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FINAL ECOLOGICAL RISK ASSESSMENT
FOR
AMERICAN CHEMICAL SERVICES
GRIFFITH, INDIANA

MARCH 1992

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SECTION 1

INTRODUCTION

1.1 PURPOSE AND SCOPE

This ecological assessment is a screening-level evaluation of the environmental risks associated with contamination at the ACS site. This evaluation focuses on identifying potential adverse effects of contamination on flora and fauna in the nearby wetland and in on-site upland habitats. This assessment is based primarily on data presented in the ACS Remedial Investigation (RI) report prepared 1990 by Warzyn, Inc. in November (Warzyn, 1990) and the Final Draft Ecological Assessment prepared by Warzyn, Inc. in April 1991 (Warzyn, 1991).

This report is not intended to be a stand-alone document. This assessment uses the information presented in the ecological risk assessment prepared by Warzyn (Warzyn, 1991), while incorporating the comments made by the U.S. EPA Biological Technical Assistance Group (BTAG).

1.2 STUDY AREA DESCRIPTION

The ecological assessment of the ACS site examines an approximately 130 acre watershed in which the ACS site is located (Figure 7-3, Warzyn, 1991). The watershed lies between transportation corridors and consists of predominantly upland and wetland habitats. The RI indicates that this watershed is hydrologically isolated. Water sources are primarily rainfall, snowmelt, and groundwater discharge into the wetlands; discharge is primarily through evaporation and infiltration (Warzyn, 1991, Subsection 7.2.3.1)

1.2.1 Surface Water Features

Surface water features within the watershed include drainage ditches and industrial ponds. Surface water runoff is toward the west and south (Warzyn, 1990, Subsection 4.4.2).

A drainage ditch flows into the site at the northern boundary (directly north of the western ACS fence line), and then flows west along the northern site boundary and into the drainage ditch that cuts north to south through Wetland I. Another drainage ditch is located along the south side of the Chesapeake and Ohio Railroad tracks. This ditch drains into Wetland II. Drainage from the landfill and the off-site containment area are routed into a City of Griffith sanitary sewer. During a field visit by members of the BTAG, it was noted that the drainage ditches are not ephemeral. The United States Fish and Wildlife Service (U.S. F&WS) wetlands delineation documented fish in the ditch through Wetland I (Nims, 1990).

Ponds on the site include a fire pond and a process lagoon on the ACS grounds and a dewatering pond at the landfill. Neither ACS pond provides aquatic habitat, due to their industrial use. The dewatering pond is continually pumped in anticipation of future use.

1.2.2 Site Wetlands

The U.S. F&WS (Nims, 1990) has delineated and described two wetland areas in the site watershed which are separated by the Chesapeake and Ohio Railroad grade. The northern wetland, Wetland I, is approximately 29 acres; Wetland II, south of the railroad, covers approximately 5 acres. Shallow groundwater flows from the upland site areas to Wetlands I and II; thus, these areas function as groundwater discharge areas for at least a portion of the year.

1.2.3 Upland Habitats

Mature oak forests are located on the western and northeastern corners and the eastern side of the site (Warzyn, 1990, Subsection 7.2.3.4). The perimeter of the woods includes species typical of disturbed areas, such as cottonwoods, aspens, and sumacs. The inactive landfill and parts of the off-site containment area provide some field (grassland) habitat. The remaining terrestrial areas on the site are developed or are devoid of vegetation. The ACS site property is fenced and devoid of vegetation; the landfill is either actively operated and bare or has scarce cover on inactive portions; and the Kapica Drum property consists of buildings and a crushed gravel surface (Warzyn, 1990, Subsection 7.2.3.4).

1.2.4 Endangered Species and Significant Areas

The U.S. F&WS report (Nims, 1990) suggested that the area around Griffith, Indiana may provide habitat for several Federal or state endangered or threatened species. The King Rail, a state threatened species, was observed by the U.S. F&WS during a site visit. Other endangered or threatened species are suspected on the site based on observations of available habitat made by the U.S. F&WS.

The ACS site is not included as a designated area of special biological significance by the Indiana Department of Natural Resources (IDNR). Approximately 1.2 miles west of the site is the Hoosier Prairie State Nature Preserve, a relatively undeveloped property managed by the IDNR (Warzyn, 1991, Subsection 7.2.7.4).

Although the site is not designated as a special area in the Natural Heritage Program database, threatened or endangered species or unique plant communities could still exist on site. The database is a growing database listing known sensitive areas. Important unknown areas are likely to exist in the state. A reconnaissance survey by a trained biologist to determine whether sensitive species/communities are present has been recommended by U.S. EPA. Due to the season, this survey cannot be completed at this time.

SECTION 2

CONTAMINANTS OF CONCERN

Chemicals of potential concern in each medium for each on-site habitat were selected based on a comparison of contaminant concentrations with toxicity criteria and background concentrations, as well as on the chemical persistence, bioaccumulation potential, and toxicity of the contaminant. Detailed information on the extent of contamination sampling at the ACS site is presented in Section 5 of the RI (Warzyn, 1990).

The on-site habitats and environmental media sampled in each were:

- Wetlands - shallow aquifer groundwater, soil/sediments.
- Drainage ditches - surface water, sediments.
- Terrestrial habitats - off-site containment area surface soils.

Surface waters in the on-site drainage ditches were sampled as part of the RI (Warzyn, 1990, Section 5). Water samples were collected from the drainage from the off-site containment (SW05), the ditch west of ACS (SW07A), and the wetlands east of the landfill (SW08).

No surface water samples were collected directly from the wetlands. Since the wetlands receive groundwater discharge, contaminant concentrations in the shallow aquifer monitoring wells (MW-1 to MW-6 and MW-11 to MW-18) were used without dilution as estimates of the surface water concentrations in the wetlands.

The maximum detected surface water and shallow aquifer groundwater concentrations in both the drainage ditches and wetlands are compared with either Federal Ambient Water Quality Criteria (AWQC) for the protection of freshwater life or the Lowest Reported Toxic Concentrations found in the literature in Table 2-1. Lowest reported toxic concentrations are provided for chemicals for which the minimum data required to derive water quality criteria are not available. All contaminants that exceeded either value were considered to be contaminants of concern. Based on this comparison, lead, iron, zinc, cadmium, mercury, cyanide, polychlorinated biphenyls (PCBs), chlorobenzene, benzene,

Table 2-1

Surface Water Concentrations
American Chemical Services
Griffith, Indiana

Contaminant	Maximum Detected Concentration (µg/L)		Water Quality Criteria[a] (µg/L)	
	Shallow Aquifer-Wetlands	Drainage Ditches	Acute	Chronic
Volatile Organics				
Chloromethane	6.8E+1	<1.0E+1	1.1E+4	None
Vinyl chloride	7.2E+2	<1.0E+1	None	None
Chloroethane	2.0E+3	3.0E+1	None	None
Methylene chloride	3.8E+2	<5.0E+0	1.1E+4	None
Acetone	9.9E+4	3.8E+2	None	None
1,1-Dichloroethane	2.4E+3	1.0E+0	1.18E+5	2.0E+4
1,2-Dichloroethene (total)	4.0E+2	3.0E+0	None	None
2-Butanone	2.2E+5	1.4E+2	None	None
Trichloroethene	4.5E+1	<5.0E+0	4.5E+4	2.19E+4
Benzene	1.0E+5	4.6E+2	5.3E+3	None
4-Methyl-2-pentanone	5.4E+4	4.9E+1	None	None
2-Hexanone	1.8E+3	4.0E+1	None	None
Tetrachloroethene	2.0E+2	<5.0E+0	5.28E+3	8.4E+2
Toluene	2.3E+3	8.0E+0	1.75E+4	None
Chlorobenzene	9.6E+1	<5.0E+0	2.5E+2	5.0E+1
Ethylbenzene	1.1E+3	6.0E+0	3.2E+4	None
Xylenes (mixed)	3.0E+3	3.5E+1	None	None
Semivolatiles				
Phenol	2.4E+2	4.5E+1	1.02E+4	2.56E+3
Bis(2-chloroethyl)ether	2.5E+2	7.7E+1	2.38E+5	None
1,3-Dichlorobenzene	3.0E+0	<1.0E+1	1.12E+3	7.63E+2

Table 2-1 (Continued)

Surface Water Concentrations
American Chemical Services
Griffith, Indiana

Contaminant	Maximum Detected Concentration (µg/L)		Water Quality Criteria[a] (µg/L)	
	Shallow Aquifer-Wetlands	Drainage Ditches	Acute	Chronic
1,4-Dichlorobenzene	1.0E+1	<1.0E+1	1.12E+3	7.63E+2
1,2-Dichlorobenzene	3.3E+1	<1.0E+1	1.12E+3	7.63E+2
2-Methylphenol	3.8E+1	5.0E+0	None	None
Bis(2-chloroisopropyl)ether	3.0E+2	2.9E+1	2.38E+5	None
4-Methylphenol	2.2E+3	5.9E+2	None	None
Isophorone	3.5E+1	5.0E+0	1.17E+5	None
2,4-Dimethylphenol	1.1E+2	1.2E+1	2.12E+3	None
Naphthalene	7.1E+1	<1.0E+1	2.3E+3	6.2E+2
4-Chloro-3-methylphenol	5.0E+0	2.0E+0	3.0E+1	None
2-Methylnaphthalene	2.7E+1	<1.0E+1	2.3E+3	6.2E+2
Diethylphthalate	9.0E+0	<1.0E+1	9.4E+2	3.0E+0
Pentachlorophenol	3.0E+0	<5.0E+1	2.0E+1	1.3E+1
Di-n-butylphthalate	2.0E+0	<1.0E+1	9.4E+2	None
Bis(2-ethylhexyl)phthalate	5.0E+1	<1.0E+1	9.4E+2	3.0E+0
Benzoic acid	1.9E+3	8.5E+1	None	None
Pesticides/PCBs				
Aroclor 1248	2.6E+0	<5.0E-1	2.0E+0	1.4E-2
Aroclor 1260	2.7E+1	<1.0E+0	2.0E+0	1.4E-2
Inorganics				
Aluminum	2.8E+2	7.6E+2	None	None
Arsenic	4.32E+1	4.5E+1	3.6E+2	1.9E+2
Barium	1.84E+3	3.3E+2	None	None

Table 2-1 (Continued)

Surface Water Concentrations
American Chemical Services
Griffith, Indiana

Contaminant	Maximum Detected Concentration (µg/L)		Water Quality Criteria[a] (µg/L)	
	Shallow Aquifer-Wetlands	Drainage Ditches	Acute	Chronic
Beryllium	2.5E-1	2.8E-1	1.3E+2	5.3E+0
Cadmium[b]	3.1E+0	3.7E-1	5.7E+0(9.1E+0)	1.5E+0(2.0E+0)
Calcium	1.04E+6	3.34E+5	None	None
Chromium (VI)[c]	3.9E-1	2.8E+0	1.6E+1	1.1E+1
Chromium (III)[c]	3.51E+0	2.52E+1	2.3E+3(3.2E+3)	2.7E+2(3.8E+2)
Cobalt	<5.0E+1	<5.0E+1	None	None
Copper[b]	<2.0E+1	<2.0E+1	2.4E+1(3.6E+1)	1.6E+1(2.2E+1)
Iron	2.18E+5	1.43E+4	None	1.0E+3
Lead[b]	4.6E+0	1.62E+1	1.2E+2(2.1E+2)	4.9E+0(8.2E+0)
Magnesium	7.88E+4	6.17E+4	None	None
Manganese	4.25E+3	1.85E+3	None	None
Mercury	1.7E+0	<2.0E-1	2.4E+0	1.2E-2
Nickel[b]	5.3E+1	8.0E+1	1.9+3(2.6E+3)	2.0E+2(3.0E+2)
Potassium	9.58E+4	3.0E+4	None	None
Selenium	6.2E+0	2.1E+0	2.0E+1	5.0E+0
Sodium	4.44E+5	7.7E+4	None	None
Thallium	4.0E+0	<5.0E+0	1.4E+3	4.0E+1
Vanadium	2.59E+1	<2.0E+0	None	None

MCL

L5-2 MCL=5

0.01 MCL

MCL= 50

Table 2-1 (Continued)

Surface Water Concentrations
American Chemical Services
Griffith, Indiana

	Maximum Detected Concentration (µg/L)		Water Quality Criteria[a] (µg/L)	
Contaminant	Shallow Aquifer-Wetlands	Drainage Ditches	Acute	Chronic
Zinc[b]	8.86E+2	8.8E+1	1.5E+2(2.2E+2)	1.4E+2(2.0E+2)
Cyanide	1.0E+1	<1.0E+1	2.2E+1	5.2E+0

140 - 200

[a] Either Ambient Water Quality Criteria or Lowest Reported Toxic Concentration.
[b] Hardness - dependent criteria: assumes 139 mg/L (Ca+Mg) for the drainage ditches and 210 mg/L (Ca+Mg) for the shallow aquifer; values in parentheses are criteria based on the shallow aquifer hardness.
[c] Assumes total chromium is 10% Cr (VI) and 90% Cr (III).
Sources: IRIS, 1991; Verschueren, 1983, U.S. EPA, 1989, U.S. EPA, 1986.
None - Criteria not available.

diethylphthalate, and bis(2-ethylhexyl)phthalate (BEHP) were considered to be contaminants of concern in water. In addition, based on elevated concentration and toxicity, 2-butanone was considered to be a contaminant of concern. In the ambient environment it is generally assumed that chromium is found in the trivalent state; thus, the total chromium concentration was assumed to be 90 percent trivalent chromium and 10 percent hexavalent chromium. Based on this, chromium was not considered to be a contaminant of concern.

Sediment samples were collected from the wetlands west of ACS (SD3, SD4, SD10 to SD12, and SD16), the drainage ditch west of ACS (SD07A, SD07B), the drainage ditch north of the landfill (SD07C), the wetlands west of the landfill (SD06, SD13, SD14), the wetlands east of the landfill (SD08, SD09), and the drainage from the off-site containment area (SD05, SD15).

A maximum of 28 soil samples were collected at less than a 4-foot depth from the off-site containment area, which includes the Kapica/Pazmey Drum Area in the far southern corner. Chemicals found in deeper soils are generally not readily available to biological communities, and thus were eliminated from the data set.

For soils and sediments, contaminants of concern were determined based on a comparison of the maximum detected concentration to background concentrations (Table 2-2), and on the toxicities of the contaminants. Background levels for organics in soil and sediments are considered to be below detection. Based on a comparison with background and on toxicity characteristics, arsenic, cadmium, chromium, copper, lead, mercury, and zinc were considered to be contaminants of concern in soil and sediments. In addition, PCBs, benzene, toluene, ethylbenzene, xylene, BEHP, heptachlor epoxide, and polycyclic aromatic hydrocarbons (PAHs) were considered to be contaminants of concern based on concentration and toxicity.

Table 2-2

Surface Soil and Sediment Concentrations
American Chemical Services
Griffith, Indiana

Contaminant	Maximum Detected Concentration (mg/kg)		Background Soil Concentration[a] (mg/kg)
	Surface Soil (mg/kg)	Sediment (mg/kg)	
Volatile Organics			
Chloroethane	1.2E-2	4.0E-2	NA
Methylene chloride	1.9E-1	4.4E-2	NA
Acetone	8.7E+0	<1.0E-2	NA
Carbon disulfide	3.0E-3	<5.0E-3	NA
1,1-Dichloroethane	7.9E-1	<5.0E-3	NA
1,2-Dichloroethene	2.6E+1	6.0E-3	NA
Chloroform	3.0E-3	8.0E-3	NA
1,2-Dichloroethane	4.4E-2	<5.0E-3	NA
2-Butanone	9.0E+1	1.1E-2	NA
1,1,1-Trichloroethane	5.6E-1	3.0E-3	NA
1,2-Dichloropropane	3.5E-2	<5.0E-3	NA
Trichloroethene	2.5E+2	<5.0E-3	NA
Benzene	2.3E+1	1.4E+1	NA
4-Methyl-2-pentanone	1.7E+1	<1.0E-2	NA
2-Hexanone	3.9E-1	<1.0E-3	NA
Tetrachloroethene	2.4E+2	<5.0E-3	NA
Toluene	1.4E+3	1.7E-1	NA
Chlorobenzene	2.7E+1	<5.0E-3	NA
Ethylbenzene	5.7E+2	1.3E-1	NA
Styrene	2.6E+2	<5.0E-3	NA

Table 2-2 (Continued)

Surface Soil and Sediment Concentrations
American Chemical Services
Griffith, Indiana

Contaminant	Maximum Detected Concentration (mg/kg)		Background Soil Concentration[a] (mg/kg)
	Surface Soil (mg/kg)	Sediment (mg/kg)	
Xylenes (mixed)	1.7E+3	2.0E-1	NA
Semivolatiles			
Phenol	1.9E-1	5.8E-2	NA
Bis(2-chloroethyl)ether	3.6E-1	5.6E-1	NA
1,4-Dichlorobenzene	9.3E-2	<3.3E-1	NA
1,2-Dichlorobenzene	2.0E-1	<3.3E-1	NA
4-Methylphenol	2.3E-1	<3.3E-1	NA
Isophorone	8.4E-1	<3.3E-1	NA
Benzoic acid	2.2E+2	1.2E+0	NA
Napthalene	6.8E-1	4.2E-1	NA
2-Methylnapthalene	8.4E-1	3.8E-1	NA
Acenapthene	4.3E-1	<1.6E+0	NA
Dibenzofuran	3.9E-1	2.3E-1	NA
Fluorene	9.8E-1	7.5E-2	NA
N-nitrosodiphenylamine	1.9E+0	<3.3E-1	NA
Pentachlorophenol	1.8E-1	2.3E-1	NA
Phenanthrene	6.4E+0	4.4E-1	NA
Anthracene	1.2E+0	1.0E-1	NA
Di-n-butylphthalate	2.4E+1	1.2E-1	NA
Fluoranthene	6.1E+0	1.0E+0	NA
Pyrene	3.2E+0	1.1E+0	NA

Table 2-2 (Continued)

Surface Soil and Sediment Concentrations
American Chemical Services
Griffith, Indiana

Contaminant	Maximum Detected Concentration (mg/kg) Surface Soil (mg/kg)	Maximum Detected Concentration (mg/kg) Sediment (mg/kg)	Background Soil Concentration[a] (mg/kg)
Butylbenzylphthalate	3.5E+0	1.7E-1	NA
Benzo(a)anthracene	2.1E+0	7.1E-1	NA
Chrysene	1.6E+0	8.0E-1	NA
Bis(2-ethylhexyl)phthalate	1.1E+2	4.4E+0	NA
Di-n-octylphthalate	3.8E+1	<3.3E-1	NA
Benzo(b)fluoranthene	3.5E+0	1.5E+0	NA
Benzo(k)fluoranthene	3.5E+0	1.5E+0	NA
Benzo(a)pyrene	1.4E+0	6.9E-1	NA
Indeno(1,2,3-c,d)pyrene	8.2E-1	4.2E-1	NA
Dibenz(a,h)anthracene	2.7E-1	2.0E-1	NA
Benzo(g,h,i)perylene	1.1E+0	5.5E-1	NA
Hexachlorobenzene	<3.3E-1	1.4E-1	NA
Pesticides/PCBs			
NAldrin	8.8E-2	<8.0E-3	NA
Endosulfan I	4.2E-2	<8.0E-3	NA
Heptachlor epoxide	<8.0E-3	6.6E-2	NA
Polychlorinated biphenyls	5.0E+1	5.4E+0	NA

Table 2-2 (Continued)

Surface Soil and Sediment Concentrations
American Chemical Services
Griffith, Indiana

Contaminant	Maximum Detected Concentration (mg/kg)		Background Soil Concentration[a] (mg/kg)
	Surface Soil (mg/kg)	Sediment (mg/kg)	
Inorganics			
Aluminum	5.5E+3	1.57E+4	7.1E+3
Antimony	9.0E+0	5.1E+0	9.7E+0
NArsenic	3.9E+0	1.6E+1	1.1E+1
Barium	1.1E+2	1.1E+2	7.2E+1
Beryllium	3.4E-1	1.0E+0	6.0E+0
Cadmium	5.0E+0	4.7E+0	2.6E+0
Calcium	5.0E+4	7.3E+4	8.2E+3
Chromium (III)	6.3E+1	2.5E+2	1.6E+1
Chromium (VI)	7.0E+0	2.7E+1	1.8E+0
Copper	1.8E+2	3.6E+2	2.7E+1
Iron	1.7E+4	3.4E+4	1.3E+4
Lead	4.0E+2	7.0E+2	1.2E+2
Magnesium	1.9E+4	2.2E+4	2.4E+3
Manganese	3.1E+2	4.2E+2	6.0E+2
Mercury	2.4E-1	8.8E+0	3.2E-1
Nickel	2.8E+1	4.0E+1	1.6E+1
Potassium	1.4E+3	2.9E+3	8.1E+2
Selenium	1.4E+0	1.1E+0	3.0E-1
Sodium[b]	2.2E+2	<2.5E-1	6.3E+3
Thallium	7.2E-1	1.4E+0	2.3E+0

Table 2-2 (Continued)

Surface Soil and Sediment Concentrations
American Chemical Services
Griffith, Indiana

Contaminant	Maximum Detected Concentration (mg/kg)		Background Soil Concentration[a] (mg/kg)
	Surface Soil (mg/kg)	Sediment (mg/kg)	
Vanadium	1.1E+1	4.8E+1	1.9E+1
Zinc	2.9E+2	2.7E+2	2.8E+2
Cyanide, total	4.6E+0	<2.0E-3	3.7E+0

[a]From Table S-1 in ACS RI/FS (Warzyn, 1990).
NA - Not applicable; assumes background organic concentrations are zero.

SECTION 3

INDICATOR SPECIES

3.1 TERRESTRIAL SPECIES

Terrestrial habitats in the ACS watershed include approximately 1 to 2 acres of open field in the off-site containment area and the Kapica Drum property, approximately 33 acres of landfill open area, and 2 to 4 acres of wooded land along Colfax Avenue (Warzyn, 1990, Subsection 7.2.5.2). These areas are likely to support small herbivorous mammal populations, including various species of field rats, mice, voles, and woodchucks that live on the ground or burrow into or through it. A burrowing rodent was chosen as the indicator species in the open field habitat. A burrowing rodent may be exposed to site contaminants through direct ingestion of contaminated soil from the off-site containment area, consumption of surface water from the drainage ditches, and ingestion of forage grown in contaminated soils found in the off-site containment area.

The potential effects of site contaminants on wetland species was assessed by considering the mink (Mustela vison) as the indicator species. Although mink were not observed during the course of RI field activities, the U.S. F&WS and the U.S. EPA requested that this species be considered because of the potential mink habitat in the area and the availability of toxicological data for this species. In addition, the mink is a carnivorous wetland mammal that is sensitive to PCBs. A mink may be exposed to contaminants through the incidental ingestion of contaminated soil in the wetlands, consumption of shallow groundwater from the wetlands, and the consumption of contaminated prey inhabiting the wetlands.

3.2 AQUATIC SPECIES

The bluegill sunfish (Lepomis macrochirus) was selected as an appropriate aquatic indicator species because it is common in northern Indiana surface waters. The primary exposure routes of the bluegill include exposure to contaminants in surface water, sediments, and macroinvertebrates in the course of feeding.

SECTION 4

EXPOSURE ESTIMATES

Tissue concentrations were not measured for the indicator species; rather, exposure doses were estimated at the point of contact using appropriate exposure algorithms. Exposure doses (in mg pollutant/kg body weight/day) were estimated from contaminant concentrations. Exposure concentrations used to calculate intake rates were the maximum detected contaminant concentrations in each medium that were presented in the RI (Warzyn, 1990). The maximum detected concentration was used in this risk assessment to represent the conservative case, at the request of the U.S. EPA BTAG. A conservative approach is followed in evaluating ecological risks at this site so that there is a high level of confidence in any no-impact conclusions made.

4.1 BURROWING RODENT

The estimated daily intake (EDI) of a contaminant by a burrowing rodent (Table 6-1) was estimated using the following algorithm:

$$EDI_{total} = EDI_{browse} + EDI_{soil} + EDI_{water}$$

where:

EDI_{total} = Estimated total daily intake of contaminant (mg/kg BW/day)

EDI_{soil} = Estimated daily intake of contaminant via incidental soil ingestion

EDI_{water} = Estimated daily intake of contaminant via water ingestion

EDI_{browse} = Estimated daily intake of contaminant via browse consumption

and:

EDI_{soil} = (Soil concentration x Soil intake rate) / Body Weight (BW)

EDI_{water} = (Water Concentration x Water intake rate) / BW

EDI_{browse} = (Soil concentration x RUF x Browse intake rate) / BW.

Root uptake factors (RUFs), which relate contaminant concentrations in the growth medium to concentrations in plant tissue, were obtained from Baes, et al. (1984) for the inorganic contaminants. For the organic contaminants, RUFs were estimated from the octanol/water partition coefficient (K_{ow}) of the contaminant, using the formula derived by Travis and Frey (1988):

$$RUF = 38.9K_{ow}^{-0.58}$$

For the burrowing rodent, the following exposure assumptions were made:

- Food and water ingestion rates and body weight for a mouse were applied (Sax and Lewis, 1989):
  - Body weight = 25 g.
  - Water consumption rate = 5 mL/day.
  - Forage consumption rate = 3 grams/day.
  - Soil consumption rate = 0.15 grams/day (assumes 5 percent of food consumption rate).
- It was assumed that the main routes of exposure were ingestion of soil, surface water, and browse.
- It was assumed that the home range of the burrowing rodent is completely within the off-site containment area, that all soil and browse consumed is from this area, and that all water consumed by the animal is from the drainage ditches.

4.2 MINK

The estimated daily intake (EDI) of a contaminant by a mink (Table 6-2) was estimated using the following algorithm:

$$EDI_{total} = EDI_{prey} + EDI_{soil} + EDI_{water}$$

where:

EDI_{total} = Estimated total daily intake of contaminant (mg/kg BW/day)

EDI_{water} = Estimated daily intake of contaminant via water ingestion

EDI_{soil} = Estimated daily intake of contaminant via incidental soil ingestion

EDI_{prey} = Estimated daily intake of contaminant via prey consumption.
= (Prey Concentration (C_{prey}) x % of diet) / BW

and:

C_{prey} = (Water Concentration x BCF)

For aquatic organisms, bioconcentration is the process by which a compound is absorbed from water and concentrated by the organism to higher than the ambient concentration. In contrast, bioaccumulation is the process by which a compound is taken up by an aquatic organism, both from water and through food. Bioconcentration factors (BCFs) for aquatic prey species were either obtained from the open literature or were derived from the octanol/water partition coefficient (K_{ow}) of the contaminant, using the following relationship from Vieth et al. (1980):

$$\log BCF = 0.76 \log K_{ow} - 0.23$$

Limited information on the quantification of contaminant concentrations in edible terrestrial animal tissue in relation to environmental concentrations is available. For terrestrial prey species, BCFs were obtained from the literature or were derived using the following relationship from Kenega (1980):

$$\log BCF = -3.825 + 0.701 \log K_{ow}$$

For inorganic contaminants, it was assumed that 100 percent of the contaminant ingested from environmental media (e.g., water) was absorbed.

Bioconcentration factors for organic compounds derived from the above equations for aquatic and terrestrial organisms are presented in Table 4-1. The BCFs used in this exposure assessment for each species of interest are presented in Table 4-2.

Table 4-1

Derivation of Bioconcentration Factors (BCFs)
for Aquatic and Terrestrial Species - Organic Compounds
American Chemical Services
Griffith, Indiana

Chemical of Potential Concern	log Kow*	Aquatic BCF[a]	Terrestrial BCF[b]
Benzene	2.13	24E+1	4.6E-3
Toluene	2.73	70E+1	1.2E-2
Ethylbenzene	3.15	1.5E+2	2.4E-2
Xylene	3.12	1.4E+2	2.3E-2
2-Butanone	0.29	9.8E-1	2.4E-4
Chlorobenzene	2.84	8.5E+1	1.5E-2
Bis(2-ethylhexyl)phthalate	5.11	4.5E+3	5.7E-1
Diethylphthalate	2.47	4.4E+1	8.1E-3
PAHs (mean)	5.42	7.7E+3	9.4E-1
PCBs	5.8	3.3E+4	1.7E+0
Heptachlor epoxide	2.70	6.6E+1	1.2E-2

[a]log BCF (aquatic) = 0.76 log Kow - 0.23 (Veith et al. 1980, as cited in U.S. EPA, 1989).
[b]log BCF (terrestrial) = -3.825 + 0.701 log Kow (Kenega, 1980).
*Sources: U.S. EPA, 1984; U.S. EPA, 1988; ATSDR, 1989; Howard, 1990a and 1990b.

Table 4-2

Bioconcentration Factors (BCFs) by Species[a]
American Chemical Services
Griffith, Indiana

Chemical of Potential Concern	Macroinvertebrates		Crayfish		Frog		Fish		Small Mammals	
	BCF	Source	BCF	Source	BCF	Source	BCF	Source	BCF	Source
Organics										
Benzene	24	Vieth et al., 1980	24	Vieth et al., 1980	24	Vieth et al., 1980	24	Vieth et al., 1980	0.0046	Kenega, 1980
Toluene	70	Vieth et al., 1980	70	Vieth et al., 1980	70	Vieth et al., 1980	70	Vieth et al., 1980	0.012	Kenega, 1980
Ethylbenzene	146	Vieth et al., 1980	146	Vieth et al., 1980	146	Vieth et al., 1980	146	Vieth et al., 1980	0.024	Kenega, 1980
Xylene	138	Vieth et al., 1980	138	Vieth et al., 1980	138	Vieth et al., 1980	138	Vieth et al., 1980	0.023	Kenega, 1980
2-Butanone	0.98	Vieth et al., 1980	0.98	Vieth et al., 1980	0.98	Vieth et al., 1980	0.98	Vieth et al., 1980	0.00024	Kenega, 1980
Chlorobenzene	85	Vieth et al., 1980	85	Vieth et al., 1980	85	Vieth et al., 1980	85	Vieth et al., 1980	0.015	Kenega, 1980
Bis(2-ethyl-hexyl)phthalate	2,600 - 9,426	Verschueren, 1983	130	Verschueren, 1983	2,600-9,426	Verschueren, 1983	130	Verschueren, 1983	0.57	Kenega, 1980
Heptachlor epoxide	66	Vieth et al., 1980	66	Vieth et al., 1980	66	Vieth et al., 1980	66	Vieth et al., 1980	0.12	Kenega, 1980
PAHs (anthracene, BaP)	760	Verschueren, 1983	30-930	AQUIRE	760	Verschueren, 1983	30-930	AQUIRE	0.94	Kenega, 1980
PCBs	2,100-4,400	Verschueren, 1983	5.1[b]	Charters, 1991	0.22[b]	Charters, 1991	238,000	Verschueren, 1983	0.07[b]	Charters, 1991

Table 4-2 (Continued)

Bioconcentration Factors (BCFs) by Species[a]
American Chemical Services
Griffith, Indiana

Chemical of Potential Concern	Macroinvertebrates		Crayfish		Frog		Fish		Small Mammals	
	BCF	Source	BCF	Source	BCF	Source	BCF	Source	BCF	Source
Inorganics										
Arsenic	350	U.S. EPA, 1989	350	U.S. EPA, 1989	350	U.S. EPA, 1989	350	U.S. EPA, 1986	1.0	Estimated
Cadmium	326	U.S. EPA, 1989	326	U.S. EPA, 1989	326	U.S. EPA, 1989	326	U.S. EPA, 1989	1.0	Estimated
Chromium	126	U.S. EPA, 1989	126	U.S. EPA, 1989	126	U.S. EPA, 1989	126	U.S. EPA, 1986	1.0	Estimated
Copper	1,175	U.S. EPA, 1989	1,175	U.S. EPA, 1986	1,175	U.S. EPA, 1989	1,175	U.S. EPA, 1989	1.0	Estimated
Cyanide	NA	—	NA	—	NA	—	NA	—	NA	—
Iron	NA	—	NA	—	NA	—	NA	—	NA	—
Lead	178	U.S. EPA, 1989	178	U.S. EPA, 1986	178	U.S. EPA, 1989	178	U.S. EPA, 1986	1.0	Estimated
Mercury	2,500-27,000	AQUIRE	27,000	AQUIRE	27,000	AQUIRE	2,500-27,000	AQUIRE	1.0	Estimated
Zinc	575	U.S. EPA, 1989	2.7-6.6	AQUIRE	575	U.S. EPA, 1989	575	U.S. EPA, 1989	1.0	Estimated

[a]In cases where species-specific BCFs were unavailable, the BCF for either aquatic or terrestrial species (derived from equations by Kenega (1980) or Vieth et al., (1980) were applied.
[b]Bioaccumulation Factor (BAF) for uptake from sediment.
NA - Not available.

For the mink, the following exposure assumptions were made:

- It was assumed that the home range of the mink is entirely within the wetlands.
- It was assumed that mink are exposed to contaminants via ingestion of surface water (upper aquifer concentrations), sediment (drainage ditches and wetlands), and prey from the wetlands.
- It was assumed that mink eat 40 percent small game, 25 percent fish, 25 percent crayfish, and 10 percent wetland amphibians.
- Contaminant concentrations in prey tissue were estimated as the product of the upper aquifer contaminant concentration and the BCF of the contaminant. As previously described, BCFs for the prey species of interest were obtained from the literature or derived from the log K_{ow} of the contaminant.
- The following food and water ingestion rates and body weight, presented in the ACS Ecological Assessment (Warzyn, 1991), were applied:
  - Body weight = 925 grams (Burt and Grossenheider, 1980).
  - Water consumption rate = 25 mL/day.
  - Prey consumption rate = 150 grams/day.
  - Soil consumption rate = 7.50 g/day (assumes 5 percent of prey consumption rate).

4.3 AQUATIC RECEPTOR

Where toxicity data are expressed in terms of a medium concentration (e.g. Ambient Water Quality Criteria, Sediment Quality Guidelines), the determination of dose is not necessary. For the aquatic receptor, comparisons of predicted media concentrations (i.e., water and sediments) with media-specific toxicity data are made, since media-specific toxicity guidelines are available. These criteria and guidelines are levels that above which adverse effects to aquatic receptors have been observed.

SECTION 5

TOXICITY ASSESSMENT

The toxicities of the contaminants of concern were assessed for aquatic life and for terrestrial life, as represented by the burrowing rodent and the mink. Based on a review of scientific literature, toxicity values were identified for the indicator or related species. These toxicity values are referred to as Critical Toxicity Values (CTVs). These CTVs range from the conservative No Observed Effect Level (NOEL) to the more drastic LD_{50} (Lethal Dose to 50 percent of a test population). Criteria pertinent to the CTV selected for the species of concern represent the conservative end of this range.

In cases where CTVs were not available in the literature, they were derived from existing dose-response data. Critical Toxicity Values developed for laboratory animals were applied to assess the effects of site contaminants on the small mammal population in the open field and wetland habitats. To arrive at CTVs for the borrowing rodent and mink, available toxicity criteria were adjusted using conservative safety factors.

Conservative safety factors or uncertainty factors are applied to account for the uncertainty inherent in extrapolating from available toxicity data. For those compounds for which only acute lethality values were available, toxicity values for this assessment were derived by dividing the acute toxicity value by appropriate safety factors. In evaluating the potential effects of pesticides on terrestrial species, U.S. EPA analyzed a subset of available dose-response data and suggested that if the estimated dose is less than one-fifth the median lethal dose for non-endangered species, no acute hazard can be presumed (Urban and Cook, 1986). This rule was adopted for this assessment and is presented in Table 5-1. A safety factor of 5 was used to account for extrapolating toxicity values for different species within the same class. In addition, a safety factor of 10 was used to adjust an acute lethality value to an acute no-observed effect level (NOEL), and to adjust a chronic or acute lowest observed effect level (LOEL) to a chronic NOEL (U.S. EPA, 1989). Table 5-2 presents the CTVs for the burrowing rodent, and Table 5-3 presents the CTVs for the mink. If toxicity criteria were obtained from the literature, safety factors were not applied.

Table 5-1

Safety Factors Used to Derive Critical Toxicity Values for Terrestrial Indicator Organisms

Available Toxicity End Points	Target End Points	Safety Factor*
Acute Lethality (i.e., LD_{50})	Acute NOEL	10
Acute NOEL	Chronic NOEL	10
Chronic LOEL	Chronic NOEL	10
Within phylogenetic class sensitivity (i.e., different species but same class)	Target species toxicity	5

As an example, in developing a critical toxicity value for a white-tailed deer when the only datum available is an LD_{50} for a rat, the following steps would be taken:

Rat LD_{50} for compound X = 500 mg/kg

1. Acute lethality ➡ Acute NOEL (500 mg/kg ÷ 10) = 50 mg/kg

2. Acute NOEL ➡ Chronic NOEL (50 mg/kg ÷ 10) = 50 mg/kg

3. Within phylogenetic class sensitivity ➡ Target species CTV (5 mg/kg ÷ 5) = 1 mg/kg

Key
CTV = Critical toxicity value.
LD_{50} = Lethal dose to 50 percent of the test population.
LOEL = Lowest observed effect level.
NOEL = No observed effect level.

* Source: U.S. EPA, 1989; Urban and Cook; 1986.

Table 5-2

Critical Toxicity Values (CTVs) - Burrowing Rodent
American Chemical Services
Griffith, Indiana

Chemical of Potential Concern	Toxicity Data		Uncertainty Factor	Critical Toxicity Value (CTV) (mg/kgBW/day)	Source
	Dose (mg/kgBW/day)	Effect/Species			
Volatile Organics					
Benzene	3,400	LD_{50}/rat	500	6.8	Sax and Lewis, 1989
Toluene	233	NOEL/rat	5	146.6	IRIS, 1991
Ethylbenzene	97.1	NOEL/rat	5	19.42	IRIS, 1991
Xylenes	179	NOEL/rat	5	35.8	IRIS, 1991
2-Butanone	46	NOEL/rat	5	9.2	IRIS, 1991
Chlorobenzene	27.25	NOEL/dog	5	27.25	IRIS, 1991
Semivolatiles/Pesticides					
Bis(2-ethylhexyl)phthalate	19	LOEL/guinea pig	50	0.38	IRIS, 1991
PAHs (as naphthalene)	35.70	NOEL/rat	5	7.14	HEAST, 1991
PCBs	--	--	--	0.0015	Eisler, 1986b
Diethylphthalate	750	NOEL/rat	5	150	HEAST, 1991
Heptachlor epoxide	0.0125	LOEL/dog	50	0.00025	IRIS, 1991
Inorganics					
Arsenic	1.2	NOEL/dog	5	0.24	ATSDR, 1991
Cadmium	--	--	--	0.1	Eisler, 1985

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Table 5-2 (Continued)

Critical Toxicity Values (CTVs) - Burrowing Rodent
American Chemical Services
Griffith, Indiana

Chemical of Potential Concern	Toxicity Data		Uncertainty Factor	Critical Toxicity Value (CTV) (mg/kgBW/day)	Source
	Dose (mg/kgBW/day)	Effect/Species			
Chromium (III)	1,468	NOEL/rat	5	293.6	IRIS, 1991
Chromium (VI)	2.4	NOEL/rat	5	0.48	IRIS, 1991
Copper	152	TD_{LO}/rat	50	3.04	Sax and Lewis, 1989
Iron (iron sulfate)	979	LD_{50}/mouse	500	1.96	U.S. EPA, 1984
Lead	--	--	--	0.05	Eisler, 1988
Mercury	0.3	NOEL/rat	5	0.06	HEAST, 1991
Zinc	250	LD_{LO}/guinea pig	500	0.5	Sax and Lewis, 1989
Cyanide	10.8	NOEL/rat	5	2.16	IRIS, 1991

NOEL = No observed effect level.
LOEL = Lowest observed effect level.
LD_{50} = Lethal dose to 50 percent of the test population.
LD_{LO} = Lowest reported lethal dose.
TD_{LO} = Lowest reported toxic dose.

Table 5-3

Critical Toxicity Values (CTV) - Mink
American Chemical Services
Griffith, Indiana

Chemical of Potential Concern	Toxicity Data		Uncertainty Factor	Critical Toxicity Value (CTV) (mg/kgBW/day)	Source
	Dose (mg/kgBW/day)	Effect/Species			
Volatile Organics					
Benzene	3,400	LD_{50}/rat	500	6.8	Sax and Lewis, 1989
Toluene	233	NOEL/rat	5	46.6	IRIS, 1991
Ethylbenzene	97.1	NOEL/rat	5	19.42	IRIS, 1991
Xylenes	179	NOEL/rat	5	35.8	IRIS, 1991
2-Butanone	46	NOEL/rat	5	9.2	IRIS, 1991
Chlorobenzene	27.25	NOEL/dog	5	5.45	IRIS, 1991
Semivolatiles/Pesticides					
Bis(2-ethylhexyl)phthalate	19	LOEL/guinea pig	50	0.38	IRIS, 1991
PAHs (as napthalene)	35.70	NOEL/rat	5	7.14	HEAST, 1991
PCBs	--	--	--	0.0015	Eisler, 1985
Diethylphthalate	750	NOEL/rat	5	150	HEAST, 1991
Heptachlor epoxide	0.0125	LOEL/dog	50	0.00025	IRIS, 1991
Inorganics					
Arsenic	1.2	NOEL/dog	5	0.24	ATSDR, 1991
Cadmium	--	--	--	0.1	Eisler, 1985

Table 5-3 (Continued)

Critical Toxicity Values (CTV) - Mink
American Chemical Services
Griffith, Indiana

Chemical of Potential Concern	Toxicity Data		Uncertainty Factor	Critical Toxicity Value (CTV) (mg/kgBW/day)	Source
	Dose (mg/kgBW/day)	Effect/Species			
Chromium (III)	1,468	NOEL/rat	5	293.6	IRIS, 1991
Chromium (VI)	2.4	NOEL/rat	5	0.48	IRIS, 1991
Copper	152	TD_{LO}/rat	50	3.04	Sax and Lewis, 1989
Iron (iron sulfate)	979	LD_{50}/mouse	25	1.96	U.S. EPA, 1984
Lead	--	--	--	0.05	Eisler, 1988
Mercury	0.3	NOEL/rat	5	0.06	HEAST, 1991
Zinc	250	LD_{LO}/guinea pig	500	0.5	Sax and Lewis, 1989
Cyanide	10.8	NOEL/rat	5	2.16	IRIS, 1991

LOEL = Lowest observed level.
NOEL = No observed effect level.
LD_{50} = Lethal dose to 50 percent of the test population.
TD_{LO} = Lowest reported toxic dose.
LD_{LO} = Lowest reported lethal dose.

Critical Toxicity Values expressed as body burden exposure (in mg/kg), were not available for fish. Rather, the toxicity of the contaminants in surface water to aquatic species can be assessed by comparing surface water concentrations in the drainage ditches and the wetlands to available acute and/or chronic AWQC or Lowest Reported Toxic Concentration values for the protection of freshwater aquatic life. AWQC are derived by U.S. EPA to protect 95 percent of all aquatic organisms, including fish, invertebrates, and aquatic plants. Lowest Reported Toxic Concentrations found in the literature were used for those chemicals for which the minimum data required to derive water quality criteria are not available.

Sediment quality guidelines can be used to assess the potential toxicity of sediments to benthic species. Various methods have been proposed to determine sediment concentrations associated with adverse biological effects, including the background approach, the sediment-water equilibrium partitioning (EP) approach, the spiked-sediment bioassay approach, the screening level concentrations approach, the Apparent Effects Threshold Approach, and the Bioeffects/Contaminant Co-Occurrence Analysis Approach. These approaches have been compared by the National Oceanic and Atmospheric Administration (NOAA) as part of the National Status and Trends program (NOAA, 1990).

The chemical concentrations observed or predicted by the different methods to be associated with biological effects were evaluated by NOAA, and the concentration at the low end (lower 10th percentile) of the range in which effects had been observed (ER-L) and the median data concentration in the range of reported values associated with biological effects (ER-M) were determined. These values were used to rank sites with regard to the potential for adverse biological effects. This range of data was for both marine and freshwater environments.

The Ontario Ministry of the Environment (Persaud et al., 1980) has established sediment quality guidelines for metals, nutrients, and organic compounds. These biological-effects-based guidelines can also be used as benchmarks to evaluate the potential impacts to benthic organisms. The guidelines define three levels of ecotoxic effects: no effect, lowest effect, and severe effect. A no-effect level is that level at which no effects have been observed in aquatic organisms. The lowest effect level is that level of sediment contamination that can be tolerated by the majority of benthic organisms. The severe effect level is that level at which pronounced disturbance of the sediment-dwelling community can be expected.

In addition, the U.S. EPA has applied the EP approach to derive interim sediment guidelines using water quality criteria and organic carbon partition coefficients for several nonpolar hydrophobic organic contaminants (U.S. EPA, 1988). The EP approach assumes that nonpolar organic compounds bound to sediment are in equilibrium with the water in the sediment pore spaces (i.e., pore water). Sediment pore water is assumed to be the primary medium of exposure to nonpolar organic compounds for sediment-dwelling aquatic organisms. The partitioning procedure utilizes the organic carbon normalized partition coefficient (K_{oc}) to estimate nonpolar organic compound concentrations in pore water. This concentration represents the concentration of a substance in sediment that will not result in adverse effects to aquatic life.

The following relationship can be used to calculate an interim sediment guidelines for a particular contaminant:

$$\text{Interim sediment guideline} = K_{oc} \times AWCQ \times \%\ OC$$

where:

K_{oc} = Organic carbon partition coefficient
AWQC = Ambient Water Quality Criterion
% OC = Percent organic carbon in the sediment.

Sediment guidelines, including interim sediment guidelines derived by the EP approach (U.S. EPA, 1988), ER-L and ER-M values determined by NOAA (1990), Ontario Ministry of the Environment Guidelines (Persaud et al., 1990), and maximum detected sediment concentrations, are presented in Table 5-4 for the nonpolar hydrophobic organic compounds detected at the site, and in Table 5-5 for the inorganic contaminants.

Table 5-4

Sediment Concentrations Compared to Sediment Guidelines - Nonpolar Organics
American Chemical Services
Griffith, Indiana

Contaminant	Maximum Detected Concentration (ppb)	Sediment Guidelines (ppb)							
		EP-Approach[b]	"Safe Level"[c] Acute	Chronic	*Effects Range*[d] Low	Median	*Effects Range*[e] No	Lowest	Severe
Naphthalene	420	—	—	—	—	—	—	2,000	1.1E+07
2-Methylnaphthalene	380	—	—	—	—	—	—	2,000	1.1E+07
Fluorene	75	7,000	—	—	—	—	—	2,000	1.1E+07
Phenanthrene	440	1,390	14,000	—	—	—	—	2,000	1.1E+07
Anthracene	100	—	—	—	—	—	—	2,000	1.1E+07
Fluoranthene	1,000	18,800	9,000	3,600	—	—	—	2,000	1.1E+07
Pyrene	1,100	13,100	49,500	—	—	—	—	2,000	1.1E+07
Benz(a)anthracene	710	13,200	55,000	—	230	1,600	—	2,000	1.1E+07
Chrysene	800	—	115,000	—	400	2,800	—	2,000	1.1E+07
Benzo(b)fluoranthene	1,500	—	—	—	—	—	—	2,000	1.1E+07
Benzo(k)fluoranthene	1,500	—	—	—	—	—	—	2,000	1.1E+07
Benzo(a)pyrene	600	10,630	450,000		400	2,500	—	2,000	1.1E+07
Indeno(1,2,3-cd)pyrene	420	—	—	—	—	—	—	2,000	1.1E+07
Dibenz(a,h)anthracene	200	—	240,000	—	60	260	—	2,000	1.1E+07
Benzo(g,h,i)perylene	550	—	—	—	—	—	—	2,000	1.1E+07
Bis(2-ethylhexyl)phthalate	4,400	—	—	3,240[a]	—	—	—	—	1.1E+07
PCBs	5,400	—	35,900[a]	250[a]	50	400	10	70	530,000
Heptachlor epoxide	66	—	1.5[a]	0.011[a]	—	—	—	5	5,000

Table 5-4 (Continued)

Sediment Concentrations Compared to Sediment Guidelines - Nonpolar Organics
American Chemical Services
Griffith, Indiana

[a] Calculated sediment quality value; where:

Sediment "safe level" = AWQC x K_{OC} x % OC (U.S. EPA, 1988), assumes 0.5% OC.

[b] EP Approach = Equilibrium Partitioning Approach; Interim mean freshwater sediment quality guideline based on the equilibrium partitioning approach at 1% total organic carbon (NOAA, 1990).

[c] Sediment safe level based upon sediment/water partitioning coefficients and acute/chronic water quality guideline (NOAA, 1990); levels below these concentrations assumes no acute and/or chronic effects to benthic organisms.

[d] Effects Range - The lower 10 percentile and median concentrations identified from chemical concentrations observed or predicted by different methods to be associated with biological effects (NOAA, 1990).

[e] Effects Level - Guidelines defining three levels of ecotoxic effects; a no effect level is that level at which no toxic effects have been observed on aquatic organisms; a lowest effect level indicates a level of sediment contamination that can be tolerated by the majority of benthic organisms; a severe effect level indicates the level at which pronounced disturbance of the sediment-dwelling community can be expected (Persaud, et al., 1990). For the individual PAHs, the effect level for total PAHs is provided. Units for severe effect levels are ug/kg organic carbon.

— - Not available.

Table 5-5

Sediment Concentrations Compared to Sediment Guidelines - Inorganics
American Chemical Services
Griffith, Indiana

Contaminant	Maximum Detected Concentration (mg/kg)	Sediment Guidelines (mg/kg)			
		Effects Range[a]		Effect Level[b]	
		Low	Median	Lowest	Severe
Arsenic	15.9	33	85	6	33
Cadmium	4.7	5	9	0.6	10
Chromium, total	274	80	145	26	110
Copper	359	70	390	16	110
Lead	702	35	110	3	250
Mercury	8.8	0.15	1.3	0.2	2
Zinc	271	120	270	120	820

[a]Effects Range - The lower 10 percentile and median concentrations identified from chemical concentrations observed or predicted by different methods to be associated with biological effects (NOAA, 1990).

[b]Effects Level - Guidelines defining three levels of exotoxic effects; No effect level is that level at which no toxic effects have been observed on aquatic organisms; lowest effect level indicates a level of sediment contamination that can be tolerated by the majority of benthic organisms; severe effect level indicates the level at which pronounced disturbance of the sediment - dwelling community can be expected (Persaud, et al., 1990).

SECTION 6

RISK CHARACTERIZATION

The risk characterization integrates the exposure and toxicity assessments to estimate the potential hazard or risk to environmental receptors. Environmental media (e.g., sediment, surface water) concentrations or estimated daily intakes (EDIs) are compared with critical toxicity values (CTVs) by using a hazard index (HI).

Since media-specific criteria (e.g., tissue concentrations) were not available, hazard indices were calculated as follows:

$$HI = EDI / CTV$$

where:

EDI = Estimated daily intake of contaminant(s)

CTV = Critical toxicity value of the same contaminant(s) through food, water, soil, sediment consumption.

Exposures through different environmental media were assumed to be cumulative. Consequently, the hazard index examines exposure to a contaminant through contact with all substantially contaminated media.

If an individual HI is greater than 1, it is suggested that the total exposure to a contaminant of concern through all exposure pathways is sufficient to produce a risk of adverse effects to the species of concern. However, if the individual HIs do not exceed 1, the risk may be negligible.

The following subsections discuss of the risks to aquatic life and terrestrial wildlife from contaminants at the ACS site.

6.1 RISK TO BURROWING RODENT

Risks to a burrowing rodent inhabiting the upland habitats found at the ACS site are presented in Table 6-1. Hazard indices exceeded unity for ethylbenzene, xylene, BEHP, PCBs, iron, lead, and zinc. For ethylbenzene and xylene, the primary potential exposure route

TABLE 6–1
Dose Estimation and Risk Characterization – Upland Habitat
Indicator Species – Burrowing Rodent

Chemicals of Potential Concern	Soil Maximum Detected Concentration (Csoil) (mg/kg)	Surface Water Maximum Detected Concentration (Csw) (mg/L)	Soil Daily Intake (Disoil) (mg/kg/day)	Surface Water Daily Intake (Disw) (mg/kg/day)	Root Uptake Factor (RUF)[1] (unitless)	Forage Daily Intake (Diforage) (mg/kg/day)	Total Daily Intake (Ditotal) (mg/kg/day)	Critical Toxicity Value (CTV) (mg/kg/day)	Hazard Index (HI) (unitless)
Volatiles									
Benzene	23.00	0.00	0.138	0.000	2.290	6.320	6.458	6.8	0.950
Toluene	1400.00	0.00	8.400	0.000	1.000	168.000	176.400	146.6	1.203
Ethylbenzene	570.00	0.00	3.420	0.000	0.580	39.672	43.092	19.42	2.2
Xylene	1700.00	0.00	10.200	0.000	0.500	102.000	112.200	35.8	3.1
2–Butanone	0.00	0.14	0.000	0.028	27.500	0.000	0.028	9.2	0.003
Semivolatiles									
Bis(2–ethylhexyl)phthalate	110.00	0.00	0.660	0.000	0.042	0.554	1.214	0.38	3.2
PAHs (total)	26.20	0.00	0.157	0.000	0.028	0.089	0.246	7.14	0.034
PCBs (total)	50.00	0.00	0.300	0.000	0.012	0.073	0.373	0.0015	249
Inorganics									
Arsenic	3.90	0.00	0.023	0.000	3.00E–04	0.00014	0.024	0.24	0.098
Cadmium	5.00	0.00037	0.030	0.000	6.50E–03	0.004	0.034	0.1	0.340
Chromium (III)	63.00	0.00	0.378	0.000	2.25E–04	0.002	0.380	293.6	0.001
Chromium (VI)	7.00	0.00	0.042	0.000	2.25E–04	0.000	0.042	0.48	0.088
Copper	176.00	0.00	1.056	0.000	1.25E–02	0.264	1.320	3.04	0.434
Iron	0	14.30	0.000	2.860	0.00E+00	0.000	2.860	1.96	1.5
Lead	401.00	0.016	2.406	0.003	4.50E–02	2.165	4.575	0.05	91
Mercury	0.24	0.00	0.001	0.000	1.00E–02	0.000	0.002	0.06	0.029
Zinc	292.00	0.088	1.752	0.018	4.50E–02	1.577	3.346	0.5	6.7
TOTAL:									360

Soil Daily Intake (mg/kg BW/day) = (Soil Concentration × IR × CF × FI)/BW
Water Daily Intake (mg/kg BW/day)= (Water Concentration × IR)/BW
Forage Daily Intake (mg/kg BW day) = (Soil Concentration × RUF × CF × IR)/BW

EXPOSURE ASSUMPTIONS

Soil	Water	Forage	
150	0.005	3000	IR = Ingestion Rate (mg/day, L/day)
1.0E–06	1	1.0E–06	CF = Conversion Factor (kg/mg)
1	1	1	FI = Fraction Ingested (unitless)
0.025	0.025	0.025	BW = Body Weight (kg)

[1]Source: Travis and Frey, 1988; Baes et al., 1984

was the consumption of forage grown in contaminated soil (maximum detected concentrations of these contaminants were found at sample location SB44-4.5). For iron, the primary exposure route was potentially through the ingestion of contaminated surface water from the drainage ditch (maximum detected concentration found at sample location SW05). For all other contaminants (lead, zinc, BEHP, and PCBs), the potential for exposure was from both consumption of browse grown in contaminated soil and incidental ingestion of contaminated soil. For lead, zinc, and BEHP, the maximum detected concentrations were found at sample location SB01-03, and for PCBs, the maximum detected concentration was found at sample location SB51-4.5.

6.2 RISK TO MINK

Risks to mink inhabiting the wetlands at the ACS site are presented in Table 6-2.

Hazard indices exceeded unity for benzene, 2-butanone, BEHP, PCBs, heptachlor epoxide, iron, lead, mercury, and zinc. For benzene, 2-butanone, and BEHP, the primary exposure route is potentially through the ingestion of aquatic prey species that have bioconcentrated these contaminants from water (maximum detected concentrations at MW3-02, MW16-02, and MW17-01 for benzene, 2-butanone, and BEHP, respectively). For iron, the primary exposure route is potentially through the ingestion of contaminated water (maximum detected concentration at MW16-02), and for heptachlor epoxide, the primary exposure route is potentially through the incidental ingestion of contaminated sediment (maximum detected concentration at sample location SD08). For all other contaminants (lead, mercury, zinc, and PCBs), the potential for exposure is through both ingestion of aquatic prey that bioconcentrated these contaminants from water and incidental ingestion of contaminated sediments. The maximum detected sediment concentrations were found at sample location SD16 for lead, mercury, and PCBs, and at SD14 for zinc. The maximum detected concentrations in shallow groundwater were found at sample locations MW6-01, MW12-02, MW15-01, and MW17-01 for zinc, mercury, lead, and PCBs, respectively.

6.3 RISK TO AQUATIC RECEPTORS

Potential impacts on aquatic receptors can be evaluated by comparing contaminant concentrations in the drainage ditches and the shallow groundwater aquifer to ambient water quality criteria

TABLE 6-2
Dose Estimation and Risk Charactization – Wetland Habitat
Indicator Species – Mink

Chemicals of Potential Concern	Sediment Maximum Detected Concentration (Csediment) (mg/kg)	Shallow Aquifer Maximum Detected Concentration (Cgw) (ug/L)	Bioconcentration Factor – mammal. (BCF)	Bioconcentration Factor – crayfish (BCF)	Bioconcentration Factor – frog (BCF)	Bioconcentration Factor – fish (BCF)
Volatiles						
Benzene	14	100000	0.0046	24	24	24
Toluene	0.17	0	0.0012	70	70	70
Ethylbenzene	0.13	0	0.024	146	146	146
Xylene	0.2	0	0.023	138	138	138
2-Butanone	0	220000	0.00024	0.98	0.98	0.98
Chlorobenzene	0	96	0.015	85	85	85
Semivolatiles						
Bis(2-ethylhexyl)phthalate	4.4	50	0.57	130	9426	130
Diethylphthalate	0	9	0.0081	44	44	44
PAHs	9.505	0	0.94	930	760	930
PCBs	5.4	29.6	0.07	5.1	0.22	238000
Heptachlor epoxide	0.066	0	0.012	66	66	66
Inorganics						
Arsenic	15.9	0	1	350	350	350
Cadmium	4.7	3.1	1	326	326	326
Chromium (III)	246.6	0	1	126	126	126
Chromium (VI)	2.74	0	1	126	126	126
Copper	359	0	1	1175	1175	1175
Iron	0	218000	0	0	0	0
Lead	702	4.6	1	178	178	178
Mercury	8.8	1.7	1	27000	27000	27000
Zinc	271	886	1	6.6	575	575
Cyanide	0	10	0	0	0	0

* For PCBs, BAFs for uptake from sediments by crayfish, small mammals, and frogs are applied.

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TABLE 6-2 (Continued)
Dose Estimation and Risk Charactization – Wetland Habitat
Indicator Species – Mink

Chemicals of Potential Concern	Small Mammal Daily Intake (DI mammal) (mg/kg/day)	Crayfish Daily Intake (DI cayfish) (mg/kg/day)	Frog Daily Intake (DI frog) (mg/kg/day)	Fish Daily Intake (DI fish) (mg/kg/day)	Water Daily Intake (DIwater) (mg/kg/day)	Prey Daily Intake (DIprey) (mg/kg/day)	Sediment Daily Intake (DIsoil) (mg/kg/day)	Total Daily Intake (DItotal) (mg/kg/day)	Critical Toxicity Value (CTV) (mg/kg/day)	Hazard Index (HI) (unitless)
Volatiles										
Benzene	2.98E-02	9.73E+01	3.89E+01	9.73E+01	2.70E+00	2.34E+02	1.14E-01	2.36E+02	6.8	35
Toluene	0	0	0	0	0	0	1.38E-03	1.38E-03	46.6	2.96E-05
Ethylbenzene	0	0	0	0	0	0	1.05E-03	1.05E-03	19.42	5.43E-05
Xylene	0	0	0	0	0	0	1.62E-03	1.62E-03	35.8	4.53E-05
2-Butanone	3.42E-03	8.74E+00	3.50E+00	8.74E+00	5.95E+00	2.10E+01	0	2.69E+01	9.2	3
Chlorobenzene	9.34E-05	3.31E-01	1.32E-01	3.31E-01	2.59E-03	7.94E-01	0	7.97E-01	5.45	0.15
Semivolatiles										
Bis(2-ethylhexyl)phthalate	1.65E-03	2.64E-01	7.64E+00	2.64E-01	1.35E-03	8.17E+00	3.57E-02	8.21E+00	0.38	22
Diethylphthalate	4.73E-06	1.61E-02	6.42E-03	1.61E-02	2.43E-04	3.85E-02	0	3.88E-02	150	2.59E-04
PAHs	0	0	0	0	0	0	7.71E-02	7.71E-02	7.14	0.01
PCBs	2.45E-02	1.12E+00	1.93E-02	2.86E+02	8.00E-04	2.87E+02	4.38E-02	2.87E+02	0.0015	191203
Heptachlor epoxide	0	0	0	0	0	0	5.35E-04	5.35E-04	0.00025	2
Inorganics										
Arsenic	0	0	0	0	0	0	1.29E-01	1.29E-01	0.24	0.54
Cadmium	2.01E-04	4.10E-02	1.64E-02	4.10E-02	8.38E-05	9.85E-02	3.81E-02	1.37E-01	0.1	1
Chromium (III)	0	0	0	0	0	0	2.00E+00	2.00E+00	293.6	0.007
Chromium (VI)	0	0	0	0	0	0	2.22E-02	2.22E-02	0.48	0.05
Copper	0	0	0	0	0	0	2.91E+00	2.91E+00	3.04	0.96
Iron	0	0	0	0	5.89E+00	0	0	5.89E+00	1.96	3
Lead	2.98E-04	3.32E-02	1.33E-02	3.32E-02	1.24E-04	8.00E-02	5.69E+00	5.77E+00	0.05	115
Mercury	1.10E-04	1.86E+00	7.44E-01	1.86E+00	4.59E-05	4.47E+00	7.14E-02	4.54E+00	0.06	76
Zinc	5.75E-02	2.37E-01	8.26E+00	2.07E+01	2.39E-02	2.92E+01	2.20E+00	3.14E+01	0.5	63
Cyanide	0	0	0	0	2.70E-04	0	0	2.70E-04	2.16	0.0001
TOTAL:										191525

DI sediment (mg/kg BW/day) = (CS × IR × CF × FI)/BW
DI water (mg/kg BW/day) = (CW × CR)/BW
DI prey (mg/kg BW/day) = (DI small mammal + DI crayfish + DI frog + DI fish)
DI small mammal (mg/kg BW/day) = (Csw × BCF × 10E-3 × % of diet × CF × FI)/ BW
DI frog (mg/kg BW/day) = (Csw × BCF × 10E-3 × % of diet × CF × FI)/ BW
DI fish (mg/kg BW/day) = (Csw × BCF × 10E-3 × % of diet × CF × FI)/ BW
DI crayfish (mg/kg BW/day) = (Csw × BCF × 10E-3 × % of diet × CF × FI)/ BW
Pecent of diet:
Small mammal – 40%
Frog – 10%
Fish – 25%
Crayfish – 25%

EXPOSURE ASSUMPTIONS

Water	Prey	Sediment	
0.025	150000	7500	IR = Ingestion Rate (mg/day or L/day)
1.0E-03	1.0E-06	1.0E-06	CF = Conversion factor (kg/mg)
1	1	1	FI = Fraction Ingested (unitless)
0.925	0.925	0.925	BW = Body Weight (kg)

or lowest reported toxic concentrations found in the literature. Since the wetlands function as groundwater discharge areas, contaminants in the shallow groundwater may potentially discharge to the wetlands and their associated ditches. Presented previously in Table 1-1 is a comparison of measured surface water and shallow groundwater contaminant concentrations to the available water quality criteria or guidelines.

Chronic water quality criteria for iron and lead were exceeded in all drainage ditch surface water samples. In the shallow aquifer groundwater samples, either chronic or acute water quality criteria or guidelines were exceeded in 10 of the 13 wells sampled. The contaminants that exceeded water quality guidelines in each sampled well were:

Contaminant	Sediment Sample Location
Organics	
Benzene	MW3-02
Chlorobenzene	MW5-01, MW5-02
Diethylphthalate	MW3-02
Bis(2-ethylhexyl)phthalate	MW3-01, MW6-02, MW15-02, MW17-01
PCBs (total)	MW4-01, MW17-01
2-Butanone	MW16-01, MW16-02
Inorganics	
Cadmium	MW4-01
Lead	MW15-01
Mercury	MW12-02
Zinc	MW3-01, MW4-01, MW5-01, MW6-01
Cyanide	MW4-01
Iron	MW2-02, MW3-01, MW3-02, MW4-01, MW4-02, MW5-01, MW5-02, MW6-01, MW6-02, MW12-02, MW14-02, MW15-02, MW16-01, MW16-02

Potential impacts on aquatic receptors, especially benthic organisms, may also be evaluated by a review of the measured sediment concentrations in comparison to the available sediment quality guidelines. Table 5-2 presents the maximum contaminant concentrations detected in the sediment at the ACS site to the various sediment quality guidelines or benchmarks. In 15 of the 16

SECTION 7

SUMMARY

Based on this semi-quantitative, screening-level analysis of ecological risks, upland, wetland, and aquatic receptors may be adversely affected by contaminants present in the environmental media within the ACS watershed. The contaminants posing the greatest risk include PCBs and lead, which posed potential risks to all receptors examined. In addition, many of the metals, including mercury and zinc, as well as BEHP and heptachlor epoxide, posed potential risks to aquatic receptors and to mink.

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