data have always played a central role in the Ohio water quality standards, particularly for the determination of appropriate and

attainable aquatic life use designations. Aquatic life use designations are assigned to individual water body segments based on the potential to support that use according to the narrative and numeric criteria (Yoder and Rankin 1995).

Data generated by sampling stream segments, within the parameters prescribed by Ohio EPA (1989), provides an indication of the stream segment's use attainment status as measured by the ICI, IBI, and MI_{wb}. Each biological index score is compared to the ecoregional biocriterion to determine if the segment achieves that criterion. For each biological index a range of data variability attributable to sources other than anthropogenic impacts was determined and is discussed at length in other sources (DeShon 1995; Yoder and Rankin 1995; Rankin and Yoder 1990; Karr and Chu 1999). Biological index scores which fall within these ranges are considered nonsignificant departures from the criterion. If all applicable indices meet or fall in the nonsignificant departure range than a stream segment is determined to fully attain its use designation. A use designation is considered partially attained if one or two biological indices indicate attainment but others do not, as long as no index falls below a fair narrative evaluation. A use is not attained if all biological indices fail to meet the biocriteria, or if either organism group (fish or macroinvertebrate) reflects poor or very poor performance.

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"**No-Observed-Adverse-Effect Level (NOAEL)**" means the highest exposure level at which there are no statistically or biologically significant increases in the frequency or severity of adverse effect between the exposed population and its appropriate control; some effects may be produced at this level, but they are not considered adverse, nor precursors to adverse effects.

"**No-Observed-Effect Level (NOEL)**" means an exposure level at which there are no statistically or biologically significant increases in the frequency or severity of any effect between the exposed population and its appropriate control.

"**One-half Order of Magnitude**" means the one-half order of magnitude uncertainty factor of three is based on a logarithmic scale and is discussed in: Regulatory History and Experimental Support of Uncertainty

(Safety) Factors, Michael L. Dourson and Jerry F. Starta, Regulatory Toxicology and Pharmacology 3: 224-238, 1983. This paper was cited by U.S. EPA as the bases for the uncertainty factors used in the derivation of RfD values in IRIS. Mathematically the half order of magnitude using the logarithmic scale can be explained as follows:

$10^0 = 1$
$10^1 = 10$

Therefore: one half the value or distance on a log scale would be represented by: $10^{0.5} = 3.162$, which equals 3 when rounded to one significant digit.

"**Ruderal**" means compacted, plowed, paved, or otherwise disturbed ground usually related to industrial or commercial activities.

"**Sensitive Environment**" The following is a list of sensitive environments as used in the Hazard Ranking system:

Critical habitat for designated endangered or threatened species; Marine Sanctuary; National Park; Designated Federal Wilderness Area, Critical areas identified under the Clean Lakes Program; National Monument; National Lakeshore Recreational Area; Habitat known to be used by Federal designated or proposed endangered or threatened species; National Preserve; National or State Wildlife Refuge; Federal land designated for the protection of natural ecosystems; Administratively Proposed Federal Wilderness Area; Spawning areas critical for the maintenance of fish/shellfish species within a river, lake, or coastal waters; Migratory pathways and feeding areas critical for maintenance of anadromous fish species within river reaches or areas of lakes or coastal tidal waters in which the fish spend extended periods of time; Terrestrial areas utilized for breeding by large or dense aggregations of animals; National river reach designated as Recreational; Habitat known to be used by state designated endangered or threatened species; Habitat known to be used by species under review as to its Federal endangered or threatened status; Federally-designated Scenic or Wild River; State land designated for wildlife or game management; State-designated Scenic or Wild River; State-designated Natural Areas; Particular areas, relatively small in size, important to maintenance of unique biotic communities; State-designated areas for the protection or maintenance of aquatic life; Wetlands.

See Federal Register, vol. 55, pp. 51624 and 51648 for additional information regarding definitions. Under the Hazard Ranking System, wetlands are tiered on the basis of size. See Federal Register, vol. 55, pp. 51625 and 51662 for additional information. The Ohio EPA designates wetlands based on quality and size. The Ohio EPA Division of Surface Water should be contacted regarding the classification of wetlands.

"**Site**" means any parcel or multiple parcels of real property, contiguous or non-contiguous, or portion of such property or properties, where the treatment, storage, disposal and/or the discharge into the waters of the state of industrial waste or other wastes or hazardous substances and petroleum, has occured, including any other area where these hazardous substances and petroleum have migrated or threatened to migrate.

"**Sub-acute (Repeated-Dose Study)**" means an exposure to a substance for approximately 14 days. Subacute toxicity tests are preformed to obtain information on the toxicity of a chemical after repeated administration and as an aid to establish the doses for sub-chronic studies (Amdur et al., 1991).

"**Sub-chronic Exposure**" means sub-chronic exposures last for a range of times, however, 90 days is the most common exposure duration for most rodents and mammals. Sub-chronic exposures will be assessed with multiple administrations of the compound under investigation.

"**Systemic Effects or Systemic Toxicity**" means toxic effects as a result of absorption and distribution of a toxicant to a site distant from its entry point, at which point effects are produced. Not all chemicals that produce systemic effects cause the same degree of toxicity in all organs.

"**Target Organ**" means the biological organ(s) most adversely effected by exposure to a chemical substance.

"**Threshold**" means the dose or exposure below which no deleterious effect is expected to occur.

"**Trophic level**" means a feeding stratum in a food chain of an ecosystem characterized by organisms that occupy a similar functional position in the ecosystem.

"**Trophic**" means of, relating to, or marked by a specified kind of nutrition or diet.

"**UCL, or ninety-five per cent upper confidence limit or ninety five UCL**" means the upper limit of an interval within a frequency distribution curve in which the observed mean of a data set will occur ninety-five percent of the time.

"**Uncertainty Factor (UF)**" means one of several, generally one half order of magnitude (3 based on a logarithmic scale) or one order of magnitude factors, used in operationally deriving the ERfD from experimental data. UFs are intended to account for (1) the variation in sensitivity among the members of the same species; (2) the uncertainty in extrapolating animal data from one species to another, i.e., interspecies variability; (3) the uncertainty in extrapolating from data obtained in a study with less-than-lifetime exposure to lifetime exposure, *i.e.*, extrapolating from sub-chronic to chronic exposure; (4) the uncertainty in extrapolating from a LOAEL rather than from a NOAEL; and (5) the uncertainty associated with extrapolation from animal data when the data base is incomplete.

"**Wetlands**" means those areas that are inundated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.

CHAPTER 7
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