EPA Region 5 Records Ctr.
364234

Sites 14 and 36
Screening Risk Analysis Work Plan
Additional and Uncharacterized Sites Operable Unit

Crab Orchard National Wildlife Refuge Superfund Site
Marion, Illinois

U.S. Fish & Wildlife Service
Crab Orchard National Wildlife Refuge
Marion, Illinois

June 2000

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Crab Orchard National Wildlife Refuge
8588 Route 148
Marion, IL 62959
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June 26, 2000

Ecological Work Group
Additional and Uncharacterized Sites Operable Unit
Crab Orchard National Wildlife Refuge

Re: Submittal of Draft Screening Risk Analysis Work Plan for
Additional and Uncharacterized Sites Operable Unit
Crab Orchard National Wildlife Refuge, Marion, Illinois

Dear Representatives of the Ecological Work Group:

The U.S. Fish and Wildlife Service (FWS) is hereby submitting the Draft Screening Risk Analysis Work Plan (Work Plan) for the Additional and Uncharacterized Sites Operable Unit (AUS OU) for your review. This Work Plan represents our approach for screening of site contaminant levels to determine if there is a need to conduct further investigation at the site. Our approach includes assessment endpoints, screening exposure estimate, risk characterization, and ecological screening concentrations.

As discussed during the April 20, 2000 conference call and subsequent e-mail, a conference call will be held 9:00 a.m. – 11:00 a.m. (Central Time) on July 25, 2000 to discuss questions or comments from the ecological work group. Information on the logistics of the conference call, i.e. conference call telephone number, will be provided to you via e-mail communications. It is important that FWS receive any significant comments by July 19, 2000 to enable us to be prepared to discuss these comments during the conference call and finalize the Work Plan by mid-August in order to meet existing schedule commitments.

We appreciate your contribution in the ecological work group. The technical support provided by the ecological work group is critical to the development of this Work Plan and will result in more efficient investigations and timely decisions. Thank you for your contribution and support.

If you have any questions, please feel free to contact Colette Charbonneau at (612) 713-5329.

Sincerely,

Elaine L. Moore

Elaine L. Moore
CERCLA Coordinator

Enclosures

Table of Contents

1 INTRODUCTION 1-1

1.1 SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT METHODOLOGY . 1-1

1.2 SCREENING-LEVEL HUMAN HEALTH RISK ASSESSMENT METHODOLOGY 1-2

1.3 MANAGEMENT GOALS 1-2

1.4 DOCUMENT ORGANIZATION 1-2

2 SITE HISTORY AND SUSPECTED CONTAMINANTS 2-1

2.1 AREA 2 2-1

2.2 AREA 4 EAST – IOP AUTOMOTIVE AND EQUIPMENT SHOP AREA (AUS-0A4E) 2-3

2.3 AREA 4 WEST – IOP WEST SHOP AREA (AUS-0A4W) 2-3

2.4 AREA 6 – IOP AMMONIUM NITRATE HIGH EXPLOSIVE AND SMOKELESS POWDER STORAGE AREA 2-3

2.5 AREA 7 – IOP INERT STORAGE AREA 2-4

2.6 AREA 8 SOUTH – IOP LOAD LINE III (AUS-0A8S) 2-5

2.7 AREA 9 – IOP LOAD LINE I (AUS-0A09) 2-5

2.8 AREA 10 – IOP FUSE AND BOOSTER STORAGE MAGAZINES (AUS-0A10) . 2-5

2.9 AREA 11 2-6

2.10 AUS-0A12 – AREA 12 FORMER AMMONIUM NITRATE PLANT 2-8

2.11 AUS-0A13 – IOP FINISHED AMMUNITION IGLOOS 2-9

2.12 AUS-0062 to AUS-0069 and AUS-0109 COC AREA SITES 2-9

2.13 AUS-0001 – IOP FIRE AND POLICE HEADQUARTERS 2-9

2.14 AUS-0002 – IOP WASTEWATER TREATMENT PLANT 2-10

2.15 AUS-0018 – IOP RAILROAD CLASSIFICATION YARD 2-10

2.16 AUS-0021 – IOP FIRE STATION FOR AREA 7 2-10

2.17 AUS-0043 – AREAS 11 AND 12 FIRE STATION 2-10

2.18 AUS-0060 – IOP FULMINATE STORAGE IGLOOS 2-10

2.19 AUS-0061 – CONCRETE STRUCTURES WEST OF WOLF CREEK ROAD 2-11

2.20 AUS-106A – DRUM DISPOSAL AREA IDENTIFIED DURING SITE RECONNAISSANCE EAST OF AREA 11 2-11

2.21 AUS-0107 – POSSIBLE DISPOSAL AREA IDENTIFIED BY AERIAL PHOTO INTERPRETATIONS 2-11

2.22 AUS-0108 –POSSIBLE SURFACE DISPOSAL AREA IDENTIFIED BY AERIAL PHOTO INTERPRETATIONS 2-11

3 ECOLOGICAL SCREENING CONCENTRATIONS 3-1

3.1 SCREENING-LEVEL PROBLEM FORMULATION AND ECOLOGICAL EFFECTS EVALUATION (STEP 1 – ERAGS) 3-1

3.1.1 Environmental Setting and Suspected Contaminants 3-1

3.1.1.1 Area 2 3-2

3.1.1.2 Area 4 East – IOP Automotive and Equipment Shop Area (AUS-0A4E) 3-3

3.1.1.3 Area 4 West – IOP West Shop Area (AUS-0A4W) 3-3

3.1.1.4 Area 6 – IOP Ammonium Nitrate High Explosive and Smokeless Powder Storage Area 3-4
3.1.1.5 Area 7 – IOP Inert Storage Area 3-4
3.1.1.6 Area 8 South – IOP Load Line III (AUS-0A8S) 3-4
3.1.1.7 Area 9 – IOP Load Line I (AUS-0A09) 3-5
3.1.1.8 Area 10 – IOP Fuse and Booster Storage Magazines (AUS-0A10). 3-5
3.1.1.9 Area 11 3-5
3.1.1.10 AUS-0A12 – Area 12 Former Ammonium Nitrate Plant 3-5
3.1.1.11 AUS-0A13 – IOP Finished Ammunition Igloos 3-6
3.1.1.12 AUS-0062 to AUS-0069 and AUS-0109 COC Area Sites 3-6
3.1.1.13 AUS-0001 – IOP Fire and Police Headquarters 3-7
3.1.1.14 AUS-0002 – IOP Wastewater Treatment Plant 3-7
3.1.1.15 AUS-0018 – IOP Railroad Classification Yard 3-7
3.1.1.16 AUS-0021 – IOP Fire Station for Area 7 3-8
3.1.1.17 AUS-0043 – Areas 11 and 12 Fire Station 3-8
3.1.1.18 AUS-0060 – IOP Fulminate Storage Igloos 3-8
3.1.1.19 AUS-0061 – Concrete Structures West of Wolf Creek Road 3-8
3.1.1.20 AUS-106A – Drum Disposal Area Identified During Site Reconnaissance East of Area 11 3-8
3.1.1.21 AUS-0107 – Possible Disposal Area Identified by Aerial Photo Interpretation 3-8
3.1.1.22 AUS-0108 –Possible Surface Disposal Area Identified by Arial Photo Interpretations 3-9
3.1.1.23 Summary of Habitats Associated with the AUS OU 3-9
3.2 ENVIRONMENTAL FATE ISSUES 3-9
3.2.1 General Chemical/Physical Properties of Organic Chemicals 3-10
3.2.2 Fate and Transport Mechanisms of Inorganics 3-13
3.3 POTENTIAL ECOLOGICAL RECEPTORS 3-14
3.3.1 Biological Characteristics and Ecological Structure 3-14
3.3.1.1 Plant Communities (Autotrophs) 3-14
3.3.1.2 Soil Communities 3-14
3.3.2 Aquatic Microorganism and Invertebrate Communities 3-15
3.3.3 Fish 3-15
3.3.4 Amphibians 3-15
3.3.5 Reptiles 3-16
3.3.6 Birds 3-16
3.3.7 Mammals 3-16
3.3.8 Species of Special Value or Concern 3-17
3.4 ECOTOXICITY 3-17
3.5 EXPOSURE PATHWAYS 3-17
3.6 SELECTION OF ASSESSMENT ENDPOINTS 3-18
3.6.1 Candidate Receptors 3-20
3.7 SCREENING-LEVEL EXPOSURE ESTIMATE AND RISK CHARACTERIZATION (STEP 2 – ERAGS) 3-21
3.7.1 Estimates of Exposure 3-21

3.7.1.1 Area Use 3-23
3.7.1.2 Dietary Composition 3-23
3.7.1.3 Food Ingestion Rate (IR_{food}) 3-23
3.7.1.4 Water Ingestion Rate (IR_{water}) 3-23
3.7.1.5 Sediment Ingestion Rate ($IR_{sediment}$) 3-24
3.7.1.6 Body Weight (BW) 3-24
3.7.2 Effects Assessment 3-24
3.7.2.1 Direct Exposure Toxicity Reference Values (TRVs) 3-24
3.7.2.2 Ingestion Pathway TRVs 3-27
3.7.3 Ecological Risk Screening Concentrations 3-29
3.7.4 Selection of Chemicals of Potential Ecological Concern 3-30
3.7.5 Uncertainties 3-30

4 HUMAN HEALTH RISK SCREENING APPROACH 4-1

5 REFERENCES 5-1

LIST OF TABLES

Table 3-1 Physiochemical Parameters Additional and Uncharacterized Sites Operable Unit Crab Orchard National Wildlife Refuge, Williamson County, Illinois

Table 3-2 Area Habitat Matrix for the Additional and Uncharacterized Sites Operable Unit Crab Orchard National Wildlife Refuge, Williamson County, Illinois

Table 3-3 Fish Known of Expected to Occur Within the Vicinity of the Crab Orchard National Wildlife Refuge, Williamson County, Illinois

Table 3-4 Amphibians and Reptiles Known or Expected to Occur Within the Vicinity of the Crab Orchard National Wildlife Refuge, Williamson County, Illinois

Table 3-5 Birds Known or Expected to Occur Within the Vicinity of the Crab Orchard National Wildlife Refuge, Williamson County, Illinois

Table 3-6 Mammals Known or Expected to Occur Within the Vicinity of the Crab Orchard National Wildlife Refuge, Williamson County, Illinois

Table 3-7 Federally Listed and State of Illinois Listed Threatened or Endangered Species Potentially Found on Crab Orchard National Wildlife Refuge, Williamson County, Illinois

Table 3-8 Summary of Candidate Receptors and Site Applicability Additional and Uncharacterized Sites Operable Unit Crab Orchard National Wildlife Refuge, Williamson County, Illinois

Table 3-9 Measures of Receptor Characteristics Additional and Uncharacterized Sites Operable Unit Crab Orchard National Wildlife Refuge, Williamson County, Illinois

Table 3-10 Ecotoxicological Screening Values for Direct Exposures to Soil Additional and Uncharacterized Sites Operable Unit Crab Orchard National Wildlife Refuge, Williamson County, Illinois

Table 3-11 Ecotoxicological Screening Values for Direct Exposures to Sediments Additional and Uncharacterized Sites Operable Unit Crab Orchard National Wildlife Refuge, Williamson County, Illinois

Table 3-12 Ecotoxicological Screening Values for Direct Exposures to Surface Water Additional and Uncharacterized Sites Operable Unit Crab Orchard National Wildlife Refuge, Williamson County, Illinois

Table 3-13 Ecotoxicological Screening Values for Indirect Exposures (Ingestion Pathway) Additional and Uncharacterized Sites Operable Unit Crab Orchard National Wildlife Refuge, Williamson County, Illinois

Table 3-14 Ingestion Pathway Screening Concentrations for Soils Additional and Uncharacterized Sites Operable Unit Crab Orchard National Wildlife Refuge, Williamson County, Illinois

Table 3-15 Ingestion Pathway Screening Concentrations for Sediments Additional and Uncharacterized Sites Operable Unit Crab Orchard National Wildlife Refuge, Williamson County, Illinois

Table 3-16 Ingestion Pathway Screening Concentrations for Surface Water Additional and Uncharacterized Sites Operable Unit Crab Orchard National Wildlife Refuge, Williamson County, Illinois

Table 3-17 Ecological Screening Concentration Summary, Additional and Uncharacterized Sites Operable Unit Crab Orchard National Wildlife Refuge, Williamson County, Illinois

FIGURES

Figure 2-1 AUS Historic Search Report Crab Orchard NWR Marion, Illinois

Figure 3-1 Eight-step Ecological Risk Assessment Process

Figure 3-2 Conceptual Exposure Model Ecological Exposures Additional and Uncharacterized Sites OU

APPENDICES

Appendix A Ingestion Pathway Screening Concentrations

Appendix B Ecological Profiles for COIs

The Crab Orchard Additional and Uncharacterized Sites Operable Unit (AUS OU) is located in the Crab Orchard National Wildlife Refuge Superfund Site near Marion, Illinois. There are 31 AUS OU sites located within a 20,000 acre former industrial-use area of the Crab Orchard National Wildlife Refuge (the Refuge). The sites vary in size from less than one acre to 550 acres. A quality assurance project plan (QAPP) was developed in February 2000 (URS 2000a) to present the organization, objectives, planned activities, and specific quality assurance/quality control (QA/QC) procedures associated with an investigation of the AUS OU. This document is a supplement to the QAPP and presents approaches for conducting screening-level ecological and human health evaluations using data collected as part of the AUS OU investigation.

1.1 SCREENING-LEVEL ECOLOGICAL RISK ASSESSMENT METHODOLOGY

Ecological risk assessment is:

> ... *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.* (USEPA 1992, USEPA 1998).

In the present context, "adverse ecological effects" are understood to be anthropogenic changes considered undesirable because they alter valued structural or functional characteristics of ecological systems (USEPA 1997, 1998). The "stressors" at issue are chemical contaminants.

There is no formally promulgated, official state guidance for performance of screening-level ecological risk assessments (SERAs) at potentially contaminated sites in Illinois. USEPA has released guidance for conducting ecological risk assessments, specifically USEPA (1992, 1998). The latter of these two references is EPA/630/R-95/002F, *Guidelines for Ecological Risk Assessment*, replaces the 1992 EPA *Framework for Ecological Risk Assessment* (EPA/630/R-92-001) by expanding upon and modifying the framework concepts to "reflect Agency [EPA] experience" since 1992 and is "intended as internal guidance for EPA." These guidelines, "set forth current scientific thinking and approaches for conducting and evaluating ecological risk assessments." However USEPA (1998) does not provide detailed guidance in specific areas and is not intended to be highly prescriptive. One of its stated purposes is to provide a basis or framework for individual EPA programs and regions to develop more specific guidance "suited to their particular needs."

The EPA Emergency Response Team (ERT, Edison, New Jersey), under the authority of OSWER Directive No. 9285.7-17 of August 12, 1994, has developed guidance for ecological risk application at Comprehensive Environmental Response, Compensation and Liability Act (CERCLA, otherwise known as Superfund) sites which is directly applicable for SERAs within the Refuge. The external review draft of *Ecological Risk Assessment Guidance for Superfund* was released in August of 1996 and the interim final was released in June of 1997. Additional information was released in October of 1999. The Superfund guidance is widely referred to as "ERAGS". Supplemental guidance has also been issued from the EPA Emergency Response team as Intermittent Bulletins (ECO Updates) beginning in 1991 and will be consulted as appropriate and relevant.

Ref?

Although not specifically labeled "guidance," several other documents are relevant, and will be consulted as appropriate. The first example is RTI (1995), a technical support document for the

proposed hazardous waste identification rule (HWIR; USEPA 1995) which outlines a rationale and approach for estimating exposures and effects of high-volume, low-toxicity wastes and constituents. A second example is USEPA (1994), a compendium of "issue papers" commissioned by EPA's Risk Assessment Forum to highlight important principles and approaches to be considered in developing ERA guidance. Additionally, certain books and the peer-reviewed scientific literature will be consulted when relevant and appropriate (e.g., Newman 1999; Ingersoll et al. 1996; Rand 1995; Cockerham and Shane 1994; Suter 1993).

1.2 SCREENING-LEVEL HUMAN HEALTH RISK ASSESSMENT METHODOLOGY

Now needs someone else to review

The overall guidance for the human health evaluation will follow the structure presented in *Risk Assessment Guidance for Superfund* (RAGS) (USEPA 1989). The evaluation will use published screening concentrations for soils and surface water. However, there are no published values for evaluating sediments. Because sediments are expected to comprise a minor portion of media applicable to the AUS OU, soil screening concentrations will be used to evaluate sediments in lieu of deriving sediment screening concentrations for all chemicals of interest.

1.3 MANAGEMENT GOALS

Overall guidance for the performance of the risk evaluation are the management goals for the Crab Orchard National Wildlife Refuge. The Refuge resources are managed so that the wildlife, agricultural, recreational and industrial purposes of the Refuge are accomplished in concert with each other and in full compliance with a long term natural resource stewardship responsibility (Berry 1993). The following goals have been developed for Crab Orchard National Wildlife Refuge.

- Protect, enhance, and manage natural resources and ecosystems to sustain optimum fish and wildlife populations.
- Emphasize the preservation, enhancement, and restoration of viable populations of animal and plant species whose existence is considered by federal or state authorities to be endangered or threatened.
- Wetlands, forests, agricultural lands and other habitat programs are managed to provide food and resting areas for migratory waterfowl with special emphasis on Canada geese (*Branta canadensis*).
- Manage specific areas primarily for non-game migratory birds.
- Create and maintain an interspersion of biologically diverse habitat types including wetlands, uplands, forests, water, and agricultural lands.

1.4 DOCUMENT ORGANIZATION

The remainder of this document presents the components of the screening level risk evaluation for the AUS OU. These sections are:

Section Two – Site History and Suspected Contaminants

This section discusses the sites located within the AUS OU and the suspected contaminants that formed the foundation for specific additional investigation in each of the areas.

Section Three – Ecological Risk Screening Approach

Section Three summarizes the ecological risk screening process that will be applied when data becomes available from the AUS OU sites. Habitat types, relevant media, and development of screening concentrations are presented. Data collected from the AUS OU areas will be compared to the screening concentrations developed in this section to assist in decision making as to whether additional evaluation of potential ecological risks may be warranted.

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Section Five - References

This section presents a list of references used in preparation of the body of the report.

Tables and Figures

Tables and figures are presented at the end of each respective section in which they are introduced.

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Tables and Figures

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This section presents information on site history and suspected contaminants as obtained from the Historic Search Report (URSGWC 1999) for the AUS OU. Each of the areas of the AUS OU is presented, with a background description, and discussion of suspected or known chemicals that may have been associated with the site. A site map is presented in Figure 2-1.

2.1 AREA 2

Area 2 consists of four IOP load lines in close proximity to each other just north of Crab Orchard Lake. These load lines are the Booster Load Line labeled as Area 2B, the Detonator Load Line labeled as Area 2D, the Fuse Load Line labeled as Area 2F, and the Primer Load Line labeled as Area 2P. Each of these areas is described in the sections below.

AREA 2B – IOP BOOSTER LOAD LINE (AUS-0A2B)

This site is the former IOP Booster Load Line. The facility was designed and built for the purpose of loading boosters, involving the preparation, mixing, and loading of tetryl. Since World War II, ordnance manufacturers have used the facility for their production operations. Post war production activities at Area 2B included explosive fuse trains, pyrotechnics, large explosives, propellant mixes, and gas generators.

The southern and eastern portions of the load line were razed in the 1980s. The remaining buildings at the site are part of Primex Corporations' ongoing production operations at the Refuge. Visual inspection of the site revealed building debris, abandoned drums and ordnance waste scattered at the southern end of the site outside the current fenceline. Aerial photo interpretation identified a suspicious pond to the southwest of the load line and excavation activity to the east of the load line. Previous sampling at the site indicated the presence of elevated levels of metals and several base/neutral/acid-extractable (BNA) compounds.

Building B-2-13 in the northeast section of Area 2B is a propellant mix house. The southern end of the building has propellant mixing machines in the east and west bays and propellant has been identified on the ground outside both of these bays in the past. In addition, to the east of this building is a hexane tank which supplies solvent to the mixing bays for use in propellant mixes.

In the southern portion of Area 2B several buildings were involved in the screening, pressing and loading of high explosives and pyrotechnic mixes. These buildings have all been flashed and razed. Because volatile solvents like $MeCl_2$ and trichlorethylene (TCE) were used extensively in production operations by the industrial tenants, dioxin is a chemical of interest (COI) in these locations. It is also a COI at the burn pad in the southwest corner of this load line. Other COIs in this area include trinitrotoluene (TNT) and tetryl (explosives), $MeCl_2$ (volatile solvents), hexane, lead (metals), and burn site residues (BNAs).

AREA 2D – IOP DETONATOR LOAD LINE (AUS-0A2D)

This site is the former IOP Detonator Load Line. The facility was designed and built for the purpose of loading detonators, involving the preparation, mixing, and loading of primary explosives. Since World War II, ordnance manufacturers have used the facility for their production operations. Post war production activities at Area 2D included explosive fuse trains,

pyrotechnics, large explosives, propellant products, gas generators and ammunition mixes (e.g. tracers and igniters). Currently Primex Corporation is using the load line for its ongoing production activities.

On the southeast corner of the load line a small building pad was used for several years as a burning ground for ignitable wastes. In addition, several of the production buildings previously contained open sumps that were emptied out on to the grounds in the area of the sumps during cleaning activities. Other cleaning activities at the site included the sweeping of wash waters in production buildings to the grounds just outside the building on a weekly basis. These wash waters reportedly ended up flowing into the ditches near the buildings. Previous sampling at the site indicated the presence of elevated levels of mercury, zinc and several BNA compounds.

In the southeast portion of the load line the chemicals of interest include mercury fulminate and lead (reactivity and metals), burn site residues (dioxin and BNAs), and propellant and pyrotechnic mixes (explosives, metals, volatile organic compounds [VOCs], and BNAs). On the southwest portion of the load line COIs include lead azide (metals), acetone (VOCs), and propellant and pyrotechnic mixes (explosives, metals, VOCs, and BNAs). On the north end of the load line COIs include propellant and pyrotechnic mixes (explosives, metals, VOCs, and BNAs), TNT, tetryl, RDX, and NG (explosives), and lead azide (metals).

AREA 2F – IOP FUSE LOAD LINE (AUS-0A2F)

Area 2F is the former IOP Fuse Load Line. The facility was designed and built for the purpose of loading fuses, including the preparation and loading of black powder, lead azide, potassium chlorate, and tetryl. Since World War II, ordnance manufacturers have used the facility for their production operations. Post war production activities at Area 2F included pyrotechnics, gas generators, and artillery projectiles. Currently, Primex Corporation is using the facility for its ongoing production operations.

Visual inspection of the site revealed the northern portion of the load line has been used as a dumping ground for construction debris over the years. In addition, several areas of stressed vegetation were observed around production buildings. Previous sampling at the site indicated the presence of elevated levels of metals.

Fuse production involved the use of tetryl (explosives), lead azide (metals), and nitrocellulose. Other activities at the load line include the use of volatile solvents for metals cleaning activities. It is believed that the disposal of these chemicals was via dumping in the areas around the building involved (F-2-2).

AREA 2P – IOP PRIMER LOAD LINE (AUS-0A2P)

Area 2P is the former IOP Primer Load Line. The facility was designed and built for the purpose of loading primers and involved the preparation and loading of black powder. Since World War II an ordnance manufacturer has used the facility for its research and development and production operations. Post war production activities at Area 2P included solid propellants, pyrotechnics, gas generators, and ammunition mixes. Primex Corporation is currently using the facility for its ongoing operations at the Refuge.

Previous sampling at the site indicated the presence of RDX in surface water effluents as well as elevated levels of metals and BNA compounds. Surface water at the site is transported off the site either to the northwest or the southeast by numerous ditches at the site. In addition, building P-1-1 formerly contained an open sump from which water was discharged to the ground during cleaning operations.

2.2 AREA 4 EAST – IOP AUTOMOTIVE AND EQUIPMENT SHOP AREA (AUS-0A4E)

Area 4 East is the former IOP Automotive and Equipment Shop. The facility was designed and built for the purpose of maintaining the trucks and equipment needed to support ordnance-manufacturing operations. Since World War II, the facility has been used by various tenants for purposes such as truck and mining equipment maintenance and repair, storage, and manufacturing. To the southeast of Area 4 a sanitary landfill was remediated as part of the Metals Area Operable Unit (MAOU). The landfill was referred to as the Fire Station Landfill. The contaminant of concern at the Fire Station Landfill was lead. An IOP vehicle refueling station once stood in the middle of the site adjacent to Highway 148. The building has been razed; however, it is suspected that the underground fuel storage tanks may have been left in place during the building demolition. Surface water at the site is transported via storm sewers to the north and then east via ditches off the site.

2.3 AREA 4 WEST – IOP WEST SHOP AREA (AUS-0A4W)

Area 4 West originally housed the construction and mechanical trades buildings along with a laboratory and laundry facility. After the end of WWII several of the buildings were leased by businesses of all types. Printing companies occupied building S-1-3. A lumber company occupied buildings S-3-2, S-3-3, and S-3-4. Most notably, however, Supreme Plating Company (a plating operation) occupied buildings S-2-4 and S-2-5. It was the waste from this plating operation that ultimately became the subject of the MAOU. The remediation of the MAOU included the ditches along the roadsides in the center of Area 4 West as well as the northern drainage swale where the storm sewers discharge their waters. Buildings S-2-1, S-2-2, and S-2-3 are no longer standing. Buildings S-2-1 and S-2-2 building pads are currently being used as compounds for vehicle storage. A review of the site characterization for the MAOU (Site 22-O'Brien & Gere, 1988) revealed that no samples were taken in the area around building S-2-5. In addition, aerial photo interpretations of the 1951 and 1960 aerial photos revealed evidence of disposal activities in a remote section of Area 4 to the southwest of building S-1-3.

2.4 AREA 6 – IOP AMMONIUM NITRATE HIGH EXPLOSIVE AND SMOKELESS POWDER STORAGE AREA

Area 6 is the former IOP Ammonium Nitrate High Explosive and Smokeless Powder Storage Area. The site has 84 explosive storage igloos in 7 rows and has been used for storage since WWII. Samples at the railroad loading docks on the north and south have exceeded screening levels. The analytes indeno[1,2,3-cd]pyrene and dibenz[a,h]anthracene exceeded USEPA soil screening levels (SSLs) in a sample at the south railroad loading dock. The analytes benzo[b]fluoranthene, benzo[k]fluoranthene, indeno[1,2,3-cd]pyrene, and dibenz[a,h]anthracene

exceeded USEPA SSLs in a sample at the northern railroad loading dock. Barium also exceeded USEPA SSLs and Refuge background values in one sample.

In addition to the northern and southern railroad loading docks each igloo has a truck loading dock. One row of igloos sits adjacent to the former rail line and had both truck loading docks and railroad loading docks.

2.5 AREA 7 – IOP INERT STORAGE AREA

Area 7 was originally built as the IOP Inert Storage complex, which warehoused metal parts and other inert materials used in the production of artillery shells, tank mines and 500-lb bombs and their component parts.[1] The building complex was constructed in 6 rows of buildings (5 to 7 buildings per row originally). Only 26 of the original buildings in Area 7 remain standing. After the end of WWII several industries began leasing space in Area 7.[2] Information on the known leasing history for Area 7 is detailed in the AUS Historic Search Report Section 7. Only one business is known to have stored hazardous materials in Area 7: Great Lakes T & T stored pesticides in buildings IN-1-5 and IN-1-6. All other businesses, which would have handled hazardous materials, used the buildings for purposes other than storage. Since the buildings in Area 7 were built strictly for storage, other uses required occupants to modify the buildings. One of the most important modifications required in the Area 7 buildings to make them capable of housing production operations was an upgrade of the electrical service. Production operations require that three-phase power be supplied to a building so that equipment and machinery can be used.[3] Only eight of the remaining 26 buildings in Area 7 have the equipment necessary for supplying three-phase power. These buildings are IN-1-1, IN-1-5, IN-1-6, IN-2-1, IN-2-5, IN-2-6, IN-3-4, and IN-6-5.

It is known that buildings IN-3-5, IN-4-4, IN–5-2 and IN-5-3 were used for production activities for several years. In fact, the 1988 O'Brien & Gere remedial investigation (RI) performed sampling around these buildings because of the appearance of black residues. Sample analyses revealed low levels of BNAs and polychlorinated biphenyls (PCBs), however, no further action was recommended for this area. Subsequently these buildings were demolished and buried at the site.

It is possible that other buildings razed in Area 7 were also involved in production activities. However, the remaining building debris is buried under 2 feet of soil and the original landscape and drainage profiles have been changed as a result. Therefore identifying areas impacted from production activities must rely on observations of current site conditions.

[1] U.S. ACE, 1944, Part I Sect. 7 page 28.
[2] Techlaw, 1992, pages 59-63b.
[3] Large motors used in pumps, lathes, metal working equipment, etc. require three phase power be supplied to the motor. Three-phase power cannot be supplied using the same electrical service that was installed to supply the single-phase power the IOP used for lighting. Therefore additional equipment had to be installed to support activities other than lighting.

2.6 AREA 8 SOUTH – IOP LOAD LINE III (AUS-0A8S)

Area 8 South was formerly a bomb loading line for the IOP where TNT was screened, melted, and loaded. After World War II, several different industrial tenants leased the site for various production operations. Products manufactured at the site after World War II included fiberglass canoes, propellants, pyrotechnics, and ground nitrocellulose. After a fire at the site in 1981, the entire site was razed and buried. No industrial activity has taken place at Area 8 South since that time.

A visual inspection of the site revealed several mounded areas in the former production buildings locations. Two drums were identified at the site to the northwest of the former IOP TNT Cooling building. In addition, a sump pit was observed to the west of the former TNT Melting building which also was the site of the American Fiber Lite production operations. Aerial photo interpretations at the site indicated ground scarring at one location to the southeast of the northern change house. No supplementary information has been found indicating a cause for the ground scarring, however, it was observed in aerial photography from 1943 to 1993. Three other features identified by aerial photo interpretations were southwest of the eastern TNT Cooling building. One was a trench like feature more than 190 feet long and 8 feet wide. The other two were identified as pits.

2.7 AREA 9 – IOP LOAD LINE I (AUS-0A09)

Area 9 was formerly an artillery and bomb loading line for the IOP where TNT was screened, melted, and loaded. After World War II, several different industrial tenants leased the site for various production operations. Products manufactured at the site after World War II included capacitors, wrapping paper, gloves, boats, and industrial finishes. Industrial tenants in Area 9 included Sangamo Electric Co., Technical Tape Corp., Good Luck Glove Co., Mark Twain Marine Industries, Pyramid Industrial Finishes, and Olin Corp. Olin Corp. (now Primex) is currently the sole tenant in Area 9.

In 1982 the Service identified PCB and lead contamination in the portion of Area 9 known as the Sangamo Dump. O'Brien & Gere (1988) investigated Area 9 as Sites 32 and 33. It was subsequently designated as part of the PCB Areas Operable Unit (PCB OU) and a Record of Decision on a remedial action was issued on August 1, 1990.[4] In 1996 and 1997, a large area in and near Area 9 was remediated as a part of the PCB OU.[5] In addition, there is an on-going remedial investigation/feasibility study in the same area for chlorinated volatile organic compound contamination.

2.8 AREA 10 – IOP FUSE AND BOOSTER STORAGE MAGAZINES (AUS-0A10)

Area 10 was formerly a group of storage magazines for the explosive components of anti-tank mines, bombs and artillery being produced at the load lines. From 1967 to 1970 the site was used for the incineration of ignitable wastes from the production operations of an ordnance

[4] U.S. EPA, 1990, Declaration for the Record of Decision, Crab Orchard National Wildlife Refuge, PCB Areas Operable Unit.

[5] International Technology Corporation, 1997, Acceptance Report for Closure of PCB Areas Operable Unit Landfill, Crab Orchard National Wildlife Refuge, Marion, IL.

manufacturer. The burning of the wastes was done in large pits called burning pits. In 1970, open burning was banned on the Refuge and the pits were covered. Since that time the site has been used by local law enforcement personnel for small arms practice.

2.9 AREA 11

Area 11 contains a group of buildings comprising the IOP Group II Melt Loading Line. It originally consisted of 31 buildings located just south of Ogden Road to the west side of Highway 148. Load Line II was designed and built for the loading of 105 or 155mm shells. Several corporations have had operations within Area 11 including:

- The Sherwin Williams Defense Corporation (SWDC) operated the Group II Melt Loading Line (Load Line II) in Area 11 during World War II, from August 1942 through September 1945. Sherwin Williams loaded shells, bombs and mines on Load Line II. They occupied all of the buildings along Load Line II in conjunction with operating the area for IOP.
- Hoosier Cardinal Corporation and the Ordill Machine Works operated in Area 11 from approximately August 1948 through 1954. Hoosier Cardinal Corporation manufactured and finished decorative metal and plastic parts. Ordill Machine Works did tool and dye workings. It is not known what buildings they occupied.
- From January 1956 through April 1964, Olin conducted operations in Area 11. Olin occupied all of the former IOP buildings and expanded the plant into the vacant property located between Areas 11 and 12. For the purposes of this report, this expanded area will be considered part of Area 11. Olin produced various types of commercial explosives in Area 11.
- Commercial Solvents Corporation (CSC) occupied Area 11 from April 1964 through 1982. CSC (and its successors, including U.S. Powder who initially operated the plant for CSC) also produced explosives in Area 11. CSC occupied the same buildings that Olin had previously occupied. Explosives were manufactured in Area 11 until June 1971, when decontamination procedures began. By 1986, there were no tenants in Area 11.[6]

AUS-A11H – AREA 11 HIGH EXPLOSIVES AREA

The majority of the Area 11 High Explosives Area was built by Olin and was occupied by both Olin and CSC. This area has been used for the production and packaging of high explosives. Contaminants identified in this area by CSC include the following: dynamite, RDX, pentaerythritol tetranitrate (PETN), nitroglycerin, nitrocellulose, TNT and ANOIL. Several buildings were also used by SWDC for IOP operations at the Melt Loading Line. These buildings were Building 7, 8, 24, 67 and 69 and the most likely explosive contaminant in these buildings would be TNT.

[6] CRO 185 – According to Techlaw, Inc., 1992, Final Draft Report - Site Operations/Ownership History – Crab Orchard National Wildlife Refuge; Prepared for U.S. Army Corps of Engineers, Page 75.

AUS-A11N – AREA 11 NITROGLYCERIN AREA

The Area 11 Nitroglycerin Area was built by Olin and was occupied by both Olin and CSC. This area has been used for the production of nitroglycerin using the Biazzi process. The only explosive contaminant identified in this area by CSC was nitroglycerin. There are numerous ditches and ponded areas in this area that will be investigated in addition to the areas around the buildings.

A previous investigation was done in AUS-A11N in the East Holding Pond (Site COP-2). Metals and nitrates were the only elevated compounds detected in this area. There were eight possible burning trenches located in AUS-A11N that were identified in historical aerial photographs, though there is currently no evidence of these trenches on site. Two were identified in the location of former Building 10, and six were identified in an open area located just east of former Building 9. The former use of these trenches is not known.

There were two railroad tank cars (RRTCs) located just west of the former Nitrator (Building 9). One of these two RRTCs had an access port and has been previously sampled. It has been reported that the ditches and holding pond in this area may have been flashed; however, the potential for contamination still exists.

AUS-A11P – AREA 11 PILOT PROPELLANT PLANT/CAP PRODUCTION AREA

The Area 11 Pilot Propellant Plant/Cap Production Area has been occupied by all of the above-mentioned occupants of Area 11 (this area may or may not have been occupied by Hoosier Cardinal/Ordill Machine Company, since it is not known what buildings these companies occupied).

This area was used by SWDC during IOP operations as a part of the Melt Loading Line for some TNT pouring operations and drilling and boostering operations. Olin used this area as a Pilot Propellant Plant that was used for research and development of propellants. Olin also manufactured gas generators and tested some explosives in this area. CSC used this area for Big Inch Cap Production that involved the use of RDX, lead azide and/or lead styphnate and possibly mercury fulminate. Testing of Big Inch Caps was also done in this area and there were numerous storage facilities also. This area was in operation during most of the time that Olin and CSC had possession of the property. There are numerous ditches and ponded areas in this area.

AUS-A11S – AREA 11 SUPPORT AREA

The Area 11 Support Area has been occupied by all of the above-mentioned occupants of Area 11. This area was used during IOP operations as a part of the Melt Loading Line, mostly for storage and for cleaning and painting operations (Buildings 56 and 66). The IOP Boiler House along with four associated underground storage tanks (USTs) was also located in this area. It has been reported that the USTs were removed from near the boiler house, there is no evidence of their presence at the site, nor has documentation been found to confirm their removal. The building has been razed; however, it is possible that the underground fuel storage tanks may have been left in place during the building demolition. Both Olin and CSC used this area as a support

area for their explosives manufacturing operations in Areas 11 and 12. This portion of the facility was in use for the duration of Olin and CSC's tenure at the site – from January 1956 through the mid-1970s when decontamination procedures began at the site. The following buildings were located in this area: Carpenter, Maintenance and Machine Shop (Building 55), Welding Shop (Building 57), Oil Stores (Building 68), Administration Buildings (various buildings), Laboratories (Buildings 75-1 and 80), Garage/Wash Room (Building 56), Boiler House (Building 60), Scrap Yard (Location 58) and other miscellaneous buildings. There are numerous ditches and ponded areas in this area.

The USEPA previously collected samples from near the cleaning and painting building and near the boiler house; both semivolatiles and metals were detected at elevated levels in samples from these locations. The depth and locations of these samples is not known.

2.10 AUS-0A12 – AREA 12 FORMER AMMONIUM NITRATE PLANT

Area 12 consists of the IOP Ammonium Nitrate Plant. It originally consisted of 12 buildings located just south of Ogden Road to the west side of Highway 148 – south of Area 11. The Ammonium Nitrate Plant was designed and built for the production of explosive-grade ammonium nitrate. Several corporations have had operations within Area 12 including:

- SWDC used Area 12 for explosive-grade ammonium nitrate production during World War II from August 1942 through May 1943.
- Silas Mason produced fertilizer-grade ammonium nitrate in this area from 1947 through 1950.
- Universal Match Corporation (UMC) tested photo flash signals in this area for approximately six months during 1955.[7]
- Olin leased this area from January 1956 through April 1964. According to John Miller, a former Olin employee, it was used mostly for storage and burning.[8] According to Mr. Robert Meyers[9] (a former Olin truck driver) and Mr. Harry Stiles[10] (former FWS project manager for entire Refuge), Area 12 was also used to make explosives for a brief time.
- CSC occupied Area 12 from April 1964 through 1982. CSC (and its successors) used Area 12 for cyclonite (RDX) production and for storage, according to the U.S. Powder Map. Additionally, according to the U.S. Powder Map the burning grounds were also still present on the western side of the property. CSC occupied the same buildings that Olin had previously occupied and they built several new buildings.

Decontamination of Area 12 began after 1971.[11] By 1986, there were no tenants in Area 12.[12]

[7] ACO 39 and ACL 670 - According to Techlaw, Inc., 1992, Final Draft Report - Site Operations/Ownership History – Crab Orchard National Wildlife Refuge; Prepared for U.S. Army Corps of Engineers, Pages 6, 25.
[8] Testimony of Mr. John Miller taken on April 9, 1998, Page 31.
[9] Testimony of Mr. Robert Meyers taken on April 10, 1998, Page 20.
[10] Testimony of Mr. Harry Stiles taken on November 18, 1997, Page 67.
[11] CRO185 – According to Techlaw, Inc., 1992, Final Draft Report - Site Operations/Ownership History – Crab Orchard National Wildlife Refuge; Prepared for U.S. Army Corps of Engineers, Page 76.

As mentioned above, SWDC, Silas Mason, UMC, Olin and CSC all occupied Area 12. SWDC operated the explosive-grade ammonium nitrate plant for the IOP. Silas Mason then operated the ammonium nitrate plant to produce fertilizer-grade ammonium nitrate. UMC was reported to have used the area to test photo flash signals. Olin used the area for storage, burning and to manufacture explosives. Olin originally manufactured ammonium nitrate in this area until the ammonium nitrate facility in Area 11 was completed. CSC used this area for storage, burning and RDX production.

There were eight storage ponds present in Area 12 also and these were used for storage of double-base propellants, smokeless powder, and possibly other explosive materials. A few metals were detected at elevated levels in a previous investigation at the powder storage ponds (Site COP-3). However, all soil samples were collected from depths of at least four feet and no surficial soil samples were collected. The area south of the burning ground was also previously investigated (Site COP-4). Volatiles, semivolatiles, metals, explosives, TRPH, nitrates and sulfates were all detected levels in this area. Removal actions are currently being done at COP-4.

2.11 AUS-0A13 – IOP FINISHED AMMUNITION IGLOOS

The site was formerly a group of storage magazines for finished ammunition. Since World War II, the igloos have been used by various manufacturers to store raw materials and products. Each igloo has a truck loading dock for material transfers. In addition, one row of igloos had an additional dock adjacent to the railroad line running through the site.

2.12 AUS-0062 TO AUS-0069 AND AUS-0109 COC AREA SITES

The original Crab Orchard Cemetery (COC) sites were identified as having been impacted by ordnance disposal activities in a 1998 UXO investigation by Parsons Engineering. The AUS sites in the COC Area consist of dumpsites and other sites, which because of their location, may be connected to ordnance disposal activities.

Ordnance scrap was identified on all of the COC sites that are part of this investigation except for AUS-0066 and AUS-0109. AUS-0066 was not investigated during Parsons' 1998 UXO investigation. AUS-0109 is a previously unidentified site. AUS-0109 was identified by aerial photo interpretations as resembling other ordnance disposal sites previously identified and characterized at the site. UXO removal activities have occurred at some sites in the COC area and are a concern at all COC area sites.

2.13 AUS-0001 – IOP FIRE AND POLICE HEADQUARTERS

AUS-0001 formerly housed the Fire and Police Headquarters for the Illinois Ordnance Plant and later the Refuge. It is less than an acre in size. The Headquarters included an administration building, and a fire station as well as a small boiler house. To the west of these buildings was a long structure with a trough running through it. Its purpose is unknown. Though all of the

[12] CRO185 – According to Techlaw, Inc., 1992, Final Draft Report - Site Operations/Ownership History – Crab Orchard National Wildlife Refuge; Prepared for U.S. Army Corps of Engineers, Page 75.

buildings at the site were razed, their foundations remain. Evidence of underground storage tanks at the site was observed near the former boiler house.

2.14 AUS-0002 – IOP WASTEWATER TREATMENT PLANT

This site is the former location of the Wastewater Treatment Plant for the Illinois Ordnance Plant's administration area and may have served portions of Area 2. The building was razed, however the settlement lagoons still exist. The site encompasses less than acre.

2.15 AUS-0018 – IOP RAILROAD CLASSIFICATION YARD

AUS-0018 was formerly the railroad classification yard for the Illinois Ordnance Plant. Railroad cars were ordered at the site for efficient transport to their final destinations. The site was not used for long-term storage; however, train cars may have waited at the yard for a few days awaiting dispensation. According to an engineering drawing contained in the War Departments' 1944 Facilities Inventory of the Illinois Ordnance Plant, the classification yard had a fuel oil column, which may have been used for refueling of locomotives. The tracks at the site were removed along with the ballast and railroad ties. One building still stands at the site. However, it has been abandoned since its post World War II tenant, the Williamson County Emergency Management Agency, moved to a new location. Previous sampling at the site revealed the presence of elevated levels of cadmium, mercury, lead, and zinc. The overall size of the site is approximately 30 acres.

2.16 AUS-0021 – IOP FIRE STATION FOR AREA 7

This site formerly housed a fire station that serviced Area 7 and other nearby IOP facilities. The building has been razed and only parts of the foundation are visible. A walkover survey of the site revealed ordnance/explosive waste at the site to the north of the former fire station building. The site footprint is less than an acre.

2.17 AUS-0043 – AREAS 11 AND 12 FIRE STATION

This site formerly housed a fire station that serviced Areas 11 and 12 as well as other nearby IOP facilities and is less than an acre in size. The building has been razed and only the foundation and debris remain at the site. A walkover survey of the site revealed sumps and a burner stack as well as abandoned farm equipment.

2.18 AUS-0060 – IOP FULMINATE STORAGE IGLOOS

This site was originally designed, built and used for the storage of mercury fulminate for use in detonators. After World War II, the storage igloos were used to store other compounds including lead azide, TNT, tetryl, and nitrocellulose. The storage igloos have been unoccupied for about 30 years. In 1996 igloo number FS 2-2 was found to contain boxes with some nitrocellulose. The igloo was decontaminated subsequent to this discovery. Previous sampling at the site showed elevated levels of metals at the site. Visual inspection of the site revealed the presence of numerous drums abandoned at the site. The site encompasses approximately 30 acres.

2.19 AUS-0061 – CONCRETE STRUCTURES WEST OF WOLF CREEK ROAD

AUS-0061 was built for the testing of ordnance and propellant systems. The site contains two structures that were used as test pits and one structure used to initiate the testing. The site area is less than an acre. Previous sampling at the site showed elevated levels of BNAs.

2.20 AUS-106A – DRUM DISPOSAL AREA IDENTIFIED DURING SITE RECONNAISSANCE EAST OF AREA 11

The history of this site is unknown. There appeared to be a road leading to this disposal area as seen in 1951 aerial photographs, which did not appear in the 1960 aerial photograph. This would indicate that the IOP (1942 through 1945), Hoosier Cardinal (1948 through 1954) or Silas Mason (1947 through 1950) could possibly be responsible for these drums. There is also an oven hood and two former smokestacks located near a soil mound. The size of the unit is approximately one acre.

During a site reconnaissance, it was estimated that 50 to 100 drums might be disposed in this area. These drums are partially buried and are located along a creek bed that usually contains water only during precipitation events. There is a grayish-bluish solid substance present in several of the exposed drums. It is speculated by the Service that this may be old paint; however there is no evidence to support this.

2.21 AUS-0107 – POSSIBLE DISPOSAL AREA IDENTIFIED BY AERIAL PHOTO INTERPRETATIONS

This site is located north of Area 8 and just south of Ogden Rd. It was identified by aerial photography interpretations as a possible disposal area.

2.22 AUS-0108 –POSSIBLE SURFACE DISPOSAL AREA IDENTIFIED BY AERIAL PHOTO INTERPRETATIONS

This site is located north of Ogden Rd. and north of Area 11. It was identified by aerial photography interpretations as a possible surface disposal area near COC 10.

The *Ecological Risk Assessment Guidance for Superfund* (USEPA 1997), hereafter referred to as ERAGS, will be used as the primary guidance for evaluating the potential for ecological risk at the AUS OU. The overall process consists of a series of eight steps as outlined in Figure 3-1. The first two steps correspond to a preliminary, or screening level assessment. Step 1 consists of a screening-level problem formulation and ecological effects evaluation. Step 2 is the screening-level exposure estimate and preliminary risk calculation.

3.1 SCREENING-LEVEL PROBLEM FORMULATION AND ECOLOGICAL EFFECTS EVALUATION (STEP 1 – ERAGS)

During the screening-level problem formulation, a conceptual model is developed for the site that addresses five issues (USEPA 1997), as follows:

1. Environmental setting and contaminants known or suspected to exist at the site;
2. Contaminant fate and transport mechanisms;
3. Mechanisms of ecotoxicity associated with contaminants and likely categories of receptors that could be effected;
4. What complete exposure pathways exist;
5. Selection of endpoints to screen for ecological risk

3.1.1 Environmental Setting and Suspected Contaminants

The Refuge is located in the temperate deciduous forest region occupying the northeastern portion of North America. Geographically the Refuge lies between the Ozarks and the Appalachians; this area serves as a link in the North American vegetation gradient due to overlap of distinctive vegetation patterns. There are plants of the eastern U.S. that generally range throughout the eastern half of North America, plants of the central U.S. with southern Illinois being near the center of distribution, and plants of the southeastern U.S. which have advanced northward and westward. Thus, the available habitat and species associated with the habitats are diverse throughout the Refuge.

Contaminants suspected to exist at the AUS OU were identified for each of the sites based on historical use and site reconnaissance as discussed in Section 2. A summary of these chemicals and their physiochemical properties is provided in Table 3-1. These chemicals formed the foundation for development of a sampling plan for the AUS OU site investigation, as presented in the *Field Sampling Plan Site Inspection Additional and Uncharacterized Sites Operable Unit* (URS 2000b).

The Refuge is unique in that it has wildlife management as well as industrial management objectives. Some AUS OU sites may contain exploitable habitat that is used for foraging and/or shelter by a number of potential ecological receptors. Others are comprised of active industrial activity, with little or no exploitable habitat. Essentially artificial habitats, such as those associated with active industrial areas, are not considered *directly* ecologically relevant because they exist and are configured to support human (industrial) functions. These areas are not self-sustaining and do not represent biological communities. As a result, organisms such as soil

invertebrates or small mammals that may reside in a lawn adjacent to an industrial building will not be directly evaluated in the ecological risk evaluation. However, receptors that reside adjacent to such sites and forage upon (exploit) the invertebrates or small mammals are considered relevant to the evaluation.

The initial step in the evaluation of the sites is to determine whether the unit has an *ecological component*, which is primarily based on the availability, within the subject unit, of *exploitable habitat*. Simply defined, the term *habitat* means the "place where a plant or animal lives" (USEPA 1997), but a more functional definition can be paraphrased as the *type of environment* where an organism (or community of similarly adapted organisms) *normally* lives. The term *exploitable* refers to the presence of attributes such as food and/or shelter. For example, robins may not generally inhabit (live in) a lawn area but they may *exploit* earthworms living in the soil.

The following subsections discuss the preliminary habitat characterizations at each of the AUS OU subareas. This information was obtained from previous descriptions of the sites and area reconnaissance by biological personnel located at the Refuge.

3.1.1.1 Area 2

Area 2 contains about 595 acres of which about one-third is occupied by the load lines. A fence surrounds each of the four active industrial sub-units in Area 2. Areas within the sub-units are highly industrial, unlike the remaining area within Area 2. The unfenced, non-industrial portion of this area is composed of patches of mixed wetland, old field, woodland and active agricultural fields. When planted in winter wheat, the fields serve as habitat for geese. Both geese and raccoon visit the agricultural fields when planted in corn. To the north of the site is state land and Southern Illinois University Coal Research Center. The area to the south consists of mixed wetland, agricultural, woodland and old field. Agricultural land is located to the west with mixed agricultural, woodland and old field to the east. Of particular interest to this area is a designated refuge natural area approximately 22 acres in size and is located partially in the nonindustrial portion of Area 2 and east, north-east of 2D. The Post Oak Flats Natural Area has a unique forest community of post oak and hickory. The area is relatively undisturbed and was set aside to preserve the native forest community typical of the glacial till flats in that area.

All of the sub-units, 2B, 2D, 2F, and 2P, have a number of ditches with intermittent flows. Drainage ditches are along the fences, and they are thickly vegetated with brush and trees aged about 10 to 20 years old. Each of the sub-units is described below.

Area 2b – IOP Booster Load Line (AUS-0A2B)

Very little natural habitat exists in this sub-unit. The total area of the sub-unit is approximately 47 acres. The landscape consists primarily of mowed fescue among the buildings, driveways, and roads. Drainage ditches along the fence are thickly vegetated with brush and young trees. Woodland exists on the southern portion of Area 2B outside a fence. An abandoned road and

building foundations are located in this woodland. The 6-foot chain link fence surrounding the area limits accessibility to the site by some organisms.

Area 2D – IOP Detonator Load Line (AUS-0A2D)

This area has little, if any, native ecology. The site consists primarily of mowed fescue with a few ornamental trees around the buildings, roads, and driveways. Drainage ditches along the fence are overgrown with brush and trees. The trees are approximately 10 to 20 years of age.

Area 2F – IOP Fuse Load Line (AUS-0A2F)

Area 2F is about 26 acres and is located east of Area 2B. Entrance to the site is through the security entrance for Area 2D. Little natural habitat exists in this area. The habitat is mostly mowed fescue with a few solitary large trees standing on the site. Ditches with tree and brush vegetation run along the fence line. Agricultural fields surround the area. Geese from the agricultural fields have been observed within Area 2F.

Area 2P – IOP Primer Load Line (AUS-0A2P)

Area 2P is located south of Areas 2D, 2B, and 2F and is approximately 60 acres in size. Vegetation consists mostly of mowed fescue. There are a number of ditches within the site with intermittent streams. Vegetated ditches also run along the fence that borders the site. Fescue that is mowed annually lies to the east of Area 2P. There is mature woodland (oak/hickory forest) to the north and west. A mixture fescue field and brushy woodlands exists south of the site. There is a swampy area, just along Crab Orchard Lake, approximately ¼ mile west of Area 2P.

3.1.1.2 Area 4 East – IOP Automotive and Equipment Shop Area (AUS-0A4E)

Very little native habitat occurs within Area 4 East. Two buildings remain on site, one is scheduled for demolition and the other is used for shipping and receiving activities. The building foundation of the IOP vehicle refueling station lies adjacent to the existing building. There is a gravel parking lot that sits directly to the east of Route 148. Mixed woodlands (cedar, maple, and oak) are to the north of the site. A small (approximately 3-acre) fescue field lies south of the existing building. There are mixed woodlands to the east of the area with a shallow drainage ditch in the tree line. An open field to the south of Area 4 East contains fescue, cedar, and autumn olive, an invasive bush. A walkover survey at the site revealed several areas of stressed vegetation, industrial debris, and debris related to the maintenance of vehicles to the north of the remaining buildings.

3.1.1.3 Area 4 West – IOP West Shop Area (AUS-0A4W)

Little available habitat exists within Area 4 West; however, there are a variety of habitats adjacent to the site. Several buildings still exist in the area and are used as office space and as shipping and receiving buildings. Three buildings have been razed since the war. There are some small patches (100 ft x 100 ft) of overgrown rose, blackberry, sumac, and small trees.

Little to no aquatic habitat exists on or near the site, with the exception of some intermittent drainage. Pigeon Creek and a moist soil unit is approximately ¼ mile west of this area. A fescue field to the south of Area 4 West has an early intrusion of autumn olive. To the west is a mature pine plantation, a mature oak/hickory forest, and newly planted hardwoods (approximately two years old). There are well-mixed hardwoods to the north. During a walkover survey of the Area 4 West buildings, several areas of stressed vegetation were observed around the S-2-5 building (Building S-2-4 was razed).

3.1.1.4 Area 6 – IOP Ammonium Nitrate High Explosive and Smokeless Powder Storage Area

This site is actively used as a storage facility and some of the area is fenced. The total area of the site is approximately 500 acres. The habitat immediately surrounding the igloos is old field and an active crop field. The old field consists of open areas with mowed fescue and some brushy growth of sumac, autumn olive, and other invasives. There is some agriculture between the magazine roads where winter wheat, soybeans, and corn are planted. Most of the igloos have mature trees (30 to 40 years old) growing on them. Roadside ditches with poor drainage contain standing water following rainfall. There is a shallow impoundment of Little Creek that receives runoff from Area 6. This impoundment has become a source of food for some waterfowl and bald eagles. Large solitary trees that may be used for perching by aerial predators are located in this area and nesting of bald eagles has been observed between Little Creek Impoundment and Crab Orchard Creek within about ½ mile to the southeast. Cattle graze the fescue field to the north of Area 6 in the summer months. There are also watering ponds for the cattle. The fescue field is bordered by mature oak/hickory forest. There are also mature woodlands to the south and west. Open fields lie to the east of Area 6. Some agriculture (corn) also exists around the borders.

3.1.1.5 Area 7 – IOP Inert Storage Area

Area 7 is located 0.5 miles north of Ogden Road on Chamness Road in a remote area of the Refuge. The site is actively used as a storage area and is about 60 acres in size. During the site walkover of Area 7, none of the typical signs of environmental impacts were observed in the areas of the razed buildings. The site is composed mainly of mowed fescue. Interspersed wet drainages hold shallow water. Young (approximately 30 years old), mixed woodland exists to the west of the site. This woodland is in a middle successional stage. A 200-foot corridor of brush and mature oaks, on the south side of Area 7, leads to an open field that is mowed annually. This field will be planted to hardwood forest. There are also a few areas along ditches to the south with mature trees. Mixed (successional) woodland lies to the north and east of Area 7. A pond with fish is located about 1/3-mile northeast of the site. This pond attracts feeding blue heron; however, the birds do not visit Area 7. Raccoons regularly visit Area 7, and turkey and bobcat have also been observed in the area.

3.1.1.6 Area 8 South – IOP Load Line III (AUS-0A8S)

Area 8 South is about 190 acres and consists of an intermixed habitat. There are no industrial activities occurring within this area. There is open field with fescue, broom sedge, goldenrod,

small cedars, and sumac. The field is spotted with large cedars, black locust, and some thick brushy areas (early successional). The brushy areas are young woodlands of about 20 years with a dense under-story and few older trees. There are a few areas of older trees (greater than 50 years) and clear under-story. Little to no standing water exists on site. There is a pond on the far south side of the area. Some older woodlands exist to the south, east, and west. Wolf Creek is southwest of the area.

3.1.1.7 Area 9 – IOP Load Line I (AUS-0A09)

Area 9 is about 70 acres and is composed primarily of mowed fescue. Some ditches and flooded areas hold water. There is an area containing cattails. Some areas, spanning approximately ¼ acre, have trees. Woodland exists to the west of the site and an agricultural field lies to the east. Crab Orchard Lake is to the north. Deer, turkey, and geese have been observed within Area 9. Piscivorous birds travel nearby but do not enter the site since the ditches do not support fish. However, these birds, along with mink and raccoon may be transient visitors to Area 9, as the ditches may contain crayfish and other food items.

3.1.1.8 Area 10 – IOP Fuse and Booster Storage Magazines (AUS-0A10)

Area 10 is composed of successional woodland and is about 40 acres in size. The habitat is primarily young, dense woodland with a few large, mature trees. There are areas of thick saplings and vines and a few patches of unmowed fescue. The northern portion of Area 10 is part of a 40 acre designated natural area. The Area 10 natural area extends north of the site and is a unique forest community designated by the occurrence of a black willow forest. Area 10 is bounded on all sides by mature woodland (oak/hickory/willow forest).

3.1.1.9 Area 11

Area 11 has been divided into five sub-units according to the specific activities that were conducted in particular areas. While this is functional for the sampling investigation and derivation of the chemicals of interest, the area is basically a continuous habitat patch of approximately 180 acres. Though relic building foundations are present, the entire area has been left untouched for 20 to 30 years. The habitat consists of thick patches of invasive vines, autumn olive, and sassafras. Roadbeds cross the site. Some patches of woodland are found in this area. There are numerous ditches and small ponds. Most of the ponds are ephemeral and too small to support fish. Wood ducks and occasional dabbling ducks visit Area 11. There is evidence of beavers, probably associated with Wolf Creek and its tributaries, that feed within Area 1. Area 11 subareas were discussed in Section 2.

3.1.1.10 AUS-0A12 – Area 12 Former Ammonium Nitrate Plant

Area 12 is about 80 acres. Though similar in habitat to that of Area 11, this site is less open and more consistently wooded with less fescue. The east-end of Area 12 has more mature (40 to 50 years old) woodlands. There are not a lot of big trees, but it is more shaded. Numerous ditches and ponded areas exist within the site. Area 12 is bound on the east, west, and south by woodlands.

3.1.1.11 AUS-0A13 – IOP Finished Ammunition Igloos

AUS-0A13 encompasses approximately 500 acres. The design of Area 13 is similar to that of Area 6, in that both sites are storage areas with igloos and parallel roads. The habitat of Area 13 consists of mowed fescue with patches of woodland, brush, and vegetation. Hayfields and agricultural fields exist on site. The hayfields within the Refuge are usually red clover or fescue. The hay is cut off once or twice per year. The hayfields usually receive more visitations by animals than the agricultural fields because the hayfields are not as disturbed. Area 13 contains wetland habitat. Ponds within this site are capable of supporting fish. Herons and ducks visit one very large pond that borders Area 13. Ditches within the site that are poorly drained contain standing water following rainfall. Area 13 is bound on all sides by woodlands. The Big Grassy Creek Natural Area borders to the southwest. This area supports a mature white/red oak and sassafras/persimmon forest community. The area also supports wood duck nesting and bald eagle use. There are also a number of cemetery sites of historic significance in the area.

3.1.1.12 AUS-0062 to AUS-0069 and AUS-0109 COC Area Sites

The Crab Orchard Cemetery (COC) sites are all in remote areas. Some of the sites are near the Lake (AUS-0069 and AUS-0066) while others border open fields or woodlands.

AUS 0062

This site is an old field. The site is brushy with young saplings (5 to 10 feet tall), vines, and invasive thorny bushes such as autumn olive, sassafras, and blackberry. A ditch runs through the site and there is ponding water in a couple of locations. AUS 0062 is surrounded on all sides by cropland. An abandoned road runs along the north side of the site.

AUS 0063

This site is an old field, within a mixed woodlands of approximately 50 to 70 years of age. There are a number of small water filled depressions from past munitions detonations dotted throughout the site. There is also a small intermittent drainage stream that runs through the site. There is an abandoned road on the north and west perimeters of the site. An agricultural field to the south and mature woodlands to the north border the site.

AUS 0065

This site is composed of a small, open mature woodland with a thicker canopy and not as much brush. There are several mounds of soil, a brick structure, two building foundations, and three ground depressions. One depression contains building debris and another has ponded water. A fence runs along the southern perimeter of the site. Fallow field surrounds AUS 0065. The field has early pioneer weeds and small hardwood saplings that have been planted. It will take approximately 50 years until this field is mature hardwood.

AUS 0066

This site, like AUS 0065, is open mature woodland with a thicker canopy and little brush. A pond of about 60 feet in diameter exists on the site. A red clay brick berm is located on the south side of the pond. An abandoned road and barbwire fence borders the north side of this site. Mixed mature woodlands surround the area. AUS 0066 is approximately 200 feet from Grassy Bay of Crab Orchard Lake.

AUS 0067

The habitat of this site is like that of AUS 0065. There is a soil pile and a sunken area with concrete slabs, brick, and old foundation pieces. A road runs along the western perimeter of the site with an adjacent barbwire fence. ASU 0067 is completely surrounded by old field habitat.

AUS 0069

This site is a small wooded area. Approximately 5 acres of the site are located on the Crab Orchard Lake shore. Scattered debris exists in three different locations within the site. Hay fields lie to the west, east, and south.

AUS 0109

This site is an agricultural field that is currently planted and completely surrounded by corn. Woodland exists several hundred feet to the northwest.

3.1.1.13 AUS-0001 – IOP Fire and Police Headquarters

There are two ditches and a gravel parking lot within this site. Brushy woodland growth exists directly around, and is beginning to overtake the foundations of former buildings. The site is bounded on the east by Wolf Creek Road. Cedar and maple woodlands (20 to 30 years old) surround the site on the north, south, and west sides. A fescue hay unit borders the east side.

3.1.1.14 AUS-0002 – IOP Wastewater Treatment Plant

Site AUS-0002 is in a stand of trees just west of a pond. New vegetation, including intrusives such as cedar, autumn olive, and sassafras, are directly around the area. A fescue hay unit exists to the east and south. A corridor of mature trees leads north from the site to a field planted to trees. A cool-season native grassland buffer planted around the site leads to this woodland. The treatment building was razed, however settling lagoons still exist. Dense vegetation now exists all around the area of the settling lagoons.

3.1.1.15 AUS-0018 – IOP Railroad Classification Yard

Site 0018 is composed primarily of woodland and brushy overgrown areas. There is shallow standing water in ditches. A parking area also exists within the site. An old field, then Old Route 13, and a residential area are located north of the site. There are some oaks on the south side. One building still stands at the site.

3.1.1.16 AUS-0021 – IOP Fire Station for Area 7

Young woodlands (20 years) of cedar and autumn olive comprise the habitat of this site. The site is bound on the south by the PCB OU landfill and on the east by Chamness Road. Older woodland exists to the north of this site and leads to AUS Area 7. A fescue field proposed for reforestation borders the west side of this site. The building has been razed and only parts of the foundation are visible.

3.1.1.17 AUS-0043 – Areas 11 and 12 Fire Station

The habitat of this site is mainly early successional woodland. A ditch runs through the site. The foundation of one building still exists. The site is bound on the south by Ogden Road and on the east and west by mature poplar, cedar, and maple woodlands. To the north is an agricultural field. This site is presently used as a staging area by tenant farmers.

3.1.1.18 AUS-0060 – IOP Fulminate Storage Igloos

All of the igloos located at Site AUS-0060 are intact and accessible, however, overgrowth in the area of the compound's fence gate limits access through the gate. There are a few areas of ponded water within the site. Ditches surround the igloos and road. The site is composed of woodland with larger trees. Crab Orchard Lake is west of the compound and open fields surround the compound on the north south and east. The storage igloos have been unoccupied for approximately 30 years.

3.1.1.19 AUS-0061 – Concrete Structures West of Wolf Creek Road

The concrete structures of AUS-0061 are approximately 0.1 miles west of Wolf Creek Road in a thin row of trees. The site is overgrown and difficult to see from Wolf Creek Road. A road runs through the site. There are ditches on either side of the road. The site has woodlands on the east and west and open fields on the north and south.

3.1.1.20 AUS-106A – Drum Disposal Area Identified During Site Reconnaissance East of Area 11

AUS-106A is located on the northern side of a former roadway (which is now impassable to vehicular traffic) that heads east from the roadway just east of former Building 9. There is a fence line crossing the former roadway, approximately 500 feet west of the site. The habitat of this site is mainly early successional woodland. A 3000 ft^2 mounded area covers 50 to 100 partially buried drums. The mounded area is located along a creek bed that contains water only during precipitation events. This site is completely surrounded by woodland.

3.1.1.21 AUS-0107 – Possible Disposal Area Identified by Aerial Photo Interpretation

The habitat of Site AUS-0107 is mature woodland. Area 8 is located southeast of the site. There is a grassy field immediately adjacent to the east. Mature woodland exists to the south and west. Ogden Road and a grassy field are to the north.

3.1.1.22 AUS-0108 –Possible Surface Disposal Area Identified by Arial Photo Interpretations

This site is located north of Ogden Road and north of Area 11. The area is partially agricultural field currently planted in corn and beans, with the remainder a mature woodland. The woodland has older trees (50 years) and brushy undergrowth. There is fairly contiguous mature woodland to the east and north. A patchy woodland/agricultural mix is located to the west. A buffer of youger woodland and a road borders the site to the south.

3.1.1.23 Summary of Habitats Associated with the AUS OU

An area habitat matrix is provided in Table 3-2 that summarizes the types of habitats and onsite and adjacent features associated with the AUS OU. Considering the areas presently characterized, there appear to be eight general habitat types presented within the areas under investigation:

- Early succession woodland
- Mid-succession woodland
- Agricultural field
- Agricultural pasture
- Urban grassland with treelines
- Urban grassland with brush
- Urban grassland with tree stands
- Old field

The term "urban" grassland is used to indicate the presence of active industrial activity, with maintained lawn present.

3.2 ENVIRONMENTAL FATE ISSUES

The largest medium in terms of areal extent associated with the AUS OU sites is soil. Windblown dust in most of the areas is not expected to be a significant pathway since most areas are vegetated. However, windblown dust may be a potential transport mechanism in areas where cultivated agricultural fields are present. The same is true for erosion. Some erosion may occur, particularly on the agricultural fields or portions of active industrial sites.

Some of the sites also contain ditches and ponds. There is the potential that offsite transport could occur during periods of rainfall. For many of the COIs, sediments in the ponds and ditches may act as contaminant sinks or reservoirs. Sediments could then sequester chemicals, and may be important to benthic invertebrates or semiaquatic receptors where sediment-dwelling organisms form a component of the food chain.

The COIs in Table 3-1 have been organized in general chemical categories (for example, alkanes, alkenes, polycyclic aromatic hydrocarbons [PAHs], inorganics, etc.), along with their physical/chemical properties. The migration and persistence of a chemical within the

environment is controlled by the physical/chemical attributes of the chemical, the physical attributes of the system, and finally by the biota within the environment. All of these attributes effect the ultimate fate of the chemical. Such interactions are site-specific, but certain generalizations can be made. This section reviews the following in general terms:

- the importance of the soil/water/sediment matrices and their character;
- the chemical attributes of the constituent in the context of fate and transport, *e.g.*, lipophilicity, solubility, and sorption phenomena; and
- relative importance of dissolution, volatilization, complexation, photolysis, advection, and biodegradation as transport processes for the chemicals.

An understanding of how a chemical stressor behaves in the environment and how it can elicit stress in an ecosystem is an important component of the ecological risk evaluation process.

3.2.1 General Chemical/Physical Properties of Organic Chemicals

One of the most illuminating properties of an organic chemical's fate and transport within the environment is its relative solubility in water and octanol (Table 3-1). The ratio between chemical concentrations in water versus octanol is represented by the octanol-water-partitioning coefficient, the K_{ow}. The K_{ow} of a chemical is a useful indication of the chemical's lipophilicity or propensity for sequestering into lipid stores within biota, the chemical's propensity towards adsorption onto organic carbon and, its ability to cross biological membranes. Empirical relationships between a chemical's K_{ow}, water solubility, organic carbon partitioning coefficient (K_{oc}), bioconcentration factor (BCF), and assimilation coefficient for biota have been drawn by numerous authors (*e.g.*, Clark *et al.* 1988, Donnelly *et al.* 1994, Lyman 1995, Mackay *et al.* 1995, Trapp and McFarlane 1995). For example, a chemical's K_{ow} is closely correlated to its affinity for organic carbon, expressed as the K_{oc}. In general, the greater the K_{ow} or K_{oc} the lower the water solubility and greater relative adsorption onto organic carbon. Donnelly *et al.* (1994) suggested relative mobility in soils based on a chemical's K_{oc}.

Soil Mobility Defined by Affinity for Organic Carbon

K_{oc}	*Log K_{oc}*	*Mobility Class*
> 2000	>3.3	Immobile
500 – 2000	2.7-3.3	Low Mobility
150 – 500	2.2-2.7	Intermediate Mobility
50 – 150	1.7-2.2	Mobile
< 50	<1.7	Very Mobile

In general, VOCs range from intermediate mobility to very mobile. In general, the majority of the semivolatile organic compounds (SVOCs)[13] that have Log K_{oc}'s in excess of 3.3 and are considered essentially immobile in soil (unless the soil itself becomes mobile through *advected transport* or *biological assimilation*).

The octanol-water partitioning (K_{oc}) of an organic chemical is also a key property affecting the environmental behavior of an organic chemical in an aquatic system. This process has a direct bearing on ecological risk assessment as it impacts exposure pathways and especially the bioavailability of a chemical.

The process and/or degree of sorption with organic carbon, whether particulate or dissolved, has been shown to reduce the apparent (effective) bioavailability of both organic and inorganic compounds (Knulst 1992; Dewitt *et al.* 1992; Goodrich *et al.* 1992). Most sorption studies used to estimate or calculate partitioning coefficients for organic chemicals involve short exposure periods (hours to days) followed by desorption periods (USEPA 1986). These studies have been performed, for the most part, under the assumption that the sediment sorption process follows first-order thermodynamic kinetics. DiToro (1985), Landrum *et al.* (1992), USACE (1985), and others have shown that this assumption is invalid. Sorption is more accurately described as a biphasic process, in which the initial phase involves the chemical sorbing onto the surface of a sediment particle, followed by a second phase in which the chemical is absorbed into the particle. This biphasic process has a greater impact on predictions of desorption than adsorption, since the contribution of the secondary absorption of a chemical within particles does not have a great influence on the overall mass or concentration. Desorption, however, can be greatly overestimated since contact time and "degree" of adsorption will affect the rate of desorption (Landrum *et al.* 1992; USACE 1985). There is evidence that, given sufficient time, desorption essentially will not occur (Karrickhoff and Morris 1985; DiToro 1985). This phenomenon is reflected in several recent articles that demonstrate reduced bioavailability (and toxicity) with the "age" of contamination in sediments (*e.g.*, Landrum *et al.* 1992).

An uncertainty in the prediction of bioavailability of sediment associated chemicals of interest is the inherent assumption of the equilibrium partitioning (EqP) approach that sorption of organic chemicals is dominated by the total organic carbon (TOC) content of the sediment. In fact, pore-water concentrations of dissolved organic carbon (DOC) also have a significant impact on the apparent bioavailability predicted by EqP (Williams *et al.* 1995).

Certain site-specific features such as soil structure have profound effects on the sorption, volatilization, and/or degradation processes of any chemical. In general, VOCs are susceptible to volatilization and degradation, and do not readily adsorb to sediments. PAHs can undergo photolysis, oxidation, and biodegradation (USEPA 1979). Some pesticides can undergo some volatilization from soils (*e.g.*, aldrin and endrin [USEPA 1979]). Others, such as chlordane and heptachlor are very resistant to degradation processes.

The significance of these processes is highly dependent on the environmental conditions to which the materials are exposed. The absorbents present in the soil, the type of soil cover, and size of macropores are highly significant site-specific considerations for most organic chemicals

[13] The SVOCs as a group comprise the BNA compounds.

due to their impact on/interaction with the process of photolysis, volatilization, and oxidation/reduction.

Volatilization of organic chemicals from soils has been measured empirically and experimentally but can be considered highly site-specific. Volatilization is hampered by sorption to the soil and entrapment by overlying moisture. Lyman (1995) provides a generalization that is useful in qualitatively describing a chemical's propensity towards volatilization using its Henry's constant where:

Volatilization Potential

H (atm m^3/mol)	*Volatilization Potential*
$< 3 \times 10^{-7}$	Chemical is less volatile than water.
3×10^{-7} to 10^{-5}	Chemical volatilizes slowly.
$> 10^{-5}$ to $<10^{-3}$	Volatilization is significant.
$> 10^{-3}$	Volatilization is rapid.

Rates of chemical biodegradation vary widely due to variations in microbial composition, nutrient concentration, chemical soil concentration (non-toxic levels), and other environmental factors (*e.g.*, temperature, anaerobic or aerobic conditions). The most significant microbial degradation PAHs occurs aerobically in acclimated populations (USEPA 1979, Lyman 1995). While strong evidence exists that significant biodegradation occurs under anaerobic conditions the best evidence is still found for aerobic degradation. Because most soils within the units under consideration here are believed to be fairly aerobic, anaerobic degradation is probably not a significant fate process.

3.2.2 Fate and Transport Mechanisms of Inorganics

The fate of metals and metalloids depends on a myriad of processes best generalized as follows (according to Kabata-Pendias and Pendias 1992);

- dissolution;
- sorption;
- complexation;
- migration;
- precipitation;
- occlusion;
- diffusion (into minerals);
- binding by organic substances;

- absorption/fixation and/or sorption by microbiota; and
- volatilization.

The most important soil parameters involved with these processes are pH and redox potential. Other factors, such as cation exchange capacity (CEC), iron and manganese hydrous oxides, humics, chlorides, and clay minerals, are all known to impact these processes as well (Kabata-Pendias and Pendias 1992).

3.3 POTENTIAL ECOLOGICAL RECEPTORS

3.3.1 Biological Characteristics and Ecological Structure

The following subsections describe the study area in the context of habitat, biological composition (structure), and system function. Habitat and composition are presented in the context of aquatic and terrestrial, or semiaquatic, *communities*. Understanding the biological characteristics and ecological structure enable the risk assessor to focus the evaluation through selection of assessment endpoints specific to the sites. *Assessment endpoints* represent ecologically relevant values based on fundamental ecological principles that consider the structure, function and dynamics of the ecological systems at risk.

Brief discussions of general community groups are presented below.

3.3.1.1 Plant Communities (Autotrophs)

Plants or plant communities are relevant in defining ecological assemblages by providing vegetative cover and shelter. Overall, eight vegetative cover types or assemblages are present at the AUS OU as described in Section 3.1:

- Early succession woodland
- Mid-succession woodland
- Agricultural field
- Agricultural pasture
- Urban grassland with treelines
- Urban grassland with brush
- Urban grassland with tree stands
- Old field

3.3.1.2 Soil Communities

Soil communities, comprised primarily of microorganisms (bacteria, fungi, molds, algae and protozoa) and invertebrates (*e.g.*, earthworms, nematodes), can be rich and diverse, both in terms of species diversity and biomass per unit area or volume (Spurr 1964, Owen 1975). Some play a significant role in the decomposition of fallen vegetation (Owen 1975), whereas some are

predaceous on other soil invertebrates. At the non-industrial portions of the AUS OU, the soil community is important for decomposition, nutrient cycling, and biomass production for utilization at higher trophic levels. However, at industrial areas, the importance of the soil communities is the role of soil invertebrates in the food web. The soil invertebrates in particular are prey items of consumers that will be considered as assessment endpoints. Through assimilation of bioaccumulative chemicals, these invertebrates represent a source of ingestion-pathway exposure to higher level consumers. Earthworms are a good example of a key pathway organism, in that they can account for up to 80% of the total macrobiotic biomass in soil (Kabata-Pendias and Pendias 1992).

3.3.2 Aquatic Microorganism and Invertebrate Communities

Several of the AUS OU sites contain ephemeral water habitats such as ditches or pools. These areas are seasonal or associated only with rainfall. Though they may be small in size and ephemeral in nature, they could potentially represent seasonal breeding areas for amphibians in the nonindustrial areas.

Several of the AUS OU sites contain permanent water (ponds) or wetlands. In permanent standing water, the aquatic microorganism and invertebrate communities may be significant in providing decomposition and nutrient cycling, and for food for higher level consumers. Because wetland sediments are anoxic, infaunal invertebrates are probably not significant. However, epifaunal invertebrates may play an important function role in decomposition and nutrient cycling. Some of the ponds contain fish, and though others do not, they may be important amphibian reproductive areas. Wetlands can also provide breeding habitat for a number of potential ecological receptors.

3.3.3 Fish

Fish are not believed to be associated with the ephemeral ditches and pools at the site since there are no direct connections to other surface water bodies that could provide recruitment. However, there are several permanent ponds, as noted in Table 3-2, which could potentially contain fish. A list of fish potentially present at the Refuge is presented in Table 3-3. Based on the preliminary types of surface water present, (ponds) likely common fish are centrarchids (i.e., sunfish), bass, and ictalurids (catfish and bullheads), as well as numerous species of minnows. Catfish and bullheads are bottom dwelling fish, and also have higher lipid content than the centrarchids and bass. Because of these characteristics, as well as an outer "skin" rather than scales, ictalurids may be more likely to contain sediment-associated contaminants.

3.3.4 Amphibians

Amphibians that may occur in the vicinity of the Refuge are presented in Table 3-4. As a group, the amphibians are the most primitive of the so-called higher vertebrates. As adults, frogs are basically terrestrial in the sense that they breathe air, but all have strictly aquatic larvae, or tadpoles. All except the treefrog and chorus frog remain in or near water most of the time. When there are temperature extremes (*e.g.*, in winter or on sunny summer days), frogs generally hibernate or aestivate in the warmest or coolest available locations. For the *Rana* sp., whose skin must remain moist, this usually means burrowing in soft aquatic sediments or riparian soils.

Amphibians at the AUS OU will generally be associated with creeks, ponds, wetlands and adjacent riparian areas.

Adult frogs are essentially sedentary in the spatial context of relevance to this investigation. All are carnivores, and their normal way of feeding is waiting in ambush. Adult frogs normally eat anything alive that is small enough to ingest, which usually means some type of crawling or flying insect, but for the bullfrog includes crayfish, fish, other frogs, mice, and small birds. The tadpoles are basically herbivorous, feeding mainly on algae and vegetable detritus.

At industrial areas with associated water bodies, amphibians are considered as potential contaminant transport pathways to higher organisms that may forage along ponds and ditches. For non-industrial areas, amphibians represent potential assessment endpoints. Though the forage biomass may be limited, amphibians are potentially components of the diets of many predatory semiaquatic vertebrates (*e.g.*, wading birds and raccoons).

3.3.5 Reptiles

Based on geographical ranges and historical information, about 31 species of reptiles could conceivably occur in the vicinity of the Refuge (Table 3-4). Reptiles like the amphibians are cold-blooded, but all are strictly air-breathing.[14] All reptiles that may be associated with the AUS OU sites, with the exception of the box turtle, are primarily carnivorous as adults, but will take other foods at times. Most are omnivorous as juveniles. All of the snakes are carnivores, with diets depending largely upon the most prevalent prey within the respective snakes' preferred habitats. Specific individuals of any of these species are unlikely to stray from relatively confined areas (i.e., a few tens or hundreds of square meters [DeGraaf and Rudis 1986; Dundee and Rossman 1989]). Snakes are potential prey items of various vertebrates, especially wading birds, some raptors, raccoons, and other snakes.

3.3.6 Birds

Many birds forage over large areas, or are seasonal migrants that are federally protected. A total of 230 species of birds are listed with at least a potential to occur in the vicinity of the Refuge based on zoogeographic information and accounts (Table 3-5). Many of these are only transient visitors that pass through the Refuge during migration and have very limited exposures. Others are present only seasonally, and some are residents of the Refuge throughout the year. For the purposes of selecting candidate ecological receptors for the screening evaluation (Section 3.6.1), focus is placed on birds believed to be relatively common and either resident or seasonally resident. This does not indicate that migratory birds are not a consideration as part of this evaluation. Rather, because resident or seasonally resident birds will be more susceptible to contaminant exposures, risks estimated based on these receptors should also be protective of birds with lower exposure[15].

[14] Many amphibians are capable of and extensively utilize "dermal" respiration via their skin. Terrestrial reptiles, for the most part, are incapable of dermal or buccal respiration and have fully developed lungs.

[15] Susceptibility is a function of both sensitivity to the chemical and degree of exposure (dose or concentration). Unless certain receptors are known to have greater sensitivity to a chemical, then identifying receptors with greater exposure is a reasonable approach to selecting those at greatest risk.

3.3.7 Mammals

A total of 38 species of mammals have a potential to occur at the Refuge (Table 3-6). There are several herbivorous ground-grazing mammals potentially present at the Refuge. These include the eastern cottontail rabbit, the white-tailed deer, the prairie vole, the woodchuck and several species of squirrels. Several mice may be common to the area. With the exception of the golden mouse (which is arboreal), these mice are herbivorous ground foragers but will consume insects and soil invertebrates on occasion (Martin *et al.* 1951, DeGraaf and Rudis 1986, USEPA 1993).

Among the carnivores, the mink is semiaquatic in nature, feeding on small mammals, birds, amphibians and fish. The weasel, though it also is generally not found far from water, feeds on small mammals, birds and insects. Six species of bat may occur at Crab Orchard. All of these species are entirely insectivorous feeding exclusively on flying insects caught in flight (air hawkers, DeGraaf and Rudis 1986). The largest carnivores potentially associated with the site are the coyote and bobcat.

The remaining mammals expected to be common or abundant within the landscape-scale ecosystem are omnivorous ground foragers. The opossum, raccoon and striped skunk are expected to be relatively common. The red fox is more carnivorous than the other common mammalian omnivores and feeds heavily on rabbits and small rodents (DeGraaf and Rudis 1986). However, the fox will also consume significant quantities of fruits when available.

3.3.8 Species of Special Value or Concern

Federally listed and State of Illinois listed threatened or endangered species potentially found on Crab Orchard National Wildlife Refuge are summarized in Table 3-7.

3.4 ECOTOXICITY

As pointed out in ERAGS, understanding the toxic mechanisms of a contaminant helps to evaluate the importance of potential exposure pathways and to focus selection of assessment endpoints. It is not the intent of this Work Plan to provide a great level of detail on the toxic mode of action of the each of the COIs listed in Table 3-1. Rather, a broader approach will be used for screening. For example, in a detailed evaluation, or where COIs are limited, it may be appropriate to limit the evaluation of PCBs to reproductive endpoints in higher level consumers because of the tendency of PCBs to biomagnify and act as a reproductive toxin in mammals. In this screening evaluation, conservative toxicity reference values will be selected using the most sensitive of reproductive, growth or survival endpoints based on information available from the readily available toxicological literature for all trophic levels for both direct and ingestion pathway exposures.

3.5 EXPOSURE PATHWAYS

The predominant source of potential contaminants at the AUS OU sites are wastes historically disposed at the sites, or releases occurring as a result of historic handling practices or spills. The primary medium associated with the AUS Sites is soils. However, transport of chemicals to other media (e.g., surface water, sediment or groundwater) may have occurred.

In the context of ecological receptors, exposure can occur via direct contact and ingestion. A diagrammatic conceptual exposure model for potential exposure pathways associated with the AUS OU sites is shown in Figure 3-2. Direct exposures are defined as direct contact between a contaminated medium and a receptor. Examples include roots of vegetation or invertebrates in direct contact with soils or sediment; or fish, amphibians or invertebrates in direct contact with surface water. Potential exposure pathways for vertebrate receptors include: (1) inhalation, dermal contact and direct ingestion of contaminated media; and/or (2) ingestion of dietary items containing chemicals as a result of bioconcentration/accumulation (i.e., food chain exposures). Although some of the COIs are volatile constituents, the inhalation exposure pathway is not considered a significant exposure pathway and is not included in the overall evaluation. There are also limitations in estimating the potential release of these chemicals from soil to subsurface soil pores or channels. However, none of the areas being evaluated represent confined areas where a "concentrated" exposure to volatile constituents may occur. Nevertheless, fossorial or burrowing organisms could potentially be exposed to volatile chemicals in soil. Though not considered significant, this remains an uncertainty in the risk evaluation.

"Direct" dermal contact with soil could potentially occur via digging for food or "dusting". However, most soil generally does not reach the epidermis because of the presence of fur or feathers and is discarded (e.g., shaken off) or ingested through preening and grooming behaviors (USEPA 1993). Semiaquatic birds and mammals can also be exposed via dermal contact to chemicals in sediment or surface water. However, as with the inhalation pathway, there is a paucity of information regarding dermal exposures to wildlife. Though inhalation and dermal pathways are considered of relatively low importance compared to direct ingestion, they contribute to uncertainty in the risk assessment.

3.6 SELECTION OF ASSESSMENT ENDPOINTS

As noted previously, assessment endpoints represent ecologically relevant values based on fundamental ecological principles that consider the structure, function and dynamics of the ecological systems at risk. They represent the focus of the ecological risk assessment. Screening level assessment endpoints are dependent upon the presence of exploitable habitat for each of the AUS OU sites. Based on the foregoing discussion, identification of potential terrestrial and aquatic assessment endpoints for the AUS Units are presented in the following subsections.

3.6.1 Aquatic and Riparian Habitat Assessment Endpoints

3.6.1.1 Assessment Endpoint #1: Protection of the Viability and Function of the Benthic Macroinvertebrate Community

Benthic invertebrate communities comprise a large portion of the base of the food chain for the entire ecosystem. Impacts to benthic invertebrate communities may have a significant direct effect (e.g., loss or reduction of forage) and indirect effect (transfer of bioaccumulative compounds) on higher trophic-level organisms. Benthic macroinvertebrates process organic material in water bodies and are important in nutrient and energy transfer as well as to the overall ecosystem function.

Hypothesis

Are the levels of site contaminants in surface water and sediment sufficient to cause adverse alterations to the structure and function of the aquatic invertebrate communities?

Measurement Endpoint

One line of evidence will be used to assess the effects of contamination within the creeks and ponds associated with the Crab Orchard AUS on the benthic invertebrate communities. Sediment and water samples collected from the various water bodies will be analyzed for contaminants. The results of these analyses will be compared with literature values that have been associated with adverse effects. Chemicals that exceed the literature values will be retained for further evaluation within the baseline risk assessment.

3.6.1.2 Assessment Endpoint #2: Protection of the Viability and Function of the Periphyton Community

The periphyton community is comprised of algae, bacteria, fungi, and meiofauna attached to the substrate in a stream. Benthic algae are generally the dominant group of organisms within the periphyton community. Stream periphyton communities can be affected by nutrient or sediment loading, light, temperature, water velocity and grazing pressure. Impacts to the periphyton community are of concern due to its role in energy flow, their potential for exposure to contaminants, and their role as a food source for higher trophic level organisms.

Hypothesis

Are levels of site contaminants in surface water and sediment sufficient to cause adverse alterations to the structure and function of the periphyton community?

Measurement Endpoint

One line of evidence will be used to assess the effects of contamination within the creeks and ponds associated with the Crab Orchard AUS on the periphyton community. Sediment and water samples collected from the various water bodies will be analyzed for contaminants. The results of these analyses will be compared with literature values that have been associated with adverse effects. Those chemicals that exceed the literature values will be retained for further evaluation within the baseline risk assessment.

3.6.1.3 Assessment Endpoint #3: Viability and Function of the Amphibian Community

The diversity, density, and reproductive success (i.e., embryonic mortality) of amphibians have been shown to be sensitive to chemical environmental stressors. Amphibians may rely on ponds associated with the Crab Orchard Site. Amphibians are important to energy transfer in the terrestrial systems as they provide a link between the aquatic and terrestrial systems and act as both predators and prey. Predation by and of amphibians contributes to balanced populations of other aquatic and terrestrial organisms, which are essential for normal ecosystem functioning.

Hypothesis

Are levels of site contaminants sufficient to cause adverse alterations to the development, growth or reproductive capacity of the amphibian community?

Measurement Endpoint

One line of evidence will be used to assess the effects of contamination within the creeks and ponds associated with the Crab Orchard AUS on the amphibian community. Sediment and water samples collected from the various water bodies will be analyzed for the contaminants. The results of these analyses will be compared with literature values, if any, that have been associated with adverse effects. Those chemicals that exceed the literature values will be retained for further evaluation within the baseline risk assessment.

3.6.1.4 Assessment Endpoint #4: Viability and Function of the Fish Community

The fish community in a stream plays a key role in ecosystem functions such as energy flow, nutrient cycling and organic matter accumulation, and is an important food resource for higher trophic level species.

Hypothesis

Are levels of site contaminants sufficient to cause toxic effects or reproductive impairment of fish that inhabit the Crab Orchard AUS?

Measurement Endpoint

One line of evidence will be used to assess the effects of contamination within the creeks and ponds associated with the Crab Orchard AUS on the fish community. Sediment and water samples collected from the various water bodies will be analyzed for the contaminants. The results of these analyses will be compared with literature values, if any, that have been associated with adverse effects. Chemicals that exceed the literature values will be retained for further evaluation within the baseline risk assessment.

3.6.1.5 Assessment Endpoint #5: Protection of Omnivorous Birds

Omnivorous birds have diverse methods of foraging (e.g., dabbling). Omnivorous birds can also have high soil/sediment ingestion rates. Soil/sediment ingestion often accounts for the majority of the contaminant uptake in food chain accumulation models. Omnivorous birds also help to regulate the growth of aquatic vegetation, algae, and benthic invertebrates. Omnivorous birds are important pathways by which nutrient and energy in the stream may be transferred between the aquatic and terrestrial environment.

Hypothesis

Are levels of site contaminants sufficient to cause toxic effects or reproductive impairment to omnivorous birds that utilize the Crab Orchard AUS?

Measurement Endpoint

A food chain accumulation Canada goose model will be used with site-specific data (sediment and water) and modeled forage concentrations (plants and benthic invertebrates) to predict the doses of chemicals ingested by omnivorous birds. These contaminant doses will then be compared to literature values to determine if a potential risk to the survival and reproduction of omnivorous birds exists as a result of the contamination at the Crab Orchard AUS.

3.6.1.6 Assessment Endpoint #6: Protection of Omnivorous Mammals

Omnivorous mammals help to regulate benthic invertebrate and fish populations. Omnivorous mammals are important pathways by which nutrient and energy are transferred between the terrestrial and aquatic environment. In many urban and/or suburban ecosystems, these species typically represent the highest trophic levels and therefore, for contaminants that biomagnify, would be receiving the greatest doses of contaminants from their forage.

Hypothesis

Are levels of site contaminants sufficient to cause toxic effects or reproductive impairment to omnivorous mammals that utilize the Crab Orchard AUS?

Measurement Endpoint

A food chain accumulation raccoon model will be used with site-specific data (sediment and water) and modeled forage concentrations (plants and benthic invertebrates) to predict the dose of the chemical ingested by omnivorous mammals. These contaminant doses will then be compared to literature values to determine if a potential risk to the survival and reproduction of omnivorous birds exists as a result of the contamination at the Crab Orchard AUS.

3.6.1.7 Assessment Endpoint #7: Protection of Herbivorous Mammals

Herbivorous mammals are organisms that rely primarily on vegetation as forage. The role of herbivores is essential to an ecosystem as they transfer the energy available in plant tissue (primary producers) to animal tissue. In addition to contributing to energy pathways in an aquatic system, herbivores foraging on vegetation regulate vegetation density, species abundance, and diversity. Herbivorous mammals may also serve as prey items for upper trophic level predators. Therefore, herbivorous mammals contribute to a balanced vegetative community, in terms of species diversity and abundance, while regulating upper trophic level terrestrial organisms.

Hypothesis

Are levels of site contaminants sufficient to cause toxic effects or reproductive impairment to herbivorous mammals that use the Crab Orchard AUS?

Measurement Endpoint

A food chain accumulation muskrat model will be used with site-specific data (sediment and water) and modeled food concentrations (plants) to predict the dose of chemicals ingested by herbivorous mammals. These doses will then be compared to literature values to determine if a potential risk to the survival and reproduction of herbivorous mammals exists as a result of the contamination within the Crab Orchard AUS.

3.6.1.8 Assessment Endpoint #8: Protection of Insectivorous Mammals

Insectivorous mammals are important in the population regulation of potentially harmful aquatic insects, such as mosquitoes. Impacts to insectivorous mammals would allow species of potentially harmful aquatic insects to obtain higher population levels than would typically occur in a system that was not impacted. Insectivores are important in nutrient processing and energy transfer between the aquatic and terrestrial environment.

Hypotheses

Are levels of site contaminants sufficient to cause toxic effects or reproductive impairment to insectivorous mammals that utilize the Crab Orchard AUS?

Measurement Endpoint

A food chain accumulation little brown bat model will be used with site-specific data (sediment and water) and modeled forage concentration (insects) to predict the dose of chemicals ingested by insectivorous mammals. The concentration in insects will be used to represent the contaminant pathway from the aquatic to the terrestrial ecosystem in this risk assessment. The contaminant doses calculated from the food chain model will then be compared to literature values to determine if a potential risk to the survival and reproduction of insectivorous mammals exists as a result of the contamination within the Crab Orchard AUS.

3.6.1.9 Assessment Endpoint #9: Protection of Insectivorous Birds

Insectivorous birds are important in the population regulation of potentially harmful aquatic insects, such as mosquitoes. Impacts to insectivorous birds would allow species of potentially harmful aquatic insects to obtain higher population levels than would typically occur in a system that was not impacted. Insectivores are important in nutrient processing and energy transfer between the aquatic and terrestrial environment.

Hypotheses

Are levels of site contaminants sufficient to cause toxic effects or reproductive impairment to insectivorous birds that use the Crab Orchard AUS?

Measurement Endpoint

In order to account for the different habitats available within the Crab Orchard AUS, two insectivorous birds will be used as measurement endpoints. For those areas which contain wetland type habitat near the water bodies, a food chain accumulation red-winged blackbird model will be used with site-specific data (sediment and water) and modeled forage concentration (insects) to predict the dose of chemicals ingested by insectivorous birds. For those areas that contain wooded habitat near water bodies, a similar food chain accumulation tree swallow model will be used.

The concentration in insects will be used to represent the contaminant pathway from the aquatic to the terrestrial ecosystem in this risk assessment. The contaminant doses calculated from the food chain model will then be compared to literature values to determine if a potential risk to the survival and reproduction of insectivorous birds exists as a result of the contamination within the Crab Orchard AUS.

3.6.1.10 Assessment Endpoint # 10: Protection of Piscivorous Birds

Piscivorous birds are upper trophic-level organisms that feed primarily on fish. Piscivorous birds selectively feed on fish of a specific size, thereby helping to regulate fish populations. The foraging behavior of piscivorous birds represents a pathway by which energy is transferred between aquatic and terrestrial ecosystems. Predators also are often required to keep prey in check, and impacts to predators could cause detrimental population explosions in prey species.

Hypothesis

Are levels of site contaminants sufficient to cause toxic effects or reproductive impairment to piscivorous birds that utilize the water bodies associated with the Crab Orchard AUS?

Measurement Endpoint

A food chain accumulation great blue heron model will be used using site-specific data (sediment and water) as well as modeled contaminant concentrations (fish) to predict the dose of chemicals ingested by piscivorous birds. These contaminant doses will then be compared to literature values to assess whether a potential risk to the survival and reproduction of piscivorous birds exists as a result of the contamination within the Crab Orchard AUS.

3.6.1.11 Assessment Endpoint #11: Protection of Piscivorous Mammals

Piscivorous mammals are upper trophic-level organisms that selectively forage on fish. Foraging behavior of piscivorous mammals represents a pathway by which energy is transferred to higher trophic levels within the terrestrial ecosystem. Predators also are often required to keep prey in check, and impacts to predators could cause detrimental population explosions in prey species.

Hypothesis

Are levels of site contaminants sufficient to cause toxic effects or reproductive impairment to piscivorous mammals that use the Crab Orchard AUS?

Measurement Endpoint

A food chain accumulation mink model will be used with site-specific data (soil and water) and modeled fish concentrations to predict the dose of chemicals consumed by piscivorous mammals. These contaminant doses will then be compared to literature values to assess whether a potential risk to the survival and reproduction of carnivorous mammals exists as a result of the contamination at the Crab Orchard AUS.

3.6.2 Terrestrial Assessment Endpoints

3.6.2.1 Assessment Endpoint #12: Protection of the Viability and Function of the Soil Community

The soil community of a terrestrial ecosystem plays a key role in ecosystem functions such as nutrient cycling and organic matter processing. Soil invertebrates can be an important food resource for upper trophic level species such as insectivorous small mammals and birds. Therefore, soil community function and viability was selected as an assessment endpoint for this risk assessment.

Hypothesis

Are levels of site contaminants in soil sufficient to cause adverse alterations to the structure and function of terrestrial invertebrate communities?

Measurement Endpoint

One line of evidence will be used to assess the effects of contamination within the soil associated with the Crab Orchard AUS on the terrestrial invertebrate communities. Soil samples collected from the various sites will be analyzed for the contaminants. The results of these analyses will be compared with literature values that have been associated with adverse effects. Those chemicals that exceed the literature values will be retained for further evaluation within the baseline risk assessment.

3.6.2.2 Assessment Endpoint #13: Protection of the Viability and Function of the Vascular Plant Community

The terrestrial rooted vascular plant community provides many functions within the ecosystem. Included within these functions are: erosion prevention (both water and wind caused erosion), promotion of rainwater percolation, restriction of sheet water flow leading to reduced flooding potential, reduction of surface wind velocity, providing nesting and cover habitat for wildlife, primary production via photosynthesis, and a source of organic mater input (energy) to streams

and soil systems. Because the terrestrial plant community is critical to the overall function of the terrestrial ecosystem, a viable terrestrial plant community was selected as an assessment endpoint for this risk assessment.

Hypothesis

Are levels of site contaminants in soil sufficient to cause adverse alterations to the structure and function of terrestrial vascular plant communities?

Measurement Endpoint

One line of evidence will be used to assess the effects of contamination within the soil associated with the Crab Orchard AUS on the terrestrial plant communities. Soil samples collected from the various sites will be analyzed for contaminants. The results of these analyses will be compared with literature values that have been associated with adverse effects. Those chemicals that exceed the literature values will be retained for further evaluation within the baseline risk assessment.

3.6.2.3 Assessment Endpoint #14: Protection of Herbivorous Birds

Herbivorous birds were selected for evaluation because they feed mostly on plant tissue (whether it be stems or fruits and seeds). Herbivorous birds also help to regulate the growth of vascular plants, and are an important pathway by which nutrient and energy in the terrestrial system may be transferred.

Hypothesis

Are levels of site contaminants sufficient to cause toxic effects or reproductive impairment to herbivorous birds that utilize the Crab Orchard AUS.

Measurement Endpoint

In order to account for the different habitats available within the Crab Orchard AUS, two herbivorous birds will be used as measurement endpoints. For those areas which contain maintained turf and low grasses, a food chain accumulation Canada goose model will be used with site specific data (soil) and modeled forage concentration (plants) to predict the doses of chemicals ingested by herbivorous birds. For those areas that contain old field and wooded habitat, a similar food chain accumulation goldfinch model will be used. The contaminant doses calculated from the food chain model will then be compared to literature values to determine if a potential risk to the survival and reproduction of insectivorous birds exists as a result of the contamination within the Crab Orchard AUS.

3.6.2.4 Assessment Endpoint #15: Protection of Herbivorous Mammals

Herbivorous mammals are organisms that rely primarily on vegetation as forage. The role of herbivores is essential to an ecosystem as they transfer the energy available in plant tissue

(primary producers) to animal tissue, and make it available to upper trophic level organisms. In addition to contributing to energy pathways in a terrestrial system, herbivore foraging on vegetation regulates vegetation density, species abundance, and diversity. In addition, herbivorous small mammals serve as prey items for upper trophic level predators. Therefore, herbivorous small mammals contribute to a balanced vegetative community, in terms of species diversity and abundance, while regulating upper trophic level terrestrial organisms.

Hypothesis

Are levels of site contaminants sufficient to cause toxic effects or reproductive impairment to herbivorous mammals that utilize the Crab Orchard AUS?

Measurement Endpoint

In order to account for the different habitats available within the Crab Orchard AUS, 2 herbivorous mammals will be used as measurement endpoints. For areas with edge habitat and old forest, a food chain accumulation white-tail deer model will be used with site specific data (sediment and water) and modeled forage concentration (vegetation) to predict the dose of chemicals ingested by herbivorous mammals. For those areas that contain old-field habitat, a similar food chain accumulation white-footed mouse model will be used. The contaminant doses calculated from the food chain model will then be compared to literature values to determine if a potential risk to the survival and reproduction of herbivorous mammals exists as a result of the contamination within the Crab Orchard AUS.

3.6.2.5 Assessment Endpoint #16: Protection of Insectivorous Birds

Insectivorous birds are organisms that rely primarily on insects as forage. The foraging behavior of insectivorous birds represents a pathway by which nutrients and energy are transferred from lower to higher links in the food chain For example, insects are consumed by mid-level insectivores which are in turn consumed by an upper level consumer. Insectivores may also transfer energy from the detrital food chain to the predator food chain in that insectivores may consume detritivores (e.g., millipedes) thereby providing a link between the two chains.

Hypothesis

Are levels of site contaminants sufficient to cause toxic effects or reproductive impairment to insectivorous birds that utilize the Crab Orchard AUS?

Measurement Endpoint

A food chain accumulation robin model will be used with site-specific data (soil) and modeled forage concentration (earthworms) to predict the dose of chemicals ingested by insectivorous birds. The contaminant doses calculated from the food chain model will then be compared to literature values to determine if a potential risk to the survival and reproduction of insectivorous birds exists as a result of the contamination within the Crab Orchard AUS.

3.6.2.6 Assessment Endpoint #17: Protection of Insectivorous Mammals

Insectivorous mammals are important in the population regulation of terrestrial insects, such as grubs and earthworms. Impacts to insectivorous mammals would allow species of terrestrial insects to obtain higher population levels than would typically occur in a system that was not impacted. Insectivores are important in nutrient processing and energy transfer in the terrestrial environment.

Hypotheses

Are levels of site contaminants sufficient to cause toxic effects or reproductive impairment to insectivorous mammals that utilize the Crab Orchard AUS?

Measurement Endpoint

A food chain accumulation short tail shrew model will be used with site-specific data (soil) and modeled forage concentration (earthworms) to predict the dose of chemicals ingested by insectivorous mammals. The contaminant doses calculated from the food chain model will then be compared to literature values to determine if a potential risk to the survival and reproduction of insectivorous mammals exists as a result of the contamination within the Crab Orchard AUS.

3.6.2.7 Assessment Endpoint #18: Protection of Carnivorous Birds

Carnivorous birds are upper trophic level organisms that rely primarily on animal tissue, such as small mammals, as forage. This foraging behavior represents a pathway by which nutrients and energy are transferred from lower to higher links in the food chain. In addition, foraging on small mammals regulates small mammal density, species abundance, and diversity. Carnivorous birds are susceptible to exposure to contaminants because certain contaminants can bioaccumulate in the organisms upon which they feed.

Hypothesis

Are levels of site contaminants sufficient to cause toxic effects or reproductive impairment to carnivorous birds that use Crab Orchard AUS?

Measurement Endpoint

A food chain accumulation red-tailed hawk model was employed using site-specific data (soil and water) and modeled small mammal concentrations to predict the doses of chemicals ingested by carnivorous birds. These contaminant doses will then be compared to literature values to determine if a potential risk to the survival and reproduction of carnivorous birds exists as a result of the contamination at the Crab Orchard AUS.

3.6.2.8 Assessment Endpoint #19: Protection of Carnivorous Mammals

Carnivorous mammals are upper trophic-level organisms that selectively forage on lower trophic-level organisms such as small mammals. Foraging behavior of carnivorous mammals

represents a pathway by which energy is transferred to higher trophic levels within the terrestrial ecosystem. Predators also are often required to keep prey in check, and impacts to predators could cause detrimental population explosions in prey species.

Hypothesis

Are levels of site contaminants sufficient to cause toxic effects or reproductive impairment to carnivorous mammals that use the Crab Orchard AUS?

Measurement Endpoint

A food chain accumulation coyote model will be used with site-specific data (soil and water) and modeled small mammal concentrations to predict the dose of chemicals ingested by carnivorous mammals. These contaminant doses will then be compared to literature values to determine if a potential risk to the survival and reproduction of carnivorous mammals exists as a result of the contamination at the Crab Orchard AUS.

3.6.3 Unit-Specific Assessment Endpoints

The assessment endpoints selected above are specific with respect to the ecological entity to which they apply, but are broad in the context of unit-specific applicability. Consistent with the Refuge management goals (Section 1.2) for sustaining wildlife, agricultural, recreational and industrial purposes, approaches to applying specific assessment endpoints to individual sites at the AUS OU were subdivided into three categories:

- Industrial area with no exploitable ecological habitat - no further ecological evaluation will be conducted.
- Active industrial areas with limited habitat – These areas may occasionally be exploited by organisms that normally reside outside the unit boundaries of the site. Vegetation and receptors such as invertebrates or small mammals that may be present on the site will not be considered as relevant assessment endpoints. Only ingestion pathway exposures are considered relevant. Though some of the units with active industry contain ditches, all are ephemeral and are not considered to contain significant aquatic habitat. Therefore, potential receptors will be limited to terrestrial or upland receptors. The vegetative information for each of the sites is currently qualitative, and the amount (i.e., biomass) of vegetation present on each of the sites is unknown. It will be assumed in the screening process that at least some vegetation such as foliage or seeds may be available as forage for some receptors. Thus, both herbivorous and carnivorous consumers may utilize the area.
- If the habitat is nonindustrial (or historically industrial but currently inactive), then selection of assessment endpoints will be consistent with the type of habitat present (i.e., terrestrial or aquatic), and whether the pathway is via direct contact, or ingestion.

The applicability of each of the assessment endpoints to a particular unit is based on the industrial character of the site and the type of habitat present. Based on the preliminary habitat descriptions presented in Section 3.1.1, and Table 3-2, assessment endpoints were assigned to each unit as summarized in Table 3-8.

3.7 SCREENING-LEVEL EXPOSURE ESTIMATE AND RISK CHARACTERIZATION (STEP 2 – ERAGS)

3.7.1 Estimates of Exposure

The types and numbers of analyses varies among each of the AUS OU sites depending on the historical activities at the site as outlined in the *Field Sampling Plan Site Inspection Additional and Uncharacterized Sites Operable Unit* (URS 2000b). For the purposes of exposure estimation at the screening level, only the maximum concentration of a constituent identified at each site will be evaluated. This is consistent with the overall conservative nature of the screening process to ensure that constituents that could potentially contribute to risk are not eliminated early in the process. The maximum concentration is directly applicable to direct exposures.

For ingestion pathway exposures, however, meaningful inferences about the potential hazards of ingesting COIs requires an understanding of the relationship between exposures, expressed as *doses* or rates (i.e., mass of COI/unit of receptor body weight/unit of time), and *responses*. Doses are estimated using:

- The measured and/or predicted concentrations of each COI in media assumed to be ingested (i.e., food, water, sediment, and soil); and
- Estimations of the mass of each COI consumed per day, obtained by multiplying the concentration (mg/kg or μg/L) in a medium by the amount of that medium (kg or L) assumed to be ingested by an individual in the population of the receptor species and expressed in terms of the mass (body weight) of the receptor (mg/(kg-day).

Ingestion-pathway exposures to the vertebrate candidate receptors are estimated as *average daily doses* using the approach outlined in USEPA (1993) as follows:

(1) $ADD = [(IR_{food}*C_{food}) + (IR_{water} * C_{water}) + (IR_{soil}*C_{soil}) * AUF/BW$

where:

ADD	=	Average Daily Dose (mg/kg/day)
IR_{food}	=	Ingestion rate of food (kg/day)
IR_{water}	=	Ingestion rate of water in (L/day)
IR_{soil}	=	Ingestion rate of soil in (kg/day)
C_{food}	=	Concentration of contaminant in food (mg/kg)
C_{food}	=	[(diet composition[16]$_{food1}$*C_{food1})+(diet composition$_{food2}$*C_{food2}) .... food$_n$]/100
C_{water}	=	Concentration of contaminant in water (mg/L)
C_{soil}	=	Concentration of contaminant in soil (mg/kg)

[16] Diet composition is input as a percentage of the overall diet. The sum of all should equal 100.

AUF = Area use factor (percent) – assumed 1 in the screening evaluation

BW = Body weight (kg)

COI concentrations in dietary items other than soil, water and sediment are not available – specifically, plants, soil and sediment invertebrates, small reptiles, mammals, and birds. Estimation of the COI concentrations within these dietary items will be derived using mathematical procedures. A detailed presentation of the mathematical approaches used in calculating concentrations in dietary items is presented in Appendix A.

To estimate the environmental dose for ingestion pathway exposures, relevant information regarding the behavior and physiological attributes of potential receptors is also required. For the assessment endpoints in which ingestion pathway exposures will be evaluated, these receptors were identified as part of the food-chain accumulation model identified in the measurement endpoint. These receptors are hereafter referred to as candidate receptors. The following ingestion-pathway exposure factors (assumptions) were identified for each of the candidate receptors:

- Area use (acres)
- Composition of the diet
- Rate of ingestion of food (kilograms/day; IR_{food})
- Rate of ingestion of water (liters/day; IR_{water})
- Rate of ingestion of sediment (kilograms/day, $IR_{sediment}$)
- Body weight (kilograms; BW)

These characteristics are summarized for the candidate receptors in Table 3-9. All of the foregoing are developed in the context of a hypothetical individual of a vertebrate consumer species representing the receptor group or guild. Relatively few empirical measurements of these attributes in wildlife species are available, and those that are available are often based on captive specimens. For these and many other reasons, *assumed* values for these attributes represent uncertainties. Uncertainty can never be totally eliminated, but prudent application of well-documented information about the behavior and physiology of the receptors minimizes uncertainty. For this reason, EPA commissioned the compilation of the *Wildlife Exposure Factors Handbook* (USEPA 1993), which warns its readers that in any given ecological risk assessment it is crucial to apply site-specific or region-specific knowledge whenever possible. The assumptions used in this analysis are all based on formally-published information for the species, or plausible surrogate species. Generally-accepted principles and qualified-professional judgment are used to derive assumptions from relevant literature (mainly USEPA 1993 and primary sources cited therein) that could be representative of conditions at sites within the AUS OU. At the same time, to avoid underestimating exposures, whenever ranges of values are available, the approach consistently incorporates a value at or near the conservative end of the range.

3.7.1.1 Area Use

Area use relates to the fraction of ingested media derived from a unit or area. However, for the purposes of a screening level evaluation, area use factors for all receptors will assumed to be one. That is, it will be assumed that a receptor obtains all of its forage from individual sites.

3.7.1.2 Dietary Composition

In nature, the diets of most vertebrates vary considerably (Allee *et al.* 1951; Martin *et al.* 1951). Some have morphological, physiological, and/or behavioral adaptations that limit their ability to use certain broad categories of food. In general, however, there is a paucity of detailed quantitative dietary studies, and these relate primarily to localized populations of only a few species (USEPA 1993). Diets identified for the candidate receptors are based on consideration of the feeding patterns of the potential receptors and the way food habits are commonly described in the literature. For some of the potential receptors, there are proportional breakdowns of the diet which conform to (or can be readily converted to) dietary components. In other cases, it is necessary to infer categorical allocations from qualitative descriptions. Dietary composition breakdowns for the selected representative receptors are presented in Table 3-9.

3.7.1.3 Food Ingestion Rate (IR_{food})

Most of the food ingestion rates in Table 3-9 are based on allometric relationships developed by Nagy (1987; all reproduced in USEPA 1993). In the absence of empirical measurements specific to the selected receptors, use of the allometric equations is appropriate because these are widely-accepted, empirically-derived relationships. Body weights at the low end of the range reported in the literature were used in the equations to derive the food ingestion rate (see below).

3.7.1.4 Water Ingestion Rate (IR_{water})

The applicable equations of Calder and Braun (1983; also available in USEPA 1993) were used to calculate the ingestion of water in liters per day. Water ingestion rates for selected representatives for the ecological receptors are shown in Table 3-9.

3.7.1.5 Sediment Ingestion Rate ($IR_{sediment}$)

Many higher vertebrates are known to ingest sediment, usually incidentally to feeding or grooming (USEPA 1993; Beyer *et al.* 1994)[17]. The quantities are often a function of the animal's feeding habits; for example, some small mammals that feed extensively on the roots of emergent vascular plants (e.g., the muskrat) ingest relatively high amounts of sediment. For some receptors, the literature provides directly measured rates that reflect conditions that might occur within the AUS OU. Otherwise, professional judgment has been used in interpreting reported rates, or extrapolating from surrogate species. The rate is normally estimated as a percentage of

[17] There are also some vertebrates which deliberately ingest soil, a phenomenon called geophagy. For example, white-tailed deer commonly lick or nibble exposed soil or rock surfaces to acquire trace minerals.

the overall diet, and then converted to mass/day. The assumed sediment ingestion rates ($IR_{sediment}$) are included in Table 3-9.

3.7.1.6 Body Weight (BW)

Body weight is an important factor because it is often used in calculating other exposure assumptions when realistic direct measurements are not available (e.g., food and water ingestion rates). When a range is reported, literature values have been adopted which, based on professional judgment, are representative of the low extreme for wild adults in Illinois habitats. Assumed body weights for the candidate receptors are presented in Table 3-9.

3.7.2 Effects Assessment

To effectively screen the COIs, it is necessary to understand the level at which a COI may affect ecological receptors via direct or ingestion pathways. Effects are based on identification of relevant toxicity reference values (TRVs). For direct exposures, TRVs essentially represent a screening concentration, and the ratio of the media-specific exposure concentration to the TRV is referred to as a hazard quotient. For ingestion pathway exposures, the ratio of the TRV to the ADD is used to develop a hazard quotient. TRVs are discussed for each of the assessment endpoints in the following subsections.

3.7.2.1 Direct Exposure Toxicity Reference Values (TRVs)

TRVs for Soil-Associated Organisms

> Soil organisms are those organisms in intimate contact with the soil. These include invertebrates such as earthworms and insects, plants such as soil algae or vascular plant roots, and soil microbes (bacteria and fungi).

There are multiple TRVs available for soil-associated organisms. The goal was to identify a single TRV from among the many values to apply in the AUS OU ecological screening evaluation. To the extent possible, TRVs that are "effect-based" are selected over those that reflect a desired or "target" level (e.g., those disseminated by US Fish and Wildlife [Beyer 1990] and some of those from MHSPE 1994). Additionally, it is recognized that some the available TRVs within the scientific literature are below typical soil and sediment concentrations considered "natural," undisturbed or background levels. Reasons for this include the reliance on laboratory-based "spiking" experiments to derive the TRVs. Additional problems are encountered when experimenters and those using experimental results to derive TRVs fail to account for the existing level of chemical within soil and/or sediment prior to the spiking experiment. Many of the soil TRVs for the naturally occurring inorganics disseminated by the Oak Ridge National Laboratory (i.e., Efroymson et al. 1997a and 1997b) suffer from this error. Thus, TRVs will first be evaluated in the context of site-specific background concentrations.

TRVs for soil organisms were obtained from US Fish and Wildlife Service (Beyer 1990), Efroymson et al (1997a, 1997b), Environment Canada (1995), NOAA (1999), the MHSPE (1994), and the scientific literature. Summaries and selection of screening TRVs for direct

exposures to soils are presented in Table 3-10. The relevant endpoints for the TRVs include no-observed adverse effect-concentrations (NOECs) and/or threshold-effects levels (e.g., *some* of the Dutch intervention levels or limits[18]). While presented, the lowest-observed adverse effect-concentrations and/or lethal concentrations (LC_{50}s) are not considered appropriate for screening purposes. Whenever possible, the TRV selected is the highest NOEC below the lowest LOEC or the highest observed NOEC if no effects level has been established for the chemical. This ensures that the screening process is conservative, while not just defaulting to the lowest chemical concentration reported. USEPA Region III screening concentrations were also compiled for fauna and flora. These values were used only in the absence of other information, since the basis for these values could not be ascertained.

TRVs for Sediment-Associated Invertebrates, Periphyton and Vascular Plants

TRVs specific to freshwater sediment were obtained from a number of sources and are summarized in Table 3-11.

Though none of the TRVs are specific to periphyton or vascular plants, it was assumed that the benthic macroinvertebrates, in general, are equally, or more sensitive to chemicals than plants. Therefore, the TRVs for sediment-associated invertebrates are reasonably protective of vascular plants. Sources included the following:

- Consensus-based freshwater sediment criteria (MacDonald et al. 1999)
- USEPA (1996 – summarized by Ingersoll *et al.* 1996)
- Ontario Ministry of the Environment and Energy (1995)
- NOAA (1999)
- Oak Ridge National Laboratory (1997 – Efroymson *et al.* 1997a and 1997b)
- USEPA Ecotox (1996a)
- Long *et al.* (1995)
- Florida Department of Environmental Protection (1994)
- Equilibrium partitioning
- Other

TRVs will first be evaluated in the context of background concentration. Background sediments were sampled as part of the Crab Orchard Lake Operable Unit evaluation. These data will be used to develop site-specific background sediment concentrations when they become available. If the background concentration is higher than chemical-specific effects-based TRVs, then the background will be selected as the default screening concentration.

With respect to effects levels, there are a number of potential sources and endpoints, as can be seen from the list above, and in examination of Table 3-11. The sources as presented in bullet form above represent the prioritization in which sediment TRVs were selected.

[18] Some of these values are based on background values and not effect levels.

There are also multiple endpoints from some sources. For example, threshold effects levels (TELs) as reported by USEPA (1996b) are the geometric mean of the 15th percentile in the effects data set and the 50th percentile in the no-effects data set. The effects-range low (ERL) and effects-range medium (ERM) are the 15th percentile and 50th percentile values in the effects datasets, respectively. The Probable Effects Level (PEL) is the geometric mean of the 50th percentile in the effects data set and the 85th percentile in the no-effects data set, and the effects range medium is the 50th percentile value of the effects dataset. A TEL or ERL is assumed to represent a concentration below which toxic effects are rarely observed. The range between the TEL and PEL is assumed to represent the range in which effects are occasionally observed. The TEL and ERL were selected initially in order of preference.

Preference was also given to freshwater-derived values (MacDonald et al. [1999], Ingersoll et al. [1996], Ontario [1995] and NOAA [1999]) as opposed to estuarine or saltwater (Long et al. [1995], FDEP [1994]). Some sources were intentionally not used. ERMs and Apparent Effects levels were not used since they are less conservative than TELs or ERLs. The ERL values from Ingersoll et al. (1996) were not used since TELs were already reported from the same source. Region IV screening values were not used since many of the values were based on detection limit considerations rather than effects levels.

If empirical data were lacking, the "equilibrium-partitioning" (EqP) approach was used. This used the lowest chronic aquatic toxicity value reported (Table 3-12) and the expected partitioning between sediment and sediment pore water (as described in USEPA 1993). Such sediment screening values were derived using the following relationship:

$$SC = Kd * Cw$$

where:

SC = Ecotoxicological Screening Concentration in sediment

Kd = water – sediment partitioning coefficient (equal to the organic carbon to water partitioning coefficient (Koc) times the fraction of organic carbon in the sediment (assuming to be 1%).

Cw = screening value in water

Organic carbon partitioning coefficients were presented, along with other salient physiochemical parameters, in Table 3-1.

Ultimately, the single TRV selected from among the multiple sources represents the screening concentration for surface sediments.

TRVs for Direct Water Exposure

TRVs for direct exposure by aquatic organisms in surface water are relevant to fish and larval amphibians. Values were obtained, in order of preference, from:

- Illinois water quality standards;
- National Recommended Ambient Water Quality Criteria (USEPA 1999);
- EcoTox (1996a) – ambient water quality criteria

- "Tier II" chronic values calculated following the Great Lakes Water Quality Initiative (e.g., those reported in EcoTox 1996 and those calculated by Suter and Tsao 1996);
- USEPA Region IV Freshwater Screening Values (1999)
- The lowest reported chronic toxicity values, USEPA Superfund screening concentrations (EcoTox – USEPA 1996a);
- Maximum Acceptable Toxicant Concentrations (MATCs) or lowest observed effect concentrations (LOECs) obtained from the USEPA ASTER database (ASessment Tools for The Evaluation of Risk 1996);
- Other sources.

A summary of TRVs for direct exposures to surface water is provided in Table 3-12. As with sediments, these values are presented in order of preference. The Illinois water quality standards are believed to be the most relevant, followed by the national recommended ambient water quality criteria. ECOTOX reports values based on ambient water quality criteria, and Tier II water quality criteria have been developed in the absence of sufficient information to support a national recommended water quality criterion. Remaining sources were prioritized based on relevance to the area and professional judgement. The single TRV selected from among the multiple sources represents the value selected for screening COIs in surface water.

3.7.2.2 Ingestion Pathway TRVs

A literature search was conducted for appropriate dietary toxicological endpoints for ingestion pathway exposures to candidate receptors. Several databases, in addition to the open literature, were consulted, including the ECOlogical TOXcity database (ECOTOX 1996a); the Hazardous Substances DataBase (HSDB); the Integrated Risk Information System (IRIS); the TOXicity NETwork (TOXNET [HSDB], which includes MEDTECS); and the Registry of Toxic Effects of Chemicals (RTECs). Also examined were U.S. Fish and Wildlife Service *Contaminant Hazard Series* synopses, RTI (1995), Oak Ridge National Laboratory technical reports (Sample *et al.* 1996), and available ATSDR *Toxicological Profiles*. The aforementioned sources were used to provide the information necessary for selecting TRVs that will be used in the screening process. Ecotoxicological profiles for many of the COIs are presented in Appendix B. Effort was focused on development of ecotoxicological profiles for on a few "key" COIs, though it is acknowledged that what constitutes a "key" COI is arbitrary at this stage of the screening process. Specifically, profiles were developed for PCBs, PAHs, several inorganics (e.g., lead and mercury) and a few other volatile and semivolatile organic compounds. Selection of TRVs for other COIs was based on examination of the above sources and selection of an appropriate no-observed-adverse-effect level (NOAEL) using the strategy outlined below.

Endpoints reported in the literature include the lethal dose, the Lowest-Observed-Adverse-Effect Level (LOAEL), and the NOAEL. The lethal dose, expressed for example as the LD_{50}, is the dose lethal to 50% of the test organisms over a specific exposure period. Another example, the LD_{lo}, is a reported dose that is capable of producing lethality. The LOAEL is the lowest dose that results in a statistically significant effect compared to a control. The NOAEL is the highest dose where there is no statistically significant difference from the control response. For the

purposes of the screening evaluation, only the NOAEL concentrations or doses, to the extent possible, were selected as TRVs. By definition, this represents a dose or concentration at which a risk is not expected to occur. However, consistent with the objectives of a screening level risk evaluation, doses or concentrations above the NOAEL represent levels at which potential effects may occur.

Lethal dose values generally represent acutely toxic endpoints, although this must be examined in the context of the exposure duration and the test animal. For example, a lethal dose based on a 1- to 5-day exposure might be considered an acutely toxic response, whereas a lethal dose reported for 50 or 100 days might be considered a chronic response. Emphasis is placed on selection of chronic endpoints (i.e., NOAELs and LOAELs) or lethal doses over extended periods. Greater weight is given to multi-day or multi-week studies rather than single-dose studies. Additional weight is placed on those assays performed during a "critical life-stage" such as during gestation, conception, and/or early development.

The general strategy for selecting (or deriving) a single NOAEL value as a TRV from among the many values reported in the literature was as follows:

- Where literature values were identified for the specific assessment receptor, the highest NOAEL that did not exceed the lowest LOAEL was selected.
- Where values were not available for a specific assessment receptor (which is characteristic of the vast majority of literature values), values from surrogate receptors were used.
- Weight was given to the duration of the study, as well as the toxicological endpoint. Preference was given to studies that were chronic or subchronic exposure versus single event or acute exposures. Where data were available for more than one dosing regime, chronic was selected first, subchronic second, and acute only if no other data were available. Critical life-stage tests also carried significant weight.
- Studies were considered based on the dosing regime. Intraparitoneal or intravenous studies were not used. Studies using gavage or oral intubation were not used when food studies were available.
- Measures of effect considered included survival, growth and reproduction. Endpoints specifically related to survival, growth and reproduction such as fetotoxicity or infertility were also considered. Effects such as carcinogenesis, liver damage, kidney function, sperm mobility, enzyme induction, blood pressure, etc., were generally not considered appropriate measures for evaluation of population-level effects.

For certain chemicals appropriate NOAELs were not obtainable. For example, for some chemicals only acute lethal doses were available, for others only LOAELs or subchronic NOAELs were available. In the absence of a chronic NOAEL screening TRVs were derived by application of "uncertainty factors." An uncertainty factor is used to "adjust" the available toxicological information to account for the uncertainty associated with extrapolation to a chronic NOAEL. Lehman and Fitzhugh (1954) are generally recognized as the first authors to advocate the use of adjustment factors to account for uncertainty associated with the extrapolation of toxicity test results in deriving an "acceptable daily intake" (now termed the "reference dose" by USEPA) of any specific chemical in a context of protecting human health

(e.g., see USEPA 1993, Lewis et al. 1990). These uncertainty factors, as reported by USEPA (1993) are all based on an order-of-magnitude approach. For each level of uncertainty a factor of 10 is applied; e.g., extrapolating from a LOAEL to a NOAEL, extrapolating from a subchronic to chronic NOAEL, and each step in extrapolating from laboratory animal results to humans. Additionally, USEPA (1993) applies a modifying factor which varies from 1 to 10 based on a review of the adequacy of the toxicological database, number of species tested, and any other scientific uncertainty not treated under the standard uncertainty factors. USEPA further states that:

> *While the original selection of the SFs[19] appears to have been rather arbitrary (Lehman and Fitzhugh 1954), subsequent analysis of the data (Dourson and Stara 1983) lends theoretical (and in some instances experimental) support for their selection. Further, some scientists, but not all, within the EPA interpret the absence of widespread effects in the exposed human populations as evidence of the adequacy of the SFs traditionally employed.*

As pointed out by Lewis et al. (1990) these order-of-magnitude uncertainty factors as discussed by both Lehman and Fitzhugh (1954) and Dourson and Stara (1983) are not the "best estimate" values for use in extrapolation but should be regarded as boundary / limit adjustment factors. Lewis et al. (1990) furthers suggests an alternate approach to assigning uncertainty factors based on a close examination of the data in the context of extrapolating to humans.

All of the foregoing were developed for extrapolation from laboratory animals to humans. Germane to this screening evaluation is the extrapolation from laboratory animals to wild populations of birds and mammals. The use of uncertainty factors (UFs) for the derivation of wildlife TRVs is discussed within the Great Lakes Water Quality Initiative guidance (USEPA 1995). USEPA (1995) states that the UFs used in extrapolation from subchronic to chronic or from LOAEL to NOAEL are to be between 1 and 10 but do not specify any specific value for the UFs, only the boundaries or limits. As stated above, the extrapolations to be considered in deriving TRVs are (1) from acute lethal doses to chronic NOAELs; (2) from LOAELs to NOAELs; and (3) from subchronic to chronic exposures.

Weil and McCollister (1963) and McNamara (1976) independently evaluated the results of subchronic and chronic NOAELs in animal toxicity tests. Weil and McCollister (1963) found that in 30 chronic tests, only one was shown to produce a subchronic to chronic NOAEL ratio above 10 (it was less than 12) and 90% of the tests produced ratios of 5 or less. McNamara (1976) examined the ratios between 41 subchronic and chronic NOAELs and found that all of the ratios were 3 or less. Given that 96% of the studies (68 out of 71) revealed an adjustment factor of 5 or less, where only subchronic NOAELs were available from the scientific literature, an uncertainty factor of 5 was applied to extrapolate to a chronic NOAEL to derive TRVs for the AUS OU screening evaluation.

Weil and McCollister (1963) also examined the ratio between LOAELs and NOAELs in subchronic and chronic toxicity tests. All of the LOAEL-to-NOAEL ratios for the subchronic

[19] SF is an abbreviation of the term "safety factor" which has been dropped by USEPA in lieu of the use of "uncertainty factor" to clarify and distinguish between aspects of risk assessment and risk management (USEPA 1993).

studies (27 studies were evaluated) were 5 or less with an average ratio of 3. Of the 25 chronic toxicity tests evaluated, all but 2 were 5 or less, all of the studies were less than 10. The average ratio for the chronic LOAELs to NOAELs was 3.5. Here again, an uncertainty factor of 5 was deemed most appropriate for extrapolation of a NOAEL from a LOAEL result and was applied to those chemicals for which only LOAEL data were available in the AUS OU screening evaluation.

The greatest degree of extrapolation is from acute lethal doses to a chronic NOAEL. Luttik and Aldenberg (1997) examined the potential for extrapolated from acute lethal doses to a NOAEL,or more specifically a HD5 (hazardous dose to 5% of the potentially exposed species). Luttik and Aldenberg (1997) employed a statistical analysis of the results of 55 compounds (primarily pesticides) with birds (between 4 and 34 species for each compound) and 69 compounds (again primarily pesticides) with mammals (between 4 and 14 species for each compound). They deduced that the statistical variance of the species sensitivity was independent of the chemical compounds and could be described as logistically distributed. Based on these results, Luttik and Aldenberg (1997) derived a HD5 and confidence limits on the HD5. Their uncertainty factor was then calculated, derived from substitution methods, using the number of available LD_{50}s and the 95% left confidence limit of the derived variance of the dataset. Luttik and Aldenberg (1997) employ the term "safety factor" in their manuscript, but for consistency and in recognition of the USEPA (1993) policy, the term is replaced herein by "uncertainty factor." Luttik and Aldenberg's results are reproduced below:

Number of LD_{50} Values	Uncertainty Factor for Birds	Uncertainty Factor for Mammals
1	32.9	14.9
2	19.6	10
3	15.6	8.4
4	13.7	7.6
5	12.4	7
6	11.6	6.7
7	11	6.4
8	10.6	6.2
9	10.2	6
10	9.9	5.9

Reproduced from Table 1 Littik and Aldenberg (1997)

These uncertainty factors, however, do not extrapolate to a chronic NOAEL, but rather to a HD5, which must be considered subchronic. Thus, the extrapolation as detailed by Luttik and Aldenberg (1997) is from a lethal subchronic dose to a subchronic NOAEL. As discussed above, extrapolation from a subchronic to chronic NOAEL is best done by applying an UF of 5 on the subchronic NOAEL. Therefore, when only LD_{50} data were available for the chemical of interest, two UFs were applied for the AUS OU screening evaluation, first that recommended by Luttik and Aldenberg (1997) based on the number of LD_{50}s obtained from the literature, followed by an additional UF of 5.

NOAEL TRVs, associated measured effect(s), uncertainty factors applied, and applicable references for the AUS OU COIs are presented in Table 3-13 for mammals and Table 3-14 for birds. Where no entries appear on the tables, no toxicity information was located..

3.7.3 Ecological Risk Screening Concentrations

As noted previously, For ingestion pathway exposures, the ecological screening concentrations are based on a dose equal to a TRV. The ratio of the average daily dose to a TRV is generally referred to as an ecological effects quotient (EEQ). An EEQ based on a NOAEL at or below 1 is indicative of low (or no) risk. The dose corresponding to an EEQ of 1 must be presented as a media-specific value to effectively apply it as a risk-based-screening concentration. This is accomplished by back-calculating from the EEQ dose concentration to a concentration in the media of interest, using the same approach outlined in Appendix A. Using this approach, a summary of the ingestion pathway screening concentrations for each of the applicable candidate receptors and assessment endpoints is presented in Tables 3-14, 3-15 and 3-16 for soils, sediments, and surface water, respectively. The lowest ingestion-pathway media-specific screening concentration among the receptors applicable to a habitat type presented in Table 3-8 will be used for evaluating chemical data and selection chemicals of potential ecological concern. A summary of screening concentrations is presented in Table 3-16 for each media and habitat type for direct and ingestion pathway exposures.

3.7.4 Selection of Chemicals of Potential Ecological Concern

A chemical of potential ecological concern (COPEC) is a chemical, based on an initial screening of its maximum concentration in applicable media (i.e., surface soil, surface water, and/or surficial sediment[20]), which has a potential to adversely interact with the environment. Selection of COPECs from the list of COIs for the AUS OU will be based on the quotient method (Suter 1993a,b, 1995). A Hazard Quotient (HQ) will be calculated as the ratio between the predicted exposure concentration and a toxicity reference value (TRV). For direct exposures, the exposure concentration will be the maximum concentration of a COI in each relevant medium. For ingestion pathway exposures, the exposure concentration will be the ADD derived from the maximum concentration of a COI in each relevant medium. The following criteria will be used in selecting COPECs:

- If a chemical is detected below site-specific background concentrations, then the chemical will not be selected as a COPEC.
- If a chemical is not detected, and there is no TRV, then the chemical will not be selected as a COPEC.
- If the HQ for a chemical exceeds 1, then the chemical will be classified as a COPEC.
- If the HQ for a chemical is less than 1, then the chemical will not be classified as a COPEC.

[20] Subsurface media are not directly considered here as there is no complete exposure pathway for the subsurface to ecological receptors.

- If a chemical is detected, and there is no TRV, then the chemical will be carried forward as an uncertainty to the Scientific Management Decision Point (SMDP), where a decision will be made for further evaluation, or to eliminate the chemical from further evaluation.

This process of COPEC selection corresponds to Step 2 within the ERAGS Screening-Level Ecological Risk Assessment (Screening-Level Exposure Estimate and Risk Calculation). If no COPECs are identified, it is concluded that the COIs are not of potential ecological concern and no further investigation for ecological concerns would be deemed warranted.

3.7.5 Uncertainties

There are basically three types of uncertainties associated with the process of selecting COPECs: a lack of knowledge (what we do not know); a lack of data (what we can know but do not presently); and a lack of technology (the limits of our ability to measure or predict). In the context of screening for chemicals that deserve a comprehensive evaluation of potential ecological impact, not all uncertainties are equal. For example, the lack of credible oral toxicity values (TRVs) for amphibians and reptiles is a significant uncertainty in that the potential risks for these receptors cannot be fully characterized. A lack of organic carbon data for soils (for example) would not be nearly as significant. While the foregoing examples are fairly clear, others are less so.

In the present context, the most often encountered uncertainty is that of a lack of technology -- analytical sensitively for detection of chemicals in environmental media. The approach used to evaluate the significance of such an uncertainty is on a case-by-case basis using a line-of-evidence approach. Where a chemical is never detected in any media, in any area, at any time, even though the detection limit may exceed the screening concentration, then the uncertainty is not believed to be significant. Conversely, if a chemical is routinely detected in multiple media but not detected in one media where the reporting limit exceeds the screening concentration, the associated uncertainty may be significant. An uncertainty evaluation and discussion will be included in the screening risk evaluation.

Assumptions made during the screening process are conservatively applied to ensure that chemicals that warrant further consideration are not eliminated early in the process. These assumptions include use of a NOAEL TRV (i.e., a TRV where it is assumed there is no risk); application of an area use factor of 1 (receptors obtain all food intake from the study area); and 100% chemical bioavailability. COPECs and associated uncertainties will be discussed as warranting or not warranting further, more detailed evaluation as part of the SMDP following completion of the initial screening process.

As noted in Section 1, the overall guidance for the human health evaluation will follow the structure presented in *Risk Assessment Guidance for Superfund* (RAGS) (USEPA 1989). Unlike the ecological evaluation, there are readily available published screening values for application in the human health evaluation. The evaluation will use published screening concentrations for soils and surface water from USEPA Region IX. Values presented by Region IX are risk-based media-specific screening concentrations using a carcinogenic risk of 1×10^{-6} or a noncarcinogenic hazard of 0.1. Note, however, that there are no published values for evaluating sediments. Because sediments are expected to comprise a minor portion of media applicable to the AUS OU (particularly for the human health evaluation), soil screening concentrations will be used to evaluate sediments in lieu of deriving sediment screening concentrations for all COIs. This is believed to be a conservative approach, since exposures to sediments will generally be less than those for soils.

Selection of chemicals of potential concern (COPCs) for human health will be in a manner similar to the approach used in the ecological risk evaluation process. Screening concentrations from USEPA Region IX will be compared to the maximum concentration of a COI at each of the AUS OU sites to chemicals of potential ecological concern. The following criteria will be used in selecting COPCs:

- If a chemical is not detected, and there is no screening concentration, then the chemical will not be selected as a COPC.
- If an inorganic chemical is detected below site-specific background concentrations, then the chemical will not be selected as a COPC.
- If the maximum concentration of a chemical exceeds the screening concentration, then the chemical will be classified as a COPC.
- If the maximum concentration of a chemical is less than the screening concentration, then the chemical will not be classified as a COPC.
- If a chemical is detected, and there is no screening concentration, then the chemical will be carried forward as an uncertainty

As with the ecological risk screening approach, the screening concentrations are based on conservative assumptions to ensure that chemicals are not inadvertently screened out. A discussion of the uncertainties associated with the human health screening process will be included in the screening evaluation. COPCs and associated uncertainties will be discussed as warranting or not warranting further, more detailed evaluation as part of the SMDP following completion of the initial screening process.

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TABLE 3-9
MEASURES OF RECEPTOR CHARACTERISTICS
ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNIT
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Candidate Receptors	Body Weight (kg)	Ingestion Rate (kg/day)	Water Ingestion (L/day)	Soil Ingestion (percent)	Sediment Ingestion (percent)	Acrea Use (acres)	Percent Diet						
							Plant Foliage, Roots and Seeds	Aquatic Plants	Benthic Invertebrates	Fish/ Amphibians	Flying Invertebrates	Soil Invertebrates	Terrestrial Vertebrates
American goldfinch	0.012	0.003	0.003	0		0.14	98					2	
American robin	0.0773	0.011	0.0106	6		1.19						100	
Canada goose (aquatic)	3.881	1.18E-01	6.87E-01		8.2	717		98	2				
Canada goose (terrestrial)	3.881	1.18E-01	6.87E-01	8.2		717	98					2	
Great blue heron	2.229	4.01E-01	1.00E-01		2	19			45	55			
Red-tailed hawk	1.126	0.108	0.0639	2		1596							100
Red-winged blackbird	0.053	0.0086	0.0082		0	0.17	37	36	13		7	7	
Coyote	9.1	0.422	0.722	2		3635						5	95
Little brown bat	0.0075	0.0025	0.0012	0		245					100		
Mink	1	0.137	0.099		1.3	575			35	65			
Muskrat	0.73	0.07	0.075		10	0.037		90	10				
Raccoon	3.91	0.211	0.338		9.4	96	15		45	40			
Short-tailed shrew	0.015	0.008	0.003	10		0.96	10					85	5
Tree Swallow	0.016	0.0042	0.004		0	776					100		
White-footed mouse	0.027	0.004	0.004	2		0.27	90					10	
White-tailed deer	45.3	1.74	3.06	2		40	100						

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TABLE 3-14
ECOTOXICOLOGY SCREENING VALUES FOR INDIRECT EXPOSURES (INGESTION PATHWAY) TO AVIAN RECEPTORS
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Effect	Species	Dose (mg/kg-BW/day)	Reference	# of LD_{50s} [a]
Halogenated Methanes/Alkanes					
Bis(2-chloroethoxy) methane					
Bromodichloromethane					
Bromoform					
Bromomethane					
Carbon tetrachloride (Tetrachloromethane)	*LD_{50} / 32.9 / 5*	Quail	13.4	Hill & Camardese 1986	1
Chloroform (Trichloromethane)					
Chloromethane					
Dibromochloromethane					
Methylene chloride					
Halogenated Ethanes					
1,1-Dichloroethane					
1,1,1-Trichloroethane					
1,1,2-Trichloroethane					
1,1,2,2-Tetrachloroethane					
1,2-Dichloroethane	*Egg Production*	Chicken	17.2	Alumot et al. 1976 as cited in Sample et al. 1996	
Chloroethane					
Hexachloroethane					
Halogenated Propanes					
1,2-Dichloropropane					
2,2'-Oxybis (1-chloropropane)					
Halogenated Alkenes					
1,1-Dichloroethene					
1,2-Dichloroethene (total)					
1,2-Dichloroethene (cis)					
1,2-Dichloroethene (trans)					
1,3-Dichloropropene (total)					
1,3-Dichloropropene (cis)					
1,3-Dichloropropene (trans)					
Tetrachloroethene					
Trichloroethene					
Vinyl chloride					
Amines					
2-Nitroaniline	*LD_{50} / 32.9 / 5*	Quail	4.56	Arch. Environ. Contam. Toxicol. 12:355, 1983 as cited in RTECS	1
3-Nitroaniline					
3,3'-Dichlorobenzidine					
4-Chloroaniline					
4-Nitroaniline					
4,4'-Methylenebis (2-chlorobenzenamine)-MOCA					
N-Nitrosodiphenylamine					

TABLE 3-14
ECOTOXICOLOGY SCREENING VALUES FOR INDIRECT EXPOSURES (INGESTION PATHWAY) TO AVIAN RECEPTORS
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Effect	Species	Dose (mg/kg-BW/day)	Reference	# of LD_{50s} [a]
N-Nitroso-di-n-propylamine					
Benzene and Derivatives					
Benzene					
Chlorobenzene					
1,2-Dichlorobenzene					
1,2,4-Trichlorobenzene					
1,3-Dichlorobenzene					
1,4-Dichlorobenzene					
Hexachlorobenzene	*Reproduction*	Japanese Quail	0.563	Vos et al. 1971 as cited in Sample et al. 1996	
Methylated Benzenes					
Toluene					
Xylenes (total)	*Survival*	Quail	8800	Hill & Camardese 1986	
Other Substituted Benzenes					
Ethylbenzene					
Styrene					
Nitrobenzene					
Arenes					
2,4-Dinitrotoluene					
2,6-Dinitrotoluene					
Chlorinated Dienes					
Hexachlorobutadiene					
Hexachlorocyclopentadiene					
Ethers					
4-Bromophenyl phenyl ether					
4-Chlorophenyl phenyl ether					
Bis (2-chloroethyl) ether					
Phenols and Substituted Phenols					
2-Chlorophenol					
2-Methylphenol					
2-Nitrophenol					
2,4-Dichlorophenol					
2,4-Dimethylphenol					
2,4-Dinitrophenol					
2,4,5-Trichlorophenol					
2,4,6-Trichlorophenol					
4-Chloro-3-methylphenol					
4-Methylphenol					
4-Nitrophenol					
4,6-Dinitro-2-Methylphenol					
Pentachlorophenol	*Growth and blood chemistry*	Chicken	43.5	Prescott et al. 1982 & 1985 as cited in RTI 1995	
Phenol					
Ketones (Carbonyl Compounds)					
2-Butanone					

TABLE 3-14
ECOTOXICOLOGY SCREENING VALUES FOR INDIRECT EXPOSURES (INGESTION PATHWAY) TO AVIAN RECEPTORS
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Effect	Species	Dose (mg/kg-BW/day)	Reference	# of LD_{50s} [a]
2-Hexanone					
4-Methyl-2-pentanone (MIBK)					
Acetone	*Survival*	Quail	17600	Hill & Camardese 1986	
Isophorone					
Low Molecular Weight PAHs	No Signs of Toxicity	Mallard	212	Patton and Dieter 1980	
2-Chloronaphthalene					
2-Methylnaphthalene					
Acenaphthene					
Acenaphthylene					
Anthracene					
Carbazole					
Dibenzofuran					
Fluorene					
Naphthalene					
Phenanthrene					
High Molecular Weight PAHs					
Benzo(a)anthracene					
Benzo(a)pyrene	Growth and Survival	Chick	280	Rigdon, R,H. & J. Neal, Texas Rept. Biol. Med. 21(4):558-566, 1963	
Benzo(ghi)perylene					
Benzo(b,k)fluoranthene					
Chrysene					
Dibenzo(a,h)anthracene					
Fluoranthene					
Indeno(1,2,3-cd)pyrene					
Pyrene					
Pathalates					
Bis (2-ethylhexyl) phthalate	*Reproduction*	Ringed Dove	1.11	Peakall 1974 as cited in Sample et al., 1996	
Butylbenzylphthalate					
Diethyl phthalate					
Dimethyl phthalate					
Di-n-butyl phthalate	*Reproduction LOAEL / 5*	Ringed Dove	2.22	Peakall 1974 as cited in Sample et al., 1996	
Di-n-octyl phthalate					
Miscellaneous Solvents					
Carbon disulfide					
Pesticides (mg/kg)					
4,4'-DDD	*Reduced Reproduction LOAEL / 5*	Mallard	0.112	Heath et al. 1969	
4,4'-DDE	*Reduced Reproduction LOAEL / 5*	Mallard	0.112	Heath et al. 1969	
4,4'-DDT					
DDT (Total)	*Reduced Reproduction LOAEL / 5*	Brown Pelican	0.0056	Anderson et al. 1975 as cited in Sample et al. 1996	
Aldrin	*Normal fertility and hatchability*	Chicken	0.049	Brown *et al.* 1965 as cited in RTI 1995	

TABLE 3-14
ECOTOXICOLOGY SCREENING VALUES FOR INDIRECT EXPOSURES (INGESTION PATHWAY) TO AVIAN RECEPTORS
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Effect	Species	Dose (mg/kg-BW/day)	Reference	# of LD_{50s} [a]
a-BHC					
b-BHC					
d-BHC					
g-BHC (Lindane)	*Reproduction*	Chicken	0.7	Whitehead *et al.* 1972 as cited in RTI 1995	
a-Chlordane					
g-Chlordane					
Chlordane (Technical)	*Survival*	Red-winged blackbird	2.14	Stickel et al. 1983 as cited in Sample et al. 1996	
Dieldrin	*Growth, survival, and development*	Mallard duckling	0.08	Nebeker *et al.* 1992 as cited in RTI 1995	
Endosufan I					
Endosufan II					
Endosufan	*LD_{50} / 32.9 /5*	Quail	7.77	Hill & Camardese 1986	1
Endosulfan sufate					
Endrin	*Reproduction*	Mallard duck	0.028	Roylance *et al*. 1985 as cited in RTI 1995	
Endrin aldehyde					
Endrin ketone					
Heptachlor	*LD_{50} / 11.6 / 5*	Quail	0.416	Hill & Camardese 1986	6
Heptachlor epoxide	*Survival*	Woodcock	0.069	Stickel *et al.* 1965	
Isodrin					
Methoxychlor	*Survival*	Quail	2200	Hill & Camardese 1986	
Toxaphene	*Reproduction and development*	Chicken	0.18	Bush *et al.* 1977 as cited in Eisler 1985	
PCBs (mg/kg)					
Aroclor 1016					
Aroclor 1221	*LD_{50} / 32.9 /5*	Quail	13.4	Hill & Camardese 1986	1
Aroclor 1248	*Reproduction/Growth*	Chicken	0.1	HSDB, Little, etal.; Pol. Sci. 53:726-32 (1974)	
Aroclor 1254	*Survival*	Am. Kestrel	0.62	Peakall, Capt. 3 Vol 2 In PCBs and the Environ. CRC Press (1986)	
Aroclor 1260	*Reduced Egg Production LOAEL / 5*	Japanese Quail	5.08	Peakall, Capt. 3 Vol 2 In PCBs and the Environ. CRC Press (1986)	
Explosives (mg/kg)					
1,3-Dinitrobenzene (DNB)	*LD_{50} / 32.9 /5*	Red-winged blackbird	0.255	Schafer 1972 as cited in Talmage et al. 1999	1
1,3,5-Trinitrobenzene (TNB)					
2-Amino-4,6-Dinitrotoluene (2-ADNT)					
2-Nitrotoluene (ONT)					
2,4,6-Trinitrotolune (TNT)					
3-Nitrotoluene					
4-Amino-2,6-Dinitrotoluene (4-ADNT)					
4-Nitrotoluene (PNT)					
Cyclonite (RDX)					
Cyclotetramethylenetetranitramine (HMX)					

TABLE 3-14
ECOTOXICOLOGY SCREENING VALUES FOR INDIRECT EXPOSURES (INGESTION PATHWAY) TO AVIAN RECEPTORS
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Effect	Species	Dose (mg/kg-BW/day)	Reference	# of LD_{50s} [a]
Nitroglycerin (NG)					
Pentaerythritol tetranitrate (PETN)					
Tetryl					
Dioxins/Furans (mg/kg)					
2,3,7,8-TCDD	*Reproduction*	Red-necked Pheasant	0.000014	Nosek et al. 1992 as cited in Sample et al. 1996	
Total Petroleum Hydrocarbons (mg/kg)					
TPH-Gasoline range organics	No Signs of Toxicity	Mallard	212	Patton and Dieter 1980	
TPH-Diesel range organics	No Signs of Toxicity	Mallard	212	Patton and Dieter 1980	
Metals (mg/kg)					
Aluminum	*Clinical Signs*	Chicken	85	NAS 1980	
Antimony					
Arsenic	*Clinical Signs*	Cowbird (G)	4.7	Thatcher et al. 1985 as cited in Eisler 1988	
Barium	*Growth & Survival*	Chicken (A)	102.5	Johnson, et al.,1960 as cited in RTI 1995	
Beryllium					
Cadmium	*Egg production*	Chicken	0.207	Leach et al. 1979 as cited in NAS 1980	
Calcium					
Chromium (Total)	*Reproduction -- 10 month exposure*	Black duck	1	Haseltine et al. (unpubl.) as cited in Sample et al. 1996	
Chromium VI	*Reproduction -- 10 month exposure*	Black duck	1	Haseltine et al. (unpubl.) as cited in Sample et al. 1996	
Cobalt	*Survival & Growth*	Chicken	0.24	HSDB, NRC, Drinking Water & Health, Vol1, 1977	
Copper	*Growth and survival*	Chicken (B) "chicks"	47	Mehring et al. 1960 as cited in Sample et al. 1996	
Iron	*Growth (starting at 1 day old)*	Chicken (A)	40.14	McGhee et al. 1965 as cited in NAS 1980	
Lead	*Reproduction*	Japanese Quail	1.13	Edens et al. 1876 as cited in Sample et al. 1996	
Magnesium					
Manganese	*No Adverse Effects*	Turkey (A) "young"	61.77	Mussehl and Ackerson 1939 as cited in NAS 1980	
Mercury	*Reproduction*	Common Loon (E)	0.007	Barr 1986	
Nickel	*Growth*	Chicken (C,D)	30.1	Weber and Reid 1968 as cited in NAS 1980	
Potassium					
Selenium	*Growth, Reproduction*	Mallard (C)	0.28	Eisler, 1985	
Silver	*Maximum Tolerable Level*	Poultry (D)	4.8	NAS, 1980	
Sodium					
Thallium	*LD_{50} / 32.9 /5*	Quail	0.075	Gough et al. 1980	
Vanadium	*Maximum Tolerable Level*	Poultry	0.48	NAS, 1980	
Zinc	*No Observable Effects*	Chicken (E)	88	NAS, 1980	
Total Cyanide	*No Adverse Effects*	Chicken (chicks)	14.9	Gomez et al. (1988) as cited in Eisler (1991)	

a The number of LD50s is applicable to the uncertainty factors applied where chronic NOAEL data are absent (see text)

Note:

COPECs with no data indicates information unavailable at the present time.

TABLE 3-13
ECOTOXICOLOGY SCREENING VALUES FOR INDIRECT EXPOSURES (INGESTION PATHWAY) TO MAMMLIAN RECEPTORS
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Effect	Species	Dose (mg/kg-BW/day)	Reference	# of LD_{50s} [a]
Total Petroleum Hydrocarbons (mg/kg)					
TPH-Gasoline range organics					
TPH-Diesel range organics					
Metals (mg/kg)					
Aluminum	*Growth rates LOAEL / 5*	Mouse (B)	0.944	Ondreicka et al. 1966 as cited in NAS 1980	
Antimony	*Growth & Reproduction*	Rat	0.35	IRIS 1993	
Arsenic	*Clinical Signs / Reproduction - 2 year exposure*	Rat	0.7	Schroeder et al. 1968 as cited in ATSDR 1993	
Barium	*Growth*	Rat	33.5	NTP 1994 as cited in IRIS	
Beryllium	*Longevity -- lifetime exposure*	Rat	0.66	Schroeder & Michner as cited in Sample et al. 1996	
Cadmium	*Reproduction*	Rat	1	Sutou et al. 1980 as cited in Sample et al. 1996	
Calcium					
Chromium (Total)	*Reproduction and longevity*	Rat	2737	Ivankovic and Preussmann 1975 as cited in Sample et al. 1996	
Chromium VI	*Survival*	Rat	18	Steven et al. 1976 as cited in Eisler 1986	
Cobalt	*No Adverse Effects*	Cattle (A)	0.66	Keener et. al. 1949 as cited in NAS 1980	
Copper	*Reproduction*	Mink	11.7	Aulerich et al. 1982 as cited in Sample et al. 1996	
Iron	*Maintenance dose for healthy felines*	Cat	2.34	Merck Veterinary Manual, 1998	
Lead	*Reproductive Effects*	Mouse (A)	2.2	Clark et al. as cited in Eisler 1988	
Magnesium					
Manganese	*Reproduction*	Rat	88	Laskey et al. 1982 as cited in Sample et al. 1996	
Mercury	*Growth -- 2 year exposure*	Rat	0.204	Fitzhugh et al. 1950 as cited in NAS 1980	
Nickel	*Growth and organ weights -- 2 year exposure*	Rat	5	Ambrose et al. As cited in IRIS	
Potassium					
Selenium	*Reproduction -- 2 generation exposure*	Rat	0.2	Rosenfeld & Beath 1954 as cited in Sample et al. 1996	
Silver	*Mortality*	Rat	0.67	HSDB, Schroeder. et al., J. Nutrit. 104: 239, 1974	
Sodium					
Thallium	*No observable effects -- 90-day exposure*	Rat	0.23	IRIS 1993, Stoltz et al. 1986 also cited in ATSDR 1992	
Vanadium	*No observable effects -- lifetime exposure*	Mouse	1.22	HSDB, Clayton, et al., Patty's Ind. Hyg. & Tox. Vol. 2A-2C, 1981-2	
Zinc	*No observable adverse effects*	Cattle	7.2	Miller et al. 1965 as cited in NAS 1980	
Total Cyanide	*Reproduction & Growth*	Rat	68.7	Sample et al. 1996	

a The number of LD50s is applicable to the uncertainty factors applied where chronic NOAEL data are absent (see text)

Note:

COPECs with no data indicates information unavailable at the present time.

TABLE 3-13
ECOTOXICOLOGY SCREENING VALUES FOR INDIRECT EXPOSURES (INGESTION PATHWAY) TO MAMMLIAN RECEPTORS
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Effect	Species	Dose (mg/kg-BW/day)	Reference	# of LD_{50s} [a]
Endosufan II					
Endosufan	*Effect on Body Weight*	Dog	0.57	Hoechst Celanese Corp. 1989 as cited in IRIS	
Endosulfan sufate					
Endrin	*Histological Lesions in Liver*	Dog	0.025	Velsicol Chemical 1969 as cited in IRIS	
Endrin aldehyde					
Endrin ketone					
Heptachlor	*Liver Weight Increase*	Rat	0.15	Velsicol Chemical 1969 as cited in IRIS	
Heptachlor epoxide	*Increase in Liver to Body Weight Ratio LEL / 5*	Dog	0.0032	Dow Chemical 1958 as cited in IRIS	
Isodrin					
Methoxychlor	*Loss of Litters*	Rabbit	5.01	Kincaid Enterprises 1986 as cited in IRIS	
Toxaphene	*Liver Histopathology*	Dog	0.200	Chu et al. 1986 as cited in ATSDR 1994	
PCBs (mg/kg)					
Aroclor 1016	*Reproductive Effect*	Monkey	0.007	Schantz et al. 1989 as cited in ATSDR 1996	
Aroclor 1221					
Aroclor 1248	*Birth Weights*	Rhesus Monkey (Female)	0.030	Schantz et al. 1989 as cited in ATSDR 1996	
Aroclor 1254	*Birth Weights*	Rhesus Monkey (Female)	0.005	Levinskas et al. 1984 as cited in IRIS	
Aroclor 1260	*Growth*	Rat	7.2	Kimbrough et al. 1975 as cited in ATSDR 1996	
Explosives (mg/kg)					
1,3-Dinitrobenzene (DNB)	*Increase in Splenic Weight*	Rat	0.4	Cody et al. 1981 as cited in IRIS	
1,3,5-Trinitrobenzene (TNB)	*Hematopoietic Toxicvity*	Rat	2.68	Reddy et al. 1996 as cited in IRIS	
2-Amino-4,6-Dinitrotoluene (2-ADNT)	*LD_{50} / 7.6 / 5*	Rat	36.7	Ellis et al. 1978 as cited in NTIS 1987	4
2-Nitrotoluene (ONT)					
2,4,6-Trinitrotolune (TNT)	*Liver Effect LOAEL / 5*	Dog	0.100	US DOD 1983 as cited in IRIS	
3-Nitrotoluene					
4-Amino-2,6-Dinitrotoluene (4-ADNT)	*LD_{50} / 7.6 / 5*	Rat	25.2	Ellis et al. 1978 as cited in NTIS 1987	4
4-Nitrotoluene (PNT)					
Cyclonite (RDX)	*Inflammation of the Prostate*	Rat	0.3	US DOD 1983 as cited in IRIS	
Cyclotetramethylenetetranitramine (HMX)	*Hepatic Lesions*	Rat	50	US DOD 1985 as cited in IRIS	
Nitroglycerin (NG)	*Physiological effect*	Rat	25.5	Normandy et al. 1987 as cited in NTIS 1991	
Pentaerythritol tetranitrate (PETN)	*Physiological effect*	Rat	2	Stokinger 1982 as cited in NTIS 1991	
Tetryl	*Body Weight*	Rat	14	Reddy et al. 1994 as cited in Talmage et al. 1999	
Dioxins/Furans (mg/kg)					
2,3,7,8-TCDD	*Fertility and Pup Survival*	Rat	0.000001	Murray et al. 1979 as cited in Sample et al. 1996	

TABLE 3-13
ECOTOXICOLOGY SCREENING VALUES FOR INDIRECT EXPOSURES (INGESTION PATHWAY) TO MAMMLIAN RECEPTORS
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Effect	Species	Dose (mg/kg-BW/day)	Reference	# of LD_{50s} [a]
Benzo(a)anthracene	*Spematogenis Single Dose LOAEL / 5 / 5*	Hamster	36	RTECS, Acta Morph. Acad. Scient. Hungaricae 27:199, 1979	
Benzo(a)pyrene	*Fertility and Fetal Body Weights LOAEL / 5*	Mouse	2	Mackenzie & Angvine 1981 as cited in Sample et al. 1996	
Benzo(ghi)perylene					
Benzo(b,k)fluoranthene					
Chrysene					
Dibenzo(a,h)anthracene					
Fluoranthene	*Clinical Signs & Liver Weights*	Mouse	125	USEPA 1989 as cited in IRIS	
Indeno(1,2,3-cd)pyrene					
Pyrene	*Kidney Histopathology*	Mouse	75	USEPA 1989 as cited in IRIS	
Pathalates					
Bis (2-ethylhexyl) phthalate	*Liver Weight LOAEL / 5*	Guinea Pig	3.8	Carpenter et al. 1953 as cited in IRIS	
Butylbenzylphthalate	*Liver & Brain Weights*	Rat	159	NTP 1985 as cited in IRIS	
Diethyl phthalate	*Growth Rates & Organ Weights*	Rat	750	Brown et al. 1978 as cited in IRIS	
Dimethyl phthalate					
Di-n-butyl phthalate	*Fetotoxicity LOAEL / 5*	Rat	240	RTECS (R) Toxicology & Applied Pharmacology 26:253, 1973	
Di-n-octyl phthalate	*Fertility LOAEL / 5*	Mouse	1950	RTECS (R) NTIS PB85-220143	
Miscellaneous Solvents					
Carbon disulfide	*Fetal Development*	Rabbit	11	Hardin et al. 1981 as cited in IRIS	
Pesticides (mg/kg)					
4,4'-DDD	*Neuropathy LOAEL / 5*	Dog	4	HSDB; Clark et al. 1981. Veterinary Toxicology 2nd Ed.	
4,4'-DDE	*Clinical signs*	Rat	23	NCI 1978 as cited in ATSDR 1994	
4,4'-DDT	*Liver Lesions*	Rat	0.05	Laug et al. 1950 as cited in IRIS	
DDT (Total)	*Decreased fertility*	Rat	0.035	Green 1969 as cited in ATSDR 1994	
Aldrin	*Survival LOAEL / 5*	Rat	1	Fitzhugh et al. 1964 as cited in IRIS	
a-BHC	*Hepatic effect*	Rat	1	Barros et al. 1991 as cited in ATSDR	
b-BHC	*Gonadal Histopathological effect*	Rat	2.5	Van Velsen et al. 1986 as cited in ATSDR 1994	
d-BHC					
g-BHC (Lindane)	*Liver & Kidney Toxicity*	Rat	0.29	Zoecon Corp. 1983 as cited in IRIS	
a-Chlordane					
g-Chlordane					
Chlordane (Technical)	*Hepatic Necrosis*	Mouse	0.15	Khasawinah & Grutsch 1989 as cited in IRIS	
Dieldrin	*Liver Lesions LOAEL / 5*	Rat	0.01	Walker et al. 1969 as cited in IRIS	
Endosufan I					

TABLE 3-13
ECOTOXICOLOGY SCREENING VALUES FOR INDIRECT EXPOSURES (INGESTION PATHWAY) TO MAMMLIAN RECEPTORS
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Effect	Species	Dose (mg/kg-BW/day)	Reference	# of LD_{50s} [a]
Phenols and Substituted Phenols					
2-Chlorophenol	*Reproductive Effects*	Rat	5	Exon & Koller 1982 as cited in IRIS	
2-Methylphenol	*Body Weight (Growth) & Neurotoxicity*	Rat	50	USEPA 1986 & 1987 as cited in IRIS	
2-Nitrophenol	*LD_{50} / 14.9 / 5*	Rat	4.48	Labor Hyg. Occup. Pathol. Estonia SSR 8:145, 1972 as cited in RTECS	1
2,4-Dichlorophenol	*Development LOAEl / 5*	Rat	4	Gigiena i Sanitarya 41(11):102, 1976 as cited in RTECS	
2,4-Dimethylphenol	*Clinical Signs*	Mouse	50	USEPA 1989 as cited in IRIS	
2,4-Dinitrophenol	*Histopathology and Growth*	Rat	10	NRC 1981 as cited in HSDB	
2,4,5-Trichlorophenol	*Liver & Kidney Histopathology*	Rat	100	McCollister et al.1951 as cited in IRIS	
2,4,6-Trichlorophenol	*Litter Size*	Rat	4.2	Exon & Koller 1985 as cited in ATSDR 1990	
4-Chloro-3-methylphenol	*LD50 / 14.9 / 5*	Mouse	9.53	USEPA 1980 as cited in HSDB	1
4-Methylphenol	*Body Weight (Growth) & Neurotoxicity*	Rat	50	USEPA 1986 & 1987 as cited in IRIS	
4-Nitrophenol	*Survival*	Rat	25	Hazleton 1989 as cited in ATSDR 1992	
4,6-Dinitro-2-Methylphenol	*Serum Chemistry*	Rat	2.5	Den Tonkelaar et al. 1983 as cited in ATSDR 1995	
Pentachlorophenol	*Liver & Kidney Histopathology*	Rat	3	Schwetz et al. 1978 as cited in IRIS	
Phenol	*Fetal Body Weights*	Rat	60	NTP 1983 as cited in IRIS	
Ketones (Carbonyl Compounds)					
2-Butanone	*Fetal Weights*	Rat	1771	Cox et al. 1975 as cited in IRIS	
2-Hexanone	*LD_{50} / 10 / 5*	Mouse	48.6	RTECs (R), Toxicology Letter 30:13, 1986	2
4-Methyl-2-pentanone (MIBK)					
Acetone	*Nephrotoxicity / Liver & Kidney Weights*	Rat	100	USEPA 1986 as cited in IRIS	
Isophorone	*No Observable Adverse Effects*	Dog	150	Nor. Am. Agric. 1972 as cited in IRIS	
Low Molecular Weight PAHs					
2-Chloronaphthalene	*Liver Size*	Mouse	250	USEPA 1989 as cited in IRIS	
2-Methylnaphthalene	*Single Dose LD_{50} / 14.9 / 5*	Rat	21.9	RTECS Izmerov, ctr. Internat. Projects 1982	1
Acenaphthene	*Hepatotoxicity*	Mouse	175	USEPA 1989 as cited in IRIS	
Acenaphthylene					
Anthracene	*No Observable Adverse Effects*	Mouse	1000	USEPA 1989 as cited in IRIS	
Carbazole	*LD_{50} / 14.9 / 5*	Rat	6.71	RTECs, J. Pharmacol. Exper. Therap. 90:260, 1947	1
Dibenzofuran	*Growth LOAEL / 5*	Mouse	20	Shepard's Catalog Tetratogenic Agents 1989 as cited in HSDB	
Fluorene	*Blood Chemistry*	Mouse	125	USEPA 1989 as cited in IRIS	
Naphthalene	*Survival, Growth, & Organ Weights*	Mouse	143	USEPA-NTIS PB90-259821 as cited in HSDB	
Phenanthrene	*Liver Function LOAEL / 5*	Mouse	14	Hyg. Sanit. 29:19, 1964 as cited in RTECS	
High Molecular Weight PAHs					

TABLE 3-13
ECOTOXICOLOGY SCREENING VALUES FOR INDIRECT EXPOSURES (INGESTION PATHWAY) TO MAMMLIAN RECEPTORS
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Effect	Species	Dose (mg/kg-BW/day)	Reference	# of LD_{50s} [a]
2-Nitroaniline					
3-Nitroaniline	*LD50 / 14.9 / 5*	Mouse	4.13	Aerospace Med. Res. Lab. Rpt. TR-72-62, 1972 as cited in RTECS	1
3,3'-Dichlorobenzidine	*Convulsions / Neurological Degeneration LOAEL / 5*	Dog	1.60	Stula et al. 1978 as cited in ATSDR 1989	
4-Chloroaniline	*Histopathology LOAEL / 5*	Rat	2.50	NCI 1979 as cited in IRIS	
4-Nitroaniline	*LD_{50} / 14.9 / 5*	Guinea Pig	6.04	Problems Communal Hygiene 6:89, 1966 as cited in RTECS	
4,4'-Methylenebis (2-chlorobenzenamine)-MOCA					
N-Nitrosodiphenylamine	*Body Weights (Growth)LOAEL / 5*	Rat	10	Cardy et al. 1979; NCI 1979 as cited in ATSDR 1993	
N-Nitroso-di-n-propylamine	*Longevity LOAEL / 5*	Rat	1.02	Lijinsky & Taylor 1978;1979 as cited in ATSDR 1989	
Benzene and Derivatives					
Benzene	*Reproductive Effects LOAEL / 5*	Mouse	52.8	Nawrot & Staples 1979 as cited in Sample et al. 1996	
Chlorobenzene	*Liver Histopathology*	Dog	19	Knapp et al. 1971 as cited in IRIS	
1,2-Dichlorobenzene	*No Observable Adverse Effects*	Rat	85.7	NTP 1985 as cited in IRIS	
1,2,4-Trichlorobenzene	*Adrenal Weights*	Rat	14.8	Robinson et al. 1984 as cited in IRIS	
1,3-Dichlorobenzene	*Serum Chemistry LOAEL / 5*	Rat	50	Ariyoshi et al. 1975 as cited in HSDB	
1,4-Dichlorobenzene	*Survival LOAEL / 5*	Rat	60	NTP 1987 as cited in ATSDR 1993	
Hexachlorobenzene	*Liver Effects*	Rat	0.08	Arnold et al. 1985 as cited in IRIS	
Methylated Benzenes					
Toluene	*Fetal Body Weights LOAEL / 5*	Mouse	52	Nawrot & Staples 1979 as cited in Sample et al. 1996	
Xylenes (total)	*Growth LOAEL / 5*	Rat	71.4	HSDB, NTP TR-327,86 NIH# 87-2583	
Other Substituted Benzenes					
Ethylbenzene	*Liver & Kidney Toxicity*	Rat	97.1	Wolf et al. 1956 as cited in IRIS	
Styrene	*Liver Effects & Blood Chemistry*	Dog	200	Quast 1979 as cited in IRIS	
Nitrobenzene	*Tesicular Necrosis Acute LOAEL / 5 / 5*	Rat	1.2	Levin et al. 1988 as cited in ATSDR 1990	
Arenes					
2,4-Dinitrotoluene	*Nuerological - Histopathology Effects*	Dog	0.2	Ellis et al. 1985 as cited in IRIS	
2,6-Dinitrotoluene	*Survival & Reproduction*	Mouse	11	Lee et al. 1976 as cited in ATSDR 1989	
Chlorinated Dienes					
Hexachlorobutadiene	*Neonatal Weights*	Rat	2	Schwetz et al. 1977 as cited in ATSDR 1994	
Hexachlorocyclopentadiene	*Stomach Lesions*	Rat	10	Abdo et al. 1984 as cited in IRIS	
Ethers					
4-Bromophenyl phenyl ether					
4-Chlorophenyl phenyl ether					
Bis (2-chloroethyl) ether	*Body Weights (Growth)*	Rat	25	Weisburger et al. 1981 as cited in ATSDR 1989	

TABLE 3-13
ECOTOXICOLOGY SCREENING VALUES FOR INDIRECT EXPOSURES (INGESTION PATHWAY) TO MAMMLIAN RECEPTORS
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Effect	Species	Dose (mg/kg-BW/day)	Reference	# of LD_{50s} [a]
Halogenated Methanes/Alkanes					
Bis(2-chloroethoxy) methane	*LD_{50} / 14.9 / 5*	Rat	0.87	J. Indust. Hy. Toxicol. 30:63, 1948 as cited in RTECS	1
Bromodichloromethane	*Renal Histopathology LOAEL / 5*	Mouse	3.58	NTP 1986 as cited in IRIS	
Bromoform	*Hepatic Lesions*	Rat	17.9	NTP 1989 as cited in IRIS	
Bromomethane	*Gastric Lesions and Body Weight*	Rat	1.4	Danse et al. 1984 as cited in IRIS	
Carbon tetrachloride (Tetrachloromethane)	*Liver Histopathology*	Rat	0.71	Danse et al. 1984 as cited in IRIS	
Chloroform (Trichloromethane)	*Liver Damage LOAEL / 5*	Dog	2.58	Heywood et al. 1979 as cited in IRIS	
Chloromethane	*Liver Histopathology - NOAEL / 5*	Rat	84	Reynolds & Yee 1967 as cited in ATSDR 1990	
Dibromochloromethane	*Hepatic Lesions*	Mouse	21.4	NTP 1985 as cited in IRIS	
Methylene chloride	*Liver Toxicity*	Rat	5.85	IRIS	
Halogenated Ethanes					
1,1-Dichloroethane	*Survival LOAEL / 5*	Rat	76.4	NCI 1977 as cited in ATSDR 1990	
1,1,1-Trichloroethane	*No Observable Adverse Effects*	Mouse	1000	Lane et al. 1982 as cited in Sample et al. 1996	
1,1,2-Trichloroethane	*Serum Chemistry*	Rat	3.9	IRIS	
1,1,2,2-Tetrachloroethane	*Hepatotoxicity Subchronic-NOAEL / 5*	Mouse	2.28	Buben & O'Flaherty 1985 as cited in Sample et al. 1996	
1,2-Dichloroethane	*Reproduction*	Mouse	50	Lane et al. 1982 as cited in Sample et al. 1996	
Chloroethane	*Histopathology and Survival*	Rabbit	1000	Adams et al. 1939 as cited in ATSDR 1989	
Hexachloroethane	*Liver Effects*	Rat	1	Gorzinski et al. 1985 as cited in IRIS	
Halogenated Propanes					
1,2-Dichloropropane	*Liver & Spleen Weights*	Rat	250	Fund. Appl. Toxicol. 12:713, 1989 as cited in RTECS	
2,2'-Oxybis (1-chloropropane)					
Halogenated Alkenes					
1,1-Dichloroethene	*Hepatic Lesions LOAEL / 5*	Rat	1.80	Quast et al. 1983 as cited in IRIS	
1,2-Dichloroethene (total)					
1,2-Dichloroethene (cis)	*Body Weights (Growth)*	Rat	32.0	McCauley et at. 1990 as cited in ATSDR 1994	
1,2-Dichloroethene (trans)	*Body Weights (Growth)*	Rat	32.0	McCauley et at. 1990 as cited in ATSDR 1994	
1,3-Dichloropropene (total)	*Increase Organ weight*	Rat	3.00	Dow Chemical 1973 as cited in IRIS	
1,3-Dichloropropene (cis)	*Survival*	Rat	30.0	Til et al. 1973 as cited in ATSDR 1992	
1,3-Dichloropropene (trans)	*Survival*	Rat	30.0	Til et al. 1973 as cited in ATSDR 1992	
Tetrachloroethene	*Weight Gain (Growth) and Liver Effects*	Rat	14.0	Buben & O'Flaherty 1985 as cited in IRIS	
Trichloroethene	*Hepatotoxicity LOAEL / 5*	Mouse	14.0	Buben & O'Flaherty 1985 as cited in Sample et al. 1996	
Vinyl chloride	*Life-time Survival LOAEL / 5*	Rat	0.34	Til et al. 1983 & 1991as cited in ATSDR 1995	
Amines					

TABLE 3-8
SUMMARY OF APPLICABLE ASSESSMENT ENDPOINTS
ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNIT
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLONOIS

AUS Unit	SITE DESCRIPTION	HABITAT TYPE(S)	Assessment Endpoint																		
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
0043	Areas 11 and 12 Fire Station	Early Succession Woodland												X	X	X	X	X	X	X	X
0060	IOP Fulminate Storage Igloos	Mid-Succession Woodland												X	X	X	X	X	X	X	X
0061	Concrete Structures	Mid-Succession Woodland												X	X	X	X	X	X	X	X
106A	Drum Disposal Area	Early Succession Woodland												X	X	X	X	X	X	X	X
107	Possible Disposal Area	Mid/Late Succession Woodland												X	X	X	X	X	X	X	X
108	Possible Surface Disposal Area	Mid-Succession Woodland/Agricultural Field												X	X	X	X	X	X	X	X

TABLE 3-8
SUMMARY OF APPLICABLE ASSESSMENT ENDPOINTS
ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNIT
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLONOIS

AUS Unit	SITE DESCRIPTION	HABITAT TYPE(S)	Assessment Endpoint																		
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
2	Non-Industrial Portion	Woodland patch and Agricultural Fields, Aquatic	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2B	IOP Booster Load Line	Urban Grassland with Tree Line														X	X	X	X	X	X
2D	IOP Detonator Load Line	Urban Grassland with Tree Line														X	X	X	X	X	X
2F	IOP Fuse Load Line	Urban Grassland with Tree Line														X	X	X	X	X	X
2P	IOP Primer Load Line	Urban Grassland with Tree Line														X	X	X	X	X	X
4E	IOP Automotive and Equipment Shop	None																			
4W	IOP West Shop Area	Urban Grassland with Brush														X	X	X	X	X	X
6	IOP Ammonium Nitrate High Explosive and Smokeless Powder Storage Area	Old Field and Agricultural Field												X	X	X	X	X	X	X	X
7	IOP Inert Storage Area	Urban Grassland														X	X	X	X	X	X
8S	IOP Load Line III	Old Field and Early Woodland, Aquatic	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
9	IOP Load Line I	Urban Grassland with Tree Stands, Aquatic														X	X	X	X	X	X
10	IOP Fuse and Booster Storage Magazine	Old Field and Early Woodland												X	X	X	X	X	X	X	X
11H	Area 11 High Explosives Area	Old Field and Early Woodland, Aquatic	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
11N	Area 11 Nitroglycerin Area	Old Field and Early Woodland, Aquatic	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
11P	Area 11 Pilot Propellant Plant	Old Field and Early Woodland, Aquatic	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
11S	Area 11 Support Area	Old Field and Early Woodland, Aquatic	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
12	Area 12 Former Ammonium Nitrate Plant	Early Woodland and Woodland, Aquatic	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
13	IOP Finished Ammunition Igloos	Agricultural Grassland and Old Field, Aquatic	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
0062	Crab Orchard Cemetery Sites	Old Field												X	X	X	X	X	X	X	X
0063	Crab Orchard Cemetery Sites	Old Field												X	X	X	X	X	X	X	X
0065	Crab Orchard Cemetery Sites	Mid/Late Succession Woodland												X	X	X	X	X	X	X	X
0066	Crab Orchard Cemetery Sites	Mid/Late Succession Woodland												X	X	X	X	X	X	X	X
0067	Crab Orchard Cemetery Sites	Mid/Late Succession Woodland												X	X	X	X	X	X	X	X
0069	Crab Orchard Cemetery Sites	Mid/Late Succession Woodland												X	X	X	X	X	X	X	X
0109	Crab Orchard Cemetery Sites	Agricultural Field												X	X	X	X	X	X	X	X
0001	IOP fire and Police Headquarters	Early Succession Woodland												X	X	X	X	X	X	X	X
0002	IOP Wastewater Treatment Plant	Mid-succession Woodland/Native Grassland												X	X	X	X	X	X	X	X
0018	IOP Railroad Classification Yard	Early Succession Woodland												X	X	X	X	X	X	X	X
0021	IOP Fire Station for Area 7	Early Succession Woodland												X	X	X	X	X	X	X	X

This section presents information on site history and suspected contaminants as obtained from the Historic Search Report (URSGWC 1999) for the AUS OU. Each of the areas of the AUS OU is presented, with a background description, and discussion of suspected or known chemicals that may have been associated with the site. A site map is presented in Figure 2-1.

2.1 AREA 2

Area 2 consists of four IOP load lines in close proximity to each other just north of Crab Orchard Lake. These load lines are the Booster Load Line labeled as Area 2B, the Detonator Load Line labeled as Area 2D, the Fuse Load Line labeled as Area 2F, and the Primer Load Line labeled as Area 2P. Each of these areas is described in the sections below.

AREA 2B – IOP BOOSTER LOAD LINE (AUS-0A2B)

This site is the former IOP Booster Load Line. The facility was designed and built for the purpose of loading boosters, involving the preparation, mixing, and loading of tetryl. Since World War II, ordnance manufacturers have used the facility for their production operations. Post war production activities at Area 2B included explosive fuse trains, pyrotechnics, large explosives, propellant mixes, and gas generators.

The southern and eastern portions of the load line were razed in the 1980s. The remaining buildings at the site are part of Primex Corporations' ongoing production operations at the Refuge. Visual inspection of the site revealed building debris, abandoned drums and ordnance waste scattered at the southern end of the site outside the current fenceline. Aerial photo interpretation identified a suspicious pond to the southwest of the load line and excavation activity to the east of the load line. Previous sampling at the site indicated the presence of elevated levels of metals and several base/neutral/acid-extractable (BNA) compounds.

Building B-2-13 in the northeast section of Area 2B is a propellant mix house. The southern end of the building has propellant mixing machines in the east and west bays and propellant has been identified on the ground outside both of these bays in the past. In addition, to the east of this building is a hexane tank which supplies solvent to the mixing bays for use in propellant mixes.

In the southern portion of Area 2B several buildings were involved in the screening, pressing and loading of high explosives and pyrotechnic mixes. These buildings have all been flashed and razed. Because volatile solvents like $MeCl_2$ and trichlorethylene (TCE) were used extensively in production operations by the industrial tenants, dioxin is a chemical of interest (COI) in these locations. It is also a COI at the burn pad in the southwest corner of this load line. Other COIs in this area include trinitrotoluene (TNT) and tetryl (explosives), $MeCl_2$ (volatile solvents), hexane, lead (metals), and burn site residues (BNAs).

AREA 2D – IOP DETONATOR LOAD LINE (AUS-0A2D)

This site is the former IOP Detonator Load Line. The facility was designed and built for the purpose of loading detonators, involving the preparation, mixing, and loading of primary explosives. Since World War II, ordnance manufacturers have used the facility for their production operations. Post war production activities at Area 2D included explosive fuse trains,

pyrotechnics, large explosives, propellant products, gas generators and ammunition mixes (e.g. tracers and igniters). Currently Primex Corporation is using the load line for its ongoing production activities.

On the southeast corner of the load line a small building pad was used for several years as a burning ground for ignitable wastes. In addition, several of the production buildings previously contained open sumps that were emptied out on to the grounds in the area of the sumps during cleaning activities. Other cleaning activities at the site included the sweeping of wash waters in production buildings to the grounds just outside the building on a weekly basis. These wash waters reportedly ended up flowing into the ditches near the buildings. Previous sampling at the site indicated the presence of elevated levels of mercury, zinc and several BNA compounds.

In the southeast portion of the load line the chemicals of interest include mercury fulminate and lead (reactivity and metals), burn site residues (dioxin and BNAs), and propellant and pyrotechnic mixes (explosives, metals, volatile organic compounds [VOCs], and BNAs). On the southwest portion of the load line COIs include lead azide (metals), acetone (VOCs), and propellant and pyrotechnic mixes (explosives, metals, VOCs, and BNAs). On the north end of the load line COIs include propellant and pyrotechnic mixes (explosives, metals, VOCs, and BNAs), TNT, tetryl, RDX, and NG (explosives), and lead azide (metals).

AREA 2F – IOP FUSE LOAD LINE (AUS-0A2F)

Area 2F is the former IOP Fuse Load Line. The facility was designed and built for the purpose of loading fuses, including the preparation and loading of black powder, lead azide, potassium chlorate, and tetryl. Since World War II, ordnance manufacturers have used the facility for their production operations. Post war production activities at Area 2F included pyrotechnics, gas generators, and artillery projectiles. Currently, Primex Corporation is using the facility for its ongoing production operations.

Visual inspection of the site revealed the northern portion of the load line has been used as a dumping ground for construction debris over the years. In addition, several areas of stressed vegetation were observed around production buildings. Previous sampling at the site indicated the presence of elevated levels of metals.

Fuse production involved the use of tetryl (explosives), lead azide (metals), and nitrocellulose. Other activities at the load line include the use of volatile solvents for metals cleaning activities. It is believed that the disposal of these chemicals was via dumping in the areas around the building involved (F-2-2).

AREA 2P – IOP PRIMER LOAD LINE (AUS-0A2P)

Area 2P is the former IOP Primer Load Line. The facility was designed and built for the purpose of loading primers and involved the preparation and loading of black powder. Since World War II an ordnance manufacturer has used the facility for its research and development and production operations. Post war production activities at Area 2P included solid propellants, pyrotechnics, gas generators, and ammunition mixes. Primex Corporation is currently using the facility for its ongoing operations at the Refuge.

Previous sampling at the site indicated the presence of RDX in surface water effluents as well as elevated levels of metals and BNA compounds. Surface water at the site is transported off the site either to the northwest or the southeast by numerous ditches at the site. In addition, building P-1-1 formerly contained an open sump from which water was discharged to the ground during cleaning operations.

2.2 AREA 4 EAST – IOP AUTOMOTIVE AND EQUIPMENT SHOP AREA (AUS-0A4E)

Area 4 East is the former IOP Automotive and Equipment Shop. The facility was designed and built for the purpose of maintaining the trucks and equipment needed to support ordnance-manufacturing operations. Since World War II, the facility has been used by various tenants for purposes such as truck and mining equipment maintenance and repair, storage, and manufacturing. To the southeast of Area 4 a sanitary landfill was remediated as part of the Metals Area Operable Unit (MAOU). The landfill was referred to as the Fire Station Landfill. The contaminant of concern at the Fire Station Landfill was lead. An IOP vehicle refueling station once stood in the middle of the site adjacent to Highway 148. The building has been razed; however, it is suspected that the underground fuel storage tanks may have been left in place during the building demolition. Surface water at the site is transported via storm sewers to the north and then east via ditches off the site.

2.3 AREA 4 WEST – IOP WEST SHOP AREA (AUS-0A4W)

Area 4 West originally housed the construction and mechanical trades buildings along with a laboratory and laundry facility. After the end of WWII several of the buildings were leased by businesses of all types. Printing companies occupied building S-1-3. A lumber company occupied buildings S-3-2, S-3-3, and S-3-4. Most notably, however, Supreme Plating Company (a plating operation) occupied buildings S-2-4 and S-2-5. It was the waste from this plating operation that ultimately became the subject of the MAOU. The remediation of the MAOU included the ditches along the roadsides in the center of Area 4 West as well as the northern drainage swale where the storm sewers discharge their waters. Buildings S-2-1, S-2-2, and S-2-3 are no longer standing. Buildings S-2-1 and S-2-2 building pads are currently being used as compounds for vehicle storage. A review of the site characterization for the MAOU (Site 22-O'Brien & Gere, 1988) revealed that no samples were taken in the area around building S-2-5. In addition, aerial photo interpretations of the 1951 and 1960 aerial photos revealed evidence of disposal activities in a remote section of Area 4 to the southwest of building S-1-3.

2.4 AREA 6 – IOP AMMONIUM NITRATE HIGH EXPLOSIVE AND SMOKELESS POWDER STORAGE AREA

Area 6 is the former IOP Ammonium Nitrate High Explosive and Smokeless Powder Storage Area. The site has 84 explosive storage igloos in 7 rows and has been used for storage since WWII. Samples at the railroad loading docks on the north and south have exceeded screening levels. The analytes indeno[1,2,3-cd]pyrene and dibenz[a,h]anthracene exceeded USEPA soil screening levels (SSLs) in a sample at the south railroad loading dock. The analytes benzo[b]fluoranthene, benzo[k]fluoranthene, indeno[1,2,3-cd]pyrene, and dibenz[a,h]anthracene

exceeded USEPA SSLs in a sample at the northern railroad loading dock. Barium also exceeded USEPA SSLs and Refuge background values in one sample.

In addition to the northern and southern railroad loading docks each igloo has a truck loading dock. One row of igloos sits adjacent to the former rail line and had both truck loading docks and railroad loading docks.

2.5 AREA 7 – IOP INERT STORAGE AREA

Area 7 was originally built as the IOP Inert Storage complex, which warehoused metal parts and other inert materials used in the production of artillery shells, tank mines and 500-lb bombs and their component parts.[1] The building complex was constructed in 6 rows of buildings (5 to 7 buildings per row originally). Only 26 of the original buildings in Area 7 remain standing. After the end of WWII several industries began leasing space in Area 7.[2] Information on the known leasing history for Area 7 is detailed in the AUS Historic Search Report Section 7. Only one business is known to have stored hazardous materials in Area 7: Great Lakes T & T stored pesticides in buildings IN-1-5 and IN-1-6. All other businesses, which would have handled hazardous materials, used the buildings for purposes other than storage. Since the buildings in Area 7 were built strictly for storage, other uses required occupants to modify the buildings. One of the most important modifications required in the Area 7 buildings to make them capable of housing production operations was an upgrade of the electrical service. Production operations require that three-phase power be supplied to a building so that equipment and machinery can be used.[3] Only eight of the remaining 26 buildings in Area 7 have the equipment necessary for supplying three-phase power. These buildings are IN-1-1, IN-1-5, IN-1-6, IN-2-1, IN-2-5, IN-2-6, IN-3-4, and IN-6-5.

It is known that buildings IN-3-5, IN-4-4, IN–5-2 and IN-5-3 were used for production activities for several years. In fact, the 1988 O'Brien & Gere remedial investigation (RI) performed sampling around these buildings because of the appearance of black residues. Sample analyses revealed low levels of BNAs and polychlorinated biphenyls (PCBs), however, no further action was recommended for this area. Subsequently these buildings were demolished and buried at the site.

It is possible that other buildings razed in Area 7 were also involved in production activities. However, the remaining building debris is buried under 2 feet of soil and the original landscape and drainage profiles have been changed as a result. Therefore identifying areas impacted from production activities must rely on observations of current site conditions.

[1] U.S. ACE, 1944, Part I Sect. 7 page 28.
[2] Techlaw, 1992, pages 59-63b.
[3] Large motors used in pumps, lathes, metal working equipment, etc. require three phase power be supplied to the motor. Three-phase power cannot be supplied using the same electrical service that was installed to supply the single-phase power the IOP used for lighting. Therefore additional equipment had to be installed to support activities other than lighting.

2.6 AREA 8 SOUTH – IOP LOAD LINE III (AUS-0A8S)

Area 8 South was formerly a bomb loading line for the IOP where TNT was screened, melted, and loaded. After World War II, several different industrial tenants leased the site for various production operations. Products manufactured at the site after World War II included fiberglass canoes, propellants, pyrotechnics, and ground nitrocellulose. After a fire at the site in 1981, the entire site was razed and buried. No industrial activity has taken place at Area 8 South since that time.

A visual inspection of the site revealed several mounded areas in the former production buildings locations. Two drums were identified at the site to the northwest of the former IOP TNT Cooling building. In addition, a sump pit was observed to the west of the former TNT Melting building which also was the site of the American Fiber Lite production operations. Aerial photo interpretations at the site indicated ground scarring at one location to the southeast of the northern change house. No supplementary information has been found indicating a cause for the ground scarring, however, it was observed in aerial photography from 1943 to 1993. Three other features identified by aerial photo interpretations were southwest of the eastern TNT Cooling building. One was a trench like feature more than 190 feet long and 8 feet wide. The other two were identified as pits.

2.7 AREA 9 – IOP LOAD LINE I (AUS-0A09)

Area 9 was formerly an artillery and bomb loading line for the IOP where TNT was screened, melted, and loaded. After World War II, several different industrial tenants leased the site for various production operations. Products manufactured at the site after World War II included capacitors, wrapping paper, gloves, boats, and industrial finishes. Industrial tenants in Area 9 included Sangamo Electric Co., Technical Tape Corp., Good Luck Glove Co., Mark Twain Marine Industries, Pyramid Industrial Finishes, and Olin Corp. Olin Corp. (now Primex) is currently the sole tenant in Area 9.

In 1982 the Service identified PCB and lead contamination in the portion of Area 9 known as the Sangamo Dump. O'Brien & Gere (1988) investigated Area 9 as Sites 32 and 33. It was subsequently designated as part of the PCB Areas Operable Unit (PCB OU) and a Record of Decision on a remedial action was issued on August 1, 1990.[4] In 1996 and 1997, a large area in and near Area 9 was remediated as a part of the PCB OU.[5] In addition, there is an on-going remedial investigation/feasibility study in the same area for chlorinated volatile organic compound contamination.

2.8 AREA 10 – IOP FUSE AND BOOSTER STORAGE MAGAZINES (AUS-0A10)

Area 10 was formerly a group of storage magazines for the explosive components of anti-tank mines, bombs and artillery being produced at the load lines. From 1967 to 1970 the site was used for the incineration of ignitable wastes from the production operations of an ordnance

[4] U.S. EPA, 1990, Declaration for the Record of Decision, Crab Orchard National Wildlife Refuge, PCB Areas Operable Unit.

[5] International Technology Corporation, 1997, Acceptance Report for Closure of PCB Areas Operable Unit Landfill, Crab Orchard National Wildlife Refuge, Marion, IL.

manufacturer. The burning of the wastes was done in large pits called burning pits. In 1970, open burning was banned on the Refuge and the pits were covered. Since that time the site has been used by local law enforcement personnel for small arms practice.

2.9 AREA 11

Area 11 contains a group of buildings comprising the IOP Group II Melt Loading Line. It originally consisted of 31 buildings located just south of Ogden Road to the west side of Highway 148. Load Line II was designed and built for the loading of 105 or 155mm shells. Several corporations have had operations within Area 11 including:

- The Sherwin Williams Defense Corporation (SWDC) operated the Group II Melt Loading Line (Load Line II) in Area 11 during World War II, from August 1942 through September 1945. Sherwin Williams loaded shells, bombs and mines on Load Line II. They occupied all of the buildings along Load Line II in conjunction with operating the area for IOP.
- Hoosier Cardinal Corporation and the Ordill Machine Works operated in Area 11 from approximately August 1948 through 1954. Hoosier Cardinal Corporation manufactured and finished decorative metal and plastic parts. Ordill Machine Works did tool and dye workings. It is not known what buildings they occupied.
- From January 1956 through April 1964, Olin conducted operations in Area 11. Olin occupied all of the former IOP buildings and expanded the plant into the vacant property located between Areas 11 and 12. For the purposes of this report, this expanded area will be considered part of Area 11. Olin produced various types of commercial explosives in Area 11.
- Commercial Solvents Corporation (CSC) occupied Area 11 from April 1964 through 1982. CSC (and its successors, including U.S. Powder who initially operated the plant for CSC) also produced explosives in Area 11. CSC occupied the same buildings that Olin had previously occupied. Explosives were manufactured in Area 11 until June 1971, when decontamination procedures began. By 1986, there were no tenants in Area 11.[6]

AUS-A11H – AREA 11 HIGH EXPLOSIVES AREA

The majority of the Area 11 High Explosives Area was built by Olin and was occupied by both Olin and CSC. This area has been used for the production and packaging of high explosives. Contaminants identified in this area by CSC include the following: dynamite, RDX, pentaerythritol tetranitrate (PETN), nitroglycerin, nitrocellulose, TNT and ANOIL. Several buildings were also used by SWDC for IOP operations at the Melt Loading Line. These buildings were Building 7, 8, 24, 67 and 69 and the most likely explosive contaminant in these buildings would be TNT.

[6] CRO 185 – According to Techlaw, Inc., 1992, Final Draft Report - Site Operations/Ownership History – Crab Orchard National Wildlife Refuge; Prepared for U.S. Army Corps of Engineers, Page 75.

AUS-A11N – AREA 11 NITROGLYCERIN AREA

The Area 11 Nitroglycerin Area was built by Olin and was occupied by both Olin and CSC. This area has been used for the production of nitroglycerin using the Biazzi process. The only explosive contaminant identified in this area by CSC was nitroglycerin. There are numerous ditches and ponded areas in this area that will be investigated in addition to the areas around the buildings.

A previous investigation was done in AUS-A11N in the East Holding Pond (Site COP-2). Metals and nitrates were the only elevated compounds detected in this area. There were eight possible burning trenches located in AUS-A11N that were identified in historical aerial photographs, though there is currently no evidence of these trenches on site. Two were identified in the location of former Building 10, and six were identified in an open area located just east of former Building 9. The former use of these trenches is not known.

There were two railroad tank cars (RRTCs) located just west of the former Nitrator (Building 9). One of these two RRTCs had an access port and has been previously sampled. It has been reported that the ditches and holding pond in this area may have been flashed; however, the potential for contamination still exists.

AUS-A11P – AREA 11 PILOT PROPELLANT PLANT/CAP PRODUCTION AREA

The Area 11 Pilot Propellant Plant/Cap Production Area has been occupied by all of the above-mentioned occupants of Area 11 (this area may or may not have been occupied by Hoosier Cardinal/Ordill Machine Company, since it is not known what buildings these companies occupied).

This area was used by SWDC during IOP operations as a part of the Melt Loading Line for some TNT pouring operations and drilling and boostering operations. Olin used this area as a Pilot Propellant Plant that was used for research and development of propellants. Olin also manufactured gas generators and tested some explosives in this area. CSC used this area for Big Inch Cap Production that involved the use of RDX, lead azide and/or lead styphnate and possibly mercury fulminate. Testing of Big Inch Caps was also done in this area and there were numerous storage facilities also. This area was in operation during most of the time that Olin and CSC had possession of the property. There are numerous ditches and ponded areas in this area.

AUS-A11S – AREA 11 SUPPORT AREA

The Area 11 Support Area has been occupied by all of the above-mentioned occupants of Area 11. This area was used during IOP operations as a part of the Melt Loading Line, mostly for storage and for cleaning and painting operations (Buildings 56 and 66). The IOP Boiler House along with four associated underground storage tanks (USTs) was also located in this area. It has been reported that the USTs were removed from near the boiler house, there is no evidence of their presence at the site, nor has documentation been found to confirm their removal. The building has been razed; however, it is possible that the underground fuel storage tanks may have been left in place during the building demolition. Both Olin and CSC used this area as a support

area for their explosives manufacturing operations in Areas 11 and 12. This portion of the facility was in use for the duration of Olin and CSC's tenure at the site – from January 1956 through the mid-1970s when decontamination procedures began at the site. The following buildings were located in this area: Carpenter, Maintenance and Machine Shop (Building 55), Welding Shop (Building 57), Oil Stores (Building 68), Administration Buildings (various buildings), Laboratories (Buildings 75-1 and 80), Garage/Wash Room (Building 56), Boiler House (Building 60), Scrap Yard (Location 58) and other miscellaneous buildings. There are numerous ditches and ponded areas in this area.

The USEPA previously collected samples from near the cleaning and painting building and near the boiler house; both semivolatiles and metals were detected at elevated levels in samples from these locations. The depth and locations of these samples is not known.

2.10 AUS-0A12 – AREA 12 FORMER AMMONIUM NITRATE PLANT

Area 12 consists of the IOP Ammonium Nitrate Plant. It originally consisted of 12 buildings located just south of Ogden Road to the west side of Highway 148 – south of Area 11. The Ammonium Nitrate Plant was designed and built for the production of explosive-grade ammonium nitrate. Several corporations have had operations within Area 12 including:

- SWDC used Area 12 for explosive-grade ammonium nitrate production during World War II from August 1942 through May 1943.
- Silas Mason produced fertilizer-grade ammonium nitrate in this area from 1947 through 1950.
- Universal Match Corporation (UMC) tested photo flash signals in this area for approximately six months during 1955.[7]
- Olin leased this area from January 1956 through April 1964. According to John Miller, a former Olin employee, it was used mostly for storage and burning.[8] According to Mr. Robert Meyers[9] (a former Olin truck driver) and Mr. Harry Stiles[10] (former FWS project manager for entire Refuge), Area 12 was also used to make explosives for a brief time.
- CSC occupied Area 12 from April 1964 through 1982. CSC (and its successors) used Area 12 for cyclonite (RDX) production and for storage, according to the U.S. Powder Map. Additionally, according to the U.S. Powder Map the burning grounds were also still present on the western side of the property. CSC occupied the same buildings that Olin had previously occupied and they built several new buildings.

Decontamination of Area 12 began after 1971.[11] By 1986, there were no tenants in Area 12.[12]

[7] ACO 39 and ACL 670 - According to Techlaw, Inc., 1992, Final Draft Report - Site Operations/Ownership History – Crab Orchard National Wildlife Refuge; Prepared for U.S. Army Corps of Engineers, Pages 6, 25.
[8] Testimony of Mr. John Miller taken on April 9, 1998, Page 31.
[9] Testimony of Mr. Robert Meyers taken on April 10, 1998, Page 20.
[10] Testimony of Mr. Harry Stiles taken on November 18, 1997, Page 67.
[11] CRO185 – According to Techlaw, Inc., 1992, Final Draft Report - Site Operations/Ownership History – Crab Orchard National Wildlife Refuge; Prepared for U.S. Army Corps of Engineers, Page 76.

As mentioned above, SWDC, Silas Mason, UMC, Olin and CSC all occupied Area 12. SWDC operated the explosive-grade ammonium nitrate plant for the IOP. Silas Mason then operated the ammonium nitrate plant to produce fertilizer-grade ammonium nitrate. UMC was reported to have used the area to test photo flash signals. Olin used the area for storage, burning and to manufacture explosives. Olin originally manufactured ammonium nitrate in this area until the ammonium nitrate facility in Area 11 was completed. CSC used this area for storage, burning and RDX production.

There were eight storage ponds present in Area 12 also and these were used for storage of double-base propellants, smokeless powder, and possibly other explosive materials. A few metals were detected at elevated levels in a previous investigation at the powder storage ponds (Site COP-3). However, all soil samples were collected from depths of at least four feet and no surficial soil samples were collected. The area south of the burning ground was also previously investigated (Site COP-4). Volatiles, semivolatiles, metals, explosives, TRPH, nitrates and sulfates were all detected levels in this area. Removal actions are currently being done at COP-4.

2.11 AUS-0A13 – IOP FINISHED AMMUNITION IGLOOS

The site was formerly a group of storage magazines for finished ammunition. Since World War II, the igloos have been used by various manufacturers to store raw materials and products. Each igloo has a truck loading dock for material transfers. In addition, one row of igloos had an additional dock adjacent to the railroad line running through the site.

2.12 AUS-0062 TO AUS-0069 AND AUS-0109 COC AREA SITES

The original Crab Orchard Cemetery (COC) sites were identified as having been impacted by ordnance disposal activities in a 1998 UXO investigation by Parsons Engineering. The AUS sites in the COC Area consist of dumpsites and other sites, which because of their location, may be connected to ordnance disposal activities.

Ordnance scrap was identified on all of the COC sites that are part of this investigation except for AUS-0066 and AUS-0109. AUS-0066 was not investigated during Parsons' 1998 UXO investigation. AUS-0109 is a previously unidentified site. AUS-0109 was identified by aerial photo interpretations as resembling other ordnance disposal sites previously identified and characterized at the site. UXO removal activities have occurred at some sites in the COC area and are a concern at all COC area sites.

2.13 AUS-0001 – IOP FIRE AND POLICE HEADQUARTERS

AUS-0001 formerly housed the Fire and Police Headquarters for the Illinois Ordnance Plant and later the Refuge. It is less than an acre in size. The Headquarters included an administration building, and a fire station as well as a small boiler house. To the west of these buildings was a long structure with a trough running through it. Its purpose is unknown. Though all of the

[12] CRO185 – According to Techlaw, Inc., 1992, Final Draft Report - Site Operations/Ownership History – Crab Orchard National Wildlife Refuge; Prepared for U.S. Army Corps of Engineers, Page 75.

buildings at the site were razed, their foundations remain. Evidence of underground storage tanks at the site was observed near the former boiler house.

2.14 AUS-0002 – IOP WASTEWATER TREATMENT PLANT

This site is the former location of the Wastewater Treatment Plant for the Illinois Ordnance Plant's administration area and may have served portions of Area 2. The building was razed, however the settlement lagoons still exist. The site encompasses less than acre.

2.15 AUS-0018 – IOP RAILROAD CLASSIFICATION YARD

AUS-0018 was formerly the railroad classification yard for the Illinois Ordnance Plant. Railroad cars were ordered at the site for efficient transport to their final destinations. The site was not used for long-term storage; however, train cars may have waited at the yard for a few days awaiting dispensation. According to an engineering drawing contained in the War Departments' 1944 Facilities Inventory of the Illinois Ordnance Plant, the classification yard had a fuel oil column, which may have been used for refueling of locomotives. The tracks at the site were removed along with the ballast and railroad ties. One building still stands at the site. However, it has been abandoned since its post World War II tenant, the Williamson County Emergency Management Agency, moved to a new location. Previous sampling at the site revealed the presence of elevated levels of cadmium, mercury, lead, and zinc. The overall size of the site is approximately 30 acres.

2.16 AUS-0021 – IOP FIRE STATION FOR AREA 7

This site formerly housed a fire station that serviced Area 7 and other nearby IOP facilities. The building has been razed and only parts of the foundation are visible. A walkover survey of the site revealed ordnance/explosive waste at the site to the north of the former fire station building. The site footprint is less than an acre.

2.17 AUS-0043 – AREAS 11 AND 12 FIRE STATION

This site formerly housed a fire station that serviced Areas 11 and 12 as well as other nearby IOP facilities and is less than an acre in size. The building has been razed and only the foundation and debris remain at the site. A walkover survey of the site revealed sumps and a burner stack as well as abandoned farm equipment.

2.18 AUS-0060 – IOP FULMINATE STORAGE IGLOOS

This site was originally designed, built and used for the storage of mercury fulminate for use in detonators. After World War II, the storage igloos were used to store other compounds including lead azide, TNT, tetryl, and nitrocellulose. The storage igloos have been unoccupied for about 30 years. In 1996 igloo number FS 2-2 was found to contain boxes with some nitrocellulose. The igloo was decontaminated subsequent to this discovery. Previous sampling at the site showed elevated levels of metals at the site. Visual inspection of the site revealed the presence of numerous drums abandoned at the site. The site encompasses approximately 30 acres.

2.19 AUS-0061 – CONCRETE STRUCTURES WEST OF WOLF CREEK ROAD

AUS-0061 was built for the testing of ordnance and propellant systems. The site contains two structures that were used as test pits and one structure used to initiate the testing. The site area is less than an acre. Previous sampling at the site showed elevated levels of BNAs.

2.20 AUS-106A – DRUM DISPOSAL AREA IDENTIFIED DURING SITE RECONNAISSANCE EAST OF AREA 11

The history of this site is unknown. There appeared to be a road leading to this disposal area as seen in 1951 aerial photographs, which did not appear in the 1960 aerial photograph. This would indicate that the IOP (1942 through 1945), Hoosier Cardinal (1948 through 1954) or Silas Mason (1947 through 1950) could possibly be responsible for these drums. There is also an oven hood and two former smokestacks located near a soil mound. The size of the unit is approximately one acre.

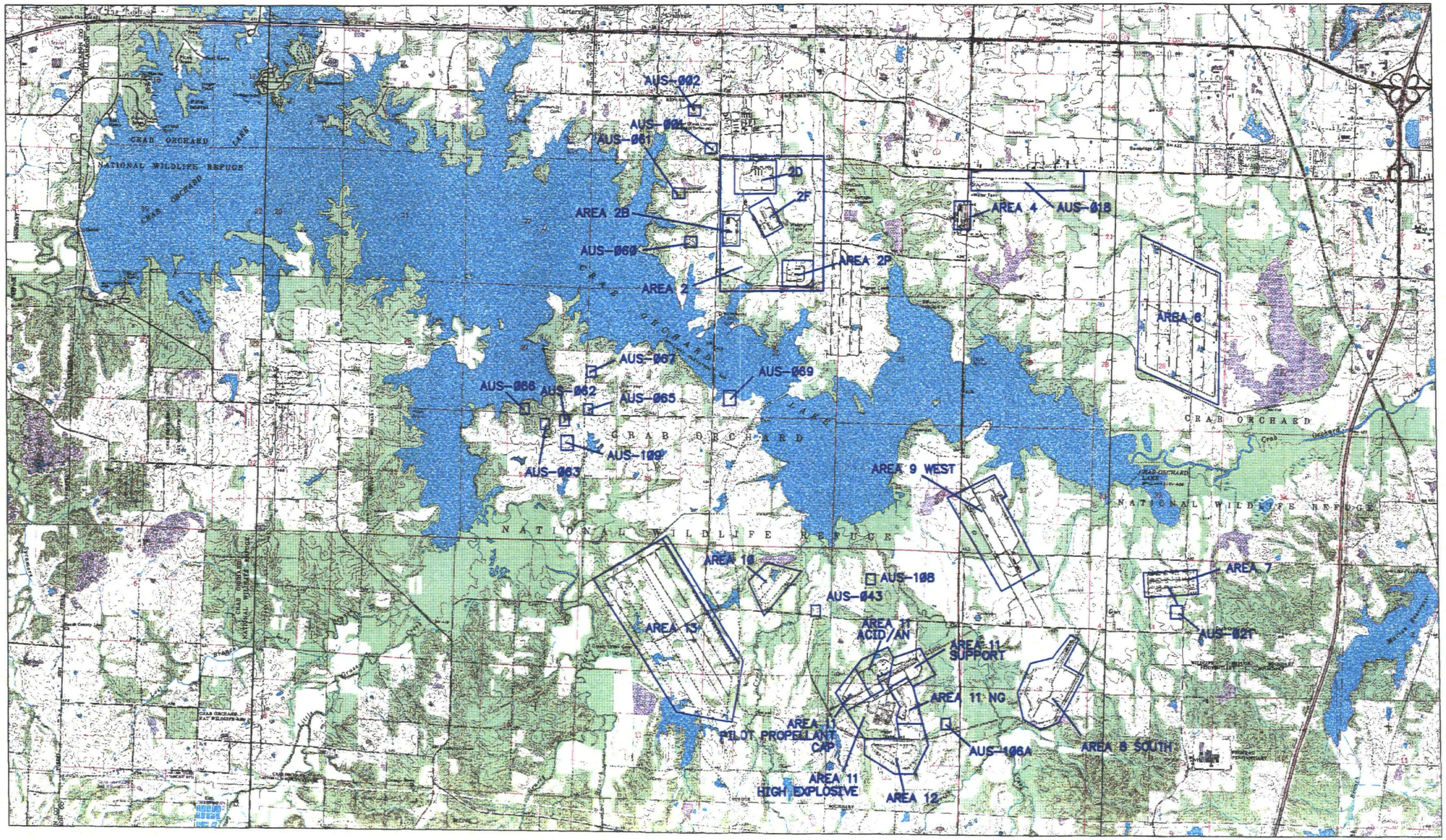
During a site reconnaissance, it was estimated that 50 to 100 drums might be disposed in this area. These drums are partially buried and are located along a creek bed that usually contains water only during precipitation events. There is a grayish-bluish solid substance present in several of the exposed drums. It is speculated by the Service that this may be old paint; however there is no evidence to support this.

2.21 AUS-0107 – POSSIBLE DISPOSAL AREA IDENTIFIED BY AERIAL PHOTO INTERPRETATIONS

This site is located north of Area 8 and just south of Ogden Rd. It was identified by aerial photography interpretations as a possible disposal area.

2.22 AUS-0108 –POSSIBLE SURFACE DISPOSAL AREA IDENTIFIED BY AERIAL PHOTO INTERPRETATIONS

This site is located north of Ogden Rd. and north of Area 11. It was identified by aerial photography interpretations as a possible surface disposal area near COC 10.



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The *Ecological Risk Assessment Guidance for Superfund* (USEPA 1997), hereafter referred to as ERAGS, will be used as the primary guidance for evaluating the potential for ecological risk at the AUS OU. The overall process consists of a series of eight steps as outlined in Figure 3-1. The first two steps correspond to a preliminary, or screening level assessment, which form the basis for this evaluation and the development of ecological screening concentrations for the AUS OU. Step 1 consists of a screening-level problem formulation and ecological effects evaluation. Step 2 is the screening-level exposure estimate and preliminary risk calculation.

3.1 SCREENING-LEVEL PROBLEM FORMULATION AND ECOLOGICAL EFFECTS EVALUATION (STEP 1 – ERAGS)

During the screening-level problem formulation, a conceptual model is developed for the site that addresses five issues (USEPA 1997), as follows:

1. Environmental setting and contaminants known or suspected to exist at the site;
2. Contaminant fate and transport mechanisms;
3. Mechanisms of ecotoxicity associated with contaminants and likely categories of receptors that could be effected;
4. What complete exposure pathways exist;
5. Selection of endpoints to screen for ecological risk

3.1.1 Environmental Setting and Suspected Contaminants

The Refuge is located in the temperate deciduous forest region occupying the northeastern portion of North America. Geographically the Refuge lies between the Ozarks and the Appalachians; this area serves as a link in the North American vegetation gradient due to overlap of distinctive vegetation patterns. There are plants of the eastern U.S. that generally range throughout the eastern half of North America, plants of the central U.S. with southern Illinois being near the center of distribution, and plants of the southeastern U.S. which have advanced northward and westward. Thus, the available habitat and species associated with the habitats are diverse throughout the Refuge.

Contaminants suspected to exist at the AUS OU were identified for each of the sites based on historical use and site reconnaissance as discussed in Section 2. A summary of these chemicals and their physiochemical properties is provided in Table 3-1. These chemicals formed the foundation for development of a sampling plan for the AUS OU site investigation, as presented in the *Field Sampling Plan Site Inspection Additional and Uncharacterized Sites Operable Unit* (URS 2000b).

The Refuge is unique in that it has wildlife management as well as industrial management objectives. Some AUS OU sites may contain exploitable habitat that is used for foraging and/or shelter by a number of potential ecological receptors. Others are comprised of active industrial activity, with little or no exploitable habitat. Essentially artificial habitats, such as those associated with active industrial areas, are not considered *directly* ecologically relevant because they exist and are configured to support human (industrial) functions. These areas are not self-

what is the point?

sustaining and do not represent biological communities. As a result, organisms such as soil invertebrates or small mammals that may reside in a lawn adjacent to an industrial building will not be directly evaluated in the ecological risk evaluation. However, receptors that reside adjacent to such sites and forage upon (exploit) the invertebrates or small mammals are considered relevant to the evaluation.

The initial step in the evaluation of the sites is to determine whether the unit has an *ecological component*, which is primarily based on the availability, within the subject unit, of *exploitable habitat*. Simply defined, the term *habitat* means the "place where a plant or animal lives" (USEPA 1997), but a more functional definition can be paraphrased as the *type of environment* where an organism (or community of similarly adapted organisms) *normally* lives. The term *exploitable* refers to the presence of attributes such as food and/or shelter. For example, robins may not generally inhabit (live in) a lawn area but they may *exploit* earthworms living in the soil.

The following subsections discuss the preliminary habitat characterizations at each of the AUS OU subareas. This information was obtained from previous descriptions of the sites and area reconnaissance by biological personnel located at the Refuge.

3.1.1.1 Area 2

Area 2 contains about 595 acres of which about one-third is occupied by the load lines. A fence surrounds each of the four active industrial sub-units in Area 2. Areas within the sub-units are highly industrial, unlike the remaining area within Area 2. The unfenced, non-industrial portion of this area is composed of patches of mixed wetland, old field, woodland and active agricultural fields. When planted in winter wheat, the fields serve as habitat for geese. Both geese and raccoon visit the agricultural fields when planted in corn. To the north of the site is state land and Southern Illinois University Coal Research Center. The area to the south consists of mixed wetland, agricultural, woodland and old field. Agricultural land is located to the west with mixed agricultural, woodland and old field to the east. Of particular interest to this area is a designated refuge natural area approximately 22 acres in size and is located partially in the nonindustrial portion of Area 2 and east, north-east of 2D. The Post Oak Flats Natural Area has a unique forest community of post oak and hickory. The area is relatively undisturbed and was set aside to preserve the native forest community typical of the glacial till flats in that area.

All of the sub-units, 2B, 2D, 2F, and 2P, have a number of ditches with intermittent flows. Drainage ditches are along the fences, and they are thickly vegetated with brush and trees aged about 10 to 20 years old. Each of the sub-units is described below.

Area 2b – IOP Booster Load Line (AUS-0A2B)

Very little natural habitat exists in this sub-unit. The total area of the sub-unit is approximately 47 acres. The landscape consists primarily of mowed fescue among the buildings, driveways, and roads. Drainage ditches along the fence are thickly vegetated with brush and young trees. Woodland exists on the southern portion of Area 2B outside a fence. An abandoned road and building foundations are located in this woodland. The 6-foot chain link fence surrounding the area limits accessibility to the site by some organisms.

Area 2D – IOP Detonator Load Line (AUS-0A2D)

This area has little, if any, native ecology. The site consists primarily of mowed fescue with a few ornamental trees around the buildings, roads, and driveways. Drainage ditches along the fence are overgrown with brush and trees. The trees are approximately 10 to 20 years of age.

Area 2F – IOP Fuse Load Line (AUS-0A2F)

Area 2F is about 26 acres and is located east of Area 2B. Entrance to the site is through the security entrance for Area 2D. Little natural habitat exists in this area. The habitat is mostly mowed fescue with a few solitary large trees standing on the site. Ditches with tree and brush vegetation run along the fence line. Agricultural fields surround the area. Geese from the agricultural fields have been observed within Area 2F.

Area 2P – IOP Primer Load Line (AUS-0A2P)

Area 2P is located south of Areas 2D, 2B, and 2F and is approximately 60 acres in size. Vegetation consists mostly of mowed fescue. There are a number of ditches within the site with intermittent streams. Vegetated ditches also run along the fence that borders the site. Fescue that is mowed annually lies to the east of Area 2P. There is mature woodland (oak/hickory forest) to the north and west. A mixture fescue field and brushy woodlands exists south of the site. There is a swampy area, just along Crab Orchard Lake, approximately ¼ mile west of Area 2P.

3.1.1.2 Area 4 East – IOP Automotive and Equipment Shop Area (AUS-0A4E)

Very little native habitat occurs within Area 4 East. Two buildings remain on site, one is scheduled for demolition and the other is used for shipping and receiving activities. The building foundation of the IOP vehicle refueling station lies adjacent to the existing building. There is a gravel parking lot that sits directly to the east of Route 148. Mixed woodlands (cedar, maple, and oak) are to the north of the site. A small (approximately 3-acre) fescue field lies south of the existing building. There are mixed woodlands to the east of the area with a shallow drainage ditch in the tree line. An open field to the south of Area 4 East contains fescue, cedar, and autumn olive, an invasive bush. A walkover survey at the site revealed several areas of stressed vegetation, industrial debris, and debris related to the maintenance of vehicles to the north of the remaining buildings.

3.1.1.3 Area 4 West – IOP West Shop Area (AUS-0A4W)

Little available habitat exists within Area 4 West; however, there are a variety of habitats adjacent to the site. Several buildings still exist in the area and are used as office space and as shipping and receiving buildings. Three buildings have been razed since the war. There are some small patches (100 ft x 100 ft) of overgrown rose, blackberry, sumac, and small trees. Little to no aquatic habitat exists on or near the site, with the exception of some intermittent drainage. Pigeon Creek and a moist soil unit is approximately ¼ mile west of this area. A fescue field to the south of Area 4 West has an early intrusion of autumn olive. To the west is a mature

pine plantation, a mature oak/hickory forest, and newly planted hardwoods (approximately two years old). There are well-mixed hardwoods to the north. During a walkover survey of the Area 4 West buildings, several areas of stressed vegetation were observed around the S-2-5 building (Building S-2-4 was razed).

3.1.1.4 Area 6 – IOP Ammonium Nitrate High Explosive and Smokeless Powder Storage Area

This site is actively used as a storage facility and some of the area is fenced. The total area of the site is approximately 500 acres. The habitat immediately surrounding the igloos is old field and an active crop field. The old field consists of open areas with mowed fescue and some brushy growth of sumac, autumn olive, and other invasives. There is some agriculture between the magazine roads where winter wheat, soybeans, and corn are planted. Most of the igloos have mature trees (30 to 40 years old) growing on them. Roadside ditches with poor drainage contain standing water following rainfall. There is a shallow impoundment of Little Creek that receives runoff from Area 6. This impoundment has become a source of food for some waterfowl and bald eagles. Large solitary trees that may be used for perching by aerial predators are located in this area and nesting of bald eagles has been observed between Little Creek Impoundment and Crab Orchard Creek within about ½ mile to the southeast. Cattle graze the fescue field to the north of Area 6 in the summer months. There are also watering ponds for the cattle. The fescue field is bordered by mature oak/hickory forest. There are also mature woodlands to the south and west. Open fields lie to the east of Area 6. Some agriculture (corn) also exists around the borders.

3.1.1.5 Area 7 – IOP Inert Storage Area

Area 7 is located 0.5 miles north of Ogden Road on Chamness Road in a remote area of the Refuge. The site is actively used as a storage area and is about 60 acres in size. During the site walkover of Area 7, none of the typical signs of environmental impacts were observed in the areas of the razed buildings. The site is composed mainly of mowed fescue. Interspersed wet drainages hold shallow water. Young (approximately 30 years old), mixed woodland exists to the west of the site. This woodland is in a middle successional stage. A 200-foot corridor of brush and mature oaks, on the south side of Area 7, leads to an open field that is mowed annually. This field will be planted to hardwood forest. There are also a few areas along ditches to the south with mature trees. Mixed (successional) woodland lies to the north and east of Area 7. A pond with fish is located about 1/3-mile northeast of the site. This pond attracts feeding blue heron; however, the birds do not visit Area 7. Raccoons regularly visit Area 7, and turkey and bobcat have also been observed in the area.

3.1.1.6 Area 8 South – IOP Load Line III (AUS-0A8S)

Area 8 South is about 190 acres and consists of an intermixed habitat. There are no industrial activities occurring within this area. There is open field with fescue, broom sedge, goldenrod, small cedars, and sumac. The field is spotted with large cedars, black locust, and some thick brushy areas (early successional). The brushy areas are young woodlands of about 20 years with a dense under-story and few older trees. There are a few areas of older trees (greater than 50

years) and clear under-story. Little to no standing water exists on site. There is a pond on the far south side of the area. Some older woodlands exist to the south, east, and west. Wolf Creek is southwest of the area.

3.1.1.7 Area 9 – IOP Load Line I (AUS-0A09)

Area 9 is about 70 acres and is composed primarily of mowed fescue. Some ditches and flooded areas hold water. There is an area containing cattails. Some areas, spanning approximately ¼ acre, have trees. Woodland exists to the west of the site and an agricultural field lies to the east. Crab Orchard Lake is to the north. Deer, turkey, and geese have been observed within Area 9. Piscivorous birds travel nearby but do not enter the site since the ditches do not support fish. However, these birds, along with mink and raccoon may be transient visitors to Area 9, as the ditches may contain crayfish and other food items.

3.1.1.8 Area 10 – IOP Fuse and Booster Storage Magazines (AUS-0A10)

Area 10 is composed of successional woodland and is about 40 acres in size. The habitat is primarily young, dense woodland with a few large, mature trees. There are areas of thick saplings and vines and a few patches of unmowed fescue. The northern portion of Area 10 is part of a 40 acre designated natural area. The Area 10 natural area extends north of the site and is a unique forest community designated by the occurrence of a black willow forest. Area 10 is bounded on all sides by mature woodland (oak/hickory/willow forest).

3.1.1.9 Area 11

Area 11 has been divided into five sub-units according to the specific activities that were conducted in particular areas. While this is functional for the sampling investigation and derivation of the chemicals of interest, the area is basically a continuous habitat patch of approximately 180 acres. Though relic building foundations are present, the entire area has been left untouched for 20 to 30 years. The habitat consists of thick patches of invasive vines, autumn olive, and sassafras. Roadbeds cross the site. Some patches of woodland are found in this area. There are numerous ditches and small ponds. Most of the ponds are ephemeral and too small to support fish. Wood ducks and occasional dabbling ducks visit Area 11. There is evidence of beavers, probably associated with Wolf Creek and its tributaries, that feed within Area 1. Area 11 subareas were discussed in Section 2.

3.1.1.10 AUS-0A12 – Area 12 Former Ammonium Nitrate Plant

Area 12 is about 80 acres. Though similar in habitat to that of Area 11, this site is less open and more consistently wooded with less fescue. The east-end of Area 12 has more mature (40 to 50 years old) woodlands. There are not a lot of big trees, but it is more shaded. Numerous ditches and ponded areas exist within the site. Area 12 is bound on the east, west, and south by woodlands.

3.1.1.11 AUS-0A13 – IOP Finished Ammunition Igloos

AUS-0A13 encompasses approximately 500 acres. The design of Area 13 is similar to that of Area 6, in that both sites are storage areas with igloos and parallel roads. The habitat of Area 13 consists of mowed fescue with patches of woodland, brush, and vegetation. Hayfields and agricultural fields exist on site. The hayfields within the Refuge are usually red clover or fescue. The hay is cut off once or twice per year. The hayfields usually receive more visitations by animals than the agricultural fields because the hayfields are not as disturbed. Area 13 contains wetland habitat. Ponds within this site are capable of supporting fish. Herons and ducks visit one very large pond that borders Area 13. Ditches within the site that are poorly drained contain standing water following rainfall. Area 13 is bound on all sides by woodlands. The Big Grassy Creek Natural Area borders to the southwest. This area supports a mature white/red oak and sassafras/persimmon forest community. The area also supports wood duck nesting and bald eagle use. There are also a number of cemetery sites of historic significance in the area.

3.1.1.12 AUS-0062 to AUS-0069 and AUS-0109 COC Area Sites

The Crab Orchard Cemetery (COC) sites are all in remote areas. Some of the sites are near the Lake (AUS-0069 and AUS-0066) while others border open fields or woodlands.

AUS 0062

This site is an old field. The site is brushy with young saplings (5 to 10 feet tall), vines, and invasive thorny bushes such as autumn olive, sassafras, and blackberry. A ditch runs through the site and there is ponding water in a couple of locations. AUS 0062 is surrounded on all sides by cropland. An abandoned road runs along the north side of the site.

AUS 0063

This site is an old field, within a mixed woodlands of approximately 50 to 70 years of age. There are a number of small water filled depressions from past munitions detonations dotted throughout the site. There is also a small intermittent drainage stream that runs through the site. There is an abandoned road on the north and west perimeters of the site. An agricultural field to the south and mature woodlands to the north border the site.

AUS 0065

This site is composed of a small, open mature woodland with a thicker canopy and not as much brush. There are several mounds of soil, a brick structure, two building foundations, and three ground depressions. One depression contains building debris and another has ponded water. A fence runs along the southern perimeter of the site. Fallow field surrounds AUS 0065. The field has early pioneer weeds and small hardwood saplings that have been planted. It will take approximately 50 years until this field is mature hardwood.

AUS 0066

This site, like AUS 0065, is open mature woodland with a thicker canopy and little brush. A pond of about 60 feet in diameter exists on the site. A red clay brick berm is located on the south side of the pond. An abandoned road and barbwire fence borders the north side of this site. Mixed mature woodlands surround the area. AUS 0066 is approximately 200 feet from Grassy Bay of Crab Orchard Lake.

AUS 0067

The habitat of this site is like that of AUS 0065. There is a soil pile and a sunken area with concrete slabs, brick, and old foundation pieces. A road runs along the western perimeter of the site with an adjacent barbwire fence. ASU 0067 is completely surrounded by old field habitat.

AUS 0069

This site is a small wooded area. Approximately 5 acres of the site are located on the Crab Orchard Lake shore. Scattered debris exists in three different locations within the site. Hay fields lie to the west, east, and south.

AUS 0109

This site is an agricultural field that is currently planted and completely surrounded by corn. Woodland exists several hundred feet to the northwest.

3.1.1.13 AUS-0001 – IOP Fire and Police Headquarters

There are two ditches and a gravel parking lot within this site. Brushy woodland growth exists directly around, and is beginning to overtake the foundations of former buildings. The site is bounded on the east by Wolf Creek Road. Cedar and maple woodlands (20 to 30 years old) surround the site on the north, south, and west sides. A fescue hay unit borders the east side.

3.1.1.14 AUS-0002 – IOP Wastewater Treatment Plant

Site AUS-0002 is in a stand of trees just west of a pond. New vegetation, including intrusives such as cedar, autumn olive, and sassafras, are directly around the area. A fescue hay unit exists to the east and south. A corridor of mature trees leads north from the site to a field planted to trees. A cool-season native grassland buffer planted around the site leads to this woodland. The treatment building was razed, however settling lagoons still exist. Dense vegetation now exists all around the area of the settling lagoons.

3.1.1.15 AUS-0018 – IOP Railroad Classification Yard

Site 0018 is composed primarily of woodland and brushy overgrown areas. There is shallow standing water in ditches. A parking area also exists within the site. An old field, then Old Route 13, and a residential area are located north of the site. There are some oaks on the south side. One building still stands at the site.

3.1.1.16 AUS-0021 – IOP Fire Station for Area 7

Young woodlands (20 years) of cedar and autumn olive comprise the habitat of this site. The site is bound on the south by the PCB OU landfill and on the east by Chamness Road. Older woodland exists to the north of this site and leads to AUS Area 7. A fescue field proposed for reforestation borders the west side of this site. The building has been razed and only parts of the foundation are visible.

3.1.1.17 AUS-0043 – Areas 11 and 12 Fire Station

The habitat of this site is mainly early successional woodland. A ditch runs through the site. The foundation of one building still exists. The site is bound on the south by Ogden Road and on the east and west by mature poplar, cedar, and maple woodlands. To the north is an agricultural field. This site is presently used as a staging area by tenant farmers.

3.1.1.18 AUS-0060 – IOP Fulminate Storage Igloos

All of the igloos located at Site AUS-0060 are intact and accessible, however, overgrowth in the area of the compound's fence gate limits access through the gate. There are a few areas of ponded water within the site. Ditches surround the igloos and road. The site is composed of woodland with larger trees. Crab Orchard Lake is west of the compound and open fields surround the compound on the north south and east. The storage igloos have been unoccupied for approximately 30 years.

3.1.1.19 AUS-0061 – Concrete Structures West of Wolf Creek Road

The concrete structures of AUS-0061 are approximately 0.1 miles west of Wolf Creek Road in a thin row of trees. The site is overgrown and difficult to see from Wolf Creek Road. A road runs through the site. There are ditches on either side of the road. The site has woodlands on the east and west and open fields on the north and south.

3.1.1.20 AUS-106A – Drum Disposal Area Identified During Site Reconnaissance East of Area 11

AUS-106A is located on the northern side of a former roadway (which is now impassable to vehicular traffic) that heads east from the roadway just east of former Building 9. There is a fence line crossing the former roadway, approximately 500 feet west of the site. The habitat of this site is mainly early successional woodland. A 3000 ft^2 mounded area covers 50 to 100 partially buried drums. The mounded area is located along a creek bed that contains water only during precipitation events. This site is completely surrounded by woodland.

3.1.1.21 AUS-0107 – Possible Disposal Area Identified by Aerial Photo Interpretation

The habitat of Site AUS-0107 is mature woodland. Area 8 is located southeast of the site. There is a grassy field immediately adjacent to the east. Mature woodland exists to the south and west. Ogden Road and a grassy field are to the north.

3.1.1.22 AUS-0108 –Possible Surface Disposal Area Identified by Arial Photo Interpretations

This site is located north of Ogden Road and north of Area 11. The area is partially agricultural field currently planted in corn and beans, with the remainder a mature woodland. The woodland has older trees (50 years) and brushy undergrowth. There is fairly contiguous mature woodland to the east and north. A patchy woodland/agricultural mix is located to the west. A buffer of youger woodland and a road borders the site to the south.

33 areas

3.1.1.23 Summary of Habitats Associated with the AUS OU

An area habitat matrix is provided in Table 3-2 that summarizes the types of habitats and onsite and adjacent features associated with the AUS OU. Considering the areas presently characterized, there appear to be eight general habitat types presented within the areas under investigation:

- Early succession woodland
- Mid-succession woodland
- Agricultural field
- Agricultural pasture
- Urban grassland with treelines (lawn)
- Urban grassland with brush
- Urban grassland with tree stands
- Old field

The term "urban" grassland is used to indicate the presence of active industrial activity, with maintained lawn present.

3.2 ENVIRONMENTAL FATE ISSUES

The largest medium in terms of areal extent associated with the AUS OU sites is soil. Windblown dust in most of the areas is not expected to be a significant pathway since most areas are vegetated. However, windblown dust may be a potential transport mechanism in areas where cultivated agricultural fields are present. The same is true for erosion. Some erosion may occur, particularly on the agricultural fields or portions of active industrial sites.

Some of the sites also contain ditches and ponds. There is the potential that offsite transport could occur during periods of rainfall. For many of the COIs, sediments in the ponds and ditches may act as contaminant sinks or reservoirs. Sediments could then sequester chemicals, and may be important to benthic invertebrates or semiaquatic receptors where sediment-dwelling organisms form a component of the food chain.

The COIs in Table 3-1 have been organized in general chemical categories (for example, alkanes, alkenes, polycyclic aromatic hydrocarbons [PAHs], inorganics, etc.), along with their physical/chemical properties. The migration and persistence of a chemical within the

environment is controlled by the physical/chemical attributes of the chemical, the physical attributes of the system, and finally by the biota within the environment. All of these attributes effect the ultimate fate of the chemical. Such interactions are site-specific, but certain generalizations can be made. This section reviews the following in general terms:

- the importance of the soil/water/sediment matrices and their character;
- the chemical attributes of the constituent in the context of fate and transport, *e.g.*, lipophilicity, solubility, and sorption phenomena; and
- relative importance of dissolution, volatilization, complexation, photolysis, advection, and biodegradation as transport processes for the chemicals.

An understanding of how a chemical stressor behaves in the environment and how it can elicit stress in an ecosystem is an important component of the ecological risk evaluation process.

3.2.1 General Chemical/Physical Properties of Organic Chemicals

One of the most illuminating properties of an organic chemical's fate and transport within the environment is its relative solubility in water and octanol (Table 3-1). The ratio between chemical concentrations in water versus octanol is represented by the octanol-water-partitioning coefficient, the K_{ow}. The K_{ow} of a chemical is a useful indication of the chemical's lipophilicity or propensity for sequestering into lipid stores within biota, the chemical's propensity towards adsorption onto organic carbon and, its ability to cross biological membranes. Empirical relationships between a chemical's K_{ow}, water solubility, organic carbon partitioning coefficient (K_{oc}), bioconcentration factor (BCF), and assimilation coefficient for biota have been drawn by numerous authors (*e.g.*, Clark *et al.* 1988, Donnelly *et al.* 1994, Lyman 1995, Mackay *et al.* 1995, Trapp and McFarlane 1995). For example, a chemical's K_{ow} is closely correlated to its affinity for organic carbon, expressed as the K_{oc}. In general, the greater the K_{ow} or K_{oc} the lower the water solubility and greater relative adsorption onto organic carbon. Donnelly *et al.* (1994) suggested relative mobility in soils based on a chemical's K_{oc}.

Soil Mobility Defined by Affinity for Organic Carbon

K_{oc}	*Log K_{oc}*	*Mobility Class*
> 2000	>3.3	Immobile
500 – 2000	2.7-3.3	Low Mobility
150 – 500	2.2-2.7	Intermediate Mobility
50 – 150	1.7-2.2	Mobile
< 50	<1.7	Very Mobile

In general, VOCs range from intermediate mobility to very mobile. In general, the majority of the semivolatile organic compounds (SVOCs)[13] that have Log K_{oc}'s in excess of 3.3 and are considered essentially immobile in soil (unless the soil itself becomes mobile through *advected transport* or *biological assimilation*).

The octanol-water partitioning (K_{oc}) of an organic chemical is also a key property affecting the environmental behavior of an organic chemical in an aquatic system. This process has a direct bearing on ecological risk assessment as it impacts exposure pathways and especially the bioavailability of a chemical.

The process and/or degree of sorption with organic carbon, whether particulate or dissolved, has been shown to reduce the apparent (effective) bioavailability of both organic and inorganic compounds (Knulst 1992; Dewitt *et al.* 1992; Goodrich *et al.* 1992). Most sorption studies used to estimate or calculate partitioning coefficients for organic chemicals involve short exposure periods (hours to days) followed by desorption periods (USEPA 1986). These studies have been performed, for the most part, under the assumption that the sediment sorption process follows first-order thermodynamic kinetics. DiToro (1985), Landrum *et al.* (1992), USACE (1985), and others have shown that this assumption is invalid. Sorption is more accurately described as a biphasic process, in which the initial phase involves the chemical sorbing <u>onto</u> the surface of a sediment particle, followed by a second phase in which the chemical is absorbed <u>into</u> the particle. This biphasic process has a greater impact on predictions of desorption than adsorption, since the contribution of the secondary absorption of a chemical within particles does not have a great influence on the overall mass or concentration. Desorption, however, can be greatly overestimated since contact time and "degree" of adsorption will affect the rate of desorption (Landrum *et al.* 1992; USACE 1985). There is evidence that, given sufficient time, desorption essentially will not occur (Karrickhoff and Morris 1985; DiToro 1985). This phenomenon is reflected in several recent articles that demonstrate reduced bioavailability (and toxicity) with the "age" of contamination in sediments (*e.g.*, Landrum *et al.* 1992).

An uncertainty in the prediction of bioavailability of sediment associated chemicals of interest is the inherent assumption of the equilibrium partitioning (EqP) approach that sorption of organic chemicals is dominated by the total organic carbon (TOC) content of the sediment. In fact, pore-water concentrations of dissolved organic carbon (DOC) also have a significant impact on the apparent bioavailability predicted by EqP (Williams *et al.* 1995).

Certain site-specific features such as soil structure have profound effects on the sorption, volatilization, and/or degradation processes of any chemical. In general, VOCs are susceptible to volatilization and degradation, and do not readily adsorb to sediments. PAHs can undergo photolysis, oxidation, and biodegradation (USEPA 1979). Some pesticides can undergo some volatilization from soils (*e.g.*, aldrin and endrin [USEPA 1979]). Others, such as chlordane and heptachlor are very resistant to degradation processes.

The significance of these processes is highly dependent on the environmental conditions to which the materials are exposed. The absorbents present in the soil, the type of soil cover, and size of macropores are highly significant site-specific considerations for most organic chemicals

[13] The SVOCs as a group comprise the BNA compounds.

due to their impact on/interaction with the process of photolysis, volatilization, and oxidation/reduction.

Volatilization of organic chemicals from soils has been measured empirically and experimentally but can be considered highly site-specific. Volatilization is hampered by sorption to the soil and entrapment by overlying moisture. Lyman (1995) provides a generalization that is useful in qualitatively describing a chemical's propensity towards volatilization using its Henry's constant where:

Volatilization Potential	
H (atm m^3/mol)	*Volatilization Potential*
$< 3 \times 10^{-7}$	Chemical is less volatile than water.
3×10^{-7} to 10^{-5}	Chemical volatilizes slowly.
$> 10^{-5}$ to $<10^{-3}$	Volatilization is significant.
$> 10^{-3}$	Volatilization is rapid.

Rates of chemical biodegradation vary widely due to variations in microbial composition, nutrient concentration, chemical soil concentration (non-toxic levels), and other environmental factors (*e.g.*, temperature, anaerobic or aerobic conditions). The most significant microbial degradation PAHs occurs aerobically in acclimated populations (USEPA 1979, Lyman 1995). While strong evidence exists that significant biodegradation occurs under anaerobic conditions the best evidence is still found for aerobic degradation. Because most soils within the units under consideration here are believed to be fairly aerobic, anaerobic degradation is probably not a significant fate process.

3.2.2 Fate and Transport Mechanisms of Inorganics

The fate of metals and metalloids depends on a myriad of processes best generalized as follows (according to Kabata-Pendias and Pendias 1992);

- dissolution;
- sorption;
- complexation;
- migration;
- precipitation;
- occlusion;
- diffusion (into minerals);
- binding by organic substances;
- absorption/fixation and/or sorption by microbiota; and
- volatilization.

The most important soil parameters involved with these processes are pH and redox potential. Other factors, such as cation exchange capacity (CEC), iron and manganese hydrous oxides, humics, chlorides, and clay minerals, are all known to impact these processes as well (Kabata-Pendias and Pendias 1992).

3.3 POTENTIAL ECOLOGICAL RECEPTORS

3.3.1 Biological Characteristics and Ecological Structure

The following subsections describe the study area in the context of habitat, biological composition (structure), and system function. Habitat and composition are presented in the context of aquatic and terrestrial, or semiaquatic, *communities*. Understanding the biological characteristics and ecological structure enable the risk assessor to focus the evaluation through selection of assessment endpoints specific to the sites. *Assessment endpoints* represent ecologically relevant values based on fundamental ecological principles that consider the structure, function and dynamics of the ecological systems at risk.

Brief discussions of general community groups are presented below.

3.3.1.1 Plant Communities (Autotrophs)

Plants or plant communities are relevant in defining ecological assemblages by providing vegetative cover and shelter. Overall, eight vegetative cover types or assemblages are present at the AUS OU as described in Section 3.1:

- Early succession woodland
- Mid-succession woodland
- Agricultural field
- Agricultural pasture
- Urban grassland with treelines
- Urban grassland with brush
- Urban grassland with tree stands
- Old field

3.3.1.2 Soil Communities

Soil communities, comprised primarily of microorganisms (bacteria, fungi, molds, algae and protozoa) and invertebrates (*e.g.*, earthworms, nematodes), can be rich and diverse, both in terms of species diversity and biomass per unit area or volume (Spurr 1964, Owen 1975). Some play a significant role in the decomposition of fallen vegetation (Owen 1975), whereas some are predaceous on other soil invertebrates. At the non-industrial portions of the AUS OU, the soil community is important for decomposition, nutrient cycling, and biomass production for utilization at higher trophic levels. However, at industrial areas, the importance of the soil communities is the role of soil invertebrates in the food web. The soil invertebrates in particular are prey items of consumers that will be considered as assessment endpoints. Through assimilation of bioaccumulative chemicals, these invertebrates represent a source of ingestion-pathway exposure to higher level consumers. Earthworms are a good example of a key pathway

organism, in that they can account for up to 80% of the total macrobiotic biomass in soil (Kabata-Pendias and Pendias 1992).

3.3.2 Aquatic Microorganism and Invertebrate Communities

Several of the AUS OU sites contain ephemeral water habitats such as ditches or pools. These areas are seasonal or associated only with rainfall. Though they may be small in size and ephemeral in nature, they could potentially represent seasonal breeding areas for amphibians in the nonindustrial areas.

Several of the AUS OU sites contain permanent water (ponds) or wetlands. In permanent standing water, the aquatic microorganism and invertebrate communities may be significant in providing decomposition and nutrient cycling, and for food for higher level consumers. Because wetland sediments are anoxic, infaunal invertebrates are probably not significant. However, epifaunal invertebrates may play an important function role in decomposition and nutrient cycling. Some of the ponds contain fish, and though others do not, they may be important amphibian reproductive areas. Wetlands can also provide breeding habitat for a number of potential ecological receptors.

3.3.3 Fish

Fish are not believed to be associated with the ephemeral ditches and pools at the site since there are no direct connections to other surface water bodies that could provide recruitment. However, there are several permanent ponds, as noted in Table 3-2, which could potentially contain fish. A list of fish potentially present at the Refuge is presented in Table 3-3. Based on the preliminary types of surface water present, (ponds) likely common fish are centrarchids (i.e., sunfish), bass, and ictalurids (catfish and bullheads), as well as numerous species of minnows. Catfish and bullheads are bottom dwelling fish, and also have higher lipid content than the centrarchids and bass. Because of these characteristics, as well as an outer "skin" rather than scales, ictalurids may be more likely to contain sediment-associated contaminants.

3.3.4 Amphibians

Amphibians that may occur in the vicinity of the Refuge are presented in Table 3-4. As a group, the amphibians are the most primitive of the so-called higher vertebrates or tetrapods. As adults, frogs are basically terrestrial in the sense that they breathe air, but all have strictly aquatic larvae, or tadpoles. All except the treefrog and chorus frog remain in or near water most of the time. When there are temperature extremes (*e.g.*, in winter or on sunny summer days), frogs generally hibernate or aestivate in the warmest or coolest available locations. For the *Rana* sp., whose skin must remain moist, this usually means burrowing in soft aquatic sediments or riparian soils. Amphibians at the AUS OU will generally be associated with creeks, ponds, wetlands and adjacent riparian areas.

Adult frogs are essentially sedentary in the spatial context of relevance to this investigation. All are carnivores, and their normal way of feeding is waiting in ambush. Adult frogs normally eat anything alive that is small enough to ingest, which usually means some type of crawling or flying insect, but for the bullfrog includes crayfish, fish, other frogs, mice, and small birds. The tadpoles are basically herbivorous, feeding mainly on algae and vegetable detritus.

At industrial areas with associated water bodies, amphibians are considered as potential contaminant transport pathways to higher organisms that may forage along ponds and ditches. For non-industrial areas, amphibians represent potential assessment endpoints. Though the forage biomass may be limited, amphibians are potentially components of the diets of many predatory semiaquatic vertebrates (*e.g.*, wading birds and raccoons).

3.3.5 Reptiles

Based on geographical ranges and historical information, about 31 species of reptiles could conceivably occur in the vicinity of the Refuge (Table 3-4). Reptiles like the amphibians are cold-blooded, but all are strictly air-breathing.[14] All reptiles that may be associated with the AUS OU sites, with the exception of the box turtle, are primarily carnivorous as adults, but will take other foods at times. Most are omnivorous as juveniles. All of the snakes are carnivores, with diets depending largely upon the most prevalent prey within the respective snakes' preferred habitats. Specific individuals of any of these species are unlikely to stray from relatively confined areas (i.e., a few tens or hundreds of square meters [DeGraaf and Rudis 1986; Dundee and Rossman 1989]). Snakes are potential prey items of various vertebrates, especially wading birds, some raptors, raccoons, and other snakes.

3.3.6 Birds

Many birds forage over large areas, or are seasonal migrants that are federally protected. A total of 230 species of birds are listed with at least a potential to occur in the vicinity of the Refuge based on zoogeographic information and accounts (Table 3-5). Many of these are only transient visitors that pass through the Refuge during migration and have very limited exposures. Others are present only seasonally, and some are residents of the Refuge throughout the year. For the purposes of selecting candidate ecological receptors for the screening evaluation (Section 3.6.1), focus is placed on birds believed to be relatively common and either resident or seasonally resident. This does not indicate that migratory birds are not a consideration as part of this evaluation. Rather, because resident or seasonally resident birds will be more susceptible to contaminant exposures, risks estimated based on these receptors should also be protective of birds with lower exposure[15].

3.3.7 Mammals

A total of 38 species of mammals have a potential to occur at the Refuge (Table 3-6). There are several herbivorous ground-grazing mammals potentially present at the Refuge. These include the eastern cottontail rabbit, the white-tailed deer, the prairie vole, the woodchuck and several species of squirrels. Several mice may be common to the area. With the exception of the golden mouse (which is arboreal), these mice are herbivorous ground foragers but will consume insects and soil invertebrates on occasion (Martin *et al.* 1951, DeGraaf and Rudis 1986, USEPA 1993).

[14] Many amphibians are capable of and extensively utilize "dermal" respiration via their skin. Terrestrial reptiles, for the most part, are incapable of dermal or buccal respiration and have fully developed lungs.

[15] Susceptibility is a function of both sensitivity to the chemical and degree of exposure (dose or concentration). Unless certain receptors are known to have greater sensitivity to a chemical, then identifying receptors with greater exposure is a reasonable approach to selecting those at greatest risk.

Among the carnivores, the mink is semiaquatic in nature, feeding on small mammals, birds, amphibians and fish. The weasel, though it also is generally not found far from water, feeds on small mammals, birds and insects. Six species of bat may occur at Crab Orchard. All of these species are entirely insectivorous feeding exclusively on flying insects caught in flight (air hawkers, DeGraaf and Rudis 1986). The largest carnivores potentially associated with the site are the coyote and bobcat.

The remaining mammals expected to be common or abundant within the landscape-scale ecosystem are omnivorous ground foragers. The opossum, raccoon and striped skunk are expected to be relatively common. The red fox is more carnivorous than the other common mammalian omnivores and feeds heavily on rabbits and small rodents (DeGraaf and Rudis 1986). However, the fox will also consume significant quantities of fruits when available.

3.3.8 Species of Special Value or Concern

Federally listed and State of Illinois listed threatened or endangered species potentially found on Crab Orchard National Wildlife Refuge are summarized in Table 3-7.

3.4 ECOTOXICITY

As pointed out in ERAGS, understanding the toxic mechanisms of a contaminant helps to evaluate the importance of potential exposure pathways and to focus selection of assessment endpoints. It is not the intent of this Work Plan to provide a great level of detail on the toxic mode of action of the each of the COIs listed in Table 3-1. Rather, a broader approach will be used for developing screening concentrations. For example, in a detailed evaluation, or where COIs are limited, it may be appropriate to limit the evaluation of PCBs to reproductive endpoints in higher level consumers because of the tendency of PCBs to biomagnify and act as a reproductive toxin in mammals. In this screening evaluation, conservative screening concentrations will be developed using the most sensitive of reproductive, growth or survival endpoints based on information available from the readily available toxicological literature for all trophic levels for both direct and ingestion pathway exposures.

3.5 EXPOSURE PATHWAYS

The predominant source of potential contaminants at the AUS OU sites are wastes historically disposed at the sites, or releases occurring as a result of historic handling practices or spills. The primary medium associated with the AUS Sites is soils. However, transport of chemicals to other media (e.g., surface water, sediment or groundwater) may have occurred.

In the context of ecological receptors, exposure can occur via direct contact and ingestion. A diagrammatic conceptual exposure model for potential exposure pathways associated with the AUS OU sites is shown in Figure 3-2. Direct exposures are defined as direct contact between a contaminated medium and a receptor. Examples include roots of vegetation or invertebrates in direct contact with soils or sediment; or fish, amphibians or invertebrates in direct contact with surface water. Potential exposure pathways for vertebrate receptors include: (1) inhalation, dermal contact and direct ingestion of contaminated media; and/or (2) ingestion of dietary items containing chemicals as a result of bioconcentration/accumulation (i.e., food chain exposures).

Although some of the COIs are volatile constituents, the inhalation exposure pathway is not considered a significant exposure pathway and is not included in the overall evaluation. There are also limitations in estimating the potential release of these chemicals from soil to subsurface soil pores or channels. However, none of the areas being evaluated represent confined areas where a "concentrated" exposure to volatile constituents may occur. Nevertheless, fossorial or burrowing organisms could potentially be exposed to volatile chemicals in soil. Though not considered significant, this remains an uncertainty in the risk evaluation.

"Direct" dermal contact with soil could potentially occur via digging for food or "dusting". However, most soil generally does not reach the epidermis because of the presence of fur or feathers and is discarded (e.g., shaken off) or ingested through preening and grooming behaviors (USEPA 1993). Semiaquatic birds and mammals can also be exposed via dermal contact to chemicals in sediment or surface water. However, as with the inhalation pathway, there is a paucity of information regarding dermal exposures to wildlife. Though inhalation and dermal pathways are considered of relatively low importance compared to direct ingestion, they contribute to uncertainty in the risk assessment.

3.6 SELECTION OF ASSESSMENT ENDPOINTS

As noted previously, assessment endpoints represent ecologically relevant values based on fundamental ecological principles that consider the structure, function and dynamics of the ecological systems at risk. They represent the focus of the ecological risk assessment. Screening level assessment endpoints are dependent upon the presence of exploitable habitat for each of the AUS OU sites. Consistent with the Refuge management goals (Section 1.2) for sustaining wildlife, agricultural, recreational and industrial purposes, approaches to developing assessment endpoints for the AUS OU can be subdivided into three categories:

- Industrial area with no exploitable ecological habitat - no further ecological evaluation will be conducted.
- Active industrial areas with limited habitat – These areas may occasionally be exploited by organisms that normally reside outside the unit boundaries of the site. Vegetation and receptors such as invertebrates or small mammals that may be present on the site will not be considered as relevant assessment endpoints. Only ingestion pathway exposures are considered relevant. Though some of the units with active industry contain ditches, all are ephemeral and are not considered to contain significant aquatic habitat. Therefore, potential receptors will be limited to terrestrial or upland receptors. The vegetative information for each of the sites is currently qualitative, and the amount (i.e., biomass) of vegetation present on each of the sites is unknown. It will be assumed in the screening process that at least some vegetation such as foliage or seeds may be available as forage for some receptors. Thus, both herbivorous and carnivorous consumers may utilize the area. The following assessment endpoints are applicable to areas falling into this category:

  Herbivores associated with the ecosystem within which the subarea resides that may occasionally forage within the subarea.

  Carnivores associated with the ecosystem within which the subarea resides that may occasionally forage within the subarea.

Still not clear this is the point where things get taken out.

- If the habitat is nonindustrial (or historically industrial but currently inactive), then selection of assessment endpoints will be consistent with the type of habitat present (i.e., terrestrial or aquatic), and whether the pathway is via direct contact, or ingestion. A summary of applicable assessment endpoints for sites that fall within this category is presented below. The structural and functional relevance is indicated adjacent to the assessment endpoint. Potentially relevant receptor groups are also noted. These will be further refined in the section on selection of candidate receptors. where?

Direct Exposures

Decomposers and detritivores – support decomposition and nutrient cycling

Primary producers - provide food, shelter, and control for higher level consumers

Sediment – rooted aquatic macrophytes

Water – Algae, phytoplankton

Soil – vascular plants

Invertebrates - provide food and control over the local community of secondary consumers and structural control over the primary producers

Sediment – Benthic invertebrates

Water – Water column invertebrates (zooplankton)

Soil – Soil Invertebrates

direct contact? birds mammals FOD SSLS

Fish and amphibians – provide food and also control over primary consumers. For amphibians, ponds on the site may also provide important reproductive habitat to support larval life stages.

GI - wildlife

Ingestion Pathway Exposures

Herbivores – provide control over primary producers and food for higher level consumers.

Semiaquatic and terrestrial – birds and mammals

Invertebrate consumers – provide control over invertebrate populations

Semiaquatic and terrestrial – birds and mammals

Higher carnivores – provide top-down control over lower trophic levels

Semiaquatic and terrestrial – birds and mammals

For each of the assessment endpoints noted above the attributes to be protected are survival, growth and reproduction. At the screening level these attributes broadly define the sustainability of individual communities that comprise the ecosystem. Not included above are assessment endpoints associated with amphibians (adults)[16] and reptiles. This is not intended to indicate that these organisms are not ecologically relevant. For ingestion-pathway exposures, little to no oral toxicity data are available for amphibians or reptiles for most chemicals. Though there may be adequate knowledge of an animal's behavior and physiology to estimate exposures with reasonable accuracy, it is of limited practical value to do so if there is no basis for evaluating the consequences of the exposures. The potential risks to reptiles and amphibians represent an uncertainty in the risk evaluation.

In addition, it is notable that omnivores were not specifically identified in the assessment endpoints. From a practical viewpoint, organisms with diets limited to either plant (herbivores) or animal (carnivores) material will be most susceptible to risk, depending upon the specific uptake characteristics of individual chemicals. For example, PCBs tend to accumulate in animal tissue, but not in plants. Therefore, carnivores will be most susceptible to exposure. Cyanide may be present in plant tissue, but is unlikely to be found in animal tissue. In this case, herbivores will have the greatest exposure. In either scenario, the omnivores fall in between, but evaluation of both the herbivore and carnivore should be protective of the omnivore. Exceptions to this scenario would be omnivores that are particularly sensitive to some constituents, or that have high soil or sediment ingestion rates and may receive higher doses via direct ingestion.

3.6.1 Candidate Receptors

To develop a measurement by which the assessment endpoint may be tested, an applicable ecological component is identified that is representative of the assessment endpoint. For direct exposures, the ecological component is generally defined by the assessment endpoint. For example, for invertebrates in soils, soil invertebrates are the receptor. However, for ingestion pathway exposures associated with higher vertebrates the generally accepted approach is to select an indicator species (USEPA 1997; 1998), which is often referred to as a *receptor of concern*, or as used in this screening work plan, a *candidate receptor*. This is because toxicity reference values (TRVs) used for comparing environmental exposures to potential effects are species-specific. Therefore, candidate receptors were selected that are characteristic of the ecosystem, and representative of the assessment endpoint. The following were taken into consideration in the selection of candidate receptors:

- Probable intensity/duration of exposure. In general, species are selected that are known or anticipated to be relatively common and abundant in and around the Refuge, and specifically, characteristic of the AUS OU subareas. Given a choice between an infrequent or seasonal immigrant and a year-round resident, the latter receives preference.
- Availability of relevant behavioral and physiological data. In general, preference is given to relatively well-studied species for which most biological attributes are readily-accessible. When appropriate, for example, candidate receptors are selected from among those covered in the *Wildlife Exposure Factors Handbook* (USEPA 1993).

[16] Larval amphibians are included in the assessment endpoint for evaluation of fish.

- Availability of relevant toxicological data. For ingestion-pathway exposures, virtually no oral toxicity data are available for amphibians or reptiles for most chemicals. Therefore, amphibians and reptiles were not selected as receptors, as indicated previously. This is also true for other potentially relevant candidate receptors. However, toxicological information in the literature based on similar types of organisms is considered reasonable surrogate information. Nevertheless, there is a substantial lack of toxicological information for some chemicals, especially for birds.

Other considerations are relative sensitivity or species warranting special consideration. In addition, size serves as an "index" to behavioral and physiological differences that may influence the animals' susceptibility (and sensitivity) to chemicals. Smaller animals tend to be shorter-lived, occupy smaller home ranges (and occur in greater densities), and have higher metabolic rates. Therefore, when multiple potential receptors of similar attributes in terms of trophic structure, guild, and relative sensitivity are available as potential candidate receptors, the smaller receptors are generally selected in preference to, or in addition to, larger receptors.

A summary of candidate receptors selected for each of the assessment endpoints based on habitat type at individual AUS OU sites is presented in Table 3-8. What are the marks?

3.7 SCREENING-LEVEL EXPOSURE ESTIMATE AND RISK CHARACTERIZATION (STEP 2 – ERAGS)

3.7.1 Estimates of Exposure

The types and numbers of analyses varies among each of the AUS OU sites depending on the historical activities at the site as outlined in the *Field Sampling Plan Site Inspection Additional and Uncharacterized Sites Operable Unit* (URS 2000b). For the purposes of exposure estimation at the screening level, only the maximum concentration of a constituent identified at each site will be evaluated. This is consistent with the overall conservative nature of the screening process to ensure that constituents that could potentially contribute to risk are not eliminated early in the process. The maximum concentration is directly applicable to direct exposures.

For ingestion pathway exposures, however, meaningful inferences about the potential hazards of ingesting COIs requires an understanding of the relationship between exposures, expressed as *doses* or rates (i.e., mass of COI/unit of receptor body weight/unit of time), and *responses*. Doses are estimated using:

- The measured and/or predicted concentrations of each COI in media assumed to be ingested (i.e., food, water, sediment, and soil); and
- Estimations of the mass of each COI consumed per day, obtained by multiplying the concentration (mg/kg or μg/L) in a medium by the amount of that medium (kg or L) assumed to be ingested by an individual in the population of the receptor species and expressed in terms of the mass (body weight) of the receptor (mg/(kg-day).

Ingestion-pathway exposures to the vertebrate candidate receptors are estimated as *average daily doses* using the approach outlined in USEPA (1993) as follows:

(1) $ADD = [(IR_{food}*C_{food}) + (IR_{water} * C_{water}) + (IR_{soil}*C_{soil}) * AUF/BW$

where:

ADD	=	Average Daily Dose (mg/kg/day)
IR_{food}	=	Ingestion rate of food (kg/day)
IR_{water}	=	Ingestion rate of water in (L/day)
IR_{soil}	=	Ingestion rate of soil in (kg/day)
C_{food}	=	Concentration of contaminant in food (mg/kg)
C_{food}	=	[(diet composition[17]$_{food1}$*C_{food1})+(diet composition$_{food2}$*C_{food2}) .... food$_n$]/100
C_{water}	=	Concentration of contaminant in water (mg/L)
C_{soil}	=	Concentration of contaminant in soil (mg/kg)
AUF	=	Area use factor (percent) – assumed 1 in the screening evaluation
BW	=	Body weight (kg)

COI concentrations in dietary items other than soil, water and sediment are not available – specifically, plants, soil and sediment invertebrates, small reptiles, mammals, and birds. Estimation of the COI concentrations within these dietary items will be derived using mathematical procedures. A detailed presentation of the mathematical approaches used in calculating concentrations in dietary items is presented in Appendix A.

To estimate the environmental dose for ingestion pathway exposures, relevant information regarding the behavior and physiological attributes of potential receptors is also required. The following ingestion-pathway exposure factors (assumptions) were identified for each of the potential candidate receptors:

- Area use (acres)
- Composition of the diet
- Rate of ingestion of food (kilograms/day; IR_{food})
- Rate of ingestion of water (liters/day; IR_{water})
- Rate of ingestion of sediment (kilograms/day, $IR_{sediment}$)
- Body weight (kilograms; BW)

These characteristics are summarized for the candidate receptors in Table 3-9. All of the foregoing are developed in the context of a hypothetical individual of a vertebrate consumer species representing the receptor group or guild. Relatively few empirical measurements of these attributes in wildlife species are available, and those that are available are often based on captive specimens. For these and many other reasons, *assumed* values for these attributes represent uncertainties. Uncertainty can never be totally eliminated, but prudent application of

[17] Diet composition is input as a percentage of the overall diet. The sum of all should equal 100.

well-documented information about the behavior and physiology of the receptors minimizes uncertainty. For this reason, EPA commissioned the compilation of the *Wildlife Exposure Factors Handbook* (USEPA 1993), which warns its readers that in any given ecological risk assessment it is crucial to apply site-specific or region-specific knowledge whenever possible. The assumptions used in this analysis are all based on formally-published information for the species, or plausible surrogate species. Generally-accepted principles and qualified-professional judgment are used to derive assumptions from relevant literature (mainly USEPA 1993 and primary sources cited therein) that could be representative of conditions at sites within the AUS OU. At the same time, to avoid underestimating exposures, whenever ranges of values are available, the approach consistently incorporates a value at or near the conservative end of the range.

3.7.1.1 Area Use

Area use relates to the fraction of ingested media derived from a unit or area. However, for the purposes of a screening level evaluation, area use factors for all receptors will assumed to be one. That is, it will be assumed that a receptor obtains all of its forage from individual sites.

good

3.7.1.2 Dietary Composition

In nature, the diets of most vertebrates vary considerably (Allee *et al.* 1951; Martin *et al.* 1951). Some have morphological, physiological, and/or behavioral adaptations that limit their ability to use certain broad categories of food. In general, however, there is a paucity of detailed quantitative dietary studies, and these relate primarily to localized populations of only a few species (USEPA 1993). Diets identified for the candidate receptors are based on consideration of the feeding patterns of the potential receptors and the way food habits are commonly described in the literature. For some of the potential receptors, there are proportional breakdowns of the diet which conform to (or can be readily converted to) dietary components. In other cases, it is necessary to infer categorical allocations from qualitative descriptions. Dietary composition breakdowns for the selected representative receptors are presented in Table 3-9.

3.7.1.3 *Food Ingestion Rate (IR_{food})*

Most of the food ingestion rates in Table 3-9 are based on allometric relationships developed by Nagy (1987; all reproduced in USEPA 1993). In the absence of empirical measurements specific to the selected receptors, use of the allometric equations is appropriate because these are widely-accepted, empirically-derived relationships. Body weights at the low end of the range reported in the literature were used in the equations to derive the food ingestion rate (see below).

3.7.1.4 *Water Ingestion Rate (IR_{water})*

The applicable equations of Calder and Braun (1983; also available in USEPA 1993) were used to calculate the ingestion of water in liters per day. Water ingestion rates for selected representatives for the ecological receptors are shown in Table 3-9.

3.7.1.5 Sediment Ingestion Rate ($IR_{sediment}$)

Many higher vertebrates are known to ingest sediment, usually incidentally to feeding or grooming (USEPA 1993; Beyer *et al.* 1994)[18]. The quantities are often a function of the animal's feeding habits; for example, some small mammals that feed extensively on the roots of emergent vascular plants (e.g., the muskrat) ingest relatively high amounts of sediment. For some receptors, the literature provides directly measured rates that reflect conditions that might occur within the AUS OU. Otherwise, professional judgment has been used in interpreting reported rates, or extrapolating from surrogate species. The rate is normally estimated as a percentage of the overall diet, and then converted to mass/day. The assumed sediment ingestion rates ($IR_{sediment}$) are included in Table 3-9.

3.7.1.6 Body Weight (BW)

Body weight is an important factor because it is often used in calculating other exposure assumptions when realistic direct measurements are not available (e.g., food and water ingestion rates). When a range is reported, literature values have been adopted which, based on professional judgment, are representative of the low extreme for wild adults in Illinois habitats. Assumed body weights for the candidate receptors are presented in Table 3-9.

3.7.2 Effects Assessment

To develop COI-specific screening concentrations, it is necessary to understand the level at which a COI may affect ecological receptors via direct or ingestion pathways. For the purposes of developing screening concentrations, effects are based on identification of relevant toxicity reference values (TRVs). For direct exposures, TRVs essentially represent the screening concentration. For ingestion pathway exposures, the ratio of the TRV to the ADD is used to develop a screening concentration. An ADD:TRV ratio of 1, back-calculated to a media-specific concentration, is equal to the screening concentration. TRVs are discussed for each of the assessment endpoints in the following subsections.

3.7.2.1 Direct Exposure Toxicity Reference Values (TRVs)

hierarchy or screen ag all?

TRVs for Soil-Associated Organisms

Soil organisms are those organisms in intimate contact with the soil. These include invertebrates such as earthworms and insects, plants such as soil algae or vascular plant roots, and soil microbes (bacteria and fungi). These TRVs correspond to the following assessment endpoints identified in Section 3.6:

Decomposers and detritivores – bacteria, fungi, molds, algae and protozoa

Primary producers - vascular plants

Invertebrates – soil macroinvertebrates

[18] There are also some vertebrates which deliberately ingest soil, a phenomenon called geophagy. For example, white-tailed deer commonly lick or nibble exposed soil or rock surfaces to acquire trace minerals.

For direct exposures, the TRV that is selected represents the screening concentration. To the extent possible, TRVs that are "effect-based" are selected over those that reflect a desired or "target" level (e.g., those disseminated by US Fish and Wildlife [Beyer 1990] and some of those from MHSPE 1994). Additionally, it is recognized that some the available TRVs within the scientific literature are below typical soil and sediment concentrations considered "natural," undisturbed or background levels. Reasons for this include the reliance on laboratory-based "spiking" experiments to derive the TRVs. Additional problems are encountered when experimenters and those using experimental results to derive TRVs fail to account for the existing level of chemical within soil and/or sediment prior to the spiking experiment. Many of the soil TRVs for the naturally-occurring inorganics disseminated by the Oak Ridge National Laboratory (i.e., Efroymson et al. 1997a and 1997b) suffer from this error. Thus, TRVs will first be evaluated in the context of site-specific background concentrations.

Screening values for soil organisms were obtained from US Fish and Wildlife Service (Beyer 1990), Efroymson et al (1997a, 1997b), Environment Canada (1995), NOAA (1999), the MHSPE (1994), and the scientific literature. Summaries of TRVs and selection of screening concentrations for direct exposures to soils are presented in Table 3-10. The relevant endpoints for the TRVs include no-observed adverse effect-concentrations (NOECs) and/or threshold-effects levels (e.g., *some* of the Dutch intervention levels or limits[19]). While presented, the lowest-observed adverse effect-concentrations and/or lethal concentrations (LC_{50}s) are not considered appropriate for screening purposes. Whenever possible, the TRV selected is the highest NOEC below the lowest LOEC or the highest observed NOEC if no effects level has been established for the chemical. This ensures that the screening concentration is conservative, while not just defaulting to the lowest chemical concentration reported. USEPA Region III screening concentrations were also compiled for fauna and flora. These values were used only in the absence of other information, since the basis for these values could not be ascertained.

TRVs for Sediment-Associated Invertebrates and Vascular Plants

TRVs specific to freshwater sediment were obtained from a number of sources and are summarized in Table 3-11. These TRVs correspond to the following assessment endpoints identified in Section 3.6:

Primary producers - vascular plants

Invertebrates – benthic macroinvertebrates

Though none of the TRVs are specific to plants, it was assumed that the benthic macroinvertebrates, in general, are equally, or more sensitive to chemicals than plants. Therefore, the TRVs for sediment-associated invertebrates are reasonably protective of vascular plants. Sources included the following:

- Consensus-based freshwater sediment criteria (MacDonald et al. 1999)
- USEPA (1996 – summarized by Ingersoll *et al.* 1996)
- Ontario Ministry of the Environment and Energy (1995)

[19] Some of these values are based on background values and not effect levels.

- NOAA (1999)
- Oak Ridge National Laboratory (1997 – Efroymson *et al.* 1997a and 1997b)
- USEPA Ecotox (1996a)
- Long *et al.* (1995)
- Florida Department of Environmental Protection (1994)
- Equilibrium partitioning
- Other

TRVs will first be evaluated in the context of background concentration. Background sediments were sampled as part of the Crab Orchard Lake Operable Unit evaluation. These data will be used to develop site specific background sediment concentrations when they become available. Background sediment concentrations are also available from Illinois EPA (1996). If the background concentration is higher than chemical-specific effects-based TRVs, then the background will be selected as the default screening concentration.

INORG S only

With respect to effects levels, there are a number of potential sources and endpoints, as can be seen from the list above, and in examination of Table 3-11. The sources as presented in bullet form above represent the prioritization in which sediment TRVs were selected.

There are also multiple endpoints from some sources. For example, threshold effects levels (TELs) as reported by USEPA (1996b) are the geometric mean of the 15th percentile in the effects data set and the 50th percentile in the no-effects data set. The effects-range low (ERL) and effects-range medium (ERM) are the 15th percentile and 50th percentile values in the effects datasets, respectively. The Probable Effects Level (PEL) is the geometric mean of the 50th percentile in the effects data set and the 85th percentile in the no-effects data set, and the effects range medium is the 50th percentile value of the effects dataset. A TEL or ERL is assumed to represent a concentration below which toxic effects are rarely observed. The range between the TEL and PEL is assumed to represent the range in which effects are occasionally observed. The TEL and ERL were selected initially in order of preference.

Preference was also given to freshwater-derived values (MacDonald et al. [1999], Ingersoll et al. [1996], Ontario [1995] and NOAA [1999]) as opposed to estuarine or saltwater (Long et al. [1995], FDEP [1994]). Some sources were intentionally not used. ERMs and Apparent Effects levels were not used since they are less conservative than TELs or ERLs. The ERL values from Ingersoll et al. (1996) were not used since TELs were already reported from the same source. Region IV screening values were not used since many of the values were based on detection limit considerations rather than effects levels.

If empirical data were lacking, the "equilibrium-partitioning" (EqP) approach was used. This used the lowest chronic aquatic toxicity value reported (Table 3-12) and the expected partitioning between sediment and sediment pore water (as described in USEPA 1993). Such sediment screening values were derived using the following relationship:

$$SC = Kd * Cw$$

where:

SC = Ecotoxicological Screening Concentration in sediment

Kd = water – sediment partitioning coefficient (equal to the organic carbon to water partitioning coefficient (Koc) times the fraction of organic carbon in the sediment (assuming to be 1%).

Cw = screening value in water

Organic carbon partitioning coefficients were presented, along with other salient physiochemical parameters, in Table 3-1.

Ultimately, the single TRV selected from among the multiple sources represents the screening concentration for surface sediments.

TRVs for Direct Water Exposure

TRVs for direct exposure by aquatic organisms in surface water are relevant to fish and larval amphibians. Values were obtained, in order of preference, from:

- Illinois water quality standards;
- National Recommended Ambient Water Quality Criteria (USEPA 1999);
- EcoTox (1996a) – ambient water quality criteria
- "Tier II" chronic values calculated following the Great Lakes Water Quality Initiative (e.g., those reported in EcoTox 1996 and those calculated by Suter and Tsao 1996);
- USEPA Region IV Freshwater Screening Values (1999)
- The lowest reported chronic toxicity values, USEPA Superfund screening concentrations (EcoTox – USEPA 1996a);
- Maximum Acceptable Toxicant Concentrations (MATCs) or lowest observed effect concentrations (LOECs) obtained from the USEPA ASTER database (ASessment Tools for The Evaluation of Risk 1996);
- Other sources.

A summary of TRVs for direct exposures to surface water is provided in Table 3-12. As with sediments, these values are presented in order of preference. The Illinois water quality standards are believed to be the most relevant, followed by the national recommended ambient water quality criteria. ECOTOX reports values based on ambient water quality criteria, and Tier II water quality criteria have been developed in the absence of sufficient information to support a national recommended water quality criterion. Remaining sources were prioritized based on relevance to the area and professional judgement. The single TRV selected from among the multiple sources represents the screening concentration for surface water.

3.7.2.2 Ingestion Pathway TRVs

A literature search was conducted for appropriate dietary toxicological endpoints for ingestion pathway exposures to candidate receptors. Several databases, in addition to the open literature,

were consulted, including the ECOlogical TOXcity database (ECOTOX 1996a); ASsessment Tools for the Evaluation of Risk (ASTER 1996); the Hazardous Substances DataBase (HSDB); the Integrated Risk Information System (IRIS); the TOXicity NETwork (TOXNET [HSDB], which includes MEDTECS); and the Registry of Toxic Effects of Chemicals (RTECs). Also examined were U.S. Fish and Wildlife Service *Contaminant Hazard Series* synopses, RTI (1995), Oak Ridge National Laboratory technical reports (Sample *et al.* 1996), and available ATSDR *Toxicological Profiles*. The aforementioned sources were used to provide the information necessary for selecting TRVs to derive ecological screening concentrations. Ecotoxicological profiles for many of the COIs are presented in Appendix B. Effort was focussed on development of ecotoxicological profiles for on a few "key" COIs, though it is acknowledged that what constitutes a "key" COI is arbitrary at this stage of the screening process. Specifically, profiles were developed for PCBs, PAHs, several inorganics (e.g., lead and mercury) and a few other volatile and semivolatile organic compounds. Selection of screening concentrations for other COIs was based on examination of the above sources and selection of an appropriate NOAEL using the strategy outlined below.

Endpoints reported in the literature include the lethal dose, the Lowest-Observed-Adverse-Effect Level (LOAEL), and the NOAEL. The lethal dose, expressed, for example as the LD_{50}, is the dose lethal to 50% of the test organisms over a specific exposure period. Another example, the LD_{lo}, is a reported dose that is capable of producing lethality. The LOAEL is the lowest dose that results in a statistically significant effect compared to a control. The NOAEL is the highest dose where there is no statistically significant difference from the control response. For the purposes of the screening evaluation, only the no-observed-adverse-effect level (NOAEL) concentrations or doses, to the extent possible, were used as TRVs. By definition, this represents a dose or concentration at which a risk is not expected to occur. However, consistent with the objectives of a screening level risk evaluation, doses or concentrations above the NOAEL represent levels at which potential effects may occur.

Lethal dose values generally represent acutely toxic endpoints, although this must be examined in the context of the exposure duration and the test animal. For example, a lethal dose based on a 1- to 5-day exposure might be considered an acutely toxic response, whereas a lethal dose reported for 50 or 100 days might be considered a chronic response. Emphasis is placed on selection of chronic endpoints (i.e., NOAELs and LOAELs) or lethal doses over extended periods. Greater weight is given to multi-day or multi-week studies rather than single-dose studies. Additional weight is placed on those assays performed during a "critical life-stage" such as during gestation, conception, and/or early development.

The general strategy for selecting (or deriving) a single NOAEL value as a TRV from among the many values reported in the literature was as follows:

- Where literature values were identified for the specific assessment receptor, the highest NOAEL that did not exceed the lowest LOAEL was selected.
- Where values were not available for a specific assessment receptor (which is characteristic of the vast majority of literature values), values from surrogate receptors were used.

- If LOAEL and/or NOAEL data were not available, but lethal dose data were reported, an uncertainty factor (division) of 10 was applied to the lowest acute lethal dose to derive a LOAEL, or an uncertainty factor of 100 to derive a NOAEL. LD_{10}s were selected preferably over LD_{50}s. An uncertainty factor (division) of 10 was also applied to the LOAEL to derive a NOAEL. Lethal dose values were only used in the absence of LOAEL and NOAEL information. Note that alternate uncertainty factors may be appropriate for some chemicals. Values of 10X and 100X were used as default values in the screening level evaluation. However, it may be more appropriate to apply alternative values in a baseline risk evaluation, if necessary.
- Weight was given to the duration of the study, as well as the toxicological endpoint. Preference was given to studies that were chronic or subchronic exposure versus single event or acute exposures. Where data were available for more than one dosing regime, chronic was selected first, subchronic second, and acute only if no other data were available. Critical life-stage tests also carried significant weight.
- Studies were considered based on the dosing regime. Intraparitoneal or intravenous studies were not used. Studies using gavage or oral intubation were not used when food studies were available.
- Measures of effect considered included survival, growth and reproduction. Endpoints specifically related to survival, growth and reproduction such as fetotoxicity or infertility were also considered. Effects such as carcinogenesis, liver damage, kidney function, sperm mobility, enzyme induction, blood pressure, etc., were generally not considered appropriate measures for evaluation of population-level effects.

NOAEL TRVs, associated measured effect, and applicable references for each of the COIs are presented in Table 3-13.

3.7.3 Ecological Risk Screening Concentrations

dose/TRV = HQ

As noted previously, ecological risk screening concentrations for direct exposures are equal to the TRVs identified for the applicable receptors (invertebrates, plants, and aquatic organisms) in specific media (i.e., surface water, sediment and soils). For ingestion pathway exposures, the ecological screening concentrations are based on a dose equal to a TRV. The ratio of the average daily dose to a TRV is generally referred to as an ecological effects quotient (EEQ). An EEQ based on a NOAEL at or below 1 is indicative of low (or no) risk. The dose corresponding to an EEQ of 1 must be presented as a media-specific value to effectively apply it as a risk-based-screening concentration. This is accomplished by back-calculating from the EEQ dose concentration to a concentration in the media of interest, using the same approach outlined in Appendix A. Using this approach, a summary of the ingestion pathway screening concentrations for each of the applicable candidate receptors and assessment endpoints is presented in Tables 3-14, 3-15 and 3-16 for soils, sediments, and surface water, respectively. The lowest ingestion-pathway media-specific screening concentration among the receptors applicable to a habitat type presented in Table 3-8 will be used for evaluating chemical data and selection chemicals of potential ecological concern. A summary of screening concentrations is presented in Table 3-16 for each media and habitat type for direct and ingestion pathway exposures.

NOPE

3.7.4 Selection of Chemicals of Potential Ecological Concern

Screening concentrations developed using the approaches outlined above are applied by comparing them to the maximum concentration of a COI at each of the AUS OU sites. The goal of this process is to identify chemicals of potential ecological concern (COPEC). A COPEC is a chemical, based on an initial screening of its maximum concentration in applicable media (i.e., surface soil, surface water, and/or surficial sediment[20]), where there is a potential that the chemical may adversely interact with the environment. Specifically, the following criteria will be used in selecting COPECs:

- If a chemical is detected below site-specific background concentrations, then the chemical will not be selected as a COPEC. inorgs only
- If a chemical is not detected, and there is no ecotoxicological benchmark, then the chemical will not be selected as a COPEC. ok
- If the maximum concentration of a chemical exceeds the ecotoxicological screening benchmark, then the chemical will be classified as a COPEC. ok
- If the maximum concentration of a chemical is less than the ecotoxicological benchmark, then the chemical will not be classified as a COPEC. ok
- If a chemical is detected, and there is no ecotoxicological benchmark, then the chemical is carried forward as an uncertainty into the Scientific Management Decision Point (SMDP), where a decision is made for further evaluation, or to eliminate the chemical from further evaluation. ok

This process of COPEC selection corresponds to Step 2 within the ERAGS Screening-Level Ecological Risk Assessment (Screening-Level Exposure Estimate and Risk Calculation). If no COPECs are identified, it is concluded that the COIs are not of potential ecological concern and no further investigation for ecological concerns would be deemed warranted.

3.7.5 Uncertainties

There are basically three types of uncertainties associated with the process of selecting COPECs: a lack of knowledge (what we do not know); a lack of data (what we can know but do not presently); and a lack of technology (the limits of our ability to measure or predict). In the context of screening for chemicals that deserve a comprehensive evaluation of potential ecological impact, not all uncertainties are equal. For example, the lack of credible oral toxicity values (TRVs) for amphibians and reptiles is a significant uncertainty in that the potential risks for these receptors cannot be fully characterized. A lack of organic carbon data for soils (for example) would not be nearly as significant. While the foregoing examples are fairly clear, others are less so.

In the present context, the most often encountered uncertainty is that of a lack of technology -- analytical sensitively for detection of chemicals in environmental media. The approach used to evaluate the significance of such an uncertainty is on a case-by-case basis using a line-of-

[20] Subsurface media are not directly considered here as there is no complete exposure pathway for the subsurface to ecological receptors.

evidence approach. Where a chemical is never detected in any media, in any area, at any time, even though the detection limit may exceed the screening concentration, then the uncertainty is not believed to be significant. Conversely, if a chemical is routinely detected in multiple media but not detected in one media where the reporting limit exceeds the screening concentration, the associated uncertainty may be significant. An uncertainty evaluation and discussion will be included in the screening risk evaluation.

Assumptions made during the screening process are conservatively applied to ensure that chemicals that warrant further consideration are not eliminated early in the process. These assumptions include use of a NOAEL TRV (i.e., a TRV where it is assumed there is no risk); application of an area use factor of 1 (receptors obtain all food intake from the study area); and 100% chemical bioavailability. COPECs and associated uncertainties will be discussed as warranting or not warranting further, more detailed evaluation as part of the SMDP following completion of the initial screening process.

TAF 3-1
PHYSIOCHEMICAL PARAMETERS ADL JNAL AND UNCHARACTERIZED SITES
OPERABLE UNIT CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Molecular Wt (g/mol)	Melting Point (°C)	Vapor Pressure (mm of Hg)	Solubility (mg/L) @20-25°C	Log Koc	Koc	Log Kow	Henry's constant (atm/m3/mole)	Species	Water BCF	Log BCF	Comments
Halogenated Methanes/Alkanes												
Bis(2-chloroethoxy) methane	173	N/A	1.31	128000	1.74		0.75	0.00000234	FM	2.00E+00		ASTER/QSAR (1998)
Bis(2-chloroethoxy) methane	173.05		0.1	120000	1.32	7-61	0.75	8.513E-08		0.84-2.2		HSDB
Bromodichloromethane	163.8	-57	64.4	3110	2.48		2.09	0.00447	FM	1.80E+01		ASTER/QSAR (1998)
Bromodichloromethane	163.8	-57.1	50	4700	2.06	53-251	2.1	0.0016			0.72-1.37	HSDB
Bromoform	252.7	8	6.3	2270	2.63		2.37	0.000923	FM	3.00E+01		ASTER/QSAR (1998)
Bromoform	252.73	8.3	40	3190			2.372	0.00066		3.74E+01		HSDB
Bromomethane	94.94	-94	1630	27200	1.92		1.08	0.00749	FM	3.00E+00		ASTER/QSAR (1998)
Bromomethane	94.95	-93.66	1620	902	1.19		2.1	0.00624		4.70E+00		HSDB
Carbon tetrachloride (Tetrachloromethane)	153.8	-23	110	361	2.9		2.88	0.0617	FM	7.40E+01		ASTER/QSAR (1998)
Carbon tetrachloride (Tetrachloromethane)	153.24	-23	108	1160	1.85	71	2.83	0.0304	RT		1.24-1.48	HSDB
Chloroform (Trichloromethane)	119.4	-64	197	3290	2.4		1.95	0.0094	FM	1.40E+01		ASTER/QSAR (1998)
Chloroform (Trichloromethane)	119.39		197	7950	1.53	34	1.97	0.00367		1.00E+00		HSDB
Chloromethane	50.49	-98	4310	21000	1.85		0.936	0.0136	FM	2.00E+00		ASTER/QSAR (1998)
Chloromethane	50.49	-97	4300	5320			0.91	0.0882				HSDB
Dibromochloromethane	208.3	N/A	18.3	2310	2.55		2.23	0.00218	FM	2.30E+01		ASTER/QSAR (1998)
Dibromochloromethane	208.28	-20		4400	2.32	95-468	2.24	0.00085			0.74-1.47	HSDB
Methylene chloride	84.93	-95	436	15300	2.02		1.25	0.00318	FM	4.00E+00		ASTER/AQUIRE/QSAR (1998)
Methylene chloride			400		1.68		1.25	0.00318		5.00E+00		HSDB
Halogenated Ethanes												
1,1-Dichloroethane	98.96	-97	228	4340	2.3		1.78	0.00683	FM	1.00E+01		ASTER/QSAR (1998)
1,1-Dichloroethane	98.97	-96.9	234	5500	1.63	43	1.9			1.30E+00		HSDB
1,1,1-Trichloroethane	133.4	-31	121	896	2.69		2.48	0.0237	FM	3.60E+01		ASTER/QSAR (1998)
1,1,1-Trichloroethane	133.42	-30.4	124	4400	1.28	2-183	2.49	0.008	BG	8.90E+00		HSDB
1,1,2-Trichloroethane	133.4	-37	22.5	2820	2.45		2.05	0.0014	FM	1.70E+01		ASTER/QSAR (1998)
1,1,2-Trichloroethane	133.42	-36.6	23.25	4500	2.05	70-183	2.17	0.000824		1.00E+00		HSDB
1,1,2,2-Tetrachloroethane	167.8	-44	5.95	729	2.78		2.64	0.0018	FM	4.90E+01		ASTER/QSAR (1998)
1,1,2,2-Tetrachloroethane	167.85	-43.8	4.62	2962	1.90	79	2.39	0.000455			0.9-1	HSDB
1,2-Dichloroethane	98.96	-35	80.3	10200	2.13		1.46	0.00102	FM	6.00E+00		ASTER/AQUIRE/QSAR (1998)
1,2-Dichloroethane	98.96	-35.3	87	8690	1.52	33	1.48		BG		0.3	HSDB
Chloroethane	64.51	-136	1200	6540	2.13		1.47	0.0156	FM	6.00E+00		ASTER/QSAR (1998)
Chloroethane	64.52	-138.7	1010	5710	1.84	33-143	1.43	0.00848			0.67-0.86	HSDB
Hexachloroethane	236.7	N/A	0.0676	3.12	3.84		4.61	0.0675	FM	1.75E+03		ASTER/QSAR (1998)
Hexachloroethane	236.74	185	0.21	7.7	2.84	220-2188	4.14	0.00389	BG	139-708		HSDB
Halogenated Propanes												
1,2-Dichloropropane	113	-100	49.7	2840	2.42		1.99	0.0026	FM	1.50E+01		ASTER/AQUIRE/QSAR (1998)
1,2-Dichloropropane	112.99	-100.4	50	260000	1.67	47	2.28	0.00207			1.26	HSDB
2,2'-Oxybis (1-chloropropane)	78.54	-122.8	344.4	2700	1.75	56	2.04	0.013		2.10E+01		HSDB
Halogenated Alkenes												
1,1-Dichloroethene	96.94	-122	600	866	2.63		2.37	0.0883	FM	3.00E+01		ASTER/QSAR (1998)
1,1-Dichloroethene	96.94	-122.5	591	6300	2.18	150	2.13	0.0261				HSDB
1,2-Dichloroethene (total)	96.95	-50	324		1.62	36-49				15-22		HSDB
1,2-Dichloroethene (cis)	96.94	-81	209	4300	2.3		1.77	0.00621	FM	1.00E+01		ASTER/QSAR (1998)
1,2-Dichloroethene (cis)	96.94	-80.5	24 (mpa)	3500	1.69	49	1.86	0.00307		1.50E+01		HSDB
1,2-Dichloroethene (trans)	96.94	-50	330	4300	2.3		1.77	0.00978	FM	1.00E+01		ASTER/QSAR (1998)
1,2-Dichloroethene (trans)	96.95	-50	395	6300	1.56	36	2.06	0.00672		2.20E+01		HSDB
1,3-Dichloropropene (total)	110.98	<-50	0.02775	150000			1.36			7.00E+00		HSDB

TABLE 3-1
PHYSIOCHEMICAL PARAMETERS ADDITIONAL AND UNCHARACTERIZED SITES
OPERABLE UNIT CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Molecular Wt (g/mol)	Melting Point (°C)	Vapor Pressure (mm of Hg)	Solubility (mg/L) @20-25°C	Log Koc	Koc	Log Kow	Henry's constant (atm/m3/mole)	Species	Water BCF	Log BCF	Comments
1,3-Dichloropropene (cis)	110.97		43	2700	2.65	450	1.36	0.0024		7.00E+00		HSDB
1,3-Dichloropropene (trans)	111	N/A	24.9	4640	2.3		1.76	0.000782	FM	1.00E+01		ASTER/QSAR (1998)
1,3-Dichloropropene (trans)	110.98		2.47(kpa)	2800	2.87	740	1.41	0.0018		7.00E+00		HSDB
Tetrachloroethene	165.8	-19	17.8	77.2	3.23		3.48	0.0503	FM	2.23E+02		ASTER/QSAR (1998)
Tetrachloroethene	165.83	-19	18.47	150	2.80	238-1685	3.4	0.0177		2.26E+02		HSDB
Trichloroethene	131.4	-87	74.3	597	2.77		2.63	0.0215	FM	4.70E+01		ASTER/QSAR (1998)
Trichloroethene	131.4	-73	19.9	1100	2	87-150	2.61	0.01	BG	17-39		HSDB
Vinyl chloride	62.5	-154	2660	5450	2.16		1.52	0.0401	FM	6.00E+00		ASTER/QSAR (1998)
Vinyl chloride	62.5	-153.8	2660	2700	1.75	56	0.6	0.056		7.00E+00		HSDB
Amines												
2-Nitroaniline	138.1	72	0.000514	2170	2.32		1.8	4.31E-08	FM	1.00E+01		ASTER/QSAR (1998)
2-Nitroaniline	138.14	69-71	0.00277	1470	1.72	53	1.85	1.81E-08		2.1-15		HSDB
3-Nitroaniline	138.1	113	0.0022	3930	2.02		1.26	0.000000102	FM	4.00E+00		ASTER/QSAR (1998)
3-Nitroaniline	138.12	114	0.0000362	910	1.94		1.37	7.2E-09		1.1-8.3	0.81	HSDB
3,3'-Dichlorobenzidine	253.1	133	0.000000115	4	3.28		3.57	9.57E-09	FM	2.64E+02		ASTER/QSAR (1998)
3,3'-Dichlorobenzidine	253.13	132-133					3.02		BG	495-940		HSDB
4-Chloroaniline	127.6	73	0.467	1.46E+03	2.37		1.91	0.0000536	FM	1.30E+01		ASTER/AQUIRE/QSAR (1998)
4-Chloroaniline	127.57	72.5	0.027	3.90E+03	2.86	96-5550	1.83	0.0000116		0.8-8.1		HSDB
4-Nitroaniline	138.1	146	2.20E-03	1.98E+03	2.02		1.26	2.07E-07	FM	4.00E+00		ASTER/QSAR (1998)
4-Nitroaniline	138.12	146	4.00E-03	7.24E+02	1.89	52-117	1.39	1.81E-08		0.83-15	0.83	HSDB
4,4'-Methylenebis (2-chlorobenzenamine)-M	267.15	110	0.0013	0	3.68	4810	3.94	4.06E-11		5.75E+00		HSDB
N-Nitrosodiphenylamine	198.2	67	0.0000755	90.9	3.06		3.16	0.000000217	FM	1.25E+02		ASTER/QSAR (1998)
N-Nitrosodiphenylamine	198.23	66.5	0.1	35.1	3.08	1200	3.13	0.00000121	BG	2.17E+02		HSDB
N-Nitroso-di-n-propylamine	130.2	N/A	3.52	1.15E+04	2.15		1.5	5.23E-05	FM	6.00E+00		ASTER/QSAR (1998)
N-Nitroso-di-n-propylamine	130.22			1.00E+04	2.11	130	1.36	5.38E-06		6.00E+00		HSDB
Benzene and Derivatives												
Benzene	78.11	6	95.2	1790	2.5		2.14	0.00547	FM	2.00E+01		ASTER/AQUIRE/QSAR (1998)
Benzene	78.11	5.5	95.2	1800	1.82	31-143	2.13	0.0053		3.5-24		HSDB
Chlorobenzene	112.6	-46	11.7	409	2.89		2.86	0.00424	FM	7.20E+01		ASTER/QSAR (1998)
Chlorobenzene	112.56	-45.2	12	502	1.59	4.8-313.1	2.89	0.00377		3.9-2187		HSDB
1,2-Dichlorobenzene	147	-17	1.28	144	3.21		3.45	0.00172	FM	2.11E+02		ASTER/QSAR (1998)
1,2-Dichlorobenzene	147	-16.7	1.36	156	4.00	280-320	3.43	0.0015		90-560		HSDB
1,2,4-Trichlorobenzene	181.2	17	0.291	45.5	3.6		4.16	0.00153	FM	1.77E+03		ASTER/AQUIRE (1998)
1,2,4-Trichlorobenzene	181.45	17	0.46	31.3	3.1-5		4.02	0.00142		91-3200		HSDB
1,3-Dichlorobenzene	147	-25	1.89	125	3.28		3.57	0.00292	FM	2.62E+02		ASTER/AQUIRE/QSAR (1998)
1,3-Dichlorobenzene	147	-24.8	2.15	125	2.48	300	3.53	0.0028		60-740		HSDB
1,4-Dichlorobenzene	147	53	1.76	30.7	3.28		3.57	0.0111	FM	2.62E+02		ASTER/AQUIRE/QSAR (1998)
1,4-Dichlorobenzene	147	52.7	1.74	76	4.8	273-390	3.44	0.0027		57-720		HSDB
Hexachlorobenzene	284.8	230	0.00000435	0.00461	4.7		6.18	N/A	Scud	4.12E+04		ASTER/AQUIRE (1998)
Hexachlorobenzene	284.78	231.8	0.000049	0.0047	4.55		5.73	0.00058		1600-4800	3.1-4.3	HSDB
Methylated Benzenes												
Toluene	92.14	-95	28.4	518	2.77		2.64	0.00665	FM	4.90E+01		ASTER/AQUIRE/QSAR (1998)
Toluene	92.13	-95	36.7		1.87	37-151	2.69	0.00664		9.00E+01		HSDB
Xylenes (total)	N/A	N/A	5.87	N/A	N/A		N/A	N/A	N/A	N/A		ASTER (1998)
Xylenes (total)	106.16		7.99	0	2.08	39-365	3.12-3.2	0.007		2.00E+01		HSDB
Other Substituted Benzenes												
Ethylbenzene	106.2	-95	9.57	153	3.06		3.17	0.00874	FM	1.27E+02		ASTER/QSAR (1998)
Ethylbenzene	106.16	-95	10	140	2.94	164	3.15	0.00844			0.67-2.16	HSDB

TAF 3-1
PHYSIOCHEMICAL PARAMETERS ADD NAL AND UNCHARACTERIZED SITES
OPERABLE UNIT CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Molecular Wt (g/mol)	Melting Point (°C)	Vapor Pressure (mm of Hg)	Solubility (mg/L) @20-25°C	Log Koc	Koc	Log Kow	Henry's constant (atm/m3/mole)	Species	Water BCF	Log BCF	Comments
Styrene	104.2	-31	6.06	250	2.9		2.87	0.00332	FM	7.30E+01		ASTER/QSAR (1998)
Styrene	104.15	-31	6.12	310	2.73	520-555	2.95	0.00275		13.5-100		HSDB
Nitrobenzene	123.1	6	0.284	1950	2.36		1.88	0.0000237	FM	1.20E+01		ASTER/QSAR (1998)
Nitrobenzene	123.11	5.7	0.245	1797	2.34	1.27-370	1.85	0.000024		1.6-24	6	HSDB
Arenes												
2,4-Dinitrotolune	182.1	71	0.00000541	1500	2.45		2.05	8.62E-10	FM	1.60E+01		ASTER/QSAR (1998)
2,4-Dinitrotolune	182.14	71	0.00014	300	2.45	282	1.98	8.79E-08		2.04E+02		HSDB
2,6-Dinitrotolune	182.1	65	0.00000541	2110	2.41		1.97	6.15E-10	FM	1.40E+01		ASTER/QSAR (1998)
2,6-Dinitrotolune		66	0.000567		2.31	204	1.72	9.26E-08		12-5225		HSDB
Chlorinated Dienes												
Hexachlorobutadiene	260.8	-21	0.329	2.74	4		4.9	0.0413	FM	2.96E+03		ASTER/QSAR (1998)
Hexachlorobutadiene	260.76	-21	0.15	2.548	3.71	5181	4.9	0.0103		5800-17000		HSDB
Hexachlorocyclopentadiene	272.8	-9	0.143	1.94	4.08		5.05	0.0264	FM	<11		ASTER/AQUIRE (1998)
Hexachlorocyclopentadiene	272.77	-9	0.08	2	3.63	4265	3.99	0.027		11-1634		HSDB
Ethers												
4-Bromophenyl phenyl ether	249.1	19	0.000217	1.05	4.19		5.24	0.000068	FM	5.52E+03		ASTER/QSAR (1998)
4-Bromophenyl phenyl ether	249.11	18.7	0.0015	0	4.28	17000	5.243	0.000117		5.69E+03		HSDB
4-Chlorophenyl phenyl ether	204.7	-8	0.00696	1.28	4.11		5.09	0.00146	FM	4.20E+03		ASTER/QSAR (1998)
4-Chlorophenyl phenyl ether	204.65	-8	0.0027	3.3	3.48	2269-3950	4.08			7.36E+02		HSDB
Bis (2-chloroethyl) ether	143	-25	0.7	50700	1.88		0.996	0.0000026	FM	2.00E+00		ASTER/QSAR (1998)
Bis (2-chloroethyl) ether	143.01	-51.9	1.55	10200	2.08	120	1.29	0.000029		0.4-11		HSDB
Phenols and Substituted Phenols												
2-Chlorophenol	128.6	9	1.87	2060	2.51		2.15	0.000153	FM	2.00E+01		ASTER/QSAR (1998)
2-Chlorophenol	128.56	9.8	2.53	11400	2.70	51-5012	2.15	0.000000559		2.14E+02	2.33	HSDB
2-Methylphenol	108.1	31	0.425	2480	2.41		1.97	0.0000243	FM	1.40E+01		ASTER/QSAR (1998)
2-Methylphenol	108.14	30	0.299	25900	1.545		1.95	0.0000012		2.00E+01		HSDB
2-Nitrophenol	139.1	44	0.163	3360	2.35		1.85	0.00000889	FM	1.20E+01		ASTER/QSAR (1998)
2-Nitrophenol	139.11	44-45	0.113	2190	1.97	32-266	1.79	0.000013		0-22		HSDB
2,4-Dichlorophenol	163	45	0.00448	203	2.95		2.96	0.00000473	FM	8.60E+01		ASTER/AQUIRE/QSAR (1998)
2,4-Dichlorophenol	163	45	0.12	4500	3.00	200-5000	3.06	0.0000055		7.1-263		HSDB
2,4-Dimethylphenol	122.2	25	0.163	838	2.68		2.47	0.0000313	FM	3.60E+01		ASTER/AQUIRE/QSAR (1998)
2,4-Dimethylphenol	122.17	25.4-26	0.102	7870	2.33	105-430	2.3	0.000017		1.50E+02		HSDB
2,4-Dinitrophenol	184.1	112	0.000000142	1300	2.31		1.79	2.64E-11	FM	1.00E+01		ASTER/AQUIRE/QSAR (1998)
2,4-Dinitrophenol	184.11	112-114	0.00039	6000	2.30	200	1.67	0.000000086		0.4-4		HSDB
2,4,5-Trichlorophenol	197.4	67	0.00398	21.6	3.35		3.7	0.0000479	FM	3.31E+02		ASTER/AQUIRE/QSAR (1998)
2,4,5-Trichlorophenol	197.45	69	0.008	1200	3.36	2200	3.72	0.0000016		121-825		HSDB
2,4,6-Trichlorophenol	197.4	70	0.00627	49	3.17		3.37	0.0000332	FM	1.82E+02		ASTER/QSAR (1998)
2,4,6-Trichlorophenol	197.45	69	0.008	800	2.76	150-2200	3.69	0.0000026		87-676		HSDB
4-Chloro-3-methylphenol	142.6	66	0.0127	107	2.96		2.98	0.0000223	FM	9.10E+01		ASTER/QSAR (1998)
4-Chloro-3-methylphenol	142.58	66		3850	1.70	50	3.1	0.000006			0.77-2.13	HSDB
4-Methylphenol	108.1	36	0.198	2240	2.41		1.97	1.26E-05	FM	1.40E+01		ASTER/QSAR (1998)
4-Methylphenol	108.14	35.5	0.11	25000(50oC)	2.25		1.94	1.00E-06		2.00E+01		HSDB
4-Nitrophenol	139.1	113	0.00043	805	2.35		1.85	9.78E-08	FM	1.20E+01		ASTER/AQUIRE/QSAR (1998)
4-Nitrophenol	139.11	113-114	0.005	16000	1.7	55	1.91	0.000000013		2-79		HSDB
4,6-Dinitro-2-Methylphenol	198.1	87	0.00000105	618	2.58		2.29	4.43E-10	FM	2.60E+01		ASTER/AQUIRE/QSAR (1998)
4,6-Dinitro-2-Methylphenol	198.13	87.5	0.000105	130(15oC)	2.56	225-590	2.564	4.8E-11		1.4-980		HSDB
Pentachlorophenol	86.18	174	N/A	0.649	3.44		3.87	N/A	RT	4.82E+02		ASTER/AQUIRE (1998)

TABLE 3-1
PHYSIOCHEMICAL PARAMETERS ADDITIONAL AND UNCHARACTERIZED SITES
OPERABLE UNIT CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Molecular Wt (g/mol)	Melting Point (°C)	Vapor Pressure (mm of Hg)	Solubility (mg/L) @20-25°C	Log Koc	Koc	Log Kow	Henry's constant (atm/m3/mole)	Species	Water BCF	Log BCF	Comments
Pentachlorophenol	266.34	174	0.00011	14	2.69	2-121681	5.12	2.45E-08		2-45000		HSDB
Phenol	94.11	43	0.53	6390	2.14		1.47	0.0000103	FM	6.00E+00		ASTER/AQUIRE/QSAR (1998)
Phenol	94.11	40.9	0.3513	82800	1.34	16-30	1.46	0.000000333		1.7-277		HSDB
Ketones (Carbonyl Compounds)												
2-Butanone	72.11	-86	95.1	223000	1.51		0.321	0.0000405	FM	1.00E+00		ASTER/QSAR (1998)
2-Butanone	72.11	-86	91	353000(10oC)	1.50	29-34	0.29	0.000047		1.00E+00		HSDB
2-Hexanone	100.2	-57	14.2	16600	2.09		1.38	0.000113	FM	5.00E+00		ASTER/QSAR (1998)
2-Hexanone	100.16	-55.5	11.6	16400	2.13	134	1.38	0.000093		7.00E+00		HSDB
4-Methyl-2-pentanone (MIBK)	100.16	-85	19.9	19000	2.09	123	1.31	0.000138		6.00E+00		HSDB
Acetone	58.08	-95	227	513000	1.22		-0.208	0.0000338	FM	1.00E+00		ASTER/QSAR (1998)
Acetone	58.08	-94.8	231		0.00	1	-0.24	0.0000187		1.00E+00		HSDB
Isophorone	138.2	-8	0.344	2650	2.47		2.09	0.0000236	FM	1.80E+01		ASTER/AQUIRE/QSAR (1998)
Isophorone	138.2	-8.1	0.38	12000	1.99	25-384	1.7	0.0000058		7.00E+00		HSDB
Low Molecular Weight PAHs												
2-Chloronaphthalene	162.6	60	0.00328	11.8	3.53		4.03	0.0000596	FM	6.07E+02		ASTER/QSAR (1998)
2-Chloronaphthalene	162.61	59.5	0.00798	11.7	3.05	1130		0.000315			3.63	HSDB
2-Methylnaphthalene	142.2	35	0.08	25.9	3.41		3.81	0.000578	FM	4.11E+02		ASTER/QSAR (1998)
2-Methylnaphthalene	142.2	34.6	0.0681	24.6	3.93	8500	3.86	0.000518		40-23500		HSDB
Acenaphthene	154.2	96	0.000719	4.44	3.39		3.77	0.0000328	FM	3.79E+02		ASTER/AQUIRE/QSAR (1998)
Acenaphthene	154.2	95	10	3.9	3.41	2065-3230	3.92	0.000155		387-397	2.59	HSDB
Acenaphthylene	152.2	92	0.00548	12.3	3.3		3.62	0.0000892	FM	2.86E+02		ASTER/QSAR (1998)
Acenaphthylene	152.2	92-93	0.000912	16.1	3.25	950-3315	4.07	0.0000113			2.11-2.76	HSDB
Anthracene	178.2	215	0.000179	0.0743	3.78		4.49	N/A	FM	5.63E+02		ASTER/AQUIRE (1998)
Anthracene	178.23	218	0.00000267	0.0434	5.30	70000-130000	4.45	0.0000488		759-17000		HSDB
Carbazole	167.2	245	0.000266	0.741	3.25		3.52	0.0000791	FM	2.39E+02		ASTER/AQUIRE (1998)
Carbazole	167.2	245	0.00000137	0	2.56	114-1180		8.65E-08			1.69-2.7	HSDB
Dibenzofuran	168.2	82	0.000688	4.76	3.56		4.09	0.0000319	FM	6.73E+02		ASTER/QSAR (1998)
Dibenzofuran	168.19	86.5	0.0044	4.22	3.67	2000-11000	4.12	0.00013		88-2858		HSDB
Fluorene	166.2	116	2.80E-04	1.99	3.55		4.07	3.08E-05	FM	6.60E+02		ASTER/QSAR (1998)
Fluorene	166.21	116-117	3.20E-04	0	3.96			1.00E-04			3.02-3.35	HSDB
Naphthalene	128.2	81	0.213	38.7	3.14		3.32	9.28E-04	FM	1.66E+02		ASTER/QSAR (1998)
Naphthalene	128.16	80.2	0.01(kpa)	30	3.26	812-4100	3.3				1.6-3	HSDB
Phenanthrene	178.2	100	1.35E-06	1.26	3.78		4.49	2.50E-07	FM	1.40E+03		ASTER/QSAR (1998)
Phenanthrene	178.22	101	6.80E-04	1.29	4.36		4.57	1.24E-04				HSDB
High Molecular Weight PAHs												
Benzo(a)anthracene	228.3	159	1.81E-10	0.0141	4.42		5.66	N/A	FM	1.19E+04		ASTER/QSAR (1998)
Benzo(a)anthracene	228.29	160	0.000000005	0.0094	4.49	545000-1870000	5.79	0.000008		350-18000		HSDB
Benzo(a)pyrene	252.3	179	6.46E-13	0.00381	4.67		6.12	N/A	FM	2.74E+04		ASTER/QSAR (1998)
Benzo(a)pyrene	252.32	179-179.3	5.49E-09	0.0016	6.14	930-1700000	5.97	0.000000457		0.2-55000		HSDB
Benzo(ghi)perylene	276.3	277	3.9E-11	0.000264	4.92		6.58	N/A	FM	6.33E+04		ASTER/QSAR (1998)
Benzo(ghi)perylene	276.34	277	1E-10	0.00026	4.98	96000	6.63	0.000000266		6.40E+04		HSDB
Benzo(b,k)fluoranthene	252.3	217	1.39E-09	7.62E-04	4.67		6.12	N/A	FM	2.74E+04		ASTER/QSAR (1998)
Benzo(b,k)fluoranthene	252.32	217	9.7E-10	7.60E-04	5.82	330000-1300000	6.84	0.000000584		27000-310000		HSDB
Chrysene	228.3	250	6.64E-11	1.99E-03	4.42		5.66	N/A	FM	1.19E+04		ASTER/QSAR (1998)
Chrysene	228.29	258.2	6.23E-09	1.89E-03	5.13	31000-580000	5.73	0.00000099		0.3-20280		HSDB
Dibenzo(a,h)anthracene	278.4	266	3.41E-14	5.07E-04	5.06		6.84	N/A	FM	1.00E+05		ASTER/QSAR (1998)
Dibenzo(a,h)anthracene	278.33	266	1E-10	5.99E-04	6.12	570000-3100000	6.5	0.00000012		652-11000		HSDB

TAF 3-1
PHYSIOCHEMICAL PARAMETERS ADD. ONAL AND UNCHARACTERIZED SITES
OPERABLE UNIT CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Molecular Wt (g/mol)	Melting Point (°C)	Vapor Pressure (mm of Hg)	Solubility (mg/L) @20-25°C	Log Koc	Koc	Log Kow	Henry's constant (atm/m3/mole)	Species	Water BCF	Log BCF	Comments
Fluoranthene	202.3	111	0.000000947	0.243	4.03		4.95	1.04E-06	FM	3.24E+03		ASTER/QSAR (1998)
Fluoranthene	202.26	111	0.00000922	0.26	4.97		5.16	9.45E-06		5.7-76696	2.58-4.09	HSDB
Indeno(1,2,3-cd)pyrene	276.3	163	3.9E-11	1.85E-03	4.92		6.58	N/A	FM	6.33E+04		ASTER/QSAR (1998)
Indeno(1,2,3-cd)pyrene	276.34	163.6	1.3E-10	6.20E-02	6.82	110000	6.7	0.000000348		1.00E+04		HSDB
Pyrene	202.3	156	4.3E-09	0.134	4.03		4.95	N/A	FM	3.24E+03		ASTER/QSAR (1998)
Pyrene	202.26	151.2	0.0000892	0.135	5.2	59675-169000	4.88	0.000012		72-970		HSDB
Pathalates												
Bis (2-ethylhexyl) phthalate	390.6	-55	1.43E-04	0.000195	6.03		8.63	N/A	RT	1.13E+02		ASTER/AQUIRE (1998)
Bis (2-ethylhexyl) phthalate	390.56	-55	7.23E-08	0.285	4-5	87420	7.6	0.00000013		14-2680	2-4	HSDB
Butylbenzylphthalate	312.4	-35	0.0000908	81.9	3.35		3.7	0.000000455	FM	3.30E+02		ASTER/AQUIRE/QSAR (1998)
Butylbenzylphthalate	312.39	-35	0.0000086	0.71	4		4.91	0.00000478		7.72E+02		HSDB
Diethyl phthalate	222.2	-41	0.00813	598	2.72		2.54	0.00000398	FM	4.00E+01		ASTER/AQUIRE/QSAR (1998)
Diethyl phthalate	222.24	-40.5	0.0021	1000	1.99	69-1726	2.47	0.00000061		1.17E+02	2.07	HSDB
Dimethyl phthalate	194.2	0	0.0546	18900	2.14		1.48	0.000000739	FM	6.00E+00		ASTER/AQUIRE/QSAR (1998)
Dimethyl phthalate	194.19	5.5	0.00308	4000	5.2	80-50000	1.6	0.0000002		3.1-57		HSDB
Di-n-butyl phthalate	278.3	-35	1.20E-03	5.64	3.87		4.65	0.0000778	FM	1.89E+03		ASTER/AQUIRE/QSAR (1998)
Di-n-butyl phthalate	278.35	-35	2.01E-05	13	2.195		4.9	0.0000045		3-1500	1.32	HSDB
Di-n-octyl phthalate	390.6	-25	0.0000134	0.0000975	6.17		8.89	N/A	FM	1.00E+05		ASTER/AQUIRE/QSAR (1998)
Di-n-octyl phthalate	390.56	-25	0.0000026	3	5	610000	8.1	0.00000045		1606-28500	0.6-3.97	HSDB
Miscellaneous Solvents												
Carbon disulfide	76.13	-112	356	N/A			N/A	N/A	N/A	N/A		ASTER (1998)
Carbon disulfide	76.14	-111.5	359	2860	2.43	270	1.94	0.0144		6.1-60		HSDB
Pesticides (mg/kg)												
4,4'-DDD	320.05	109	0.00000135	0.09	4.91	80500	6.02	0.0000214		2710-83200		HSDB
4,4'-DDE	318	88.4	0.0000065	0.01	3.92	8300	6.51	0.05		8300-180000		HSDB
4,4'-DDT	354.5	108.5	0.00000016	0.025	5.30	113000-350000	6.91	0.0038		600-1000000		HSDB
DDT (Total)												
Aldrin	364.93	104	0.00014	0.2	3.53		6.5	0.0000127		3890-12260		HSDB
a-BHC	290.85	159-160	0.000045	2	3.28	1780-1995	3.8	0.00000668		32-2400		HSDB
b-BHC	290.83		0.00000036	0.2	3.75		3.78	0.00000069			2.8	HSDB
d-BHC	290.83	141.5	0.000035	31.4	3.14	700-2700	4.14	0.00000043		8.00E+02		HSDB
g-BHC (Lindane)	290.8	113	0.0000359	10.6	3.38		3.75	0.0000013	FM	3.67E+02		ASTER/AQUIRE/QSAR (1998)
g-BHC (Lindane)	290.83	112.5	0.000042	7.3	3.53	1080.9-4800	3.72	0.0000035		32-4240	2.16-3.32	HSDB
a-Chlordane								0.00086				HSDB
g-Chlordane								0.0013				HSDB
Chlordane (Technical)	409.8	107-108.8	0.00000975	0.1	3.71	1720-15500	5.16	0.0000486		108-6227	2.03-4.58	HSDB
Dieldrin	380.93	175-176	0.00000589	0.195	3.87		5.4	0.000058		3-10000		HSDB
Endosufan I												
Endosufan II												
Endosufan	406.93	106	0.0000062	0.53	3.30	2000	3.83	0.000066		2650-11583		HSDB
Endosulfan sufate	422.95	181	0.00001	0.117	3.76	2330-14200	3.66	0.00047		356-2070		HSDB
Endrin	380.9		1.28E-09	81.4	3.31		3.63	7.9E-12	FF	1.84E+04		ASTER/AQUIRE (1998)
Endrin	380.93	<200	0.0000002	0.23	4.53	34000	5.2	0.0000004		140-49000		HSDB
Endrin aldehyde	380.89	235	0.0000002	0.25-0.26	4.29	8500-45000	5.6	2.9E-09		1000-10000		HSDB
Endrin ketone												
Heptachlor	373.35	95-96	0.0004	0.18	4.48		5.5	0.00148		3600-21379		HSDB
Heptachlor epoxide	389.4	160-161.5		0.347	4.10	7800-20000	5.4	0.000032		851-66000		HSDB
Isodrin	364.9	240-242	0.000006	0.2	3.52	400-28000		0.000496		3890-12260		HSDB

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PHYSIOCHEMICAL PARAMETERS ADDITIONAL AND UNCHARACTERIZED SITES
OPERABLE UNIT CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Molecular Wt (g/mol)	Melting Point (°C)	Vapor Pressure (mm of Hg)	Solubility (mg/L) @20-25°C	Log Koc	Koc	Log Kow	Henry's constant (atm/m3/mole)	Species	Water BCF	Log BCF	Comments
Methoxychlor	345.7	77	2.24E-09	0.592	4.15		5.17	1.72E-09	PS	5.00E+03		ASTER/AQUIRE/QSAR (1998)
Methoxychlor	345.65	89		0.1	3.90	620-100000	4.83	0.000016		138-12000		HSDB
Toxaphene	413.8		3.79E-09	12	3.69		4.33	1.71E-10	FM	1.05E+03		ASTER/AQUIRE/QSAR (1998)
Toxaphene	414	65-90	0.4	3	4.59	7200-210000	3.3	0.00498-0.063		3100-60000		HSDB
PCBs (mg/kg)												
Aroclor 1016			0.0004	0.225-0.25	4.97	52100-171000	4.38	0.000343		13000-43100	4.53-4.63	HSDB
Aroclor 1221	192	1	0.0067	2	4.46		4.09	0.000228			2.98-4.14	HSDB
Aroclor 1248	288		0.000494	0.054			6.11			52000-120000		HSDB
Aroclor 1254	327		0.000077	0.012	5.58	110000-1330000	6.3	0.000283		3800-340000	3.0-5.66	HSDB
Aroclor 1260	375.7		0.0000405	0.027	5.83	61000-7400000	6.8	0.000336		2.70E+05	5.28-5.57	HSDB
Explosives (mg/kg)												
1,3-Dinitrobenzene (DNB)	168.12	89-90	0.00000513	370	1.39		1.49	0.00000233			0.9024-0.93	HSDB
1,3-Dinitrobenzene (DNB)	168.11	89-90	0.0039	500	2.05		1.49-1.62	0.0000023				Talmage et al. 1999
1,3-Dinitrobenzene (DNB)	168.12	90	0.000193	533	1.56		1.49			4.70E+00		NTIS 1991
1,3-Dinitrobenzene (DNB)			0.0002	180			1.49	0.14 (L-torr)/mol				NTIS 1987
1,3,5-Trinitrobenzene (TNB)	213.11	122.5	0.0000032	340	2.13	104-178	1.18	3.08E-09		5-23		HSDB
1,3,5-Trinitrobenzene (TNB)	213.11	122.5	0.0000032	340	2.25		1.18-1.36	3.08E-09				Talmage et al. 1999
1,3,5-Trinitrobenzene (TNB)	213.12	122	0.00000303	385	1.3		1.18			2.65E+00		NTIS 1991
1,3,5-Trinitrobenzene (TNB)			0.0001	0.0015			1.18	0.07(L-torr/mol)				NTIS 1987
2-Amino-4,6-Dinitrotoluene (2-ADNT)	197.17	173-176	0.00004	2800			0.5-1.94	0.003(L-torr/mol)				Talmage et al. 1999
2-Nitrotoluene (ONT)	137.13	-9.5	0.1	652	2.36	124-425	2.3	0.000056		16-100		HSDB
2,4,6-Trinitrotolune (TNT)	227.13	80.1	0.000199	100	3.16	1100-1900	1.6	0.000000457		4.00E+01		HSDB
2,4,6-Trinitrotolune (TNT)				130000	3.2			0.000000457		9.5-453		Talmage et al. 1999
2,4,6-Trinitrotolune (TNT)	227.15	80.75	0.00000551	150	2.72		1.84-2			8.95E+00		NTIS 1991
2,4,6-Trinitrotolune (TNT)			0.0000011	123			1.6-1.84	0.002 (L-torr)/mol				NTIS 1987
3-Nitrotoluene	137.15	15.5	0.207	498	2.16	143	2.45	0.000075		16-49		HSDB
4-Amino-2,6-Dinitrotoluene	197.15		0.00002	2800			0.6	0.001				NTIS 1987
4-Nitrotoluene (PNT)	137.14	53-54	0.1	442	2.43	153-464	2.37	0.00005		20-100		HSDB
Cyclonite (RDX)	222.12	205	N/A	0			N/A	N/A	FM	1.00E+03		ASTER (1998)
Cyclonite (RDX)	222.26	205-206		59.8	1.92	42-167	0.87	0.000000063		4-5.9		HSDB
Cyclonite (RDX)	222.15	205	4.03E-09	60	2		0.81-0.87			1.50E+00		NTIS 1991
Cyclonite (RDX)			0.000000001	42.2			0.87	0.000005(L-torr)/mol				NTIS 1987
Cyclonite (RDX)	222.26	205-206	0.000000001-0.000000004	38.4	1.64		0.81-0.87	0.000012				Talmage et al. 1999
Cyclotetramethylenetetranitramine (HMX)	296.2	286	3.3E-14	6.6	2.8		0.06-0.26	2.6E-15				Talmage et al. 1999
Cyclotetramethylenetetranitramine (HMX)	296.2	286	3.33E-14	5	0.54		0.06-0.26			4.90E-01		NTIS 1991
Cyclotetramethylenetetranitramine (HMX)			9E-16	2.6			0.13	0000000001(L-torr)/mol				NTIS 1987
Nitroglycerin (NG)	227.09	13	0.00025	1800			1.62	0.06-3.3(torr-1/mole)				HSDB
Nitroglycerin (NG)	227.11	13.2	0.00177	1950	2.22		1.62-2.81			≤15		NTIS 1991

TAP 3-1
PHYSIOCHEMICAL PARAMETERS ADD. NAL AND UNCHARACTERIZED SITES
OPERABLE UNIT CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Molecular Wt (g/mol)	Melting Point (°C)	Vapor Pressure (mm of Hg)	Solubility (mg/L) @20-25°C	Log Koc	Koc	Log Kow	Henry's constant (atm/m3/mole)	Species	Water BCF	Log BCF	Comments
Pentaerythritol tetranitrate (PETN)	316.15	140	1.035E-10	43	2.74	179-1720	1.61	1.2E-11		7.40E+01		HSDB
Pentaerythritol tetranitrate (PETN)	316.17	141	5.38E-09	2.1	3.39		3.71			2.81E+02		NTIS 1991
Pentaerythritol tetranitrate (PETN)			0.000000002	2			2.2	0.0003 (L-torr)/mol				
Tetryl	287.15	130-132	0.00000001	75	2.61	406		1E-11		5.40E+01		HSDB
Tetryl	287.15	130-132	5.7E-09	75	2.60		1.65-2	1E-11				Talmage et al. 1999
Tetryl	287.17	129.5	5.69E-09	80	1.69		1.65			6.31E+00		NTIS 1991
Tetryl			4E-10	75			2	0.000002 (L-torr)/mol				
Dioxins/Furans (mg/kg)												
1,2,3,7,8-PeCDD												
1,2,3,4,6,7,8-HpCDD												
1,2,3,4,6,7,8-HpCDF												
1,2,3,4,7,8-HxCDD												
1,2,3,4,7,8,8-HpCDF												
1,2,3,4,7,8-HxCDF												
1,2,3,6,7,8-HxCDD	390.84	285-286	3.6E-11		5.6-7.6		7.8	0.0000256				HSDB
1,2,3,6,7,8-HxCDF												
1,2,3,7,8-PeCDF												
1,2,3,7,8,9-HxCDD		243-244										HSDB
1,2,3,7,8,9-HxCDF												
2,3,4,6,7,8-HxCDF												
2,3,4,7,8-PeCDF												
2,3,7,8-TCDD	322	305-306	7.4E-10	19300	7.39		6.8	0.0000162		5840-29200	3.2-3.9	HSDB
2,3,7,8-TCDF	305.99			4280		35000-400000	5.82	0.0000535		1.56E+04		HSDB
OCDD	459.8	330	8.25E-13	0.000000074	7-7.9	50000-350000	8.78-13.37	0.00000674		34-22300		HSDB
OCDF												
Total Petroleum Hydrocarbons (mg/kg)												
TPH-Gasoline range organics												
TPH-Diesel range organics												

Note:
a=Lowest value recorded among several other values
FM=Fathead Minnow
RT= Rainbow Trout
BT= Brook Trout
CAL= Calculated
DM= Daphnia magma
OL= Medaka (*Oryzias latipes*).
SB= Striped bass
SF= Stonefly
BB=Black bullhead
ZF= Zebrafish
BG=Bluegill sunfish

TABLE 3-1
PHYSIOCHEMICAL PARAMETERS ADDITIONAL AND UNCHARACTERIZED SITES
OPERABLE UNIT CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Molecular Wt (g/mol)	Melting Point (°C)	Vapor Pressure (mm of Hg)	Solubility (mg/L) @20-25°C	Log Koc	Koc	Log Kow	Henry's constant (atm/m3/mole)	Species	Water BCF	Log BCF	Comments

FF= Flag fish
PS= puch snail

TABLE 3-2

AREA HABITAT MATRIX FOR THE ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNIT CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Area	Habitat Classification	Area Size - Arces (approximate)	Industrial Activity (Y / N?)	Agricultural Activity (Y / N?)	Primary Vegetative Cover	Secondary Vegetative Cover	Tertiary Vegetative Cover	Ephemeral Water (Ditches / Pools)	Permenant Water (Ponds / Creeks)	Fenced (Y / N?)	Active Buildlings (Y / N?)	Abandoned Buildlings (Y / N?)	Building Foundations (Y / N?)	Adjacent Water Body	Adjacent Old-Filed	Adjacent Woodland	Adjacent Open Field	Adjacent Road	Adjacent Cropland
2	Woodland Patch and Agricultural Fields	405	N	Y	W	AG (w,c)	---	D		N	N	Y	Y		S	N,W	E		
2B	Urban Grassland with Tree Line	47	Y	N	F	B,T	---	D		Y	Y	N	N						
2D	Urban Grassland with Tree Line	57	Y	N	F	B,T	---	D		Y	Y	Y	Y						
2F	Urban Grassland with Tree Line	26	Y	N	F	B,T	---	D		Y	Y	Y	N						All
2P	Urban Grassland with Tree Line	60	Y	N	F	B,T	---	D		Y	Y	?	N		S	N,W	E		
4 East	None		Y	N	F	---	---	D		N	Y	Y	Y			N	S,E	W	
4 West	Urban Grassland with Brush		Y	N	F	B	---	D		N	Y	N	Y	W-C		W,N	S	E	
6	Old Field and Agriculture Field	500	Y	Y	OF	Ag (w,c,s)	MIT	D,P		P	Y	N	Y			N,W,S	N,E		
7	Urban Grassland	60	Y	N	F	---	---	D		N	Y	Y	Y	NE-P(f)		N,W,E	S		
8 South	Old Field and Early Woodland	190	N	N	OF	B	W	D	P (f)	N	N	N	Y buried	SW-C		S,E,W			
9	Urban Grassland with Tree Stands	70	Y	N	F	T	---	D	W	Y	Y	Y	Y	SW-W		W			E
10	Old Field and Early Woodland	40	N(o)	N	OF	W	---	P		Y	N	Y	N			All			
11	Old Field and Early Woodland	180	N	N	OF	W	---	D,P	P	P	N	N	Y			W,E			N
12	Early Woodland and Woodland	80	N	N	W	---	---	D,P	P	N	N	N	Y			W,E,S			
13	Agricultural Grassland and Old Field	500	Y	Y	OF	Ag (h)	W	D	P (f)	P	Y	N	Y buried			All			
AUS 0062	Old Field		N	N	OF	---	---	D,P		N	N	N	N					N*	All
AUS 0063	Old Field		N	N	OF	---	---	D		N	N	N	N			All		N,W*	
AUS 0065	Mid/Late Succession Woodland		N	N	W	B	---	P		P	N	Y	Y		All				
AUS 0066	Mid/Late Succession Woodland		N	N	W	B	---		P	P	N	N	N	N-COL (200')		All		N*	
AUS 0067	Mid/Late Succession Woodland		N	N	W	B	---			P	N	N	Y		All			W	

TABLE 3-2

AREA HABITAT MATRIX FOR THE ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNIT CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Area	Habitat Classification	Area Size - Arces (approximate)	Industrial Activity (Y / N?)	Agricultural Activity (Y / N?)	Primary Vegetative Cover	Secondary Vegetative Cover	Tertiary Vegetative Cover	Ephemeral Water (Ditches / Pools)	Permenant Water (Ponds / Creeks)	Fenced (Y / N?)	Active Buildlings (Y / N?)	Abandoned Buildlings (Y / N?)	Building Foundations (Y / N?)	Adjacent Water Body	Adjacent Old-Filed	Adjacent Woodland	Adjacent Open Field	Adjacent Road	Adjacent Cropland
AUS 0069	Mid/Late Succession Woodland		N	N	W	B	---			N	N	N	N	N-COL					W,E,S (h)
AUS 0109	Agriculture Field		N	N	AG (c)	—	—			N	N	N	N						All (c)
0001	Early Succession Woodland		N	N	W	B	---	D		N	N	N	Y			N,S,W		E	E (h)
0002	Mid-succession Woodland and Native Grassland		N	N	W	B	F		P	N	N	N	N			N			E, S (h)
0018	Early Succession Woodland		N	N	W	B	---	D		N	N	Y	N		N	S		W	
0021	Early Succession Woodland		N	N	W	B	---			N	N	N	Y			N	W	E	
0043	Early Succession Woodland		N	Y	W	B	---	D		N	N	N	Y			W,E		S	N
0060	Mid-succession Woodland		N	N	W	B	---	D,P		Y		Y		W-COL (2000')			N,S,E		
0061	Mid-succession Woodland		N	N	W	---	---	D		N	N	Y*	N			W,E	N,S	through site	
106A	Early Succession Woodland		N	N	W	---	---	D		N	N	N	N			All			
0107	Mid/Late Succession Woodland		N	N	W	—	---			N	N	N	N			W,S	N,E	N	
0108	Mid-succession Woodland and Agriculture Field		N	N	W	AG (c)	B			P	N	N	N			E,S			N,W

egetative Cover

- W Woodland
- F Grass Field
- OF Old Field (brush, forbs)
- AG Agricultural Field
- (h) hay crop
- (w) wheat crop
- (c) corn crop
- (s) soybean crop
- B Brush
- T Trees (open)
- MIT Mature Isolated Trees

ermanent Water

- P(f) Pond with fish
- W Wetland

Fenced

- P Partially Fenced

Abandoned Buildings

- * Concrete Structures

Adjacent Road

- * Abandoned Road

TABLE 3-3
FISH KNOWN OR EXPECTED TO OCCUR WITHIN THE VICINITY OF THE CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
Ichthyomyzon castaneus	chestnut lamprey	parasitic stage-large rivers and reservoirs; spawning adults and larvae-clear, permanent streams with stable bars of silt, sand and organic debris	Pis	Par
Scaphirhynchus platorynchus	shovelnose sturgeon	open channels of large rivers; bottom dweller in areas of swift current with a sand or gravel bottom	Ins	Ben Gle
Polyodon spathula	paddlefish	slow-moving waters rich in microscopic life; spawning needs access to large, free-flowing river with gravel bars	Mic/Ins	Fil
Lepisosteus osseus	longnose gar	sluggish pools, backwaters, and oxbows along large, moderately clear streams; thrives in man-made impoundments	Pis	Amb/Pur
Lepisosteus platostomus	shortnose gar	quiet pools, backwaters and oxbow lakes of major rivers, also permanent pools of prairie creeks	Pis	Amb/Pur
Lepisosteus oculatus	spotted gar	quiet, clear waters with much aquatic vegetation or standing timber	Pis	Amb/Pur
Amia calva	bowfin	swamps, sloughs, borrow pits, ditches, abandoned stream channels and pools of sluggish streams	Pis	Amb/Pur
Anguilla rostrata	American eel	streams of moderate or large size having continuous flow and moderately clear water	Det/Pis	Gle
Dorosoma cepedianum	gizzard shad	quiet-water habitats in lowland lakes and ponds, man-made impoundments, and pools and backwaters of	Mic/Ins	Fil

TABLE 3-3
FISH KNOWN OR EXPECTED TO OCCUR WITHIN THE VICINITY OF THE CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
		streams		
Dorosoma petenense	threadfin shad	quiet-water habitats in lowland lakes and ponds, man-made impoundments, and pools and backwaters of streams; more often found in waters with a noticeable current	Mic	Fil
Salmo gairdneri	rainbow trout	variety of habitats including streams, lakes, and reservoirs	Ins	Amb/Pur
Salmo trutta	brown trout	streams and lakes; found around dense cover or deep water below riffles	Ins/Pis	Amb/Pur
Esox americanus	grass pickerel	areas characterized by clear water, little current, and thick growths of aquatic vegetation	Ins/Pis	Amb
Labidesthes sicculus	brook silverside	clear, warm waters with no noticeable current	Ins	Gle/Pur
Carassius auratus	goldfish	not native; streams and lakes where they continually escape from bait buckets, artificial lakes and home aquaria	Omn	Ben Gle
Cyprinus carpio	common carp	not native; large streams, lakes and man-made impoundments that are highly productive	Omn	Ben Gle
Ctenopharyngodon idella	grass carp	not native; large streams and rivers	Omn	Ben Gle
Notemigonus crysoleucas	golden shiner	sloughs, ponds, lakes, impoundments, quiet pools of low-gradient streams and ditches, and permanent pools of intermittent upland creeks	Omn	Gle
Semotilus atromaculatus	creek chub	small headwater creeks	Ins/Pis	Gle/Pur

TABLE 3-3
FISH KNOWN OR EXPECTED TO OCCUR WITHIN THE VICINITY OF THE CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
Notropis cornutus	common shiner	small, moderately clear streams having high gradients and a predominance of gravel, rubble, and bedrock pools	Omn	Gle
Notropis lutrensis	red shiner	streams of all sizes, most abundant in large creeks and rivers	Ins	Amb/Pur
Notropis umbratilis	redfin shiner	prairie region-permanent pools of rocky or gravelly creeks having high gradient and low or intermittent flow; Ozark uplift-weedy backwaters and overflow pools	Ins	Amb/Pur
Hybognathus nuchalis	central silvery minnow	low-gradient sections of clear, moderately large streams	Det	Ben Gle
Campostoma anomalum	central stoneroller	streams with moderate or high gradients, well-defined gravel, rubble or bedrock riffles and permanent flow	Her	Ben Gle
Pimephales promelas	fathead minnow	streams of all sizes but is abundant only in pools of small, intermittent prairie creeks	Omn	Gle
Pimephales notatus	bluntnose minnow	quiet pools and backwaters of medium to moderately large streams with clear, warm waters, permanent flow and moderate amounts of aquatic vegetation	Omn	Gle
Ictiobus cyprinellus	bigmouth buffalo	deeper pools of large streams, lowland lakes, and man-made impoundments	Ins	Fil
Ictiobus niger	black buffalo	deeper pools of large streams, lowland lakes, and man-made impoundments, but occurs more often in strong currents	Unknown	Unknown

TABLE 3-3
FISH KNOWN OR EXPECTED TO OCCUR WITHIN THE VICINITY OF THE CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
Catostomus commersoni	white sucker	small headwater creeks	Ins	Ben Gle
Minytrema melanops	spotted sucker	clear, warm water having no noticeable current, and abundance of submerged aquatic vegetation, and soft bottoms containing large quantities of organic debris	Inv	Ben Gle (?)
Erimyzon oblongus	creek chubsucker	clear, quiet waters with thick growths of submergent vegetation and bottoms composed of sand or silt mixed with organic debris	Ins	Ben Gle (?)
Ictalurus melas	black bullhead	turbid water, a silt bottom, no noticeable current or strong flow, and a lack of diversity in fish fauna	Omn	Ben Gle
Ictalurus natalis	yellow bullhead	less turbid water, no noticeable current or strong flow	Omn	Ben Gle
Ictalurus punctatus	channel catfish	large streams with low or moderate gradients; larger pools, in deep water or near submerged logs or other cover	Omn/Det	Ben Gle
Pylodictis olivaris	flathead catfish	variety of streams with low gradients; pools, near submerged logs, piles of drift or other cover	Inv/Pis	Ben Gle
Noturus gyrinus	tadpole madtom	clear to moderately turbid waters with little current but with abundance of cover	Inv	Ben Gle
Aphredoderus sayanus	pirate perch	clear, warm water, absence of current and abundant cover	Inv/Pis	Amb/Pur
Fundulus notatus	blackstripe topminnow	slightly warmer, more turbid water permanent-flowing streams in quiet water along the margins of pools, near thick stands of emergent aquatic plants	Inv	Gle
Fundulus olivaceus	blackspotted topminnow	clear, permanent-flowing streams in quiet water along	Inv	Gle

TABLE 3-3
FISH KNOWN OR EXPECTED TO OCCUR WITHIN THE VICINITY OF THE CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
		the margins of pools, near thick stands of emergent aquatic plants		
Morone mississippiensis	yellow bass	quiet pools and backwaters of large streams and reservoirs	Inv/Pis	Pur/Amb
Morone saxatilis	striped bass	reservoirs	Ins/Pis	Pur/Amb
Morone chrysops	white bass	deeper pools of streams and open water of lakes and reservoirs	Inv/Pis	Gle
Micropterus salmoides	largemouth bass	warm, moderately clear waters with no noticeable current	Pis/Inv	Amb/Pur
Lepomis cyanellus	green sunfish	tolerates extremes of turbidity, dissolved oxygen, temperature, and flow; survives in fluctuating environment of small prairie streams	Inv/Pis	Amb/Pur
Lepomis gibbosus	pumpkinseed	clear, quiet waters with much aquatic vegetation	Inv	Gle
Lepomis gulosus	warmouth	streams with clear water and thick growths of submergent vegetation	Inv/Pis	Amb/Pur
Lepomis humilis	orangespotted sunfish	tolerant of siltation and high turbidity, commonly found in streams with low or intermittent flow	Inv	Gle
Lepomis macrochirus	bluegill	warm, clear waters with aquatic plants for cover; deeper pools and backwaters of streams; most abundant in overflow ponds, oxbow lakes and impoundments	Inv/Pis	Amb/Gle
Lepomis megalotis	longear sunfish	clear, permanent-flowing streams with sandy or rocky bottoms	Inv	Gle

TABLE 3-3
FISH KNOWN OR EXPECTED TO OCCUR WITHIN THE VICINITY OF THE CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
Lepomis microlophus	redear sunfish	warm, clear waters with no noticeable current and an abundance of aquatic plants	Inv	Gle
Pomoxis annularis	white crappie	reservoirs with standing timber or other cover; deeper pools of streams, overflow ponds and lakes away from any stream channel	Pis/Inv	Amb/Pur
Pomoxis nigromaculatus	black crappie	clear water, absence of noticeable current and abundant cover in for of submerged timber or aquatic vegetation	Pis/Inv	Amb/Pur
Centrarchus macropterus	flier	clear, heavily vegetated waters without noticeable current	Inv/Pis	Gle
Stizostedion vitreum	walleye	open water of lakes and reservoirs and pools of streams	Pis	Amb/Pur
Perca flavescens	yellow perch	lakes and reservoirs	Inv/Pis	Gle/Pur
Percina caprodes	logperch	deeper, more sluggish sections of riffles; pools if the bottoms is free of silt; reservoirs along gravelly wave-swept shores	Inv	Gle
Percina maculata	blackside darter	small to medium-sized streams with low or moderate gradients, permanent flow, and gravelly or sandy bottoms	Ins	Gle/Pur
Etheostoma asprigene	mud darter	lakes, ponds, and sluggish riffles and pools of large low-gradient streams	Unknown	Unknown
Etheostoma chlorosomum	bluntnose darter	sluggish streams; pools and backwaters without noticeable current and bottom is sand and organic debris	Ins	Gle

TABLE 3-3
FISH KNOWN OR EXPECTED TO OCCUR WITHIN THE VICINITY OF THE CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
Etheostoma gracile	slough darter	oxbows and overflow waters along floodplains of streams; pools of sluggish streams and ditches of lowlands and upland prairies; moderately clear, warm water without current and with soft bottoms including much organic debris	Inv	Gle
Etheostoma spectabile	orangethroat darter	small creeks and spring branches over gravelly or rocky bottom on sluggish riffles, or in pools with enough current to prevent silt deposition	Inv	Gle
Aplodinotus grunniens	freshwater drums	large rivers, lakes and impoundments	Pis/Inv	Ben Gle

[1]Trophic Level Codes: Her = herbivore; Det = detritivore; Omn = omnivore; Mic = microscopic animals/plants; Pis = piscivore; Ins = insectivore; Inv = invertivore; Unknown = life history has not been studied. Note that "predators", "insectivores", and "invertivores" are all carnivores (consumers of other animals). Note further that the designations refer to the "typical" or predominant composition of the diet and should not be interpreted as representing the overall diets.

[2]Foraging Behavior Codes: Ben = benthic; Par = parasitic; Fil = filter feeder/strainer; Gle = glean, Amb = ambush; Pur = pursuit; Unknown = life history has not been studied. Note that these foraging behaviors are "typical" and do not reflect the potential full range of possible foraging behaviors.

Pflieger, W.L. 1975. The Fishes of Missouri. M. Sullivan, ed. Missouri Department of Conservation.

TABLE 3-4
AMPHIBIANS AND REPTILES KNOWN OR EXPECTED TO OCCUR WITHIN THE VICINITY OF THE CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
AMPHIBIANS				
Necturus maculosus	mudpuppy	lakes, ponds, rivers, streams, or other permanent water	Pre	Ben Amb
Siren intermedia nettingi	western lesser siren	shallow waters such as ditches and ponds	Inv	Ben Amb
Ambystoma opacum	marbled salamander	variety of habitats ranging from moist sandy areas to dry hillsides	Inv	Grd Amb
Ambystoma texanum	smallmouth salamander	under debris near ponds or swamps, in river bottoms, or other areas where moisture is abundant	Inv	Rip/Foss Amb
Ambystoma maculatum	spotted salamander	hardwood forests around pools and flooded swampy areas	Inv	Rip/Foss Amb
Ambystoma tigrinum tigrinum	eastern tiger salamander	small ponds	Inv	Wt Amb
Plethodon glutinousus	northern slimy salamander	moist woodland ravines or hillsides	Inv	Grd/Rip Amb
Eurycea longicauda longicauda	longtail salamander	under rotting logs, under stones, shale banks near seepages, under rocks at streamside, and caves	Inv	Rip/Foss Amb

TABLE 3-4
AMPHIBIANS AND REPTILES KNOWN OR EXPECTED TO OCCUR WITHIN THE VICINITY OF THE CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
Eurycea longicauda melanopleura	dark-sided salamander	caves; twilight zone of caverns and grottoes, but do venture out of caves	Inv	Rip Amb
Eurycea lucifuga	cave salamander	caves; twilight zone of caves, also outside beneath logs, stones or debris in wooded or open places	Inv	Foss Amb
Scaphiopus holbrookii holbrookii	Eastern spadefood	forests with sandy or light soils - fossorial	Inv	Grd Amb
Bufo americanus charlesmithi	dwarf American toad	need soil to burrow in, water to soak in and breed, and plenty of live insects	Ins	Grd/Foss Amb
Bufo woodhousii fowleri	Fowler's toad	sandy areas, around shores of lakes or in river valleys	Inv	Rip/Wt Amb
Acris crepitans blanchardi	Blanchard's cricket frog	permanent bodies of shallow water with vegetation	Ins	Rip/Wt Amb
Hyla versicolor	gray treefrog	mainly arboreal along woodlot edges	Ins	Amb
Pseudacris crucifer	spring peeper	woodlands; brushy areas near small temporary and semipermanent ponds or swamps	Inv	Rip/Grd Amb

TABLE 3-4
AMPHIBIANS AND REPTILES KNOWN OR EXPECTED TO OCCUR WITHIN THE VICINITY OF THE CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
Pseudacris triseriata triseriata	western chorus frog	low shrubs, wet ground plants	Ins	Grd/Rip Amb
Pseudacris triseriata feriarum	upland chorus frog	grassy swales, moist woodlands, river-bottom swamps, ponds, bogs, and marshes	Inv	Grd/Rip Amb
Rana catesbeiana	bullfrog	often in/near water	Pre	Rip/Wt Amb
Rana pipiens	northern leopard frog	often in/near water	Ins	Rip/Wt Amb
Rana areolata	gopher frog	old crayfish holes containing water, small mammal burrows, storm or drainage sewers	Inv	Rip/Wt Amb
REPTILES				
Chelydra serpentina	snapping turtle	quiet, slow moving waters with muddy bottom and ample vegetation	Omn	Wt Gle
Sternotherus odoratus	common musk turtle	found in streams, ditches, ponds, and lakes; permanent water	Omn	Ben Gle
Kinosternon flavescens	yellow mud turtle	bodies of water with muddy bottoms	Omn	Ben Gle

TABLE 3-4
AMPHIBIANS AND REPTILES KNOWN OR EXPECTED TO OCCUR WITHIN THE VICINITY OF THE CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
Terrapene carolina carolina	eastern box turtle	open woods	Omn	Grd Gle
Trachemys scripta elegans	red-eared slider	quiet water with a muddy bottom and profusion of vegetation	Omn	Ben Gle
Chrysemys picta picta	painted turtle	soft-bottomed streams, lakes, ponds with ample vegetation	Omn	Wt Gle
Apalone mutica	smooth softshell	streams ranging in size from creeks to large rivers	Omn	Wt Gle
Apalone spinifera spinifera	eastern spiny softshell	rivers and lakes with sand and mud bars	Omn	Wt Gle
Sceloporus undulatus	eastern fence lizard	treed areas; seen on rail fences or rotting logs or stumps	Ins	Grd Amb
Scincella lateralis	ground skink	woodlands	Ins	Grd Amb
Eumeces fasciatus	five-lined skink	damp cutover woodlots with many rotting stumps and logs, rock piles, decaying debris	Ins	Grd Amb
Eumeces laticeps	broadhead skink	extensively arboreal; swamp forests to empty urban lots with debris	Ins	Grd Amb
Nerodia rhombifera rhombifera	diamondback water	many types of aquatic habitat; big	Pre	Wt Amb

TABLE 3-4
AMPHIBIANS AND REPTILES KNOWN OR EXPECTED TO OCCUR WITHIN THE VICINITY OF THE CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
	snake	lakes and rivers to ditches		
Nerodia erythrogaster flavigaster	yellowbelly water snake	in or near larger, more permanent bodies of water	Pre	Wt Amb
Nerodia sipedon pleuralis	midland water snake	utilizes wide variety of habitats; streams, ponds, swales, marshes	Pre	Wt Amb
Nerodia fasciata fasciata	banded water snake	all types of freshwater habitats; streams, ponds, lakes, marshes	Pre	Wt Amb
Storeria occipitomaculata	redbelly snake	in or near open woods	Pre	Grd Amb
Thamnophis proximus proximus	western ribbon snake	streams, ditches, edges of lakes and ponds	Pre	Rip Amb
Heterodon platirhinos	eastern hognose snake	sandy areas	Pre	Grd Amb
Diadophis punctatus arnyi	prairie ringneck snake	rocky hillsides in open woods	Pre	Grd Amb
Carphophis amoenus helenae	midwest worm snake	under stones or boards, rotting logs; partial to moist earth	Ins	Grd/Foss Amb
Farancia abacura reinwardti	western mud snake	swamps and lowlands	Pre	Rip Amb/Pur
Coluber constrictor flaviventris	eastern yellowbelly racer	fields, grasslands, brushy areas, and open woods	Pre	Grd Amb/Pur

TABLE 3-4
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Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
Opheodrys aestivus	rough green snake	dense growth of vegetation overhanging a stream or lake border	Ins	Rip Amb
Elaphe obsoleta obsoleta	black rat snake	rocky, timbered hillsides to flat farmlands	Pre	Grd Amb
Lampropeltis getulus niger	black kingsnake	dry, rocky hills, open woods, dry prairies, and stream valleys	Pre	Grd Amb
Lampropeltis getula holbrooki	speckled kingsnake	river swamps, upland wooded areas, stream valleys across the open plains and prairies	Pre	Rip Amb
Lampropeltis triangulum triangulum	eastern milk snake	fields, woodlands, rocky hillsides, river bottoms	Pre	Grd Amb
Lampropeltis calligaster calligaster	prairie kingsnake	grassland and prairies, open woodlands, patches of prairie and savannah in the midst of essentially forested country	Pre	Grd Amb
Agkistrodon contortrix mokasen	northern copperhead	rocky, wooded hillsides and mountainous areas	Pre	Grd Amb
Crotalus horridus	timber rattlesnake	in south, lowlands, favoring cane thickets and swamplands	Pre	Grd Amb/Pur

TABLE 3-4
AMPHIBIANS AND REPTILES KNOWN OR EXPECTED TO OCCUR WITHIN THE VICINITY OF THE CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

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[1]Trophic Level Codes: Her = herbivore; Det = detritivore; Omn = omnivore; Pre = predator; Ins = insectivore; Inv = invertivore. Note that "predators", "insectivores", and "invertivores" are all carnivores (consumers of other animals). Note further that the designations refer to the "typical" or predominant composition of the diet and should not be interpreted as representing the overall diets.

[2]Foraging Behavior Codes: Grd = ground; Wt = Water; Ben = benthic; Rip = riparian; Foss = fossorial; Gle = glean, Amb = ambush; Pur = pursuit. Note that these foraging behaviors are "typical" and do not reflect the potential full range of possible foraging behaviors.

[3]Occurance is determined or predicted based on zoogeographic literature (Conant and Collins 1998) and limited site-specific observations. Primary designations relate to degree of certainty or likelihood of occurrence at the specific locations in question: No = assumed absent; Po = occurrence is possible, although location-specific confirmation is lacking; Kn = known to occur; location-specific confirmation.

Conant, R. and J.T. Collins. 1998. A field guide to reptiles and amphibians, eastern/central North America. 3rd edition. Houghton Mifflin Company, New York, NY.

TABLE 3-5
BIRDS KNOWN OR EXPECTED TO OCCUR WITHIN THE VICINITY OF THE CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIMASON COUNTY, ILLINOIS

Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
Gavia immer	common loon	forested lakes and rivers; winters on oceans and bays	Pre	Wt Dvr
Podilymbus podiceps	pied-billed grebe*	marshes, ponds; sinter in salt marshes if freshwater habitats freeze	Pre	Wt Dvr
Podiceps auritus	horned grebe	marshes and lakes; winters on salt water and the Great Lakes	Pre	Wt Dvr
Phalacrocorax auritus	double-crested cormorant	lakes, rivers, swamps, and coasts	Pre	Wt Dvr
Botaurus lentiginosus	American bittern	freshwater and brackish marshes and marshy lake shores	Pre	Wt Stk
Ardea herodias	great blue heron	lakes, ponds, rivers and marshes	Pre	Wt Stk
Ardea alba	great egret	freshwater and salt marshes, marshy ponds, and tidal flats	Pre	Wt Stk
Egretta thula	snowy egret	marshes, swamps, ponds, and shores	Inv	Wt Stk
Egretta caerulea	little blue heron	freshwater swamps and lagoons in the south; coastal thickets on islands in the north	Pre	Wt Stk
Bubulcus ibis	cattle egret	dry land in open fields where it feeds alongside livestock, but breeds near water with other herons	Ins	Grd Gle
Butorides virescens	green heron*	lake margins, streams, ponds, and marshes	Pre	Wt Stk

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Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
Nycticorax nycticorax	black-crowned night heron*	marshes, swamps, and wooded streams	Pre	Wt Stk
Nycticorax violaceus	yellow-crowned night heron*	wooded swamps and coastal thickets	Pre	Wt/Grd Stk
Anser albifrons	greater white-fronted goose	marshy tundra; winters on marshes and bays	Her	Grd Gle
Chen caerulescens	snow goose	tundra; winters in salt marshes and marshy coastal bays, less commonly in freshwater marshes and adjacent grain fields	Her	Grd Gle
Branta canadensis	Canada goose*	lakes, bays, rivers, and marshes, often feeds in open grassland and stubble fields	Her	Grd Gle
Aix sponsa	wood duck*	wooded rivers, ponds and swamps; freshwater marshes in late summer and fall	Omn	Wt Gle
Anas crecca	green-winged teal	marshes, ponds, and marshy lakes	Omn	Wt Gle
Anas rubripes	American black duck	marshes, lakes, streams, coastal mud flats and estuaries	Omn	Wt Gle
Anas platyrhynchos	mallard*	ponds, lakes, and marshes	Omn	Wt Gle
Anas acuta	northern pintail	marshes, prairie ponds, and tundra; salt marshes in winter	Omn	Wt Gle
Anas discors	blue-winged teal*	marshes, shallow ponds, and lakes	Her	Wt Gle
Anas clypeata	northern shoveler	marshes and prairie potholes	Omn	Wt Gle

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Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
Anas strepera	gadwall	freshwater marshes, ponds, and rivers; winter in salt marshes	Her	Wt Gle
Anas americana	American widgeon	marshes, ponds, and shallow lakes	Her	Wt/Grd Gle
Aythya valisineria	canvasback	nests on marshes; winters on lakes, bays and estuaries	Her	Wt Gle
Aythya americana	redhead	nests in marshes, other times found on lakes and bays; winters on salt water	Omn	Wt Dvr
Aythya collaris	ring-necked duck	wooded lakes, ponds, and rivers; seldom winters on salt water except in the southern states	Omn	Wt Dvr
Aythya affinis	lesser scaup	ponds and marshes; migration and winter occurs on lakes, rivers, and ponds	Omn	Wt Dvr
Bucephala clangula	common goldeneye	nests on lakes and ponds in the north; winters mainly along the coast in bays and inlets	Inv	Wt Dvr
Bucephala albeola	bufflehead	northern lakes and ponds; winters on salt bays and estuaries	Ins	Wt Dvr
Lophodytes cucullatus	hooded merganser	wooded ponds, lakes and rivers	Pre	Wt Dvr
Mergus merganser	common merganser	wooded rivers and ponds; winters on salt bays	Pre	Wt Dvr

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Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
Mergus serrator	red-breasted merganser	northern lakes and tundra ponds; winters on the ocean and in salt bays	Pre	Wt Dvr
Oxyura jamaicensis	ruddy duck	freshwater marshes, marshy lakes and ponds; shallow salt bays and rivers in winter	Omn	Wt Dvr
Coragyps atratus	black vulture	open lowland areas, garbage dumps, avoids forested areas	Det	S/Grd Gle
Cathartes aura	turkey vulture*	open habitat in both lowlands and mountains	Det	S/Grd Gle
Pandion haliaetus	osprey	lakes, rivers, and seacoasts	Pre	Ar Ha
Haliaeetus leucocephalus	bald eagle*	lakes, rivers, marshes, and sea coasts	Pre/ Det	PSw
Circus cyaneus	northern harrier	marshes and open grasslands	Pre	Ar Ha
Accipeter striatus	sharp-shinned hawk	woodland and mountains	Pre	Ar Ha
Accipter cooperii	Cooper's hawk*	forests and woodlands prefers riparian areas	Pre	Ar Ha
Buteo lineatus	red-shouldered hawk*	deciduous woodlands, especially near standing water	Pre	PSw
Buteo platypterus	broad-winged hawk*	deciduous woodland	Pre	PSw
Buteo jamaicensis	red-tailed hawk*	woodland and open country with scattered trees, desert	Pre	S/Grd Pou
Buteo lagopus	rough-legged hawk	tundra; winters on open plains, agricultural	Pre	H/PSw

TABLE 3-5
BIRDS KNOWN OR EXPECTED TO OCCUR WITHIN THE VICINITY OF THE CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIMASON COUNTY, ILLINOIS

Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
		areas, and marshes		
Aquila chrysaetos	golden eagle	open habitat, especially in mountains and hilly areas	Pre	S/Grd Pou
Falco sparverius	American kestrel*	open or partly opened habitats with scattered trees, also cultivated and urban areas	Ins	H/Grd Pou
Meleagris gallopavo	wild turkey*	mixed forest and open woodland	Omn	Grd Gle
Colinus virginianus	northern bobwhite*	tall grassland, brushy fields, open woodland, cultivated fields	Omn	Grd Gle
Rallus limicola	Virginia rail	freshwater and brackish marshes	Inv	Grd Gle/Pur
Porzana carolina	sora	freshwater marshes and marshy ponds; winters in rice fields and salt marshes	Omn	Grd Gle
Fulica americana	American coot	open ponds and marshes, winter in saltwater bays and inlets	Omn	Wt Gle/Dvr
Pluvialis asuatarola	black-bellied plover	tundra; winter on beaches and coastal marshes, inland marshes, lakeshores, and plowed fields	Inv	Wt/Grd Prb
Pluvialis dominica	American golden-plover	tundra; migration coastal beaches and mudflats and inland prairies and plowed fields	Ins	Wt/Grd Prb

TABLE 3-5
BIRDS KNOWN OR EXPECTED TO OCCUR WITHIN THE VICINITY OF THE CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIMASON COUNTY, ILLINOIS

Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
Charadrius semipalmatus	semipalmated plover	beaches and tidal flats, shallow pools in salt marshes; lakeshores in the interior during migration	Inv	Wt/Grd Prb
Charadrius vociferus	killdeer*	variable; fields, meadows, pastures, mud flats, urban and rural areas	Ins	Grd Gle
Recurvirostra americana	American avocet	freshwater marshes and shallow marshy lakes	Inv	Wt Prb/Gle
Tringa melanoleuca	greater yellowlegs	open wet tundra and marshy ground; migration and winter in pools, lakeshores, and tidal mud flats	Pre	Wt Gle/Pur
Tringa flavipes	lesser yellowlegs	marshy ponds, lake and river shores, mudflats	Pre	Wt Gle
Tringa solitaria	solitary sandpiper	inland ponds and bogs, wet swampy places and woodland streams	Inv	Wt Prb/Gle
Catoptrophorus semipalmatus	willet	coastal beaches, freshwater and slat marshes, lakeshores, and wet prairies	Inv	Wt Prb
Actitis macularia	spotted sandpiper*	almost anyplace with water nearby, both in open country and in wooded areas	No	Wt Prb/Stk
Bartramia longicauda	upland sandpiper	grassy prairies, open meadows, and fields	Omn	Grd Gle
Calidris alba	sanderling	ocean beaches, sandbars, occasionally mud flats, inland lake and river shores	Inv	Wt Prb

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Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
Calidris pusilla	semipalmated sandpiper	coastal beaches, lake and river shores, flats, and pools in salt marshes	Inv	Wt Prb/Gle
Calidris minutilla	least sandpiper	grassy pools, bogs, and marshes with open areas, also flooded fields and mud flats	Inv	Wt Prb/Gle
Calidris fuscicollis	white-rumped sandpiper	tundra; winter on flats, grassy pools, wet meadows, and shores	Inv	Wt./Grd Prb/Gle
Calidris bairdii	Baird's sandpiper	tundra; winter in inland areas with grassy pools, wet meadows, and lake and river shores	Ins	Wt Gle
Calidris melanotos	pectoral sandpiper	wet, short-grass areas, grassy pools, golf courses and airports after heavy rains	Ins	Wt/Grd Prb/Gle
Calidris alpina	dunlin	beaches, extensive mud and sand flats, tidal inlets and lagoons, also inland lake and river shores	Inv	Wt Prb
Calidris himantopus	stilt sandpiper	grassy pools and shores of ponds and lakes	Inv	Wt Prb
Limnodromus griseus	short-billed dowitcher	mud flats, creeks, salt marshes and tidal estuaries	Inv	Wt Prb
Limnodromus scolopaceus	long-billed dowitcher	muskeg; migration and winter occurs on mud flats, marshy pools, and margins of freshwater ponds	Inv	Wt Prb
		freshwater marshes, ponds, flooded		Grd/Wt

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Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
Gallinago gallinago	common snipe	meadows, and fields	Ins	Prb
Scolopax minor	American woodcock*	moist woodland and thickets near open fields	Ins	Grd/Wt
Phalaropus tricolor	Wilson's phalarope	prairie pools and marshes, lake and river shores, marshy pools along the coast	Inv	Wt Prb/Gle
Larus pipixcan	Franklin's gull	prairie marshes and sloughs, often feeds in plowed fields	Ins	Grd/Ar Scr
Larus philadelphia	Bonaparte's gull	forested lakes and rivers; winters along the coast, in estuaries and at the mouth of large rivers	Pre	Ar Pur
Larus delawarensis	ring-billed gull	lakes and rivers; winter in salt water	Omn	Ar/Grd Gle/Scr
Larus argentatus	herring gull	lakes, rivers, estuaries, and beaches	Omn	Ar/Grd Gle/Scr
Sterna caspia	Caspian tern	sandy or pebbly shores of lakes and large rivers and along seacoasts	Pre	Ar H/Pou
Sterna hirundo	common tern	lakes, ponds, rivers, coastal beaches and islands	Pre	Ar H/Pou
Sterna forsteri	Forster's tern	salt marshes in the east; freshwater marshes in the west	Pre/Ins	Ar H/Pou
Chlidonias niger	black tern	freshwater marshes and marshy lakes;	Pre/Ins	Ar

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Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
		winters on sandy coasts		Gle/Pur
Columba livia	rock dove*	cities, towns, rural areas, always near human habitation	Her	Grd Gle
Zenaidura macroura	mourning dove*	variable; generally open areas, common in agricultural areas	Her	Grd Gle
Coccyzus erythropthalmus	black-billed cuckoo	moist thickets in low, overgrown pastures and orchards	Ins	Lca Gle
Coccyzus americanus	yellow-billed cuckoo*	open woodland, especially with dense undergrowth, parks, riparian woodland and thickets	Ins	Lca/Grd Gle
Otus asio	eastern screech owl*	woodland, especially oak and riparian, scrub, orchards, woodlots	Pre	PSw/Grd Pou
Bubo virginianus	great horned owl*	dense conifer and mixed forests, wooded swamps, and river valleys	Pre	PSw/Grd Pou
Strix varia	barred owl*	low, wet woods and swamp forest	Pre	PSw/H Pou
Asio flammeus	short-eared owl	prairie, meadow, tundra, marsh, and savanna	Pre	H/Grd Pou
Chorodeiles minot	common nighthawk*	open and semi-open habitats, especially savanna, grassland, fields, cities and towns	Ins	Ar Scr

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Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
Caprimulgus carolinensis	Chuck-will's-widow*	open woodland and clearings near agricultural country	Ins	Ar Scr
Caprimulgus vociferus	whip-poor-will*	dry open woodland near fields	Ins	Ar Scr
Chaetura pelagica	chimney swift*	breeds and roosts in chimneys	Ins	Ar Scr
Archilochus colubris	ruby-throated hummingbird*	suburban gardens, parks, and woodlands	Her	H Fl
Ceryle alcyon	belted kingfisher*	rivers, lakes, and saltwater estuaries	Pre	PSw Pou
Melanerpes erythrocephalus	red-headed woodpecker*	open country, farms, rural roads, open park-like woodland, and golf courses	Omn	Ar/Ba Gle/Pur
Melanerpes carolinus	red-bellied woodpecker*	open and swamp woodland	Omn	Ba Gle
Sphyrapicus varius	yellow-bellied sapsucker	mixed forests and parks	Omn	Ba Gle
Picoides pubescens	downy woodpecker*	wood lots, parks and gardens	Ins	Ba Gle
Denrocopos villosus	hairy woodpecker*	conifer forests, occasionally mixed or riparian forests	Omn	Ba Gle
Colaptes auratus	common flicker*	open country with trees, parks and rural estates	Ins	Grd/Ba Gle
Dryocopus pileatus	pileated woodpecker*	dense forest and borders	Omn	Ba Prb
Contopus borealis	olive-sided flycatcher	boreal spruce and fir forests, near openings, burns, ponds and bogs	Ins	PSw Pur

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Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
Contopus virens	eastern wood-pewee*	forest, open woodland, orchards, and shade trees in parks and along roadsides	Ins	PSw Pur
Empidonax flaviventris	yellow-bellied flycatcher	thickets of alder and will in northern coniferous forests; migration second-growth forests	Ins	PSw/Lca Pur
Empidonax virescens	Acadian flycatcher*	beech-maple or hemlock forest, usually under the canopy but also in clearings, often in wooded ravines	Ins	PSw/Lca Pur
Empidonax alnorum	alder flycatcher	alder swamps, streamside and lakeside thickets and second growth	Ins	PSw/Lca Pur
Empidonax traillii	willow flycatcher	swampy thickets, upland pastures, and old abandoned orchards	Ins	PSw Pur
Empidonax minimus	least flycatcher	widely distributed in open country, nests in shade trees, orchards, villages, city parks, rural roadsides and woodland borders	Ins	PSw Pur
Sayornis phoebe	eastern phoebe*	open woodland near streams, cliffs, bridges, and buildings with ledges	Omn	PSw Pur
Myiarchus crinitus	great crested flycatcher*	open forest, orchards, and large trees in farm country	Ins	PSw Pur
Tyrannus tyrannus	eastern kingbird*	open country, farms, orchards, roadsides, and lake and river shores	Omn	PSw/H Pur

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Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
Eremophila alpestris	horned lark*	plains, fields, airports, and beaches	Omn	Grd Gle
Progne subis	purple martin*	open woodland, residential areas, and agricultural land	Ins	Ar Scr
Tachycineta bicolor	tree swallow*	lake shores, flooded meadows, marshes, and streams	Omn	Ar Scr
Stelgidopteryx ruficollis	northern rough-winged swallow*	streams and rivers, especially in the vicinity of steep banks and man-made structures for nesting sites	Ins	Ar Scr
Riparia riparia	bank swallow	rivers and streams, especially near sandbanks; more widespread during migration	Ins	Ar Scr
Petrochelidon pyrrhonota	cliff swallow*	open country, savanna, especially near running water	Ins	Ar Scr
Hirundo rustica	barn swallow*	agricultural land, suburban areas, marshes, and lake shores	Ins	Ar Scr
Cyanocitta cristata	blue jay*	chiefly oak forest, but now also city parks and suburban yards	Omn	Lca/Grd Gle
Corvus brachyrhynchos	American crow*	woodland, farmland, orchards, and tidal flats; riparian woodland in arid regions	Omn	Grd Gle
Parus carolinensis	Carolina chickadee*	deciduous woodlands and residential areas	Omn	Lca Gle

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Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
Parus bicolor	tufted titmouse*	swampy or moist woodland and shade trees in villages and city parks; at feeders in winter	Omn	Lca/Grd Gle
Sitta canadensis	red-breasted nuthatch*	coniferous forests; widespread during winter	Omn	Ba Gle
Sitta carolinensis	white-breasted nuthatch*	deciduous forests (especially mature), mixed forests, woodland, forest edge	Ins	Ba Gle
Certhia familiaris	brown creeper	woodlands, groves, shade trees	Ins	Ba Gle
Thryothorus ludovicianus	Carolina wren*	woodland thickets, ravines, and rocky slopes covered with brush	Ins	Ba/Grd Gle
Thryomanes bewickii	Bewick's wren*	open woodland, scrub land, farms, and suburbs	Ins	Grd Gle
Troglodytes aedon	house wren*	residential areas, city parks, farmlands, and woodland edges	Ins	Ba/Grd Gle/Prb
Troglodytes troglodytes	winter wren	dense tangles and thickets in coniferous and mixed forests	Ins	Grd/Ba Gle
Cistothorus platensis	sedge wren	grassy freshwater marshes and sedges; winter brackish marshes and wet meadows	Ins	Grd Gle
Cistothorus palustris	marsh wren	fresh and brackish marshes with cattails, reeds, bulrushes, or sedges	Ins	Grd Gle
Regulus satrapa	golden-crowned kinglet	open conifer forests	Ins	Ca Gle

TABLE 3-5
BIRDS KNOWN OR EXPECTED TO OCCUR WITHIN THE VICINITY OF THE CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIMASON COUNTY, ILLINOIS

Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
Regulus calendula	ruby-crowned kinglet	conifer and mixed forests	Ins	Ca Gle
Polioptila caerula	blue-gray gnatcatcher*	variable; forests, woodlands, swamps, scrub, desert	Ins	Ca Gle
Sialia sialis	eastern bluebird*	open farmlands with scattered trees	Omn	PSw/H Pur
Catharus fuscescens	veery	moist deciduous woodlands	Omn	Grd Gle
Catharus minimus	gray-checked thrush	coniferous forests; widespread during migration	Omn	Grd Gle
Catharus ustulatus	Swainson's thrush	coniferous forests and willow thickets	Omn	Grd/Lca Gle
Hylocicla guttata	hermit thrush	conifer or mixed forests and forest edges	Ins	Grd Gle
Hylocichla mustelina	wood thrush*	moist, deciduous woodlands with a thick understory	Omn	Grd/Gle
Turdus migratorius	American robin*	habitat generalist; forests, woodlands, garden, parks	Ins	Grd Gle
Dumetella carolinensis	gray catbird*	thickets and brush, residential areas and gardens	Omn	Grd Gle
Mimus polyglottos	northern mockingbird*	residential areas, city parks, farmlands, open country with thickets, and desert brushland	Omn	Grd Gle
		brush and scrub lands, forest edges and		

TABLE 3-5
BIRDS KNOWN OR EXPECTED TO OCCUR WITHIN THE VICINITY OF THE CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIMASON COUNTY, ILLINOIS

Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
Toxostoma rufum	brown thrasher*	clearings	Omn	Grd Gle
Anthus rubescens	American pipit	arctic and alpine tundra; migration and winter on beaches, barren fields, agricultural land and golf courses	Omn	Grd/Wt Gle
Bombycilla cedorum	cedar waxwing*	woodlands, forests edges, well-planted suburbs	Her	Ca Gle
Lanius ludovicianus	loggerhead shrike*	open fields with scattered trees, open	Pre	PSw/Grd
Sturnus vulgaris	European starling*	variable; open fields, woodlots, suburbs and cities	Omn	Grd Gle
Vireo griseus	white-eyed vireo*	dense swampy thickets and hillsides with blackberry and briar tangles	Omn	Lca Gle
Vireo bellii	Bell's vireo*	dense bottomland thickets, willow scrub, and mesquite	Ins	Lca H/Gle
Vireo solitaris	solitary vireo	mixed woodlands	Ins	Ca Gle
Vireo flavifrons	yellow-throated vireo*	tall deciduous trees at the edge of forests, along streams, roadsides, orchards, parks and estates	Omn	Ca Gle
Vireo gilvus	warbling vireo*	open woodlands, riparian forests and thickets	Ins	Ca Gle
Vireo alivaceus	red-eyed vireo*	deciduous forest, and shade trees in residential areas	Omn	Lca H/Gle

TABLE 3-5
BIRDS KNOWN OR EXPECTED TO OCCUR WITHIN THE VICINITY OF THE CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIMASON COUNTY, ILLINOIS

Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
Vermivora pinus	blue-winged warbler	abandoned fields and pastures grown up to saplings, forest clearings and edges with clumps of catbrier, blackberry, and various bushes and young trees	Ins	Lca Gle
Vermivora chrysoptera	golden-winged warbler	abandoned fields and pastures grown up to saplings but usually in moister situations	Ins	Ca Gle
Vermivora peregrina	Tennessee warbler	open mixed woodlands; trees and bushes during migration	Omn	Lca Gle
Vermivora celata	orange-crowned warbler	thickets and brushy woodlands	Omn	Lca Gle/Fl
Vermivora ruficapilla	Nashville warbler	woodland edges; thickets in open mixed forest or brushy borders of swamps	Ins	Lca Gle
Parula americana	northern parula*	wet, coniferous woods, swamps, and along lakes and ponds; widespread during migration	Ins	Lca H
Dendroica petechia	yellow warbler*	second-growth woodlands, gardens, scrub, riparian thickets	Ins	Ca Gle
Dendroica pensylvanica	chestnut-sided warbler	young, open second-growth woodland and scrub	Ins	Ba Gle/H
Dendroica magnolia	magnolia warbler	open stands of young spruce and fir; migration any place where shrubbery or trees occur	Ins	Ba Gle

TABLE 3-5
BIRDS KNOWN OR EXPECTED TO OCCUR WITHIN THE VICINITY OF THE CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIMASON COUNTY, ILLINOIS

Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
Dendroica tigrina	Cape May warbler	open spruce forests; migration, in evergreen or deciduous woodlands and often in parks or suburban yards	Omn	Ca Gle
Dendroica coronata	yellow-rumped warbler	coniferous and mixed forests; wide spread during winter	Omn	Grd/Lca Gle/H
Dendroica virens	black-throated green warbler	open stands of hemlock or pine; migration variety of habitats	Ins	Lca Gle/H
Dendroica fusca	Blackburian warbler	most numerous in mixed forests or hemlock, spruce, and various hardwoods; high in the trees	Ins	Ca Gle
Dendroica dominica	yellow-throated warbler*	forests of pine, cypress, sycamore and oak, in both swampy places and dry upland	Ins	Ba Gle
Dendroica pinus	pine warbler*	pine forests	Omn	Ba Gle
Dendroica discolor	prairie warbler*	in north, mixed pine-oak barrens, old pastures and on hillsides with scattered red cedar; in south, open scrub	Ins	Lca/Ba Gle
Dendroica palmarum	palm warbler	bogs; during migration in open places, weedy fields, borders of marshes	Omn	Grd Gle
Dendroica castanea	bay-breasted warbler	open spruce forests; migration deciduous forests as well	Omn	Lca Gle
		coniferous forests; migration found in tall		

TABLE 3-5
BIRDS KNOWN OR EXPECTED TO OCCUR WITHIN THE VICINITY OF THE CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIMASON COUNTY, ILLINOIS

Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
Dendroica striata	blackpoll warbler	trees	Omn	Ca Gle
Dendroica cerulea	cerulean warbler*	open woodland, often near streams and rivers	Ins	Ca Gle
Mniotilta varia	black-and-white warbler	primary and secondary forest; during migration parks, gardens and lawn areas with trees and shrubs	Ins	Ba Gle
Setophaga ruticilla	American redstart	second-growth woodlands, thickets with saplings	Ins	Ar H/Pur
Protonotaria citrea	prothonotary warbler*	wooded swamps, flooded bottomland forest, and streams with dead trees	Inv	Lca/Wt Gle
Helmitheros vermivorus	worm-eating warbler*	dry wooded hillsides	Ins	Ba Gle
Limnothlypis swainsonii	Swainson's warbler	wooded swamps and southern canebrakes	Ins	Grd Gle
Seiurus aurocapillus	ovenbird	mature, dry forest with little undergrowth	Ins	Grd Gle
Seiurus noveboracensis	northern waterthrush	cool bogs, wooded swamps, and lake shores in breeding season; wooded habitat during migration	Ins	Grd/Wt Gle
Seiurus motacilla	Louisiana waterthrush*	swift-moving brooks on hillsides, occurs in river swamps and along sluggish streams	Inv	Grd/Ar Gle
Oporornis formosus	Kentucky warbler*	low, moist, rich woodland with luxuriant undergrowth, ravines	Ins	Grd Gle

TABLE 3-5
BIRDS KNOWN OR EXPECTED TO OCCUR WITHIN THE VICINITY OF THE CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIMASON COUNTY, ILLINOIS

Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
Geothlypis trichas	common yellowthroat*	moist thickets and grassy marshes	Ins	Lca H/Gle
Wilsonia citrina	hooded warbler	mature, moist forest with luxuriant undergrowth, especially in ravines, wood swamps	Ins	Grd/Lca Gle
Wilsonia pusilla	Wilson's warbler	moist thickets in woodland and along streams; alder and willow thickets and bogs	Ins	Grd/Lca Gle
Wilsonia canadensis	Canada warbler	cool, moist woodland that is nearly mature and has thick undergrowth	Ins	Grd/Lca Pur/Gle
Icteria virens	yellow-breasted chat*	dense thickets and brush, often with thorns, streamside tangles and dry brushy hillsides	Omn	Lca Gle
Piranga rubra	summer tanager*	deciduous forests, open and riparian woodland, pine-oak woodlots, parks	Ins	Ca Gle
Piranga olivacea	scarlet tanager*	mature woodland, especially oak and pine	Omn	Ca Gle
Cardinalis cardinalis	northern cardinal*	woodland edges, thickets, brushy swamps and gardens	Omn	Grd/Lca Gle
Pheucticus ludovicianus	rose-breasted grosbeak	moist woodland adjacent to open fields with tall shrubs, old and overgrown orchards	Omn	Lca Gle
Guiraca caerulea	blue grosbeak*	riparian thickets, overgrown fields, open woodland, hedgerows, orchards	Omn	Grd Gle
Passerina cyanea	indigo bunting*	brushy slopes, abandoned farmland, old	Omn	Grd/Lca

TABLE 3-5
BIRDS KNOWN OR EXPECTED TO OCCUR WITHIN THE VICINITY OF THE CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIMASON COUNTY, ILLINOIS

Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
		pastures and fields grown up to scrub, woodland clearings and forest edge adjacent to fields		Gle
Spiza americana	dickcissel*	open country in grain or hay fields and in weed patches	Omn	Grd Gle
Pipilo erythrophthalmus	eastern towhee*	forest edges, chaparral, riparian thickets, woodlands	Omn	Grd Gle
Spizella arborea	American tree sparrow	arctic willow and birch thickets; fields, weedy woodland edges and roadside thickets in winter	Omn	Grd Gle
Spizella passerina	chipping sparrow*	open conifer forests, forest edges, oak and pine-oak woodlands, thickets, and parks	Omn	Grd Gle
Spizella atrogularis	field sparrow*	abandoned fields and pastures grown up to seeds, scattered bushes and small saplings	Omn	Grd Gle
Pooecetes gramineus	vesper sparrow	grassland, prairie, savanna, old fields, arid scrub, open woodlands	Her	Grd Gle
Passerculus sandwichensis	savannah sparrow	grassland, meadows, marsh, grassy areas	Omn	Grd Gle
Ammodramus savannarum	grasshopper sparrow*	grassland, cultivated fields, prairie, old fields, open savanna	Omn	Grd Gle
Ammodramus henslowii	Henslow's sparrow	moist or dry grassland with scattered weeds and small shrubs	Omn	Grd Gle

TABLE 3-5
BIRDS KNOWN OR EXPECTED TO OCCUR WITHIN THE VICINITY OF THE CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIMASON COUNTY, ILLINOIS

Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
Ammodramus leconteii	Le Conte's sparrow	moist grassland and boggy meadows; dry fields in winter	Omn	Grd Gle
Passerella iliaca	fox sparrow	coniferous forest undergrowth in summer; winter dense woodland thickets, weedy pastures and brushy roadsides	Omn	Grd Gle
Melospiza melodia	song sparrow*	dense vegetation along watercourses, forest edges, clearings, bogs, gardens	Omn	Grd Gle
Melaspiza lincolnii	Lincoln's sparrow	bogs, wet meadows, riparian thickets	Omn	Grd Gle
Melospiza georgiana	swamp sparrow	freshwater marshes and open wooded swamps; in migration in weedy fields, parks and brush piles	Omn	Grd Gle
Zonotrichia albicollis	white-throated sparrow	mixed forests, edges, thickets, and open woodlands	Omn	Grd Gle
Zonotrichia leucophrys	white-crowned sparrow	stunted woody vegetation, coastal scrub, wet meadows, thickets, chaparral, parks	Omn	Grd Gle
Junco hyemalis	dark-eyed junco	coniferous or mixed forests; winters in fields, gardens, city parks and roadside thickets	Omn	Grd Gle
Calcarius lapponicus	lapland longspur	arctic tundra; winters in open windswept fields and on grassy coastal dunes	Omn	Grd Gle
Dolichonyx oryzivorus	bobolink	prairies and meadows; marshes during	Omn	Grd Gle

TABLE 3-5
BIRDS KNOWN OR EXPECTED TO OCCUR WITHIN THE VICINITY OF THE CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIMASON COUNTY, ILLINOIS

Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
		migration		
Agelaius phoeniceus	red-winged blackbird*	marshes, riparian habitats agricultural fields	Omn	Grd Gle
Sturnella magna	eastern meadowlark*	grassland, savanna, fields	Omn	Grd Gle
Euphagus carolinus	rusty blackbird	boreal bogs; wooded swamps and damp woods with pools during migration	Omn	Grd/Wt Gle
Quiscalus quiscula	common grackle*	lawns, parks, fields, open woodland	Omn	Grd/Wt Gle
Molothrus ater	brown-headed cowbird*	woodland, forest, forest edge, grassland	Her	Grd/Ca Gle
Icterus spurius	orchard oriole*	orchards, shade trees in parks and gardens, and scattered trees along lakes and streams	Omn	Lca Gle/Fl
Icterus galbula	Baltimore oriole*	deciduous woodland and shade trees	Omn	Lca Gle/Fl
Carpodacus purpureus	purple finch	mixed and coniferous woodlands, ornamental conifers in gardens	Omn	Lca/Grd Gle
Carduelis pinus	pine siskin	coniferous and mixed woodlands, alder thickets, and brushy pastures	Omn	Ca Gle
Spinus tristis	American goldfinch*	weedy and cultivated fields, deciduous open forests, riparian woodlots	Her	Ca Gle
		conifer and mixed forests, second growth		

TABLE 3-5
BIRDS KNOWN OR EXPECTED TO OCCUR WITHIN THE VICINITY OF THE CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIMASON COUNTY, ILLINOIS

Scientific Name	Common Name	Habitat	Trophic Level[1]	Foraging Behavior[2]
Hesperiphona vespertina	evening grosbeak	woodlots and parks	Omn	Grd Gle
Passer domesticus	house sparrow*	cultivated lands, woodland and edges, generally around human habitation	Omn	Grd Gle

*Birds that nest on the Refuge.

[1] Trophic Level Codes: Her = herbivore; Det = detritivore; Omn = omnivore; Pre = predator; Ins = insectivore; Inv = invertivore. Note that "predators", "insectivores", and "invertivores" are all carnivores (consumers of other animals). Note further that the designations refer to the "typical" or predominant composition of the diet and should not be interpreted as representing the overall diets.

[2] Foraging Behavior Codes: S = soars; PSw = swoops from a perch; H = hovers; Grd = ground; Wt = Water; Ar = air; Lca = lower tree canopy; Ba = bark; Ca = tree canopy, Gle = glean, Ha = hawk; Pou = pounce; Pur = pursuit; Dvr = dive; Prb = Probe; Stk = stalk; Scr = screen; Fl = floral. Note that these foraging behaviors are "typical" and do not reflect the potential full range of possible foraging behaviors.

[3] Occurance is determined or predicted based on zoogeographic literature (Bull and Farrand 1977, Kaufman 1996) and limited site-specific observations. Primary designations relate to degree of certainty or likelihood of occurrence at the specific locations in question: No = assumed absent; Po = occurrence is possible, although location-specific confirmation is lacking; Kn = known to occur, location-specific confirmation.

Bull, J. and J. Farrand, Jr. 1977. The Audubon Society field guide to North American birds. Alfred A. Knopf, Inc., New York, NY.

Kaufman, K. 1996. Lives of North American birds. Roger Tory Peterson Institute. New York, NY.

TABLE 3-6
MAMMALS KNOWN OR EXPECTED TO OCCUR WITHIN THE VICINITY OF THE CRAB ORCHARD NATIONAL WILDLIFE REFUGE, MARION, ILLINOIS

Scientific Name	Common Name	Habitat	Foraging Behavior[2]	Guild[3]
Didelphis marsupialis	Virginia opossum	variable, but prefers woodlands	Grd/Lca Gle	Omn & Det
Sorex longirostris	southeastern shrew	found in many kinds of vegetation; prefers moist areas	Grd Amb	Ins
Blarina brevicauda	short-tailed shrew	found nearly all land habitats	Foss Gle	Omn
Cryptotis parva	least shrew	open, grassy fields	Grd Amb	Pre
Scalopus aquaticus	eastern American mole	well-drained soil in fields, meadows, pastures, and open woodlands	Foss Gle	Ins
Myotis lucifugus	little brown bat	fields, forests, wood edges or over water	Ar Scr	Ins
Myotis sodalis	Indiana bat	winter found in caves and mines; summer found in wooded and riparian areas	Ar Scr	Ins
Lasionycteris noctivagans	silver-haired bat	streams and rivers in wooded areas; mainly a tree dweller	Ar Scr	Ins
Pipistrellus subflavus	eastern pipistrelle	open woods near water; roosts in rock crevices	Ar Scr	Ins
Eptesicus fuscus	big brown bat	forest dweller, using hollow trees for roosting in warmer months and hibernating in caves in winter, also uses buildings	Ar Scr	Ins

TABLE 3-6
MAMMALS KNOWN OR EXPECTED TO OCCUR WITHIN THE VICINITY OF THE CRAB ORCHARD NATIONAL WILDLIFE REFUGE, MARION, ILLINOIS

Scientific Name	Common Name	Habitat	Foraging Behavior[2]	Guild[3]
Lasiurus borealis	red bat	wooded areas, roost in foliage or buildings	Ar Scr	Ins
Sylvilagus floridanus	eastern cottontail	fields, woodlands, swamps, prairies, hardwood forests	Grd Bro	Her
Tamias striatus	eastern American chipmunk	deciduous forests and bushy areas near broken rocky ground, stone fences, and fallen logs	Grd Gle	Omn
Marmota monax	woodchuck	pastures and forest edge	Grd Bro	Her
Sciurus carolinensis	gray squirrel	deciduous and coniferous forests	Lca/Grd Gle	Her
Sciurus niger	fox squirrel	deciduous and coniferous forests	Lca/Grd Gle	Her
Glaucomys volans	southern flying squirrel	wooded areas	Uca/Lca Gle	Omn
Castor canadensis	beaver	semiaquatic; streams and small lakes with willow, aspen, poplar, birch or alder growing near	Rip Bro	Her
Oryzomys palustris	marsh rice rat	wet swampy fields and marshes; along ditches, lowland meadows, and wet areas of woods and grass	Grd Gle	Omn
Peromyscus maniculatus	deer mouse	woodlands, grasslands, brushlands	Grd Gle	Omn
Peromyscus gossypinus	cotton mouse	bottomland hardwood forest and swamp	Grd Gle	Omn

TABLE 3-6
MAMMALS KNOWN OR EXPECTED TO OCCUR WITHIN THE VICINITY OF THE CRAB ORCHARD NATIONAL WILDLIFE REFUGE, MARION, ILLINOIS

Scientific Name	Common Name	Habitat	Foraging Behavior[2]	Guild[3]
Peromyscus leucopus	white-footed mouse	deep woodlands or brushy areas	Grd Gle	Omn
Ochrotomys nuttalli	golden mouse	brushy and wooded areas, often found in thickets of honeysuckle and greenbrier	Grd Gle	Her
Microtus ochrogaster	prairie vole	dry grasslands	Grd Bro	Her
Microtus pinetorum	pine vole	fossorial, seldom comes above ground	Foss Bro	Her
Ondatra zibethicus	muskrat	semiaquatic; marshes, lakes, ponds, rivers, and sloughs	Rip Gle	Omn
Zapus hudsonius	meadow jumping mouse	wooded areas and grassy fields, common in thick vegetation bordering streams, ponds or marshes	Grd Gle	Omn
Rattus norvegicus	Norway rat	buildings, grain bins, and cultivated fields	Grd Gle	Omn
Mus musculus	house mouse	buildings and fields	Grd Gle	Omn
Vulpes vulpes	red fox	deep forest to open prairie and farmland, prefers areas of highly diverse vegetation	Grd Amb-Pou	Omn
Urocyon cinereoargenteus	gray fox	wooded and brushy country	Grd Amb-pou	Omn
Canis latrans	coyote	open grassland, brush country and	Grd Amb-	Pre

TABLE 3-6
MAMMALS KNOWN OR EXPECTED TO OCCUR WITHIN THE VICINITY OF THE CRAB ORCHARD NATIONAL WILDLIFE REFUGE, MARION, ILLINOIS

Scientific Name	Common Name	Habitat	Foraging Behavior[2]	Guild[3]
		broken forests	Pou	
Procyon lotor	raccoon	timbered and brushy areas near water	Rip Gle	Omn
Mustela frenata	long-tailed weasel	open, brushy or grassy areas near water	Grd Pur	Pre
Mustela vison	American mink	densely vegetated areas along streams, lakes, swamps and marshes	Grd Pur	Pre
Mephitis mephitis	striped skunk	woods and grasslands	Grd Gle	Omn
Felis rufus	bobcat	forests, mountainous areas, and brushlands	Grd Pou-Pur	Pre
Odocoileus virginianus	white-tailed deer	low mixed woodlands, forest edges, and second growth	Grd/Lca Bro	Her

[1] Occurance is determined or predicted based on zoogeographic literature (critter lit.) and limited site-specific observations. Primary designations relate to degree of certainty or likelihood of occurrence at the specific locations in question: No = assumed absent; Un = occurrence highly unlikely; Po = occurrence is possible, although location-specific confirmation is lacking; Kn = known to occur; location-specific confirmation.

[2] Her = herbivore; Det = detritivore; Omn = omnivore; Gen = generalist; Pre = predator; Ins = insectivore; Inv = invertivore. Note that "predators", "insectivores", and "invertivores" are all carnivores (consumers of other animals). Note further that the designations refer to the "typical" or predominant composition of the diet and should not be interpreted as representing the overall diets.

[3]Ar = Air; Grd = ground; Foss = fossorial; Rip = riparian; Lca = lower canopy; Uca = upper canopy; Amb = ambush; Gle = glean; Bro = browse; Scr = screen; Pou = pounce; Pur = pursuit. Not that these foraging behaviors are "typical" and do not reflect the potential full range of possible foraging behaviors.

Table 3-7
Federally Listed and State of Illinois Listed Threatened or Endangered Species Potentially Found on Crab Orchard National Wildlife Refuge, Williamson County, Illinois

Common Name	Scientific Name	State/Federally Listed	Habitat
Little blue heron	*Egretta caerulea*	E[1]	Little blue herons use stands of young trees, forming dense thickets; feeding takes place in shallow waters of lagoons, marshes and swampy areas
Great egret	*Ardea alba*	E	Great egret rookeries are shared with great blue herons and occasionally other herons in floodplain forests; foraging occurs in floodplain lagoons of major rivers
Snowy egret	*Egretta thula*	E	Snowy egrets use lowland thickets or forest for nesting; foraging is generally restricted to floodplain lagoons of rivers and marshes
Black-crowned night heron	*Nycticorax nycticorax*	E	Black-crowned night herons use bottomland forests
Upland sandpiper	*Bartramia longicauda*	E	Upland sandpipers use prairies, pastureland and hayfields with an average grass height less than 30 cm
Sharp-shinned hawk	*Accipiter striatus*	E	Sharp-shinned hawks use deciduous and coniferous forests and open woodlands
American bittern	*Botaurus lentiginosus*	E	The American bittern is found in freshwater marshes and marshy, lake shores
Least bittern	*Ixobrychus exilis*	E	Least bitterns use shallow freshwater lakes and marshes with tall dense vegetation for nesting
Double-crested cormorant	*Phalacrocorax auritus*	T	Double-crested cormorants are found near lakes, rivers, swamps and coasts
Osprey	*Pandion haliaetus*	E	Ospreys are found near lakes, rivers, and seacoasts
Cooper's hawk	*Accipiter cooperii*	E	The Cooper's hawk uses mature

separate whether state or federal

Table 3-7
Federally Listed and State of Illinois Listed Threatened or Endangered Species Potentially Found on Crab Orchard National Wildlife Refuge, Williamson County, Illinois

Common Name	Scientific Name	State/Federally Listed	Habitat
			deciduous forests, open woodlands and forest edges
Northern harrier	*Circus cyaneus*	E	Northern harries occur in large undisturbed grasslands and marshes
Red-shouldered hawk	*Buteo lineatus*	E	The red-shouldered hawk is found in moist and riparian forests including wooded swamps
Bald eagle	*Haliaeetus leucocephalus*	E/T	Bald eagles are found within undisturbed areas near large rivers and lakes
Barn owl	*Tyto alba*	E	Barn-owls occur in open to partly open areas often near human habituation
Brown creeper	*Certhia americana*	T	The brown creeper uses deciduous and mixed woodlands, with cypress swamps and floodplain forests
Bewick's wren	*Thryomanes bewickii*	E	The Bewick's wren uses thickets, brushy areas, hedgerows in farming country, and open and riparian woodlands
Bachman's sparrow	*Aimophila aestivalis*	E	Bachman's sparrows occur in open oak woods with adjoining grass; also neglected fields with old dead trees
Golden mouse	*Ochrotomys nuttalli*	T	Golden mice use dense thickets in a variety of wooded habitats including bottomland hardwood forests, pines, drainage-ways, abandoned upland fields, roadside right-of-ways, and successional sites dominated by cedar. This species appears to be dependent on the presence of a dense understory including honeysuckle, catbrier, and grape.
Marsh rice rat	*Oryzomys palustris*	T	Marsh rice rats use wet swampy fields and marshes in areas of the Shawnee Hills or Ozark Uplift. They have been found along drainage ditches, farm

Table 3-7
Federally Listed and State of Illinois Listed Threatened or Endangered Species Potentially Found on Crab Orchard National Wildlife Refuge, Williamson County, Illinois

Common Name	Scientific Name	State/Federally Listed	Habitat
			ponds, marshy railroad right-of-ways, cypress swamps, lowland meadows, and wet areas of woods and grass
Bobcat	*Lynx rufus*	T	Bobcats use heavily wooded areas near rocky outcrops, brushy hollows, and timbered swamps
Indiana bat	*Myotis sodalis*	E/E	The Indiana bat's winter habitat includes caves and mines; summer habitat includes a variety of wooded and riparian settings
Pallid shiner	*Notropis amnis*	E	The pallid shiner is found in pools with negligible current in medium to large rivers having clear water and a sand-silt substrate
Least brook lamprey	*Lampetra aepyptera*	T	The adult least brook lamprey is found in clean, clear, gravelly riffles, runs of creeks and small rivers; the larval stage occurs in spring-fed wetlands, quiet pools and backwaters of small sand or mud bottom streams
Indiana crayfish	*Orconectes indianensis*	E	Indiana crayfish use rocky riffles and pools of small to medium-sized streams in the southern part of the state
Timber rattlesnake	*Crotalus horridus*	T	Timber rattlesnakes use forested areas with bluffs and rock outcrops, and occasionally upland forests or crop fields
Bellow's beak sedge	*Carex physorhyncha*	E	The bellow's beak sedge occurs in sand or chert outcrops in forests in the Ozark Natural Division of southwestern Illinois
Bent sedge	*Carex styloflexa*	E	The bent sedge occurs in mesic floodplain forests
Eryngo	*Eryngium prostratum*	E	The eryngo occurs in muddy and sandy shores
Turk's cap lily	*Lilium superbum*	E	Turk's-cap lilies occur in mesic woods

Table 3-7
Federally Listed and State of Illinois Listed Threatened or Endangered Species Potentially Found on Crab Orchard National Wildlife Refuge, Williamson County, Illinois

Common Name	Scientific Name	State/Federally Listed	Habitat
			and stream banks
Bead grass	*Paspalum dissectum*	E	The bead grass is found in disturbed sites and shallow water
Hairy synandra	*Synandra hispidula*	E	The hairy synandra occurs in rich mesic forests
Climbing milkweed	*Matelea decipiens*	E	Climbing milkweed occurs in floodplain forests
Spring ladies' tresses	*Spiranthes vernalis*	E	The spring ladies' tresses occur in acidic soils in prairies and old fields
Green trillium	*Trillium vifide*	T	In southern Illinois, green trilliums occur in forested bottomlands, talus slopes, blufftops, and prairies

[1]E=endangered, T=threatened.

From:
Illinois Department of Natural Resources, Office of Resource Conservation, Division of Natural History, 1998, Habitat Database for State Listed Endangered and Threatened Species of Illinois.

Illinois Department of Natural Resources, Office of Resource Conservation, Division of Natural History, 1998, List of Endangered and Threatened Species by County; Williamson County, Illinois.

Illinois Endangered Species Protection Board, 1991, Endangered and Threatened Species of Illinois: Status and Distribution, Volume I-Plants, Volume II-Animals, Williamson County.

Illinois Endangered Species Protection Board, 1994, Checklist of Endangered and Threatened Animals and Plants of Illinois.

TABLE 3-8
SUMMARY OF CANDIDATE RECEPTORS AND SITE APPLICABILITY
ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNIT
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Habitat Type	Urban grassland with treelines, brush or stands[a]	Successional woodland[b]	Agriculture field/pasture or old field[b]	Woodland/field mix[b]	Aquatic
Areas	2B, 2D, 2F, 2P, 4 West, 7, 9	AUS 0065, AUS 0066, AUS 0067, AUS 0069, 0001, 0002, 0018, 0021, 0060, 0061, 106A, 0108	2, 6, 8 South, 10, 11, 12, 13, AUS 0062, AUS 0063, AUS 0109	0002, 0108	11, 12, AUS 0002, 8 South, 13, 9
DIRECT EXPOSURES					
Decomposers and detritivores	not applicable	✓	✓	✓	✓
Primary producers	not applicable	✓	✓	✓	✓
Soil Invertebrates	not applicable	✓	✓	✓	not applicable
Sediment Invertebrates	not applicable	not applicable	not applicable	not applicable	✓
fish/ larval amphibians	not applicable	not applicable	not applicable	not applicable	✓
INGESTION PATHWAY EXPOSURES					
Herbivores					
birds	Canada goose	Brown-headed cowbird	Canada goose American goldfinch	American goldfinch	red-winged blackbird
mammals	white-tailed deer	white-tailed deer, white-footed mouse	white-tailed deer, white-footed mouse	white-tailed deer, white-footed mouse	muskrat
Invertebrate consumers					
birds	American robin	American woodcock American kestrel	American kestrel	American kestrel	tree swallow
mammals	little brown bat	short-tailed shrew	short-tailed shrew	short-tailed shrew	little brown bat
Higher trophic level consumers					
birds	red-tailed hawk	red-tailed hawk	red-tailed hawk	red-tailed hawk	great blue heron
mammals	coyote	coyote	coyote	coyote	mink

Not going to have tox data for cowbird, goose finch : rwb

why model each?

1) Ign: home range

2) Not as sensitive to cont.

What is basis of tox data?

feeding on the wing. ∴ you have conversion from larval to adult stages

how is conver. of dose handled?

What does the / mean?

TABLE 3-9
MEASURES OF RECEPTOR CHARACTERISTICS
ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNIT
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Candidate Receptors	Body wt-kg	Food kg/day	Water L/day	Area use - acres	Soil Ingestion kg/day	Sediment Ingestion kg/day	Plant Foliage	Plant Roots	Plant Seeds or Nuts	Plant Fruits and Berries	Emergent Aquatic Plants
American Goldfinch	0.012	0.003	0.003	0.14	0.0%				98.0%		
American Kestrel	0.116	1.07E-02	1.40E-02	32.4	1.0%						
American Robin	0.0773	0.011	0.0106	1.19	6.0%						
American Woodcock	0.176	0.019	0.018	2.8	10.4%						
Brownheaded Cowbird	0.0439	9.90E-03	7.00E-03	20	0.0%				96.0%		
Canada Goose (aquatic)	3.881	1.18E-01	6.87E-01	717		8.2%					98.0%
Canada Goose (terrestrial)	3.881	1.18E-01	6.87E-01	717	8.2%		98%				98.0%
Great Blue Heron	2.229	4.01E-01	1.00E-01	19		2.0%					
Red-tailed Hawk	1.126	0.108	0.0639	1596	2.0%						
Red-winged Blackbird											
Tree Swallow	0.016	4.20E-03	4.00E-03	776		0.0%					
Coyote	9.1	0.422	0.722	3635	2.0%						
Little Brown Bat	0.0075	0.0025	0.0012	245	0.0%						
Mink	1	0.137	0.099	575		1.3%					
Muskrat	0.73	0.07	0.075	0.37		10.0%					90.0%
Short-tailed Shrew	0.015	0.008	0.003	0.96	10.0%			5.0%	2.5%	2.5%	
White-footed Mouse	0.027	0.004	0.004	0.27	2.0%		15.0%		70.0%	5.0%	
White-tailed deer	45.3	1.74E+00	3.06E+00	40	2.0%		95.0%		5.0%		

Sources for each value?

TABLE 3-9
MEASURES OF RECEPTOR CHARACTERISTICS
ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNIT
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Candidate Receptors	Aquatic Benthic Invertebrates	Fish	Soil Invertebrates	Herbivores Invertebrates	Carnivorous Invertebrates	Upland Herbivorous Vertebrates	Upland Omnivorous Vertebrates	Upland Insectivorous Vertebrates	Semi-Aquatic Herbivorous Vertebrates	Semi-Aquatic Omnivorous Vertebrates
American Goldfinch				2.0%						
American Kestrel			10.0%	30.0%	20.0%	40.0%				
American Robin			80.0%	10.0%	10.0%					
American Woodcock			90.0%	10.0%						
Brownheaded Cowbird			2.0%	2.0%						
Canada Goose (aquatic)	2.0%									
Canada Goose (terrestrial)			2.0%							
Great Blue Heron	40.0%								7.5%	7.5%
Red-tailed Hawk						70.0%	15.0%	15.0%		
Red-winged Blackbird										
Tree Swallow	100.0%									
Coyote			1.0%	2.0%	2.0%	80.0%	10.0%	5.0%		
Little Brown Bat				50.0%	50.0%					
Mink	35.0%								10.0%	10.0%
Muskrat	10.0%									
Short-tailed Shrew			65.0%	10.0%	10.0%	5.0%				
White-footed Mouse			3.0%	5.0%	2.0%					
White-tailed deer										

Nowak, R.M. 1991. Walker's Mammals of the World: Fifth Edition. Volumes I and II. The John Hopkins University Press, Baltimore, MD.

USEPA. 1993a. Wildlife Exposure Factors Handbook. United States Environmental Protection Agency, Office of Research and Development. Washington, D.C. EPA/600/R-93/187a&b (Volumes I and II).

DeGraaf, R.M., and D.D. Rudis. 1986. New England Wildlife: Habitat, Natural History, and Distribution. U.S. Department of Agriculture, Forest Service, Northeastern Forest Experimental Station. General Technical Report NE-108.

TABLE 3-9
MEASURES OF RECEPTOR CHARACTERISTICS
ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNIT
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Candidate Receptors	Semi-Aquatic Insectivorous Vertebrates
American Goldfinch	
American Kestrel	
American Robin	
American Woodcock	
Brownheaded Cowbird	
Canada Goose (aquatic)	
Canada Goose (terrestrial)	
Great Blue Heron	45.0%
Red-tailed Hawk	
Red-winged Blackbird	
Tree Swallow	
Coyote	
Little Brown Bat	
Mink	45.0%
Muskrat	
Short-tailed Shrew	
White-footed Mouse	
White-tailed deer	

TABLE 3-10
ECOTOXICOLOGICAL SCREENING VALUES FOR DIRECT EXPOSURES TO SOIL
ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNIT
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Background	Worms (NOEC)[c]	Worms (EC50)[c]	Micro-organisms (NOEC)[d]	Micro-organisms (EC50)[d]	Soil Phytotoxicity (NOEC)[e]	Soil Phytotoxicity (LOEC)[e]	Soil Phytotoxicity (EC50)[e]	CCME RC[e]	RIVM EIV	Seed Emergence NOEC	Seed Emergence LOEC	Worm Survival NOEC	Worm Survival LOEC	EPA Region 4 Screening value	EPA Region 3 SL Flora	EPA Region 3 SL Fauna	USFWS	Netherlands Limit Values	Screening TRV Selected
Halogenated Methanes/Alkanes (mg/kg)																				
Bis(2-chloroethoxy) methane																				NA
Bromodichloromethane																				NA
Bromoform																				NA
Bromomethane																				NA
Carbon tetrachloride (Tetrachloromethane)				0.001											<0.3	<0.3				0.001
Chloroform (Trichloromethane)															<0.3	<0.3				0.3
Chloromethane																				NA
Dibromochloromethane																450				450
Methylene chloride															<0.3	<0.3				0.3
Halogenated Ethanes (mg/kg)																				
1,1-Dichloroethane															<0.3	<0.3				0.3
1,1,1-Trichloroethane																				NA
1,1,2-Trichloroethane																				NA
1,1,2,2-Tetrachloroethane																				NA
1,2-Dichloroethane																870				870
Chloroethane																				NA
Hexachloroethane																				NA
Halogenated Propanes (mg/kg)																				
1,2-Dichloropropane		700													<0.3	<0.3				700
2,2'-Oxybis (1-chloropropane)																				NA
Halogenated Alkenes (mg/kg)																				
1,1-Dichloroethene																				NA
1,2-Dichloroethene (total)																				NA
1,2-Dichloroethene (cis)															<0.3	<0.3				0.3
1,2-Dichloroethene (trans)															<0.3	<0.3				0.3
1,3-Dichloropropene (total)																				NA
1,3-Dichloropropene (cis)																				NA
1,3-Dichloropropene (trans)																				NA
Tetrachloroethene										13	28	84	165		<0.3	<0.3			0.01	13
Trichloroethene										9	16	60	159		<0.3	<0.3			0.001	9
Vinyl chloride															0.3	0.3				0.3
Amines (mg/kg)																				
2-Nitroaniline																				NA
3-Nitroaniline																				NA

TAI]-10
ECOTOXICOLOGICAL SCREENING VA..ES FOR DIRECT EXPOSURES TO SOIL
ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNIT
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Background	Worms (NOEC)[c]	Worms (EC50)[c]	Micro-organisms (NOEC)[d]	Micro-organisms (EC50)[d]	Soil Phytotoxicity (NOEC)[e]	Soil Phytotoxicity (LOEC)[e]	Soil Phytotoxicity (EC50)[e]	CCME RC[a]	RIVM EIV	Seed Emergence NOEC	Seed Emergence LOEC	Worm Survival NOEC	Worm Survival LOEC	EPA Region 4 Screening value	EPA Region 3 SL Flora	EPA Region 3 SL Fauna	USFWS	Netherlands Limit Values	Screening TRV Selected
3,3'-Dichlorobenzidine																				NA
4-Chloroaniline																				NA
4-Nitroaniline																				NA
4,4'-Methylenebis (2-chlorobenzenamine)-MOCA																				NA
N-Nitrosodiphenylamine		20																		20
N-Nitroso-di-n-propylamine																				NA
Benzene and Derivatives (mg/kg)																				
Benzene										16	31	133	266		0.1	0.1	0.5			16
Chlorobenzene		40							30							0.1	2	0.1		40
1,2-Dichlorobenzene															<0.1	<0.1				0.1
1,2,4-Trichlorobenzene		20							30									0.05		20
1,3-Dichlorobenzene																				NA
1,4-Dichlorobenzene		20							30						<0.1	<0.1		0.1		20
Hexachlorobenzene				1000					30									0.05		30
Methylated Benzenes (mg/kg)																				
Toluene						200			130	<3	3	34	71		0.1	0.1	3	0.1		3
Xylenes (total)										0.6	19	33	124		<0.1	<0.1	5			0.6
Other Substituted Benzenes (mg/kg)																				
Ethylbenzene										5	9	73	192		0.1	0.1	5			5
Styrene						300									0.1	0.1	5	0.1		300
Nitrobenzene		40		1000																40
Arenes (mg/kg)																				
2,4-Dinitrotolune																				NA
2,6-Dinitrotolune																				NA
Chlorinated Dienes (mg/kg)																				
Hexachlorobutadiene																				NA
Hexachlorocyclopentadiene						10														10
Ethers (mg/kg)																				
4-Bromophenyl phenyl ether																				NA
4-Chlorophenyl phenyl ether																				NA
Bis (2-chloroethyl) ether																				NA
Phenols and Substituted Phenols (mg/kg)																				
2-Chlorophenol									10						0.1	0.1		0.05		10
2-Methylphenol															0.1	0.1				NA
2-Nitrophenol																				NA
2,4-Dichlorophenol									10						0.1	0.1		0.05		10
2,4-Dimethylphenol															0.1	0.1				0.1

TABLE 3-10
ECOTOXICOLOGICAL SCREENING VALUES FOR DIRECT EXPOSURES TO SOIL
ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNIT
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Background	Worms (NOEC)[c]	Worms (EC50)[c]	Micro-organisms (NOEC)[d]	Micro-organisms (EC50)[d]	Soil Phytotoxicity (NOEC)[e]	Soil Phytotoxicity (LOEC)[e]	Soil Phytotoxicity (EC50)[e]	CCME RC[e]	RIVM EIV	Seed Emergence NOEC	Seed Emergence LOEC	Worm Survival NOEC	Worm Survival LOEC	EPA Region 4 Screening value	EPA Region 3 SL Flora	EPA Region 3 SL Fauna	USFWS	Netherlands Limit Values	Screening TRV Selected
2,4-Dinitrophenol						20			10									0.05		20
2,4,5-Trichlorophenol		9				4			10						0.1	0.1		0.05		4
2,4,6-Trichlorophenol		10							10						0.1	0.1		0.05		10
4-Chloro-3-methylphenol																				NA
4-Methylphenol															0.1	0.1				0.1
4-Nitrophenol		7													0.1	0.1		0.01		7
4,6-Dinitro-2-Methylphenol																				NA
Pentachlorophenol		6		400		3			5	6	11	17	30		0.1	0.1		0.05		3
Phenol		30		100		70			40	40	79	160	320		0.1	0.1	1	0.01		70
Ketones (Carbonyl Compounds) (mg/kg)																				
2-Butanone																				NA
2-Hexanone																				NA
4-Methyl-2-pentanone (MIBK)																100				100
Acetone																				NA
Isophorone																				NA
Low Molecular Weight PAHs (mg/kg)																				
2-Chloronaphthalene																				NA
2-Methylnaphthalene																				NA
Acenaphthene						20									0.1	0.1				20
Acenaphthylene															0.1	0.1				0.1
Anthracene															0.1	0.1	10		0.05	10
Carbazole																				NA
Dibenzofuran																				NA
Fluorene		30													0.1	0.1				30
Naphthalene										430	850	249	498		0.1	0.1	5		0.015	430
Phenanthrene															0.1	0.1	5		0.05	5
High Molecular Weight PAHs (mg/kg)																				
Benzo(a)anthracene															0.1	0.1			0.05	0.1
Benzo(a)pyrene										4400	8800	26000	>26000		0.1	0.1	1		0.05	4400
Benzo(ghi)perylene															0.1	0.1			0.05	0.1
Benzo(b,k)fluoranthene															0.1	0.1			0.2	0.1
Chrysene															0.1	0.1			0.05	0.1
Dibenzo(a,h)anthracene															0.1	0.1			0.05	0.1
Fluoranthene															0.1	0.1	10		0.3	10
Indeno(1,2,3-cd)pyrene															0.1	0.1			0.05	0.1
Pyrene																0.1	10		0.05	10
Pathalates (mg/kg)																				
Bis (2-ethylhexyl) phthalate																				NA
Butylbenzylphthalate																				NA
Diethyl phthalate						100														100

TAI 3-10
ECOTOXICOLOGICAL SCREENING VALUES FOR DIRECT EXPOSURES TO SOIL
ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNIT
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Background	Worms (NOEC)[c]	Worms (EC50)[c]	Micro-organisms (NOEC)[d]	Micro-organisms (EC50)[d]	Soil Phytotoxicity (NOEC)[e]	Soil Phytotoxicity (LOEC)[e]	Soil Phytotoxicity (EC50)[e]	CCME RC[e]	RIVM EIV	Seed Emergence NOEC	Seed Emergence LOEC	Worm Survival NOEC	Worm Survival LOEC	EPA Region 4 Screening value	EPA Region 3 SL Flora	EPA Region 3 SL Fauna	USFWS	Netherlands Limit Values	Screening TRV Selected
Dimethyl phthalate		200																		200
Di-n-butyl phthalate						200														200
Di-n-octyl phthalate																				NA
Miscellaneous Solvents (mg/kg)																				
Carbon disulfide																				NA
Pesticides (mg/kg)																				
4,4'-DDD															<0.1	<0.1				0.1
4,4'-DDE															<0.1	<0.1				0.1
4,4'-DDT																				NA
DDT (Total)																				NA
Aldrin															<0.1	<0.1				0.1
a-BHC																				NA
b-BHC																				NA
d-BHC																				NA
g-BHC (Lindane)		29													<0.1	<0.1			0.001	29
a-Chlordane															<0.1	<0.1				0.1
g-Chlordane																				NA
Chlordane (Technical)																			0.02	0.02
Dieldrin				57											<0.1	<0.1			0.02	56
Endosufan I																				NA
Endosufan II																				NA
Endosufan																				NA
Endosulfan sufate																			0.01	0.01
Endrin															<0.1	<0.1			0.04	0.1
Endrin aldehyde																				NA
Endrin ketone																				NA
Heptachlor																				NA
Heptachlor epoxide															<0.1	<0.1			0.02	0.1
Isodrin																				NA
Methoxychlor															<0.1	<0.1				0.1
Toxaphene																				NA
PCBs (mg/kg)																				
Aroclor 1016																				NA
Aroclor 1221																				NA
Aroclor 1248																				NA
Aroclor 1254																				NA
Aroclor 1260															0.1					0.1
Explosives (mg/kg)																				
1,3-Dinitrobenzene (DNB)																				NA
1,3,5-Trinitrobenzene (TNB)																				NA

TABLE 3-10
ECOTOXICOLOGICAL SCREENING VALUES FOR DIRECT EXPOSURES TO SOIL
ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNIT
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Background	Worms (NOEC)[c]	Worms (EC50)[c]	Micro-organisms (NOEC)[d]	Micro-organisms (EC50)[d]	Soil Phytotoxicity (NOEC)[e]	Soil Phytotoxicity (LOEC)[e]	Soil Phytotoxicity (EC50)[e]	CCME RC[e]	RIVM EIV	Seed Emergence NOEC	Seed Emergence LOEC	Worm Survival NOEC	Worm Survival LOEC	EPA Region 4 Screening value	EPA Region 3 SL Flora	EPA Region 3 SL Fauna	USFWS	Netherlands Limit Values	Screening TRV Selected
2-Amino-4,6-Dinitrotoluene (2-ADNT)										80										80
2-Nitrotoluene (ONT)																				NA
2,4,6-Trinitrotolune (TNT)						10	60			80		110								10
3-Nitrotoluene																				NA
4-Amino-2,6-Dinitrotoluene																				NA
4-Nitrotoluene (PNT)																				NA
Cyclonite (RDX)							100													100
Cyclotetramethylenetetranitramine (HMX)																				NA
Nitroglycerin (NG)																				NA
Pentaerythritol tetranitrate (PETN)																				NA
Tetryl							25													25
Dioxins/Furans (mg/kg)																				
2,3,7,8-TCDD		5	10																	5
***Total Petroleum Hydrocarbons* (mg/kg)**																				
TPH-Gasoline range organics																				NA
TPH-Diesel range organics																				NA
Metals (mg/kg)																				
Aluminum	30071			600		50									1					30071
Antimony	ND					5												20		5
Arsenic	19.4	60		100		10			40	9	13	83	163		328		30	12	55	19.4
Barium	163			3000					625						440	440	400	750		625
Beryllium	1.02					10									0.02			4		10
Cadmium	1.4	20		20	433	4		44	12	44	102	433	1033		2.5		5	3	2	12
Calcium																				NA
Chromium (Total)	35.1								230	56	107	323	677		0.02	0.0075	250	750	380	56
Chromium VI		0.4		10		1				117	243	900	1733							1
Cobalt	16.3			1000		20			240						100	200	50	40		20
Copper	16	60		100	428	100			190	31	60	210	447		15		100	150	36	31
Iron															3260	12				12
Lead	17.6	500		900		50			290	433	833	1433	2967		2	0.01	150	375	530	500
Magnesium															4400	4400				4400
Manganese	5884														330	330				5884
Mercury	ND	0.1		30	36	0.3			10	7	12	96	194		0.058	0.058	2	0.8	0.5	7
Nickel	22	200		90	922	30			210						2		100	150	35	200
Potassium																				NA
Selenium	0.6	70		100		1									1.8	1.8		2		70
Silver	0.27			50		2												20		2
Sodium																				NA

TAI)-10
ECOTOXICOLOGICAL SCREENING VALUES FOR DIRECT EXPOSURES TO SOIL
ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNIT
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Background	Worms (NOEC)[c]	Worms (EC50)[c]	Micro-organisms (NOEC)[d]	Micro-organisms (EC50)[d]	Soil Phytotoxicity (NOEC)[e]	Soil Phytotoxicity (LOEC)[e]	Soil Phytotoxicity (EC50)[e]	CCME RC[e]	RIVM EIV	Seed Emergence NOEC	Seed Emergence LOEC	Worm Survival NOEC	Worm Survival LOEC	EPA Region 4 Screening value	EPA Region 3 SL Flora	EPA Region 3 SL Fauna	USFWS	Netherlands Limit Values	Screening TRV Selected
Thallium	0.36			1000		1									0.001			1		1
Vanadium	79.4			20		2				46	127	207	417		0.5	58		200		46
Zinc	79.1	100		100	1010.33	50			720	153	310	400	833		0.11	10	500	600	480	153
Total Cyanide										0.9	1.8	12	23			>0.005	50			0.9

NA - Screening concentration not available

NOEC - No Observed Effect Concentration

LOEC - Lowest Observed Effect Concentration

CCMR RC

RIVM EIV

TABLE 3-11
ECOTOXICOLOGICAL SCREENING VALUES FOR DIRECT EXPOSURES TO SEDIMENTS
ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNITCRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Background (Illinois EPA 1996)	Background (NOAA 1999)	Threshold / Lowest Effect Level						Effects - Range Low				Effects - Range Median		Apparent Effect Level			Probable / Severe Effect Level						EPA Region 4 Screening value	Netherlands Limit Values	Equilibrium Partitioning ESV	Screening TRV Selected
			Consensus-Based (MacDonald, et.al. 1999)	Ingersoll et.al. (1996)	NOAA (1999)	Ontario (1995)	Florida DEP (1994)	ORNL (1997)	Ingersoll et.al. (1996)	EPA ECOTOX(1996)	Long et.al. (1995)	EPA Region 3 BTAG (1995)	Ingersoll et.al. (1996)	Long et.al. (1995)	Ingersoll et.al. (1996)	NOAA (1999)	EPA Region 3 BTAG (1995)	Ingersoll et.al. (1996)	NOAA (1999)	Ontario (1995)	Florida DEP (1994)	ORNL (1997)	Consensus-Based (MacDonald, et.al. 1999)				
Halogenated Methanes/Alkanes (mg/kg)																											
Bis(2-chloroethoxy) methane																											NA
Bromodichloromethane																										17.5	17.5
Bromoform																										1.2	1.2
Bromomethane																										10.5	10.5
Carbon tetrachloride (Tetrachloromethane)																										0.007	0.0
Chloroform (Trichloromethane)																										0.010	0.0
Chloromethane																										47.8	47.8
Dibromochloromethane																										30.8	30.8
Methylene chloride																										0.92	0.9
Halogenated Ethanes (mg/kg)																											
1,1-Dichloroethane																										0.020	0.020
1,1,1-Trichloroethane										0.17																0.002	0.17
1,1,2-Trichloroethane																										1.06	1.1
1,1,2,2-Tetrachloroethane										0.94																0.19	0.94
1,2-Dichloroethane																										0.30	0.30
Chloroethane																										14.5	14.5
Hexachloroethane																										0.068	0.068
Halogenated Propanes (mg/kg)																											
1,2-Dichloropropane																										0.25	0.25
2,2'-Oxybis (1-chloropropane)																											NA
Halogenated Alkenes (mg/kg)																											
1,1-Dichloroethene																										0.038	0.038
1,2-Dichloroethene (total)																										0.25	0.25
1,2-Dichloroethene (cis)																										0.29	0.29
1,2-Dichloroethene (trans)																										0.21	0.21
1,3-Dichloropropene (total)																											0.0002475
1,3-Dichloropropene (cis)																										0.0002475	0.0002475
1,3-Dichloropropene (trans)																										0.049	0.049
Tetrachloroethene										0.53						0.057								0.01	0.53	0.53
Trichloroethene										1.6														0.001	0.002	1.6
Vinyl chloride																									10.22	10.22
Amines (mg/kg)																											
2-Nitroaniline																									12.25996	12.25996
3-Nitroaniline																									59.51	59.51
3,3'-Dichlorobenzidine																									0.0038	0.0038
4-Chloroaniline																									5.27	5.27
4-Nitroaniline																									36.2	36.2

TABLE 3-11
ECOTOXICOLOGICAL SCREENING VALUES FOR DIRECT EXPOSURES TO SEDIMENTS
ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNITCRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Background (Illinois EPA 1996)	Background (NOAA 1999)	Threshold / Lowest Effect Level						Effects - Range Low				Effects - Range Median		Apparent Effect Level			Probable / Severe Effect Level						EPA Region 4 Screening value	Netherlands Limit Values	Equilibrium Partitioning ESV	Screening TRV Selected
			Consensus-Based (MacDonald, et.al. 1999)	Ingersoll et.al. (1996)	NOAA (1999)	Ontario (1995)	Florida DEP (1994)	ORNL (1997)	Ingersoll et.al. (1996)	EPA ECOTOX(1996)	Long et.al. (1995)	EPA Region 3 BTAG (1995)	Ingersoll et.al. (1996)	Long et.al. (1995)	Ingersoll et.al. (1996)	NOAA (1999)	EPA Region 3 BTAG (1995)	Ingersoll et.al. (1996)	NOAA (1999)	Ontario (1995)	Florida DEP (1994)	ORNL (1997)	Consensus-Based (MacDonald, et.al. 1999)				
4,4'-Methylenebis (2-chlorobenzenamine)-MOCA																											NA
N-Nitrosodiphenylamine																	0.028									0.67	0.03
N-Nitroso-di-n-propylamine																											NA
Benzene and Derivatives (mg/kg)																											
Benzene										0.057																0.031	0.057
Chlorobenzene																										0.019	0.019
1,2-Dichlorobenzene																	0.035									0.227	0.035
1,2,4-Trichlorobenzene										9.2																0.634	9.2
1,3-Dichlorobenzene																										0.151	0.151
1,4-Dichlorobenzene																	0.11									0.213	0.110
Hexachlorobenzene						0.02										0.1	0.022			0.24						1.31	0.02
Methylated Benzenes (mg/kg)																											
Toluene										0.67																0.073	0.67
Xylenes (total)										0.025							0.04									0.002	0.025
Other Substituted Benzenes (mg/kg)																											
Ethylbenzene																	0.01									0.064	0.010
Styrene																										21.6	21.6
Nitrobenzene																										0.59	0.59
Arenes (mg/kg)																											
2,4-Dinitrotolune																										0.65	0.65
2,6-Dinitrotolune																											NA
Chlorinated Dienes (mg/kg)																											
Hexachlorobutadiene																	0.011									0.048	0.011
Hexachlorocyclopentadiene																										0.003	0.003
Ethers (mg/kg)																											
4-Bromophenyl phenyl ether																										0.23	0.23
4-Chlorophenyl phenyl ether																										1.37	1.37
Bis (2-chloroethyl) ether																										1.81	1.81
Phenols and Substituted Phenols (mg/kg)																											
2-Chlorophenol																										0.14	0.14
2-Methylphenol																	0.063									0.0046	0.0630
2-Nitrophenol																										3.18	3.18
2,4-Dichlorophenol																										0.33	0.33
2,4-Dimethylphenol																	0.029									0.045	0.029
2,4-Dinitrophenol																										0.012	0.012
2,4,5-Trichlorophenol																										1.41	1.41
2,4,6-Trichlorophenol																										0.018	0.018

TABLE 3-11
ECOTOXICOLOGICAL SCREENING VALUES FOR DIRECT EXPOSURES TO SEDIMENTS
ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNITCRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Background (Illinois EPA 1996)	Background (NOAA 1999)	Threshold / Lowest Effect Level						Effects - Range Low				Effects - Range Median		Apparent Effect Level			Probable / Severe Effect Level						EPA Region 4 Screening value	Netherlands Limit Values	Equilibrium Partitioning ESV	Screening TRV Selected
			Consensus-Based (MacDonald, et.al. 1999)	Ingersoll et.al. (1996)	NOAA (1999)	Ontario (1995)	Florida DEP (1994)	ORNL (1997)	Ingersoll et.al. (1996)	EPA ECOTOX(1996)	Long et.al. (1995)	EPA Region 3 BTAG (1995)	Ingersoll et.al. (1996)	Long et.al. (1995)	Ingersoll et.al. (1996)	NOAA (1999)	EPA Region 3 BTAG (1995)	Ingersoll et.al. (1996)	NOAA (1999)	Ontario (1995)	Florida DEP (1994)	ORNL (1997)	Consensus-Based (MacDonald, et.al. 1999)				
4-Chloro-3-methylphenol																										0.0002	0.0002
4-Methylphenol																	0.67									4.00	0.67
4-Nitrophenol																										0.041	0.041
4,6-Dinitro-2-Methylphenol																										0.008	0.008
Pentachlorophenol																	0.36									0.064	0.360
Phenol																0.048	0.42									0.0004	0.0480
Ketones (Carbonyl Compounds) (mg/kg)																											
2-Butanone																										4.40	4.40
2-Hexanone																										0.122	0.122
4-Methyl-2-pentanone (MIBK)																										0.209	0.209
Acetone																										0.249	0.249
Isophorone																										1.146	1.146
Total Polynuclear Aromatic Hydrocarbons (PAHs) (mg/kg)						4	1.684	3.553			4.022			44.8						100	16.77	13.66					4
Low Molecular Weight PAHs (mg/kg)				0.076			0.312	0.786	0.08		0.552		0.65	3.16	29			1.2			1.442	3.369					0.076
2-Chloronaphthalene																										3.50	3.50
2-Methylnaphthalene							0.0202				0.07	0.07		0.67							0.201			0.33		10.72	0.0202
Acenaphthene							0.00671				0.016	0.016		0.5		0.29					0.0889			0.33		0.417	0.00671
Acenaphthylene							0.00587				0.044	0.044		0.64		0.16					0.128			0.33		0.002	0.00587
Anthracene			0.0572	0.01			0.0469		0.01			0.0853	0.14		2	0.26		0.17			0.245	0.845	0.845	0.33	0.05	0.001	0.0572
Carbazole																										3.28	3.28
Dibenzofuran																5.1	0.54									0.134	5.100
Fluorene			0.0774				0.0212	0.03464				0.019				0.3					0.144	0.65192	0.536	0.33		0.138	0.0774
Naphthalene			0.176				0.0346	0.03275				0.16				0.6					0.391	0.68739	0.561	0.33	0.015	0.0014	0.176
Phenanthrene			0.204		0.0419		0.0867				0.24	0.24		1.5		0.8			0.515		0.544	1.17	1.17	0.33	0.05	0.0012	0.204
High Molecular Weight PAHs (mg/kg)				0.19			0.655	2.9	0.17		1.7		1.7	9.6	33			2.3			6.7	4.4					0.19
Benzo(a)anthracene			0.108		0.0317		0.0748	0.26				0.261				0.5			0.385		0.693	4.2	1.05	0.33	0.05	0.0021	0.108
Benzo(a)pyrene			0.15		0.0319		0.0888	0.35				0.43				0.7			0.782		0.763	0.3937	1.45	0.33	0.05	0.002	0.15
Benzo(ghi)perylene				0.016		0.17		0.29	0.013				0.28		1.2		0.67	0.25		3.2		6.3			0.05	0.003	0.016
Benzo(b,k)fluoranthene				0.027		0.24		0.0272	0.037				0.071		4	13.4	3.2	0.16		13.4					0.2	0.009	0.027
Chrysene			0.166		0.0571		0.108	0.5				0.384				0.8			0.862		0.846	5.2	1.29	0.33	0.05	0.002	0.166
Dibenzo(a,h)anthracene				0.01			0.00622	0.282	0.01			0.0634	0.015		0.87	0.1		0.028			0.135			0.33	0.05		0.01
Fluoranthene			0.423		0.111		0.113	0.06423				0.6				1.5			2.355		1.494	0.83427	2.23	0.33	0.3	0.008	0.423
Indeno(1,2,3-cd)pyrene				0.017		0.2		0.078	0.03				0.25		0.77	0.33	0.6	0.24		3.2		0.83666			0.05	0.003	0.017
Pyrene			0.195		0.053		0.153					0.665				1			0.875		1.398	1.52	1.52	0.33	0.05	6.536	0.195
Phthalates (mg/kg)																											
Bis (2-ethylhexyl) phthalate							0.182									0.75	1.3				2.647			0.182		0.949	0.182
Butylbenzylphthalate																	0.063									0.067	0.063

TABLE 3-11
ECOTOXICOLOGICAL SCREENING VALUES FOR DIRECT EXPOSURES TO SEDIMENTS
ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNITCRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Background (Illinois EPA 1996)	Background (NOAA 1999)	Threshold / Lowest Effect Level						Effects - Range Low				Effects - Range Median		Apparent Effect Level			Probable / Severe Effect Level						EPA Region 4 Screening value	Netherlands Limit Values	Equilibrium Partitioning ESV	Screening TRV Selected
			Consensus-Based (MacDonald, et.al. 1999)	Ingersoll et.al. (1996)	NOAA (1999)	Ontario (1995)	Florida DEP (1994)	ORNL (1997)	Ingersoll et.al. (1996)	EPA ECOTOX(1996)	Long et.al. (1995)	EPA Region 3 BTAG (1995)	Ingersoll et.al. (1996)	Long et.al. (1995)	Ingersoll et.al. (1996)	NOAA (1999)	EPA Region 3 BTAG (1995)	Ingersoll et.al. (1996)	NOAA (1999)	Ontario (1995)	Florida DEP (1994)	ORNL (1997)	Consensus-Based (MacDonald, et.al. 1999)				
Diethyl phthalate																	0.2									0.003	0.200
Dimethyl phthalate																	0.071									0.004	0.071
Di-n-butyl phthalate																0.11	1.4									0.005	0.110
Di-n-octyl phthalate																	6.2									0.30	6.20
Miscellaneous Solvents (mg/kg)																											
Carbon disulfide																										0.0025	0.0025
Pesticides (mg/kg)																											
4,4'-DDD			0.00488		0.00354		0.00122									0.06	<0.016		0.00851		0.00781	0.028	0.028	0.0033		0.005	0.005
4,4'-DDE			0.00316		0.00142		0.00207				0.0022	0.0022		0.027		0.05			0.00675		0.374	0.0313	0.0313	0.003		0.872	0.003
4,4'-DDT	0.01		0.00416			0.008	0.00119									0.05				0.71	0.00477	0.0629	0.0629	0.003		0.001	0.01
Aldrin	0.001					0.002										0.04				0.08						0.041	0.001
a-BHC						0.006														0.1						0.124	0.006
b-BHC						0.005														0.21						0.001	0.005
d-BHC																										0.0002	0.0002
g-BHC (Lindane)			0.00237		0.00094	0.003	0.00032									0.09			0.00014	0.01	0.00099	0.00499	0.00499	0.0033	0.001		0.002
a-Chlordane																											NA
g-Chlordane																										0.0001	0.0001
Chlordane (Technical)	0.005		0.00324		0.0045	0.007	0.00226									0.03			0.0089	0.06	0.00479	0.0176	0.0176	0.0017	0.02	0.0001	0.005
Dieldrin	0.0034		0.0019		0.00285	0.002	0.00072									0.3			0.00667	0.91	0.0043	0.0618	0.0618	0.0033	0.02		0.0034
Endosufan I																											NA
Endosufan II																										0.0010	0.001
Endosufan																										0.0006	0.0006
Endosulfan sufate																									0.01	4.696E-05	0.01
Endrin			0.00222		0.00267	0.003										0.5			0.0624	1.3		0.207	0.207	0.0033	0.04		0.00222
Endrin aldehyde																											NA
Endrin ketone																										0.0006	0.0006
Heptachlor																0.01										0.0002	0.0002
Heptachlor epoxide	0.001		0.00247		0.0006	0.005										0.03			0.00274	0.05		0.016	0.016		0.02		0.001
Isodrin																										0.0014961	0.0014961
Methoxychlor																										9.796E-06	9.796E-06
Toxaphene										0.028																	0.028
PCBs (mg/kg)						0.07	0.0216				0.0227	0.0227		0.18						5.3	0.189					0.013	0.07
Aroclor 1016						0.007														5.3						0.004	0.007
Aroclor 1221																								0.067			0.067
Aroclor 1248						0.03														1.5						0.054	0.03
Aroclor 1254						0.06														0.34						0.094	0.06
Aroclor 1260						0.005														0.24							0.005
PCBs (total)	0.01																										0.01

TABLE 3-11
ECOTOXICOLOGICAL SCREENING VALUES FOR DIRECT EXPOSURES TO SEDIMENTS
ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNITCRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Background (Illinois EPA 1996)	Background (NOAA 1999)	Threshold / Lowest Effect Level						Effects - Range Low				Effects - Range Median		Apparent Effect Level			Probable / Severe Effect Level						EPA Region 4 Screening value	Netherlands Limit Values	Equilibrium Partitioning ESV	Screening TRV Selected
			Consensus-Based (MacDonald, et.al. 1999)	Ingersoll et.al. (1996)	NOAA (1999)	Ontario (1995)	Florida DEP (1994)	ORNL (1997)	Ingersoll et.al. (1996)	EPA ECOTOX(1996)	Long et.al. (1995)	EPA Region 3 BTAG (1995)	Ingersoll et.al. (1996)	Long et.al. (1995)	Ingersoll et.al. (1996)	NOAA (1999)	EPA Region 3 BTAG (1995)	Ingersoll et.al. (1996)	NOAA (1999)	Ontario (1995)	Florida DEP (1994)	ORNL (1997)	Consensus-Based (MacDonald, et.al. 1999)				
Explosives (mg/kg)																											
1,3-Dinitrobenzene (DNB)																										0.006	0.006
1,3,5-Trinitrobenzene (TNB)																											NA
2-Amino-4,6-Dinitrotoluene (2-ADNT)																										16.8	16.8
2-Nitrotoluene (ONT)																										0.210	0.21
2,4,6-Trinitrotolune (TNT)																										11.9	11.9
3-Nitrotoluene																											NA
4-Amino-2,6-Dinitrotoluene																										18.7	18.7
4-Nitrotoluene (PNT)																										0.083	0.083
Cyclonite (RDX)																										0.011	0.011
Cyclotetramethylenetetranitramine (HMX)																										0.328	0.325
Nitroglycerin (NG)																										472	472
Pentaerythritol tetranitrate (PETN)																											NA
Tetryl																											NA
Dioxins/Furans (mg/kg)																											
2,3,7,8-TCDD																											
Total Petroleum Hydrocarbons (mg/kg)																											
TPH-Gasoline range organics																											NA
TPH-Diesel range organics																											NA
Metals (mg/kg)																											
Aluminum		2600		26000					14000				58000		73000			60000				58030					26000
Antimony		0.16														3	150							12			3
Arsenic	14	1.1		11	5.9	6			13			8.2	50		100	17		48	17	33				7.24	55		14
Barium	271	0.7																									271
Beryllium																											NA
Cadmium	5	0.1-0.3		0.58	0.596	0.6			0.7			<81	3.9		8	3		3.2	3.53	10				1	2		5
Calcium																								52.3	380		NA
Chromium (Total)																											
Chromium VI												<81															
Cobalt		10																									10
Copper	100	10-25		28	35.7	16	18.7		41			34	190		580	86		100	197	110	108			18.7	36		28
Iron	37000	9900-188400		190000		20000			200000				280000		290000	40000		250000		40000							190000
Lead	59	4-17		37	35	31	30.2		55			46.7	99		130	127		82	91.3	250	112			30.2	530		59
Magnesium																											NA
Manganese	1700	400		630		460		1673	730				1700		4500	1100		1200		1100		1081					1700
Mercury	0.15	0.004-0.051			0.174	0.2	0.13					0.15				0.56			0.486	2	0.696			0.13	0.5		0.174
Nickel	31	9.9		20	18	16	15.9		24			20.9	45		43	43		33	35.9	75	42.8			15.9	35		31

TABLE 3-11
ECOTOXICOLOGICAL SCREENING VALUES FOR DIRECT EXPOSURES TO SEDIMENTS
ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNITCRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Background (Illinois EPA 1996)	Background (NOAA 1999)	Threshold / Lowest Effect Level						Effects - Range Low				Effects - Range Median		Apparent Effect Level			Probable / Severe Effect Level					EPA Region 4 Screening value	Netherlands Limit Values	Equilibrium Partitioning ESV	Screening TRV Selected
			Consensus-Based (MacDonald, et.al. 1999)	Ingersoll et.al. (1996)	NOAA (1999)	Ontario (1995)	Florida DEP (1994)	ORNL (1997)	Ingersoll et.al. (1996)	EPA ECOTOX(1996)	Long et.al. (1995)	EPA Region 3 BTAG (1995)	Ingersoll et.al. (1996)	Long et.al. (1995)	Ingersoll et.al. (1996)	NOAA (1999)	EPA Region 3 BTAG (1995)	Ingersoll et.al. (1996)	NOAA (1999)	Ontario (1995)	Florida DEP (1994)	ORNL (1997)	Consensus-Based (MacDonald, et.al. 1999)				
Potassium	2100																									NA
Selenium		0.29																								0.29
Silver	0.1	<0.5					0.733				1	1		3.7		4.5					1.77			2			0.733
Sodium																										NA
Thallium																										NA
Vanadium		50																								50
Zinc	145	7-38		98	123.1	120	124		110			150	550		1300	520		540	315	820	271			124	480		145
Total Cyanide																									5		5

TABLE 3-12
ECOTOXICOLOGICAL SCREENING VALUES FOR DIRECT EXPOSURES TO SURFACE WATER
ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNIT,
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Illinois Chronic	EPA NRWQC (Chronic)[3]	ECOTOX AWQC/FCV[4]	ECOTOX GLWQI Tier II[4]	ORNL Tier II Chronic[5]	EPA Region 4 FWSV[7]	Lowest Reported Chronic[6]	NOAA Chronic[1]	Aster Chronic[10] or Alternative ESV	EPA Region 3 SL Flora[8]	EPA Region 3 SL Fauna[8]	Netherlands Limit Values[9]	Illinois (Max allowable Concentration)	Screening TRV Selected
Halogenated Methanes/Alkanes (ug/L)														
Bis(2-chloroethoxy) methane														NA
Bromodichloromethane									15215					15215
Bromoform						293			13386					293
Bromomethane									67647					67647
Carbon tetrachloride (Tetrachloromethane)					9.8	352	1970		2971					9.8
Chloroform (Trichloromethane)					28	289	1240	1240	2971		1240			28
Chloromethane									67467					67467
Dibromochloromethane									14607					14607
Methylene chloride					2200	1930	42667		142000					2200
Halogenated Ethanes (ug/L)														
1,1-Dichloroethane				47	47		14680		17251					47
1,1,1-Trichloroethane				60	11	528	3493		5678					60
1,1,2-Trichloroethane					1200	940	9400	9400	13451					1200
1,1,2,2-Tetrachloroethane				420	610	240	2400	2400	5152					420
1,2-Dichloroethane					910	2000	15200	20000	59000		20000			910
Chloroethane									21069					21069
Hexachloroethane				12	12	9.8		540	141		540			12
Halogenated Propanes (ug/L)														
1,2-Dichloropropane						525		5700	25000		5700			5700
2,2'-Oxybis (1-chloropropane)														NA
Halogenated Alkenes (ug/L)														
1,1-Dichloroethene					25	303	2800		5114					25
1,2-Dichloroethene (total)					590		9538							590
1,2-Dichloroethene (cis)					590		9538		17036					590
1,2-Dichloroethene (trans)					590	1350	9538		17036					590
1,3-Dichloropropene (total)														NA

TABLE 3-12
ECOTOXICOLOGICAL SCREENING VALUES FOR DIRECT EXPOSURES TO SURFACE WATER
ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNIT,
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Illinois Chronic	EPA NRWQC (Chronic)[3]	ECOTOX AWQC/FCV[4]	ECOTOX GLWQI Tier II[4]	ORNL Tier II Chronic[5]	EPA Region 4 FWSV[7]	Lowest Reported Chronic[6]	NOAA Chronic[1]	Aster Chronic[10] or Alternative ESV	EPA Region 3 SL Flora[8]	EPA Region 3 SL Fauna[8]	Netherlands Limit Values[9]	Illinois (Max allowable Concentration)	Screening TRV Selected
1,3-Dichloropropene (cis)					0.055	24.4	244					1		0.055
1,3-Dichloropropene (trans)						24.4								24.4
Tetrachloroethene				120	98	84	750	840	952		840			120
Trichloroethene				350	47		7257	21900	4173		21900	2		350
Vinyl chloride									18242					18242
Amines (ug/L)														
2-Nitroaniline									23132					23132
3-Nitroaniline									68321					68321
3,3'-Dichlorobenzidine									105			0.2		0.2
4-Chloroaniline									2250					2250
4-Nitroaniline									46418					46418
4,4'-Methylenebis (2-chlorobenzenamine)-MOCA														NA
N-Nitrosodiphenylamine					210	58.5	332							210
N-Nitroso-di-n-propylamine														NA
Benzene and Derivatives (ug/L)														
Benzene				46	130	53	525000		3100					46
Chlorobenzene				130	64	195	1203	50	2263		50			130
1,2-Dichlorobenzene				14	14	15.8		763	900		763			14
1,2,4-Trichlorobenzene				110	110	44.9		50	350					110
1,3-Dichlorobenzene				71	71	50.2			1000		763			71
1,4-Dichlorobenzene				15	15	11.2		763	570		763			15
Hexachlorobenzene								3.68			3.68			3.68
Methylated Benzenes (ug/L)														
Toluene				130	98	175	1269		6000					130
Xylenes (total)				1.8	13		62308							1.8
Other Substituted Benzenes (ug/L)														
Ethylbenzene				290	7.3	453	440		1135					290

TABLE 3-12
ECOTOXICOLOGICAL SCREENING VALUES FOR DIRECT EXPOSURES TO SURFACE WATER
ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNIT,
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Illinois Chronic	EPA NRWQC (Chronic)[3]	ECOTOX AWQC/FCV[4]	ECOTOX GLWQI Tier II[4]	ORNL Tier II Chronic[5]	EPA Region 4 FWSV[7]	Lowest Reported Chronic[6]	NOAA Chronic[1]	Aster Chronic[10] or Alternative ESV	EPA Region 3 SL Flora[8]	EPA Region 3 SL Fauna[8]	Netherlands Limit Values[9]	Illinois (Max allowable Concentration)	Screening TRV Selected
Styrene									4020					4020
Nitrobenzene						270			17317					270
Arenes (ug/L)														
2,4-Dinitrotolune						310		230			230			310
2,6-Dinitrotolune														NA
Chlorinated Dienes (ug/L)														
Hexachlorobutadiene						0.93		9.3			9.3			0.93
Hexachlorocyclopentadiene						0.07		5.2	7.3		5.2			0.07
Ethers (ug/L)														
4-Bromophenyl phenyl ether				1.5		12.2	1.5		42					1.5
4-Chlorophenyl phenyl ether									46					46
Bis (2-chloroethyl) ether						2380			19000					2380
Phenols and Substituted Phenols (ug/L)														
2-Chlorophenol						43.8			2056					43.8
2-Methylphenol					13		489		2251					13
2-Nitrophenol						3500			3451					3500
2,4-Dichlorophenol						36.5		365	103		365			36.5
2,4-Dimethylphenol						21.2			3110					21.2
2,4-Dinitrophenol						6.2		150	594		150			6.2
2,4,5-Trichlorophenol								63	297		63			63
2,4,6-Trichlorophenol						3.2		970	538		970			3.2
4-Chloro-3-methylphenol						0.3			680					0.3
4-Methylphenol									2251					2251
4-Nitrophenol					300	82.8	481	150	989		150			300
4,6-Dinitro-2-Methylphenol						2.3			183					2.3
Pentachlorophenol		15	13			13		15	13		13			15
Phenol						256	200	2560	118			2	100	256

TABLE 3-12
ECOTOXICOLOGICAL SCREENING VALUES FOR DIRECT EXPOSURES TO SURFACE WATER
ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNIT,
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Illinois Chronic	EPA NRWQC (Chronic)[3]	ECOTOX AWQC/FCV[4]	ECOTOX GLWQI Tier II[4]	ORNL Tier II Chronic[5]	EPA Region 4 FWSV[7]	Lowest Reported Chronic[6]	NOAA Chronic[1]	Aster Chronic[10] or Alternative ESV	EPA Region 3 SL Flora[8]	EPA Region 3 SL Fauna[8]	Netherlands Limit Values[9]	Illinois (Max allowable Concentration)	Screening TRV Selected
Ketones (Carbonyl Compounds) (ug/L)														
2-Butanone					14000		282170		233553					14000
2-Hexanone					99		32783		38868					99
4-Methyl-2-pentanone (MIBK)					170		77400							170
Acetone					1500		1560		543494					1500
Isophorone						1170			19000					1170
Low Molecular Weight PAHs (ug/L)														
2-Chloronaphthalene									310		620			620
2-Methylnaphthalene									417					417
Acenaphthene			23			17	74	520	345		520			23
Acenaphthylene					0.73		0.09		665					0.73
Anthracene									<6		0.1	0.02		0.1
Carbazole									893					893
Dibenzofuran				20	3.7		1003		286					20
Fluorene				3.9	39				289		430			3.9
Naphthalene				24	12	62	620	620	1022		100	0.1		24
Phenanthrene				6.3			200	6.3	19a		6.3	0.02		6.3
High Molecular Weight PAHs (ug/L)														
Benzo(a)anthracene					0.027		0.65				6.3	0.008		0.027
Benzo(a)pyrene				0.014	0.014		0.3					0.005		0.014
Benzo(ghi)perylene												0.004		0.004
Benzo(b,k)fluoranthene												0.02		0.02
Chrysene									16			0.008		0.008
Dibenzo(a,h)anthracene														NA
Fluoranthene			8.1			39.8	15		61			0.07		8.1

TABLE 3-12
ECOTOXICOLOGICAL SCREENING VALUES FOR DIRECT EXPOSURES TO SURFACE WATER
ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNIT,
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Illinois Chronic	EPA NRWQC (Chronic)[3]	ECOTOX AWQC/FCV[4]	ECOTOX GLWQI Tier II[4]	ORNL Tier II Chronic[5]	EPA Region 4 FWSV[7]	Lowest Reported Chronic[6]	NOAA Chronic[1]	Aster Chronic[10] or Alternative ESV	EPA Region 3 SL Flora[8]	EPA Region 3 SL Fauna[8]	Netherlands Limit Values[9]	Illinois (Max allowable Concentration)	Screening TRV Selected
Indeno(1,2,3-cd)pyrene												0.004		0.004
Pyrene									61					61
Pathalates (ug/L)														
Bis (2-ethylhexyl) phthalate				32	3	<0.3	912	360	54		30			32
Butylbenzylphthalate				19	19	22		3	280		3			19
Diethyl phthalate				220	210	521	85600	3	25000		3			220
Dimethyl phthalate						330		3	11000		3			330
Di-n-butyl phthalate				33	35	9.4	697	3	100					33
Di-n-octyl phthalate							708	3	8300		0.3			708
Miscellaneous Solvents (ug/L)														
Carbon disulfide					0.92		244				2			0.92
Pesticides (ug/L)														
4,4'-DDD					0.011	0.0064	1.69							0.011
4,4'-DDE						10.5								10.5
4,4'-DDT		0.001		0.013	0.013	0.001	0.3	0.0005			0.001			0.001
Aldrin						0.3			1.3					0.3
a-BHC					2.2	500	95							2.2
b-BHC					2.2	5000	95							2.2
d-BHC					2.2	0.08	95							2.2
g-BHC (Lindane)			0.08				3.3	0.08	40		0.08	0.01		0.08
a-Chlordane							1.09							1.09
g-Chlordane							1.09							1.09
Chlordane (Technical)		0.0043				0.0043		0.00215			0.0043			0.0043
Dieldrin		0.056	0.062			0.0019		0.056			0.0019	0.002		0.056
Endosufan I		0.056		0.051	0.051	0.056		0.028			0.056			0.056
Endosufan II		0.056		0.051	0.051	0.056		0.028			0.056			0.056
Endosufan					0.051									0.051
Endosulfan sufate					0.051							0.01		0.051
Endrin		0.036	0.061			0.0023		0.036	0.1		0.0023			0.036

TABLE 3-12
ECOTOXICOLOGICAL SCREENING VALUES FOR DIRECT EXPOSURES TO SURFACE WATER
ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNIT,
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Illinois Chronic	EPA NRWQC (Chronic)[3]	ECOTOX AWQC/FCV[4]	ECOTOX GLWQI Tier II[4]	ORNL Tier II Chronic[5]	EPA Region 4 FWSV[7]	Lowest Reported Chronic[6]	NOAA Chronic[1]	Aster Chronic[10] or Alternative ESV	EPA Region 3 SL Flora[8]	EPA Region 3 SL Fauna[8]	Netherlands Limit Values[9]	Illinois (Max allowable Concentration)	Screening TRV Selected
Endrin aldehyde														NA
Endrin ketone														NA
Heptachlor		0.0038		0.0069	0.0069	0.0038	1.26	0.0019			0.0038			0.0038
Heptachlor epoxide		0.0038				0.0038		0.0019			0.0038			0.0038
Isodrin														NA
Methoxychlor		0.03		0.019	0.019	0.03		0.03	9.2		0.03			0.03
Toxaphene		0.0002		0.011		0.0002		0.0002	0.054		0.0002			0.0002
PCBs (ug/L)														
Aroclor 1016						0.014								0.014
Aroclor 1221					0.28	0.014	60							0.28
Aroclor 1248					0.081	0.014								0.081
Aroclor 1254					0.033	0.014								0.033
Aroclor 1260					94	0.014	1.3							94
Explosives (ug/L)														
1,3-Dinitrobenzene (DNB)							240a		20a1					240
1,3,5-Trinitrobenzene (TNB)							100a		30a1					100
2-Amino-4,6-Dinitrotoluene (2-ADNT)									20a1					20
2-Nitrotoluene (ONT)							7300b							7300
2,4,6-Trinitrotolune (TNT)							40a		93a2					40
3-Nitrotoluene							8300b							8300
4-Amino-2,6-Dinitrotoluene							540c							540
4-Nitrotoluene (PNT)							7000b							7000
Cyclonite (RDX)							3200a		190a1					3200
Cyclotetramethylenetetranitramine (HMX)							3300a		330a1					3300
Nitroglycerin (NG)							200d							200
Pentaerythritol tetranitrate (PETN)							85000b1							85000

TABLE 3-12
ECOTOXICOLOGICAL SCREENING VALUES FOR DIRECT EXPOSURES TO SURFACE WATER
ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNIT,
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Illinois Chronic	EPA NRWQC (Chronic)[3]	ECOTOX AWQC/FCV[4]	ECOTOX GLWQI Tier II[4]	ORNL Tier II Chronic[5]	EPA Region 4 FWSV[7]	Lowest Reported Chronic[6]	NOAA Chronic[1]	Aster Chronic[10] or Alternative ESV	EPA Region 3 SL Flora[8]	EPA Region 3 SL Fauna[8]	Netherlands Limit Values[9]	Illinois (Max allowable Concentration)	Screening TRV Selected
Tetryl														NA
Total Petroleum Hydrocarbons (ug/L)														
TPH-Gasoline range organics									150e					150
TPH-Diesel range organics									150e					150
Metals (ug/L)														
Aluminum		87				87	460	87	87					87
Antimony						160	610	30			30			160
Arsenic	190					190	914	150	188.6		190	10		190
Barium				3.9	4								5000	3.9
Beryllium				5.1	0.66	0.53	5.3	5.3			5.3			5.1
Cadmium	2.3	2.2	1			0.66	0.15	1.1	1.13	1.1	0.53	0.2		2.3
Calcium							116000							116000
Chromium (Total)	5.3	74	180			117.32	44	74			120	20		5.3
Chromium VI	11	11	10			11	2	11		2	11			11
Cobalt				3	2.3		5.1							3
Copper	2.5	9	11			6.54	0.23	9			6.5	3		2.5
Iron		1000	1000			1000	158	1000			320		1000	1000
Lead	3.0	2.5	2.5			1.32	12.3	2.5	3.181592		3.2	25		3
Magnesium							82000							82000
Manganese				80	120		1100		1000		14500		1000	80
Mercury	1.3	0.77	1.3		1.3	0.012	2.3	0.012		0.012	0.012	0.03		1.3
Nickel		52	160			87.71	5	52			160	10	1000	52
Potassium							53000							5300
Selenium		5	5			5	88.3				5		1000	5
Silver					0.36	0.012	0.12	0.12			0.0001		5	0.36
Sodium							680000							680000
Thallium					12	4	57	40			40			12
Vanadium				19	20		80							19

TABLE 3-12
ECOTOXICOLOGICAL SCREENING VALUES FOR DIRECT EXPOSURES TO SURFACE WATER
ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNIT,
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Illinois Chronic	EPA NRWQC (Chronic)[3]	ECOTOX AWQC/FCV[4]	ECOTOX GLWQI Tier II[4]	ORNL Tier II Chronic[5]	EPA Region 4 FWSV[7]	Lowest Reported Chronic[6]	NOAA Chronic[1]	Aster Chronic[10] or Alternative ESV	EPA Region 3 SL Flora[8]	EPA Region 3 SL Fauna[8]	Netherlands Limit Values[9]	Illinois (Max allowable Concentration)	Screening TRV Selected
Zinc		120	100			58.91	30	110		110		30	1000	120
Total Cyanide	5.2	5.2	5.2			5.2	7.8	5.2			5.2			5.2

1 = NOAA SQuiRT Tables, Chronic Toxicity Value - NOAA 1999. Hazmat Report No. 99-1.
3 = Recommended National Water Quality Criterai - Correction - USEPA 1999
4 = Ecotox Threshold EcoUpdate - USEPA 1996
5 = Tier II Chronic Toxicity Value - Tsao and Suter 1996
6 = Lowest chroic toxicity - Suter and Tsao 1996 unless otherwise noted
7 = Freshwater ecotox screening values USEPA Region 4 1999
8 = Ecotox screening values USEPA Region 3 1999
9 = Ministry of Housing, Spatial Planning and Environment 1994
10 = (ASTER) Assessment Tools for Evaluation of Risk Database USEPA 2000 unless otherwise noted

a = Talmage et al. 1999
a1 = Tier II chronic value calculated by Talmage et al 1999
a2 = Final Chronic Value value calculated by Talmage et al 1999
b = (AQUIRE) Aquatic Toxicity Information Retrieval Database USEPA 2000
c = Mallon et al. 1987
d = Rosenblatt et al 1991
e = Entrix Inc. 1993

Hardness-dependent Cd, Cr, Cu and Pb values for Illinois Water quality criteria are based on a water hardness of 100 mg/L. For region IV, values are based on a hardness of 50 mg/L.

TA1 3-13
ECOTOXICOLOGY SCREENING VALUES FOR INDIRECT EXPOSURES (INGESTION PATHWAY)
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Effect	Species	Dose (mg/kg-BW/day)	Body Weight (kg)	Water Ingestion (L/day)	Food Ingestion (kg/day)	Water Concentration (mg/L)	Screening Concentration (mg/kg)	Reference
Halogenated Methanes/Alkanes									
Bis(2-chloroethoxy) methane	*LD_{50} / 100*	Rat	0.65	0.325	0.0435	0.0265	5	8	J. Indust. Hy. Toxicol. 30:63, 1948 as cited in RTECS
Bromodichloromethane	*Renal Histopathology LOAEL/10*	Mouse	1.79	0.0325	0.036	0.0058	1.6	10	NTP 1986 as cited in IRIS
Bromoform	*Hepatic Lesions*	Rat	17.9	0.325	0.0435	0.0265	134	220	NTP 1989 as cited in IRIS
Bromomethane	*Gastric Lesions and Body Weight*	Rat	1.4	0.325	0.0435	0.0265	10	17	Danse et al. 1984 as cited in IRIS
Carbon tetrachloride (Tetrachloromethane)	*Liver Histopathology*	Rat	0.71	0.325	0.0435	0.0265	5	9	Danse et al. 1984 as cited in IRIS
Chloroform (Trichloromethane)	*Liver Damage LOAEL/10*	Dog	1.29	14	0.550	0.435	33	42	Heywood et al. 1979 as cited in IRIS
Chloromethane	*Liver Histopathology - Single Dose NOAEL / 10*	Rat	42	0.325	0.0435	0.0265	314	515	Reynolds & Yee 1967 as cited in ATSDR 1990
Dibromochloromethane	*Hepatic Lesions*	Mouse	21.4	0.325	0.0435	0.0265	160	262	NTP 1985 as cited in IRIS
Methylene chloride	*Liver Toxicity*	Rat	5.85	0.325	0.0435	0.0265	44	72	IRIS
Halogenated Ethanes									
1,1-Dichloroethane	*Survival LOAEL/10*	Rat	38.2	0.325	0.0435	0.0265	285	468	NCI 1977 as cited in ATSDR 1990
1,1,1-Trichloroethane	*No Observable Adverse Effects*	Mouse	1000	0.0325	0.036	0.0058	903	5,603	Lane et al. 192 as cited in Sample et al. 1996
1,1,2-Trichloroethane	*Serum Chemistry*	Rat	3.9	0.0325	0.036	0.0058	3.5	22	IRIS
1,1,2,2-Tetrachloroethane	*Hepatotoxicity Subchronic-NOAEL/10*	Mouse	1.14	0.0325	0.036	0.0058	1.0	6.4	Buben & O'Flaherty 1985 as cited in Sample et al. 1996
1,2-Dichloroethane	*Egg Production*	Chicken	17.2	1.7	0.194	0.11	151	266	Alumot et al. 1976 as cited in Sample et al. 1996
Chloroethane	*Histopathology and Survival*	Rabbit	1000	1.2	0.114	0.069	10,490	17,435	Adams et al. 1939 as cited in ATSDR 1989
Hexachloroethane	*Liver Effects*	Rat	1	0.325	0.0435	0.0265	7	12	Gorzinski et al. 1985 as cited in IRIS
Halogenated Propanes									
1,2-Dichloropropane	*Liver & Spleen Weights*	Rat	250	0.325	0.0435	0.0265	1,868	3,066	Fund. Appl. Toxicol. 12:713, 1989 as cited in RTECS
2,2'-Oxybis (1-chloropropane)									
Halogenated Alkenes									
1,1-Dichloroethene	*Hepatic Lesions LOAEL/10*	Rat	0.9	0.325	0.0435	0.0265	7	11	Quast et al. 1983 as cited in IRIS
1,2-Dichloroethene (total)									

Conversion factors?

TABLE 3-13
ECOTOXICOLOGY SCREENING VALUES FOR INDIRECT EXPOSURES (INGESTION PATHWAY)
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Effect	Species	Dose (mg/kg-BW/day)	Body Weight (kg)	Water Ingestion (L/day)	Food Ingestion (kg/day)	Water Concentration (mg/L)	Screening Concentration (mg/kg)	Reference
1,2-Dichloroethene (cis)	*Body Weights (Growth)*	Rat	32	0.325	0.0435	0.0265	239	392	McCauley et at. 1990 as cited in ATSDR 1994
1,2-Dichloroethene (trans)	*Body Weights (Growth)*	Rat	32	0.325	0.0435	0.0265	239	392	McCauley et at. 1990 as cited in ATSDR 1994
1,3-Dichloropropene (total)	*Increase Organ weight*	Rat	3	0.325	0.0435	0.0265	22	37	Dow Chemical 1973 as cited in IRIS
1,3-Dichloropropene (cis)	*Survival*	Rat	30	0.325	0.0435	0.0265	224	368	Til et al. 1973 as cited in ATSDR 1992
1,3-Dichloropropene (trans)	*Survival*	Rat	30	0.325	0.0435	0.0265	224	368	Til et al. 1973 as cited in ATSDR 1992
Tetrachloroethene	*Weight Gain (Growth) and Liver Effects*	Rat	14	0.325	0.0435	0.0265	105	172	Buben & O'Flaherty 1985 as cited in IRIS
Trichloroethene	*Hepatotoxicity LOAEL/10*	Mouse	7	0.0325	0.036	0.0058	6.3	39.2	Buben & O'Flaherty 1985 as cited in Sample et al. 1996
Vinyl chloride	*Life-time Survival LOAEL/10*	Rat	0.17	0.325	0.0435	0.0265	1	2	Til et al. 1983 & 1991as cited in ATSDR 1995
Amines									
2-Nitroaniline	*LD_{50} / 100*	Quail	7.5	0.191	0.0195	0.015	74	96	Arch. Environ. Contam. Toxicol. 12:355, 1983 as cited in RTECS
3-Nitroaniline	*LD_{50} / 100*	Mouse	3.08	0.0325	0.036	0.0058	2.8	17.3	Aerospace Med. Res. Lab. Rpt. TR-72-62, 1972 as cited in RTECS
3,3'-Dichlorobenzidine	*Convulsions / Neurological Degeneration LOAEL/10*	Dog	0.8	14	0.550	0.435	20	26	Stula et al. 1978 as cited in ATSDR 1989
4-Chloroaniline	*Histopathology LOAEL/10*	Rat	1.25	0.325	0.0435	0.0265	9	15	NCI 1979 as cited in IRIS
4-Nitroaniline	*LD_{50} / 100*	Guinea Pig	4.5	0.0875	0.091	0.039	4	10	Problems Communal Hygiene 6:89, 1966 as cited in RTECS
4,4'-Methylenebis (2-chlorobenzenamine)-MOCA									
N-Nitrosodiphenylamine	*Body Weights (Growth)LOAEL/10*	Rat	5	0.325	0.0435	0.0265	37	61	Cardy et al. 1979; NCI 1979 as cited in ATSDR 1993
N-Nitroso-di-n-propylamine	*Longevity LOAEL/10*	Rat	0.51	0.325	0.0435	0.0265	4	6	Lijinsky & Taylor 1978;1979 as cited in ATSDR 1989
Benzene and Derivatives									
Benzene	*Reproductive Effects LOAEL/10*	Mouse	26.4	0.0325	0.036	0.0058	24	148	Nawrot & Staples 1979 as cited in Sample et al. 1996
Chlorobenzene	*Liver Histopathology*	Dog	19	14	0.550	0.435	484	611	Knapp et al. 1971 as cited in IRIS
1,2-Dichlorobenzene	*No Observable Adverse Effects*	Rat	85.7	0.325	0.0435	0.0265	640	1,051	NTP 1985 as cited in IRIS
1,2,4-Trichlorobenzene	*Adrenal Weights*	Rat	14.8	0.325	0.0435	0.0265	111	182	Robinson et al. 1984 as cited in IRIS

TAl 3-13
ECOTOXICOLOGY SCREENING VALUES FOR INDIRECT EXPOSURES (INGESTION PATHWAY)
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Effect	Species	Dose (mg/kg-BW/day)	Body Weight (kg)	Water Ingestion (L/day)	Food Ingestion (kg/day)	Water Concentration (mg/L)	Screening Concentration (mg/kg)	Reference
1,3-Dichlorobenzene	*Serum Chemistry LOAEL/10*	Rat	25	0.325	0.0435	0.0265	187	307	Ariyoshi et al. 1975 as cited in HSDB
1,4-Dichlorobenzene	*Survival LOAEL/10*	Rat	30	0.325	0.0435	0.0265	224	368	NTP 1987 as cited in ATSDR 1993
Hexachlorobenzene	*Liver Effects*	Rat	0.08	0.325	0.0435	0.0265	0.60	0.98	Arnold et al. 1985 as cited in IRIS
Methylated Benzenes									
Toluene	*Fetal Body Weights LOAEL/10*	Mouse	26	0.325	0.0435	0.0265	194	319	Nawrot & Staples 1979 as cited in Sample et al. 1996
Xylenes (total)	*Growth LOAEL/10*	Rat	35.7	0.325	0.0435	0.0265	267	438	HSDB, NTP TR-327,86 NIH# 87-2583
Other Substituted Benzenes									
Ethylbenzene	*Liver & Kidney Toxicity*	Rat	97.1	0.325	0.0435	0.0265	725	1,191	Wolf et al. 1956 as cited in IRIS
Styrene	*Liver Effects & Blood Chemistry*	Dog	200	14	0.550	0.435	5,091	6,437	Quast 1979 as cited in IRIS
Nitrobenzene	*Tesicular Necrosis Acute LOAEL/10*	Rat	3	0.325	0.0435	0.0265	22	37	Levin et al. 1988 as cited in ATSDR 1990
Arenes									
2,4-Dinitrotolune	*Nuerological - Histopathology Effects*	Dog	0.2	14	0.550	0.435	5.1	6.4	Ellis et al. 1985 as cited in IRIS
2,6-Dinitrotolune	*Survival & Reproduction*	Mouse	11	0.0325	0.036	0.0058	10	62	Lee et al. 1976 as cited in ATSDR 1989
Chlorinated Dienes									
Hexachlorobutadiene	*Neonatal Weights*	Rat	2	0.325	0.0435	0.0265	15	25	Schwetz et al. 1977 as cited in ATSDR 1994
Hexachlorocyclopentadiene	*Stomach Lesions*	Rat	10	0.325	0.0435	0.0265	75	123	Abdo et al. 1984 as cited in IRIS
Ethers									
4-Bromophenyl phenyl ether	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
4-Chlorophenyl phenyl ether	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
Bis (2-chloroethyl) ether	*Body Weights (Growth)*	Rat	25	0.325	0.044	0.027	186	305	Weisburger et al. 1981 as cited in ATSDR 1989
Phenols and Substituted Phenols									
2-Chlorophenol	*Reproductive Effects*	Rat	5	0.325	0.0435	0.0265	37	61	Exon & Koller 1982 as cited in IRIS
2-Methylphenol	*Body Weight (Growth) & Neurotoxicity*	Rat	50	0.325	0.0435	0.0265	374	613	USEPA 1986 & 1987 as cited in IRIS

TABLE 3-13
ECOTOXICOLOGY SCREENING VALUES FOR INDIRECT EXPOSURES (INGESTION PATHWAY)
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Effect	Species	Dose (mg/kg-BW/day)	Body Weight (kg)	Water Ingestion (L/day)	Food Ingestion (kg/day)	Water Concentration (mg/L)	Screening Concentration (mg/kg)	Reference
2-Nitrophenol	*$LD_{50}/100$*	Rat	3.34	0.325	0.0435	0.0265	25	41	Labor Hyg. Occup. Pathol. Estonia SSR 8:145, 1972 as cited in RTECS
2,4-Dichlorophenol	*Development LOAEL/10*	Rat	2	0.325	0.0435	0.0265	15	25	Gigiena i Sanitarya 41(11):102, 1976 as cited in RTECS
2,4-Dimethylphenol	*Clinical Signs*	Mouse	50	0.0325	0.036	0.0058	45	280	USEPA 1989 as cited in IRIS
2,4-Dinitrophenol	*Histopathology and Growth*	Rat	10	0.325	0.0435	0.0265	75	123	NRC 1981 as cited in HSDB
2,4,5-Trichlorophenol	*Liver & Kidney Histopathology*	Rat	100	0.325	0.0435	0.0265	747	1,226	McCollister et al.1951 as cited in IRIS
2,4,6-Trichlorophenol	*Litter Size*	Rat	4.2	0.325	0.0435	0.0265	31	52	Exon & Koller 1985 as cited in ATSDR 1990
4-Chloro-3-methylphenol	*LD_{50} / 100*	Mouse	7.1	0.0325	0.036	0.0058	6.4	40	USEPA 1980 as cited in HSDB
4-Methylphenol	*Body Weight (Growth) & Neurotoxicity*	Rat	50	0.325	0.0435	0.0265	374	613	USEPA 1986 & 1987 as cited in IRIS
4-Nitrophenol	*Survival*	Rat	25	0.325	0.0435	0.0265	187	307	Hazleton 1989 as cited in ATSDR 1992
4,6-Dinitro-2-Methylphenol	*Serum Chemistry*	Rat	2.5	0.325	0.0435	0.0265	19	31	Den Tonkelaar et al. 1983 as cited in ATSDR 1995
Pentachlorophenol	*Liver & Kidney Histopathology*	Rat	3	0.325	0.0435	0.0265	22	37	Schwetz et al. 1978 as cited in IRIS
Phenol	*Fetal Body Weights*	Rat	60	0.325	0.0435	0.0265	448	736	NTP 1983 as cited in IRIS
Ketones (Carbonyl Compounds)									
2-Butanone	*Fetal Weights*	Rat	1771	0.325	0.0435	0.0265	13,232	21,720	Cox et al. 1975 as cited in IRIS
2-Hexanone	*LD_{50} / 100*	Mouse	24.3	0.0325	0.036	0.0058	21.9	136	RTECs (R), Toxicology Letter 30:13, 1986
4-Methyl-2-pentanone (MIBK)									
Acetone	*Nephrotoxicity / Liver & Kidney Weights*	Rat	100	0.325	0.0435	0.0265	747	1,226	USEPA 1986 as cited in IRIS
Isophorone	*No Observable Adverse Effects*	Dog	150	14	0.550	0.435	3,818	4,828	Nor. Am. Agric. 1972 as cited in IRIS
Low Molecular Weight PAHs									
2-Chloronaphthalene	*Liver Size*	Mouse	250	0.0325	0.036	0.0058	226	1,401	USEPA 1989 as cited in IRIS
2-Methylnaphthalene	*Single Dose LD_{50} / 100*	Rat	16.3	0.325	0.0435	0.0265	122	200	RTECS Izmerov, ctr. Internat. Projects 1982
Acenaphthene	*Hepatotoxicity*	Mouse	175	0.0325	0.036	0.0058	158	981	USEPA 1989 as cited in IRIS
Acenaphthylene	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
Anthracene	*No Observable Adverse Effects*	Mouse	1000	0.0325	0.036	0.0058	903	5,603	USEPA 1989 as cited in IRIS

TAl 3-13
ECOTOXICOLOGY SCREENING VALUES FOR INDIRECT EXPOSURES (INGESTION PATHWAY)
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Effect	Species	Dose (mg/kg-BW/day)	Body Weight (kg)	Water Ingestion (L/day)	Food Ingestion (kg/day)	Water Concentration (mg/L)	Screening Concentration (mg/kg)	Reference
Carbazole	*LD_{50} / 100*	Rat	5	0.325	0.0435	0.0265	37	61	RTECs, J. Pharmacol. Exper. Therap. 90:260, 1947
Dibenzofuran	*Growth LOAEL/10*	Mouse	10	0.0325	0.036	0.0058	9.0	56	Shepard's Catalog Tetratogenic Agents 1989 as cited in HSDB
Fluorene	*Blood Chemistry*	Mouse	125	0.0325	0.036	0.0058	113	700	USEPA 1989 as cited in IRIS
Naphthalene	*Survival, Growth, & Organ Weights*	Mouse	143	0.0325	0.036	0.0058	129	801	USEPA-NTIS PB90-259821 as cited in HSDB
Phenanthrene	*Liver Function LOAEL/10*	Mouse	7	0.0325	0.036	0.0058	6.3	39	Hyg. Sanit. 29:19, 1964 as cited in RTECS
High Molecular Weight PAHs									
Benzo(a)anthracene	*Spematogenis Single Dose LOAEL/10*	Hamster	90						RTECS, Acta Morph. Acad. Scient. Hungaricae 27:199, 1979
Benzo(a)pyrene	*Fertility and Fetal Body Weights LOAEL/10*	Mouse	1	0.0325	0.036	0.0058	0.90	5.6	Mackenzie & Angvine 1981 as cited in Sample et al. 1996
Benzo(ghi)perylene	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
Benzo(b,k)fluoranthene	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
Chrysene	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	*Clinical Signs & Liver Weights*	Mouse	125	0.0325	0.036	0.0058	113	700	USEPA 1989 as cited in IRIS
Indeno(1,2,3-cd)pyrene	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
Pyrene	*Kidney Histopathology*	Mouse	75	0.0325	0.036	0.0058	68	420	USEPA 1989 as cited in IRIS
Pathalates									
Bis (2-ethylhexyl) phthalate	*Liver Weight LOAEL/10*	Guinea Pig	1.9	0.0875	0.091	0.039	2	4	Carpenter et al. 1953 as cited in IRIS
Butylbenzylphthalate	*Liver & Brain Weights*	Rat	159	0.325	0.0435	0.0265	1,188	1,950	NTP 1985 as cited in IRIS
Diethyl phthalate	*Growth Rates & Organ Weights*	Rat	750	0.325	0.0435	0.0265	5,603	9,198	Brown et al. 1978 as cited in IRIS
Dimethyl phthalate	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
Di-n-butyl phthalate	*Fetotoxicity LOAEL/10*	Rat	120	0.325	0.0435	0.0265	897	1,472	RTECS (R) Toxicology & Applied Pharmacology 26:253, 1973
Di-n-octyl phthalate	*Fertility LOAEL/10*	Mouse	975	0.0325	0.036	0.0058	880	5,463	RTECS (R) NTIS PB85-220143
Miscellaneous Solvents									
Carbon disulfide	*Fetal Development*	Rabbit	11	1.2	0.114	0.069	115	192	Hardin et al. 1981 as cited in IRIS

TABLE 3-13
ECOTOXICOLOGY SCREENING VALUES FOR INDIRECT EXPOSURES (INGESTION PATHWAY)
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Effect	Species	Dose (mg/kg-BW/day)	Body Weight (kg)	Water Ingestion (L/day)	Food Ingestion (kg/day)	Water Concentration (mg/L)	Screening Concentration (mg/kg)	Reference
Pesticides (mg/kg)									
4,4'-DDD	*Reduced Reproduction LOAEL/10*	Mallard	0.056						Heath et al. 1969
4,4'-DDE	*Reduced Reproduction LOAEL/10*	Mallard	0.056						Heath et al. 1969
4,4'-DDT	*Liver Lesions*	Rat	0.05	0.325	0.0435	0.0265	0.37	0.61	Laug et al. 1950 as cited in IRIS
DDT (Total)	*Reduced Reproduction LOAEL/10*	Brown Pelican	0.0028						Anderson et al. 1975 as cited in Sample et al. 1996
Aldrin	*Survival LOAEL/10*	Rat	0.5	0.325	0.0435	0.0265	3.736	6.132	Fitzhugh et al. 1964 as cited in IRIS
a-BHC	*Hepatic effect*	Rat	1	0.325	0.0435	0.0265	7.471	12.264	Barros et al. 1991 as cited in ATSDR
b-BHC	*Gonadal Histopathological effect*	Rat	2.5	0.325	0.0435	0.0265	18.678	30.660	Van Velsen et al. 1986 as cited in ATSDR 1994
d-BHC									
g-BHC (Lindane)	*Liver & Kidney Toxicity*	Rat	0.29	0.325	0.0435	0.0265	2.2	3.6	Zoecon Corp. 1983 as cited in IRIS
a-Chlordane									
g-Chlordane									
Chlordane (Technical)	*Hepatic Necrosis*	Mouse	0.15	0.0325	0.036	0.0058	0.14	0.84	Khasawinah & Grutsch 1989 as cited in IRIS
Dieldrin	*Liver Lesions LOAEL/10*	Rat	0.005	0.325	0.0435	0.0265	0.037	0.061	Walker et al. 1969 as cited in IRIS
Endosufan I									
Endosufan II									
Endosufan	*Effect on Body Weight*	Dog	0.57	14	0.550	0.435	15	18	Hoechst Celanese Corp. 1989 as cited in IRIS
Endosulfan sufate									
Endrin	*Histological Lesions in Liver*	Dog	0.025	14	0.550	0.435	0.64	0.80	Velsicol Chemical 1969 as cited in IRIS
Endrin aldehyde									
Endrin ketone									
Heptachlor	*Liver Weight Increase*	Rat	0.15	0.325	0.0435	0.0265	1.1	1.8	Velsicol Chemical 1969 as cited in IRIS
Heptachlor epoxide	*Increase in Liver to Body Weight Ratio LEL/10*	Dog	0.0016	14	0.550	0.435	0.041	0.051	Dow Chemical 1958 as cited in IRIS
Isodrin									

TA 3-13

ECOTOXICOLOGY SCREENING VALUES FOR INDIRECT EXPOSURES (INGESTION PATHWAY)
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Effect	Species	Dose (mg/kg-BW/day)	Body Weight (kg)	Water Ingestion (L/day)	Food Ingestion (kg/day)	Water Concentration (mg/L)	Screening Concentration (mg/kg)	Reference
Methoxychlor	*Loss of Litters*	Rabbit	5.01	1.2	0.114	0.069	53	87	Kincaid Enterprises 1986 as cited in IRIS
Toxaphene	*Liver Histopathology*	Dog	0.2	14	0.550	0.435	5.091	6.437	Chu et al. 1986 as cited in ATSDR 1994
PCBs (mg/kg)									
Aroclor 1016	*Reproductive Effect*	Monkey	0.007	8.50	0.470	0.330	0.13	0.18	Schantz et al. 1989 as cited in ATSDR 1996
Aroclor 1221	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
Aroclor 1248	*Birth Weights*	Rhesus Monkey (Female)	0.03	8.50	0.470	0.330	0.54	0.77	Schantz et al. 1989 as cited in ATSDR 1996
Aroclor 1254	*Birth Weights*	Rhesus Monkey (Female)	0.005	8.50	0.470	0.330	0.09	0.13	Levinskas et al. 1984 as cited in IRIS
Aroclor 1260	*Growth*	Rat	7.2	0.325	0.0435	0.0265	54	88	Kimbrough et al. 1975 as cited in ATSDR 1996
Explosives (mg/kg)									
1,3-Dinitrobenzene (DNB)	*Increase in Splenic Weight*	Rat	0.4	0.325	0.0435	0.0265	3.0	4.9	Cody et al. 1981 as cited in IRIS
1,3,5-Trinitrobenzene (TNB)	*Hematopoietic Toxicvity*	Rat	2.68	0.325	0.0435	0.0265	20	33	Reddy et al. 1996 as cited in IRIS
2-Amino-4,6-Dinitrotoluene (2-ADNT)	*LD_{50} / 100*	Rat	13.94	0.325	0.0435	0.0265	104	171	Ellis et al. 1978 as cited in NTIS 1987
2-Nitrotoluene (ONT)									
2,4,6-Trinitrotolune (TNT)	*Liver Effect LOAEL/10*	Dog	0.05	14	0.550	0.435	1.27	1.61	US DOD 1983 as cited in IRIS
3-Nitrotoluene									
4-Amino-2,6-Dinitrotoluene (4-ADNT)	*LD_{50} / 100*	Rat	9.59	0.325	0.0435	0.0265	72	118	Ellis et al. 1978 as cited in NTIS 1987
4-Nitrotoluene (PNT)									
Cyclonite (RDX)	*Inflammation of the Prostate*	Rat	0.3	0.325	0.0435	0.0265	2.2	3.7	US DOD 1983 as cited in IRIS
Cyclotetramethylenetetranitramine (HMX)	*Hepatic Lesions*	Rat	50	0.325	0.0435	0.0265	374	613	US DOD 1985 as cited in IRIS
Nitroglycerin (NG)	*Physiological effect*	Rat	25.5	0.325	0.0435	0.0265	191	313	Normandy et al. 1987 as cited in NTIS 1991
Pentaerythritol tetranitrate (PETN)	*Physiological effect*	Rat	2	0.325	0.0435	0.0265	15	25	Stokinger 1982 as cited in NTIS 1991
Tetryl	*Body Weight*	Rat	14	0.325	0.0435	0.0265	105	172	Reddy et al. 1994 as cited in Talmage et al. 1999
Dioxins/Furans (mg/kg)									

TABLE 3-13
ECOTOXICOLOGY SCREENING VALUES FOR INDIRECT EXPOSURES (INGESTION PATHWAY)
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Effect	Species	Dose (mg/kg-BW/day)	Body Weight (kg)	Water Ingestion (L/day)	Food Ingestion (kg/day)	Water Concentration (mg/L)	Screening Concentration (mg/kg)	Reference
2,3,7,8-TCDD	*Fertility and Pup Survival*	Rat	0.000001	0.325	0.0435	0.0265	7.47E-06	1.23E-05	Murray et al. 1979 as cited in Sample et al. 1996
Total Petroleum Hydrocarbons (mg/kg)									
TPH-Gasoline range organics									
TPH-Diesel range organics									
Metals (mg/kg)									
Aluminum	*Clinical Signs*	Chicken	85	1.7	0.194	0.11	744	1,314	NAS 1980
Antimony	*Growth & Reproduction*	Rat	0.35	0.325	0.0435	0.0265	2.6	4.3	IRIS 1993
Arsenic	*Clinical Signs / Reproduction - 2 year exposure*	Rat	0.7	0.325	0.0435	0.0265	5.2	8.6	Schroeder et al. 1968 as cited in ATSDR 1993
Barium	*Growth*	Rat	33.5	0.325	0.0435	0.0265	250	411	NTP 1994 as cited in IRIS
Beryllium	*Longevity -- lifetime exposure*	Rat	0.66	0.325	0.0435	0.0265	4.9	8.1	Schroeder & Michner as cited in Sample et al. 1996
Cadmium	*Reproduction*	Rat	1	0.325	0.0435	0.0265	7.5	12.3	Sutou et al. 1980 as cited in Sample et al. 1996
Calcium	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
Chromium (Total)	*Reproduction -- 10 month exposure*	Black duck	1	1.25		0.125		10	Haseltine et al. (unpubl.) as cited in Sample et al. 1996
Chromium VI	*Reproduction -- 10 month exposure*	Black duck	1	1.25		0.125		10	Haseltine et al. (unpubl.) as cited in Sample et al. 1996
Cobalt	*Survival & Growth*	Chicken	0.24	1.7	0.194	0.11	2.1	3.7	HSDB, NRC, Drinking Water & Health, Vol1, 1977
Copper	*Reproduction*	Mink	11.7	1.00	0.099	0.137	118	342	Aulerich et al. 1982 as cited in Sample et al. 1996
Iron	*Maintenance dose for healthy felines*	Cat	2.34	3.55		0.104		80	Merck Veterinary Manual, 1998
Lead	*Reproduction*	Japanese Quail	1.13	0.15	0.017	0.017	10	40	Edens et al. 1876 as cited in Sample et al. 1996
Magnesium	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
Manganese	*Reproduction*	Rat	88	0.325	0.0435	0.0265	657	1,079	Laskey et al. 1982 as cited in Sample et al. 1996
Mercury	*Growth -- 2 year exposure*	Rat	0.204	0.325	0.0435	0.0265	1.5	2.5	Fitzhugh et al. 1950 as cited in NAS 1980
Nickel	*Growth and organ weights -- 2 year exposure*	Rat	5	0.325	0.0435	0.0265	37	61	Ambrose et al. As cited in IRIS
Potassium	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
Selenium	*Reproduction -- 2 generation exposure*	Rat	0.2	0.325	0.0435	0.0265	1.5	2.5	Rosenfeld & Beath 1954 as cited in Sample et al. 1996

TA. 3-13
ECOTOXICOLOGY SCREENING VALUES FOR INDIRECT EXPOSURES (INGESTION PATHWAY)
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Effect	Species	Dose (mg/kg-BW/day)	Body Weight (kg)	Water Ingestion (L/day)	Food Ingestion (kg/day)	Water Concentration (mg/L)	Screening Concentration (mg/kg)	Reference
Silver	*Mortality*	Rat	0.67	0.325	0.0435	0.0265	5.0	8.2	HSDB, Schroeder, et al., J. Nutrit. 104: 239, 1974
Sodium	*NA*	NA	NA	NA	NA	NA	NA	NA	NA
Thallium	*No observable effects -- 90-day exposure*	Rat	0.23	0.325	0.0435	0.0265	1.7	2.8	IRIS 1993, Stoltz et al. 1986 also cited in ATSDR 1992
Vanadium	*No observable effects -- lifetime exposure*	Mouse	1.22	0.0325	0.036	0.0058	1.1	6.8	HSDB, Clayton, et al., Patty's Ind. Hyg & Tox. Vol. 2A-2C, 1981-2
Zinc	*No observable adverse effects*	Cattle	7.2	329	7.193	6.401	329	370	Miller et al. 1965 as cited in NAS 1980
Total Cyanide	*Reproduction & Growth*	Rat	68.7	0.325	0.0435	0.0265	513	843	Sample et al. 1996

TABLE 3-14
INGESTION PATHWAY SCREENING CONCENTRATIONS FOR SOILS
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Canada goose	Brown-headed cowbird	American goldfinch	American Robin	American woodcock	American Kestrel	Red-Tailed Hawk	Little Brown Bat	White-tailed deer	White-footed Mouse	Short-tailed Shrew	Coyote
Halogenated Methanes/Alkanes												
Bis(2-chloroethoxy) methane	1.3	0.3	0.3	9.0	11.8	21.6	81.0	4.0	1.1	0.4	0.7	131
Bromodichloromethane	10.8	2.0	1.7	24.3	35.3	36.2	120	6.1	8.6	2.9	3.5	202
Bromoform	422	98.4	87.2	961	1396	1417	4596	171	465	150	159	7835
Bromomethane	3.7	0.8	0.7	22.2	30.5	42.4	151	7.4	3.0	1.1	1.8	248
Carbon tetrachloride (Tetrachloromethane)	44.0	6.1	5.4	40.6	58.5	59.9	185	10.1	34.7	9.7	8.2	323
Chloroform (Trichloromethane)	34.1	6.4	5.6	90.1	131	136	454	22.9	27.0	9.5	11.9	763
Chloromethane	96.3	20.5	18.2	589	794	1252	4562	224	76.3	29.6	45.9	7425
Dibromochloromethane	377	65.8	58.2	730	1061	1081	3545	182	298	99.4	112	6009
Methylene chloride	18.9	3.9	3.5	98.3	138	173	607	29.9	15.0	5.7	8.6	1000
Halogenated Ethanes												
1,1-Dichloroethane	280	54.1	47.9	905	1308	1390	4704	236	222	79.8	107	7859
1,1,1-Trichloroethane	13561	2186	1938	19474	28239	28676	92054	4836	10706	3358	3385	157695
1,1,2-Trichloroethane	21.8	4.0	3.5	52.1	75.7	77.9	259	13.2	17.3	6.0	7.2	436.1
1,1,2,2-Tetrachloroethane	12.5	1.9	1.7	14.9	21.8	21.9	70.1	3.7	9.9	3.0	2.8	120.6
1,2-Dichloroethane	93.4	18.9	16.7	411	585	673	2325	115	74.0	27.6	40.0	3853
Chloroethane	5856	1187	1050	25524	36284	42167	145905	7223	4639	1731	2503	241637
Hexachloroethane	640	38.7	34.5	126	173	192	475	32.7	522.4	68.1	31.7	927
Halogenated Propanes												
1,2-Dichloropropane	2722	503	446	6906	10029	10368	34614	1752	2153	750	930	58189
2,2'-Oxybis (1-chloropropane)												
Halogenated Alkenes												
1,1-Dichloroethene	12.8	2.1	1.9	20.7	30.3	30.7	100.6	5.2	10.1	3.2	3.5	171
1,2-Dichloroethene (total)												
1,2-Dichloroethene (cis)	230	44.5	39.4	743	1074	1143	3870	194	182	65.7	87.6	6465
1,2-Dichloroethene (trans)	230	44.5	39.4	743	1074	1143	3870	194	182	65.7	87.6	6465
1,3-Dichloropropene (total)												
1,3-Dichloropropene (cis)	107	17.6	15.6	144	205	241	808	41.3	84.6	27.0	26.2	1371
1,3-Dichloropropene (trans)	112	15.7	14.0	95.7	137	158	513	27.0	87.3	24.8	20.2	887
Tetrachloroethene	2793	293	260	1338	1882	158	5685	341	2220	484	307	10353
Trichloroethene	125	1.9	1.7	15.1	21.9	22.2	70.4	37.5	9.8	3.0	2.8	122

Soil C3 compared to Soil E3

TAI 3-14
INGESTION PATHWAY SCREENING CONCENTRATIONS FOR SOILS
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Canada goose	Brown-headed cowbird	American goldfinch	American Robin	American woodcock	American Kestrel	Red-Tailed Hawk	Little Brown Bat	White-tailed deer	White-footed Mouse	Short-tailed Shrew	Coyote
Vinyl chloride	0.3	0.1	0.1	0.7	0.9	1.9	7.3	0.4	0.3	0.1	0.1	11.8
Amines												
2-Nitroaniline	59.2	11.4	10.1	183	265	281	949	47.6	46.8	16.8	22.1	1587
3-Nitroaniline	4.6	1.0	0.8	24.0	33.7	42.2	148	7.3	3.7	1.4	2.1	244
3,3'-Dichlorobenzidine	177	17.1	15.2	78.2	114	114	332	19.1	137.3	28.7	18.6	603
4-Chloroaniline	9.4	1.3	1.2	9.1	13.3	13.7	44.1	2.3	7.4	2.1	1.8	76.3
4-Nitroaniline	2.7	0.6	0.5	14.1	19.7	24.7	86.5	4.3	2.1	0.8	1.2	143
4,4'-Methylenebis (2-chlorobenzenamine)-MOCA												
N-Nitrosodiphenylamine	578	69.3	61.5	370	528	550	1626	92.9	457	112	81.0	2901
N-Nitroso-di-n-propylamine	1.9	0.4	0.3	7.7	10.9	13.0	45.2	2.2	1.5	0.6	0.8	74.9
Benzene and Derivatives												
Benzene	173	31.0	27.4	372	542	554	1831	93.5	137	46.5	54.5	3093
Chlorobenzene	3313	465	413	3112	4465	4600	14161	777	2616	734	620	24743
1,2-Dichlorobenzene	9983	467	416	1576	2331	2265	5948	379	7352	842	424	11609
1,2,4-Trichlorobenzene	5886	281	251	912	1312	1343	3398	226	4521	505	241	6686
1,3-Dichlorobenzene	6492	653	580	2832	3939	4298	11883	730	5194	1086	656	21821
1,4-Dichlorobenzene	917	28.7	25.5	90.4	135	129	329	21.5	633	52.9	25.2	662
Hexachlorobenzene	261	26.1	23.2	48.4	51.4	104	165	19.8	381	41.9	10.2	341
Methylated Benzenes												
Toluene	1084	166	147	1312	1895	1933	6106	326	855	258	242	10538
Xylenes (total)	69923	14757	13052	265249	292425	547696	1241875	100080	56588	21243	25972	2241215
Other Substituted Benzenes												
Ethylbenzene	11805	1444	1281	7830	11114	11669	34460	1974	9343	2332	1696	61423
Styrene	35581	4961	4400	32746	46991	48397	148770	8172	28095	7836	6567	260175
Nitrobenzene	25.0	4.7	4.2	71.3	103	109	365	18.4	19.8	7.0	9.0	612
Arenes												
2,4-Dinitrotolune	5.6	1.0	0.9	13.3	19.3	19.9	66.4	3.4	4.4	1.5	1.9	112
2,6-Dinitrotolune	32.8	6.1	5.4	82.4	119	127	430	21.6	25.9	9.1	11.2	721
Chlorinated Dienes												
Hexachlorobutadiene	4086	320	285	793	937	1450	2849	260	4370	540	180	5756
Hexachlorocyclopentadiene	5625	413	367	1425	1946	2200	5563	375	4613	712	350	10663

TABLE 3-14
INGESTION PATHWAY SCREENING CONCENTRATIONS FOR SOILS
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Canada goose	Brown-headed cowbird	American goldfinch	American Robin	American woodcock	American Kestrel	Red-Tailed Hawk	Little Brown Bat	White-tailed deer	White-footed Mouse	Short-tailed Shrew	Coyote
Ethers												
4-Bromophenyl phenyl ether												
4-Chlorophenyl phenyl ether												
Bis (2-chloroethyl) ether	61.0	12.5	11.1	238	325	477	1712	84.4	48.3	18.2	25.3	2808
Phenols and Substituted Phenols												
2-Chlorophenol	73.2	11.7	10.3	102	149	150	489	25.3	57.7	18.0	18.0	835
2-Methylphenol	503	93.4	82.7	1301	1889	1959	6556	331	398	139	174	11013
2-Nitrophenol	24.9	4.7	4.2	72.1	104	110	373	18.7	19.7	7.0	9.0	624
2,4-Dichlorophenol	162	20.8	18.4	122	175	180	544	30.3	128	33.3	25.8	960
2,4-Dimethylphenol	460	74.5	66.1	675	985	993	3224	167	363	114	117	5508
2,4-Dinitrophenol	60.2	11.6	10.3	187	269	291	991	49.5	47.6	17.1	22.6	1654
2,4,5-Trichlorophenol	36068	3394	3017	13626	18688	20972	56071	3574	29183	5688	3198	104293
2,4,6-Trichlorophenol	802	89.3	79.3	428	600	646	1840	109.5	639	146.3	96.2	3330
4-Chloro-3-methylphenol	277	36.9	32.7	225	322	334	1011	56.4	219	58.7	46.6	1781
4-Methylphenol	494	91.6	81.1	1275	1851	1921	6431	325	390	136.5	170	10801
4-Nitrophenol	208	39.6	35.0	608	881	925	3118	157	165	58.6	75.9	5220
4,6-Dinitro-2-Methylphenol	49.9	8.6	7.6	90.6	132	134	437	22.6	39.4	13.0	14.3	743
Pentachlorophenol	10544	5956	5278	3998	3152	25964	17056	13108	18165	5274.5	643	35173
Phenol	258	52.2	46.2	1112	1584	1821	6290	312	205	76.2	110	10423
Ketones (Carbonyl Compounds)												
2-Butanone	2989	658	582	18343	22829	70415	305846	15169	2373	939	1444	470613
2-Hexanone	42.5	8.6	7.6	183	260	308	1068	52.8	33.7	12.6	18.1	1767
4-Methyl-2-pentanone (MIBK)												
Acetone	155	34.7	30.7	689	825	4666	30183	1535	123	49.3	69.1	39914
Isophorone	2469	446	395	5413	7846	8373	28222	1420	1950	669	790	47426
Low Molecular Weight PAHs												
2-Chloronaphthalene	74366	6210	5524	21640	28737	34415	85554	5915	62444	10540	5138	163295
2-Methylnaphthalene												
Acenaphthene	32610	2933	2608	11347	15508	17523	46189	2989	26501	4944	2686	86475
Acenaphthylene												
Anthracene	48440	1437	1281	4472	6655	6417	16170	1068	33464	2659	1245	32760

TAl 3-14
INGESTION PATHWAY SCREENING CONCENTRATIONS FOR SOILS
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Canada goose	Brown-headed cowbird	American goldfinch	American Robin	American woodcock	American Kestrel	Red-Tailed Hawk	Little Brown Bat	White-tailed deer	White-footed Mouse	Short-tailed Shrew	Coyote
Carbazole	7.5	1.3	1.2	2.6	3.2	13.7	61.1	3.6	6.0	1.9	0.7	99.6
Dibenzofuran	3049	220	195	734	992	1147	2840	196	2538	379	180	5479
Fluorene	28192	1487	1324	4833	6848	7209	18127	1219	22198	2648	1255	35515
Naphthalene	10327	1037	922	4703	6714	6967	19928	1177	8136	1727	1100	36288
Phenanthrene	2180	91.5	81.5	279	395	418	1013	70.6	1718	166	73.9	2029
High Molecular Weight PAHs												
Benzo(a)anthracene												
Benzo(a)pyrene	218	6.8	6.1	20.6	30.0	30.2	74.3	5.1	160	12.6	5.6	151
Benzo(ghi)perylene												
Benzo(b,k)fluoranthene												
Chrysene												
Dibenzo(a,h)anthracene												
Fluoranthene	34733	1193	1064	3596	5167	5311	12880	892	26304	2188	972	26123
Indeno(1,2,3-cd)pyrene												
Pyrene	11477	360	321	1106	1621	1606	3979	268	8249	665	304	8070
Phthalates												
Bis (2-ethylhexyl) phthalate	1694	9384	8361	491	377	4056	2105	7155	5393	1328	79.1	4350
Butylbenzylphthalate	33716	1610	1434	5376	7871	7789	20227	1307	25218	2895	1435	39541
Diethyl phthalate	21690	3429	3039	29251	42513	42993	137870	7247	17110	5288	5213	236566
Dimethyl phthalate	0.0173	0.0005	0.0005	0.0014	0.0020	0.0022	0.0056	0.0004	0.0119	0.0009	0.0004	0.0115
Di-n-butyl phthalate	195891	14721	13106	40288	49563	69945	148191	12321	190512	25095	9379	295477
Di-n-octyl phthalate	2034470	837661	746504	514051	432829	2105112	1821155	620010	5252176	843420	89655	3770232
Miscellaneous Solvents												
Carbon disulfide	154.1	28.4	25.1	380	552	572	1914	96.7	122	42.3	52.0	3217
Pesticides (mg/kg)												
4,4'-DDD												
4,4'-DDE												
4,4'-DDT	212	45.0	40.1	47.6	43.4	145	162	33.4	454	59.4	8.9	335.6
DDT (Total)												
Aldrin	12.0	40.1	35.7	3.5	2.7	28.1	15.0	38.2	36.4	9.0	0.6	30.9
a-BHC	463	48.9	43.5	199	263	319	827	54.9	383	80.5	44.8	1538

TABLE 3-14
INGESTION PATHWAY SCREENING CONCENTRATIONS FOR SOILS
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Canada goose	Brown-headed cowbird	American goldfinch	American Robin	American woodcock	American Kestrel	Red-Tailed Hawk	Little Brown Bat	White-tailed deer	White-footed Mouse	Short-tailed Shrew	Coyote
b-BHC	823	50.6	45.0	176	252	260	680	43.9	642	89.0	45.2	1308
d-BHC												
g-BHC (Lindane)	99.3	7.7	6.9	28.9	40.5	43.4	116	7.4	79.1	13.3	7.1	217.9
a-Chlordane												
g-Chlordane												
Chlordane (Technical)	215	35.7	31.8	56.4	54.3	151.2	207	31.4	316	51.6	10.8	424
Dieldrin	17.8	3.3	2.9	4.4	4.2	12.8	16.0	2.8	29.7	4.6	0.8	33.0
Endosulfan I												
Endosulfan II												
Endosulfan	728	75.3	66.9	300	396	482	1241	82.9	604	124	67.9	2314
Endosulfan sufate												
Endrin	122	6.6	5.9	17.2	21.9	28.7	60.4	5.0	120	11.6	4.2	123.2
Endrin aldehyde												
Endrin ketone												
Heptachlor	420	33.6	30.0	72.1	81.5	140	248	25.7	532	56.2	16.0	510
Heptachlor epoxide	10.7	1.4	1.2	2.3	2.3	5.5	8.1	1.1	15.9	2.1	0.5	16.7
Isodrin												
Methoxychlor	11548	705	628	1912	2424	3197	6853	558	11106	1230	461	13814
Toxaphene	17.7	0.6	0.5	1.9	2.8	2.7	6.8	0.4	12.3	1.1	0.5	13.6
PCBs (mg/kg)												
Aroclor 1016	2.6	0.1	0.1	0.3	0.4	0.4	0.9	0.1	1.8	0.2	0.1	1.9
Aroclor 1221												
Aroclor 1248												
Aroclor 1254	23.2	1.2	1.1	3.0	3.8	5.1	10.4	0.9	24.5	2.1	0.7	21.5
Aroclor 1260	21136	1493	1330	3213	3699	6080	10896	1106	27197	2534	729	22594
Explosives (mg/kg)												
1,3-Dinitrobenzene (DNB)	1.8	0.4	0.4	41.4	56.2	70.8	233	12.2	1.5	0.6	1.1	387
1,3,5-Trinitrobenzene (TNB)	7.9	1.6	1.4	30.8	43.0	55.8	197	9.7	6.3	2.3	3.3	324
2-Amino-4,6-Dinitrotoluene (2-ADNT)												
2-Nitrotoluene (ONT)												
2,4,6-Trinitrotolune (TNT)	0.6	0.1	0.1	0.3	0.4	0.5	1.5	0.1	0.5	0.1	0.1	2.6

TA 3-14
INGESTION PATHWAY SCREENING CONCENTRATIONS FOR SOILS
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Canada goose	Brown-headed cowbird	American goldfinch	American Robin	American woodcock	American Kestrel	Red-Tailed Hawk	Little Brown Bat	White-tailed deer	White-footed Mouse	Short-tailed Shrew	Coyote
3-Nitrotoluene												
4-Amino-2,6-Dinitrotoluene (4-ADNT)												
4-Nitrotoluene (PNT)												
Cyclonite (RDX)	0.7	0.1	0.1	3.3	4.5	7.3	26.7	1.3	0.5	0.2	0.3	43.4
Cyclotetramethylenetetranitramine (HMX)												
Nitroglycerin (NG)												
Pentaerythritol tetranitrate (PETN)												
Tetryl												
Dioxins/Furans (mg/kg)												
1,2,3,7,8-PeCDD												
1,2,3,4,6,7,8-HpCDD												
1,2,3,4,6,7,8-HpCDF												
1,2,3,4,7,8-HxCDD												
1,2,3,4,7,8,8-HpCDF												
1,2,3,4,7,8-HxCDF												
1,2,3,6,7,8-HxCDD												
1,2,3,6,7,8-HxCDF												
1,2,3,7,8-PeCDF												
1,2,3,7,8,9-HxCDD												
1,2,3,7,8,9-HxCDF												
2,3,4,6,7,8-HxCDF												
2,3,4,7,8-PeCDF												
2,3,7,8-TCDD	0.00019	0.00001	0.00001	0.00002	0.00003	0.00003	0.00007	0.000004	0.00014	0.00001	0.000005	0.000129
2,3,7,8-TCDF												
OCDD												
OCDF												
Total Petroleum Hydrocarbons (mg/kg)												
TPH-Gasoline range organics												
TPH-Diesel range organics												
Metals (mg/kg)												
Aluminum												

TABLE 3-14
INGESTION PATHWAY SCREENING CONCENTRATIONS FOR SOILS
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Canada goose	Brown-headed cowbird	American goldfinch	American Robin	American woodcock	American Kestrel	Red-Tailed Hawk	Little Brown Bat	White-tailed deer	White-footed Mouse	Short-tailed Shrew	Coyote
Antimony												
Arsenic	2284	847	833	212	242	637	59569	115	3887	761	54.7	5282
Barium	56565	11667	10529	13123	14416	37555	131899	7703	60774	15721	3043	146052
Beryllium	2862	3149	3026	542	503	532	478	540	7024	1631	97.8	593
Cadmium	496.0	62.4	67.3	11.1	14.5	28.4	140	4.8	527	62.8	3.4	424
Calcium												
Chromium (Total)	2555	859	864	192	226	473	1980	98.0	4268	771	50.9	1842
Chromium VI												
Cobalt												
Copper	52368	10848	10366	4175	5112	10218	10120	1990	61761	12593	1152.9	40052
Iron												
Lead	126	17.5	15.4	865	1004	2283	5181	452	98.3	28.2	54.2	9649
Magnesium												
Manganese												
Mercury												
Nickel	16636	4559	6318	385	488	998	3617	174	42012	2913	114.5	8873
Potassium												
Selenium	106	15.9	14.5	16.5	20.9	44.2	78.6	7.5	92.3	22.9	4.6	420
Silver	1971	383	602	27.4	35.4	72.0	1090	12.1	6292	234	8.4	1222.5
Sodium												
Thallium												
Vanadium	2558	4784	4889	471	434	1836	10097	488	7162	1615	93.7	4339
Zinc	24033	3423	3502	797	1037	1881	8189	347	24958	3731	241	11719
Total Cyanide												

TABLE 3-15
INGESTION PATHWAY SCREENING CONCENTRATIONS FOR SEDIMENTS
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Red-Winged Blackbird	Tree Swallow	Great Blue Heron	Muskrat	Little Brown Bat	Mink
Halogenated Methanes/Alkanes (mg/kg)						
Bis(2-chloroethoxy) methane	1.6	0.4	1.9	5.3	0.3	2.3
Bromodichloromethane	8.0	2.2	9.2	26.0	1.8	10.7
Bromoform	234	91.7	269	1062	72.2	433
Bromomethane	4.8	1.4	5.7	16.0	1.1	6.8
Carbon tetrachloride (Tetrachloromethane)	14.3	4.0	16.3	45.9	3.2	18.3
Chloroform (Trichloromethane)	28.7	8.0	33.3	93.9	6.3	38.9
Chloromethane	116	32.2	136	383	25.3	163
Dibromochloromethane	244	68.4	282	795	53.8	326
Methylene chloride	23.8	6.6	27.9	78.6	5.2	33.2
Halogenated Ethanes (mg/kg)						
1,1-Dichloroethane	276	77.0	321	905	60.6	378
1,1,1-Trichloroethane	6705	1880	7685	21684	1481	8808
1,1,2-Trichloroethane	16.9	4.7	19.6	55.3	3.7	22.9
1,1,2,2-Tetrachloroethane	5.1	1.4	5.8	16.5	1.1	6.6
1,2-Dichloroethane	111	30.9	130	366	24.4	154
Chloroethane	6791	1893	7942	22395	1491	9417
Hexachloroethane	46.6	13.3	51.3	142	10.5	54.4
Halogenated Propanes (mg/kg)						
1,2-Dichloropropane	2218	620	2571	7256	488	3003
2,2'-Oxybis (1-chloropropane)						
Halogenated Alkenes (mg/kg)						
1,1-Dichloroethene	5.1	1.9	7.8	22.3	1.5	9.0
1,2-Dichloroethene (total)						
1,2-Dichloroethene (cis)	170	63.0	263	741	49.6	309
1,2-Dichloroethene (trans)	170	63.0	263	741	49.6	309
1,3-Dichloropropene (total)						
1,3-Dichloropropene (cis)	27.5	10.2	41.9	121.7	8.0	48.1
1,3-Dichloropropene (trans)	18.8	7.0	28.3	83.1	5.5	31.9
Tetrachloroethene	367	138	545	1515	109	600
Trichloroethene	39.6	1.5	60.1	17.0	1.2	6.8
Vinyl chloride	0.1	0.0	0.1	0.4	0.0	0.2
Amines (mg/kg)						
2-Nitroaniline	42.2	15.7	65.4	184	12.4	76.8
3-Nitroaniline	4.4	1.6	6.9	19.3	1.3	8.2
3,3'-Dichlorobenzidine	20.7	7.7	30.5	89.2	6.1	33.4
4-Chloroaniline	2.1	0.8	3.1	9.2	0.6	3.5
4-Nitroaniline	2.6	1.0	4.0	11.3	0.8	4.8
4,4'-Methylenebis (2-chlorobenzenamine)-MOCA						
N-Nitrosodiphenylamine	100	37.5	150	420	29.5	166
N-Nitroso-di-n-propylamine	1.5	0.6	2.3	6.5	0.4	2.7
Benzene and Derivatives (mg/kg)						
Benzene	92.2	34.3	141.9	401	27.0	164.9
Chlorobenzene	830	311	1253	3515	245	1414

TABLE 3-15
INGESTION PATHWAY SCREENING CONCENTRATIONS FOR SEDIMENTS
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Red-Winged Blackbird	Tree Swallow	Great Blue Heron	Muskrat	Little Brown Bat	Mink
1,2-Dichlorobenzene	414	154	599	1813	121	628
1,2,4-Trichlorobenzene	246	92.2	357	1043	72.6	374
1,3-Dichlorobenzene	786	297	1165	3198	233.7	1278
1,4-Dichlorobenzene	23.6	8.7	33.9	104	6.9	34.9
Hexachlorobenzene	18.8	8.1	28.1	49.7	6.4	30.5
Methylated Benzenes (mg/kg)						
Toluene	344	129	523	1472	101	596
Xylenes (total)	96544	40430	154452	275560	31838	189984
Other Substituted Benzenes (mg/kg)						
Ethylbenzene	2123	797	3179	8867	628	3541
Styrene	8726	3269	13179	36996	2574	14861
Nitrobenzene	16.6	6.2	25.7	72.7	4.9	30.2
Arenes (mg/kg)						
2,4-Dinitrotolune	3.2	1.2	4.9	13.9	0.9	5.7
2,6-Dinitrotolune	18.4	6.8	28.5	81.0	5.4	33.2
Chlorinated Dienes (mg/kg)						
Hexachlorobutadiene	264	106	390	849	83.5	419
Hexachlorocyclopentadiene	403	153	591	1602	120	634
Ethers (mg/kg)						
4-Bromophenyl phenyl ether						
4-Chlorophenyl phenyl ether						
Bis (2-chloroethyl) ether	36.9	13.7	57.6	163	10.8	68.5
Phenols and Substituted Phenols (mg/kg)						
2-Chlorophenol	25.1	9.3	38.2	110	7.3	43.7
2-Methylphenol	311	116	480	1356	91.1	561
2-Nitrophenol	16.5	6.1	25.6	72.3	4.8	30.0
2,4-Dichlorophenol	32.5	12.2	48.8	138	9.6	54.6
2,4-Dimethylphenol	171	63.6	260	742	50.1	298
2,4-Dinitrophenol	41.2	15.3	63.8	181	12.0	74.9
2,4,5-Trichlorophenol	3834	1454	5674	15331	1145	6193
2,4,6-Trichlorophenol	117.9	44.4	176	484	35.0	194
4-Chloro-3-methylphenol	60.5	22.7	91.0	255	17.9	102
4-Methylphenol	304	113	469	1326	89.0	548
4-Nitrophenol	141.9	52.8	220	620	41.6	257
4,6-Dinitro-2-Methylphenol	23.0	8.6	35.2	99.3	6.7	40.7
Pentachlorophenol	3737	5351	6907	3620	4214	10869
Phenol	225.2	83.7	351	989	65.9	416
Ketones (Carbonyl Compounds) (mg/kg)						
2-Butanone	1920	712	3022	8498	561	3641
2-Hexanone	35.7	13.3	55.7	157	10.4	66.0
4-Methyl-2-pentanone (MIBK)						
Acetone	62.4	23.1	98.4	277	18.2	119
Isophorone	1202	446	1850	5287	351	2152

TABLE 3-15
INGESTION PATHWAY SCREENING CONCENTRATIONS FOR SEDIMENTS
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Red-Winged Blackbird	Tree Swallow	Great Blue Heron	Muskrat	Little Brown Bat	Mink
Low Molecular Weight PAHs (mg/kg)						
2-Chloronaphthalene	6291	2411	9276	24109	1899	10044
2-Methylnaphthalene						
Acenaphthene	3204	1217	4734	12755	958	5150
Acenaphthylene						
Anthracene	1174	436	1686	5172	343	1733
Carbazole	0.2	0.1	0.4	1.1	0.1	0.4
Dibenzofuran	210	80.0	308	823	63.0	330
Fluorene	1322	497	1920	5501	391	2023
Naphthalene	1272	477	1885	5346	376	2065
Phenanthrene	76.6	28.8	111	318	22.7	115
High Molecular Weight PAHs (mg/kg)						
Benzo(a)anthracene						
Benzo(a)pyrene	5.5	2.1	7.9	23.7	1.6	8.2
Benzo(ghi)perylene						
Benzo(b,k)fluoranthene						
Chrysene						
Dibenzo(a,h)anthracene						
Fluoranthene	972	364	1401	4114	287	1446
Indeno(1,2,3-cd)pyrene						
Pyrene	294	109	423	1273	86.2	435
Phthalates (mg/kg)						
Bis (2-ethylhexyl) phthalate	544	2921	1072	439	2300	1980
Butylbenzylphthalate	1427	532	2067	6177	419	2169
Diethyl phthalate	7549	2815	11493	32569	2217	13139
Dimethyl phthalate	0.0003	0.0001	0.0004	0.0012	0.0001	0.0004
Di-n-butyl phthalate	12740	5027	18771	43737	3959	20147
Di-n-octyl phthalate	357099	253065	594863	479595	199289	752790
Miscellaneous Solvents (mg/kg)						
Carbon disulfide	90.5	33.7	140	395	26.5	163
Pesticides (mg/kg)						
4,4'-DDD						
4,4'-DDE						
4,4'-DDT	25.6	13.6	40.3	46.0	10.7	46.6
DDT (Total)						
Aldrin	3.8	15.6	7.5	3.1	12.3	13.5
a-BHC	58.2	22.3	86.7	221	17.6	95.5
b-BHC	47.7	17.9	69.5	201	14.1	73.9
d-BHC						
g-BHC (Lindane)	8.0	3.0	11.7	32.7	2.4	12.6
a-Chlordane						
g-Chlordane						
Chlordane (Technical)	26.6	12.8	41.2	55.8	10.1	47.3
Dieldrin	2.2	1.1	3.5	4.3	0.9	4.1

TABLE 3-15
INGESTION PATHWAY SCREENING CONCENTRATIONS FOR SEDIMENTS
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Red-Winged Blackbird	Tree Swallow	Great Blue Heron	Muskrat	Little Brown Bat	Mink
Endosulfan I						
Endosulfan II						
Endosulfan	87.9	33.7	131	334	26.6	144
Endosulfan sufate						
Endrin	5.2	2.0	7.6	18.9	1.6	8.0
Endrin aldehyde						
Endrin ketone						
Heptachlor	25.4	10.5	37.7	75.9	8.3	40.3
Heptachlor epoxide	1.0	0.4	1.5	2.3	0.3	1.6
Isodrin						
Methoxychlor	584	228	854	2098	179	904
Toxaphene	0.5	0.2	0.7	2.1	0.1	0.7
PCBs (mg/kg)						
Aroclor 1016	0.1	0.0	0.1	0.3	0.0	0.1
Aroclor 1221						
Aroclor 1248						
Aroclor 1254	0.9	0.4	1.4	3.3	0.3	1.4
Aroclor 1260	1106	451	1631	3406	355	1728
Explosives (mg/kg)						
1,3-Dinitrobenzene (DNB)	8.9	3.4	14.1	37.3	2.6	17.1
1,3,5-Trinitrobenzene (TNB)	5.4	2.0	8.4	23.7	1.6	9.9
2-Amino-4,6-Dinitrotoluene (2-ADNT)						
2-Nitrotoluene (ONT)						
2,4,6-Trinitrotolune (TNT)	0.1	0.0	0.1	0.3	0.0	0.1
3-Nitrotoluene						
4-Amino-2,6-Dinitrotoluene (4-ADNT)						
4-Nitrotoluene (PNT)						
Cyclonite (RDX)	0.5	0.2	0.7	2.1	0.1	0.9
Cyclotetramethylenetetranitramine (HMX)						
Nitroglycerin (NG)						
Pentaerythritol tetranitrate (PETN)						
Tetryl						
Dioxins/Furans (mg/kg)						
1,2,3,7,8-PeCDD						
1,2,3,4,6,7,8-HpCDD						
1,2,3,4,6,7,8-HpCDF						
1,2,3,4,7,8-HxCDD						
1,2,3,4,7,8,8-HpCDF						
1,2,3,4,7,8-HxCDF						
1,2,3,6,7,8-HxCDD						
1,2,3,6,7,8-HxCDF						
1,2,3,7,8-PeCDF						
1,2,3,7,8,9-HxCDD						
1,2,3,7,8,9-HxCDF						

TABLE 3-15
INGESTION PATHWAY SCREENING CONCENTRATIONS FOR SEDIMENTS
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Red-Winged Blackbird	Tree Swallow	Great Blue Heron	Muskrat	Little Brown Bat	Mink
2,3,4,6,7,8-HxCDF						
2,3,4,7,8-PeCDF						
2,3,7,8-TCDD	0.000005	0.000002	0.000007	0.000020	0.000001	0.000007
2,3,7,8-TCDF						
OCDD						
OCDF						
Total Petroleum Hydrocarbons (mg/kg)						
TPH-Gasoline range organics						
TPH-Diesel range organics						
Metals (mg/kg)						
Aluminum						
Antimony						
Arsenic	356	229	1140	605	180	972
Barium	1366	428	3940	7067	337	2260
Beryllium	455	256	523	697	202	256
Cadmium	81.3	77.9	158	186	61.3	74.9
Calcium						
Chromium (Total)	463	381	1096	710	300	726
Chromium VI						
Cobalt						
Copper	2406	836	5057	9702	659	2686
Iron						
Lead	22.1	2153	3848	43.4	1695	2406
Magnesium						
Manganese						
Mercury						
Nickel	1338	481	2186	3757	341	1213
Potassium						
Selenium	1.6	0.5	4.6	9.9	0.4	2.6
Silver	40.8	11.9	103	228	9.4	59.1
Sodium						
Thallium						
Vanadium	84.3	26.0	221	349	20.5	135
Zinc	1755	728	4441	6194	573	2306
Total Cyanide						

TABLE 3-16
INGESTION PATHWAY SCREENING CONCENTRATIONS FOR SURFACE WATER
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Canada goose	American Kestrel	Brown-headed cowbird	American goldfinch	Great Blue Heron	Red-winged blackbird	Robin	Tree Swallow	American woodcock	Red-Tailed Hawk
Halogenated Methanes/Alkanes (ug/L)										
Bis(2-chloroethoxy) methane	3.7	5.4	4.1	2.6	91.4	25.7	4.7	19.4	6.4	11.5
Bromodichloromethane	10.1	14.8	11.2	7.2	18.0	8.5	13.1	6.5	17.5	31.5
Bromoform	101	148	112	71.6	1242	707	131	535	175	315
Bromomethane	7.9	11.6	8.8	5.6	182	55.3	10.2	41.8	13.7	24.7
Carbon tetrachloride (Tetrachloromethane)	4.0	5.9	4.5	2.8	33.0	28.0	5.2	21.2	6.9	12.5
Chloroform (Trichloromethane)	7.3	10.7	8.1	5.2	400	174	9.4	131	12.6	22.7
Chloromethane	237	348	263	168	5654	1659	306	1255	411	740
Dibromochloromethane	121	177	134	85.6	1643	845	156	640	209	377
Methylene chloride	33.0	48.5	36.7	23.4	722	231	42.7	175	57.2	103
Halogenated Ethanes (ug/L)										
1,1-Dichloroethane	216	317	240	153	3827	1509	279	1142	374	673
1,1,1-Trichloroethane	5649	8286	6271	4000	7726	4772	7292	3611	9778	17621
1,1,2-Trichloroethane	22.0	32.3	24.5	15.6	40.6	18.6	28.4	14.1	38.1	68.7
1,1,2,2-Tetrachloroethane	6.4	9.4	7.1	4.6	7.7	5.4	8.3	4.1	11.1	20.1
1,2-Dichloroethane	97.2	142.5	108	68.8	2316	796	125	603	168	303
Chloroethane	5649	8286	6271	4000	161307	55446	7292	41959	9778	17621
Hexachloroethane	5.6	8.3	6.3	4.0	7.3	39.5	7.3	29.9	9.8	17.6
Halogenated Propanes (ug/L)										
1,2-Dichloropropane	1412	2071	1568	1000	22264	9873	1823	7471	2444	4405
2,2'-Oxybis (1-chloropropane)										
Halogenated Alkenes (ug/L)										
1,1-Dichloroethene	5.1	7.5	5.6	3.6	62.4	35.5	6.6	26.9	8.8	15.9
1,2-Dichloroethene (total)										
1 [illegible]loroethene (cis)	181	265	201	[illegible]28	3206	1264	233	956	313	[illegible]64

TABLE 3-16
INGESTION PATHWAY SCREENING CONCENTRATIONS FOR SURFACE WATER
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Canada goose	American Kestrel	Brown-headed cowbird	American goldfinch	Great Blue Heron	Red-winged blackbird	Robin	Tree Swallow	American woodcock	Red-Tailed Hawk
1,2-Dichloroethene (trans)	181	265	201	128	3206	1264	233	956	313	564
1,3-Dichloropropene (total)	16.9	24.9	18.8	12.0			21.9		29.3	52.9
1,3-Dichloropropene (cis)	169	249	188	120	2017	1185	219	897	293	529
1,3-Dichloropropene (trans)	169	249	188	120	1467	1185	219	897	293	529
Tetrachloroethene	79.1	116	87.8	56.0	362	553	102	418	137	247
Trichloroethene	39.5	58.0	43.9	28.0	48.2	33.4	51.0	25.3	68.4	123
Vinyl chloride	1.0	1.4	1.1	0.7	19.1	6.7	1.2	5.1	1.7	3.0
Amines (ug/L)										
2-Nitroaniline	42.4	62.1	47.0	30.0	969	389	54.7	294	73.3	132
3-Nitroaniline	17.4	25.5	19.3	12.3	45.9	14.7	22.5	11.1	30.1	54.3
3,3'-Dichlorobenzidine	4.5	6.6	5.0	3.2	64.0	108	5.8	81.5	7.8	14.1
4-Chloroaniline	7.1	10.4	7.8	5.0	61.7	49.4	9.1	37.4	12.2	22.0
4-Nitroaniline	25.4	37.3	28.2	18.0	71.5	22.9	32.8	17.3	44.0	79.3
4,4'-Methylenebis (2-chlorobenzenamine)-MOCA										
N-Nitrosodiphenylamine	28.2	41.4	31.4	20.0	171	197	36.5	149	48.9	88.1
N-Nitroso-di-n-propylamine	2.9	4.2	3.2	2.0	57.8	20.1	3.7	15.2	5.0	9.0
Benzene and Derivatives (ug/L)										
Benzene	149	219	166	106	260	126	193	95.3	258	465
Chlorobenzene	107	157	119	76.0	3061	2556	139	1935	186	335
1,2-Dichlorobenzene	484	710	537	343	440	3384	625	2561	838	1510
1,2,4-Trichlorobenzene	83.6	123	92.8	59.2	68.0	584	108	442	145	261
1,3-Dichlorobenzene	141	207	157	100	587	987	182	747	244	441
1,4-Dichlorobenzene	169	249	188	120	25.2	1185	219	897	293	529
Hexachlorobenzene	0.5	0.7	0.5	0.3	0.1	3.2	0.6	2.4	0.8	1.4
Methylated Benzenes (ug/L)										

TABLE 3-16
INGESTION PATHWAY SCREENING CONCENTRATIONS FOR SURFACE WATER
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Canada goose	American Kestrel	Brown-headed cowbird	American goldfinch	Great Blue Heron	Red-winged blackbird	Robin	Tree Swallow	American woodcock	Red-Tailed Hawk
Toluene	147	215	163	104	1481	1027	190	777	254	458
Xylenes (total)	202	296	224	143	59588	19747	260	14944	349	629
Other Substituted Benzenes (ug/L)										
Ethylbenzene	549	805	609	388	3438	3835	708	2902	949	1711
Styrene	1130	1657	1254	800	31701	26909	1458	20364	1956	3524
Nitrobenzene	16.9	24.9	18.8	12.0	284	118	21.9	89.7	29.3	52.9
Arenes (ug/L)										
2,4-Dinitrotolune	1.1	1.7	1.3	0.8	58.7	26.9	1.5	20.4	2.0	3.5
2,6-Dinitrotolune	62.1	91.1	69.0	44.0	120	52.5	80.2	39.7	108	194
Chlorinated Dienes (ug/L)										
Hexachlorobutadiene	11.3	16.6	12.5	8.0	10.3	79.0	14.6	59.8	19.6	35.2
Hexachlorocyclopentadiene	56.5	82.9	62.7	40.0	114.9	395	72.9	299	97.8	176
Ethers (ug/L)										
4-Bromophenyl phenyl ether										
4-Chlorophenyl phenyl ether										
Bis (2-chloroethyl) ether	141	207	157	100	2963	984	182	745	244	441
Phenols and Substituted Phenols (ug/L)										
2-Chlorophenol	28.2	41.4	31.4	20.0	314	197	36.5	149	48.9	88.1
2-Methylphenol	282	414	314	200	4500	1975	365	1494	489	881
2-Nitrophenol	18.9	27.7	20.9	13.4	319	132	24.4	99.8	32.7	58.9
2,4-Dichlorophenol	11.3	16.6	12.5	8.0	78.7	79.0	14.6	59.8	19.6	35.2
2,4-Dimethylphenol	282	414	314	200	392	239	365	181	489	881
2,4-Dinitrophenol	56.5	82.9	62.7	40.0	993	395	72.9	299	97.8	176
2,4,5-Trichlorophenol	565	829	627	400	1998	3949	729	2989	978	1762
2, chlorophenol	23.7	34.8	26.3	6.8	122	166	30.6	126	41.1	4.0

TABLE 3-16
INGESTION PATHWAY SCREENING CONCENTRATIONS FOR SURFACE WATER
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Canada goose	American Kestrel	Brown-headed cowbird	American goldfinch	Great Blue Heron	Red-winged blackbird	Robin	Tree Swallow	American woodcock	Red-Tailed Hawk
4-Chloro-3-methylphenol	40.1	58.8	44.5	28.4	36.1	33.9	51.8	25.6	69.4	125
4-Methylphenol	282	414	314	200	4500	1975	365	1494	489	881
4-Nitrophenol	141	207	157	100	2390	987	182	747	244	441
4,6-Dinitro-2-Methylphenol	14.1	20.7	15.7	10.0	185	98.7	18.2	74.7	24.4	44.1
Pentachlorophenol	16.9	24.9	18.8	12.0	194	118	21.9	89.7	29.3	52.9
Phenol	339	497	376	240	6844	2369	438	1793	587	1057
Ketones (Carbonyl Compounds) (ug/L)										
2-Butanone	10005	14674	11107	7084	266029	69939	12915	52926	17316	31207
2-Hexanone	137	201	152	97.2	338	116	177	87.8	238	428
4-Methyl-2-pentanone (MIBK)										
Acetone	565	829	627	400	15773	3949	729	2989	978	1762
Isophorone	847	1243	941	600	43100	20182	1094	15273	1467	2643
Low Molecular Weight PAHs (ug/L)										
2-Chloronaphthalene	1412	2071	1568	1000	428	1193	1823	903	2444	4405
2-Methylnaphthalene	92.1	135	102	65.2			119		159	287
Acenaphthene	989	1450	1098	700	382	835	1276	632	1711	3084
Acenaphthylene										
Anthracene	5649	8286	6271	4000	33	4772	7292	3611	9778	17621
Carbazole	28.2	41.4	31.4	20.0	377	197	36.5	149.4	48.9	88.1
Dibenzofuran	56.5	82.9	62.7	40.0	12.7	47.7	72.9	36.1	97.8	176
Fluorene	706	1036	784	500	85.7	596	912	451	1222	2203
Naphthalene	808	1185	897	572	421	682	1043	516	1398	2520
Phenanthrene	39.5	58.0	43.9	28.0	1.9	33.4	51.0	25.3	68.4	123
High Molecular Weight PAHs (ug/L)										
Benzo(a)anthracene	508	746	564	360			656		880	1586

TABLE 3-16
INGESTION PATHWAY SCREENING CONCENTRATIONS FOR SURFACE WATER
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Canada goose	American Kestrel	Brown-headed cowbird	American goldfinch	Great Blue Heron	Red-winged blackbird	Robin	Tree Swallow	American woodcock	Red-Tailed Hawk
Benzo(a)pyrene	5.6	8.3	6.3	4.0	0.0	4.8	7.3	3.6	9.8	17.6
Benzo(ghi)perylene										
Benzo(b,k)fluoranthene										
Chrysene										
Dibenzo(a,h)anthracene										
Fluoranthene	706	1036	784	500	8.6	596	912	451	1222	2203
Indeno(1,2,3-cd)pyrene										
Pyrene	424	621	470	300	3.0	358	547	271	733	1322
Phthalates (ug/L)										
Bis (2-ethylhexyl) phthalate	10.7	15.7	11.9	7.6	0.4	9.7	13.9	7.3	18.6	33.5
Butylbenzylphthalate	898	1317	997	636	816	6279	1160	4752	1555	2802
Diethyl phthalate	4237	6214	4704	3000	45966	29618	5469	22414	7333	13216
Dimethyl phthalate										
Di-n-butyl phthalate	678	994	753	480	855	4936	875	3736	1173	2115
Di-n-octyl phthalate	5508	8079	6115	3900	4.2	4653	7110	3521	9533	17181
Miscellaneous Solvents (ug/L)										
Carbon disulfide	62.1	91.1	69.0	44.0	1359	610	80.2	462	108	194
Pesticides (ug/L)										
4,4'-DDD	0.3	0.5	0.4	0.2			0.4		0.5	1.0
4,4'-DDE	0.3	0.5	0.4	0.2			0.4		0.5	1.0
4,4'-DDT	0.3	0.4	0.3	0.2	0.0	2.0	0.4	1.5	0.5	0.9
DDT (Total)	0.0	0.0	0.0	0.0			0.0		0.0	0.0
Aldrin	2.8	4.1	3.1	2.0	0.0	0.1	3.6	0.1	4.9	8.8
a-BHC	5.6	8.3	6.3	4.0	23.7	39.5	7.3	29.9	9.8	17.6
b	14.1	20.7	15.7	'0.0	22.2	98.7	18.2	74.7	24.4	'4.1

TABLE 3-16
INGESTION PATHWAY SCREENING CONCENTRATIONS FOR SURFACE WATER
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Canada goose	American Kestrel	Brown-headed cowbird	American goldfinch	Great Blue Heron	Red-winged blackbird	Robin	Tree Swallow	American woodcock	Red-Tailed Hawk
d-BHC										
g-BHC (Lindane)	1.6	2.4	1.8	1.2	4.1	11.5	2.1	8.7	2.8	5.1
a-Chlordane										
g-Chlordane										
Chlordane (Technical)	0.8	1.2	0.9	0.6	0.2	0.7	1.1	0.5	1.5	2.6
Dieldrin	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.1
Endosulfan I										
Endosulfan II										
Endosulfan	3.2	4.7	3.6	2.3	43.8	76.7	4.2	58.0	5.6	10.0
Endosulfan sufate										
Endrin	0.1	0.2	0.2	0.1	0.1	3.4	0.2	2.5	0.2	0.4
Endrin aldehyde										
Endrin ketone										
Heptachlor	0.8	1.2	0.9	0.6	0.3	5.9	1.1	4.5	1.5	2.6
Heptachlor epoxide	0.0	0.0	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.0
Isodrin										
Methoxychlor	28.3	41.5	31.4	20.0	25.8	278	36.5	210	49.0	88.3
Toxaphene	1.1	1.7	1.3	0.8	0.9	26.9	1.5	20.4	2.0	3.5
PCBs (ug/L)										
Aroclor 1016	0.0	0.1	0.0	0.0	0.0	0.7	0.1	0.5	0.1	0.1
Aroclor 1221										
Aroclor 1248	0.2	0.2	0.2	0.1			0.2		0.3	0.5
Aroclor 1254	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.4	0.0	0.1
Aroclor 1260	40.7	59.7	45.2	28.8	0.6	284	52.5	215	70.4	127
Explosives (ug/L)										

TABLE 3-16
INGESTION PATHWAY SCREENING CONCENTRATIONS FOR SURFACE WATER
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Canada goose	American Kestrel	Brown-headed cowbird	American goldfinch	Great Blue Heron	Red-winged blackbird	Robin	Tree Swallow	American woodcock	Red-Tailed Hawk
1,3-Dinitrobenzene (DNB)	2.3	3.3	2.5	1.6	61.5	15.8	2.9	12.0	3.9	7.0
1,3,5-Trinitrobenzene (TNB)	15.1	22.2	16.8	10.7	307	106	19.5	80.1	26.2	47.2
2-Amino-4,6-Dinitrotoluene (2-ADNT)	78.7	116	87.4	55.8			102		136	246
2-Nitrotoluene (ONT)										
2,4,6-Trinitrotolune (TNT)	0.3	0.4	0.3	0.2	5.0	6.7	0.4	5.1	0.5	0.9
3-Nitrotoluene										
4-Amino-2,6-Dinitrotoluene (4-ADNT)	54.2	79.5	60.1	38.4			69.9		93.8	169
4-Nitrotoluene (PNT)										
Cyclonite (RDX)	1.7	2.5	1.9	1.2	39.0	11.8	2.2	9.0	2.9	5.3
Cyclotetramethylenetetranitramine (HMX)	282	414	314	200			365		489	881
Nitroglycerin (NG)	144	211	160	102			186		249	449
Pentaerythritol tetranitrate (PETN)	11.3	16.6	12.5	8.0			14.6		19.6	35.2
Tetryl	79.1	116	87.8	56.0			102		137	247
Dioxins/Furans (mg/kg)										
1,2,3,7,8-PeCDD										
1,2,3,4,6,7,8-HpCDD										
1,2,3,4,6,7,8-HpCDF										
1,2,3,4,7,8-HxCDD										
1,2,3,4,7,8,8-HpCDF										
1,2,3,4,7,8-HxCDF										
1,2,3,6,7,8-HxCDD										
1,2,3,6,7,8-HxCDF										
1,2,3,7,8-PeCDF										
1,2,3,7,8,9-HxCDD										

TABLE 3-16
INGESTION PATHWAY SCREENING CONCENTRATIONS FOR SURFACE WATER
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Canada goose	American Kestrel	Brown-headed cowbird	American goldfinch	Great Blue Heron	Red-winged blackbird	Robin	Tree Swallow	American woodcock	Red-Tailed Hawk
1,2,3,7,8,9-HxCDF										
2,3,4,6,7,8-HxCDF										
2,3,4,7,8-PeCDF										
2,3,7,8-TCDD	0.00001	0.000008	0.00001	0.000004	0.000000002	0.000039	0.00001	0.00003	0.00001	0.00002
2,3,7,8-TCDF										
OCDD										
OCDF										
Total Petroleum Hydrocarbons (ug/L)										
TPH-Gasoline range organics										
TPH-Diesel range organics										
Metals (ug/L)										
Aluminum	480	704	533	340			620		831	1498
Antimony	2.0	2.9	2.2	1.4			2.6		3.4	6.2
Arsenic	4.0	5.8	4.4	2.8	8.1	0.3	5.1	0.1	6.8	12.3
Barium	189	278	210	134	14.0	13.5	244	5.8	328	590
Beryllium	3.7	5.5	4.1	2.6	0.4	0.3	4.8	0.1	6.5	11.6
Cadmium	5.6	8.3	6.3	4.0	0.1	0.4	7.3	0.2	9.8	17.6
Calcium										
Chromium (Total)	5.6	8.3	6.3	4.0			7.3		9.8	17.6
Chromium VI	5.6	8.3	6.3	4.0			7.3		9.8	17.6
Cobalt	1.4	2.0	1.5	1.0			1.8		2.3	4.2
Copper	66.1	96.9	73.4	46.8	2.1	6.4	85.3	2.8	114	206
Iron	13.2	19.4	14.7	9.4			17.1		22.9	41.2
Lead	6.4	9.4	7.1	4.5	0.3	0.6	8.2	0.2	11.0	19.9
Magnesium										

TABLE 3-16
INGESTION PATHWAY SCREENING CONCENTRATIONS FOR SURFACE WATER
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Canada goose	American Kestrel	Brown-headed cowbird	American goldfinch	Great Blue Heron	Red-winged blackbird	Robin	Tree Swallow	American woodcock	Red-Tailed Hawk
Manganese	497	729	552	352			642		860	1551
Mercury	1.2	1.7	1.3	0.8			1.5		2.0	3.6
Nickel	28.2	41.4	31.4	20.0	8.5	2.0	36.5	0.9	48.9	88.1
Potassium										
Selenium	1.1	1.7	1.3	0.8	0.1	0.1	1.5	0.0	2.0	3.5
Silver	3.8	5.6	4.2	2.7	1.8	0.3	4.9	0.1	6.6	11.8
Sodium										
Thallium	1.3	1.9	1.4	0.9	0.2		1.7		2.2	4.1
Vanadium	6.9	10.1	7.7	4.9	0.1	0.1	8.9	0.0	11.9	21.5
Zinc	40.7	59.7	45.2	28.8	4.1	17.7	52.5	7.7	70.4	127
Total Cyanide	388	569	431	275			501		672	1211

TABLE 3-16
INGESTION PATHWAY SCREENING CONCENTRATIONS FOR SURFACE WATER
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Muskrat	White-tailed deer	White-footed Mouse	Short-tailed Shrew	Little Brown Bat	Brown Bat	Mink	Coyote
Halogenated Methanes/Alkanes (ug/L)								
Bis(2-chloroethoxy) methane	47.3	9.6	4.4	3.3	4.1	30.4	48.4	8.2
Bromodichloromethane	15.7	26.5	12.1	9.0	11.2	10.1	15.4	22.6
Bromoform	1302	265	121	89.5	111.9	836	1251	226
Bromomethane	102	20.7	9.5	7.0	8.8	65.4	103.5	17.6
Carbon tetrachloride (Tetrachloromethane)	51.6	10.5	4.8	3.6	4.4	33.2	47.9	8.9
Chloroform (Trichloromethane)	320	19.1	8.7	6.5	8.1	205	315	16.3
Chloromethane	3054	622	284	210	263	1961	3114	529
Dibromochloromethane	1556	317	144	107	134	999	1510	270
Methylene chloride	425	86.6	39.5	29.3	36.6	273	431	73.7
Halogenated Ethanes (ug/L)								
1,1-Dichloroethane	2778	566	258	191	239	1784	2760	481
1,1,1-Trichloroethane	8787	14804	6750	5000	6250	5642	8385	12604
1,1,2-Trichloroethane	34.3	57.7	26.3	19.5	24.4	22.0	33.6	49.2
1,1,2,2-Tetrachloroethane	10.0	16.9	7.7	5.7	7.1	6.4	9.4	14.4
1,2-Dichloroethane	1466	255	116	86.0	108	941	1475	217
Chloroethane	102101	14804	6750	5000	6250	65562	102696	12604
Hexachloroethane	72.7	14.8	6.8	5.0	6.3	46.7	58.8	12.6
Halogenated Propanes (ug/L)								
1,2-Dichloropropane	18180	3701	1688	1250	1563	11674	17876	3151
2,2'-Oxybis (1-chloropropane)								
Halogenated Alkenes (ug/L)								
1,1-Dichloroethene	65.4	13.3	6.1	4.5	5.6	42.0	62.9	11.3
1,2-Dichloroethene (total)								
1,2-Dichloroethene (cis)	2327	474	216	160	200	1494	2312	403

TABLE 3-16
INGESTION PATHWAY SCREENING CONCENTRATIONS FOR SURFACE WATER
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Muskrat	White-tailed deer	White-footed Mouse	Short-tailed Shrew	Little Brown Bat	Brown Bat	Mink	Coyote
1,2-Dichloroethene (trans)	2327	474	216	160	200	1494	2312	403
1,3-Dichloropropene (total)		44.4	20.3	15.0	18.8			37.8
1,3-Dichloropropene (cis)	2182	444	203	150	188	1401	2091	378
1,3-Dichloropropene (trans)	2182	444	203	150	188	1401	2031	378
Tetrachloroethene	1018	207	94.5	70.0	87.5	654	899	176
Trichloroethene	61.5	104	47.3	35.0	43.8	39.5	58.1	88.2
Vinyl chloride	12.4	2.5	1.1	0.9	1.1	7.9	12.4	2.1
Amines (ug/L)								
2-Nitroaniline	716	111.0	50.6	37.5	46.9	460	711	94.5
3-Nitroaniline	27.1	45.6	20.8	15.4	19.3	17.4	27.4	38.8
3,3'-Dichlorobenzidine	198	11.8	5.4	4.0	5.0	127.3	173	10.1
4-Chloroaniline	90.9	18.5	8.4	6.3	7.8	58.4	84.7	15.8
4-Nitroaniline	42.1	66.6	30.4	22.5	28.1	27.0	42.6	56.7
4,4'-Methylenebis (2-chlorobenzenamine)-MOCA								
N-Nitrosodiphenylamine	364	74.0	33.8	25.0	31.3	233	328	63.0
N-Nitroso-di-n-propylamine	37.1	7.6	3.4	2.6	3.2	23.8	37.3	6.4
Benzene and Derivatives (ug/L)								
Benzene	232	391	178	132	165	149	226	333
Chlorobenzene	4707	281	128	95.0	119	3023	4372	239
1,2-Dichlorobenzene	6232	1269	578	429	536	4002	4921	1080
1,2,4-Trichlorobenzene	1076	219	100	74.0	92.5	691	847	187
1,3-Dichlorobenzene	1818	370	169	125	156	1167	1593	315
1,4-Dichlorobenzene	2182	444	203	150	188	1401	1632	378
Hexachlorobenzene	5.8	1.2	0.5	0.4	0.5	3.7	4.6	1.0
Methylated Benzenes (ug/L)								

TABLE 3-16
INGESTION PATHWAY SCREENING CONCENTRATIONS FOR SURFACE WATER
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Muskrat	White-tailed deer	White-footed Mouse	Short-tailed Shrew	Little Brown Bat	Brown Bat	Mink	Coyote
Toluene	1891	385	176	130	163	1214	1786	328
Xylenes (total)	36364	529	241	179	223	23350	36710	450
Other Substituted Benzenes (ug/L)								
Ethylbenzene	7061	1437	655	486	607	4534	6397	1224
Styrene	49552	2961	1350	1000	1250	31818	45960	2521
Nitrobenzene	218	44.4	20.3	15.0	18.8	140	216	37.8
Arenes (ug/L)								
2,4-Dinitrotolune	49.6	3.0	1.4	1.0	1.3	31.8	48.6	2.5
2,6-Dinitrotolune	96.7	163	74.3	55.0	68.8	62.1	95.1	139
Chlorinated Dienes (ug/L)								
Hexachlorobutadiene	145	29.6	13.5	10.0	12.5	93.4	117	25.2
Hexachlorocyclopentadiene	727	148	67.5	50.0	62.5	467	605	126
Ethers (ug/L)								
4-Bromophenyl phenyl ether								
4-Chlorophenyl phenyl ether								
Bis (2-chloroethyl) ether	1812	370	169	125	156	1164	1828	315
Phenols and Substituted Phenols (ug/L)								
2-Chlorophenol	364	74.0	33.8	25.0	31.3	233	346	63.0
2-Methylphenol	3636	740	338	250	313	2335	3579	630
2-Nitrophenol	243	49.4	22.5	16.7	20.9	156.0	240.3	42.1
2,4-Dichlorophenol	145	29.6	13.5	10.0	12.5	93.4	133	25.2
2,4-Dimethylphenol	439	740	338	250	313	282	420	630
2,4-Dinitrophenol	727	148	67.5	50.0	62.5	467	722	126
2,4,5-Trichlorophenol	7272	1480	675	500	625	4670	6295	1260
2,4,6-Trichlorophenol	305	62.2	28.4	21.0	26.3	196	272	52.9

TABLE 3-16
INGESTION PATHWAY SCREENING CONCENTRATIONS FOR SURFACE WATER
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Muskrat	White-tailed deer	White-footed Mouse	Short-tailed Shrew	Little Brown Bat	Brown Bat	Mink	Coyote
4-Chloro-3-methylphenol	62.4	105	47.9	35.5	44.4	40.1	57.4	89.5
4-Methylphenol	3636	740	338	250	313	2335	3579	630
4-Nitrophenol	1818	370	169	125	156	1167	1799	315
4,6-Dinitro-2-Methylphenol	182	37.0	16.9	12.5	15.6	117	176	31.5
Pentachlorophenol	218	44.4	20.3	15.0	18.8	140	217	37.8
Phenol	4363	888	405	300	375	2802	4386	756
Ketones (Carbonyl Compounds) (ug/L)								
2-Butanone	128788	26218	11954	8855	11069	82698	132535	22321
2-Hexanone	214	360	164	122	152	137	215	306
4-Methyl-2-pentanone (MIBK)								
Acetone	7272	1480	675	500	625	4670	7514	1260
Isophorone	37164	2221	1013	750	938	23864	36361	1891
Low Molecular Weight PAHs (ug/L)								
2-Chloronaphthalene	2197	3701	1688	1250	1563	1411	1857	3151
2-Methylnaphthalene		241	110	81.5	102			205
Acenaphthene	1538	2591	1181	875	1094	987	1321	2206
Acenaphthylene								
Anthracene	8787	14804	6750	5000	6250	5642	6513	12604
Carbazole	364	74.0	33.8	25.0	31.3	233	352	63.0
Dibenzofuran	87.9	148	67.5	50.0	62.5	56.4	72.7	126
Fluorene	1098	1850	844	625	781	705	874	1575
Naphthalene	1257	2117	965	715	894	807	1103	1802
Phenanthrene	61.5	104	47.3	35.0	43.8	39.5	47.2	88.2
High Molecular Weight PAHs (ug/L)								
Benzo(a)anthracene		1332	608	450	563			1134

TABLE 3-16
INGESTION PATHWAY SCREENING CONCENTRATIONS FOR SURFACE WATER
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Muskrat	White-tailed deer	White-footed Mouse	Short-tailed Shrew	Little Brown Bat	Brown Bat	Mink	Coyote
Benzo(a)pyrene	8.8	14.8	6.8	5.0	6.3	5.6	6.5	12.6
Benzo(ghi)perylene								
Benzo(b,k)fluoranthene								
Chrysene								
Dibenzo(a,h)anthracene								
Fluoranthene	1098	1850	844	625	781	705	821	1575
Indeno(1,2,3-cd)pyrene								
Pyrene	659	1110	506.3	375.0	469	423	490	945
Phthalates (ug/L)								
Bis (2-ethylhexyl) phthalate	17.8	28.1	12.8	9.5	11.9	11.4	18.1	23.9
Butylbenzylphthalate	11563	2354	1073	795	994	7425	9137	2004
Diethyl phthalate	54540	11103	5063	3750	4688	35022	51843	9453
Dimethyl phthalate								
Di-n-butyl phthalate	9090	1776	810	600	750	5837	7394	1512
Di-n-octyl phthalate	8567	14434	6581	4875	6094	5501	7567	12289
Miscellaneous Solvents (ug/L)								
Carbon disulfide	1123	163	74.3	55.0	68.8	721	1103	139
Pesticides (ug/L)								
4,4'-DDD		0.8	0.4	0.3	0.4			0.7
4,4'-DDE		0.8	0.4	0.3	0.4			0.7
4,4'-DDT	3.6	0.7	0.3	0.3	0.3	2.3	3.0	0.6
DDT (Total)		0.0	0.0	0.0	0.0			0.0
Aldrin	0.2	7.4	3.4	2.5	3.1	0.1	0.2	6.3
a-BHC	72.7	14.8	6.8	5.0	6.3	46.7	63.9	12.6
b-BHC	182	37.0	16.9	12.5	15.6	117	148	31.5

TABLE 3-16
INGESTION PATHWAY SCREENING CONCENTRATIONS FOR SURFACE WATER
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Muskrat	White-tailed deer	White-footed Mouse	Short-tailed Shrew	Little Brown Bat	Brown Bat	Mink	Coyote
d-BHC								
g-BHC (Lindane)	21.1	4.3	2.0	1.5	1.8	13.5	17.8	3.7
a-Chlordane								
g-Chlordane								
Chlordane (Technical)	1.3	2.2	1.0	0.8	0.9	0.8	1.1	1.9
Dieldrin	0.4	0.1	0.0	0.0	0.0	0.2	0.3	0.1
Endosulfan I								
Endosulfan II								
Endosulfan	141.2	8.4	3.8	2.9	3.6	90.7	124	7.2
Endosulfan sufate								
Endrin	6.2	0.4	0.2	0.1	0.2	4.0	4.8	0.3
Endrin aldehyde								
Endrin ketone								
Heptachlor	10.9	2.2	1.0	0.8	0.9	7.0	8.6	1.9
Heptachlor epoxide	0.3	0.0	0.0	0.0	0.0	0.2	0.3	0.0
Isodrin								
Methoxychlor	512	74.2	33.8	25.1	31.3	328	403	63.1
Toxaphene	49.6	3.0	1.4	1.0	1.3	31.8	37.4	2.5
PCBs (ug/L)								
Aroclor 1016	1.2	0.1	0.0	0.0	0.0	0.8	0.9	0.1
Aroclor 1221								
Aroclor 1248		0.4	0.2	0.2	0.2			0.4
Aroclor 1254	0.9	0.1	0.0	0.0	0.0	0.6	0.7	0.1
Aroclor 1260	524	107	48.6	36.0	45.0	336	402	90.7
Explosives (ug/L)								

TABLE 3-16
INGESTION PATHWAY SCREENING CONCENTRATIONS FOR SURFACE WATER
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Muskrat	White-tailed deer	White-footed Mouse	Short-tailed Shrew	Little Brown Bat	Brown Bat	Mink	Coyote
1,3-Dinitrobenzene (DNB)	29.1	5.9	2.7	2.0	2.5	18.7	30.0	5.0
1,3,5-Trinitrobenzene (TNB)	195	39.7	18.1	13.4	16.8	125	196	33.8
2-Amino-4,6-Dinitrotoluene (2-ADNT)		206	94.1	69.7	87.1			176
2-Nitrotoluene (ONT)								
2,4,6-Trinitrotolune (TNT)	12.4	0.7	0.3	0.3	0.3	8.0	11.0	0.6
3-Nitrotoluene								
4-Amino-2,6-Dinitrotoluene (4-ADNT)		142	64.7	48.0	59.9			120.9
4-Nitrotoluene (PNT)								
Cyclonite (RDX)	21.8	4.4	2.0	1.5	1.9	14.0	22.2	3.8
Cyclotetramethylenetetranitramine (HMX)		740	338	250	313			630
Nitroglycerin (NG)		378	172	128	159			321
Pentaerythritol tetranitrate (PETN)		29.6	13.5	10.0	12.5			25.2
Tetryl		207	94.5	70.0	87.5			176
Dioxins/Furans (mg/kg)								
1,2,3,7,8-PeCDD								
1,2,3,4,6,7,8-HpCDD								
1,2,3,4,6,7,8-HpCDF								
1,2,3,4,7,8-HxCDD								
1,2,3,4,7,8,8-HpCDF								
1,2,3,4,7.8-HxCDF								
1,2,3,6,7,8-HxCDD								
1,2,3,6,7,8-HxCDF								
1,2,3,7,8-PeCDF								
1,2,3,7,8,9-HxCDD								

TABLE 3-16
INGESTION PATHWAY SCREENING CONCENTRATIONS FOR SURFACE WATER
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Muskrat	White-tailed deer	White-footed Mouse	Short-tailed Shrew	Little Brown Bat	Brown Bat	Mink	Coyote
1,2,3,7,8,9-HxCDF								
2,3,4,6,7,8-HxCDF								
2,3,4,7,8-PeCDF								
2,3,7,8-TCDD	0.000073	0.00001	0.00001	0.00001	0.00001	0.000047	0.00005	0.00001
2,3,7,8-TCDF								
OCDD								
OCDF								
Total Petroleum Hydrocarbons (ug/L)								
TPH-Gasoline range organics								
TPH-Diesel range organics								
Metals (ug/L)								
Aluminum		1258	574	425	531			1071
Antimony		5.2	2.4	1.8	2.2			4.4
Arsenic	5.6	10.4	4.7	3.5	4.4	0.1	7.6	8.8
Barium	266	496	226	168	209	2.7	364	422
Beryllium	5.2	9.8	4.5	3.3	4.1	0.1	7.2	8.3
Cadmium	7.9	14.8	6.8	5.0	6.3	0.1	10.9	12.6
Calcium								
Chromium (Total)		14.8	6.8	5.0	6.3			12.6
Chromium VI		14.8	6.8	5.0	6.3			12.6
Cobalt		3.6	1.6	1.2	1.5			3.0
Copper	125.6	173	79.0	58.5	73.1	1.3	172	147
Iron		34.6	15.8	11.7	14.6			29.5
Lead	10.9	16.7	7.6	5.7	7.1	0.1	14.9	14.2
Magnesium								

TABLE 3-16
INGESTION PATHWAY SCREENING CONCENTRATIONS FOR SURFACE WATER
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Muskrat	White-tailed deer	White-footed Mouse	Short-tailed Shrew	Little Brown Bat	Brown Bat	Mink	Coyote
Manganese		1303	594	440	550			1109
Mercury		3.0	1.4	1.0	1.3			2.6
Nickel	39.7	74.0	33.8	25.0	31.3	0.4	54.4	63.0
Potassium								
Selenium	1.6	3.0	1.4	1.0	1.3	0.0	2.2	2.5
Silver	5.3	9.9	4.5	3.4	4.2	0.1	7.3	8.4
Sodium								
Thallium		3.4	1.6	1.2	1.4			2.9
Vanadium	1.2	18.1	8.2	6.1	7.6	0.0	1.6	15.4
Zinc	350	107	48.6	36.0	45.0	3.6	479	90.7
Total Cyanide		1017	464	344	429			866

TABLE 3-17
ECOLOGICAL SCREENING CONCENTRATION SUMMARY
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Direct Exposures			Ingestion Pathway Exposures					
	Soils (mg/kg)	*Sediments* (mg/kg)	*Surface Water* (ug/L)	*Urban Soils*[1] (mg/kg)	Woodland Soils[2] (mg/kg)	*Field Soils*[3] (mg/kg)	Mixed Woodland/ *Field Soils*[4] (mg/kg)	*Sediments* (mg/kg)	*Surface Water* (ug/L)
Halogenated Methanes/Alkanes									
Bis(2-chloroethoxy) methane	NA	NA	NA	1.06	0.29	0.25	0.25	0.35	2.60
Bromodichloromethane	NA	17.5	15215	6.11	1.95	1.73	1.73	1.75	6.46
Bromoform	NA	1.2	293	171	98.4	87.2	87.2	72.2	71.6
Bromomethane	NA	10.5	67647	2.97	0.79	0.70	0.70	1.06	5.60
Carbon tetrachloride (Tetrachloromethane)	0.001	0.01	9.8	10.1	6.1	5.4	5.4	3.2	2.8
Chloroform (Trichloromethane)	0.3	0.01	28	22.9	6.4	5.6	5.6	6.3	5.2
Chloromethane	NA	47.8	67467	76.3	20.5	18.2	18.2	25.3	168.0
Dibromochloromethane	450	30.8	14607	182.3	65.8	58.2	58.2	53.8	85.6
Methylene chloride	0.3	0.92	2200	15.0	3.9	3.5	3.5	5.2	23.4
Halogenated Ethanes									
1,1-Dichloroethane	0.3	0.02	47	222	54.1	47.9	47.9	60.6	153
1,1,1-Trichloroethane	NA	0.17	60	4836	2186	1938	1938	1481	3611
1,1,2-Trichloroethane	NA	1.06	1200	13.2	4.0	3.5	3.5	3.7	14.1
1,1,2,2-Tetrachloroethane	NA	0.94	420	3.7	1.9	1.7	1.7	1.1	4.1
1,2-Dichloroethane	870	0.30	910	74.0	18.9	16.7	16.7	24.4	68.8
Chloroethane	NA	14.5	21069	4639	1187	1050	1050	1491	4000
Hexachloroethane	NA	0.07	12	32.7	31.7	31.7	31.7	10.5	4.0
Halogenated Propanes									
1,2-Dichloropropane	700	0.25	5700	1752	503	446	446	488	1000
2,2'-Oxybis (1-chloropropane)	NA	NA	NA	NA	NA	NA	NA	NA	[illegible]
Halogenated Alkenes									
1,1-Dichloroethene	NA	0.04	25	5.2	2.1	1.9	1.9	1.5	3.6
1,2-Dichloroethene (total)	NA	0.25	590	NA	NA	NA	NA	NA	NA
1,2-Dichloroethene (cis)	0.30	0.29	590	182	44.5	39.4	39.4	49.6	128
1,2-Dichloroethene (trans)	0.30	0.21	590	182	44.5	39.4	39.4	49.6	128
1,3-Dichloropropene (total)	NA	0.00	NA	NA	NA	NA	NA	NA	NA
1,3-Dichloropropene (cis)	NA	0.00	0.055	41.3	17.6	15.6	15.6	8.0	120
1,3-Dichloropropene (trans)	NA	0.05	24.4	27.0	15.7	14.0	14.0	5.5	120
Tetrachloroethene	13	0.53	120	341	158	158	158	109	56.0
Trichloroethene	9	1.60	350	9.8	1.9	1.7	1.7	1.2	25.3
Vinyl chloride	0.30	10.2	18242	0.25	0.06	0.06	0.06	0.02	0.68
Amines									
2-Nitroaniline	NA	12.3	23132	46.8	11.4	10.1	10.1	12.4	30.0
3-Nitroaniline	NA	59.5	68321	3.7	1.0	0.8	0.8	1.3	11.1
3,3'-Dichlorobenzidine	NA	0.0038	0.2	19.1	17.1	15.2	15.2	6.1	3.2
4-Chloroaniline	NA	5.3	2250	2.3	1.3	1.2	1.2	0.6	5.0
4-Nitroaniline	NA	36.2	46418	2.1	0.6	0.5	0.5	0.8	17.3
4,4'-Methylenebis (2-chlorobenzenamine)-MOCA	NA	NA	NA	NA	NA	NA	NA	NA	NA
N-Nitrosodiphenylamine	20	0.028	210	92.9	69.3	61.5	61.5	29.5	20.0
N-Nitroso-di-n-propylamine	NA	NA	NA	1.5	0.38	0.34	0.34	0.43	2.0
Benzene and Derivatives									
Benzene	16.0	0.06	46.0	93.5	31.0	27.4	27.4	27.0	95.3
Chlorobenzene	40.0	0.02	130	777	465	413	413	245	76.0
1,2-Dichlorobenzene	0.10	0.04	14.0	379	424	416	416	121	[illegible]
1,2,4-Trichlorobenzene	20.0	9.2	110	226	241	241	241	72.6	[illegible]
1,3-Dichlorobenzene	NA	0.15	71.0	730	653	580	580	234	100

TABLE 3-17
ECOLOGICAL SCREENING CONCENTRATION SUMMARY
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Direct Exposures			Ingestion Pathway Exposures					
	Soils (mg/kg)	Sediments (mg/kg)	Surface Water (ug/L)	Urban Soils[1] (mg/kg)	Woodland Soils[2] (mg/kg)	Field Soils[3] (mg/kg)	Mixed Woodland/ Field Soils[4] (mg/kg)	Sediments (mg/kg)	Surface Water (ug/L)
1,4-Dichlorobenzene	20.0	0.11	15.0	21.5	25.2	25.2	25.2	6.9	25.2
Hexachlorobenzene	30.0	0.02	3.7	19.8	10.2	10.2	10.2	6.4	0.1
Methylated Benzenes									
Toluene	3.0	0.67	130	326	166	147	147	101	104
Xylenes (total)	0.60	0.03	1.8	56588	14757	13052	13052	31838	143
Other Substituted Benzenes									
Ethylbenzene	5.0	0.010	290	1974	1444	1281	1281	628	388
Styrene	300	21.60	4020	8172	4961	4400	4400	2574	800
Nitrobenzene	40	0.59	270	18.4	4.7	4.2	4.2	4.9	12.0
Arenes									
2,4-Dinitrotoluene	NA	0.65	310	3.4	1.0	0.90	0.90	0.93	0.80
2,6-Dinitrotoluene	NA	NA	NA	21.6	6.1	5.4	5.4	5.4	39.7
Chlorinated Dienes									
Hexachlorobutadiene	NA	0.01	0.93	259.8	180.3	180.3	180.3	83.5	8.0
Hexachlorocyclopentadiene	10	0.003	0.07	375.3	349.5	349.5	349.5	120.4	40.0
Ethers									
4-Bromophenyl phenyl ether	NA	0.23	1.5	NA	NA	NA	NA	NA	NA
4-Chlorophenyl phenyl ether	NA	1.37	46	NA	NA	NA	NA	NA	NA
Bis (2-chloroethyl) ether	NA	1.81	2380	48.3	12.5	11.1	11.1	10.8	100
Phenols and Substituted Phenols									
[illegible]phenol	10	0.14	43.8	25.3	11.7	10.3	10.3	7.3	20.0
[illegible]ylphenol	NA	0.06	13	331	93.4	82.7	82.7	91.1	200
2-Nitrophenol	NA	3.2	3500	18.7	4.7	4.2	4.2	4.8	13.4
2,4-Dichlorophenol	10	0.33	36.5	30.3	20.8	18.4	18.4	9.6	8.0
2,4-Dimethylphenol	0.1	0.03	21.2	167	74.5	66.1	66.1	50.1	181
2,4-Dinitrophenol	20	0.01	6.2	47.6	11.58	10.25	10.25	12.04	40.00
2,4,5-Trichlorophenol	4	1.41	63	3574	3198	3017	3017	1145	400
2,4,6-Trichlorophenol	10	0.02	3.2	110	89	79.3	79.3	35.0	16.8
4-Chloro-3-methylphenol	NA	0.00	0.3	56.4	36.9	32.7	32.7	17.9	25.6
4-Methylphenol	0.1	0.67	2251	325	91.6	81.1	81.1	89.0	200
4-Nitrophenol	7	0.04	300	157	39.6	35.0	35.0	41.6	100
4,6-Dinitro-2-Methylphenol	NA	0.01	2.3	22.6	8.6	7.6	7.6	6.74	10.0
Pentachlorophenol	3	0.36	15	3998	643	643	643	3620	12.0
Phenol	70	0.05	256	205	52.2	46.2	46.2	65.9	240
Ketones (Carbonyl Compounds)									
2-Butanone	NA	4.40	14000	2373	658	582	582	561	7084
2-Hexanone	NA	0.12	99	33.71	8.63	7.64	7.64	10.45	87.75
4-Methyl-2-pentanone (MIBK)	100	0.21	170	NA	NA	NA	NA	NA	NA
Acetone	NA	0.25	1500	123.4	34.7	30.7	30.7	18.2	400
Isophorone	NA	1.15	1170	1420	446	395	395	351	600
Low Molecular Weight PAHs		0.08							
2-Chloronaphthalene	NA	3.50	620	5915	5138	5138	5138	1899	428
2-Methylnaphthalene	NA	0.02	417	NA	NA	NA	NA	NA	NA
Acenaphthene	20	0.01	23	2989	2686	2608	2608	958	382
[illegible]thylene	0.1	0.01	0.73	NA	NA	NA	NA	NA	NA
[illegible]ene	10	0.06	0.1	1068	1245	1245	1245	343	32.6
Carbazole	NA	3.28	893	2.59	0.71	0.71	0.71	0.07	20.0

TABLE 3-17
ECOLOGICAL SCREENING CONCENTRATION SUMMARY
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Direct Exposures			Ingestion Pathway Exposures					
	Soils (mg/kg)	Sediments (mg/kg)	Surface Water (ug/L)	Urban Soils[1] (mg/kg)	Woodland Soils[2] (mg/kg)	Field Soils[3] (mg/kg)	Mixed Woodland/ Field Soils[4] (mg/kg)	Sediments (mg/kg)	Surface Water (ug/L)
Dibenzofuran	NA	5.10	20	196	180	180	180	62.99	12.7
Fluorene	30	0.08	3.9	1219	1255	1255	1255	391	85.7
Naphthalene	430	0.18	24	1177	1037	922	922	376	421
Phenanthrene	5	0.20	6.3	70.58	73.85	73.85	73.85	22.68	1.93
High Molecular Weight PAHs		0.19							
Benzo(a)anthracene	0.1	0.11	0.027	NA	NA	NA	NA	NA	NA
Benzo(a)pyrene	4400	0.15	0.014	5.05	5.65	5.65	5.65	1.62	0.00
Benzo(ghi)perylene	0.1	0.02	0.004	NA	NA	NA	NA	NA	NA
Benzo(b,k)fluoranthene	0.1	0.03	0.02	NA	NA	NA	NA	NA	NA
Chrysene	0.1	0.17	0.008	NA	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	0.1	0.01	NA	NA	NA	NA	NA	NA	NA
Fluoranthene	10	0.42	8.1	892	972	972	972	287	8.6
Indeno(1,2,3-cd)pyrene	0.1	0.02	0.004	NA	NA	NA	NA	NA	NA
Pyrene	10	0.20	61	268	304	304	304	86.2	3.04
Phthalates									
Bis (2-ethylhexyl) phthalate	NA	0.18	32	491	79.1	79.1	79.1	439	0.41
Butylbenzylphthalate	NA	0.06	19	1307	1435	1434	1434	419	636
Diethyl phthalate	100	0.20	220	7247	3429	3039	3039	2217	3000
Dimethyl phthalate	200	0.07	330	0.0004	0.0004	0.0004	0.0004	0.0001	VA
Di-n-butyl phthalate	200	0.11	33	12321	9379	9379	9379	3959	480
Di-n-octyl phthalate	NA	6.20	708	514051	89655	89655	89655	199289	4
Miscellaneous Solvents									
Carbon disulfide	NA	0.00	0.92	96.70	28.35	25.10	25.10	26.51	44.00
Pesticides (mg/kg)									
4,4'-DDD	0.1	0.00	0.011	NA	NA	NA	NA	NA	0.2
4,4'-DDE	0.1	0.00	10.5	NA	NA	NA	NA	NA	0.2
4,4'-DDT	NA	0.01	0.001	33.4	8.9	8.9	8.9	10.7	0.013
DDT (Total)	NA	0.00	NA	NA	NA	NA	NA	NA	0.011
Aldrin	0.1	0.01	0.3	3.5	0.6	0.6	0.6	3.1	0.04
a-BHC	NA	0.01	2.2	54.9	44.8	43.5	43.5	17.6	4.0
b-BHC	NA	0.00	2.2	43.9	45.2	45.0	45.0	14.1	10.0
d-BHC	NA	0.00	2.2	NA	NA	NA	NA	NA	NA
g-BHC (Lindane)	29	NA	0.08	7.4	7.1	6.9	6.9	2.4	1.2
a-Chlordane	0.1	0.00	1.09	NA	NA	NA	NA	NA	NA
g-Chlordane	NA	0.01	1.09	NA	NA	NA	NA	NA	NA
Chlordane (Technical)	0.02	0.00	0.0043	31.4	10.8	10.8	10.8	10.1	0.2
Dieldrin	56	NA	0.056	2.8	0.8	0.8	0.8	0.9	0.0
Endosulfan I	NA	0.00	0.056	NA	NA	NA	NA	NA	NA
Endosulfan II	NA	0.00	0.056	NA	NA	NA	NA	NA	NA
Endosulfan	NA	0.01	0.051	82.9	67.9	66.9	66.9	26.6	2.3
Endosulfan sufate	0.01	0.00	0.0510000	NA	NA	NA	NA	NA	NA
Endrin	0.1	NA	0.036	5.0	4.2	4.2	4.2	1.6	0.1
Endrin aldehyde	NA	0.00	NA	NA	NA	NA	NA	NA	NA
Endrin ketone	NA	0.00	NA	NA	NA	NA	NA	NA	NA
Heptachlor	NA	0.00	0.0038	25.7	16.0	16.0	16.0	8.3	0
Heptachlor epoxide	0.1	0.00	0.0038	1.1	0.5	0.5	0.5	0.3	0
Isodrin	NA	0.00	NA	NA	NA	NA	NA	NA	NA

TABLE 3-17
ECOLOGICAL SCREENING CONCENTRATION SUMMARY
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Direct Exposures			Ingestion Pathway Exposures					
	Soils (mg/kg)	Sediments (mg/kg)	Surface Water (ug/L)	Urban Soils[1] (mg/kg)	Woodland Soils[1,2] (mg/kg)	Field Soils[3] (mg/kg)	Mixed Woodland/ Field Soils[4] (mg/kg)	Sediments (mg/kg)	Surface Water (ug/L)
Methoxychlor	0.1	0.03	0.03	558	461	461	461	179	20.0
Toxaphene	NA	0.07	0.0002	0.44	0.52	0.52	0.52	0.14	0.80
PCBs (mg/kg)		0.01							
Aroclor 1016	NA	0.07	0.014	0.061	0.070	0.070	0.070	0.020	0.010
Aroclor 1221	NA	0.03	0.28	NA	NA	NA	NA	NA	NA
Aroclor 1248	NA	0.06	0.081	NA	NA	NA	NA	NA	0.120
Aroclor 1254	NA	0.01	0.033	0.896	0.735	0.735	0.735	0.288	0.002
Aroclor 1260	0.1	0.01	94	1106	729	729	729	355	0.571
Explosives (mg/kg)									
1,3-Dinitrobenzene (DNB)	NA	0.01	240	1.5	0.4	0.4	0.4	2.6	1.6
1,3,5-Trinitrobenzene (TNB)	NA	NA	100	6.3	1.6	1.4	1.4	1.6	10.7
2-Amino-4,6-Dinitrotoluene (2-ADNT)	80	16.8	20	NA	NA	NA	NA	NA	55.8
2-Nitrotoluene (ONT)	NA	0.21	7300	NA	NA	NA	NA	NA	NA
2,4,6-Trinitrotolune (TNT)	10	11.9	40	0.1	0.1	0.1	0.1	0.0	0.2
3-Nitrotoluene	NA	NA	8300	NA	NA	NA	NA	NA	NA
4-Amino-2,6-Dinitrotoluene (4-ADNT)	NA	18.7	540	NA	NA	NA	NA	NA	38.4
4-Nitrotoluene (PNT)	NA	0.08	7000	NA	NA	NA	NA	NA	NA
Cyclonite (RDX)	100	0.01	3200	0.5	0.1	0.1	0.1	0.1	1.2
Cyclotetramethylenetetranitramine (HMX)	NA	0.33	3300	NA	NA	NA	NA	NA	200.0
Nitroglycerin (NG)	NA	472	200	NA	NA	NA	NA	NA	102.0
[illegible] thritol tetranitrate (PETN)	NA	NA	85000	NA	NA	NA	NA	NA	8.0
[illegible]	25	NA	NA	NA	NA	NA	NA	NA	56.0
Dioxins/Furans (mg/kg)									
1,2,3,7,8-PeCDD				NA	NA	NA	NA	NA	NA
1,2,3,4,6,7,8-HpCDD				NA	NA	NA	NA	NA	NA
1,2,3,4,6,7,8-HpCDF				NA	NA	NA	NA	NA	NA
1,2,3,4,7,8-HxCDD				NA	NA	NA	NA	NA	NA
1,2,3,4,7,8,8-HpCDF				NA	NA	NA	NA	NA	NA
1,2,3,4,7,8-HxCDF				NA	NA	NA	NA	NA	NA
1,2,3,6,7,8-HxCDD				NA	NA	NA	NA	NA	NA
1,2,3,6,7,8-HxCDF				NA	NA	NA	NA	NA	NA
1,2,3,7,8-PeCDF				NA	NA	NA	NA	NA	NA
1,2,3,7,8,9-HxCDD				NA	NA	NA	NA	NA	NA
1,2,3,7,8,9-HxCDF				NA	NA	NA	NA	NA	NA
2,3,4,6,7,8-HxCDF				NA	NA	NA	NA	NA	NA
2,3,4,7,8-PeCDF				NA	NA	NA	NA	NA	NA
2,3,7,8-TCDD	5	NA		0.00000420	0.00000487	0.00000487	0.00000487	0.00000135	0.000000002
2,3,7,8-TCDF				NA	NA	NA	NA	NA	NA
OCDD				NA	NA	NA	NA	NA	NA
OCDF				NA	NA	NA	NA	NA	NA
Total Petroleum Hydrocarbons (mg/kg)									
TPH-Gasoline range organics	NA	NA	150	NA	NA	NA	NA	NA	NA
TPH-Diesel range organics	NA	NA	150	NA	NA	NA	NA	NA	NA
Metals (mg/kg)									
A[illegible]um	30071	26000	87	NA	NA	NA	NA	NA	340.0
[illegible]y	5	3.0	160	NA	NA	NA	NA	NA	1.4
Arsenic	19.4	14.0	190	115	54.7	54.7	54.7	180	0.1

TABLE 3-17
ECOLOGICAL SCREENING CONCENTRATION SUMMARY
ADDITIONAL AND UNCHARACTERIZED SITES
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Constituent	Direct Exposures			Ingestion Pathway Exposures					
	Soils (mg/kg)	Sediments (mg/kg)	Surface Water (ug/L)	Urban Soils[1] (mg/kg)	Woodland Soils[2] (mg/kg)	Field Soils[3] (mg/kg)	Mixed Woodland/ Field Soils[4] (mg/kg)	Sediments (mg/kg)	Surface Water (ug/L)
Barium	625	271.0	3.9	7703	3043	3043	3043	337	2.7
Beryllium	10	NA	5.1	478	97.8	97.8	97.8	202	0.05
Cadmium	12	5.0	2.3	4.8	3.4	3.4	3.4	61.3	0.08
Calcium	NA	NA	116000	NA	NA	NA	NA	NA	NA
Chromium (Total)	56	0.0	5.3	98.0	50.9	50.9	50.9	300.0	4.0
Chromium VI	1	0.0	11	NA	NA	NA	NA	NA	4.0
Cobalt	20	10.0	3	NA	NA	NA	NA	NA	1.0
Copper	31	28.0	2.5	1990	1153	1153	1153	659	1.3
Iron	12	190000	1000	NA	NA	NA	NA	NA	9.4
Lead	500	59.0	3	98.3	17.5	15.4	15.4	22.1	0.1
Magnesium	4400	NA	82000	NA	NA	NA	NA	NA	NA
Manganese	5884	1700.0	80	NA	NA	NA	NA	NA	352.0
Mercury	7	0.2	1.3	NA	NA	NA	NA	NA	0.8
Nickel	200	31.0	52	174	114	114	114	341	0.4
Potassium	NA	NA	5300	NA	NA	NA	NA	NA	NA
Selenium	70	0.29	5	7.5	4.6	4.6	4.6	0.4	0.0163
Silver	2	0.73	0.36	12.1	8.4	8.4	8.4	9.4	0.1
Sodium	NA	NA	680000	NA	NA	NA	NA	NA	NA
Thallium	1	NA	12	NA	NA	NA	NA	NA	0.2
Vanadium	46	50.0	19	471.0	93.7	93.7	93.7	20.5	0.01202
Zinc	153	145	120	346.8	240.7	240.7	240.7	573.4	[illegible]
Total Cyanide	0.9	5.0	5.2	NA	NA	NA	NA	NA	27

NA - Screening concentration not available

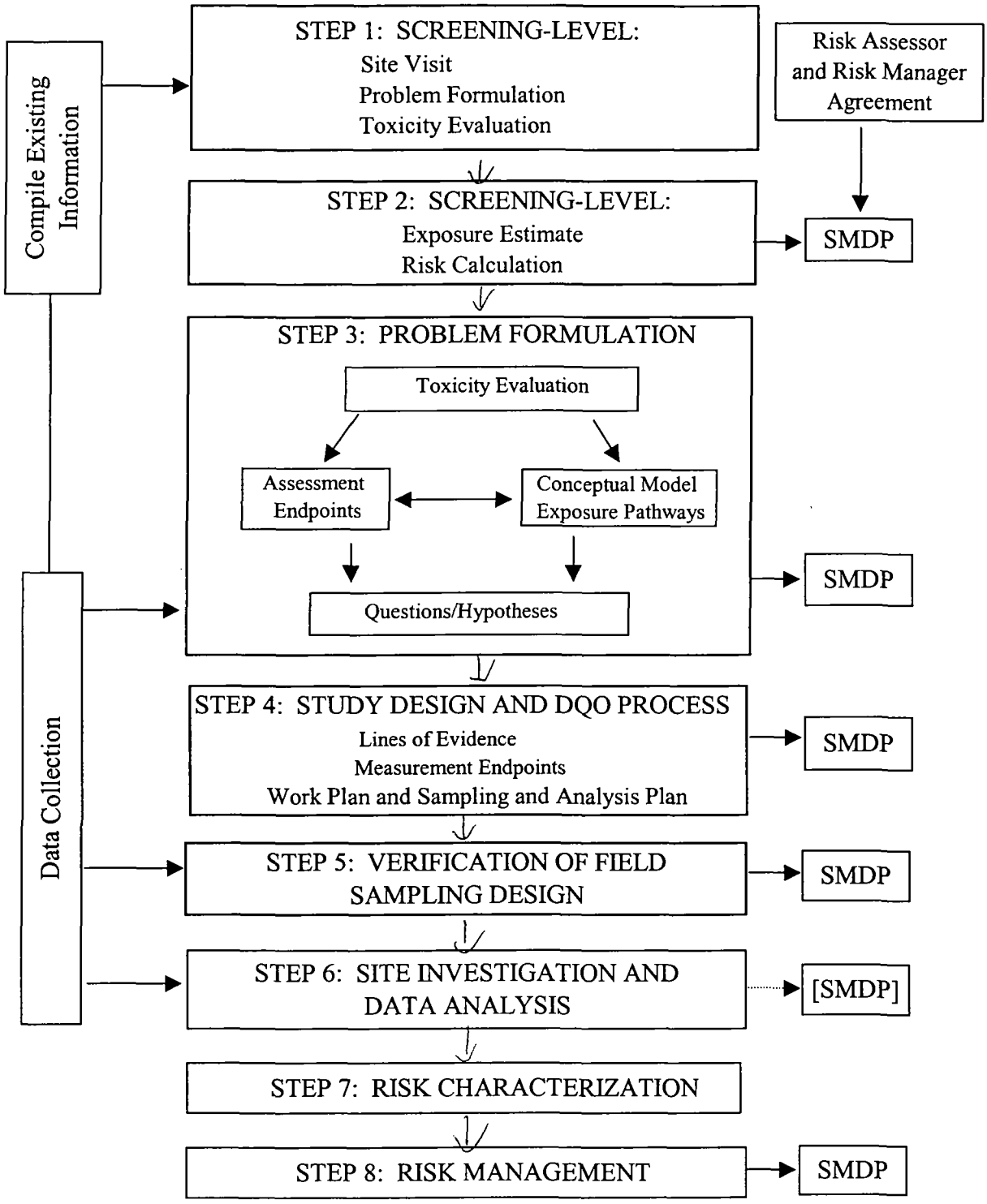
[1] Corresponds to urban Grassland with treelines, brush or stands in Table 3-8

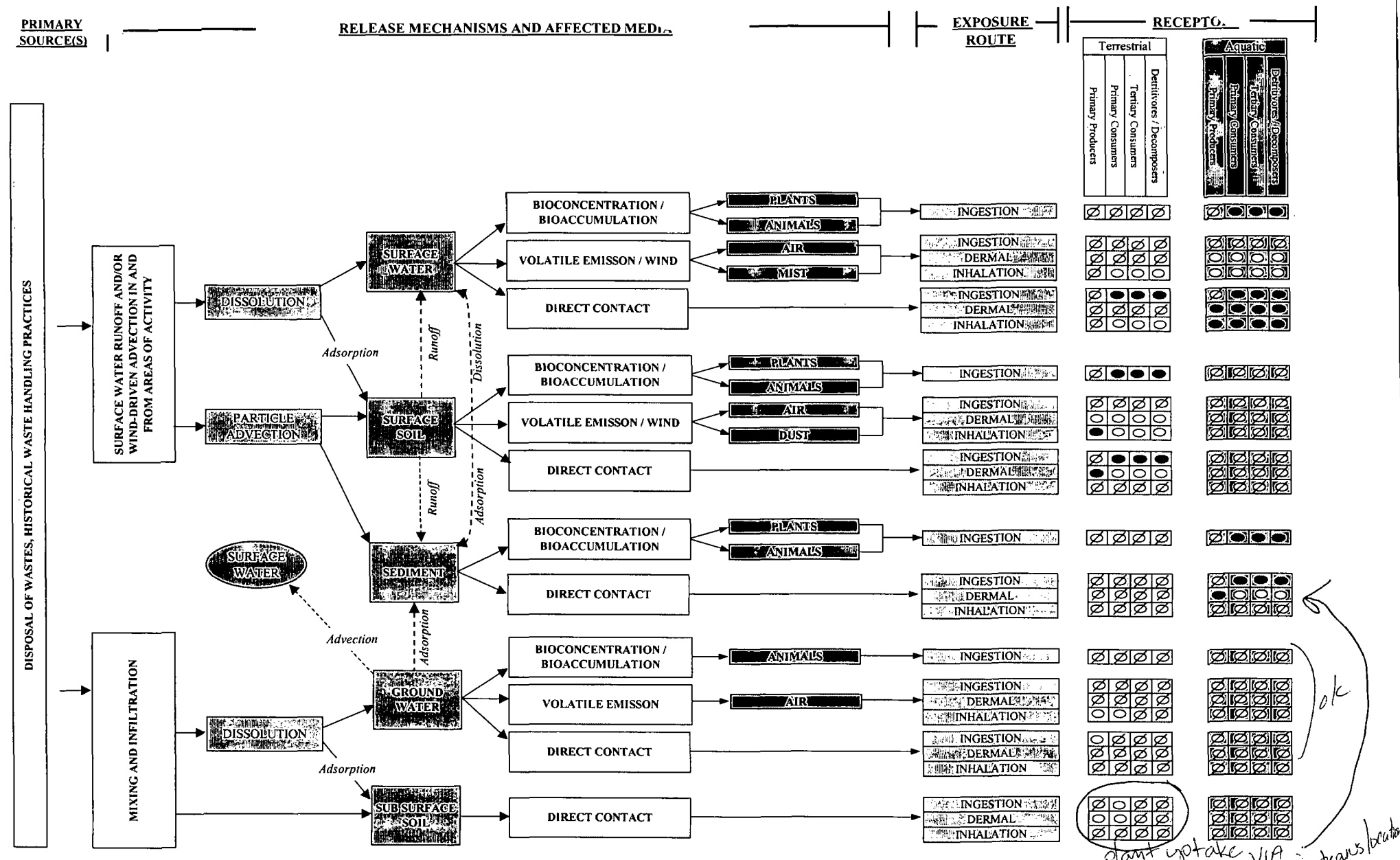
[2] Corresponds to successional woodland in Table 3-8

[3] Corresponds to agriculture field, pasture or old field in Table 3-8

[4] Corresponds to woodland/field mix in Table 3-8

FIGURE 3-1
EIGHT-STEP ECOLOGICAL RISK ASSESSMENT PROCESS





NOTE:
SOLID LINES REPRESENT POTENTIALLY COMPLETE PATHWAYS
DASHED LINES REPRESENT SECONDARY PATHWAYS

● Potentially Complete Pathway
○ Minor or Insignificant Pathway
⊘ Incomplete Pathway

DRN BY MSG	DATE 06/12/00	CONCEPTUAL EXPOSURE MODEL ECOLOGICAL EXPOSURES ADDITIONAL AND UNCHARACTERIZED SITES OU	PROJECT NO. 2320000026.00 TASK 01011	FIG NO. 3-2
CHK'D BY	REVISIONS: 0			

plant uptake VIA roots & translocation to other parts

ok

As noted in Section 1, the overall guidance for the human health evaluation will follow the structure presented in *Risk Assessment Guidance for Superfund* (RAGS) (USEPA 1989). Unlike the ecological evaluation, there are readily available published screening values for application in the human health evaluation. The evaluation will use published screening concentrations for soils and surface water from USEPA Region IX. Values presented by Region IX are risk-based media-specific screening concentrations using a carcinogenic risk of 1×10^{-6} or a noncarcinogenic hazard of 0.1. Note, however, that there are no published values for evaluating sediments. Because sediments are expected to comprise a minor portion of media applicable to the AUS OU (particularly for the human health evaluation), soil screening concentrations will be used to evaluate sediments in lieu of deriving sediment screening concentrations for all COIs. This is believed to be a conservative approach, since exposures to sediments will generally be less than those for soils.

Selection of chemicals of potential concern (COPCs) for human health will be in a manner similar to the approach used in the ecological risk evaluation process. Screening concentrations from USEPA Region IX will be compared to the maximum concentration of a COI at each of the AUS OU sites to chemicals of potential ecological concern. The following criteria will be used in selecting COPCs:

- If a chemical is not detected, and there is no screening concentration, then the chemical will not be selected as a COPC.
- If an inorganic chemical is detected below site-specific background concentrations, then the chemical will not be selected as a COPC.
- If the maximum concentration of a chemical exceeds the screening concentration, then the chemical will be classified as a COPC.
- If the maximum concentration of a chemical is less than the screening concentration, then the chemical will not be classified as a COPC.
- If a chemical is detected, and there is no screening concentration, then the chemical will be carried forward as an uncertainty

As with the ecological risk screening approach, the screening concentrations are based on conservative assumptions to ensure that chemicals are not inadvertently screened out. A discussion of the uncertainties associated with the human health screening process will be included in the screening evaluation. COPCs and associated uncertainties will be discussed as warranting or not warranting further, more detailed evaluation as part of the SMDP following completion of the initial screening process.

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Concentrations of the chemicals of interest (COIs) in dietary items other than water, sediment, and soil are not available. These dietary items include plants, invertebrates, fish and mammals. For screening purposes, estimated concentrations of COIs in potential dietary items, were used to back-calculate screening concentrations (SCs) that will be used to select chemicals of potential ecological concern (COPECs). The following discussion presents methods for estimation of the constituent concentrations within dietary items.

Accumulation of Inorganic COIs in Biological Tissues

The accumulation of inorganic COIs into vascular plants is predicted using the methods described by Bechtel Jacobs Company (1998a) and RTI (1995). Bechtel and Jacobs (1998a) developed natural log-based regression equations that describe the uptake of specific inorganic chemicals into vascular plants. The regression equations (Table 1) are for the whole plant and are not specific to particular parts of the plant. The general form of the regression is as follows:

$$\text{Tissue Concentration (mg/kg)} = e^{\{a + (b \times \ln[\text{soil or sediment-mg/kg}])\}}$$

where:

e = the natural logarithm

a = the log intercept for the regression

b = slope of the regression

ln(soil) = the natural transformed measured concentration of the inorganic COI

Such a form for the predictive equation is intuitive, in that, the shape is sigmoid suggesting that at low and high soil concentrations, the ratio between plant concentration and soil concentration is asymptotic.

Not all of inorganic chemicals have reliable regression equations, and as such, the median and 90th percentile of the empirically observed plant factors as reported by Bechtel and Jacobs (1998a) will be used (Table 1). These uptake factors represent a predicted ratio between soil/sediment[1] concentration and plant tissue concentrations where:

$$\text{Tissue Concentration (mg/kg)} = \text{UF} \bullet \text{Soil or Sediment -mg/kg}$$

where:

UF = the uptake factor for the COI

Similar uptake regressions for earthworms, small mammals, and benthic macro-invertebrates for inorganics from soil and sediment have been developed (Sample *et al.* 1998a, b, and Bechtel and Jacobs 1998b). When not available, a theoretical BSAF was derived from the water-associated BCFs, as reported by USEPA (ASTER database), and equilibrium partitioning, as follows:

[1] There is sufficient evidence that the uptake of inorganic chemicals by aquatic (wetland) plants and upland plants is virtually the same (Folsom et al. 1988) such that the equations for soil are also applicable to sediment.

$$BSAF = Kd * BCF$$

where:

BASF = biota-sediment accumulation factor

Kd = sediment partitioning coefficient (Koc x the organic carbon content [1%])

BCF = Bioconcentration Factor for water-only exposure

All of the uptake factors for small mammals and invertebrates are specific to whole body concentrations. While this may not be an issue regarding the accumulation into earthworms and benthic invertebrates, there is some question regarding a whole body concentration of certain metals in small mammals and somewhat for plants[2]. For example, if the majority of a certain COI, say lead, is strongly associated with bone tissue, is the lead truly bio-available? The approach here is to assume that the material is bio-available and thus assures that the dietary concentration for relevant ecological receptor groups is not underestimated.

Accumulation of Organic COIs in Biological Tissues

Uptake of organic COIs into plants from soil/sediment is modeled following the fugacity methods presented in Trapp and McFarlane (1995) and Mackay and Paterson (1991). Uptake of organic COIs into invertebrates, secondary and tertiary consumers are modeled following fugacity methods (Mackay and Paterson 1981; Clark *et al.* 1988; 1990; Mackay and Paterson 1991; Thomann *et al.* 1992; Mackay, *et al.* 1995; Spacie *et al.* 1995) as well as guidance obtained from Belfroid *et al.* (1994) and Belfroid *et al.* (1995).

Fugacity and Fugacity Capacities

The fugacity approach enables considerations of both chemical-specific and organism-specific attributes (e.g., Clark *et al.* 1988). Fugacity (*F*) is regarded as the "escaping tendency" of a chemical from a particular phase (Mackay and Paterson 1981) with units of pressure (pascals, Pa), and can be related to phase concentrations. For any particular environmental phase (e.g., water, soil, air, or biota) there is a corresponding "fugacity capacity" with units of mol/m^3-Pa which is denoted by a Z value. The relationship between fugacity, fugacity capacity and chemical concentration (C) is defined by:

$$C = ZF$$

Fugacity capacities for a given chemical are calculated for the phases of interest in order for the exposure point concentration estimation methodology (Mackay and Paterson 1981; Mackay *et al.* 1995). The following calculations require chemical-specific parameters and an assumption of the system temperature, 25°C.

$$Z_{water} = 1 \div H$$

$$Z_{soil} = K_d \times \rho_{soil} \div H$$

$$Z_{air} = 1 \div (R \times T)$$

[2] Many of the COIs while taken up by vascular plants are not readily translocated from the roots of the plants (e.g., see Kabata-Pendias and Pendias 1992).

$$Z_{biota} = lipid \times K_{ow} \times \rho_{biota} \div H$$

where:

H = Henry's Constant

K_d = soil or sediment partitioning coefficient = fraction organic carbon × K_{oc} (partitioning coefficient between water and organic carbon)

ρ_{soil} = bulk density of the soil (g/cm^3)

R = Universal Gas Constant (8.31 Joules-m^3/mol-^{o}K)

T = temperature in degrees Kelvin

lipid = fraction of lipid in the organism

K_{ow} = octanol to water partitioning coefficient

ρ_{biota} = the density of the organism (g/cm^3)

The resultant fugacity capacities (Z values) can be used in concert with phase volumes and transport mechanisms (e.g., advection, biotransformation, photolysis, etc) to calculate chemical flux, distributions, mass balance, and persistence (e.g., Mackay and Paterson 1981, 1991). In the risk assessment application here, Z values are used to estimate partitioning between the phases under steady-state conditions assuming no degradation, biotransformation, and unlimited chemical mass (i.e., concentration-based).

Concentration-based modeling departs from the strict fugacity approach due to the assumption that mass is unlimited. The application here uses the relationship between fugacity capacities and partitioning coefficients (i.e., Biota-Transfer Factors, BTFs) to predict COI concentrations in the diet of the receptors of concern. In order for the relationship between fugacity and partitioning to be functional, in this context, the system is assumed to be at steady-state (Mackay et al. 1995). This is an implicit assumption for this modeling approach[3].

By definition (Mackay, et al. 1995), the ratio between Z values of different phases equals the steady-state partitioning coefficient (e.g., the bioconcentration factor; BCF).

For example:

$$Z_{octanol} \div Z_{water} = K_{ow}$$

$$Z_{fish} \div Z_{water} = BCF$$

This approach allows estimation of the partitioning between abiotic media, biological tissue, and ingested materials.

[3] Unlimited mass assumes that there is sufficient chemical mass to result in steady-state concentrations within all components within the model -- abiotic and biotic. This often results in severe over-estimation as kilograms of chemical can be required to produce the predicted concentrations in secondary and tertiary consumers within an ecosystem.

Terrestrial and Semiaquatic Vascular Plants

A soil or sediment concentration does not solely determine the direct exposure concentration considering uptake of organic contaminants into plants (Bacci *et al.* 1990). For plants there are two pertinent uptake pathways: (1) water taken into the root and transported via the transpiration stream; and (2) uptake from soil-air where soil contaminants have volatilized[4].

A soil pore-water concentration must be estimated to use this approach in terrestrial plants. This was accomplished following the equations of Trapp and McFarlane (1995) given soil moisture, total volumetric porosity, and organic carbon content within soil:

$$C_{soil\text{-}water} = C_b \div K_{bw}$$

$$K_{bw} = \rho_b \times K_d + \theta + (\varepsilon - \theta) \times K_{aw}$$

where:

$C_{soil\text{-}water}$ = the soil water concentration

C_b = the bulk soil concentration

K_{bw} = the bulk soil-to-soil water partitioning coefficient

K_d = the soil-to-water partitioning coefficient ($K_d = K_{oc} \times OC$)

(K_{oc} = the organic carbon-to-water partitioning coefficient and OC = the fraction organic carbon in the soil)

ρ_b = soil bulk density (gm/cm^3)

θ = the volumetric water fraction of the soil

ε = the volumetric total porosity of the soil

K_{aw} = the air-to-water partitioning coefficient ($K_{aw} = H \div (R \times T)$)

To calculate a sediment pore water concentration of the COI, the bulk sediment concentration is divided by the product of the fraction of organic carbon in sediment and the COI K_{oc} (organic carbon-to-water partitioning coefficient):

$$C_{pw} = C_s \div (f_{organic\ carbon} \times K_{oc})$$

Given the soil or sediment pore-water concentration of the COI, the partitioning between the water and plant root is defined by the root water (W_r) lipid content (L_r), and the K_{ow} of the COI adjusted by a correction exponent, b, using the default value 0.75 (Trapp and McFarlane 1995). This is to account for the differences between plant lipid and octanol. Finally, the root density compared to water adjusts the partitioning:

$$K_{rw} = (W_r + L_r \times K_{ow}^{\ b}) \times \rho_r \div \rho_w$$

[4] Volatilization of chemicals into surface air is not considered in this model. Proper estimations would require wind velocities, consideration of spatial volumes (e.g., 1 foot above the ground), and a more complete characterization of the soil surface (i.e., bare ground, vegetated, littered, etc.) such that estimates are not practical.

Combining these equations results in a solution for the root concentration based on the soil-water and soil-air uptake routes:

$$C_{root} = [(W_r + L_r \times K_{ow}^{b}) \times \rho_r \div \rho_w)] \times [C_b \div (\rho_b \times K_d + \theta + (\varepsilon - \theta) \times K_{aw})]$$

Once within the root tissue the contaminant can be transported via the xylem transpiration stream (Trapp and McFarlane 1995). This translocation, represented below as the transpiration stream concentration factor (TSCF) is defined by the K_{ow} and the soil-water concentration (it is not dependent on the root concentration):

$$TSCF = 0.784 \times \exp[-(\log K_{ow} - 1.78)^2 \div 2.44]$$

and thus the concentration within the xylem is calculated as:

$$C_{Xy} = TSCF \times C_{\text{soil-water}}$$

The relationship between the concentration in the foliage, fruits, seeds or nuts and the concentration in the xylem is related to the fugacity capacities of the respective phases. The partitioning coefficients are calculated based on the fugacity capacities (Z's):

$$Z_{xylem} = TSCF \div H$$

$$Z_{foliage} = fZ_{air} + fZ_{water} + fZ_{lipid}$$

$$Z_{fruits} = fZ_{air} + fZ_{water} + fZ_{lipid}$$

$$Z_{seeds\ or\ nuts} = fZ_{air} + fZ_{water} + fZ_{lipid}$$

The fugacity capacities of the different plant parts are weighted by the fractions of its constituents: air, water, and lipids (i.e., f's of 18, 80, and 2% respectively for foliage). The partitioning between these plant parts and xylem is then:

$$C_{\text{plant part}} = (Z_{\text{plant part}} \div Z_{xylem}) \times C_{xylem}$$

Terrestrial Invertebrates

Invertebrate detritivores dwelling within the soil are exposed to both soil-water and via the ingestion of soil (Belfroid, *et al.* 1994). Insects, in the context of the model presented, are exposed primarily via the ingestion of plant material and other insects. Given the chitonous exoskeleton, uptake from soil-water is considered insignificant for most insects (Crommentaijn et al. 1994). The concentration in invertebrates is calculated as a combination of uptake from soil pore-water and ingested soil across the gastro-intestinal tract:

$$C_{invertebrate} = [C_b \times (Z_{invertebrate} \div Z_{soil})] + [C_{soil\ water} \times (Z_{invertebrate} \div Z_{soil\ water})]$$

The model assumes a lipid content of 1% in invertebrates as reported by Cobb et al. (1995) for earthworms. Z values are calculated as specified above. For insects, only exposure to soil via ingestion of plants or other insects are considered; therefore:

$$C_{herbivorous\ insects} = C_{plant\ foliage} \times (Z_{insect} \div Z_{foliage})$$

$$C_{carnivorous\ insects} = C_{herbivorous\ insect} \times (Z_{insect} \div Z_{herbivorous\ insects})$$

Aquatic Invertebrates and Auwfuchs

Bioconcentration factors (BCFs) between aquatic organisms and water are based on the lipid content of the species under evaluation and the chemical-specific K_{ow}. There is no correction for the differences between lipids and octanol as the differences are considered insignificant in these organisms (USEPA 1995) and can be derived as follows:

$$BCF = f_{lipid} \times K_{ow}$$

Algae and zooplankton are, in the context of this model, exposed only to surface water, whereas benthic invertebrates are assumed to be infaunal[5] species exposed to sediment pore water. Sediment pore-water concentrations are calculated based on the COI K_{oc} and the sediment organic carbon content.

$$C_{algae} = BCF \times C_{surface\ water}$$

$$C_{zooplankton} = BCF \times C_{surface\ water} + [(Z_{zooplankton} \div Z_{algae}) \times C_{algae}]$$

$$C_{benthos} = BCF \times C_{pore\ water}$$

Forage fish and amphibians and certain larger invertebrates (e.g., crayfish) may play a significant role within the foodwebs of these sites. The concentrations within amphibians are expected to be highly influenced by the animals aquatic stage as a tadpole. This stage is essentially herbivorous and the concentration is represented by:

$$C_{fish\ /\ amphibian} = BCF \times C_{surface\ water} + [(Z_{fish\ /\ amphibian} \div Z_{algae}) \times C_{algae}]$$

Crayfish are essentially epifaunal detritivores who receive direct exposures to surface water, as well ingestion of sediment. Thus the predicted concentration is as follows:

$$C_{crayfish} = BCF \times C_{surface\ water} + [(Z_{crayfish} \div Z_{sediment}) \times C_{sediment}]$$

Semi-Aquatic and Terrestrial Tetrapod Consumers

Modeling of organic COI concentrations in secondary consumers begins with the calculation of total ingested mass of COI based on ingestion rates and COI concentrations within the ingested materials.

$$M_{abiotic} = (C_{soil\ or\ sediment} \times IR_{soil\ or\ sediment}) + (C_{water} \times IR_{water})$$

$$M_{biotic} = (C_{dietary\ item\ 1} \times IR \times P_{dietary\ item\ 1}) + (C_{dietary\ item\ 2} \times IR \times P_{dietary\ item\ 2}) + (C_{dietary\ item\ n} \times IR \times P_{dietary\ item\ n})$$

$$M_{total} = M_{abiotic} + M_{biotic}$$

where:

$M_{abiotic}$ = mass of COI ingested from abiotic items (soil, sediment and water)

M_{biotic} = mass of COI ingested from biological tissues

M_{total} = total mass of COI ingested

[5] Infaunal refers to those invertebrates, which live *within* the sediment versus epifaunal species that live *upon* the sediment.

$C_{dietary\ item\ i}$ = COI concentration in dietary item

IR = food ingestion rate

$P_{dietary\ item\ i}$ = percentage of diet comprised by dietary item

The COI concentration within the diet or more specifically within the gastro-intestinal tract (GIT) of the animal is calculated as:

$$C_{diet} = M_{total} \div [\text{Water Consumed (kg/day)} + \text{Soil or Sediment Consumed (kg/day)} + \text{Food Consumed (kg/day)}]$$

Partitioning between the gut contents of an organism and the organism itself can be estimated via fugacity. The fugacity capacity of the receptor (Z_{biota}) is calculated based on the percent lipid in the animal, the K_{ow} of the COI, the density of the animal, assumed to be 1, and the COI Henry's constant. The Z_{diet} is calculated by weighting the individual Z values for each component by its percentage (f) of the total material ingested (food + water + soil or sediment). Thus for the terrestrial foodweb:

$$Z_{diet} = [(f_{soil\ in\ diet}) \times Z_{soil}] + [(f_{water\ in\ diet}) \times Z_{water}] + [(f_{plants\ in\ diet}) \times Z_{plants}] + [(f_{insects\ in\ diet}) \times Z_{insects}] + [(f_{soil\ invertebrates\ in\ diet}) \times Z_{soil\ invertebrates}] + [(f_{small\ mammals\ in\ diet}) \times Z_{small\ mammals}] + [(f_{birds\ in\ diet}) \times Z_{birds}]$$

and for the semiaquatic foodweb:

$$Z_{diet} = [(f_{sediment\ in\ diet}) \times Z_{sediment}] + [(f_{water\ in\ diet}) \times Z_{water}] + [(f_{plants\ in\ diet}) \times Z_{plants}] + [(f_{benthos\ in\ diet}) \times Z_{benthos}] + [(f_{amphibians\ /\ fish\ in\ diet}) \times Z_{amphibians\ /\ fish}] + [(f_{crayfish\ in\ diet}) \times Z_{crayfish}]$$

As previously stated, the ratio of Z values between environmental phases is equal to the partitioning coefficient, thus:

$$C_{animal} = C_{diet} \times (Z_{animal} \div Z_{diet})$$

Ecological Risk Screening Concentrations

For ingestion pathway exposures, ecological screening concentrations are based on an average daily dose (ADD) equal to a toxicity reference value (TRV) (see text Section 3). The ratio of the average daily dose to a TRV is generally referred to as an ecological effects quotient (EEQ). An EEQ based on a no-observed effect concentration (NOAEL) at or below 1 is indicative of low (or no) risk. The dose corresponding to an EEQ of 1 must be presented as a media-specific value to effectively apply it as a risk-based-screening concentration. This is accomplished using the procedures presented in the Appendix essentially in reverse, i.e., by back-calculating from the EEQ dose concentration (i.e., the dose at which the TRV equals the ADD), to a concentration in the media of interest.

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BIOLOGICAL UPTAKE F[illegible]ORS AND REGRESSIONS
ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNIT
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Metals (mg/kg)		Inorganic Kd	Source	Aquatic BCF	Source	BSAF Regression Slope	Source	BSAF Regression Intercept	Source	BSAF 90th Percentile	Source	Median BSAF	Source	Theoretical BSAF	Source	Soil Invertebrate Regression Slope	Source	Soil Invertebrate Regression Intercept	Source	Soil Invertebrate 90th Percentile BCF
7429905	Aluminum		15	1.36E+02	1															1.18E-01
7440360	Antimony	4.50E+00	15	1.08E+01	2									2.40E+00	17					
7440382	Arsenic	2.90E+01	15	2.90E+00	3	0.754	16	-0.292	16	6.90E-01	16	1.43E-01	16	1.00E-01	17	0.706	19	-1.421	19	5.23E-01
7440393	Barium	4.10E+01	15	1.50E+02	4									3.66E+00	17					1.60E-01
7440417	Beryllium	7.90E+02	15	9.50E+01	5									1.20E-01	17					1.18E+00
7440439	Cadmium	7.50E+01	15	7.13E+02	6	0.692	16	0.0395	16	7.99E+00	16	6.00E-01	16	9.51E+00	17	0.795	19	2.114	19	4.07E+01
7440702	Calcium																			
7440473	Chromium (Total)	1.80E+06	15	3.00E+00	5	0.365	16	0.2092	16	4.68E-01	16	1.00E-01	16	1.67E-06	17					3.16E+00
18540299	Chromium VI																			
7440484	Cobalt			9.80E-01	7															2.91E-01
7440508	Copper	2.20E+01	5	4.69E+02	8	0.278	16	1.089	16	5.25E+00	16	1.56E+00	16	2.13E+01	17	0.264	19	1.675	19	1.53E+00
7439896	Iron																			7.80E-02
7439921	Lead	2.80E+05	5	3.31E+02	9	0.801	16	-0.776	16	6.07E-01	16	7.10E-02	16	1.18E-03	17	0.807	19	-0.218	19	1.52E+00
7439954	Magnesium																			
7439965	Manganese			7.30E+01	10											0.682	19	-0.809	19	1.24E-01
7439976	Mercury									2.87E+00	16	1.14E+00	16			0.118	19	-0.684	19	2.06E+01
7440020	Nickel	6.50E+01	15	3.51E+01	11					2.32E+00	16	4.86E-01	16	5.40E-01	17					4.73E+00
7440097	Potassium																			
7782492	Selenium	5.00E+00	15	9.40E+01	12									1.88E+01	17	0.733	19	-0.075	19	1.34E+00
7440224	Silver	8.30E+00	15	2.18E+01	13									2.63E+00	17					1.53E+01
7440235	Sodium																			
7440280	Thallium	7.10E+01	15	6.70E+01	5									9.44E-01	17					
7440622	Vanadium	1.00E+02	15	1.00E+02	4									1.00E+00	17					8.80E-02
7440666	Zinc	6.20E+01	15	6.82E+02	14	0.208	16	1.8	16	7.53E+00	16	1.94E+00	16	1.10E+01	17	0.328	19	4.449	19	1.29E+01
57125	Total Cyanide																			

TABLE 1
BIOLOGICAL UPTAKE FACTORS AND REGRESSIONS
ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNIT
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Metals (mg/kg)		Source	Soil Invertebrate Median BCF	Source	Plant Regression Slope	Source	Plant Regression Intercept	Source	Plant 90th Percentile BCF	Source	Plant Median BCF	Source	Herbivore Regression Slope	Source	Herbivore Regression Intercept	Source	Herbivore 90th Percentile BCF	Source	Herbivore Median BCF	Source
7429905	Aluminum	19	4.30E-02	19					5.00E-03	18	2.87E-03	18					3.10E-02	20	1.71E-02	20
7440360	Antimony								1.14E-02	18	1.02E-02	18					8.00E-03	5	8.00E-03	5
7440382	Arsenic	19	2.24E-01	19	0.564	18	-1.992	18	1.10E+00	18	3.75E-02	18	1.1382	20	-5.6531	20	1.60E-02	20	4.20E-03	20
7440393	Barium	19	1.60E-01	19					4.77E-01	18	1.56E-01	18	3.86E-01	20	3.36E-01	20	2.53E-01	20	3.15E-02	20
7440417	Beryllium	19	4.50E-02	19					1.00E-02	5	1.00E-02	5					3.20E-01	5	3.20E-01	5
7440439	Cadmium	19	7.71E+00	19	0.546	18	-0.476	18	3.25E+00	18	5.86E-01	18	0.4723	20	-1.2571	20	4.48E-01	20	1.26E-01	20
7440702	Calcium								6.03E+00	18	1.19E+00	18					1.73E+01	20	1.11E+01	20
7440473	Chromium (Total)	19	3.06E-01	19					8.39E-02	18	4.10E-02	18	0.3887	20	-1.35E-01	20	3.09E-01	20	8.84E-02	20
18540299	Chromium VI																			
7440484	Cobalt	19	1.22E-01	19					2.48E-02	18	7.45E-03	18	1.31E+00	20	-4.26E+00	20	1.40E-01	20	2.10E-02	20
7440508	Copper	19	5.15E-01	19	0.394	18	0.669	18	6.25E-01	18	1.24E-01	18	0.0675	20	2.04E+00	20	1.29E+00	20	1.09E-01	20
7439896	Iron	19	3.60E-02	19					1.00E-02	18	4.25E-03	18	0.6207	20	-0.4758	20	2.40E-02	20	1.26E-02	20
7439921	Lead	19	2.66E-01	19	0.561	18	-1.328	18	4.68E-01	18	1.06E+01	18	0.5181	20	-0.6114	20	1.87E-01	20	5.22E-02	20
7439954	Magnesium								2.06E+00	18	8.10E-01	18					1.15E+00	20	7.69E-01	20
7439965	Manganese	19	5.40E-02	19					2.31E-01	18	7.92E-02	18					7.90E-02	20	1.56E-02	20
7439976	Mercury	19	1.69E+00	19	0.544	18	-0.996	18	5.00E+00	18	6.52E-01	18	-2.2764	21	-4.87E+00	21	2.40E-02	20	2.39E-02	20
7440020	Nickel	19	1.06E+00	19	0.748	18	-2.224	18	1.41E+00	18	1.80E-02	18	0.3766	20	0.3174	20	8.98E-01	20	5.13E-02	20
7440097	Potassium								1.13E+01	18	5.59E+00	18					7.73E+00	20	6.34E+00	20
7782492	Selenium	19	9.85E-01	19	1.104	18	-0.678	18	3.01E+00	18	6.72E-01	18	0.3764	21	-0.4158	21	1.55E-01	20	0.00E+00	20
7440224	Silver	19	2.05E+00	19					3.67E-02	18	1.40E-02	18					7.00E-03	20	0.00E+00	20
7440235	Sodium								8.20E-01	18	1.92E-01	18					1.00E+02	20	6.13E+01	20
7440280	Thallium								4.00E-03	5	4.00E-03	5					1.23E-01	20	1.12E-01	20
7440622	Vanadium	19	4.20E-02	19					9.70E-03	18	4.85E-03	18					1.90E-02	20	1.29E-02	20
7440666	Zinc	19	3.20E+00	19	0.555	18	1.575	18	1.82E+00	18	3.66E-01	18	0.0738	20	4.4713	20	2.32E+00	20	5.04E-01	20
57125	Total Cyanide																			

TABLE 1
BIOLOGICAL UPTAKE FACTORS AND REGRESSIONS
ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNIT
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

Metals (mg/kg)		Omnivore Rgeression Slope	Source	Omnivore Regression Intercept	Source	Omnivore 90th Percentile BCF	Source	Omnivore Median BCF	Source	Insectivore Regression Slope	Source	Insectivore Regression Intercept	Source	Invertivore 90th Percentile BCF	Source	Invertivore Median BCF	Source
7429905	Aluminum					9.30E-02		6.18E-02						9.30E-02	20	6.18E-02	20
7440360	Antimony													8.00E-03	5	8.00E-03	5
7440382	Arsenic	7.35E-01	20	-4.58E+00	20	1.60E-02	20	4.20E-03	20	0.8188	21	-4.88471	21	1.30E-03	20	1.30E-03	20
7440393	Barium	2.35E+00	20	-1.01E+01	20	6.90E-02	20	4.63E-02	20					1.12E-01	21	5.66E-02	21
7440417	Beryllium									3.20E-01	5	3.20E-01	5	3.20E-01	5	3.20E-01	5
7440439	Cadmium	5.66E-01	20	-1.54E+00	20	4.62E-01	20	1.22E-01	20	0.9638	20	0.815	20	7.02E+00	20	2.11E+00	20
7440702	Calcium					9.72E+00		8.52E+00						9.72E+00	20	8.52E+00	20
7440473	Chromium (Total)	0.7326	20	-1.4945	20	3.49E-01	20	6.99E-02	20	0.7338	21	-1.4599	21	9.50E-02	20	8.15E-02	20
18540299	Chromium VI																
7440484	Cobalt	-6.18E-01	20	-2.03E-01	20	2.50E-02	20	1.58E-02	20	1.31E+00	21	-4.47E+00	21	1.00E-01	21	2.05E-02	21
7440508	Copper	0.7326	20	-1.4945	20	5.54E-01	20	1.27E-01	20	0.1783	20	2.1042	20	1.12E+00	20	7.71E-01	20
7439896	Iron	-0.0643	20	6.2403	20	1.50E-02	20	1.24E-02	20	0.5969	21	-0.2879	21	1.71E-02	21	1.24E-02	21
7439921	Lead	0.2194	20	0.5669	20	2.86E-01	20	6.59E-02	20	0.4869	20	0.4819	20	3.39E-01	20	1.60E-01	20
7439954	Magnesium					7.43E-01		6.54E-01						7.43E-01	20	6.54E-01	20
7439965	Manganese					3.70E-02		3.09E-02						3.70E-02	20	3.09E-02	20
7439976	Mercury	-8.97E-01	20	-4.03E+00	20	1.30E-01	20	5.42E-02	20	-2.2764	21	-4.87E+00	21	1.05E+00	20	1.05E+00	20
7440020	Nickel	0.478	20	-0.414	20	5.89E-01	20	1.68E-01	20	0.5444	20	-0.4266	20	5.78E-01	20	3.64E-01	20
7440097	Potassium					5.25E+00		4.48E+00						5.52E+00	20	4.48E+00	20
7782492	Selenium	0.3786	20	-0.426	20	1.26E+00	20	2.06E-01	20	0.3764	21	-0.4158	21	8.13E-01	20	7.24E-01	20
7440224	Silver					8.10E-01		1.51E-01						8.10E-01	20	1.51E-01	20
7440235	Sodium					8.01E+01		7.57E+01						8.01E+01	20	7.57E+01	20
7440280	Thallium													1.23E-01	20	1.12E-01	20
7440622	Vanadium					1.31E-02		1.04E-02						1.31E-02	20	1.04E-02	20
7440666	Zinc	0.0745	20	4.4987	20	2.78E+00	20	5.58E-01	20	0.1324	20	4.2479	20	2.90E+00	20	8.33E-01	20
57125	Total Cyanide																

TABLE 1 CONTINUED
BIOLOGICAL UPTAKE FACTORS AND REGRESSIONS - REFERENCE CODES
ADDITIONAL AND UNCHARACTERIZED SITES OPERABLE UNIT
CRAB ORCHARD NATIONAL WILDLIFE REFUGE, WILLIAMSON COUNTY, ILLINOIS

1 USEPA. 1988b. Ambient Water Quality Criteria for Aluminum. United States Environmental Protection Agency. EPA 440/5-88-008.

2 Ministry of Ontario Environment and Energy (MOEE). 1996. Scientific Criteria Document for the Development of an Interim Provincial Water Quality Objective for Antimony. Queen's Printer for Ontario. PIBS 3348E02.

3 USEPA. 1984a. Ambient Water Quality Criteria for Arsenic. United States Environmental Protection Agency. EPA 440/5-84-033.

4 OHM/TADS Database (no data in ASTER or AQUIRE)

5 RTI. 1995. Supplemental Technical Support Document for the Hazardous Waste Identification Rule: Risk Assessment for Human and Ecological Receptors. Research Triangle Institute, Center for Environmental Analysis. EPA Contract Number 68-W3-0028.

6 USEPA. 1984b. Ambient Water Quality Criteria for Cadmium. United States Environmental Protection Agency. EPA 440/5-84-032.

7 ASTER Database (only marine data available)

8 USEPA. 1985a. Ambient Water Quality Criteria for Copper. United States Environmental Protection Agency. EPA 440/5-84-031.

9 USEPA. 1985b. Ambient Water Quality Criteria for Lead. United States Environmental Protection Agency. EPA 440/5-84-027.

10 ASTER Database

11 USEPA. 1986b. Ambient Water Quality Criteria for Nickel. United States Environmental Protection Agency. EPA 440/5-86-04.

12 USEPA. 1980a. Ambient Water Quality Criteria for Selenium. United States Environmental Protection Agency. EPA 440/5-80-070.

13 USEPA. 1980b. Ambient Water Quality Criteria for Silver. United States Environmental Protection Agency. EPA 440/5-80-071.

14 USEPA. 1987. Ambient Water Quality Criteria for Zinc. United States Environmental Protection Agency. EPA 440/5-87-003.

15 USEPA. 1996c. Soil Screening Guidance: Technicial Background Document. United States Environmental Protection Agency, Office of Solid Waste and Emergancy Response. Washington, DC. EPA/540/R-95/128.

16 Bechtel Jacobs Company. 1998a. Biota Sediment Accumulation Factors for Invertebrates: Review and Recommendations for the Oak Ridge Reservation. Oak Ridge National Laboratory. BJC/OR-112.

17 Theoretical BSAF = BCF / Kd

18 Bechtel Jacobs Company. 1998b. Empirical Models for the Uptake of Inorganic Chemicals from Soil by Plants. Oak Ridge National Laboratory. BJC/OR-133.

19 Sample, B.E., J.J. Beauchamp, R.A. Efroymson, G.W. Suter, II., and T.L. Ashwood 1998a. Development and Validation of Bioaccumulation Models for Earthworms. Oak Ridge National Laboratory, Oak Ridge, Tennessee. ES/ER/TM-220.

20 Sample, B.E., J.J. Beauchamp, R.A. Efroymson, and G.W. Suter, II. 1998b. Development and Validation of Bioaccumulation Models for Small Mammals. Oak Ridge National Laboratory, Oak Ridge, Tennessee. ES/ER/TM-219.

21 General Value from Sample, B.E., J.J. Beauchamp, R.A. Efroymson, and G.W. Suter, II. 1998b. Development and Validation of Bioaccumulation Models for Small Mammals. Oak Ridge National Laboratory, Oak Ridge, Tennessee. ES/ER/TM-219.

Nutritional Requirements for Selected Minerals in Dietary Concentrations (mg/kg-diet)[1]

	Dog		Cat		Swine	Duck		Chicken		Turkey	Reptile	
	Maintenance	Maximum	Maintenance	Maximum	Maintenance	Chicks	Breeders	Chicks	Breeders	Breeders	Carnivores	Omnivores
Calcium	10000	25000	10000	NA	7470	6500	27500	NA	NA	22500	9500	12500
Phosphorous	8000	16000	8000	NA	6000	4000	3000	NA	NA	3500	7000	7500
Potassium	6000	NA	6000	NA	2000	NA	NA	2500	2500	6000	5000	5000
Sodium	3000	NA	2000	NA	1470	1500	1500	1500	1500	1500	2000	2000
Chloride	4500	NA	3000	NA	1210	1200	1200	1500	1500	1200	NA	NA
Magnesium	400	3000	800	NA	421	500	500	600	500	500	400	2000
Iron	80	3000	80	NA	80	NA	NA	80	60	60	70	200
Copper	7.3	250	5	NA	5	NA	NA	5	4	8	6.5	15
Manganese	5	NA	7.5	NA	10	50	NA	60	20	60	5	150
Zinc	120	1000	75	2000	50	60	NA	40	45	65	50	130
Iodine	1.5	50	0.35	NA	0.158	NA	NA	0.35	0.01	0.4	0.45	0.4
Selenium	0.11	2	0.1	NA	0.158	0.2	NA	0.15	0.06	0.2	0.3	0.3

Nutritional Requirements for Selected Minerals - Dervived Daily Doses (mg/kg-body weight/day)

	Dog		Cat		Swine	Duck		Chicken		Turkey	Reptile	
	Maintenance	Maximum	Maintenance	Maximum	Maintenance	Chicks	Breeders	Chicks	Breeders	Breeders	Carnivores	Omnivores
Calcium	171	429	293		87.3	835	1533			625	190	361
Phosphorous	137	274	234		70.2	514	167			97.2	140	217
Potassium	103		176		23.4			363	121	167	100	145
Sodium	51.4		58.6		17.2	193	83.6	218	72.5	41.6	40.0	57.8
Chloride	77.1		87.9		14.1	154	66.9	218	72.5	33.3		
Magnesium	6.86	51.4	23.4		4.92	64.3	27.9	87.1	24.2	13.9	8.00	57.8
Iron	1.37	51.4	2.34		0.935			11.6	2.90	1.67	1.40	5.78
Copper	0.125	4.29	0.146		0.0585			0.726	0.193	0.222	0.130	0.434
Manganese	0.0857		0.220		0.117	6.43		8.71	0.967	1.67	0.100	4.34
Zinc	2.06	17.1	2.20	58.6	0.585	7.71		5.81	2.18	1.80	1.00	3.76
Iodine	0.0257	0.857	0.0103		0.00185			0.0508	0.000484	0.0111	0.00900	0.0116
Selenium	0.00189	0.0343	0.00293		0.00185	0.0257		0.0218	0.00290	0.00555	0.00600	0.00867

Notes: [1] Reproduced from The Merck Veterinary Manual 8th Edition (1998); NA = not available; Mature dog weight = 14 kg, food ingestion = 0.24 kg/day (dry diet; USEPA 1988); Average mature cat weight = 3.55 kg, average food consumption = 0.104 kg/day (dry diet; USEPA 1988); Swine body weight = 162.5 kg, food consumption = 1.9 kg/day (Merck 1998); 10-day old mallard body weight = 92 to 115 g, average = 0.1035 kg (USEPA 1993); Bird food ingestion (based on all birds) = 0.0582 x $BW(kg)^{0.651}$(USEPA 1993); Adult mallard body weight = (average male & female) = 1.134 kg (USEPA 1993); Chick body weight estimated at an age of 7 days = 0.073 kg (USEPA 1988); Chicken body weight (mature) = 1.7 kg (USEPA 1988); Turkey body weight = 13.4 kg, food consumption = 0.372 kg/day (USEPA 1988); Snapping turtle average body weight (Michigan) = 1.66, food consumption (captive) = 0.048 kg/day (USEPA 1993); Racer average (approximate) body weight = 0.175 kg, food consumption = 0.0035 kg/day (USEPA 1993).

Aluminum Oral Toxicity Values

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Mouse (A)	LD_{50}	Single Dose	Mortality		6207	RTECS, Brit. J. Indust. Med. 23:305, 1966
Mouse (A)	LD_{50}	Single Dose	Mortality		4210	HSDB, Venugopal & Luckey, Metal Toxicity on Mammals, 1978
Mouse (A)	LD_{50}	Single Dose	Mortality		770	HSDB, CHRIS Vol2, 1984
Mouse (A)	LD_{50}	Single Dose	Mortality		970	HSDB, NRC, Drinking Water and Health Vol4, 1981
Mouse (A)	LD_{50}	Single Dose	Mortality		6100	HSDB, Gosselin, et al., Clin. Tox. of Comm. Prod., 5th Ed., 1984
Rat (A)	LD_{50}	Single Dose	Mortality		1930	HSDB, Venugopal & Luckey, Metal Toxicity on Mammals, 1978
Chicken (A, B, H, I)	LD_{lo}	3-week	Mortality	5000 mg/kg-diet	345	Storer and Nelson 1978 as cited in NAS 1980
Cattle (A)	LOAEL	Post weaning	Diet aversion	1215 mg/kg-diet	42.0	Bailey 1977 as cited in NAS 1980
Dairy cow (F)	LOAEL	Not specified	Depressed growth	2000 mg/kg-diet	52.3	Crowe et al. 1990 as cited in Sparling et al. 1998
Sheep (B)	LOAEL	77-day	Reduced Growth and P uptake	2200 mg/kg-diet	35.5	Valdivia-Rodriguez 1977 as cited in NAS 1980
Lamb (F)	LOAEL	Not specified	Depressed growth	1450 mg/kg-diet	26.5	Rosa et al 1982 as cited in Sparling et al. 1998
Rat (B)	LOAEL	21-day (gestation)	Postnatal Mortality		272	HSDB, Shepard, Cat. Teratog. Agents, 4th Ed., 1986
Rat (B)	LOAEL	14-day(gestation)	Postnatal Mortality		155	Bernuszzi et al. 1986
Rat (C)	LOAEL	21-day (gestation)	Postnatal Mortality		378	HSDB, Shepard, Cat. Teratog. Agents, 4th Ed., 1986
Rat (D)	LOAEL	14-day(gestation)	Growth of Offspring	1000 mg/kg-diet	88	HSDB, NRC, Drinking Water and Health Vol4, 1981
Rat (E)	LOAEL	4-week (weaning)	Growth Rate	1100 mg/kg-diet	330	Thurston et al. 1972 as cited in NAS 1980
Rat (F)	LOAEL	100-day	Weight gain	(water)	540	Domingo et al. 1984 as cited in ATSDR 1992
Mouse (D)	LOAEL	14-day(gestation)	Fetal Reabsorbtion	200 mg/day	5714	HSDB, Shepard, Cat. Teratog. Agents, 4th Ed., 1986
Mouse (K)	LOAEL	4-month	Impaired reproduction	2070 mg/kg-diet	369	Schaeffer et al. 1928 as cited in NAS 1980
Mouse (B)	LOAEL	3-generations	Growth rates	19.3 mg/L - water	4.72	Ondreicka et al. 1966 as cited in NAS 1980
Chicken (K)	LOAEL	8-day	Reduced growth rate - started with 10-day old chicks	8000 mg/kg-diet	834	Grau and Klein 1957 as cited in NAS 1980

Aluminum Oral Toxicity Values

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Chicken (A)	LOAEL	2-week	Reduced growth rate, feed efficiency, and bone ash - started with 1-day old chicks	1000 mg/kg-diet	111	Storer and Nelson 1978 as cited in NAS 1980
Chicken (B)	LOAEL	2-week	Reduced growth rate, feed efficiency, and bone ash - started with 1-day old chicks	500 mg/kg-diet	55.7	Storer and Nelson 1978 as cited in NAS 1980
Chicken (F)	LOAEL	4-week	Depressed egg lying	1500 mg/kg-diet	104	Hussein et al. 1988 as cited in Sparling et al. 1998
Chicken (A)	LOAEL	5-week	Reduced bone strength - started with 1-day old chicks	2200 mg/kg-diet	221	Deobald and Elvehjem 1935 as cited in NAS 1980
Chicken (F)	LOAEL	Not specified	Reduced bone strength	2500 mg/kg-diet	173	Hussein et al. 1989 as cited in Sparling et al. 1998
Japanese Quail (F)	LOAEL	3-week	Depressed egg production	3000 mg/kg-diet	233	Hussein et al. 1989 as cited in Sparling et al. 1998
Black and Mallard ducklings (F)	LOAEL	10-week	Depressed growth	1000 mg/kg-diet	85	Sparling 1990 as cited in Sparling et al. 1998
Cattle (A)	NOAEL	14-day	No Adverse Effects	1215 mg/kg-diet	42	Bailey 1977 as cited in NAS 1980
Cattle (B)	NOAEL	84-day	No Adverse Effects	1200 mg/kg-diet	41.5	Validiva et al. 1978 as cited in NAS 1980
Sheep (A)	NOAEL	14-day	No Adverse Effects	900 mg/kg-diet	14.5	Thompson et al. 1959 as cited in NAS 1980
Sheep (A)	NOAEL	20-day	No Adverse Effects	1251 mg/kg-diet	20.2	Bailey 1977 as cited in NAS 1980
Dog beagle (F)	NOAEL	90-day	No Adverse Effects	2600 mg/kg-diet	80.8	Indust. Bio-Test Lab.s 1972 as cited in NAS 1980
Dog (G)	NOAEL	6-month	Reproduction	(diet)	60	Katz et al. 1979 as cited in ATSDR 1992
Rat (D)	NOAEL	14-day(gestation)	No Adverse Fetal Effects	0.1% (water)	14400	HSDB, Shepard, Cat. Teratog. Agents, 4th Ed., 1986
Rat (A)	NOAEL	24-day	No Adverse Effects	180 mg/kg-diet	14.7	Ondreicka et al. 1966 as cited in NAS 1980
Rat (A)	NOAEL	30-day	Neuro-behavioral	0.3% (water)	43200	HSDB, Conner, et al., Pharm. Biochem. Behav. 31:467, 1988
Rat (B)	NOAEL	90-day	Reproduction	(water)	100	Dixon et al. 1979 as cited in ATSDR 1992
Mouse (B)	NOAEL	390-day	Reproduction	(water)	19	Ondreicka et al. 1966 as cited in ATSDR 1992
Ring Dove (A)	NOAEL	63-day	Egg production, fertility, fledging	1000 mg/kg-diet	110	Carriere et al. 1986 as cited in Sample et al. 1996
Chicken (K)	NOAEL	8-day	Growth rate - started with 10-day old chicks	4900 mg/kg-diet	511	Grau and Klein 1957 as cited in NAS 1980
Chicken (G)	NOAEL	3-week	No Adverse Effects - started with 1-day old chicks	5000 mg/kg-diet	524	Storer and Nelson 1978 as cited in NAS 1980

Aluminum Oral Toxicity Values

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Chicken (J)	NOAEL	3-week	No Adverse Effects - started with 1-day old chicks	16000 mg/kg-diet	167.8	Storer and Nelson 1978 as cited in NAS 1980
Chicken (A)	NOAEL	28-day	No Adverse Effects - started with 1-day old chicks	486 mg/kg-diet	48.8	Cakir et al. 1978 as cited in NAS 1980
Turkey (A)	NOAEL	28-day	No Adverse Effects - started with 1-day old chicks	486 mg/kg-diet		Cakir et al. 1978 as cited in NAS 1980
Starling (F)	NOAEL	Not specified	Egg shell thickness	5000 mg/kg-diet	696	Miles et al. 1993 as cited in Sparling et al. 1998

Mature Dog Body Weight (average male & female) = 14 kg, USEPA 1988
Mature Dog Food Consumption (average male & female) = 0.435 kg/day, USEPA 1988
Mature Rat Body Weight (average male & female) = 0.325 kg, USEPA 1988
Mature Rat Food Consumption (average male & female) = 0.0265 kg/day, USEPA 1988
Mature Rat Water Consumption (average male & female) = 0.0435 L/day, Reference is USEPA, 1988 EPA/600/6-87/008
Mature Rat Body Weight (female) = 0.25 kg, USEPA 1988
Mature Rat Food Consumption (female) = 0.022 kg/day, USEPA 1988
Mature Rat Water Consumption (female) = 0.036 L/day, USEPA 1988
Mature Mouse Body Weight (average male & female) = 0.0325 kg, USEPA 1988
Mature Mouse Average Food Consumption = 0.0058 kg/day, USEPA 1988
Mature Mouse Water Ingestion (average male & female) = 0.00795 L/day, USEPA, 1988
Cattle body weight = 3471 kg; food ingestion = 120 kg/day Reference is Table 7-1;USEPA, 1988
Mature sheep body weight = 47.8 (Table 3-12) food ingestion = 16.14 g/kg-body weight (Table 6-1) USEPA 1988
Lamb body weight = 31.5 kg, food ingestion = 0.575 kg Reference is Table 6-1; USEPA, 1988
Chicken Body Weight (mature) = 1.7 kg, USEPA 1988
Chicken water food kg/day = $0.075 * BW(kg)^{0.8449}$ USEPA 1988
Chicken 14-days old body weight = 0.12 kg USEPA 1988
Chicken average body weight between 1 and 14 days of age = 0.07825 kg USEPA 1988
Chicken average body weight between 1 and 21 days of age = 0.115 kg USEPA 1988
Chicken average body weight between 1 and 28 days of age = 0.153 kg USEPA 1988
Juvenile Mallard (average from 15 to 30-days of age) Body Weight = 0.333 kg, USEPA 1993
Adult Quail Body Weight = (average over seasons) = 0.191 kg , USEPA 1993
Adult Quail Food Consumption = (average over seasons) = 0.07776 g/g-BW , USEPA 1993
Starling body weight (average male and female) = 0.082 kg; Dunning 1993
Bird Food Ingestion (based on all birds) kg/day = $0.0582 \times BW(kg)^{0.651}$, USEPA1993

A = Aluminum Sulfate
B = Aluminum Chloride
C = Aluminum Lactate
D = Aluminum Trichloride
E = Aluminum Hydroxide
F = not specified
G = Aluminum Phosphate
H = Aluminum Nitrate
I = Aluminum Acetate
J = Aliminum Trioxide
K = Alum
L = Aluminum Potassium Sulfate

Antimony Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	LD_{50}	14 days or less	Mortality		700	NIOSH 1987
Rat	LD_{50}	14 days or less	Mortality		100	Venugopal & Luckey 1978
Rat	LD_{50}	14 days or less	Mortality		>16700	Venugopal & Luckey 1978
Rat	LD_{50}	14 days or less	Mortality		675	Venugopal & Luckey 1978
Rabbit	MTL	more than 364 days		110	3.3	NAS 1980
Rat	NOAEL	more than 364 days	No observable adverse effects		0.35	IRIS 1993

MTL = Maximum tolerable level

FORM

Sb203 = Antimony trioxide

SbCl3 = Antimony trichloride

Arsenic Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Cattle (H)	LD_{LO}	Single Dose	Mortality		33 to 55	Robinson et al. 1984 as cited in Eisler 1988
Cattle (H)	LD_{LO}	Single Dose	Mortality	15 to 45 g total dose	45.6	NRCC 1978 as cited in Eisler 1988
Cattle (A)	LD_{LO}	Single Dose	Mortality	1 to 4 g total dose	3.04	NRCC 1978 as cited in Eisler 1988
Dog (A)	LD_{LO}	Single Dose	Mortality	50 to 150 g-total dose	3.6	NRCC 1978 as cited in Eisler 1988
Dog (I)	LD_{50}	Single Dose	Mortality		1000	Hood 1985 as cited in Eisler 1988
Mouse (H)	LD_{50}	Single Dose	Mortality		39.4	NAS 1977 as cited in Eisler 1988
White-tailed Deer (A)	LD_{LO}	Not Reported	Mortality		34	NAS 1977 as cited in Eisler 1988
Mallard (A)	LD_{50}	Single Dose	Mortality		323	Vreman et al. 1986 as cited in Eisler 1988
Mallard (A)	LD_{50}	6-day	Mortality	1000 mg/kg-diet	13.95	Thacher et al. 1985 as cited in Eisler 1988
Mallard (C)	LD_{LO}	11-day	Mortality	5000 mg/kg-diet	553	NAS 1977 as cited in Eisler 1988
Mallard (A)	LD_{50}	32-day	Mortality	500 mg/kg-diet	27.9	Thacher et al. 1985 as cited in Eisler 1988
Pheasant (A)	LD_{50}	Single Dose	Mortality		386	Vreman et al. 1986 as cited in Eisler 1988
Pheasant (C)	LD_{50}	Single Dose	Mortality		1.4	NRCC 1978 as cited in Eisler 1988
Quail (A)	LD_{50}	Single Dose	Mortality		47.6	Vreman et al. 1986 as cited in Eisler 1988
Bobwhite (C)	LD_{50}	11-day	Mortality	480 mg/kg-diet	49.8	Thacher et al. 1985 as cited in Eisler 1988
Turkey (E)	LD_{50}	Single Dose	Mortality		17.4	Thacher et al. 1985 as cited in Eisler 1988
Cowbird (G)	LD_{50}	11-day	Mortality	99.8 mg/kg-diet	14.2	Thacher et al. 1985 as cited in Eisler 1988
Cowbird (G)	LD_{100}	3-month	Mortality	100 mg/kg-diet	14.2	Thacher et al. 1985 as cited in Eisler 1988
Horse (A)	LOAEL	14-week	Survival		2	NRCC 1978 as cited in Eisler 1988
Sheep (F)	LOAEL	56-day	Convulsions and weight loss (body weoght = 34 kg)	570 mg/kg-diet	9.20	Bucy et al. 1955 as cited in NAS 1980
Sheep (M)	LOAEL	56-day	Weight loss (body weight = 30 kg)	570 mg/kg-diet	9.20	Bucy et al. 1955 as cited in NAS 1980
Swine (F)	LOAEL	18-day	Quadriplegia (body weight = 17 kg)	1000 mg/kg-diet	36.0	Ledet et al. 1973 as cited in NAS 1980
Pig (Q)	LOAEL	28-day	Survival	(diet)	5.8	Edmonds and Baker 1986 as cited in ATSDR 1993
Pig (Q)	LOAEL	28-day	Muscle tumors	(diet)	2.9	Edmonds and Baker 1986 as cited in ATSDR 1993
Pig (Q)	LOAEL	30-day	Seizures	(diet)	0.87	Rice et al. 1985 as cited in ATSDR 1993
Dog (O, P)	LOAEL	2-year	Survival	(diet)	3.1	Byron et al. 1967 as cited in ATSDR 1993

Arsenic Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Cat (A,K)	LOAEL	Chronic	Survival		1.5	Pershagen and Vahter 1979 as cited in Eisler 1988
Guinea Pig (F)	LOAEL	25-day	Blindness	350 mg/kg-diet	14.9	Pershagen and Vahter 1979 as cited in Eisler 1988
Hamster (K)	LOAEL	Maternal Dose	Fetotoxicity		5	NRCC 1978 as cited in Eisler 1988
Mouse (K)	LOAEL	Maternal Dose	Fetotoxicity		10	NRCC 1978 as cited in Eisler 1988
Mouse (I)	LOAEL	10-day (gestation)	Fetal Malformations		400	Hood 1985 as cited in isler 1988
Mouse (J)	LOAEL	19-day	Reduced male fertility	(gavage)	55	Prukop and Savage 1986 as cited in ATSDR 1993
Mouse (A)	LOAEL	3-generation	Reduced Litter Size	5 mg/kg-diet	0.8	Pershagen and Vahter 1979 as cited in Eisler 1988
Rat (Q)	LOAEL	13-week	Survival	(diet)	5.8	Kerr et al. 1963 as cited in ATSDR 1993
Rat (Q)	LOAEL	13-week	Ataxia	(diet)	11.4	NTP 1989 as cited in ATSDR 1993
Rat (F)	LOAEL	7-generation	Survival & Reduced Litter Size	17.5 mg/kg-diet	1.4	Pershagen and Vahter 1979 as cited in Eisler 1988
Pheasant (L)	LOAEL	Not specified	Survival	4989 mg/kg-diet	290	NAS 1977 as cited in Eisler 1988
Chicken (N)	LOAEL	56-day	Decreased body weight, feed consumption and egg production (22-week olds)	100 mg/kg-diet	6.91	Hermayer et al. 1977 as cited in NAS 1980
Cattle (L)	NOAEL	126-day	No Adverse Effects (body weight = 400 kg)	4.68 mg/kg-diet	0.087	Marshall et al. 1963 as cited in NAS 1980
Sheep (F, J, M)	NOAEL	84-day	No Adverse Effects (body weight = 45 kg)	17.1 mg/kg-diet	0.276	Bucy et al. 1954 as cited in NAS 1980
Sheep (F, J, M)	NOAEL	56-day	No Adverse Effects (body weight = 30 kg)	285 mg/kg-diet	4.60	Bucy et al. 1954 as cited in NAS 1980
Pig (Q)	NOAEL	28-day	Muscle tumors	(diet)	1.44	Edmonds and Baker 1986 as cited in ATSDR 1993
Dog (I)	NOAEL	90-day	No Adverse Effects	30 mg/kg-diet	0.9	Hood 1985 as cited in Eisler 1988
Dog (J)	NOAEL	90-day	No Adverse Effects	30 mg/kg-diet	0.9	Hood 1985 as cited in Eisler 1988
Dog (O, P)	NOAEL	2-year	No Adverse Effects	(diet)	1.2	Byron et al. 1967 as cited in ATSDR 1993
Rat (Q)	NOAEL	90-day	Clinical signs	(diet)	1.4	NTP 1989 as cited in ATSDR 1993
Rat (O, P)	NOAEL	2-year	No Adverse Effects	(diet)	12	Byron et al. 1967 as cited in ATSDR 1993
Rat (O)	NOAEL	2-year	No Adverse Effects	(water)	0.7	Schroeder et al. 1968 as cited in ATSDR 1993
Mouse (Q)	NOAEL	91-day	Clinical signs	(diet)	14.8	NTP 1989 as cited in ATSDR 1993
Mouse (O)	NOAEL	3-generation	Reproduction	(water)	1	Schroeder and Mitchner 1971as cited in ATSDR 1993

Arsenic Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Bobwhite (B)	NOAEL	5-day	Clinical Signs	1740 mg/kg-diet	481	Hood 1985 as cited in Eisler 1988
Mallard (L)	NOAEL	11-day	Survival	5000 mg/kg-diet	259	NAS 1977 as cited in Eisler 1988
Chicken (D)	NOAEL	9-week	Clinical Signs	23.3 mg/kg-diet	1.1	Woolson 1975 as cited in Eisler 1988
Chicken (E)	NOAEL	9-week	Clinical Signs	187 mg/kg-diet	9	NRCC 1978 as cited in Eisler 1988
Chicken (F)	NOAEL	9-week	Clinical Signs	455 mg/kg-diet	22	NRCC 1978 as cited in Eisler 1988
Chicken (I)	NOAEL	10-day	No Adverse Effects		100	Hood 1985 as cited in Eisler 1988
Chicken (N)	NOAEL	56-day	Body weight and egg production (22 weeks old)	10 mg/kg-diet	0.691	Hermayer et al. 1977 as cited in NAS 1980
Cowbird (G)	NOAEL	6 month	Clinical Signs	33 mg/kg-diet	4.7	Thatcher et al. 1985 as cited in Eisler 1988

A = Sodium Arsenite
B = Sodium Cacodylate
C = Copper acetoarsenite
D = Dodecylamine p- chlorophenylarsonic acid
E = 3-Nitro-4-Hydroxy phenylarsonic acid
F = Arsanilic Acid
G = Copper Acetoarsenite
H = Arsenic Trioxide
I = Cacodylic Acid
J = Methanearsonic Acid
K = Arsenate
L = Lead Arsenate
M = Potassium Arsenite
N = Arsenic Pentaoxide
O = specified only as As^{+3}
P = specified only as As^{+5}
Q = Roxasone

Barium Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rabbit (A)	LD_{50}	Single Dose	Mortality		170	HSDB, Friberg, et al., Hand. Toxicol. Metals, 2Ed., Vol2, 1986
Rat (A)	LD_{50}	Single Dose	Mortality		300-500	HSDB, Friberg, et al., Hand. Toxicol. Metals, 2Ed., Vol2, 1986
Rat (A)	LD_{50}	Single Dose	Mortality		150	HSDB, Venugopal & Luckey, Metal Toxicity in Mammals, 1978
Rat (A)	LD_{50}	Single Dose	Mortality		132	Tardiff, et al., 1980 as cited in ATSDR 1992
Rat (A)	LD_{50}	Single Dose	Mortality		118	RTECS, Food Res. 7:313, 1942
Rat [A] (weaning)	LD_{50}	Single Dose	Mortality		220	Tardiff, et al., 1980 as cited in ATSDR 1992
Guinea Pig (A)	LD_{50}	Single Dose	Mortality		76	RTECS, Food Res. 7:313, 1942
Mouse (A)	LD_{LO}	Single Dose	Mortality		70	RTECS, Environ. Qual Saf, Suppl. 1:1, 1975
Rabbit (A)	LD_{LO}	Single Dose	Mortality		170	RTECS, Drug Dosages in La. Animals, Barnes&Elterington Ed.s, 1973
Dog (A)	LD_{LO}	Single Dose	Mortality		90	RTECS, Drug Dosages in La. Animals, Barnes&Elterington Ed.s, 1973
Rat (A)	LD_{LO}	10-day	Survival & ovary size		198	Borzelleca et al. 1988 as cited in Sample et al. 1996 and ATSDR 1992
Rat	LOAEL	36-week	Kidney Histopathology	1000 mg/L (water)	134	IRIS, McCauley, et al., 1985
Chicken (A, C)	LOAEL	Not Specified	Depressed weight gain	330 mg/kg-diet		Taucins et al. 1969 as cited in NAS 1980
Chicken (A, C)	LOAEL	Not Specified	Survival	6000 mg/kg-diet		Taucins et al. 1969 as cited in NAS 1980
Chicken (A)	LOAEL	4-week	Growth & Survival		210	Johnson, et al.,1960 as cited in RTI 1995
Rat (A)	NOAEL	Chronic	No Measurable Effects	250 mg/L (water)	33.5	HSDB, Friberg, et al., Hand. Toxicol. Metals, 2Ed., Vol2, 1986
Rat [A] (young)	NOAEL	16-months	No Measurable Effects		5.06	Perry et al. 1983 as cited in Sample et al. 1996
Rat (A)	NOAEL	Lifetime	No Measurable Effects		0.25	IRIS, Schroeder & Mitchener, 1975
Mouse	NOAEL	Lifetime	No Measurable Effects		0.825	IRIS, Schroeder & Mitchener, 1975
Chicken (A)	NOAEL	4-week	Growth & Survival		102.5	Johnson, et al.,1960 as cited in RTI 1995

A = Barium Chloride

Barium Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference

B = Barium Nitrate
C = Barium carbonate

Chicken Body Weight (mature) = 1.7 kg, Reference in USEPA, 1987 EPA/600/6-87/008
Bird Food Ingestion (based on all birds) = 0.0582 x BW(kg)$^{0.651}$, Reference is USEPA 93, EPA/600/R-93/187a
Mature Rat Body Weight (average male & female) = 0.325 kg, Reference is USEPA, 1987 EPA/600/6-87/008
Mature Rat Food Consumption (average male & female) = 0.0265 kg/day, Reference is USEPA, 1987 EPA/600/6-87/008
Mature Rat Water Consumption (average male & female) = 0.0435 L/day, Reference is USEPA, 1987 EPA/600/6-87/008

Beryllium Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat (A)	LD_{50}	Not reported	Mortality		86	RTECS; Hygiene & Sanit. 30(1-3):169, 1965
Rat (A)	LD_{50}	Single Dose	Mortality		200	Kimmerle 1966 as cited in ATSDR 1993
Rat (B)	LD_{50}	Single Dose	Mortality		18.8	Venugopal and Luckey 1977 as cited in ATSDR 1993
Rat (B)	LD_{50}	Not Reported	Mortality		98	RTECS, U. of Roch. Res. & Dev. Rep. UR-154, 1951
Rat (C)	LD_{50}	Single Dose	Mortality		120.0	Lanchow 1978 as cited in ATSDR 1993
Rat (C)	LD_{50}	Not Reported	Mortality		82	RTECS; Hygiene & Sanit. 30(1-3):169, 1965
Mouse (A)	LD_{50}	Not Reported	Mortality		92	RTECS; Hygiene & Sanit. 30(1-3):169, 1965
Mouse (B)	LD_{50}	Not Reported	Mortality		100	RTECS; U.S.Pub. Health Service Pub. 2173:23, 1972
Mouse (C)	LD_{50}	Not Reported	Mortality		80	RTECS; Hygiene & Sanit. 30(1-3):169, 1965
Muskrat (B)	LD_{50}	Not Reported	Mortality		100	OHM/TADS
Rat (D)	LOAEL	13-42-day	Rickets	(diet)	121	Jacobson 1933 as cited in ATSDR 1993
Rat (D)	LOAEL	24-28-day	Rickets	(diet)	10	Guyatt et al. 1933 as cited in ATSDR 1993
Dog (C)	LOAEL	33-week	Survival	500 mg/kg-diet	12.2	Morgareidge et al. 1976 as cited in IRIS 1998
Dog (C)	LOAEL	172-week	Intestinal lessions	50 mg/kg-diet	1.1	Morgareidge et al. 1976 as cited in IRIS 1998
Dog (C)	NOAEL	172-week	Growth, reproduction, and development	5 mg/kg-diet	0.36	Morgareidge et al. 1976 as cited in IRIS 1998
Rat (C)	NOAEL	104-week	Growth, reproduction, and histopathology	500 mg/kg-diet	37	Morgareidge et al. 1975 and 1977 as cited in IRIS 1998
Rat (C)	NOAEL	Lifetime	Longevity	5 mg/L-drinking water	0.66	Schroeder & Michner 1975 as cited in Sample et al. 1996
Mouse (C)	NOAEL	Lifetime	No Adverse Effects	5 mg/L-drinking water	1.20	Schroeder & Michner 1975b as cited in IRIS 1998

A = Beryllium Chloride
B = Beryllium Fluoride
C = Beryllium Sulfate

Cadmium Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	LD_{50}	Single Dose	Mortality		890	RTECS, Taraasenko, Current Prob. Labor Hyg. Moscow, Pervyi Mosk. Institut.. 1978
Rat (A)	LD_{50}	Single Dose	Mortality		88	RTECS(R), Assoc. Food Drug Officials of U.S., 15:122, 1951
Mouse (A)	LD_{50}	Single Dose	Mortality		60	RTEC(R), Acta Pharm. Tox. 48:108, 1981
Guinea Pig (A)	LD_{50}	Single Dose	Mortality		63	RTEC(R), Food Research, 7:313, 1942
Chicken (A)	LD_{50}	Single Dose	Mortality		165	RTEC(R), Wissenschaftliche Pub., 1979 -:160, 1979
Rabbit	LD_{LO}	Single Dose	Mortality		70	RTECS, Arch. Mal. Prof. Med. Travail Sec. Soc. 34:127, 1973
Rat	LD_{LO}	Single Dose	Mortality		250	Eisler, 1985
Guinea Pig	LD_{LO}	Single Dose	Mortality		150	Eisler, 1985
Cattle (A)	LOAEL	63-day	Decreased body weight and food intake	(gavage-capsule)	15	Lynch et al. 1976 as cited in NAS 1980
Cattle (B)	LOAEL	343-day	Low body weight gain	50 mg/kg-diet	1.73	Wright et al. 1977 as cited in NAS 1980
Sheep (A)	LOAEL	191-day	Decreased weight gain	30 mg/kg-diet	0.484	Doyle and Pfander 1975 as cited in NAS 1980
Sheep (B)	LOAEL	287-day	Fertilty	50 mg/kg-diet	0.807	Wright et al. 1977 as cited in NAS 1980
Sheep (C)	LOAEL	13-week of pregency to parturition + 7.5-weeks	Lamb plasma effects and wool	12.3 mg/kg-diet	0.224	Mills and Dalgarno 1972 as cited in NAS 1980
Goat	LOAEL	19-month	Maturnal survival and fetotoxicty	75 mg/kg-diet		Anke et al. 1970 as cited in NAS 1980
Swine (A)	LOAEL	42-day	Decreased weight gain	150 mg/kg-diet	6.04	Cousins et al. 1973 as cited in NAS 1980
Rat	LOAEL	16-week	Growth & Behavior of Offspring	155 mg/kg-total dose	1.4	RTECS, Bull. Environ. Contam. Toxicol. 20:96, 1978
Rat (A)	LOAEL	6-week (mating and gestation)	Fetotoxicity		10	Sutou et al. 1980 as cited in Sample et al. 1996
Rat (A)	LOAEL	10-day (gestation)	Fertility, Litter size	652 mg/kg-total dose	65.2	RTECS(R), J. Applied Tox., 2:255, 1982
Rat (A)	LOAEL	20-day (gestation)	Fetotoxicity	326 mg/kg-total dose	16.3	RTECS(R), Gigiena i Sanitariya 54(4):86, 1989
Rat (A)	LOAEL	9-day (gestation)	Fetal Death	14.68 mg/kg-total dose	1.6	RTECS(R), Tox. and Applied Pharm, 23:222, 1972

Cadmium Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat (A)	LOAEL	9-week	Developmental Abnormalities	17 mg/kg-total dose	3.7	RTECS, Ecotox. & Env. Safety, 4:51, 1980
Rat (A)	LOAEL	13-day (gestation)	Developmental Abnormalities	280 mg/kg-total dose	21.5	RTECS(R), Nature,239:231, 1972
Rat (A)	LOAEL	4-week	Growth	412 mg/kg-total dose	14.7	RTECS(R), Food & Chem. Tox., 28:435, 1990
Rat (D)	LOAEL	Lifetime	Shortened lifespan	5 mg/L (water)	0.669	Kanisawa and Schroeder 1969 as cited in NAS 1980
Rat	LOAEL	31-month	peripheral neuropathy	in drinking water	4	Sato et al. 1978 as cited in ATSDR 1993
Rat	LOAEL	12-week	testicular necrosis	in drinking water	14	Cha 1987 as cited in ATSDR 1993
Mouse (A)	LOAEL	19-day (gestation)	Fetotoxicity	248 mg/kg-total dose	13.1	RTECS(R), J. of Nutrition, 109:1640, 1979
Mouse (A)	LOAEL	2-day (gestation)	Fetotoxicity	33 mg/kg-total dose	16.5	RTECS(R), Chiba Med. J., 61:335, 1985
Mouse	LOAEL	2-generations	Reproductive failure	in drinking water	1.9	Schroeder and Michener 1971 as cited in ATSDR 1993
Rabbit (A)	LOAEL	6-day (gestation)	Fertility	990 mg/kg-total dose	165	RTECS(R), J. Reproduction & Fert., 70:323, 1984
Rabbit (A)	LOAEL	200-day	Decreased growth	160 mg/L (water)		Stowe et al. 1972 as cited in NAS 1980
Chicken (A)	LOAEL	21-day	Reduced growth starting at 1-day old chicks	75 mg/kg-diet	7.87	Freeland and Cousins 1973 as cited in NAS 1980
Chicken (C)	LOAEL	24-day	Growth and survival (14-day old chicks)	400 mg/kg-diet	40.1	Prizl et al. 1974 as cited in NAS 1980
Chicken	LOAEL	48-week	Reduced eggshell thickness	12 mg/kg-diet	0.829	Leach et al. 1979 as cited in NAS 1980
Chicken	LOAEL	Not Reported	Reduced Egg Production	200 mg/kg-diet	13.8	Eisler, 1985
Japanese Quail (A)	LOAEL	28-day	Growth and survival (1-day old chicks)	75 mg/kg-diet		Fox et al. 1971 as cited in NAS 1980
Japanese Quail (A)	LOAEL	28-day	Growth and survival (1-day old chicks)	75 mg/kg-diet		Richardson et al. 1974 as cited in NAS 1980
Japanese Quail (A)	LOAEL	6-week	Hyperpasia, Anemia, Testicular Damage	75 mg/kg-diet	7.8	Richardson et al. 1974 as cited in Eisler, 1985 and NAS 1980
Pigeon	LOAEL	Not Reported	Cardiovascular Disease	0.6 mg/L (water)		Eisler, 1985
Black Duck	LOAEL	4-month	Hyperresponsiveness	4 mg/kg-diet		Eisler, 1985
Mallard	LOAEL	90-day	Egg production		20.03	White and Finley 1978 as cited in Sample et al. 1996
Mallard Duckling	LOAEL	12-week	Hematology, Kidney Lesions	20 mg/kg-diet	1.7	Eisler, 1985

Cadmium Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Sheep (C)	NOAEL	13-week of pregency to parturition	No Adverse Effects	7.1 mg/kg-diet	0.115	Mills and Dalgarno 1972 as cited in NAS 1980
Swine (A)	NOAEL	42-day	Weight gain	50 mg/kg-diet	2.01	Cousins et al. 1973 as cited in NAS 1980
Rat (A)	NOAEL	6-week (mating and gestation)	Reproduction		1	Sutou et al. 1980 as cited in Sample et al. 1996
Rat	NOAEL	11-week	Reproduction	gavage	4	Baranski et al. 1983 as cited in ATSDR 1993
Dog	NOAEL	3-month	Reproduction	in diet	0.75	Loser and Lorke 1977 as cited in ATSDR 1993
Dog (A)	NOAEL	4-year	No Adverse Effects	2.5 mg/L (water)		Anwar et al. 1961 as cited in NAS 1980
Chicken	NOAEL	48-week	Egg production	3 mg/kg-diet	0.207	Leach et al. 1979 as cited in NAS 1980
Mallard Duckling	NOAEL	90-day	Egg production		1.45	White and Finley 1978 as cited in Sample et al. 1996
Mallard	NOAEL	90-day	Survival & Growth	200 mg/kg-diet	11.1	Eisler, 1985

Cattle body weight = 3471 kg; food ingestion = 120 kg/day Reference is Table 7-1;USEPA, 1988
Mature sheep body weight = 47.8 (Table 3-12) food ingestion = 16.14 g/kg-body weight (Table 6-1) USEPA 1988
Lamb body weight = 31.5 kg, food ingestion = 0.575 kg Reference is Table 6-1; USEPA, 1988
Young Pig Body Weight (assume white-cross) = 10 kg, USEPA, 1988
Pig Food Ingestion (based on all animals) = 0.065 x $BW(kg)^{0.7919}$, USEPA, 1988
Mature Rat Body Weight (average male & female) = 0.325 kg, USEPA 1988
Mature Rat Water Consumption (average male & female) = 0.0435 L/day, USEPA, 1988
Chicken Body Weight (mature) = 1.7 kg, USEPA 1988
Chicken average body weight between 1 and 21 days of age = 0.115 kg USEPA 1988
Chicken average body weight between 1 and 28 days of age = 0.153 kg USEPA 1988
Chicken food ingestion kg/day = 0.075 * $BW(kg)^{0.8449}$ USEPA 1988
Chicken water ingestion L/day = 0.130 * $BW(kg)^{0.7555}$ USEPA 1988
Mature Mallard Body Weight (average male & female) = 1.134 kg, USEPA 1993
Mature Quail Body Weight (seasonal average) = 0.191 kg, USEPA 1993
Juvenile Mallard (average from 15 to 30-days of age) Body Weight = 0.333 kg, USEPA 1993
Bird Food Ingestion (based on all birds) = 0.0582 x $BW(kg)0.^{651}$, USEPA 1993

A = Cadmium Chloride
B = Cadminate (Cadmium Succinate)
C = Cadmium Sulfate
D = Cadmium Acetate

Chloride Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
"Lievstock" - cattle, sheep	LOAEL	Long-Term	Diaherra, water avoidance (assumed sheep)	3000 mg/L (as salt)	137	USEPA 1973
Chicken (chicks)[A]	LOAEL	Long-Term	Endema, salt poisoning	5000 mg/L (as salt)	528	McKee 1954
Swine [young]	NOAEL	Long-term	No Observable Adverse Effects	1500 mg/L - water	60.4	Fed. Water. Poll. Control Fed. 1968
Dog	NOAEL	Lifetime	Minimal requirement for good health	4500 mg/kg-diet	77.1	Merck Veterinary Manual, 1998
Cat	NOAEL	Lifetime	Minimal requirement for good health	3000 mg/kg-diet	87.9	Merck Veterinary Manual, 1998
Swine	NOAEL	Lifetime	Minimal requirement for good health	1210 mg/kg-diet	14.1	Merck Veterinary Manual, 1998
Ducklings	NOAEL	Chick to adulthood	Minimal requirement for good health	1200 mg/kg-diet	154	Merck Veterinary Manual, 1998
Ducks	NOAEL	During Breeding	Minimal requirement for good health and egg production	1200 mg/kg-diet	66.9	Merck Veterinary Manual, 1998
Chicken (chicks)	NOAEL	Chick to adulthood	Minimal requirement for good health	1500 mg/kg-diet	218	Merck Veterinary Manual, 1998
Chicken	NOAEL	During Breeding	Minimal requirement for good health and egg production	1500 mg/kg-diet	72.5	Merck Veterinary Manual, 1998
Turkey	NOAEL	During Breeding	Minimal requirement for good health and egg production	1200 mg/kg-diet	33.3	Merck Veterinary Manual, 1998

Chromium Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Mouse (Cr VI)	LD_{50}	Single Dose	Mortality		5	Steven et al. 1976 as cited in Eisler 1986
Mouse (Cr III)	LD_{50}	Single Dose	Mortality		260	Steven et al. 1976 as cited in Eisler 1986
Rat (Cr III)	LD_{50}	Single Dose	Mortality		183 (female) - 200 (male)	Vernot et al. 1977 as cited in ATSDR 1993
Rat (Cr VI)	LD_{50}	Single Dose	Mortality		14 (female) - 21 (male)	Gad et al. 1986 as cited in ATSDR 1993
Rat (Cr VI)	LD_{50}	Single Dose	Mortality		25	Am. Chrome and Chem. 1989 as cited in ATSDR 1993
Rat (Cr VI)	LD_{50}	Single Dose	Mortality		108 (female) - 249 (male)	Vernot et al. 1977 as cited in ATSDR 1993
Rat (Cr VI)	LD_{50}	Single Dose	Mortality		13 (female) - 28 (male)	Gad et al. 1986 as cited in ATSDR 1993
Rat (Cr VI) (female)	LD_{50}	Single Dose	Mortality		811	Shubochkin and Pokhodzei 1980 as cited in ATSDR 1993
Dog (Cr VI)	LD_{LO}	3-month	Mortality	100 mg/kg-diet	3	Steven et al. 1976 as cited in Eisler 1986
Rat (Cr VI)	LD_{LO}	3-month	Mortality	1000 mg/kg-diet	82	Steven et al. 1976 as cited in Eisler 1986
Mouse (CrIV)	LOAEL	19-day (gestation)	Reduced maternal weight gain		120	Trivedi et al. 1989 as cited in ATSDR 1993
Mouse (CrIV)	LOAEL	19-day (gestation)	Increased fetal reabsorptions and gross abnormalities		57	Trivedi et al. 1989 as cited in ATSDR 1993
Chicken (Cr III)	LOAEL	21-day	Reduced Growth	2000 mg/kg-diet	138	Hill and Maltrone 1970 as cited in NAS 1980
Black Duck (young)[CrIII]	LOAEL	10-week	Reduced Survival	10 mg/kg-diet	2.7	Haseltine et al. 1985 as cited in Eisler 1986
Black Duck (adult[CrIII]	LOAEL	10-month	Reproduction	50 mg/kg-diet	5	Haseltine et al. (unpubl.) as cited in Sample et al. 1996
Rat (Cr III)	NOAEL	90-day (5x week)	No Effects		1806	Ivankovic and Preussmann 1975 as cited in ATSDR 1993
Rat (Cr III)	NOAEL	600 feedings (840-day)	No Effects	5% -diet, 5x-week	170	IRIS, Jvankovik & Preussman, Food Cosmet. Toxicol. 13:347, 1975
Rat (Cr III)	NOAEL	1-year	Blood serum, renal and liver function		2.7	Mackenzie et al. 1958 as cited in ATSDR 1993
Rat (Cr III)	NOAEL	2-year	Reproduction and longevity		2737	Ivankovic and Preussmann 1975 as cited in Sample et al. 1996

Chromium Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Guinea Pig (Cr III)	NOAEL	21-week	No Adverse Effects	50 mg/kg-diet	2.1	Preston et al. 1976 as cited in Eisler, 1986
Rat (Cr VI)	NOAEL	3-month	Survival	134 mg/L (water)	18	Steven et al. 1976 as cited in Eisler 1986
Rat (Cr VI)	NOAEL	1-year	No Effects		2.4	IRIS, MacKenzie, et al., Am. Med. Assoc. Ach. Ind. Health, 18:232, 1958
Rat (Cr VI)	NOAEL	1-year	No Effects	25 mg/L (water)	3.3	IRIS, MacKenzie, et al., Am. Med. Assoc. Ach. Ind. Health, 18:232, 1958
Dog (Cr VI)	NOAEL	4-year	No Effects		0.3	IRIS, Anwar, *et al*., 1961
Dog (Cr VI)	NOAEL	4-year	No observable effects	6 mg/L (water)	0.30	Steven et al. 1976 as cited in Eisler 1986
Chicken (Cr VI)	NOAEL	32-day	No Adverse Effects	100 mg/kg-diet	4.8	Rosomer et al. 1961 as cited in Eisler 1986
Chicken (Cr III)	NOAEL	21-day	No Adverse Effects	1000 mg/kg-diet	48	Hill and Maltrone 1970 as cited in NAS 1980
Black Duck (adult[CrIII]	NOAEL	10-month	Reproduction	10 mg/kg-diet	1.0	Haseltine et al. (unpubl.) as cited in Sample et al. 1996
Black Duck (adult[CrIII]	NOAEL	5-month	Survival, Growth, Reproduction	50 mg/kg-diet	2.8	Haseltine et al. 1985 as cited in Eisler 1986
Black Duck (young) [CrIII]	NOAEL	Parental & 7-day	Fright Stimulus Response	100 mg/kg-diet	26.8	Heinz and Haseltine 1980 as cited in Esiler 1986

Cobalt Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	LD_{50}	Single Dose	Mortality		6171	RTECS, J. Am. Coll. Toxicol. 1:686, 1992
Rat	LD_{LO}	30-day	Mortality	30 mg/kg-diet	2	HSDB, Venugopal & Luckey, Metal Toxicity in Mammals, 1978
Sheep	LD_{LO}	Not Reported	Mortality		6	HSDB, NRC, Drinking Water & Health, Vol1, 1977
Rabbit	LD_{LO}	Single Dose	Mortality		750	RTECS, Arch. Internat. Pharmod. Therapy, 62:347, 1939
Cattle (A)	LOAEL	13-week	Hyperchromemia (Heart effects)	(water)	1.1	Keener et. al. 1949 as cited in NAS 1980
Sheep (B)	LOAEL	8-week	Weight loss and survival	(diet)	4.40	Becker and Smith 1951 as cited in NAS 1980
Swine (C)	LOAEL	from weight of 5.2 kg to 100 kg	Anorexia, muscular tremors	400 mg/kg-diet	11.40	Huck and Clawson 1976 as cited in NAS 1980
Guinea Pig	LOAEL	5-week	Heart Damage		20	HSDB, Mohiuddin, et al., Am. Heart J. 80:532, 1970
Rat (B)	LOAEL	8-week	Decreased weight gain	(diet)	4.2	Clyne et al. 1988 as cited in ATSDR 1992
Rat (C)	LOAEL	14-day to lacation (gestation)	Stunted pup growth	(gavage)	5.4	Domingo et al. as cited in ATSDR 1992
Rat (C)	LOAEL	69-day	Testicular atrophy	(diet)	20	Nation et al. 1983 as cited in ATSDR 1992
Rat (C)	LOAEL	98-day	Testicular degeneration	(diet)	13.25	Mollenhauer et al. as cited in ATSDR 1992
Mouse (C)	LOAEL	13-week	Testicular degeneration	(diet)	5.7	Pedigo et al. 1988 as cited in ATSDR 1992
Chicken	LOAEL	Not Specified	Emaciation and survival	50 mg/kg-diet	3.5	Turk and Kratzer 1960 as cited in NAS 1980
Cattle (A)	NOAEL	28-week	No Adverse Effects	(water)	0.66	Keener et. al. 1949 as cited in NAS 1980
Sheep (B)	NOAEL	8-week	No Adverse Effects	(diet)	3.52	Becker and Smith 1951 as cited in NAS 1980
Swine (C)	NOAEL	from weight of 5.2 kg to 100 kg	No Adverse Effects	200 mg/kg-diet	5.70	Huck and Clawson 1976 as cited in NAS 1980
Rat (C)	NOAEL	Gestation days 6 - 15	No Adverse Effects	(gavage)	24.80	Paternian et al. 1988 as cited in ATSDR 1992
Rat (C)	NOAEL	69-day	Testicular atrophy	(diet)	5	Nation et al. 1983 as cited in ATSDR 1992
Rat	NOAEL	14-week	Survival	1 mg/L (water)	0.13	HSDB, Clayton & Clayton, Patty's Ind. Hyg. Toxicol. Vol2, 1982
Mouse (C)	NOAEL	Gestation days 8-12	No Adverse Effects	(gavage)	81.7	Seidenberg 1986 as cited in ATSDR 1992
Chicken	NOAEL	Not Specified	No Adverse Effects	4.7 mg/kg-diet	0.325	Turk and Kratzer 1960 as cited in NAS 1980

Mature Rat Body Weight (average male & female) = 0.325 kg, USEPA 1988

A = Cobaltous sulfate

Mature Rat Food Consumption (average male & female) = 0.0265 kg/day, USEPA 1988
Mature Rat Water Consumption (average male & female) = 0.0435 L/day, USEPA, 1988
Average Swine body weight = 52.6 kg
Swine Food Ingestion (based on all animals) = 0.065 x $BW(kg)^{0.7919}$, USEPA 1988
Chicken Body Weight (mature) = 1.7 kg, USEPA 1988
Chicken food ingestion kg/day = 0.075 * $BW(kg)^{0.8449}$ USEPA 1988

B = Cobalt Sulfate
C = Cobalt Chloride

Copper Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	LD_{50}	Single Dose	Mortality		140	RTECS, Environ. Qual. Saf., Suppl. 1:1, 1975
Rat	LD_{50}	Single Dose	Mortality		1,000	RTECS, Farm. Chem. Handbook, C81, 1991
Duck	LD_{50}	Single Dose	Mortality		5,000	RTEC, Pest. Manual, 9:184, 1991
Quail	LD_{50}	Single Dose	Mortality		3,400	RTEC, Pest. Manual, 9:184, 1991
Dog	LDLo	Single Dose	Mortality		60	RTEC, Abdernalden's Handbuch der Biol., 4:1289, 1935
Goat, Sheep	LDLo	Single Dose	Mortality		5	RTEC, J. of Comp. Path., 82:47, 1972
Duck	LDLo	Single Dose	Mortality		600	RTEC, Austral. Vet. J., 16:147, 1940
Pigeon	LDLo	Single Dose	Mortality		1,000	RTEC, Austral. Vet. J., 16:147, 1940
Wild Bird Species	LDLo	Single Dose	Mortality		300	RTEC, Austral. Vet. J., 16:147, 1940
Cattle (A)	LOAEL	13-week	Hemolysis; icterus, hepatic necrosis (1-week old calves)	115 mg/kg-diet		Shand and Lewis 1957 as cited in NAS 1980
Cattle (A)	LOAEL	129-day	Survival, hepatic necrosis (46-56 kg body weights)	300 mg/kg-diet		Weiss and Bauer 1968 as cited in NAS 1980
Sheep (A)	LOAEL	daily from 20 kg to 36 kg live weight	Reduced weight gain	20.6 mg/kg-diet		Hill and Williams 1965 as cited in NAS 1980
Sheep (A)	LOAEL	"Long-term"	Survival, hepatic and renal abnormalities	80 mg/kg-diet		Doherty et al. 1969 as cited in NAS 1980
Rat	LOAEL	4-week	Growth, Organ weight		412	RTECS, Food Chem. Tox., 28:435, 1990
Rat	LOAEL	2 to 15-week	Body weight and hepatic narcosis		150	Hayword 1985 as cited in ATSDR 1990
Rat (A)	LOAEL	15-week	Body weight and hepatic narcosis		150	Hayword and Loughran 1985 as cited in ATSDR 1990
Rat (C)	LOAEL	18-week	Growth and decreased testes weight		130	Llewellyn 1985 as cited in ATSDR 1990
Rat (A)	LOAEL	20-day	Weight Loss & Hepatic Narcosis		100	Rana and Kumar 1980 as cited in ATSDR 1990
Mouse (D)	LOAEL	850-day	Decreased survival	(diet)	4.2	Massie and Aiello 1984 as cited in ATSDR 1990
Swine (A)	LOAEL	From 18 kg to slaughter weight	Growth rate and survival	500 mg/kg-diet		DeGoey et al 1980 as cited in NAS 1980
Swine (A) - "young"	LOAEL	11-week	Reduced growth	250 mg/kg-diet		Gipp et al. 1973 as cited in NAS 1980
Swine (A)	LOAEL	from 3 to 9 weeks of age	Reduced growth and skin ulcers	425 mg/kg-diet		Suttle and Mills 1966 as cited in NAS 1980
Pig (A)	LOAEL	54-day	Decreased body weight gain	(diet)	14.6	Kline et al. 1971 as cited in ATSDR 1990
Mink	LOAEL	357-day	Reproduction	110.5 mg/kg-diet	15.14	Aulerich et al. 1982 as cited in Sample et al. 1996

Copper Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Chicken (chicks)	LOAEL	4-week	Growth, Muscular Dystrophy	324 mg/kg-diet		Mayo et al. 1956 as cited in NAS 1980
Chicken (C)	LOAEL	6-week	Loss of weight and survival	800 mg/kg-diet		Goldberg et al. 1956 as cited in NAS 1980
Chicken (B) "chicks"	LOAEL	10-week	Growth and survival	749 mg/kg-diet	62	Mehring et al. 1960 as cited in Sample et al. 1996
Turkey (C)	LOAEL	from 1 to 4 weeks of age	Reduced Growth	800 mg/kg-diet		Supplee 1964 as cited in NAS 1980
Turkey (B) "poults"	LOAEL	21-day	Reduced Growth	800 mg/kg-diet		Vohra and Kratzer 1968 as cited in NAS 1980
Cattle (A)	NOAEL	122-day	No Adverse Effects (227 kg body weight)	1950 mg/kg-diet		Kidder 1949 as cited in NAS 1980
Cattle (A)	NOAEL	18-week	No Adverse Effects	780 mg/kg-diet		Ferguson 1943 as cited in NAS 1980
Cattle (A)	NOAEL	9-month	Normal calving	1950 mg/kg-diet		Cunningham 1946 as cited in NAS 1980
Sheep (A)	NOAEL	daily from 20 kg to 36 kg live weight	No Adverse Effects	7.3 mg/kg-diet		Hill and Williams 1965 as cited in NAS 1980
Swine (A)	NOAEL	57-day	No Adevrse Effects (26 kg body weight)	250 mg/kg-diet		Combs et al. 1966 as cited in NAS 1980
Swine (A)	NOAEL	15-week	No Adevrse Effects (starting with 7-week olds)	125 mg/kg-diet		Richie et al. 1963 as cited in NAS 1980
Pig (A)	NOAEL	54-day	Body weight gain	(diet)	8.8	Kline et al. 1971 as cited in ATSDR 1990
Horse (A)	NOAEL	225-day	No Adverse Effects (started with 103 to 185 day old animals)	109 mg/kg-diet		Cupps and Howell 1949 as cited in NAS 1980
Rabbit (A)	NOAEL	Not specified	No Adverse Effects (growth promotion)	200 mg/kg-diet		King 1975 as cited in NAS 1980
Mink	NOAEL	357-day	Reproduction	85.5 mg/kg-diet	12	Aulerich et al. 1982 as cited in Sample et al. 1996
Duck (A)	NOAEL	8-week	No Adverse Effects (growth promotion)	100 mg/kg-diet		King 1975 as cited in NAS 1980
Chicken (B) "chicks"	NOAEL	10-week	Growth and survival	570 mg/kg-diet	47	Mehring et al. 1960 as cited in Sample et al. 1996
Turkey (C)	NOAEL	from 1 to 4 weeks of age	Growth and survival	300 mg/kg-diet		Supplee 1964 as cited in NAS 1980
Turkey (B) "poults"	NOAEL	21-day	No Adverse Effects	400 mg/kg-diet		Vohra and Kratzer 1968 as cited in NAS 1980

Chick Body Weight estimated at an age of 7 days = 0.073 kg, Reference in USEPA, 1987 EPA/600/6-87/008
Chick/Chicken Food Ingestion (based on all birds) = 0.0582 x $BW(kg)^{0.651}$, Reference is USEPA 93, EPA/600/R-93/
Average Pig Body Weight = 40 kg, Reference is USEPA, 1987 EPA/600/6-87/008
Pig Food Ingestion (based on all animals) = 0.065 x $BW(kg)^{0.7919}$, Reference is USEPA, 1987, EPA/600/6-87/008

A = CuSO4
B = CuO3
C = Cu acetate
D = Copper gluconate

Cyanide Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Turkey vulture(A)	LD_{100}	Single Dose	Mortality		19.1	Wiemeyer et. Al. 1986 cited in Eisler, 1991
Black vulture (A)	LD_{100}	Single Dose	Mortality		3.7	Wiemeyer et. Al. 1986 cited in Eisler, 1991
Rabbit (A)	LD_{100}	Single Dose	Mortality		5.3	Yamamoto et al. 1979 cited in Eisler, 1991
Black vulture (A)	LD_{50}	Single Dose	Mortality		2.54	Wiemeyer et. Al. 1986
American kestral (A)	LD_{50}	Single Dose	Mortality		2.12	Wiemeyer et. Al. 1986
Japanese quail (A)	LD_{50}	Single Dose	Mortality		5.0	Wiemeyer et. Al. 1986
Japanese quail (female) (A)	LD_{50}	Single Dose	Mortality		4.5	Wiemeyer et. Al. 1986
Japanese quail (male) (A)	LD_{50}	Single Dose	Mortality		5.5	Wiemeyer et. Al. 1986
Domestic chicken (A)	LD_{50}	Single Dose	Mortality		11.1	Wiemeyer et. Al. 1986
Eastern screech-owl (A)	LD_{50}	Single Dose	Mortality		4.6	Wiemeyer et. Al. 1986
European starling (A)	LD_{50}	Single Dose	Mortality		9.0	Wiemeyer et. Al. 1986
European starling (female) (A)	LD_{50}	Single Dose	Mortality		9.0	Wiemeyer et. Al. 1986
European starling (male) A)	LD_{50}	Single Dose	Mortality		9.5	Wiemeyer et. Al. 1986
Mallard (A)	LD_{50}	Single Dose	Mortality		1.43	Henny et al. 1994 cited by Eisler et al.
Coyote (A)	LD_{50}	Single Dose	Mortality		2.2	Sterner, 1979 cited by Eisler, 1991
Laboratory rat (A)	LD_{50}	Single Dose	Mortality		2.7	Ballantyne, 1987 cited by Eisler, 1991
Laboratory rat (B)	LD_{50}	Single Dose	Mortality		3.5	Ballantyne, 1987 cited by Eisler, 1991
Laboratory rat (C)	LD_{50}	Single Dose	Mortality		2.3	Keniston et al., 1987 cited by Eisler, 1991
Laboratory rat (A)	LD_{50}	Single Dose	Mortality		3.4	Egekeze and Oehme (1980) cited by Eisler, 1991
Laboratory rat (C)	LD_{50}	Single Dose	Mortality		3.0	Ballantyne, 1987 cited by Eisler, 1991
Laboratory rat (C)	LD_{50}	Single Dose	Mortality		4.0	Egekeze and Oehme (1980) cited by Eisler, 1991
Laboratory rat (C)	LD_{50}	Single Dose	Mortality		4.0	EPA, 1989 cited by Eisler, 1991
Rat (A)	LD_{50}	Single Dose	Mortality		8.0	Smyth et al. 1969 cited in ATSDR 1995
Rat (D)	LD_{50}	Single Dose	Mortality		11.0	Smyth et al. 1969 cited in ATSDR 1995
Little brown bat (A)	LD_{50}	Single Dose	Mortality		4.5	Clark et al. (1991) cited by Eisler et al.
House mouse (A)	LD_{50}	Single Dose	Mortality		4.6	Clark et al. (1991) cited by Eisler et al.
Domestic mouse (C)	LD_{50}	Single dose	Mortality		3.4	Ballantyne, 1987, and EPA 1989 cited by Eisler, 1991
Mouse (Swiss-Webster) (C)	LD_{50}	Single dose	Mortality		4.3	Ferguson 1962, cited in ATSDR 1995
Rabbit (B)	LD_{50}	Single dose	Mortality		2.4	Ballantyne, 1987 cited by Eisler, 1991
Rabbit (A)	LD_{50}	Single dose	Mortality		2.7	Ballantyne, 1987 cited by Eisler, 1991
Rabbit (C)	LD_{50}	Single dose	Mortality		2.3	Ballantyne, 1987 cited by Eisler, 1991
Hwhite-footed mouse (A)	LD_{50}	Single Dose	Mortality		14.9	Clark et al. (1991) cited by Eisler et al.
Dog (A)	LD_{50}	Single Dose	Mortality		2.9	Sterner, 1979 cited by Eisler, 1991
Hamster (Female)	LOAEL	3-14	Weight loss and development		1.1	Frakes et al. 1986 cited in ATSDR 1995
Domestic chicken (B)	LOAEL	20 days	Growth	135 mg/kg-diet	18.9	Elzubier & Davis 1988 cited in Eisler, 1991
Laboatory W[illegible] Rat Weanlings (C)	LOAEL	50 weeks	Weight loss, thyroid effects, and myelin degeneration	600 mg/kg-diet	30	Philbrick et al., 1979 cited in IRIS, 19[illegible]

Cyanide Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
African Giant Rat (B)	LOAEL	2 weeks	Growth	720 mg/kg-diet	27.0	Tewe, 1988, cited in Eisler, 1991
African Giant Rat (C)	LOAEL	12 weeks	Body weight and hormonal effect	1000 mg/kg-diet	37.5	Tewe, 1982, cited in Eisler, 1991
Laboatory White Rat Weanlings (C)	LOAEL	3 weeks	Increase in enzyme activity	727 mg/kg-diet	59.3	Aletor and Fetuga, 1988 cited in Eisler, 1991
Rat (C)	LOAEL	3 weeks	Growth		51	Tewe and Maner, 1981, cited in ATSDR 1995
Rat S/D (E)	LOAEL	3 months	Mortality		14.5	Gerhart, 1987 cited in ATSDR 1995
Rat S/D (F)	LOAEL	3 months	Mortality		2.6	Gerhart, 1987 cited in ATSDR 1995
Rat Fischer-344 (male) (A)	LOAEL	13 weeks	Reproduction		12.7	NTP 1993 cited in ATSDR 1995
Domestic chicken	NOAEL	8 weeks	No Adverse Effects	103 mg/kg-diet	14.9	Gomez et al. 1988 cited in Eisler, 1991
Rat (B)	NOAEL		No Adverse Effects		10.8	Howard & Hanzal, 1955 cited in IRIS, 1997
Rat Fischer-344 (A)	NOAEL	13 weeks	No Adverse Effects		4.8	NTP 1993 cited in ATSDR 1995
Dog (A)	NOAEL	30 days	No Adverse Effects	150 mg/kg-diet	2.5	EPA 1980 cited in Eisler, 1991
African Giant Rat (B)	NOAEL	16 weeks	No Adverse Effects	575 mg/kg-diet	21.5	Tewe, 1984, cited in Eisler, 1991
Laboatory White Rat (B)	NOAEL	2 years	No Adverse Effects	12 mg/kg-diet	12	Epa, 1980 cited in Eisler, 1991
Laboatory White Rat (B)	NOAEL	2 years	No Adverse Effects in reproductior	20 mg/kg-diet	20	Epa, 1989 cited in Eisler, 1991
Laboatory White Rat (C)	NOAEL	8 weeks	No Adverse Effects in growth	750 mg/kg-diet	61.2	Tewe and Maner, 1985, cited in Eisler, 1991
Domestic Pig	NOAEL	72 days	No Adverse Effects	96 mg/kg-diet	3.9	Tewe and Pessu, 1982, cited in Eisler, 1991
Hamster (Female)	NOAEL	3-14	No Adverse Effects		11.9	Frakes et al. 1986 cited in ATSDR 1995
Rat (C)	NOAEL	3 weeks	No Adverse Effects		12	Tewe and Maner, 1981, cited in ATSDR 1995
Note:						
A= Sodium Cyanide						
B= Hydrogen Cyanide						
C= Potassium Cyanide						
D= Calcium Cyanide						
E= Cupper Cyanide						
F= Potassium Silver Cynanide						
Chick Body Weight estimated at an age of 7 days= 0.073 kg, Reference in USEPA, 1987 EPA/600/6-87/008						
Chick/Chicken Food Injection (based on all birds) = $0.0582 \times BW(kg)^{0.651}$, Reference is USEPA 93, EPA/600/R-93/187a						
Mature African Giant Rat Body Weight (average male & female) =1.134 kg, Reference is Silva & Downing 1995						
Mature Rat Food Consumption (average male & female) = $0.04 \times BW(kg)^{0.479}$, Reference is USEPA, 1988						
Mature Rat Body Weight (average male & female) = 0.325 kg, Reference is USEPA, 1987 EPA/600/6-87/008						
Mature Rat Food Consumption (average male & female) = 0.0265 kg/day, Reference is USEPA, 1987 EPA/600/6-87/008						
Mature Dog Body Weight (average male & female) = 14 kg, Reference is USEPA, 1987 EPA/600/6-87/008						
Mature Dog Food Consumption (average male & female) = 0.435 kg/day, Reference is USEPA, 1987 EPA/600/6-87/008						
Young Pig Body Weight (assume white-cross) = 10 kg, USEPA, 1988						
Pig Food Ingestion (based on all animals) = $0.065 \times BW(kg)^{0.7919}$, USEPA 1988				0.023348131		

Cyanide Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Mallard	LD_{50}	Single Dose	Mortality		1.43	Hill (per. Comm.) as cited in Eisler 1991
Black Vulture	LD_{50}	Single Dose	Mortality		2.54	Wiemeyer et al. 1986 as cited in Eisler 1991
Turkey Vulture	LD_{100}	Single Dose	Mortality		19.1	Krynitski et al. 1986 as cited in Eisler 1991
Japanese Quail (male)	LD_{50}	Single Dose	Mortality		5.5	Wiemeyer et al. 1986 as cited in Eisler 1991
Japanese Quail (female)	LD_{50}	Single Dose	Mortality		4.5	Wiemeyer et al. 1986 as cited in Eisler 1991
American Kestrel	LD_{50}	Single Dose	Mortality		2.12	Wiemeyer et al. 1986 as cited in Eisler 1991
Eastern Screech Owl	LD_{50}	Single Dose	Mortality		4.6	Wiemeyer et al. 1986 as cited in Eisler 1991
Starling	LD_{50}	Single Dose	Mortality		9.0	Wiemeyer et al. 1986 as cited in Eisler 1991
Chicken	LD_{50}	Single Dose	Mortality		11.1	Wiemeyer et al. 1986 as cited in Eisler 1991
Dog	LD_{50}	Single Dose	Mortality		24.0	Cristel et al. 1977 as cited in Eisler 1991
Coyote	LD_{50}	Single Dose	Mortality		4.1	Sterner 1979 as cited in Eisler 1991
Rabbit	LD_{50}	Single Dose	Mortality		2.5	Ballantyne 1987 as cited in Eisler 19991
Rat	LD_{50}	Single Dose	Mortality		4.0	USEPA 1989 as cited in Eisler 1991
Mouse	LD_{50}	Single Dose	Mortality		3.4	Ballantyne 1987 as cited in Eisler 19991
Chicken (chicks)	LOAEL	20-day	Growth	135 mg/kg-diet	19.6	Elzubier and Davis (1986) as cited in Eisler (1991)
Rat	LOAEL	21-day	Liver size	in drinking water	21	USEPA 1989 as cited in Eisler 1991
Rat	LOAEL	4-week	Growth	200 mg/L (water)	26.8	Palmer & Olson 1981 as cited in Eisler 1991
Rat	LOAEL	50-week	Growth	1500 mg/kg-diet	122.5	Eisler, 1991
Chicken (chicks)	NOAEL	8-week	No Adverse Effects	103 mg/kg-diet	14.9	Gomez et al. (1988) as cited in Eisler (1991)
Dog	NOAEL	30-day	No Adverse Effects	150 mg/kg-diet	4.7	USEPA 1980 as cited in Eisler 1991
Dog	NOAEL	15-month	No Adverse Effects		2	USEPA 1980 as cited in Eisler 1991
Pig	NOAEL	72-day	No Adverse Effects	96 mg/kg-diet		Tewe & Pessu 1982 as cited in Eisler 1991
Rat	NOAEL	21-day	Liver size	in drinking water	8	USEPA 1989 as cited in Eisler 1991
Rat	NOAEL	2-year	No Adverse Effects		12	USEPA 1980 as cited in Eisler 1991
Rat	NOAEL	Gestation & Lactation	No Reproductive Effects	500 mg/kg-diet	68.7	Tewe & Mancer 1981 as cited in Eisler 1991; Sample et al. 1996

Cyanide Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference

Chick Body Weight estimated at an age of 7 days = 0.073 kg, Reference in USEPA, 1987 EPA/600/6-87/008

Chick/Chicken Food Ingestion (based on all birds) = 0.0582 x BW(kg)$^{0.651}$, Reference is USEPA 93, EPA/600/R-93/187a

Mature Rat Body Weight (average male & female) = 0.325 kg, Reference is USEPA, 1987 EPA/600/6-87/008

Mature Rat Food Consumption (average male & female) = 0.0265 kg/day, Reference is USEPA, 1987 EPA/600/6-87/008

Mature Rat Water Consumption (average male & female) = 0.0435 L/day, Reference is USEPA, 1987 EPA/600/6-87/008

Mature Dog Body Weight (average male & female) = 14 kg, Reference is USEPA, 1987 EPA/600/6-87/008

Mature Dog Food Consumption (average male & female) = 0.435 kg/day, Reference is USEPA, 1987 EPA/600/6-87/008

Iron Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	LD_{50}	Single Dose	Mortality		30000	RTECS, Ind. J. Pharmacy 13:240, 1951
Rat	LD_{50}	Single Dose	Mortality		319	RTECS, J. Pediatrics, 69:663, 1966
Rat	LD_{50}	Single Dose	Mortality		450	RTECS, Gigiena &Sanitariyu, 39:16, 1974
Rat (A)	LD_{50}	Single Dose	Mortality		1000	Shanas and Boyd 1969 as cited in NAS 1980
Rat (C)	LD_{50}	Single Dose	Mortality		1000	Shanas and Boyd 1969 as cited in NAS 1980
Cat (A)	LD_{50}	Single Dose	Mortality		100	Hoppe et al. 1955 as cited in NAS 1980
Mouse	LD_{50}	Single Dose	Mortality		895	RTECS, Annual Rpt. Tokyo, Metro. Res. Lab. Public Health, 27:159, 1976
Mouse	LD_{50}	Single Dose	Mortality		680	British J. Pharmacol. Chemo., 24:352, 1965
Mouse (A)	LD_{50}	Single Dose	Mortality		306	Hoppe et al. 1955 as cited in NAS 1980
Mouse (D)	LD_{50}	Single Dose	Mortality		429	Hoppe et al. 1955 as cited in NAS 1980
Guinea Pig	LD_{50}	Single Dose	Mortality		20000	RTECS, Ind. J. Pharmacy 13:240, 1951
Guinea Pig	LD_{50}	Single Dose	Mortality		1200	RTECS Clinical Pediatrics, 5:485, 1966
Guinea Pig (A)	LD_{50}	Single Dose	Mortality		300	Hoppe et al. 1955 as cited in NAS 1980
Guinea Pig (B)	LD_{50}	Single Dose	Mortality		350	Hoppe et al. 1955 as cited in NAS 1980
Guinea Pig (C)	LD_{50}	Single Dose	Mortality		200	Hoppe et al. 1955 as cited in NAS 1980
Guinea Pig (D)	LD_{50}	Single Dose	Mortality		300	Hoppe et al. 1955 as cited in NAS 1980
Rabbit	LD_{Lo}	Single Dose	Mortality		890	RTECS, Env. Qual. Saf. Suppl., 1:1, 1975
Dog (A)	LD_{100}	Single Dose	Mortality		250	Franklin et al. 1958 as cited in NAS 1980
Cattle (A)	LOAEL	84-day	Slight decrease in weight gains and feed conversions (body weight = 235 kg)	477 mg/kg-diet	9.95	Standish et al. 1969 as cited in NAS 1980
Cattle (A)	LOAEL	77-day	Significant reduction in growth and feed intake (198 to 234 kg - BW)	1000 mg/kg-diet	20.9	Standish et al. 1971 as cited in NAS 1980
Cattle (B)	LOAEL	98-day	Reduced growth and feed intake (125 kg - BW)	2500 mg/kg-diet	59.5	Koong et al. 1970 as cited in NAS 1980
Sheep (A,B)	LOAEL	44-day	Reduced feed intake (34 kg - BW)	1600 mg/kg-diet	25.8	Standish and Ammerman 1971 as cited in NAS 1980
Swine (A)	LOAEL	56-day	Reduced growth and feed intake (6 kg - BW)	4000 mg/kg-diet	179	O'Donovan et al. 1963 as cited in NAS 1980
Swine (A)	LOAEL	60-day	Reduced growth and feed intake (20 kg - BW)	5100 mg/kg-diet	178	Furugouri 1972 as cited in NAS 1980
Rat	LOAEL	6-Day (gestation)	Fetotoxicity	7200 mg/kg-Total Dose	1200	RTECS, Yakuri, Pharmeometrics, 17:483, 1979

Iron Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Dog	LOAEL	Lifetime	Maximum Tolerable Dose	Diet	51.4	Merck Vet. Manual 1998
Chicken (A)	LOAEL	28-day	Reduced growth (starting at 1 day old)	800 mg/kg-diet	80.3	McGhee et al. 1965 as cited in NAS 1980
Chicken (A)	LOAEL	28-day	Rickets	4500 mg/kg-diet	311	Deobald and Elvehjem 1935 as cited in NAS 1980
Cattle (B)	NOAEL	98-day	Growth and feed intake (125 kg - BW)	2000 mg/kg-diet	47.6	Koong et al. 1970 as cited in NAS 1980
Sheep (A)	NOAEL	49-day	Growth and feed intake (23 kg - BW)	280 mg/kg-diet	4.52	Lawlor et al. 1965 as cited in NAS 1980
Swine (A)	NOAEL	56-day	Growth and feed intake (6 kg - BW)	3000 mg/kg-diet	134	O'Donovan et al. 1963 as cited in NAS 1980
Swine (A)	NOAEL	30-day	No adverse effects (15 kg - BW)	3100 mg/kg-diet	115	Furugouri 1972 as cited in NAS 1980
Dog	NOAEL	Lifetime	Required in Mainatance Diet	Diet	1.37	Merck Vet. Manual 1998
Cat	NOAEL	Lifetime	Required in Mainatance Diet	Diet	2.34	Merck Vet. Manual 1998
Chicken (A)	NOAEL	28-day	Growth (starting at 1 day old)	400 mg/kg-diet	40.1	McGhee et al. 1965 as cited in NAS 1980

A = Ferrous sulfate
B = Iron citrate
C= Ferrous chloride
D = Ferrous gluconate

Lead Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Cattle	LD_{50}	Single Dose	Mortality		600-800	Allcroft & Baxter, No Yr as cited in EPA-600/3-77-009, 1977
Calf	LD_{50}	Single Dose	Mortality		200-400	Allcroft & Baxter, No Yr as cited in EPA-600/3-77-009, 1977
Cattle	LD_{LO}	69-day	Mortality		5	Shupe et al. 1967 as cited in EPA-600/3-77-009, 1977
Dog	LD_{LO}	2-day	Mortality		600	Robertson 1970 as cited in EPA-600/3-77-009, 1977
Mallard (A)	LD_{50}	Single Dose	Mortality		107	Belrose 1951 as cited in Eisler, 1988
Quail (A)	LD_{50}	Single Dose	Mortality		24.6	Hudson et al. 1984 as cited in Eisler, 1988
Duck	LD_{LO}	25-day	Mortality		8 to 12	Coburn at al. 1951 as cited in EPA-600/3-77-009, 1977
Pigeon	LD_{LO}	Single Dose	Mortality		160	RTECS, Abdernalden's Handbuch Biologischen Arb. 4:1289, 1935
Starling (A)	LD_{100}	11-day	Mortality		2.8	Osborn et al. 1983 as cited in Eisler, 1988
Cattle	LOAEL	Chronic	Mortality	275	7	Hammond & Aronson 1961 as cited in EPA-600/3-77-009, 1977
Sheep	LOAEL	106-day	Fetotoxicity		9	James et al. 1966 as cited in EPA-600/3-77-009, 1977
Dog	LOAEL	Not Reported	Symptomatic Lead Poisoning	100 mg/kg-diet	38	Stowe et al. 1973 as cited in EPA-600/3-77-009, 1977
Rat (B)	LOAEL	11-day (Gestation)	Fetal Reabsorption & Maternal Toxicity	in the diet	390	Kenndy et al. 1975 as cited in ATSDR 1993
Rat	LOAEL	56-day (incl. gestation)	Offspring Behavior	1140 mg/kg-total dose	20	RTECS, Pharmacologist, 20:201, 1978
Rat (B)	LOAEL	7-8-week	Growth (Body Weight)	in the diet	318	Walsh & Ryden 1984 as cited in ATSDR 1993
Rat (E)	LOAEL	52-day	Cortical Development	in drinking water	28	Taylor et al. 1982 as cited in ATSDR 1993
Rat (B)	LOAEL	41-day	Decreased Fetal Weight	gavage	64	Miller et al. 1982 as cited in ATSDR 1993
Rat	LOAEL	3-generation	Reduced Offspring Weight	1000 mg/kg-diet	80	Azar et al. 1973 as cited in Sample et al. 1996
Mouse	LOAEL	21-day (gestation)	Effects on Fertility	6300 mg/kg-total dose	300	RTECS, Experimentia, 31:1312, 1975
Mouse	LOAEL	1 to 2-day (gestation)	Effects on Fertility	300 mg/kg-total dose	150	RTECS, Toxicology 6:129, 1976
Mouse (A)	LOAEL	Multi-generation	Reproductive Effects		2.2	Clark et al. as cited in Eisler 1988

Lead Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Dog (B)	LOAEL	2-year	Renal Effects	in the diet	12.5	Azar et al. 1973 as cited in ATSDR 1993
Poultry	LOAEL	4-week	Growth	1000 mg/kg-diet	48	Damron et al. 1969 as cited in EPA-600/3-77-009, 1977
Rock Dove (B)	LOAEL	64-week	Anemia, Learning Effects, Kidney Pathology	gavage	6.25	Anders et al. 1982 as cited in Eisler, 1988
Japanese Quail	LOAEL	12-week	Egg Production, Fertility	100 mg/kg-diet	11.3	Edens et al. 1976 as cited in Sample et al. 1996
Am. Kestrel (nestlings) (C)	LOAEL	10-day	Growth		125	Hoffman et al. 1984 as cited in Eisler, 1988
Cattle	NOAEL	2-3 years	No Adverse Effects	250 mg/kg-diet	6	Allcroft & Baxter, No Yr as cited in EPA-600/3-77-009, 1977
Sheep	NOAEL	45-days	No Effects		5	James et al. 1966 as cited in EPA-600/3-77-009, 1977
Sheep	NOAEL	26-week	No Effects		4.5	Carson et al. 1973 as cited in EPA-600/3-77-009, 1977
Sheep	NOAEL	30-day	No Effects		100	Van Gelder et al. 1973 as cited in EPA-600/3-77-009, 1977
Dog (B)	NOAEL	2-year	No Adverse Effects	in the diet	12.5	Azar et al. 1973 as cited in ATSDR 1993
Rat (B)	NOAEL	11-day (Gestation)	Reproduction	in the diet	39	Kenndy et al. 1975 as cited in ATSDR 1993
Rat	NOAEL	3-generation	Reproduction	100 mg/kg-diet	8	Azar et al. 1973 as cited in Sample et al. 1996
Poultry (B)	NOAEL	4-week	No Effects	100 mg/kg-diet	4.8	Damron et al. 1969 as cited in EPA-600/3-77-009, 1977
Poultry	NOAEL	35-day	No Effects		160	Vengris & Mare 1974 as cited in EPA-600/3-77-009, 1977
Mallard (D)	NOAEL	12-week	No Adverse Effects	25 mg/kg-diet	1.3	Hudson et al. 1984 as cited in Eisler, 1988
Duck	NOAEL	137-day	No Effects		6	Coburn at al. 1951 as cited in EPA-600/3-77-009, 1977
Japanese Quail	NOAEL	12-week	Egg Production, Fertility	10 mg/kg-diet	1.13	Edens et al. 1976 as cited in Sample et al. 1996
Quail (B, C, D)	NOAEL	5-day	No Effects	5000 mg/kg-diet	16	Hill and Camardese 1986
Am. Kestrel	NOAEL	7-month	No Effects	10 mg/kg-diet	3.85	Pattee 1984 as cited in Sample et al. 1996
Turtle Dove	NOAEL	2-weeks through breeding cycle	Egg Production, Fertility	0.1 mg/L (Pb^{+2} in water)		Kendall & Scanlon 1982 as cited in Eisler, 1988

Lead Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference

A = triethyllead
B = Lead acetate
C = Lead powder
D = Lead nitrate
E = Lead chloride

Mature Mallard Body Weight (average male & female) = 1.134 kg, Reference is USEPA, 1993, EPA/600/R-93/187a
Mature Dog Body Weight (average male & female) = 14 kg, Reference is USEPA, 1987 EPA/600/6-87/008
Mature Dog Food Consumption (average male & female - moist diet) = 0.435 kg/day, Reference is USEPA, 1987 EPA/600/6-87/008
Average Rat Gestation Period = 21 days, Reference is USEPA, 1987 EPA/600/6-87/008
Assumed Poultry as a Chicken Body Weight = 1.7 kg, Reference in USEPA, 1987 EPA/600/6-87/008
Bird Food Ingestion (based on all birds) = 0.0582 x BW(kg)$0.^{651}$, Reference is USEPA 93, EPA/600/R-93/187a
Mature Bald Eagle Body Weight (average male & female) = 4.551 kg, Reference is USEPA, 1993, EPA/600/R-93/187a
No Quail age was provided, assumed "young" i.e. 10-day, baby weight at 10-day averages 0.0115 kg (EPA 600/R-93/187a)
Mature Kestrel Body Weight (average male & female) = 0.116 kg, Reference is USEPA, 1993, EPA/600/R-93/187a
Mature Kestrel Food Consumption (seasonal average) = 0.29 g/g-BW, Reference is USEPA, 1993, EPA/600/R-93/187a
Bird and Lead Shot Toxicity data NOT included here

Manganese Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	LD_{50}	Single Dose	Mortality		250 to 275	RTECS, WHO, Environ. Health Crit: Mn, 1981
Guinea Pig	LD_{50}	Single Dose	Mortality		400 to 810	RTECS, WHO, Environ. Health Crit: Mn, 1981
Mouse	LD_{50}	Single Dose	Mortality		275 to 450	RTECS, WHO, Environ. Health Crit: Mn, 1981
Rat	LD_{50}	21-day	Mortality	gavage	225	Rehnberg et al. 1980 as cited in ATSDR 1992
Cattle (A) "young"	LOAEL	84-day	Decreased growth and food intake	2460 mg/kg-diet		Cunningham et al. 1966 as cited in NAS 1980
Swine (A) "young"	LOAEL	not specified	Decreased growth and food intake	500 mg/kg-diet		Grummer et al. 1950 as cited in NAS 1980
Swine (A) "young"	LOAEL	8-week	Decreased growth	2025 mg/kg-diet		Leibholz et al. 1962 as cited in NAS 1980
Swine (A) "young"	LOAEL	12-week	Decreased growth	4000 mg/kg-diet		Leibholz et al. 1962 as cited in NAS 1980
Rat	LOAEL	Not Reported	Growth	1.75%-diet	1.43E+05	HSDB, Venugopal & Luckey, Metal Tox. Mammals, 1978
Rat	LOAEL	20-day (gestation)	Reduced litter weight	in drinking water	1240	Kontur and Fechter 1988 as cited in ATSDR 1992
Rat	LOAEL	224-day through gestation	Reproductive Effects	3550 mg/kg-diet	284	Laskey et al. 1982 as cited in Sample et al. 1996
Rat	LOAEL	133-week	Survival and clinical signs		930	Hejtmancik et al. 1987 as cited in ATSDR 1992
Mouse	LOAEL	90-day	Delayed growth of testes		140	Gray and Laskey 1980 as cited in ATSDR 1992
Chicken (B) "young"	LOAEL	Not specified	Growth and survival	4779 mg/kg-diet		Heller and Penquite 1937 as cited in NAS 1980
Turkey (A) "young"	LOAEL	21-day	Decreased Growth	4800 mg/kg-diet		Mussehl and Ackerson 1939 as cited in NAS 1980
Cattle (A) "young"	NOAEL	84-day	No Adverse Effect	820 mg/kg-diet		Cunningham et al. 1966 as cited in NAS 1980
Cattle (A)	NOAEL	4.5 - month	No Adverse Effect	200 mg/kg-diet		Fain et al. 1952 as cited in NAS 1980
Swine (A) "young"	NOAEL	8-week	Growth	225 mg/kg-diet		Leibholz et al. 1962 as cited in NAS 1980

Rat (weaning)	NOAEL	1-month (parental)	Histology		4.1	HSDB, Friberg, *et al*., Handbook Toxicol. Metals, 1979
Rat	NOAEL	224-day through gestation	Reproductive Effects	1100 mg/kg-diet	88	Laskey et al. 1982 as cited in Sample et al. 1996
Rat	NOAEL	Not Reported	Growth (enhancement)	100 mg/kg-diet	8.2	HSDB, Clayton & Clayton, Patty's Ind. Hyg. Toxicol. Vol2, 1982
Rat	NOAEL	Gestation & Lactation	Development	1004 mg/kg-diet	81.9	HSDB, Venugopal & Luckey, Metal Tox. Mammals, 1978
Rat	NOAEL	20-day (gestation)	Reduced litter weight	in drinking water	620	Kontur and Fechter 1988 as cited in ATSDR 1992
Rat	NOAEL	133-week	Survival and clinical signs		290	Hejtmancik et al. 1987 as cited in ATSDR 1992
Mouse	NOAEL	133-week	Survival and clinical signs		250	Hejtmancik et al. 1987 as cited in ATSDR 1992
Chicken (B) "young"	NOAEL	20-week	No Adverse Effects	1000 mg/kg-diet		Gallop and Norris 1939 as cited in NAS 1980
Turkey (A,B) "young"	NOAEL	Not specified	No Adverse Effects	350 mg/kg-diet		Mussehl and Ackerson 1939 as cited in NAS 1980
Turkey (A) "young"	NOAEL	21-day	No Adverse Effects	4080 mg/kg-diet		Mussehl and Ackerson 1939 as cited in NAS 1980
Japanese Quail	NOAEL	75-day	Growth	5056 mg/kg-diet	977	Hill and Schaffner 1976 as cited in Sample et al. 1996

Mature Rat Body Weight (average male & female) = 0.325 kg, Reference is USEPA, 1987 EPA/600/6-87/008 A = Mn Sulfate
Mature Rat Food Consumption (average male & female) = 0.0265 kg/day, Reference is USEPA, 1987 EPA/600/6-87 B = Mn Carbonate

Mercury Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Mouse (A)	LD_{66}	Single Dose	Mortality	gavage	16.0	Yasutake et al. 1991 as cited in ATSDR 1993
Mouse (D)	LD_{50}	Single Dose	Mortality		6.0	Gigiena i Sanitariya 51(1):76, 1986 as cited in RTECS
Mouse (A)	LD_{50}	Single Dose	Mortality		57.6	Karger and Basel 1979
Mouse (D)	LD_{50}	Single Dose	Mortality		180	Gigiena Truda i Professional' nye Zabolevaniia (Labor Hygiene and Occupational Diseases), v/o Mezhdunarodnaya Kniga, Moscow, 25(7), 27, 1981.
Mouse (D)	LD_{50}	Single Dose	Mortality		23.9	Gigiena i Sanitariya 46(8):12, 1981 as cited in RTECS
Mouse (D)	LD_{90}	14-days (5-days a week)	Mortality	gavage	59	NTP 1993 as cited in ATSDR 1993
Guiney pig (A)	LD_{50}	Single Dose	Mortality		21.0	Toxicol Appl Pharmacol. 1973; 24:545 as cited in RTECS
Rat (D)	LD_{50}	Single Dose	Mortality	gavage	25.9	Kostial et al. 1978 as cited in ATSDR 1993
Rat (D)	LD_{50}	Single Dose	Mortality		1.0	Pesticide Manual, British Crop Protection Council, Thornton Health, UK, 8, 530, 1987.
Rat (A)	LD_{50}	Single Dose	Mortality		29.9	Bulletin of Environmental Contamination and Toxicology, Springer-Verlag, Secaucus, NJ,14, 140, 1975.
Rat (D)	LD_{50}	Single Dose	Mortality		40.9	Gigiena i Sanitariya 46(8):12, 1981 as cited in RTECS
Rat (D)	LD_{40}	14-days (5-days a week)	Mortality	gavage	14.8	NTP 1993 as cited in ATSDR 1993
Rat (D)	LD_{50}	Single Dose	Mortality		166	Gigiena Truda i Professional' nye Zabolevaniia (Labor Hygiene and Occupational Diseases), v/o Mezhdunarodnaya Kniga, Moscow, 25(7), 27, 1981.
Swine (A)	LD_{100}	Single Dose	Mortality	capsule	53.8	Piper et al. 1971 as cited in NAS 1980
Mule Deer (E)	LD_{50}	Single Dose	Mortality		17.88	Hudson et al. 1984
Harp Seal (D)	LD_{LO}	20 to 26-day	Mortality	capsule	25	Ronald et al. 1977 as cited in Wolfe et al. 1998
Mink (A)	LD_{100}	2-month	Mortality	5 mg/kg-diet	0.784	Aulerich et al. 1974
Swine (A)	LD_{100}	35-day	Mortality	capsule	13.4	Piper et al. 1971 as cited in NAS 1980
Mallard (B,F)	LD_{50}	Single Dose - 1 to 9 days for mortality	Mortality		> 45	Hudson et al., 1984

Mercury Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Whistling Duck (B,F)	LD_{50}	Single Dose - 1 to 9 days for mortality	Mortality		38	Hudson et al., 1984
Bobwhite (B,F)	LD_{50}	Single Dose - 1 to 9 days for mortality	Mortality		24	Hudson et al., 1984
Japanese Quail (B,F)	LD_{50}	Single Dose - 1 to 9 days for mortality	Mortality		34	Hudson et al., 1984
Pheasant (B,F)	LD_{50}	Single Dose - 1 to 9 days for mortality	Mortality		27	Hudson et al., 1984
Mallard (A,G)	LD_{50}	Single Dose - few days to few weeks for mortality	Mortality		> 72	Hudson et al., 1984
Mallard Ducklings (A,G)	LD_{50}	Single Dose - few days to few weeks for mortality	Mortality		> 72	Hudson et al., 1984
Praire Chicken (A,G)	LD_{50}	Single Dose - few days to few weeks for mortality	Mortality		12	Hudson et al., 1984
Pheasant (A,G)	LD_{50}	Single Dose - few days to few weeks for mortality	Mortality		12	Hudson et al., 1984
Chukar (A,G)	LD_{50}	Single Dose - few days to few weeks for mortality	Mortality		27	Hudson et al., 1984
Gray Partridge (A,G)	LD_{50}	Single Dose - few days to few weeks for mortality	Mortality		18	Hudson et al., 1984
Rock Dove (A,G)	LD_{50}	Single Dose - few days to few weeks for mortality	Mortality		23	Hudson et al., 1984
Mallard (C,H)	LD_{50}	Single Dose - few hours to days for mortality	Mortality		525	Hudson et al., 1984
Pheasant (C,H)	LD_{50}	Single Dose - few hours to days for mortality	Mortality		101	Hudson et al., 1984
Mallard (A,J)	LD_{50}	Single Dose	Mortality		24	Hudson et al., 1984
Pheasant (A,J)	LD_{50}	Single Dose	Mortality		24	Hudson et al., 1984

Mercury Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
House Sparrow (A,J)	LD_{50}	Single Dose	Mortality		12.6 to 37.8 (geomean = 21.8)	Hudson et al., 1984
Japanese Quail (D)	LD_{50}	Single Dose	Mortality		31.1	Hill and Soares 1984
Japanese Quail (G)	LD_{50}	5-day - started with 14-day olds	Mortality	147 mg/kg-diet	2.04	Hill and Camaedese 1986
Japanese Quail (N)	LD_{50}	5-day - started with 14-day olds	Mortality	45 mg/kg-diet	0.220	Hill and Camaedese 1986
Japanese Quail (D)	LD_{50}	5-day - started with 14-day olds	Mortality	5086 mg/kg-diet	574	Hill and Camaedese 1986
Japanese Quail (A)	LD_{50}	5-day - started with 14-day olds	Mortality	47 mg/kg-diet	15.8	Hill and Camaedese 1986
Quail (A)	LD_{50}	5-day	Mortality	31 to 47 mg/kg-diet (geomean = 38.2)	16.8	Hill 1981 as cited in Eisler 1987
Quail (D)	LD_{50}	5-day	Mortality	2956 to 5086 mg/kg-diet (geomean = 3877)	171	Hill 1981 as cited in Eisler 1987
Pheasant (B)	LD_{50}	15-day	Mortality	112 mg/kg-diet	5.86	Spann et al. 1972 as cited in Eisler 1987
Japanese Quail (A)	LD_{LO}	5-day	Mortality	8 mg/kg-diet	3.52	Hill and Soares 1984
"Birds" (4-species)(A)	LD_{33}	6-11 day	Mortality	40 mg/kg-diet	NAP	Finney et al. 1979 as cited in Esiler 1987
Chicken (D)	LD_{LO}	3-day	Mortality	500 mg/L - drinking water	57.1	Grissom and Thaxton 1985 as cited in Eisler 1987
Chicken (A)	LD_{50}	33-day	Mortality	5 mg/kg-diet	0.345	Soares et al. 1973 as cited in NAS 1980
Chicken (D)	LD_{50}	98-day	Mortality -48%	250 mg/L-drinking water	28.5	Parkhurst and Thaxton 1973 as cited in NAS 1980
Japanese Quail (A)	LD_{50}	112-day	Mortality	10 mg/kg-diet	4.07	El-Begearmi et al. 1974 as cited in NAS 1980
Japanese Quail (D)	LD_{55}	28-day	Mortality	500 mg/kg-diet	204	El-Begearmi et al. 1980 as cited in Esiler 1987
Pheasant (B)	LD_{50}	28-day	Mortality	37.4 mg/kg-diet	1.96	Spann et al. 1972 as cited in Eisler 1987
Pheasant (B)	LD_{50}	70-day	Mortality	12.5 mg/kg-diet	0.654	Spann et al. 1972 as cited in Eisler 1987
Quail (A)	LD_{LO}	27-day	Mortality	50 mg/kg-diet	20.3	Chang et al. 1977 as cited in NAS 1980
Hamster (D)	LOAEL	single dose	Fetal resorption	gavage	22	Gale 1974 as cited in ATSDR 1993
Rat (A)	LOAEL	single dose during gestation	Fetotoxicity and developmental abnormalities	gavage	24	Inouye and Murakami 1975 as cited in ATSDR 1993

Mercury Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat (A)	LOAEL	single dose during gestation	Fetal edema and brain lessions	gavage	2	Inouye and Murakami 1975 as cited in ATSDR 1993
Guiney Pig (A)	LOAEL	single dose during gestation	Retarded fetal brain development and increased abortions	gavage	11.5	Inouye and Kajiwara 1988 as cited in ATSDR 1993
Hamster (A)	LOAEL	single dose during gestation	Degeration of cerebellar nerons	gavage	1.6	Reuhl et al. 1981 as cited in ATSDR 1993
Mouse (A)	LOAEL	single dose during gestation	Survival of offspring and brain weights	gavage	16	Inouye et al. 1985 as cited in ATSDR 1993
Mouse (A)	LOAEL	single dose during gestation	Cleft palate and decreased fetal weight	gavage	12	Fuyuta et al. 1979 as cited in ATSDR 1993
Mouse (A)	LOAEL	single dose during gestation	Cleft palate and decreased fetal weight	gavage	16	Yasuda at al. 1985 as cited in ATSDR 1993
Rat (A)	LOAEL	10-day	Lethargy, ataxia, and peripheral nerve damage	in diet	6.9	Miyakawa et al. 1974 as cited in ATSDR 1993
Mouse (A)	LOAEL	single dose during gestation	Fetal reabsorption and decreased fetuses per litter	gavage	20	Fuyuta at al. 1979 as cited in ATSDR 1993
Mouse (A)	LOAEL	single dose during gestation	Decreased number of pups per litter	gavage	3	Huges and Annau 1976 as cited in ATSDR 1993
Cattle (A)	LOAEL	91-day	Ataxia - prostration		0.2	Herigstad et al. 1972 as cited in NAS 1980
Cattle (K)	LOAEL	27-day	Incoordination: death	capsule	0.48	Palmer et al. 1973 as cited in NAS 1980
Cattle (A)-yearling	LOAEL	56-day	Incoordination: unsteady gait	oral	0.225	Wright et al. 1973 as cited in NAS 1980
Sheep (A)-yearling	LOAEL	49-day	Incoordination: unsteady gait	oral	0.225	Wright et al. 1973 as cited in NAS 1980
Sheep (K)	LOAEL	31-day	Survival	capsule	0.48	Palmer et al. 1973 as cited in NAS 1980
Swine (C)	LOAEL	63-day	Decreased growth, kidney & coon necrosis, diarrhea	capsule	2.38	Tryphonas and Nielson 1970 as cited in NAS 1980
Swine (A)	LOAEL	46-day	Necrosis of nerve tissue	capsule	0.76	Tryphonas and Nielson 1973 as cited in NAS 1980
Swine (A)	LOAEL	33-day	Anorexia, vomiting, CNS depression	capsule	3.4	Piper et al. 1971 as cited in NAS 1980
Swine (A)	LOAEL	Gestation	Increased stillbirths	diet	0.5	Khera 1979 as cited in Wolfe et al. 1998
Dog (A)	LOAEL	Gestation	Increased stillbirths	diet	0.1	Khera 1979 as cited in Wolfe et al. 1998
Cat (A)	LOAEL	90-day (5x @ week)	Survival - mean survival was 78 days	dosed in beef liver	0.25	Eaton et al. 1980 as cited in Wolfe et al. 1998
Norway Rat (D)	LOAEL	60-day	Weight loss and survival	gavage	3.00	Andres 1984 as cited in IRIS 1995

Mercury Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat (C)	LOAEL	2-year	Reduced Growth	10 mg/kg-diet	0.815	Fitzhugh et al. 1950 as cited in NAS 1980
Rat (D)	LOAEL	2-year	Reduced Growth	160 mg/kg-diet	8.00	Fitzhugh et al. 1950 as cited in IRIS 1995
Rat (D)	LOAEL	3-month	Lethargy and abnormal gait	in diet	2.20	Goldman and Elackburn 1979 as cited in ATSDR 1993
Rat (A)	LOAEL	2-year	10% decrease in growth	drinking water	0.400	Solecki et al. 1991 as cited in ATSDR 1993
Mouse (D)	LOAEL	6-month (5-days week)	26% decrease in growth	gavage	14.8	NTP 1993 as cited in ATSDR 1993
Mouse (A)	LOAEL	90-day	Survival	5 mg/L-drinking water	1.22	Schroeder and Mitchener 1975 as cited in NAS 1980
Mouse (A)	LOAEL	104-week	Decreased spermogensis	in diet	0.73	Hirano et al. 1986 as cited in ATSDR 1993
Mouse (A)	LOAEL	109-week	Tubular atrophy of the testes	in diet	0.69	Mitsumori et al. 1990 as cited in ATSDR 1993
Mouse (A)	LOAEL	26-week	Survival	in diet	3.1	Mitsumori et al. 1981 as cited in ATSDR 1993
Rat (A)	LOAEL	12-week	Ataxia, edema necrosis of the cerebellum	gavage	1.68	Magos and Butler 1972 as cited in ATSDR 1993
Rat (A)	LOAEL	52-day	Increased incidence of eye defects in fetuses	in diet	0.25	Khera and Tabacova 1973 as cited in ATSDR 1993
Rat (A)	LOAEL	104-week	Survival	in diet	0.69	Mitsumori et al. 1990 as cited in ATSDR 1993
Rat (D)	LOAEL	6-month (5-days week)	10% decrease in growth	gavage	0.93	Dieter et al. 1992 as cited in ATSDR 1993
Rat (D)	LOAEL	2-year (5-days week)	Reduced survival	gavage	1.9	Dieter et al. 1992 as cited in ATSDR 1993
Rat (D)	LOAEL	4-week	Growth	in diet	5.6	Jonker et al. 1993 as cited in ATSDR 1993
Cat (E)	LOAEL	10 to 58-day (gestation)	Developmental Abnormalities		0.25	Khera 1979 as cited in Eisler, 1987
Ferret (A)	LOAEL	58-day	Survival	5 mg/kg-diet (WW)	0.62	Hanko 1970 as cited in Thompson 1996
Otter (A)	LOAEL	199-day	Anorexia, ataxia, and survival	2-mg/kg-diet (WW)	0.10	O'Conner and Nielson, 1980
Mink (A)	LOAEL	93-day	Anorexia and death	1.8 mg/kg-diet	0.288	Wobeser et al. 1976 as cited in NAS 1980
Mink (A)	LOAEL	6-month	Kit and maternal survival	1 mg/kg-diet	0.16	Wren et al. 1987
Monkey (A)	LOAEL	29-day	Ataxia and blindness	drinking water	0.5	Wolles et al. 1978 as cited in ATSDR 1993
Monkey (A)	LOAEL	4-month	Abortion, stillbirth, and decreased conception	gavage	0.06	Burbacher et al. 1988 as cited in ATSDR 1993
Harp Seal (D)	LOAEL	90-day	Reduced activity, appetite, and body weight	capsule	0.25	Ronald et al. 1977 as cited in Wolfe et al. 1998

Mercury Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Quail (D)	LOAEL	Not specified	Tetsticular development in "young" quail	2 mg/kg-diet	0.814	Hill and Soares 1984
Kestrel (A)	LOAEL	Not specified	Survival	13.3 mg/kg-diet (wet weight) [=19.6 ppm DW]	5.88	Koeman et al. 1971 as cited in Thompson 1996
Pheasant (A)	LOAEL	Breeding season	Egg production and enbryo survival	4.2 mg/kg-diet	0.220	Spann et al. 1972 as cited in Thompson 1996
Chicken (A)	LOAEL	Breeding	Reduced reporduction, amterinal ataxia	10 mg/kg-diet	0.691	Scott et al. 1975 as cited in Thonpson 1996
Goshawk (juveniles) (A)	LOAEL	30 to 47-day	Growth and survival	10 to 13 mg/kg-diet (wet weight) [14.7 to 19.1 ppm DW]	1.46	Borg et al. 1970 as cited in Thompson 1996 (used Red-tailed hawk biological parameters)
Pheasant (A)	LOAEL	12-week	Egg hatchability, mating success, fetotoxity	2 to 3 mg/kg-diet	0.105	Borg et al. 1969 as cited in Thompson 1996
Red-tailed hawk - juveniles (A)	LOAEL	4-week	Growth and survival	10 mg/kg-diet (wet weight)[14.7 ppm DW]	1.46	Fimeite and Karstand 1971
Zebra Finch (A)	LOAEL	76-day	Lethargy and Survival	5 mg/kg-diet	1.75	Scheuhammer, 1988
Chicken (A)	LOAEL	35-day	Reduced growth and 7.5% mortality	33 mg/kg-diet	2.28	Gardiner 1972 as cited in NAS 1980
Chicken (D)	LOAEL	42-day	Decreased growth	125 mg/L-drinking water	14.3	Thaxton et al. 1975 as cited in NAS
Chicken (D)	LOAEL	98-day	Survival - 7.5% mortality	250 mg/L-drinking water	28.5	Parkhurst and Thaxton 1973 as cited in NAS
Mallard (B,F)	LOAEL	30-day	Survival (EMLD-about 10% mortality)		0.675	Hudson et. al, 1984
Duck (A)	LOAEL	35-day	Reduced growth and survival (85% mortality)	33 mg/kg-diet	1.71	Gardiner 1972 as cited in NAS 1980
Japanese Quail (D)	LOAEL	3-week	Reduced gonal weights	8 mg/kg-diet	3.26	Hill and Soares 1984
Japanese Quail (D)	LOAEL	42-day	Reduced growth, survival, and mating success	125 mg/kg-diet	50.9	Thaxton and Parkhurst 1973 as cited in NAS 1980
Japanese Quail (D)	LOAEL	1-year	Reduced egg fertilization	8 mg/kg-diet	3.26	Hill & Schaffer 1976 as cited in NAS 1980
Pheasant (A,G)	LOAEL	30-day	Reduced egg production		0.64	Hudson et. al, 1984
Pheasant (A)	LOAEL	12-week	Decreased hatchability - fetotoxicity	2 to 3 mg/kg-diet	0.105	Fimreite 1971 as cited in Scheuhammer 1987

Mercury Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Turkey (K)	LOAEL	42-day	Weakness, ataxia, incoordination	capsule	0.16	Palmer et al. 1973 as cited in NAS 1980
Mallard (A)	LOAEL	73-day	Survival, growth reproduction	9.2 mg/kg-diet	0.476	Heinz and Hoffman 1998
Mallard (M)	LOAEL	3-generation	Fewer Eggs	0.5 mg/kg-diet	0.064	Heinz 1979
Starling (E)	LOAEL	8-week	Kidney lesions	1.1 mg/kg-diet	0.032	Nicholson and Osborn 1984 as cited in Eslier 1987
Black Duck (A)	LOAEL	28-week	Reproduction	3 mg/kg-diet	0.142	Finley and Stendell 1978 as cited in Eisler 1987
Gray Pheasant (A)	LOAEL	30-day	Reproduction		0.64	McEwen et al. 1973 as cited in Eisler 1987
Great egret (A)	LOAEL	90-day	Feeding/hunting behavior - lethargy	0.50 mg/kg-diet	0.031	Bouton et al. 1999
Common Loon (E)	LOAEL	Breeding season	Reproduction	0.3 mg/kg-diet (fresh weight)[0.4 ppm DW]	0.020	Barr 1986
Macaque (A)	NOAEL	150-day	No adverse effects	in apple juice	0.05	Petruccioli and Turillazzi 1991 as cited in Wolfe et al. 1998
Cattle (A)	NOAEL	96-day	No adverse effects		0.10	Herigstad et al. 1972 as cited in NAS 1980
Swine (C)	NOAEL	90-day	No adverse effects	capsule	0.38	Tryphonas and Nielson 1970 as cited in NAS 1980
Swine (A)	NOAEL	60-day	No adverse effects	capsule	0.38	Tryphonas and Nielson 1973 as cited in NAS 1980
Swine (A)	NOAEL	32-day	No adverse effects	capsule	1.7	Piper et al. 1971 as cited in NAS 1980
Swine (D)	NOAEL	27-day	No adverse effects	0.5 mg/kg-diet	0.031	Chang et al. 1977 as cited in NAS 1980
Mink (A)	NOAEL	145-day	No adverse effects	0.33 mg/kg-diet (WW) (75% of diet)	0.046	Wobese et al 1976
Mink (A)	NOAEL	93-day	No adverse effects	1.1 mg/kg-diet	0.176	Wobeser et al. 1976 as cited in NAS 1980
Rat (A)	NOAEL	6-mo	Growth	1 mg/L-drinking water	0.134	Bull 1976
Rat (A)	NOAEL	12-week	Ataxia, edema necrosis of the cerebellum	gavage	0.84	Magos and Butler 1972 as cited in ATSDR 1993
Rat (A)	NOAEL	52-day	Incidence of eye defects in fetuses	in diet	0.05	Khera and Tabacova 1973 as cited in ATSDR 1993
Rat (A)	NOAEL	2-year	Reproductive effects	in diet	0.1	Verschuuren et al. 1976 as cited in ATSDR 1993
Rat (C)	NOAEL	2-year	Growth and survival	0.5 mg/kg-diet	0.041	Fitzhugh et al. 1950 as cited in NAS 1980

Mercury Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat (D)	NOAEL	2-year	Growth	2.5 mg/kg-diet	0.204	Fitzhugh et al. 1950 as cited in NAS 1980
Rat (D)	NOAEL	6-month (5-days week)	Growth	gavage	0.46	Dieter et al. 1992 as cited in ATSDR 1993
Rat (D)	NOAEL	4-week	Growth	in diet	2.8	Jonker et al. 1993 as cited in ATSDR 1993
Monkey (A)	NOAEL	4-month	Reproduction, motor coordination and blindness	gavage	0.04	Burbacher et al. 1988 as cited in ATSDR 1993
Mouse (A)	NOAEL	104-week	Reproductive effects	in diet	0.13	Hirano et al. 1986 as cited in ATSDR 1993
Mouse (A)	NOAEL	109-week	Reproductive effects	in diet	0.14	Mitsumori et al. 1990 as cited in ATSDR 1993
Mouse (A)	NOAEL	Life-term	No adverse effects	1 mg/L-drinking water	0.245	Schroeder and Mitchener 1975 as cited in NAS 1980
Mouse (D)	NOAEL	Life-term	No adverse effects	5 mg/L-drinking water	1.22	Schroeder and Mitchener 1975 as cited in NAS 1980
Mouse (D)	NOAEL	6-month (5-days week)	Growth	gavage	7.4	NTP 1993 as cited in ATSDR 1993
Cat (D)	NOAEL	90-day	Clinical signs and behavior	100g /day seal liver at 26.2 mg/kg Hg (WW)		Eaton et al. 1980 as cited in Thompson 199
Mink (A)	NOAEL	100-day	Survival, growth, and behavior	5.7 mg/kg-diet (WW)	1.3	Wobeser et al. 1976
Mink (A)	NOAEL	93-day	Survival, growth, and behavior	1.8 mg/kg-diet (WW)	0.411	Wobeser et al. 1976
Mink (D)	NOAEL	6-month + 4weeks for kits	Reproduction and kit growth	10 mg/kg-diet	1.60	Aulerich et al. 1974
Red-tailed hawk - juveniles (A)	NOAEL	4-week	Growth and survival	7.2 mg/kg-diet (wet weight)[10.6 ppm DW]	1.05	Fimeite and Karstand 1971
Common Loon (E)	NOAEL	Breeding season	Reproduction	0.134 mg/kg-diet	0.007	Barr 1986
Great blue heron (A)	NOAEL	Chronic - free-living	Reproduction and population growth		0.073 to 0.21	Wolfe and Norman 1998
Comorant (A)	NOAEL	Chronic - free-living	Reproduction and population growth		0.073 to 0.21	Wolfe and Norman 1998
Zebra Finch (A)	NOAEL	76-day	Lethargy and Survival	2.5 mg/kg-diet	0.88	Scheuhammer, 1988
Kestrel (A)	NOAEL	Not specified	Eggshell thinning		10.0	Peakall and Lincer 1972 as cited in Thompson 1996

Mercury Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Ring dove (A)	NOAEL	Not specified	Eggshell thinning		10.0	Peakall and Lincer 1972 as cited in Thompson 1996
Chicken (D)	NOAEL	42-day	No adverse effects	25 mg/L-drinking water	2.85	Thaxton et al. 1975 as cited in NAS
Chicken (A)	NOAEL	49-day	Survival	2.2 mg/kg-diet	0.152	Soares et al. 1973 as cited in NAS 1980
Chicken (A)	NOAEL	35-day	No adverse effects	3.3 mg/kg-diet	0.228	Gardiner 1972 as cited in NAS 1980
Chicken (D)	NOAEL	42-day	No adverse effects	250 mg/L-drinking water	28.5	Thaxton et al. 1973 as cited in NAS 1980
Chicken (D)	NOAEL	Breeding	No effects on reproduction or clinical signs	200 mg/kg-diet	13.8	Scott et al. 1975 as cited in Thonpson 1996
Duck (A)	NOAEL	35-day	No adverse effects	3.3 mg/kg-diet	0.171	Gardner 1972 as cited in NAS 1980
Mallard (A)	NOAEL	From 18-mo old through breeding season	Egg production and thickness	5 mg/kg-diet	0.259	Heinz, 1980
Bobwhite Quail (A)	NOAEL	6-week starting with 12-day olds	Survival	5.4 mg/kg-diet	0.420	Spann et al. 1986
Japanese Quail (D)	LOAEL	42-day	Growth and survival	25 mg/kg-diet	10.2	Thaxton and Parkhurst 1973 as cited in NAS 1980
Japanese Quail (D)	NOAEL	1-year	No adverse effects (reproduction / growth)	4 mg/kg-diet	1.63	Hill & Schaffer 1976 as cited in NAS 1980
Pheasant (C,H)	NOAEL	30-day	Survival		10.8	Hudson et. al, 1984
Quail (D)	NOAEL	Hatch to 9-week	Survival	32 mg/kg-diet	2.49	Hill 1981 as cited in Eisler 1987
Quail (A)	NOAEL	Hatch to 9-week	Survival	4 mg/kg-diet	0.311	Hill 1981 as cited in Eisler 1987
Pheasant (B)	NOAEL	70-day	Survival	4.2 mg/kg-diet	0.220	Spann et al. 1972 as cited in Eisler 1987
Chicken (A)	NOAEL	28-week	Clinical Signs	0.45 mg/kg-diet	0.0311	March et al. 1983 as cited in Eisler 1987

A = Methylmercury

B = Ethylmercury

C = Phenylmercury

D = Inorganic

E = Unspecified Organo-mercury

F = Ceresan L - value reported as mercury (Ceresan L = 2.25% Hg)

G = Ceresan M - value reported as mercury (Ceresan M = 3.2% Hg)

H = PMA - value reported as mercury (PMA = 60% Hg)

J = Panogen (aka methylmercuric cyanoguanidine) - value reported as mercury (Panogen formulation used = 4.2% Hg)

K = Alkylmercury

Mercury Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference

M = Cyano-methylmercury

N = Panogen (aka methylmercuric cyanoguanidine) - value reported as mercury (Panogen formulation used = 1.51% Hg)

Nickel Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	LD_{LO}	Single Dose	Mortality		5000	RTECS, Food Drug Res, Inc., Papers 7684D, 83
Rat (C)	LD_{LO}	Single Dose	Mortality		39.0	Mastromatteo 1986 as cited in ATSDR 1995
Rat (D)	LD_{LO}	Single Dose	Mortality		116	Haro et al. 1968 as cited in ATSDR 1995
Mouse (D)	LD_{LO}	Single Dose	Mortality		136	Haro et al. 1968 as cited in ATSDR 1995
Guinea Pig	LD_{LO}	Single Dose	Mortality		5000	RTECS, Pharmac. Monthy, 22:445, 1980
Cattle (A,B)	LOAEL	8-week	Decreased growth rate	1000 mg/kg-diet	20.9	O'Dell et al. 1971 as cited in NAS 1980
Cattle (A)	LOAEL	8-week	Decreased growth rate	1000 mg/kg-diet	20.9	O'Dell et al. 1971 as cited in NAS 1980
Rat (D)	LOAEL	6-week	88% decrease in body weight gain		25.0	Whanger 1973 as cited in ATSDR 1995
Rat	LOAEL	90-day	Organ Weight		35.0	IRIS, ABC Laboratories, 1986
Rat (B)	LOAEL	91-day	26% decrease in body weight		8.60	American Biogenics Corp. 1988 as cited in ATSDR 1995
Rat (B)	LOAEL	24-week	Decreased body weight		20.0	RTI 1988 as cited in ATSDR 1995
Rat	LOAEL	2-year	Growth, Organ Weight		50.0	IRIS, Ambrose, et al., F. Sci Technol. 13:181, 1976
Rat	LOAEL	3-generations	Lower Offspring Body Weight	1000 mg/kg-diet	40.0	Ambrose et al. 1976 as cited in Sample et al. 1996
Mouse (B)	LOAEL	Gestation (day 2 - 17)	Spontaneous abortions		160	Berman and Rehnberg 1983 as cited in ATSDR 1995
Mouse (C)	LOAEL	180-day	26% decrease in body weight gain		108	Dieter et al. 1988 as cited in ATSDR 1995
Dog	LOAEL	2-year	Growth		63.0	IRIS, Ambrose, et al., F. Sci Technol. 13:181, 1976
Chicken (C,D)	LOAEL	4-week	Decreased growth and N retention	500 mg/kg-diet	50.2	Weber and Reid 1968 as cited in NAS 1980
Mallard Duck (C)	LOAEL	from 1-day to 90 days of age	Survival, tremors, and effects on bone density	1200 mg/kg-diet	62.1	Eastin and O'Shea 1981 as cited in Eisler 1998
Cattle (A,B)	NOAEL	8-week	Growth rate	250 mg/kg-diet	5.22	O'Dell et al. 1971 as cited in NAS 1980
Cattle (A)	NOAEL	6-week	No Adverse Effects	(diet)	1835	O'Dell et al. 1970 as cited in NAS 1980
Cattle (B)	NOAEL	2-month	No Adverse Effects	(diet)	145	Archibald 1949 as cited in NAS 1980
Rat	NOAEL	2-year	Growth, Organ Weight		5.0	IRIS, Ambrose, et al., F. Sci Technol. 13:181, 1976
Rat (D)	NOAEL	6-week	No Adverse Effects		5.0	Whanger 1973 as cited in ATSDR 1995
Rat	NOAEL	90-day	Growth, Organ Weight		5.0	IRIS, ABC Laboratories, 1986

Nickel Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat (B)	NOAEL	91-day	No Adverse Effects		1.2	American Biogenics Corp. 1988 as cited in ATSDR 1995
Rat (B)	NOAEL	24-week	No Adverse Effects		4.0	RTI 1988 as cited in ATSDR 1995
Rat	NOAEL	3-generations	Lower Offspring Body Weight	500 mg/kg-diet	80.0	Ambrose et al. 1976 as cited in Sample et al. 1996
Mouse (B)	NOAEL	Gestation (day 8 - 12)	No adverse effects		90.6	Seidenberg et al. 1986 as cited in ATSDR 1995
Mouse (B)	NOAEL	Gestation (day 2 - 17)	No Adverse Effects		80.0	Berman and Rehnberg 1983 as cited in ATSDR 1995
Mouse (C)	NOAEL	180-day	No Adverse Effects		44	Dieter et al. 1988 as cited in ATSDR 1995
Dog	NOAEL	2-year	Growth		25.0	IRIS, Ambrose, et al., F. Sci Technol. 13:181, 1976
Dog	NOAEL	100 to 200-day	No Adverse Effects		6 to 12	HSDB, Browning, Toxic. Indust. Metals, 2Ed., 1969
Cat	NOAEL	200-day	No Adverse Effects		25	NAS 1975 as cited in Eisler 1998
Chicken (C,D)	NOAEL	4-week	Growth	300 mg/kg-diet	30.1	Weber and Reid 1968 as cited in NAS 1980
Coturnix Quail	NOAEL	4-generations	No Adverse Effects	0.074 mg/kg-diet	0.0058	NAS 1975 as cited in Eisler 1998

A = Nickel carbonate
B = Nickel chloride
C = Nickel sulfate
D = Nickel acetate

Selenium Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat (A)	LD_{50}	Single Dose	Mortality		6700	RTECS, Toxicol. Appl. Pharmacol. 20:89, 1971
Rat (B)	LD_{50}	Single Dose	Mortality		7	ASTDR, 1989
Mouse (B)	LD_{50}	Single Dose	Mortality		3.2 to 3.5	ASTDR, 1989
Guinea Pig (B)	LD_{50}	Single Dose	Mortality		2.3	ASTDR, 1989
Rabbit (B)	LD_{50}	Single Dose	Mortality		1	ASTDR, 1989
Dog (D)	LD_{50}	Single Dose	Mortality		4	OHM/TADS
Cow (D)	LD_{50}	Single Dose	Mortality		2	OHM/TADS
Horse (D)	LD_{LO}	Single Dose	Mortality		2	OHM/TADS
Cow (D)	LD_{LO}	Single Dose	Mortality		4.5 to 5	OHM/TADS
Pig (D)	LD_{LO}	Single Dose	Mortality		6 to 8	OHM/TADS
Sheep (D)	LD_{LO}	Single Dose	Mortality		3.2 to 12.8	Eisler, 1985
Horses/Mules (D)	LD_{LO}	Single Dose	Mortality		3.3	Eisler, 1985
Cattle (D)	LD_{LO}	Single Dose	Mortality		11	Eisler, 1985
Pig (D)	LD_{LO}	Single Dose	Mortality		15	Eisler, 1985
Rat (B)	LD_{LO}	1-year	Mortality		1.05	ASTDR, 1989
Mallard (B)	LD_{LO}	3-month	Mortality	100 mg/kg-diet	5.57	Eisler, 1985
Chicken (D)	LOAEL	Not Reported	Reduced Hatching	7 to 9 mg/kg-diet	0.34	Eisler, 1985
Quail (D)	LOAEL	Not Reported	Reduced Hatching	6 to 12 mg/kg-diet	0.62	Eisler, 1985
Mallard (C)	LOAEL	Not Reported	Growth, Reproduction	25 mg/kg-diet	1.39	Eisler, 1985
Mallard (C)	LOAEL	100-day	Duckling Survival	8 mg/kg-diet	0.8	Heinz et al. 1989 as cited in Sample et al. 1996
Screech Owl (C)	LOAEL	30-day	Reproduction	12 mg/kg-diet	1.5	Wiemeyer & Hoffman 1996 as cited in Sample et al. 1996
Black-crowned Night Heron (C)	LOAEL	94-day	Reproduction	10 mg/kg-diet	1.8	Smith et al. 1988 as cited in Sample et al. 1996
Rat (B)	LOAEL	2-generations	Reproduction	1.5 mg/L - water	0.33	Rosenfeld & Beath 1954 as cited in Sample et al. 1996
Pig (B)	LOAEL	4-week	Paralysis		0.55	ASTDR, 1989
Pig (B)	LOAEL	6-week	Fetotoxicity		0.41	ASTDR, 1989
Rat (B)	LOAEL	1-year	Reproduction		0.35	ASTDR, 1989
Mouse (B)	LOAEL	3-generation	Fetotoxicity		0.42	ASTDR, 1989

Selenium Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Mallard (C)	NOAEL	100-day	Duckling Survival	4 mg/kg-diet	0.4	Heinz et al. 1989 as cited in Sample et al. 1996
Screech Owl (C)	NOAEL	30-day	Reproduction	3.53 mg/kg-diet	0.44	Wiemeyer & Hoffman 1996 as cited in Sample et al. 1996
Rat (B)	NOAEL	2-generations	Reproduction	2.5 mg/L - water	0.2	Rosenfeld & Beath 1954 as cited in Sample et al. 1996
Mallard (C)	NOAEL	Not Reported	Growth, Reproduction	5 mg/kg-diet	0.28	Eisler, 1985
Mouse (B)	NOAEL	48-day	Reproduction		0.17	ASTDR, 1989

A = Elemental
B = Se +4 or +6
C = Organo-selenium
D = Not Specified

Chicken Body Weight (mature) = 1.7 kg, Reference in USEPA, 1987 EPA/600/6-87/008
Mature Mallard Body Weight (average male & female) = 1.134 kg, Reference is USEPA, 1993, EPA/600/R-93/187a
Mature Bobwhite Body Weight (seasonal average) = 0.191 kg, Reference is USEPA, 1993, EPA/600/R-93/187a
Bird Food Ingestion (based on all birds) = $0.0582 \times BW(kg)^{0.651}$, Reference is USEPA 93, EPA/600/R-93/187a

Silver Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Livestock	LD_{Lo}	Single Dose	Mortality	.05 ppm		OHM/TADS,
Livestock	LD_{Lo}	Single Dose	Mortality		5	RTECS (R),Gekkan Yakuji, Pharm. Monthly, 22:455, 1980
Livestock	LD_{Lo}	Single Dose	Mortality		5	OHM/TADS,
Cat (A)	LOAEL	Single Dose	Blindness	3,000 mg	845	HSDB, Grant, W.M., Tox. of the Eye, 3rd ed., 1986
Turkey, poults (A)	LOAEL	4 week	Survival, Growth	0.9% of diet	1.30E+05	HSDB, Peterson et al., Avian Dis. 17: 802, 1973
Chicken (A)	LOAEL	28-day	Survival, Growth	900 mg/kg-diet	43.5	NAS, 1980
Turkey (C)	LOAEL	28-day	Growth	900 mg/kg-diet		NAS, 1980
Turkey (C)	LOAEL	35-day	Growth	300 mg/kg-diet		NAS, 1980
Rat (A)	LOAEL	10 to 50 week	Pathological	0.2% (water)	2.70E+04	IRIS, Ambrose, et al., F. Sci Technol. 13:181, 1976
Rat (A)	LOAEL	11-month	Neurotoxicity	0.4 mg/L (water)	0.05	USEPA, Ambient Water Quality Criteria Doc. P. C-93, 1980
Rat (A)	LOAEL	11-month	Growth	20 mg/L (water)	2.7	USEPA, Ambient Water Quality Criteria Doc. P. C-93, 1980
Poultry	NOAEL	Chronic	Maximum Tolerable Level	100 mg/kg-diet	17.5	NAS, 1980
Chicken (B)	NOAEL	3-week	Clinical Signs	100 mg/kg-diet	4.8	NAS, 1980
Turkey (C)	NOAEL	28-day	Growth	300 mg/kg-diet		NAS, 1980
Poultry (D)	NOAEL	Chronic	Maximum Tolerable Level	100 mg/kg-diet	4.8	NAS, 1980
Rat (A)	NOAEL	33-month	Growth, Neurotoxicity	0.2 mg/L (water)	0.03	USEPA, Ambient Water Quality Criteria Doc. P. C-93, 1980
Rat (A)	NOAEL	90-day	Growth, Organ Weight		5	IRIS, ABC Laboratories, 1986
Rat (A)	NOAEL	lifetime	Mortality	5 ppm (water)	0.67	HSDB, Schroeder, et al., J. Nutrit. 104: 239, 1974
Rat (A)	NOAEL	2-year	Growth		25	IRIS, Ambrose, et al., F. Sci Technol. 13:181, 1976
Rat (A)	NOAEL	100-200 days	Clinical Signs		6 to 12	HSDB, Browning, E., Tox. of Indust. Metals, 1969
Rat (A)	NOAEL	15 week	Clinical signs, Growth	100ug/mL (water)	0.01	HSDB, Blakely, J. Appl. Tox. 7 (6): 387-90, 1987

A = Silver Nitrate
B = Silver Sulfate
C= Silver Acetate

Silver Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference

D = Not Specified

Mature Rat Body Weight (average male & female) = 0.325 kg, Reference is USEPA, 1987 EPA/600/6-87/008
Mature Rat Water Consumption (average male & female) = 0.0435 L/day, Reference is USEPA, 1987 EPA/600/6-87/008
Poult Body Weight estimated at an age of 7 days = 0.073 kg, (based on chicken) Reference in USEPA, 1987 EPA/600/6-87/008
Poult Water Ingestation (based on all birds) = 0.059 x $BW(kg)^{0.67}$, Reference is USEPA 93, EPA/600/R-93/187a
Chicken Body Weight (also for Poultry) = 1.7 kg, Reference in USEPA, 1987 EPA/600/6-87/008
Bird Food Ingestion (based on all birds) = 0.0582 x $BW(kg)0.^{651}$, Reference is USEPA 93, EPA/600/R-93/187a
Mature Cat Body Weight (average male & female) = 3.55 kg, Reference is USEPA, 1987 EPA/600/6-87/008

Thallium Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	LD_{50}	14 days or less	Mortality		40.6	Venugopal & Luckey 1978
Rat	LD_{50}	14 days or less	Mortality		20.8	Venugopal & Luckey 1978
Rat	LD_{50}	14 days or less	Mortality		25	Venugopal & Luckey 1978
Rat	LD_{50}	14 days or less	Mortality		50	Venugopal & Luckey 1978
Rat (A)	LD_{50}	7-day	Mortality	Single dose	39	Downs et al. 1960 as cited in ATSDR 1992
Rat (B)	LD_{50}	7-day	Mortality	Single dose	32	Downs et al. 1960 as cited in ATSDR 1992
Guinea pig	LD_{50}	14 days or less	Mortality	20	1.2	Gough et al. 1980
Guinea pig	LD_{50}	14 days or less	Mortality		5.2	Venugopal & Luckey 1978
Dog	LD_{50}	14 days or less	Mortality		31.2	Venugopal & Luckey 1978
Dog	LD_{100}	14 days or less	Mortality		45	Venugopal & Luckey 1978
Mouse	LD_{50}	14 days or less	Mortality		24	Venugopal & Luckey 1978
Mouse	LD_{50}	14 days or less	Mortality		32.5	Venugopal & Luckey 1978
Mouse	LD_{50}	14 days or less	Mortality		29	Venugopal & Luckey 1978
Mallard ducks	LD_{50}	14 days or less	Mortality	625	125	Gough et al. 1980
Quail	LD_{50}	14 days or less	Mortality	60	12	Gough et al. 1980
Rat (A)	LOAEL	15-week	Reduced survival		4.5	Downs et al. 1960 as cited in ATSDR 1992
Rat (B)	LOAEL	15-week	Reduced survival		2.3	Downs et al. 1960 as cited in ATSDR 1992
Rat (C)	LOAEL	36-week	Reduced survival and peripheral nerve damage		1.4	Manzo et al. 1983 as cited in ATSDR 1992
Rat (C)	NOAEL	90 days	No observable adverse effects	3.06	0.23	IRIS 1993, Stoltz et al. 1986 also cited in ATSDR 1992

A = Tl_2O_3 = Thallic oxide

B = $TlC_2H_3O_2$ = Thallium acetate

C = Tl_2SO_4 = Thallous sulfate

Zinc Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat (A)	LD_{50}	Single Dose	Mortality		794	RTECS, Vet. Human Toxicol. 30:224, 1988
Mouse (A)	LD_{50}	Single Dose	Mortality		287	RTECS, Vet. Human Toxicol. 30:224, 1988
Rat (B)	LD_{50}	Single Dose	Mortality		350	RTECS, Food Res. 7:313, 1942
Mouse (B)	LD_{50}	Single Dose	Mortality		350	RTECS, Food Res. 7:313, 1942
Guinea Pig (B)	LD_{50}	Single Dose	Mortality		200	RTECS, Food Res. 7:313, 1942
Rat (C)	LD_{50}	Single Dose	Mortality		133	RTECS, Vet. Human Toxicol. 30:224, 1988
Mouse (C)	LD_{50}	Single Dose	Mortality		926	RTECS, Vet. Human Toxicol. 30:224, 1988
Rat (D)	LD_{50}	Single Dose	Mortality		2949	RTECS, Toxicol. European Res. 1:371, 1978
Rat (A)	LOAEL	3-month	Mortality	in drinking water	191	Llobet et al. 1988 as cited in ATSDR 1994
Rat (E)	LOAEL	16-day (gestation)	Fetotoxicity	4000 mg/kg-diet	320	Schlicher & Cox 1968 as cited in Sample et al. 1996
Rat (D)	LOAEL	13-week	Growth	226226 mg/kg-total dose	2486	RTECS, Nut. Rep. Internat. 13:33, 1976
Rat (D)	LOAEL	18-day (Gestation)	Fertility	in the diet	200	Pal & Pal 1987 as cited in ATSDR 1994
Rat (F)	LOAEL	150-day	Fetotoxicity	in the diet	250	Sutton & Nelson 1937 as cited in ATSDR 1994
Mouse (D)	LOAEL	13-week	Mortality	in the diet	1110	Maita et al. 1981 as cited in ATSDR 1994
Mouse (D)	LOAEL	1-year	Servere Anemia	5000 mg/L (water)	1223	HSDB, Encycopedia Occup. Health Saf., Vol1&2, 1983
Pig (weaning) (D)	LOAEL	>1-month	Growth	1000 mg/L (water)		HSDB, Freighburg, et al., Hand. Toxicol. Metals 2nd Ed., 1986
Cow (E)	LOAEL	5-week	Growth	in the diet	91	Jenkins & Hidiroglou 1991 as cited in ATSDR 1994
Ferret (E)	LOAEL	90-day	Intestinal Hemorrhages	in the diet	390	Straube et al. as cited in ATSDR 1994
Chicken (D)	LOAEL	44-week	Egg Production, Growth	2028 mg/kg-diet	131	Stahl et al. 1990 as cited in Sample et al. 1996
Chicken (E)	LOAEL	10-week	Growth	3000 mg/kg-diet	145	Gassaway & Buss, 1972
Rat (A)	NOAEL	3-month	Body Weight	in drinking water	191	Llobet et al. 1988 as cited in ATSDR 1994
Rat (E)	NOAEL	16-day (gestation)	Fetotoxicity	2000 mg/kg-diet	160	Schlicher & Cox 1968 as cited in Sample et al. 1996
Rat (F)	NOAEL	150-day	Fetotoxicity	in the diet	50	Sutton & Nelson 1937 as cited in ATSDR 1994
Cow (E)	NOAEL	5-week	Growth	in the diet	64	Jenkins & Hidiroglou 1991 as cited in ATSDR 1994
Ferret (E)	NOAEL	90-day	No Observable Effects	in the diet	65	Straube et al. as cited in ATSDR 1994

Zinc Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Mink (D)	NOAEL	25-week	Reproduction	in the diet	20.8	Bleavins et al. 1983 as cited in ATSDR 1994
Mink (D)	NOAEL	144-day	No Observable Effects	in the diet	323.6	Aulerich et al. 1991 as cited in ATSDR 1994
Rabbit (F)	NOAEL	22-week	Body Weight	in the diet	174	Bently & Grubb 1991 as cited in ATSDR 1994
Chicken (D)	NOAEL	44-week	Egg Production, Growth	228 mg/kg-diet	14.49	Stahl et al. 1990 as cited in Sample et al. 1996
Chicken (E)	NOAEL	10-week	No Observable Effects	1784 mg/kg-diet	88	NAS, 1980
Chicken (E)	NOAEL	10-week	No Observable Effects	1000 mg/kg-diet	50	Gassaway & Buss, 1972

A = Zinc Acetate
B = Zinc Chloride
C = Zinc Nitrate
D = Zinc Sulfate
E = Zinc Oxide
F = Zinc Carbonate

Chicken Body Weight (mature) = 1.7 kg, Reference in USEPA, 1987 EPA/600/6-87/008
Bird Food Ingestion (based on all birds) = 0.0582 x BW(kg)$^{0.651}$, Reference is USEPA 93, EPA/600/R-93/187a
Chicken Water Ingestation (based on all birds) = 0.059 x BW(kg)$^{0.67}$, Reference is USEPA 93, EPA/600/R-93/187a
Mature Mouse Body Weight (average male & female) = 0.0325 kg, Reference in USEPA, 1987 EPA/600/6-87/008
Mature Mouse Water Ingestion (average male & female) = 0.00795 L/day Reference in USEPA, 1987 EPA/600/6-87/008
Young Pig Body Weight (assume white-cross) = 10 kg, Reference is USEPA, 1987 EPA/600/6-87/008
Pig Food Ingestion (based on all animals) = 0.065 x BW(kg)$^{0.7919}$, Reference is USEPA, 1987, EPA/600/6-87/008

1,3,5-Trinitrobenzene (TNB) Oral Toxicity						
Test Species	**Endpoint**	**Duration**	**Effect**	**Concentration**	**Dose (mg/kg-BW/day)**	**Reference**
Rat	LD_{50}		Mortality	505 mg/kg		Fogleman et al. 1955 cited in NTIS 1987
Rat (female)	LD_{50}		Mortality	280 mg/kg		Korolev et al. 1977 cited in NTIS 1987
Dguinea pig	LD_{50}		Mortality	730 mg/kg		Timofievskaya and Rodionova 1973 cited in NTIS 1987
Rat (Fischer-344)	LOAEL	13 week	Testicular effects		22.73	Reddy et al.1994 cited in Talmage et al. 1999
Rat (Fischer-344)	LOAEL	2 years	Testicular effects		13.4	TV Reddy et Al. 1996 cited in Talmage et al. 1999
White-footed mouse	LOAEL	13 week	Testicular effects		113.51	Pathology Associates, Inc. 1994 cited in Talmage et al. 1999
Dog	LOAEL	52 days	Hepatic, Hematological, and Renal effect		17	Fogleman et al. 1955 cited in NTIS 1987
Rat (Fischer-344)	NOAEL	13 week	Testicular effects		3.9	Reddy et al.1994 cited in Talmage et al. 1999
Rat (Fischer-344)	NOAEL	2 years	Testicular effects		2.6	TV Reddy et Al. 1996 cited in Talmage et al. 1999
White-footed mouse	NOAEL	13 week	Testicular effects		67.4	Pathology Associates, Inc. 1994 cited in Talmage et al. 1999
Rat (S/D)	NOAEL	3 months	Reproduction	300 mg/kg-diet		Kinkead et al. 1995 cited in Talmage et al. 1999
Rat (S/D)	NOAEL		Developmental effect in of	oral gavage	90.0	Cooper & Caldwell 1995 cited in Talmage et al. 1999

2,4,6-trinitrotoluene (TNT) Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat (Fischer-344)	LOAEL	24 month	Kidney, bone, spleen		2	Furedi et al. 1984 cited in Talmage et al. 1999
Rat (S/D)	LOAEL	13 week	Anemia		7	Dilley et al. 1982 cited in Talmage et al. 1999
Rat (Fischer-344)	LOAEL	13 week	Anemia in males		25.0	Levine et al. 1984 cited in Talmage et al. 1999
Rat (Fischer-344)	LOAEL	13 week	Testicular atrophy		25	Levine et al. 1984 cited in Talmage et al. 1999
Rat (S/D)	LOAEL	13 week	Testicular atrophy		160	Dilley et al. 1982 cited in Talmage et al. 1999
Mouse Swiss-Webster (male)	LOAEL	13 week	Anemia		35.7	Dilley et al. 1982 cited in Talmage et al. 1999
Mouse Swiss-Webster (female)	LOAEL	13 week	Anemia		37.8	Dilley et al. 1982 cited in Talmage et al. 1999
Mouse ($B6C3F_1$)	LOAEL	24 month	Liver, anemia		70	Furedi et al. 1984 cited in Talmage et al. 1999
Dog	LOAEL	25 weeks	Liver		0.5	Levine et al. 1984 cited in Talmage et al. 1999
Dog	LOAEL	13 weeks	Liver, anemia		2.0	Dilley et al. 1982 cited in Talmage et al. 1999
Rat (Fischer-344)	NOAEL	24 month	Kidney, bone, spleen		0.4	Furedi et al. 1984 cited in Talmage et al. 1999
Rat (S/D)	NOAEL	13 week	Anemia		1.4	Dilley et al. 1982 cited in Talmage et al. 1999
Rat (Fischer-344)	NOAEL	13 week	Anemia in males		5.0	Levine et al. 1984 cited in Talmage et al. 1999
Rat (Fischer-344)	NOAEL	13 week	Testicular atrophy		5.0	Levine et al. 1984 cited in Talmage et al. 1999
Rat (S/D)	NOAEL	13 week	Testicular atrophy		34.7	Dilley et al. 1982 cited in Talmage et al. 1999
Mouse Swiss-Webster (male)	NOAEL	13 week	Anemia		7.5	Dilley et al. 1982 cited in Talmage et al. 1999
Mouse Swiss-Webster (female)	NOAEL	13 week	Anemia		8.0	Dilley et al. 1982 cited in Talmage et al. 1999
Mouse ($B6C3F_1$)	NOAEL	24 month	Liver, anemia		10.0	Furedi et al. 1984 cited in Talmage et al. 1999
Dog	NOAEL	25 weeks	Liver		0.5	Levine et al. 1984 cited in Talmage et al. 1999
Dog	NOAEL	13 weeks	Liver, anemia		0.2	Dilley et al. 1982 cited in Talmage et al. 1999
Rat (Fischer-344)	NOAEL	13 weeks			1.4-1.45	Dilley et al. 1978 cited in NTIS 1991
Mouse Swiss-Webster	NOAEL	13 weeks	Enlarge spleen and hearts		1.45-1.6	Dilley et al. 1978 cited in NTIS 1991

1,3-Dinitrobenzene (DNB) Oral Toxicity						
Test Species	**Endpoint**	**Duration**	**Effect**	**Concentration**	**Dose (mg/kg-BW/day)**	**Reference**
Starling	LD_{50}		Death	>100 mg/kg diet		Schafer 1972
Red-winged blackbird	LD_{50}		Death	42 mg/kg diet		Schafer 1972
Rat (S/D)	LOAEL	12 week	Testes, sperm production	Gavage	2.1	Linder et al.1986 cited in Talmage et al. 1999
Rat (Fischer-344)	LOAEL	90 day	Testicular degeneration	30 mg/kg Diet	1.73	Reddy et al. 1995 cited in Talmage et al. 1999
Rat	LOAEL	16 week	Testes, sperm production	20 mg/l Drinking v	2.64	Cody et al.1981 cited in Talmage et al. 1999
Rat (S/D)	NOAEL	12 week	Testes, sperm production	Gavage	1.1	Linder et al.1986 cited in Talmage et al. 1999
Rat (Fischer-344)	NOAEL	90 day	Testicular degeneration	30 mg/kg Diet	0.35	Reddy et al. 1995 cited in Talmage et al. 1999
Rat	NOAEL	16 week	Testes, sperm production	20 mg/l Drinking v	1.13	Cody et al.1981 cited in Talmage et al. 1999

Cyclonite (RDX) Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat (Fischer-344)	LOAEL	2 years	Mortality, neuro,, reproduc	in diet	40	Levine et al.1983 cited in Talmage et al. 1999
Rat (Fischer-344)	LOAEL	13 week/gene	Mortality	Two generation	50.00	Cholakis et al.1980 cited in Talmage et al. 1999
Rat	LOAEL	13 week/gene	Reduced pup weight	Two generation in	16	Cholakis et al.1980 cited in Talmage et al. 1999
Rat	LOAEL	14 days	Toxic to dams and embryo:	Gavage on d 6 to 19 of gestation	20.0	Cholakis et al.1980 cited in Talmage et al. 1999
Mouse	LOAEL	2 years	Testicular degeneration	in diet	35.00	Lish et al. 1984 cited in Talmage et al. 1999
Rabbit	LOAEL	23 days	Toxic to dams and embryo:	Gavage on d 7 to	20.00	Cholakis et al.1980 cited in Talmage et al. 1999
Rat (S/D)	NOAEL	2 years	Survival		10.0	Hart 1976 cited in Talmage et al. 1999
Rat (Fischer-344)	NOAEL	2 years	Mortality	in diet	8	Levine et al.1983 cited in Talmage et al. 1999
Rat (Fischer-344)	NOAEL	13 week/gene	Mortality, neuro,, reproduc	Two generation in diet	16.00	Cholakis et al.1980 cited in Talmage et al. 1999
Rat	NOAEL	13 week/gene	Reduced pup weight	Two generation in	5	Cholakis et al.1980 cited in Talmage et al. 1999
Rat	NOAEL	14 days	Toxic to dams and embryo:	Gavage on d 6 to 19 of gestation	2.0	Cholakis et al.1980 cited in Talmage et al. 1999
Mouse	NOAEL	2 years	Testicular degeneration	in diet	7.00	Lish et al. 1984 cited in Talmage et al. 1999
Rabbit	NOAEL	23 days	Toxic to dams and embryo:	Gavage on d 7 to 29 of gestation	2.00	Cholakis et al.1980 cited in Talmage et al. 1999
Rat	NOAEL	13 week	Nervous system		15	McLellan et al. 1988 cited in NTIS 1991
mouse	NOAEL	13 week	Nervous system		80	McLellan et al. 1988 cited in NTIS 1991
Monkey	NOAEL	13 week	Nervous system		1	McLellan et al. 1988 cited in NTIS 1991
Rat	NOAEL	2 years	Nervous system		0.3	Brown et al. 1988 cited in NTIS 1991
mouse	NOAEL	2 years	Nervous system		1.5	Hiatt et al. 1988 cited in NTIS 1991

Cyclotetramethylenetetranitramine (HMX) Oral Toxicity						
Test Species	**Endpoint**	**Duration**	**Effect**	**Concentration**	**Dose (mg/kg-BW/day)**	**Reference**
Rat male (Fischer-344)	LOAEL	13 week	Hepatic effects	in diet	150	Everett et al. 1985 cited in Talmage et al. 1999
Rat female (Fischer-344)	LOAEL	13 week	Renal effects	in diet	270.00	Everett et al. 1985 cited in Talmage et al. 1999
Mouse male	LOAEL	13 week	Mortality	in diet	75	Everett and Maddock 1985 cited in Talmage et al. 1999
Mouse female	LOAEL	13 week	Mortality	in diet	250.0	Everett and Maddock 1985 cited in Talmage et al. 1999
Rat male (Fischer-344)	NOAEL	13 week	Hepatic effects	in diet	50.00	Everett et al. 1985 cited in Talmage et al. 1999
Rat female (Fischer-344)	NOAEL	13 week	Renal effects	in diet	115.00	Everett et al. 1985 cited in Talmage et al. 1999
Mouse male	NOAEL	13 week	Mortality	in diet	30.0	Everett and Maddock 1985 cited in Talmage et al. 1999
Mouse female	NOAEL	13 week	Mortality	in diet	30	Everett and Maddock 1985 cited in Talmage et al. 1999
Rat	NOAEL	13 week	Nervous system		50-115	McLellan et al. 1988 cited in NTIS 1991
Mouse	NOAEL		Mortality	in diet	10.0	Wilson 1985 cited in NTIS 1987

Nitroglycerin (NG) Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	NOAEL	13 week	Physiological effect		25.5	Normandy et al. 1987 cited in NTIS 1991
Rat	NOAEL	24 month	Physiological effect		3-4	Ellis et al. 1984 cited in NTIS 1991
Mouse	NOAEL	24 month	Physiological effect		10-11	Ellis et al. 1984 cited in NTIS 1991
Dog	NOAEL	12 month	Physiological effect		1	Ellis et al. 1984 cited in NTIS 1991

Tetryl Oral Toxicity						
Test Species	**Endpoint**	**Duration**	**Effect**	**Concentration**	**Dose (mg/kg-BW/day)**	**Reference**
Rabbit	LOAEL	6-9 months	Histological alteration	gavage	125	Fati and Daniele 1965 cited in Talmage et al. 1999
Rat male (Fischer-344)	LOAEL	3 months	Body weight	3000 mg/kg in diet	180	Reddy et al. 1994 cited in Talmage et al. 1999
Rat female (Fischer-344)	LOAEL	3 months	Body weight	1000 mg/kg in diet	69	Reddy et al. 1994 cited in Talmage et al. 1999
Rat (Fischer-344)	NOAEL	14 days	Body weight	500 mg/kg diet		Reddy et al. 1994 cited in Talmage et al. 1999
Rat male (Fischer-344)	NOAEL	3 months	Body weight	200 mg/kg in diet	13	Reddy et al. 1994 cited in Talmage et al. 1999
Rat female (Fischer-344)	NOAEL	3 months	Body weight	200 mg/kg in diet	14	Reddy et al. 1994 cited in Talmage et al. 1999

Pentaerythritol tetranitrate (PETN) Oral Toxicity						
Test Species	**Endpoint**	**Duration**	**Effect**	**Concentration**	**Dose (mg/kg-BW/day)**	**Reference**
Rat	NOAEL	1 year	Physiological effect		2.0	Stokinger 1982 cited in NTIS 1991
Rat	NOAEL	1 year	Pathological effect	2 mg/kg in diet		Von Oettingen 1944 cited in NTIS 1987

Xylenes

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	LD50	Single Dose	Mortality		4300	RTECS, AMA Arch. Industr. Health 14:387, 1956
Rat	LDLO	Single Dose	Mortality	6 ml/kg		HSDB, Muralidhara&Krishnakumari, Ind. J. Exper. Biol. 18:1148, 1980
Mouse	LDLO	Single Dose	Mortality		6000	RTECS, NTP-TR-327,86
Mouse	LOAEL	9-day (gestation)	Developmental Abnormalities	2.4/mL/kg-day		HSDB, Marks, et al., J. Toxicol. Environ. Health, 9:97, 1982
Rat	LOAEL	103-week	Growth	500 mg/kg-BW, 5X - week	357	HSDB, NTP TR-327, 86 NIH#87-2583
Rat (F344)	LOAEL	14-day	Growth (Body Weight)		1000	ATSDR 1995
Mouse (B6C3F1)	LOAEL	13-week	Growth (Body Weight)		2000	ATSDR 1995
Mouse (CD-1)	LOAEL	10-day (Gestation)	Malformation (cleft palate)		2060	**Marks et al. 1982 as cited in ATSDR 1995**
Rat (SD)	LOAEL	90-day	Nephropathy		150	ATSDR 1995
Rat (F344)	LOAEL	13-week	Growth (Body Weight)		1000	ATSDR 1995
Rat (F344)	NOAEL	14-day	Growth (Body Weight)		500	ATSDR 1995
Mouse (B6C3F1)	NOAEL	13-week	Growth (Body Weight)		1000	ATSDR 1995
Mouse (CD-1)	NOAEL	10-day (Gestation)	Malformation (cleft palate)		1030	ATSDR 1995
Rat (F344)	NOAEL	13-week	Growth (Body Weight)		500	ATSDR 1995
Mouse	NOAEL	10-day (Gestation)	Fetal Body Weights and Malformations		2.1	**Marks et al. 1982 as cited in Sample et al. 1996**
Rat (F344)	NOAEL	103-week	Reproduction		500	ATSDR 1995
Mouse (B6C3F1)	NOAEL	103-week	Reproduction		1000	ATSDR 1995
Quail	NOAEL	5-day	Survival	5000 mg/kg-diet		Hill and Camardeses, 1986

Xylenes

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	LD50	Single Dose	Mortality		4300	RTECS, AMA Arch. Industr. Health 14:387, 1956
Rat	LDLO	Single Dose	Mortality	6 ml/kg		HSDB, Muralidhara&Krishnakumari, Ind. J. Exper. Biol. 18:1148, 1980
Mouse	LDLO	Single Dose	Mortality		6000	RTECS, NTP-TR-327,86
Mouse	LOAEL	9-day (gestation)	Developmental Abnormalities	2.4/mL/kg-day		HSDB, Marks, et al., J. Toxicol. Environ. Health, 9:97, 1982
Rat	LOAEL	103-week	Growth	500 mg/kg-BW, 5X - week	357	HSDB, NTP TR-327, 86 NIH#87-2583
Rat (F344)	LOAEL	14-day	Growth (Body Weight)		1000	ATSDR 1995
Mouse (B6C3F1)	LOAEL	13-week	Growth (Body Weight)		2000	ATSDR 1995
Mouse (CD-1)	LOAEL	10-day (Gestation)	Malformation (cleft palate)		2060	**Marks et al. 1982 as cited in ATSDR 1995**
Rat (SD)	LOAEL	90-day	Nephropathy		150	ATSDR 1995
Rat (F344)	LOAEL	13-week	Growth (Body Weight)		1000	ATSDR 1995
Rat (F344)	NOAEL	14-day	Growth (Body Weight)		500	ATSDR 1995
Mouse (B6C3F1)	NOAEL	13-week	Growth (Body Weight)		1000	ATSDR 1995
Mouse (CD-1)	NOAEL	10-day (Gestation)	Malformation (cleft palate)		1030	ATSDR 1995
Rat (F344)	NOAEL	13-week	Growth (Body Weight)		500	ATSDR 1995
Mouse	NOAEL	10-day (Gestation)	Fetal Body Weights and Malformations		2.1	**Marks et al. 1982 as cited in Sample et al. 1996**
Rat (F344)	NOAEL	103-week	Reproduction		500	ATSDR 1995
Mouse (B6C3F1)	NOAEL	103-week	Reproduction		1000	ATSDR 1995
Quail	NOAEL	5-day	Survival	5000 mg/kg-diet		Hill and Camardeses, 1986

Benzene						
Test Species	**Endpoint**	**Duration**	**Effect**	**Concentration**	**Dose (mg/kg-BW/day)**	**Reference**
Rat	LD_{50}	Not Reported	Mortality		5600	OHM/TADS
Rat	LD_{50}	Not Reported	Mortality		3000	OHM/TADS
Rat	LD_{50}	Not Reported	Mortality		3400	
Rat	LD_{50}	14 days	Mortality		10000	OHM/TADS
Rat	LD_{50}	Not Reported	Mortality		930	RTECS Toxicology & Applied Pharmacology 7:767, 1965
Mouse	LD_{50}	Not Reported	Mortality		4700	RRTECS Hygiene & Sanitation 32:349, 1967
Dog	LD_{LO}	Not Reported	Mortality		2000	RTECS (R), Abdernalden's Handbuch der Biologischen Arbeitsmethoden 4:1313, 1935
Mouse	LOAEL	10 days	Fetotoxicity		900	RTECS (R), Teratology 19:41A, 1979
Mouse	LOAEL	10 days	Fertility		1200	RTECS (R), Teratology 19:41A, 1979
Mouse	LOAEL	5 days	Growth		1300	RTECS (R), Teratogenesis, Carcinogenesis, & Mutagenesis 6:361, 1986

Bis (2-ethylhexyl) phthalate

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	LD_{50}	Single Dose	Mortality		30000	OHM/TADS
Rat	LD_{50}	Single Dose	Mortality		30600	RTECS, Environ. Health Perspec. 3:131, 1973
Rat	LD_{50}	Single Dose	Mortality		26000	OHM/TADS
Mouse	LD_{50}	Single Dose	Mortality		14200	OHM/TADS
Mouse	LD_{50}	Single Dose	Mortality		30000	RTECS, Internat. J. Abnormal Develop. 14:259, 1976
Rabbit	LD_{50}	Single Dose	Mortality		34000	OHM/TADS
Guinea Pig	LD_{50}	Single Dose	Mortality		26000	RTECS, IARC, 29:269, 1982
Rat	LOAEL	21-day	Fetotoxicity	7.14 g/kg-total dose	340	RTECS, Toxicol. Appll. Pharmacol. 26:253, 1973
Rat	LOAEL	10-day (gestation)	Fetotoxicity	10 g/kg-total dose	1000	RTECS, Indian J. Exper. Biol. 27:885, 1989
Rat	LOAEL	12-day (gestation)	Developmentary Abnormalities	9766 mg/kg-total dose	465	RTECS, Inter. J. Abnormal Develop. 35:41, 1987
Rat	LOAEL	90-day	Growth	1.5 g/kg-diet	130.5	HSDB, IARC, V29, 280, 1982
Rat	LOAEL	3-week	Liver & Kidney Weight	0.1%-diet	8694	HSDB, EPA Document 40-8226118
Rat	LOAEL	7-day	Survival	17.5 g/kg-total dose	2500	RTECS,Toxicol. Appl. Pharm. 61:205, 1981
Rat	LOAEL	6-week	Survival	59388 mg/kg-total dose	1414	RTECS, Food Cosmetics Toxicol. 15:389, 1977
Rat	LOAEL	17-week	Decreased Weight Gain	168 g/kg-total dose	1412	RTECS, Food Cosmetics Toxicol. 15:389, 1977
Rat	LOAEL	21-day	Liver Weight	19796 mg/kg-total dose	943	RTECS, Food Cosmetics Toxicol. 15:389, 1977
Rat	LOAEL	21-day	Liver Weight	25.2 g/kg-total dose	1200	RTECS, Toxicol. Appl. Pharm. 77:116, 1985
Rat	LOAEL	14-day	Liver Weight	14 g/kg-total dose	1000	RTECS, Toxicol. Letters 66:317, 1993
Dog	LOAEL	1-year	Cloudy & Enlarged Liver	0.09ml/kg-BW/day	88.7	HSDB, Patty's Indust. Hyg & Toxicol., 1982
Mouse	LOAEL	14-day	Survival	84 g/kg-total dose	6000	RTECS, Toxicol. Letters 66:317, 1993
Mouse	LOAEL	13-week	Survival	33852 mg/kg-total dose	372	RTECS, NTP-TR-217, 82
Mouse	LOAEL	103-week	Kidney & Pituitary Histopathology	6000 mg/kg-diet	1033	HSDB, Kluwe *et al*., 1982
Mouse	LOAEL	Gestation	Birth Defects, Maternal Weight Gain	0.2%-diet	34857	HSDB, Shiota & Nishimura, 1982
Mouse	LOAEL	8-day (gestation)	Decreased Litter Size	78.88 g/kg-total dose	9860	RTECS, Terat. Carcin. Mutagen. 7:29, 1987

Bis (2-ethylhexyl) phthalate						
Test Species	**Endpoint**	**Duration**	**Effect**	**Concentration**	**Dose (mg/kg-BW/day)**	**Reference**
Mouse	LOAEL	7-day (gestation)	Fetotoxicity	1 g/kg-total dose	143	RTECS, Environ. Health Prespect. 45:71, 1982
Mouse	LOAEL	17-day (gestation)	Fertility & Fetotoxicity	2.04 g/kg-total dose	120	RTECS, NTIS PB85-105674
Mouse	LOAEL	105-day	Reproduction	1000 mg/kg-diet	183.3	Lamb et al. 1987 as cited in Sample et al., 1996
Rat	NOAEL	7-day	Histopathology	2%-diet	17405	HSDB, EPA Document #878210916, ihe# OTS026292, 1982
Rat	NOAEL	90-day	Body Weight & Histopathology	7.5 g/kg-diet	579	HSDB, IARC, V29, 280, 1982
Rat	NOAEL	103-week	Survival	12000 mg/kg-diet	1044	HSDB, IARC, V29, 279, 1982
Dog	NOAEL	1-year	Organ Weight & Liver Function	0.06ml/kg-BW/day	59.2	HSDB, Patty's Indust. Hyg & Toxicol., 1982
Mouse	NOAEL	Gestation	Fetal Development	0.1%-diet	17429	HSDB, Shiota & Nishimura, 1982
Mouse	NOAEL	105-day	Reproduction	100 mg/kg-diet	18.3	Lamb et al. 1987 as cited in Sample et al., 1996
Marmoset	NOAEL	14-day	Liver & Testes Effects	5mM/kg-BW/day	1953	HSDB, Rhodes, et al., Environ. Health Prespect. 65:299, 1986
Ringed Dove	NOAEL	4-weeks	Reproduction	10 mg/kg-diet	1.11	Peakall 1974 as cited in Sample et al., 1996

DEHP Density = 0.9864 g/ml, Reference is HSDB
DEHP Molecular Weight = 390.6, Reference is ASTER
Rat Average Body Weight (Chronic Exposure) = 0.3045 kg, Reference is USEPA, 1987, EPA 600/6-87/008
Rat Average Food Consumption (Chronic Exposure) = 0.0.0265 kg/day, Reference is USEPA, 1987, EPA 600/6-87/008
Mouse Average Body Weight (Chronic Exposure) = 0.0363 kg, Reference is USEPA, 1987, EPA 600/6-87/008
Mouse Average Food Consumption (Chronic Exposure) = 0.00625 kg/day, Reference is USEPA, 1987, EPA 600/6-87/008
Female Mouse Average Body Weight (Mature) = 0.035 kg, Reference is USEPA, 1987, EPA 600/6-87/008
Female Mouse Average Food Consumption (Mature) = 0.0061 kg/day, Reference is USEPA, 1987, EPA 600/6-87/008

Butyl benzyl phthalate

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	LD50	Not reported	Mortality		13500	HSDB, GIG Sanit (6): 25-8, 1974
Rat	LD50	Not Reported	Mortality		2330	RTECS (R) IARC Monographs on the Evalution of Carcinogenic Risk of Chemicals to Man 29:193, 1982
Mouse	LD50	Not Reported	Mortality		4170	RTECS (R) IARC Monographs on the Evalution of Carcinogenic Risk of Chemicals to Man 29:193, 1982
Guinea Pig	LD50	Not Reported	Mortality		13750	RTECS (R) Labor Hygiene & Occupational Diseases 24:25, 1980
F344 Rat (Male)	LOAEL	26 weeks	Growth	2.5% in diet	833	IRIS, NTP Final Report Project No 12307-02 1985
F344 Rat (Male)	LOAEL	10 weeks	Growth	2.5% in diet	833	IRIS, NTP Final Report Project No 12307-02 1985
Rat	LOAEL	90 days	Growth	1.5% in diet	500	IRIS, Krauskopf Environ. Health Perspect. 3:61 1973
Rat	LOAEL	10 days	Fetotoxicity & Development		1640	RTECS (R) National Technical Information Service PB90-115346
Rat	LOAEL	7 days	Fertility		700	RTECS (R), J. of Applied Toxicology 12:57, 1992
F344 Rat (Male)	NOAEL	26 weeks	Growth	0.83% in diet	277	IRIS, NTP Final Report Project No 12307-02 1985
Rat	NOAEL	90 days	Growth	1.0% in diet	333	IRIS, Krauskopf Environ. Health Perspect. 3:61 1973

Di-n-butylphthalate						
Test Species	**Endpoint**	**Duration**	**Effect**	**Concentration**	**Dose (mg/kg-BW/day)**	**Reference**
White Rat	LD50	Not reported	Mortality		8000-10000	HSDB, R. Practical Tox. of Plastics, Cleveland, 1968. 346
Rat	LD50	Not Reported	Mortality		8000	RTECS (R) Farm Chemicals Handbook C101, 1991
Rat	LD50	Not Reported	Mortality		1200-12000	OHM/TADS
Mouse	LD50	Not reported	Mortality		9000	USEPA, AWQCD :Phthalate p.C-21 (1980) EPA 440/5-80-067
Mouse	LD50	Not Reported	Mortality		5289	RTECS (R) Labor Hygiene & Occupational Diseases 17:51, 1973
Rabbit	LD50	Not Reported	Mortality		1000	OHM/TADS
Guinea Pig	LD50	Not Reported	Mortality		10000	RTECS (R) Labor Hygiene & Occupational Diseases 24:25, 1980
Sprague-Dawley Rat (Male)	LOAEL	One year	Mortality	1.25% in diet		IRIS, Smith Arch. Hyg. Occup. Med. 7:310 1953
Rat	LOAEL	21 days	Fetotoxicity		120	RTECS (R) Toxicology & Applied Pharmacology 26:253, 1973
Rat	LOAEL	9 days	Fertility		980	RTECS (R), Toxicology Letters 69:197, 1993
Mouse	LOAEL	18 days	Fertility		400	RTECS (R), Res. Rep. Osaka Prefectural Ins. of Public Health, Food Sanitation Section 8:29, 1977
Mouse	LOAEL	18 days	Fetotoxicity		480	RTECS (R), Environmental Health Perspectives 45:65, 1982
Mouse	LOAEL	8 days	Fertility		2500	RTECS (R), Teratogenesis, Carcinogenesis, & Mutagenesis 7:29, 1987
Mouse	LOAEL	Gestation	Resorption, Malform, Neual Tube	1%		HSDB; Environ. Res. 22:245 (1980)
Mouse	LOAEL	7 days	Reduced litters, Red. pups	1%		HSDB; Toxicol. Appl. Pharmacol. 88 (2): 255-69. 1987
Ringed Dove	LOAEL	4-weeks	Reproduction	10 mg/kg-diet	1.11	Peakall 1974 as cited in Sample et al., 1996
Wistar Rat	NOAEL	3 Generations	Growth	500 mg/kg	39.5	HSDB, R. Practical Tox. of Plastics, Cleveland, 1968. 348
Sprague-Dawley Rat (Male)	NOAEL	One year	Survival	0.25% in diet		IRIS, Smith Arch. Hyg. Occup. Med. 7:310 1953

Di-n-butylphthalate						
Test Species	**Endpoint**	**Duration**	**Effect**	**Concentration**	**Dose (mg/kg-BW/day)**	**Reference**
Rat	NOAEL	1.5 Year	Hematology, Organs	1 ml/kg of BW/ 2x a week		HSDB, Am. Conf. of Gov. Ind. Hygienists, 1986. 176
Rat	NOAEL	Single dose	Survival		8000	OHM/TADS
Rat	NOAEL	One Year	Survival	0.25% per day		OHM/TADS

Trichloroethene Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	LD_{50}		Lethality	Gavage	7208	Smyth et al. 1969 as cited in ASTDR 1995
Mouse (Female CD-1)	LD_{50}		Lethality	Gavage in water	2443	Tucker et al. 1982 as cited in ASTDR 1995 / HSDB
Mouse (Male CD-1)	LD_{50}		Lethality	Gavage in water	2402	Tucker et al. 1982 as cited in ASTDR 1995 / HSDB
Dog	LD_{50}		Lethality	Oral	5680	WHO 1985 as cited in HSDB
Rat (F344)	LOAEL	14-day	Survival & Growth	4.41% in diet	7192	Melnick et al. 1987 as cited in the HSDB
Rat (F344)	LOAEL	14-day	Liver Effects	2.21% in diet	3604	Melnick et al. 1987 as cited in the HSDB
Rat (F344)	LOAEL	103-week	Survival & Nephrosis	1000 mg/kg 5x@week - gavage	714	NTP 1990; NIH Publ. #90-1779 as cited in the HSDB
Rat (F344)	LOAEL	102-week	Survival	5x@week - gavage	500	NTP 1990 as cited in ATSDR 1995
Rat (F-344)	LOAEL	13-week	Growth in body weight	5x@week - gavage	2000	NTP 1990 as cited in ATSDR 1995
Rat (Sprauge Dawley)	LOAEL	21-day (Gestation)	Fetal heart abnormalities	in drinking water	0.18	Dawson et al. 1993 as cited in ATSDR 1995
Rat (Sprauge Dawley)	LOAEL	21-day (Gestation)	Brain histopathlogy	in drinking water	37	Isaacson & Taylor 1989 as cited in ATSDR 1995
Rat (Male Sprauge Dawley)	LOAEL	52-week	Renal effects	5x@week - gavage	250	Maltoni et al. 1986 as cited in ATSDR 1995
Rat (Female Osborne-Mendel)	LOAEL	78-week	Survival & toxic nephrosis	5x@week - gavage	549	NCI 1976 as cited in ATSDR 1995
Rat (Female Osborne-Mendel)	LOAEL	103-week	Toxic nephrosis	5x@week - gavage	500	NTP 1988 as cited in ATSDR 1995
Rat (Male Long-Evans)	LOAEL	6-week	Reproductive behavior	5x@week - gavage	1000	Zenick et al. 1984 as cited in ATSDR 1995
Mouse (CD-1)	LOAEL	17-week	Survial & sperm motility	in diet	750	NTP 1985 as cited in ATSDR 1995
Mouse (B6C3F1)	LOAEL	3-week	Liver enlargement	5x@week - gavage	500	Scott et al. 1982 as cited in ATSDR 1995
Mouse (B6C3F1)	LOAEL	4-week	Focal necrosis & liver enlargement	5x@week - gavage	600	Merrick et al. 1989 as cited in ATSDR 1995
Mouse (B6C3F1)	LOAEL	103-week	Survival & toxic nephrosis	5x@week - gavage	1000	NTP 1990 as cited in ATSDR 1995
Mouse (Female B6C3F1)	LOAEL	78-week	Survival & toxic nephrosis	5x@week - gavage	869	NCI 1976 as cited in ATSDR 1995
Mouse (Swiss-Ca)	LOAEL	6-week	Hepatotoxicity	100mg/kg - 5x@week - gavage	70	Buben & O'Flarerty 1985 as cited in Sample et al. 1996[a]

Trichloroethene Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat (Sprague Dawley)	NOAEL	70-day	Reproduction & offspring behavior	1250 mg/L in Drinking Water	151	Taylor et al. 1984 as cited in the HSDB
Rat (Male Sprauge Dawley)	NOAEL	52-week	Renal effects	5x@week - gavage	50	Maltoni et al. 1986 as cited in ATSDR 1995
Rat (F-344)	NOAEL	18-week	Reproduction & development	in diet	300	NTP 1986 as cited in ATSDR 1995
Rat (F-344)	NOAEL	13-week	Growth in body weight	5x@week - gavage	1000	NTP 1990 as cited in ATSDR 1995
Rat (Male Long-Evans)	NOAEL	6-week	Reproductive behavior	5x@week - gavage	100	Zenick et al. 1984 as cited in ATSDR 1995
Rat (Female Long-Evans)	NOAEL	31-day	Reproduction	Gavage	1000	Manson et al. 1984 as cited in ATSDR 1995
Mouse (CD-1)	NOAEL	17-week	Sperm motility	in diet	375	NTP 1985 as cited in ATSDR 1995
Mouse (B6C3F1)	NOAEL	3-week	Liver enlargement	5x@week - gavage	250	Scott et al. 1982 as cited in ATSDR 1995
Mouse (B6C3F1)	NOAEL	6-month	Hepatic, renal, and hematological effects	in drinking water	660	Tucker et al. 1982 as cited in ATSDR 1995

a = Sample et al. 1996 appl;ied a safety factor of 10 to this value to dervive a "chronic" LOAEL and a factor of 100 to dervive a "chronic" NOAEL
the ASTDR (1995) reports this study and that the lowest test dose (70) is a NOAEL for liver effects and a LOAEL of 286.

Sprague-Dawley Rat body weight (average male & female [mature]) = 0.475 kg (USEPA 1988)

Sprague-Dawley Rat water consumption (average male & female [mature]) = 0.0575 L/day (USEPA 1988)

Fisher-344 Rat body weight (average male & female [mature]) = 0.325 kg (USEPA 1988)

Fisher-344 Rat food consumption (average male & female [mature]) = 0.053 kg/day (USEPA 1988)

Chlorobenzene Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	se (mg/kg-BW/d	Reference
Rat	LOAEL	90 days	Liver & kidney weight	in diet	100	Knapp et al. 1971 cited in IRIS
Rat	LOAEL	6 months	Liver histopathology	gavage	144	Irish 1963 cited in IRIS
Rat	LOAEL	90 days	Liver weight	gavage	125	NTP 1985 cited in IRIS
Mouse	LOAEL	90 days	Liver weight	gavage	125	NTP 1985 cited in IRIS
Rat	LOAEL	2 years	Liver weight	gavage	120	NTP 1985 cited in IRIS
Mouse	LOAEL	2 years	Liver weight	gavage	120	NTP 1985 cited in IRIS
Dog	NOAEL	13 weeks	Histopathologic changes in liver	27.25 mg/kg/day x 5 orally in capsule	19	Knapp et al. 1971 cited in IRIS
Rat	NOAEL	90 days	Liver & kidney weight	in diet		Knapp et al. 1971 cited in IRIS
Rat	NOAEL	6 months	Liver histopathology	gavage	14	Irish 1963 cited in IRIS
Rat	NOAEL	90 days	Liver weight	gavage	60	NTP 1985 cited in IRIS
Mouse	NOAEL	90 days	Liver weight	gavage	60	NTP 1985 cited in IRIS
Rat	NOAEL	2 years	Liver weight	gavage	60	NTP 1985 cited in IRIS
Mouse	NOAEL	2 years	Liver weight	gavage	60	NTP 1985 cited in IRIS

Acetone

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	LD_{50}	Single Dose	Mortality		9700	OHM/TADS
Rat (young)	LD_{50}	Single Dose	Mortality		5600	OHM/TADS
Mouse	LD_{50}	Single Dose	Mortality		3000	RTECS, Pharma. Chem. J., 14:162, 1980
Rabbit	LD_{50}	Single Dose	Mortality		5300	OHM/TADS
Rabbit	LD_{50}	Single Dose	Mortality		5340	RTECS, FAO Rpt. Series 48A:86, 1970
Rat	ED_{50}	Single Dose	Tremors		5800	RTECS, J. Toxicol. Environ. Health 15:609, 1985
Dog	ED_{LO}	Single Dose	Coma		8000	RTECS, Ach. Exper. Path. Pharmakol. 18:218, 1984
Rat	LOAEL	14-day	Histopathology-Bone Marrow		6942	ASTDR, 1993
Rat	LOAEL	90-day	Kidney Damage & Organ Weights		500	IRIS, Office of Solid Waste, EPA, 1986
Rat	LOAEL	13-week	Reproductive Effects		3400	ASTDR, 1993
Rat	LOAEL	13-week	Liver&Kidney Weight, Hematology	273 g/kg-total dose	3000	RTECS, NTP-TR NIH-91-3122
Mouse	LOAEL	14-day	Liver Histopathology		3896	ASTDR, 1993
Mouse	LOAEL	13-week	Liver & Spleen Weight	546 g/kg-total dose	6000	RTECS, NTP-TR NIH-91-3122
Rat	NOAEL	90-day	Kidney Damage & Organ Weights		100	IRIS, Office of Solid Waste, EPA, 1986
Rat	NOAEL	13-week	No Clinical Effects		3400	ASTDR, 1993
Mouse	NOAEL	14-day	Body Weight & Renal Effects		12725	ASTDR, 1993
Japanese Quail	NOAEL	Single Dose	Survival	40000 mg/kg-Diet		HSDB, Hill & Camardese, US Fish Wild. TR-2, 1986
Pheasant	NOAEL	Single Dose	Survival	40000 mg/kg-Diet		HSDB, US Fish Wild. SSR Wildlife #191, 1975

Methyl Ethyl Ketone Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	LD_{50}	Not Reported	Mortality		2737	IRIS, Kimura et al. Toxicol. Appl. Pharmacol. 19:699 1971
Rat	LD_{50}	Not Reported	Mortality		3980	OHM/TADS
Rat	LD_{50}	Not Reported	Mortality		3100	OHM/TADS
Rat	LD_{50}	14 days	Mortality		5488	OHM/TADS
Rat	LD_{50}	Not Reported	Mortality		2,737	RTECS (R), Toxicology & Applied Pharmacology 19:699 1971
Young Rat	LD_{50}	Not Reported	Mortality		2700	OHM/TADS
Mice	LD_{50}	Not Reported	Mortality		4044	IRIS, Tanii et al. Toxicol. Lett. 30:13 1986
Mouse	LD_{50}	Not Reported	Mortality		4,050	RTECS (R), Toxicology Letters 30:13, 1986
FDRL-Wistar Rat	LOAEL	8 weeks	Growth	2% in drinking water	3122	IRIS, FDRL Inc. Report No 91MR R 1673 1975
FDRL-Wistar Rat	LOAEL	9 weeks + gestation	Fertility & Pups survival	2% in drinking water	3122	IRIS, FDRL Inc. Report No 91MR R 1673 1975
FDRL-Wistar Rat	LOAEL	21 days + 1 generation	Pups Survival & Growth	2% in drinking water	3122	IRIS, FDRL Inc. Report No 91MR R 1673 1975
FDRL-Wistar Rat	NOAEL	8 weeks	Growth	1% in drinking water	1771	IRIS, FDRL Inc. Report No 91MR R 1673 1975
FDRL-Wistar Rat	NOAEL	9 weeks + gestation	Fertility & Pups survival	1% in drinking water	1771	IRIS, FDRL Inc. Report No 91MR R 1673 1975
FDRL-Wistar Rat	NOAEL	21 days + F1 generation	Pups Survival & Growth	1% in drinking water	1771	IRIS, FDRL Inc. Report No 91MR R 1673 1975

Methylene Chloride Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	LD_{50}	Single Dose	Mortality		1600	RTECS, FAO Rpt. Series 48a:94, 1970
Rabbit	LD_{LO}	Single Dose	Mortality		1900	RTECS, Handbook of Toxicology, Saunders Co., 1:94, 1955
Dog	LD_{LO}	Single Dose	Mortality		3000	RTECS, Quart. J. Pharm. Pharmacol. 7:205, 1934
Mouse	LOAEL	104-week	Liver Damage		250	HSDB, Serota, *et a*l., Food Chem. Toxicol. 24(9):959, 1986
Rat	LOAEL	90-day	Liver Damage		166	ASTDR, 1992
Rat	LOAEL	90-day	Liver Damage		55	ASTDR, 1992
Mouse	LOAEL	90-day	Liver Damage		587	ASTDR, 1992
Rat	LOAEL	90-day	Liver Histopathology		1200	ASTDR, 1992
Rat	LOAEL	24-month	Liver Histopathology		50	IRIS, Hazelton Lab., Viena, VA, 1982 (unpubl)
Rat	LOAEL	104-week	Decreased Body Weight		131	ASTDR, 1992
Mouse	NOAEL	24-month	Multiple Histo & Growth		250	HSDB, EPA 45-8303005, 1983
Rat	NOAEL	18-week	Reproduction & Growth		225	HSDB, EPA 878210710 (OTS0205887)
Mouse	NOAEL	104-week	Liver Histopathology		185	HSDB, Serota, *et a*l., Food Chem. Toxicol. 24(9):959, 1986
Rat	NOAEL	24-month	Liver Histopathology		5	IRIS, Hazelton Lab., Viena, VA, 1982 (unpubl)

Toluene Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	LD_{50}	Single Dose	Mortality		636	RTECS, Neurotoxicology, 2:567, 1981
Rat	LD_{50}	Single Dose	Mortality		7000	ASTDR, 89
Rat	LD_{50}	Single Dose	Mortality		5580	ASTDR, 89
Mouse	LOAEL	10-day (gestation)	Fetotoxicity	9 g/kg-total dose	900	RTECS, Internat. J. Abnorm. Develop., 19:41a, 1979
Mouse	LOAEL	10-day (gestation)	Cranofacial Abnormalities in Pups	30 g/kg-total dose	3000	RTECS, Internat. J. Abnorm. Develop., 19:41a, 1979
Mouse	LOAEL	7-day (gestation)	Fetotoxicity	0.3mL/Kg-BW/day	260	Nawrot & Staples, 1979 as cited in Sample et al., 1996
Mouse	LOAEL	42-day	Behavioral		98.3	ASTDR, 89
Rat	LOAEL	13-week	Brain, Liver, Kidneys Weights	162 g/kg-total dose	1780	RTECS, NTP-TR-371, 90
Mouse	LOAEL	13-week	Brain, Liver, Kidneys Weights	227 g/kg-total dose	2494	RTECS, NTP-TR-371, 90
Rat	LOAEL	13-week	Liver & Kidney Weights		446	IRIS, NTP Tech. Rpt. 371, 1989
Rat	LOAEL	13-week	Survival & Growth	2500 mg/kg 5x/week	1786	IRIS, NTP Tech. Rpt. 371, 1989
Rat	NOAEL	13-week	Liver & Kidney Weights		223	IRIS, NTP Tech. Rpt. 371, 1989
Rat	NOAEL	6-month	Hepatic, Renal, Hematol. Effects		590	ASTDR, 1989
Mouse	NOAEL	42-day	Behavioral		19.7	ASTDR, 89
Mouse	NOAEL	13-week	Survival, Growth, Organs Weights	1250 mg/kg 5x/week	893	IRIS, NTP Tech. Rpt. 371, 1989

Tetrachloroethene Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat (Female Sprague-Dawley)	LD_{50}		Lethality	Gavage	3005	Hayes et al. 1986 as cited in ATSDR 1995
Mouse (Male Swiss Webster)	LD_{50}		Lethality	Gavage	3835	Wenzel & Gibson 1986 as cited in ATSDR 1995
Rat	LOAEL	11-day	Increased liver weight	Gavage	250	Schumann as cited in IRIS
Rat (Sprague-Dawley)	LOAEL	90-day	Weight gain and liver effects	Drinking water	400	Hayes et al. 1986 as cited in IRIS / ASTDR 1995
Mouse	LOAEL	11-day	Increased liver weight	Gavage	1000	Schumann as cited in IRIS
Mouse (Swiss-Cox)	LOAEL	6-week	Hepatotoxicity	Gavage	71	Buben and O'Flarety 1985 as cited in IRIS
Mouse (Female B6C3F1)	LOAEL	78-week	Shorter life-span	Gavage (Corn-oil)	386	IARC, 1979; Volume 20:497 WHO as cited in the HSDB
Mouse (Male B6C3F1)	LOAEL	78-week	Shorter life-span	Gavage (Corn-oil)	536	IARC, 1979; Volume 20:497 WHO as cited in the HSDB
Rat (Sprague-Dawley)	NOAEL	90-day	Weight gain and liver effects	Drinking water	14	Hayes et al. 1986 as cited in IRIS / ASTDR 1995
Mouse (Swiss-Cox)	NOAEL	6-week	Hepatotoxicity	Gavage	14	Buben and O'Flarety 1985 as cited in IRIS

Vinyl Chloride Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat (Wistar)	LOAEL	2-year	Survival	in the diet	5.6	Feron et al. 1981 as cited in ATSDR 1995
Rat (Wistar)	LOAEL	149-week	Survival	in the diet	1.7	Til wt al. 1983 & 1991 as cited in ATSDR 1995
Rat (Wistar)	NOAEL	Lifespan	Survival, Growth, and Clinical signs	on the diet	1.3	HSDB; Civo Institute TNO; Lifespan Oral Carcinogenicity Study of Vinyl Chloride in Rats. (1983), EPA Document No. FYI-AX-1084-0353, Fiche No. 0353

Aldrin Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	LD_{50}	Single Dose	Mortality		39	RTECS, Entomol. Soc. Am., Special Publ., 78-1:12, 1978
Mouse	LD_{50}	Single Dose	Mortality		44	RTECS, Entomol. Soc. Am., Special Publ., 78-1:12, 1978
Rabbit	LD_{50}	Single Dose	Mortality		50	RTECS, Assoc. Am. Pest. Control Off., 1966-:7, 1966
Guinea Pig	LD_{50}	Single Dose	Mortality		33	RTECS, Assoc. Am. Pest. Control Off., 1966-:7, 1966
Hamster	LD_{50}	Single Dose	Mortality		100	RTECS, Internat. J. Abnormal Develop. 9:11, 1974
Dog	LD_{50}	Single Dose	Mortality		65	RTECS, Assoc. Am. Pest. Control Off., 1966-:7, 1966
Calf (1-2 wk old)	LD_{LO}	Single Dose	Mortality		5	HSDB, Clarke, *et a*l., Veterinary Toxicology, 2nd Ed., 1981
Cattle	LD_{LO}	Single Dose	Mortality		25	HSDB, Clarke, *et a*l., Veterinary Toxicology, 2nd Ed., 1981
Sheep	LD_{LO}	Single Dose	Mortality		25	HSDB, Clarke, *et a*l., Veterinary Toxicology, 2nd Ed., 1981
Mule Deer males 12-18mo. old	LD_{50}	Single Dose	Mortality		18.8 to 37.5	Hudson *et al*. 1984.
Mallard females 3-4mo. old	LD_{50}	Single Dose	Mortality		520	Hudson *et al*. 1984.
Pheasant females 3-4mo. old	LD_{50}	Single Dose	Mortality		16.8	Hudson *et al*. 1984.
Bobwhite Quail females 3-4mo. old	LD_{50}	Single Dose	Mortality		6.59	Hudson *et al*. 1984.
Fulvous whistling-duck males 3-6mo. Old	LD_{50}	Single Dose	Mortality		29.2	Hudson *et al*. 1984.
Japanese Quail 14-day old	LD_{50}	5-day	Mortality	62 mg/kg-diet	15.1	Hill and Camardese 1986.

Aldrin Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Cat	LOAEL	Single Dose	Pulmonary endema		15	RTECS, Communicationes Veterinariae, 2:71, 1958
Hamster	LOAEL	Single Dose during gestation	Fetotoxicity		50	Ottolenghi *et al.* 1974 as cited in ASTDR 1993
Mouse	LOAEL	Single Dose during gestation	Developmental abnormalities		25	Ottolenghi *et al.* 1974 as cited in ASTDR 1993
Dog	LOAEL	9-month	Tremors, convulsions, neuronal degeneration		1.78	Treon *et al.* 1951 as cited in ATSDR 1993
Dog	LOAEL	44-week	Live Birth Index	73 mg/kg-total dose	0.24	RTECS, J. Am. Veterin. Med. Assoc. 123:28, 1953
Rat	LOAEL	31-month	Decreased lifespan in females		2.5	Deichmann *et al.* 1970 as cited in ASTDR 1993
Rat	LOAEL	2-year	Survival	50 mg/kg-diet	4.1	HSDB, IARC V5 31, 1974
Rat	LOAEL	2-year	Survival		5	Fitzhugh *et al.* 1964 as cited in ASTDR 1993
Rat	LOAEL	3-generations	Number of litters and offspring mortality		1	Treon and Cleveland 1955 as cited in Sample *et al.* 1996
Mouse	LOAEL	6-week	Survival		2.6	NCI 1978 as cited in ASTDR 1993
Mouse	LOAEL	6-generation	Low preweaning pup survival		1.2	Keplinger *et al.* 1972 as cited in RTI 1995
Mallard 17-26 weeks old	LOAEL	30-day	EMLD - empirical minimum lethal dosage		5	Hudson *et al*. 1984
Pheasant	LOAEL	162-day	Egg production		0.06	DeWitt 1956 as cited in RTI 1995
Dog	NOAEL	15.7-month	Adverse effects beyond minor histopatholical idices		0.25	Treon *et al.* 1955 as cited in ATSDR 1993
Rat	NOAEL	2-year	Survival & Growth	25 mg/kg-diet	2	HSDB, Patty's Indust. Hyg & Toxicol., 1982
Rat	NOAEL	2-year	Survival	10 mg/kg-diet	0.82	HSDB, IARC V5 31, 1974
Rat	NOAEL	25-months	Survival		0.25	Deichmann *et al.* 1967 as cited in RTI 1995
Rat	NOAEL	31-month	No adverse effects		1.5	Deichmann *et al.* 1970 as cited in ATSDR 1993
Rat	NOAEL	3-generation	Number of litters and offspring mortality		0.2	Treon and Cleveland 1955 as cited in Sample *et al.* 1996
Mouse	NOAEL	6-week	Survival		1.3	NCI 1978 as cited in ATSDR 1993
Chicken	NOAEL	2-year	Normal fertility and hatchability	1 mg/kg-diet	0.049	Brown *et al.* 1965 as cited in RTI 1995
Quail	NOAEL	127-day	No effects on egg production, fertility, or hatachability	1 mg/kg-diet	0.078	DeWitt 1956 as cited in RTI 1995

Mature Rat Body Weight (Averag male & female) = 0.325 kg, Reference is USEPA, 1987 EPA/600/6-87/008

Aldrin Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference

Mature Rat Food Consumption (Average male & female) = 0.0265 kg/day, Reference is USEPA, 1987 EPA/600/6-87/008

Adult Quail Body Weight = (average over seasons) = 0.191 kg Reference is USEPA, 1993, EPA/600/R-93/187a

Adult Quail Food Consumption = (average over seasons) = 0.07776 g/g-BW Reference is USEPA, 1993, EPA/600/R-93/187a

14-day old Quail Body Weight = 13 to 20 g (average = 0.0165 kg), Reference is USEPA, 1993 EPA/600/R-93/187a

Average Chicken Body Weight (female) =1.6 kg Reference is USEPA, 1987 EPA/600/6-87/008 (used USEPA 1993 formula for all birds for Food Consumption)

Young quail and chicken Food Ingestion (based on all birds) = 0.0582 x BW(kg)$^{0.651}$, Reference is USEPA 93, EPA/600/R-93/187a

Dieldrin Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	LD_{50}	Single Dose	Mortality		38.3	RTECS, J. Agric. Food Chem. 3:402, 1955
Mouse	LD_{50}	Single Dose	Mortality		38	RTECS, Entomol. Soc. Am. Special Publ. 78-1:13, 1978
Rabbit	LD_{50}	Single Dose	Mortality		45	RTECS, Assoc. Am. Pest. Control Off. 1966-:377, 1966
Guinea Pig	LD_{50}	Single Dose	Mortality		49	RTECS, Assoc. Am. Pest. Control Off. 1966-:377, 1966
Hamster	LD_{50}	Single Dose	Mortality		60	RTECS, Internat. J. Abnormal Develop. 9:11, 1974
Dog	LD_{50}	Single Dose	Mortality		65	RTECS, Guide Chem. Used Crop Protect. 6:198, 1974
Pig	LD_{50}	Single Dose	Mortality		38	RTECS, Europ. J. Toxicol. Environ. Hyg. 7:159, 1974
Monkey	LD_{50}	Single Dose	Mortality		3	RTECS, Jager, Aldrin Dieldrin Endrin and Telodrin, Elesvier Publ. 1970
Sheep	LD_{50}	Single Dose	Mortality		50 to 75	HSDB, Jager, Aldrin Dieldrin Endrin and Telodrin, Elesvier Publ. 1970
Mule deer males 8-18mo. old	LD_{50}	Single Dose	Mortality		75-150	Hudson *et al*. 1984.
Goat males 6-8mo. old	LD_{50}	Single Dose	Mortality		100-200	Hudson *et al*. 1984.
Canada goose	LD_{50}	Single Dose	Mortality		<141	Hudson *et al*. 1984.
Fulvous whistling-duck females	LD_{50}	Single Dose	Mortality		100-200	Hudson *et al*. 1984.
Mallard females 6-7mo. old	LD_{50}	Single Dose	Mortality		381	Hudson *et al*. 1984.
California Quail males 7mo. old	LD_{50}	Single Dose	Mortality		8.78	Hudson *et al*. 1984.
Japanese Quail males 2mo. old	LD_{50}	Single Dose	Mortality		69.7	Hudson *et al*. 1984.
Pheasant males 10-23mo. old	LD_{50}	Single Dose	Mortality		79	Hudson *et al*. 1984.
Chukar 8-11mo. old	LD_{50}	Single Dose	Mortality		25.3	Hudson *et al*. 1984.

Dieldrin Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Gray partridge females 3-10mo. old	LD_{50}	Single Dose	Mortality		8.84	Hudson *et al*. 1984.
Rock dove	LD_{50}	Single Dose	Mortality		26.6	Hudson *et al*. 1984.
House sparrow	LD_{50}	Single Dose	Mortality		47.6	Hudson *et al*. 1984.
Duck	LD_{50}	Single Dose	Mortality		381	RTECS, Toxicol. Appl. Pharmocol. 29:57, 1971
Pigeon	LD_{50}	Single Dose	Mortality		23.7	RTECS, ASTM STP(680):157, 1979
Japanese Quail 14-day old	LD_{50}	5-day	Mortality	60 mg/kg-diet	14.6	Hill and Camardese 1986.
Cat	LD_{LO}	Single Dose	Mortality		500	RTECS, Communicationes Veterinariae 2:78, 1958
Quail	ED_{50}	Single Dose	Altered sleep time & righting reflex		10.78	RTECS, Environ. Toxicol. Chem 1:157, 1982
Chicken	ED_{50}	Single Dose	Behavioral effects		20	RTECS, J. Econom Entomol. 44:1013, 1951
Raccoons	LOAEL	Not Reported	Reduced litter size & fertlity	2 mg/kg-diet	0.101	HSDB, NRC, Drinking Water & Health Vol1, 1977
Dog	LOAEL	44-week	Live birth index	219 mg/kg-total dose	0.71	RTECS, J. Am. Veterin. Med. Assoc. 123:28, 1953
Mouse	LOAEL	9-day (gestation)	Skeletal malformations		6	HSDB, Patty's Indust. Hyg & Toxicol., 1982
Mouse	LOAEL	9-day (gestation)	Fetotoxicity	2.25 mg/kg-total dose	0.25	RTECS, Internat. J. Abnormal Develop. 16:57, 1977
Mouse	LOAEL	74-day	Fertility and pup survival		0.65	Virgo and Bellward 1975 as cited in ATSDR 1993
Mouse	LOAEL	120-day	Litter size		0.65	Good and Ware 1969 as cited in ASTDR 1993
Mouse	LOAEL	2-generation	Histopathology, lung, kidney, brain	3mg/kg-diet	0.535	HSDB, Patty's Indust. Hyg & Toxicol., 1982
Mouse	LOAEL	80-week	Tremers		0.33	NCI 1978 as cited in ATSDR 1993
Mouse	LOAEL	132-week	Survival		1.3	Walker *et al.* 1972 as cited in ASTDR 1993
Hamster	LOAEL	8-day (gestation)	Fetotoxicity	30 mg/kg-total dose	3.75	RTECS, Internat. J. Abnormal Develop. 9:11, 1974
Hamster	LOAEL	Lifetime	Growth	20 mg/kg-diet	1.87	HSDB, Cabral, *et al*., Cancer Lett 6:241, 1979
White-tailed Deer	LOAEL	3-year	Decreased growth in fawns	25 mg/kg-diet	0.77	Murphy&Korschgen, Wildlife Mgmt. 34:887, 1970 as cited in Peakall 1996
Dog	LOAEL	9-month	Histopatholgy, gastric effects and survival		1.95	Treon *et al.* 1951 as cited in ATSDR 1993

Dieldrin Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	LOAEL	88-day	Growth	88 mg/kg-total dose	1	RTECS, J. Toxicol. Environ. Health 25:461, 1988
Rat	LOAEL	105-week	Convulsions		2.5	NCI 1978 as cited in ATSDR 1993
Rat	LOAEL	2-year	Hepatic lesions		0.05	IRIS, Walker, et al., Toxicol. Appl. Pharmacol. 15:345, 1969
Rat	LOAEL	2-year	Convulsions		0.5	Walker *et al.* 1969 as cited in ASTDR 1993
Rat	LOAEL	2-year	Survival		2.5	Fitzhugh *et al.* 1964 as cited in ASTDR 1993
Rat	LOAEL	31-month	Survival		1.5	Deichmann *et al.* 1970 as cited in ASTDR 1993
Rat	LOAEL	3-generation	Fertility		0.2	Treon and Cleveland 1955 as cited in Sample *et al.* 1996
Rat	LOAEL	3-generation	Number of litters and survival of pups		0.125	Treon 1954 *et al.* as cited in ATSDR 1993
Mallard	LOAEL	30-day	EMLD - empirical minimum lethal dosage		5	Hudson *et al*. 1984.
Fulvous whistling duck	LOAEL	30-day	EMLD - empirical minimum lethal dosage		2.5	Hudson *et al*. 1984.
Gray partridge	LOAEL	30-day	EMLD - empirical minimum lethal dosage		1.25-2.5	Hudson *et al*. 1984.
Pigeon	LOAEL	Not Reported	Hyperplastic goiters		1	HSDB, Jefferies&French, Wildlife Mgmt. 36:24, 1972
Mallard	LOAEL	Not Reported	Egg fertility and chick mortality	4 mg/kg-diet	0.22	Winn 1972 as cited in Peakall 1996
Mallard	LOAEL	7-week	Egg production, fertility, and hatchability	20 mg/kg-diet	1.11	Walker *et al.* 1969 as cited in Peakall 1996
Mallard duckling	LOAEL	24-day	Growth and survival		4.27	Nebeker *et al.* 1992 as cited in RTI 1995
Pheasant	LOAEL	61-day	Egg hatchability and chick survival	10 mg/kg-diet	0.56	Dewitt 1956 as cited in RTI 1995
Quail	LOAEL	154-day	Egg hatchability and chick viability		0.8	Dewitt 1955 as cited in RTI 1995
Rat	NOAEL	9-day (gestation)	Tetratology		6	HSDB, Patty's Indust. Hyg & Toxicol., 1982
Mouse	NOAEL	9-day (gestation)	Tetratology		3	HSDB, Patty's Indust. Hyg & Toxicol., 1982
Mouse	NOAEL	74-day	Fertility and pup survival		0.33	Virgo and Bellward 1975 as cited in ATSDR 1993
Swiss mouse	NOAEL	6-generation	No effects on fertility, viability, or gestation	3 mg/kg-diet	5.87	Keplinger *et al.* as cited in RTI 1995
Hamster	NOAEL	50-week	Survival	80 mg/kg-diet	7.48	HSDB, Cabral, *et al*., Cancer Lett 6:241, 1979

Dieldrin Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
White-tailed Deer	NOAEL	3-year	Fawn production, survival, and growth	5 mg/kg-diet	0.15	Murphy&Korschgen, Wildlife Mgmt. 34:887, 1970 as cited in Peakall 1996
Rat	NOAEL	105-week	Convulsions		0.5	NCI 1978 as cited in ASTDR 1993
Rat	NOAEL	2-year	Survival and hematology		0.5	IRIS, Walker, et al., Toxicol. Appl. Pharmacol. 15:345, 1969
Rat	NOAEL	2-year	Convulsions		0.05	Walker *et al.* 1969 as cited in ATSDR 1993
Rat females	NOAEL	Lifetime	Reproduction	0.24 mg/kg-diet	0.021	Harr *et al.* 1970 as cited in RTI 1995
Dog	NOAEL	9-month	Histopatholgy, gastric effects and survival		1.85	Treon *et al.* 1951 as cited in ATSDR 1993
Dog	NOAEL	2-year	Neurological effects		0.05	Walker *et al.* 1969 as cited in ATSDR 1993
Mallard duckling	NOAEL	24-day	Growth, survival, and development		0.08	Nebeker *et al.* 1992 as cited in RTI 1995
Quail	NOAEL	61-day	Egg production, fertility, and hatchability	1 mg/kg-diet	0.078	Dewitt 1956 as cited in RTI 1995
Barn Owl	NOAEL	2-year	Reproduction		0.077	Mendehenhal *et al.* 1983 as cited in Sample *et al.* 1996

White-tailed deer body weight = 56.5; Reference is Sample and Suter 1994
White-tailed deer Food Ingestion = 1.74 kg; Reference is Sample and Suter 1994
Swiss mouse body weight (average male and femeale) = 0.0332 kg; Reference is USEPA, 1987 EPA/600/6-87/008
Swiss mouse Food Ingestion (average male and femeale) = 0.0065 kg; Reference is USEPA, 1987 EPA/600/6-87/008
Mature Rat Body Weight (female) = 0.25 kg, Reference is USEPA, 1987 EPA/600/6-87/008
Mature Rat Food Consumption (female) = 0.022 kg/day, Reference is USEPA, 1987 EPA/600/6-87/008
14-day old Quail Body Weight = 13 to 20 g (average = 0.0165 kg), Reference is USEPA, 1993 EPA/600/R-93/187a
Adult Mallard Body Weight = (average male & female) = 1.134 kg Reference is USEPA, 1993, EPA/600/R-93/187a
Ring-necked pheasant Body Weight = (average male and female) = 1135g: Reference is Dunning 1993
Bird Food Ingestion (based on all birds, kg/day) = 0.0582 x Body Weight $(kg)^{0.651}$ Reference is USEPA, 1993 EPA/600/R-93/187a
Adult Quail Body Weight = (average over seasons) = 0.191 kg Reference is USEPA, 1993, EPA/600/R-93/187a
Adult Quail Food Consumption = (average over seasons) = 0.07776 g/g-BW Reference is USEPA, 1993, EPA/600/R-93/187a

Endrin Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat (Sherman)	LD_{50}	Single Dose	Mortality		17.8	Gaines 1960 as cited in ATSDR 1995
Rat (Carworth - female)	LD_{50}	Single Dose	Mortality		7.3	Teron *et al.* 1955 as cited in ATSDR 1995
Rat (Carworth - male)	LD_{50}	Single Dose	Mortality		43.4	Teron *et al.* 1955 as cited in ATSDR 1995
Rat (Carworth - female)	LD_{50}	Single Dose	Mortality		16.8	Teron *et al.* 1955 as cited in ATSDR 1995
Rat (Carworth - male)	LD_{50}	Single Dose	Mortality		28.8	Teron *et al.* 1955 as cited in ATSDR 1995
Guinea Pig females	LD_{50}	Single Dose	Mortality		16	Teron *et al.* 1955 as cited in ATSDR 1995
Guinea Pig males	LD_{50}	Single Dose	Mortality		36	Teron *et al.* 1955 as cited in ATSDR 1995
Hamster females	LD_{50}	Single Dose	Mortality		18.6	Chernoff *et al.* 1979 as cited in ATSDR 1995
Rabbit females	LD_{50}	Single Dose	Mortality		7 - 10	Teron *et al.* 1955 as cited in ATSDR 1995
Mule deer females 10mo. old	LD_{50}	Single Dose	Mortality		6.25 - 12.5	Hudson *et al*. 1984.
Goat female 12-24mo. old	LD_{50}	Single Dose	Mortality		25.0 - 50.0	Hudson *et al*. 1984.
Cat	LD_{100}	Single Dose	Mortality		6	Ressang *et al.* 1959 as cited in ATSDR 1995
Mallard females 12mo. old	LD_{50}	Single Dose	Mortality		5.64	Hudson *et al*. 1984.
Sharp-tailed grouse females	LD_{50}	Single Dose	Mortality		1.06	Hudson *et al*. 1984.
California quail females 9-10mo. old	LD_{50}	Single Dose	Mortality		1.19	Hudson *et al*. 1984.
Pheasant males 3-4mo. old	LD_{50}	Single Dose	Mortality		1.78	Hudson *et al*. 1984.
Rock dove	LD_{50}	Single Dose	Mortality		2.0 - 5.0	Hudson *et al*. 1984.
Japanese quail 14-day old	LD_{50}	5-day	Mortality	17 mg/kg-diet	4.14	Hill and Camardese 1986. Lethal
Dog (beagle)	LOAEL	64 - 156 -week	Convulsions		0.1	Kettering 1971 as cited in ATSDR 1995

Endrin Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Dog (beagle)	LOAEL	9.9-month	Survival		0.2	Treon *et al.* 1955 as cited in ATSDR 1995
Mouse	LOAEL	120-day	Reduced survival & litter size		0.92	Good & Ware 1969 as cited in Sample *et al.* 1996
Mouse (CD-1)	LOAEL	11-day during gestation	Development and fetal weight		1	Kavlock *et al.* 1981 as cited in ASTDR 1995
Rat (CD)	LOAEL	9-day during gestation	Fetal body weight and development		2	Goldenthal *et al.* 1978 as cited in ASTDR 1995
Rat (Osborne-Mendel)	NOAEL	80-week	Bodty weight and weight gain		0.25	NCI 1978 as cited in ATSDR 1995
Rat (Carworth)	LOAEL	2-year	Reduced weight gain		0.25	Treon *et al.* 1955 as cited in ATSDR 1995
Rat (Carworth)	LOAEL	2-year	Survival		1.25	Treon *et al.* 1955 as cited in ATSDR 1995
Hamster (Golden Syrian)	LOAEL	10-day during gestation	Fetotoxicity		1.5	Chernoff *et al.* 1979 as cited in ATSDR 1995
Mallard duck	LOAEL	30-day	EMLD - empirical minimum lethal dosage		0.25	Hudson *et al*. 1984. Handbook of Toxicity of Pesticides to Wildlife. US Fish and Wildlife, Resource Publ. 153
Mallard duck	LOAEL	20-week	Reduced embryo survival	3 mg/kg-diet	0.17	Roylance *et al*. 1985 as cited in RTI 1995
Screech owl	LOAEL	>83-day	Egg production and hatching success		0.1035	Fleming et al. 1982 as cited in Sample *et al*. 1996
Dog beagle	NOAEL	64 - 156 -week	Reproduction and development		0.059	Kettering 1971 as cited in ATSDR 1995
Dog beagle	NOAEL	2-year	Growth in body weight		0.075	Treon *et al.* 1955 as cited in ATSDR 1995
Mouse (B6C3F1)	NOAEL	80-week	Clinical signs and histopathology		0.65	NCI 1978 as cited in ATSDR 1995
Mouse (CD-1)	NOAEL	11-day during gestation	Development and fetal weight		0.5	Kavlock *et al.* 1981 as cited in ASTDR 1995
Rat (CD)	NOAEL	9-day during gestation	Reproduction		0.3	Gray *et al.* 1981 as cited in ATSDR 1995
Rat (CD)	NOAEL	9-day during gestation	Fetal body weight and development		0.5	Goldenthal *et al.* 1978 as cited in ASTDR 1995
Rat (CD)	NOAEL	14-day during gestation	Reproduction and development		0.45	Kavlock *et al.* 1981 as cited in ASTDR 1995
Rat (Long Evans)	NOAEL	2-year	Reproduction and development		0.1	Eisenlord *et al.* 1968 as cited in ATSDR 1995

Endrin Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Hamster (Golden Syrian)	NOAEL	10-day during gestation	Growth in body weight		0.75	Chernoff *et al.* 1979 as cited in ATSDR 1995
Hamster (Golden Syrian)	NOAEL	9-day during gestation	Reproduction		1.5	Gray *et al.* 1981 as cited in ATSDR 1995
Mallard duck	NOAEL	>200-days	Reproduction		0.3	Spann *et al.* 1986 as cited in Sample *et al*. 1996
Mallard duck	NOAEL	20-week	Reproduction	0.5 mg/kg-diet	0.028	Roylance *et al*. 1985 as cited in RTI 1995

14-day old Quail Body Weight = 13 to 20 g (average = 0.0165 kg), Reference is USEPA, 1993 EPA/600/R-93/187a
Adult Mallard Body Weight = (average male & female) = 1.134 kg Reference is USEPA, 1993, EPA/600/R-93/187a
Bird Food Ingestion (based on all birds, kg/day) = 0.0582 x Body Weight $(kg)^{0.651}$ Reference is USEPA, 1993 EPA/600/R-93/187a

Chordane Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	LD_{50}	Single Dose	Mortality		500	RTECS, NTIS PB85-143766
Mouse	LD_{50}	Single Dose	Mortality		125	RTECS, J. Agric. Food Chem., 21:1113, 1973
Rat (newborn)	LD_{50}	Single Dose	Mortality		539	HSDB, Harbinson, Toxicol. Appl. Pharm. 32:443, 1975
Rat	LD_{50}	Single Dose	Mortality		590	HSDB, Am Confer. Goverm. Industr. Hyg. 1986;114
Mouse	LD_{50}	Single Dose	Mortality		430	HSDB, Am Confer. Goverm. Industr. Hyg. 1986;114
Rabbit	LD_{50}	Single Dose	Mortality		300	HSDB, Am Confer. Goverm. Industr. Hyg. 1986;114
Hamster	LD_{50}	Single Dose	Mortality		1720	EPA 1980 as cited in Esiler 1990
Cow	LD_{50}	Single Dose	Mortality		25-95	WHO 1984 as cited in Eisler 1990
Mallard females 4-5mo. old	LD_{50}	Single Dose	Mortality		1200	Hudson *et al*. 1984.
California Quail males 12mo. old	LD_{50}	Single Dose	Mortality		14.1	Hudson *et al*. 1984.
Pheasant females 3mo. old	LD_{50}	Single Dose	Mortality		24.0 - 72.0	Hudson *et al*. 1984.
Mallard	LD_{50}	Not Specified	Mortality	709 mg/kg-diet	39.5	NRCC 1975 as cited in Eisler 1990
Chicken	LD_{50}	Not Specified	Mortality		220 - 230	NRCC 1975 as cited in Eisler 1990
Bobwhite Quail	LD_{50}	5-day	Mortality	331 mg/kg-diet	46.5	HSDB, US Fish Wild., Special Report Wildlife #191, 1975
Bobwhite Quail - juveniles	LD_{50}	10-day	Mortality	250mg/kg-diet	60.9	WHO 1984 as cited in Eisler 1990
Bobwhite Quail - adults	LD_{50}	100-day	Mortality	250mg/kg-diet	19.4	WHO 1984 as cited in Eisler 1990
Japanese Quail	LD_{100}	7-day	Mortality	200 mg/kg-diet	15.6	NRCC 1975 as cited in Eisler 1990
Japanese Quail	LD_{50}	5-day	Mortality	350 mg/kg-diet	49.2	HSDB, US Fish Wild., Special Report Wildlife #191, 1975
Pheasant	LD_{50}	5-day	Mortality	430 mg/kg-diet		HSDB, US Fish Wild., Special Report Wildlife #191, 1975

Chordane Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Mallard	LD_{50}	5-day	Mortality	858 mg/kg-diet	54.5	HSDB, US Fish Wild., Special Report Wildlife #191, 1975
Japanese quail 14-day old	LD_{50}	5-day	Mortality	657 mg/kg-diet	160	Hill and Camardese 1986.
Starling	LD_{50}	6 - 7-day	Mortality	150 mg/kg-diet	20.9	Stickel *et al.* 1979 as cited in Eisler 1990
Cowbird	LD_{50}	6 - 7-day	Mortality	150 mg/kg-diet	26	Stickel *et al.* 1979 as cited in Eisler 1990
Red-winged blackbird	LD_{50}	6 - 7-day	Mortality	150 mg/kg-diet	24.8	Stickel *et al.* 1979 as cited in Eisler 1990
Red-winged blackbird	LD_{50}	9-day	Mortality	200 mg/kg-diet	33.1	Stickel *et al.* 1983 as cited in Eisler 1990
Barn owl	LD_{50}	40-day	Mortality	75 mg/kg-diet	5.47	Pattee (per. com.) as cited in Esiler 1990
Dog	LOAEL	2-year	Liver abnormalaities	15 mg/kg-diet	0.47	NRCC 1795 as cited in Esiler 1990
Mouse	LOAEL	19-day during gestation	Survial of offspring		8	Cranmer *et al.* 1984 as cited in ATSDR 1994
Mouse	LOAEL	18-month	Decreased Survival		6.5	IRDC 1973 as cited in ATSDR 1994
Mouse	LOAEL	80-week	Decreased Survival		3.9	NCI 1977 as cited in ATSDR 1994
Mouse	LOAEL	6-generations	Number of Offspring		9.2	WHO 1984 as cited in Sample *et al.* 1996
Rat	LOAEL	80-week	Decreased Survival		6	NCI 1977 as cited in ATSDR 1994
Rat	LOAEL	407-day	Growth		16	Ambrose *et al.* 1953 as cited in ATSDR 1994
Rat	LOAEL	2-year	Growth & Liver Damage	150 mg/kg-diet	12.2	HSDB, Patty's Indust. Hyg & Toxicol., 1982
Rat	LOAEL	2-year	Liver Damage	10 mg/kg-diet	0.82	HSDB, Patty's Indust. Hyg & Toxicol., 1982
Rat	LOAEL	30-month	Liver Lesions		0.273	IRIS, Velisicol Co., unpublished)
Rat	LOAEL	Weaning to Reproduction	Decreased fertility and survival		16	Ambrose *et al.* 1953 as cited in ATSDR 1994
Rat	LOAEL	80-week	Decreased growth in females		12.1	NCI 1977 as cited in ATSDR 1994
Red-winged blackbird	LOAEL	84-day	Survival		10.7	Stickel *et al.* 1983 as cited in Sample *et al.* 1996
Dog	NOAEL	2-year	Survival, weight gain, blood chemistry, and behavior	3 mg/kg-diet	0.093	NRCC 1795 as cited in Esiler 1990
Mouse	NOAEL	19-day during gestation	Development		0.16	Spyker *et al.* 1982 as cited in ATSDR 1994
Mouse	NOAEL	30-month	Clinical sings including growth		1.409	Khasawinah and Grutsch 1989 as cited in ATSDR 1994
Mouse	NOAEL	6-generations	Number of Offspring		4.6	WHO 1984 as cited in Sample et al. 1996
Rat	NOAEL	80-week	Growth in females		6	NCI 1977 as cited in ATSDR 1994

Chordane Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	NOAEL	407-day	Growth		8	Ambrose *et al.* 1953 as cited in ATSDR 1994
Rat	NOAEL	2-year	Liver damage	5 mg/kg-diet	0.41	HSDB, Patty's Indust. Hyg & Toxicol., 1982
Rat	NOAEL	2-year	Growth	30 mg/kg-diet	2.4	HSDB, Patty's Indust. Hyg & Toxicol., 1982
Japanese Quail	NOAEL	4-week	Survival, weight gain, and activity	25 mg/kg-diet	1.94	NRCC 1975 as cited in Eisler 1990
Chicken	NOAEL	4-week	Growth, egg hatchability, or chick growth		0.3	NRCC 1975 as cited in Eisler 1990
Red-winged blackbird	NOAEL	84-day	Survival		2.14	Stickel et al. 1983 as cited in Sample et al. 1996

Mature Dog Body Weight (average male & female) = 14 kg, Reference is USEPA, 1987 EPA/600/6-87/008
Mature Dog Food Consumption (average male & female - moist diet) = 0.435 kg/day, Reference is USEPA, 1987 EPA/600/6-87/008
14-day old Quail Body Weight = 13 to 20 g (average = 0.0165 kg), Reference is USEPA, 1993 EPA/600/R-93/187a
Adult Mallard Body Weight = (average male & female) = 1.134 kg Reference is USEPA, 1993, EPA/600/R-93/187a
Red Winged Blackbird Body Weight = (mid-point in range) 0.05 kg Reference is Dunning, 1993
Barn owl body weight (average male and female) = 0.523 kg; Reference is Dunning 1993
Starling body weight (average male and female) = 0.082 kg; Reference is Dunning 1993
Cowbird body weight (average male and female) = 0.044 kg; Reference is Dunning 1993
Bird Food Ingestion (based on all birds, kg/day) = 0.0582 x Body Weight $(kg)^{0.651}$ Reference is USEPA, 1993 EPA/600/R-93/187a
Adult Quail Body Weight = (average over seasons) = 0.191 kg Reference is USEPA, 1993, EPA/600/R-93/187a
Adult Quail Food Consumption = (average over seasons) = 0.07776 g/g-BW Reference is USEPA, 1993, EPA/600/R-93/187a

DDD, DDE, and DDT							
Form	**Test Species**	**Endpoint**	**Duration**	**Effect**	**Concentration**	**Dose (mg/kg-BW/day)**	**Reference**
DDT	Bullfrog	LD_{50}	NA	Mortality	>2000 mg/kg-diet		Hudson *et al*. 1984. US Fish Wildl. Resorce Pub. 153.
DDT	Bullfrog	LD_{50}	NA	Mortality		72000	USEPA 1993 as cited in RTI 1995
DDT	Bullfrog	LD_{50}	NA	Mortality		7600	RTECs 1994 as cited in RTI 1995
DDD	Rat	LD_{50}	Single Dose	Mortality		400	Ben-Dyke *et al.* 1970 as cited in ATSDR 1994
DDD	Mouse	LD_{50}	Single Dose	Mortality		1466	Tomatis *et al.* 1974 as cited in ATSDR 1994
DDD	Dog	LD_{50}	14-day	Mortality		50	Cueto 1970 as cited in ASTDR 1994
DDE	Rat	LD_{50}	Single Dose	Mortality		880	Gaines 1969 as cited in ATSDR 1994
DDE	Mouse	LD_{50}	Single Dose	Mortality		810	Tomatis *et al.* 1974 as cited in ATSDR 1994
DDT	Rat	LD_{50}	Single Dose	Mortality		217	Gaines 1969 as cited in ATSDR 1994
DDT	Rat	LD_{50}	Single Dose	Mortality		800	Cameron and Burgess 1945 as cited in ATSDR 1994
DDT	Rabbit	LD_{50}	Single Dose	Mortality		300	Cameron and Burgess 1945 as cited in ATSDR 1994
DDT	Guinea pig	LD_{50}	Single Dose	Mortality		400	Cameron and Burgess 1945 as cited in ATSDR 1994
DDT	Mouse	LD_{50}	Single Dose	Mortality		237	Tomatis *et al.* 1974 as cited in ATSDR 1994
DDD	Japanese Quail (7-day old)	LD_{50}	5-day	Mortality	3165 mg/kg-diet	919	HSDB; US Fish Wildl. 1975. Special Sci. Rpt#191.
DDD	Bobwhite Quail (23-day old)	LD_{50}	5-day	Mortality	2178 mg/kg-diet	459	HSDB; US Fish Wildl. 1975. Special Sci. Rpt#191.
DDD	Pheasant (10-day old)	LD_{50}	5-day	Mortality	445 mg/kg-diet		HSDB; US Fish Wildl. 1975. Special Sci. Rpt#191.
DDD	Mallard (17-day old)	LD_{50}	5-day	Mortality	4814 mg/kg-diet	461	HSDB; US Fish Wildl. 1975. Special Sci. Rpt#191.
DDE	Japanese Quail (14-day old)	LD_{50}	5-day	Mortality	859 mg/kg-diet	209	Hill and Camardese 1986.
DDE	American Kestrel	LD_{50}	Acute	Mortality	160 mg/kg-diet	19.8	Blus 1996
DDT	Japanese Quail (14-day old)	LD_{50}	5-day	Mortality	416 mg/kg-diet	101	Hill and Camardese 1986.

DDD, DDE, and DDT

Form	Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
DDT	Blue jay	LD_{50}	Not Specified	Mortality	415 mg/kg-diet	56.7	Van Velzen. 1975
DDT	House Sparrow	LD_{50}	Not Specified	Mortality	415 mg/kg-diet	84.4	Van Velzen. 1975
DDT	Cardinal	LD_{50}	Not Specified	Mortality	535 mg/kg-diet	62.1	Van Velzen. 1975
DDT	Clapper Rail	LD_{50}	5-day	Mortality males	1612 mg/kg-diet	139	Van Velzen. 1975
DDT	Clapper Rail	LD_{50}	5-day	Mortality females	1882 mg/kg-diet	173	Van Velzen. 1975
DDT	Mallard (3-mo. old)	LD_{50}	5-day	Mortality	> 2240 mg/kg-diet	125	Hudson *et al*. 1984.
DDT	California Quail (6-mo. old)	LD_{50}	5-day	Mortality	595 mg/kg-diet	46.3	Hudson *et al*. 1984.
DDT	Japanese Quail (2-mo. old)	LD_{50}	5-day	Mortality	841 mg/kg-diet	109	Hudson *et al*. 1984.
DDT	Pheasant (3-4-mo. old)	LD_{50}	5-day	Mortality	1334 mg/kg-diet	74.3	Hudson *et al*. 1984.
DDT	Sandhill Crane	LD_{50}	5-day	Mortality	>1200 mg/kg-diet	46.7	Hudson *et al*. 1984.
DDT	Rock Dove	LD_{50}	5-day	Mortality	>4000 mg/kg-diet	334	Hudson *et al*. 1984.
DDT	Mallard	LD_{50}	30-day	Mortality	50 mg/kg-diet	2.78	Hudson *et al*. 1984.
DDT	Sandhill Crane	LD_{50}	12-day	Mortality	1000 mg/kg-diet	38.9	Hudson *et al*. 1984.
DDD	Dog	LOAEL	Not Specified	Neuropathy		20	HSDB; Clark et al. 1981. Veterinary Toxicology 2nd Ed.
DDE	Hamster	LOAEL	128-week	Heptocellar necrosis		41.5	Rossi *et al.* 1983 as cited in ATSDR 1994
DDT	Mouse	LOAEL	Lifetime	Offspring survival		32.5	Turusov *et al.* 1973 as cited in ATSDR 1994
DDT	Mouse	LOAEL	12-week	Decreased fertility		1.37	Lundberg 1974 as cited in ATSDR 1994
DDT	Mouse	LOAEL	28-day	Decreased fertility		39	Bernard and Gaertner 1964 as cites in ATSDR 1994
DDT	Rat	LOAEL	60-day	Decreased fertility		0.35	Green 1969 as cited in ATSDR 1994
DDT	Rat	LOAEL	36-week	Sterility		7.5	Johnson *et al.* 1976 as cited in ATSDR 1994
DDT	Rat	LOAEL	7-month	Growth of pups		10	Clement and Okey 1794 as cited in ATSDR 1994
DDT	Rat	LOAEL	2-year	Number of offspring		4	Fitzhugh 1948 as cited in Sample *et al.* 1996
DDT	Rat	LOAEL	2-generation	Tail abnormalities		10	Ottoboni 1969 as cited in ASTDR 1994
DDD	Mallard	LOAEL	2-year	Reduced reproductive success	10 mg/kg-diet	0.56	Heath *et al*. 1969

DDD, DDE, and DDT							
Form	**Test Species**	**Endpoint**	**Duration**	**Effect**	**Concentration**	**Dose (mg/kg-BW/day)**	**Reference**
DDE	Mallard	LOAEL	2-year	Reduced reproductive success	10 mg/kg-diet	0.56	Heath *et al*. 1969
DDE	Black Duck	LOAEL	5-month	Reduced reproductive success	10 mg/kg-diet	0.54	Loncore and Samson 1973
DDE	Barn Owl	LOAEL	2-year	Egg hatchability and fledgling success	3 mg/kg-diet	0.22	Mendenhall *et al.* 1983
DDE	American Kestrel	LOAEL	Chronic	Survival	2.8 mg/kg-diet	0.35	Blus 1996
DDE	Peregrine Falcon	LOAEL	Chronic	Reduced reproductive success	1 mg/kg-diet	0.063	Blus 1996
DDT	Mallard	LOAEL	2-year	Reduced reproductive success	25 mg/kg-diet	1.39	Heath *et al*. 1969
DDT	Mallard	LOAEL	1-year	Mortality	100 mg/kg-diet	5.57	Hudson *et al*. 1984.
DDT	Mallard (female)	LOAEL	Not Specified	Reduced eggshell thickness		1.16	Davidson & Sell. 1974 as cited in RTI 1995
DDT	Mallard	LOAEL	Not Specified	Reduced eggshell thickness		2.91	Kolaja et al.1977, as cited in RTI 1995
DDT	American Kestrel	LOAEL	Not Specified	Reduced eggshell thickness		0.87	Peakall et al. 1973, as cited in RTI 1995
DDT	White-throated sparrow	LOAEL	6-week	Effect on migratory fat stores and activity	25 mg/kg-diet	5.21	Mahoney 1975
DDT	Brown Pelican	LOAEL	5-year	Reduced reproductive success		0.028	Anderson et al. 1975, as cited in Sample *et al.* 1996
DDT	Japanese Quail	LOAEL	> 30-day	Survival and egg hatchability	400 mg/kg-diet	31.1	Smith et al. 1969, as cited in RTI 1995
DDT	Japanese Quail	LOAEL	45-day	Reduced eggshell thickness	100 mg/kg-diet	7.78	Bitman *et al.* 1969
DDD	Mouse	NOAEL	78-week	Clinical signs		107	NCI 1978 as cited in ATSDR 1994
DDD	Rat	NOAEL	78-week	Clinical signs		85	NCI 1978 as cited in ATSDR 1994
DDE	Mouse	NOAEL	78-week	Clinical signs		34	NCI 1978 as cited in ATSDR 1994
DDE	Rat	NOAEL	9-week	Reproduction		10	Kornburst *et al.* 1986 as cited in ATSDR 1994
DDE	Rat	NOAEL	78-week	Clinical signs		23	NCI 1978 as cited in ATSDR 1994
DDT	Old-field mouse	NOAEL	15-month	Reproduction		2.4	Wolfe *et al.* 1979
DDT	Mouse	NOAEL	70-week	Reproduction and development		1	Del Pup *et al*. 1978 as citred in ATSDR 1994
DDT	Mouse	NOAEL	Lifetime	Reproduction		6.5	Turusov *et al.* 1973 as cited in ATSDR 1994

DDD, DDE, and DDT

Form	Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
DDT	Rat	NOAEL	20-week	Reproduction		2	Wren *et al.* 1971 as cited in ATSDR 1994
DDT	Rat	NOAEL	36-week	Sterility		3.75	Johnson *et al.* 1976 as cited in ATSDR 1994
DDT	Rat	NOAEL	7-month	Growth of pups		1	Clement and Okey 1794 as cited in ATSDR 1994
DDT	Rat	NOAEL	2-year	Number of offspring		0.8	Fitzhugh 1948 as cited in Sample *et al.* 1996
DDT	Rat	NOAEL	11 (eleven) - generation	Reproduction		1	Ottoboni 1972 as cited in ASTDR 1994
DDT	Dog	NOAEL	39-40-month	Hepatic effects		16	Lehman 1965 as cited in ASTDR 1994
DDT	Dog	NOAEL	2-generation	Reproduction		10	Ottoboni *et al.* 1977 as cited in ASTDR 1994
DDE	Chicken	NOAEL	Gestation	Eggshell thickness - hatchability	300 mg/kg-diet	14.5	Blus 1996
DDT	Japanese Quail	NOAEL	> 30-day	Survival and egg hatchability	200 mg/kg-diet	15.5	Smith et al. 1969, as cited in RTI 1995
DDT	California Quail	NOAEL	60-day	Eggshell thickness	100 mg/kg-diet	7.78	Hudson *et al*. 1984.
DDT	Bobwhite Quail	NOAEL	60-day	Eggshell thickness	100 mg/kg-diet	7.78	Hudson *et al*. 1984.
DDT	Mallard	NOAEL	90-day	Survival and intoxication	30 mg/kg-diet	1.67	Hudson *et al*. 1984.
DDT	Bobwhite Quail	NOAEL	90-day	Survival and intoxication	30 mg/kg-diet	2.33	Hudson *et al*. 1984.
DDT	Chicken	NOAEL	Gestation	Eggshell thickness - hatchability	300 mg/kg-diet	14.8	Blus 1996
DDT	White-throated sparrow	NOAEL	6-week	Migratory fat stores and activity	5 mg/kg-diet	1.04	Mahoney 1975
DDT	Chicken	NOAEL	12-week	Reproduction	200 mg/kg-diet	9.67	Davidson & Sell 1972, as cited in RTI 1995
DDT	Mallard (female)	NOAEL	Not Specified	Eggshell thickness		0.116	Davidson & Sell. 1974 as cited in RTI 1995
DDT	Mallard	NOAEL	2-year	Reproductive success	10 mg/kg-diet	0.56	Heath *et al*. 1969

7-day old Quail Body Weight is approximately 10 g; Reference is USEPA, 1993, EPA/600/R-93/187a
13 to 14-day old Quail Body Weight is approximately 16.5g; Reference is USEPA, 1993, EPA/600/R-93/187a
17-day old Mallard Body Weight approximately 215 to 265 g (average = 0.240 kg) Reference is USEPA, 1993, EPA/600/R-93/187a
23-day old Quail Body Weight is approximately 25 g; Reference is USEPA, 1993, EPA/600/R-93/187a
2-month old Quail Body Weight is approximately 100g; Reference is USEPA, 1993, EPA/600/R-93/187a
Adult Quail Body Weight = (average over seasons) = 0.191 kg Reference is USEPA, 1993, EPA/600/R-93/187a

DDD, DDE, and DDT

Form	Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference

Adult Quail Food Consumption = (average over seasons) = 0.07776 g/g-BW Reference is USEPA, 1993, EPA/600/R-93/187a
Adult Mallard Body Weight = (average male & female) = 1.134 kg Reference is USEPA, 1993, EPA/600/R-93/187a
House sparrow Body Weight = (average male and female) = 27.7 g: Reference is Dunning 1993
Male clapper rail Body Weight = 323 g: Reference is Dunning 1993
Female clapper rail Body Weight = 271g: Reference is Dunning 1993
Ring-necked pheasant Body Weight = (average male and female) = 1135g: Reference is Dunning 1993
Sandhill crane Body Weight = (average male and female) = 3166g: Reference is Dunning 1993
Rock dove Body Weight = (average male and female) = 354.5g: Reference is Dunning 1993
American kestrel Body Weight = (average male and female) = 115.5g: Reference is Dunning 1993
Black duck Body Weight = (average male and female) = 1250g: Reference is Dunning 1993
Barn owl Body Weight = (average male and female) = 523.5g: Reference is Dunning 1993
Peregrine falcon Body Weight = (average male and female) = 781.5g: Reference is Dunning 1993
White-throated sparrow Body Weight = (average male and female) = 25.98g: Reference is Dunning 1993
Bluejay Body Weight = 86.8g; Reference is Dunning 1993
Cardinal Body Weight = 44.65g; Reference is Dunning 1993
Average Chicken Body Weight =1.7 kg Reference is USEPA, 1987 EPA/600/6-87/008 (used USEPA 1993 formula for all birds for Food Consumption)
Average Chicken Body Weight (females) is 1.6kg Reference is USEPA, 1987 EPA/600/6-87/008 (used USEPA 1993 formula for all birds for Food Consumption)
Bird Food Ingestion (based on all birds, kg/day) = 0.0582 x Body Weight $(kg)^{0.651}$ Reference is USEPA, 1993 EPA/600/R-93/187a

Alpha, Beta, and Delta Hexachlorocyclohexane Oral Toxicity[1]

Form	Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Technical grade	Mallard females 3mo. old	LD_{50}	Single Dose	Mortality		1414	Hudson *et al*. 1984.
Technical grade	Pheasant females 3-4mo. old	LD_{50}	Single Dose	Mortality		118	Hudson *et al*. 1984.
Technical grade	Japanese Quail 14-day old	LD_{50}	5-day	Mortality	663 mg/kg-diet	162	Hill and Camardese 1986.
α -BHC	Mouse	LOAEL	26-week	Liver histopathology	600 mg/kg-diet	118	HSDB, IARC, V20:218, 1979
α -BHC	Mouse	LOAEL	24-week	Enlarged liver	500 mg/kg-diet	98	HSDB, IARC, V20:212, 1979
α -BHC	Mouse	LOAEL	24-week	Liver histopathology		13	Ito *et al.* 1973 as cited in ATSDR 1994
α -BHC	Rat	LOAEL	48-week	Liver histopathology		25	Ito *et al.* 1975 as cited in ATSDR 1994
α -BHC	Rat	LOAEL	64-week	Liver histopathology		2.5	Fitzhugh *et al.* 1950 as cited in ATSDR 1994
α -BHC	Rat	LOAEL	Life-span	Growth & Survival	800 mg/kg-diet	59.5	HSDB, IARC, V20:217, 1979
β - BHC	Rat	LOAEL	2-week	Liver size and enzyme induction		50	Ikegamai *et al.* 1991 as cited in ATSDR 1994
β - BHC	Rat	LOAEL	2-week	Nephropathy		40	Srinivassan *et al.* 1984 as cited in ATSDR 1994
β - BHC	Rat	LOAEL	13-week	Comatose, gonadal histopathological, and growth effects		12.5	Van Velsen *et al.* 1986 as cited in ATSDR 1994
β -BHC	Rat	LOAEL	48-week	Liver histopathology		25	Ito *et al.* 1975 as cited in ATSDR 1994
Technical grade	Mouse	LOAEL	Single Dose - day 9 of gestation	Fetal reasorptions		25	Dikshith *et al.* 1990 as cited in ATSDR 1994
Technical grade	Mouse	LOAEL	2-week	Liver histopathology		26	Ravinder *et al.* 1990 as cited in ATSDR 1994
Technical grade	Mouse	LOAEL	80-week	Seizures		13	Kashyap *et al.* 1979 as cited in ATSDR 1994
Technical grade	Rat	LOAEL	180-day	Gonadal histopathological effects		6	Roy Chowdhury and Gautam 1990 as cited in ATSDR 1994
Technical grade	Rat	LOAEL	360-day	Survival		0.4	Dikshith *et al.* 1991 as cited in ATSDR 1994
"Mixed isomers"	Rat	LOAEL	4-generation	Reproduction		3.2	Grant *et al.* 1984 as cited in Sample *et al.* 1996
"Mixed isomers"	Mink	LOAEL	331-day	Kit mortality and body weight		0.137	Bleavins *et al.* 1984 as cited in Sample *et al.* 1996

1 = Certain mixed isomer, technicial grade and "lindane" entries are included for completeness.

Alpha, Beta, and Delta Hexachlorocyclohexane Oral Toxicity[1]

Form	Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
"Mixed isomers"	Japanese Quail	LOAEL	90-day	Egg hatchability and egg volume		2.25	Vos *et al.* 1971 as cited in Sample *et al.* 1996
"Lindane"	Chicken	LOAEL	Varied	Reproduction		7	Whitehead *et al.* 1972 as cited in RTI 1995
α -BHC	Rat	NOAEL	30-day	Hepatic effects		1	Barros *et al.* 1991 as cited in ATSDR 1994
α -BHC	Rat	NOAEL	56-week	Liver histopathology		0.5	Fitzhugh *et al.* 1950 as cited in ATSDR 1994
β - BHC	Mouse	NOAEL	30-day	Reproduction		39	Cornacoff *et al.* 1988 as cited in ATSDR 1994
β - BHC	Mouse	NOAEL	32-week	Hepatic effects		13	Hanada *et al.* 1973 as cited in ATSDR 1994
β - BHC	Rat	NOAEL	13-week	Gonadal histopathological effects		2.5	Van Velsen *et al.* 1986 as cited in ATSDR 1994
β -BHC	Rat	NOAEL	48-week	Hepatic effects		0.5	Fitzhugh *et al.* 1950 as cited in ATSDR 1994
Technical grade	Rat	NOAEL	180-day	Gonadal histopathological effects		3	Roy Chowdhury and Gautam 1990 as cited in ATSDR 1994
"Mixed isomers"	Japanese Quail	NOAEL	90-day	Egg hatchability and egg volume		0.563	Vos *et al.* 1971 as cited in Sample *et al.* 1996
"Lindane"	Chicken	NOAEL	Varied	Reproduction		0.7	Whitehead *et al.* 1972 as cited in RTI 1995
"Lindane"	Chicken	NOAEL	27-day	Reproduction	4 mg/kg-diet	0.19	Harrison *et al.* 1963 as cited in RTI 1995
"Lindane"	Chicken	NOAEL	60-day	Reproduction	10 mg/kg-diet	0.48	Ware and Naber 1961 as cited in RTI 1995
"Lindane"	Chicken	NOAEL	28-week	Reproduction	200 mg/kg-diet	9.67	Whitehead *et al.* 1974 as cited in RTI 1995

Mouse Average Body Weight (Chronic exposure) = 0.02415 kg, Reference is USEPA, 1987 EPA/600/6-87/008
Mouse Average Food Consumption (Chronic Exposure) = 0.00475 kg/day, Reference is USEPA, 1987 EPA/600/6-87/008
MatureRat Body Weight (Average male & female) = 0.41kg, Reference is USEPA, 1987 EPA/600/6-87/008
Mature Rat Food Consumption (Average male & female) = 0.0305 kg/day, Reference is USEPA, 1987 EPA/600/6-87/008
14-day old Quail Body Weight = 13 to 20 g (average = 0.0165 kg), Reference is USEPA, 1993 EPA/600/R-93/187a
Average Chicken Body Weight =1.7 kg Reference is USEPA, 1987 EPA/600/6-87/008 (used USEPA 1993 formula for all birds for Food Consumption)
Adult Quail Body Weight = (average over seasons) = 0.191 kg Reference is USEPA, 1993, EPA/600/R-93/187a
Adult Quail Food Consumption = (average over seasons) = 0.07776 g/g-BW Reference is USEPA, 1993, EPA/600/R-93/187a
Bird Food Ingestion (based on all birds, kg/day) = 0.0582 x Body Weight $(kg)^{0.651}$ Reference is USEPA, 1993 EPA/600/R-93/187a

1 = Certain mixed isomer, technicial grade and "lindane" entries
are included for completeness.

Heptachlor Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	LD_{50}	Single Dose	Mortality		40	RTECS, Entonom. Soc Am. 78-1:12, 1978
Rat	LD_{50}	Single Dose	Mortality		130	HSDB, Res. Instit. Canada, Public. 1093, 1982
Rat	LD_{50}	Single Dose	Mortality		40 to 188	HSDB, Am. Conf. Gover. Indust. Hyg. 1986. 296
Rat	LD_{50}	Single Dose	Mortality		71	Podowski *et al.* 1979 as cited in ATSDR 1993
Rat	LD_{50}	Single Dose	Mortality		100 (males) to 162 (females)	Gaines 1969 as cited in ATSDR 1993
Mouse	LD_{50}	Single Dose	Mortality		68	RTECS, Entonom. Soc Am. 78-1:12, 1978
Guinea Pig	LD_{50}	Single Dose	Mortality		116	RTECS, Assoc. Am. Pest. Control Off. 1966-:576, 1966
Hamster	LD_{50}	Single Dose	Mortality		100	RTECS, Europ. J. Toxicol. Environ. Hyg. 7:159, 1974
Calf	LD_{50}	Single Dose	Mortality		20	HSDB, Jones, et al., Veterin. Pharmocl. Therap. 4thEd, Ames Iowa, 1977
Cat	LD_{LO}	Single Dose	Mortality		50	RTECS, Labor Hyg. Occup. Diseases, 2:15, 1958
Mallard males 3-mo. old	LD_{50}	Single Dose	Mortality		2080	Hudson *et al*. 1984.
Bobwhite quail 23-day	LD_{50}	5-day	Mortality	92 mg/kg-diet	19.5	HSDB, US Fish Wildlife, SSR-Wildlife #191, 1975
Pheasant	LD_{50}	5-day	Mortality	224 mg/kg-diet		HSDB, US Fish Wildlife, SSR-Wildlife #191, 1975
Japanese quail 19-day	LD_{50}	5-day	Mortality	93 mg/kg-diet	20.3	HSDB, US Fish Wildlife, SSR-Wildlife #191, 1975
Mallard 10-day	LD_{50}	5-day	Mortality	480 mg/kg-diet	59.4	HSDB, US Fish Wildlife, SSR-Wildlife #191, 1975
Japanese quail 14-day	LD_{50}	5-day	Mortality	99 mg/kg-diet	24.1	Hill and Camardese 1986.
Dog	LOAEL	1-year	Survival		1	HSDB, Am. Conf. Goverment. Indust. Hyg. 1986. 296
Pig	LOAEL	78 to 86-day	Hepatic Necrosis		2	HSDB, EPA Contract#68-02-4131, 1985
Sheep	LOAEL	78 to 86-day	Hepatic Necrosis		2	HSDB, EPA Contract#68-02-4131, 1985
Rat females	LOAEL	6-week	Survival		8	NCI 1977 as cited in ATSDR 1993
Rat	LOAEL	78 to 86-day	Hepatic Necrosis		2	HSDB, EPA Contract#68-02-4131, 1985

Heptachlor Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Mink	LOAEL	28-day	Loss of Body Weight		5.67	Aulerich, *et al*. 1990 as cited in ATSDR 1993
Mink	LOAEL	181-day	Reproduction - Kit Growth		1	Crum *et al.* 1993 as cited in Sample *et al.* 1996
Rat	LOAEL	60-day	Embryo survival and fertility in F1 generation		0.25	Green 1970 as cited in ATSDR 1993
Rat	LOAEL	18-month	Litter size and pup mortality		6	Mestitzova 1967 as cited in ATSDR 1993
Rat	LOAEL	80-week	Vaginal bleeding		1.28	NCI 1977 as cited in ATSDR 1993
Rat	LOAEL	2-year	Hepatic Lesions & Liver Weight	7 mg/kg-diet	0.57	IRIS, Velsicol Chem. Co. MRID#00062599, 1955
Mouse females	LOAEL	6-week	Survival		8	NCI 1977 as cited in ATSDR 1993
Mouse	LOAEL	6-week	Survival		10.4	NCI 1977 as cited in ATSDR 1993
Mouse	LOAEL	10-week	Infertility		6.5	Akay and Alp 1981 as cited in ATSDR 1993
Pig	LOAEL	78-day	Reduced body weight gain		5	Halacka *et al.* 1974 as cited in ATSDR 1993
Mink	LOAEL	28-day	Survival		6.19	Aulerich *et al.* 1990 as cited in ATSDR 1993
Mink	LOAEL	28-day	Decreased body weight		5.67	Aulerich *et al.* 1990 as cited in ATSDR 1993
Mouse	NOAEL	5-day	Reproduction		10	Epstein *et al.* 1972 as cited in ATSDR 1993
Rat	NOAEL	2-year	Hepatic Lesions & Liver Weight	5 mg/kg-diet	0.41	IRIS, Velsicol Chem. Co. MRID#00062599, 1955
Rat	NOAEL	3-generation	Reproduction		0.5	IRIS, Velsicol Chem. Co. 1967
Mouse	NOAEL	90-weeks	Survival	18 mg/kg-diet	3.1	HSDB, IARC, V20, 142, 1979
Pig	NOAEL	78-day	Growth - body weight		2	Halacka *et al.* 1974 as cited in ATSDR 1993
Mink	NOAEL	28-day	Survival		5.67	Aulerich *et al.* 1990 as cited in ATSDR 1993

23-day Old Quail (Bobwhite) Body Weight = (appox.) = 0.025 kg; Reference is USEPA, 1993, EPA/600/R-93/187a
19-day Old Quail (Japanese) Body Weight = (average) = 0.0225 kg; Reference is USEPA, 1993, EPA/600/R-93/187a
10-day Old Mallard Body Weight is approximately 115g; Reference is USEPA, 1993, EPA/600/R-93/187a
14-day old Quail Body Weight = 13 to 20 g (average = 0.0165 kg), Reference is USEPA, 1993 EPA/600/R-93/187a
Bird Food Ingestion (based on all birds, kg/day) = 0.0582 x Body Weight $(kg)^{0.651}$ Reference is USEPA, 1993 EPA/600/R-93/187a
Mature Rat Body Weight = (average male & female) = 0.325 kg, Reference is USEPA, 1987, EPA/600/6-87/008
Mature Rat Food Consumption = (average male & female) = 0.0265 kg/day, Reference is USEPA, 1987, EPA/600/6-87/008
Mature Mouse Body Weight (B6C3FI) (average male & female) = 0.0375 kg, Reference is USEPA, 1987, EPA/600/6-87/008
Mature Mouse Food Consumption (B6C3FI) (average male & female) = 0.0034 kg/day, Reference is USEPA, 1987, EPA/600/6-87/008

Heptaclor Epoxide Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	LD_{50}	Single Dose	Mortality		60	Podowski *et al.* 1979 as cited in ATSDR 1993
Rat	LD_{50}	Single Dose	Mortality		15	RTECS as cited in RTI 1995
Mouse	LD_{50}	Single Dose	Mortality		39	RTECS as cited in RTI 1995
Rabbit	LD_{50}	Single Dose	Mortality		144	RTECS as cited in RTI 1995
Dog (Beagle)	LOAEL	60-week	Liver Weight	0.5 mg/kg-diet	0.016	IRIS, Dow Chem. Co., 1958
Calf	LOAEL	11-week	Kidney Damage	50 mg/kg-diet		HSDB, Clarke, *et al*., Veterinary Toxicology, 2Ed, 1981
Rat	LOAEL	2-year	Liver Histopathology		0.025	IRIS, Velsicol Chem. Co., 1959
Dog	LOAEL	2-generation	Pup Survival		0.175	IRIS, Velsicol Chem. Co., 1973
Rat	LOAEL	3-generation	Pup Survival		0.5	IRIS, Velsicol Chem. Co., 1973
Woodcock	LOAEL	60-day	Survival		0.33	Stickel *et al.* 1965
Mouse (male)	NOAEL	Single Dose	Reproduction		15	HSDB, IARC, V20, 144, 1979
Mouse	NOAEL	5-day	Reproduction		8	Epstein *et al.* 1972 as cited in ATSDR 1993
Calf	NOAEL	100-day	No Harmful Effects		0.2	HSDB, Clarke, *et al*., Veterinary Toxicology, 2Ed, 1981
Rat	NOAEL	2-year	Cataracts	12.5 mg/kg-diet	1.02	HSDB, Hayes, Pesticides Studies in Man, Williams & Walker Ed.s, 1982
Dog	NOAEL	2-year	Cataracts	12.5 mg/kg-diet	0.39	HSDB, Hayes, Pesticides Studies in Man, Williams & Walker Ed.s, 1982
Dog	NOAEL	2-generation	Reproduction		0.125	IRIS, Velsicol Chem. Co., 1973
Rat	NOAEL	3-generation	Reproduction		0.25	IRIS, Velsicol Chem. Co., 1973
Rat	NOAEL	3-generation	Reproduction	7 mg/kg-diet	0.57	IRIS, Velsicol Chem. Co., 1967
Woodcock	NOAEL	60-day	Survival		0.069	Stickel *et al.* 1965

Mature Rat Body Weight (Average male & female) = 0.325 kg, Reference is USEPA, 1987 EPA/600/6-87/008
Mature Rat Food Consumption (Average male & female) = 0.0265 kg/day, Reference is USEPA, 1987 EPA/600/6-87/008
Mature Dog Body Weight (Average male & female) = 14 kg, Reference is USEPA, 1987 EPA/600/6-87/008
Mature Dog Food Consumption (Average male & female, moist diet) = 0.435 kg/day, Reference is USEPA, 1987 EPA/600/6-87/008

Toxaphene Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat (Wistar)	LD_{50}	Single Dose	Mortality		80	Boyd and Taylor 1971 as cited in ATSDR 1994
Rat (Sherman)	LD_{50}	Single Dose	Mortality		90	Gaines 1969 as cited in ATSDR 1994
Mule deer males 18mo. old	LD_{50}	Single Dose	Mortality		139 - 240	Hudson *et al*. 1984.
Goat male over 60mo. old	LD_{50}	Single Dose	Mortality		>160	Hudson *et al*. 1984.
Rat (CD)	LD_{low}	10-day during gestation	Mortality - females		35	Chernoff and Carver 1976 as cited in ATSDR 1994
Rat (Sprague-Dawley)	LD_{low}	10-day during gestation	Mortality - females		32	Chernoff *et al.* 1990 as cited in ATSDR 1994
Mouse (CD-1)	LD_{low}	10-day during gestation	Mortality - females		35	Chernoff and Carver 1976 as cited in ATSDR 1994
Mouse (ICR/HASwiss)	LD_{low}	5-day	Mortality		40	Epstein *et al.* 1972 as cited in ATSDR 1994
Dog	LD_{low}	Single Dose	Mortality		15	Lackey 1949 as cited in ATSDR 1994
Fulvous whistling duck males 3-6-mo. old	LD_{50}	Single Dose	Mortality		99	Hudson *et al*. 1984.
Mallard duckling 1-week old	LD_{50}	Single Dose	Mortality		30.8	Hudson *et al*. 1984.
Mallard females 3-5mo. old	LD_{50}	Single Dose	Mortality		70.7	Hudson *et al*. 1984.
Sharp-tailed grouse males 12-48mo. old	LD_{50}	Single Dose	Mortality		19.9	Hudson *et al*. 1984.
Bobwhite quail males 3mo. old	LD_{50}	Single Dose	Mortality		85.5	Hudson *et al*. 1984.

Toxaphene Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
California quail males 9-11mo. old	LD_{50}	Single Dose	Mortality		23.7	Hudson *et al*. 1984.
Pheasant females 2-3mo. old	LD_{50}	Single Dose	Mortality		40	Hudson *et al*. 1984.
Gray partridge - adult males	LD_{50}	Single Dose	Mortality		23.7	Hudson *et al*. 1984.
Sandhill crane females	LD_{50}	Single Dose	Mortality		100 - 316	Hudson *et al*. 1984.
Horned lark adults	LD_{50}	Single Dose	Mortality		581	Hudson *et al*. 1984.
Japanese quail 14-day old	LD_{50}	5-day	Mortality	529 mg/kg-diet	129	Hill and Camardese 1986.
Japanese quail 14-day old	LD_{50}	5-day	Mortality - commerical formulation	565 mg/kg-diet	138	Hill and Camardese 1986.
Rat (CD)	LOAEL	10-day during gestation	Reduced maternal body weight gain		15	Chernoff and Carver 1976 as cited in ATSDR 1994
Rat (Osborne-Mendel)	LOAEL	6-week	Survival		128	NCI 1977 as cited in ATSDR 1994
Rat (Osborne-Mendel)	LOAEL	80-week	Survival of females, vaginal bleeding, leg paralysis and ataxia in males		27	NCI 1977 as cited in ATSDR 1994
Mouse (B6C3F1)	LOAEL	6-week	Survival		42	NCI 1977 as cited in ATSDR 1994
Mouse (B6C3F1)	LOAEL	80-week	Survival, decreased body weight, diarrhea, and labored breathing		25.7	NCI 1977 as cited in ATSDR 1994
Dog	LOAEL	13-week	Liver histopathogy		2	Chu *et al.* 1986 as cited in ATSDR 1994
Ring-necked pheasant	LOAEL	Not Specified	Reduced hatch and chick survival	100 mg/kg-diet	5.57	Pollock and Kilgore 1978 as cited in Eisler 1985
Black duck - ducklings	LOAEL	90-day	Growth and impaired backbone development	10 mg/kg-diet		Merhle *et al.* 1979 as cited in Eisler 1985
Bobwhite quail	LOAEL	4-month	Thyroid effects and behavioral abnormalities	5 mg/kg-diet	0.39	Pollock and Kilgore 1978 and Kreitzer 1980 as cited in Eisler 1985

Toxaphene Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Bobwhite quail 3-day old at start	LOAEL	20-week	Tempory behavioral abnormalities	10 mg/kg-diet	0.78	Pollock and Kilgore 1978 and Kreitzer 1980 as cited in Eisler 1985
Chicken	LOAEL	30-week	Chick bone defomation and kidney lesions	100 mg/kg-diet	4.84	Bush *et al.* 1977 as cited in Eisler 1985
Rat (Osborne-Mendel)	NOAEL	6-week	Growth - body weights		128	NCI 1977 as cited in ATSDR 1994
Rat	NOAEL	6-month	Reproduction		2.4	Peakall 1976 as cited in ATSDR 1994
Rat (Sprague-Dawley)	NOAEL	42-week	Reproduction		1.25	Kenndy *et al.* 1973 as cited in ATSDR 1994
Rat (Sprague-Dawley)	NOAEL	48-week	Reproduction		37	Chu *et al.* 1988 as cited in ATSDR 1994
Rat	NOAEL	2-year - multi-generation	No observable effect	20 mg/kg-diet	1.63	USEPA 1980 as cited in Eisler 1985
Rat	NOAEL	3-generations	Reproduction		8	Kenndy *et al.* 1973 as cited in Sample *et al.* 1996
Mouse (B6C3F1)	NOAEL	6-week	Growth - body weights		41.6	NCI 1977 as cited in ATSDR 1994
Mouse	NOAEL	2-year - multi-generation	No observable effect	20 mg/kg-diet	3.57	USEPA 1980 as cited in Eisler 1985
Mouse (Swiss)	NOAEL	5-6 generations	Reproduction	25 mg/kg-diet	4.89	Keplinger *et al.* 1970 as cited in RTI 1995
Dog	NOAEL	13-week	Liver histopathogy		0.2	Chu *et al.* 1986 as cited in ATSDR 1994
Dog	NOAEL	2-year	No observable effect	20 mg/kg-diet	0.62	USEPA 1980 as cited in Eisler 1985
Monkey	NOAEL	2-year	No observable effect	0.7 mg/kg-diet	0.028	Pollock and Kilgore 1978 as cited in Eisler 1985
Deer	NOAEL	Not specified	No observable effect	1000 mg/kg-diet	30.8	Schwartz and Nagy 1974 as cited in Eisler 1985
Cattle	NOAEL	19-week	No observable effect	306 mg/kg-diet	5.95	Pollock and Kilgore 1978 as cited in Eisler 1985
Chicken	NOAEL	Lifetime	Reproduction and development	3.8 mg/kg-diet	0.18	Bush *et al.* 1977 as cited in Eisler 1985
Black duck	NOAEL	2-Breeding seasons	Reproduction and development of chicks	10 mg/kg-diet	0.54	Haseltine *et al.* 1979 as cited in Eisler 1985

Toxaphene Oral Toxicity

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference

Mature Rat Body Weight (Averag male & female) = 0.325 kg, Reference is USEPA, 1987 EPA/600/6-87/008
Mature Rat Food Consumption (Average male & female) = 0.0265 kg/day, Reference is USEPA, 1987 EPA/600/6-87/008
Mature Dog Body Weight (average male & female) = 14 kg, Reference is USEPA, 1987 EPA/600/6-87/008
Mature Dog Food Consumption (average male & female - moist diet) = 0.435 kg/day, Reference is USEPA, 1987 EPA/600/6-87/008
White-tailed deer body weight = 56.5; Reference is Sample and Suter 1994
White-tailed deer Food Ingestion = 1.74 kg; Reference is Sample and Suter 1994
Swiss mouse body weight (average male and femeale) = 0.0332 kg; Reference is USEPA, 1987 EPA/600/6-87/008
Swiss mouse Food Ingestion (average male and femeale) = 0.0065 kg; Reference is USEPA, 1987 EPA/600/6-87/008
Average Cattle Body Weight = 329 kg Reference is USEPA, 1987 EPA/60/6-87/008
Cattle Food Ingestion (based on all animals) = 0.065 x $BW(kg)^{0.7919}$, Reference is USEPA, 1987, EPA/600/6-87/008
Mature Mouse Body Weight (average male & female) = 0.0325 kg, Reference in USEPA, 1987 EPA/600/6-87/008
Mouse Average Food Consumption = 0.0058 kg/day, Reference is USEPA, 1987, EPA 600/6-87/008
Average Monkey Body Weight = 9.45kg Reference is USEPA, 1987 EPA/60/6-87/008
Monkey Average Food Consumption = 0.38 kg/day, Reference is USEPA, 1987, EPA 600/6-87/008
Adult Quail Body Weight = (average over seasons) = 0.191 kg Reference is USEPA, 1993, EPA/600/R-93/187a
Adult Quail Food Consumption = (average over seasons) = 0.07776 g/g-BW Reference is USEPA, 1993, EPA/600/R-93/187a
14-day old Quail Body Weight = 13 to 20 g (average = 0.0165 kg), Reference is USEPA, 1993 EPA/600/R-93/187a
Average Chicken Body Weight =1.7 kg Reference is USEPA, 1987 EPA/600/6-87/008 (used USEPA 1993 formula for all birds for Food Consumption)
Black duck Body Weight = (average male and female) = 1250g: Reference is Dunning 1993
Ring-necked pheasant Body Weight = (average male and female) = 1135g: Reference is Dunning 1993
Bird Food Ingestion (based on all birds, kg/day) = 0.0582 x Body Weight $(kg)^{0.651}$ Reference is USEPA, 1993 EPA/600/R-93/187a

Polycyclic Aromatic Hydrocarbon Oral Toxicity

PAH	Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Low Molecular Weight Polycyclic Aromatic Hydrocarbon Oral Toxicity							
2-Methyl-naphthalene	Rat	LD50	Single Dose	Mortality		1,630	RTECS, Izmerov, Ctr. Internat. Projects, 1982
Flouranthene	Rat	LD50	Single Dose	Mortality		2000	RTECS, Am. Indust. Hyg. Assoc. J. 23:95, 1962
Phenanthrene	Rodent	LD_{50}	Single Dose	Mortality		700	Sims & Overcash 1978 as cited in Eisler, 1987
Naphthalene	Rodent	LD_{50}	Single Dose	Mortality		1780	Eisler, 1987
Naphthalene	Rat	LD_{50}	Single Dose	Mortality		2600	HSDB, Papciak & Mallory, J. Am. Coll. Toxicol. Pt. B, 1:17, 1990
Naphthalene	Rat (male)	LD_{50}	Single Dose	Mortality		2200	HSDB, USEPA, NTIS PB90-259821
Naphthalene	Rat (female)	LD_{50}	Single Dose	Mortality		2400	HSDB, USEPA, NTIS PB90-259821
Naphthalene	Mouse (male)	LD_{50}	Single Dose	Mortality		533	HSDB, USEPA, NTIS PB90-259821
Naphthalene	Mouse (female)	LD_{50}	Single Dose	Mortality		710	HSDB, USEPA, NTIS PB90-259821
Naphthalene	Rat	LD_{50}	Single Dose	Mortality		490	RTECS, Izmerov, et al., Moscow, Cnetre Internat. Projects, GKNT, 1982-:89
Naphthalene	Mouse	LD_{50}	Single Dose	Mortality		533	RTECS, Fundam. Appl. Toxicol. 4:406, 1984
Naphthalene	Guinea Pig	LD_{50}	Single Dose	Mortality		1200	RTECS, Gigiena i Sanitariya 47:78, 1982
Carbazole	Rat	LD_{LO}	Not Specified	Mortality		500	RTECS J. Pharmacol. Exper.Therap. 90:260 1947
Naphthalene	Rabbit	LD_{LO}	Single Dose	Mortality		3000	RTECS, Abdernalden's Handbuch der Biologischen Arbeitsmethoden, 4:1289, 1935
Naphthalene	Dog	LD_{LO}	Single Dose	Mortality		400	RTECS, Abdernalden's Handbuch der Biologischen Arbeitsmethoden, 4:1289, 1935
Naphthalene	Cat	LD_{LO}	Single Dose	Mortality		1000	RTECS, Abdernalden's Handbuch der Biologischen Arbeitsmethoden, 4:1289, 1935
Acenaphthalene	Mouse	LOAEL	90-day	Liver Damage		350	IRIS, Hazelton Laboratory, USEPA, 1989
Acenaphthalene	Rat	LOAEL	32-day	Growth, Liver & Kidney Histopathology		2000	HSDB, Knobloch, et al., Med. Pracy. 20:210, 1969
Dibenzofuran	Mouse	LOAEL	not specified	Growth		100	Shepard's Catalog Tetratogenic Agents 1989 as cited in the HSDB
Flourene	Mouse	LOAEL	13-week	Hematological Effects		250	IRIS, Toxcity Research Lab.s LTD, USEPA, 1989
Flourene	Mouse	LOAEL		Blood Chemistry		125	IRIS, USEPA, 1989
Naphthalene	Rabbit	LOAEL	2-week	Cataract		1000	HSDB, Amdur, et al., Casarett and Doull's Toxicology, 4th Ed., 1991

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Polycyclic Aromatic Hydrocarbon Oral Toxicity

PAH	Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Naphthalene	Rabbit	LOAEL	3-doses (gestation)	Cataracts & Retnal Damage in Offspring		16	HSDB, Shepard, Catal. Terat. Agents, 5th Ed., 1986
Naphthalene	Mouse	LOAEL	9-day (gestation)	Fetotoxicity		300	HSDB, USEPA, NTIS PB90-259821
Phenanthrene	Mouse	LOAEL	13-week	Liver Function	6370 mg/kg-total dose	70	RTECS, Hyg. Sanit. 29:19, 1964
2-Chloro-naphthalene	Mouse	NOAEL		Liver Size		250	USEPA 1989 as cited in IRIS
Acenaphthalene	Mouse	NOAEL		Hepatotoxicity		175	USEPA 1989 as cited in IRIS
Acenaphthalene	Mouse	NOAEL	90-day	Clinical Signs		175	IRIS, Hazelton Laboratory, USEPA, 1989
Anthracene	Mouse	NOAEL		No Observable Effects		1,000	USEPA 1989 as cited in IRIS
Anthracene	Mouse	NOAEL	90-day	Clinical Signs		1000	IRIS, Hazelton Laboratory, USEPA, 1989
Flourene	Mouse	NOAEL	13-week	Clinical Signs		125	IRIS, Toxcity Research Lab.s LTD, USEPA, 1989
Naphthalene	Mouse	NOAEL	14-day	Survival, Growth, Organ Weights		53	HSDB, USEPA, NTIS PB90-259821
Naphthalene	Rat	NOAEL	13-week	Survival, Growth, Organ Weights	50mg/kg-5x week	36	HSDB, USEPA, NTIS PB90-259821
Naphthalene	Mouse	NOAEL	13-week	Survival, Growth, Organ Weights	200mg/kg-5x week	143	HSDB, USEPA, NTIS PB90-259821
Low MW PAHs	Mallard	NOAEL	7-months	No Signs of Toxicity	4000 mg/kg-diet	212	Patton and Dieter 1980
High Molecular Weight Polycyclic Aromatic Hydrocarbon Oral Toxicity							
9,10-Anthracenedione	Mouse	LD50	Single Dose	Mortality		>5000	RTECS, Pest. Msnual 9:37, 1991
9,10-Anthracenedione	Quail	LD50	Single Dose	Mortality		>2000	RTECS, Farm Chemicals Handbook,-:c23, 1991
Benzo(a)pyrene	Rodent	LD50	Single Dose	Mortality		50	Eisler, 1987
Pyrene	Rat	LD50	Single Dose	Mortality		2700	RTECS, Labor Hyg. Prof. nye Zabolevaniya, Lab. Hyg. Occ. Die. 15:59, 1971
Pyrene	Mouse	LD50	Single Dose	Mortality		800	RTECS, Labor Hyg. Prof. nye Zabolevaniya, Lab. Hyg. Occ. Die. 15:59, 1971
Benz(a)-anthracene	Hamster	LOAEL	Single Dose	Spermagensis		900	RTECS, Acta Morph. Acad. Scient. Hungaricae 27:199, 1979
Benzo(a)pyrene	Rat	LOAEL	50-day (note A)	Fetotoxicity	2000 mg/kg-total dose	40	RTECS, Experimentia 20:244, 1964
Benzo(a)pyrene	Rat	LOAEL	41-day (Note B)	Live Birth Index	1344 mg/kg-total dose	32.8	RTECS, DOE Symposium Series 54:410, 1981
Benzo(a)pyrene	Rat	LOAEL	Gestation (Note C)	Fetotoxicity	1000 mg/kg-diet	88	HSDB, Shephard, Catal. Teretog. Agents, 4th Ed., 1983
Benzo(a)pyrene	Rat	LOAEL	Gestation	Fetotoxicity	not specified	50	Cervello et al. 1992 as cited in the HSDB
Benzo(a)pyrene	Mouse	LOAEL	10-day (gestation)	Delayed Effects on Newborn	100 mg/kg-total dose	10	RTECS, Internat. J. Abnormal Develop. 19:37a, 1979

Polycyclic Aromatic Hydrocarbon Oral Toxicity

PAH	Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Benzo(a)pyrene	Mouse	LOAEL	10-day (gestation)	Fertility and Fetal Body Weights		10	Mackenzie & Angvine 1981 as cited in Sample et al. 1996
Benzo(a)pyrene	Mouse	LOAEL	10-day (gestation)	Newborn Growth	100 mg/kg-total dose	10	RTECS, Biol. Reprod. 24:183, 1981
Benzo(a)pyrene	Mouse	LOAEL	Gestation	Fertility	Oral Intubation	10	Kristensen et al. 1995
Benzo(a)pyrene	Mouse	LOAEL	10-day (gestation)	Sterility of Offspring		40	HSDB, Shephard, Catal. Teretog. Agents, 4th Ed., 1983
Flouranthene	Mouse	LOAEL	13-week	Liver Pathology & Hematology		250	IRIS, Toxicity Res. Lab.s, USEPA, 1988
Pyrene	Mouse	LOAEL	13-week	Kindey Disfuction & Histopathology		125	IRIS, Toxicity Res. Lab.s, USEPA, 1989
Benzo(a)pyrene	Rodent	NOAEL	Single Dose	Testicular Damage		100	Eisler, 1987
Benzo(a)pyrene	Mouse	NOAEL	10-day (gestation)	Offspring Body, Reproduction		10	HSDB, IARC, V32:214, 1983
Benzo(a)pyrene	Chicken	NOAEL	Single Dose	Survival	250 mg-total dose	147	Rigdon, R,H. & J. Neal, Texas Rept. Biol. Med. 21(2):247-556, 1963
Benzo(a)pyrene	Duck	NOAEL	Single Dose	Survival	250 mg-total dose	220	Rigdon, R,H. & J. Neal, Texas Rept. Biol. Med. 21(2):247-556, 1963
Benzo(a)pyrene	Chicken	NOAEL	Not Specified	Fertility & Reproduction	100 mg/kg-diet	4.84	Rigdon, R,H. & J. Neal, Texas Rept. Biol. Med. 21(4):558-566, 1963
Benzo(a)pyrene	Chick	NOAEL	24-days	Growth and Survival	2500 mg/kg-diet	280	Rigdon, R,H. & J. Neal, Texas Rept. Biol. Med. 21(4):558-566, 1963
Flouranthene	Mouse	NOAEL	13-week	Liver Pathology & Hematology		125	IRIS, Toxicity Res. Lab.s, USEPA, 1989
Pyrene	Mouse	NOAEL	13-week	Kindey Disfuction & Histopathology		75	IRIS, Toxicity Res. Lab.s, USEPA, 1989

Note A, dosing began 28 days prior ot mating and continued through 22 days of pregnancy
Note B, dosing began 15 days prior to mating through 5 days after birth, assumed a gestation period of 21 days based on USEPA, 1987 Reference (EPA/600/6-87/008)
Note C, assume normal rat gestation = 21 day, adult female rat body = 0.25 kg, adult female food consumption = 0.022 kg/day EPA 600/6-89/008
Note D, dosing began 16 days prior to mating through 5 days after birth, assumed a gestation period of 21 days based on USEPA, 1987 Reference (EPA/600/6-87/008)
Chicken Body Weight = 1.7 kg, Reference in USEPA, 1987 EPA/600/6-87/008
Chick Body Weight at 1 day = 0.036 kg, at 21 days = 0.270 kg (average = 0.153 kg) Reference in USEPA, 1987 EPA/600/6-87/008
Bird Food Ingestion (based on all birds) = $0.0582 \times BW(kg)^{0.651}$, Reference is USEPA 93, EPA/600/R-93/187a
Adult Mallard Body Weight during experiment = 1.3 kg Reference is Patton and Dieter 1980
Adult Duck Body Weight (based on Mallard) = 1.134 kg Reference is USEPA, 1993 EPA/600/R-93/187a

Polychlorinated Biphenyls Oral Toxicity - Mammals

Test Species	Endpoint	Duration	Aroclor Form	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat	LD_{50}	Not Reported	1016	Mortality		2300	RTECS, National Technical Information Service PB85-143766
Rat (Male - S/D)	LD_{50}	Single Dose	1242	Mortality	gavage in oil	4,250	Bruckner et al. 1973 as cited in ATDSR 1996
Rat (NS)	LD_{50}	Not Reported	1242	Mortality		794-1269	HSDB, USEPA, AWQCD: PCBs, p. C-35 (1980) EPA 440/5-80-068
Rat (NS)	LD_{50}	Single dose	1242	Mortality		800-8700	EPA 1980, NAS 1979 as cited in Eisler 1986
Mink	LD_{50}	Not Reported	1242	Mortality		3	Aulerich & Ringer 1977 as cited in Eisler 1986
Mink	LD_{50}	9 months	1242	Mortality	8.6 mg/kg diet	2	Ringer 1983 as cited in Eisler 1986
Rat (NS)	LD_{50}	Single dose	1248	Mortality		800-11,000	EPA 1980, NAS 1979 as cited in Eisler 1986
Rat	LD_{50}	Not Reported	1248	Mortality		11,000	RTECS, Annual Review of Pharmacology 14:139, 1974
Rat	LD_{50}	Single dose	1254	Mortality		500 - 1400	Hudson et al. 1984 as cited in Eisler 1986
Rat (Male - O/M)	LD_{50}	Single dose	1254	Mortality	gavage in oil	1010	Garthoff et al. 1981 as cited in ATSDR 1996
Rat (Male - S)	LD_{50}	Single dose	1254	Mortality	gavage in oil	1295	Linder et al 1974 as cited in ATSDR 1996
Rat	LD_{LO}	8-month	1254	Mortality	500 mg/kg-diet	40.8	EPA 440/5-80-068, 1980
Mouse (Male - ICR)	LD_{50}	2-week	1254	Mortality	in diet but conc. not provided	130	Sanders et al. 1974 as cited in ATSDR 1996
White-footed mouse	LD_{50}	3-week	1254	Mortality	>100 mg/kg-diet	19.5	Sanders & Kirkpatrick 1977 as cited in Eisler 1986
Raccoon	LD_{50}	8-day	1254	Mortality	>50 mg/kg-diet	2.5	Montz et al. 1982 as cited in Eisler 1986
Cottontail Rabbit	LD_{50}	12-week	1254	Mortality	>10 mg/kg-diet	0.6	Zepp & Kirkpatrick 1976 as cited in Eisler 1986
Mink	LD_{50}	Single dose	1254	Mortality	gavage	4000	Aulerich & Ringer 1977 as cited in Eisler 1986
Mink	LD_{50}	9-month	1254	Mortality	6.7 mg/kg-diet	1.5	Ringer et al. 1984 as cited in Eisler 1986
Rat (Male - S)	LD_{50}	Single dose	1260	Mortality	gavage in oil	1315	Linder et al 1974 as cited in ATSDR 1996
Rat	LD_{50}	Single dose	1260	Mortality		1300 - 10000	NAS 1979 as cited by Eisler 1986
Rat	LD_{50}	Single dose	1262	Mortality		1300 - 3200	EPA 1980, NAS 1979 as cited in Eisler 1986
Rat	LD_{50}	Single dose	1262	Mortality		11300	RTECS, Ann. Rev. Pharmacol., 1974
Rat	LOAEL	21-day	1016	Fertility		2	RTECS, Toxicologist 12:320, 1992
Mouse	LOAEL	6-week	1016	Immune Resistance	5 mg/kg-diet	0.65	Loose et al. 1978 as cited in IRIS 1996
Mink	LOAEL	18-month	1016	Kit Growth	25 mg/kg-diet	3.43	Aulerich & Ringer 1980 as cited in Sample et al. 1996

Polychlorinated Biphenyls Oral Toxicity - Mammals

Test Species	Endpoint	Duration	Aroclor Form	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Mink	LOAEL	247-day	1016	Reproductive Succes and Postnatal Mortality	20 mg/kg-diet	3.80	Bleavins et al. 1980 as cited in IRIS 1996
Rhesus Monkey (Female)	LOAEL	18.2-month	1016	Birth Weight	in diet but conc. not provided	0.03	Levin et al. 1988 as cited in ATSDR 1996
Rhesus Monkey (Female)	LOAEL	18.2-month	1016	Birth Weight and Behavior	in diet but conc. not provided	0.03	Schantz et al. as cited in ATSDR 1996
Rhesus Monkey	LOAEL	22-month	1016	Birth Weights	1 mg/kg-diet	0.028	Barsotti & van Miller as cited in IRIS 1996
Rat (S/D)	LOAEL	Single dose	1242	Ataxia & Coma	gavage in oil	6000	Bruckner et al. 1973 as cited in ATSDR 1996
Rat (S/D)	LOAEL	2-month	1242	Increased Liver Weight	in diet but conc. not provided	0.3	Bruckner et al. 1974 as cited in ATSDR 1996
Rat (F-344)	LOAEL	21-day post natal	1242	Lethargy and Abnormal Behavior	gavage in oil	2.0	Pantaleoni et al. 1988 as cited in ATSDR 1996
Mouse (BALB/C)	LOAEL	6-week	1242	Reduced Resistance to Disease	in diet but conc. not provided	22.0	Loose et al. 1978 as cited in ATSDR 1996
Pig	LOAEL	91-day	1242	Reduced Growth	20 mg/kg-diet	9.2	Hansen et al. 1976 as cited in ATSDR 1996
Pig	LOAEL	16 weeks	1242	Birth Weights		5.8	RTECS, Amer. J. of Veterinary Research 36:23, 1975
Ferret	LOAEL	9-month	1242	Reproductive failure	20 mg/kg-diet	1.4	Bleavins et al. 1980 as cited in Fuller & Hobson 1986
Mink	LOAEL	7-months	1242	Reproductive failure	5 ppm of diet	0.69	Bleavins et al. 1980 as cited in Sample et al. 1996
Rat	LOAEL	6-weeks	1248	Growth	1000 mg/kg-diet	82	Allen & Abrahamson 1973 as cited in NIOSH 1977
Rat (Male W)	LOAEL	20-day	1248	Increased Liver Weight	in diet but conc. not provided	15	Kato et al. 1982 as cited in ATSDR 1996
Mouse (ARSF1)	LOAEL	5-week	1248	Reduced Resistance to Disease	in diet but conc. not provided	13.0	Thomas & Hinsdill 1978 as cited in ATSDR 1996
Mouse	LOAEL	26-weeks	1248	Increased Liver Weight		12.8	RTECS, Ach. Environ. Health 21:620, 1970
New Zealand Rabbit (Females)	LOAEL	4-weeks	1248	Growth of Offspring	250 mg/kg-diet	7.63	Thomas & Hinsdill 1980 as cited in IRIS 1996
New Zealand Rabbit (Females)	LOAEL	11-weeks	1248	Liver Histopathology in pups		28.0	Thomas & Hinsdill 1980 as cited in ATSDR 1996
Rhesus Monkey (Female)	LOAEL	7-months	1248	Reduced Live-Birth Rates	2.5 mg/kg-diet	0.1	Barsotti et al. 1976 as cited in Sample et al. 1996

Polychlorinated Biphenyls Oral Toxicity - Mammals

Test Species	Endpoint	Duration	Aroclor Form	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rhesus Monkey (Female)	LOAEL	2-months	1248	Decreased Conception	in diet but conc. not provided	4.3	Allen 1974 as cited in ATSDR 1996
Rhesus Monkey (Female)	LOAEL	18-month	1248	Infant Survival	in diet but conc. not provided	0.1	Allen & Barsotti 1976 as cited in ATSDR 1996
Rhesus Monkey (Female)	LOAEL	18-month	1248	Infant Survival	in diet but conc. not provided	0.1	Allen et al. 1980 as cited in ATSDR 1996
Rhesus Monkey (Female)	LOAEL	18.2-month	1248	Birth Weight and Behavior	in diet but conc. not provided	0.08	Levin et al. 1988 as cited in ATSDR 1996
Rhesus Monkey (Female)	LOAEL	18.2-month	1248	Birth Weight and Behavior	in diet but conc. not provided	0.08	Schantz et al. as cited in ATSDR 1996
Rhesus Monkey (Male)	LOAEL	2-months	1248	Gastric Ulceration	in diet but conc. not provided	4	Allen 1975; Allen & Norback 1976 as cited in ATSDR 1996
Rhesus Monkey (Male)	LOAEL	2-months	1248	Weight Loss	in diet but conc. not provided	12	Allen 1975; Allen & Norback 1976 as cited in ATSDR 1996
Rhesus Monkey (Male)	LOAEL	3-months	1248	Pericardial Edema, Gastric Ulceration, and Weight Loss	in diet but conc. not provided	12	Allen et al. 1973; Allen & Norback 1973 as cited in ATSDR 1996
Rat (Female W)	LOAEL	2-week	1254	Growth	in diet but conc. not provided	50	Kling et al. 1978 as cited in ATSDR 1996
Rat (W)	LOAEL	Gestation - Lactation	1254	Birth Weight, Growth, and Pup Survival	269 mg/kg-diet	13.5	Overman et al. 1987 as cited in IRIS 1996
Rat (S)	LOAEL	186-day	1254	Growth and Pup Survival	100 mg/kg-diet	7.2	Linder et al. 1974 as cited in IRIS 1996
Rat (S)	LOAEL	2-generation	1254	Reduced Litter Size	20 mg/kg-diet	1.5	Linder et al. 1974 as cited in IRIS 1996
Rat (W)	LOAEL	1-month	1254	Fertility, Litter Size, and Pup Survival	in diet but conc. not provided	30	Brezner et al. 1984 as cited in ATSDR 1996
Rat (S)	LOAEL	9-day - gestation	1254	Pup Survival	gavage in oil	100	Linder et al. 1974 as cited in ATSDR 1996
Rat (H)	LOAEL	9-day - lactation	1254	Decreased Fertility and Reproductive Success in F1 Generation	gavage in oil	8	Sager et al. 1987 as cited in ATSDR 1996
Rat (H)	LOAEL	9-day - lactation	1254	Decreased Fertility and Deveolpmental Effects	gavage in oil	32	Sager 1983 as cited in ATSDR 1996
Rat (S/D)	LOAEL	10-day - gestation	1254	Fetal Body Weight and Survival	in diet but conc. not provided	5	Spencer 1982 as cited in ATSDR 1996

Polychlorinated Biphenyls Oral Toxicity - Mammals

Test Species	Endpoint	Duration	Aroclor Form	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat (F-344)	LOAEL	5-week	1254	Increased Liver & Kidney Weights	gavage in oil	10	Andrews 1989 as cited in ATSDR 1996
Rat (F-344)	LOAEL	5-week	1254	Growth	gavage in oil	25	Andrews 1989 as cited in ATSDR 1996
Rat (Female S)	LOAEL	2-month	1254	Increased Liver Weight	in diet but conc. not provided	5	Goldstein et al. 1974 as cited in ATSDR 1996
Rat (Male F-344)	LOAEL	15-week	1254	Increased Liver Weight	gavage in oil	1	Gray et al. 1993 as cited in ATSDR 1996
Rat (Male F-344)	LOAEL	15-week	1254	Growth	gavage in oil	10	Gray et al. 1993 as cited in ATSDR 1996
Rat (Male F-344)	LOAEL	15-week	1254	Reduced Sperm Count	gavage in oil	25	Gray et al. 1993 as cited in ATSDR 1996
Rat (Male F-344)	LOAEL	104-week	1254	Decreased Survival	in diet but conc. not provided	2.5	NCI 1978 as cited in ATSDR 1996
Rat (Male F-344)	LOAEL	104-week	1254	Growth	in diet but conc. not provided	1.25	NCI 1978 as cited in ATSDR 1996
Rat (S)	LOAEL	8-month	1254	Growth	in diet but conc. not provided	36.4	Kimbrough et al. 1972 as cited in ATSDR 1996
Rat (W)	LOAEL	30-day	1254	Growth	in diet but conc. not provided	50.0	Kling et al. 1978 as cited in ATSDR 1996
Rat (W)	LOAEL	52-week	1254	Growth	in diet but conc. not provided	10	Phillips et al. 1972 as cited in ATSDR 1996
Rat (S/D)	LOAEL	10-gestation	1254	Decreased Fetal Weight	900 mg/kg-diet	21.5	HSDB, Spencer, Bull. Environ. Contam. Toxicol. 28:270, 1982
Rat (S/D)	LOAEL	35-day	1254	Liver Weight	in diet but conc. not provided	1.3	Bruckner et al. 1977 as cited in ATSDR 1996
Rat (W)	LOAEL	9-week	1254	Fetal Reabsorption	70 mg/L in drinking water	9.7	Baker et al 1977 as cited in Fuller & Hobson 1986
Mouse (Female ICR)	LOAEL	108-days	1254	Decreased Conception	in diet but conc. not provided	2.5	Welsh 1985 as cited in ATSDR 1996
Mouse (BALB/C)	LOAEL	11-month	1254	Liver Necrosis and Adenofibrosis	in diet but conc. not provided	49.8	Kimbrough & Linder 1974 as cited in ATSDR 1996
Mouse (BALB/C)	LOAEL	6-month	1254	Liver Weight and Necrosis	in diet but conc. not provided	4.88	Koller 1977 as cited in ATSDR 1996
Rabbit (NS)	LOAEL	28-day - gestation	1254	Fetotoxicity	gavage in oil	12.5	Villeneuve et al. 1971 as cited in ATSDR 1996
Rabbit (NZ)	LOAEL	14-week (dosed 1@wk)	1254	Reduced Uterus Size	Oral Intubation	300	Koller & Zinkle 1973 as cited in Fuller & Hobson 1986
Pig	LOAEL	182-days	1254	Fewer Pigs	in diet but conc. not provided	1.0	Earl et al. 1974 as cited in Fuller&Hobson 1986
Pig	LOAEL	11-day	1254	Gastric Ulceration	Gavage	100	Hansen et al. 1976 as cited in ATSDR 1996
Dog (Beagle)	LOAEL	60-day	1254	Fetal Reabsorbation	in diet but conc. not provided	5.0	Earl et al. 1974 as cited in Fuller&Hobson 1986

Polychlorinated Biphenyls Oral Toxicity - Mammals

Test Species	Endpoint	Duration	Aroclor Form	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Dog (Beagle - male)	LOAEL	2-year	1254	Effects on Spermogenesis and Testes Size	100 mg/kg-diet	3.1	Kimbrough et al. 1973 as cited in Fuller & Hobson 1986
Mink	LOAEL	8-month	1254	Reproductive Failure	2 mg/kg-diet	0.4	Aulerich & Ringer 1977 as cited in IRIS 1996
Mink	LOAEL	6-month	1254	Offspring Mortality	1 mg/kg-diet	0.15	Wren et al. 1987 as cited in IRIS 1996
Mink	LOAEL	4-month	1254	Reproductive Failure	5 mg/kg-diet	0.69	Aulerich & Ringer 1977 as cited in Sample et al. 1996
Mink	LOAEL	28-day	1254	Growth	in diet but conc. not provided	1.8	Hornshaw et al. 1986 as cited in ATSDR 1996
Mink	LOAEL	90-day	1254	100% Stillbirths	in diet but conc. not provided	1.3	Kihlstrom et al. as cited in ATSDR 1996
White-Footed Mouse	LOAEL	2-3-weeks	1254	Frank Effect Level on Reproduction	400 mg/kg-diet	62	Sanders & Kirkpatrick 1975 as cited in Sample et al. 1996
White-Footed Mouse	LOAEL	60-day	1254	Reproductive Effects	200 mg/kg-diet	31	Merson & Kirkpatrick 1976 as cited in Sample et al. 1996
White-Footed Mouse	LOAEL	18-month	1254	Reduced Litter Size	10 mg/kg-diet	1.35	Linzey 1987 as cited in Sample et al. 1996
Oldfield Mouse	LOAEL	12-month	1254	Reduced Litter Size and Pup Survival	5 mg/kg-diet	0.68	McCoy et al. 1995 as cited in Sample et al. 1996
Rhesus Monkey	LOAEL	5-year	1254	Immune Response	in the diet adjusted to body weight	0.005	Tryphonas et al. 1991 as cited in IRIS 1996
Rhesus Monkey	LOAEL	14-month	1254	Birth Weight and Infant Growth	in the diet adjusted to body weight	0.025	Levinskas et al. 1984 as cited in IRIS 1996
Rhesus Monkey (Female)	LOAEL	14-month	1254	Fertility, Live Births, and Survival	in the diet adjusted to body weight	0.1	Levinskas et al. 1984 as cited in IRIS 1996
Rhesus Monkey (Female)	LOAEL	38-week	1254	Conception and Fetotoxicity	in diet but conc. not provided	0.2	Arnold et al. 1990 as cited in ATSDR 1996
Rhesus Monkey (Female)	LOAEL	267-day	1254	Fetotoxicity and Development Effects	in the diet adjusted to body weight	0.1	Truelove et al. 1982 as cited in IRIS 1996
Rhesus Monkey (Female)	LOAEL	121-week	1254	Fetotixicty	in the diet adjusted to body weight	0.2	Tryphonas et al. 1986 as cited in IRIS 1996
Rat (Female S)	LOAEL	8-month	1260	Growth	in diet but conc. not provided	38.2	Kimbrough et al. 1972 as cited in ATSDR 1996
Rat (S)	LOAEL	67-day	1260	Litter Size	in diet but conc. not provided	35.4	Linder et al. 1974 as cited in ATDSR 1996
Rat	LOAEL	186-day	1260	Litter Size/Pup Survival	500 mg/kg-diet	40.8	Fuller&Hobson, Capt. 7 Vol 2 In PCBs and the Environ. CRC Press (1986)

Polychlorinated Biphenyls Oral Toxicity - Mammals

Test Species	Endpoint	Duration	Aroclor Form	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Mink	NOAEL	18-month	1016	Reproduction/Kit Growth	10 mg/kg-diet	1.37	Aulerich & Ringer 1980 as cited in Sample et al. 1996
Mink	NOAEL	39-week	1016	Reproduction/Kit Growth	2 mg/kg-diet	0.4	Aulerich & Ringer 1977 as cited in IRIS 1996
Ferret	NOAEL	9-month	1016	Reproduction	20 mg/kg-diet	1.4	Beavins et al. 1980 as cited in Fuller & Hobson 1986
Rhesus Monkey (Female)	NOAEL	22-month	1016	Birth Weights and Learning Behavior	0.25 mg/kg-diet	0.007	Barsotti & van Miller as cited in IRIS 1996
Rhesus Monkey (Female)	NOAEL	18.2-month	1016	Birth Weight	in diet but conc. not provided	0.007	Levin et al. 1988 as cited in ATSDR 1996
Rhesus Monkey (Female)	NOAEL	18.2-month	1016	Birth Weight and Behavior	in diet but conc. not provided	0.007	Schantz et al. as cited in ATSDR 1996
Pig-tailed Macaque (Male)	NOAEL	20-week	1016	Clinical Signs, Growth	in the diet adjusted to body weight	3.2	Seegal et al. 1991 as cited in IRIS 1996
Rat (S/D)	NOAEL	2-month	1242	Growth	in diet but conc. not provided	1.5	Bruckner et al. 1974 as cited in ATSDR 1996
Rat (S/D)	NOAEL	10-day gestation	1242	Fertility of F1 generation	not specified	30	Gellart & Wilson 1979 as cited in Fuller & Hobson 1986
Rat (F-344)	NOAEL	21-day post natal	1242	Lethargy and Abnormal Behavior	gavage in oil	1	Pantaleoni et al. 1988 as cited in ATSDR 1996
Mink	NOAEL	247-day	1242	Growth and Gastric Ulceration	2 mg/kg-diet	0.9	Bleavins et al. 1980 as cited in ATSDR 1996
Rat	NOAEL	8-week	1248	Growth	300 mg/kg-diet	24.5	HSDB, Quazi, et al., Agri. Biol. Chem. 48:1581-1586, 1984
Rat	NOAEL	4-week	1248	Clinical Signs	100 mg/kg-diet	8.15	Alen et al. 1975 as cited in NIOSH 1977
New Zealand Rabbit (Females)	NOAEL	4-week	1248	Reproduction/Growth of Offspring	100 mg/kg-diet	3.05	Thomas & Hinsdill 1980 as cited in IRIS 1996
Rhesus Monkey (Female)	NOAEL	18.2-month	1248	Birth Weight and Behavior	in diet but conc. not provided	0.03	Schantz et al. as cited in ATSDR 1996
Rat (Male F-344)	NOAEL	4-day	1254	Growth	in diet but conc. not provided	3.9	Carter 1984 as cited in ATSDR 1996
Rat (Male F-344)	NOAEL	4-day	1254	Growth	in diet but conc. not provided	1.9	Carter 1985 as cited in ATSDR 1996

Polychlorinated Biphenyls Oral Toxicity - Mammals

Test Species	Endpoint	Duration	Aroclor Form	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Rat (Male F-344)	NOAEL	2-week	1254	Growth	in diet but conc. not provided	1.9	Carter & Koo 1984 as cited in ATSDR 1996
Rat (Female W)	NOAEL	10-day gestation	1254	Reproductive Success	gavage in oil	100	Villeneuve et al. 1971 as cited in ATSDR 1996
Rat (S)	NOAEL	9-day - gestation	1254	Reproductive Success	gavage in oil	50	Linder et al. 1974 as cited in ATSDR 1996
Rat (H)	NOAEL	9-day - lactation	1254	Fertility and Deveolpment	gavage in oil	8	Sager 1983 as cited in ATSDR 1996
Rat (S/D)	NOAEL	10-day - gestation	1254	Fetal Body Weight and Survival	in diet but conc. not provided	2.5	Spencer 1982 as cited in ATSDR 1996
Rat (F-344)	NOAEL	5-week	1254	Liver & Kidney Weights	gavage in oil	1	Andrews 1989 as cited in ATSDR 1996
Rat (F-344)	NOAEL	5-week	1254	Growth	gavage in oil	10	Andrews 1989 as cited in ATSDR 1996
Rat (S/D)	NOAEL	35-day	1254	Liver Weight	in diet but conc. not provided	0.3	Bruckner et al. 1977 as cited in ATSDR 1996
Rat (Female S/D)	NOAEL	5-month	1254	Growth	in diet but conc. not provided	4.3	Byrne et al. 1987 as cited in ATSDR 1996
Rat (Female S)	NOAEL	2-month	1254	Growth	in diet but conc. not provided	5.0	Goldstein et al. 1974 as cited in ATSDR 1996
Rat (Male F-344)	NOAEL	15-week	1254	Liver Weight	gavage in oil	0.1	Gray et al. 1993 as cited in ATSDR 1996
Rat (Male F-344)	NOAEL	15-week	1254	Growth	gavage in oil	1	Gray et al. 1993 as cited in ATSDR 1996
Rat (Male F-344)	NOAEL	15-week	1254	Reproductive Success	gavage in oil	10	Gray et al. 1993 as cited in ATSDR 1996
Rat (W)	NOAEL	52-week	1254	Growth	in diet but conc. not provided	1	Phillips et al. 1972 as cited in ATSDR 1996
Rat (S)	NOAEL	8-month	1254	Growth	in diet but conc. not provided	7.5	Kimbrough et al. 1972 as cited in ATSDR 1996
Mouse (BALB/C)	NOAEL	11-month	1254	Growth	in diet but conc. not provided	49.8	Kimbrough & Linder 1974 as cited in ATSDR 1996
Mouse (BALB/C)	NOAEL	6-month	1254	Liver Weight and Necrosis	in diet but conc. not provided	0.49	Koller 1977 as cited in ATSDR 1996
Mouse (ICR)	NOAEL	108-days through gestation	1254	Fertility, Litter Size, Devolpment, Growth	100 mg/kg-diet	12.5	Welsh 1985 as cited in IRIS 1996
Rabbit (NZ)	NOAEL	8-week	1254	Body Weight	in diet but conc. not provided	6.5	Street & Sharma 1975 as cited in ATSDR 1996
Rabbit (NS)	NOAEL	28-day - gestation	1254	Reproduction	gavage in oil	10	Villeneuve et al. 1971 as cited in ATSDR 1996
Cow	NOAEL	180-day	1254	Reproduction	1000 mg/day	3	HSDB, Willett, et al., Fundam. Appl. Toxicol. 9:60, 1987
Dog (Beagle)	NOAEL	60-day (Including gestation)	1254	No effects on reproduction		1.0	Earl et al. 1974 as cited in Fuller & Hobson 1986
Mink	NOAEL	4.5-month	1254	Reproduction	1 mg/kg-diet	0.14	Aulerich & Ringer 1977 as cited in Sample et al. 1996

Polychlorinated Biphenyls Oral Toxicity - Birds

Test Species	Endpoint	Duration	Effect	Concentration	Dose (mg/kg-BW/day)	Reference
Screech Owl	NOAEL	2-breeding seasons (1248)	Reproductive Effects	3 mg/kg-diet	0.4	McLane & Huges 1980 as cited in Eisler 1986
Japanese Quail	NOAEL	8-weeks (1248)	Reproductive Effects	20 mg/kg-diet	8.1	Peakall, Capt. 3 Vol 2 In PCBs and the Environ. CRC Press (1986)
Japanese Quail	NOAEL	Long-Term (1254)	Reproductive Effects	50 mg/kg-diet	3.9	NAS 1979 as cited in Eisler 1986
Bobwhite Quail	NOAEL	Long-Term (1254)	Reproductive Effects	50 mg/kg-diet	3.9	NAS 1979 as cited in Eisler 1986
Mallard	NOAEL	2-seasons (1254)	Reproductive Effects	25 mg/kg-diet	1.4	Custer & Heinz 1980 as cited in Eisler 1986
Chicken	NOAEL	9-weeks (1254)	Reproductive Effects	2 mg/kg-diet	0.10	Peakall, Capt. 3 Vol 2 In PCBs and the Environ. CRC Press (1986)
Ring Dove	NOAEL	56-day (1254)	Survival	100 mg/kg-diet	11.2	Peakall, Capt. 3 Vol 2 In PCBs and the Environ. CRC Press (1986)
White pelican	NOAEL	70-day (1254)	Survival	144 mg/kg-diet	27.2	Peakall, Capt. 3 Vol 2 In PCBs and the Environ. CRC Press (1986)
Am. Kestrel	NOAEL	100-day (1254)	Survival	5 mg/kg-diet	0.62	Peakall, Capt. 3 Vol 2 In PCBs and the Environ. CRC Press (1986)

10-day old Quail Body Weight = 10 to 13 g (average = 0.0115 kg) Reference is USEPA, 1993, EPA/600/R-93/187a
14-day old Quail Body Weight = 13 to 20 g (average = 0.0165 kg), Reference is USEPA, 1993 EPA/600/R-93/187a
10-day old Mallard Body Weight = 92 to 115 g (average = 0.1035 kg), Reference is USEPA, 1993 EPA/600/R-93/187a
Red Winged Blackbird Body Weight = (mid-point in range) 0.05 kg Reference is Dunning, 1993
Bird Food Ingestion (based on all birds, kg/day) = 0.0582 x Body Weight $(kg)^{0.651}$ Reference is USEPA, 1993 EPA/600/R-93/187a
Adult Quail Body Weight = (average over seasons) = 0.191 kg Reference is USEPA, 1993, EPA/600/R-93/187a
Adult Quail Food Consumption = (average over seasons) = 0.07776 g/g-BW Reference is USEPA, 1993, EPA/600/R-93/187a
Adult Mallard Body Weight = (average male & female) = 1.134 kg Reference is USEPA, 1993, EPA/600/R-93/187a
Adult Robin Body Weight (for dove, cowbird & starling) = (average over seasons) = 0.0773 kg Reference is USEPA, 1993, EPA/600/R-93/187a
Adult Robin Food Consumption (for dove, cowbird, & starling) = (average over seasons) = 1.205 g/g-BW Reference is USEPA, 1993, EPA/600/R-93/187a
Average Chicken Body Weight (female) =1.6 kg Reference is USEPA, 1987 EPA/600/6-87/008 (used USEPA 1993 formula for all birds for Food Consumption)
Average Kestrel Body Weight =0.116 kg Reference is USEPA, 1993 EPA/600/R-93/187 used USEPA 1993 formula for all birds for Food Consumption)
Average Dove Body Weight =0.155 kg Reference is Opresko, et al. 1994 used USEPA 1993 formula for all birds for Food Consumption)
Average Pelican Body Weight = 3.5 kg, Food ingestion 0.66 kg/day, Reference is Opresko, et al. 1994