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FINAL

REMEDIAL INVESTIGATION REPORT  
COLD CREEK SWAMP OPERABLE UNIT  
COLD CREEK/LEMOYNE SUPERFUND SITES  
MOBILE, ALABAMA

VOLUME I  
REMEDIAL INVESTIGATION REPORT

Prepared for:

Akzo Chemicals Inc.  
Chicago, Illinois

and

ICI Americas Inc.  
Wilmington, Delaware

Prepared by:

EA Mid-Atlantic Regional Operations  
EA Engineering, Science, and Technology, Inc.  
15 Loveton Circle  
Sparks, Maryland 21152

June 1992

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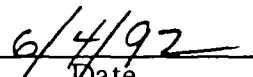
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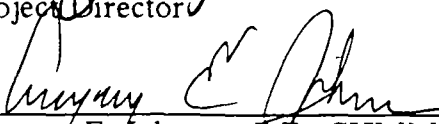
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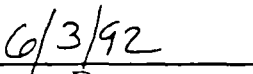
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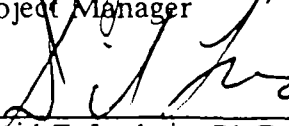
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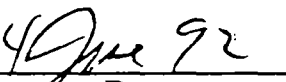
  
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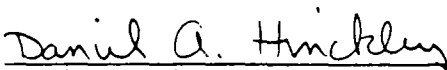
  
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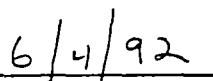
  
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## 1. INTRODUCTION

### 1.1 PURPOSE OF REPORT

The purpose of this supplemental Remedial Investigation (RI) Report is to present the data obtained from the Stage I, Stage II, and Stage III field activities, and to assess the nature and extent of contamination in the Cold Creek Swamp Operable Unit based upon these data. The specific objective was to develop a database sufficient to:

1. Characterize the nature and extent of pollutant-specific contamination within the swamp, both vertically and horizontally.
2. Characterize the nature and extent of pollutant-specific contamination within the biologically active sediment zone of Cold Creek Swamp.
3. Characterize potential impacts of pollutant-specific contamination in Cold Creek Swamp on the biological community within and around the swamp.
4. Further assess the potential relationship between surface water in the swamp and the underlying ground-water system.
5. Identify the areal and ecological limits of Cold Creek Swamp.
6. Evaluate potential baseline human health and environmental risks based upon data collection and ecological modeling.
7. Develop an RI report.

8. Support an informed risk management alternatives analysis for remedial actions to be evaluated in the Feasibility Study (FS).

## 1.2 SITE BACKGROUND AND SETTING

Cold Creek Swamp is located in the northeast section of Mobile County, Alabama, approximately 20 mi north of Mobile, 6 mi south of Mt. Vernon, and 5 mi north of Creola (Figure 1-1). The swamp site encompasses approximately 650 acres situated between U.S. Highway 43 to the west and the Mobile River to the east. The site is bounded by the Power Plant Discharge Canal to the northeast, the Mobile River to the east, and the surveyed boundary line of the wetlands as delineated for this study by EA. The surrounding area is sparsely populated and consists primarily of riverbottom swamp and other wetlands (Figure 1-2).

The project site is along the Mobile River, approximately 10 mi south of the confluence of the Tombigbee and Alabama rivers, and 20 mi north of Mobile Bay. The Mobile River in Mobile County is an important water source for river barge transportation, as well as other industrial, agricultural, and recreational uses. Other water supply sources in the site vicinity include wells, springs, and ponds.

Surrounding land use in the vicinity of Cold Creek Swamp is predominantly industrial, related to chemical processing and electrical power generation. The Alabama Power Company Barry Steam Generating Plant is a major coal-fired power generating station located immediately north of the swamp. Timber production (southern pine) is the other major land use in the immediate site vicinity. Most land east of the project site (across the Mobile River) is undeveloped riverbottom swamp with some timber harvesting use.

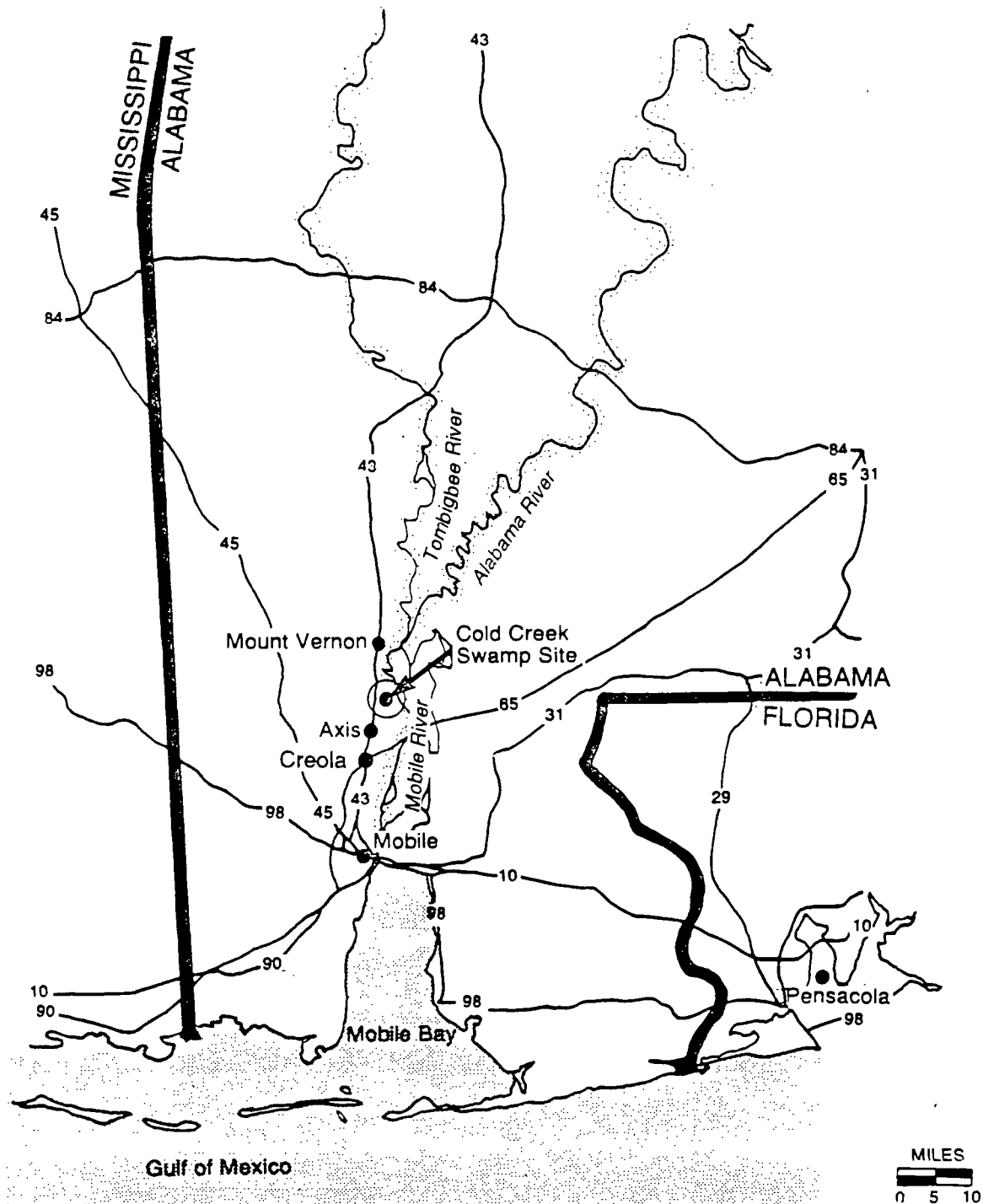
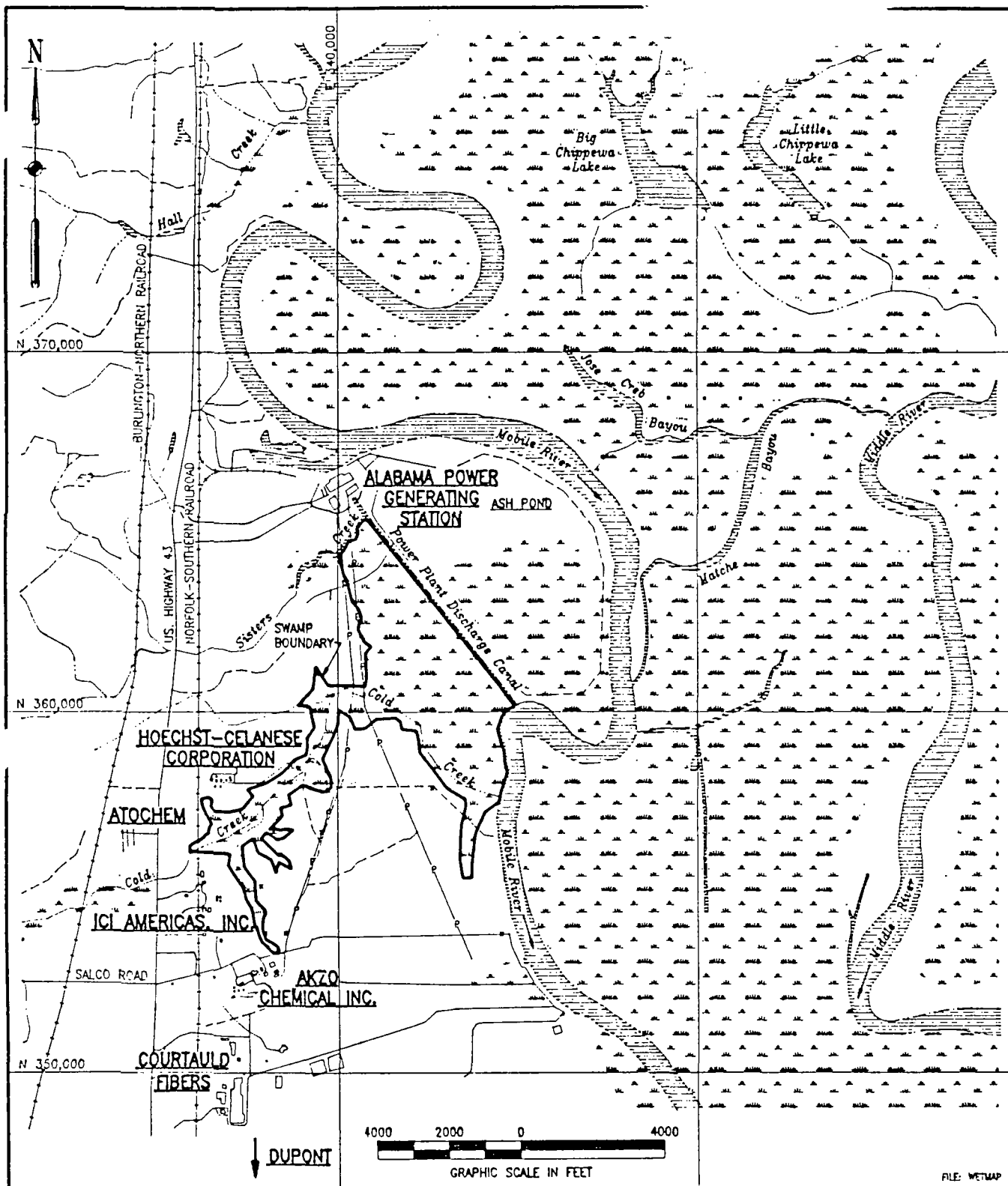


Figure 1-1. Cold Creek Swamp site location map.



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# REMEDIAL INVESTIGATION REPORT COLD CREEK SWAMP MOBILE, ALABAMA

## WETLANDS MAP

|                    |                    |                 |                   |                   |                |                        |               |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|
| PROJECT MGR<br>GEJ | DESIGNED BY<br>PWK | DRAWN BY<br>MSM | CHECKED BY<br>GEJ | SCALE<br>1"=4000' | DATE<br>6-5-92 | PROJECT NO<br>11653.08 | FIGURE<br>1-2 |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|

3 10 0027



### 1.2.1 Site Description

#### 1.2.1.1 Regional Geology, Physiography, and Soils

##### 1.2.1.1.1 Regional Geologic Setting

Cold Creek Swamp is located within the Southern Pine Hills Section (Piney Meadows subsection) of the East Gulf Coastal Plain Physiographic Province. The generalized geology of the Coastal Plain region includes several types of Mesozoic- and Cenozoic-age sedimentary rocks that occur in narrow northwest/southeast-trending bands which dip gently southward at approximately 20 to 40 ft/mi. Within the Southern Pine Hills Section of the Coastal Plain, the underlying sedimentary units are overlain by Miocene estuarine deposits consisting of interbedded sands and clays, and in some areas the younger Pliocene Citronelle Formation which generally consists of sand and gravel [Environmental Resources Technology (ERT) 1988]. These deposits are in many areas overlain and incised by younger Pleistocene- and Holocene-age alluvial deposits, with deposition occurring from long-term sedimentation from several north/south-trending streams and rivers.

##### 1.2.1.1.2 Site Geology

The site is underlain by low river terrace and alluvial deposits that are approximately 110 to 130 ft thick. These deposits thin to approximately 60 ft adjacent to the Mobile River, which is located approximately 1-1/2 mi east of the westernmost edge of the swamp study area. The deposits consist of generally clean, unconsolidated, fine to very coarse-grained sands that contain some interbedded, discontinuous clayey seams as well as some gravelly zones. Table 1-1 summarizes the stratigraphic column in the site area. The upper sands, varying in thickness from 0 to 50 ft, consist of fine to medium-grained sands, fine-grained sandy silts, silty clays, and clays. The upper sands have moderate to low permeability. The lowermost sands, situated generally 80 ft below ground surface, contain the most highly permeable material. A very stiff, dense, bluish-

gray clay (permeability  $4.4 \times 10^{-8}$  cm/sec), presumably of marine origin, underlies the alluvial deposits. Previous studies indicate that the clay unit dips very slightly to the southwest (ERT 1988).

#### 1.2.1.1.3 Physiography and Topography

Cold Creek Swamp is a flat, low-lying area on the west bank of the Mobile River. Cold Creek drains the swamp, flowing generally west to east through the swamp and ultimately discharging to the Mobile River (Figure 1-3). The uppermost portion of the swamp (Zone I) is located on the LeMoyne and Cold Creek plant property, and is characterized by nearly level to undulating topography with several pools and minimal stream flow through most of the year. The swamp is relatively narrow and heavily wooded in the Middle Swamp Zone (Zone II) until it reaches two powerline cuts. At the powerline cuts, the swamp broadens and supports dense woody vegetation (Zone III). Cold Creek flows along the south and southeastern edge of the swamp and discharges into the Mobile River approximately 1/2 mi downstream of the Alabama Power Company cooling water discharge canal. An unnamed tributary to Cold Creek discharges to the swamp in the vicinity of the powerline cuts.

Surface elevations in the swamp range from highs of about 30 ft above mean sea level (MSL) in the Upper Swamp Zone (Zone I) at the two plant sites, to lows of approximately 6 ft MSL in the Lower Swamp Zone (Zone III) along the Mobile River. Most of the narrow Middle Swamp Zone (Zone II) and all of the broad lower swamp zone (east of the powerline right-of-way) have an elevation less than 10 ft MSL. Much of the lower and middle swamp zones becomes flooded by overflow from the Mobile River during spring storm events.

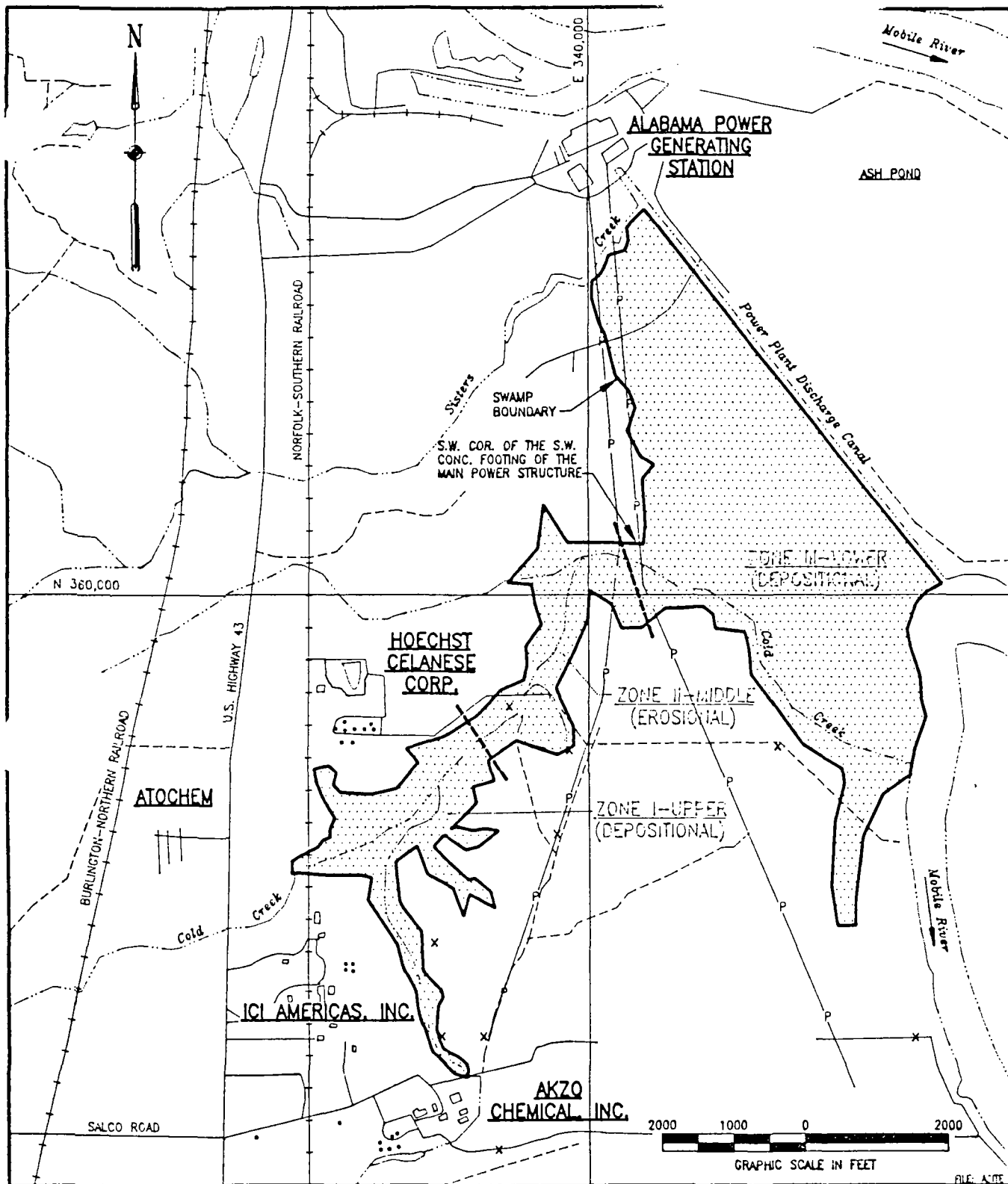
#### 1.2.1.1.4 Soils

There are two main soil associations within Cold Creek Swamp: the Izagora-Bethera association and the Dorovan-Levy association (Figure 1-4) [U.S. Department of Agriculture (USDA) 1980].

TABLE 1-1 STRATIGRAPHIC COLUMN

| Range of<br>Thickness (ft) | Range of Depths (ft) |         | Description                                                                                                                 |
|----------------------------|----------------------|---------|-----------------------------------------------------------------------------------------------------------------------------|
|                            | Top                  | Bottom  |                                                                                                                             |
| 10-17                      | 0                    | 8-22    | Red, yellow to brown stiff clay with basal sandy clay section pinching out locally.                                         |
| 0-35                       | 10-15                | 11-74   | Sand and clay interbeds grading laterally into sand.                                                                        |
| 14-34                      | 8-63                 | 30-63   | Clean coarse sand with some clay interbeds.                                                                                 |
| 18-45                      | 30-74                | 63-102  | Sand and gravel with lenses of sand or sand with some clay interbeds. Clay occurs interbedded with sand and gravel locally. |
| 3-20                       | 63-82                | 75-110  | Gray sand and clay grading laterally into either sandy clay or sand.                                                        |
| 1-23                       | 75-110               | 75-115  | Gray sand with some clay with lenses of sandy clay.                                                                         |
| 0-23                       | 80-115               | 111-131 | Sand and gravel with some clay interbeds.                                                                                   |
|                            | 111-131              |         | Blue clay                                                                                                                   |

Source: ERT Remedial Investigation Report (1988).



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REMEDIAL INVESTIGATION REPORT  
COLD CREEK SWAMP  
MOBILE, ALABAMA

HYDROLOGIC ZONES  
SITE MAP

PROJECT MGR  
GEJ

DESIGNED BY  
PWK

DRAWN BY  
MSM

CHECKED BY  
GEJ

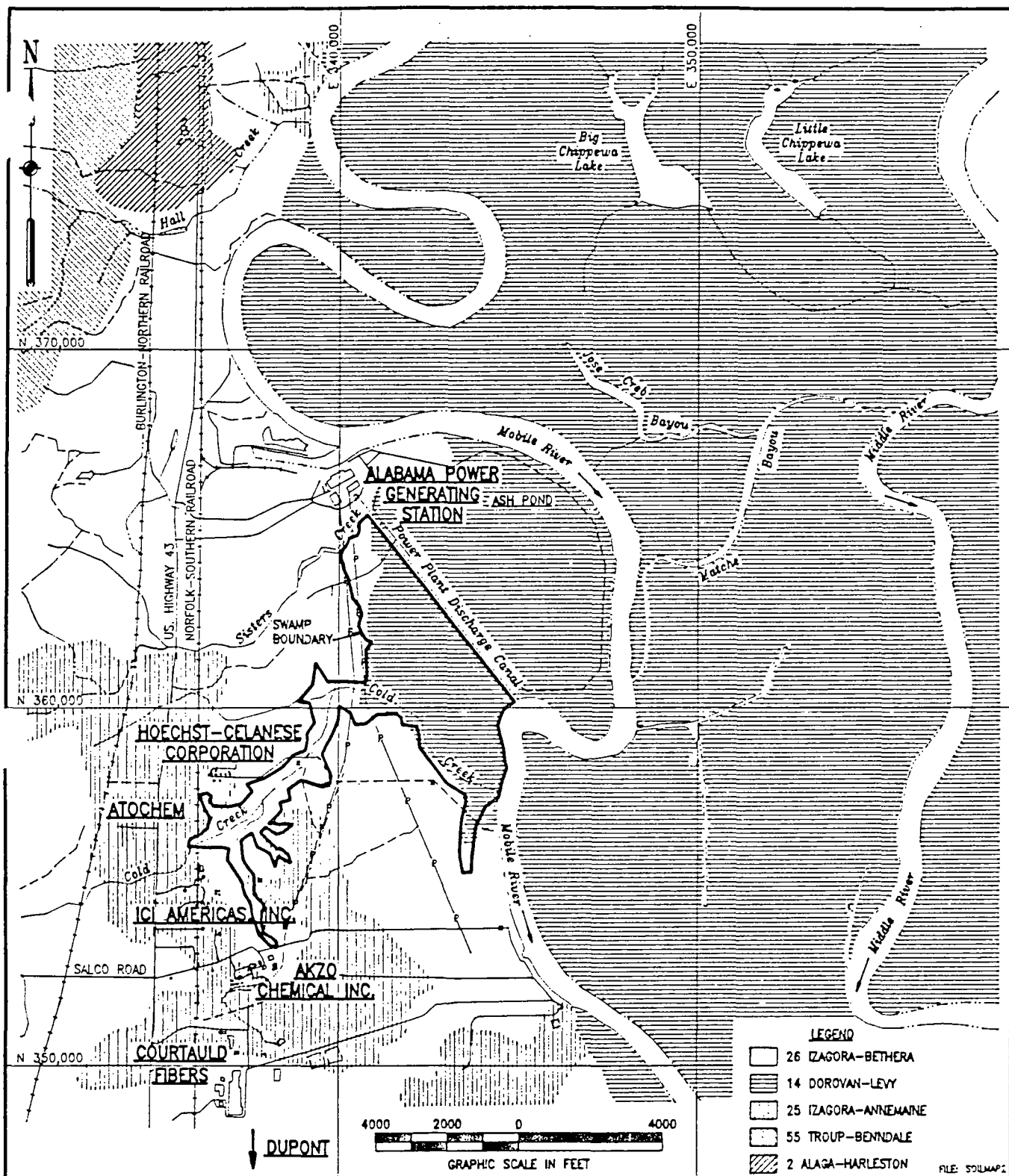
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FIGURE  
1-3

3 10 0030



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# REMEDIAL INVESTIGATION REPORT COLD CREEK SWAMP MOBILE, ALABAMA

SOILS DISTRIBUTION  
MAP

3 10 0031

Izagora-Bethera Association

The Izagora-Bethera association is most prominent in the narrow western portion of the site (Upper Swamp Zone and part of Middle Swamp Zone). This association consists of gently undulating soil types which support woodland vegetation.

Izagora Soil

The predominant soil is the Izagora which encompasses 60 percent of the area. It is a moderately well-drained soil consisting of loamy marine sediments located on broad terraces of the Coastal Plain. The typical stratigraphy of this soil is as follows:

|                                                                                                    |           |
|----------------------------------------------------------------------------------------------------|-----------|
| Dark grayish brown sandy loam                                                                      | 0-5 in.   |
| Brown sandy loam                                                                                   | 5-8 in.   |
| Yellowish brown loam                                                                               | 8-14 in.  |
| Yellowish brown and light yellowish<br>brown clay loam with light gray,<br>yellow, and red mottles | 14-54 in. |
| Light gray and light brownish gray<br>clay with red, yellow, and brown<br>mottles                  | 54-80 in. |

The upper part of the Izagora subsoil is moderately permeable (approximately  $10^{-3}$  cm/sec); the lower part exhibits lower permeability ( $10^{-5}$  cm/sec). Slopes are typically less than 2 percent but range up to 5 percent. The water table is generally 2-3 ft below the surface of the ground during the winter months, with brief flooding occurring during periods of unusually high rainfall.

Izagora soil has a high available water capacity, is low in natural fertility and organic matter content, is acidic, has good tilth (soils can be worked over a wide range of moisture content), and has a deep root zone which is easily penetrated by plants. The capability subclass and woodland group for Izagora soil are IIw and 2w, respectively.

#### Bethera Soil

Bethera is the other major soil in this association, comprising 20 percent of the area. It is a poorly drained clayey soil located in narrow to broad depressions and narrow drainageways. The typical stratigraphy of this soil is as follows:

|                                                                   |           |
|-------------------------------------------------------------------|-----------|
| Dark gray loam                                                    | 0-4 in.   |
| Gray loam                                                         | 4-6 in.   |
| Light brownish gray clay loam                                     | 6-12 in.  |
| Light gray clay loam with gray,<br>brown, yellow, and red mottles | 12-80 in. |

This soil is moderately permeable ( $10^{-4}$  to  $10^{-5}$  cm/sec), and the water table is near the surface during the winter and spring with periods of occasional brief flooding.

Bethera soil has a high available water capacity, is low in natural fertility and organic content, and is acidic. The capability subclass and woodland group for Bethera soils are IVw and 2w, respectively.

#### Other Soils

The remaining 20 percent of the Izagora-Bethera association consists of minor soils identified below:

Alga - Excessively drained, loamy sand  
 Annemaine - Moderately well-drained, sandy loam  
 Harleston - Moderately well-drained, sandy loam  
 Smithton - Poorly drained, sandy loam  
 Johnston - Very poorly drained, mucky loam  
 Dorovan - Very poorly drained, muck

#### Dorovan-Levy Association

The Dorovan-Levy association is the dominant soil association found in the broad eastern portion of Cold Creek Swamp (lower swamp--Zone III). This association consists of very poorly drained soils located in depressional swamps and bottoms along the Mobile River, and it is dissected by meandering streams. This association supports woodland vegetation and wildlife habitats.

#### Dorovan Soil

The predominant soil type is Dorovan, which covers approximately 60 percent of the area and consists entirely of muck. The typical stratigraphy of this soil is as follows:

|                         |          |
|-------------------------|----------|
| Dark grayish brown muck | 0-8 in.  |
| Black muck              | 8-80 in. |

The soil is of low permeability and the water table is above or near the surface most of the year. The area is frequently flooded. It has a high available water capacity and is acidic. The capability subclass and woodland group for Dorovan soil are VIIw and 4w, respectively.

#### Levy Soil

Levy soil makes up about 20 percent of this association. The typical stratigraphy is as follows:



Gray silty clay loam 0-6 in.

Gray clay with yellow and  
brown mottles in upper part 6-75 in.

This soil is of low permeability and water is near or above the surface most of the year. The area is frequently flooded. Levy soil has a high available water capacity and is acidic.

The capability subclass and woodland group for Levy soil are VIIw and 3w, respectively.

#### Other Soils

Minor soils included in this association comprise the remaining 20 percent. They include:

Bibb - poorly drained, sandy loam  
Pamlico - very poorly drained, muck

#### 1.2.1.2 Climatology

In the general area of Cold Creek Swamp, climate is temperate, bordering on subtropical (U.S. National Weather Service, Bates Field, Alabama). Summers are hot and humid with an average temperature of 81°F and a daily high average of over 90°F. The hottest month is July and the highest recorded temperature was 104°F on 25 July 1952. Winters are generally warm, with only occasional freezing. Average winter temperature is 53°F with an average daily minimum of 43°F. The coldest month is January and the lowest recorded temperature was 3°F on 21 January 1985.

Average annual precipitation is 63.6 in. Most precipitation falls in summer. July, August, and September average 7.1 in./month of precipitation. July has the highest monthly average with 7.8 in. October and

November are generally the driest months. October has the lowest average precipitation, 2.5 in. Thunderstorms are common, occurring about 80 days per year. Snowfall is rare.

The average relative humidity is 60 percent in mid-afternoon and 90 percent at dawn. Sunshine probability is 60 percent during the summer and 50 percent during the winter. Prevailing winds are from the west and northwest, with hurricanes originating in the south.

Weather information presented herein is based on data from the closest U.S. National Weather Service (USNWS) station. Information was compiled by the Coastal Weather Research Center at the University of South Alabama in Mobile.

#### 1.2.1.3 Land Use

Land use in the immediate vicinity of Cold Creek Swamp is primarily industrial, with chemical production plants located to the north, south, and west (Figure 1-2). In addition to the Cold Creek Plant and the LeMoyne Plant are Courtaulds Fibers, Inc., which manufactures viscose rayon fiber and nylon; DuPont, Inc., which manufactures insecticides; Hoechts-Celanese, Inc. (HCI), which produces sulfur dioxide, amines, sodium hydrosulfite, sodium bisulfite, and tetramethylfuran disulfide; and Atochem Chemicals, Inc., which manufactures organotin compounds. Directly north of the swamp area are a sand pit mining operation and a coal burning power plant. Near the northeast boundary of the swamp study area is a canal which carries cooling water discharge from the power plant southeast to the Mobile River. East of the canal is the continuation of the swamp to the Mobile River, and north of this swamp area is a large ash disposal area (greater than 150 acres) for the power plant.

#### 1.2.1.4 Demography

The project site and most of the area immediately surrounding the site is used for industrial purposes. Land on the east side of the Mobile River is primarily undeveloped and very sparsely populated due to its swampy nature. No residences are present in the immediate site vicinity. The largest residential areas proximate to the site are Mt. Vernon (population 902; 1990 Census), located 8 mi to the north, and Creola (population 1,896; 1990 Census), located 5 mi to the south (Figure 1-1).

#### 1.2.1.5 Natural Resources

The primary natural resource in the site vicinity is the Mobile River. In the vicinity of the site it is approximately 500 ft wide with an average depth of 28 ft. Minimum flow is 4,800 ft<sup>3</sup>/sec (136 m<sup>3</sup>/sec, 3.1 billion gallons per day) at a flow velocity of over 0.33 ft/sec (10 cm/sec). Minimum flow is exceeded 99 percent of the time. The river flows south, discharging into Mobile Bay and ultimately to the Gulf of Mexico. The river is heavily used for industrial barge transportation, with a minor component of recreational use.

In the Mobile River Basin, soil is a key natural resource. The region supports cultivated crop farms, livestock grazing on pasture, and natural timber production. In the immediate vicinity of the swamp, timber production (cypress trees and pulp wood) is the only form of agriculture due to the lowland nature of the area and the development of the surrounding uplands for industrial use.

Several oil and gas exploration and production wells are located within 10 mi of the area. No oil or gas wells are located in the immediate site vicinity.

Ground water is used for industrial processes at several of the surrounding plants. There are two ground-water production wells at the Cold Creek Plant and four ground-water production wells at the LeMoyne Plant.

There are no wells used for drinking water purposes on the LeMoyne Plant. There are two wells used for in plant use as a drinking water supply on the Cold Creek Plant. These wells are located in the northwest corner of the Cold Creek Plant, upgradient of the Cold Creek Swamp site. The wells are classified as "non-transient, non-community" (NTNC) sources under the Safe Drinking Water Act and are monitored by ICI for water quality parameters on the drinking water lists as well as for volatile organics.

#### 1.2.1.6 Surface Water Hydrology

Surface water runoff from several hundred acres, including the western part of the LeMoyne Plant property, a portion of the north-central part of the adjacent Courtaulds Fibers property, and a part of the adjacent Route 43 right-of-way, flows through drainage channels within the LeMoyne Plant, ultimately discharging to an unnamed tributary to Cold Creek at the head of the Upper Swamp Zone (Figure 1-5). This stream flows generally north-northwest through a series of ponds and pools within the Upper Swamp Zone (Zone I) of Cold Creek Swamp. Flow from another unnamed tributary joins Cold Creek from the east in the Middle Swamp Zone west of the western powerline right-of-way. At this point, Cold Creek then flows southeasterly to a series of ponds in the Lower Swamp Zone. Discharge channels emanating from the lowest pond in the Lower Swamp Zone cut through the shoreline levee at no less than two points where the swamp meets the Mobile River. Water flow through Cold Creek Swamp is a function of stormwater runoff and fluctuating Mobile River stages. Under static conditions, there is generally no flow and the swamp is a series of ponds and pools.

Potential for flooding in the site area located on the LeMoyne Plant and the Cold Creek Plant property is minimal. Although high intensity rain storms (greater than 2 in./hour) are not uncommon, they generally do not last long. Based on current flood insurance rate maps, the 100 year flood zone within the site area is confined to the easternmost section

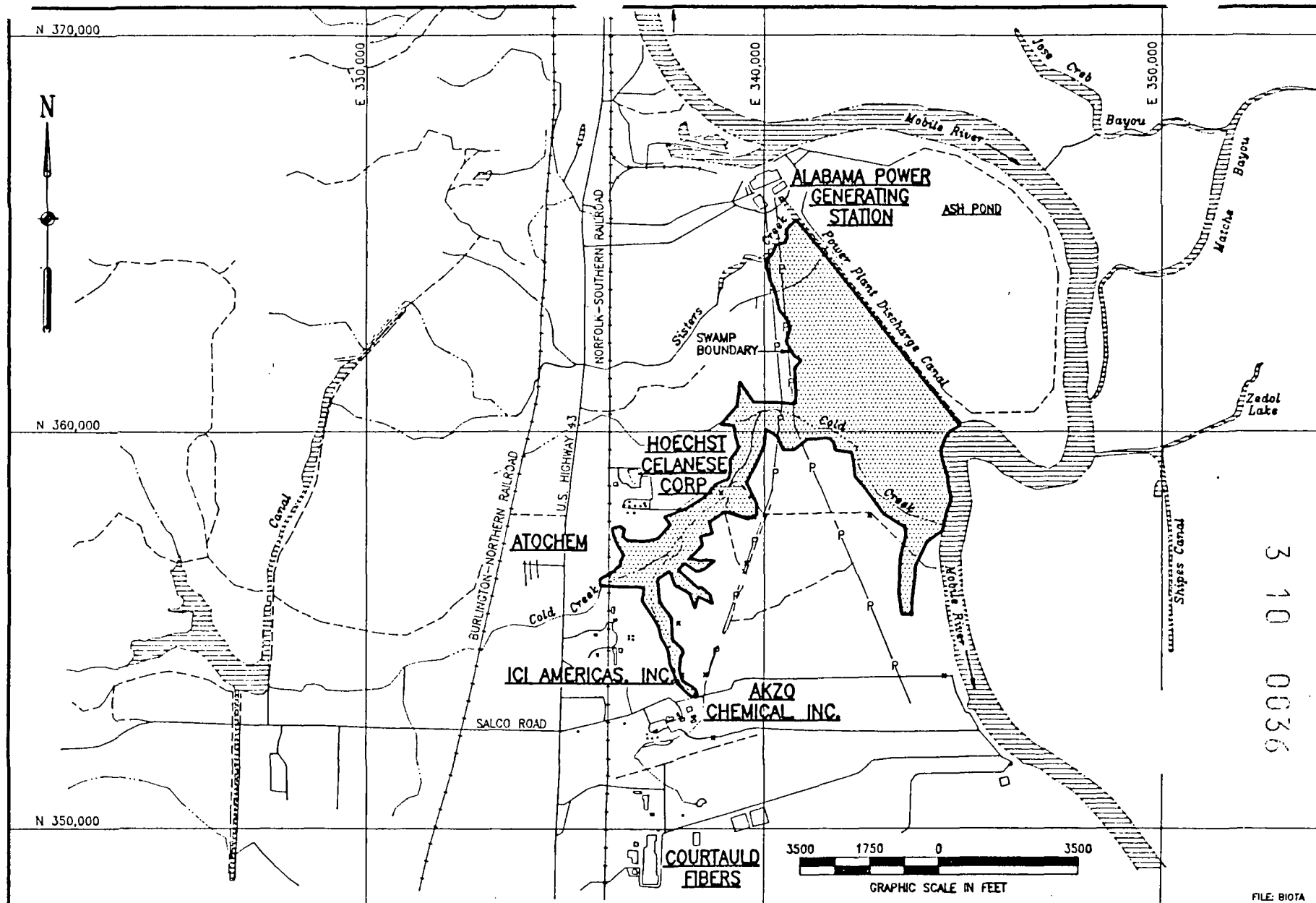
of the LeMoyne Plant property adjacent to the Mobile River (Figure 1-6). The approximate area covered by the 100-year floodplain in this part of the site, as calculated by planimeter from flood insurance maps, is 55 acres. The zone of influence of the 500-year floodplain is only slightly larger than that of the 100-year floodplain.

An extension of the present floodplain also occurs north of the plant sites along the lower portion of Cold Creek and portions of the middle and lower zones of Cold Creek Swamp. The combined 100- and 500-year floodplain areas are indicated as an approximate 800-ft-wide band along the section of Cold Creek, which flows in a northeasterly direction, with the floodplain broadening where Cold Creek begins its east-southeasterly direction of flow. The floodplain falls within, but does not completely encompass, Cold Creek Swamp, and does not extend southward toward the plant sites along the swamp area which is associated with the unnamed stream. Portions of the plant site and surrounding properties not within the 100- or 500-year flood areas are classified as Zone C, or areas considered as having a minimal flooding potential.

#### 1.2.1.7 Ground Water Hydrology

##### Regional Hydrogeologic Setting

There are two principal water-table aquifers in Mobile County. A major aquifer is located several miles west of the site in the Miocene Uplands section of the county. The second aquifer is within the Mobile River Valley, where the site is located. The second aquifer is the principal source of water for users within the valley. Existing municipal and industrial water supply wells in this aquifer typically yield 470 to 846 gpm, with specific capacities of 6 to 73 gpm per foot of drawdown (ERT 1988).



3 10 0036

FILE: BIOTA



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REMEDIAL INVESTIGATION  
COLD CREEK SWAMP  
MOBILE, ALABAMA

COLD CREEK SWAMP  
SURFACE WATER  
DRAINAGE

DESIGNED BY  
PWK

CHECKED BY  
GEJ

DRAWN BY  
MSM

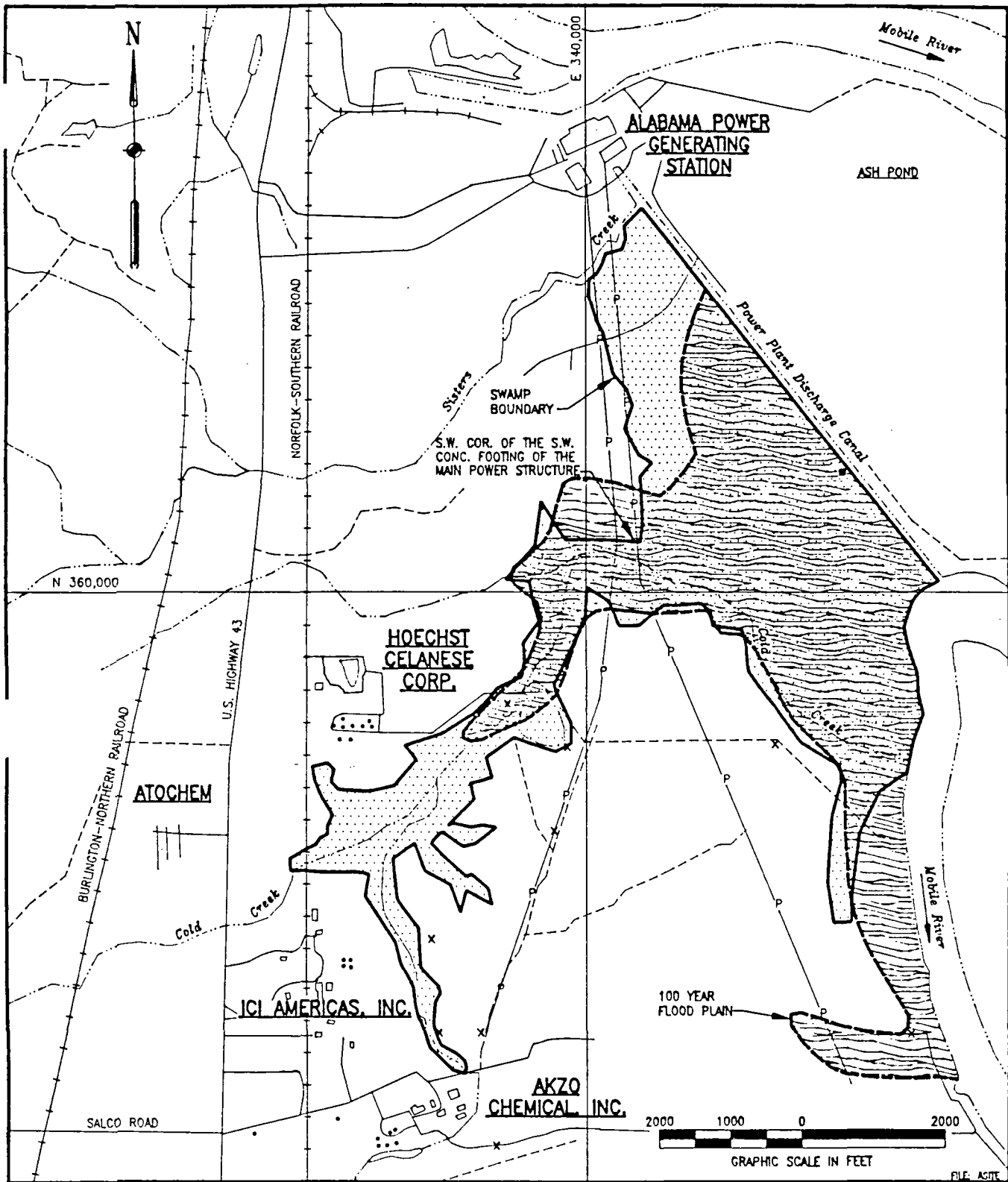
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6-5-92

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FIGURE  
1-5



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# REMEDIAL INVESTIGATION REPORT COLD CREEK SWAMP MOBILE, ALABAMA

## 100 YEAR FLOOD PLAIN SITE MAP

|                    |                    |                 |                   |                   |                |                        |               |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|
| PROJECT MGR<br>GEJ | DESIGNED BY<br>PWK | DRAWN BY<br>MSM | CHECKED BY<br>GEJ | SCALE<br>1"=2000' | DATE<br>6-5-92 | PROJECT NO<br>11653.08 | FIGURE<br>1-6 |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|

3 10 0037

### Site Hydrogeology

The Mobile River Valley water-table aquifer is recharged through infiltration from the Mobile River, Cold Creek Swamp and associated swamp lands, and rainfall. The background water quality is potable, with low total dissolved solids and iron. Prior to industrialization, ground-water flow was toward the Mobile River. The ground-water table varied from 0 to 20 ft below ground level depending on the topography. Presently, the direction of flow is toward the south-southeast, because of the local influence of pumpage at Courtaulds Fibers and from interceptor wells at the southern limits of the LeMoyné Plant. The advent of industrialization and accompanying ground-water pumpage at the Courtaulds Fibers plant site and surrounding area has resulted in a lower water table and localized changes in the direction of ground-water flow, i.e., presently, ground water in the immediate plant vicinity flows away from the Mobile River [Environmental Resources Technology (ERT) 1988].

Relatively few deep borings or well installations that extend into stratigraphic units beneath the blue clay layer have been completed within the immediate site area. Well-construction information indicates a total of eight borings which extend to a significant depth beneath the clay layer. Three of these borings represent injection wells which were drilled to depths varying from 4,330 to 4,750 ft below ground surface, with screens set for injection at varying depths greater than 3,400 ft below ground surface. Five monitoring wells installed in association with the injection wells have been installed with screens at depths varying between 207 and 1,160 ft below ground surface. Lithologic logs available for two of the borings, IM-1 and IM-2, indicate numerous alternating layers of clay with silty fine sand extending several hundred feet beneath the blue clay layer. Both logs indicate that clay is the dominant lithologic formation encountered with relatively thin layers of fine sand or silt to depths approaching 500 ft below ground surface. Ground-water usage within the site area is believed to be limited to the upper aquifer above the clay layer.

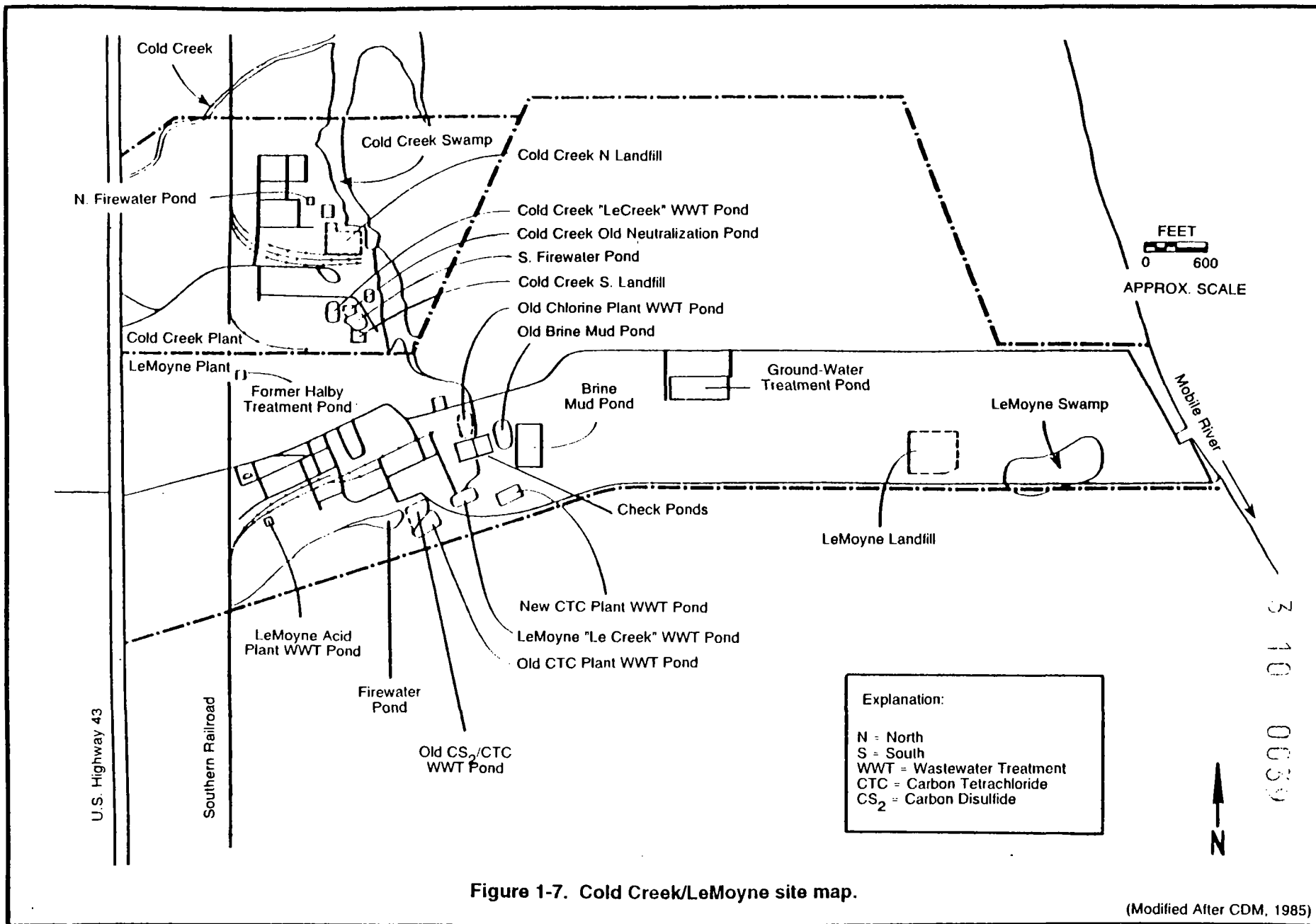


Ground Water Associates (ERT 1988) conducted aquifer pumping tests with existing production wells LM-2 and CNA-1 to evaluate hydraulic responses and determine aquifer characteristics in the site area. Transmissivity from LM-2 testing was determined to be 93,123 gpd/ft, and the storage coefficient was calculated to be 0.31. Transmissivity from CNA-1 testing was 85,232 gpd/ft, and the storage coefficient was 0.15. Based on an average saturated thickness of 77 ft, the average hydraulic conductivity was calculated to be 1,100 gpd/ft<sup>2</sup>.

#### 1.2.2 Site History

Stauffer Chemical Company previously owned and operated a multi-product chemical manufacturing plant at LeMoyne, Alabama, and an agricultural chemical facility at the adjacent Cold Creek site. The LeMoyne Plant, acquired by Akzo Chemie America (Now Akzo Chemicals Inc.) in 1987, began operations in 1953 with a retort carbon disulfide (CS<sub>2</sub>) plant followed by a reactor CS<sub>2</sub> plant in 1956. Several other production facilities were subsequently added and include a sulfuric acid plant (online in 1957), a carbon tetrachloride (CTC) plant (1963), a caustic/chlorine plant (1964), and Crystex (a proprietary sulfur compound) plant (1974). The Cold Creek Plant has been in operation since 1966 and is currently owned by ICI Americas Inc. This facility has also expanded its operations over the past 20 years and has manufactured, and continues to manufacture, a variety of agricultural chemicals, including several thiocarbamates. Halby Chemical Company (later part of Witco, Inc.) also operated a facility from approximately 1965 to 1979 on a leased section of the LeMoyne property (Figure 1-7).

Wastewaters from the Stauffer processes were held in clay-lined lagoons and discharged to Cold Creek Swamp, which received effluent from the LeMoyne and Cold Creek plants as well as from a previous tenant, the Halby Chemical Company (HCC) until approximately 1975 (Figure 1-7). The effluent from the LeMoyne Plant included discharges of process waters from several production units. Process water discharges from one of the production units contained mercury. Neutralized waste brine from the



Cold Creek Plant was also discharged to the swamp during the late 1960s. Data from the June 1988 RI indicate that the contribution from HCC may have included thiocyanate and metal-contaminated wastewater (ERT 1988). Processed wastewater discharge to Cold Creek Swamp ceased in 1975 when an effluent transport line was constructed to convey wastewater from treatment areas directly to the Mobile River. Treated effluent discharge to the Mobile River is conducted in accordance with ICI and Akzo individual National Pollutant Discharge Elimination System (NPDES) permits, and no wastewater is currently discharged to the swamp.

A small parcel of land on the western portion of the Cold Creek/LeMoyne site was leased from 1965 to 1979 to HCC, as noted above. Witco, Inc., purchased the HCC facility in 1974, and continued to operate the plant until approximately 1979, when the buildings were razed. Although little is known of this operation, waste products and effluents were reported to have been discharged to Cold Creek Swamp to the east and/or held in a pond on the property (Figure 1-7). The Halby Pond has since been closed and filled.

Presumably as a result of these practices, ground-water contamination developed. This was recognized in the early 1970s, and many improvements and waste-handling modifications were made. Two unlined waste burial sites at Cold Creek and the LeMoyne landfill were capped. The use of clay lined wastewater treatment ponds was discontinued, and several were closed. New lined ponds were installed, and treated wastewater was discharged to the Mobile River instead of to Cold Creek Swamp. Spill control and stormwater recycling and drainage controls were upgraded. Low lying plant areas adjacent to the unnamed stream feeding Cold Creek Swamp were selectively backfilled with clean fill material to control flooding. Additionally, solid wastes were diverted for offsite treatment and/or disposal, and the existing disposal sites were cleaned, consolidated, and capped with impermeable covers. The ground-water contamination was addressed by installation of an interception and treatment system. The latter was conducted with review and approval by the Alabama Water Improvement Commission (AWIC), the predecessor agency to the present Alabama Department of Environmental Management (ADEM).

There are currently nine closed or inactive wastewater ponds and five active ponds near the swamp (Figure 1-7). The five active ponds, LeMoyne "LeCreek," Cold Creek "LeCreek," the new carbon tetrachloride plant wastewater treatment (WWT) pond, the ground-water treatment pond, and the LeMoyne acid plant WWT (solids settling) pond, are all membrane lined and monitored regularly. Of the nine inactive wastewater treatment ponds, six (the old carbon disulfide plant WWT pond, old chlorine plant WWT pond, Halby treatment pond, and Cold Creek old neutralization pond and the north and south chlorine plant wastewater check ponds) are closed and covered. The old carbon tetrachloride plant WWT pond was lined and contains approximately 1,900 yd<sup>3</sup> of sulfur sludge. The old brine mud pond is a lined pond previously used for storage of brine muds from the chlorine plant. It was originally a RCRA facility, but contents have been delisted and the pond has been closed and is no longer a RCRA facility. One pond is presently a permitted RCRA facility (new brine mud pond) that meets current RCRA standards.

### 1.2.3 Previous Investigations

#### 1.2.3.1 Initial Studies

After ground-water contamination (carbon tetrachloride and other volatile organic compounds) was discovered in the early to mid-1970s, investigations of potential sources were initiated. A number of monitoring wells were installed and ground-water analysis commenced. A limited swamp sediment sampling program was also conducted. In 1982, an assessment of the plant sites was made by the Alabama Department of Public Health in response to submissions made by Stauffer to the House Committee on Interstate Commerce ("the Eckhardt Survey"). At the request of the Alabama Department of Public Health, additional monitoring wells were installed around the three closed landfills. In 1983, the U.S. Environmental Protection Agency (EPA) concluded that data from these monitoring wells justified inclusion of the former Stauffer chemical facilities on the National Priorities List (NPL), which ranks sites

contaminated with hazardous substances under provisions of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), commonly known as "Superfund" (ERT 1988).

#### 1.2.3.2 Cold Creek/LeMoyne Superfund Sites RI/FS

In early 1986, field activities for an RI were initiated. Components of the RI sampling program related to this investigation included soil borings and tissue sampling within the swamp, as well as soil borings and ground-water sampling around existing ponds and landfills on the plant sites.

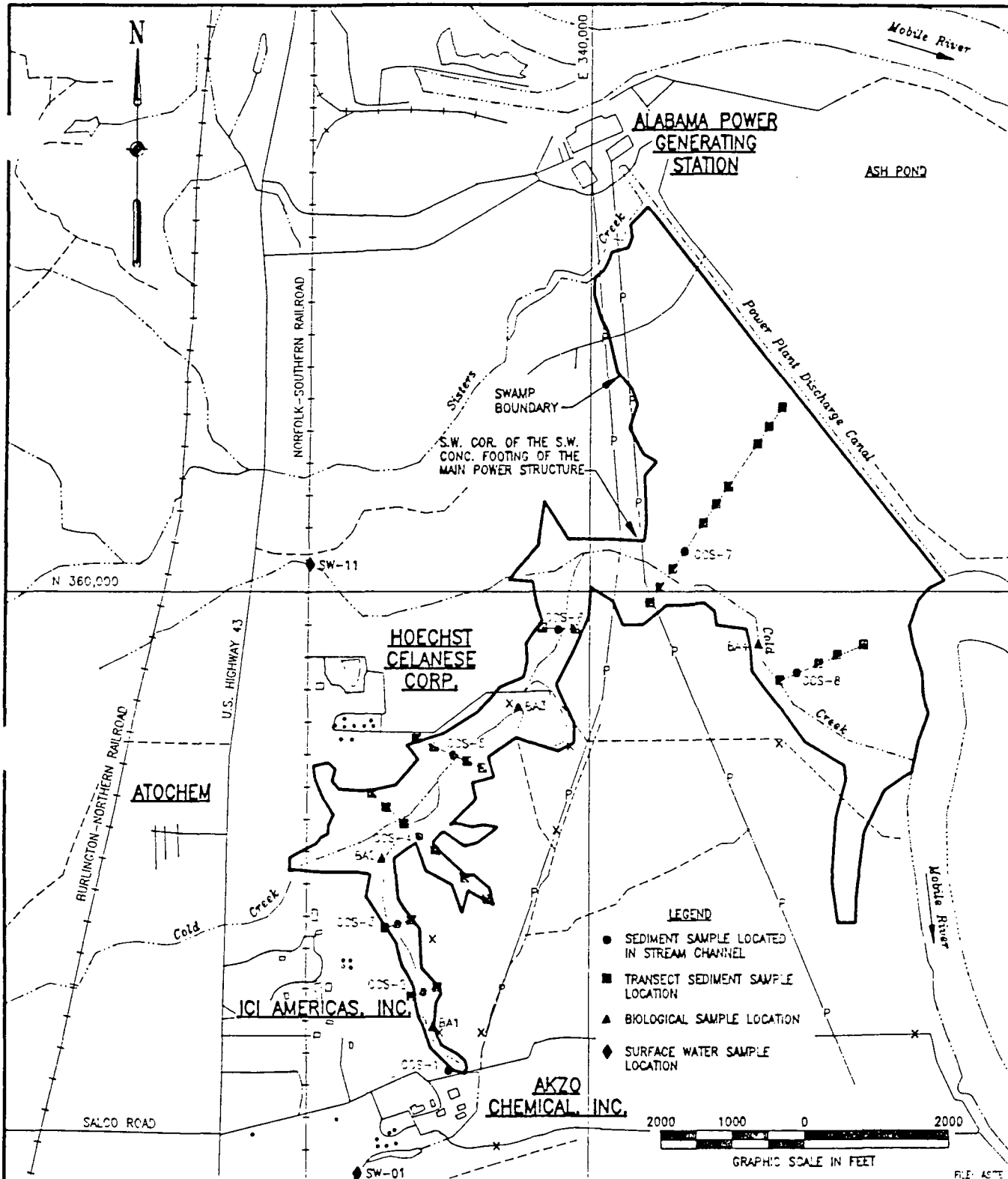
Cold Creek Swamp was sampled at 34 locations with 3-ft-deep soil borings (Figure 1-8). Three composite soil samples were analyzed for thiocarbamates, chlorides, and priority pollutants, including mercury. Remaining composite samples were analyzed for mercury only. Priority pollutant volatile or semivolatile organic compounds were not detected in any of the samples that were analyzed. Mercury was the only priority pollutant detected at concentrations exceeding trace element content ranges for natural soils (ERT 1988). Observed metal concentrations were found to compare favorably with regional soil analytical data provided by ADEM. Three locations in the upper swamp were analyzed for thiocarbamates. Results of Cold Creek Swamp sediment sample thiocarbamate analyses are presented in Table 1-2. Thiocarbamates were found at concentrations ranging from below method detection limits (BMDL) (at CCS-1S) to 1.8 mg/kg (at CCS-3S). Mercury concentrations, as shown in Table 1-3, ranged from BMDL to 690 mg/kg.

One finding of the Cold Creek/LeMoyne Superfund sites RI/FS was that no mercury was detected in any of the ground-water samples taken on the plant sites. It was concluded that residual mercury in swamp soils existed in a relatively insoluble form and that mercury contamination is not being transmitted from the swamp to underlying ground water. [See Final RI (ERT 1988), Appendix XXV]

Biological tissue samples were collected at four locations within the swamp and at one background location, and were analyzed for mercury (Figure 1-9). Levels ranged from below quantitation limits to 3.1 mg/kg based on whole body analysis. Table 1-4 shows the results of biota sampling. Because of the small size of individual fish that were collected, composite samples of multiple individuals were analyzed. Analysis was performed on a "whole body" basis.

A total of twelve soil samples were taken around the three landfills. No priority pollutants were found other than low parts-per-million levels of a few heavy metals. A few samples showed above-average values for arsenic and mercury. The area around and under the Cold Creek landfills showed no detectable levels of site-specific (production-related) compounds with minor exceptions, the highest being 1.5 mg/kg molinate (a thiocarbamate pesticide) with an average value of 0.2 mg/kg. The presence of molinate in subsurface soils is considered to reflect residual contamination from prior facility operations. The synthetic membrane covering of each of the landfills was exposed, sampled, and tested. These were found to be sound with no apparent deterioration.

Eighteen soil borings were made around nine ponds. Analysis of composite samples did not detect priority pollutants except for background levels of some heavy metals. A sample taken inside the closed Halby Pond showed high levels of copper (442 mg/kg), zinc (1,170 mg/kg), and cyanide (240 mg/kg), but samples taken adjacent to the pond were at or below background levels for these compounds. Heavy metals were not found in the ground water. Thiocyanate was detected in several soil samples collected from the Halby Pond borings. Low levels of thiocarbamates were detected in soil samples collected from under Cold Creek's closed neutralization pond. The presence of thiocarbamates in subsurface soils is considered to reflect residual contamination from prior facility operations.



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# REMEDIAL INVESTIGATION REPORT COLD CREEK SWAMP MOBILE, ALABAMA

ORIGINAL RI/FS  
SAMPLING LOCATIONS

|                    |                    |                 |                   |                   |                |                        |               |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|
| PROJECT MGR<br>GEJ | DESIGNED BY<br>PWK | DRAWN BY<br>MSM | CHECKED BY<br>GEJ | SCALE<br>1"=2000' | DATE<br>6-5-92 | PROJECT NO<br>11653.08 | FIGURE<br>1-6 |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|

3 10 0042

3 10 0043

TABLE 1-2 RESULTS OF THIOCARBAMATE SAMPLING AND ANALYSIS OF SOIL SAMPLES  
IN COLD CREEK SWAMP FROM THE 1988 COLD CREEK/LEMOYNE SUPERFUND  
SITES RI/FS

| <u>Thiocarbamate Compound</u> | <u>Sample Location</u> |               |               |
|-------------------------------|------------------------|---------------|---------------|
|                               | <u>CCS-1S</u>          | <u>CCS-2S</u> | <u>CCS-3S</u> |
| EPTC (Eptam)                  | 0.1                    | 0.2           | 1.0           |
| Butylate (Sultan)             | ND                     | 0.3           | 1.8           |
| Vernolate (Vernam)            | ND                     | 0.2           | 1.1           |
| Pebulate (Tillam)             | ND                     | ND            | 0.3           |
| Molinate (Ordram)             | 0.1                    | 0.4           | 0.9           |
| Cycloate (Ro neet)            | ND                     | 0.5           | 1.8           |

Notes:

- (1) ND = Not detected.
- (2) All concentrations shown are reported as mg/kg.
- (3) Sample locations refer to Figure 1-8.
- (4) Samples are composite of top 3 ft of soil at each location.
- (5) Source: Final RI Report for the Cold Creek/LeMoyne Site, Mobile County, Alabama, May 1988.



TABLE 1-3 RESULTS OF MERCURY SAMPLING AND ANALYSIS OF SOIL SAMPLES IN  
COLD CREEK SWAMP FROM THE 1988 COLD CREEK/LEMOYNE SUPERFUND  
SITES RI/FS

| <u>Sample Station</u> | <u>Mercury Concentration<sup>(1)</sup><br/>(mg/kg)</u> |
|-----------------------|--------------------------------------------------------|
| CCS-1S                | 300                                                    |
| CCS-2S                | 190                                                    |
| CCS-2-1E              | 1.8                                                    |
| CCS-2-1W              | 7.3                                                    |
| CCS-3S                | 230                                                    |
| CCS-3-1E              | 29                                                     |
| CCS-3-1W              | 690                                                    |
| CCS-4-1E              | 58                                                     |
| CCS-4-2E              | 1.2                                                    |
| CCS-4-3E              | 2.0                                                    |
| CCS-4-3W              | BMDL                                                   |
| CCS-4-2W              | 0.14                                                   |
| CCS-4-1W              | 15                                                     |
| CCS-5-1E              | 1.8                                                    |
| CCS-5-2E              | 5.3                                                    |
| CCS-5-1W              | 9.3                                                    |
| CCS-5-2W              | 12.7                                                   |
| CCS-6-1E              | 4.9                                                    |
| CCS-6-1W              | 6.0                                                    |
| CCS-6-2W              | 5.6                                                    |
| CCS-7-1E              | 103                                                    |
| CCS-7-2E              | 35                                                     |
| CCS-7-3E              | 49                                                     |
| CCS-7-4E              | 25                                                     |
| CCS-7-5E              | 10.5                                                   |
| CCS-7-6E              | 17                                                     |
| CCS-7-3W              | 0.9                                                    |
| CCS-7-2W              | 22                                                     |
| CCS-7-1W              | 7.7                                                    |
| CCS-8-1E              | 8.3                                                    |
| CCS-8-2E              | 2.2                                                    |
| CCS-8-3E              | 1.7                                                    |
| CCS-8-4E              | 7.0                                                    |
| CCS-8-1W              | 2.1                                                    |

Notes:

- (1) Mercury data are shown based on chemical analyses from samples collected in May 1986.
- (2) Samples are composite of top 3 ft of soil at each location.
- (3) Sample stations refer to Figure 1-8.
- (4) Source: Final RI Report for the Cold Creek/LeMoyne Site, Mobile County, Alabama, May 1988.
- (5) Sample stations are referenced based on position with respect to the stream channel. For instance, station CCS-8-3E refers to the third sample to the east of the stream centerline along the transect established at location CCS-8; station CCS-4-2W is the second sample to the west of the stream centerline along the transect established at CCS-4; and so on.

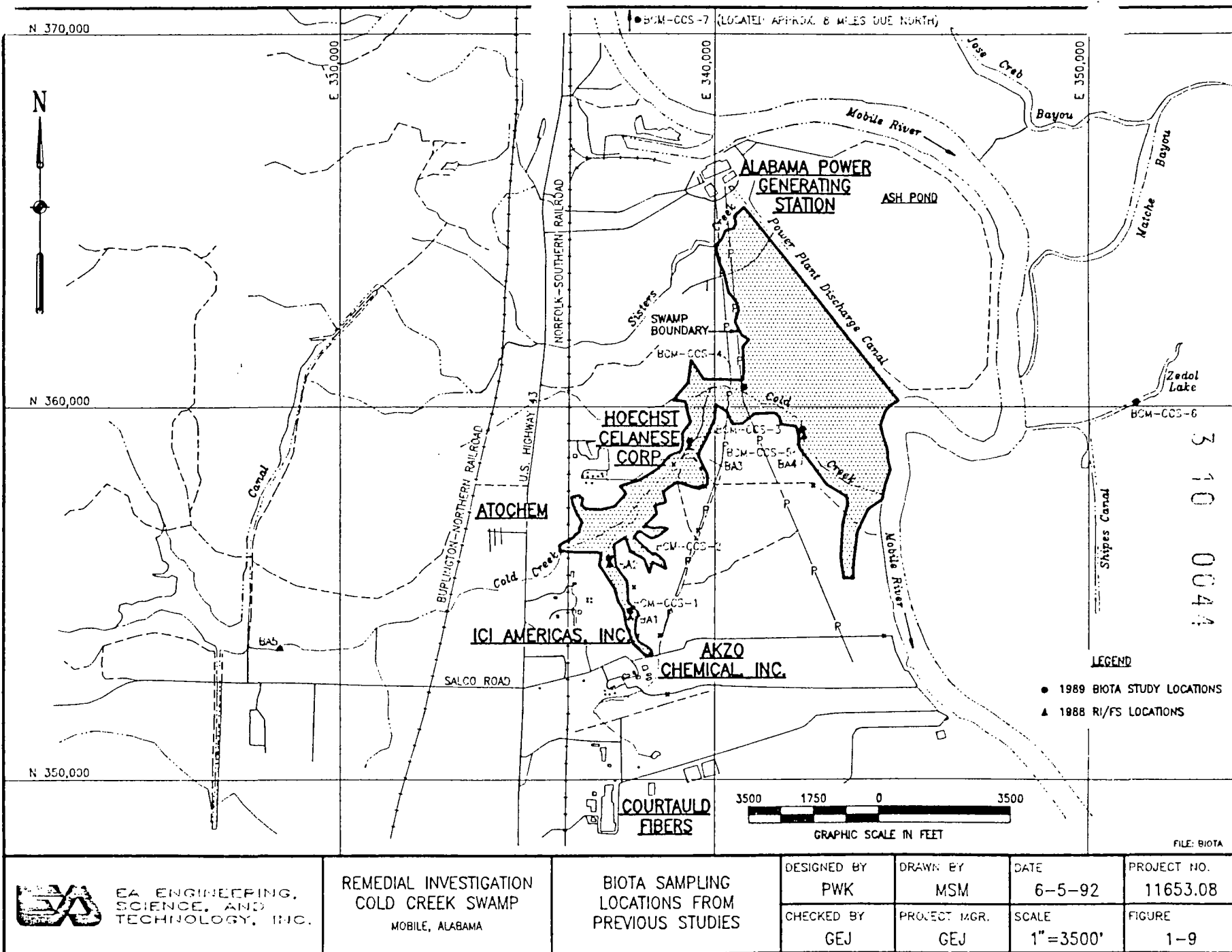


TABLE 1-4 RESULTS OF MERCURY SAMPLING AND ANALYSIS OF FINFISH SAMPLES  
FROM COLD CREEK SWAMP FROM THE 1988 COLD CREEK/LEMOYNE  
SUPERFUND SITES RI/FS

---

| <u>Sample Location</u> | <u>Mercury Concentration (mg/kg whole body)</u> |
|------------------------|-------------------------------------------------|
| BA-1                   | 0.59                                            |
| BA-2                   | 3.1                                             |
| BA-3                   | 0.91                                            |
| BA-4                   | 1.1                                             |
| BA-5                   | 0.42                                            |

---

Notes:

- (1) Mercury data shown are based on chemical analyses from samples collected May 1986.
- (2) Samples are composite whole body analysis of multiple individual finfish.
- (3) See Figure 1-9 for sample stations.
- (4) Source: Final RI Report for the Cold Creek/LeMoyne Site, Mobile County, Alabama, May 1988.

Surface water samples were collected from two locations in small unnamed tributaries to Cold Creek (Figure 1-8). Surface water sample location SW-01 was located near the southern LeMoyné property line at the railroad tracks. Sample location SW-11 was taken from the unnamed tributary to Cold Creek near the Norfolk Southern Railroad line north of the Hoechst-Celanese Corporation plant. The surface water locations were not within the limits of Cold Creek Swamp and were intended to represent background conditions. No priority pollutants, organics, or polychlorinated biphenyls (PCBs) were detected in these samples. The only compounds detected were mercury at 0.0002 mg/L and zinc at 0.31 mg/L in the surface water sample at SW-01.

Ground-water samples were collected from five monitoring wells within and around the swamp (Figure 1-10). Samples were analyzed for priority pollutants, PCBs, metals, and thiocarbamates. Mercury was not detected in any of the ground-water samples.

#### 1.2.3.3 BCM Biota Study (1989)

As a follow-up to the 1988 RI, BCM Engineers (Mobile, Alabama) conducted a more detailed biota study on finfish within Cold Creek Swamp. In November 1988, BCM field personnel collected finfish, crayfish, and earthworms considered to be representative of the aquatic community in Cold Creek Swamp from seven sample stations in the swamp. A listing of the species selected for analysis in the BCM study is presented in Table 1-5. Table 1-6 shows a summary of all finfish species actually collected during the November 1988 sampling event. Sample station locations are shown in Figure 1-10. Samples were analyzed for arsenic, chromium, copper, lead, mercury, nickel, and zinc. Samples for analysis were composites of individuals of the same species, due to the small size of individuals that were collected. The study concluded that concentrations of copper, lead, mercury, nickel, and zinc exceeded background levels for certain species, but that based on assessment of toxicity data, the levels for most compounds were not considered to present risk to the sampled species and/or subsequent predators.

The study further indicated that total mercury was measured in all of the samples collected from Cold Creek Swamp, at concentrations ranging from 0.3 to 1.9 mg/kg in fish, 0.2 to 1.2 mg/kg in crayfish, and 0.1 to 2.5 mg/kg in earthworms. A summary of mercury data from the BCM Biota Study is presented in Table 1-7.

#### 1.2.3.4 Summary of Previous Investigations

Previous studies at Cold Creek Swamp have focused on assessing potential contamination in swamp soil/sediments and in biota within the swamp. Sample activities to date have included:

- . Collection of composite 3-ft soil core sections at 34 locations within the swamp. All samples were analyzed for total mercury. Three of the 34 samples (all from the upper swamp) were analyzed for priority pollutant volatile and semivolatile organics, priority pollutant metals, PCBs, and thiocarbamates.
- . Collection of surface water samples at two locations proximate to Cold Creek Swamp. These samples were not within the boundaries of the swamp. Surface water samples were analyzed for priority pollutant volatile and semi-volatile organics, metals, PCBs, and thiocarbamates.
- . Collection of composite finfish samples from four locations within the swamp and a background location upstream of the swamp in the Cold Creek watershed. Finfish samples were analyzed for whole body total mercury.
- . Subsequent collection of composite finfish samples, crayfish, and worms from a total of 35 tissue samples from 7 sampling stations (BCM study). Once again, samples were analyzed for whole body total mercury.

TABLE 1-5 ORGANISMS SELECTED FOR ANALYSIS FOR BCM BIOTA STUDY

| <u>Scientific Name</u>         | <u>Common Name</u>     |
|--------------------------------|------------------------|
| <b>FINFISH</b>                 |                        |
| <b>Predators</b>               |                        |
| <u>Lepomis marginatus</u>      | Dollar sunfish         |
| <u>Lepomis macrochirus</u>     | Bluegill               |
| <u>Lepomis megalotis</u>       | Longear sunfish        |
| <b>Foragers</b>                |                        |
| <u>Fundulus chrysotus</u>      | Gold-spotted topminnow |
| <u>Notemigonus crysoleucas</u> | Golden shiner          |
| <u>Gambusia affinis</u>        | Mosquitofish           |
| <u>Notropis candidus</u>       | Silverside shiner      |
| <u>Lepomis punctatus</u>       | Spotted sunfish        |
| <b>Bottom Feeder</b>           |                        |
| <u>Erismyzon suetta</u>        | Lake chubsucker        |
| <b>CRAYFISH</b>                |                        |
| <u>Procambarus</u> sp.         |                        |
| <b>WORM</b>                    |                        |
| <u>Sparganophilus</u> sp.      |                        |

**Notes:**

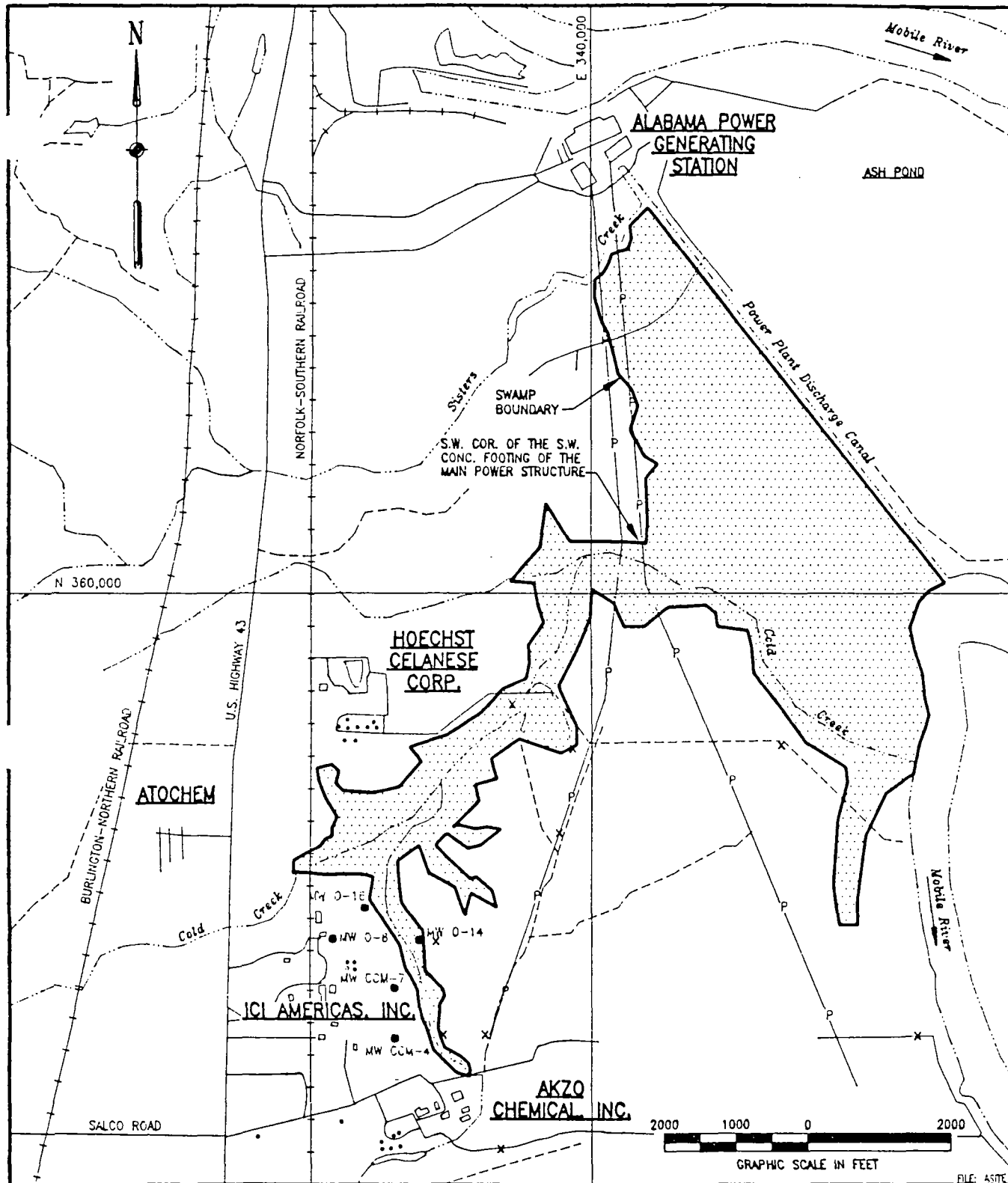
- (1) Sample blanks were comprised of catfish (Ictalurus sp.) purchased from a local fish market, crayfish (Procambarus sp.) from a local seafood market, and worms (Eisenia andrei) from a culture maintained at Vittor and Associates laboratory in Mobile, Alabama.
- (2) Source: Heavy Metals Levels in Cold Creek Swamp Biota, June 1989 (BCM).

TABLE 1-6 FINFISH SPECIES OBTAINED FOR TISSUE SAMPLING DURING THE 1988 COLD CREEK/LEMOYNE SUPERFUND SITES RI/FS AND 1989 BIOTA STUDY

| Scientific Name                | Common Name            | Station(s) <sup>(1)</sup>  |
|--------------------------------|------------------------|----------------------------|
| <u>Anquilla rostrata</u>       | American eel           | BCM-CCS2, 7                |
| <u>Aphredoderus savanus</u>    | Pirate perch           | BCM-CCS3, 4, 5, 7          |
| <u>Dorosoma cepedianum</u>     | Gizzard shad           | BCM-CCS6                   |
| <u>Elassoma zonatum</u>        | Banded pygmy sunfish   | BCM-CCS1, 5, 7             |
| <u>Erimyzon sucetta</u>        | Lake chubsucker        | BCM-CCS1, 3, 7             |
| <u>Erimyzon tenuis</u>         | Sharpfin chubsucker    | BCM-CCS4, 7                |
| <u>Esox americanus</u>         | Redfin pickerel        | BCM-CCS4, 7                |
| <u>Etheostoma fusiforme</u>    | Swamp darter           | BCM-CCS7                   |
| <u>Fundulus chrysotus</u>      | Gold-spotted topminnow | BCM-CCS1, 2, 3, 4, 5, 7    |
| <u>Fundulus notti</u>          | Starhead topminnow     | BCM-CCS1, 2, 4, 5, 6, 7    |
| <u>Fundulus olivaceus</u>      | Blackspotted topminnow | BCM-CCS6, 7                |
| <u>Gambusia affinis</u>        | Mosquitofish           | BCM-CCS1, 2, 3, 4, 5, 6, 7 |
| <u>Ictalurus natalis</u>       | Yellow bullhead        | BCM-CCS3                   |
| <u>Labidesthes sicculus</u>    | Brook silverside       | BCM-CCS6, 7                |
| <u>Lepomis culosus</u>         | Warmouth               | BCM-CCS1, 2, 3, 4, 5, 7    |
| <u>Lepomis macrochirus</u>     | Bluegill               | BCM-CCS1, 2, 3, 6, 7       |
| <u>Lepomis marginatus</u>      | Dollar sunfish         | BCM-CCS1, 2, 3, 4, 5, 7    |
| <u>Lepomis megalotis</u>       | Longear sunfish        | BCM-CCS6                   |
| <u>Lepomis microlophus</u>     | Redear sunfish         | BCM-CCS6                   |
| <u>Lepomis punctatus</u>       | Spotted sunfish        | BCM-CCS1, 2, 3, 4, 7       |
| <u>Micropterus salmoides</u>   | Largemouth bass        | BCM-CCS2, 3, 4, 6, 7       |
| <u>Minytrema melanops</u>      | Spotted sucker         | BCM-CCS7                   |
| <u>Moxostoma poecilurum</u>    | Blacktail redhorse     | BCM-CCS6                   |
| <u>Notemigonus crysoleucas</u> | Golden shiner          | BCM-CCS2, 3, 5             |
| <u>Notropis candidus</u>       | Silverside shiner      | BCM-CCS6                   |
| <u>Notropis emiliae</u>        | Pugnose shiner         | BCM-CCS6, 7                |
| <u>Notropis roseipinnis</u>    | Cherryfin shiner       | BCM-CCS7                   |
| <u>Notropis texanus</u>        | Weed shiner            | BCM-CCS6, 7                |
| <u>Percina nigrofasciata</u>   | Blackbanded darter     | BCM-CCS7                   |

Notes:

- (1) Station locations refer to station locations from the June 1989 Biota Study by BCM engineers (see Figure 1-9).
- (2) Sources: Final RI Report for the Cold Creek/LeMoyne Site, Mobile County, Alabama, May 1988; Heavy Metals in Cold Creek Swamp Biota, June 1989 (BCM).



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# REMEDIAL INVESTIGATION REPORT COLD CREEK SWAMP MOBILE, ALABAMA

GROUND WATER  
MONITORING WELLS  
(1988 RI)

|                    |                    |                 |                   |                   |                |                        |                |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|----------------|
| PROJECT MGR<br>GEJ | DESIGNED BY<br>PWK | DRAWN BY<br>MSM | CHECKED BY<br>GEJ | SCALE<br>1"=2000' | DATE<br>6-5-92 | PROJECT NO<br>11653.08 | FIGURE<br>1-10 |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|----------------|

3 10 0048



TABLE 1-7 RESULTS OF MERCURY SAMPLING AND ANALYSIS OF BIOTA SAMPLES FROM COLD CREEK SWAMP FROM THE 1989 BCM BIOTA STUDY

| Species                        | Mercury Concentration (mg/kg, wet weight) |       |       |       |       |       |       | Blank |
|--------------------------------|-------------------------------------------|-------|-------|-------|-------|-------|-------|-------|
|                                | CCS-1                                     | CCS-2 | CCS-3 | CCS-4 | CCS-5 | CCS-6 | CCS-7 |       |
| FINFISH                        |                                           |       |       |       |       |       |       |       |
| Predators                      |                                           |       |       |       |       |       |       |       |
| <u>Lepomis marginatus</u>      | 0.3                                       | 1.7   | 1.1   | 1.3   | 0.5   | ---   | ---   | ---   |
| <u>Lepomis macrochirus</u>     | ---                                       | 1.9   | 0.3   | ---   | ---   | <0.1  | <0.1  | ---   |
| <u>Lepomis megalotis</u>       | ---                                       | ---   | ---   | ---   | ---   | ---   | <0.1  | ---   |
| Foragers                       |                                           |       |       |       |       |       |       |       |
| <u>Fundulus chrysotus</u>      | 0.3                                       | ---   | ---   | ---   | ---   | ---   | ---   | ---   |
| <u>Notemigonus crysoleucas</u> | ---                                       | 0.9   | 0.8   | ---   | ---   | ---   | ---   | ---   |
| <u>Gambusia affinis</u>        | ---                                       | ---   | ---   | ---   | 0.8   | ---   | ---   | ---   |
| <u>Notropis candidus</u>       | ---                                       | ---   | ---   | ---   | ---   | <0.1  | ---   | ---   |
| <u>Lepomis punctatus</u>       | ---                                       | ---   | 1.4   | 1.3   | ---   | ---   | <0.1  | ---   |
| Bottom Feeder                  |                                           |       |       |       |       |       |       |       |
| <u>Erimyzon sucetta</u>        | 0.2                                       | ---   | 0.9   | 1.2   | ---   | ---   | <0.1  | ---   |
| Blank                          |                                           |       |       |       |       |       |       |       |
| <u>Ictalurus sp.</u>           | ---                                       | ---   | ---   | ---   | ---   | ---   | ---   | <0.1  |

Notes:

--- Species not encountered.

<0.1 Below method detection limit.

(1) Mercury data shown are based on chemical analyses from samples collected November 1988.

(2) Samples are whole body analysis of composites of multiple individuals of the same species.

(3) See Figure 1-9 for sample stations.

(4) Source: Heavy Metals Levels in Cold Creek Swamp Biota, June 1989 (BCM).

3 10 0049

TABLE 1-7 (Cont.)

[illegible]

- . Collection of ground-water samples from five monitoring wells within and around the swamp. Ground-water samples were analyzed for priority pollutant volatiles, semi-volatiles, PCBs, metals, and thiocarbamates.

Briefly, previous studies found that:

- . No priority pollutant volatile or semivolatile organics or PCBs were found in any of the swamp characterization samples.
- . Mercury was observed in all but one of the 34 soil/sediment locations within the swamp. The mercury concentration ranged from a low of BMDL to a high of 690 mg/kg at sample location CCS-3-1E. The geometric mean of mercury concentration was 51.7 mg/kg (Figure 1-8; Table 1-3). Four samples exceeded 100 mg/kg. They were all located in the upper portion of the swamp in the section north of the LeMoyné Plant but prior to the point where Cold Creek flows into the swamp.
- . Thiocarbamates were observed in the three swamp soil/sediment samples that were analyzed for thiocarbamates. Concentrations ranged from "not detected" to 1.8 mg/kg. The highest concentration of thiocarbamates was at station CCS-3S where both butylate and cycloate were measured at 1.8 mg/kg (Figure 1-8; Table 1-2).
- . Mercury was detected in all four of the finfish samples within the swamp that were analyzed during the initial round of biota sampling. Concentration ranged from 0.59 mg/kg at station BA-1 to 3.1 mg/kg at station BA-2.

Station BA-2 is physically proximate to soil sample station CCS-3 (Figure 1-9; Table 1-4). The mercury level at background station BA-5 was 0.42 ppm.

- . Mercury was detected in 16 of the 23 finfish samples, 5 of the 7 crayfish samples, and 4 of the 7 worm samples. The highest mercury levels were observed in predatory type fish at station CCS-2 (1.9 mg/kg), crayfish at station CCS-2 (1.2 mg/kg), and worms at station CCS-4 (2.5 mg/kg) (Figure 1-9; Table 1-7).
- . Mercury was not detected in water samples from any of the five ground-water monitoring wells that were tested within and around the swamp.

EPA and the natural resources trustees [National Oceanic and Atmospheric Administration (NOAA) and the U.S. Fish and Wildlife Service (USFWS)] reviewed the RI report and subsequent biota study.

Following such review, in a letter dated 4 May 1990, EPA requested that Akzo and ICI initiate a supplemental RI/FS to further examine the nature and extent of contamination within the swamp. Copies of regulatory correspondence regarding the scope of this project are included as Appendix A. This RI report presents the findings of the supplemental study, which focused on the nature and extent of contamination in Cold Creek Swamp.

### 1.3 REPORT ORGANIZATION

This RI report is divided into seven sections:

- . Section 1, Introduction: This section identifies the primary purpose of the RI and summarizes the site background and setting, which includes a site description, site history, and previous investigations.

- . Section 2, Study Area Investigation: This section describes the objectives of the field collection activities, the field collection methods, and the staged approach.
- . Section 3, Physical Characterization of the Study Area: This section reports the data obtained from the three field activities stages.
- . Section 4, Nature and Extent of Contamination: This section identifies possible sources of contamination and uses the data obtained during the field collection activities to characterize contamination in Cold Creek Swamp's surface water, soil/sediment, and biota.
- . Section 5, Contaminant Fate and Transport: In this section, potential routes of contaminant migration are discussed, along with the persistence of contaminants in the environment.
- . Section 6, Baseline Risk Assessment: This section details the human health and environmental risks associated with site contaminants. It includes the detailed baseline human health and ecological risk assessments.
- . Section 7, Summary and Conclusions: This section summarizes the findings of this RI report and recommends remedial action objectives for the Feasibility Study.

REFERENCES  
CHAPTER 1

- BCM Engineers, Inc. 1989. Heavy Metal Levels in Cold Creek Swamp Biota. Prepared for AKZO Chemicals, Inc. June. 26 pp. plus appendices.
- Coastal Weather Research Center, University of South Alabama, Mobile. 1991. Personal communication.
- Environmental Resources Technology (ERT). 1988. Final RI Report for the Cold Creek/LeMoyne Site, Mobile County, Alabama. May. 120 pp.
- U.S. Department of Agriculture (USDA) Soil Conservation Service. 1980. Soil Survey of Mobile County, Alabama. 134 pp. plus 114 map sheets.
- U.S. National Weather Service, Bates Field, Alabama. 1991. Personal communication.

## 2. STUDY AREA INVESTIGATION

### 2.1 FIELD INVESTIGATION ACTIVITIES

A three stage data collection approach was used to optimize the selection of sampling locations, to satisfy data needs for the risk investigation, and to ensure flexibility in focusing the investigation on contaminants of greatest concern. Stage I and II data collection efforts concentrated on soil/sediment characterization and characterization of surface water within and around the swamp. The frequency and types of sampling proposed for Stages I and II were developed based upon results of previous site characterizations of Cold Creek Swamp done during the original RI/FS for the Cold Creek/LeMoyne Superfund sites, and pursuant to data needs indicated in regulatory review comments on the original RI/FS. Existing data indicated that mercury represented the primary contaminant of concern. The Stage II sampling program had been developed based upon this premise; however, the scope of Stage II sampling was modified based on assessment of Stage I data.

Data collection in Stage III concentrated on biological tissue characterization. The scope of Stage III sampling was determined subsequent to results of Stage I and II data collection and ecological modeling, in order to provide the most meaningful biological characterization with the minimum amount of species sacrifice.

The data were collected for use in the following tasks:

- . Site Contamination Characterization--Assess the nature and extent of contamination within and around Cold Creek Swamp.
- . Bioaccessible Contaminant Characterization--Assess the nature and extent of contamination within the biologically active zone of Cold Creek Swamp sediments.

- . Biological Tissue Characterization--Assess the nature and extent of contamination within potentially affected biota.
- . Risk Assessment--Perform a baseline risk assessment of the potential threat posed by the site to ecological and human receptors.
- . Evaluation of Alternatives--Develop a database for evaluation of remedial technologies during the feasibility study phase.
- . Engineering Design--Support engineering design.

#### Data Quality/Quantity Needs

The following sections discuss determination of the specific data quality/quantity needs for each environmental medium sampled during field activities for the supplemental RI/FS at the Cold Creek Swamp Operable Unit.

#### Soil/Sediment Sampling Data Requirements

Existing data collected during the original RI/FS revealed concentrations of mercury ranging from below quantitation limits to 690 mg/kg in samples collected from upper-3-ft composite soil cores throughout Cold Creek Swamp. Other observed compounds included arsenic (5 mg/kg), beryllium (0.31-8.1 mg/kg), chromium (130-180 mg/kg), copper (14-35 mg/kg), lead (below detection level to 31 mg/kg), nickel (32-56 mg/kg), zinc (171-561 mg/kg), and several thiocarbamate pesticides (not detected to 1.8 mg/kg). Concentrations of all observed compounds were within the range of typical levels found in natural soils (Table 2-1) with the exception of mercury and the thiocarbamates. Volatile and semivolatile organics and PCBs were not detected. Previous data collection did not characterize contaminant concentrations at discrete vertical depths and did not differentiate between total and organic (methyl) mercury. The vertical distribution



TABLE 2-1 PREVIOUS SOIL/SEDIMENT ANALYTICAL RESULTS FOR COLD CREEK SWAMP (1988 RI DATA)

| Compound           | No. of Locations<br>sampled | Concentration<br>Range<br>(mg/kg) | Average<br>Concentration<br>(mg/kg) | Average<br>Concentration<br>in Natural Soils <sup>(a)</sup><br>(mg/kg) |         |
|--------------------|-----------------------------|-----------------------------------|-------------------------------------|------------------------------------------------------------------------|---------|
| VOCs               | 3                           | ND <sup>(b)</sup>                 | ND                                  | NA <sup>(c)</sup>                                                      |         |
| Semivolatiles      | 3                           | ND                                | ND                                  | NA                                                                     |         |
| PCBs/Pesticides    | 3                           | ND                                | ND                                  | NA                                                                     |         |
| Metals             |                             |                                   |                                     | Range                                                                  | Average |
| Mercury            | 34                          | ND-690                            | 54.7                                | 0.01-0.3                                                               | (.03)   |
| Arsenic            | 3                           | 5-5                               | 5                                   | 1-50                                                                   | (5)     |
| Beryllium          | 3                           | 0.31-8.1                          | 0.53                                | 0.1-40                                                                 | (6)     |
| Chromium           | 3                           | 120-180                           | 150                                 | 1-1,000                                                                | (100)   |
| Copper             | 3                           | 14-35                             | 27.7                                | 2-100                                                                  | (30)    |
| Lead               | 3                           | ND-31                             | 19                                  | 2-200                                                                  | (10)    |
| Nickel             | 3                           | 32-56                             | 46.9                                | 5-500                                                                  | (40)    |
| Zinc               | 3                           | 171-561                           | 348                                 | 10-300                                                                 | (50)    |
| Thiocarbamates     |                             |                                   |                                     |                                                                        |         |
| EPTC (Eptam)       | 3                           | 0.1-1.0                           | 0.4                                 | NA                                                                     |         |
| Butylate (Sutan)   | 3                           | ND-1.8                            | 0.7                                 | NA                                                                     |         |
| Vernolate (Vernam) | 3                           | ND-1.1                            | 0.4                                 | NA                                                                     |         |
| Pebulate (Tillam)  | 3                           | ND-0.3                            | 0.1                                 | NA                                                                     |         |
| Molinate (Ordram)  | 3                           | 0.1-0.9                           | 0.5                                 | NA                                                                     |         |
| Cycloate (Ro neet) | 3                           | ND-1.8                            | 0.8                                 | NA                                                                     |         |
| Chloride           | 3                           | ND-50                             | 33.3                                | NA                                                                     |         |

(a) Reference: U.S. EPA. 1983. Hazardous Waste Land Treatment. SW-874. Office of Solid Waste and Emergency Response. April. p.275, Table 6.46.

(b) ND - Not Detected.

(c) NA - Not Available.

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was needed to identify whether contamination is concentrated in the biologically active zone of swamp sediments or is distributed throughout the soil matrix. Differentiation of total and organic (methyl) mercury was needed to indicate how much mercury is inorganic and how much is organic. Table 2-2 identifies the sampling requirements for investigation activities for this supplemental RI/FS. The number of samples and the specific parameters shown are the actual number of samples that were taken. This sampling program was determined through consultation with EPA, USFWS, and NOAA based upon assessment of results of each of the successive stages of the field sampling effort. Available data indicated that mercury was the primary contaminant of concern in swamp soil/sediment. Results of Stage I sampling supported this observation. As such, Stage II and Stage III sampling was designed to focus on refining mercury characterization.

Data collected from soil/sediment sampling were used for several purposes. All of the Stage I and Stage II soil/sediment sampling data were used for determination of the nature and vertical and horizontal extent of contamination; potential migration pathways (erosional and depositional) and rate of migration; and preliminary indication of potential source areas and "hot spots." Background concentrations of metals were determined by calculating the geometric mean of soil/sediment samples taken at selected background locations.

Stage I Cold Creek Swamp soil/sediment sample locations were selected based upon examination of previous Cold Creek Swamp characterization and preliminary site reconnaissance by EA in August 1990. These samples were analyzed to determine which contaminants of concern needed to be further examined in Stage II samples. Some of the Stage II sampling data were used to assess the nature and extent of contamination located specifically within the biologically active zone (upper 4 in.) of Cold Creek Swamp sediments.

In addition to site characterization, soil/sediment data were used for ecological modeling and risk assessment purposes.

## Surface Water Sampling Data Requirements

No surface water sampling had been previously conducted in Cold Creek Swamp, although limited surface water sampling was conducted in the vicinity of Cold Creek Swamp as a component of the original RI/FS. Two surface water samples were collected from unnamed tributaries to Cold Creek. One tributary is located north of the Hoechst-Celanese Plant (north of Cold Creek), and the other is located approximately 100 ft north of the LeMoyné-Courtaulds Fibers property line near the railroad tracks (Figure 1-8). Previous surface water samples did not exhibit concentrations of priority pollutants above detection levels, with the exception of mercury (0.0002 mg/L) and zinc (0.31 mg/L) in the samples from one of the sample stations.

Surface water data collection for this supplemental RI/FS was used to characterize surface water quality within the Cold Creek Swamp, within waters discharging to Cold Creek Swamp, at the mouth of Cold Creek, and within the Mobile River upstream and downstream of the swamp discharge location; These data would also be used to characterize contaminant transport via surface water and the potential for ground-water contamination through surface water aquifer recharge. Table 2-3 shows the sampling program used for investigation activities for this supplemental RI/FS.

## Biological Tissue Sampling Data Requirements

Biological tissue sampling was previously conducted in Cold Creek Swamp in 1986 (ERT 1988) and in 1988 (BCM 1989). Five species-composite samples of finfish were analyzed for whole-body mercury concentrations in 1986, and species-specific analyses of finfish, crayfish, and worms at seven sample stations were conducted in 1988. These data showed mercury concentrations of up to 3.1 mg/kg mercury on whole-body analysis at one of the five RI sample stations.

TABLE 2-2 CHEMICAL COMPOUNDS ANALYZED IN SOIL/SEDIMENT SAMPLES

| <u>Compound</u>                            | <u>Number of<br/>Sample Locations</u> | <u>Number of<br/>Analyses</u> |
|--------------------------------------------|---------------------------------------|-------------------------------|
| <u>Stage I</u>                             |                                       |                               |
| Target Compound List Volatile Organics     | 12                                    | 17                            |
| Target Compound List Semivolatile Organics | 12                                    | 17                            |
| Target Compound List Pesticides/PCBs       | 12                                    | 17                            |
| Cyanide                                    | 12                                    | 17                            |
| Thiocarbamates                             | 12                                    | 17                            |
| Mercury (Total)                            | 19                                    | 51                            |
| Other Target Analyte List Metals           | 16                                    | 21                            |
| Methyl Mercury                             | 19                                    | 51                            |
| Sulfide                                    | 15                                    | 47                            |
| Thiocyanates                               | 12                                    | 17                            |
| <u>Stage II</u>                            |                                       |                               |
| Mercury (Total)                            | 105                                   | 153                           |
| Methyl Mercury                             | 72                                    | 96                            |
| Sulfide                                    | 105                                   | 153                           |
| Total Organic Carbon                       | 60                                    | 60                            |
| <u>Stage III</u>                           |                                       |                               |
| Mercury (Total)                            | 20                                    | 25                            |
| Methyl Mercury                             | 20                                    | 24                            |
| Total Organic Carbon                       | 20                                    | 26                            |
| Acid Volatile Sulfide                      | 20                                    | 24                            |
| Simultaneously Extracted Metals            | 20                                    | 24                            |

TABLE 2-3 CHEMICAL COMPOUNDS ANALYZED IN STAGE I SURFACE WATER SAMPLES

| <u>Compound</u>                            | <u>Number of Samples</u> |
|--------------------------------------------|--------------------------|
| Target Compound List Volatile Organics     | 6                        |
| Target Compound List Semivolatile Organics | 6                        |
| Target Compound List PCBs/Pesticides       | 6                        |
| Thiocarbamates                             | 6                        |
| Cyanide                                    | 6                        |
| Total and dissolved mercury                | 6                        |
| Methyl Mercury                             | 6                        |
| Other Target Analyte List Metals           | 6                        |
| Thiocyanates                               | 6                        |
| Chloride                                   | 6                        |
| Sulfides                                   | 6                        |
| pH                                         | 6                        |
| Hardness                                   | 6                        |
| Total dissolved solids                     | 6                        |

Note: Stage II and Stage III surface water sampling programs focused on physical and water quality parameters (i.e., dissolved oxygen, pH, temperature, flowrate, etc.). No further chemical analyses of surface water samples were included in the Stage II or Stage III field sampling programs.

Samples to support quantitative risk estimates in the supplemental RI/FS were based on mercury food web and bioaccumulation model calculations. These models incorporate information on resources present in the swamp, trophodynamics of the swamp ecosystem, and key receptor species chosen on the basis of scientific and regulatory requirements. Criteria to support selection of key receptors included (1) potential risk of contaminant uptake and associated population effects, (2) unique value or regulatory status, and (3) potential for community or ecosystem-level effects. Samples were taken of appropriate species to determine potential bioaccumulation, toxicity, and impacts as indicated by models. This approach minimized the number of destructive samples that had to be taken from swamp populations, and maximized the value of each sample by providing a mechanistic basis for understanding mercury dynamics in the ecosystem.

Tissue data are required for specific comparative and risk assessment purposes. Data quality objectives were to provide accuracy and precision sufficient to meet modeling objectives and characterize site-related risks.

The database from previous investigations was used to assess temporal trends in tissue contamination, allowing projection of future conditions given ongoing ecological processes. Biological tissue sampling for mercury was conducted to characterize possible changes since 1986 and to support quantitative estimation of risks to human health and ecological resources. Samples to characterize temporal trends reproduced as closely as possible the sampling that was conducted in 1986. Reports, notes, and interviews with and direction by personnel present at the past sampling were employed to locate new samples in the vicinity of the old ones. Collection, analysis, and reporting methods were similar, maximizing the comparative value of these samples.

## Date Requirements Synopsis

In order to meet the stated objectives of this supplemental RI and to satisfy specific data requirements as identified in this section, a staged field investigation was used. A synopsis of the data requirements for the Cold Creek Swamp supplemental RI follows:

- . To further define the nature and extent of soil/sediment contamination within and around Cold Creek Swamp, including a primary objective to characterize contamination both vertically and horizontally--previous investigations did not sufficiently characterize vertical extent of characterization. Additionally, the nature of contamination was more thoroughly characterized.
- . To examine the bioavailability of identified contamination at the site--this program included a series of soil and biological tissue sampling events. Soil sampling was designed to examine contaminant concentrations within discrete zones of the soil/sediment column.
- . A program to identify the areal and ecological limits of the swamp was conducted. The program included wetlands delineation, qualitative modeling of the wetland, and an ecological assessment based upon the flora and fauna identified within and around the swamp.
- . To further characterize surface water quality both within and upstream of Cold Creek Swamp.
- . To assess surface-water/ground-water interactions based on data collected in the field investigations, data from previous and ongoing investigations at the site, and other available information.

- . To assess the potential impact to the Mobile River from the swamp through review of sediment and surface water sample data, surface water physical measurements, and data from other previous and ongoing investigations.

As noted previously, based upon the project data requirements, a three-stage field investigation program was developed. The program was implemented on a staged basis to allow results of previous stages to be reviewed prior to initiation of subsequent stages, and to focus subsequent stages on identified contaminants of concern. The following sections describe field activities that were performed in the three-stage field investigation at Cold Creek Swamp.

#### 2.1.1 Stage I Field Activities

The primary objectives of Stage I Field Activities were to (1) characterize the nature of contamination within and around the swamp, (2) characterize the depth of contamination at selected locations within the swamp, (3) characterize surface water quality both within and upstream of Cold Creek Swamp, (4) delineate and map the wetlands at the site and establish biophysical limits of the swamp, and (5) initiate characterization of the Cold Creek Swamp ecological community via species monitoring. The Stage I field activities were developed to address specific concerns related to previous characterization of the nature and extent of chemical contamination within the swamp.

Previous studies identified mercury to be the primary contaminant of concern impacting the biota of Cold Creek Swamp. Sampling activities in Stage I were designed to provide a comprehensive scan of potential contaminants at selected locations within the swamp and to characterize the vertical contamination profile at selected locations at the site. Available information indicated that other contaminants were not expected to be found in concentrations that may potentially impact biological



communities of the swamp. Stage I sampling was designed to verify these conditions. A surface water quality characterization was another major component of the Stage I field activity.

Ecological assessment/wetland characterization and an initial compilation of site-specific biota inventory were the other primary objectives of Stage I sampling. These activities were conducted as one of the first site characterization actions, as it was important to understand the limits of areas and ecological communities that may be potentially impacted.

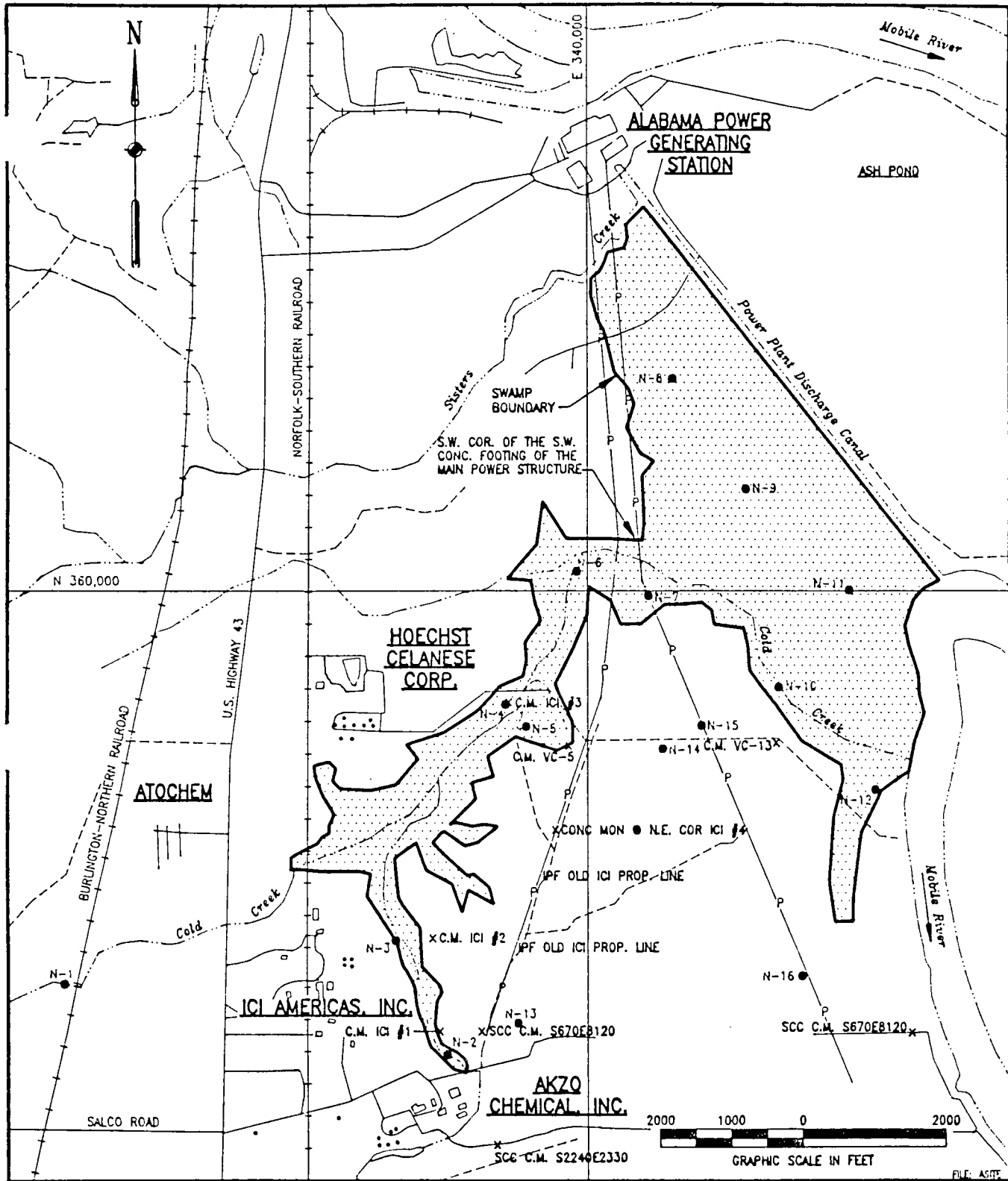
#### 2.1.1.1 Contaminant Nature Characterization

An assessment of the nature of chemical contamination in the sediment/soil in Cold Creek Swamp was completed during Stage I. This assessment was used to screen samples for a wide variety of contaminants typically found at waste sites, and to verify that mercury is the primary contaminant of concern at the site.

To address concerns that all potential contamination has been investigated, a focused sampling program to further characterize contaminant nature was conducted as part of Stage I field work. Cold Creek Swamp is conceptualized as having three hydrologic zones (Figure 1-3). For this program, samples were collected from each of the three hydrologic zones of the swamp (upper, middle, lower), including sample location CCS-3 (sample N-3) of the original RI. As noted in Section 1, this location exhibited the highest mercury and thiocarbamate concentrations during original RI site characterization.

#### Number and Location of Samples

A total of 12 locations were selected for Stage I contaminant nature characterization (Figure 2-1). The locations were chosen to provide a screening of samples from each of the three hydrologic zones of the swamp, assess background conditions, and examine the site of highest



|                                                                                                                                          |                    |                                                                                    |                   |                                                                    |                |                        |
|------------------------------------------------------------------------------------------------------------------------------------------|--------------------|------------------------------------------------------------------------------------|-------------------|--------------------------------------------------------------------|----------------|------------------------|
|  <b>EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.</b> |                    | <b>REMEDIAL INVESTIGATION REPORT</b><br><b>COLD CREEK SWAMP</b><br>MOBILE, ALABAMA |                   | <b>STAGE I</b><br><b>SAMPLING LOCATIONS</b><br><b>'N' STATIONS</b> |                |                        |
| PROJECT MGR<br>GEJ                                                                                                                       | DESIGNED BY<br>PWK | DRAWN BY<br>MSM                                                                    | CHECKED BY<br>GEJ | SCALE<br>1"=2000'                                                  | DATE<br>6-5-92 | PROJECT NO<br>11653.08 |
|                                                                                                                                          |                    |                                                                                    |                   |                                                                    |                | FIGURE<br>2-1          |

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observed contamination during previous investigation activities. Sample locations were distributed to maximize the likelihood of detecting previously undetected and/or suspected contaminants. Sampling for Stage I contaminant nature characterization was as follows:

- . One location above the discharge source areas for the determination of background levels (N-1).
- . Two locations in the upper depositional zone (N-2, N-3).
- . One location between the upper and middle hydrologic zones (N-4).
- . Two locations in the middle erosional zone (N-5, N-6).
- . Six locations in the lower depositional zone (N-7, N-8, N-9, N-10, N-11, N-12).

All locations were sampled from 0 to 12 in. and analyzed for the full range of Target Compound List (TCL) parameters, including pesticides/PCBs, Target Analyte List (TAL) metals, thiocarbamates, thiocyanate, methyl mercury, and sulfide. Four sampling locations (N-1, N-2, N-3, and N-4) also had samples taken from the 12-24 in. increment that were analyzed for the full suite of compounds as stated above.

The basis for this approach was as follows:

1. Previous samples have covered the upper (depositional) zone; therefore, sampling in this zone was for confirmation and was limited to two samples.
2. In the middle (erosional) zone there are relatively few sediment deposits. Therefore, only two additional sample locations were proposed. One sample was located at the interface of the upper and middle zones.

3. The lower (depositional) zone is the most expansive zone and was considered to have the greatest potential for contaminant deposition in the sediment. Therefore, a total of six sample locations were selected for sampling in this zone.

Additionally, four samples were taken from background locations (N-13, N-14, N-15, N-16). Background sample N-15 was analyzed for the full suite of compounds stated previously. Background samples N-13, N-14, and N-16 were analyzed for TAL metals scan only. The purpose of these samples was to confirm local background conditions for these analytes. Inorganics in nature have a large variance and these samples decreased the risk of an anomalous background hit.

This sampling approach was designed to address the nature of contamination in both erosional and depositional areas of the swamp. It was intended to identify contaminants of concern present in swamp soil/sediment and was used as a basis for justification of Stage II sampling parameters.

The sample numbering system designated Stage I contaminant nature samples as "N" (contaminant nature) samples. Sample numbers were "N," followed by a numeric qualifier (1, 2, 3...) for the sample location, and another numeric qualifier for the depth interval (1 = surficial sample, 2 = deeper sample). For example, a Stage I contaminant nature sample taken from the second sampling location at the deeper depth interval was N-2-2, while a sample taken from the surficial depth interval at the first sample location was N-1-1, and so forth. Duplicates were designated as N-DUP-1, N-DUP-2, etc. For field sampling quality control purposes, one duplicate was taken per 20 samples and one field blank was taken per sampling event. Trip blanks were taken for volatile organic analysis samples only. All field activities were conducted in accordance with the Site Health and Safety Plan. The number of samples, including

duplicates, rinsate blanks, field blanks, sample identification, and analytical parameters for Stage I contaminant nature sampling is summarized in Table 2-4.

#### Sampling Equipment and Procedures

Two samples were collected from four of the sampling locations. A surficial sample was collected from the upper 0-1 ft of soil. The deeper sample was collected between 1 and 2 ft below ground.

Surficial soil samples were collected in the following manner. The sampling technician collected a soil sample from the upper 12 in. of soil after leaves, grass, and/or any other debris were removed. Surficial soil samples were collected using stainless steel sampling trowels and/or WILDCO hand core samplers with stainless steel liners. All sampling equipment was pre-cleaned prior to sampling and decontaminated between uses. Samples for volatile organics analysis were placed in 4-oz laboratory-cleaned, wide-mouth glass jars with Teflon-lined lids. The sample jars were sufficiently filled and examined for evidence of air space prior to capping. Soil samples for other analytes were mixed in accordance with EPA Region IV Standard Operating Procedure (SOP) and placed directly into 8-oz laboratory-cleaned glass soil jars with Teflon-lined lids (i.e., one jar per sample location).

Deeper soil samples were collected immediately after surficial soil samples had been collected. The deeper soil samples were collected approximately from the interval between 1 and 2 ft below ground surface. Samples were collected using 24-in.-long, 2-in. outside diameter (OD), 1-3/8-in. inside diameter (ID) WILDCO hand core samplers with stainless steel liners. All sampling equipment was pre-cleaned prior to sampling and decontaminated between each use. The sampler was driven by hand to the desired depth at each of the surficial soil sample locations.

Samples were extracted from the sampler in as near an intact, undisturbed condition as practical. Once at the surface, the sampler liner tube was removed and the sample extracted, peeled, and bottled in as short a time as possible. "Peeling" is a process whereby that portion of the sample which was in direct contact with the sampler, as well as the ends of the sample, are removed and discarded.

Samples for volatile organics analysis were collected in 4-oz laboratory-cleaned, wide-mouth glass jars with Teflon-lined lids. The sample jars were filled and examined for evidence of air space prior to capping. After the portion of sample for volatile organic analysis had been collected, the remaining soil was thoroughly mixed in accordance with the EPA Region IV SOP prior to collection of samples for other analyses. Soil samples for other analyses were placed in 8-oz laboratory-cleaned glass soil jars with Teflon-lined lids (i.e., one jar per sample location).

Locations of sampling points were marked in the field by wooden stakes flagged with fluorescent pink ribbon. The sample location designation (i.e., N-1, N-2 . . .) was clearly written on the wooden stake in permanent black marker. The sample locations were surveyed during Stage II.

#### Sample Containers, Preservation, Holding Time, and Analytical Methods

Table 2-4 shows the sample containers, preservation and holding time considerations, analytical procedures, and total number of samples for the Stage I contaminant nature characterization.

##### 2.1.1.2 Contaminant Depth Characterization

A preliminary assessment of the depth profile of contamination was conducted during Stage I. This assessment was designed to examine mercury contamination at various depths below ground surface, and to identify if any contamination was found below the 2-3 ft depth at which contamination was expected.

TABLE 2-4 SUMMARY OF SAMPLES, ANALYTICAL PROCEDURES, HOLDING TIME, AND CONTAINERS FOR STAGE I CONTAMINANT NATURE CHARACTERIZATION

| Parameter                 | Number of Sample Locations | Number of Samples | Field Duplicates | Field Blanks | Trip <sup>(a)</sup> Blanks | Total Samples | Analytical <sup>(b)</sup> Procedures | Preservation <sup>(c)</sup> | Holding Time <sup>(d)</sup>          | Total Number of Containers                  | Containers        |
|---------------------------|----------------------------|-------------------|------------------|--------------|----------------------------|---------------|--------------------------------------|-----------------------------|--------------------------------------|---------------------------------------------|-------------------|
| Volatile Organics         | 13                         | 17                | 1                | 1            | 1                          | 20            | CLP (2/88)                           | Hold @ 4 C                  | 14 days                              | 4 oz wide-mouth glass jar with Teflon liner | 42 <sup>(g)</sup> |
| Semivolatile Organics     | 13                         | 17                | 1                | 1            | 0                          | 19            | CLP (2/88)                           | Hold @ 4 C                  | 7 days extraction<br>40 days extract | 8 oz wide-mouth glass jar with Teflon liner | 20                |
| Pesticides/PCBs           | 13                         | 17                | 1                | 1            | 0                          | 19            | CLP (2/88)                           | Hold @ 4 C                  | 5 days extraction<br>40 days extract | 8 oz wide-mouth glass jar with Teflon liner | 20                |
| Metals (TAL)              | 16                         | 20                | 1                | 1            | 0                          | 23            | CLP (7/88)                           | Hold @ 4 C                  | (f)                                  | 8 oz wide-mouth glass jar with Teflon liner | 24                |
| Methyl Mercury            | 13                         | 17                | 1                | 1            | 0                          | 19            | (e)                                  | Hold @ 4 C                  | 7 days extraction<br>40 days extract | 8 oz wide-mouth glass jar with Teflon liner | 20                |
| Thio-Carbamate Pesticides | 13                         | 17                | 1                | 1            | 0                          | 19            | EPA 634                              | Hold @ 4 C                  | 7 days extraction<br>40 days extract | 8 oz wide-mouth glass jar with Teflon liner | 20                |
| Sulfide                   | 13                         | 17                | 1                | 1            | 0                          | 19            | 9030                                 | Hold @ 4 C                  | 7 days                               | 8 oz wide-mouth glass jar with Teflon liner | 20                |

(a) Trip blanks taken for volatile organics analysis only.

(b) All methods are EPA SW-846 unless otherwise noted.

(c) No chemical preservatives added to soils.

(d) From time of sample collection.

(e) Method for methyl mercury analysis is described in Appendix B.

(f) Holding time for all metals is 6 months, with the exception of mercury which has a holding time of 28 days.

(g) Two containers per sample.

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### Number and Location of Samples

A total of three locations were selected for Stage I contaminant depth characterization (Figure 2-2). The sample locations were chosen to represent each of the three hydrologic zones of the swamp (SB-1 through SB-3). Specific sample locations were selected based upon data available from the original RI/FS. Locations with the highest observed mercury concentrations were chosen as the sample points for the current study.

Nine samples were collected from each sampling location at discrete depth intervals down to a depth of 20 ft. Samples were taken from the following approximate depth intervals:

| <u>Subsample No.</u> | <u>Depth Interval</u> |
|----------------------|-----------------------|
| 1                    | 0-1 ft                |
| 3                    | 1-2 ft                |
| 4                    | 2-3 ft                |
| 5                    | 3-4 ft                |
| 6                    | 4-5 ft                |
| 7                    | 5-7.5 ft              |
| 8                    | 7.5-10 ft             |
| 9                    | 12.5-15 ft            |
| 10                   | 17.5-20 ft            |

Samples were analyzed for total mercury, methyl mercury, and sulfide.

The soil sample numbering system designated samples for the Stage I contaminant depth characterization as "SB" because samples were collected from shallow soil borings. Sample numbers were "SB," followed by a numeric designation (1, 2, 3 . . .) for the sample location, and a second numeric designation for the subsample depth interval (1, 2, 3 . . .). For example, a soil sample from the upper swamp sample location in the 0-1 ft depth interval was designated as sample number SB-1-1. (The samples in the 0-1 ft depth interval were actually labeled SB-1-1A, SB-2-1A, and SB-3-1A because it was intended to sample in the 0-0.5 ft



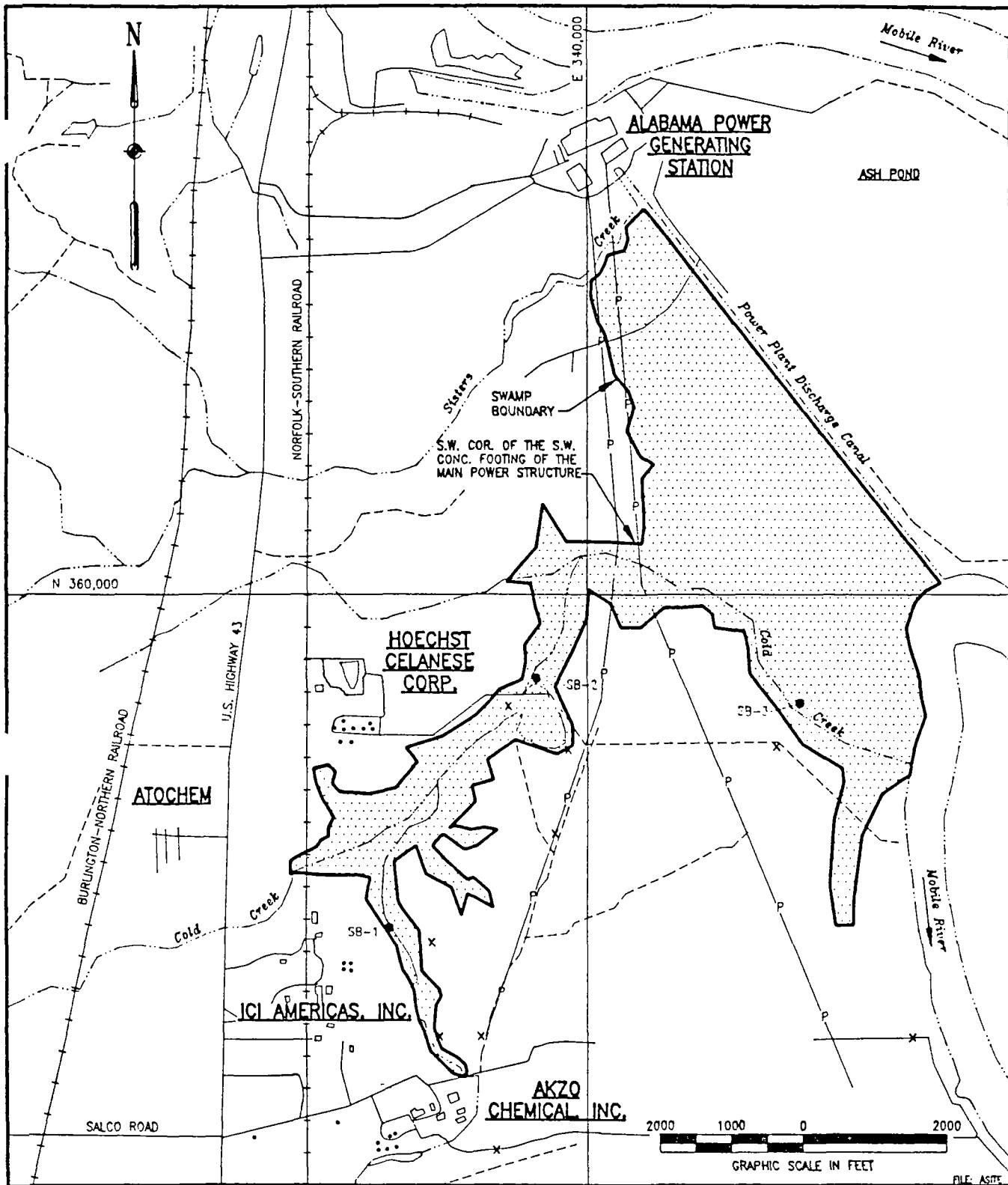
depth interval and the 0.5-1 ft depth interval. Due to the nature of the sediment it was not possible to do this and these two samples were consolidated.) A sample from the same location but collected from the 1-2 ft depth interval was SB-1-3, and so forth. Duplicates were designated by the same name as the original sample. For field sampling quality control purposes, two duplicates were taken (one per 20 samples) in addition to one field blank and trip blank.

#### Sampling Equipment and Procedures

Samples at each of the three locations were collected from the shallow soil borings. A hollow stem auger drilling rig, mounted on an all-terrain vehicle (ATV), capable of operating in marsh land and swamp conditions was used. Boreholes were drilled to a depth of approximately 20 ft (thickness of upper geologic strata in the vicinity of the swamp). Soil samples were collected using 36-in.-long, 2-in. OD, 1-3/8-in. ID, split-barrel samplers with stainless steel inserts. Stainless steel inserts and other sampling devices were pre-cleaned in the laboratory prior to mobilization onsite. Stainless steel inserts or other sampling devices as required were properly decontaminated according to EPA Region IV SOP between each use. Decontamination of the entire drill rig was only required prior to drilling at a new location.

Samples were extruded from the sampler and contained immediately following collection of the sample. Samples were placed directly into 8-oz laboratory-cleaned glass soil jars with Teflon-lined lids. One jar was used for each discrete depth interval sample.

Boreholes were sealed with bentonite grout immediately after samples were collected. Borehole cuttings were containerized to the maximum extent practicable and handled in accordance with Resource Conservation and Recovery Act (RCRA) provisions. Due to the fact that drilling was performed under water, most of the cuttings remained onsite in the vicinity of the borehole. Borehole locations were marked with wooden



|                                                                                                                                          |                    |                 |                                                                                    |                   |                |                                                                                                  |               |
|------------------------------------------------------------------------------------------------------------------------------------------|--------------------|-----------------|------------------------------------------------------------------------------------|-------------------|----------------|--------------------------------------------------------------------------------------------------|---------------|
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| PROJECT MGR<br>GEJ                                                                                                                       | DESIGNED BY<br>PWK | DRAWN BY<br>MSM | CHECKED BY<br>GEJ                                                                  | SCALE<br>1"=2000' | DATE<br>6-5-92 | PROJECT NO<br>11653.08                                                                           | FIGURE<br>2-2 |

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stakes and flagged with fluorescent pink ribbon. Wooden stakes were marked in black permanent marker with the sample location designation. Borehole locations were surveyed during Stage II.

#### Sample Containers, Preservation, Holding Time, and Analytical Methods

Table 2-5 shows the sample containers, preservation and holding time considerations, analytical procedures, and total number of samples for Stage I contaminant depth characterization.

##### 2.1.1.3 Surface Water Characterization

This section describes the various field sampling methods, sample numbers and locations, and sampling quality control for Stage I water sampling field activities at the Cold Creek Swamp.

#### Number and Location of Samples

A total of six samples were collected from surface waters for the Stage I surface water characterization (Figure 2-3). The locations were (1) Cold Creek approximately 500 ft upstream of U.S. Highway 43; (2) the natural drainage channel that flows from the Cold Creek Plant property within the upper zone of the swamp; (3) Cold Creek downstream of the discharge point of the natural drainage channel, upstream of the backwater area and due east of the Hoechst-Celanese Plant, representing the middle zone of Cold Creek Swamp; (4) Cold Creek downstream from where it crosses the power lines, representing the lower zone of Cold Creek Swamp; (5) the Mobile River upstream of the discharge point of Cold Creek; and (6) the Mobile River downstream of the discharge point of Cold Creek. All samples were laboratory analyzed for the full TCL list including pesticides/PCBs, TAL metals, thiocarbamates, thiocyanate, chloride, sulfides, hardness, total dissolved solids, total and dissolved mercury, and methyl mercury. Samples were also analyzed in the field for dissolved oxygen, temperature, conductivity, and pH.

The water sample numbering system designated samples for the Stage I surface water characterization sampling event as "W" samples. Sample numbers were "W" followed by a numeric designation (1, 2, 3 . . .) for the sample location, e.g., W-1 for the sample downstream of the dam.

#### Sampling Equipment and Procedures

Surface water samples were collected as single subsurface grabs using discrete, laboratory-cleaned sample containers. Care was taken to ensure that the air/water interface was not sampled by opening and closing the lid of the jar underwater, preventing excess oils, particulates, and other floating substances from being collected and affecting the sample. In addition, estimates of streamflow rates were made and recorded at each sampling location using an in-stream flow meter. Field measurements of dissolved oxygen, conductivity, pH, and temperature were obtained and recorded. The sampling crew collected the surface water sample from the bank, if possible; however, if it was necessary to collect the sample from within the water course, the sampling agent approached the sample point from the downstream direction and stood downstream of the collection point. The Mobile River sampling required the use of a boat, as the locations would have been difficult to reach by land. In addition, it was necessary to take the sample away from the shore to eliminate boundary/shoreline effects, and the average depth of the river at this location is 28 ft. Prior to sample collection, the sampling device was rinsed downstream of the sampling location. Surface water samples were placed in the appropriate aliquot container and preserved in the field in accordance with the preservation and sample handling criteria outlined in the work plan. Samples for dissolved solids and dissolved mercury required filtering the appropriate volume of water through a 0.45- $\mu$  filter prior to placing the sample into the container. Care was taken to properly label filtered samples.

A staff gauge was installed at each surface water sampling location prior to the sampling event. The staff gauge was horizontally tied into the surveyed traverse and was vertically located in reference to existing

TABLE 2-5 SUMMARY OF SAMPLES, ANALYTICAL PROCEDURES, HOLDING TIME, AND CONTAINERS FOR STAGE I SOIL/SEDIMENT CONTAMINANT CHARACTERIZATION

| Parameter      | Number of Sample Locations | Number of Samples | Filed Duplicates | Field Blanks | Trip <sup>(a)</sup> Blanks | Total Samples | Analytical Procedures <sup>(b)</sup> | Preservation <sup>(c)</sup> | Holding Time <sup>(d)</sup>          | Containers                                  | Total Number of Containers |
|----------------|----------------------------|-------------------|------------------|--------------|----------------------------|---------------|--------------------------------------|-----------------------------|--------------------------------------|---------------------------------------------|----------------------------|
| Methyl mercury | 3                          | 30                | 2                | 1            | 0                          | 33            | (e)                                  | Hold @ 4 C                  | 7 days extraction<br>40 days extract | 8 oz wide-mouth glass jar with Teflon liner | 33                         |
| Total mercury  | 3                          | 30                | 2                | 1            | 0                          | 33            | 245.2-CLP                            | Hold @ 4 C                  | 28 days                              | 8 oz wide-mouth glass jar with Teflon liner | 33                         |
| Sulfide        | 3                          | 30                | 2                | 1            | 0                          | 33            | 9030                                 | Hold @ 4 C                  | 7 days                               | 8 oz wide-mouth glass jar with Teflon liner | 33                         |
| pH             | 3                          | 30                | 2                | 1            | 0                          | 33            | 9045                                 | None                        | Analyze immediately                  | 8 oz wide-mouth glass jar with Teflon liner | 33                         |

(a) Trip blanks taken for volatile organics analysis only.

(b) Unless otherwise noted, methods were from USEPA SW-846.

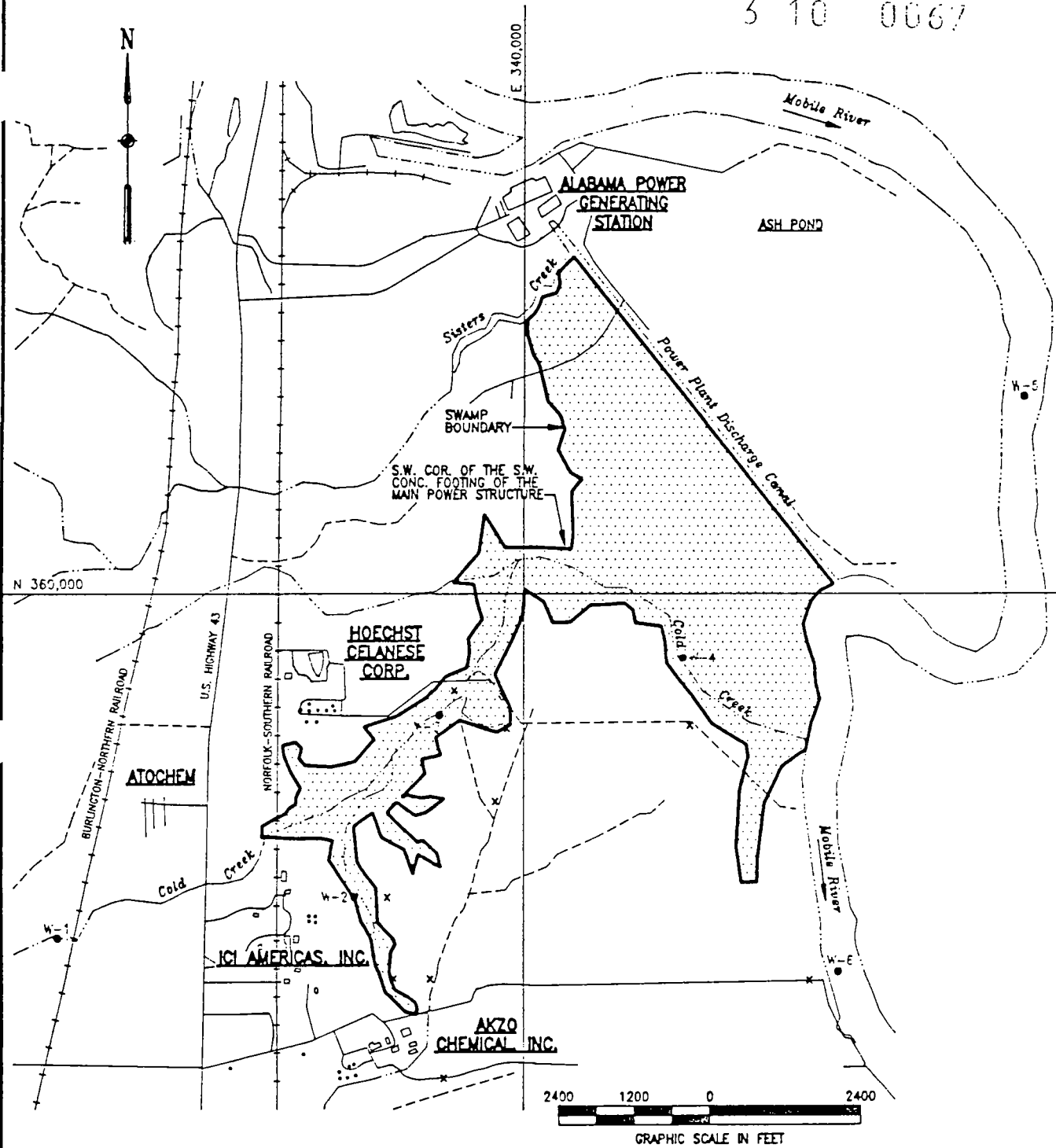
(c) No chemical preservatives added to soils.

(d) From time of sample collection.

(e) Method for methyl mercury analysis is described in Appendix B.

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## STAGE I SURFACE WATER CHARACTERIZATION SAMPLE LOCATIONS

|                    |                    |                 |                   |                   |                |                        |               |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|
| PROJECT MSR<br>GEJ | DESIGNED BY<br>PWK | DRAWN BY<br>MSM | CHECKED BY<br>GEJ | SCALE<br>1"=2400' | DATE<br>6-5-92 | PROJECT NO<br>11653.08 | FIGURE<br>2-3 |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|

onsite benchmarks. Water level, flow measurements, and dissolved oxygen content measurements were taken during this stage and both subsequent stages. Field physical testing was done in accordance with provisions outlined in EPA Region IV SOP.

#### Sample Containers, Preservation, Holding Time, and Analytical Methods

Table 2-6 shows the sample containers, preservation and holding time considerations, analytical procedures, and total number of samples for the surface water characterization.

#### 2.1.1.4 Wetlands Delineation and Characterization

The Cold Creek Swamp system was delineated through a combination of data obtained from a survey of existing information (aerial photographs, topographic maps, soil survey, and existing wetland maps) and from detailed field reconnaissance efforts (hydric soil characteristics, wetland hydrology, and hydrophytic community composition). Aerial photographs were used to identify signature differences among the various plant communities. The soil survey was evaluated for the distribution of soils listed in the publication "Hydric Soils of the United States" (USDA 1985). In addition, soils with a capability listing of IIw or greater in the Mobile County, Alabama, soil survey were considered and evaluated for their potential hydric condition. Topography was used to identify low-gradient areas, drainage areas, and to assess the degree of stream channel incision.

Field reconnaissance efforts included an evaluation of soil color, moisture, and texture, with the soil color generally determining whether the soil could be characterized as hydric. Soil samples were collected using an Oakland soil probe with a core tube length of 16 in. and a diameter of 1 in. Several hundred soil samples were evaluated along the upland/wetland boundary to identify the transition area. Evidence of wetland hydrology was evaluated for wetland delineation and to assist

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in establishing the duration and frequency of wetland saturation/inundation. In addition, plant community composition and dominance were evaluated using standard prism counting techniques and other procedures outlined in the Federal Manual for Identifying and Delineating Jurisdictional Wetlands [EPA, USFWS, Soil Conservation Service (SCS), and U.S. Army Corp of Engineers (USACOE) 1989].

An area was identified as a wetland where 50 percent or more of the plant species in a community was characterized as facultative or obligate wetland species, where wetland hydrology was present, and where the underlying soils were mottled, gleyed (chroma less than 2), or exhibited other hydric characteristics. Such an area was identified on a map with an estimate of its areal distribution.

Observed patterns of aerial photo textures, plant community composition, hydric soils distribution, and topography were used to develop the map of wetland distribution on the site. This information was also used to differentiate the various wetland communities which comprise the Cold Creek Swamp wetland system. )

During the field effort, data sheets for the Federal Manual's delineation approach were completed. In addition, input information required by the Wetland Evaluation Technique (WET) model (USACOE 1987) was also obtained, using the standard data sheets provided in the WET manual. The WET model was run in EA's office after the field reconnaissance effort was completed.

#### 2.1.1.5 Biota Inventory Observations

Beginning in Stage I and continuing through Stage III, an inventory of biota present in the Cold Creek Swamp area was compiled from direct observation by a team of field ecologists, including botanists, wetlands specialists, and field zoologists. These observations concentrated on macrophytic vegetation and resource and food web fauna, as these define

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TABLE 2-6 SUMMARY OF SAMPLES, ANALYTICAL PROCEDURES, HOLDING TIME, AND CONTAINERS FOR STAGE I IN SITU SURFACE WATER CHARACTERIZATION

| Parameter               | Number of<br>Samples and<br>Locations | Field<br>Duplicates | Field<br>Blanks | Total<br>Samples | Analytical <sup>(a)</sup><br>Procedure | Preservation                               | Holding Time <sup>(b)</sup>          | Containers    |
|-------------------------|---------------------------------------|---------------------|-----------------|------------------|----------------------------------------|--------------------------------------------|--------------------------------------|---------------|
| Total dissolved solids  | 6                                     | 1                   | 1               | 8                | EPA 160.1                              | Hold @ 4 C                                 | 7 days                               | P, G          |
| Hardness                | 6                                     | 1                   | 1               | 8                | APHA 314A                              | Hold @ 4 C<br>HNO <sub>3</sub> to pH<2     | 6 months                             | P, G          |
| pH                      | 6                                     | 1                   | 1               | 8                | 9040                                   | None                                       | Analyze<br>immediately               | P, G          |
| Chlorides               | 6                                     | 1                   | 1               | 8                | 9250                                   | None                                       | 28 days                              | P, G          |
| Sulfides                | 6                                     | 1                   | 1               | 8                | 9030                                   | Hold @ 4 C<br>Zinc acetate<br>NaOH to pH>9 | 7 days                               | P, G          |
| Total dissolved mercury | 6                                     | 1                   | 1               | 8                | 245.1 CLP-M                            | HNO <sub>3</sub> to pH<2                   | 28 days                              | P, G          |
| Total mercury           | 6                                     | 1                   | 1               | 8                | 245.1 CLP-M                            | HNO <sub>3</sub> to pH<2                   | 28 days                              | P, G          |
| Methyl mercury          | 6                                     | 1                   | 1               | 8                | (c)                                    | Hold @ 4 C                                 | 7 days extraction<br>40 days extract | G, Teflon cap |
| Volatile Organics       | 6                                     | 1                   | 1               | 8                | CLP<br>(2/88)                          | pH<2<br>Hold @ 4 C                         | 14 days                              | G, Teflon cap |
| Semivolatile Organics   | 6                                     | 1                   | 1               | 8                | CLP<br>(2/88)                          | Hold @ 4 C                                 | 7 days extraction<br>40 days extract | G, Teflon cap |
| Pesticides/PCBs         | 6                                     | 1                   | 1               | 8                | CLP<br>(2/88)                          | Hold @ 4 C                                 | 5 days extract<br>40 days extract    | G, Teflon Cap |
| Metals (TAL)            | 6                                     | 1                   | 1               | 8                | CLP<br>(7/88)                          | Hold @ 4 C                                 | (d)                                  | P, G          |

(a) All analytical procedures are from EPA SW-846 unless otherwise noted; see Table 7-1 in QAPP.

(b) From time of sample collection.

(c) Described in Appendix B.

(d) Holding time for all metals is 6 months, with the exception of mercury which has a holding time of 28 days.

P = plastic

G = glass

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the basic community types. Observations were combined with published habitat data and community structural information to ensure that species observed and potentially present were included in inventories.

Particular attention was paid to potential presence of endangered or threatened species. Any such species observed were noted.

#### 2.1.2 Stage II Field Activities

The Stage II field investigation was developed to expand the Stage I nature and extent characterization of contamination within Cold Creek Swamp, and to investigate the extent of contamination within the biologically active zone of swamp soil/sediment. Primary objectives of Stage II field activities were to:

1. Characterize the vertical and horizontal extent of contaminants of concern within and around the swamp.
2. Examine the bioaccessibility of mercury in soil/sediment samples.
3. Examine the physical characteristics (flow rate, stream gage, dissolved oxygen content) of swamp surface water under differing environmental conditions.

The final scope of Stage II sampling was based upon assessment of Stage I data results pursuant to review and comment by EPA, USFWS, and NOAA on scope proposed by EA in May 1991 and on the May 1991 Stage I Findings Report (EA 1991). Stage II data were used to characterize the potential bioaccessibility of contamination at the site in addition to providing the input parameters needed to conduct ecological risk modeling prior to Stage III field activities.

### Sample Management Trailer

Stage II field activities included mercury contamination characterization and bioaccessible contaminant characterization. Two three-person sampling teams collected soil and sediment samples. Two members of each team were engaged in sample collection at all times. The third team member was engaged in sample handling (extrusion, characterizing, marking, packaging, shipping, and tracking) and equipment decontamination. All samples were extruded, containerized, and labeled in the field immediately after collection. Sample containers were inventoried and stored in an air conditioned, onsite sample management trailer. The trailer was equipped with sufficient bench space for sample packaging, shipping, and tracking activities. The sample management trailer was located on the property of the LeMoyne chemical plant (Akzo Chemicals).

Soil samples were stored on ice to 4°C in locked coolers at all times prior to shipment. Every other day, or more frequently if required, samples were shipped to the analytical chemistry laboratory via overnight priority air delivery.

### Field Surveying

Prior to locating the sample points, the field surveying team re-established the survey traverse that had been developed for the original Cold Creek LeMoyne RI/FS. Then, all Stage I sampling points that had been marked in the field after samples were collected were located. Next, all Stage II sample locations south of S-10 were surveyed and located prior to sample collection. Sample locations north of S-10 could not be located/surveyed in the field during Stage II sampling due to high water in lower swamp. These were surveyed several months later when conditions permitted. The sample locations were marked in the field with wooden stakes that were flagged with fluorescent ribbon. The locations were surveyed into the newly established benchmarks to accurately determine sample location.

After all sample locations had been marked in the field, the surveyor developed a site map showing the location of all sample points and major site features (Figure 2-4). A table listing the horizontal coordinates of all sample points was provided with the site map and is included in Appendix C.

#### 2.1.2.1 Mercury Contamination Characterization

Sediment soil core samples were collected from a total of 45 locations for total mercury analysis. Samples were taken from one 0-12 in. interval at each of the 22 locations, and from three 1-ft intervals at each of the 23 other locations. Figures 2-5 and 2-6 show the sample locations.

Sediment soil core samples ("D" samples) were collected from 23 of the 45 locations (Figure 2-4) to characterize the depth profile of mercury contamination. The samples were collected at three discrete depth ranges: (1) 0-1 ft, (2) 1-2 ft, and (3) 2-3 ft, and are referenced as "D" samples. The samples were collected using 36-in.-long, 2-in. OD, 1-3/8-in. ID WILDCO hand core samplers with stainless steel inserts. The samplers were pushed to the desired depth and extracted by hand. The soil samples were extruded in the field immediately after sampling onto clean aluminum foil, peeled and placed into clean stainless steel bowls for mixing, and placed in 8-oz laboratory-cleaned, glass soil jars with Teflon-lined lids. One jar was used for each discrete depth interval from each sample location. Samples were stored in locked ice-packed coolers to 4°C at all times.

At the remaining 22 sample locations ("S" samples), sediment soil core samples were collected from the 0-1 ft interval only (Figure 2-5). The sample collection procedure was identical to the procedure used for collecting "D" samples.

All of the "D" and "S" samples were analyzed for total mercury. Appendix D includes a copy of the field progress reports indicating the dates when locations were sampled and samples shipped.

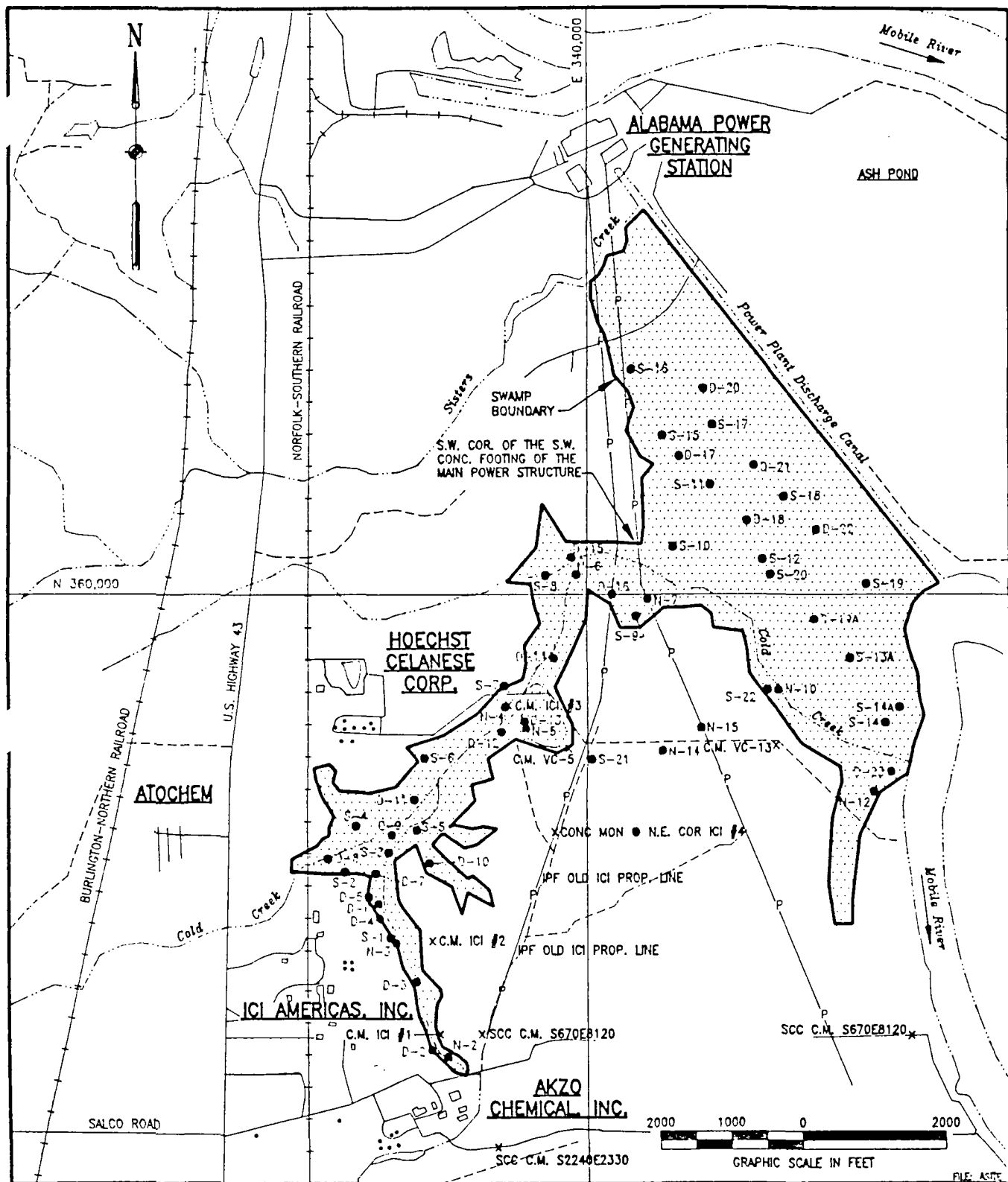
#### 2.1.2.2 Bioaccessible Contaminant Characterization

An additional 60 sample locations were identified for bioaccessible contamination screening. Of the 60 samples, the locations of 18 samples (B-1 through B-18) were selected using a statistically derived stratified random distribution methodology. A map showing locations of the 60 "B" samples is included as Figure 2-7. The following parameters were analyzed for in all "B" samples:

- . total mercury
- . methyl mercury
- . total sulfide
- . total cadmium, copper, aluminum, and zinc

The final field progress report (Appendix D) summarizes the dates that samples were collected and shipped. All samples were collected in accordance with the final approved Work Plan. Most samples were taken in the lower swamp area. Samples at 20 of the 60 locations were field screened for temperature, Eh, and pH. These 20 samples were also analyzed in the laboratory for total organic carbon (TOC) and acid volatile sulfide with simultaneously extracted metals (AVS/SEM).

Samples were collected from the upper 4 in. using stainless steel trowels and/or stainless steel post-hole diggers, depending on sample accessibility. Soil samples were thoroughly mixed in stainless steel bowls and were placed in 8-oz laboratory-cleaned, glass soil jars with Teflon-lined lids. Samples were stored in locked ice-packed coolers at 4°C at all times.



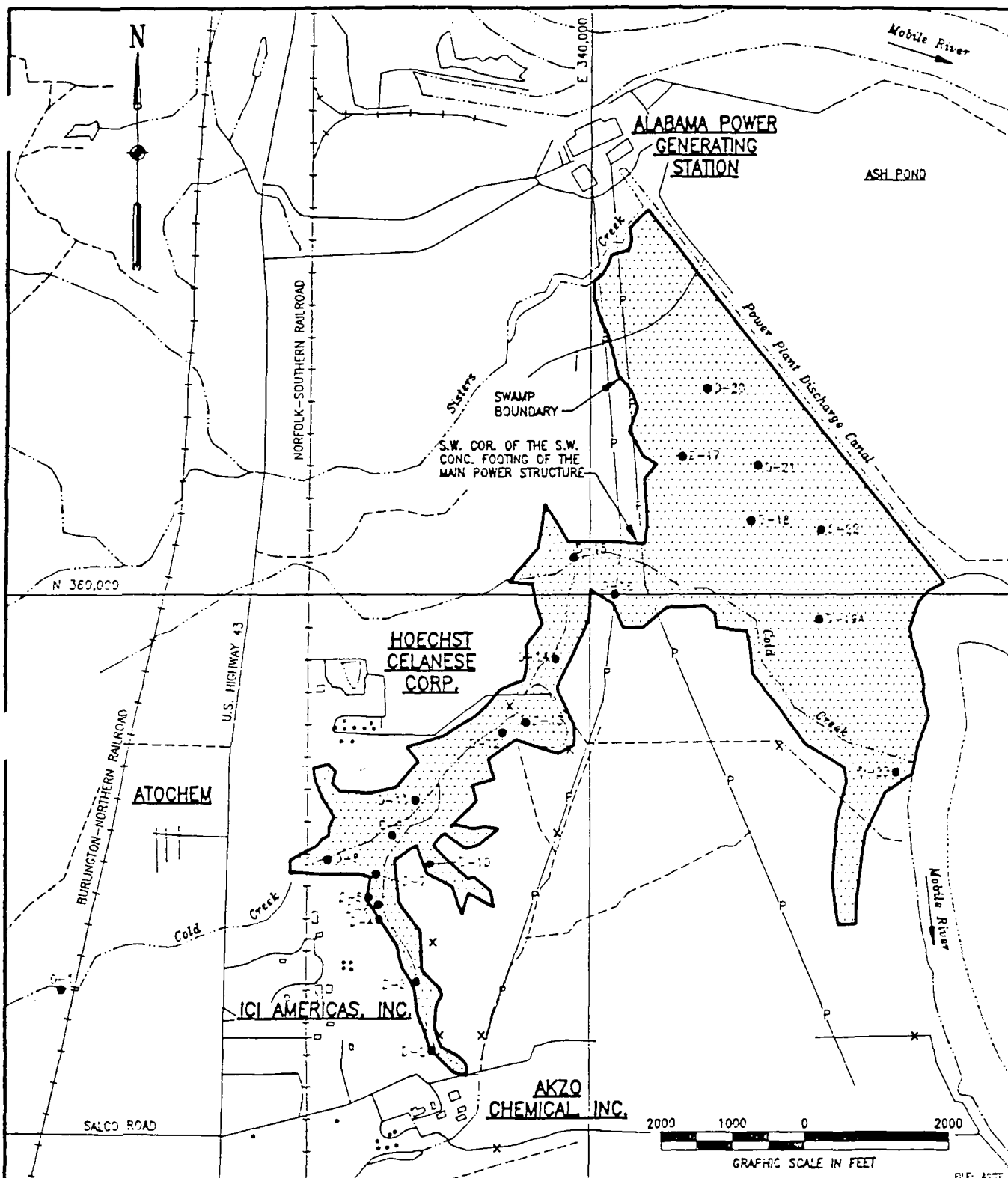
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STAGE I & II  
SURVEYED SAMPLING  
LOCATIONS

|                    |                    |                 |                   |                   |                |                        |               |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|
| PROJECT MGR<br>GEJ | DESIGNED BY<br>PWK | DRAWN BY<br>MSM | CHECKED BY<br>GEJ | SCALE<br>1"=2000' | DATE<br>6-5-92 | PROJECT NO<br>11653.08 | FIGURE<br>2-4 |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|

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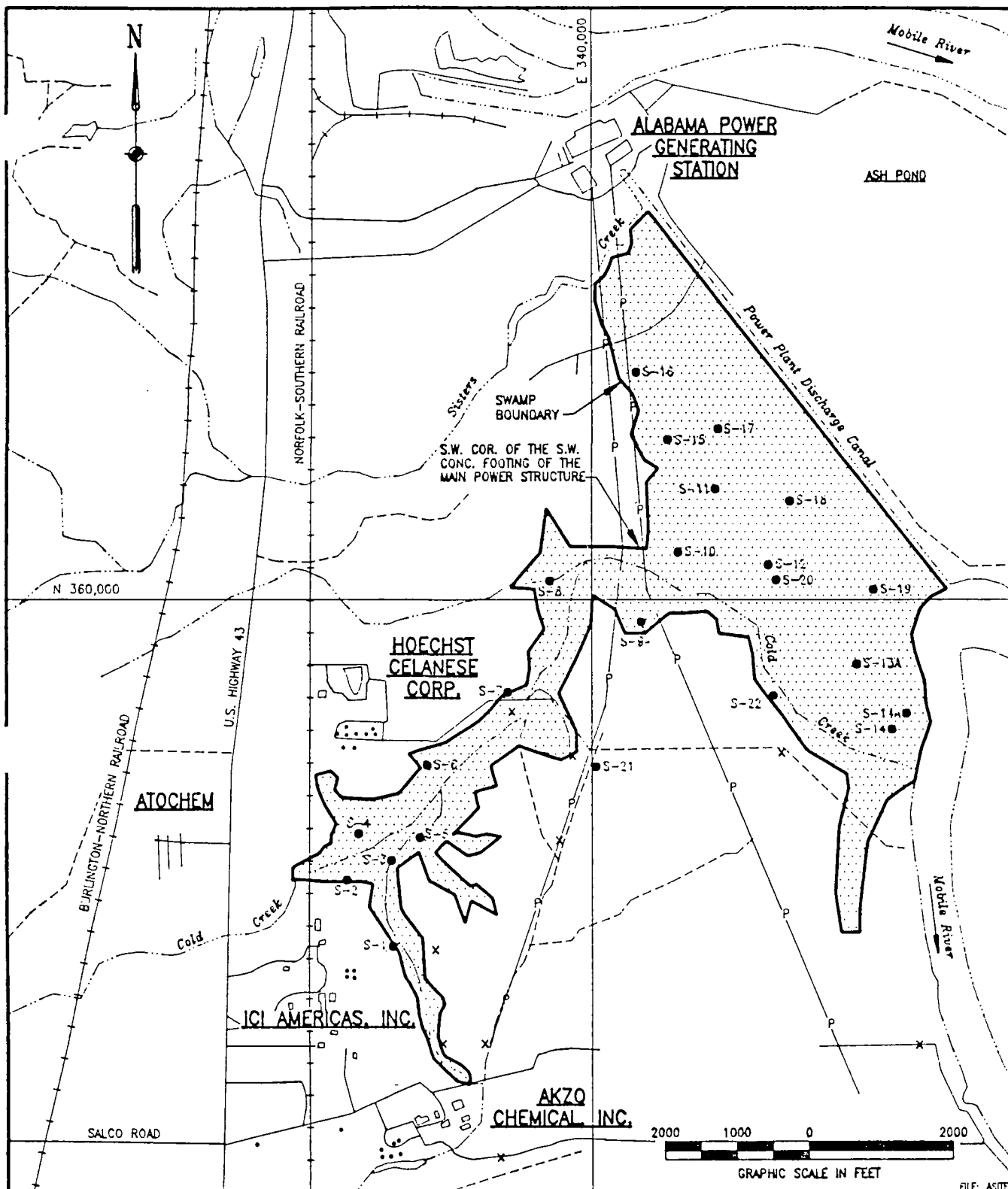
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REMEDIAL INVESTIGATION REPORT  
COLD CREEK SWAMP  
MOBILE, ALABAMA

STAGE II  
SAMPLING LOCATIONS  
'D' STATIONS

|                    |                    |                 |                   |                   |                |                        |               |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|
| PROJECT MGR<br>GEJ | DESIGNED BY<br>PWK | DRAWN BY<br>MSM | CHECKED BY<br>GEJ | SCALE<br>1"=2000' | DATE<br>6-5-92 | PROJECT NO<br>11653.08 | FIGURE<br>2-5 |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|

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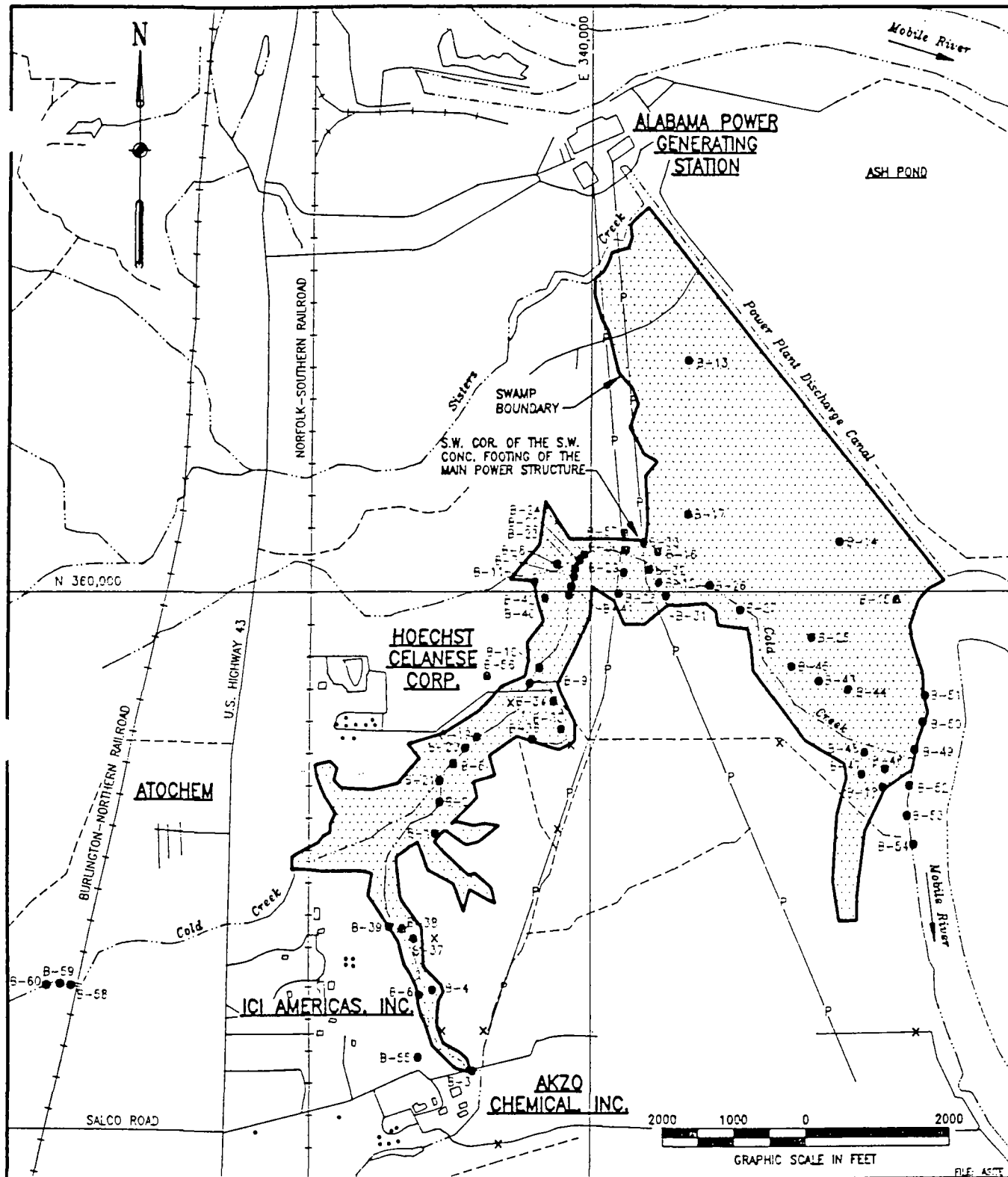
# REMEDIAL INVESTIGATION REPORT COLD CREEK SWAMP MOBILE, ALABAMA

## STAGE II SAMPLING LOCATIONS 'S' STATIONS

|                    |                    |                 |                   |                   |                |                        |               |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|
| PROJECT MGR<br>GEJ | DESIGNED BY<br>PWK | DRAWN BY<br>MSM | CHECKED BY<br>GEJ | SCALE<br>1"=2000' | DATE<br>6-5-92 | PROJECT NO<br>11653.08 | FIGURE<br>2-6 |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|

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# REMEDIAL INVESTIGATION REPORT COLD CREEK SWAMP MOBILE, ALABAMA

BIOACCESSIBLE ZONE  
SEDIMENT SAMPLE  
LOCATIONS

|                    |                    |                 |                   |                   |                |                        |               |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|
| PROJECT MGR<br>GEJ | DESIGNED BY<br>PWK | DRAWN BY<br>MSM | CHECKED BY<br>GEJ | SCALE<br>1"=2000' | DATE<br>6-5-92 | PROJECT NO<br>11653.08 | FIGURE<br>2-7 |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|

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#### 2.1.2.3 Surface Water Characterization

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Seven locations were identified for onsite water quality characterization, one background and six within Cold Creek Swamp. Four of the locations (W-1 through W-4) were previously examined in Stage I (Figure 2-3). The three remaining locations were chosen for additional characterization within the swamp (Figure 2-8).

The following information was collected from each of the six surface water sample locations:

- . maximum channel depth
- . channel width
- . flow rate
- . flow velocity
- . pH
- . conductivity
- . temperature
- . dissolved oxygen

#### 2.1.2.4 Mineralogical/Physical Soil Characterization

Samples were collected using sampling techniques similar to those for "B" samples (Section 2.1.2.2) from 10 locations throughout the swamp for physical/mineralogical characterization. Figure 2-9 shows the locations of samples collected for physical/mineralogical analyses. The samples were analyzed for grain size characterization, organic matter and carbon, and X-ray and/or optical mineralogical characterization.

#### 2.1.2.5 Biota Inventory Observations

As described in Section 2.1.1.5, this activity included a continuing investigation of biota present in the Cold Creek Swamp area, compiled from direct observations by a team of field ecologists, including botanists, wetlands specialists, and field zoologists.

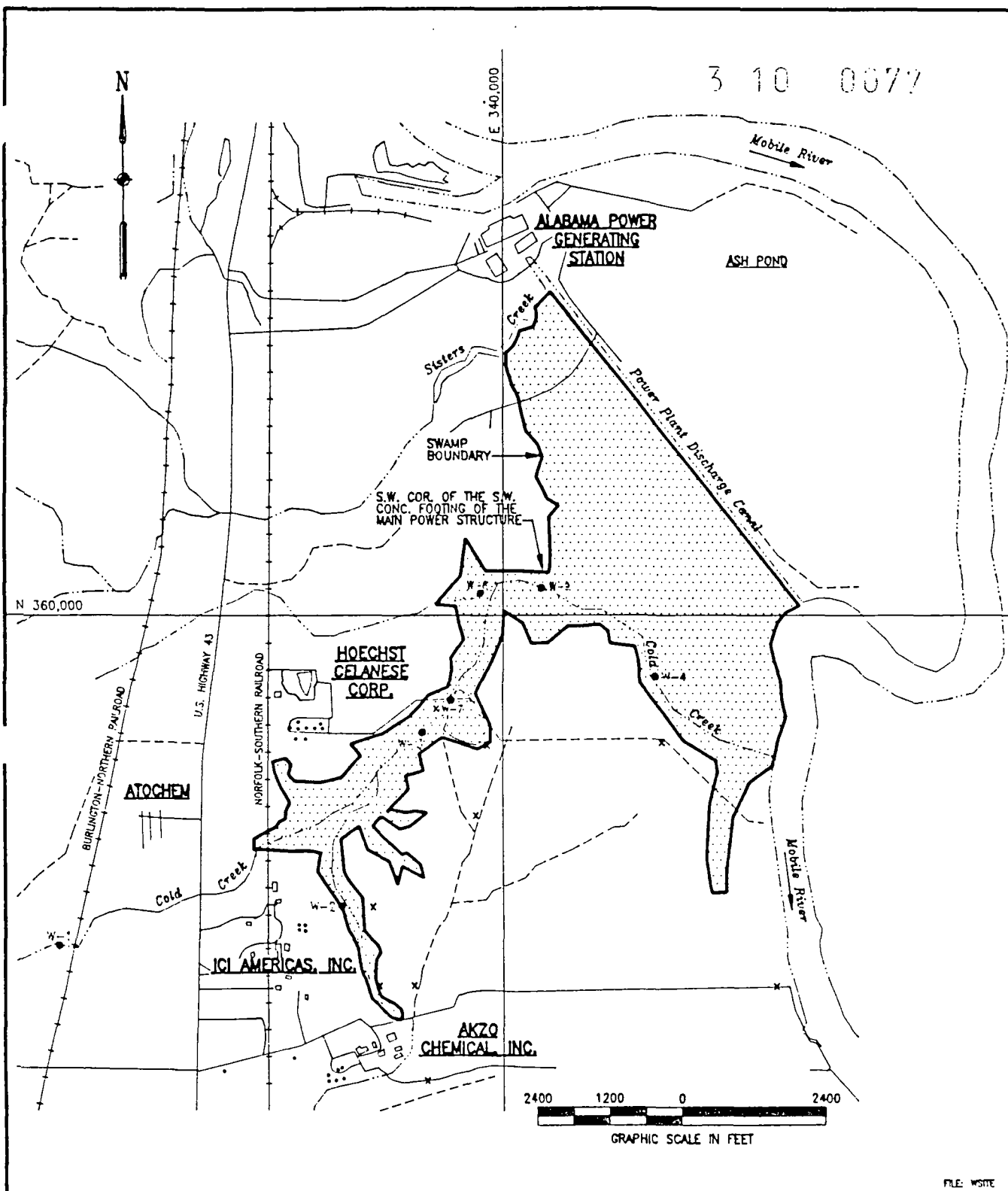
### 2.1.3 Stage III Field Activities

Stage III studies were conducted after ecological risk modeling and Stage II field studies had been completed. The goal of this approach was to apply early stage results to focus and define Stage III. The scope of Stage III sampling was established pursuant to review and comment by EPA, USFWS, and NOAA, in accordance with the September 1991 Stage II Findings Report (EA September 1991). In this way, Stage III was able to concentrate on resources potentially at greatest risk, on those of greatest potential value as indicators of contamination and/or environmental effects, on those most appropriate from a regulatory standpoint, and/or on those most likely to drive food-web dynamics for ecological risks. In addition to targeting particular biota, sediment contamination was further assessed in Stage III. Finally, additional assessment of physical surface water conditions (depth of flow, flow rate, dissolved oxygen content) was made for comparison with similar data collected at other stages.

#### 2.1.3.1 Biological Tissue Characterization

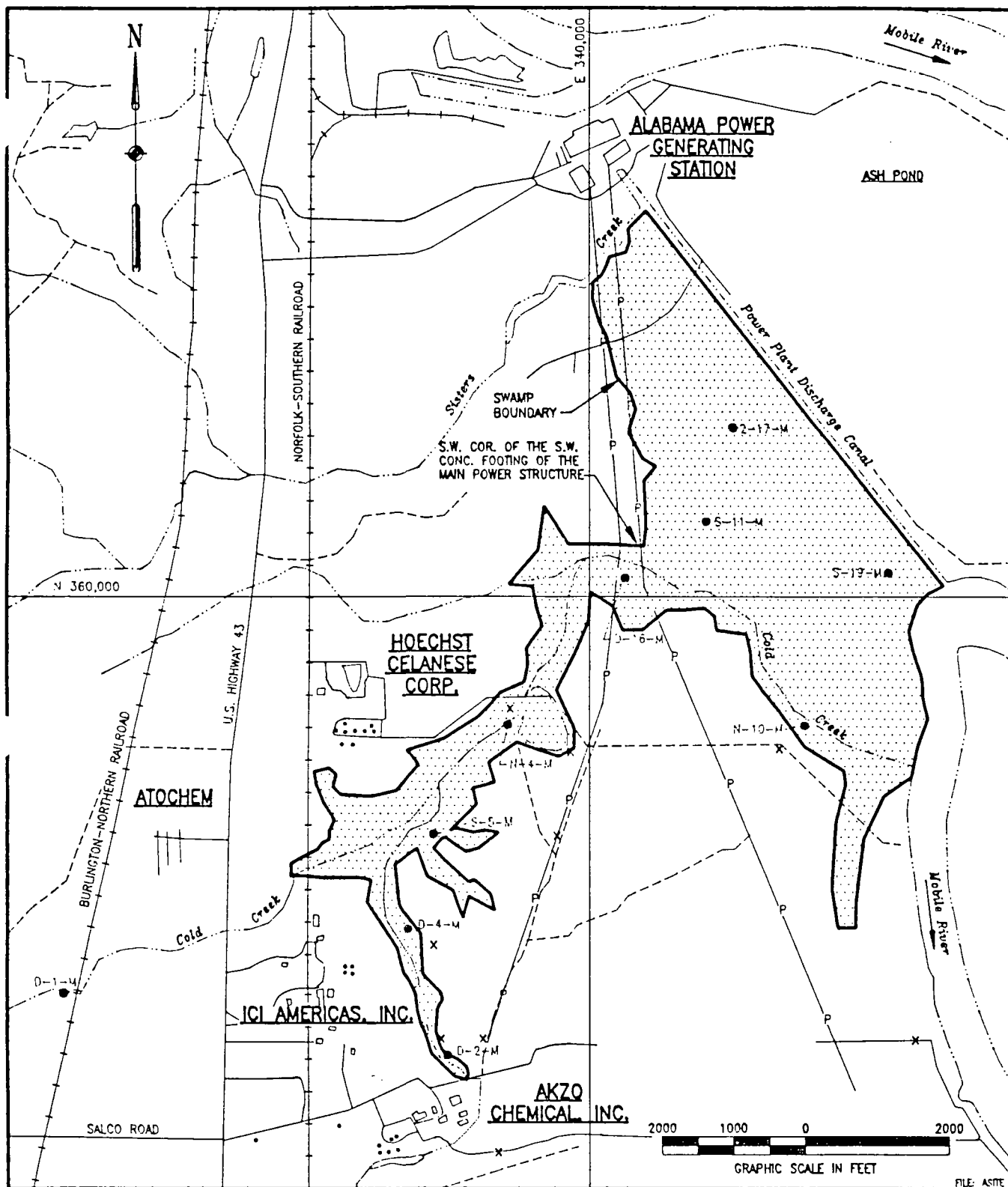
##### Rationale for Biota Selection

Based upon the results of the ecological risk model, it was determined that the greatest potential impact from Cold Creek Swamp contamination would be to resident higher trophic taxa such as carnivores and predators rather than taxa lower in the trophic food web such as herbivores, detritivores, or omnivores, or those taxa present in Cold Creek Swamp periodically or temporally. Specific receptors-of-concern for detailed characterization were selected based on site use, trophic status, habitat, human use, and practicality of sampling.



FILE: WSITE

|                                                         |                    |                 |                                                                      |                   |                |                                                                           |               |
|---------------------------------------------------------|--------------------|-----------------|----------------------------------------------------------------------|-------------------|----------------|---------------------------------------------------------------------------|---------------|
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| PROJECT MGR<br>GEJ                                      | DESIGNED BY<br>PWK | DRAWN BY<br>MSM | CHECKED BY<br>GEJ                                                    | SCALE<br>1"=2400' | DATE<br>6-5-92 | PROJECT NO<br>11653.08                                                    | FIGURE<br>2-8 |



|                                                         |                    |                 |                                                                      |                   |                |                                |               |
|---------------------------------------------------------|--------------------|-----------------|----------------------------------------------------------------------|-------------------|----------------|--------------------------------|---------------|
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| PROJECT MGR<br>GEJ                                      | DESIGNED BY<br>PWK | DRAWN BY<br>MSM | CHECKED BY<br>GEJ                                                    | SCALE<br>1"=2000' | DATE<br>6-5-92 | PROJECT NO<br>11653.08         | FIGURE<br>2-9 |

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The taxa that were selected for sampling are listed below. In recognition that collection of biota is subject to the capricious nature of ecological systems, both primary taxa and surrogates were identified. Surrogates are biota that provide data similar to primary taxa for ecological modeling purposes. The recommended taxa for sampling included finfish, herptiles, and invertebrates from all trophic levels. Biota from higher trophic levels (predator and carnivore) were preferred for collection as these taxa were identified to be the most likely at risk from mercury through bioaccumulation. Samples from other trophic levels were collected to assess model predictions across the entire food web. Receptors of concern that were recommended for sampling during Stage III were as follows:

#### Finfish Predators

- . Largemouth bass (Micropterus salmoides) are a large, long-lived carnivorous gamefish species and were, therefore, considered an ideal taxon for investigating potential bioaccumulation of mercury. Surrogate taxa included sunfishes (Lepomis centrarchidae), pickerels (Esox), and gars (Lepisosteus).

#### Finfish Carnivores

- . Mosquitofish (Gambusia affinis) are small aquatic carnivores feeding lower in the food web than the largemouth bass. Their role in the food web makes them trophically important. A number of forage fish species of similar trophic position occur in suitable habitat in Cold Creek Swamp, and any were considered acceptable species for sampling.

## Finfish Omnivores

- . Carp (Cyprinus carpio) are large aquatic omnivores. Because they feed at the lower end of the food web, they are unlikely to accumulate maximal mercury body burdens. However, their longevity and relatively large size render them of value in assessing mercury fate in the ecosystem, because they will integrate exposure to mercury in the swamp ecosystem. Other omnivorous demersal feeders were considered effective surrogates.

## Herptile Predators

- . American alligator (Alligator mississippiensis) is a carnivorous aquatic species on the federal threatened/endangered species list. It was ranked first by all factors except practicality. Surrogate species were easily available, and destructive sampling was neither necessary nor recommended. Acceptable surrogate species were the other receptor-of-concern reptiles, discussed below.
- . The cottonmouth (Agkistrodon piscivorous) and non-venomous aquatic snakes (genus Nerodia and Farancia) are aquatic, carnivorous reptiles that were easily sampled and processed. These taxa are among the most likely accumulators of mercury in this environment, and served as reasonable surrogates for the alligator. Surrogate taxa for fully aquatic snakes included such semi-aquatic forms such as Thamnophis, Opheodrys, and A. Contortix.

## Herptile Carnivores

- . Common snapping turtles (Chelydra serpentina) are large, long-lived aquatic carnivores. They are the only species of snapping turtle that had been observed in the site area during the three field observation periods. In recognition that the ephemeral nature of much of the open water in Cold Creek Swamp makes it likely that snapping turtles, especially larger, older individuals, are not lifelong residents, but may travel into and out of the swamp over the course of years, snapping turtles were not considered ideal candidates for sampling. The other member of the family (the alligator snapping turtle, Macroclemys temmincki) was not considered likely to be found in this habitat because it prefers large river systems. Therefore, target surrogate species included other aquatic carnivorous turtles, especially soft-shelled turtles, Trionychidae.
- . Frogs (Ranidae) are aquatic herbivores/detritivores as larvae and aquatic carnivores as adults. Ranids are larger, longer lived, and more closely tied to the aquatic food web than hylids. Therefore, they were preferred for sampling. Surrogate taxa included various other aquatic amphibians such as amphiuma (Amphiumidae) and sirens (Sirenidae).

## Invertebrate Detritivore

- . Crayfish (Asticidae) are polytrophic aquatic invertebrates which play important roles in aquatic food webs of the Gulf Coast. Surrogate species were not listed, as crayfish were expected to be abundant in Cold Creek Swamp.



### Number and Location of Samples

The target species and number of samples for Stage III biological tissue sampling are identified in Tables 2-7, 2-8, and 2-9. Every effort was made to collect the desired number of species during Stage III.

#### Specific Taxa Whole-Body Biota Samples from Cold Creek Swamp

Species collection was conducted in each region (upper, middle, lower) of the swamp. Ten whole-body finfish samples were collected in each region of the swamp (30 samples total) (Figure 2-10). Seventeen samples from the swamp were from the predator trophic level, and thirteen were from the omnivore trophic level. Ten additional whole-body finfish samples were taken from control locations beyond the limit of the site but within the Cold Creek drainage basin. Attempts were made to collect adult fish whenever possible. Five herptile and/or invertebrate samples were collected in each region of the swamp with the exception of the middle zone, where six samples were collected (16 samples total). Five herptile/invertebrate samples were collected at the control site. Table 2-10 identifies the actual finfish that were collected for analysis during Stage III. Table 2-11 identifies the actual herptiles or invertebrates that were collected for analysis during Stage III. A complete listing of biota collected in Stage III is included in Appendix E.

Criteria for collection of similar species at all sites were to ensure data compatibility and to support further ecological modeling efforts. If neither the target nor the surrogate taxa was collected in sufficient numbers for analysis, the onsite fisheries scientist used best professional judgment in taxa selection. Every effort was made to collect the desired taxa and number of individuals; however, the outcome of the sampling effort was ultimately dependent on the natural diversity and abundance of biota within Cold Creek Swamp at the time of collection. In all cases, sufficient tissues from appropriately interpretable taxa were collected for site characterization.

TABLE 2-7 NUMBER OF BIOTA SAMPLES COLLECTED DURING STAGE III FIELD  
ACTIVITY

---

1. Specific Taxa Whole-Body Samples from Cold Creek Swamp

Finfish

- . 10 samples per swamp zone (upper, middle, lower) = 30
- . 10 samples at background location = 10

40 finfish  
samples

Herptiles

- . 5 samples per swamp zone (upper, middle, lower) = 15
- . 5 samples at background location = 5
- . 1 extra sample in the middle zone = 1

21 herptile  
samples

Subtotal = 61 Whole-Body Tissue Samples

2. Composite Taxa Whole-Body Biota from Cold Creek Swamp

Finfish

- . 7 sample locations consistent with BCM (1989)

Subtotal = 7 Whole-Body Tissue Samples

3. Total = 61 + 7 = 68 Whole-Body Tissue Samples.

TABLE 2-8 TARGET AND ALTERNATE WHOLE-BODY FINFISH SPECIES FOR STAGE III FIELD INVESTIGATION

| <u>Trophic Status</u> | <u>Target Taxa</u> | <u>Scientific Name</u>       | <u>Alternate Taxa</u>       | <u>Scientific Names</u>                            | <u>Comments</u>                                                        |
|-----------------------|--------------------|------------------------------|-----------------------------|----------------------------------------------------|------------------------------------------------------------------------|
| Predator              | Largemouth bass    | <u>Micropterus salmoides</u> | Sunfish<br>Pickerel<br>Gars | Centrarchidae<br><u>Esox</u><br><u>Lepisosteus</u> | Collect at least one predator in each zone of the swamp.               |
| Carnivore             | Mosquitofish       | <u>Gambusia affinis</u>      | Other<br>forage fish        |                                                    |                                                                        |
| Omnivore              | Carp               | <u>Cyprinus carpio</u>       | None                        | N/A                                                | Not as important as predators; however, if found they should be taken. |

NUMBER OF SAMPLES

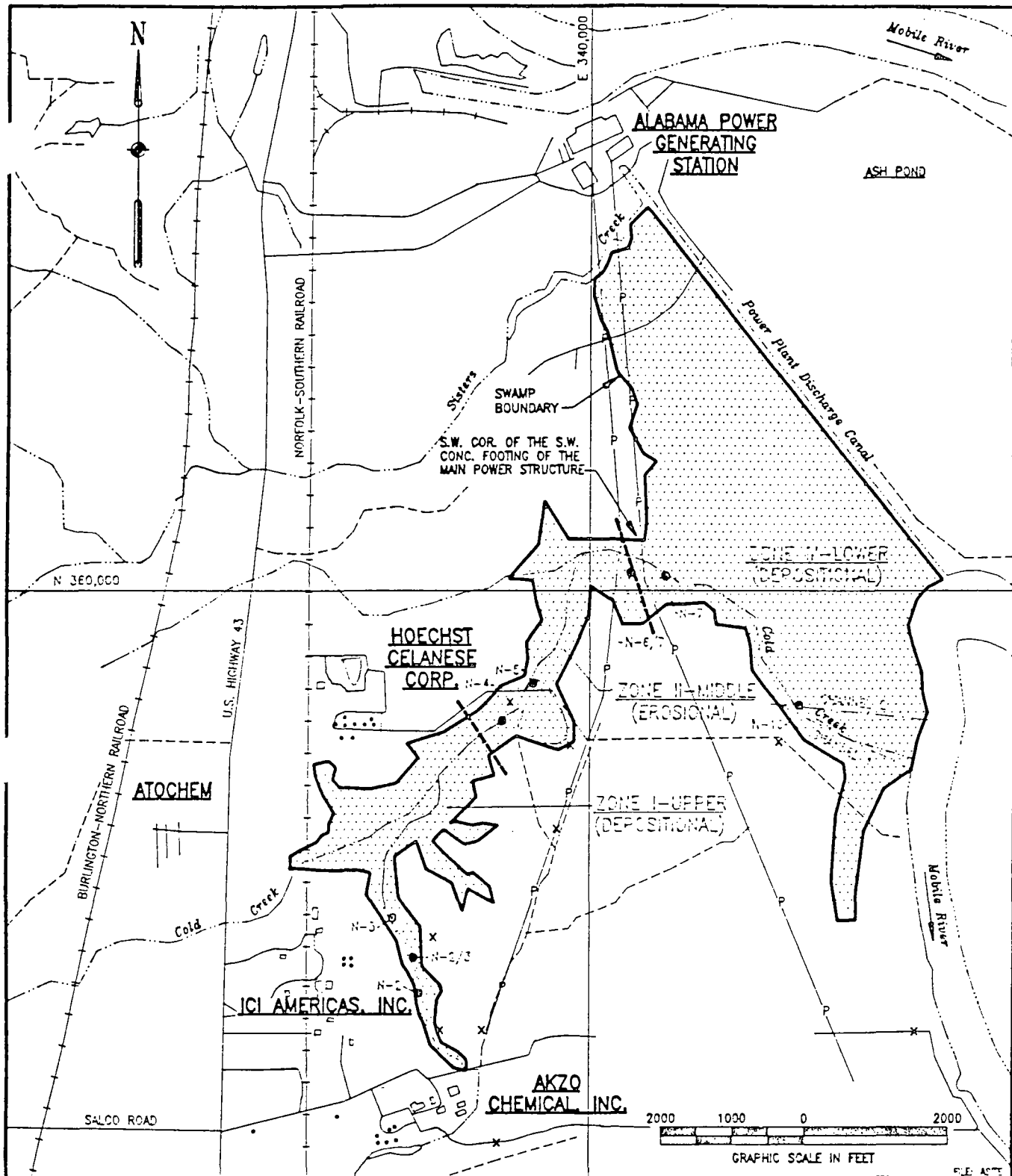
- . Collect at least 10 whole-body finfish samples per swamp zone (at least three to five samples per zone from predator trophic level).
- . Collect 10 whole-body finfish samples from background locations (at least one sample from predator trophic level).
- . TOTAL NUMBER OF WHOLE-BODY FINFISH SAMPLES (SPECIFIC TAXA) = 40.

TABLE 2-9 TARGET AND ALTERNATE HERP AND INVERTEBRATE TAXA FOR STAGE III FIELD INVESTIGATION

| Type          | Preferred Taxa              | Scientific Name                          | Alternate Taxa                              | Scientific Name                         |
|---------------|-----------------------------|------------------------------------------|---------------------------------------------|-----------------------------------------|
| Frogs         | Frogs                       | Ranidae                                  | Amphiuma, Sirens                            | Amphiumidae, Sirenidae                  |
| Turtles       | Common snapping turtle      | <u>Chelydra serpentina</u>               | Soft-shelled turtles<br>Carnivorous emydids | Trionychidae                            |
| Snakes        | Cottonmouth                 | <u>Agkistrodon</u><br><u>piscivorous</u> | semiaquatic snakes                          | <u>Thamnophis</u>                       |
|               | Non-venmous<br>water snakes | <u>Nerodia</u><br><u>Farancia</u>        |                                             | <u>Opheodrys</u><br><u>A. Cantortix</u> |
| Invertebrates | Crayfish                    | Asticidae                                | None                                        |                                         |

NUMBER OF SAMPLES

- . Collect at least five herptile or invertebrate samples in each swamp zone (upper, lower, middle).
- . Collect five herptile or invertebrate samples at background location.
- . TOTAL HERPTILE AND INVERTEBRATE SAMPLES = 21.



|                                                                                                                                          |             |          |                                                                                    |          |        |                                                                             |        |
|------------------------------------------------------------------------------------------------------------------------------------------|-------------|----------|------------------------------------------------------------------------------------|----------|--------|-----------------------------------------------------------------------------|--------|
|  <b>EA ENGINEERING, SCIENCE, AND TECHNOLOGY, INC.</b> |             |          | <b>REMEDIAL INVESTIGATION REPORT</b><br><b>COLD CREEK SWAMP</b><br>MOBILE, ALABAMA |          |        | <b>STAGE III</b><br><b>ELECTROFISHING STATIONS &amp; HYDROLOGICAL ZONES</b> |        |
| PROJECT MGR                                                                                                                              | DESIGNED BY | DRAWN BY | CHECKED BY                                                                         | SCALE    | DATE   | PROJECT NO                                                                  | FIGURE |
| GEJ                                                                                                                                      | PWK         | MSM      | GEJ                                                                                | 1"=2000' | 6-5-92 | 11653.08                                                                    | 2-10   |

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TABLE 2-10 SUMMARY OF FINFISH COLLECTED DURING STAGE III FIELD WORK  
(OCTOBER 1991) THAT WERE SELECTED FOR MERCURY ANALYSIS

| <u>Sample Location</u> |        | <u>Sample Description</u> |
|------------------------|--------|---------------------------|
| Upper Swamp Zone       | F-U-1  | Spotted gar               |
|                        | F-U-2  | Spotted gar               |
|                        | F-U-3  | Bowfin                    |
|                        | F-U-4  | Redear sunfish            |
|                        | F-U-5  | Largemouth bass           |
|                        | F-U-6  | Largemouth bass           |
|                        | F-U-7  | Largemouth bass           |
|                        | F-U-8  | Golden shiner             |
|                        | F-U-9  | Golden shiner             |
|                        | F-U-10 | Bluegill                  |
| Middle Swamp Zone      | F-M-1  | Bowfin                    |
|                        | F-M-2  | Largemouth bass           |
|                        | F-M-3  | Largemouth bass           |
|                        | F-M-4  | Redfin pickerel           |
|                        | F-M-5  | Redfin pickerel           |
|                        | F-M-6  | Chain pickerel            |
|                        | F-M-7  | Chain pickerel            |
|                        | F-M-8  | Common carp               |
|                        | F-M-9  | Golden shiner             |
|                        | F-M-10 | Yellow bullhead           |
| Lower Swamp Zone       | F-L-1  | American eel              |
|                        | F-L-2  | Chain pickerel            |
|                        | F-L-3  | Chain pickerel            |
|                        | F-L-4  | Chain pickerel            |
|                        | F-L-5  | Redfin pickerel           |
|                        | F-L-6  | Redfin pickerel           |
|                        | F-L-7  | Longear sunfish           |
|                        | F-L-8  | Longear sunfish           |
|                        | F-L-9  | Largemouth bass           |
|                        | F-L-10 | Warmouth                  |
| Background--Pond       | F-BP-1 | Largemouth bass           |
|                        | F-BP-2 | Brown bullhead            |
|                        | F-BP-3 | Common carp               |
|                        | F-BP-4 | Chain pickerel            |
|                        | F-BP-5 | Spotted gar               |
| Background--Stream     | F-BS-1 | Lake chubsucker           |
|                        | F-BS-2 | Largemouth bass           |
|                        | F-BS-3 | Largemouth bass           |
|                        | F-BS-4 | Redfin pickerel           |
|                        | F-BS-5 | Yellow bullhead           |

TABLE 2-11 SUMMARY OF HERPTILES OR INVERTEBRATES COLLECTED DURING  
STAGE III FIELD WORK (OCTOBER 1991) THAT WERE SELECTED  
FOR MERCURY ANALYSIS

| Sample Location   |        | Sample Description        |
|-------------------|--------|---------------------------|
| Upper Swamp Zone  | HI-U-1 | Snake                     |
|                   | HI-U-2 | Amphiuma                  |
|                   | HI-U-3 | Bronze frog               |
|                   | HI-U-4 | Toad                      |
|                   | HI-U-5 | Frog (composite of 11)    |
| Middle Swamp Zone | HI-M-1 | Snake                     |
|                   | HI-M-2 | Clams                     |
|                   | HI-M-3 | Frog                      |
|                   | HI-M-4 | Frog                      |
|                   | HI-M-5 | Crayfish (composite of 3) |
|                   | HI-M-7 | Frog                      |
| Lower Swamp Zone  | HI-L-1 | Snake                     |
|                   | HI-L-2 | Snake                     |
|                   | HI-L-3 | Crayfish (composite of 5) |
|                   | HI-L-4 | Bronze frog               |
|                   | HI-L-5 | Frog (composite of 2)     |
| Background        | HI-B-1 | Snake                     |
|                   | HI-B-2 | Leopard frog              |
|                   | HI-B-3 | Frog                      |
|                   | HI-B-4 | Frog                      |
|                   | HI-B-5 | Frog                      |

Legend:

F = Finfish sample  
 HI = Herptile/invertebrate sample  
 U = Upper swamp zone  
 M = Middle swamp zone  
 L = Lower swamp zone  
 BP = Background (pond)  
 BS = Background (stream)  
 B = Background

### Composite Taxa Whole-Body Biota Samples from Cold Creek Swamp

In November 1988, composite whole-body finfish samples were collected from seven sites in the Cold Creek Swamp area (BCM 1989). To examine potential temporal trends in finfish body burdens, the BCM sampling approach was duplicated as part of Stage III in this study. Composite finfish samples (five fish) were collected from the five BCM sample locations within the swamp. Samples were not collected at Station CCS-1 and CCS-7 since these sites were not proximate to the study area. These sites were replaced with two other background locations that were more proximate to the project site. Attempts were made to collect composite samples of the same species rather than of mixed species. The previous study (BCM 1989) examined mercury body burdens in the taxa shown in Table 2-12. They found no significant differences in mercury body burden between predators, foragers, or bottom feeders. Differences were observed, however, between the composite mercury concentrations at the seven sites. Table 2-13 lists the actual composite finfish samples that were collected for analysis in Stage III.

#### Sampling Equipment and Procedures

Standard sampling methods as approved in the Final Work Plan were used to collect target organisms. Finfish were sampled using backpack or boat electroshocking techniques, seines, or gill nets, as appropriate. Other species were sampled using taxa-specific gear. All required permits were obtained from the Alabama Department of Environmental Management prior to mobilization onsite for Stage III activities. (Copies of biota collection permits are included in Appendix F.)

#### Number of Samples, Sample Containers, Preservation, Holding Times, and Analytical Procedures

Number of samples, preservation, analytical procedures and holding time requirements for biotic samples are shown in Table 2-14. Field observations were made for:



- . identification,
- . lifestage characterization (i.e., young-of-the-year, juvenile, adult, etc.),
- . individual length,
- . individual weight, and
- . gross examination (noting lesions, finrot, etc.).

Laboratory analyses were for

- . total mercury
- . lipid content

Total mercury concentration in finfish and herptile tissue was analyzed as described in Appendix B. All analytical activities conformed to CLP QA/QC requirements, and a CLP report format was used in accordance with the approved QAPP.

To address issues of homogeneity within the samples, approximately 33 percent of the tissue samples collected during Stage III were analyzed in duplicate (21 samples). These replicate samples are reflected in Table 2-11.

Invertebrate samples were stored in clean bags or jars. Vertebrates were stored in clean bags. All biological samples were frozen until returned to the laboratory for sample preparation and chemical analysis.

#### Other Tissue Collection Issues

To assess potential contribution of inorganic mercury from sediment within the gut to whole-body mercury tissue concentration, an examination of the gut contents of several target finfish taxa was conducted. Finfish samples for gut characterization were collected concurrently with finfish for chemical analysis by electroshocking. The number of samples for gut characterization were dependent on the number of fish collected

TABLE 2-12 TARGET FINFISH FOR COMPOSITE SAMPLES

---

| <u>Common Name</u>     | <u>Scientific Name</u>         |
|------------------------|--------------------------------|
| PREDATORS              |                                |
| Dollar sunfish         | <u>Lepomis marginatus</u>      |
| Bluegill               | <u>Lepomis macrochirus</u>     |
| Longear sunfish        | <u>Lepomis megalotis</u>       |
| FORAGERS               |                                |
| Gold-spotted topminnow | <u>Fundulus chrysotus</u>      |
| Golden shiner          | <u>Notemigonus crysoleucas</u> |
| Mosquitofish           | <u>Gambusia affinis</u>        |
| Silverside shiner      | <u>Notropis candidus</u>       |
| Spotted sunfish        | <u>Lepomis punctatus</u>       |
| BOTTOM FEEDER          |                                |
| Lake chubsucker        | <u>Erimyzon sucetta</u>        |

TABLE 2-13 SUMMARY OF COMPOSITE WHOLE-BODY BIOTA SAMPLES FROM COLD CREEK  
SWAMP (OCTOBER 1991)

---

| <u>Sample Location</u> | <u>Sample Description</u>       |
|------------------------|---------------------------------|
| BCM1                   | Spotted sunfish (5 individuals) |
| BCM2                   | Bluegill (5 individuals)        |
| BCM3                   | Bluegill (5 individuals)        |
| BCM4                   | Spotted sunfish (5 individuals) |
| BCM5                   | Bluegill (5 individuals)        |
| BCM6                   | Bluegill (5 individuals)        |
| BCM7                   | Bluegill (5 individuals)        |

TABLE 2-14 SUMMARY OF SAMPLES, ANALYTICAL PROCEDURES, HOLDING TIME, AND CONTAINERS FOR STAGE III BIOTIC CONTAMINANT CHARACTERIZATION

| Parameter                         | No. of Locations | No. of Samples <sup>(b)</sup> | Laboratory Repliates | Total Samples | Analytical Procedures | Preservation | Holding Time | Containers         | Total No. of Containers |
|-----------------------------------|------------------|-------------------------------|----------------------|---------------|-----------------------|--------------|--------------|--------------------|-------------------------|
| SPECIFIC TAXA WHOLE-BODY SAMPLES  |                  |                               |                      |               |                       |              |              |                    |                         |
| Species ID                        | 4 <sup>(a)</sup> | 51                            | NA                   | 51            | (d)                   | NA           | field        | NA                 | NA                      |
| Fish or herp length (weight)      | 4 <sup>(a)</sup> | 51                            | NA                   | 51            | (d)                   | NA           | field        | NA                 | NA                      |
| Gross examination                 | 4 <sup>(a)</sup> | 51                            | NA                   | 51            | (d)                   | NA           | field        | NA                 | NA                      |
| Total mercury                     | 4 <sup>(a)</sup> | 51                            | 18                   | 69            | (e)                   | freeze       | 28 days      | clean plastic bags | 51                      |
| COMPOSITE TAXA WHOLE-BODY SAMPLES |                  |                               |                      |               |                       |              |              |                    |                         |
| Species ID                        | 7 <sup>(c)</sup> | 7                             | NA                   | 7             | (d)                   | NA           | field        | NA                 | NA                      |
| Gross examination                 | 7 <sup>(c)</sup> | 7                             | NA                   | 7             | (d)                   | NA           | field        | NA                 | NA                      |
| Total mercury                     | 7 <sup>(c)</sup> | 7                             | 3                    | 10            | (e)                   | freeze       | 28 days      | clean plastic bags | 7                       |

(a) Control site, upper, middle, and lower swamp.

(b) Minimum number--collect all samples caught.

(c) Site locations for 5 of 7 samples as described in BCM (1989).

(d) Performed by field ecologists.

(e) Unpublished modified version of EPA (1980) Interim Methods for the Sampling and Analysis of Priority Pollutants in Sediments and Fish Tissue (Appendix B).

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during the electroshocking. Priority was given to samples for analytical testing. Samples from each of the finfish trophic levels collected (predator, carnivore, omnivore) were subjected to gut contents analysis. The gut contents analysis included inventory and weighing of gut contents including sediment, and other fish tissue, and comparison to the total gut weight.

In response to requests from USFWS and EPA, in the event that edible finfish of edible size were collected during the finfish collection activities (provided that sufficient finfish are available for whole-body analysis), the field program provided for collection and analysis of both the fillet and the remaining body tissue for incorporation into the final risk assessment.

#### 2.1.3.2 Bioaccessible Contaminant Characterization

##### Number and Location of Samples

In order to expand upon the data collected in Stages I and II, additional characterization of the bioaccessible sediment zone (0-4 in.) was performed at 20 sample locations which were previously sampled as part of Stage II (B-1 through B-18, B-51, and B-54).

The sample numbering system designated Stage III bioaccessible contaminant characterization samples as "BB" samples. Sample numbers were "BB," followed by a numeric designation for the discrete sample location (1, 2, 3 . . .), and corresponded to Stage II sample identifications. Therefore, Stage III sample BB-1 was collected from approximately the same location as Stage II sample B-1 (Figure 2-11).

Duplicates were designated as BB-DUP-1, BB-DUP-2, etc. The field notebook indicated which sample the duplicate samples correspond to. For field sampling quality control purposes, one duplicate was taken per 10 samples for all analyses except TOC. Due to potential for sample inhomogeneity (as evidenced from Stage I data) and the small sample

quantity used for TOC analyses, one duplicate was taken per five samples for TOC analyses. In addition, two rinsate blanks were taken. Rinsate blanks were collected and analyzed at the beginning and end of the sampling event. Soil sampling was conducted in accordance with the Site Health and Safety Plan. The following analyses were performed.

#### Simultaneous Extracted Metals (SEM) and Acid Volatile Sulfides (AVS)

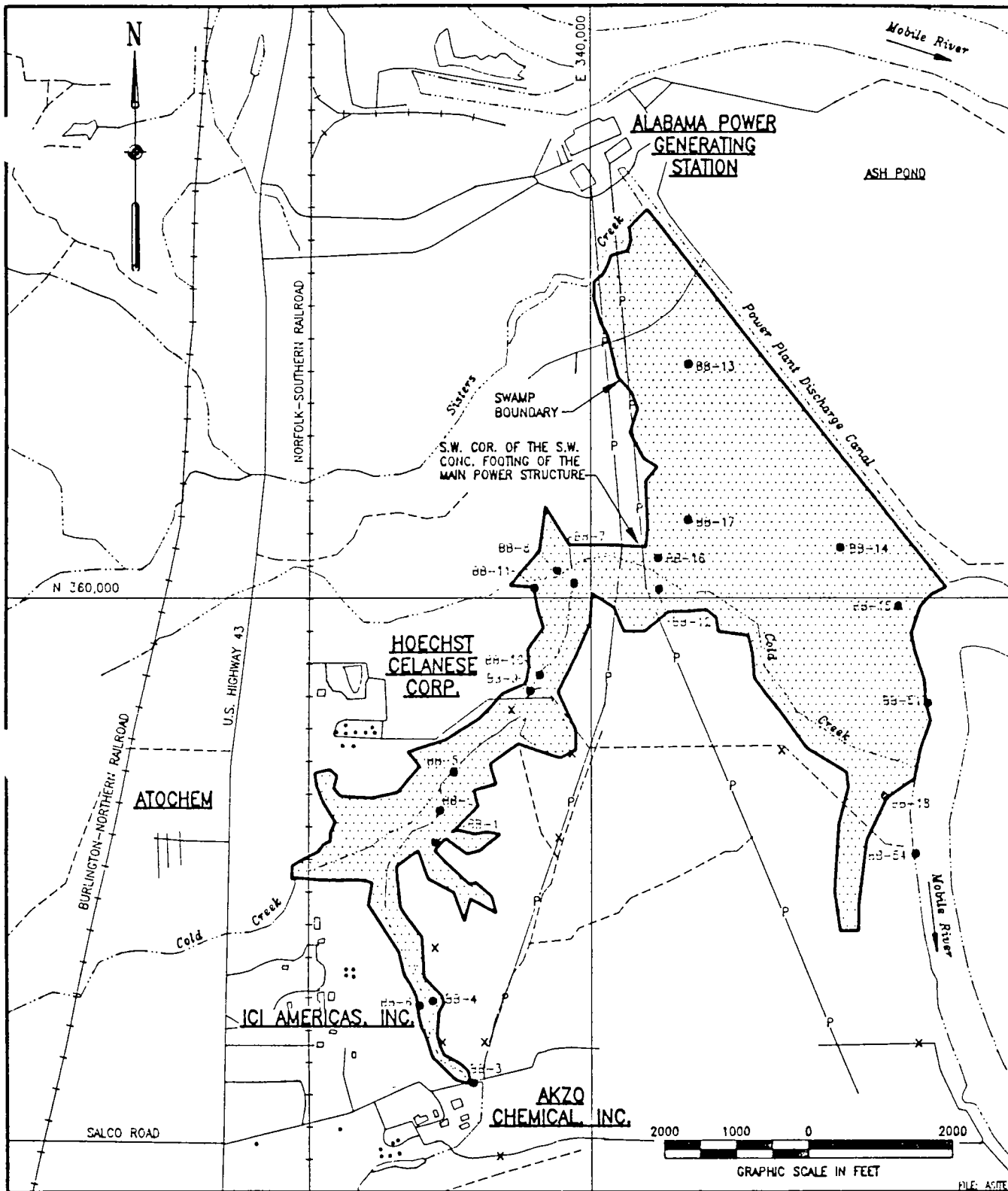
One sediment sample from each station was collected for SEM and AVS analyses. Because AVS oxidizes very easily (U.S. EPA 1991), the sample was not mixed in the field according to the EPA Region IV SOP. This approach was determined to be acceptable to EPA prior to initiation of Stage III field work. These samples were placed directly into wide-mouth, 8-oz, laboratory-cleaned glass jars with Teflon-lined lids. Each jar was completely filled leaving no air head space, tightly-sealed, and held at 4°C. In the laboratory these samples were analyzed for:

- . acid volatile sulfides
- . simultaneously extracted metals
  - . mercury
  - . cadmium
  - . copper
  - . zinc

All data are reported as  $\mu\text{mol/g}$  dry weight (U.S. EPA 1991).

#### Additional Laboratory Analyses

The second sample from each location was sampled as described in the Stage II Work Plan, including mixture in the field. Field splits were taken, one for methyl mercury, the other for all other analyses. These samples were analyzed for:



|                                                                                                                                                 |                    |                 |                                                                               |                   |                |                                                           |                |
|-------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|-----------------|-------------------------------------------------------------------------------|-------------------|----------------|-----------------------------------------------------------|----------------|
|  <b>EA ENGINEERING,<br/>SCIENCE, AND<br/>TECHNOLOGY, INC.</b> |                    |                 | <b>REMEDIAL INVESTIGATION REPORT<br/>COLD CREEK SWAMP<br/>MOBILE, ALABAMA</b> |                   |                | <b>STAGE III<br/>SAMPLING LOCATIONS<br/>'BB' STATIONS</b> |                |
| PROJECT MGR<br>GEJ                                                                                                                              | DESIGNED BY<br>PWK | DRAWN BY<br>MSM | CHECKED BY<br>GEJ                                                             | SCALE<br>1"=2000' | DATE<br>6-5-92 | PROJECT NO<br>11653.08                                    | FIGURE<br>2-11 |

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- . total mercury
- . methyl mercury
- . total organic carbon

#### Other Field Parameters

In addition to the above analyses, the following measurements were taken in the field:

- . Eh
- . pH
- . temperature

#### Sampling Equipment and Procedures

Sampling equipment and procedures were as described for Stage II in Section 2.1.2. One difference was that the samples collected for SEM/AVS analysis were not mixed in the field. While this is not consistent with EPA Region IV SOP, it is specifically required as a component of EPA's method for SEM/AVS analyses (U.S. EPA 1991) and was determined to be acceptable to EPA Region IV prior to initiation of Stage III field work.

#### Sample Containers, Preservation, Holding Time, and Analytical Methods

Sample containers, preservation and holding time considerations, and analytical methods were as described previously for the Stage II bio-accessible contaminant characterization. For Stage III, this information is summarized in Table 2-15.

#### 2.1.3.3 Surface Water Characterization

Stage I stations W-1 through W-4 and W-7 through W-9 (seven stations) were characterized during this field effort in the same manner as in Stage II (Figure 2-8). The following data were collected at each of the stations:



- . maximum channel depth
- . channel width
- . flow rate
- . flow velocity
- . pH
- . conductivity
- . temperature
- . dissolved oxygen

#### 2.1.3.4 Biota Inventory Observations

During Stage III sampling, detailed field notes were recorded describing habitat, environment species diversity and coexistence, and community organization. The physical habitat for each collection area was described and physical parameters were measured, including water quality and streamflow. The general nature of the environment was discussed. The sampling teams counted the number of each species or taxonomic group and measured their sizes and weights. A brief description of the community organization was also included. Two channels connecting the lower swamp with the Mobile River were sampled to assess fish movement between Cold Creek Swamp and the river, one on three consecutive days and the other once.

Also as part of this stage, any observations of tracks, scat, or direct sightings and their locations were recorded.

#### 2.1.4 Decontamination and Waste Handling Procedure

All drilling and split-spoon sampling equipment were decontaminated according to EPA Region IV SOP. The soil boring/drilling rig was cleaned before being mobilized and brought onsite with a power washer or steam generator, or it was hand washed. Detergent was used (laboratory detergent or other suitable degreaser) to remove oil, grease, and hydraulic fluid from the exterior of the unit. The unit was rinsed

TABLE 2-15 SUMMARY OF SAMPLES, ANALYTICAL PROCEDURES, HOLDING TIME, AND CONTAINERS FOR STAGE III BIOACCESSIBLE CONTAMINANT CHARACTERIZATION

| Parameter            | Number of Sample Locations | Number of Samples | Field Duplicates | Rinsate Blanks | Total Samples | Analytical Procedures <sup>(a)</sup> | Preservation <sup>(b)</sup> | Holding Time <sup>(c)</sup>          | Containers                                  | Total No. of Containers |
|----------------------|----------------------------|-------------------|------------------|----------------|---------------|--------------------------------------|-----------------------------|--------------------------------------|---------------------------------------------|-------------------------|
| AVS                  | 20                         | 20                | 2                | 2              | 24            | (d)                                  | Hold @ 4 C                  | 14 days                              | 4-oz wide-mouth glass jar with Teflon liner | 24                      |
| SEM                  |                            |                   |                  |                |               |                                      |                             |                                      |                                             |                         |
| . Hg                 | 20                         | 20                | 2                | 2              | 24            | 245.1-CLP                            | Hold @ 4 C                  | 14 days extract                      | (e)                                         | (e)                     |
| . Cd                 | 20                         | 20                | 2                | 2              | 24            | 200.7-CLP                            | Hold @ 4 C                  | 14 days extract                      | (e)                                         | (e)                     |
| . Cu                 | 20                         | 20                | 2                | 2              | 24            | 200.7-CLP                            | Hold @ 4 C                  | 14 days extract                      | (e)                                         | (e)                     |
| . Zn                 | 20                         | 20                | 2                | 2              | 24            | 200.7-CLP                            | Hold @ 4 C                  | 14 days extract                      | (e)                                         | (e)                     |
| Total Mercury        | 20                         | 20                | 2                | 2              | 24            | 245.5-CLP                            | Hold @ 4 C                  | 28 days                              | 8-oz wide-mouth glass jar with Teflon liner | 24                      |
| Total Organic Carbon | 20                         | 20                | 4                | 2              | 26            | 9060                                 | Hold @ 4 C                  | 28 days                              | (f)                                         | (f)                     |
| Methyl Mercury       | 20                         | 20                | 2                | 2              | 24            | (g)                                  | Hold @ 4 C                  | 7 days extraction<br>40 days extract | 4-oz wide-mouth glass jar with Teflon liner | 24                      |
| Eh                   | 20                         | 20                | 2                | 2              | 24            | (h)                                  | None                        | Analyze in field                     | 8-oz wide-mouth glass jar with Teflon liner | 24                      |
| pH                   | 20                         | 20                | 2                | 2              | 24            | 9045                                 | None                        | Analyze in field                     | 4-oz wide-mouth glass jar with Teflon liner | 24                      |

(a) Analytical procedures are in accordance with SW-846, unless otherwise noted.

(b) No chemical preservations added to soils.

(c) From time of sample collection.

(d) Draft Analytical Method for Determination of Acid Volatile Sulfide in Sediment. USEPA Office of Science and Technology, Washington, D.C., August 1991.

(e) SEM samples from same bottles as AVS samples.

(f) TOC and sulfide analyses from same bottles as total mercury analyses.

(g) Method for methyl mercury analysis is described in the QAPP.

(h) Method 2580A. Standard Methods for the Examination of Water and Wastewater. 17th Edition Supplement. 1991.

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thoroughly with tap water prior to being brought onsite and between boreholes. Auger flights, auger bits, drilling rods, drill bits, hollow-stem augers, split-spoon samplers, Shelby tubes, or other parts of the drilling equipment that contacted the soil or ground water were cleaned as follows:

1. Washed with tap water and laboratory detergent using a brush if necessary to remove particulate matter and surface films.
2. Rinsed thoroughly with tap water.
3. Rinsed thoroughly with deionized water.
4. Rinsed twice with isopropanol solvent.
5. Rinsed thoroughly with organic-free water and allowed to air dry as long as possible.
6. If organic-free water was not available, equipment was air dried as long as possible. Equipment was not rinsed with deionized or distilled water.
7. Wrapped with aluminum foil, if appropriate, to prevent contamination if equipment was going to be stored or transported.

The hand corers and other stainless steel sampling equipment (i.e., trowels, bowls, spoons) were also decontaminated as per the above seven-step procedure.

All discarded personal protective clothing was placed in drums. Different potentially contaminated materials (e.g., oil, Tyvek-wear, cement bags) were segregated into individual drums. Drums containing

waste personal protective equipment and site debris were labeled and dated and handled by Akzo plant personnel in accordance with RCRA.

## 2.2 FIELD INVESTIGATION MEMORANDA AND DOCUMENTATION

During field collection activities, detailed notes were recorded describing the sampling station environment, collection methodology, dates, times, and other pertinent data. Copies of field notebooks that were used during the field collection activities and contain this information are provided in Appendix D. Copies of field summary reports are also included in Appendix D.

## 2.3 SUMMARY OF FIELD ACTIVITIES

Table 2-16 is provided for easy reference to summarize the sampling activities that were conducted in this supplemental RI/FS.

TABLE 2-16 SUMMARY OF FIELD ACTIVITIES FOR COLD CREEK SWAMP OPERABLE UNIT RI/FS

1. Stage I Field Activities--February 1991

| <u>Sample Designation</u> | <u>Text Section</u> | <u>Description</u>                  | <u>No. of Sample Locations</u> | <u>No. of Samples</u> |
|---------------------------|---------------------|-------------------------------------|--------------------------------|-----------------------|
| N                         | 2.1.1.1             | Contaminant Nature Characterization | 16                             | 20                    |
| SB                        | 2.1.1.2             | Contaminant Depth Characterization  | 3                              | 30                    |
| W                         | 2.1.1.3             | Surface Water Characterization      | 6                              | 6                     |

2. Stage II Field Activities--June 1991

| <u>Sample Designation</u> | <u>Text Section</u> | <u>Description</u>                              | <u>No. of Sample Locations</u> | <u>No. of Samples</u> |
|---------------------------|---------------------|-------------------------------------------------|--------------------------------|-----------------------|
| D                         | 2.1.2.1             | Discrete Depth Mercury Characterization         | 23                             | 69                    |
| S                         | 2.1.2.1             | Upper 12 in. Mercury Characterization           | 22                             | 22                    |
| B                         | 2.1.2.2             | Upper 4 in. Bioaccessible Zone Characterization | 60                             | 60                    |
| W                         | 2.1.2.3             | Surface Water Characterization                  | 7                              | 7                     |

3. Stage III Field Activities--September 1991

| <u>Sample Designation</u> | <u>Text Section</u> | <u>Description</u>                              | <u>No. of Sample Locations</u> | <u>No. of Samples</u> |
|---------------------------|---------------------|-------------------------------------------------|--------------------------------|-----------------------|
| BB                        | 2.1.3.2             | Upper 4 in. Bioaccessible Zone Characterization | 20                             | 20                    |
| F                         | 2.1.3.1             | Finfish Tissue                                  | 40                             | 40                    |
| H                         | 2.1.3.1             | Herptile Tissue                                 | 21                             | 21                    |
| W                         | 2.1.3.3             | Surface Water Characterization                  | 7                              | 7                     |

REFERENCES  
CHAPTER 2

- BCM Engineers, Inc. 1989. Heavy Metal Levels in Cold Creek Swamp Biota. Prepared for AKZO Chemicals, Inc. June. 26 pp. plus appendices.
- EA Engineering, Science, and Technology. 1991. Stage I Findings Report. April. 78 pp. plus attachments.
- EA Engineering, Science, and Technology. 1991. Stage II Findings Report. August. 88 pp. plus attachments.
- Environmental Resources Technology (ERT). 1988. Final RI Report for the Cold Creek/LeMoyne Site, Mobile County, Alabama. May. 120 pp.
- Federal Interagency Committee for Wetland Delineation. 1989. Federal Manual for Identifying and Delineating Jurisdictional Wetlands. U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and USDA Soil Conservation Service, Washington, D.C., Cooperative Technical Publication. 76 pp. plus appendices.
- U.S. Army Corps of Engineers (USACE). 1987. Wetland Evaluation Technique (WET) Model. 206 pp. plus appendices.
- U.S. Department of Agriculture (USDA) Soil Conservation Service. 1985. Hydric Soils of the United States. 188 pp.
- U.S. Environmental Protection Agency (EPA). 1986. EPA Region IV Engineering Support Branch Standard Operating Procedures and Quality Assurance Manual. April. 197 pp. plus appendices.

### 3. PHYSICAL CHARACTERIZATION OF THE STUDY AREA

#### 3.1 STAGE I FIELD ACTIVITIES

##### 3.1.1 Contaminant Nature Characterization

Tables 3-1 and 3-2 contain the results of the volatile organics analysis, and Tables 3-3 and 3-4 contain the results of the semivolatile organics analyses. All compounds on EPA's TCL were assessed. In addition, tentatively identified compounds were identified in the library search in the GC/MS analysis. Compounds not detected are not listed in the tables. TCL compounds detected above the instrument detection limit, but below the Contract Required Quantitation Limits (CRQLs), are denoted with "J" values. It should be noted that concentrations reported as "J" values are estimated values of contaminant characterization, since the CLP quality assurance does not extend to concentrations below the linear response range. Any TCL compound which was quantified or which had more than two "J" values was subjected to the human health and ecological risk screens.

Acetone was detected in all samples, some of which were above the level in the background samples. No acetone was found in the trip blank, but acetone was found in the laboratory method blank. Acetone is a common laboratory contaminant and it is likely that the identified concentrations represent laboratory contamination. Aside from sample N-3, volatile organic compounds were very rarely detected.

Only "J" values are present in the semivolatiles tables (Tables 3-3 and 3-4). Furthermore, other than benzo(a)pyrene, benzoic acid, bis(2-ethylhexyl)phthalate, 1,3-dichlorobenzene, and di-n-butylphthalate, all identified semivolatiles were tentatively identified compounds not listed on the TCL. Any of the five named semivolatile compounds that were quantified or that had more than two "J" values were included in the risk assessment screens.

Table 3-5 lists the results of the thiocarbamate analyses. These compounds were subjected to the human health and ecological risk screens.

Table 3-6 lists the results of the methyl mercury analysis from the 14 samples taken to characterize the nature of contamination within the swamp. Methyl mercury was also analyzed in the deep borings samples (SB-1, SB-2, SB-3) and was included in the risk screens.

### Inorganics

The results of the inorganics sampling and analyses (TAL) are tabulated in Table 3-7. Most of the metals were subjected to the human health and ecological risk screens. The following metals were not screened because they are considered to be essential nutrients for human and ecological life: calcium, cobalt, iron, magnesium, potassium, and sodium. Silver was not present in any sediment samples and was not subjected to the ecological screen.

#### 3.1.2 Contaminant Depth Characterization

Table 3-8 contains the analytical results from the three deep borings. Mercury was only found at levels above background in surface and near surface samples. In examining both Tables 3-6 and 3-8, it can be seen that methyl mercury was, in most cases, below the detection limit. Furthermore, it was not found in subsurface samples except for one of the depth intervals at Boring SB-3. Soil samples both above and below this sample did not show any methyl mercury concentrations above detection levels.

The observed mercury and methyl mercury concentrations in the SB-3 subsurface sample are suspect based on several factors. Soil boring SB-3 was drilled in a ponded area of the lower swamp in standing water approximately 4 ft deep. Surficial soil at this location was black silty muck to a depth of about 4 ft below surface, where the soil changed to a brownish tan coarse sand. Samples collected in the split spoons from



TABLE 3-1 ANALYTICAL RESULTS OF STAGE I SEDIMENT SAMPLING AT COLD CREEK SWAMP, ALABAMA--FEBRUARY 1991 VOLATILE ORGANICS--TCL

| Compound<br>( $\mu\text{g/kg}$ ) | Background |       |        | Swamp Samples |       |       |       |       |              |       |       |       |       |       |       |        |        |        |
|----------------------------------|------------|-------|--------|---------------|-------|-------|-------|-------|--------------|-------|-------|-------|-------|-------|-------|--------|--------|--------|
|                                  | N-1-1      | N-1-2 | N-15-1 | N-2-1         | N-2-2 | N-3-1 | N-3-2 | N-4-1 | N-4-1<br>DUP | N-4-2 | N-5-1 | N-6-1 | N-7-1 | N-8-1 | N-9-1 | N-10-1 | N-11-1 | N-12-1 |
| Acetone                          | 36         | 160J  | 21B    | 15B           | 40B   | 74    | 37    | 1,100 | 700          | 970   | 41B   | 92    | 19BJ  | 26J   | 2,300 | 220B   | 1,400  | 110    |
| Benzene                          |            |       |        |               |       | 59    | 10    |       |              |       |       |       |       |       |       |        |        |        |
| 2-Butanone                       |            |       |        |               |       | 6J    | 3J    |       |              | 3J    | 4J    |       |       | 8J    |       | 10J    |        |        |
| Carbon<br>Disulfide              |            |       |        |               |       | 17    |       |       |              |       |       |       |       |       |       |        |        |        |
| Chlorobenzene                    |            |       |        |               |       | 45    | 2J    |       |              |       |       |       |       | 5J    |       | 8J     |        |        |
| Ethylbenzene                     |            |       |        |               |       |       | 5J    |       |              |       |       |       |       |       |       |        |        |        |
| Methylene<br>Chloride            |            | 2J    | 1J     |               |       |       |       | 3J    |              |       |       |       | 20J   |       |       |        |        |        |
| Toluene                          |            |       |        |               |       |       | 15J   | 3J    |              |       |       |       |       |       | 5J    |        |        |        |
| M&P-Xylene                       |            |       |        |               |       |       | 41J   | 6J    |              |       |       |       |       |       |       |        |        |        |
| O-Xylene                         |            |       |        |               |       |       | 28J   | 4J    |              |       |       |       |       |       |       |        |        |        |

J = Estimated value.

B = Analyte found in blank.

3 10 0096

TABLE 3-1 (Extended)

| Compound<br>( $\mu\text{g/kg}$ ) | <u>Blanks</u> | <u>Trip</u> | <u>Wash Water</u> | <u>Corer</u> |
|----------------------------------|---------------|-------------|-------------------|--------------|
| Acetone                          |               |             |                   |              |
| Benzene                          |               |             |                   |              |
| 2-Butanone                       |               |             |                   |              |
| Carbon<br>Disulfide              |               |             |                   |              |
| Chlorobenzene                    |               |             |                   |              |
| Ethylbenzene                     |               |             |                   |              |
| Methylene<br>Chloride            |               |             |                   |              |
| Toluene                          |               |             |                   |              |
| M&P-Xylene                       |               |             |                   |              |
| O-Xylene                         |               |             |                   |              |

TABLE 3-2 ANALYTICAL RESULTS OF STAGE I SEDIMENT SAMPLING AT COLD CREED SWAMP, ALABAMA--FEBRUARY 1991 VOLATILE ORGANICS--  
TENTATIVELY IDENTIFIED COMPOUNDS

| Compound ( $\mu\text{g/kg}$ )    | Background |       |        | Swamp Samples |       |       |       |       |          |       |       |       |       |       |       |
|----------------------------------|------------|-------|--------|---------------|-------|-------|-------|-------|----------|-------|-------|-------|-------|-------|-------|
|                                  | N-1-1      | N-1-2 | N-15-1 | N-2-1         | N-2-2 | N-3-1 | N-3-2 | N-4-1 | N-4-1Dup | N-4-2 | N-5-1 | N-6-1 | N-7-1 | N-8-1 | N-9-1 |
| Decane                           |            |       |        |               |       | 180J  |       |       |          |       |       |       |       |       |       |
| Decane, 2, 6, 7-<br>Trimethyl    |            |       |        |               |       | 440J  |       |       |          |       |       |       |       |       |       |
| Diisopropyl<br>Ether             |            | 79J   | 83J    |               | 29J   |       |       | 37J   | 59J      | 34J   |       |       |       |       |       |
| Dodecane, 2, 7, 10-<br>Trimethyl |            |       |        |               |       |       | 300J  |       |          |       |       |       |       |       |       |
| Octane, 4-<br>Methyl             |            |       |        |               |       | 200J  |       |       |          |       |       |       |       |       |       |
| Tetradecane<br>4-methyl          |            |       |        |               |       |       | 54J   |       |          |       |       |       |       |       |       |

J = Estimated Value.

B = Analyte found in blank.

3 10 0097

Table 3-2 (Extended)

| <u>Compound (<math>\mu\text{g}/\text{kg}</math>)</u> | <u>Swamp Samples</u> |               |               |               |             |                   |              |
|------------------------------------------------------|----------------------|---------------|---------------|---------------|-------------|-------------------|--------------|
|                                                      | <u>N-10-1</u>        | <u>N-11-1</u> | <u>N-12-1</u> | <u>Blanks</u> | <u>Trip</u> | <u>Wash Water</u> | <u>Corer</u> |
| Decane                                               |                      |               |               |               |             |                   |              |
| Decane, 2, 6, 7-<br>Trimethyl                        |                      |               |               |               |             |                   |              |
| Diisopropyl<br>Ether                                 |                      |               |               |               |             |                   | 30J          |
| Dodecane, 2, 7, 10-<br>Trimethyl                     |                      |               |               |               |             |                   |              |
| Octane, 4-<br>Methyl                                 |                      |               |               |               |             |                   |              |
| Tetradecane<br>4-methyl                              |                      |               |               |               |             |                   |              |

TABLE 3-3 ANALYTICAL RESULTS OF STAGE I SEDIMENT SAMPLING AT COLD CREED SWAMP, ALABAMA--FEBRUARY 1991 SEMIVOLATILE--TCL

| Compound ( $\mu\text{g/kg}$ )   | Background |       |        | Swamp Samples |       |       |       |       |          |       |       |       |       |       |       |
|---------------------------------|------------|-------|--------|---------------|-------|-------|-------|-------|----------|-------|-------|-------|-------|-------|-------|
|                                 | N-1-1      | N-1-2 | N-15-1 | N-2-1         | N-2-2 | N-3-1 | N-3-2 | N-4-1 | N-4-1Dup | N-4-2 | N-5-1 | N-6-1 | N-7-1 | N-8-1 | N-9-1 |
| Benzo-a-pyrene                  |            |       |        |               |       |       |       |       |          |       | 86J   |       |       |       |       |
| Benzoic<br>Acid                 |            |       |        |               |       |       | 65J   | 57J   |          | 50J   | 45J   |       |       | 150J  | 70J   |
| Bis-(2-Ethylhexyl)<br>phthalate | 120J       | 170J  |        | 220J          |       | 130BJ |       |       |          |       |       | 230J  |       |       |       |
| 1,3-Dichlorobenzene             |            |       |        |               |       | 710J  | 310J  |       |          |       |       |       |       |       |       |
| Di-n-butylphthalate             |            |       |        |               |       |       |       |       |          |       | 95J   |       |       |       |       |
| M&P-Xylene                      |            |       |        |               |       | 41J   | 6J    |       |          |       |       |       |       |       |       |
| O-Xylene                        |            |       |        |               |       | 28J   | 4J    |       |          |       |       |       |       |       |       |

J = Estimated Value.

B = Analyte found in blank.

310 0098

Table 3-3 (Extended)

| <u>Compound (<math>\mu\text{g}/\text{kg}</math>)</u> | <u>Swamp Samples</u> |               |               | <u>Blanks</u> | <u>Trip</u> | <u>Wash Water</u> | <u>Corer</u> |
|------------------------------------------------------|----------------------|---------------|---------------|---------------|-------------|-------------------|--------------|
|                                                      | <u>N-10-1</u>        | <u>N-11-1</u> | <u>N-12-1</u> |               |             |                   |              |
| Benzo-a-pyrene                                       |                      |               |               |               |             |                   |              |
| Benzoic<br>Acid                                      |                      |               |               |               |             |                   |              |
| Bis-(2-Ethylhexyl)<br>phthalate                      |                      | 170BJ         |               |               |             |                   |              |
| 1,3-Dichlorobenaene                                  |                      |               |               |               |             |                   |              |
| Di-n-butylphthalate                                  |                      |               |               |               |             |                   |              |
| M&P Xylene                                           |                      |               |               |               |             |                   |              |
| O-Xylene                                             |                      |               |               |               |             |                   |              |

TABLE 3-4 ANALYTICAL RESULTS OF STAGE I SEDIMENT SAMPLING AT COLD CREEK SWAMP, ALABAMA--FEBRUARY 1991 SEMIVOLATILE ORGANICS--  
TENTATIVELY IDENTIFIED COMPOUNDS

| Compound ( $\mu\text{g/kg}$ )           | Background |       |        | Swamp Samples |       |        |        |       |           |       |       |       |       |        |
|-----------------------------------------|------------|-------|--------|---------------|-------|--------|--------|-------|-----------|-------|-------|-------|-------|--------|
|                                         | N-1-1      | N-1-2 | N-15-1 | N-2-1         | N-2-2 | N-3-1  | N-3-2  | N-4-1 | N-4-1 DUP | N-4-2 | N-5-1 | N-6-1 | N-7-1 | N-8-1  |
| Asctetic Acid,<br>1-Methylethyl         |            |       |        | 7,200BJ       |       |        |        |       |           |       |       |       |       |        |
| Butanoic acid                           |            |       |        |               |       |        | 2,100J |       |           |       |       |       |       |        |
| Butanoic acid,<br>3-hydroxy             |            |       |        |               |       |        |        |       |           |       |       |       |       |        |
| 2-Butanol,<br>3-methyl,<br>acetate      |            |       |        |               | 430J  |        |        |       |           |       |       |       |       |        |
| Butylate                                |            |       |        |               |       | 1,700J | 300J   |       |           |       |       |       |       |        |
| Cineole (van)                           |            |       |        |               |       |        |        |       |           |       |       |       |       |        |
| Dodecane, 2-<br>methyl-6-propyl         |            |       |        |               |       | 2,500J |        |       |           |       |       |       |       |        |
| Dodecane,<br>2,7,10-Trimethyl           |            |       |        |               |       | 520J   |        |       |           |       |       |       |       |        |
| Ethane,<br>1,1,2,2-Tetrachloro          | 230J       |       |        |               |       |        |        |       |           |       |       | 440J  |       |        |
| Ethanol,<br>2-methoxy                   |            |       |        |               |       |        |        |       |           |       | 470J  |       |       |        |
| Ethanone,<br>1-(2-hydroxy-4-<br>methyl) |            |       | 170J   |               |       |        |        |       |           |       |       |       |       |        |
| D-Friedoolean-<br>14-en-3-one           |            |       |        |               |       |        | 1,600J |       |           |       |       |       |       | 2,200J |
| Heptacosane                             |            |       |        |               |       |        |        |       |           | 340J  |       |       |       |        |

J = Estimated Value.

B = Analyte found in blank.

3 10 0099

TABLE 3-4 (Extended)

| Compound ( $\mu\text{g/kg}$ )           | Swamp Samples |         |        |        | Blanks | Trip | Wash Water | Corer |
|-----------------------------------------|---------------|---------|--------|--------|--------|------|------------|-------|
|                                         | N-9-1         | N-10-1  | N-11-1 | N-12-1 |        |      |            |       |
| Ascectic Acid,<br>1-Methylethyl         |               |         |        |        |        |      |            |       |
| Butanoic acid                           |               |         |        |        |        |      |            |       |
| Butanoic acid,<br>3-hydroxy             | 620J          |         |        |        |        |      |            |       |
| 2-Butanol,<br>3-methyl,<br>acetate      |               |         |        |        |        |      |            |       |
| Butylate                                |               |         |        |        |        |      |            |       |
| Cineole (van)                           |               | 2,700J  |        |        |        |      |            |       |
| Dodecane, 2-<br>methyl-6-propyl         |               |         |        |        |        |      |            |       |
| Dodecane,<br>2,7,10-Trimethyl           |               |         |        |        |        |      |            |       |
| Ethane,<br>1,1,2,2-Tetrachloro          |               |         |        |        |        |      |            |       |
| Ethanol,<br>2-methoxy                   |               |         |        |        |        |      |            |       |
| Ethanone,<br>1-(2-hydroxy-4-<br>methyl) |               |         |        |        |        |      |            |       |
| D-Friedoolean-<br>14-en-3-one           |               | 15,000J |        |        |        |      |            |       |
| Heptacosane                             |               |         |        |        |        |      |            |       |



TABLE 3-4 (Cont.)

| Compound (μg/kg)                   | Background |       |        | Swamp Samples |       |        |        |        |           |        |         |       |       |        |  |
|------------------------------------|------------|-------|--------|---------------|-------|--------|--------|--------|-----------|--------|---------|-------|-------|--------|--|
|                                    | N-1-1      | N-1-2 | N-15-1 | N-2-1         | N-2-2 | N-3-1  | N-3-2  | N-4-1  | N-4-1 DUP | N-4-2  | N-5-1   | N-6-1 | N-7-1 | N-8-1  |  |
| Heptane, 3-ethyl-5-methyl          |            |       |        |               |       |        |        |        |           |        | 190J    |       |       |        |  |
| 1-Heptene, 2-methyl                |            |       |        |               | 240J  |        |        |        |           |        |         |       |       |        |  |
| Hexadecane, 2,6,10,14-Tetramethyl  |            |       |        |               |       | 840J   |        |        |           |        |         |       |       |        |  |
| Hexadecanoic acid                  |            |       |        |               |       |        |        |        |           |        | 680J    |       | 590J  |        |  |
| Hexanoic acid (DOT)                |            |       | 210J   |               |       |        |        |        |           |        |         |       |       |        |  |
| Hexanoic acid, 2-ethyl             | 200J       | 240J  | 440J   | 330J          |       |        | 810J   | 200J   | 550J      | 550J   | 820J    |       | 920BJ | 2,300J |  |
| Hexatriacontane                    |            |       |        |               |       | 720J   |        |        |           |        |         |       |       |        |  |
| 3-Hexene-2, 5-dione                |            |       | 560J   | 630J          | 280J  |        |        |        |           |        | 1200J   |       | 890J  |        |  |
| Iron, Tricarbonyl (N-phenol)       |            |       |        |               |       | 770J   |        |        |           | 1,200J |         |       |       |        |  |
| Nonadecane                         |            |       |        |               |       | 2,000J |        |        |           |        |         |       |       |        |  |
| Octadecanal                        |            | 220J  |        |               |       |        |        |        |           |        |         |       |       |        |  |
| 1-Octadecanol                      |            |       | 680J   |               |       |        |        |        |           |        | 1,400BJ |       |       |        |  |
| Pentadecane, 2,6,10,14-Tetramethyl |            |       |        |               |       | 5,000J |        |        |           | 380J   |         |       |       |        |  |
| Pentatriacontane                   |            |       |        |               |       |        | 2,300J | 1,500J |           |        |         |       |       | 1,900J |  |
| 3-Penten-2-one, 4-Methyl           |            |       | 880BJ  | 870BJ         | 650BJ |        |        |        |           |        | 1,300BJ |       | 820J  | 3      |  |
| Phosphohic acid, Dioctadecyl       |            |       |        | 440J          |       | 1,200J | 700J   |        |           |        |         |       | 850J  | 10     |  |
| 1,2-Propanediol                    |            |       |        |               |       |        |        |        |           | 250J   | 990J    |       |       |        |  |

TABLE 3-4 Extended (Cont.)

[illegible]

TABLE 3-4 (Cont.)

| Compound (μg/kg)                 | Background |       |        | Swamp Samples |       |       |       |       |           |       |       |       |       |       |
|----------------------------------|------------|-------|--------|---------------|-------|-------|-------|-------|-----------|-------|-------|-------|-------|-------|
|                                  | N-1-1      | N-1-2 | N-15-1 | N-2-1         | N-2-2 | N-3-1 | N-3-2 | N-4-1 | N-4-1 DUP | N-4-2 | N-5-1 | N-6-1 | N-7-1 | N-8-1 |
| 3H-Pyrazol-3-one,<br>2,4-Dihydro |            |       |        |               |       |       |       |       |           |       |       |       |       |       |
|                                  |            |       |        |               |       |       |       |       |           |       |       |       |       |       |
| Tetratetracontane                |            |       |        |               |       |       |       |       |           |       |       |       |       |       |
|                                  |            |       |        |               |       |       |       |       |           |       |       |       |       |       |
| Tetradecane,<br>4-Methyl         |            |       |        |               |       |       |       |       |           |       |       |       |       |       |
|                                  |            |       |        |               |       |       |       |       |           |       |       |       |       |       |

980J

1,100J

54J

3 10 0101

TABLE 3-4 Extended (Cont.)

|                                               | <u>Swamp Samples</u> |               |               |               |                                     |
|-----------------------------------------------|----------------------|---------------|---------------|---------------|-------------------------------------|
| <u>Compound (<math>\mu\text{g/kg}</math>)</u> | <u>N-9-1</u>         | <u>N-10-1</u> | <u>N-11-1</u> | <u>N-12-1</u> | <u>Blanks Trip Wash Water Corer</u> |
| 3H-Pyrazol-3-one,<br>2,4-Dihydro              |                      |               |               |               |                                     |
| Tetratetracontane                             |                      |               |               |               |                                     |
| Tetradecane,<br>4-Methyl                      |                      |               |               |               |                                     |

TABLE 3-5. ANALYTICAL RESULTS OF STAGE I SEDIMENT SAMPLING  
AT COLD CREEK SWAMP, ALABAMA -- FEBRUARY 1991  
THIOCARBAMATES

|                    | BUTYLATE<br>ug/kg | CYCLOATE<br>ug/kg | EPTC<br>ug/kg | MOLINATE<br>ug/kg | PEBULATE<br>ug/kg | VERNOLATE<br>ug/kg |
|--------------------|-------------------|-------------------|---------------|-------------------|-------------------|--------------------|
| BACKGROUND SAMPLES |                   |                   |               |                   |                   |                    |
| N-1-1              | ND                | ND                | ND            | ND                | ND                | ND                 |
| N-1-2              | ND                | ND                | ND            | ND                | ND                | ND                 |
| N-15-1             | ND                | ND                | ND            | ND                | ND                | ND                 |
| SWAMP SAMPLES      |                   |                   |               |                   |                   |                    |
| N-2-1              | ND                | ND                | ND            | 11                | ND                | ND                 |
| N-2-2              | ND                | ND                | ND            | ND                | ND                | ND                 |
| N-3-1              | 3800              | 2500              | 590           | 520               | 900               | 1900               |
| N-3-2              | 320               | 510               | 260           | 390               | 120               | 270                |
| N-4-1              | 9.8               | 13 J              | 34            | 17 J              | ND                | 10 J               |
| N-4-2              | 6.4 J             | ND                | 28            | 5.3 J             | ND                | ND                 |
| N-5-1              | 32                | 79                | 170           | 120               | ND                | 34                 |
| N-6-1              | ND                | ND                | 82            | ND                | ND                | ND                 |
| N-7-1              | 100               | 350               | 410           | 680               | 74                | 250                |
| N-8-1              | ND                | ND                | ND            | ND                | ND                | ND                 |
| N-9-1              | ND                | ND                | 230           | 11 J              | ND                | ND                 |
| -10-1              | 45 J              | 63 J              | 380           | 36 J              | ND                | ND                 |
| N-11-1             | ND                | ND                | ND            | ND                | ND                | ND                 |
| N-12-1             | ND                | ND                | ND            | ND                | ND                | ND                 |

BLANK SAMPLES

TRIP

WASH WATER

CORER

NOT ANALYZED FOR

ALL COMPOUNDS BELOW DETECTION LIMIT

ALL COMPOUNDS BELOW DETECTION LIMIT

NOTES:

(1) J = ESTIMATED VALUE

(2) B = ANALYTE FOUND IN BLANK

(3) ND = NOT DETECTED

(4) SEE FIGURE 2-1 FOR SAMPLE LOCATIONS

TABLE 3-6 ANALYTICAL RESULTS OF STAGE I SEDIMENT SAMPLING AT COLD CREEK SWAMP, ALABAMA--FEBRUARY 1991 METHYL MERCURY

| Compound                            | Sample Number |         |       |       |       |              |       |       |     |       |       |       |       |       |       |        |         |        |
|-------------------------------------|---------------|---------|-------|-------|-------|--------------|-------|-------|-----|-------|-------|-------|-------|-------|-------|--------|---------|--------|
|                                     | N-1-1         | N-1-2   | N-2-1 | N-3-1 | N-3-2 |              | N-4-1 | N-4-1 | DUP | N-4-2 | N-5-1 | N-6-1 | N-7-1 | N-8-1 | N-9-1 | N-10-1 | N-11-1  | N-12-1 |
| Methyl Mercuric Chloride, Wet (ppb) | 5 <DL         | 2.5 <DL | 5 <DL | 5 <DL | 4.4   | Interference | 5.7   | 5 <DL |     | 6.2   | 7.3   | 5 <DL | 21    | 15    | 11    | 5 <DL  | 2.5 <DL | 5 <DL  |
| Methyl Mercury, Wet (ppb)           |               |         |       |       | 3.78  |              | 4.90  |       |     | 5.32  | 6.27  |       | 18.03 | 12.88 | 9.45  |        |         |        |
| Percent Moisture                    |               |         |       |       | 45.67 |              | 18.65 |       |     | 27.59 | 63.68 |       | 57.93 | 73.91 | 73.90 |        |         |        |
| Methyl Mercury, Dry (ppb)           |               |         |       |       | 6.96  |              | 6.02  |       |     | 7.35  | 17.26 |       | 42.87 | 49.38 | 36.19 |        |         |        |

## Notes:

- (1) \* = Composite over first foot.  
 (2) \*\* = Material changed from mud to sand at 5-ft level.  
 (3) <DL = less than detection limit.  
 (4) See Figures 2-1 and 2-2 for sample locations.

TABLE 3-6 (Extended)

| Compound                            | Sample Number |                 |        |        |        |        |        |        |        |         |          |        |        |        |        |
|-------------------------------------|---------------|-----------------|--------|--------|--------|--------|--------|--------|--------|---------|----------|--------|--------|--------|--------|
|                                     | N-15-1        | *SB-1-1A        | SB-1-3 | SB-1-4 | SB-1-5 | SB-1-6 | SB-1-7 | SB-1-8 | SB-1-9 | SB-1-10 | *SB-2-1A | SB-2-3 | SB-2-4 | SB-2-5 | SB-2-6 |
| Methyl Mercuric Chloride, Wet (ppb) | 2.5 <DL       | 16 Interference | 5 <DL  | 5 <DL  | 5 <DL  | 5 <DL  | 5 <DL  | 5 <DL  | 5 <DL  | 5 <DL   | 8.5      | 5 <DL  | 5 <DL  | 5 <DL  | 5 <DL  |
| Methyl Mercury, Wet (ppb)           |               | 13.74           |        |        |        |        |        |        |        |         | 7.30     |        |        |        |        |
| Percent Moisture                    |               | 71.62           |        |        |        |        |        |        |        |         | 49.32    |        |        |        |        |
| Methyl Mercury, Dry (ppb)           |               | 48.42           |        |        |        |        |        |        |        |         | 14.40    |        |        |        |        |

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TABLE 3-6 (Extended)

| Compound                            | Sample Number |        |        |         |          |         |           |           |         |         |         |         |         |        |        |  |
|-------------------------------------|---------------|--------|--------|---------|----------|---------|-----------|-----------|---------|---------|---------|---------|---------|--------|--------|--|
|                                     | SB-2-7        | SB-2-8 | SB-2-9 | SB-2-10 | *SB-3-1A | SB-3-4  | **SB-3-5A | **SB-3-5B | SB-3-6  | SB-3-7  | SB-3-8  | SB-3-9  | SB-3-10 | SB-D-1 | SB-D-2 |  |
| Methyl Mercuric Chloride, Wet (ppb) | 5 <DL         | 5 <DL  | 5 <DL  | 5 <DL   | 7.9      | 2.5 <DL | 2.5 <DL   | 13        | 2.5 <DL | 2.5 <DL | 2.5 <DL | 2.5 <DL | 2.5 <DL | 5 <DL  | 5 <DL  |  |
| Methyl Mercury, Wet (ppb)           |               |        |        |         | 6.78     |         |           | 11.16     |         |         |         |         |         |        |        |  |
| Percent Moisture                    |               |        |        |         | 76.99    |         |           | 80.47     |         |         |         |         |         |        |        |  |
| Methyl Mercury, Dry (ppb)           |               |        |        |         | 29.49    |         |           | 57.17     |         |         |         |         |         |        |        |  |



TABLE 3-7 ANALYTICAL RESULTS OF STAGE I SEDIMENT SAMPLING AT COLD CREEK SWAMP, ALABAMA--FEBRUARY 1991 INORGANICS

| Inorganics (mg/kg) | Background |       |        |        |        |        | Swamp Samples |        |        |       |       |           |       |         |  |
|--------------------|------------|-------|--------|--------|--------|--------|---------------|--------|--------|-------|-------|-----------|-------|---------|--|
|                    | N-1-1      | N-1-2 | N-13-1 | N-14-1 | N-15-1 | N-16-1 | N-2-1         | N-2-2  | N-3-1  | N-3-2 | N-4-1 | N-4-1 DUP | N-4-2 | N-5-1   |  |
| Aluminum           | 646        | 582   | 6,410  | 4,990  | 5,190  | 7,910  | 11,700        | 9,550  | 2,150  | 1,040 | 362   | 440       | 347   | 120,000 |  |
| Antimony           |            |       |        |        |        |        |               |        |        |       |       |           |       |         |  |
| Arsenic            | 0.036B     |       | 4.1    | 5.5    | 5.2    | 6.4    | 5.9           | 4.1    | 5.2    | 1.2B  |       |           |       | 10.6    |  |
| Barium             | 2.3B       | 3.4B  | 24.5   | 16.3B  | 29.9   | 21.2B  | 76.1          | 33     | 17,000 | 1,560 | 11.2B | 11B       | 9.8B  | 337B    |  |
| Beryllium          |            |       | 0.14B  | 0.15B  | 0.23B  | 0.23B  | 0.53          | 0.5B   | 0.58B  | 0.2B  |       |           |       | 11.6B   |  |
| Cadmium            |            |       | 1.3    | 0.42B  | 0.32B  | 0.92   | 2.7           | 3.4    | 3.4    |       |       |           |       |         |  |
| Calcium            | 56.9B      | 88.1B | 109B   | 51.6B  | 82.5B  | 63.1B  | 411B          | 364B   | 3,350  | 948   | 177B  | 170B      | 235B  | 23,900  |  |
| Chromium           | 0.9        | 0.9B  | 13.5   | 5.7    | 4.8    | 11.4   | 30.3          | 27.2   | 192    | 28.5  | 3.5   | 5.8       | 5.7   | 173     |  |
| Cobalt             |            |       |        | 0.66B  | 1.8B   | 0.75B  | 3.2B          | 2B     | 23.7   | 3.8B  |       |           |       | 29.4B   |  |
| Copper             | 0.47B      | 0.38B | 3.5    | 1.5B   | 1.1B   | 1.5B   | 5.7           | 5.3    | 47.8   | 8     | 0.82B | 0.78B     | 1.4B  | 29.7B   |  |
| Iron               | 263        | 444   | 11,500 | 4,220  | 4,360  | 7,800  | 24,400        | 32,700 | 21,000 | 3,140 | 260   | 245       | 250   | 14,700  |  |
| Lead               | 0.78       | 1.3   | 29.4   | 3.7    | 6.5    | 6.1    | 8.2           | 5.9    | 45.9   | 11.4  | 1.1   | 1         | 0.85  | 5.9     |  |
| Magnesium          | 20.5B      | 23.9B | 128B   | 182B   | 150B   | 284B   | 506           | 389B   | 1,330  | 293B  | 16.2B | 20.3B     | 20.6B | 3,620B  |  |
| Manganese          | 2.9        | 3.5   | 43.9   | 24.9   | 198    | 17.9   | 50.8          | 32.8   | 256    | 36.5  | 1.2B  | 1.3B      | 1.4B  | 208     |  |
| Mercury            |            |       | 0.17   | 0.25   | 0.82   | 2.1    | 2.6           | 863    | 122    | 10.3  | 27    | 23.9      | 1.8   | 10.6    |  |
| Nickel             |            |       | 1.8B   | 1.5    | 0.99B  | 5.6    | 2.2B          | 127    | 16.3   |       |       |           |       |         |  |
| Potassium          | 41B        | 37.8B | 97.6B  | 118B   | 125B   |        | 389B          |        | 646B   | 189B  | 57B   | 52.1B     |       | 3,720B  |  |
| Selenium           |            |       | 0.74   | 0.23B  | 0.22B  | 0.23B  | 1             | 0.72   |        |       |       |           |       | 1.8     |  |
| Silver             |            |       |        | 0.18B  |        |        |               |        |        |       |       |           |       |         |  |
| Sodium             |            |       |        | 12.2B  | 5.8B   | 32.7B  | 224B          | 235B   | 2,040  | 1,420 | 9.8B  | 11.7B     | 12.3B | 1,170B  |  |

## Notes:

- (1) B = Value less than CRDL but greater than IDL.  
 (2) See Figure 2-1 for sample locations.

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0104

TABLE 3-7 (Extended)

| Inorganics (mg/kg) | Swamp Samples |        |        |        |        |        |        | Maximum | Minimum | Blanks | Trip             | Wash Water | Corer |
|--------------------|---------------|--------|--------|--------|--------|--------|--------|---------|---------|--------|------------------|------------|-------|
|                    | N-6-1         | N-7-1  | N-8-1  | N-9-1  | N-10-1 | N-11-1 | N-12-1 |         |         |        |                  |            |       |
| Aluminum           | 14,500        | 5,600  | 30,500 | 31,600 | 21,500 | 20,200 | 287    | 120,000 | 287     |        | Not analyzed for |            |       |
| Antimony           |               |        |        | 16.7B  |        |        |        | 16.7B   | 16.7B   |        |                  |            |       |
| Arsenic            | 6.4           | 3.9    | 8.6    | 4.7    | 14.3   | 6.9    |        | 14.3    | 1.2B    |        |                  |            |       |
| Barium             | 158           | 51.3   | 239    | 213    | 167    | 138    | 2.2B   | 17,000  | 2.2B    |        |                  | 18.1B      |       |
| Beryllium          | 1.4           | 0.82B  | 1.2B   | 1B     | 2.6B   | 1      |        | 11.6B   | 0.2B    |        |                  |            |       |
| Cadmium            | 4.2           |        | 3.2    |        |        | 4      |        | 4.2     | 2.7     |        |                  |            |       |
| Calcium            | 2,980         | 274B   | 2,620  | 2,510  | 3,770  | 2,170  | 95.8B  | 23,900  | 95.8B   |        |                  | 23,600     | 93.3B |
| Chromium           | 32.7          | 26.4   | 63.2   | 53     | 39.1   | 36     | 0.54B  | 192     | 0.54B   |        |                  |            |       |
| Cobalt             | 14.3          | 1.7B   | 6.5B   | 4.6B   | 12.1B  | 6.8B   |        | 29.4    | 1.7B    |        |                  |            |       |
| Copper             | 23.9          | 4.9B   | 61.2   | 29.4   | 22     | 29.9   | 1.3B   | 61.2    | 0.78B   |        |                  | 77.3       |       |
| Iron               | 30,600        | 52,700 | 22,700 | 12,100 | 11,200 | 28,700 | 114    | 52,700  | 114     |        |                  |            |       |
| Lead               | 17.6          | 5.5    | 26     | 26.5   | 21.7   | 19.8   | 0.59   | 45.9    | 0.59    |        |                  | 2B         | 7.6   |
| Magnesium          | 2,060         | 164B   | 2,940  | 2,500  | 1,670B | 2,190  | 43.1   | 3,620   | 16.2B   |        |                  | 1,440B     |       |
| Manganese          | 402           | 7.5    | 117    | 115    | 129    | 205    | 1.6    | 402     | 1.2     |        |                  | 9B         |       |
| Mercury            | 10.6          | 23.2   | 14.3   | 35.4   | 19.9   | 27     | 1.1    | 863     | 1.1     |        |                  |            |       |
| Nickel             | 22.7          | 5.2B   | 25.3   | 22.1   | 17.5B  | 17.1   | 1.2B   | 127     | 1.2B    |        |                  |            |       |
| Potassium          | 1,280         | 215B   | 2,070  | 1,860  |        | 1,390  | 64.2B  | 3,720   | 52.1B   |        |                  | 1,220B     |       |
| Selenium           |               | 0.74   | 3.5    |        | 2.2B   | 1.1    |        | 3.5     | 0.72    |        |                  |            |       |
| Silver             |               |        |        |        |        |        |        |         |         |        |                  |            |       |
| Sodium             | 187B          | 109B   | 276B   | 196B   |        | 140B   | 283B   | 2,040   | 9.8B    |        |                  | 5,740      | 227B  |

TABLE 3-7 (Cont.)

| Inorganics (mg/kg) | Background |       |        |        |        |        | Swamp Samples |       |       |       |       |           |       |       |
|--------------------|------------|-------|--------|--------|--------|--------|---------------|-------|-------|-------|-------|-----------|-------|-------|
|                    | N-1-1      | N-1-2 | N-13-1 | N-14-1 | N-15-1 | N-16-1 | N-2-1         | N-2-2 | N-3-1 | N-3-2 | N-4-1 | N-4-1 DUP | N-4-2 | N-5-1 |
| Sulfide            | 11.5       |       |        |        |        |        |               |       | 904   | 117   |       |           |       |       |
| Vanadium           |            | 1.68  | 23.6   | 8.8    | 8.3    | 18.3   | 37.2          | 42.3  | 37.5  | 8.5   |       | 1.5       | 1.3B  | 149   |
| Zinc               | 1.9        | 2.8   | 11.6   | 7.5    | 7.5    | 11.8   | 30.1          | 15.5  | 442   | 61.6  | 5     | 6         | 5.1   | 156   |

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TABLE 3-7 (Extended) (Cont.)

| <u>Inorganics (mg/kg)</u> | <u>Swamp Samples</u> |              |              |              |               |               |               | <u>Maximum</u> | <u>Minimum</u> | <u>Blanks</u> | <u>Trip</u> | <u>Wash Water</u> | <u>Corer</u> |
|---------------------------|----------------------|--------------|--------------|--------------|---------------|---------------|---------------|----------------|----------------|---------------|-------------|-------------------|--------------|
|                           | <u>N-6-1</u>         | <u>N-7-1</u> | <u>N-8-1</u> | <u>N-9-1</u> | <u>N-10-1</u> | <u>N-11-1</u> | <u>N-12-1</u> |                |                |               |             |                   |              |
| Sulfide                   | 252                  |              | 36.5         | 47.1         |               | 37.4          | 16.9          | 904            | 16.9           |               |             |                   |              |
| Vanadium                  | 39.4                 | 12.3         | 68.6         | 59.7         | 38.9          | 42.9          |               | 149            | 1.38           |               |             |                   |              |
| Zinc                      | 108                  | 43.3         | 86           | 74.3         | 81.6          | 69.9          | 2.5           | 442            | 2.5            |               |             | 15.88             |              |

TABLE 3-8 ANALYTICAL RESULTS OF STAGE I SOIL BORINGS AT COLD CREEK SWAMP, ALABAMA--FEBRUARY 1991 DEPTH CHARACTERIZATION

| Sample Number | Depth Interval (ft) | Percent Moisture | pH   | Sulfide (mg/kg) | Total Mercury (mg/kg) | Methyl Mercury (ppb) |
|---------------|---------------------|------------------|------|-----------------|-----------------------|----------------------|
| SB-1-1A       | 0-1                 | 71.65            | NA   | 332             | 530                   | 48.42                |
| SB-1-3        | 1-2                 | 50.21            | 7.12 | 269             | 42.6                  | ND                   |
| SB-1-4        | 2-3                 | 20.98            | 7.26 | 217             | 1.3                   | ND                   |
| SB-1-5        | 3-4                 | 16.35            | 7.26 | 134             | 0.33                  | ND                   |
| SB-1-6        | 4-5                 | 14.65            | 7.12 | ND              | ND                    | ND                   |
| SB-1-7        | 5-7                 | 17.44            | 6.86 | ND              | 0.68                  | ND                   |
| SB-1-8        | 8-10                | 17.80            | 6.80 | ND              | 0.43                  | ND                   |
| SB-1-9        | 13-15               | 17.16            | 6.49 | ND              | 0.12                  | ND                   |
| SB-1-10       | 18-20               | 13.04            | 6.94 | ND              | 0.74                  | ND                   |
| SB-D-2        | 18-20               | 16.64            | NA   | ND              | 0.9                   | ND                   |
| SB-2-1A       | 0-1                 | 49.32            | 6.04 | ND              | 0.41                  | 14.40                |
| SB-2-3        | 1-2                 | 71.08            | 5.35 | ND              | 0.77                  | ND                   |
| SB-2-4        | 2-3                 | 71.70            | NA   | ND              | ND                    | ND                   |
| SB-2-5        | 3-4                 | 60.01            | 5.06 | ND              | ND                    | ND                   |
| SB-2-6        | 4-5                 | 63.32            | 6.19 | ND              | 0.25                  | ND                   |
| SB-2-7        | 5-7                 | 27.54            | 6.46 | ND              | ND                    | ND                   |
| SB-2-8        | 8-10                | 26.10            | 7.56 | ND              | 0.11                  | ND                   |
| SB-2-9        | 13-15               | 33.29            | 6.43 | ND              | ND                    | ND                   |
| SB-2-10       | 18-20               | 20.96            | NA   | ND              | 0.12                  | ND                   |
| SB-D-1        | 18-20               | 22.88            | NA   | ND              | ND                    | ND                   |

Notes:

1. Samples SB-1-1A, SB-2-1A, and SB-3-1A were composited over the 0-1 ft interval. The original workplan had proposed taking discrete samples (i.e., SB-1-1 and SB-1-2) from the 0-6 and 6-12-in. intervals. Based upon the amount of material required, these samples were combined. The sample numbering change was made to allow subsequent sample numbers to remain as indicated in the workplan.
2. The sample volume collected at SB-3-3 was insufficient to be analyzed for all parameters. Only mercury and sulfide were analyzed.
3. Sample SB-3-5A was resampled as SB-3-5B since the original sample was almost entirely liquid.
4. Insufficient sample to run pH at SB-1-1A, SB-2-4, SB-3-5A, SB-3-8, and SB-3-10.
5. See Figure 2-2 for sample locations.

TABLE 3-8 (Cont.)

| <u>Sample<br/>Number</u> | <u>Depth<br/>Interval<br/>(ft)</u> | <u>Percent<br/>Moisture</u> | <u>pH</u> | <u>Sulfide<br/>(mg/kg)</u> | <u>Total<br/>Mercury<br/>(mg/kg)</u> | <u>Methyl<br/>Mercury<br/>(ppb)</u> |
|--------------------------|------------------------------------|-----------------------------|-----------|----------------------------|--------------------------------------|-------------------------------------|
| SB-3-1A                  | 0-1                                | 76.99                       | 4.78      | 28.7                       | 7.8                                  | 29.49                               |
| SB-3-3                   | 1-2                                | NA                          | 4.93      | ND                         | 8                                    | NA                                  |
| SB-3-4                   | 2-3                                | 90.04                       | 5.37      | 256                        | 7.4                                  | ND                                  |
| SB-3-5A                  | 3-4                                | 91.79                       | NA        | ND                         | 8.8                                  | ND                                  |
| SB-3-5B                  | 3-4                                | 80.47                       | 5.27      | ND                         | 1.8                                  | 57.17                               |
| SB-3-6                   | 4-5                                | 26.00                       | 5.16      | ND                         | 0.13                                 | ND                                  |
| SB-3-7                   | 5-7                                | 17.04                       | 5.10      | ND                         | 0.12                                 | ND                                  |
| SB-3-8                   | 8-10                               | 22.66                       | NA        | ND                         | ND                                   | ND                                  |
| SB-3-9                   | 13-15                              | 19.92                       | 5.58      | 9.1                        | ND                                   | ND                                  |
| SB-3-10                  | 18-20                              | 20.04                       | NA        | ND                         | ND                                   | ND                                  |

the black silty muck (SB-3-1A through SB-3-5B) were primarily liquid (75-90 percent). Given the sample collection conditions (i.e., standing water, runny muck samples) it is questionable whether the SB-3-1A through SB-3-5B samples actually represent discrete depth intervals. Because of this, the observed methyl mercury in SB-3-5B most likely represents soil infiltration from the surface into the split spoon sampler at depth.

### 3.1.3 Surface Water Characterization

Volatile organic compounds, semivolatile organic compounds, pesticides, PCBs, thiocarbamates, or thiocyanates were not found in any of the surface water samples. The only observed compounds in surface water samples were metals. Table 3-9 contains the results of the inorganics analysis. The following metals were not detected in surface waters: antimony, cadmium, cobalt, selenium, and vanadium. Table 3-10 summarizes physical data and water quality parameters (i.e., dissolved oxygen, pH, temperature) from the surface water sample locations.

### 3.1.4 Wetlands Delineation and Characterization

Ecological characterization of the Cold Creek study area was conducted to survey for the presence of gross effects (bare areas, etc.), aid in the evaluation of impacts to the environment, and help identify potential effects of remedial action alternatives if implemented. The characterization includes a general inventory of flora and fauna associated in and around the site with particular emphasis on the sensitive resources of wetlands and rare, threatened, and endangered species.

#### 3.1.4.1 Site Description

For characterization purposes, the study site was divided into three zones (Figure 1-3):

Zone I            the Upper "depositional" zone,  
Zone II           the Middle "erosional" zone, and  
Zone III          the Lower "depositional" zone.

Zone I begins at the Akzo Chemical Company and ends at the confluence of the tributary stream with Cold Creek at the edge of the Cold Creek floodplain. This zone has an approximately 300 ft average width and is nearly 3,000 ft long. The zone consists of a series of ponds between constrictions of densely vegetated sediment deposits.

Zone II is the section of Cold Creek that extends from the railroad tracks between the ICI and Hoeschts-Celanese plants to the intersection of the Creek with two large transmission line rights-of-way. Zone II is approximately 1,000 ft in average width, and approximately 6,000 ft long. Zone II is a broad floodplain area containing braided channels and consisting primarily of forested and scrub-shrub wetlands. This zone also contains several depression basins vegetated by emergents, which are flooded during periods of high water. Unlike the mainstem of Cold Creek and its riparian corridor, these offsite depression basins are deposition zones, acquiring sediment unidirectionally during high water.

North of the transmission line the Cold Creek floodplain expands into a large swamp extending to the discharge canal and the Mobile River. This area is designated Zone III. The average width of this zone is about 3,000 ft, and the zone extends approximately 7,000 ft in length.

#### 3.1.4.2 Methodology

##### 3.1.4.2.1 Site Investigation

The investigation of Cold Creek Swamp was conducted in accordance with the Site-Specific Health and Safety Plan.



TABLE 3-9 ANALYTICAL RESULTS OF STAGE I WATER SAMPLING AT COLD CREEK SWAMP, ALABAMA--FEBRUARY 1991 INORGANICS (TOTAL)

| Inorganics (Total) (µg/L) | Background | Swamp Samples |         |        |        |        | Maximum | Minimum | Mobile River |  |
|---------------------------|------------|---------------|---------|--------|--------|--------|---------|---------|--------------|--|
|                           | W-1        | W-2           | W-2 DUP | W-3    | W-4    | W-5    |         |         | W-6          |  |
| Aluminum                  | 288        | 431           | 63.4    | 8,520  | 180B   | 8,520  | 63.4    | 706     | 863          |  |
| Antimony                  |            |               |         |        |        |        |         |         |              |  |
| Arsenic                   |            |               |         | 2.6B   |        | 2.6    | 2.6     |         |              |  |
| Barium                    | 65.2B      | 71.4B         | 24.8B   | 66.8B  | 88.5B  | 88.5B  | 24.8B   | 43.3B   | 37.2B        |  |
| Beryllium                 |            |               | 1.5B    | 1.4B   | 1.9B   | 1.9B   | 1.4B    |         | 1.7B         |  |
| Cadmium                   |            |               |         |        |        |        |         |         |              |  |
| Calcium                   | 5,660      | 5,980         | 5,760   | 11,106 | 12,400 | 12,400 | 5,760   | 14,200  | 12,800       |  |
| Chloride                  | 10.7       | 10.5          | 5.5     | 7.7    | 17.2   | 17.2   | 5.5     | 11.4    | 18.7         |  |
| Chromium                  |            |               |         | 6.6B   |        | 6.6B   | 6.6B    |         |              |  |
| Cobalt                    |            |               |         |        |        |        |         |         |              |  |
| Copper                    | 11.9B      | 12.9B         | 15.9B   | 15B    | 9.7B   | 15.9B  | 9.7B    | 16B     | 15.6B        |  |
| Iron                      | 811        | 972           | 285     | 746    | 687    | 972    | 285     | 1,490   | 1,010        |  |
| Lead                      |            |               |         | 1.2B   |        | 1.2B   | 1.2B    | 1.7B    |              |  |
| Magnesium                 | 1,090B     | 1,160B        | 1,560B  | 1,040B | 3,520B | 3,520B | 1,040B  | 2,470B  | 2,380B       |  |
| Manganese                 | 287        | 305           | 9.3B    | 41.6   | 296    | 305    | 9.3B    | 92.8    | 78.8         |  |
| Mercury                   |            |               |         | 0.85   | 0.29   | 0.85   | 0.29    |         |              |  |
| Nickel                    |            | 10B           |         |        |        | 10B    | 10B     |         |              |  |
| Potassium                 | 610B       | 471B          | 1,200B  | 925B   | 1,560B | 1,560B | 471B    | 1,800B  | 1,360B       |  |
| Selenium                  |            |               |         |        |        |        |         |         |              |  |
| Silver                    |            |               | 5.1B    | 7B     | 6.2B   | 7B     | 5.1B    | 10      | 8.7B         |  |
| Sodium                    | 13,100     | 14,100        | 5,000   | 18,000 | 19,100 | 19,100 | 5,000   | 10,800  | 11,400       |  |
| Sulfide                   | 2.6        | 4.2           | 8.2     |        |        |        |         |         |              |  |

## Notes:

1. B = Value less than CRDL but greater than IDL.
2. See Figure 2-3 for sample locations.

TABLE 3-9 (Cont.)

[illegible]

TABLE 3-10 SURFACE WATER PHYSICAL/WATER QUALITY DATA FROM STAGE I SAMPLING, FEBRUARY 1991

| Location | Maximum<br>Channel Depth<br>(ft) | Channel Width<br>(ft) | Flow Rate<br>(cfs) | Flow Velocity<br>(fps) | pH  | Conductivity | Temperature<br>(°C) | Dissolved<br>Oxygen<br>(mg/L) |
|----------|----------------------------------|-----------------------|--------------------|------------------------|-----|--------------|---------------------|-------------------------------|
| W-1      | 0.5                              | 6                     | 1.78               | 0.42                   | 6.8 | 64           | 11.5                | 8.4                           |
| W-2      | 1.35                             | 3.75                  | 0.08               | 0.03                   | 6.5 | 117          | 12.0                | 7.4                           |
| W-3      |                                  | [No Flow]             |                    |                        | 6.2 | 158          | 14.3                | 4.3                           |
| W-4      |                                  | [No Flow]             |                    |                        | 4.7 | 228          | 12.7                | 7.9                           |
| W-5      |                                  | [Mobile River]        |                    |                        | 7.0 | 154          | 12.6                | 9.6                           |
| W-6      |                                  | [Mobile River]        |                    |                        | 7.0 | 173          | 13.2                | 9.6                           |

Note: Mobile River flow rates were not measured.

Flagging was used to mark off inspection areas, creating an Exclusion Zone. Waders were worn during all activities within the swamp. Latex or nitrile gloves were used whenever soil or vegetation was handled. All field equipment used in the swamp (waders, gloves, soil corers, etc.) was thoroughly rinsed with potable water in the Contamination Reduction Zone. The vehicle used to traverse the site and the field gear used were washed at an established decontamination pad (near the Akzo Plant) at the end of each work day.

#### 3.1.4.2.2 Wetland Characterization

Wetlands were characterized and delineated on the basis of three main factors: hydrology, soils, and vegetation according to the Unified Federal Manual for Identifying and Delineating Jurisdictional Wetlands (1989). The hydrology factor describes the duration and timing of surface inundation and the fluctuations in ground water. Hydrology is determined by reviewing topographic maps, soil surveys, and field indicators such as mud marks on trees and stained leaves.

Hydric soils are the second indicator used to characterize wetlands. These are poorly drained soils which have held water long enough for chemical reactions characteristic of saturated conditions to occur, changing the color of the soil. The color and texture of the soil are used to determine how well it drains and whether it could support wetland vegetation. The Mobile County Soil Survey provides an indication of where hydric soils may be located in the soil type map. Each soil type has been given a capability unit. Capability units are designations made by the Soil Conservation Service which describe limitations for cultivation and are also useful in locating potential wetland areas. Capability classes are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations. Capability subclasses are designated by small letters: e--erosion, s--stony, and w--water in or on the soil which interferes with plant growth or cultivation.

Soils with capability units of Iw-IIw may or may not have wetlands.  
Soils with capability units of IIIw generally support some wetlands.  
Capability units greater than III nearly always support wetlands.

Finally, the vegetation of wetlands under natural conditions is composed of species adapted to hydric soils and/or periodic flooding. Species that are commonly found in wetlands have been categorized by the USFWS in the National List of Plant Species That Occur in Wetlands: Southeast (1988). Each plant listed is categorized by a regional indicator or "hydrophytic status," which describes the occurrence percentage of a given species in wetlands throughout its range.

There are four indicators:

OBL = >99 percent of these plants are found in wetlands  
FACW = 67-99 percent of these plants are found in wetlands  
FAC = 34-66 percent of these plants are found in wetlands  
FACU = 1-33 percent of these plants are found in wetlands

Hydrophytes have been defined as species with indicators of OBL, FACW, and FAC characteristics for purposes of Army Corps of Engineers permitting. Wetlands are characterized by a predominance (greater than 50 percent cover) of hydrophytic species.

Wetlands of the three zones were characterized by structural type (e.g., emergent, scrub-shrub, forested) according to the Cowardin System (1978). A black-and-white aerial photograph of the site was interpreted to differentiate the various structural community types. The photo interpretations were ground-truthed according to conditions noted during the field survey and were used to produce a map of the wetland types of the study area. Army Corps of Engineers Routine Determination data sheets were completed for the main types of wetlands in each of the three zones and are included in Appendix G.

In addition, each of the three zones was evaluated as a wetland system to determine the value of these wetlands relative to other bottomland hardwoods in the Southeast Region. The wetland functional analysis followed the Wetland Evaluation Technique (WET) for Bottomland Hardwood Functions (Adamus 1987, Draft) developed for the USACOE and the Federal Highway Administration (FHWA). The main premise of this evaluation is that not all wetlands function in the same way or to the same extent. In order to make intelligent decisions in wetland resources management, it is important to understand how well a given wetland performs the functions for which wetlands are valued by society relative to other wetlands in the region. This is a technique by which 10 well-defined wetland functions are evaluated for specific wetland sites.

Under WET, the physical, chemical, and biological characteristics of a given wetland are reviewed and scored to yield a qualitative evaluation of wetland functions in terms of social significance, effectiveness, and performance opportunity. The "social significance" scale evaluates the wetland characteristics relative to the resources of the locality--in this case, wetlands of the Lower Mobile River Basin. The "effectiveness" scale assesses the capability of a wetland to perform a given function relative to its inherent characteristics (e.g., basin shape). The "opportunity" scale relates the capabilities of a wetland to its opportunity to deliver those functions in the landscape matrix.

The specific functions evaluated under WET are ground-water discharge, flood flow alteration, sediment stabilization, sediment/toxicant retention, nutrient retention/transformation, production export, wildlife habitat, shellfish habitat, finfish habitat, and uniqueness/heritage.

WET assesses functions and values by characterizing a wetland in terms of its physical, chemical, and biological processes and attributes. This characterization is accomplished by identifying threshold values for predictors. Predictors are simple or integrated variables that directly or indirectly measure the physical, chemical, and biological processes or attributes of a wetland and its surroundings. Threshold values for

predictors are established by addressing a series of questions concerning each predictor. Responses to the questions are analyzed in a series of interpretation keys that define the relationship between predictors and wetland functions and values as defined in the technical literature. The interpretation results in the assignment of a qualitative probability rating of HIGH, MODERATE, or LOW to functions and values in terms of social significance, effectiveness, and opportunity.

### Wetland Evaluations

A series of 83 questions was addressed and the responses were entered into the WET model for each of the three wetland systems. The questions, responses, and assumptions made to respond are included in Appendix G. Data used in the functional analyses of these wetlands included:

- . Mobile County Soil Survey (1978)
- . Aerial photographs of the site and vicinity
- . U.S. Geological Survey (USGS) 7.5-minute topographic maps
- . Site maps provided by Akzo
- . Field observations

The wetlands of the study area are part of a larger wetland system that extends from a reservoir and cooling water canal system to the Mobile River. The watershed of the area between the reservoir and the river is approximately 3,500 acres (5.6 mi<sup>2</sup>). The watershed of the tributary to Cold Creek that forms Zone I is approximately 1,200 acres. The remaining 2,800 acres of the study area watershed are drained through Cold Creek. The watershed includes three chemical plants and portions of two railroads and Highway 43. The remaining area is wooded, primarily in pine plantation. The lower portion of the watershed along the Mobile River is predominantly poorly drained mature tupelo/cypress swamp.

The Mobile River basin was identified as the "service area" that receives the benefit of the functions provided by the Cold Creek study area wetlands.

### 3.1.4.3 Ecological Characterization Results

Ecological characterization of the study site was conducted on 5-12 February 1991. Vegetation identified across the entire study site is listed in Table 3-11. A map of vegetative community types is provided in Figure 3-1. No rare, threatened, or endangered plant species were identified by state or federal agencies as known to exist onsite, and none were encountered during the field study. Identification of herbaceous species was constrained by the winter sampling dates. Soils identified by the Mobile County Soil Survey are listed in Table 3-12 and are shown in Figure 1-4.

#### 3.1.4.3.1 Zone I--Upper Depositional Area

##### Hydrology

Zone I was characterized as a series of ponds within an approximately 300-ft-broad floodplain area. Hydrology of this wetland system is provided primarily by the second order stream that passes through it (Figure 1-3). The Soil Survey shows two first-order streams joining at the Akzo Plant. These streams were modified as stormwater collection basins during the expansion of the plant. Modifications to the stream included piping, channelization, and ponding. Overland and channelized storm runoff are contributors of water to the system in Zone I. Groundwater discharge also occurs throughout the length of the tributary stream to a limited extent. The depth of the open water in Zone I ranges from 1 to 4 ft.

##### Soils

Soils of the wetlands in this zone range from permanently inundated to intermittently exposed organic muck and silty sediments.



## Vegetation

The vegetation of Zone I (Figure 3-1) is dominated by submerged aquatics and emergent species, and also includes peripheral and island areas of scrub-shrub and scattered trees. The upper storm basins were dominated by cattails. The ponds were dominated by soft rush, red-top panic grass, or dotted smartweed. Shrub margins were dominated by red maple. Data sheets in Appendix G list species assemblages at three locations in Zone I.

## WET Model Results

Results of the evaluations generated by the WET model are presented in Table 3-13. Social significance values were low because this wetland system is not rare or limited in type or size relative to the wetland resources of the lower Mobile River basin. Wetlands of this type are relatively abundant in this area, and this wetland system has no features that indicate an exceptional value. Significance criteria for the eight functions are:

1. Ground-Water Discharge--Low significance was assigned for Zone I wetlands because there is no shortage of ground-water supply and no high demand.
2. Flood Flow Alteration--Low significance was assigned to Zone I because there are no floodable manmade structures downstream of these wetlands.
3. Sediment Stabilization--Low significance was assigned because erosion-susceptible property is distant from river erosion and there are no downstream turbidity problems.

TABLE 3-11 VEGETATION IDENTIFIED IN THE COLD CREEK SWAMP STUDY SITE,  
5-12 FEBRUARY 1991

| <u>Scientific Name</u>         | <u>Common Name</u> | <u>Hydrophytic Status</u> <sup>(a)</sup> |
|--------------------------------|--------------------|------------------------------------------|
| <b>TREES</b>                   |                    |                                          |
| <u>Acer rubrum</u>             | Red maple          | FAC                                      |
| <u>Cornus florida</u>          | Dogwood            | FACU                                     |
| <u>Fagus grandifolia</u>       | Beech              | FACU                                     |
| <u>Fraxinus</u> sp.            | Ash                | UNK                                      |
| <u>Ilex opaca</u>              | American holly     | FAC                                      |
| <u>Juniperus virginiana</u>    | Eastern red cedar  | FACU                                     |
| <u>Liquidambar styraciflua</u> | Sweetgum           | FAC                                      |
| <u>Liriodendron tulipifera</u> | Tulip tree         | FAC                                      |
| <u>Magnolia grandiflora</u>    | Southern magnolia  | FAC                                      |
| <u>Magnolia virginiana</u>     | Sweetbay magnolia  | FACW                                     |
| <u>Nyssa aquatica</u>          | Water tupelo       | OBL                                      |
| <u>Pinus elliotii</u>          | Slash pine         | FACW                                     |
| <u>Pinus palustris</u>         | Longleaf pine      | FACU                                     |
| <u>Pinus taeda</u>             | Loblolly pine      | FAC                                      |
| <u>Pinus virginiana</u>        | Virginia pine      | UP*                                      |
| <u>Quercus alba</u>            | White oak          | FACU                                     |
| <u>Quercus laurifolia</u>      | Laurel oak         | FACW                                     |
| <u>Quercus nigra</u>           | Water oak          | FAC                                      |
| <u>Quercus rubra</u>           | Northern red oak   | FACU                                     |
| <u>Quercus virginiana</u>      | Live oak           | FACU                                     |
| <u>Salix nigra</u>             | Black willow       | OBL                                      |
| <u>Taxodium distichum</u>      | Bald cypress       | OBL                                      |
| <b>SHRUBS</b>                  |                    |                                          |
| <u>Aralia spinosa</u>          | Hercules club      | FAC                                      |
| <u>Baccharis halimifolia</u>   | Groundsel          | FAC                                      |
| <u>Ilex glabra</u>             | Ink-berry          | FACW                                     |
| <u>Ilex vomitoria</u>          | Yaupon             | FAC                                      |
| <u>Itea virginica</u>          | Virginia willow    | FACW                                     |
| <u>Lyonia lucida</u>           | Fetter-bush        | FACW                                     |

- (a) Hydrophytic status follows Reed, P.B. Jr. (1988) The U.S. Fish and Wildlife National List of Plant Species that Occur in Wetlands unless indicated otherwise. Abbreviations:
- OBL = Obligate (found in wetlands in more than 99% of all findings)
- FACW = Faculative wetland (66-99%)
- FAC = Faculative (33-66%)
- FACU = Faculative upland (1-33%)
- UP = Upland (<1%)

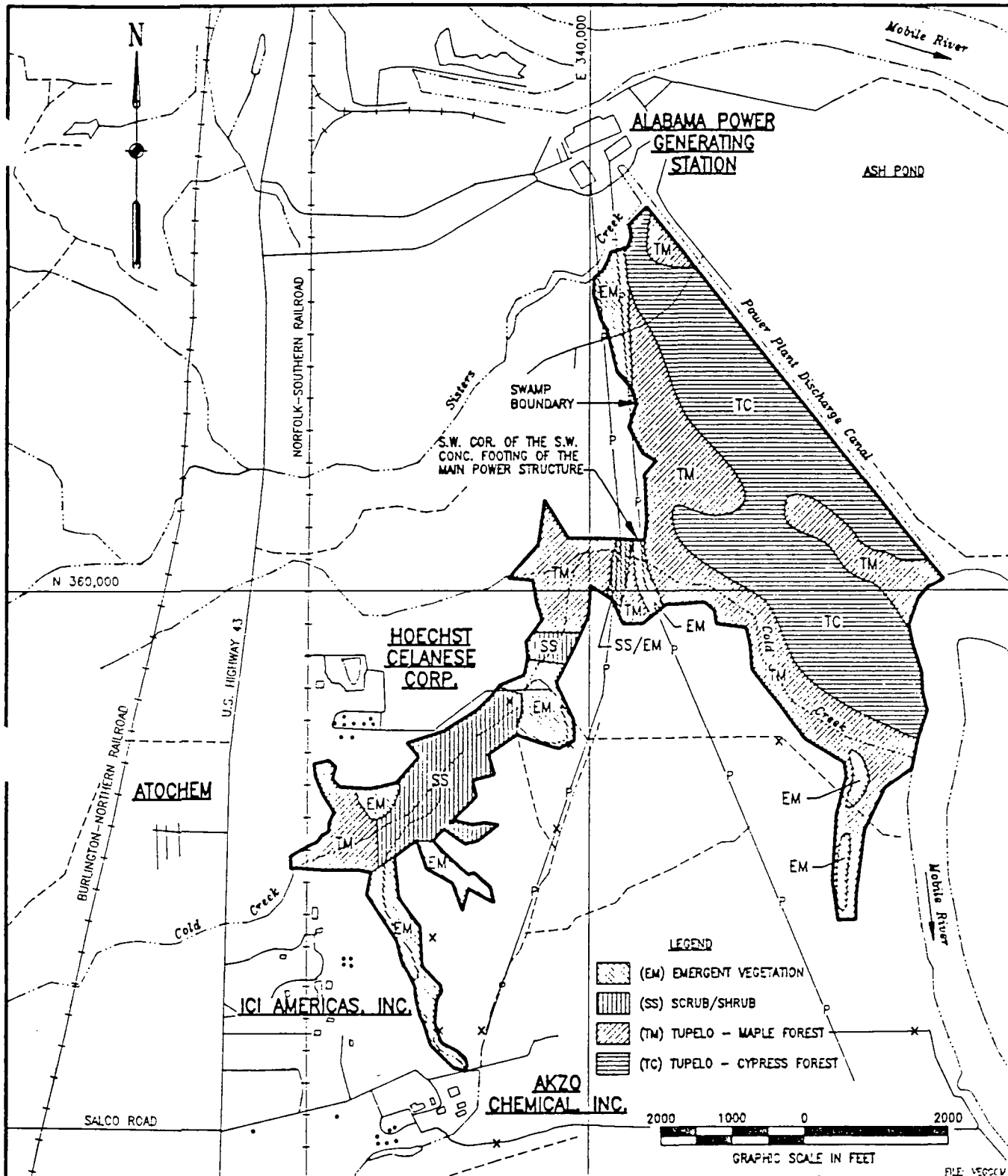
Note: \*Hydrophytic status not reported; status presented is based on professional judgment and is supported by appropriate literature.

TABLE 3-11 (Cont.)

| <u>Scientific Name</u>       | <u>Common Name</u>     | <u>Hydrophytic Status</u> <sup>(a)</sup> |
|------------------------------|------------------------|------------------------------------------|
| SHRUBS (Cont.)               |                        |                                          |
| <u>Myrica cerifera</u>       | Southern bayberry      | FAC                                      |
| <u>Rhus typhina</u>          | Staghorn sumac         | UP*                                      |
| <u>Rubus hispidus</u>        | Bristly blackberry     | FACW                                     |
| <u>Sambucus canadensis</u>   | American elder         | FACW                                     |
| <u>Vaccinium corymbosum</u>  | Highbush blueberry     | FACW                                     |
| VINES AND EPIPHYTES          |                        |                                          |
| <u>Lonicera sempervirens</u> | Trumpet honeysuckle    | FAC                                      |
| <u>Mikania scandens</u>      | Climbing hempweed      | FACW                                     |
| <u>Mitchella repens</u>      | Partridge-berry        | FACU                                     |
| <u>Rhus radicans</u>         | Poison ivy             | FAC                                      |
| <u>Smilax bona-nox</u>       | Saw greenbrier         | FAC                                      |
| <u>Smilax waltherii</u>      | Coral greenbrier       | OBL                                      |
| <u>Smilax laurifolia</u>     | Laurel-leaf greenbrier | OBL                                      |
| <u>Tillandsia usneoides</u>  | Spanish moss           | FAC*                                     |
| <u>Vitis rotundifolia</u>    | Muscadine grape        | FAC                                      |
| FERNS AND FERN ALLIES        |                        |                                          |
| <u>Lygodium japonicum</u>    | Climbing fern          | FAC                                      |
| <u>Onoclea sensibilis</u>    | Sensitive fern         | FACW                                     |
| <u>Osmunda cinnamomea</u>    | Cinnamon fern          | FACW                                     |
| <u>Osmunda regalis</u>       | Royal fern             | OBL                                      |
| <u>Pteridium aquilinum</u>   | Bracken fern           | FACU                                     |
| <u>Thelypteris palustris</u> | Marsh fern             | FACW                                     |
| GRASSES, SEDGES, AND RUSHES  |                        |                                          |
| <u>Andropogon virginicus</u> | Broomsedge             | FAC                                      |
| <u>Arundinaria tecta</u>     | Giant cane             | FACW                                     |
| <u>Erianthus giganteus</u>   | Sugar-cane plumegrass  | FACW                                     |
| <u>Carex sp.</u>             | Sedge                  | UNK                                      |
| <u>Cyperus sp.</u>           | Flatsedge              | UNK                                      |
| <u>Cyperus virens</u>        | Green flatsedge        | FACW                                     |
| <u>Erianthus giganteus</u>   | Sugarcane plumegrass   | FACW                                     |
| <u>Juncus effusus</u>        | Soft rush              | FACW                                     |
| <u>Leersia lenticularis</u>  | Catchfly cutgrass      | OBL                                      |
| <u>Panicum agrostoides</u>   | Red-top panic grass    | FACW                                     |
| <u>Panicum gymnocarpon</u>   | Savannah panic grass   | OBL                                      |
| <u>Scirpus cyperinus</u>     | Wool-grass             | OBL                                      |
| <u>Tridens flavus</u>        | Purple-top             | FACU                                     |

TABLE 3-11 (Cont.)

| <u>Scientific Name</u>            | <u>Common Name</u>  | <u>Hydrophytic Status</u> <sup>(a)</sup> |
|-----------------------------------|---------------------|------------------------------------------|
| HERBS                             |                     |                                          |
| <u>Cassia obtusifolia</u>         | Sicklepod           | UP*                                      |
| <u>Diodia virginiana</u>          | Virginia buttonweed | OBL                                      |
| <u>Eichhornia crassipes</u>       | Water hyacinth      | OBL                                      |
| <u>Eupatorium compositifolium</u> | Yankee weed         | FAC                                      |
| <u>Hydrocotyle umbellata</u>      | Pennywort           | OBL                                      |
| <u>Ludwigia alternifolia</u>      | Bushy seedbox       | FACW                                     |
| <u>Ludwigia leptocarpa</u>        | River seedbox       | OBL                                      |
| <u>Lycopus sp.</u>                | Bugleweed           | OBL                                      |
| <u>Peltandra virginica</u>        | Arrow arum          | OBL                                      |
| <u>Polygonum punctatum</u>        | Dotted smartweed    | OBL                                      |
| <u>Pontederia cordata</u>         | Pickernelweed       | OBL                                      |
| <u>Rhexia mariana</u>             | Meadow beauty       | FACW                                     |
| <u>Senecio smallii</u>            | Groundsel           | UP*                                      |
| <u>Typha latifolia</u>            | Broad-leaf cattail  | OBL                                      |
| <u>Verbena brasilliensis</u>      | Brazilian vervain   | FAC                                      |



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# REMEDIAL INVESTIGATION REPORT COLD CREEK SWAMP MOBILE, ALABAMA

## VEGETATIVE COMMUNITIES MAP

|                    |                    |                 |                   |                   |                |                        |               |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|
| PROJECT MGR<br>GEJ | DESIGNED BY<br>PWK | DRAWN BY<br>PMS | CHECKED BY<br>GEJ | SCALE<br>1"=2000' | DATE<br>6-5-92 | PROJECT NO<br>11653.08 | FIGURE<br>3-1 |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|

3 10 . 0115

TABLE 3-12 SOILS OF THE STUDY AREA IDENTIFIED BY THE MOBILE COUNTY  
SOIL SURVEY (1980)

---

| <u>Soil Type</u>              | <u>Capability Unit</u> |
|-------------------------------|------------------------|
| Dorovan-Levy Association      | VIIw                   |
| Izagora-Annemaine Association | II-IIIw                |
| Izagora-Bethera Association   | IIw                    |

TABLE 3-13 SUMMARY OF WET EVALUATION FOR ZONE I (UPPER SWAMP), COLD CREEK TRIBUTARY, 5-12 FEBRUARY 1991

| <u>Function</u>                   | <u>Social<br/>Significance</u> | <u>Effectiveness</u> | <u>Opportunity</u> |
|-----------------------------------|--------------------------------|----------------------|--------------------|
| Ground-Water Discharge            | L                              | H                    | *                  |
| Flood Flow Alteration             | L                              | H                    | H                  |
| Sediment Stabilization            | L                              | *                    | H                  |
| Sediment/Toxicant Retention       | L                              | H                    | H                  |
| Nutrient Retention/Transformation | L                              | H                    | H                  |
| Production Export                 | *                              | M                    | *                  |
| Shellfish Habitat                 | L                              | M                    | *                  |
| Finfish Habitat                   | L                              | M                    | *                  |
| Wildlife Habitat                  | L                              | H                    | *                  |
| Uniqueness/Heritage               | L                              | *                    | *                  |

\* This value is not provided by the WET Model.

L = Low.

H = High.

M = Moderate.

4. Sediment/Toxicant Retention--Low significance is assigned near rivers without recognized severe pollution and without rare or economically significant aquatic life. Visible evidence of pollution is not established as a "recognized severe" problem from a community structure standpoint. The only reason these wetlands would be impacted or removed would be to clean up potential contaminants, if it was established that contaminants are being discharged from the wetland system. Therefore, the relative social significance of these wetlands as a pollutant retention system is low.
5. Nutrient Transformation/Retention--Low significance is assigned near rivers not used for drinking water (within 10 mi of the site) and without eutrophication problems.
6. Finfish and Shellfish--Low significance is assigned to sites not containing threatened/endangered species, strongly specialized fish, regional deficiencies of fishing opportunities, or important fishing economies.
7. Wildlife Habitat--Low significance is assigned to sites not containing threatened/endangered species, strongly specialized wildlife, hunting lease areas, or within regions deficient of hunting opportunities.
8. Uniqueness/Heritage--Low significance is assigned to sites not unique on a broad geographical basis, not used for education or research, and not receiving public investments.



Results of the Effectiveness evaluations ranked the Zone I wetlands with moderate and high values for the potential of providing all functions. Each of the criteria for these scores and the relative values of the wetlands of Zone I are described below by function.

1. Ground-Water Discharge--Zone I wetlands rated high because there was flow during the "dry" winter season.
2. Flood Flow Alteration--The watershed of Zone I is predominantly built-out and, therefore, impervious to stormwaters and consequently rated high in its effectiveness for flood flow alteration.

Effectiveness scores indicated that the combinations of constrictions, woody vegetation interspersed with surface water, and storage space available in Zone I wetlands make them able to function in flood flow alteration if given the opportunity.

3. Sediment/Toxicant Retention--Effectiveness is evaluated to be similar to that for the function of flood flow alteration. Sedimentation is most likely to occur where conditions are best for slowing floodwaters. Zone I rates high in this category.
4. Nutrient Removal/Transformation--Effectiveness is similar to that of the function of flood flow alteration because the longer floodwaters are in contact with the wetland, the more nutrients will be taken up in the soils and by the vegetation. Zone I rates high in this category.

5. Production Export--Zone I wetlands were rated moderate in effectiveness for this function. The upper zone is a constricted depressional site flooded semi-permanently with shallow waters, and has habitat and access available for fish.
6. Finfish and Shellfish Habitat--Effectiveness values for Zone I are moderate due to the lack of permanent surface water contact over the majority of the wetland during the "dry" season.
7. Wildlife Habitat--Effectiveness values were high due to the abundance of wooded acreage in the wetland systems and adjacent uplands.

Opportunity evaluations ranked high for functions rated by the WET model. These functions were:

1. Flood Flow Alteration--For the same reasons as described in effectiveness, Zone I ranked high in its opportunity to alter flood flow.
2. Sediment Stabilization--Opportunity to provide this function is highest where banks are intrinsically erodible, such as in a braided stream system. Wetland vegetation holds soil in place. These conditions were applicable to Zone I which rated high in this function.
3. Sediment/Toxicant Retention--Opportunity to provide this function is highest where potential sources of sediments or toxicants are available. Zone I consequently rates high in this category.

4. Nutrient Removal/Transformation--Opportunity is highest where watersheds have anthropogenic sources of nutrients such as developed land with stormwater outfalls, warranting high ratings for Zone I.

#### 3.1.4.3.2 Zone II--Middle Erosional Zone

##### Hydrology

Zone II was characterized by forested and scrub-shrub wetlands connected by a braided channel system across a broad floodplain basin. In addition, several depressional basins separated by topographic constrictions from the main floodplain occurred in Zone II. These separate basins were dominated by emergents.

The hydrology of Zone II is most directly influenced by the flow levels of Cold Creek. There was evidence of frequent flooding in the main floodplain. Evidence of flooding included high water marks and dead herbaceous material, 3-6 ft high on woody vegetation and exposed areas of sandy substrate in or near channels, which appeared to be recently deposited. The separate basins also apparently flood, but these waters are attenuated over a longer period of time. Dead vegetation carried by high waters was stacked against the constricted outflow to the main floodplain. Small ponds, which contained live fish, remained in the separate basins during the dry winter season. Beaver are also active in this area, and the hydrology of the floodplain has been affected by numerous snags and dams placed by the beavers. Channels in the braided stream system varied in width from 1 to 10 ft and in depth from 1 to 4 ft. Most of the channels were poorly incised. Only the central channel contained water at the time of the field study and this went subterranean for a length of about 200 ft just south of the Hoescht Plant.

### Soils

Soils in this zone were alluvial and ranged from white sands in the main floodplains to dense silt to organic mucks in basin areas.

### Vegetation

Vegetation in Zone II was primarily woody and was dominated by red maple. Groundsel formed dense thickets with greenbriers under a canopy of scattered mature and immature trees. Herbaceous cover was limited in the main floodplain. The separate basins, however, were primarily vegetated by herbaceous (emergent) species. Soft rush, dotted smartweed, or red-top panic grass dominated these wetlands. Nine data sheets in Appendix G provide more specific vegetation lists for the sample points in Zone II.

### WET Model Results

Results of the evaluations for Zone II generated by the WET model are presented in Table 3-14. Social significance values were low because this wetland system is not rare or limited in type or size relative to the wetland resources of the lower Mobile River basin. WET model results for social significance of Zone II are similar to those described for Zone I (Section 1.3.1.4, Significance Criteria).

Zone II effectiveness ratings were similar to those of Zone I with the exception of:

1. Flood Flow Alteration--Zone II was evaluated to have a low opportunity score because the soils of its watershed were primarily Hydrologic Group C with undeveloped woodland cover. This soil type is not expected to provide excessive flooding because stormwaters can infiltrate.

2. Sediment/Toxicant Retention--Effectiveness is evaluated to be similar to that for the function of flood flow alteration. Sedimentation is most likely to occur where conditions are best for slowing floodwaters. Zone II has a relatively steep gradient and, therefore, has only a moderate effectiveness for this function.
3. Nutrient Retention/Transformation--For reasons similar to those for sediment/toxicant retention, Zone II rated moderate in this category.

Zone II opportunity ratings were all similar to those found for Zone I with the exception of:

1. Flood Flow Alteration--Zone II was evaluated to have a low opportunity score because the soils of its watershed were primarily Hydrologic Group C with undeveloped woodland cover. This soil type is not expected to provide excessive flooding because stormwaters can infiltrate.

#### 3.1.4.3.3 Zone III--Lower Depositional Zone

##### Hydrology

Zone III was characterized as a broad tupelo/cypress swamp. A cooling water discharge canal separates a portion of this broad swamp from the rest of the wetlands within a broad meander of the Mobile River. Downstream of the area where Cold Creek enters the Mobile River floodplain, Zone III is in surface water communication with the Mobile River.

The hydrology of this zone is influenced by base flow from Cold Creek and flood flow from the Mobile River. The substrate was nearly dry at the surface during the field survey. However, high water marks on the

TABLE 3-14 SUMMARY OF WET EVALUATION FOR ZONE II (MIDDLE SWAMP),  
MIDDLE SECTION OF COLD CREEK, 11 FEBRUARY 1991

| <u>Function</u>                   | <u>Social<br/>Significance</u> | <u>Effectiveness</u> | <u>Opportunity</u> |
|-----------------------------------|--------------------------------|----------------------|--------------------|
| Ground-Water Discharge            | L                              | H                    | *                  |
| Flood Flow Alteration             | L                              | M                    | L                  |
| Sediment Stabilization            | L                              | *                    | H                  |
| Sediment/Toxicant Retention       | L                              | M                    | H                  |
| Nutrient Retention/Transformation | L                              | M                    | H                  |
| Production Export                 | *                              | M                    | *                  |
| Shellfish Habitat                 | L                              | M                    | *                  |
| Finfish Habitat                   | L                              | M                    | *                  |
| Wildlife Habitat                  | L                              | H                    | *                  |
| Uniqueness/Heritage               | L                              | *                    | *                  |

\* This value is not provided by the WET Model.

L = Low.

H = High.

M = Moderate.

trees showed that water stands for long periods of time at least 5 ft above the surface, and may reach up to 8-10 ft above the surface during major floods.

### Soils

Soils of this zone were organic mucks with fine silty sediments. The organic soil was held in place by a network of roots from the tupelo and cypress trees.

### Vegetation

Vegetation in this zone was dominated by trees. The areas of permanent flooding along the Cold Creek channel and other tributary channels entering the swamp were dominated by red maple woods similar to those found in Zone II. The majority of the area was dominated by water tupelo with scattered cypress. Occasional openings in the canopy contained patches of herbaceous species including giant cane, climbing fern, catchfly cut-grass, arrow arum, sensitive fern, pickerel weed, and savannah panic grass.

The powerline right-of-way is also included in this zone. This area was maintained in herbaceous and low shrubby vegetation. This area was dominated by patches of woolgrass and contained a great diversity of other herbaceous species.

Vegetation observed in all portions of the study area did not indicate an adverse impact due to contaminants. All size classes of woody vegetation were observed (seedling, sapling, immature, and mature individual trees and shrubs). Herbaceous vegetation also showed no indication of adverse impact. All areas of exposed soil with little or no vegetative growth appeared to be due to one or more normally occurring disturbances (e.g., flood sediment deposition).

### WET Model Results

Results of the evaluations for Zone III generated by the WET model are presented in Table 3-15. Social significance values of Zone III were the same as for both Zone I and Zone II.

Results of the Effectiveness and Opportunity evaluations ranked the Zone III wetlands with moderate and high values for the potential of providing all functions for reasons described for Zone I (Section 1.3.1.4).

#### 3.1.4.3.4 *Summary of Ecological Characterization*

The overall evaluations of these wetlands show them to be of high quality for most of the functions that make bottomland hardwood forests valuable to humankind. They were not, however, found to be socially significant due to the relative abundance of this resource in this locality.

## 3.2 STAGE II FIELD ACTIVITIES

### 3.2.1 Mercury Contamination Characterization

Analytical results of sediment samples from the 23 "D" sample locations and the 22 "S" sample locations are presented in Tables 3-16 and 3-17, respectively. These results confirm Stage I sample results, which showed the highest mercury levels in the vicinity of Stage I sample locations N-3 and SB-1 (Figures 2-1 and 2-2).

For ecological risk modeling, composite plots of Stage I and II data were prepared. Figures 3-2 through 3-4 are two-dimensional plots showing mercury isoconcentration contours in the 0-1, 1-2, and 2-3 ft intervals, respectively. These figures include data from both Stage I and II.



TABLE 3-15 SUMMARY OF WET EVALUATION FOR ZONE III (LOWER SWAMP),  
MOBILE RIVER FLOODPLAIN SWAMP, 5-12 FEBRUARY 1991

| <u>Function</u>                   | <u>Social<br/>Significance</u> | <u>Effectiveness</u> | <u>Opportunity</u> |
|-----------------------------------|--------------------------------|----------------------|--------------------|
| Ground-Water Discharge            | L                              | H                    | *                  |
| Flood Flow Alteration             | L                              | H                    | H                  |
| Sediment Stabilization            | L                              | *                    | H                  |
| Sediment/Toxicant Retention       | L                              | H                    | H                  |
| Nutrient Retention/Transformation | L                              | H                    | H                  |
| Production Export                 | *                              | M                    | *                  |
| Shellfish Habitat                 | L                              | M                    | *                  |
| Finfish Habitat                   | L                              | M                    | *                  |
| Wildlife Habitat                  | L                              | H                    | *                  |
| Uniqueness/Heritage               | L                              | *                    | *                  |

\* This value is not provided by the WET Model.

L = Low.

H = High.

M = Moderate.

TABLE 3-16. TOTAL MERCURY CONCENTRATIONS IN STAGE II "D" SAMPLES  
COLLECTED FROM COLD CREEK SWAMP, ALABAMA - JUNE 1991  
(PER JULY 1991 DATA VALIDATION)

| BACKGROUND SAMPLES   | TOTAL MERCURY CONCENTRATION<br>(MG/KG DRY WEIGHT) |
|----------------------|---------------------------------------------------|
| D-1-1                | 0.11 U                                            |
| D-1-2                | 0.12 U                                            |
| D-1-3                | 0.11 U                                            |
| UPPER SWAMP SAMPLES  |                                                   |
| D-2-1                | 473                                               |
| D-2-2                | 262                                               |
| D-2-3                | 84.2                                              |
| D-3-1                | 193 J                                             |
| D-DUP-1 (D-3-1)      | 176 J                                             |
| D-3-2                | 1.3                                               |
| D-3-3                | 0.78                                              |
| D-4-1                | 193 J                                             |
| D-4-2                | 731 J                                             |
| D-4-3                | 251 J                                             |
| D-5-1                | 39.1 J                                            |
| D-5-2                | 83.1                                              |
| D-5-3                | 237 J                                             |
| D-6-1                | 1600 J                                            |
| D-6-2                | 7560 J                                            |
| D-6-3                | 953 J                                             |
| D-7-1                | 5.4 J                                             |
| D-7-2                | 14 J                                              |
| D-7-3                | 41.3 J                                            |
| MIDDLE SWAMP SAMPLES |                                                   |
| D-8-1                | 0.2 UJ                                            |
| D-8-2                | 0.37 UJ                                           |
| D-8-3                | 0.32 UJ                                           |
| D-9-1                | 123                                               |
| D-9-2                | 14.3                                              |
| D-9-3                | 1.3                                               |
| D-10-1               | 59.9 J                                            |
| D-10-2               | 14.3 J                                            |
| D-10-3               | 38.4 J                                            |
| D-11-1               | 7.6                                               |
| D-11-2               | 5.8                                               |
| D-11-3               | 0.34                                              |
| D-12-1               | 105 J                                             |
| D-DUP-2 (D-12-1)     | 110 J                                             |
| D-12-2               | 27.2 J                                            |
| D-12-3               | 10.6 J                                            |

NOTES:

- (1) J = ESTIMATED CONCENTRATION PER DATA VALIDATION
- (2) U = BELOW DETECTION LIMIT
- (3) SEE FIGURE 2-5 FOR SAMPLE LOCATIONS

TABLE 3-16. (CONT.)

| MIDDLE SWAMP SAMPLES | TOTAL MERCURY CONCENTRATION<br>(MG/KG DRY WEIGHT) |
|----------------------|---------------------------------------------------|
| D-13-1               | 53.5 J                                            |
| D-13-2               | 62.5 J                                            |
| D-13-3               | 26.5 J                                            |
| D-14-1               | 0.99 J                                            |
| D-14-2               | 0.39 UJ                                           |
| D-14-3               | 0.2 UJ                                            |
| D-15-1               | 3.2 J                                             |
| D-15-2               | 1 J                                               |
| D-15-3               | 2.9 J                                             |
| LOWER SWAMP SAMPLES  |                                                   |
| D-16-1               | 29.2 J                                            |
| D-16-2               | 36.6 J                                            |
| D-16-3               | 30 J                                              |
| D-17-1               | 39.4 J                                            |
| D-17-2               | 2.5 J                                             |
| D-17-3               | 1.8 J                                             |
| D-18-1               | 141 J                                             |
| D-DUP-3 (D-18-1)     | 32.5 J                                            |
| D-18-2               | 77 J                                              |
| D-18-3               | 55.1 J                                            |
| D-19-1               | 8.7 J                                             |
| D-19-2               | 0.5 UJ                                            |
| D-19-3               | 0.45 UJ                                           |
| D-20-1               | 62 J                                              |
| D-DUP-4 (D-20-1)     | 37.2 J                                            |
| D-20-2               | 34.5 J                                            |
| D-20-3               | 45.2 J                                            |
| D-21-1               | 12.1 J                                            |
| D-21-2               | 12.3 J                                            |
| D-21-3               | 101 J                                             |
| D-22-1               | 2.9 J                                             |
| D-22-2               | 25.1 J                                            |
| D-22-3               | 18.3 J                                            |
| D-23-1               | 1.7 J                                             |
| D-DUP-5 (D-23-1)     | 1.2 J                                             |
| D-23-2               | 0.26 J                                            |
| D-23-3               | 0.15 UJ                                           |
| BLANKS               |                                                   |
| D-RINSATE-1          | 0.2 UJ (ug/l)                                     |
| D-RINSATE-2          | 0.2 U (ug/l)                                      |

## NOTES:

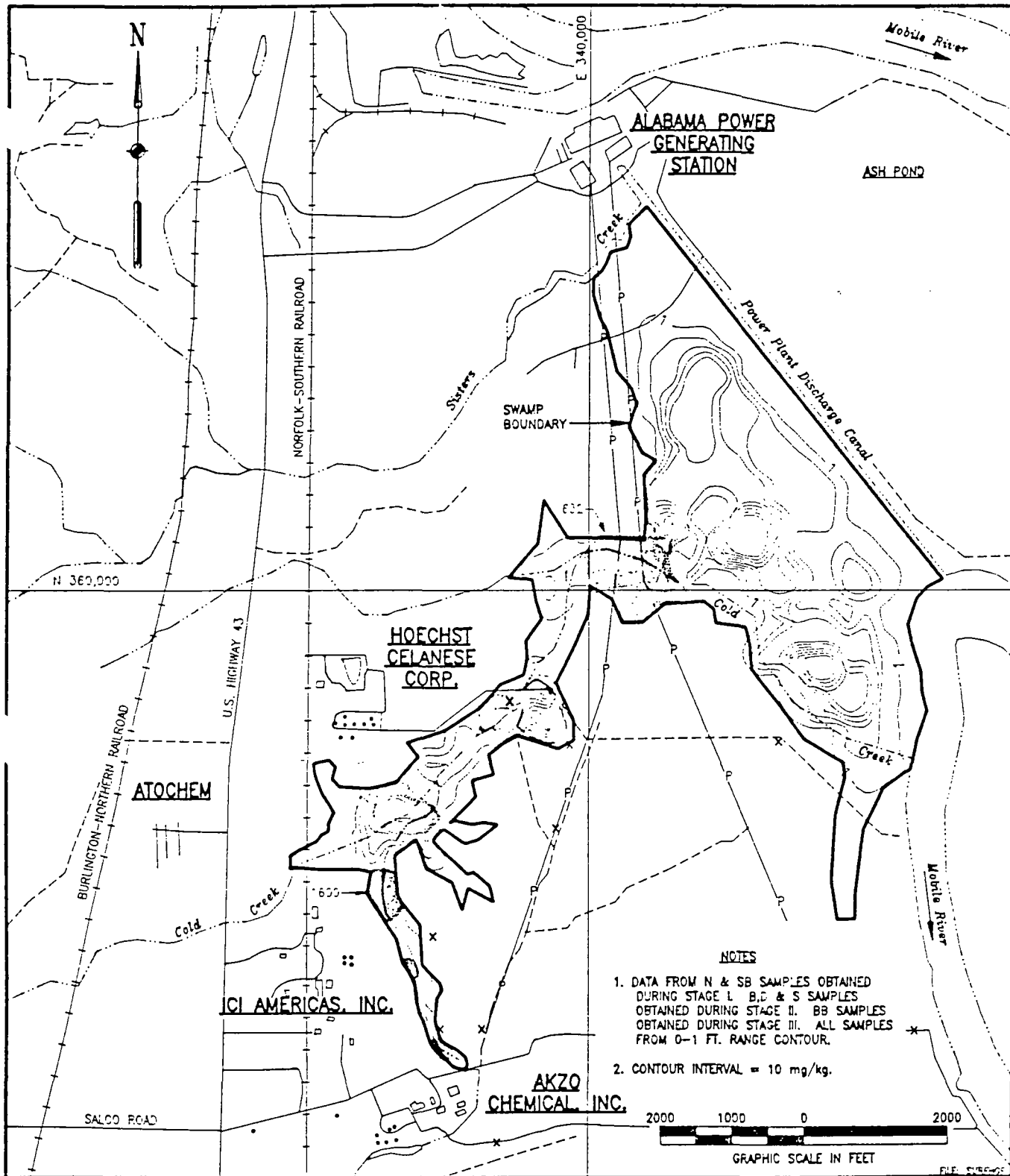
- (1) J = ESTIMATED CONCENTRATION PER DATA VALIDATION
- (2) U = BELOW DETECTION LIMIT
- (3) SEE FIGURE 2-5 FOR SAMPLE LOCATIONS

TABLE 3-17. TOTAL MERCURY CONCENTRATIONS IN STAGE II "S" SAMPLES  
COLLECTED FROM COLD CREEK SWAMP, ALABAMA - JUNE 1991  
(PER JULY 1991 DATA VALIDATION)

| BACKGROUND SAMPLE | TOTAL MERCURY CONCENTRATION<br>(MG/KG DRY WEIGHT) |
|-------------------|---------------------------------------------------|
| S-21              | 0.11 U                                            |
| SWAMP SAMPLES     |                                                   |
| S-1               | 928                                               |
| S-2               | 0.1 U                                             |
| S-3               | 28.4                                              |
| S-4               | 0.16 U                                            |
| S-5               | 285                                               |
| S-6               | 0.16                                              |
| S-7               | 0.1 U                                             |
| S-8               | 2.8 J                                             |
| S-9               | 107 J                                             |
| S-10              | 98.1 J                                            |
| S-11              | 16.7 J                                            |
| S-12              | 42.4 J                                            |
| S-13              | 28.2 J                                            |
| S-14              | 1 J                                               |
| S-14A             | 5.4 J                                             |
| S-15              | 47.1 J                                            |
| S-16              | 2.8 J                                             |
| S-17              | 24.4 J                                            |
| S-18              | 15.7 J                                            |
| S-19              | 1.2 J                                             |
| S-20              | 9.6 J                                             |
| S-22              | 0.36 J                                            |

NOTES:

- (1) J = ESTIMATED CONCENTRATION PER DATA VALIDATION
- (2) U = BELOW DETECTION LIMIT
- (3) S-14A IS AN EXTRA SAMPLE TAKEN IN THE VICINITY OF S-14
- (4) SEE FIGURE 2-6 FOR SAMPLE LOCATIONS



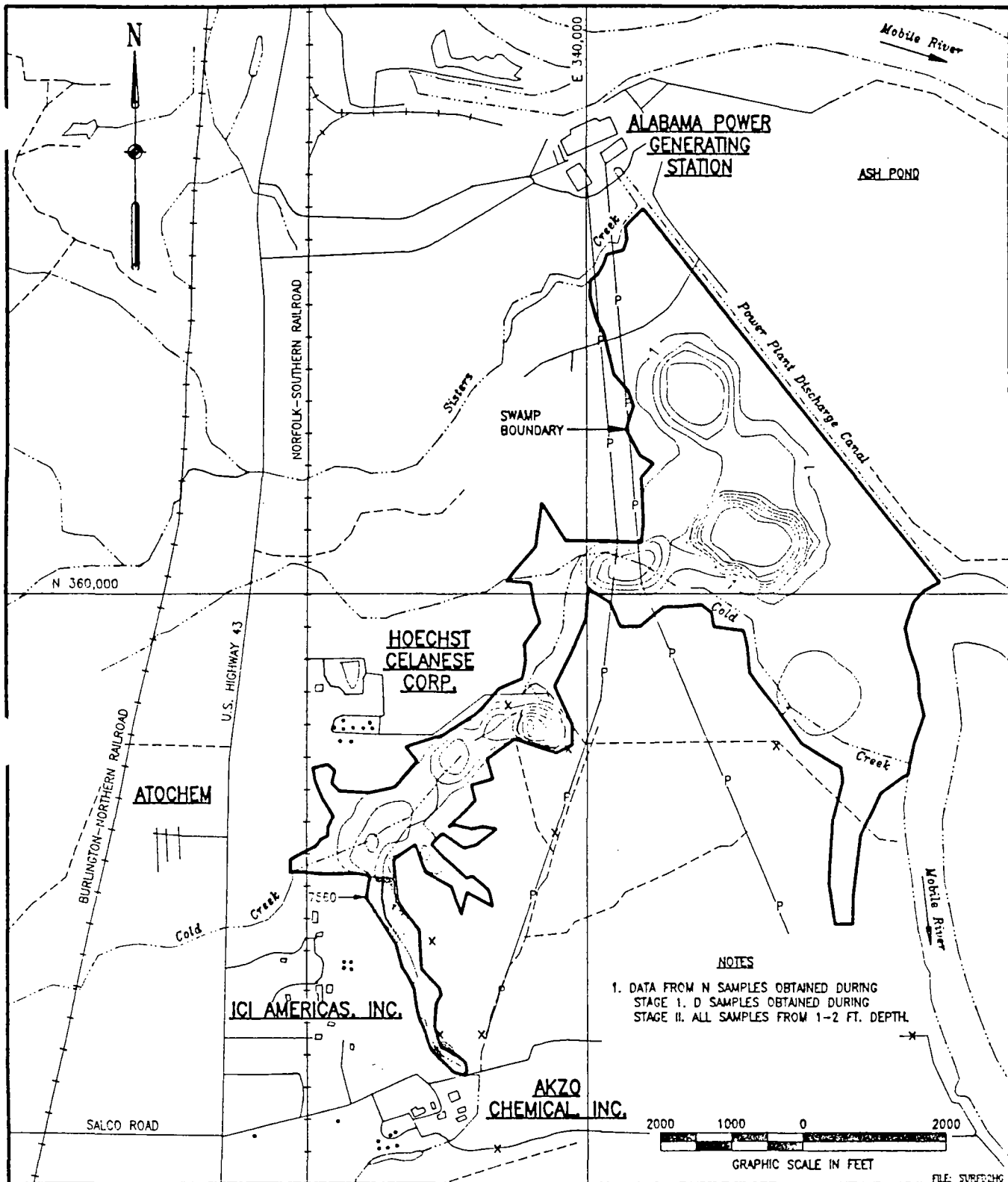
EA ENGINEERING,  
SCIENCE, AND  
TECHNOLOGY, INC.

# REMEDIAL INVESTIGATION REPORT COLD CREEK SWAMP MOBILE, ALABAMA

MERCURY CONCENTRATIONS  
(0-1 FT.)

|                    |                    |                 |                   |                   |                |                        |               |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|
| PROJECT MGR<br>GEJ | DESIGNED BY<br>PWK | DRAWN BY<br>MSM | CHECKED BY<br>GEJ | SCALE<br>1"=2000' | DATE<br>6-5-92 | PROJECT NO<br>11653.08 | FIGURE<br>3-2 |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|

3 10 0124



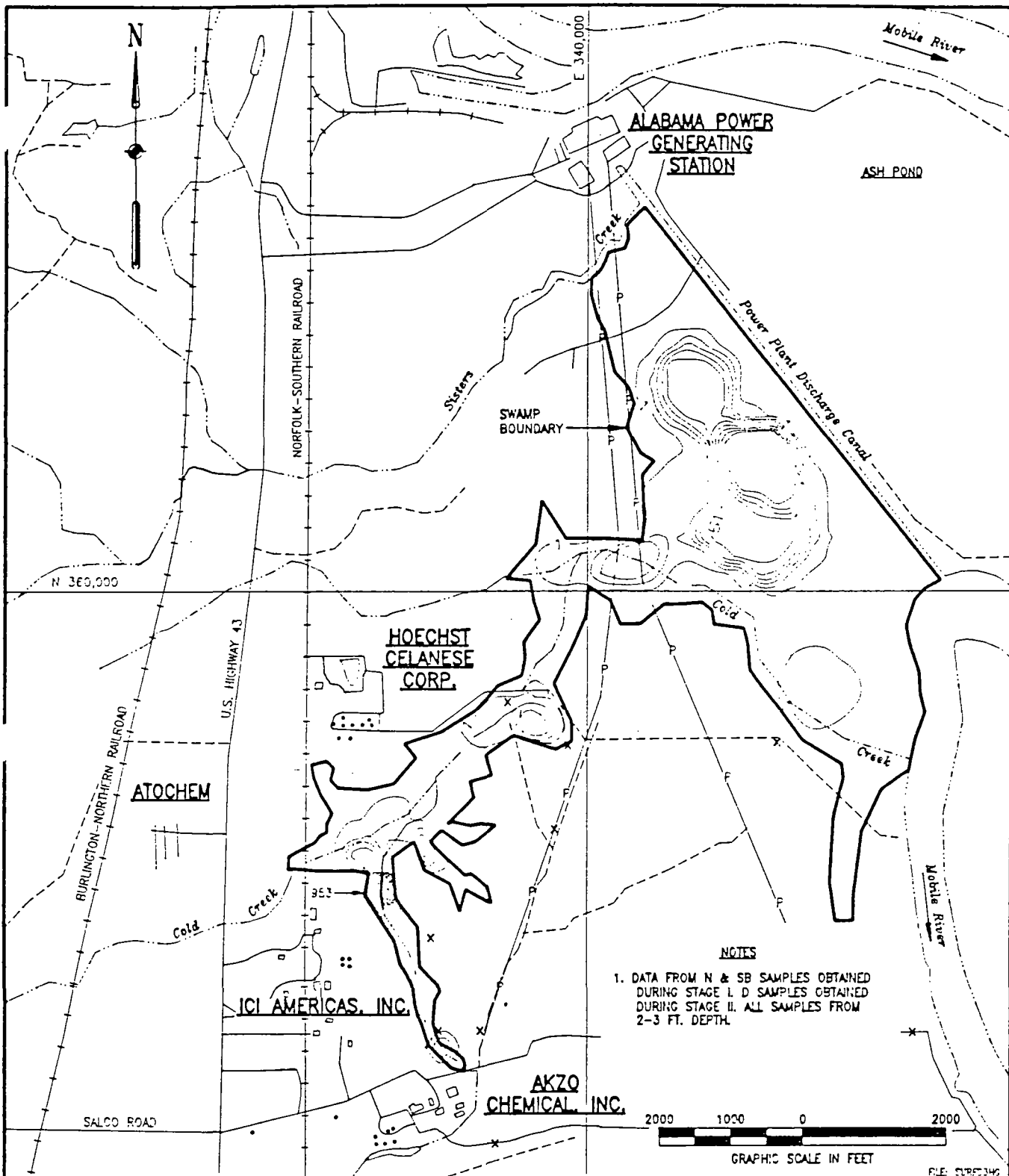
EA ENGINEERING,  
SCIENCE, AND  
TECHNOLOGY, INC.

# REMEDIAL INVESTIGATION REPORT COLD CREEK SWAMP MOBILE, ALABAMA

MERCURY CONCENTRATIONS  
(1-2 FT.)

|                    |                    |                 |                   |                   |                |                        |               |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|
| PROJECT MGR<br>GEJ | DESIGNED BY<br>PWK | DRAWN BY<br>MSM | CHECKED BY<br>GEJ | SCALE<br>1"=2000' | DATE<br>6-5-92 | PROJECT NO<br>11653.08 | FIGURE<br>3-3 |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|

3 10 0125



EA ENGINEERING,  
SCIENCE, AND  
TECHNOLOGY, INC.

# REMEDIAL INVESTIGATION REPORT COLD CREEK SWAMP MOBILE, ALABAMA

MERCURY CONCENTRATIONS  
(2-3 FT.)

|                    |                    |                 |                   |                   |                |                        |               |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|
| PROJECT MGR<br>GEJ | DESIGNED BY<br>PWK | DRAWN BY<br>MSM | CHECKED BY<br>GEJ | SCALE<br>1"=2000' | DATE<br>6-5-92 | PROJECT NO<br>11653.08 | FIGURE<br>3-4 |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|

3 10 0126

### 3.2.2 Bioaccessible Contaminant Characterization

Analytical results of sediment samples from the 60 locations in the bioaccessible zone (upper 4 in.) are presented in Tables 3-18 through 3-20 ("B" samples). Table 3-18 summarizes concentrations of total mercury, methyl mercury, sulfide, and other metals that were identified as potential chemicals of concern from Stage I (total aluminum, cadmium, copper, and zinc). Table 3-19 includes concentrations of AVS/SEM and TOC that were analyzed for 20 of the 60 samples. Table 3-20 includes pH, Eh, and temperature values determined in the field for 20 of the 60 sample locations.

In Table 3-19 it should be noted that, due to problems associated with the laboratory procedure, it was not possible to obtain valid data for AVS analyses. The SEM concentrations, however, were not adversely impacted.

For ecological risk modeling, two-dimensional composite plots of Stage I and II data were prepared. Figures 3-5 through 3-9 are two-dimensional plots showing isoconcentration contours in the bioaccessible zone for methyl mercury, aluminum, cadmium, copper, and zinc, respectively. These five figures include data from Stages I and II.

### 3.2.3 Surface Water Characterization

Stage II surface water characterization included water quality parameters and physical parameters. Table 3-21 includes results of Stage II surface water characterization. The locations of Stage II surface water sample stations are shown in Figure 2-8.



#### 3.2.4 Mineralogical/Physical Soil Characterization

Samples were analyzed for grain size distribution, percent organic matter, percent organic clay, and percent water. These data are reported in Table 3-22. Sample locations refer to the map in Figure 2-9. The primary finding of the study was that the aluminum concentrations observed during Stage I chemical analysis were associated with overbank flooding of the Mobile River depositing river sediments with high aluminum oxide content throughout the middle and lower swamp.

The complete mineralogical/physical soil characterization report is presented in Appendix H.

#### 3.2.5 Biota Inventory Observations

Wildlife observations were conducted during the periods of 6-19 August 1990, 5-12 February 1991, 24-26 July 1991, and 7-11 October 1991. A list of birds and a list of reptiles and amphibians potentially present on the Cold Creek study area are provided in Tables 3-23 and 3-24, respectively. A list of birds actually observed on the site is also provided in Table 3-23. Figure 3-10 maps other wildlife observations.

The Cold Creek Swamp drainage system supports diverse wildlife habitats including mature forest in the lower swamp and scrub-shrub areas which provide nesting and escape cover in the middle zone and the upland areas. The power line rights-of-way contain additional brush cover, grass and herbaceous communities, and open (sparsely vegetated) areas. Forested, herbaceous, and emergent wetlands are all present in the basin, supporting various associated fauna and flora.

The highly diverse vegetation provides a variety of specific wildlife foods, including Tupelo nuts and cypress seeds along with grass and weed seeds and fruits, including magnolia, persimmon, pokeweed, and blackberry. Seasonally abundant insects serve as food for birds, fish, reptiles, amphibians, and small mammals.

TABLE 3-18. ANALYTICAL RESULTS FROM STAGE II BIOACCESSIBLE CONTAMINANT CHARACTERIZATION  
SEDIMENT SAMPLES - COLD CREEK SWAMP, ALABAMA - JUNE 1991  
(PER JULY 1991 DATA VALIDATION)

TOTAL METALS  
METHYL MERCURY  
TOTAL SULFIDE

|                | TOTAL<br>MERCURY<br>mg/kg | METHYL<br>MERCURY<br>ug/kg | TOTAL<br>SULFIDE<br>mg/kg | ALUMINUM<br>mg/kg | CADMIUM<br>mg/kg | COPPER<br>mg/kg | ZINC<br>mg/kg |
|----------------|---------------------------|----------------------------|---------------------------|-------------------|------------------|-----------------|---------------|
| BACKGROUND     |                           |                            |                           |                   |                  |                 |               |
| B-58           | 0.12 U                    | 11.7 U                     | 13.9 J                    | 206 J             | 0.58 U           | 0.5 J           | 1.8 U         |
| B-59           | 0.11 U                    | 10.5 U                     | 20.2 J                    | 162 J             | 0.42 U           | 0.46 J          | 1.2 U         |
| B-60           | 0.11 U                    | 10.9 U                     | 4.7 UJ                    | 189 J             | 0.56 U           | 0.42 J          | 2 U           |
| SWAMP SAMPLES  |                           |                            |                           |                   |                  |                 |               |
| B-1            | 44.7 J                    | 204                        | 6.6 U                     | 5030 J            | 1 U              | 11.2 J          | 19.5          |
| B-2            | 4.7 J                     | 10.3 U                     | 62.6                      | 284 J             | 0.63 U           | 0.59 UJ         | 4.5           |
| B-3            | 33.2 J                    | 33.3                       | 239 J                     | 5040 J            | 0.93 U           | 11.2 J          | 72.5          |
| B-4            | 63.8 J                    | 98.7                       | 725 J                     | 13400 J           | 3.2 UJ           | 48.4 J          | 563 J         |
| B-5            | 2.1 J                     | 9.74 U                     | 153 J                     | 126 J             | 0.36 U           | 1.1 UJ          | 2             |
| B-6            | 75.6                      | 197                        | 150 J                     | 33200             | 10.3             | 62.2 J          | 655 J         |
| B-DUP-2 (B-6)  | 69                        | 95.3                       | 160 J                     | 42100             | 8.6              | 45.2 J          | 483 J         |
| B-7            | 5.7 J                     | 10.2 U                     | 72.9                      | 166 J             | 0.61 U           | 0.24 UJ         | 5.7           |
| B-8            | 1.3 J                     | 359                        | 276                       | 8130 J            | 2 U              | 7 UJ            | 8.6 U         |
| B-9            | 1.6 J                     | 9.88 U                     | 94.2                      | 274 J             | 0.55 U           | 0.71 UJ         | 3.9 U         |
| B-10           | 1.1 J                     | 9.74 U                     | 83.2                      | 243 J             | 0.48 U           | 0.39 UJ         | 3.9 U         |
| B-11           | 3.2 J                     | 13.4                       | 159 J                     | 1060 J            | 0.91 UJ          | 4.1 J           | 16.3 J        |
| B-12           | 218 J                     | 187                        | 490 J                     | 17900 J           | 1.1 UJ           | 27.3 J          | 51.2 J        |
| B-DUP-1 (B-12) | 203 J                     | 101                        | 455 J                     | 9280 J            | 1 UJ             | 22.6 J          | 38.5 J        |
| B-13           | 38.9 J                    | 332                        | 286                       | 10300 J           | 3.1              | 52.5 J          | 54.3          |
| B-14           | 1.8 J                     | 28.6                       | 286 J                     | 16500 J           | 2.7 UJ           | 33.1 J          | 80.2 J        |
| B-15           | 0.18 UJ                   | 36.3                       | 216 J                     | 14700 J           | 2.3 U            | 13.4 J          | 68.3          |
| B-16           | 1.1                       | 10.6 U                     | 60.5 J                    | 333               | 0.47 U           | 0.92 UJ         | 3.2 J         |
| B-DUP-3 (B-16) | 1.2                       | 10.5 U                     | 46.6 J                    | 376               | 0.49 U           | 0.8 UJ          | 3.2 J         |
| B-17           | 37.6 J                    | 166                        | 127 J                     | 26800 J           | 1.9 UJ           | 17.6 J          | 55.3 J        |
| B-18           | 3.4                       | 34.5                       | 77.7 J                    | 21900             | 4.2              | 10.7 J          | 41.2 J        |
| B-19           | 9.3 J                     | 341                        | 9.43 U                    | 5540 J            | 0.92 U           | 6.4 J           | 46.2          |
| B-20           | 15.1 J                    | 9.64 U                     | 9.76                      | 304 J             | 0.41 U           | 0.96 UJ         | 4.7           |
| B-21           | 21.7 J                    | 26.9                       | 5.72 U                    | 1510 J            | 0.66 U           | 5.1 J           | 63.6          |
| B-22           | 0.45 J                    | 9.78 U                     | 18.6                      | 61.9 J            | 0.52 U           | 0.21 UJ         | 1.4 U         |
| B-23           | 31.4 J                    | 129                        | 31.4                      | 3870 J            | 0.8              | 8 J             | 14.7          |
| B-24           | 1.2 J                     | 9.82 U                     | 5 U                       | 102 J             | 0.58 U           | 0.23 UJ         | 2.1 U         |
| B-25           | 25.7 J                    | 36.4                       | 558 J                     | 22600 J           | 1.3 UJ           | 68.6 J          | 108 J         |

NOTES: (1) J = ESTIMATED CONCENTRATION PER DATA VALIDATION  
(2) U = BELOW DETECTION LIMIT  
(3) ALL SAMPLE CONCENTRATIONS REPORTED ON DRY WEIGHT BASIS  
(4) SEE FIGURE 2-7 FOR SAMPLE LOCATIONS

3 10 0128

TABLE 3-18. (CONT.)

|                     | TOTAL<br>MERCURY<br>mg/kg | METHYL<br>MERCURY<br>ug/kg | TOTAL<br>SULFIDE<br>mg/kg | ALUMINUM<br>mg/kg | CADMIUM<br>mg/kg | COPPER<br>mg/kg | ZINC<br>mg/kg |
|---------------------|---------------------------|----------------------------|---------------------------|-------------------|------------------|-----------------|---------------|
| SWAMP SAMPLES       |                           |                            |                           |                   |                  |                 |               |
| B-26                | 0.51                      | 9.92 U                     | 28.8 J                    | 368               | 0.44 U           | 0.72 UJ         | 2.2 J         |
| B-27                | 0.77                      | 9.96 U                     | 55.3 J                    | 391               | 0.52 U           | 0.75 UJ         | 9.1 J         |
| B-28                | 2.5                       | 10.5 U                     | 4.7 UJ                    | 207 J             | 0.59 U           | 0.79 J          | 3.1 U         |
| B-29                | 632 J                     | 269                        | 31.3 J                    | 18600 J           | 1.6 J            | 22.4 J          | 78.3 J        |
| B-30                | 1.8                       | 10.1 U                     | 4.5 UJ                    | 155 J             | 0.47 U           | 0.8 J           | 2.8 U         |
| B-31                | 137 J                     | 188                        | 28 J                      | 16000 J           | 3.1 J            | 27 J            | 55.7 J        |
| B-32                | 300 J                     | 156                        | 8.8 UJ                    | 9880 J            | 2.1 J            | 23.7 J          | 75.2 J        |
| B-33                | 3                         | 10.4 U                     | 9.8 UJ                    | 182 J             | 0.52 U           | 0.43 J          | 6.4 J         |
| B-34                | 108 J                     | 470                        | 5.8 U                     | 9070 J            | 1.4              | 17.9 J          | 26.6          |
| B-35                | 67 J                      | 320                        | 19.3                      | 11400 J           | 2                | 18.7 J          | 55.2          |
| B-36                | 84.7 J                    | 241                        | 8.2 U                     | 13500 J           | 2.4              | 19.3 J          | 92.9          |
| B-37                | 108 J                     | 224                        | 183 J                     | 9190 J            | 2 UJ             | 21.2 J          | 233 J         |
| B-38                | 12.5 J                    | 198                        | 165 J                     | 5660 J            | 2.2 J            | 11.4 J          | 152 J         |
| B-39                | 43.9                      | 25.1                       | 97.4 J                    | 10800 J           | 3.1              | 19.4 J          | 135 J         |
| B-40                | 1.1 J                     | 10.2 U                     | 40.5                      | 156 J             | 0.55 U           | 0.22 UJ         | 2.3 U         |
| B-41                | 0.77 J                    | 10.1 U                     | 4.8 U                     | 121 J             | 0.61 U           | 0.24 UJ         | 3.1 U         |
| B-42                | 19.1 J                    | 73.9                       | 5 U                       | 2280 J            | 1                | 4.5 J           | 37.4          |
| B-43                | 98.2 J                    | 264                        | 528 J                     | 12300 J           | 2.3 UJ           | 45.4 J          | 262 J         |
| B-44                | 55.3 J                    | 92.4                       | 440 J                     | 17600 J           | 1.3 UJ           | 62.2 J          | 75.9 J        |
| B-45                | 29 J                      | 100                        | 696 J                     | 15100 J           | 1.3 UJ           | 58 J            | 89.1 J        |
| B-46                | 2.3 J                     | 77.2                       | 582 J                     | 25700 J           | 4.5 UJ           | 37.2 J          | 165 J         |
| B-47                | 8 J                       | 76.1                       | 337 J                     | 16100 J           | 2.5 UJ           | 32.2 J          | 99.4 J        |
| B-48                | 17.5 J                    | 162                        | 475 J                     | 12400 J           | 2 UJ             | 35 J            | 139 J         |
| B-49                | 0.15                      | 41.6                       | 210 J                     | 5340 J            | 1.3 U            | 8.6 J           | 37.3          |
| B-50                | 0.16                      | 41.8                       | 203 J                     | 9770 J            | 1.9 U            | 10.9 J          | 54.3          |
| B-51                | 0.57                      | 15.9                       | 189 J                     | 9430 J            | 1.5 U            | 12.2 J          | 58.2          |
| B-52                | 1.6                       | 28.5                       | 31.8 J                    | 9060 J            | 3                | 14.9 J          | 53.5 J        |
| B-53                | 0.53 J                    | 39.5                       | 42.6 J                    | 5700 J            | 1.6 J            | 10.3 J          | 33.8 J        |
| B-54                | 0.12                      | 10.5 U                     | 20.5 J                    | 1590 J            | 0.91             | 1.5 J           | 11.7 J        |
| UPLAND SOILS (WEST) |                           |                            |                           |                   |                  |                 |               |
| B-55                | 3                         | 69.4                       | 17.5 J                    | 9200 J            | 2.2              | 5.6 J           | 15.1 J        |
| B-56                | 0.38                      | 104                        | 29.9 J                    | 2480 J            | 0.96             | 5.8 J           | 5.9 J         |
| B-57                | 0.11 U                    | 67.2                       | 12.8 J                    | 1840 J            | 0.54 U           | 1.9 J           | 5.2 J         |
| BLANKS              |                           |                            |                           |                   |                  |                 |               |
| B-RINSATE-1         | 0.2 UJ                    |                            | 14 J                      | 78                | 5 U              | 5 U             | 5.4           |
| B-RINSATE-2         | 0.37                      |                            | 2.8 J                     | 82.4              | 5 U              | 5 U             | 10.5 U        |
| WASH BLANK          | 0.2 U                     |                            | 0.5 U                     | 51 U              | 3 U              | 2.6             | 53.7 J        |

- NOTES: (1) J = ESTIMATED CONCENTRATION PER DATA VALIDATION  
 (2) U = BELOW DETECTION LIMIT  
 (3) ALL SAMPLE CONCENTRATIONS REPORTED ON DRY WEIGHT BASIS  
 (4) SEE FIGURE 2-7 FOR SAMPLE LOCATIONS

TABLE 3-19 ANALYTICAL RESULTS FROM STAGE II BIOACCESSIBLE CONTAMINANT CHARACTERIZATION  
 SEDIMENT SAMPLES - COLD CREEK SWAMP, ALABAMA - JUNE 1991  
 (PER JULY 1991 DATA VALIDATION)  
 SIMULTANEOUSLY EXTRACTED METALS (SEM)  
 ACID-VOLATILE SULFIDES (AVS)  
 TOTAL ORGANIC CARBON (TOC)

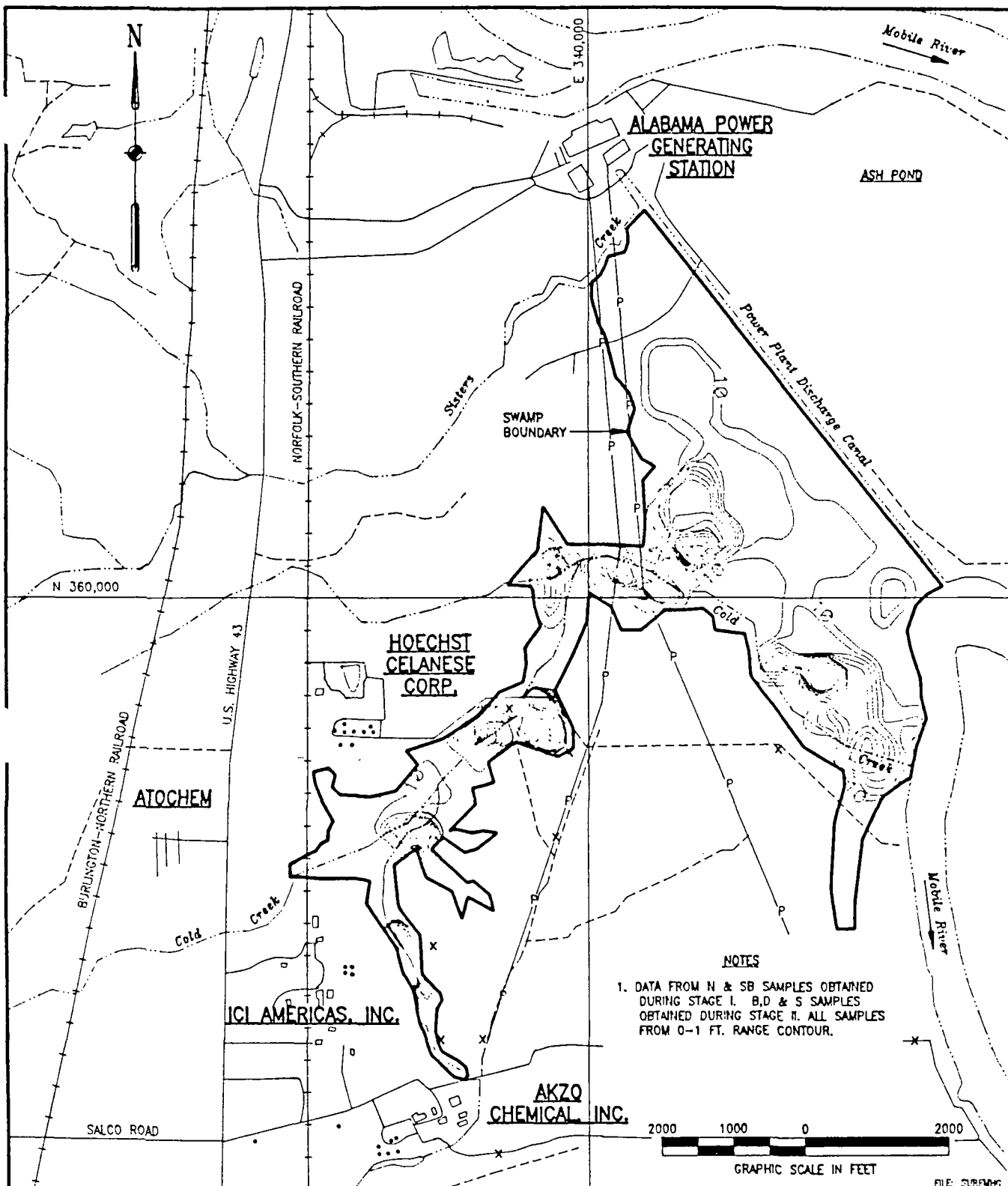
|                             | Mercury<br>ug/l      | Cadmium<br>umole/g   | Copper<br>umole/g    | Zinc<br>umole/g      | AVS<br>mg/kg | TOC<br>mg/kg (dry) |
|-----------------------------|----------------------|----------------------|----------------------|----------------------|--------------|--------------------|
| BACKGROUND<br>SWAMP SAMPLES |                      |                      |                      |                      |              |                    |
| B-1                         | $6.1 \times 10^{-5}$ | $1.5 \times 10^{-3}$ | $7.0 \times 10^{-2}$ | $1.4 \times 10^{-1}$ | X            | 61900 J            |
| B-2                         | $4.7 \times 10^{-4}$ | $5.7 \times 10^{-4}$ | $1.2 \times 10^{-2}$ | $3.9 \times 10^{-2}$ | X            | 466 J              |
| B-3                         | $6.5 \times 10^{-5}$ | $1.0 \times 10^{-3}$ | $2.7 \times 10^{-3}$ | $3.1 \times 10^{-1}$ | X            | 6980 J             |
| B-4                         | $5.3 \times 10^{-5}$ | $3.7 \times 10^{-3}$ | $6.3 \times 10^{-2}$ | $3.1 \times 10^{-1}$ | X            | 90300 J            |
| B-5                         | $3.2 \times 10^{-5}$ | $5.5 \times 10^{-4}$ | $1.8 \times 10^{-3}$ | $1.2 \times 10^{-2}$ | X            | 697 J              |
| B-6                         | $1.8 \times 10^{-5}$ | $2.1 \times 10^{-3}$ | $4.8 \times 10^{-2}$ | $5.5 \times 10^{-1}$ | X            | 23800 J            |
| B-7                         | $3.3 \times 10^{-4}$ | $5.4 \times 10^{-4}$ | $2.6 \times 10^{-2}$ | $5.5 \times 10^{-2}$ | X            | 272 J              |
| B-8                         | $4.9 \times 10^{-5}$ | $2.2 \times 10^{-3}$ | $1.0 \times 10^{-2}$ | $8.7 \times 10^{-2}$ | X            | 154000 J           |
| B-9                         | $1.3 \times 10^{-5}$ | $5.7 \times 10^{-4}$ | $3.2 \times 10^{-3}$ | $2.1 \times 10^{-2}$ | X            | 1180 J             |
| B-10                        | $1.2 \times 10^{-5}$ | $5.4 \times 10^{-4}$ | $2.9 \times 10^{-3}$ | $2.3 \times 10^{-2}$ | X            | 710 J              |
| B-11                        | $1.1 \times 10^{-5}$ | $5.1 \times 10^{-4}$ | $3.3 \times 10^{-3}$ | $2.7 \times 10^{-2}$ | X            | 1830 J             |
| B-12                        | $4.7 \times 10^{-5}$ | $4.9 \times 10^{-3}$ | $3.2 \times 10^{-2}$ | $1.7 \times 10^{-1}$ | X            | 11000 J            |
| B-DUP-1                     | $4.1 \times 10^{-5}$ | $3.9 \times 10^{-3}$ | $3.7 \times 10^{-2}$ | $1.2 \times 10^{-1}$ | X            | 140000 J           |
| B-13                        | $4.5 \times 10^{-5}$ | $5.3 \times 10^{-3}$ | $1.3 \times 10^{-1}$ | $2.1 \times 10^{-1}$ | X            | 116000 J           |
| B-14                        | $2.5 \times 10^{-5}$ | $8.9 \times 10^{-3}$ | $1.1 \times 10^{-1}$ | $2.3 \times 10^{-1}$ | X            | 39700 J            |
| B-15                        | $1.7 \times 10^{-5}$ | $2.8 \times 10^{-3}$ | $1.7 \times 10^{-2}$ | $7.5 \times 10^{-2}$ | X            | 18100 J            |
| B-16                        | $2.6 \times 10^{-5}$ | $5.5 \times 10^{-4}$ | $1.6 \times 10^{-3}$ | $9.3 \times 10^{-1}$ | X            | 582 J              |
| B-17                        | $4.5 \times 10^{-5}$ | $2.0 \times 10^{-3}$ | $4.7 \times 10^{-2}$ | $1.8 \times 10^{-1}$ | X            | 46000 J            |
| B-18                        | $1.8 \times 10^{-5}$ | $1.5 \times 10^{-3}$ | $2.0 \times 10^{-2}$ | $3.2 \times 10^{-2}$ | X            | 23500 J            |
| B-19                        |                      |                      |                      |                      |              | 49800 J            |
| B-20                        |                      |                      |                      |                      |              | 21000 J            |
| B-21                        |                      |                      |                      |                      |              | 11100 J            |
| B-51                        | $1.8 \times 10^{-5}$ | $5.8 \times 10^{-3}$ | $7.6 \times 10^{-2}$ | $1.8 \times 10^{-1}$ | X            | 13600 J            |
| B-54                        | $1.3 \times 10^{-5}$ | $1.2 \times 10^{-3}$ | $1.3 \times 10^{-2}$ | $3.8 \times 10^{-2}$ | X            | 1270 J             |
| BLANKS                      |                      |                      |                      |                      |              |                    |
| B-RINSATE-1                 | $1.7 \times 10^{-5}$ | $3 \times 10^{-3}$   | $5.0 \times 10^{-2}$ | 250000               | X            | <10.0 J            |
| B-RINSATE-2                 | $5.5 \times 10^{-5}$ | $4 \times 10^{-3}$   | $3.0 \times 10^{-3}$ | 313000               | X            | <10.0              |
| WASH BLANK                  |                      |                      |                      |                      |              | <10.0              |

- NOTES: (1) J = ESTIMATED VALUE PER DATA VALIDATIO  
 (2) GREATER THAN THE INSTRUMENT DETECTION LIMIT (IDL)  
 (3) X = UNUSABLE DATA DUE TO DIFFICULTIES ENCOUNTERED DURING ANALYSIS  
 (4) SEE FIGURE 2-7 FOR SAMPLE LOCATIONS

TABLE 3-20 SUMMARY OF FIELD SCREENING FOR TEMPERATURE, Eh, and pH  
STAGE II SAMPLING, JUNE 1991

| <u>Sample Location</u> | <u>Temp (°C)</u> | <u>pH</u> | <u>Eh(mV)</u> |
|------------------------|------------------|-----------|---------------|
| B-1                    | 21.5             | 4.9       | +335          |
| B-2                    | 26.0             | 6.0       | -218          |
| B-3                    | 23.9             | 6.8       | -129          |
| B-4                    | 23.9             | 6.1       | -212          |
| B-5                    | 20.7             | 5.7       | -284          |
| B-6                    | 24.9             | 6.5       | -154          |
| B-7                    | 23.9             | 6.3       | -224          |
| B-8                    | 23.6             | 6.1       | -210          |
| B-9                    | 26.6             | 5.9       | -113          |
| B-10                   | 24.1             | 6.2       | -35           |
| B-11                   | 29.6             | 6.0       | -186          |
| B-12                   | 28.2             | 5.7       | -123          |
| B-12 Dup               | 27.9             | 5.7       | -157          |
| B-13                   | 28.5             | 6.4       | -226          |
| B-14                   | 30.1             | 6.5       | -215          |
| B-15                   | 29.4             | 6.7       | -145          |
| B-16                   | 24.0             | 6.4       | -65           |
| B-17                   | 26.1             | 5.6       | -45           |
| B-18                   | 27.1             | 6.0       | -160          |
| B-51                   | 29.7             | 6.6       | -131          |
| B-54                   | 25.7             | 6.8       | +222          |

Note: Sample locations are shown in Figure 2-6.



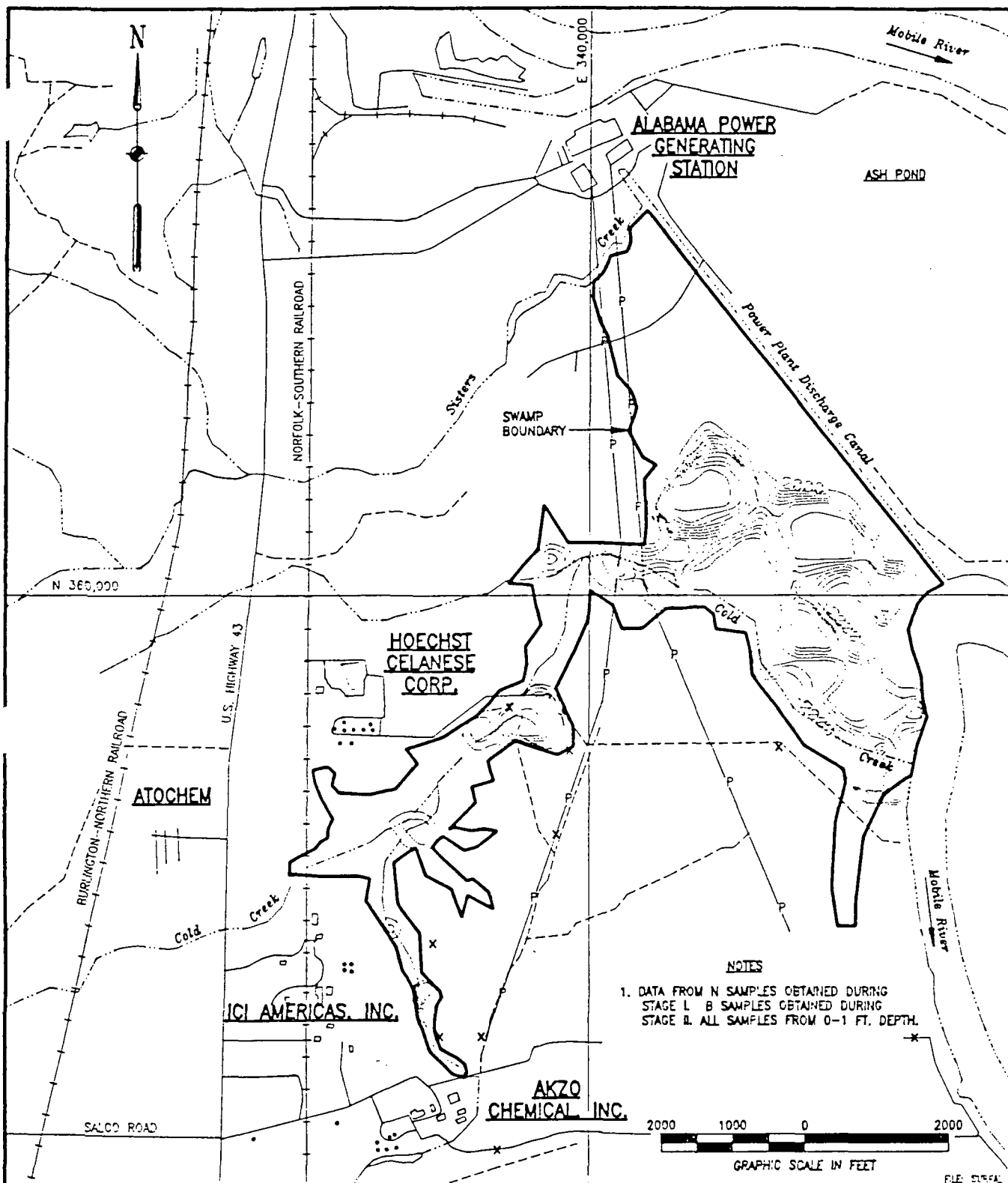
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METHYL-MERCURY  
CONCENTRATIONS

|                    |                    |                 |                   |                   |                |                        |               |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|
| PROJECT MGR<br>GEJ | DESIGNED BY<br>PWK | DRAWN BY<br>MSM | CHECKED BY<br>GEJ | SCALE<br>1"=2000' | DATE<br>6-5-92 | PROJECT NO<br>11653.08 | FIGURE<br>3-5 |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|

3 10 0160



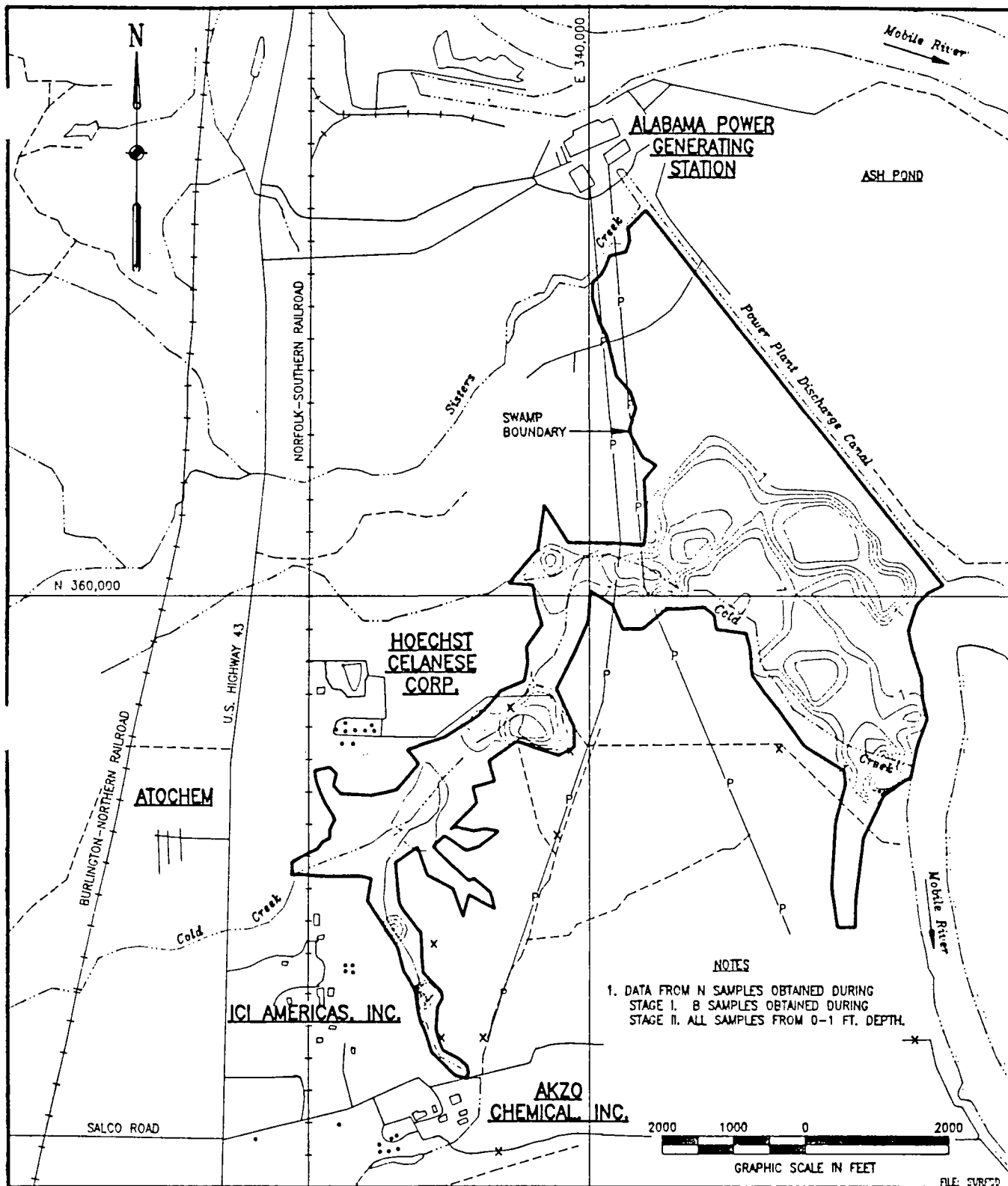
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# REMEDIAL INVESTIGATION REPORT COLD CREEK SWAMP MOBILE, ALABAMA

## ALUMINUM CONCENTRATIONS

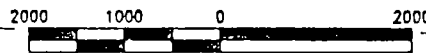
|                    |                    |                 |                   |                   |                |                        |               |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|
| PROJECT MGR<br>GEJ | DESIGNED BY<br>PWK | DRAWN BY<br>MSM | CHECKED BY<br>GEJ | SCALE<br>1"=2000' | DATE<br>6-5-92 | PROJECT NO<br>11653.08 | FIGURE<br>3-6 |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|

3 10 0131



# NOTES

1. DATA FROM N SAMPLES OBTAINED DURING STAGE I. B SAMPLES OBTAINED DURING STAGE II. ALL SAMPLES FROM 0-1 FT. DEPTH.



GRAPHIC SCALE IN FEET

FILE SUBCD



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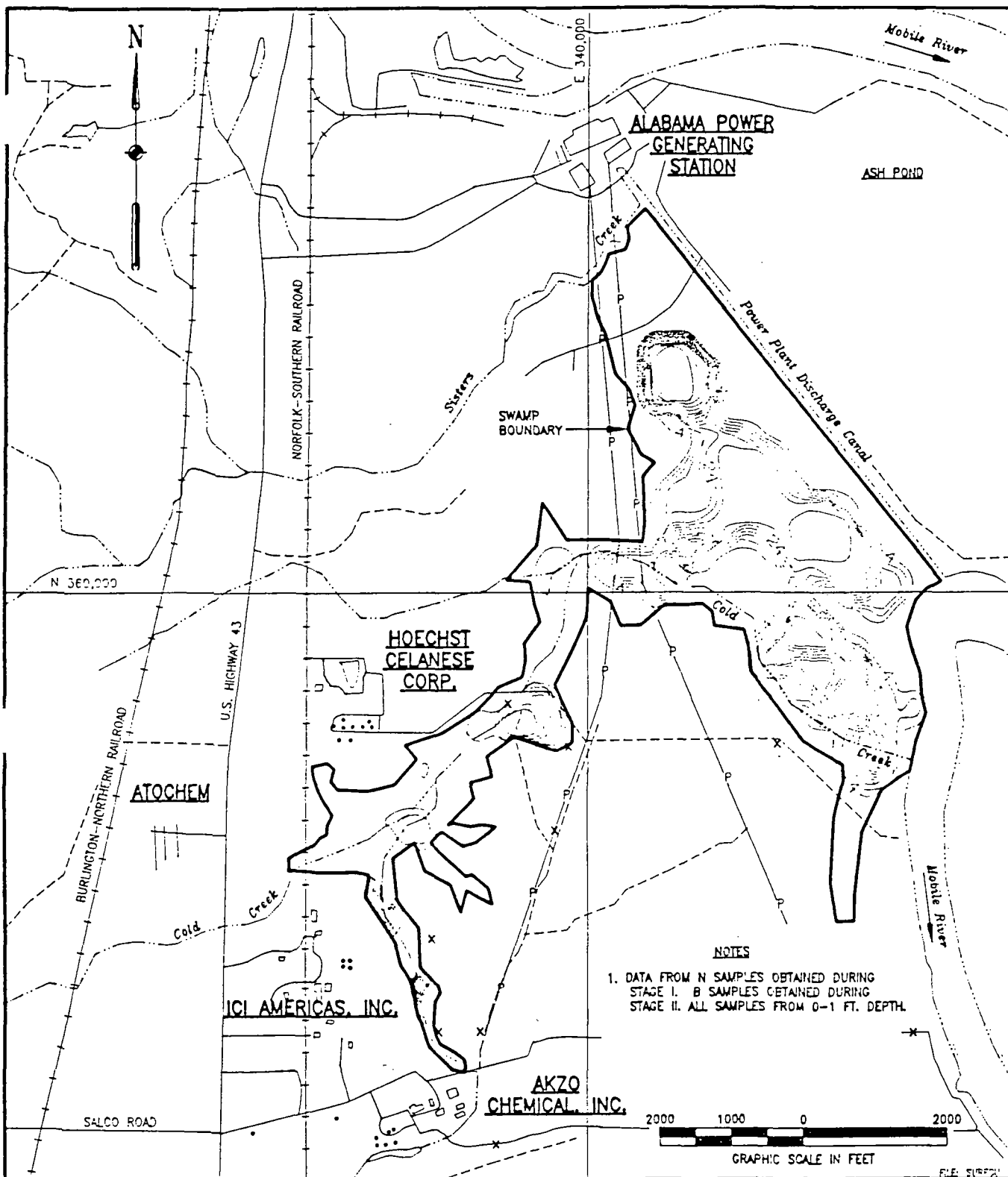
## REMEDIAL INVESTIGATION REPORT COLD CREEK SWAMP MOBILE, ALABAMA

CADMIUM CONCENTRATIONS

|                    |                    |                 |                   |                   |                |                        |               |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|
| PROJECT MGR<br>GEJ | DESIGNED BY<br>PWK | DRAWN BY<br>MSM | CHECKED BY<br>GEJ | SCALE<br>1"=2000' | DATE<br>6-5-92 | PROJECT NO<br>11653.08 | FIGURE<br>3-7 |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|

3 10 0132





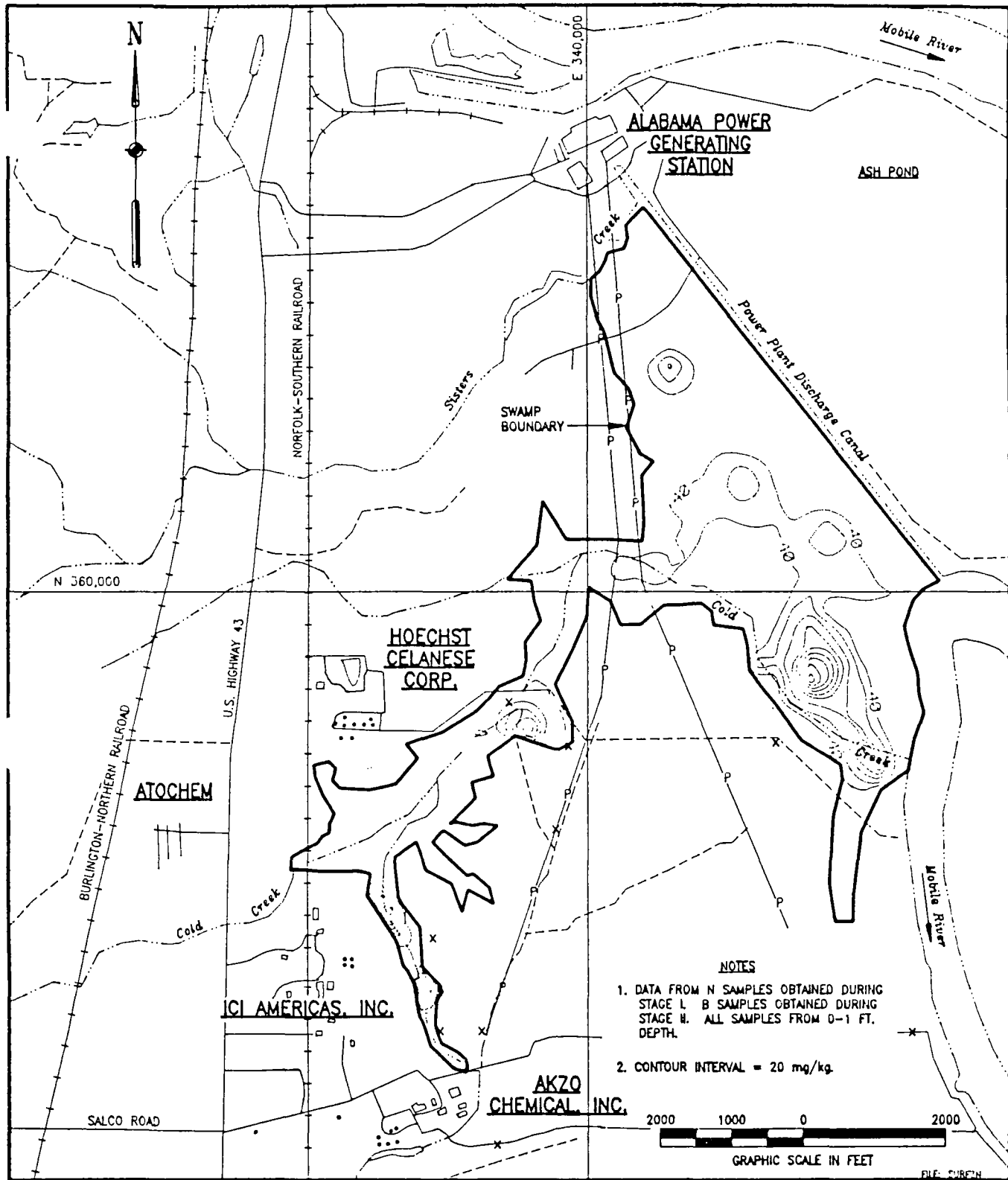
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MOBILE, ALABAMA

COPPER CONCENTRATIONS

|                    |                    |                 |                   |                   |                |                        |               |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|
| PROJECT MGR<br>GEJ | DESIGNED BY<br>PWK | DRAWN BY<br>MSM | CHECKED BY<br>GEJ | SCALE<br>1"=2000' | DATE<br>6-5-92 | PROJECT NO<br>11653.08 | FIGURE<br>3-8 |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|

3 10 0133



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MOBILE, ALABAMA

ZINC CONCENTRATIONS

|                    |                    |                 |                   |                   |                |                        |               |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|
| PROJECT MGR<br>GEJ | DESIGNED BY<br>PWK | DRAWN BY<br>MSM | CHECKED BY<br>GEJ | SCALE<br>1"=2000' | DATE<br>6-5-92 | PROJECT NO<br>11653.08 | FIGURE<br>3-9 |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|

3 10 0134

3 10 0135

TABLE 3-21 SURFACE WATER PHYSICAL/WATER QUALITY DATA FROM STAGE II SAMPLING, JUNE 1991

| Location           | Maxi-<br>mum<br>Channel<br>Depth<br>(ft) | Channel<br>Width<br>(ft) | Flow<br>Rate<br>(cfs) | Flow<br>Velocity<br>(fps) | pH  | Conduc-<br>tivity | Temp<br>(°C) | Dis-<br>solved<br>Oxygen<br>(%) |
|--------------------|------------------------------------------|--------------------------|-----------------------|---------------------------|-----|-------------------|--------------|---------------------------------|
| W-1                | 1.05                                     | 14.7                     | 2.47                  | 0.27                      | 6.0 | 69                | 24.0         | 3.4                             |
| W-2                | 0.5                                      | 13                       | No Flow               | No Flow                   | 7.7 | 229               | 27.6         | 3.3                             |
| W-3                | 2.5                                      | 24.5                     | No Flow               | No Flow                   | 5.8 | 167               | 25.0         | 0.9                             |
| W-4                | 4.0                                      | (a)                      | No Flow               | No Flow                   | 6.4 | 122               | 26.9         | 0.7                             |
| W-7 <sup>(b)</sup> | 0.4                                      | 40.0                     | No Flow               | No Flow                   | 6.2 | 158               | 24.1         | 0.7                             |
| W-8 <sup>(c)</sup> | 0.2                                      | 2.0                      | 0.04                  | 0.18                      | 6.3 | 142               | 24.9         | 2.0                             |
| W-9 <sup>(d)</sup> | 1.9                                      | 16.2                     | 1.27                  | 0.07                      | 6.1 | 93                | 24.8         | 3.9                             |

Notes: See Figure 2-8 for Stage II surface water sample locations.  
 (a) Channel submerged in pool behind beaver pond. Width not discernible.  
 (b) W-7 located at Virginia Chemicals bridge.  
 (c) W-8 located at Stage I Sample N-6.  
 (d) W-9 located at east power line crossing.

TABLE 3-22 RESULTS OF MINERALOGICAL AND PHYSICAL ANALYSES FROM STAGE II FIELD WORK, JUNE 1991

| <u>Sample</u> | <u>Clay</u> | <u>Silt</u> | <u>Sand</u> | <u>Silt <math>\bar{X}</math></u> | <u>Silt m</u> | <u>Silt std</u> | <u>OM%</u> | <u>OC%</u> | <u>H2O%</u> |
|---------------|-------------|-------------|-------------|----------------------------------|---------------|-----------------|------------|------------|-------------|
| D-1-M         |             |             | ~100.00     |                                  |               |                 |            |            |             |
| D-2-M         | 42.07       | 28.99       | 28.94       | 16.22                            | 17.01         | 1.02            | 3.95       | 0.84       | 1.47        |
| D-4-M         | 58.99       | 27.99       | 13.02       | 15.42                            | 15.81         | 0.90            | 19.71      | 6.41       | 5.59        |
| D-16-M        | 63.84       | 28.58       | 7.58        | 15.53                            | 15.75         | 0.90            | 28.59      | 12.15      | 7.95        |
| N-4-M         |             |             | ~100.00     |                                  |               |                 |            |            |             |
| N-10-M        | 50.99       | 38.65       | 10.37       | 16.81                            | 17.12         | 0.81            | 25.97      | 13.33      | 5.78        |
| S-5-M         | 39.20       | 45.74       | 15.06       | 15.55                            | 15.84         | 0.92            | 11.59      | 4.37       | 3.94        |
| S-11-M        | 89.03       | 8.05        | 2.92        | 12.98                            | 12.93         | 0.96            | 27.69      | 11.33      | 8.36        |
| S-17-M        | 91.69       | 5.54        | 2.77        | 11.96                            | 11.75         | 1.00            | 26.04      | 6.72       | 9.28        |
| S-19-M        | 69.26       | 29.07       | 1.68        | 16.51                            | 17.05         | 0.89            | 8.90       | 1.55       | 5.93        |

## Notes:

- (1) Sample locations are shown in Figure 2-9.
- (2) All values shown refer to percentages.
- (3) OM = percent organic material.  
OC = percent organic clay.  
H2O = percent water.
- (4) See Appendix H for additional information on the physical/mineralogical study.

TABLE 3-23 BIRDS POTENTIALLY AND OBSERVED TO BE PRESENT IN THE COLD CREEK SWAMP STUDY AREA

| <u>Common Name</u>         | <u>Season Present</u> | <u>Observed</u> |
|----------------------------|-----------------------|-----------------|
| Pied-billed grebe          | Y                     |                 |
| Anhinga                    | Y                     |                 |
| Double-crested cormorant   | Y                     |                 |
| Least bittern              | S                     |                 |
| American bittern           | W                     |                 |
| Black-crowned night heron  | Y                     | *               |
| Yellow-crowned night heron | Y                     |                 |
| Green-backed heron         | Y                     | *               |
| Little blue heron          | Y                     | *               |
| Tricolored heron           | Y                     |                 |
| Cattle egret               | Y                     | *               |
| Snowy egret                | Y                     | *               |
| Great egret                | Y                     | *               |
| Great blue heron           | Y                     | *               |
| Wood stork                 | Y                     |                 |
| Glossy ibis                | Y                     |                 |
| Canada goose               | W                     |                 |
| White ibis                 | Y                     |                 |
| Sandhill crane             | Y                     |                 |
| Snow goose                 | W                     |                 |
| Wood duck                  | Y                     | *               |
| Mallard                    | W                     | *               |
| Gadwall                    | W                     | *               |
| Green-winged teal          | W                     |                 |
| American wigeon            | W                     |                 |
| Northern pintail           | W                     |                 |
| Blue-winged teal           | W                     |                 |
| Fulvous whistling duck     | S                     |                 |
| Ring-necked duck           | W                     |                 |
| Common merganser           | W                     |                 |
| King rail                  | Y                     | *               |
| Virginia rail              | W                     |                 |
| Sora                       | W                     |                 |
| Purple gallinule           | S                     |                 |
| American avocet            | W                     |                 |
| Common moorhen             | Y                     |                 |

Season Present:

Y = Year-round range

W = Winter range

S = Summer range

Observed:

\* = Species was either observed or heard.

TABLE 3-23 (Cont.)

| <u>Common Name</u>        | <u>Season Present</u> | <u>Observed</u> |
|---------------------------|-----------------------|-----------------|
| American coot             | Y                     |                 |
| Killdeer                  | Y                     | *               |
| American woodcock         | Y                     |                 |
| Common snipe              | W                     |                 |
| Spotted sandpiper         | W                     |                 |
| Laughing gull             | Y                     | *               |
| Turkey vulture            | Y                     | *               |
| Black vulture             | Y                     | *               |
| Bald eagle                | W                     |                 |
| Mississippi kite          | S                     | *               |
| Swallow-tailed kite       | S                     |                 |
| Northern harrier          | W                     |                 |
| Cooper's hawk             | Y                     |                 |
| Sharp skinned hawk        | W                     |                 |
| Red-shouldered hawk       | Y                     | *               |
| Broad-winged hawk         | S                     |                 |
| Red-tailed hawk           | Y                     | *               |
| Osprey                    | S                     |                 |
| Kestrel                   | Y                     | *               |
| Merlin                    | W                     |                 |
| Bob white                 | Y                     | *               |
| Turkey                    | Y                     | *               |
| Rock dove                 | Y                     |                 |
| Mourning dove             | Y                     | *               |
| Ground dove               | Y                     |                 |
| Yellow-billed cuckoo      | S                     | *               |
| Short-eared owl           | W                     |                 |
| Great Horned owl          | Y                     | *               |
| Barred owl                | Y                     | *               |
| Screech owl               | Y                     |                 |
| Chuck-will's-widow        | S                     |                 |
| Whip-poor-will            | W                     |                 |
| Common Nighthawk          | S                     |                 |
| Chimney swift             | S                     |                 |
| Ruby-throated hummingbird | S                     | *               |
| Kingfisher                | Y                     | *               |
| Flicker                   | Y                     | *               |
| Red-bellied woodpecker    | Y                     | *               |
| Downy woodpecker          | Y                     | *               |
| Red-headed woodpecker     | Y                     |                 |
| Hairy woodpecker          | Y                     | *               |
| Pileated woodpecker       | Y                     | *               |
| Eastern kingbird          | S                     | *               |
| Great-crested flycatcher  | S                     |                 |
| Yellow-bellied sapsucker  | W                     |                 |
| Pee wee                   | S                     | *               |
| Eastern phoebe            | W                     |                 |
| Acadian flycatcher        | S                     |                 |

TABLE 3-23 (Cont.)

| <u>Common Name</u>      | <u>Season Present</u> | <u>Observed</u> |
|-------------------------|-----------------------|-----------------|
| Tree swallow            | W                     |                 |
| Purple martin           | S                     | *               |
| Rough-wing swallow      | S                     |                 |
| Barn swallow            | S                     | *               |
| Blue jay                | Y                     | *               |
| American crow           | Y                     | *               |
| Fish crow               | Y                     | *               |
| Tufted titmouse         | Y                     | *               |
| Carolina chickadee      | Y                     | *               |
| Brown creeper           | W                     |                 |
| White breasted nuthatch | Y                     | *               |
| Brown headed nuthatch   | Y                     | *               |
| Carolina wren           | Y                     | *               |
| House wren              | W                     |                 |
| Winter wren             | W                     |                 |
| Bewick's wren           | W                     |                 |
| Ruby-crowned kinglet    | W                     |                 |
| Gnatcatcher (bluegray)  | Y                     | *               |
| Bluebird                | Y                     |                 |
| Hermit thrush           | S                     |                 |
| Wood thrush             | S                     | *               |
| Robin                   | Y                     | *               |
| Loggerhead shrike       | Y                     |                 |
| Catbird                 | Y                     | *               |
| Mocking bird            | Y                     | *               |
| Brown thrasher          | Y                     | *               |
| Starling                | Y                     | *               |
| White-eyed vireo        | Y                     | *               |
| Yellow throated vireo   | S                     |                 |
| Solitary vireo          | W                     |                 |
| Red-eyed vireo          | S                     |                 |
| Warbling vireo          | S                     |                 |
| Prothonotary warbler    | S                     | *               |
| Orange crowned warbler  | W                     |                 |
| Northern parula         | S                     | *               |
| Black and white warbler | W                     |                 |
| Yellow-throated warbler | Y                     | *               |
| Yellow-rumped warbler   | W                     |                 |
| Prairie warbler         | S                     |                 |
| Pine warbler            | Y                     | *               |
| Palm warbler            | S                     |                 |
| Hooded warbler          | S                     |                 |
| Kentucky warbler        | S                     |                 |
| Swainson's warbler      | S                     |                 |
| Worm-eating warbler     | S                     |                 |
| Common yellow throat    | Y                     | *               |
| Yellow-breasted chat    | S                     |                 |
| American redstart       | S                     |                 |

TABLE 3-23 (Cont.)

| <u>Common Name</u>     | <u>Season Present</u> | <u>Observed</u> |
|------------------------|-----------------------|-----------------|
| Cardinal               | Y                     | *               |
| Blue grosbeak          | S                     | *               |
| Indigo bunting         | S                     | *               |
| Painted bunting        | S                     |                 |
| Rufous-sided towhee    | Y                     | *               |
| Le Conte's sparrow     | W                     |                 |
| Song sparrow           | W                     |                 |
| Bachmann's sparrow     | Y                     |                 |
| Field sparrow          | Y                     |                 |
| Chipping sparrow       | Y                     |                 |
| Dark-eyed junco        | W                     |                 |
| White-throated sparrow | W                     |                 |
| Fox sparrow            | W                     |                 |
| Lincoln's sparrow      | W                     |                 |
| Swamp sparrow          | W                     |                 |
| Brewers blackbird      | W                     |                 |
| Rusty blackbird        | W                     |                 |
| Eastern meadowlark     | Y                     | *               |
| Red-winged blackbird   | Y                     | *               |
| Brown-headed cowbird   | Y                     | *               |
| Common grackle         | Y                     | *               |
| Orchard oriole         | S                     |                 |
| Summer tanager         | S                     | *               |
| House sparrow          | Y                     | *               |
| American goldfinch     | W                     |                 |
| Pine siskin            | W                     |                 |
| American goldfinch     | W                     |                 |



TABLE 3-24 REPTILES AND AMPHIBIANS POTENTIALLY PRESENT IN THE COLD CREEK  
SWAMP STUDY AREA

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Alligator

American Alligator

Turtles

Common snapping turtle  
Stinkpot  
Razor-backed musk turtle  
Striped mud turtle  
Mississippi mud turtle  
Alabama map turtle  
Back-knobbed sawback  
Southern painted turtles  
Mobile cooter  
Missouri slider  
Yellow-bellied pond slider  
Red-eared pond slider  
Three-toed box turtle  
Eastern chicken turtle  
Smooth softshell turtle  
Spiny soft shelled turtle

Lizards

Green anole  
Southern fence lizard  
Ground skink  
Five-lined skink  
Broad-headed skink  
South-eastern five-lined  
skink  
Six-lined racerunner  
Eastern glass lizard  
Island glass lizard

Snakes

Southern hognose snake  
Rough green snake  
Mud snake  
Coachwhip  
Gray rat snake  
Scarlet snake  
Mole snake  
Crowned snake  
Copperhead  
Pigmy rattlesnake  
Eastern diamondback  
rattlesnake  
Midland water snake  
Banded water snake  
Yellow-bellied water snake  
Diamondback water snake  
Green water snake  
Glossy water snake  
Queen snake  
Eastern garter snake  
Easter ribbon snake  
Pine woods snake  
Rough earth snake  
Smooth earth snake  
Red-bellied snake  
Brown snake  
Eastern hognose snake  
Ring-neck snake  
Rainbow snake  
Black racer  
Pine snake  
Corn snake  
Scarlet king snake  
Speckled king snake  
Cottonmouth  
Eastern coral snake  
Timber rattlesnake

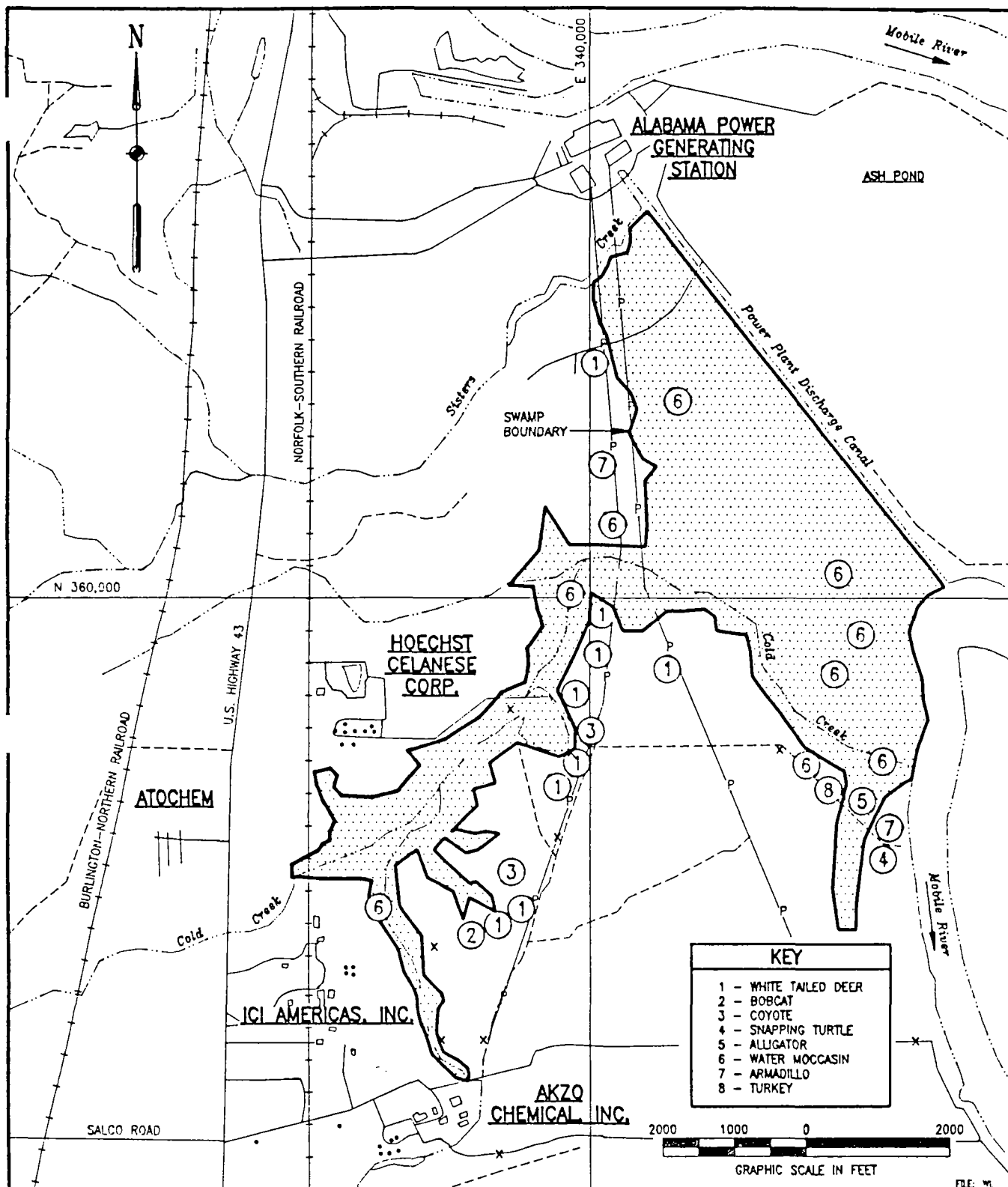
TABLE 3-24 (Cont.)

Salamanders

Two-toed amphiuma  
 Central newt  
 Flatwood salamander  
 Spotted salamander  
 Dusty salamander  
 Red salamander  
 Slimy salamander  
 Long-tailed salamander  
 Lesser siren  
 Alabama water dog  
 Mole salamander  
 Tiger salamander  
 Marbled salamander  
 Southern dusty salamander  
 Mud salamander  
 Two-lined salamander

Frogs

Spadefoot toad  
 Narrow-mouthed toad  
 Fowler's toad  
 Barking tree frog  
 Green tree frog  
 Squirrel tree frog  
 Gray tree frog  
 Southern chorus frog  
 Southern cricket frog  
 Pig frog  
 Bull frog  
 Gopher frog  
 Southern toad  
 Oak toad  
 Spring peeper  
 Bird-voiced tree frog  
 Pine woods tree frog  
 Ornate chorus frog  
 Northern cricket frog  
 Green frog  
 River frog  
 Leopard frog



EA ENGINEERING,  
SCIENCE, AND  
TECHNOLOGY, INC.

REMEDIAL INVESTIGATION REPORT  
COLD CREEK SWAMP  
MOBILE, ALABAMA

WILDLIFE  
SIGHTING  
LOCATIONS

|                    |                    |                 |                   |                   |                |                        |                |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|----------------|
| PROJECT MGR<br>GEJ | DESIGNED BY<br>PWK | DRAWN BY<br>MSM | CHECKED BY<br>GEJ | SCALE<br>1"=2000' | DATE<br>6-5-92 | PROJECT NO<br>11653.08 | FIGURE<br>3-10 |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|----------------|

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Habitat structure ranges from some relatively permanent open water in the lower swamp, through meadows and emergent wetlands, to mature forests. Old stands and flooded areas are characterized by many dead standing trunks which provide nesting habitat for cavity-dwelling animals such as wood ducks, woodpeckers, owls, and squirrels (including fox and flying squirrels), and foraging habitat for lizards, snakes, and insect-gleaning birds.

Signs of several species of wildlife were frequently observed throughout the Cold Creek Swamp study area. These animals included raccoon, opossum, white-tailed deer, armadillo, beaver, red fox, and turkey. The signs observed include deer, turkey, fox, raccoon, and opossum tracks, and scat, bird nests, beaver cuttings, den holes in trees, and burrows.

Standing water in the upper zone of Cold Creek is inhabited by small fish, toads, and frogs. Turtle shells were found on the banks. Raccoon tracks, squirrel, and rabbit were observed in the vicinity of station B-3 in the upper swamp (Figure 2-6). Numerous birds were either observed or heard in this area. Birds observed by site included red-winged black-bird, cattle egret, great egret, snowy egret, great blue heron, killdeer, mourning dove, wood thrush, eastern kingbird, mocking bird, barn swallow, house sparrow and indigo bunting. Birds identified based on song included eastern wood pee wee, brown-headed nuthatch, Carolina wren, white-eyed vireo, and pine warbler. A Mississippi kite was observed feeding on dragon flies over a marshy area. During August and July visits, the middle zone of Cold Creek Swamp was observed to have fish trapped in small ephemeral puddles and ponds left by receding flood waters. Ponded areas supported black crappie, bluegill, other sunfishes, and a variety of cyprinids and cyprinodontids.

Beaver sign including freshly cut trees and debarked logs, and sticks were seen throughout the middle zone. Approximately five intact beaver dams were observed. An adult beaver (roughly 40+ pounds) was found

dead due to predation (possibly bobcat). Armadillo, marsh rabbits, and white-tailed deer were frequently observed, and a single river otter was recorded. Reptiles observed in this area included a cottonmouth, an eastern ribbon snake, a common snapping turtle, southern painted turtles, pond sliders, cooters, anoles, fence lizards, southern toads, and green tree frogs.

A variety of birds were observed in the middle zone, including turkey, crows, mourning doves, black vultures, red-tailed hawks, bobwhite, robins, blue grosbeak, indigo bunting, and common flickers.

Wildlife observed in the lower area of Cold Creek Swamp included wood ducks, gadwall, and mallards flying over the site and along the Mobile River. Hawks were occasionally observed passing over the area. Birds observed within the lower swamp included snowy egret, great egret, great blue heron, green-backed egret, little blue heron, black vulture, ruby-throated hummingbird, kingfisher, pileated woodpecker, summer tanager, and a variety of warblers. A great horned owl was heard, but not observed. Reptiles observed included skinks (ground and five-lined group) and numerous southern toads. A black racer, several cottonmouths, and Nerodia water snakes were found in open water in the lower swamp and on both sides of the Mobile River levee.

A number of species whose range incorporates the Cold Creek Swamp area appear to be excluded by lack of suitable habitat. These include the alligator snapping turtle and Alabama red bellied turtle (both of which are inhabitants of large, slow river stretches), sparrows and other emberizids characteristic of open meadow uplands, and other reptiles and birds associated with extensive sandy upland ridges. In general, the fauna and flora populations of the Cold Creek Swamp basin appear to be healthy and characteristic of similar drainages in the region, and are little disturbed by human use as the parcel is privately owned and protected.

### 3.3 STAGE III FIELD ACTIVITIES

#### 3.3.1 Biological Tissue Characterization

Table 3-25 presents the results of the mercury analyses in biological tissue samples. The table indicates the type of animal sampled, its relative trophic level, the swamp zone and location from which it was collected, the animal's lipid content, the whole-body mercury concentration reported as total mercury, the animal's length, and the animal's weight and the animal's life stage.

For swamp samples, the highest mercury concentration was 3.5 mg/kg (ppm) for a chain pickerel caught in the lower swamp and the lowest was 0.14 mg/kg (ppm) for a bluegill caught in the upper swamp. For background samples, the highest mercury concentration was 1.5 mg/kg (ppm) for a largemouth bass caught in a pool; the lowest was 0.02 mg/kg (ppm) for a leopard frog. For swamp samples, the average mercury concentration was 0.9 mg/kg (ppm) and for background samples the average concentration was 0.327 mg/kg (ppm). A discussion of sampling procedures, locations of sampling stations, and locations where specific samples (i.e., F-U-1) were collected is included in Section 3.3.4. A statistical analysis of these data is discussed in Section 4.5.

#### Temporal Trends in Biota Mercury Concentrations

Table 3-26 compares mercury body burdens for crayfish and several types of fish for 1988 and 1991. As can be seen, levels have remained comparable over time, and thus no temporal trends are obvious from these data over the 3-year interval.

#### Fish Gut Content Analysis

During the course of this study it was hypothesized that gut contents containing sediments could affect body burden measurements of mercury. To investigate this possibility, 26 fish from Cold Creek Swamp were

selected for gut content analysis (Appendix I). Only four of the fish examined contained sediment material. These included a spotted gar (containing sediment which was apparently associated with a fish found inside the gar's stomach/gut), a spotted sunfish, and two golden shiners. For each of the four fish the content weight of plant/animal material was greater than that of sediment. For each of these individuals, proportion of gut content weight was as follows: 1 percent (gar,) 5 percent (golden shiner), 20 percent (golden shiner), and 40 percent (spotted sunfish). With one exception all 26 fish contained plant/animal material within their stomach/gut. This material consisted of insect (aquatic and terrestrial) exoskeletons, fish, fish scales and vertebrae, plant debris, mollusks, mollusk shells, crayfish claws, and unidentified partially digested material. These site-specific data support the conclusion that bioaccumulation of chemicals at Cold Creek Swamp is not driven by the content of chemical associated with coincidentally consumed sediment. The complete report examining fish gut contents is provided in Appendix I.

### 3.3.2 Bioaccessible Contaminant Characterization

Table 3-27 contains the results of chemical analyses on the Stage III sediment samples. These samples were taken at 20 of the same locations as the Stage II samples, and were numbered accordingly (i.e., BB-1 for Stage III was taken at the same location as B-1 during Stage II). Table 3-28 summarizes field screening of "BB" samples for temperature, Eh, and pH. The samples were analyzed for total mercury, methyl mercury, total organic carbon, AVS, and SEM of cadmium, copper, mercury, and zinc. In addition, the AVS/SEM ratios are given for the 20 samples.

### 3.3.3 Surface Water Characterization

Surface water characterization for Stage III included water quality parameters and physical parameters. Table 3-29 includes results of the Stage III surface water characterization.

TABLE 3-25. SUMMARY OF ANALYTICAL RESULTS FOR STAGE III BIOTA SAMPLING

| SAMPLE<br>DESIGNATION | SAMPLE<br>LOCATION  | SAMPLE<br>DESCRIPTION | TROPHIC<br>LEVEL | TOTAL MERCURY<br>mg/kg<br>(wet weight) | LIPIDS<br>% | LENGTH<br>(mm) | WEIGHT<br>(gm) | LIFE<br>STAGE |
|-----------------------|---------------------|-----------------------|------------------|----------------------------------------|-------------|----------------|----------------|---------------|
| FINFISH SAMPLES       |                     |                       |                  |                                        |             |                |                |               |
| F-U-1                 | N3                  | SPOTTED GAR           | P                | 0.71                                   | 2.1         | 259            | 38             | JUVENILE      |
| F-U-2                 | N3                  | SPOTTED GAR           | P                | 0.69                                   | 1.6         | 250            | 37             | JUVENILE      |
| F-U-3                 | N2                  | BOWFIN                | C                | 0.64                                   | 0.22        | 241            | 127            | ADULT         |
| F-U-4                 | N2-N3               | REDEAR SUNFISH        | C                | 0.62                                   | 0.94        | 142            | 59             | ADULT         |
| F-U-5                 | N2-N3               | LARGEMOUTH BASS       | P                | 0.30                                   | 0.35        | 191            | 81             | ADULT         |
| F-U-6                 | N2                  | LARGEMOUTH BASS       | P                | 0.64                                   | 0.41        | 203            | 87             | ADULT         |
| F-U-7                 | N2                  | LARGEMOUTH BASS       | P                | 0.93                                   | 0.075       | 146            | 34             | JUVENILE      |
| F-U-8                 | N2-N3               | GOLDEN SHINER         | PC               | 0.29                                   | 0.80        | 160            | 38             | ADULT         |
| F-U-9                 | N4                  | GOLDEN SHINER         | PC               | 1.0                                    | 0.61        | 135            | 22             | ADULT         |
| F-U-10                | N2-N3               | BLUEGILL              | C                | 0.14                                   | 0.98        | 175            | 101            | ADULT         |
| F-M-1                 | N5                  | BOWFIN                | C                | 0.91                                   | 0.28        | 305            | 269            | ADULT         |
| F-M-2                 | N6-N7               | LARGEMOUTH BASS       | P                | 1.4                                    | 1.4         | 287            | 298            | ADULT         |
| F-M-3                 | N6-N7               | LARGEMOUTH BASS       | P                | 1.4                                    | 1.5         | 298            | 371            | ADULT         |
| F-M-4                 | N6-N7               | REDFIN PICKEREL       | P                | 1.5                                    | 7.1         | 187            | 38             | ADULT         |
| F-M-5                 | N6-N7               | REDFIN PICKEREL       | P                | 0.65                                   | 1.1         | 196            | 46             | ADULT         |
| F-M-6                 | N6-N7               | CHAIN PICKEREL        | P                | 2.8                                    | 0.54        | 190            | 31             | ADULT         |
| F-M-7                 | N6-N7               | CHAIN PICKEREL        | P                | 0.81                                   | 0.37        | 271            | 124            | ADULT         |
| F-M-8                 | N6-N7               | COMMON CARP           | PC               | 0.82                                   | 0.10        | 266            | 245            | ADULT         |
| F-M-9                 | N5                  | GOLDEN SHINER         | PC               | 0.81                                   | 1.1         | 131            | 21             | ADULT         |
| F-M-10                | N6-N7               | YELLOW BULLHEAD       | PC               | 0.71                                   | 0.19        | 165            | 54             | ADULT         |
| F-L-1                 | MOUTH OF COLD CREEK | AMERICAN EEL          | C                | 0.43                                   | 5.3         | 600            | 517            | ADULT         |
| F-L-2                 | N7                  | CHAIN PICKEREL        | P                | 1.5                                    | 0.93        | 325            | 188            | ADULT         |
| F-L-3                 | N7                  | CHAIN PICKEREL        | P                | 1.8                                    | 0.81        | 343            | 208            | ADULT         |
| F-L-4                 | N7                  | CHAIN PICKEREL        | P                | 3.5                                    | 1.4         | 262            | 119            | ADULT         |
| F-L-5                 | N7                  | REDFIN PICKEREL       | P                | 2.3                                    | 1.7         | 261            | 126            | ADULT         |
| F-L-6                 | N7                  | REDFIN PICKEREL       | P                | 0.69                                   | 1.1         | 212            | 61             | ADULT         |
| F-L-7                 | N7                  | LONGEAR SUNFISH       | C                | 1.4                                    | 0.33        | 104            | 21             | ADULT         |
| F-L-8                 | N7                  | LONGEAR SUNFISH       | C                | 1.1                                    | 0.13        | 101            | 22             | ADULT         |
| F-L-9                 | MOUTH OF COLD CREEK | LARGEMOUTH BASS       | P                | 1.1                                    | 0.23        | 126            | 21             | ADULT         |
| F-L-10                | MOUTH OF COLD CREEK | WARMOUTH              | C                | 0.58                                   | 4.0         | 132            | 43             | ADULT         |

## NOTES:

- (1) SEE FIGURE 2-10 FOR SAMPLE LOCATIONS.
- (2) SAMPLES WERE COLLECTED 7-11 OCTOBER 1991.
- (3) MERCURY ANALYSES ARE REPORTED ON A WHOLE BODY BASIS AS TOTAL MERCURY.

## LEGEND:

P = PREDATOR  
 C = CARNIVORE  
 PC = PRIMARY CONSUMER  
 F = FINFISH  
 NA = NOT APPLICABLE

U = UPPER ZONE  
 M = MIDDLE ZONE  
 L = LOWER ZONE  
 H = HERPTILE/INVERTEBRATE  
 NR = NOT REPORTED

BP = BACKGROUND POND  
 BS = BACKGROUND STREAM  
 BCM = COMPOSITE SAMPLE SITE

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TABLE 3-25. (CONTINUED)

| SAMPLE<br>DESIGNATION         | SAMPLE<br>LOCATION | SAMPLE<br>DESCRIPTION     | TROPHIC<br>LEVEL | TOTAL MERCURY<br>mg/kg<br>(wet weight) | LIPIDS<br>% | LENGTH<br>(mm) | WEIGHT<br>(gm) | LIFE<br>STAGE |
|-------------------------------|--------------------|---------------------------|------------------|----------------------------------------|-------------|----------------|----------------|---------------|
| HERPTILE/INVERTEBRATE SAMPLES |                    |                           |                  |                                        |             |                |                |               |
| H1-U-1                        | NR                 | COTTONMOUTH SNAKE         | P                | 0.93                                   | 0.62        | NR             | 51             | NR            |
| H1-U-2                        | NR                 | AMPHIUMA (TWO-TOED)       | C                | 0.41                                   | 1.4         | 580            | 197            | NR            |
| H1-U-3                        | NR                 | BRONZE FROG               | C                | 0.73                                   | 2.0         | 70             | 33             | NR            |
| H1-U-4                        | NR                 | SOUTHERN TOAD             | C                | 0.19                                   | 0.57        | 63             | 19             | NR            |
| H1-U-5                        | NR                 | FROG (COMPOSITE OF 11)    | C                | 1.6                                    | 0.15        | NA             | NA             | NR            |
| H1-M-1                        | NR                 | BANDED WATER SNAKE        | P                | 0.70                                   | 0.98        | 630            | 103            | NR            |
| H1-M-2                        | NR                 | CLAMS                     | PC               | 0.68                                   | 0.46        | NA             | NA             | NR            |
| H1-M-3                        | NR                 | BRONZE FROG               | C                | 0.54                                   | 0.33        | 70             | 27             | NR            |
| H1-M-4                        | NR                 | BRONZE FROG               | C                | 0.58                                   | 0.35        | 67             | 25             | NR            |
| H1-M-5                        | NR                 | CRAYFISH (COMPOSITE OF 3) | PC               | 0.95                                   | 6.5         | NA             | NA             | NR            |
| H1-M-7                        | NR                 | BRONZE FROG               | C                | 0.55                                   | 0.12        | 41             | 8              | NR            |
| H1-L-1                        | NR                 | COTTONMOUTH SNAKE         | P                | 1.6                                    | 2.6         | 660            | 253            | NR            |
| H1-L-2                        | NR                 | COTTONMOUTH SNAKE         | P                | 0.90                                   | 2.7         | 770            | 339            | NR            |
| H1-L-3                        | NR                 | CRAYFISH (COMPOSITE OF 5) | PC               | 0.74                                   | 0.49        | NA             | NA             | NR            |
| H1-L-4                        | NR                 | BRONZE FROG               | C                | 0.24                                   | 0.84        | 630            | 103            | NR            |
| H1-L-5                        | NR                 | FROG (COMPOSITE OF 2)     | C                | 0.16                                   | 3.9         | NA             | NA             | NR            |

## NOTES:

- (1) SEE FIGURE 2-10 FOR SAMPLE LOCATIONS.  
 (2) SAMPLES WERE COLLECTED 7-11 OCTOBER 1991.  
 (3) MERCURY ANALYSES ARE REPORTED ON A WHOLE BODY BASIS AS TOTAL MERCURY.

## LEGEND:

P = PREDATOR  
 C = CARNIVORE  
 PC = PRIMARY CONSUMER  
 F = FINFISH  
 NA = NOT APPLICABLE

U = UPPER ZONE  
 M = MIDDLE ZONE  
 L = LOWER ZONE  
 H = HERPTILE/INVERTEBRATE  
 NR = NOT REPORTED

BP = BACKGROUND POND  
 BS = BACKGROUND STREAM  
 BCM = COMPOSITE SAMPLE SITE

TABLE 3-25. (CONTINUED)

| SAMPLE<br>DESIGNATION | SAMPLE<br>LOCATION | SAMPLE<br>DESCRIPTION | TROPHIC<br>LEVEL | TOTAL MERCURY<br>mg/kg<br>(wet weight) | LIPIDS<br>% | LENGTH<br>(mm) | WEIGHT<br>(gm) | LIFE<br>STAGE |
|-----------------------|--------------------|-----------------------|------------------|----------------------------------------|-------------|----------------|----------------|---------------|
| BACKGROUND SAMPLES    |                    |                       |                  |                                        |             |                |                |               |
| F-BP-1                | POND               | LARGEMOUTH BASS       | P                | 1.5                                    | 1.5         | 454            | 1480           | ADULT         |
| F-BP-2                | POND               | BROWN BULLHEAD        | PC               | 0.04                                   | 1.2         | 308            | 347            | ADULT         |
| F-BP-3                | POND               | COMMON CARP           | PC               | 0.12                                   | 1.5         | 264            | 281            | ADULT         |
| F-BP-4                | POND               | CHAIN PICKEREL        | P                | 0.56                                   | 1.2         | 255            | 82             | ADULT         |
| F-BP-5                | POND               | SPOTTED GAR           | P                | 0.42                                   | 0.72        | 431            | 212            | ADULT         |
| F-BS-1                | STREAM             | LAKE CHUBSUCKER       | PC               | 0.17                                   | 0.29        | 244            | 223            | ADULT         |
| F-BS-2                | STREAM             | LARGEMOUTH BASS       | P                | 0.38                                   | 1.2         | 282            | 261            | ADULT         |
| F-BS-3                | STREAM             | LARGEMOUTH BASS       | P                | 0.50                                   | 0.58        | 223            | 132            | ADULT         |
| F-BS-4                | STREAM             | REDFIN PICKEREL       | P                | 0.46                                   | 0.66        | 231            | 78             | ADULT         |
| F-BS-5                | STREAM             | YELLOW BULLHEAD       | PC               | 0.29                                   | 0.16        | 178            | 59             | ADULT         |
| H1-B-1                | NR                 | COTTONMOUTH SNAKE     | P                | 0.66                                   | 0.23        | 630            | 135            | NR            |
| H1-B-2                | NR                 | LEOPARD FROG          | C                | 0.02                                   | 0.68        | 86             | 60             | NR            |
| H1-B-3                | NR                 | LEOPARD FROG          | C                | 0.04                                   | 0.84        | 86             | 60             | NR            |
| H1-B-4                | NR                 | BRONZE FROG           | C                | 0.03                                   | 2.4         | 59             | 24             | NR            |
| H1-B-5                | NR                 | BRONZE FROG           | C                | 0.06                                   | 2.4         | 57             | 17             | NR            |
| COMPOSITE SAMPLES     |                    |                       |                  |                                        |             |                |                |               |
| BCM1                  | N2                 | SPOTTED SUNFISH (5)   | C                | 0.42                                   | 1.5         | NA             | NA             | ADULT         |
| BCM2                  | N4                 | BLUEGILL (5)          | C                | 0.73                                   | 2.2         | NA             | NA             | ADULT         |
| BCM3                  | N5                 | BLUEGILL (5)          | C                | 0.72                                   | 1.1         | NA             | NA             | ADULT         |
| BCM4                  | N6-N7              | SPOTTED SUNFISH (5)   | C                | 0.44                                   | 2.4         | NA             | NA             | ADULT         |
| BCM5                  | N7                 | BLUEGILL (5)          | C                | 0.46                                   | 1.6         | NA             | NA             | ADULT         |
| BCM6                  | POND               | BLUEGILL (5)          | C                | 0.12                                   | 2.0         | NA             | NA             | ADULT         |
| BCM7                  | STREAM             | BLUEGILL (5)          | C                | 0.18                                   | 1.2         | NA             | NA             | ADULT         |

## NOTES:

- (1) SEE FIGURE 2-10 FOR SAMPLE LOCATIONS.  
 (2) SAMPLES WERE COLLECTED 7-11 OCTOBER 1991.  
 (3) MERCURY ANALYSES ARE REPORTED ON A WHOLE BODY BASIS AS TOTAL MERCURY.

## LEGEND:

P = PREDATOR  
 C = CARNIVORE  
 PC = PRIMARY CONSUMER  
 F = FINFISH  
 NA = NOT APPLICABLE

U = UPPER ZONE  
 M = MIDDLE ZONE  
 L = LOWER ZONE  
 H = HERPTILE/INVERTEBRATE  
 NR = NOT REPORTED

BP = BACKGROUND POND  
 BS = BACKGROUND STREAM  
 BCM = COMPOSITE SAMPLE SITE

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TABLE 3-26 TEMPORAL COMPARISONS OF MERCURY IN BIOTA (RANGE OF SWAMP CONCENTRATIONS mg/kg WET WEIGHT)

| <u>Organism Types</u>          | <u>1988<sup>(a)</sup></u> | <u>1991<sup>(b)</sup></u> |
|--------------------------------|---------------------------|---------------------------|
| Crayfish                       | 0.2-1.2                   | 0.74-0.95                 |
| Bottom feeders <sup>(c)</sup>  | 0.2-1.2                   | 0.12-0.82                 |
| Golden shiner <sup>(d)</sup>   | 0.8-0.9                   | 0.29-1.0                  |
| Bluegill <sup>(e)</sup>        | 0.3-1.9                   | 0.46-0.72                 |
| Spotted sunfish <sup>(f)</sup> | 0.8-0.9                   | 0.42-0.44                 |
| Fish <sup>(g)</sup>            | 0.59-3.1 <sup>(h)</sup>   | 0.14-3.5                  |
|                                | 0.2-1.9 <sup>(a)</sup>    |                           |

- 
- (a) BCM 1989.  
 (b) This report.  
 (c) Common carp and lake chubsucker.  
 (d) Notemigonus crysoleucas.  
 (e) Lepomis macrochirus.  
 (f) Lepomis punctatus.  
 (g) All fish sampled.  
 (h) ERT 1988.

TABLE 3-27. STAGE III BIOACCESSIBLE CONTAMINANT CHARACTERIZATION  
CHEMICAL ANALYSES  
OCTOBER 1991

| STATION          | SIMULTANEOUSLY EXTRACTED METALS |                         |                                  |                                     |                    |                   |                    |                 |                  |
|------------------|---------------------------------|-------------------------|----------------------------------|-------------------------------------|--------------------|-------------------|--------------------|-----------------|------------------|
|                  | TOTAL MERCURY<br>mg/kg          | METHYL MERCURY<br>ug/kg | TOTAL<br>ORGANIC CARBON<br>mg/kg | ACID<br>VOLATILE SULFIDE<br>umole/g | CADMIUM<br>umole/g | COPPER<br>umole/g | MERCURY<br>umole/g | ZINC<br>umole/g | SEM/AVS<br>RATIO |
| BB-1             | 96.9                            | 46                      | 17700                            | 8.6                                 | 1.1E-03            | 1.7E-02           | 2.7E-05            | 5.3E-01         | 0.06352          |
| BB-DUP-4 (BB-1)  | NA                              | NA                      | 103000                           | NA                                  | NA                 | NA                | NA                 | NA              | NA               |
| BB-2             | 4.3                             | <10                     | 2520                             | 3.9                                 | 4.2E-04            | 3.5E-03           | 9.6E-06            | 1.3E-03         | 0.00128          |
| BB-3             | 8.0                             | 12                      | 5760                             | 7.2                                 | 1.0E-03            | 2.1E-03           | 1.3E-05            | 7.7E-01         | 0.10754          |
| BB-4             | 3.8                             | 24                      | 65700                            | 74.5                                | 8.5E-03            | 1.0E-02           | 8.9E-05            | 1.3             | 0.01836          |
| BB-5             | 1.4                             | <10                     | 9780                             | 5.2                                 | 5.4E-04            | 1.9E-03           | 1.2E-05            | 1.4E-03         | 0.00071          |
| BB-6             | 65.5                            | 14                      | 61700                            | 34.9                                | 3.9E-03            | 1.4E-02           | 9.5E-05            | 4.2             | 0.12269          |
| BB-7             | 0.93                            | <10                     | 987                              | 3.3                                 | 5.1E-03            | 2.5E-03           | 1.6E-05            | 3.7E-02         | 0.01345          |
| BB-DUP-1 (BB-7)  | 1.2                             | <10                     | 784                              | 28.4                                | 3.8E-04            | 1.3E-03           | 1.2E-05            | 1.9E-02         | 0.00718          |
| BB-8             | 3.2                             | <10                     | 32000                            | 6.7                                 | 8.3E-04            | 2.9E-03           | 1.9E-05            | 6.5E-02         | 0.01005          |
| BB-9             | 2.2                             | <10                     | 1060                             | 3.5                                 | 4.5E-04            | 2.4E-03           | 2.0E-05            | 2.7E-02         | 0.00850          |
| BB-DUP-3 (BB-9)  | NA                              | NA                      | 1350                             | NA                                  | NA                 | NA                | NA                 | NA              | NA               |
| BB-10            | 9.0                             | <10                     | 3190                             | 2.4                                 | 4.7E-04            | 2.3E-03           | 1.0E-05            | 5.1E-02         | 0.02197          |
| BB-11            | 10.3                            | <10                     | 3900                             | 8.9                                 | 8.1E-04            | 3.2E-03           | 4.1E-05            | 1.0E-01         | 0.01179          |
| BB-12            | 139                             | 36                      | 99900                            | 7.0                                 | 1.0E-03            | 2.4E-02           | 3.7E-05            | 1.9E-01         | 0.03056          |
| BB-13            | 10.1                            | 23                      | 130000                           | 12.5                                | 1.5E-03            | 8.2E-02           | 3.5E-05            | 2.5E-01         | 0.02691          |
| BB-14            | 0.33                            | <10                     | 11400                            | 5.5                                 | 6.8E-04            | 1.2E-02           | 1.5E-05            | 1.0E-01         | 0.02107          |
| BB-DUP-2 (BB-14) | 0.33                            | <10                     | 11600                            | 5.6                                 | 1.8E-02            | 1.4E-02           | 1.6E-05            | 1.9E-01         | 0.04821          |
| BB-15            | 0.09                            | 83                      | 15100                            | 4.4                                 | 5.6E-04            | 6.0E-03           | 1.3E-05            | 8.5E-02         | 0.02075          |
| BB-16            | 0.79                            | <10                     | 1240                             | 4.4                                 | 5.4E-04            | 2.0E-03           | 1.2E-05            | 5.1E-02         | 0.01213          |
| BB-17            | 1.6                             | <10                     | 2200                             | 5.6                                 | 5.1E-04            | 2.5E-03           | 1.7E-05            | 3.6E-02         | 0.00698          |
| BB-18            | 5.9                             | 21                      | 82400                            | 20.1                                | 5.5E-04            | 1.9E-02           | 2.5E-05            | 1.5E-01         | 0.00827          |
| BB-51            | 0.27                            | <10                     | 7350                             | 7.8                                 | 6.3E-03            | 2.2E-03           | 1.5E-05            | 5.0E-02         | 0.00740          |
| BB-54            | 0.11                            | <10                     | 5220                             | 4.2                                 | 5.3E-04            | 5.8E-03           | 1.2E-05            | 2.5E-02         | 0.00748          |
| BB-63            | 0.08                            | NA                      | NA                               | NA                                  | NA                 | NA                | NA                 | NA              | NA               |
| BB-RINSATE-1     | 0.20                            | <3                      | 18.4                             | <0.50                               | 7.5E-04            | 1.7E-03           | 1.0E-05            | 22.2            | 284.522          |
| BB-RINSATE-2     | 0.20                            | <3                      | 1.8                              | 0.55                                | 9.2E-04            | 1.6E-03           | 1.0E-05            | 3.0             | 176.590          |

NOTES:

- (1) SAMPLE LOCATIONS ARE SHOWN ON FIGURE 2-11.
- (2) STATION NAMES IN PARENTHESES REFER TO THE STATION WHERE THE DUPLICATE SAMPLE WAS COLLECTED.
- (3) NA = NOT ANALYZED

TABLE 3-28 SUMMARY OF FIELD SCREENING FOR TEMPERATURE, Eh, AND pH FROM  
STAGE III SAMPLING, OCTOBER 1991

| <u>Sample Location</u> <sup>(a)</sup> | <u>Temperature (°C)</u> | <u>pH</u> | <u>Eh (Zobels)</u> | <u>Eh (mV)</u> |
|---------------------------------------|-------------------------|-----------|--------------------|----------------|
| BB-1                                  | (b)                     | (b)       | (b)                | (b)            |
| BB-2                                  | (b)                     | (b)       | (b)                | (b)            |
| BB-3                                  | (b)                     | (b)       | (b)                | (b)            |
| BB-4                                  | (b)                     | (b)       | (b)                | (b)            |
| BB-5                                  | (b)                     | (b)       | (b)                | (b)            |
| BB-6                                  | (b)                     | (b)       | (b)                | (b)            |
| BB-7                                  | 19.8                    | 4.97      | +231.5             | +378.5         |
| BB-7 Dup                              | 20.0                    | 5.00      | +232.0             | +370.9         |
| BB-8                                  | 15.6                    | 5.96      | +234.5             | -150.1         |
| BB-9                                  | 23.2                    | 5.04      | +234.1             | +248.2         |
| BB-9 Dup                              | 23.3                    | 5.09      | +234.3             | +243.6         |
| BB-10                                 | 22.7                    | 4.77      | +235.7             | -220.0         |
| BB-11                                 | 22.8                    | 4.73      | +231.7             | +207.3         |
| BB-12                                 | 17.2                    | 5.60      | +249.4             | +384.7         |
| BB-13                                 | 12.3                    | 4.60      | +259.4             | +456.3         |
| BB-14                                 | 14.6                    | 4.66      | +259.2             | +318.1         |
| BB-14 Dup                             | 14.6                    | 4.68      | +259.3             | +299.8         |
| BB-15                                 | 14.3                    | 4.32      | +256.4             | +372.6         |
| BB-16                                 | 15.2                    | 7.20      | -190.1             | +252.1         |
| BB-17                                 | 12.9                    | 6.35      | +260.4             | +114           |
| BB-18                                 | (b)                     | (b)       | (b)                | (b)            |
| BB-51                                 | 22.9                    | 6.00      | +252.6             | -81.0          |
| BB-54                                 | 22.6                    | 5.44      | +245.9             | -97.6          |

(a) Sample locations are shown in Figure 2-11.

(b) Samples were not analyzed for Eh, pH, and temperature due to malfunctioning equipment.

TABLE 3-29 SURFACE WATER PHYSICAL/WATER QUALITY DATA FROM STAGE III SAMPLING, OCTOBER 1991

| Location  | Maximum<br>Channel<br>Depth<br>(ft) | Channel<br>Width<br>(ft) | Flow Rate<br>(cfs) | Flow Velocity<br>(fps) | pH  | Conductivity | Temperature<br>(°C) | Dissolved<br>Oxygen<br>(%) |
|-----------|-------------------------------------|--------------------------|--------------------|------------------------|-----|--------------|---------------------|----------------------------|
| W-1       | 0.8                                 | 6.4                      | 2.74               | 1.33                   | 6.4 | 99           | 15.8                | 6.5                        |
| W-2       | 2.0                                 | 19.6                     | No Flow            | No Flow                | 7.6 | 341          | 17.7                | 5.1                        |
| W-3(e)    | 0.5                                 | 12                       | No Flow            | No Flow                | 6.4 | 224          | 17.6                | 3.8                        |
| W-4(e)    | 4.0                                 | (a)                      | No Flow            | No Flow                | 7.0 | 108          | 16.3                | 9.4                        |
| W-7(b)(e) | 1.0                                 | 10.5                     | No Flow            | No Flow                | 6.8 | 236          | 17.5                | 3.4                        |
| W-8(c)(e) | 0                                   | 0                        | No Water           | No Water               | -   | -            | -                   | -                          |
| W-9(d)    | 1.5                                 | 15.0                     | No Flow            | No Flow                | 7.5 | 87           | 16.9                | 7.3                        |

- (a) Channel submerged in pool behind beaver pond. Width not discernible.  
 (b) W-7 located at Virginia Chemicals bridge.  
 (c) W-8 located at Stage I Sample N-6.  
 (d) W-9 located at east power line crossing.  
 (e) Stream bed was dried up.

### 3.3.4 Biota Inventory Observations

Collections of fishes, reptiles, amphibians, and crayfish were made primarily for whole-body mercury tissue analysis (Section 3.3.1). Throughout the collection process, organisms not retained for tissue analysis were noted but not always quantified. Field observations were made to derive fish and herptile inventories.

#### 3.3.4.1 Aquatic Community Structure

Field observations of Cold Creek Swamp in October indicate considerable variability in available aquatic habitat throughout the study area during low flow conditions. Many areas of the upper and middle swamp had been reduced to isolated pools with little or no flow while others within this reach had a distinct channel and flow. In the lower swamp, the location of the main stream channel was apparent. At the mouth of the swamp, two distinct channels were located. These ran from the lower swamp to the tidal Mobile River (Figure 3-11). The channels were isolated from the rest of Cold Creek Swamp due to low water levels and natural impoundments (i.e., beaver dams) but had open access to the river under all but the lowest flows. The area sampled for background tissue levels (creek and impoundment upstream of the swamp) was typical of a low gradient coastal watershed, but was more free flowing than the rest of the swamp. Areas sampled for fish and herptiles contained ample habitat structure: logs, felled trees, dead standing trunks, soft substrate, undercut banks, overhanging vegetation.

Thirty-five fish and 12 herptile taxa were identified within the study area. The fish species identified at each sampling station are presented in Table 3-30. Some stations lack the observations of mosquitofish and other small species because only larger individuals were targeted and collected for tissue analysis.

In general, the upper and middle zones had higher fish diversities than the lower zone. This can be attributed to the variety of available habitat within this reach. Few minnow, sucker, catfish, or sunfish species were collected from the lower swamp. Sunfish were particularly diverse in the middle zone. Upper and middle zone stations were similar in species composition. Shortnose gar, bowfin, golden shiner, pirate perch, flier and green sunfish were only observed in these zones. Fish diversity in the middle zone was highest overall, reflecting favorable aquatic conditions. In addition to the available habitat, the middle zone is predominantly wooded, providing good cover (canopy) for most areas sampled.

The background stations (upstream) and lower reaches of the swamp contained some fish species unique within the study area. Lake chubsucker and longnose gar were taken exclusively from the background stations. American eel and quillback were only observed at stations near the mouth of the swamp. Bay anchovy and gobies, as well as brook silverside, were collected exclusively from the channels connecting the mouth of Cold Creek Swamp to the Mobile River. The former were the only estuarine species found within the study area.

Among fish, 30 carnivores and 5 omnivores were identified in Cold Creek Swamp (Table 3-30). Most of the carnivores are insectivorous. These include: suckers, bullhead catfish, pirate perch, topminnows, mosquitofish, brook silverside, and many of the sunfish. Most insectivores will feed at the surface or within the water column. These species (e.g., topminnows, mosquitofish, sunfishes) were found throughout the study area but were most abundant in the upper and middle reaches within isolated pools and other low flow areas. The suckers, bullhead catfish, and many omnivores are bottom feeders. Bottom feeders were almost exclusively observed in the upper and middle zones.

Several carnivorous species are both insectivorous and piscivorous or predominantly piscivorous. These would represent the higher level predators within the aquatic system and include: three species of gar,





TABLE 3-30 SPECIES COLLECTED BY ELECTROFISHING AT VARIOUS STATIONS AND ZONES THROUGHOUT COLD CREEK SWAMP, OCTOBER 1991.

|                       | Trophic Level (a) | Background |            | Upper |           |    | Middle |    |       | Lower |         | Channels |   |
|-----------------------|-------------------|------------|------------|-------|-----------|----|--------|----|-------|-------|---------|----------|---|
|                       |                   | Pond (b)   | Stream (b) | N2    | N2/N3 (b) | N3 | N4     | N5 | N6/N7 | N7    | N10 (b) | 1 (c)    | 2 |
| Spotted gar           | C                 | X          |            |       |           | X  |        |    | X     |       |         |          |   |
| Longnose gar          | C                 | X          |            |       |           |    |        |    |       |       |         |          |   |
| Shortnose gar         | C                 |            |            | X     |           |    |        |    |       |       |         |          |   |
| Bowfin                | C                 |            |            | X     |           |    |        | X  |       |       |         |          |   |
| American eel          | C                 |            |            |       |           |    |        |    |       | X     | X       |          |   |
| Gizzard shad          | O                 | X          |            |       |           |    |        |    |       |       | X       |          |   |
| Bay anchovy (c)       | O                 |            |            |       |           |    |        |    |       |       |         |          | X |
| Common carp           | O                 | X          |            |       |           |    |        |    | X     |       |         |          |   |
| Golden shiner         | O                 |            |            | X     | X         |    | X      | X  |       |       |         |          |   |
| Shiner spp.           | O                 |            |            |       |           |    |        |    |       |       |         |          | X |
| Spotted sucker        | C                 |            |            |       |           |    |        |    | X     |       |         |          |   |
| Lake chubsucker       | C                 | X          | X          |       |           |    |        |    |       |       |         |          |   |
| Sharpfin chubsucker   | C                 |            |            | X     |           |    |        |    |       |       |         |          |   |
| Quillback             | C                 |            |            |       |           |    |        |    |       |       | X       |          |   |
| Yellow bullhead       | C                 |            | X          | X     |           |    |        |    | X     |       |         |          |   |
| Brown bullhead        | C                 | X          |            |       |           |    |        | X  |       |       |         |          |   |
| Tadpole madtom        | C                 |            |            |       |           |    |        |    |       |       |         | X        |   |
| Redfin pickerel       | C                 |            | X          |       |           | X  | X      | X  | X     | X     |         |          |   |
| Chain pickerel        | C                 | X          |            |       |           |    |        |    | X     | X     |         |          |   |
| Pirate perch          | C                 |            |            | X     |           | X  |        | X  |       |       |         |          |   |
| Starhead topminnow    | C                 |            |            |       |           | X  |        |    |       | X     |         |          |   |
| Blackstripe topminnow | C                 |            |            |       |           |    |        |    |       |       |         |          | X |
| Mosquitofish          | C                 |            |            |       |           | X  | X      | X  |       |       |         | X        |   |
| Brook silverside      | C                 |            |            |       |           |    |        |    |       |       |         |          | X |

(a) - C = Carnivore; O = Omnivore

(b) - Only organisms for tissue analysis were recorded. Forage and other small species are lacking from the station inventory.

(c) - Sampled on three consecutive days. All other stations surveyed once only.

(d) - Typically an Estuarine species.

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TABLE 3-30 (Cont.)

[illegible]

bowfin, American eel, redbfin and chain pickerel, and five species of sunfish. Among sunfish, largemouth bass was the most important gamefish species collected.

Frogs, particularly Rana spp., were widely distributed throughout the study area but were most abundant in the isolated pools within the middle and upper zones of the swamp. Toads and salamanders were also more common to this area. In the open water of the lower swamp, herptiles were generally less abundant, but snakes, particularly cottonmouths, were more prevalent than in other zones.

All herptile species collected were carnivores. Some, particularly eastern cottonmouth and banded water snake, are important predators within the ecosystem. The Ranid frogs (bronze, pig, and leopard frogs), salamanders, and snakes are almost exclusively aquatic carnivores/predators, whereas the other frog and toads species feed on both aquatic and terrestrial organisms.

The Red swamp crayfish (Procambarus clarkii) was ubiquitous in Cold Creek Swamp. Both juvenile and adult stages were collected. Crayfish are among the most important scavengers within the ecosystem but are also predatory, as needed.

Because sampling targeted organisms for tissue analysis, the aquatic inventory will be incomplete. Some species known to occur regionally and prefer the habitats available in Cold Creek Swamp may not have been observed due to limited collections or unavailable habitat under low flow conditions. The organisms collected in Cold Creek Swamp were typical of southern bottomland hardwood ecosystems (Gosselink et al. 1990).

#### 3.3.4.2 Fishes

Fishes were collected by backpack or boat electrofishing at 12 stations throughout the Cold Creek Swamp study area between 7 and 11 October 1991 (Figure 3-11). The sample stations for electrofishing were identified in

relation to known Stage I sample stations (i.e., N-1, N-3, etc.). A total of ten sample stations were established (eight within the swamp and two background). The level of effort at each station varied from 15 to 90 minutes as needed to obtain adequate quantities of fish for tissue analysis. Table 3-31 correlates the specific biota samples identified in Table 3-20 with the electrofishing stations shown in Figure 3-11. One pass was made at each of the 10 tissue stations. In addition to tissue sampling, the channels connecting the lower swamp (N10) to the Mobile River were sampled to assess potential fish movement between Cold Creek Swamp and the river. Channel 1 was sampled ("fished out") on three consecutive days, Channel 2 only once.

Thirty-five taxa representing 15 families were identified within Cold Creek Swamp (Table 3-32). Sunfish comprised the greatest number of species (10) followed by bullhead catfishes (4), suckers (3), carps and minnows (3), and gars (3). All other families were represented by only one or two species. The inventory will be somewhat skewed due to gear selectivity and study focus. Predatory and bottom feeding species, particularly larger individuals, were specifically targeted for the tissue characterization (Section 2.1.3.1). In terms of abundance, mosquitofish and topminnows were the dominant species. Thousands of young Gambusia and Fundulus were noted throughout the swamp, particularly in the upper and middle zones.

Fishes retained for tissue analysis and those collected in Channels 1 and 2 were measured to the nearest millimeter (total length) and weighed to the nearest gram. (Smaller individuals worked-up in the laboratory were measured to a tenth of a gram.) Length and weight data for biota collected in Stage III are included in Appendix E.

Most species found were typical of shallow freshwater ecosystems within bottomland hardwood forests (Gosselink et al. 1990). Two typically estuarine taxa, bay anchovy and goby (Gobiosoma spp.), were identified from the channels at the mouth of Cold Creek indicating interaction with the tidal Mobile River.

TABLE 3-31 LOCATIONS OF STAGE III BIOTA SAMPLES THAT WERE ANALYZED FOR MERCURY, OCTOBER 1991

| <u>Sample ID</u> | <u>Electrofishing Station</u> |
|------------------|-------------------------------|
| UPPER ZONE       |                               |
| F-U-1            | N3                            |
| F-U-2            | N3                            |
| F-U-3            | N2                            |
| F-U-4            | N2-N3                         |
| F-U-5            | N2-N3                         |
| F-U-6            | N2                            |
| F-U-7            | N2                            |
| F-U-8            | N2-N3                         |
| F-U-9            | N4                            |
| F-U-10           | N2-N3                         |
| MIDDLE ZONE      |                               |
| F-M-1            | N5                            |
| F-M-2            | N6-N7                         |
| F-M-3            | N6-N7                         |
| F-M-4            | N6-N7                         |
| F-M-5            | N6-N7                         |
| F-M-6            | N6-N7                         |
| F-M-7            | N6-N7                         |
| F-M-8            | N6-N7                         |
| F-M-9            | N5                            |
| F-M-10           | N6-N7                         |
| LOWER ZONE       |                               |
| F-L-1            | Mouth of Cold Creek           |
| F-L-2            | N7                            |
| F-L-3            | N7                            |
| F-L-4            | N7                            |
| F-L-5            | N7                            |
| F-L-6            | N7                            |
| F-L-7            | N7                            |
| F-L-8            | N7                            |
| F-L-9            | Mouth of Cold Creek           |
| F-L-10           | Mouth of Cold Creek           |

Note: Sample locations are shown in Figure 3-11.

TABLE 3-31 (Cont.)

| <u>Sample ID</u>                       | <u>Electrofishing Station</u> |
|----------------------------------------|-------------------------------|
| BACKGROUND (Pond)                      |                               |
| F-BP-1                                 | Pond                          |
| F-BP-2                                 | Pond                          |
| F-BP-3                                 | Pond                          |
| F-BP-4                                 | Pond                          |
| F-BP-5                                 | Pond                          |
| BACKGROUND (Stream)                    |                               |
| F-BS-1                                 | Stream                        |
| F-BS-2                                 | Stream                        |
| F-BS-3                                 | Stream                        |
| F-BS-4                                 | Stream                        |
| F-BS-5                                 | Stream                        |
| COMPOSITE WHOLE-BODY (TEMPORAL TRENDS) |                               |
| BCM-1                                  | N2                            |
| BCM-2                                  | N4                            |
| BCM-3                                  | N5                            |
| BCM-4                                  | N6-N7                         |
| BCM-5                                  | N7                            |
| BCM-6                                  | Pond                          |
| BCM-7                                  | Stream                        |

TABLE 3-32 FISHES COLLECTED IN COLD CREEK SWAMP, OCTOBER 1991

| Common Name        |                       | Scientific Name |                                |
|--------------------|-----------------------|-----------------|--------------------------------|
| Family             | Species               | Family          | Species                        |
| Gars               | Spotted gar           | Lepisosteidae   | <u>Lepisosteus oculatus</u>    |
|                    | Longnose gar          |                 | <u>Lepisosteus osseus</u>      |
|                    | Shortnose gar         |                 | <u>Lepisosteus platostomus</u> |
| Bowfins            | Bowfin                | Amiidae         | <u>Amia calva</u>              |
| Freshwater eels    | American eel          | Anguillidae     | <u>Anguilla rostrata</u>       |
| Herrings           | Gizzard shad          | Clupeidae       | <u>Dorosoma cepedianum</u>     |
| Anchovies          | Bay anchovy           | Engraulidae     | <u>Anchoa mitchilli</u>        |
| Carps and Minnows  | Common carp           | Cyprinidae      | <u>Cyprinus carpio</u>         |
|                    | Golden shiner         |                 | <u>Notemigonus crysoleucas</u> |
|                    | Shiner species        |                 | <u>Notropis spp.</u>           |
| Suckers            | Spotted sucker        | Catostomidae    | <u>Carpiodes melanops</u>      |
|                    | Lake chubsucker       |                 | <u>Erimyzon sucetta</u>        |
|                    | Sharpfin chubsucker   |                 | <u>Erimyzon tenuis</u>         |
| Bullhead catfishes | Quillback             | Ictaluridae     | <u>Carpiodes cyprinus</u>      |
|                    | Yellow bullhead       |                 | <u>Ameiurus natalis</u>        |
|                    | Brown bullhead        |                 | <u>Ameiurus nebulosus</u>      |
|                    | Tadpole madtom        |                 | <u>Noturus gyrinus</u>         |
| Pikes              | Redfin pickerel       | Esocidae        | <u>Esox americanus</u>         |
|                    | Chain pickerel        |                 | <u>Esox niger</u>              |
| Pirate perches     | Pirate perch          | Aphredoderidae  | <u>Aphredoderus sayanus</u>    |
| Killifishes        | Starhead topminnow    | Cyprinodontidae | <u>Fundulus dispar</u>         |
|                    | Blackstripe topminnow |                 | <u>Fundulus notatus</u>        |

- (a) The taxonomy of this species is still in question for the Mobile River drainage (Wooten et al. 1988; Robins et al. 1991). For the purposes of this study we have identified all mosquitofish as G. affinis following the trend for the western Mobile basin described in Wooten et al (1988). We do recognize that the mosquitofish population in Cold Creek Swamp is very likely comprised of both G. affinis, G. holbrooki, and Gambusia hybrids.



TABLE 3-32 (Cont.)

| Common Name          |         | Scientific Name                        |         |
|----------------------|---------|----------------------------------------|---------|
| Family               | Species | Family                                 | Species |
| Livebearers          |         | Poeciliidae                            |         |
| Western mosquitofish |         | <u>Gambusia affinis</u> <sup>(a)</sup> |         |
| Silversides          |         | Atherinidae                            |         |
| Brook silverside     |         | <u>Labidesthes sicculus</u>            |         |
| Sunfishes            |         | Centrarchidae                          |         |
| Flier                |         | <u>Centrarchus macropterus</u>         |         |
| Green sunfish        |         | <u>Lepomis cyanellus</u>               |         |
| Warmouth             |         | <u>Lepomis gulosus</u>                 |         |
| Bluegill             |         | <u>Lepomis macrochirus</u>             |         |
| Dollar sunfish       |         | <u>Lepomis marginatus</u>              |         |
| Longear sunfish      |         | <u>Lepomis megalotis</u>               |         |
| Redear sunfish       |         | <u>Lepomis microlophus</u>             |         |
| Spotted sunfish      |         | <u>Lepomis punctatus</u>               |         |
| Largemouth bass      |         | <u>Micropterus salmoides</u>           |         |
| White crappie        |         | <u>Pomoxis annularis</u>               |         |
| Gobies               |         | Gobidae                                |         |
| Goby spp.            |         | <u>Gobiasoma</u> spp.                  |         |

#### 3.3.4.3 Herptiles and Invertebrates

Reptiles and amphibians were collected from the background area (upstream of Cold Creek Swamp) and the three hydrologic zones (upper, middle, and lower swamp) identified in Stage I (Section 2.1, Figure 3-11). Table 3-33 lists the reptiles and amphibians observed or collected during Stage III biological tissue characterization in Cold Creek Swamp. Seven species of frogs and toads were identified on the site, as well as at least two species of chorus frogs (Pseudacris spp.). One salamander (two-toed amphiuma) and two snake species (banded water snake and eastern cottonmouth) were also collected.

The most common herptile species observed were the bronze frog (Rana clamitans) and the southern leopard frog (Rana pipiens). Both species were ubiquitous in the swamp. Because of the focus of the tissue characterization (Section 2.1.3.1), only species common to the aquatic areas of the swamp were observed. All herptiles found were expected to occur on the site. American alligators were deliberately avoided during tissue collections because of their protected status. Snapping turtles or surrogate turtle species were targeted as important carnivore species for the tissue characterization, but were not encountered during October 1991 collections.

All herptiles collected for tissue analysis were weighed and measured. Measurements included snout to vent for toads and frogs, and total length for snakes and salamanders. These data are presented in Appendix E.

The Red swamp crayfish (Procambarus clarkii) was also collected throughout the swamp. This was the only crayfish species observed in the study area. No freshwater or saltwater crabs were observed during the sample event.

Attempts were made to collect other invertebrates, including clams or mussels. Freshwater clams were found in the Middle Swamp Zone in Cold Creek along the powerline cuts. A sample was collected and analyzed for mercury. Results are presented in Table 3-25.

TABLE 3-33 AMPHIBIANS AND REPTILES OBSERVED OR COLLECTED IN COLD CREEK SWAMP, OCTOBER 1991

| Common Name            | Scientific Name                          |
|------------------------|------------------------------------------|
| Amphibians             | Amphibia                                 |
| Frogs and Toads        | Anura                                    |
| Southern Toad          | <u>Bufo terrestris</u>                   |
| Fowler's Toad          | <u>Bufo woodhousei fowleri</u>           |
| Green Treefrog         | <u>Hyla cinerea</u>                      |
| Chorus Frogs           | <u>Pseudacris spp.</u>                   |
| Eastern spadefoot toad | <u>Scaphiopus holbrooki</u>              |
| Bronze frog            | <u>Rana clamitans</u>                    |
| Pig frog               | <u>Rana grvlio</u>                       |
| Southern leopard frog  | <u>Rana pipiens</u>                      |
| Salamanders            | Caudata                                  |
| Two-toed amphiuma      | <u>Amphiuma means</u>                    |
| Reptiles               | Reptilia                                 |
| Lizards and Snakes     | Squamata                                 |
| Banded water snake     | <u>Natrix fasciata</u>                   |
| Eastern Cottonmouth    | <u>Agkistrodon piscivorus piscivorus</u> |

REFERENCES  
CHAPTER 3

- Adamus, P.R. 1987. Draft. Wetland Evaluation Technique for Bottomland Hardwood Functions. 75 pp.
- Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1978. Classification of Wetlands and Deepwater Habitats of the United States. FWS/OBS-79/31. U.S. Fish and Wildlife Service. 103 pp.
- Federal Interagency Committee for Wetland Delineation. 1989. Federal Manual for Identifying and Delineating Jurisdictional Wetlands. U.S. Army Corps of Engineers, U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, and U.S.D.A. Soil Conservation Service, Washington, D.C., Cooperative Technical Publication. 76 pp. plus appendices.
- Gosselink, J.G., L.C. Lee, and T.A. Muier, eds. 1990. Ecological Processes and Cumulative Impacts Illustrated by Bottomland Hardwood Wetland Ecosystems. Lewis Publishers, Chelsea, Michigan. 708 pp.
- Robins, C.R., R.M. Bailey, C.E. Bond, J.R. Brooker, E.A. Lachner, R.N. Lea, and W.B. Scott. 1991. Common and Scientific Names of Fishes from the United States and Canada. American Fisheries Society Special Publication 20. Bethesda, Maryland. 183 pp.
- Reed, P.B., Jr. 1988. National List of Plant Species That Occur in Wetlands: Southeast (Region 2). U.S. Fish Wildlife Service Biological Report 88 (26.2). 124 pp.
- U.S. Department of Agriculture (USDA), Soil Conservation Service. 1980. Soil Survey of Mobile County, Alabama. 134 pp. plus 114 map sheets.
- Wooten, M.C., K.T. Scribner, and M.H. Smith. 1988. Genetic variability and systematics of Gambusia in the southeastern United States. Copeia 1988:283-289.

#### 4. NATURE AND EXTENT OF CONTAMINATION

##### 4.1 IDENTIFICATION OF CONTAMINANT SOURCES

Anthropogenic contamination in Cold Creek Swamp is presumably associated with previous disposal practices at the Stauffer Chemical Company processing facilities. Mercury-contaminated wastewaters from the chlor-alkali processing facility at the LeMoyne Plant were previously discharged into the drainage channel that feeds the Upper Swamp Zone of Cold Creek Swamp. This practice was ceased in 1975 when an effluent transport line was constructed to convey wastewater from treatment areas directly to the Mobile River. The other potential contaminant source is related to thiocarbamates associated with the Cold Creek Plant in the Upper Swamp Zone near the point of confluence with Cold Creek.

Assessment of the data from the three-stage field program indicated that mercury was the primary contaminant of concern. Other potential contaminants of concern that were identified included thiocarbamates, aluminum, cadmium, copper, and zinc. Detailed examination of these compounds based on risk assessment and mineralogical analyses revealed that mercury was the only critical contaminant of concern (see discussion in Chapter 5). One source of mercury in Cold Creek Swamp is presumably the former chloro-alkali plant discharge. Other non-site-related activities, including atmospheric deposition of mercury, may also have contributed to mercury contamination at the site, particularly in the Lower Swamp Zone.

##### 4.2 CHARACTERIZATION OF SURFACE WATER

Surface water samples collected during the Stage I field activities did not contain any volatile or semivolatile organic compounds, pesticides, PCBs, thiocarbamates, or thiocyanates above detection levels. The only observed compounds in surface water samples were metals. Table 3-9 contains the results of surface water analysis. The following metals were not detected in surface water samples: antimony, cadmium, cobalt,

selenium, and vanadium. The concentrations of mercury, silver, and zinc in some samples were found to exceed water quality criteria for toxicity to aquatic organisms. Results of subsequent analytical procedures (Chapter 5) and human health and ecological risk assessments (Chapter 6), indicated that the observed levels of silver and zinc did not present risk to human health or the environment. Mercury was determined to represent a potential risk to ecological receptors, but not to human health based on the established exposure scenarios.

Stage II and Stage III surface water characterization consisted of measurements for physical and water quality parameters only. There was not additional chemical characterization of surface water. The observed physical and water quality data indicated conditions typical of southern swamp surface waters.

#### 4.3 CHARACTERIZATION OF SOIL BORINGS AND SOIL/SEDIMENT CORES

Soil/sediment samples obtained during the Stage I field activities consisted of 20-ft soil borings ("SB" samples), and 1-2 ft hand cores ("N" samples). Soil/sediment samples obtained during Stage II field activities consisted of 3-ft hand cores ("D" samples), and 1-ft hand cores ("S" samples). Soil borings or sediment cores were not taken as part of the Stage III field program. Analysis of the Stage I "N" samples confirmed that mercury was the primary contaminant of concern. Other potential chemicals of concern that were identified included methyl mercury, aluminum, cadmium, copper, and zinc. A discussion of the methodology used to determine potential contaminants of concern is presented in Section 6.2.1. Examination of the results of the "SB" samples analyses indicated that the mercury contamination is restricted primarily to the upper 1-3 ft of the soil/sediment (Table 3-8). It appears from these data that mercury is bound to the soil/sediment particles in the upper 3 ft of sediment, and the hydrodynamics of the swamp system are not driving contamination vertically downward. Results of ground-water sampling substantiate this conclusion (Section 4.6).

It was observed that several of the "D" sample locations in the Lower Swamp Zone exhibit higher mercury concentrations in the 1-2 and 2-3 ft intervals than in the 0-1 ft interval (see samples D-4 through D-7 in Table 3-16). This is likely due to sediment buildup over time in the lower swamp from flooding by the Mobile River, and downstream lateral sediment transport as discussed in Section 5.2.2.

Examination of composite Stage I and Stage II data indicates that mercury is concentrated in two major locations in Cold Creek Swamp (Figures 3-2, 3-3, and 3-4). The first location is in the Upper Swamp Zone in the vicinity of stations N-3, D-4, D-6, and S-1. The second location is at the transition from the Middle Swamp Zone to the Lower Swamp Zone where Cold Creek bends and crosses the powerlines. The stations located here are D-16, S-9, and S-10. These two locations are areas where the topography causes the velocity of the stream to fall as the gradient flattens into ponds of standing water. Consequently, heavier soil/sediment particles tend to settle onto the streambed in the depositional areas. Over time, soil/sediment particles containing mercury would be expected to concentrate in these two regions. Observed mercury soil concentrations support this assessment.

#### 4.4 CHARACTERIZATION OF SURFICIAL SOIL/SEDIMENT

Surficial soil/sediment samples were not collected during the Stage I field program. Surficial soil and sediment samples obtained during Stage II consisted of "B" samples collected from 0 to 4 in. depth throughout the swamp. Samples obtained during Stage III consisted of "BB" samples, also collected from 0 to 4 in. depth. Assessment of mercury data from these samples reinforces the findings of the "D" and "S" samples by indicating that there are two areas where mercury is concentrated. The highest mercury concentrations were B-37 (108 mg/kg) (located in Upper Swamp Zone) and B-12 (218 mg/kg), B-29 (632 mg/kg), B-31 (137 mg/kg), B-32 (300 mg/kg), and BB-12 (139 mg/kg) (located at transition of Middle and Lower swamp zones, at powerline crossing).



Figure 2-7 shows the locations of "B" samples. These locations are the same two areas indicated from assessment of soil borings and soil/sediment sample data.

#### 4.5 CHARACTERIZATION OF BIOTA SAMPLES

Biota samples were only collected in Stage III. Samples of finfish, herptiles, and invertebrates from all three zones of the swamp, as well as from background locations, were analyzed for whole body mercury tissue concentration. A statistical analysis was performed using the results of Stage III biota analyses. Trophic levels (organisms which exploit similar ecological niches) were assigned for these organisms based on the following classification scheme:

primary consumers: clams, crayfish

consumers: amphiuma, frogs, toads, bowfin, sunfish, golden shiner, bluegill, carp, catfish, eel

predators: snakes, spotted gar, largemouth bass, pickerel

The mean, high, and low mercury concentrations and the standard deviation were calculated on the basis of swamp zones and trophic level. The results of the statistical analysis are presented in Table 4-1.

Based on the analysis of all biota samples, predators contained significantly different concentrations of mercury than consumers [Student-Newman-Keuls (SNK),  $\alpha = 0.05$ ]; however, primary consumers could not be distinguished from either predators or consumers as shown below:

| <u>Trophic Level</u> | <u>n</u> | <u>Mean (mg/kg)</u> | <u>SNK Ranking</u> <sup>*</sup> |
|----------------------|----------|---------------------|---------------------------------|
| Predator             | 28       | 1.12                | A                               |
| Primary Consumer     | 3        | 0.79                | A B                             |
| Consumer             | 37       | 0.50                | B                               |

\* Observations with the same alphabetic designation are not significantly different at  $\alpha = 0.05$ .

TABLE 4-1 STATISTICAL ANALYSIS OF MERCURY IN BIOTA TISSUE SAMPLES,  
OCTOBER 1991

| <u>Swamp Zone</u> | <u>Trophic Level</u> | <u>No. of<br/>Samples</u> | <u>Average<br/>Mercury<br/>Concen-<br/>tration<br/>(ppm)</u> | <u>Standard<br/>Deviation</u> | <u>High<br/>Conc.<br/>(ppm)</u> | <u>Low<br/>Conc.<br/>(ppm)</u> |
|-------------------|----------------------|---------------------------|--------------------------------------------------------------|-------------------------------|---------------------------------|--------------------------------|
| Upper             | Primary Consumer     | 0                         | --                                                           | --                            | --                              | --                             |
|                   | Consumer             | 11                        | 0.62                                                         | 0.42                          | 1.60                            | 0.14                           |
|                   | Predator             | 6                         | 0.70                                                         | 0.23                          | 0.93                            | 0.30                           |
| Middle            | Primary Consumer     | 2                         | 0.82                                                         | 0.19                          | 0.95                            | 0.68                           |
|                   | Consumer             | 9                         | 0.68                                                         | 0.16                          | 0.91                            | 0.44                           |
|                   | Predator             | 7                         | 1.30                                                         | 0.75                          | 2.80                            | 0.65                           |
| Lower             | Primary Consumer     | 1                         | 0.74                                                         | --                            | --                              | --                             |
|                   | Consumer             | 9                         | 0.53                                                         | 0.44                          | 1.40                            | 0.12                           |
|                   | Predator             | 8                         | 1.70                                                         | 0.90                          | 3.50                            | 0.69                           |
| Whole Swamp       | Primary Consumer     | 3                         | 0.79                                                         | 0.14                          | 0.95                            | 0.68                           |
|                   | Consumer             | 29                        | 0.61                                                         | 0.36                          | 1.60                            | 0.12                           |
|                   | Predator             | 21                        | 1.30                                                         | 0.79                          | 3.50                            | 0.30                           |
| Background        | Primary Consumer     | 0                         | --                                                           | --                            | --                              | --                             |
|                   | Consumer             | 8                         | 0.10                                                         | 0.09                          | 0.29                            | 0.02                           |
|                   | Predator             | 7                         | 0.64                                                         | 0.39                          | 1.50                            | 0.38                           |

Assignment of the same alphabetical letter to different classifications signifies that these classifications are not significantly different at the 95 percent significance level. For example, predators were not significantly different from primary consumers (SNK ranking = A) and primary consumers are not significantly different from consumers (SNK ranking = B). However, predators (SNK ranking = A) are significantly different from consumers (SNK ranking = B).

The inability to differentiate primary consumers and consumers is probably due to the small sample size (three) of the primary consumers. These results are consistent with the expectation that higher mercury concentrations were anticipated to occur at higher trophic (predator) levels.

Analysis of all biota (regardless of trophic level) indicates that it was not possible to distinguish zonation in the swamp on the basis of total mercury body burdens. Lower and Middle swamp zones were significantly different from background but cannot be distinguished from the Upper Swamp Zone (SNK,  $\alpha = 0.05$ ):

| <u>Location</u> | <u>n</u> | <u>Mean (mg/kg)</u> | <u>SNK Ranking</u> |
|-----------------|----------|---------------------|--------------------|
| Lower           | 18       | 1.05                | A                  |
| Middle          | 18       | 0.94                | A                  |
| Upper           | 17       | 0.65                | A B                |
| Background      | 15       | 0.35                | B                  |

When all tissue samples from all zones of the swamp are combined and compared with background mercury tissue concentrations, it is apparent that swamp biota tissue mercury concentrations are significantly elevated above background (T-test,  $p = 0.0003$ ).

#### 4.6 CHARACTERIZATION OF COLD CREEK SWAMP GROUND WATER

There were no ground-water samples collected as part of this Supplemental RI/FS. Ground-water samples had been collected from five monitoring wells in the vicinity of Cold Creek Swamp during the 1988 RI. Analyses of samples from these wells indicated that mercury was not detected in any of the five wells within and around the swamp. Additional monitoring well installation and ground-water sampling and analysis was conducted under another operable unit RI/FS focusing on ground-water contamination at the Cold Creek/LeMoyne sites.

#### 4.7 SUMMARY OF CONTAMINANTS OF CONCERN

Based on assessment of the nature and extent of site contamination as indicated by review of Stage I, Stage II, and Stage III data, it was determined that mercury in swamp sediment is the primary contaminant of concern in Cold Creek Swamp. Other potential contaminants of concern, including thiocarbamates, aluminum, cadmium, copper, and zinc in sediment were also identified. Based upon results of subsequent examination, however, those compounds were found not to be contaminants of concern at this site (see Chapter 5).

## 5. CONTAMINANT FATE AND TRANSPORT

### 5.1 CONTAMINANT BEHAVIOR

Persistence and migration of chemicals in the environment are dependent upon physicochemical properties of the individual compounds. At Cold Creek Swamp, the following compounds were identified as potential contaminants of concern:

- . aluminum
- . cadmium
- . copper
- . zinc
- . mercury
- . thiocarbamates

The following sections discuss the environmental chemistry of these compounds as well as factors influencing whether or not each compound is considered a contaminant of concern for detailed evaluation.

#### 5.1.1 Aluminum

##### 5.1.1.1 Discussion

The Stage I chemical ranking model identified aluminum as a potential contaminant of concern in Cold Creek Swamp sediments (Section 6.2.1). It was believed that the aluminum levels observed in Stage I were representative of natural mineralogical structure of the sediments rather than anthropogenic activities. To further investigate aluminum as a potential contaminant of concern, a physical/mineralogical study of Cold Creek Swamp sediments was performed (Section 2.1.2.4). The complete mineralogical report, entitled "Sedimentary Analysis of Samples from Cold Creek Swamp, Alabama," is included in Appendix H.

Results of this study indicated that Cold Creek Swamp sediment in the Lower Swamp Zone contains Illite and Illite/Smectite clay as well as Kaolinite clay. The Illite and Illite/Smectite clay are representative of clay sources in the Mobile River drainage system, which has a large area underlain by soils enriched in aluminum oxides. Cation exchange capacity (CEC) is high for Illite (ca. 10-40 me/100 g) and Smectite (ca. 80-150 me/100 g). Based on the CEC levels, the pH data from Stages II and III, and physical and mineralogical analyses of sediment samples, the mineralogical report supports the conclusion that aluminum in Cold Creek Swamp is most likely associated with Mobile River sediments and not anthropogenic activities associated with the former Stauffer activities. The report indicated that ". . . aluminum is probably delivered to the lower swamp via overbank flooding from the Mobile, adsorbed to clay and/or organics, and remains there owing to low solubility."

To further confirm that aluminum observed in Cold Creek Swamp samples was not associated with industrial activities, measured aluminum concentrations in Cold Creek Swamp samples were compared to naturally occurring aluminum levels in typical soils as published in the literature. The aluminum concentrations in the lower swamp zone (287-31,600 mg/kg with an average of 18,300 mg/kg) compared very favorably to typical levels in natural soils as compiled by the EPA office of Solid Waste and Emergency Response (10,000-300,000 mg/kg with an average of 71,000 mg/kg) (EPA 1983). Furthermore, the Cold Creek levels also compare favorably with aluminum levels in loess and alluvium from the lower Mississippi River valley (10,000-50,000 mg/kg with an average of 38,000 mg/kg) (Miller, Lewis, et al. 1984). These data are most interesting since they are derived from Mississippi River alluvium samples collected in southern Louisiana. These data should be quite similar to what would be expected in Mobile River alluvium since both are similar river systems draining ecologically similar regions of the south central Gulf Coast. No specific data on Mobile River sediment aluminum concentrations was found.

#### 5.1.1.2 Conclusion--Aluminum

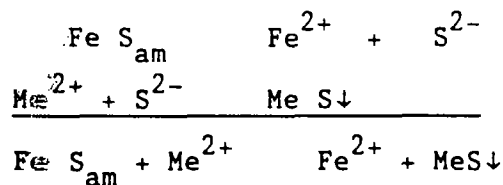
Based on this assessment, it is concluded that the source of aluminum to Cold Creek Swamp is not associated with Cold Creek or LeMoyne plant past or present industrial activities, but is actually naturally occurring, most likely as deposition from the Mobile River. Therefore, aluminum is not considered a contaminant of concern at this site.

#### 5.1.2 Cadmium, Copper, and Zinc

Recent studies have shown that toxicity of metals associated with sediments is directly influenced by the degree of metal binding onto these sediments (Shea 1988; DiToro et al. 1990 and 1992). There is strong evidence that metals in aqueous ecosystems are available for uptake when they are dissolved. Sediments and soils are made up primarily of silicates, oxides, and metals such as aluminum and zinc which are permanent solids. Metals bound within the sediment matrix do not represent bioavailable compounds. A methodology that has been developed to assess potential bioavailability of +2 valence state heavy metals (i.e., cadmium, copper, zinc) in sediments was used to assess conditions at Cold Creek Swamp. The methodology, known as acid volatile sulfide and simultaneously extracted metals (AVS-SEM), has been recommended by the EPA Office of Water: Office of Science and Technology for use in assessing contaminated sediments.

##### 5.1.2.1 AVS-SEM

During Stage II and Stage III sampling, estimates of potential metal toxicity were made based on AVS and SEM (DiToro et al. 1990, U.S. EPA 1991). Acid volatile sulfides represent amorphous iron sulfides present in the sediment, which are readily broken apart, releasing hydrogen sulfide ( $\text{H}_2\text{S}$ ).  $\text{H}_2\text{S}$  reacts with divalent metal ions ( $\text{Hg}^{2+}$ ,  $\text{Cd}^{2+}$ ,  $\text{Zn}^{2+}$ , and  $\text{Cu}^{2+}$ ) forming insoluble and non-biologically available metal sulfides (DiToro et al. 1990). The chemical reactions involved are as follows:



where

$\text{FeS}_{\text{am}}$  is amorphous iron sulfide,

$\text{Me}^{2+}$  represents  $\text{Hg}^{2+}$ ,  $\text{Cd}^{2+}$ ,  $\text{Zn}^{2+}$ , or  $\text{Cu}^{2+}$ , and

$\text{MeS}\downarrow$  is solid phase, non-biologically available metal sulfide.

When insufficient  $\text{H}_2\text{S}$  is present, excess metal (SEM) is available for organisms to take up. DiToro et al. (1990) presented data showing acute toxic effects on amphipods due to cadmium when cadmium SEM exceeded available sediment AVS. Those data, presented in Figure 5-1, show that acute toxicity rapidly increased when cadmium SEM/AVS ratios exceeded one and that toxicity was not present when ratios were below one. This process is additive for SEM; therefore, for Cold Creek analyses:

$$\text{SEM} = \Sigma[\text{Me}^{2+}] = [\text{Hg}^{2+}] + [\text{Cd}^{2+}] + [\text{Zn}^{2+}] + [\text{Cu}^{2+}]$$

Data shown in Figure 5-1 represent acute toxicity for amphipods due to cadmium. Similar data have been shown for blue mussel (Mytilus edulis), grass shrimp (Palaemonetes pugio), and hard shell clam (Mercenaria mercenaria) after exposure to sediment containing cadmium and copper (Rule and Alden 1990); amphipods, worms, and snails with marine and freshwater sediments spiked with cadmium, nickel, and zinc (Hansen et al. 1990); amphipods and oligochaetes exposed to nickel and cadmium (Ankley et al. 1991); and oligochaetes and snails exposed to cadmium (Carlson et al. 1991).

As a result of the ecological risk screening conducted at the completion of the Stage I field investigation, zinc, copper, and cadmium (all divalent metal ions) could not be eliminated from consideration as contaminants of concern (see discussion in Section 6.2). AVS-SEM



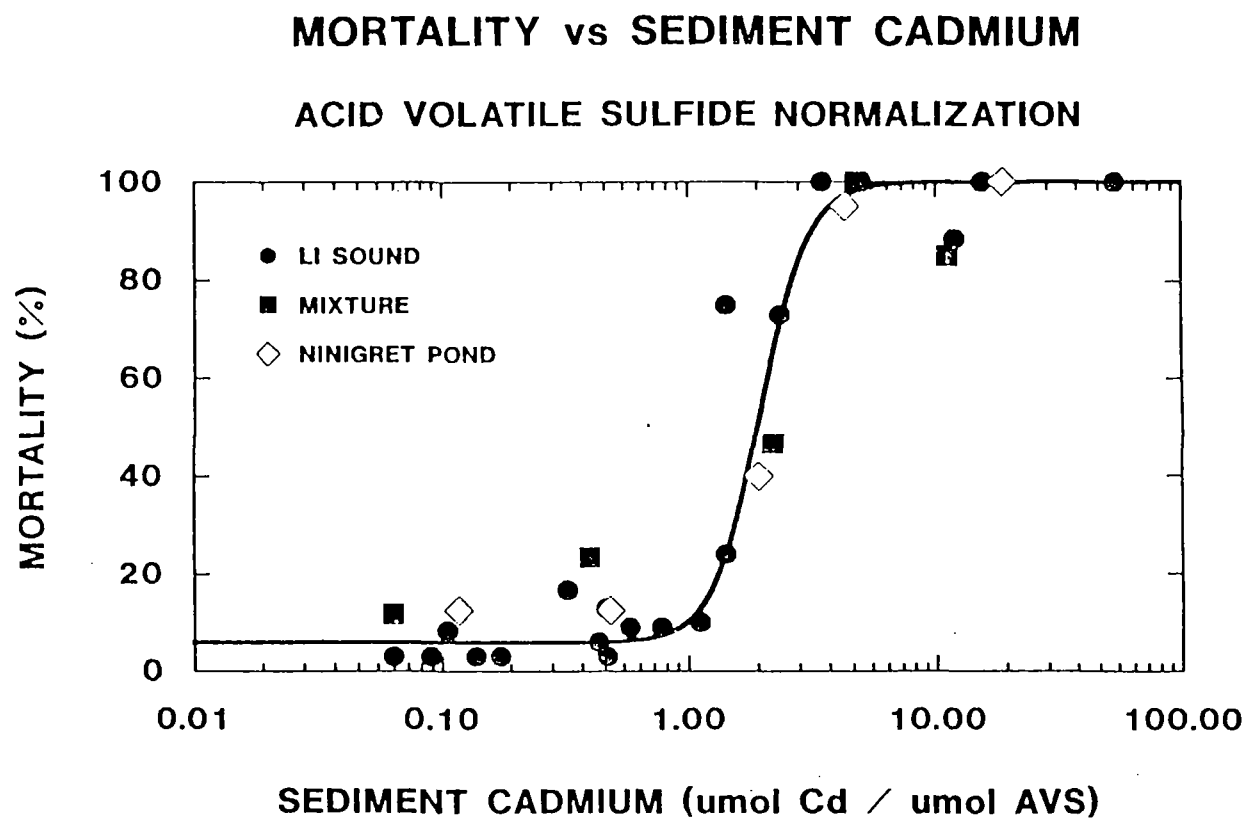


Figure 5-1. Amphipod mortality versus AVS normalized cadmium in Long Island Sound (saltwater) and Ninigret Pond (freshwater) sediment. (from DiToro et al. 1990).

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analyses were attempted as part of Stage II sampling at Cold Creek Swamp to provide additional information on the potential effects of these metals to the Cold Creek Swamp ecosystem.

#### 5.1.2.2 Stage II AVS-SEM Analyses

Due to experimental difficulties in performing AVS analyses, Stage II AVS data were not usable; however, Stage II SEM measurements for chemicals of potential concern were not adversely affected. These experiments showed that cadmium and mercury exhibited SEM concentrations that were less than or equal to 0.01  $\mu\text{mol/g}$  dry and zinc and copper had slightly higher SEM (highest for zinc, Station B-4, at 3.1  $\mu\text{mol/g}$  dry). Without concurrent AVS concentrations, ratios of total SEM to AVS could not be directly calculated. However, DiToro et al. (1990) had reported AVS concentrations for several freshwater systems ranging from 0.31  $\mu\text{mol/g}$  dry in Everglades peat basins to 112  $\mu\text{mol/g}$  dry in Lake Mendota. Most freshwater systems have AVS concentrations in the 20-40  $\mu\text{mol/g}$  dry range (DiToro et al. 1990; Crecelius and Lasorsa 1990). For comparative purposes, an AVS concentration of 20  $\mu\text{mol/g}$  dry sediment was selected as typical of freshwater ecosystems. Table 5-1 presents total SEM ( $[\text{Hg}^{2+}] + [\text{Cd}^{2+}] + [\text{Zn}^{2+}] + [\text{Cu}^{2+}]$ )/AVS ratios for the twenty Cold Creek Stations for which SEM was determined. These data show no potential bioavailability for inorganic mercury, cadmium, copper, or zinc. The selected AVS value (20  $\mu\text{mol/g}$ ) is at the low end of average values reported in the literature for AVS found in freshwater systems and therefore yielded conservative estimates of SEM/AVS ratios. The calculated SEM/AVS (based on AVS = 20  $\mu\text{mol/g}$  dry) averaged 0.018, and ranged from 0.0007 (Station B-5) to 0.159 (Station B-4).

Because total SEM/AVS ratios were significantly less than one, toxic effects from observed inorganic mercury, cadmium, zinc, or copper at Cold Creek Swamp were not expected to occur. However, mercury is unique among the metal potential contaminants of concern because of its ability to be readily methylated by bacteria. It is important to note that AVS-SEM interaction is an equilibrium process and that at any given point

TABLE 5-1 ESTIMATED  $\Sigma$ SEM/AVS RATIOS FOR STAGE II SAMPLES, COLD CREEK SWAMP, JUNE 1991

| <u>Station</u> | <u><math>\Sigma</math>SEM<sup>(a)</sup></u><br><u><math>\mu\text{mol/g dry}</math></u> | <u><math>\Sigma</math>SEM/AVS<sup>(b)</sup></u><br><u>Ratio</u> |
|----------------|----------------------------------------------------------------------------------------|-----------------------------------------------------------------|
| B-1            | 0.211                                                                                  | 0.011                                                           |
| B-2            | 0.052                                                                                  | 0.003                                                           |
| B-3            | 0.318                                                                                  | 0.016                                                           |
| B-4            | 3.186 <sup>(c)</sup>                                                                   | 0.159                                                           |
| B-5            | 0.014                                                                                  | 0.0007                                                          |
| B-6            | 0.598                                                                                  | 0.030                                                           |
| B-7            | 0.082                                                                                  | 0.004                                                           |
| B-8            | 0.098                                                                                  | 0.005                                                           |
| B-9            | 0.024                                                                                  | 0.001                                                           |
| B-10           | 0.026                                                                                  | 0.001                                                           |
| B-11           | 0.030                                                                                  | 0.002                                                           |
| B-12           | 0.207                                                                                  | 0.010                                                           |
| B-13           | 0.339                                                                                  | 0.017                                                           |
| B-14           | 0.347                                                                                  | 0.017                                                           |
| B-15           | 0.095                                                                                  | 0.005                                                           |
| B-16           | 0.935                                                                                  | 0.047                                                           |
| B-17           | 0.226                                                                                  | 0.011                                                           |
| B-18           | 0.054                                                                                  | 0.003                                                           |
| B-51           | 0.265                                                                                  | 0.013                                                           |
| B-54           | 0.053                                                                                  | 0.003                                                           |

(1)  $\Sigma$ SEM =  $[\text{Hg}^{2+}] + [\text{Cd}^{2+}] + [\text{Zn}^{2+}] + [\text{Cu}^{2+}]$ .

(2) Ratio based on AVS of 20  $\mu\text{mol/g dry}$ , typical of freshwater systems.

(3)  $\Sigma$ SEM is driven by zinc with 3.1  $\mu\text{mol/g dry}$  at this location.

in time there will be divalent mercury ions in solution. These ions are very susceptible to methylation, thereby accounting for the quantity of methyl mercury measured in Cold Creek Swamp sediments. For this reason mercury could not be eliminated as a contaminant of concern based on SEM/AVS results.

#### 5.1.2.3 Stage III AVS-SEM Analyses

Based on the fact that Stage II SEM/AVS calculations were made using an estimated value for AVS, SEM/AVS analyses were repeated during Stage III. In Stage III, a total of 20 samples were collected for analysis. The sample locations were selected to coincide with the Stage II SEM/AVS sample locations to the greatest extent practicable. Thus, Stage III sample "BB-4" was taken from approximately the same location as Stage II sample "B-4."

Results of Stage III AVS measurements, presented in Table 5-2, show a range of 2.5-75  $\mu\text{mol/g}$  dry, reflective of the various sediment environments found in Cold Creek Swamp. These data confirm that the assumed average AVS value of 20  $\mu\text{mol/g}$  dry in Stage II was within the range of actual measured values. Ratios of  $\Sigma\text{SEM/AVS}$  for all Stage III stations are shown in Table 5-2, and the geometric mean for all Stage III stations is presented graphically in Figure 5-2. Ratios of  $\Sigma\text{SEM/AVS}$  ranged over three orders of magnitude (0.005 at Station BB-2 to 0.13 at Station BB-6, Table 5-2) and averaged 0.014 (Figure 5-2).

As predicted based on the Stage II data, potential toxic effects at Cold Creek Swamp are not expected from observed inorganic mercury, cadmium, zinc, or copper because the total SEM/AVS ratios are significantly less than one.  $\Sigma\text{SEM/AVS}$  ratios eliminate concerns about inorganic mercury toxicity; however, organic bioaccumulative mercury was still considered to represent a potential concern for biota in Cold Creek Swamp due to both direct toxicity and/or bioaccumulation up food-chains.

TABLE 5-2 ACTUAL ESEM/AVS RATIOS FOR STAGE III SAMPLES, COLD CREEK SWAMP, OCTOBER 1991

| <u>Station</u> | <u>ESEM</u><br><u>(<math>\mu</math>mol/g dry)</u> | <u>AVS</u><br><u>(<math>\mu</math>mol/g dry)</u> | <u>ESEM/AVS</u><br><u>Ratio</u> |
|----------------|---------------------------------------------------|--------------------------------------------------|---------------------------------|
| BB-1           | 0.549                                             | 8.65                                             | 0.0645                          |
| BB-2           | 0.005                                             | 3.89                                             | 0.005                           |
| BB-3           | 0.774                                             | 7.20                                             | 0.107                           |
| BB-4           | 1.37                                              | 74.5                                             | 0.018                           |
| BB-5           | 0.004                                             | 5.17                                             | 0.0007                          |
| BB-6           | 4.22                                              | 34.4                                             | 0.122                           |
| BB-7           | 0.044                                             | 3.31                                             | 0.014                           |
| BB-8           | 0.067                                             | 6.69                                             | 0.010                           |
| BB-9           | 0.030                                             | 3.49                                             | 0.009                           |
| BB-10          | 0.054                                             | 2.45                                             | 0.022                           |
| BB-11          | 0.105                                             | 8.90                                             | 0.012                           |
| BB-12          | 0.214                                             | 7.01                                             | 0.031                           |
| BB-13          | 0.337                                             | 12.5                                             | 0.027                           |
| BB-14          | 0.116                                             | 5.49                                             | 0.021                           |
| BB-15          | 0.091                                             | 4.39                                             | 0.021                           |
| BB-16          | 0.053                                             | 4.38                                             | 0.012                           |
| BB-17          | 0.039                                             | 5.58                                             | 0.007                           |
| BB-18          | 0.167                                             | 20.2                                             | 0.008                           |
| BB-51          | 0.058                                             | 7.79                                             | 0.007                           |
| BB-54          | 0.031                                             | 4.18                                             | 0.008                           |

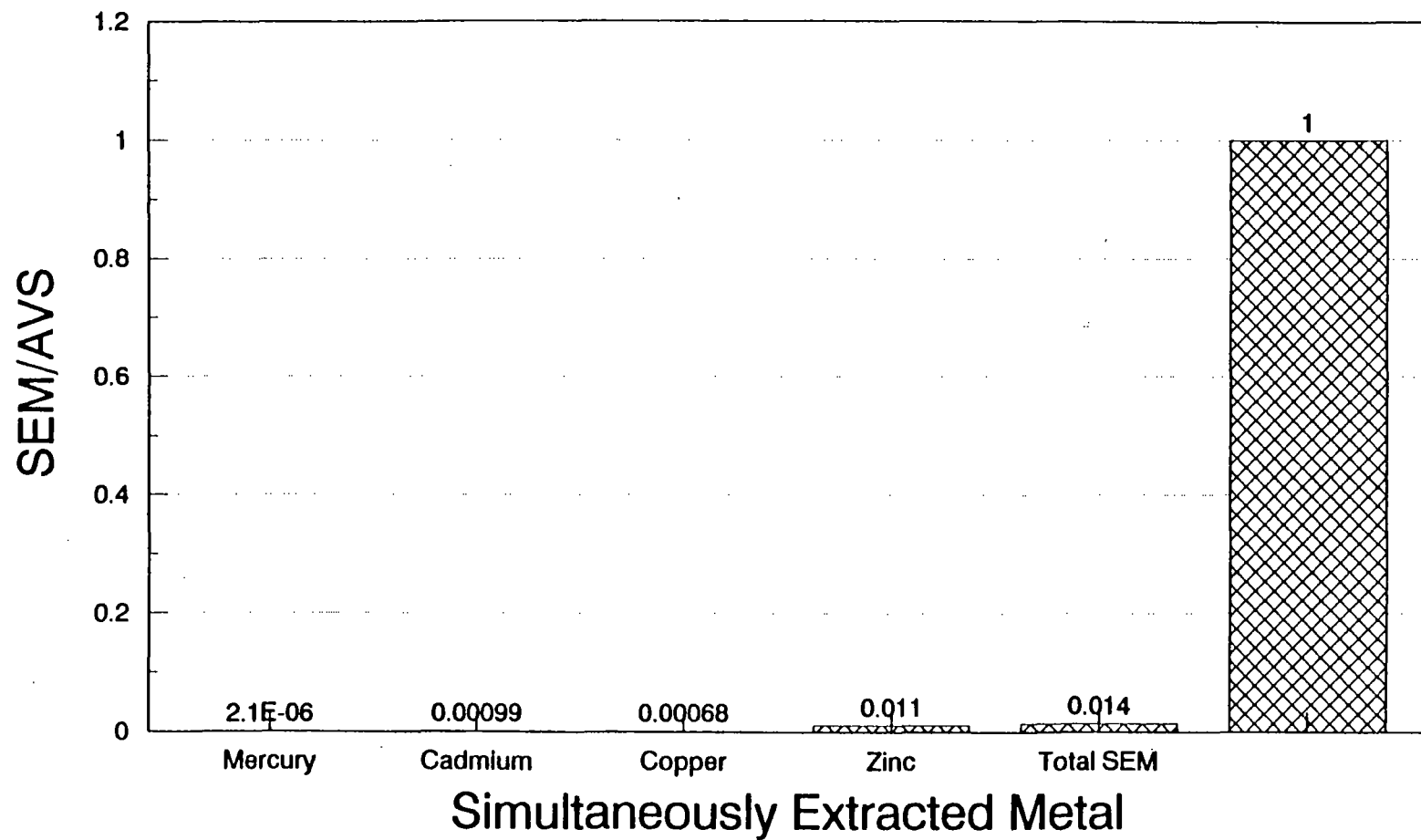


Figure 5-2. Comparison of Stage III SEM/AVS ratios.

3 10 0166



#### 5.1.2.4 Conclusion--Cadmium, Copper, and Zinc

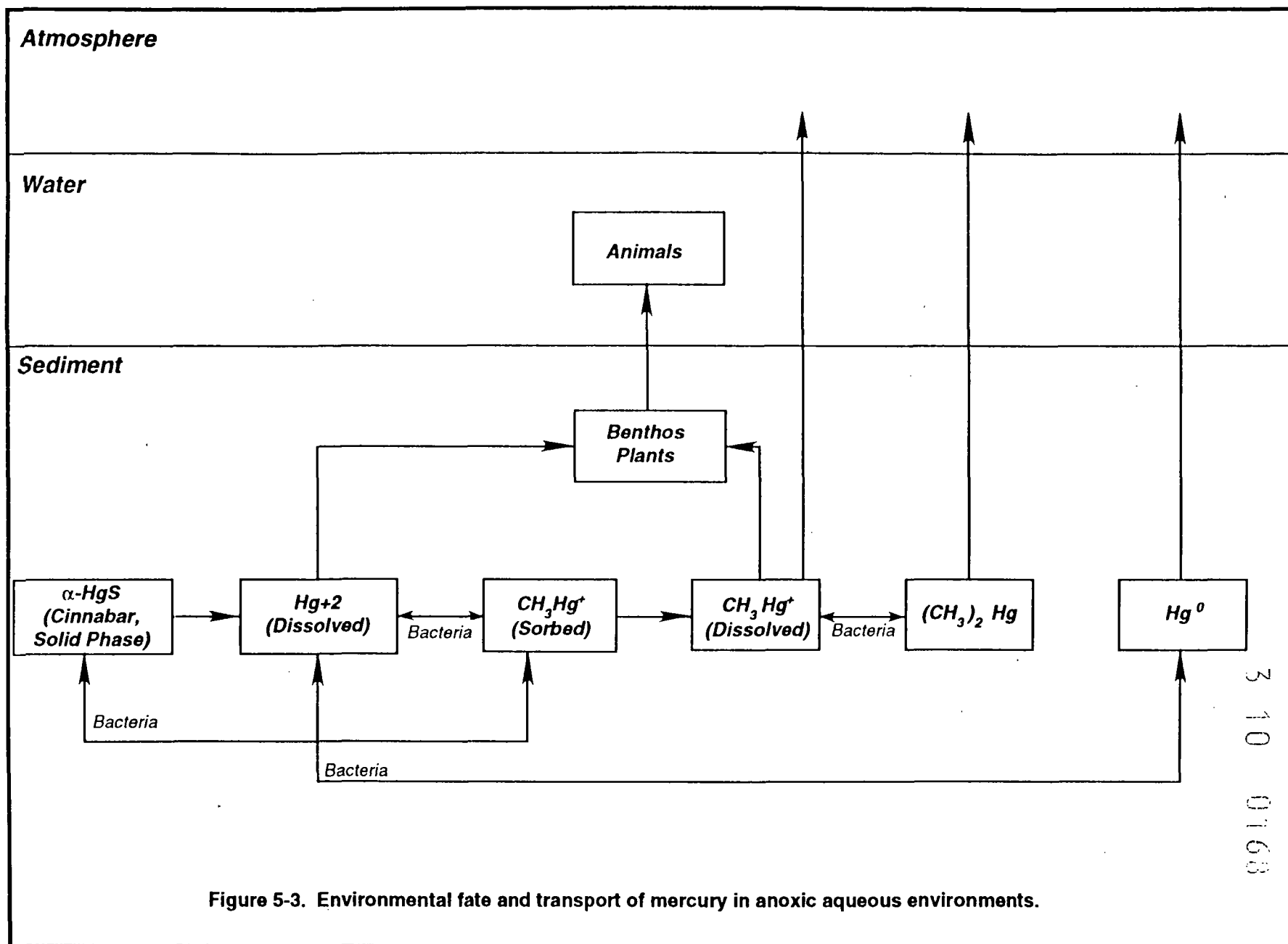
Based on the data presented in Table 5-2 and Figure 5-2, it is apparent that SEM/AVS ratios were substantially less than one. Consequently, it can be stated that toxic effects from observed inorganic cadmium, copper, and zinc are not expected to occur.

#### 5.1.3 Environmental Behavior of Mercury

Environmental fate and transport of mercury is dependent upon factors that affect metal speciation such as Eh (redox potential), pH, temperature, and reactivity and solubility of parent metal and products of metal reactions, as well as microbiological methylation-demethylation. Figure 5-3 characterizes mercury's fate and transport in an anoxic (low oxygen, low Eh) environment such as Cold Creek Swamp. A meaningful estimate of biotic exposure depends on not only the concentration of inorganic mercury ( $\text{Hg}^{2+}$ ) but also that of methyl mercury ( $\text{CH}_3\text{Hg}^+$ ). During the course of chemical and biological transformations, dimethyl mercury [ $(\text{CH}_3)_2\text{Hg}$ ] and elemental mercury ( $\text{Hg}^0$ ) may also be formed. These latter compounds are volatile under environmental conditions typical of those in Cold Creek Swamp and are quickly lost to the atmosphere. To a lesser degree methyl mercury may also be lost to the atmosphere, but the proportion volatilized is expected to be small. The following parts of this section discuss some of what is presently known regarding the transport and fate of mercury in the environment.

##### 5.1.3.1 Mercuric Sulfide ( $\text{HgS}$ )

Section 5.1.2 discussed AVS-SEM, both in general terms and specifically related to data from Cold Creek Swamp. It is expected that the vast majority of inorganic mercury found in Cold Creek Swamp exists in the stable and nontoxic  $\alpha$ - $\text{HgS}$  (cinnabar) mineral form of mercury sulfide (DiToro et al. 1992; DiToro et al. 1990; D'Itri 1990; Brown et al. 1979; Jernelov and Asell 1975; Fagerstrom and Jernolov 1972). Cinnabar is an extremely insoluble solid [solubility product constant,  $K_{sp} = 10^{-53}$



3 10 0168



(D'Itri 1990; DiToro et al. 1990)] under anoxic conditions such as those found in Cold Creek Swamp. Breteler and Saksa (1985) reported that uptake of mercury by mussels was directly related to the amount of acid-leachable metal, a direct corollary of SEM.

#### 5.1.3.2 Organic Mercury

There are many forms of organic mercury, including ethyl-, phenyl-, and methyl-mercury; however, because of the instability of most of the organic mercury forms, methyl mercury constitutes the organic mercury of primary concern to biota. Formation of dimethyl mercury is favored under basic conditions (pH greater than 8.0) while acidic and neutral conditions favor formation of monomethyl mercury (Beijer and Jernelov 1979). The pH conditions in Cold Creek Swamp favor the formation of monomethyl mercury (Tables 3-8, 3-10, 3-20, 3-21, and 3-28). As discussed earlier, dimethyl mercury is rapidly transported to the atmosphere and is consequently of little concern to biota within the swamp ecosystem. Methyl mercury production is a consequence of competing microbiological methylation and demethylation of inorganic mercury (D'Itri 1990). Methyl mercury is produced by aerobes, facultative anaerobes, and anaerobes; therefore, methyl mercury can be formed in environments containing or devoid of oxygen (Beijer and Jernelov 1979). The efficiency of these methylation processes is dependent upon the metabolic activity of bacteria and total concentration of mercury available for methylation. At sufficiently high concentrations, mercury produces toxic effects on methylating bacteria, thus methylation can be expected to decrease or even cease at high mercury concentrations (Beijer and Jernelov 1979). Within aquatic environments usually less than 0.1 percent of total mercury exists as methyl mercury (D'Itri 1990). Methylation processes are highest in surface sediments and decrease with sediment depth (Korthals and Winfrey 1987; Callister and Winfrey 1986; Jernelov 1970). Methylation processes exhibit a seasonal effect with greatest production in the summer (Korthals and Winfrey 1987; Callister and Winfrey 1986), indicative of increased microbiological activity at higher temperatures. It has been observed that methylation also increases as pH decreases

(Winfrey and Rudd 1990; Xun et al. 1987). Regnell (1990) reported increased methyl mercury production in reduced sediment (low Eh). Bartlett and Craig (1981) noted significant correlations between sediment organic carbon and silt content and higher methyl mercury production, presumably due to use of organic matter as a food source by methylating bacteria. Similar correlations were observed in Cold Creek Swamp which can be used to estimate methyl mercury concentrations (Section 6.2.3).

#### 5.1.3.3 Sorption of Mercury

Sorption studies of inorganic mercury have shown that dissolved inorganic mercury ( $\text{Hg}^{2+}$ ) adsorbs onto many substrates, including clay matrices such as kaolinite, montmorillonite, and illite, sand and organics such as steric acid, amines, and thiols (Reimers and Krenkel 1974, 1975). Thanabalasingam and Pickering (1985) reported on the sorption of inorganic mercury onto humic acids.

Studies have also shown that methyl mercury adsorbs to similar substrates as inorganic mercury (Reimers and Krenkel 1974; Jernelov and Asell 1975) as well as to dissolved organic carbon (Miskimmin 1991).

#### 5.1.3.4 Conclusion--Mercury

Mercury is considered to be the primary contaminant of concern at Cold Creek Swamp, primarily due to concerns for bioaccumulation.

#### 5.1.4 Thiocarbamates

##### 5.1.4.1 Thiocarbamate Chemistry

Although thiocarbamate herbicides were not identified as contaminants of concern (Section 6.2.1.2), the physical fate and transport parameters for these compounds have been examined. Physical properties of the compounds are provided in Table 5-3. Fate, transport, and persistence of these herbicides are not well characterized; however, it is known that they

TABLE 5-3 PHYSICAL PROPERTIES OF THIOCARBAMATES<sup>(a)</sup>

| Common Name | Chemical Name                               | Molecular Weight (g/mol) | Vapor Pressure (mm Hg at 25°C) | Solubility (ppm) | K <sub>oc</sub> <sup>(b)</sup> |
|-------------|---------------------------------------------|--------------------------|--------------------------------|------------------|--------------------------------|
| Butylate    | S-ethyl diisobutyl-thiocarbamate            | 217.4                    | 0.0013                         | 45               | 1,304                          |
| Cycloate    | S-ethyl N-ethylcyclohexyl-thiocarbamate     | 215.4                    | 0.0062                         | 85               | 729                            |
| EPTC        | S-ethyl dipropyl-thiocarbamate              | 189.3                    | 0.155                          | 375              | 286                            |
| Molinate    | S-ethyl hexahydro-1H-azepine-1-carbothioate | 187.3                    | 0.0056                         | 800              | 244                            |
| Pebulate    | S-propyl butylethyl-thiocarbamate           | 203.3                    | 0.0048                         | 92               | 657                            |
| Vernolate   | S-propyl dipropylthio-1-carbothioate        | 203.4                    | 0.0104                         | 107              | 766                            |

(a) From Fang 1975, unless otherwise noted.

(b) Miller 1991.

volatilize to the atmosphere relatively rapidly, have a high solubility, and tend not to strongly associate with sediment organic carbon. There are few data available on the persistence of thiocarbamates in sediments or soils.

Loss of the thiocarbamate EPTC from soils is correlated with evaporation of soil moisture (Fang 1975). During the first 15 minutes after spraying on soil surface, 20 percent of EPTC disappeared from dry soil, 27 percent from moist soil, and 44 percent from wet soil. After 6 days the loss rate was 44, 68, and 90 percent from dry, moist, and wet soils, respectively (Fang 1975). Of the five thiocarbamates tested, cycloate was the least volatile, followed by molinate, pebulate, vernolate, and EPTC. Temperature and moisture affected the rates of volatilization for these compounds. Less thiocarbamate mass volatilized from dry soil, and the rate was not as affected by temperature relative to moist and wet soils. Adsorption onto soil and soil organic carbon decreased rates of volatilization of thiocarbamates (Fang 1975). Application instructions of several thiocarbamates recommend incorporation of the herbicides to a depth of 2-4 in. immediately after application to decrease losses due to volatilization [Fang 1975; U.S. Department of Defense (DOD) 1970].

Soil microorganisms play a key role in degradation of thiocarbamates in soils. EPTC, butylate, cycloate, molinate, and vernolate all disappear more rapidly in nonautoclaved soil than in autoclaved soil (Fang 1975). N-dealkylation (loss of an alkyl group, i.e.  $-\text{CH}_2-\text{CH}_2-\text{CH}_3$  in vernolate) was a significant detoxification reaction carried out by micro-organisms (Bollag and Liu 1990). Thiocarbamates are also susceptible to a physico-chemical breakdown by hydrolysis of the carbonyl C=O double bond (Wolfe et al. 1990; Drossman et al. 1988).

Thiocarbamate herbicides are not strongly bioconcentrated into organisms, particularly when compared to the highly bioconcentratable chlorinated pesticides such as p,p'-DDT (Figure 5-4). For this reason, accumulation of the herbicides into food chains, is not expected. If toxic effects are expected to be observed for the thiocarbamate herbicides,

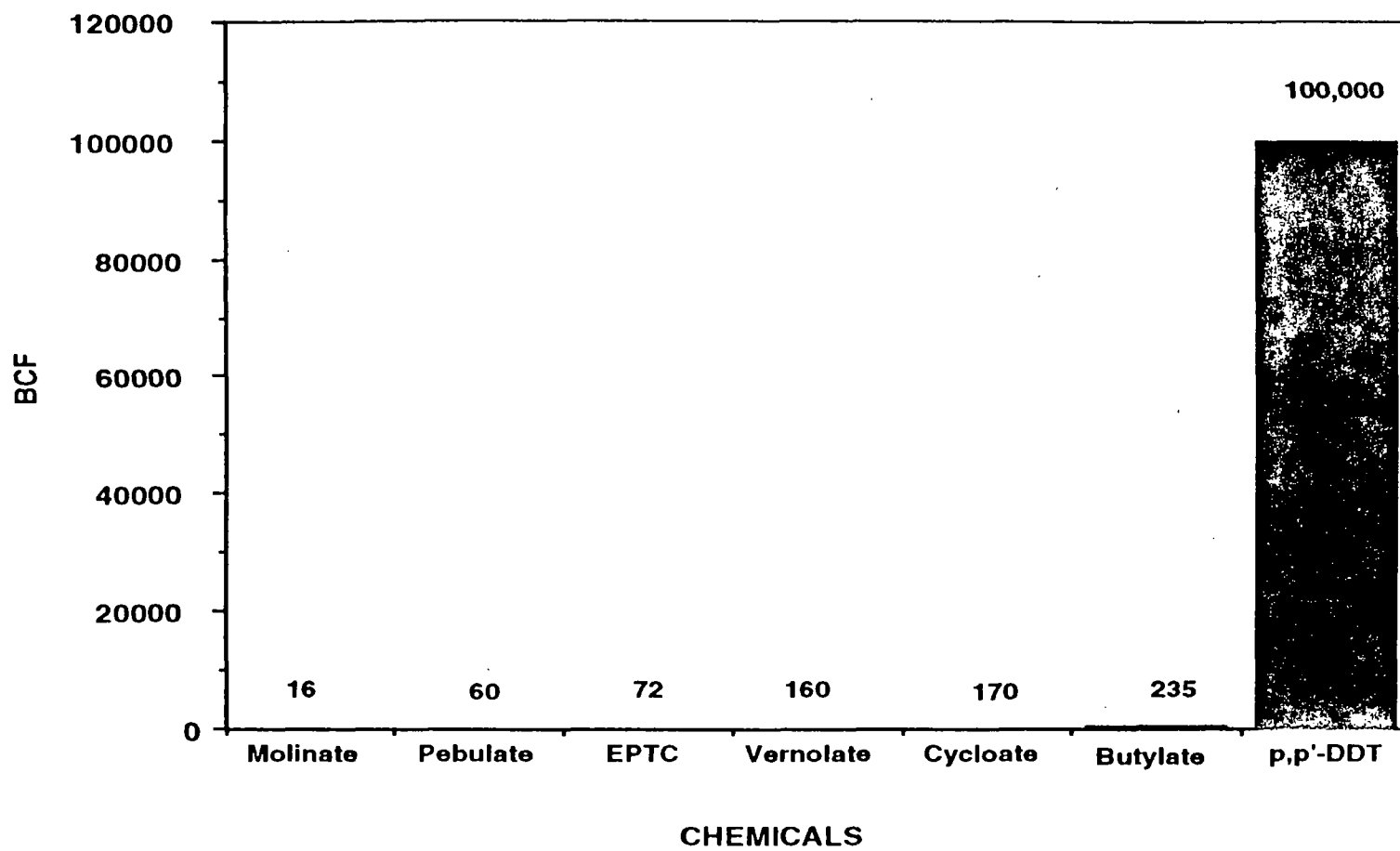


Figure 5-4. Comparison of thiocarbamate herbicides with DDT bioconcentrations factors.

they are expected to be seen in acute or chronic toxicity events. A thorough review of the available toxicity data has been performed and is presented in Appendix J. At levels found, and based upon observations of biota, toxic effects are not expected.

#### 5.1.4.2 Thiocarbamate Analysis

As a part of the Stage I ecological risk analysis (methodology described in Section 6.2), thiocarbamates along with compounds or elements detected in Stage I were considered in the contaminants-of-concern analysis. This analysis was conducted using sorption onto organic carbon with an assumed percent organic carbon of 4 percent to estimate the bioavailable fraction of each chemical. Subsequent to this analysis, site-specific TOC has been obtained, the results of which are shown in Table 3-19 (Stage II) and Table 3-27 (Stage III). Sediment thiocarbamate concentrations reported in Stage I were re-analyzed based on the swamp-wide geometric mean of these TOC data (0.85 percent). The following equation was used to again estimate pore water concentrations (the geometric means of  $F_{oc}$  and sediment thiocarbamate concentrations were calculated and used to then calculate equilibrium pore water estimates for the whole swamp):

$$K_d = K_{oc} F_{oc} = (C_{\text{sediment}} / C_{\text{water}})$$

where

$K_d$  is the sediment-water partition coefficient,

$K_{oc}$  is the organic carbon-water partition coefficient,

$F_{oc}$  is the fraction organic carbon of the sediment,

$C_{\text{sediment}}$  is the equilibrium sediment concentration of chemical, and

$C_{\text{water}}$  is the equilibrium pore-water concentration of chemical.

However, it can be seen from Table 5-4 that pore water (interstitial water) concentrations determined by this calculation are two or more orders of magnitude above the method detection limit. As can be seen from Table 5-5, there were no detectable levels of thiocarbamates in surface water samples. Comparison of estimated pore-water concentrations

TABLE 5-4 THIOCARBAMATE ANALYSIS, COLD CREEK SWAMP (ALL ZONES)

| <u>Chemical Name</u> | <u>Sediment<br/>Concentration<br/>(<math>\mu\text{g/kg dry}</math>)<br/>(Geometric Mean)</u> | <u>Predicted<br/>Equilibrium<br/>Pore Water<br/>Concentration<br/>(<math>\mu\text{g/L}</math>)</u> | <u>Chronic<br/>Endpoint<br/>(<math>\mu\text{g/L}</math>)</u> | <u>Toxic<br/>Quotient</u> |
|----------------------|----------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|--------------------------------------------------------------|---------------------------|
| Butylate             | 308                                                                                          | 25.9                                                                                               | 360                                                          | 0.07                      |
| Cycloate             | 251                                                                                          | 37.8                                                                                               | 260                                                          | 0.15                      |
| EPTC                 | 156                                                                                          | 59.9                                                                                               | 1,450                                                        | 0.04                      |
| Molinate             | 127                                                                                          | 57.2                                                                                               | 18                                                           | 3.2                       |
| Pebulate             | 78                                                                                           | 13.0                                                                                               | 210                                                          | 0.06                      |
| Vernoloate           | 176                                                                                          | 25.2                                                                                               | 23                                                           | 1.10                      |

Note:  $F_{oc} = 0.0085$ --Geometric mean for entire swamp.

TABLE 5-5 DETECTION LIMITS FOR AQUEOUS DETERMINATION OF THIOCARBAMATE CONCENTRATIONS ( $\mu\text{g/L}$ )

| <u>Thiocarbamate</u> | <u>MDL (a)</u> | <u>Observed<sup>(b)</sup><br/>Surface Water<br/>Concentration<br/>(<math>\mu\text{g/L}</math>)</u> |
|----------------------|----------------|----------------------------------------------------------------------------------------------------|
| Butylate             | 0.10           | ND                                                                                                 |
| Cycloate             | 0.20           | ND                                                                                                 |
| EPTC                 | 0.24           | ND                                                                                                 |
| Molinate             | 0.08           | ND                                                                                                 |
| Pebulate             | 0.09           | ND                                                                                                 |
| Vernolate            | 0.15           | ND                                                                                                 |

(a) Method Detection Limit.

(b) All thiocarbamates were "not detected" in any of the Stage I surface water sample analyses.



with method detection limits is shown visually in Figure 5-5. Actual exposure in the environment includes various dilution mechanisms. The actual exposure concentrations are much lower than pore water concentrations and more accurately represented by actual water column measurements. Therefore, toxic quotients from the six thiocarbamate compounds were calculated utilizing the MDLs and the chronic endpoints. In all cases, the toxic quotients were well below 1.0. Had calculated pore water concentrations been utilized instead, only molinate and vernolate would have exceeded toxic quotient values of 1.0.

#### 5.1.4.3 Conclusion--Thiocarbamates

Contaminant of concern selection (Section 6.2.1.2) was made based on a combination of three factors: toxic quotients, bioconcentration potential, and frequency of detection. The multi-parameter approach to COC identification is designed to ensure that uncertainty in assumptions, for example, single high or low values for any parameter, do not bias results. Thus, the approach is robust with respect to assumptions and uncertainty. In particular, the ratio of toxicity to exposure, bioaccumulation potential, and ubiquity (frequency of detection) provide a site-specific integrated evaluation of the potential fate and effects of compounds in the environment. Based on this analysis it was suggested that no thiocarbamate herbicides needed to be considered as contaminants of potential concern. As aquatic sediments in Cold Creek Swamp are strongly anoxic, biota are primarily epibenthic or water-column inhabitants. The further analysis provided above also concludes that no toxic effects due to thiocarbamates are expected for biota in overlying water in Cold Creek Swamp.

Because of the environmental behavior of the thiocarbamates, i.e., they are not strongly bioaccumulated, and a lack of any expected toxic effects due to exposure, thiocarbamates are not considered as potential contaminants of concern.

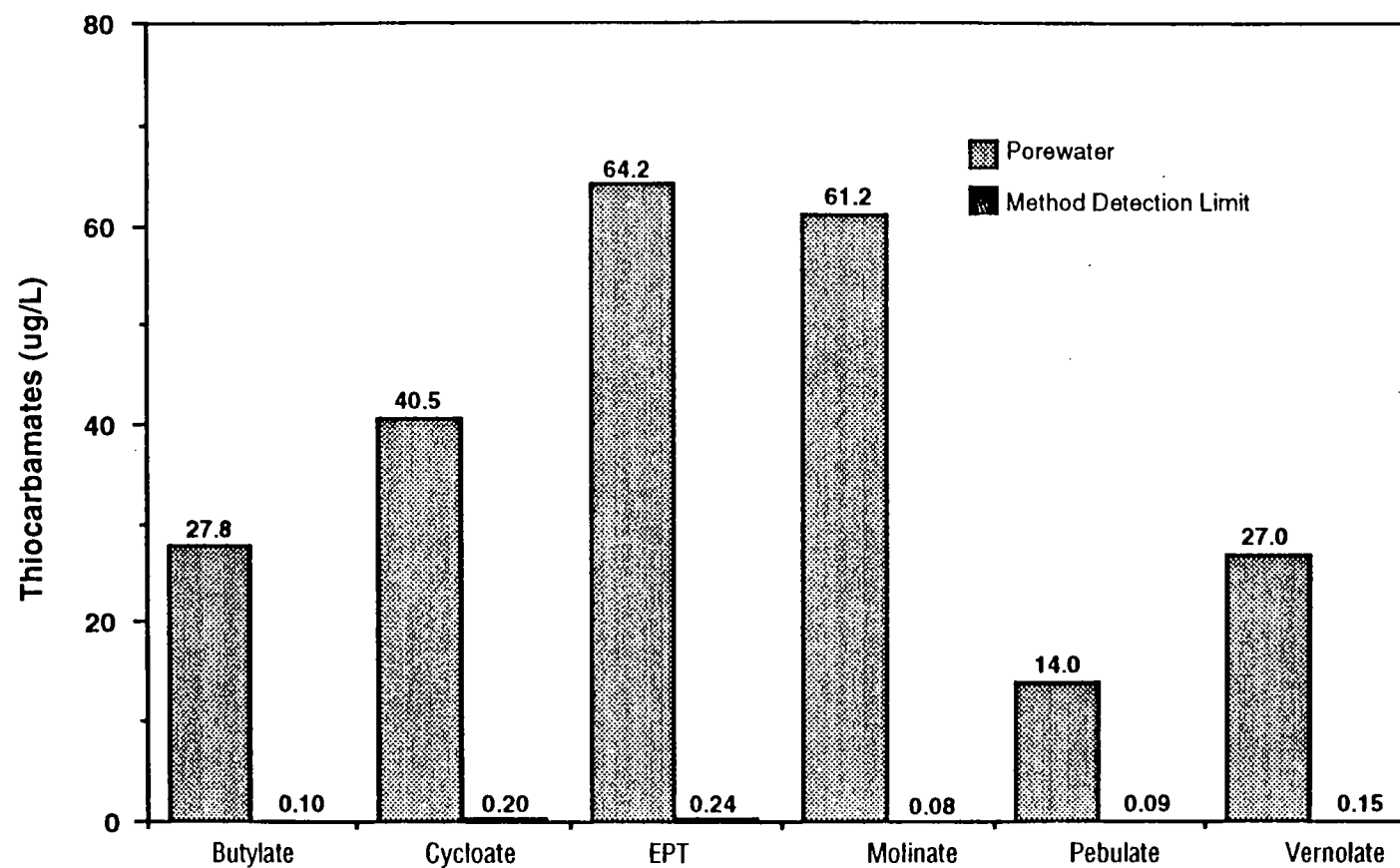


Figure 5-5. Comparison of estimated thiocarbamate porewater concentrations with detection limits.

## 5.2 POTENTIAL ROUTES OF MIGRATION

### 5.2.1 Chemical Transformation of Mercury

Chemical transformation of mercury to methyl mercury is an important contaminant transport pathway with regard to Cold Creek Swamp.

Two routes of mercury exposure have been identified. Chemicals can be taken up directly from the abiotic environment, for example, from water passing across fish gill membranes. Chemicals are also taken up in food, a route of exposure particularly important to upper trophic levels. Modeling body burdens, followed by validation and calibration using measured body burdens obtained during Stage III, negates the need to differentiate the two paths of exposure for practical risk assessment purposes, because both pathways are included in the evaluation. Risk management decisions, however, require some idea of direct exposure to determine if risks are increased by potential remediation. For this reason, methyl mercury exposure has been estimated based on known methyl Bmercury sediment concentrations and sediment-water partition coefficients.

Methyl mercury measured in stations B-1 through B-18 is shown in Table 5-6. Reimers and Krenkel (1974) determined the sediment-water partition coefficient for methyl mercury on the clays illite and montmorillonite. Methyl mercury sorption-desorption was estimated using montmorillonite, which sorbed less methyl mercury. Thus, these estimates are conservative, as other clay forms dominate in Cold Creek Swamp sediments (discussion above). The partition coefficient for methyl mercury to montmorillonite was estimated as 34 (Reimers and Krenkel 1974). Using the interstitial water mercury concentrations for Cold Creek Swamp (Table 5-6),

$$K_d = \frac{[\text{methyl mercury}] \text{ sediment}}{[\text{methyl mercury}] \text{ pore water}}$$

3 10 0178

TABLE 5-6 ESTIMATED DISSOLVED METHYL MERCURY CONCENTRATIONS

| <u>Station</u> | <u>Measured<br/>Methyl Mercury<br/>(<math>\mu\text{g/kg dry}</math>)</u> | <u>Estimated Interstitial<br/>Dissolved Methyl Mercury<br/>(<math>\mu\text{g/L}</math>)</u> |
|----------------|--------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| B-1            | 204                                                                      | 6                                                                                           |
| B-2            | 5.13 u                                                                   | 0.2                                                                                         |
| B-3            | 33.3                                                                     | 1.0                                                                                         |
| B-4            | 98.7                                                                     | 2.9                                                                                         |
| B-5            | 4.87 u                                                                   | 0.1                                                                                         |
| B-6            | 197                                                                      | 5.8                                                                                         |
| B-7            | 5.09 u                                                                   | 0.2                                                                                         |
| B-8            | 359                                                                      | 10.5                                                                                        |
| B-9            | 4.94 u                                                                   | 0.2                                                                                         |
| B-10           | 4.87 u                                                                   | 0.1                                                                                         |
| B-11           | 13.4                                                                     | 0.4                                                                                         |
| B-12           | 187                                                                      | 5.5                                                                                         |
| B-13           | 332                                                                      | 9.8                                                                                         |
| B-14           | 28.6                                                                     | 0.8                                                                                         |
| B-15           | 36.3                                                                     | 1.1                                                                                         |
| B-16           | 5.28 u                                                                   | 0.2                                                                                         |
| B-17           | 166                                                                      | 4.9                                                                                         |
| B-18           | 34.5                                                                     | 1.0                                                                                         |

where [methyl mercury] sediment is the sediment concentration ( $\mu\text{g/kg}$  dry) and [methyl mercury] water is the equilibrium interstitial water concentration.

The methylation and demethylation of mercury in Cold Creek Swamp is an important contaminant transport pathway. The impact of methylation-demethylation on ecological risk evaluation is discussed in Sections 6.2.2.3 and 6.2.3.1.

#### 5.2.2 Sediment and Surface Water

Hydrogeologic transport of mercury through sediment deposition and surface water flow is another potential contaminant transport pathway. Sediment and surface water transport can be assessed based on physical conditions and on analytical considerations. This assessment is provided in the following sections.

##### Physical Conditions Considerations

As part of this study, field observations of swamp hydrology, including water level, and flow characteristics were made on five separate occasions.

|               |                           |
|---------------|---------------------------|
| August 1990   | Initial Conditions Survey |
| February 1991 | Stage I Field Work        |
| June 1991     | Stage II Field Work       |
| October 1991  | Stage III Field Work      |
| April 1992    | EPA-RPM Onsite Briefing   |

It is evident that this distribution allowed the field team to observe conditions during spring (April 1992), summer (August 1990 and June 1991), fall (October 1991), and winter (February 1991). Furthermore, the distribution allowed the team to observe a variety of hydrological conditions, as shown in Table 5-7.

TABLE 5-7 OBSERVATIONS OF FIELD CONDITIONS ASSOCIATED WITH SITE HYDROGEOLOGY

| Visit No. | Description               | Date          | Season      | Weather Conditions                                                                                                                                                                           | Site Conditions                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|-----------|---------------------------|---------------|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1         | Initial Conditions Survey | August 1990   | Summer      | <ul style="list-style-type: none"> <li>. very hot and dry (90°)</li> <li>. very dry summer preceding site visit</li> </ul>                                                                   | <ul style="list-style-type: none"> <li>. heavy vegetation (overgrown)</li> <li>. water level very low</li> <li>. pools in upper swamp and lower swamp</li> <li>. majority of upper and lower swamp dry except for pools</li> <li>. middle swamp zone Cold Creek channel dry</li> <li>. no flowing water</li> <li>. outfall water level low, minimal flow from river to swamp</li> </ul>                                                                                                                                                                                |
| 2         | Stage I Field Work        | February 1991 | Late winter | <ul style="list-style-type: none"> <li>. cool temperatures (50°±)</li> <li>. December 1990 and January 1991 were relatively rainy</li> </ul>                                                 | <ul style="list-style-type: none"> <li>. average winter vegetation</li> <li>. water level 0.5-1.35 ft in upper swamp zone ponds</li> <li>. middle swamp zone Cold Creek channel dry</li> <li>. outfall water level low, no visible flow</li> </ul>                                                                                                                                                                                                                                                                                                                     |
| 3         | Stage II Field Work       | June 1991     | Summer      | <ul style="list-style-type: none"> <li>. warm to hot (80-90°)</li> <li>. preceding 3 months considerably higher than normal precipitation</li> <li>. river stage at site up 5 ft±</li> </ul> | <ul style="list-style-type: none"> <li>. heavy vegetation</li> <li>. water level 0.5-3.5 ft in upper swamp zone ponds</li> <li>. water level 2.5 ft in middle swamp zone</li> <li>. water level 5 ft± throughout lower swamp zone, back toward power line cuts</li> <li>. Mobile River overbank flooding backed up into lower swamp zone-flooded all of lower swamp zone and raised water levels in Cold Creek back to Virginia Chemicals bridge (SB-2) in middle swamp zone</li> <li>. as river stage dropped, low flow rate observed in middle swamp zone</li> </ul> |
| 4         | Stage III Field Work      | October 1991  | Fall        | <ul style="list-style-type: none"> <li>. mild to hot (70-85°)</li> <li>. no rain during field work</li> </ul>                                                                                | <ul style="list-style-type: none"> <li>. water level 0.8-2.5 ft in upper swamp zone pools</li> <li>. middle swamp zone Cold Creek channel dry</li> <li>. no flowing water observed in Cold Creek channel</li> <li>. lower swamp zone ponds at average depth 2.5 ft±</li> <li>. no visible flow from swamp to Mobile River</li> </ul>                                                                                                                                                                                                                                   |

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0130

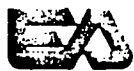
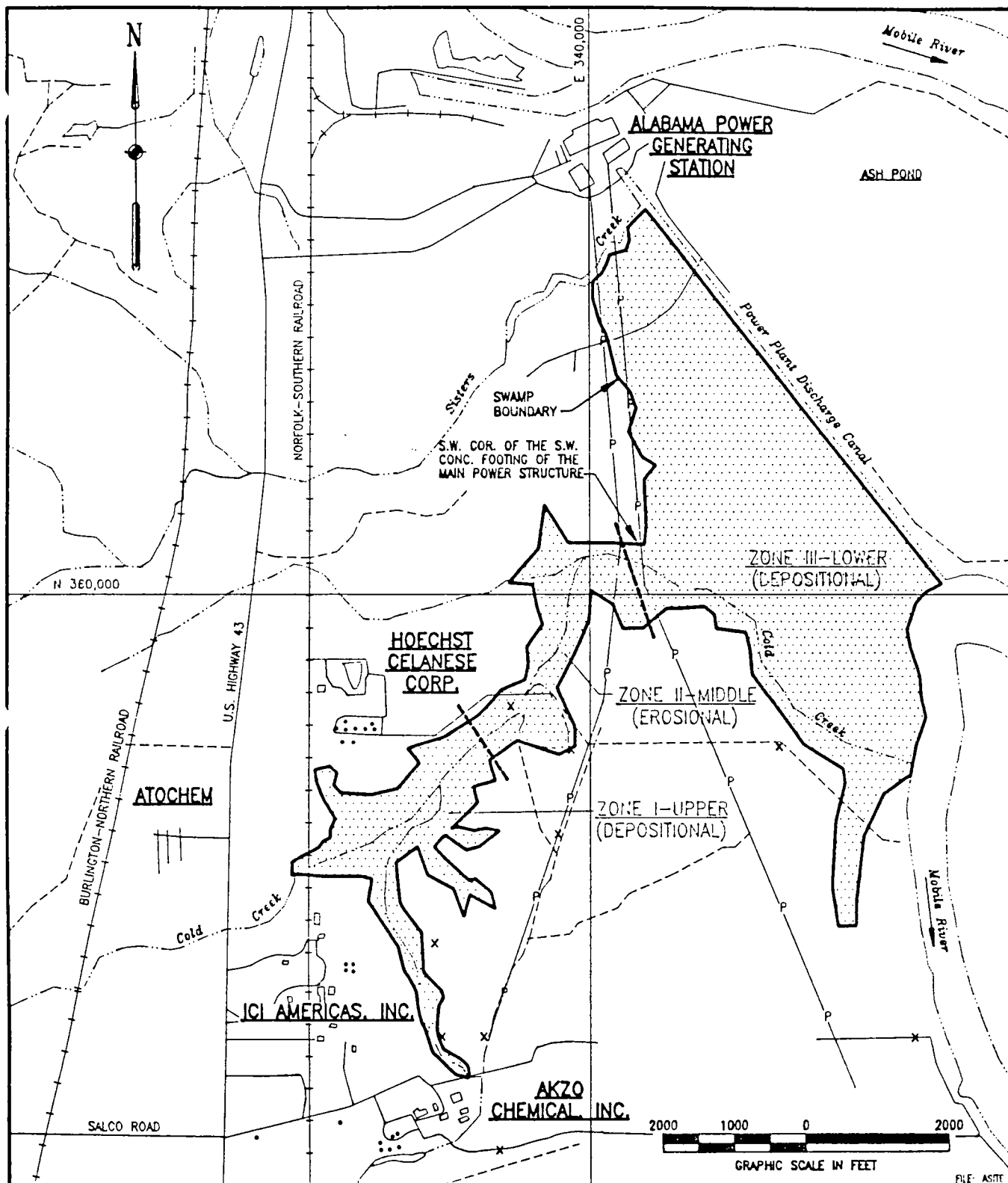
TABLE 5-7 OBSERVATIONS OF FIELD CONDITIONS ASSOCIATED WITH SITE HYDROGEOLOGY

| Visit No. | Description             | Date       | Season | Weather Conditions                                                                                                                                                    | Site Conditions                                                                                                                                                                                                                                                                                                                                                                             |
|-----------|-------------------------|------------|--------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5         | EPA-RPM Onsite Briefing | April 1992 | Spring | <ul style="list-style-type: none"><li>. mild and pleasant (60-70°)</li><li>. clear, cloudless</li><li>. average precipitation level during preceding winter</li></ul> | <ul style="list-style-type: none"><li>. vegetation not yet overgrown</li><li>. ponds in upper and lower swamp zone at average depth</li><li>. middle swamp zone Cold Creek channel dry except at Virginia Chemicals bridge where ponded due to downstream beaver dam</li><li>. no visible flow from swamp to Mobile River. Two beaver dams immediately upstream of outfall point.</li></ul> |

Some general observations can be made based on these five site visits.

1. In most circumstances, water within Cold Creek Swamp is associated with non-flowing ponded areas in the Upper Swamp and Middle Swamp zones. Beaver activity (i.e., dams) was observed downstream of all the ponded areas on all occasions.
2. Downstream water flow and sediment transport within Cold Creek Swamp is primarily associated with storm flow events.
3. The Upper Swamp Zone is primarily a depositional zone, where upland runoff discharges into a series of interconnected ponds. During storm events, water and sediment can be transported from this zone through the stream channel to the point of confluence with Cold Creek and to points downstream (Figure 5-6).
4. The Middle Swamp Zone begins shortly past the point of confluence with Cold Creek and ends at the east power line cut. The Middle Swamp Zone is primarily erosional in nature as evidenced by the sandy nature of middle zone soil samples. A backwater depositional area exists toward the upper portion of the Middle Swamp Zone near the Virginia Chemicals bridge. Another important feature within the Middle Swamp Zone is the unnamed tributary that flows eastward to join Cold Creek immediately west of the west power line cut. This stream was observed to provide a majority of the water volume from the Middle to the Lower swamp zones. In fact, flowing water was observed in this channel on all occasions, except for the Stage II field work, even when no other flowing water was observed within the swamp (Figure 5-6).





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REMEDIAL INVESTIGATION REPORT  
COLD CREEK SWAMP  
MOBILE, ALABAMA

HYDROLOGIC ZONES  
SITE MAP

|                    |                    |                 |                   |                   |                |                        |               |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|
| PROJECT MGR<br>GEJ | DESIGNED BY<br>PWK | DRAWN BY<br>MSM | CHECKED BY<br>GEJ | SCALE<br>1"=2000' | DATE<br>6-5-92 | PROJECT NO<br>11653.08 | FIGURE<br>5-6 |
|--------------------|--------------------|-----------------|-------------------|-------------------|----------------|------------------------|---------------|

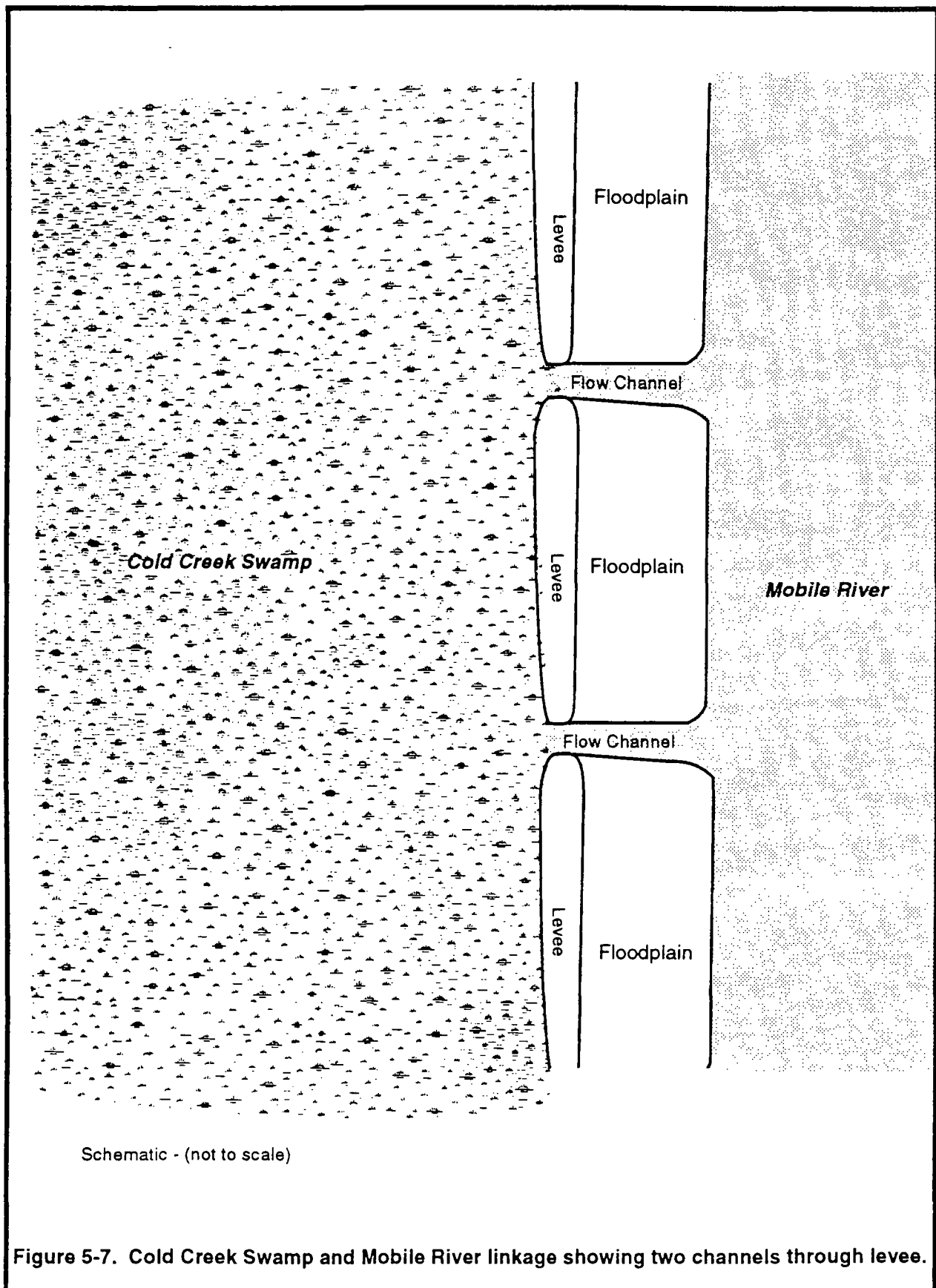
3 10 0182

5. The Lower Swamp Zone is primarily a depositional area that begins at the east powerline cut and ends at the Mobile River floodplain to the southeast, and the Alabama Power Company discharge canal to the northeast. The southern boundary of this zone is the limits of wetland as identified in the Stage I field work.

The Lower Swamp Zone is impacted by depositional activity from Cold Creek and the unnamed tributary to the west and from the Mobile River to the southeast. The Alabama Power Company discharge canal is a distinct barrier to the northeast.

Discharge from the Lower Swamp to the Mobile River is through at least two discernible channels within the Mobile River levee (Figure 5-7). These channels emanate from the lowest of the lower swamp ponds and are about 3 ft wide by 1 ft deep at the outfall points. The Mobile River shoreline alongside Cold Creek Swamp is dominated by the levee-floodplain as shown in Figure 5-7. The levee has built up over time as the Mobile River has washed up over its banks at the turn in the river immediately above the horseshoe swamp. As the river floods, it deposits sediment in the lower swamp. When the river recedes to the point where it is trapped behind the levee, seepage and flow through the discharge channels drop the water level within the swamp ultimately back to river level.

6. Net sediment exchange is believed to be primarily from the Mobile River to the lower swamp. This is supported by field observations (Table 5-7), and by the assessment of the soils maps (Figure 1-4) and the mineralogical survey (Section 3.2.4 and Appendix H). Furthermore, based on the physical configuration of the levee, the



floodplain, and the discharge channels, sediment discharge from the swamp to the river is severely inhibited. Finally, assessment of floodplain analytical mercury data (samples B-49 through B-54) indicates mercury levels similar to background levels (B-58 through B-60).

7. Water flow from the swamp to the Mobile River at the outfall channels was not observed on any of the five visits. It is apparent, however, that there must be water flow from the swamp to the river during falling river stages as the river level stabilizes subsequent to a major river level rise.

#### Analytical Considerations

Examination of analytical data can also yield worthwhile observations with respect to potential contaminant transport through sediment deposition or surface water flow. In the upper swamp, mercury sediment concentrations in excess of 100 mg/kg have been identified (vicinity of "N-3" in Figure 2-1). Mercury has adsorbed onto sediment particles and/or precipitated as insoluble mercury sulfide over time. The mercury contaminated sediment appears to have been transported downstream from the upper swamp through surface water flow and flooding as described above. Highest mercury concentrations remain in the UPPER Swamp Zone, as evidenced by review of sediment analytical data (Sections 4.3 and 4.4).

The mainstem Middle Swamp Zone has been determined to be predominantly erosional in nature, based on the mineralogical/physical study data and field observations as described above. Analytical mercury sediment data confirm this observation because lower mercury levels were observed in middle zone samples than in samples from the upper or lower zones. Consequently, when sediment is transported from the Upper Swamp Zone, the erosional forces in the Middle Swamp Zone continue to transport the majority of it through this zone to the upper part of the Lower Swamp Zone. There is, however, a back water area where samples showed elevated

levels of mercury (vicinity of N-5 and D-13). It is presumed a portion of the sediment load is deposited here during periods of flooding.

The Lower Swamp Zone has been determined to be a depositional zone, subject to deposition from flow downstream through Cold Creek and the unnamed tributary to the west, and to deposition from overbank flooding of the Mobile River. Analytical results (Sections 4.2 and 4.3) indicate an area of elevated mercury concentrations in the vicinity of the two power line rights-of-way where Cold Creek widens and the stream velocity drops, allowing for sediment deposition to occur.

Review of analytical data further indicates that contaminant migration through sediment transport from the Lower Swamp Zone to the Mobile River is not a significant pathway (see observations no. 5 and no. 6 above). Mercury has generally settled in the power line crossing area and is not further transported. In fact, mercury concentrations in sediments from the floodplain below the levee immediately adjacent to the Mobile River (B-49 through B-53 in Table 3-18) showed levels comparable to background mercury concentrations (B-58 through B-60 in Table 3-18). Furthermore, field observations and the physical/mineralogical study report indicate that Mobile River flooding to Cold Creek Swamp further reduces likelihood of contaminant transport via sediment to the Mobile River because sediments are retained within the swamp area by the river levee when the Mobile River levels recede. This is confirmed by the fact that the lower swamp soils are more representative of Mobile River sediments than of sediments from the upper zone of Cold Creek Swamp.

The overall conclusion is that contaminant migration via surface water and sediment transport pathways is a migration pathway for mercury within Cold Creek Swamp. Furthermore, although there is some sediment and surface water discharge from the swamp to the Mobile River, the net flux is primarily from the river to the swamp, particularly with respect to sediment. Consequently, it is concluded that sediment and surface water transport do not represent a significant pathway for contribution of Cold Creek Swamp mercury to the Mobile River.

### 5.2.3 Ground Water

Ground-water transport of mercury from Cold Creek Swamp sediment was investigated as a potential contaminant migration pathway. Mercury was not detected in ground-water samples from five wells in and around Cold Creek Swamp during the 1988 RI. Furthermore, analysis of soil borings during Stage I of this study indicated that mercury contamination in soil samples was limited to the upper 3 ft. Based on this information, it is concluded that ground-water transport is not an important mechanism for contaminant migration at this site.

### 5.2.4 Exchange with the Mobile River

Potential exchange of the ecosystem components between Cold Creek Swamp and the Mobile River was examined through a combination of physical observations, soil and mineralogical data, analytical data, and biota collection data. This activity was included as a supplemental task pursuant to comments from natural resources trustees between the Stage II ecological modeling and the Stage III field work. A limited scope assessment of this issue was conducted for this project. Based on assessment of available data from literature and fieldwork, and from observations during the five visits to the site during the course of this project (Section 5.2.2), the following conclusions are presented.

Sediment flux--The net sediment flux appears to be from the Mobile River to Cold Creek Swamp. This conclusion is based primarily on soils map information and the mineralogical data collected in this study. It is also supported by the physical observations as described in Section 5.2.2 and by results of mercury sediment analyses (also described in Section 5.2.2). It is acknowledged that there is some component of sediment discharge from the swamp when swamp

water levels recede, subsequent to major river stage rises, but it can be stated with confidence that, under most circumstances, sediment flux is from the river to the site.

Surface Water flux--Under most observed conditions, no flux of surface water between the river and the swamp has been observed. During a period of rising river stage (June 1991), significant water flow from the river to the lower swamp was observed. During a subsequent visit in October 1991, lower swamp levels had receded to more normal levels, indicating that surface water had flowed back from the swamp to the river. Based on the nature of Cold Creek Swamp (i.e., primarily pools and ponds associated with beaver dams and the levee-floodplain topography at the river discharge), and the fact that surface water flow from the site to the river was not observed during any of the five site visits, it is concluded that, under most circumstances, there is minimal, if any, exchange of surface water between the Mobile River and Cold Creek Swamp. Surface water exchange is limited to periods of significant Mobile River water level fluctuation. Discharge from the river to the swamp occurs when river water level rises sufficiently to flow over the levee. Discharge from the swamp to the river occurs as the river stage recedes and the water ponded behind the levee seeps out through the levee and flows through the outfall channels from the swamp to the Mobile River.

Biota flux--There is not sufficient information presently available to conclusively assess biotic flux between the swamp and the Mobile River. A preliminary attempt was made during Phase III of this study to evaluate short-term exchange of potential "indicator" taxa, either swamp exclusive or river residents. EA electroshocked the two narrow channels which connect the swamp to the river through the levee, removing all fish. Two days later, we again

shocked and recorded all fish. Numbers present were somewhat lower, and two individuals of estuarine species were present in the channels, suggesting exchange for the river to the swamp. No indicator species were available for swamp resident fauna.

Qualitatively, the very narrow and obstructed nature of the connecting channels (one is completely blocked by a beaver dam at baseflow water levels) make it unlikely that a large number of individuals are exchanged between swamp and rivers. However, such exchange undoubtedly occurs at some levee, as indicated by our finding for the shocking surveys.

#### 5.2.5 Other Potential Pathways

Other potential contaminant migration pathways at this site that were identified were airborne transport and possible contribution from chemical processing activities from other chemical plants in the site vicinity. It is known that burning of fossil fuels for electrical power generation typically releases concentrations of various contaminants, including mercury. There is a potential for atmospheric deposition of mercury associated with electricity production at coal-fired power plants dependent on factors such as predominant wind flow direction, other meteorological factors, and technical considerations such as off-gas treatment and controls. Possible mercury contribution from chemical processing activities at other chemical plants in the vicinity of the swamp was also considered but not investigated. Therefore, no conclusions can be made with respect to potential contribution from other industrial activities in the vicinity.



REFERENCES  
CHAPTER 5

- Ankley, G.T., G.L. Phipps, E.N. Leonard, D.A. Benoit, V.R. Mattson, P.A. Kosian, A.M. Cotter, J.R. Dierkes, D.J. Hansen, and J.D. Mahony. 1991. Acid-volatile sulfide as a factor mediating cadmium and nickel bioavailability in contaminated sediments. *Environ. Toxicol. Chem.* 10:1299-1307.
- Bartlett, P.D., and P.J. Craig. 1981. Total mercury and methyl mercury levels in British Estuarine Sediments-II. *Wat. Res.* 15:37-47.
- Beijer, K., and A. Jernelov. 1979. Methylation of mercury in aquatic environments, in *The Biochemistry of Mercury in the Environment* (J.D. Nriagu, ed.), pp. 203-310. Elsevier/North-Holland.
- Bollag, J.-M., and S.-Y. Liu. 1990. Biological transformation processes of pesticides, in *Pesticides in the Soil Environment: Processes, Impacts, and Modeling* (H.H. Cheng, ed.), p. 176. Soil Science Society of America Book Series, Madison, Wisconsin.
- Breteler, R.J., and F.I. Saksa. 1985. The role of sediment organic matter on sorption-desorption reactions and bioavailability of mercury and cadmium in an intertidal ecosystem, in *Aquatic Toxicology and Hazard Assessment: Seventh Symposium, ASTM STP 854* (R.D. Cardwell, R. Purdy, and R.C. Bahner, eds.), pp. 454-468.
- Brown, J.R., G.M. Bancroft, W.S. Fyfe, and R.A.N. McLean. 1979. Mercury removal from water by iron sulfide minerals. An Electron Spectroscopy for Chemical Analysis (ESCA) study. *Environ. Sci. Technol.* 13:1142-1144.
- Callister, S.M., and M.R. Winfrey. 1986. Microbial methylation of mercury in Upper Wisconsin river sediments. *Water, Air, Soil Pollut.* 29:453-465.
- Carlson, A.R., G.L. Phipps, V.R. Mattson, P.A. Kosian, and A.M. Cotter. 1991. The role of acid-volatile sulfide in determining cadmium bioavailability and toxicity in freshwater sediments. *Environ. Toxicol. Chem.* 10:1309-1319.
- Crecelius, E.A., and B.K. Lasorsa. 1990. Concentrations of acid volatile sulfides in contaminated sediments of the Great Lakes. Abstract from the 11th Annual Meeting of the Society of Environmental Toxicology and Chemistry, Arlington, Virginia, 11-15 November.
- D'Itri, F.M. 1990. The biomethylation and cycling of selected metals and metalloids in aquatic sediments, in *Sediments: Chemistry and Toxicity of In-Place Pollutants* (R. Baudo, J. Giesy, and H. Montau, eds.), pp. 163-214. Lewis Publishers.

- DiToro, D.M., J.D. Mahony, D.J. Hansen, K.J. Scott, A.R. Carlson, and G.T. Ankley. 1992. Acid volatile sulfide predicts the acute toxicity of cadmium and nickel in sediments. *Environ. Sci. Technol.* 26:96-101.
- DiToro, D.M., J.D. Mahony, D.J. Hansen, K.J. Scott, M.D. Hicks, S.M. Mayr, and M.S. Redmond. 1990. Toxicity of cadmium in sediments: The role of acid volatile sulfide. *Environ. Tox. Chem.* 9:1487-1502.
- Drossman, H., H. Johnson, and T. Hill. 1988. Structure activity relationships for environmental processes 1: Hydrolysis of esters and carbamates. *Chemosphere.* 8:1509-1530.
- Fagerstrom, T., and A. Jernelov. 1972. Some aspects of the quantitative ecology for mercury. *Water Res.* 6:1193-1202.
- Fang, S.C. 1975. Thiocarbamates, in *Herbicides: Chemistry, Degradation, and Mode of Action. Volume 1* (P.C. Kearney and D.D. Kaufman, eds.). Marcel Dekker, Inc., New York.
- Hansen, D.J., W.J. Berry, J.D. Mahony, A.R. Carlson, K.M. McKenna, D.L. Robinson, and W.S. Boothman. 1990. Acid volatile sulfide controls divalent metal toxicity in sediments. Abstract from the 11th Annual Meeting of the Society of Environmental Toxicology and Chemistry, Arlington, Virginia. 11-15 November.
- Jernelov, A. 1970. Release of methyl mercury from sediments with layers containing inorganic mercury at different depths. *Limnol. Oceanogr.* 15:958-960.
- Jernelov, A., and B. Asell. 1975. The feasibility of restoring mercury-contaminated waters, in *Heavy Metals in the Aquatic Environment* (P.A. Krenkel, ed.), pp. 299-309. Pergamon Press.
- Korthals, E.T., and M.R. Winfrey. 1987. Seasonal and spatial variations of mercury methylation and demethylation in an oligotrophic lake. *App. Environ. Microbio.* 53:2397-2404.
- Miller, B.J., G.C. Lewis, J.J. Alford, and W.J. Day. 1984. Loesses in Louisiana and at Vicksburg, Mississippi Guidebook for the Friends of the Pleistocene Field Trip April 12, 13, and 14. LSU Agricultural Center, Baton Rouge, Louisiana.
- Miller, J. 1991. ICI Americas, Inc. Personal communication, 10 June.
- Miskimmin, B.M. 1991. Effect of natural levels of dissolved organic carbon (DOC) on methyl mercury formation and sediment-water partitioning. *Bull. Environ. Contam. Toxicol.* 47:743-750.

- Regnell, O. 1990. Conversion and Partitioning of radio-labelled mercury chloride in aquatic model systems. *Can. J. Aquat. Sci.* 47:548-553.
- Reimers, R.S., and P.A. Krenkel. 1975. Sorption phenomenon in the organics of bottom sediments, in *Heavy Metals in the Aquatic Environment* (P.A. Krenkel, ed.). Pergamon Press.
- Reimers, R.S., and P.A. Krenkel. 1974. Kinetics of mercury adsorption and desorption in sediments. *J. Water Poll. Con. Fed.* 46:352-365.
- Rule, J.H., and R.W. Alden. 1990. Interactions of cadmium and copper in geochemical phases of sediments and in body burdens and respiration rates of estuarine test organisms. Abstract from the 11th Annual Meeting of the Society of Environmental Toxicology and Chemistry, Arlington, Virginia. 11-15 November.
- Shea, D. 1988. Developing national sediment quality criteria: Equilibrium partitioning of contaminants as a means of evaluating sediment quality. *Environ. Sci. Technol.* 22:1256-1261.
- Thanabalasingam, P., and W.F. Pickering. 1985. The sorption of mercury (II) by humic acids. *Environ. Poll.* 9(B):267-279.
- U.S. Department of Defense (U.S. DOD). 1970. Herbicide manual for noncropland weeds. Depts. of the Army, Navy, and Air Force, Washington, D.C.
- U.S. Environmental Protection Agency (EPA). 1991. Interim Guidance for Dermal Exposure Assessment. Review Draft. Office of Research and Development, March 1991. EPA/600/8-91/011A.
- U.S. Environmental Protection Agency. 1983. Office of Solid Waste and Emergency Response. Hazardous Waste Land Treatment. SW-874. April.
- Winfrey, M.R., and J.W.M. Rudd. 1990. Environmental factors affecting the formation of methylmercury in low pH lakes. *Environ. Toxicol. Chem.* 9:853-869.
- Wolfe, N.L., U. Mingelgrin, and G.C. Miller. 1990. Abiotic transformations in water, sediments and soil, in *Pesticides in the Soil Environment: Processes, Impacts, and Modeling* (H.H. Cheng, ed.), p. 176. Soil Science Society of America Book Series, Madison, Wisconsin.
- Xun, L., N.E.R. Campbell, and J.W.M. Rudd. 1987. Measurements of specific rates of net methyl mercury production in the water column and surface sediments of acidified and circumneutral lakes. *Can. J. Aquat. Sci.* 44:750-757.

## 6. BASELINE RISK ASSESSMENT

### 6.1 HUMAN HEALTH EVALUATION

The purpose of this human health evaluation was to determine those chemicals occurring in Cold Creek Swamp which pose a potential risk to humans coming in contact with the swamp. Risk was quantified for TCL and TAL chemicals detected in surface water and sediment during Stage I sampling, and in select aquatic biota during Stage III sampling. These risk calculations were based upon pre-determined exposure scenarios and assumptions.

#### 6.1.1 Exposure Assessment

The conditions at the swamp are not conducive to swimming or wading activities. Potential incidental ingestion of water while swimming or contact with sediment while wading are, therefore, not viable routes of exposure and will not be given further consideration. The two routes of potential exposure to be considered in this risk analysis were agreed upon with EPA in previous communications. These pathways are

1. oral ingestion of fish and/or shellfish caught recreationally within swamp waters, and
2. dermal contact with potentially contaminated water within the swamp during recreational fishing.

Qualitative site-specific properties were considered in formulating the recreational fishing scenario exposure assumptions which were also agreed upon in advance of Stage I sampling. These site-specific considerations included accessibility, seasonality, and the nature of the fish population.

The swamp was characterized as being too dry for much of the year to support year-round fishing. Land access to the swamp was limited by posted restrictions for trespassers and the position of the manufacturing facilities. The only water access route entailed entrance from the Mobile River, a process considered difficult if not impossible. During Stage III, field crews employed this access route, and found the going extremely difficult. It is impossible to access swamp water by boat this way, and even a light equipment kit is a severe hindrance. Typical fish in the swamp waters were small in size, limiting the ingestible amounts of tissue and hence of potential contaminants.

Contaminant concentrations in fish were estimated for this human health risk assessment based upon the concentrations encountered in water and sediment samples quantified in Stage I. Subsequent analyses of specific aquatic biota during Stage III sampling allowed quantitation of risk for a single contaminant (mercury) to be based upon concentrations measured directly in fish. Levels of contaminants in fish tissue which were estimated from Stage I sediment and water sample concentrations were derived from the application of chemical-specific sediment-water partition coefficients ( $K_{oc}$ ) and bioconcentration factors (BCFs). For compounds actually detected in water, i.e., the metals, fish concentrations were calculated simply as the product of the maximum detected water concentration and the chemical-specific BCF. If a chemical was not detected in water but was detected in sediment, the concentration in water was first estimated using chemical-specific partition coefficients ( $K_{oc}$ ) and the fraction organic carbon. The water concentration was then multiplied by the chemical-specific BCF to derive the corresponding fish concentration. Sediment values used to estimate fish concentrations for this risk assessment were either the upper 95 percent confidence limit value or the maximum detected value in cases where the small sample size yielded an upper confidence value greater than the maximum detected value. Use of the maximum value is warranted, in these cases, by current risk assessment guidance (U.S. EPA 1989).

Fish tissue concentrations used in this risk assessment are shown in Table 6-1. The individual mercury concentrations and both the upper 95 percent confidence limit value and the average concentration measured in tissues of fish collected in Stage III sampling are shown in Table 6-2.

With respect to the dermal contact with potentially contaminated water during the course of recreational fishing, exposure was limited to incidental splashing of water on exposed body surfaces. Fishermen were considered to be wearing shoes or boots, shorts, and shirts, allowing potential water contact only with hands, arms, and legs. The concentrations of potential contaminants used in this exposure pathway were those found in water samples from Stage I analyses. No additional water samples were collected during subsequent stages. Chemical concentrations measured in water samples are shown in Table 6-3. Due to the small size of the data set for each chemical, use of the upper 95 percent confidence limit value yielded a value greater than the maximum detected value. Therefore, in accordance with risk assessment guidance (U.S. EPA 1989) the maximum detected values for each chemical were used to estimate dermal risks for this risk assessment.

The series of exposure assumptions employed in the fish ingestion and the dermal contact pathway scenarios, as agreed among the parties, are shown in Table 6-4.

#### Calculation of Average Daily Intakes or Absorbed Doses

Based upon the assumptions in Table 6-4 and the exposure point concentrations in either fish tissue or water, the intakes and absorbed doses of potential chemicals of concern for the risk population (i.e., recreational fishermen) were calculated for the two routes of exposure. According to EPA risk assessment guidance, intakes were not estimated for chemicals that are considered either essential or required nutrients or elements, such as calcium, chloride, cobalt, iron, magnesium, potassium, or sodium.

Table 6-1 CONCENTRATIONS OF POTENTIAL CONTAMINANTS IN FISH TISSUE AND VALUES USED TO CALCULATE FISH TISSUE CONCENTRATIONS

| Chemical                   | Water<br>Conc. ( $\mu\text{g/L}$ ) | Sediment<br>Conc. ( $\mu\text{g/Kg}$ ) | $K_{oc}$ | Calculated<br>Water Conc. (a)<br>( $\mu\text{g/L}$ ) | BCF      | Calculated<br>Fish Tissue<br>Conc.<br>( $\text{mg/Kg}$ ) |
|----------------------------|------------------------------------|----------------------------------------|----------|------------------------------------------------------|----------|----------------------------------------------------------|
| INORGANIC COMPOUNDS        |                                    |                                        |          |                                                      |          |                                                          |
| Aluminum                   | 8520.                              | -                                      | -        | -                                                    | 82.5     | 703.                                                     |
| Antimony                   | <60.0                              | -                                      | -        | -                                                    | 1.0      | 0.060                                                    |
| Arsenic                    | 2.6                                | -                                      | -        | -                                                    | 1.9      | 0.0049                                                   |
| Barium                     | 88.5                               | -                                      | -        | -                                                    | 100.0    | 8.85                                                     |
| Beryllium                  | 1.9                                | -                                      | -        | -                                                    | 20.0     | 0.038                                                    |
| Cadmium                    | <5.0                               | -                                      | -        | -                                                    | 407.4    | 2.04                                                     |
| Chromium                   | 6.6                                | -                                      | -        | -                                                    | 1.7      | 0.011                                                    |
| Copper                     | 15.0                               | -                                      | -        | -                                                    | 17.0     | 0.255                                                    |
| Lead                       | 1.2                                | -                                      | -        | -                                                    | 42.0     | 0.05                                                     |
| Manganese                  | 305.                               | -                                      | -        | -                                                    | 930.0    | 284.                                                     |
| Mercury (total)            | -                                  | -                                      | -        | -                                                    | 16,876.0 | 1.72 (b)                                                 |
| Nickel                     | 10.0                               | -                                      | -        | -                                                    | 23.7     | 0.237                                                    |
| Selenium                   | <2.0                               | -                                      | -        | -                                                    | 64.5     | 0.129                                                    |
| Silver                     | 7.0                                | -                                      | -        | -                                                    | 25.7     | 0.180                                                    |
| Vanadium                   | <50.                               | -                                      | -        | -                                                    | 10.0     | 0.50                                                     |
| Zinc                       | 126.                               | -                                      | -        | -                                                    | 397.1    | 50.0                                                     |
| ORGANIC COMPOUNDS          |                                    |                                        |          |                                                      |          |                                                          |
| Acetone                    | -                                  | 909.                                   | 18.0     | 1260.                                                | 0.389    | 0.49                                                     |
| Benzene                    | -                                  | 59.0                                   | 343.3    | 4.30                                                 | 6.5      | 0.028                                                    |
| Benzoic Acid               | -                                  | 114.                                   | 247.9    | 11.5                                                 | 14.1     | 0.162                                                    |
| Bis(2-ethylhexyl)phthalate | -                                  | 230.                                   | 87,420.0 | 0.066                                                | 1,175.0  | 0.078                                                    |
| 2-Butanone                 | -                                  | 10.0                                   | 33.0     | 7.58                                                 | 0.087    | 0.00066                                                  |
| Carbon Disulfide           | -                                  | 17.0                                   | 69.3     | 6.13                                                 | 0.34     | 0.0021                                                   |
| Chlorobenzene              | -                                  | 21.5                                   | 835.5    | 0.64                                                 | 33.1     | 0.0213                                                   |
| Toluene                    | -                                  | 15.0                                   | 692.4    | 0.542                                                | 23.4     | 0.013                                                    |
| m,p-Xylene                 | -                                  | 41.0                                   | 1,232.0  | 0.832                                                | 75.9     | 0.063                                                    |
| o-xylene                   | -                                  | 28.0                                   | 765.4    | 0.915                                                | 28.2     | 0.026                                                    |
| THIOCARBAMATES             |                                    |                                        |          |                                                      |          |                                                          |
| Butylate                   | -                                  | 894.                                   | 1,304.0  | 17.1                                                 | 235.0    | 4.02                                                     |
| Cycloate                   | -                                  | 642.                                   | 729.0    | 22.0                                                 | 169.0    | 3.72                                                     |
| EPTC                       | -                                  | 270.                                   | 286.0    | 23.6                                                 | 72.0     | 1.70                                                     |
| Molinate                   | -                                  | 263.                                   | 244.0    | 27.0                                                 | 16.0     | 0.432                                                    |
| Pebulate                   | -                                  | 900.                                   | 657.0    | 34.2                                                 | 60.0     | 2.05                                                     |
| Vernolate                  | -                                  | 474.                                   | 766.0    | 15.5                                                 | 160.0    | 2.48                                                     |

(a) Calculated based on an assumed 4% organic carbon.

(b) Total mercury was measured in samples of fish species collected and is presented as the upper (95 %) confidence limit value in edible tissue (fillet).

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TABLE 6-2 CONCENTRATIONS OF MERCURY IN EDIBLE FISH TISSUE (FILLET)<sup>(a)</sup>

| Cold Creek Swamp                          |         | Background                                |         |
|-------------------------------------------|---------|-------------------------------------------|---------|
| Mercury Concentration<br>in Edible Tissue |         | Mercury Concentration<br>in Edible Tissue |         |
| Fish No.                                  | (mg/kg) | Fish No.                                  | (mg/kg) |
| F-U-1                                     | 0.91    | F-BP-1                                    | 1.92    |
| F-U-2                                     | 0.88    | F-BP-2                                    | 0.05    |
| F-U-3                                     | 0.82    | F-BP-3                                    | 0.15    |
| F-U-4                                     | 0.79    | F-BP-4                                    | 0.72    |
| F-U-5                                     | 0.38    | F-BP-5                                    | 0.55    |
| F-U-6                                     | 0.82    | F-BS-1                                    | 0.22    |
| F-U-7                                     | 1.19    | F-BS-2                                    | 0.49    |
| F-U-8                                     | 0.37    | F-BS-3                                    | 0.64    |
| F-U-9                                     | 1.28    | F-BS-4                                    | 0.59    |
| F-U-10                                    | 0.18    | F-BS-5                                    | 0.37    |
| F-M-1                                     | 1.16    |                                           |         |
| F-M-2                                     | 1.79    |                                           |         |
| F-M-3                                     | 1.79    |                                           |         |
| F-M-4                                     | 1.92    |                                           |         |
| F-M-5                                     | 0.83    |                                           |         |
| F-M-6                                     | 3.58    |                                           |         |
| F-M-7                                     | 1.04    |                                           |         |
| F-M-8                                     | 1.05    |                                           |         |
| F-M-9                                     | 1.04    |                                           |         |
| F-M-10                                    | 0.91    |                                           |         |
| F-L-1                                     | 0.55    |                                           |         |
| F-L-2                                     | 1.92    |                                           |         |
| F-L-3                                     | 2.30    |                                           |         |
| F-L-4                                     | 4.48    |                                           |         |
| F-L-5                                     | 2.94    |                                           |         |
| F-L-6                                     | 0.86    |                                           |         |
| F-L-7                                     | 1.79    |                                           |         |
| F-L-8                                     | 1.41    |                                           |         |
| F-L-9                                     | 1.41    |                                           |         |
| F-L-10                                    | 0.74    |                                           |         |

Upper (95 %) Confidence Limit Value in Swamp Fish Fillet = 1.72 mg/kg  
Average Mercury Concentration in Swamp Fish Fillet = 1.37 mg/kg

Upper (95 %) Confidence Limit Value in Background Fish Fillet = 0.94 mg/kg  
Average Mercury Concentration in Background Fish Fillet = 0.57 mg/kg

(a) Values calculated from muscle to whole body ratio of 1.28 (McKim et al. 1976) as described in the section entitled, "Fish Ingestion Scenario."



TABLE 6-3 CONCENTRATIONS ( $\mu\text{g/L}$ ) OF POTENTIAL CONTAMINANTS IN WATER SAMPLES, COLD CREEK SWAMP

| Chemical            | Water Data |        |        |        | Background Data |       |        |
|---------------------|------------|--------|--------|--------|-----------------|-------|--------|
|                     | W2         | W3     | W4     | Mean   | W1              | W-D-1 | Mean   |
| INORGANIC COMPOUNDS |            |        |        |        |                 |       |        |
| Aluminum            | 431        | 8,520  | 180    | 3,044  | 288             | 63.4  | 176    |
| Arsenic             | 1          | 2.6    | 1      | 1.53   | 1               | 1     | 1      |
| Barium              | 71.4       | 66.8   | 88.5   | 75.6   | 65.2            | 24.8  | 45.0   |
| Beryllium           | 1          | 1.4    | 1.9    | 1.43   | 1               | 1.5   | 1.25   |
| Calcium             | 5,980      | 11,106 | 12,400 | 9,829  | 5,660           | 5,760 | 5,710  |
| Chromium            | 3          | 6.6    | 3      | 4.20   | 3               | 3     | 3      |
| Copper              | 12.9       | 15     | 9.7    | 12.5   | 11.9            | 15.9  | 13.9   |
| Iron                | 972        | 746    | 687    | 802    | 811             | 285   | 548    |
| Lead                | 0.5        | 1.2    | 0.5    | 0.73   | 0.5             | 0.5   | 0.5    |
| Magnesium           | 1,160      | 1,040  | 3,520  | 1,907  | 1,090           | 1,560 | 1,325  |
| Manganese           | 305        | 41.6   | 296    | 214    | 287             | 9.3   | 148.15 |
| Mercury             | 0.1        | 0.85   | 0.29   | 0.41   | 0.1             | 0.1   | 0.1    |
| Nickel              | 10         | 4.5    | 4.5    | 6.33   | 4.5             | 4.5   | 4.5    |
| Potassium           | 471        | 925    | 1,560  | 985    | 610             | 1,200 | 905    |
| Silver              | 2          | 7      | 6.2    | 5.07   | 2               | 5.1   | 3.55   |
| Sodium              | 14,100     | 18,000 | 19,100 | 17,067 | 13,100          | 5,000 | 9,050  |
| Zinc                | 126        | 99.3   | 44.6   | 90.0   | 8.5             | 65.75 | 37.1   |
| Sulfide             | 4.2        | 0.5    | 0.5    | 1.73   | 2.6             | 8.2   | 5.4    |
| Chloride            | 10.5       | 7.7    | 17.2   | 11.8   | 10.7            | 5.5   | 8.1    |

## ORGANIC COMPOUNDS

None Detected

TABLE 6-4 EXPOSURE PATHWAY ASSUMPTIONS

| Ingestion Due to Recreational Fishing |                                                                                                                                                              | Dermal Contact with Water<br>Due to Recreational Fishing |                                                                                                                                                                                                                                                                                                                                    |
|---------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <u>Exposure Frequency</u>             | 6 meals/yr (based on an estimate of 1 recreational fish meal per month from Cold Creek Swamp for the months swamp has water)                                 | <u>Exposure Frequency</u>                                | 6 times/yr (same exposure frequency as assumed for recreational fishing)                                                                                                                                                                                                                                                           |
| <u>Exposure Duration</u>              | 30 years (based on the national upper-bound (90th percentile) estimate of time that people live at one residence, an EPA assumption per the guidance manual) | <u>Skin Surface Area</u>                                 | Arms - 0.23 m <sup>2</sup><br>Hands - 0.082 m <sup>2</sup><br>Legs - 0.55 m <sup>2</sup><br>0.862 m <sup>2</sup> (EPA assumption per guidance manual)                                                                                                                                                                              |
| <u>Body Weight of Fishermen</u>       | 70 kg (standard adult weight, an EPA assumption per the guidance manual)                                                                                     | <u>Exposure Time</u>                                     | 4 hrs/day (expected duration of fishing event)                                                                                                                                                                                                                                                                                     |
| <u>Ingestion Rate</u>                 | 113 grams/meal (the average (50th percentile) size of a fin fish meal, based on EPA assumptions in the guidance manual.                                      | <u>Exposure Duration</u>                                 | 30 years (same duration as assumed for recreational fishing)                                                                                                                                                                                                                                                                       |
| <u>Averaging Time</u>                 | 30 yr for noncarcinogenic effects; 70 yr for carcinogenic effects (EPA assumptions per the guidance manual)                                                  | <u>Body Weight</u>                                       | 70 kg (standard EPA assumption per the guidance manual)                                                                                                                                                                                                                                                                            |
| <u>Fraction Ingested</u>              | 1, i.e., entire fish/shellfish meal comes from swamp.                                                                                                        | <u>Averaging Time</u>                                    | 30 yr for noncarcinogenic effects; 70 yr for carcinogenic effects (EPA assumptions per guidance manual)                                                                                                                                                                                                                            |
|                                       |                                                                                                                                                              | <u>Permeability Constants</u>                            | These are compound-specific and measure the amount of the compound which is absorbed through each cm <sup>2</sup> of skin per hour of exposure. Values will be obtained from EPA guidance or the permeability constant for water (0.0015 cm/hr) will be used if no compound-specific value is available (per EPA guidance manual). |

In addition, cobalt was eliminated from the human health risk assessment because of the lack of environmental and human health data on potential toxicity. Cobalt was detected in the sediment but not in water from the swamp. Because there are no environmental standards such as ambient water quality criteria, there are few data such as sediment/water partition coefficients and BCFs. Without these numbers, a fish concentration cannot be derived.

For the assessment of chromium, it has been assumed that chromium in Cold Creek Swamp is primarily trivalent as opposed to hexavalent. This conclusion is based on an examination of site-specific Eh-pH data (Tables 3-20 and 3-28 for Stage II and III, respectively), which show that the highest pH observed was 7.2 and the highest Eh was +335 mV. The formation of hexavalent chromium is favored under conditions of high pH and Eh (Bodek et al. 1988). Comparisons of the Cold Creek Eh-pH data with Eh-pH diagrams indicates that the trivalent form of chromium will predominate at Cold Creek Swamp.

#### Fish Ingestion Scenario

Fish tissue concentrations of the potential chemicals of concern were estimated from Stage I water and sediment data using sediment-water partition coefficients ( $K_{oc}$ s) and BCFs. If a contaminant was detected in water, contaminant concentrations in fish tissue were estimated from Stage I water samples by the application of the chemical-specific BCFs. Inorganics (i.e., metals) were the only compounds detected in water samples. The maximum detected value was used as the water exposure point concentration for all metals except antimony, cadmium, selenium, and vanadium, since calculation of the upper 95 percent confidence limit on the mean value yielded estimates of concentrations which exceeded the maximum detected value due to the small size of the data sets. Use of the maximum detected value in these cases is in accordance with current EPA guidelines (U.S. EPA 1989). Antimony, cadmium, selenium, and vanadium were not detected in water samples, but in the absence of

established sediment-water partition coefficients the detection limits for these compounds in water were used as the water concentrations for further calculations.

If a contaminant was detected in sediment but not in water, contaminant levels in fish tissue were derived from Stage I sediment sample concentrations by initially using chemical-specific partition coefficients to yield estimates of water concentrations ( $\text{Water concentration} = \text{Sediment concentration} / [\text{Partition Coefficient} \times \text{Fraction Organic Carbon}]$ ). The fraction organic carbon used in this analysis was estimated at 4 percent. Chemical-specific BCFs were then used to estimate the concentration in the organism (fish). All partition coefficients and bioconcentration factors used to calculate fish tissue levels are shown in Table 6-1. Organics and thiocarbamates were detected in sediments, and sediment values were thus used to estimate fish concentrations for these compounds. Upper 95 percent confidence limit on the mean values for sediment concentrations were used to derive fish tissue levels, unless the small size of the data set would result in values exceeding the maximum detected value. In these cases, the maximum sediment value was used. When upper confidence limit values were calculated, samples where contaminants were not detected were given a value of one-half the detection limit. For contaminants which are often common laboratory contaminants (i.e., acetone), levels less than ten times the associated blank were excluded from the data set. All fish concentrations based upon Stage I water or sediment samples represent whole body, wet weight tissue concentrations. A more detailed discussion of the use of  $K_{oc}$ s and BCFs in estimating contaminant levels in fish tissue can be found in Section 6.2.1.3.

Stage III collection and sampling of specific fish types yielded actual measurements of total mercury concentrations in fish tissue. Mercury levels were initially reported as whole body, wet weight concentrations. To allow for more precise delineation of potential risks from ingestion of mercury-contaminated fish species, and in accordance with the EPA, the levels in whole body were converted to levels in fillets by applying an

adjustment factor. McKim et al. (1976) exposed brook trout to methylmercuric chloride and concluded that whole body mercury residue levels were essentially the same as those observed for muscle tissue alone. However, after reviewing the muscle and whole body mercury residue data, the average ratio of muscle mercury residue to whole body mercury residue (across experimental treatments) was 1.28. For the purposes of this risk assessment, the Stage III whole body fish mercury levels were therefore multiplied by the muscle-to-whole body ratio of 1.28, and mercury concentrations were then expressed as edible, fillet concentrations. These values are shown in Table 6-2. The upper 95 percent confidence limit on the mean value was used as the exposure point fish tissue concentration of mercury.

It was assumed that fish were ingested with a standardized ingestion rate of 113 g/meal (U.S. EPA 1989) and that six fish meals per year came entirely from the swamp. This rate of consumption was assumed to continue for 30 years, the standardized national upper-bound time (90th percentile) at one residence (U.S. EPA 1989). The typical weight of an adult human was assumed to be 70 kg (U.S. EPA 1989). For quantifying the toxicity component of the human health risk, i.e., the non-carcinogenic risk, the exposure was averaged over the exposure duration of 30 years. For estimating carcinogenic risks, exposure was averaged over a standard adult lifetime of 70 years (U.S. EPA 1989).

Average daily intakes for the ingestion of fish and shellfish were calculated using the following equation (U.S. EPA 1989):

$$\text{Daily Average Intake (mg/kg}\cdot\text{day)} = \frac{\text{CF} \times \text{IR} \times \text{FI} \times \text{EF} \times \text{ED}}{\text{BW} \times \text{AT}}$$

(Ingested)

Equation 6-1

where

CF = Concentration in fish (mg/kg)  
IR = Ingestion rate (kg/meal)  
FI = Fraction ingested (unitless)  
EF = Exposure frequency (meals/year)  
ED = Exposure duration (years)  
BW = Average body weight (kg)  
AT = Averaging time (days)

Exposure point concentrations in fish tissue and the resulting average daily intake from ingestion of fish and/or shellfish are shown in Tables 6-5 and 6-6, for noncarcinogenic and carcinogenic intakes, respectively. Only those compounds which are known, probable, or possible carcinogens (weight-of-evidence classifications of A, B1, B2, or C) are included in Table 6-6.

#### Dermal Contact with Potentially Contaminated Water

The concentrations of potential chemicals of concern were obtained directly from analysis of swamp water data. Exposure point water concentrations used were the maximum values of the three swamp water sample values from stations W2, W3, and W4, as shown in Table 6-3. Maximum values were used since data sets were small, and upper 95 percent confidence limit on the mean values exceeded the maximum value detected. This is in accordance with EPA guidance (U.S. EPA 1989). For chemicals detected in at least one water sample it was assumed that the other samples could also contain this chemical; hence, nondetects were given values of one-half the detection limit.

To estimate actual surface areas of exposed skin, standardized values for respective body parts were employed for a total of 8,620 cm<sup>2</sup> on hands, arms, and legs (U.S. EPA 1989). The extent to which a chemical in contact with skin could be absorbed was accounted for by the use of chemical-specific permeability constants, where possible. Lacking these, the constant for water ( $1.5 \times 10^{-3}$ ) was used as a default value

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TABLE 6-5 FISH INGESTION EXPOSURE CONCENTRATIONS AND INTAKES FOR  
NONCARCINOGENIC TOXICITY

| Chemical                   | Fish Concentration<br>(mg/kg) | Average Daily<br>Intake<br>(mg/kg·day) |
|----------------------------|-------------------------------|----------------------------------------|
| INORGANIC COMPOUNDS        |                               |                                        |
| Aluminum                   | 703.                          | 1.9E-2                                 |
| Antimony                   | 0.060                         | 1.6E-6                                 |
| Arsenic                    | 0.0049                        | 1.3E-7                                 |
| Barium                     | 8.85                          | 2.3E-4                                 |
| Beryllium                  | 0.038                         | 1.0E-6                                 |
| Cadmium                    | 2.04                          | 5.4E-5                                 |
| Chromium                   | 0.011                         | 2.9E-7                                 |
| Copper                     | 0.255                         | 6.8E-6                                 |
| Lead                       | 0.05                          | 1.3E-6                                 |
| Manganese                  | 284.                          | 7.5E-3                                 |
| Mercury (TTL)              | 1.72                          | 4.6E-5                                 |
| Nickel                     | 0.237                         | 6.3E-6                                 |
| Selenium                   | 0.129                         | 3.4E-6                                 |
| Silver                     | 0.180                         | 4.8E-6                                 |
| Vanadium                   | 0.50                          | 1.3E-5                                 |
| Zinc                       | 50.0                          | 1.3E-3                                 |
| ORGANIC COMPOUNDS          |                               |                                        |
| Acetone                    | 0.49                          | 1.3E-5                                 |
| Benzene                    | 0.028                         | 7.4E-7                                 |
| Benzoic acid               | 0.162                         | 4.3E-6                                 |
| Bis(2-ethylhexyl)phthalate | 0.078                         | 2.1E-6                                 |
| 2-Butanone                 | 0.00066                       | 1.8E-8                                 |
| Carbon disulfide           | 0.0021                        | 5.6E-8                                 |
| Chlorobenzene              | 0.0213                        | 5.7E-7                                 |
| Toluene                    | 0.013                         | 3.4E-7                                 |
| m,p-Xylene                 | 0.063                         | 1.7E-6                                 |
| o-Xylene                   | 0.026                         | 6.9E-7                                 |
| THIOCARBAMATES             |                               |                                        |
| Butylate                   | 4.02                          | 1.1E-4                                 |
| Cycloate                   | 3.72                          | 9.9E-5                                 |
| EPTC                       | 1.70                          | 4.5E-5                                 |
| Molinate                   | 0.432                         | 1.1E-5                                 |
| Pebulate                   | 2.05                          | 5.4E-5                                 |
| Vernolate                  | 2.48                          | 6.6E-5                                 |

TABLE 6-6 FISH INGESTION EXPOSURE CONCENTRATIONS AND INTAKES FOR  
POTENTIAL CARCINOGENS

| Chemical                   | Fish Concentration<br>(mg/kg) | Lifetime Average<br>Daily Intake<br>(mg/kg·day) |
|----------------------------|-------------------------------|-------------------------------------------------|
| INORGANIC COMPOUNDS        |                               |                                                 |
| Arsenic                    | 0.0049                        | 5.6E-8                                          |
| Beryllium                  | 0.038                         | 4.3E-7                                          |
| Lead                       | 0.05                          | 5.7E-7                                          |
| ORGANIC COMPOUNDS          |                               |                                                 |
| Benzene                    | 0.028                         | 3.2E-7                                          |
| Bis(2-ethylhexyl)phthalate | 0.078                         | 8.9E-7                                          |



(U.S. EPA 1991a). Exposure assumptions for this route parallel the assumptions used in the ingestion scenario (Table 6-4) with the addition of an assumed exposure time of 4 hours/day for each fishing event. The assumptions for average body weight and the averaging times were also those used previously.

Average daily doses for the dermal contact with water scenario were calculated using the following equation (U.S. EPA 1989):

$$\text{Daily Average Dose (mg/kg}\cdot\text{day)} = \frac{\text{CW} \times \text{SA} \times \text{PC} \times \text{ET} \times \text{EF} \times \text{ED} \times \text{CF}}{\text{BW} \times \text{AT}}$$

(Absorbed)

Equation 6-2

where

- CW = Concentration in water (mg/L)
- SA = Surface area exposed (cm<sup>2</sup>)
- PC = Permeability constant (cm/hour)
- ET = Exposure time (hours/day)
- EF = Exposure frequency (days/year)
- ED = Exposure duration (years)
- CF = Conversion factor (1 L/1,000 cm<sup>3</sup>)
- BW = Average body weight (kg)
- AT = Averaging time (days)

The exposure point concentrations in water and the resulting average daily absorbed doses from dermal contact with water are shown in Tables 6-7 and 6-8 for noncarcinogenic and potentially carcinogenic doses, respectively.

#### 6.1.2 Toxicity Assessment

All detected chemicals of potential concern are typically assessed for their respective toxic or noncarcinogenic effects, and chemicals considered to be potential human carcinogens are also assessed for the extent of their carcinogenicity. The level of noncarcinogenic or toxic

TABLE 6-7 DERMAL CONTACT WITH WATER EXPOSURE CONCENTRATIONS AND  
DOSES FOR NONCARCINOGENIC TOXICITY

---

| <u>Chemical</u>     | <u>Water<br/>Concentration<br/>(mg/L)</u> | <u>Average Daily<br/>Absorbed Dose<br/>(mg/kg·day)</u> |
|---------------------|-------------------------------------------|--------------------------------------------------------|
| INORGANIC COMPOUNDS |                                           |                                                        |
| Aluminum            | 8.52                                      | 1.0E-4                                                 |
| Arsenic             | 0.0026                                    | 3.2E-8                                                 |
| Barium              | 0.0885                                    | 1.1E-6                                                 |
| Beryllium           | 0.0019                                    | 2.3E-8                                                 |
| Chromium            | 0.0066                                    | 8.0E-8                                                 |
| Copper              | 0.015                                     | 1.8E-7                                                 |
| Lead                | 0.0012                                    | 1.5E-8                                                 |
| Manganese           | 0.305                                     | 3.7E-6                                                 |
| Mercury             | 0.00085                                   | 1.0E-8                                                 |
| Nickel              | 0.010                                     | 1.2E-7                                                 |
| Silver              | 0.007                                     | 8.5E-8                                                 |
| Zinc                | 0.126                                     | 1.5E-6                                                 |

## ORGANIC COMPOUNDS

None Detected

TABLE 6-8 DERMAL CONTACT WITH WATER EXPOSURE CONCENTRATIONS AND DOSES  
FOR POTENTIAL CARCINOGENS

| <u>Chemical</u>     | <u>Water Concentration<br/>(mg/L)</u> | <u>Lifetime Average<br/>Daily Absorbed Dose<br/>(mg/kg·day)</u> |
|---------------------|---------------------------------------|-----------------------------------------------------------------|
| INORGANIC COMPOUNDS |                                       |                                                                 |
| Arsenic             | 0.0026                                | 1.4E-8                                                          |
| Beryllium           | 0.0019                                | 9.9E-9                                                          |
| Lead                | 0.0012                                | 6.2E-9                                                          |
| ORGANIC COMPOUNDS   |                                       |                                                                 |
| None Detected       |                                       |                                                                 |

effects is assessed with respect to a reference dose (RfD) which has been established for each individual substance and is usually based upon the most sensitive toxic endpoint. The RfD is considered to be a threshold level or dose of a particular substance. Daily lifetime intakes/doses less than this threshold are considered to be free of toxic effects, while intakes/doses exceeding this threshold have the potential to result in toxic manifestations which include the critical toxic effect and may include other toxicities as well. RfD values for all chemicals of potential concern are given in Table 6-9. Values were obtained primarily from the current EPA database, the Integrated Risk Information System (IRIS) (U.S. EPA 1992) or the Health Effects Summary Tables FY-1991 (U.S. EPA 1991b).

For the dermal contact with water exposure route, toxicity values needed to be expressed in a manner consistent with the derivation of the average daily absorbed dose. For this purpose, oral RfDs were adjusted with respect to the fraction of each chemical which is orally absorbed ( $\text{RfD} \times \text{oral absorption fraction} = \text{absorption-adjusted RfD}$ ), as per EPA guidance (U.S. EPA 1989). Oral absorption-adjusted RfDs for chemicals of potential concern are shown in Table 6-10. In the case of silver, the oral retention fraction (0.04) was used rather than an absorption fraction in deriving the dermal toxicity value (U.S. EPA 1992). Use of the EPA recommended guidance value (0.05) would not significantly alter this toxicity analysis.

The carcinogenic risk associated with a particular compound or element is assessed using a compound-specific value termed the slope factor (SF). A slope factor measures the level of risk associated with a unit dose of a substance, and allows the actual risk level to be adjusted with respect to the exposure dose. All SFs for potential carcinogens are shown in Table 6-11. Values are obtained primarily from the current EPA database (IRIS) (U.S. EPA 1992). The oral slope factor used for arsenic was derived from an oral Unit Risk value (U.S. EPA 1992). The oral SFs for use in conjunction with absorbed dose estimates from dermal contact

TABLE 6-9 TOXICITY VALUES FOR POTENTIAL NONCARCINOGENIC EFFECTS

| Chemical                | Chronic Oral RfD (mg/kg-day) | Confidence Level | Critical Effect                                                   | Oral RfD Basis/Source    | Uncertainty Factors | Modifying Factors |
|-------------------------|------------------------------|------------------|-------------------------------------------------------------------|--------------------------|---------------------|-------------------|
| INORGANIC COMPOUNDS     |                              |                  |                                                                   |                          |                     |                   |
| Aluminum                | ND                           |                  |                                                                   |                          |                     |                   |
| Antimony                | 4E-4                         | Low              | Decreased longevity and blood glucose; altered cholesterol        | Water/IRIS               | 1,000               | 1                 |
| Arsenic                 | 3E-4                         | Medium           | Hyperpigmentation, keratosis, and possible vascular complications | Water & Diet/IRIS        | 3                   | 1                 |
| Barium                  | 7E-2                         | Medium           | High blood pressure                                               | Water/IRIS               | 3                   | 1                 |
| Beryllium               | 5E-3                         | Low              | None                                                              | Water/IRIS               | 100                 | 1                 |
| Cadmium                 | 5E-4; Water<br>1E-3; Food    | High             | Proteinuria (renal damage)                                        | Water/IRIS<br>Food/IRIS  | 10<br>10            | 1<br>1            |
| Chromium <sup>(a)</sup> | 1E+0                         | Low              | Hepatotoxic                                                       | Diet/IRIS                | 100                 | 10                |
| Cobalt                  | ND                           |                  |                                                                   |                          |                     |                   |
| Copper <sup>(b)</sup>   | 4E-2                         |                  | Local GI irritation                                               | Dose/HEAST               |                     |                   |
| Lead (Inorganic)        | NA                           |                  | CNS/Heme Synthesis; encephalopathy                                |                          |                     |                   |
| Manganese               | 1E-1                         | Medium           | CNS/Reproductive                                                  | Diet/IRIS                | 1                   | 1                 |
| Mercury <sup>(c)</sup>  | 3E-4                         |                  | CNS                                                               | Human blood levels/HEAST | 10                  |                   |
| Nickel (Soluble Salt)   | 2E-2                         | Medium           | Decrease body weight/organ weight                                 | Diet/IRIS                | 300                 | 1                 |
| Selenium                | 5E-3                         | High             | Clinical selenosis; epidemiology study                            | Diet/IRIS                | 3                   | 1                 |
| Silver                  | 5E-3                         | Low              | Argyria                                                           | i.v./IRIS                | 3                   | 1                 |

ND No data/not done.

NA Not available, although data may exist.

(a) Oral RfD given is for trivalent chromium.

(b) Oral RfD is derived from drinking water MCL of 1.3 mg/L.

(c) Oral RfD is for alkyl plus inorganic mercury.

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TABLE 6-9 (Cont.)

| Chemical                    | Chronic<br>Oral RfD<br>(mg/kg day) | Confidence<br>Level | Critical Effect                                                | Oral RfD Basis/Source | Uncertainty<br>Factors | Modifying<br>Factors |
|-----------------------------|------------------------------------|---------------------|----------------------------------------------------------------|-----------------------|------------------------|----------------------|
| INORGANIC COMPOUNDS (cont.) |                                    |                     |                                                                |                       |                        |                      |
| Vanadium                    | 7E-3                               |                     | None Observed                                                  | Water/HEAST           | 100                    |                      |
| Zinc                        | 2E-1                               |                     | Anemia                                                         | Therap. Dose/HEAST    | 10                     | 1                    |
| ORGANIC COMPOUNDS           |                                    |                     |                                                                |                       |                        |                      |
| Acetone                     | 1E-1                               | Low                 | Increased liver and<br>kidney weights;<br>nephrotoxicity       | Gavage/IRIS           | 1,000                  | 1                    |
| Benzene                     | ND; pending                        |                     |                                                                |                       |                        |                      |
| Benzoic Acid                | 4E+0                               |                     | Irritation; malaise                                            | Diet/HEAST            | 1                      |                      |
| Bis(2-ethylhexyl)phthalate  | 2E-2                               | Medium              | Increased relative<br>liver weight                             | Diet/IRIS             | 1,000                  | 1                    |
| 2-Butanone                  | 5E-2                               | Medium              | None observed                                                  | Inhalation/IRIS       | 1,000                  | 1                    |
| Carbon disulfide            | 1E-1                               | Medium              | Fetal toxicity;<br>malformations                               | Inhalation/IRIS       | 100                    | 1                    |
| Chlorobenzene               | 2E-2                               | Medium              | Histopathologic liver<br>changes                               | Oral capsule/IRIS     | 1,000                  | 1                    |
| Toluene                     | 2E-1                               | Medium              | Liver/Kidney weight<br>changes                                 | Gavage/IRIS           | 1,000                  | 1                    |
| m-Xylene                    | 2E+0                               | Medium              | Increase mortality;<br>decreased body weight.<br>Hyperactivity | Gavage/HEAST          | 100                    |                      |
| o-Xylene                    | 2E+0                               | Medium              | Increase mortality;<br>decreased body weight.<br>Hyperactivity | Gavage/HEAST          | 100                    |                      |
| p-Xylene                    | ND                                 |                     |                                                                |                       |                        |                      |

TABLE 6-9 (Cont.)

| Chemical       | Chronic<br>Oral RfD<br>(mg/kg day) | Confidence<br>Level | Critical Effect                | Oral RfD Basis/Source | Uncertainty<br>Factors | Modifying<br>Factors |
|----------------|------------------------------------|---------------------|--------------------------------|-----------------------|------------------------|----------------------|
| THIOCARBAMATES |                                    |                     |                                |                       |                        |                      |
| Butylate       | 5E-2                               |                     | Liver effects                  | Gavage/HEAST          | 100                    |                      |
| Cycloate       | ND                                 |                     |                                |                       |                        |                      |
| EPTC           | 2.5E-2                             |                     | Degenerative<br>cardiomyopathy | Diet/HEAST            | 100                    |                      |
| Molinate       | 2E-3                               |                     | Reproductive toxicity          | Gavage/HEAST          | 100                    |                      |
| Pebulate       | 5E-2                               |                     | Anticoagulant effects          | Diet/HEAST            | 100                    |                      |
| Vernolate      | 1E-3                               |                     | Decreased body weight          | Diet/HEAST            | 1,000                  |                      |

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TABLE 6-10 ADJUSTED TOXICITY VALUES FOR EVALUATION OF DERMAL EXPOSURE

| Chemical            | Administered Dose<br>Chronic RfD<br>(mg/kg·day) | Oral<br>Absorption<br>Fraction | Reference Source                     | Absorbed Dose<br>(Adjusted)<br>Chronic RfD<br>(mg/kg·day) |
|---------------------|-------------------------------------------------|--------------------------------|--------------------------------------|-----------------------------------------------------------|
| INORGANIC COMPOUNDS |                                                 |                                |                                      |                                                           |
| Aluminum            | NA                                              |                                |                                      |                                                           |
| Arsenic             | 3E-4                                            | 0.95                           | Health Assessment Document; U.S. EPA | 2.9E-4                                                    |
| Barium              | 7E-2                                            | 0.1                            | ATSDR; U.S. Public Health Service    | 7.0E-3                                                    |
| Beryllium           | 5E-3                                            | 0.01                           | Health Assessment Document; U.S. EPA | 5.0E-5                                                    |
| Chromium            | 1E+0                                            | 0.004                          | ATSDR; U.S. Public Health Service    | 4.0E-3                                                    |
| Copper              | 4E-2                                            | 0.6                            | ATSDR; U.S. Public Health Service    | 2.4E-2                                                    |
| Lead (Inorganic)    | NA                                              |                                |                                      |                                                           |
| Manganese           | 1E-1                                            | 0.04                           | Health Effects Assessment; U.S. EPA  | 4.0E-3                                                    |
| Mercury             | 3E-4                                            | 0.07                           | Health Effects Assessment; U.S. EPA  | 2.1E-5                                                    |
| Nickel              | 2E-2                                            | 0.1                            | ATSDR; U.S. Public Health Service    | 2.0E-3                                                    |
| Silver              | 5E-3                                            | 0.04 <sup>(a)</sup>            | IRIS; U.S. EPA                       | 2.0E-4                                                    |
| Zinc                | 2E-1                                            | 0.8                            | Health Effects Assessment; U.S. EPA  | 1.6E-1                                                    |

NA Not Available.

(a) 0.04 is a retention factor [U.S. EPA (IRIS) 1992].



TABLE 6-11 CARCINOGENICITY VALUES FOR POTENTIAL CARCINOGENS

| <u>Chemical</u>            | <u>Oral Slope<br/>Factor<br/>(mg/kg day)<sup>-1</sup></u> | <u>Weight of<br/>Evidence<br/>Class</u> | <u>Type of<br/>Cancer</u> | <u>SF Basis/SF Source</u> |
|----------------------------|-----------------------------------------------------------|-----------------------------------------|---------------------------|---------------------------|
| INORGANIC COMPOUNDS        |                                                           |                                         |                           |                           |
| Arsenic (a)                | 1.8E+0                                                    | A                                       | Skin                      | Water/IRIS                |
| Beryllium                  | 4.3E+0                                                    | B2                                      | Gross Tumors              | Water/IRIS                |
| Lead (Inorganic)           | NA                                                        | B2                                      | Kidney                    |                           |
| ORGANIC COMPOUNDS          |                                                           |                                         |                           |                           |
| Benzene                    | 2.9E-2                                                    | A                                       | Leukemia                  | Diet/IRIS                 |
| Bis(2-ethylhexyl)phthalate | 1.4E-2                                                    | B2                                      | Liver                     | Diet/IRIS                 |

ND No Data/Not Done.

NA Not Available, although data may exist.

(a) Oral slope factor is derived from oral Unit Risk value.

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with water also needed to be adjusted. Absorption-adjusted oral SFs (oral SF / absorption fraction = absorption-adjusted SF) are shown in Table 6-12.

### 6.1.3 Risk Characterization

Average daily intakes or doses calculated for either route of exposure were subsequently used with toxicity values presented in Section 6.1.2 to quantify both noncarcinogenic and carcinogenic risks associated with Cold Creek Swamp. To assess potential toxicity (i.e., the noncarcinogenic risks), the ratio of the average daily intake or absorbed dose for an individual compound to the current established RfD for that particular substance was calculated for each potential contaminant. This ratio, termed the hazard quotient (HQ), was used as the criterion for determining if there was a toxic effect associated with any individual compound that would warrant analysis of this chemical in future stages. Hazard quotient values of greater than 1.0 were used to designate a substance as a potential toxic hazard.

Potential carcinogenic risk was determined by multiplying the lifetime average daily intake or absorbed dose by the SF. A risk level of  $1 \times 10^{-6}$  has been termed the de minimis level of risk. This level is used as a point of departure for determining remediation goals when ARARs are not available. Risks which fall within the range of  $1 \times 10^{-4}$  to  $1 \times 10^{-6}$  are typically managed on a site-specific basis. As a preliminary assessment, the  $1 \times 10^{-6}$  risk level was used as the criterion above which risk from any individual potential carcinogen was deemed unacceptable.

#### Fish Ingestion

Intakes of potential contaminants via the ingestion of contaminated fish and/or shellfish were determined as average daily intakes. Estimations of the chemical concentrations in fish were made following exposure of fish to potentially contaminated swamp water or sediments for all relevant contaminants. Concentrations of total mercury in fish were obtained

TABLE 6-12 ADJUSTED CARCINOGENICITY VALUES FOR EVALUATION OF DERMAL EXPOSURE

| <u>Chemical</u>     | <u>Administered Dose<br/>Slope Factor<sub>-1</sub><br/>(mg/kg·day)<sup>-1</sup></u> | <u>Oral<br/>Absorption<br/>Fraction</u> | <u>Reference Source</u>              | <u>Adjusted Dose<br/>(Adjusted)<br/>Slope Factor<sub>-1</sub><br/>(mg/kg·day)<sup>-1</sup></u> |
|---------------------|-------------------------------------------------------------------------------------|-----------------------------------------|--------------------------------------|------------------------------------------------------------------------------------------------|
| INORGANIC COMPOUNDS |                                                                                     |                                         |                                      |                                                                                                |
| Arsenic             | 1.8E+0                                                                              | 0.95                                    | Health Assessment Document; U.S. EPA | 1.9E+0                                                                                         |
| Beryllium           | 4.3E+0                                                                              | 0.01                                    | Health Assessment Document; U.S. EPA | 4.3E+2                                                                                         |
| Lead <sup>(a)</sup> | NA                                                                                  |                                         |                                      |                                                                                                |

(a) There is no established oral slope factor for lead; hence, no adjusted slope factor can be derived.

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directly via analyses of fish collected within or outside of the Cold Creek Swamp, yielding potentially contaminated tissue levels and background tissue levels. The hazard quotients calculated for these substances (i.e., substances detected in either sediment or water from the swamp) are shown in Table 6-13. Based upon the toxicity assessment criteria it can be seen that there is no toxic, i.e., noncarcinogenic, risk associated with the ingestion of potentially contaminated aquatic biota, since none of the hazard quotients exceed 1.0, including the hazard quotient for mercury (HQ = 0.2) and all organic chemicals.

Estimates of the carcinogenic risks posed by ingestion are shown in Table 6-14. By comparison with the de minimis risk level it can be seen that a potential for an unacceptable risk is obtained for beryllium, where the risk is just above the  $10^{-6}$  de minimis level ( $2 \times 10^{-6}$ ). Beryllium has been classified by the EPA's weight-of-evidence classification scheme as a B2 carcinogen, primarily on the basis of its carcinogenicity in animals upon inhalation and its possible carcinogenicity in animals after ingestion of drinking water (U.S. EPA 1992).

#### Dermal Contact with Water

The intakes of chemicals via the dermal contact with water route of exposure were determined as average daily absorbed doses using a permeability constant. Estimating the absorbed dose reflects the extent of absorption across intact skin on a temporal (per hour) basis. For purposes of deriving the hazard quotient, average daily absorbed dose estimates were divided by the absorption-adjusted oral RfD values. The hazard quotients determined for each compound of potential concern are shown in Table 6-15. It can be seen that there are no chemicals of potential concern that have hazard quotients that exceed a value of 1.0. On this basis, there is no evidence of noncarcinogenic toxicity via the dermal contact route.

TABLE 6-13 RISKS FROM NONCARCINOGENIC EFFECTS FROM INGESTED FISH

| Chemical                   | Exposure<br>Intake<br>(mg/kg·day) | RfD<br>(mg/kg·day) | Hazard<br>Quotient |
|----------------------------|-----------------------------------|--------------------|--------------------|
| INORGANIC COMPOUNDS        |                                   |                    |                    |
| Aluminum                   | 1.9E-2                            | NA                 | —                  |
| Antimony                   | 1.6E-6                            | 4E-4               | 4E-3               |
| Arsenic                    | 1.3E-7                            | 3E-4               | 4E-4               |
| Barium                     | 2.3E-4                            | 7E-2               | 3E-3               |
| Beryllium                  | 1.0E-6                            | 5E-3               | 2E-4               |
| Cadmium                    | 5.4E-5                            | 5E-4               | 1E-1               |
| Chromium <sup>(a)</sup>    | 2.9E-7                            | 1E+0               | 3E-7               |
| Copper                     | 6.8E-6                            | 4E-2               | 2E-4               |
| Lead                       | 1.3E-6                            | NA                 | —                  |
| Manganese <sup>(b)</sup>   | 7.5E-3                            | 1E-1               | 8E-2               |
| Mercury <sup>(b)</sup>     | 4.6E-5                            | 3E-4               | 2E-1               |
| Nickel                     | 6.3E-6                            | 2E-2               | 3E-4               |
| Selenium                   | 3.4E-6                            | 5E-3               | 7E-4               |
| Silver                     | 4.8E-6                            | 5E-3               | 1E-3               |
| Vanadium                   | 1.3E-5                            | 7E-3               | 2E-3               |
| Zinc                       | 1.3E-3                            | 2E-1               | 7E-3               |
| ORGANIC COMPOUNDS          |                                   |                    |                    |
| Acetone                    | 1.3E-5                            | 1E-1               | 1E-4               |
| Benzene                    | 7.4E-7                            | NA                 | —                  |
| Benzoic Acid               | 4.3E-6                            | 4E+0               | 1E-6               |
| Bis(2-ethylhexyl)phthalate | 2.1E-6                            | 2E-2               | 1E-4               |
| 2-Butanone                 | 1.8E-8                            | 5E-2               | 4E-7               |
| Carbon disulfide           | 5.6E-8                            | 1E-1               | 6E-7               |
| Chlorobenzene              | 5.7E-7                            | 2E-2               | 3E-5               |
| Toluene                    | 3.4E-7                            | 2E-1               | 2E-6               |
| m&p Xylene <sup>(c)</sup>  | 1.7E-6                            | 2E+0               | 9E-7               |
| o-Xylene                   | 6.9E-7                            | 2E+0               | 3E-7               |
| THIOCARBAMATES             |                                   |                    |                    |
| Butylate                   | 1.1E-4                            | 5E-2               | 2E-3               |
| Cycloate                   | 9.9E-5                            | NA                 | —                  |
| EPTC                       | 4.5E-5                            | 2.5E-2             | 2E-3               |
| Molinate                   | 1.1E-5                            | 2E-3               | 6E-3               |
| Pebulate                   | 5.4E-5                            | 5E-2               | 1E-3               |
| Vernolate                  | 6.6E-5                            | 1E-3               | 7E-2               |

(a) Assumes all chromium is trivalent chromium.

(b) RfD for alkyl & inorganic mercury (IRIS)

(c) m&p Xylene is treated as m-xylene.

NA Not Available.

TABLE 6-14 RISKS FROM CARCINOGENIC EFFECTS FROM INGESTED FISH

| Chemical                   | Cancer<br>Intake<br>Dose<br>(mg/kg·day) | Oral Slope<br>Factor<br>(mg/kg·day) <sup>-1</sup> | Risk |
|----------------------------|-----------------------------------------|---------------------------------------------------|------|
| INORGANIC COMPOUNDS        |                                         |                                                   |      |
| Arsenic                    | 5.6E-8                                  | 1.8E+0                                            | 1E-7 |
| Beryllium                  | 4.3E-7                                  | 4.3E+0                                            | 2E-6 |
| Lead                       | 5.7E-7                                  | NA                                                | —    |
| ORGANIC COMPOUNDS          |                                         |                                                   |      |
| Benzene                    | 3.2E-7                                  | 2.9E-2                                            | 9E-9 |
| Bis(2-ethylhexyl)phthalate | 8.9E-7                                  | 1.4E-2                                            | 1E-8 |

NA Not Available.

TABLE 6-15 RISKS FROM NONCARCINOGENIC EFFECTS FROM DERMAL CONTACT WITH WATER

| <u>Chemical</u>     | <u>Absorbed<br/>Dose<br/>(mg/kg·day)</u> | <u>Absorption<br/>Adjusted<br/>RfD<br/>(mg/kg·day)</u> | <u>Hazard<br/>Quotient</u> |
|---------------------|------------------------------------------|--------------------------------------------------------|----------------------------|
| INORGANIC COMPOUNDS |                                          |                                                        |                            |
| Aluminum            | 1.0E-4                                   | NA                                                     | —                          |
| Arsenic             | 3.2E-8                                   | 2.9E-4                                                 | 1E-4                       |
| Barium              | 1.1E-6                                   | 7.0E-3                                                 | 2E-4                       |
| Beryllium           | 2.3E-8                                   | 5.0E-5                                                 | 5E-4                       |
| Chromium            | 8.0E-8                                   | 4.0E-3                                                 | 2E-5                       |
| Copper              | 1.8E-7                                   | 2.4E-2                                                 | 8E-6                       |
| Lead                | 1.5E-8                                   | NA                                                     | —                          |
| Manganese           | 3.7E-6                                   | 4.0E-3                                                 | 9E-4                       |
| Mercury             | 1.0E-8                                   | 2.1E-5                                                 | 5E-4                       |
| Nickel              | 1.2E-7                                   | 2.0E-3                                                 | 6E-5                       |
| Silver              | 8.5E-8                                   | 2.0E-4                                                 | 4E-4                       |
| Zinc                | 1.5E-6                                   | 1.6E-1                                                 | 9E-6                       |
| ORGANIC COMPOUNDS   |                                          |                                                        |                            |
| None detected       |                                          |                                                        |                            |

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NA Not Available.

In a similar fashion, the calculation of carcinogenic risks from dermal exposure required the use of absorption-adjusted oral SFs. Risks were calculated as the product of the carcinogenic average daily absorbed dose and the absorption-adjusted oral SF. Estimations of carcinogenic risks are shown in Table 6-16. This table shows that there is a potentially elevated risk level associated with dermal contact with beryllium ( $4 \times 10^{-6}$ ).

Again, it must be pointed out that beryllium has been classified by the EPA's weight-of-evidence classification scheme as a B2 carcinogen, primarily on the basis of its carcinogenicity via inhalation and potential oral carcinogenicity in animal systems. The beryllium carcinogenic risk would also be reduced by using a less conservative oral absorption fraction in Table 6-12 to adjust the oral slope factor to that appropriate for use with the dermal absorbed dose. U.S. EPA guidance for risk assessment suggests that an oral absorption fraction of 5 percent (0.05) be used in the absence of chemical-specific information on oral absorption (U.S. EPA 1989). If the oral absorption fraction of 0.05 were used in place of the chemical-specific conservative value of 0.01 used here, the excess cancer risk attributable to beryllium would be reduced to  $8 \times 10^{-7}$ .

#### Uncertainties Associated With the Risk Characterization

Uncertainties involved in the estimation of both noncarcinogenic and carcinogenic risk exist due to factors such as the method of data analysis, the exposure assumptions, and the availability of quantitative toxicity values and/or carcinogenicity factors. Specific uncertainties associated with this risk assessment are discussed below.

#### Fish Ingestion Scenario

For the exposure scenario of ingesting potentially contaminated fish and/or shellfish, the derivation of fish tissue concentrations from water and sediment concentrations as opposed to obtaining actual fish tissue



TABLE 6-16 RISKS FROM CARCINOGENIC EFFECTS FROM DERMAL CONTACT WITH WATER

| <u>Chemical</u>     | <u>Cancer<br/>Absorbed<br/>Dose<br/>(mg/kg·day)</u> | <u>Absorption<br/>Adjusted<br/>Oral<br/>Slope Factor<sub>1</sub><br/>(mg/kg·day)<sup>-1</sup></u> | <u>Risk</u> |
|---------------------|-----------------------------------------------------|---------------------------------------------------------------------------------------------------|-------------|
| INORGANIC COMPOUNDS |                                                     |                                                                                                   |             |
| Arsenic             | 1.4E-8                                              | 1.9E+0                                                                                            | 3E-8        |
| Beryllium           | 9.9E-9                                              | 4.3E+2                                                                                            | 4E-6        |
| Lead                | 6.2E-9                                              | NA                                                                                                | —           |

NA Not Available.

data introduced uncertainty. Concentrations derived using water samples have the uncertainty associated with the use of BCFs, although using the geometric mean BCF yields a better representative value from among the values available in the literature. The derivation of fish concentrations from sediment data for organics and thiocarbamates introduced the additional uncertainty inherent in the estimation of  $K_{oc}$  values, due to the need to first estimate partitioning from sediment into water.

In the case of mercury, however, uncertainty associated with the risk estimate is substantially reduced by the use of measured tissue concentrations for collected fish species and the additional conversion from whole-body concentrations to edible fillet concentrations. The potential for risk from ingestion of potentially contaminated fish caught onsite is further diminished by a comparison of mercury fillet concentrations for fish collected within the Swamp (average = 1.37 mg/kg; upper 95 percent confidence limit on the mean = 1.72 mg/kg) or fillet concentrations in fish collected outside of the Swamp (average background = 0.57 mg/kg; upper 95 percent confidence limit on the mean value = 0.94 mg/kg). There is less than a two-fold difference between background and on-site levels of total mercury in sampled fish.

Due to the lack of RfD values for aluminum, lead, benzene, and cycloate, quantitative estimates of toxicity could not be made for these compounds. However, based on their low ingestion doses and/or knowledge of their respective toxicities, no toxic effects are anticipated.

The lack of a slope factor for lead made quantitation of cancer risks attributable to this compound impossible. Inorganic lead has been classed as a B2 carcinogen via the oral route. The average daily carcinogenic intake of  $5.7 \times 10^{-7}$  mg/kg·day is not overly high, when coupled with the actual low extent of oral absorption of inorganic lead

(from 1 to 15 percent) (Agency for Toxic Substances and Disease Registry (ATSDR) Final). The lack of carcinogenic effects and a weight-of-evidence classification for ingested cadmium negated its consideration as a potential carcinogen for either the fish ingestion or dermal exposure routes, although it is a B1 carcinogen via inhalation.

#### Dermal Contact Exposure

For the dermal contact with water scenario, there are also uncertainties associated with the assessment of site-specific risks. These include the use of the dermal permeability constant for water ( $1.5 \times 10^{-3}$ ) (U.S. EPA 1991a) versus chemical-specific values. Metals were the only chemicals of potential concern in water samples used for the dermal contact route, and the permeability constant for water was used to calculate absorbed dose. The use of the permeability constant for water in estimating the dermally absorbed dose of beryllium added some uncertainty to the estimation of risk from beryllium exposure. Uncertainty in the beryllium cancer risk is also introduced by the use of a very conservative absorption fraction which leads to an overestimation of excess cancer risk.

Due to the lack of an RfD value for aluminum a quantitative toxicity value could not be obtained. Based on both its low dermal absorbed dose and knowledge of its toxicity, no toxic effects are expected.

The lack of RfD and slope factor values for lead hinders quantitation of dermal contact risks due to lead exposure. While lead has been shown to be both toxic and carcinogenic, the dermal absorption fraction for inorganic lead across intact human skin is approximately 0 to 0.3 percent (absorption fraction = 0.003) (ATSDR Final), severely limiting lead absorption via this route.

### Human Health Risk Conclusions

Based upon the predetermined exposure scenarios for the Cold Creek Swamp site, namely, ingestion of recreationally caught fish and dermal contact with water stemming from this activity, and considering the qualifying statements put forth in the preceding section, the site does not present unacceptable human health risks.

Noncarcinogenic effects, as measured by hazard quotients, are not a concern for either route of exposure, i.e., all hazard quotients are less than 1.0. Carcinogenic risks are less than  $1 \times 10^{-6}$  for both routes of exposure for all carcinogenic compounds except beryllium.

The carcinogenic risk from beryllium is, in fact, considered negligible for four reasons. First, while the de minimis risk of  $1 \times 10^{-6}$  was used here for screening purposes, the beryllium risks of  $2 \times 10^{-6}$  (ingestion) and  $4 \times 10^{-6}$  (dermal) would not warrant remediation based on the extremely small population that potentially might be exposed. Second, when compared with the background beryllium levels in surface water (average =  $1.25 \mu\text{g/L}$ , Table 6-3), the concentrations of beryllium in the swamp surface water (average =  $1.4 \mu\text{g/L}$ , Table 6-3) are not elevated. Third, although beryllium has an oral slope factor, it is based primarily on the development of lung tumors via inhalation and on non-statistically significant increases in the frequencies of gross tumors in animals following oral ingestion in drinking water (U.S. EPA (IRIS) 1992). Neither of these are pathways of concern for the Cold Creek Swamp site. Lastly, application of the guidance value for the oral absorption fraction (0.05) reduces the beryllium risk to  $8 \times 10^{-7}$ , an acceptable level.

In summary, based upon the exposure pathways that were examined and specific exposure factors related to beryllium, Cold Creek Swamp does not pose unacceptable risk, noncarcinogenic or carcinogenic, to human health.

## 6.2 ENVIRONMENTAL RISK EVALUATION

The environmental risk characterization was designed to:

1. Objectively determine a technically tractable list of contaminants of potential concern for further detailed analyses.
2. Objectively determine receptors of potential concern to best characterize site-specific ecological risks.
3. Estimate hazards and exposures for contaminants and receptors of concern.
4. Calculate quantitative risks of contamination to Cold Creek Swamp receptors of concern.

By this process, an objective evaluation of potential risk to ecological receptors in the swamp ecosystem was determined.

To meet these objectives, a phased approach was applied to ecological risk modeling consistent with the three-stage field data collection approach. Figure 6-1 shows the interrelationship of the three-stage field data collection and the three-phase approach to ecological risk assessment.

Stage I field work provided data that were used in the Stage I Ecological Risk Evaluation, which focused on identification of contaminants of concern through application of a potential contaminant of concern ranking model. Based on the results of this Stage I ecological model, the Stage II field program scope was refined.

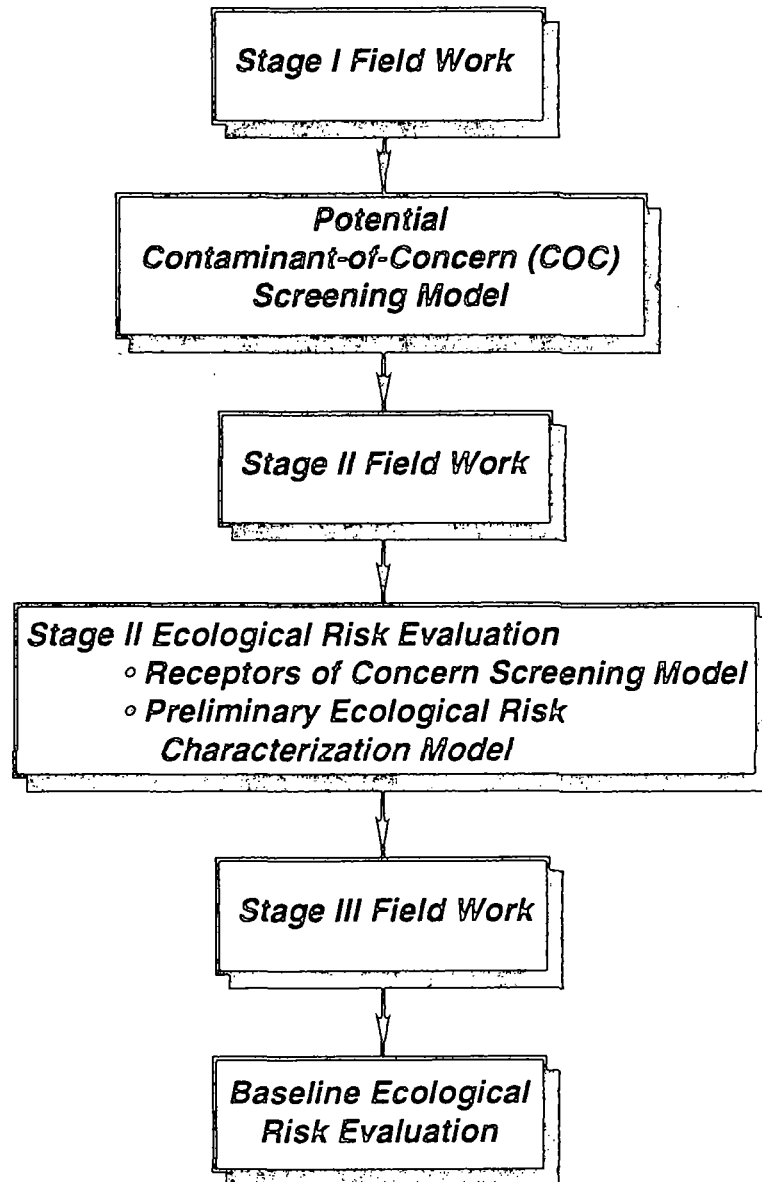


Figure 6-1. Interrelationship of Staged Field Sampling Program and Ecological Risk Evaluation.

Stage II analytical data were then used in the Stage II Ecological Risk Evaluation. The scope of this activity included two modeling efforts. One model was developed to screen and rank potential receptors of concern. The other model was applied to assess potential risk to ecological receptors based on the data available at the end of Stage II, and to predict mercury body burdens in the potential receptors of concern that were identified in the first model. Data gathered through these two models were used to refine the scope of Stage III field activities.

Finally, when Stage III analytical data were available, it was possible to perform a comprehensive Baseline Ecological Risk Evaluation, which used all of the analytical and ecological modeling data that were generated during previous stages to assess the potential risk to ecological receptors of concern in Cold Creek Swamp. This risk evaluation included an exposure assessment, toxicity assessment, and risk characterization. The ecological risk characterization model that had been developed in Stage II was refined based on actual tissue data and a comprehensive literature survey of toxicity endpoints for mercury. This model was used to predict mercury body burdens in all potential receptors of concern in Cold Creek Swamp. In addition, potential risk was calculated using actual data for species that were analyzed during the Stage III field program. The results of the modeled and actual risk calculations for used to project potential risk due to mercury exposure by ecological receptors of concern in the Cold Creek Swamp ecosystem.

#### 6.2.1 Stage I Ecological Risk Evaluation

The Stage I Ecological Risk Evaluation focused on identification of potential contaminants of concern based on a contaminant screening ranking model (Section 6.1). Physicochemical properties, bioconcentration potential, toxicity, and environmental concentration were identified as key parameters for screening potential contaminants of concern to be carried from Stage I to Stage II analyses. An objective, semiquantitative modeling methodology was applied in developing the contaminants of

concern screening model. This approach applies a factor weighting technique (Dean and Nishry 1965) to the relative hazard ranking model for site contaminants developed by Halfon and Reggiani (1986). All compounds were evaluated against scientific and regulatory thresholds in order to determine the rank of each compound relative to these established thresholds. Compounds that exceeded thresholds were recommended for additional data gathering in Stage II and subsequent data evaluation.

#### 6.2.1.1 Potential Contaminant of Concern Screening Model Description

A paired rank comparison analysis was used to screen compounds detected at the Cold Creek Swamp. The following criteria were used in this evaluation:

- . Measured water concentrations ([water]) were used when available under the assumption that water mediates uptake. When water concentrations were below detection limits, potential water concentrations were modeled based on sediment concentrations using an organic carbon partition coefficient and an estimated organic carbon content of four percent.
- . Freshwater chronic toxicity endpoints were utilized. These endpoints were obtained from U.S. EPA Ambient Water Quality Criteria documents or from the U.S. EPA's AQUIRE database.
- . Measured water concentrations and chronic criteria were combined to determine a toxicity quotient (TQ) where

$$TQ = [water] / \text{chronic criterion.}$$

- . Detection frequency: the ratio of number of measurements in excess of background concentrations to the total number of measurements.



- . Bioconcentration factors: taken from water quality criteria documents or estimated using quantitative structure activity relationships (QSAR).

These data were used in a paired comparison analysis (PCA) to generate a rank-ordering of identified compounds. The ranking was evaluated relative to threshold criteria presented in Figure 6-2. This provided a reference above which compounds required further examination and below which no further analyses were recommended.

The reader should note that acetone was carried through the model only for completeness. Acetone was not detected in water, and the modeled concentration is far higher than would be expected under any circumstances. This is an artifact of the modeling process itself, and results should not be construed as actual or projected concentrations. In fact, acetone is likely spurious in this data set; measured concentrations are likely due to laboratory contamination.

#### 6.2.1.2 Screening Procedure for Potential Contaminants of Concern

The principle of the PCA (Dean and Nishry 1965; Canter 1977) is to reduce the decision making process to individual components so that a numerical score can be developed for each contaminant based on pertinent information (factors). The first step in the technique was to make comprehensive lists of all of the compounds and decision-making factors. Factors were then weighted as to their relative importance. For example, chronic toxicity quotient (a direct measure of effect) was considered more important than detection frequency (a simple measure of presence), so this factor was weighted more heavily. The PCA was designed to make the weighting process as objective as possible. This was done by pairwise comparison of each factor to every other factor. For example, in the instance of chronic toxic quotient versus detection frequency, the chronic toxicity quotient factor would be assigned a score of 1 since it is the more important. The detection frequency factor would be assigned

## "Threshold" Contaminant

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Toxic Quotient = 1.0

Bioconcentration Factor = 100

\*

Frequency of Detection

Above Background = 10 %

- \* USEPA 1991. Assessment and control of bioconcentratable contaminants in surface waters. Draft.

Figure 6-2. Definition of threshold contaminant.

a score of 0. The chronic toxicity quotient factor would then be compared with the BCF, etc., until every factor had been compared with every other. In cases where no clear decision can be made, factor importance is considered equal and each factor receives a score of 0.5. All of the scores from each comparison are then summed and divided by the total of all scores. The result is a weight (which can be expressed as a percentage) for each factor relative to every other factor. Factors which have high scores (weights) have a greater influence on the final decision; those with low weights influence the decision process to a lesser degree.

Once factors have been weighted, each compound (or element) is compared (one at a time) to every other compound, one factor at a time. As with factor weighting, each time a comparison is made, a score of 0, 1, or 0.5 is assigned. Since this portion of the PCA is entirely data-driven, no subjectivity enters in at this point. These comparisons are performed for each factor, and final scores for each factor and compound are calculated in the same manner as for factor weights.

The final step is to multiply each compound score by the factor weights and sum the results for each compound. This generates the final score for each compound. These scores can then be sorted by magnitude and assigned ranks. A threshold which has the minimum characteristics required for assignment as a contaminant of concern is included in the PCA process. All compounds which rank higher are considered contaminants of concern and those which rank lower are not.

The factor weighting process, illustrated in Figure 6-3, produced weights for the toxic quotient of 0.5000 (of greatest importance), followed by a rank for the BCF of 0.3333 (of intermediate importance), and a rank for the detection frequency of 0.1667 (of least importance).

The final scores, because they derived from importance weighted comparisons of empirical and analytical data, reflect the potential of each compound to present an ecological risk relative to the concern threshold

|                     |   |   |   |   |   |   |                |
|---------------------|---|---|---|---|---|---|----------------|
| Toxic Quotient      | 1 | 1 | 1 |   |   |   | 3 / 6 = 0.5000 |
| BCF                 | 0 |   |   | 1 | 1 |   | 2 / 6 = 0.3333 |
| Detection Frequency |   | 0 |   | 0 |   | 1 | 1 / 6 = 0.1667 |
| Neutral Parameter   |   |   | 0 |   | 0 | 0 | 0 / 6 = 0.0000 |

Total = 1.0000

Toxic Quotient vs. BCF -

Toxicity is a direct potential impact whereas bioconcentration is complex, mediated and is not in and of itself an "impact".

Toxic Quotient vs. Detection Frequency -

Toxicity is a direct potential impact whereas frequency of detection above background is only an indicator of ubiquity of distribution.

Bioconcentration Factor vs. Detection Frequency -

Bioconcentration factor is related to biological processes and as such presents greater potential risk than ubiquity of distribution.

Figure 6-3. Contaminant of concern selection factor weighting criteria.

3 10 0217

and to other compounds. Because these final scores are relative, not absolute, no specific degree of risk can be assigned, only the potential to present an ecological risk can be inferred.

#### 6.2.1.3 Input Data

##### Concentration

Measured water concentrations are listed in Table 6-17. Sediment concentration values were converted to water concentration values for organics using the following equation:

$$K_d = (F_{oc})(K_{oc}) = (C_{\text{sediment}}/C_{\text{water}}) \quad (\text{Equation 6-3})$$

where

- $K_d$  = Sediment/water partition coefficient
- $F_{oc}$  = Fraction organic carbon
- $K_{oc}$  = Chemical-specific organic carbon partition coefficient
- $C_{\text{sediment}}$  = Concentration of the chemical in sediment ( $\mu\text{g}/\text{kg}$ )
- $C_{\text{water}}$  = Concentration of the chemical in water ( $\mu\text{g}/\text{L}$ )

Freshwater chronic toxicity endpoints are also listed in Table 6-17. While a number of alternate screening values based on the AWQC are available (e.g., Region IV Superfund Water Quality Screening Values), at this stage in the analysis, actual toxicity values have been utilized. These values are freshwater chronic criteria, lowest reported chronic toxic endpoints in respective Water Quality Criteria Documents, or lowest reported acute or chronic toxic endpoints from an AQUIRE database search (U.S. EPA 1987 or ICI 1989). In some cases, chronic toxicity data were not available and in such instances an Acute to Chronic Ratio of 10 (U.S. EPA 1985) was used to convert these values to chronic endpoints.

TABLE 6-17 CALCULATED AND MEASURED CONCENTRATIONS OF CHEMICALS IN SEDIMENT AND WATER, WITH THEIR RESPECTIVE CHRONIC TOXICITY ENDPOINTS

| <u>Chemical</u> | <u>Measured<br/>Sediment<br/>Concentration<br/>(µg/Kg)</u> | <u>Measured<br/>Water<br/>Concentration<br/>(µg/L)</u> | <u>Calculated<br/>Water<br/>Concentration<br/>(µg/L)</u> | <u>Chronic<br/>Toxic<br/>Endpoint</u> | <u>Source</u> |
|-----------------|------------------------------------------------------------|--------------------------------------------------------|----------------------------------------------------------|---------------------------------------|---------------|
| Aluminum        | -                                                          | 3040.0                                                 | -                                                        | 87.0                                  | WC            |
| Antimony        | -                                                          | <60                                                    | -                                                        | 1600.0                                | WC            |
| Arsenic         | -                                                          | 1.5                                                    | -                                                        | 48.0                                  | WC            |
| Barium          | -                                                          | 75.0                                                   | -                                                        | 41000.0                               | AC            |
| Beryllium       | -                                                          | 1.4                                                    | -                                                        | 5.3                                   | WC            |
| Cadmium         | -                                                          | <5.0                                                   | -                                                        | 0.4636                                | WC            |
| Chromium        | -                                                          | 4.2                                                    | -                                                        | 11.0                                  | WC            |
| Copper          | -                                                          | 12.5                                                   | -                                                        | 4.47                                  | WC            |
| Lead            | -                                                          | 0.73                                                   | -                                                        | 0.746                                 | WC            |
| Mercury (total) | -                                                          | 0.41                                                   | -                                                        | 0.012                                 | WC            |
| Nickel          | -                                                          | 6.3                                                    | -                                                        | 60.1                                  | WC            |
| Selenium        | -                                                          | <2.0                                                   | -                                                        | 35.0                                  | WC            |
| Vanadium        | -                                                          | <50                                                    | 370                                                      | EA                                    |               |
| Zinc            | -                                                          | 90.0                                                   | -                                                        | 40.4                                  | WC            |
| Acetone         | 503.0                                                      | -                                                      | 700.0                                                    | 1000.0                                | AC            |
| Benzene         | 4.9                                                        | -                                                      | 0.36                                                     | 530.0                                 | VC            |
| Benzoic Acid    | 34.8                                                       | -                                                      | 3.5                                                      | 18000.0                               | AC            |

- WC Freshwater Chronic Criteria from respective Ambient Water Quality Criteria Document.
- AC Lowest acute toxic value from an AQUIRE Database Search (U.S. EPA 1987), converted to chronic by U.S. EPA (1985) method of dividing by 10.
- W Lowest reported chronic value in respective Ambient Water Quality Criteria Document.
- A Lowest chronic value derived from an AQUIRE Database Search (U.S. EPA 1987).
- VC Lowest freshwater acute toxicity value reported in Verschueren (1983), converted to chronic by U.S. EPA (1985) method of dividing by 10.
- WCC Lowest reported acute value or freshwater acute criteria from respective Ambient Water Quality Criteria Document, converted to chronic value by U.S. EPA (1985) method of dividing by 10.
- ICI Lowest acute toxic value from ICI (1989) converted to chronic by U.S. EPA (1985) method of dividing by 10.

TABLE 6-17 (Cont.)

| <u>Chemical</u>            | <u>Measured<br/>Sediment<br/>Concentration<br/>(µg/Kg)</u> | <u>Measured<br/>Water<br/>Concentration<br/>(µg/L)</u> | <u>Calculated<br/>Water<br/>Concentration<br/>(µg/L)</u> | <u>Chronic<br/>Toxic<br/>Endpoint</u> | <u>Source</u> |
|----------------------------|------------------------------------------------------------|--------------------------------------------------------|----------------------------------------------------------|---------------------------------------|---------------|
| Bis(2-ethylhexyl)phthalate | 53.6                                                       | -                                                      | 0.015                                                    | 3.0                                   | W             |
| 2-Butanone                 | 2.4                                                        | -                                                      | 1.8                                                      | 52000.0                               | AC            |
| Carbon Disulfide           | 1.2                                                        | -                                                      | 0.43                                                     | 210.0                                 | AC            |
| Chlorobenzene              | 4.3                                                        | -                                                      | 0.13                                                     | 1590.0                                | WCC           |
| Hexanoic Acid, 2 ethyl     | 655.7                                                      | -                                                      | 64.0                                                     | 1500.0                                | VC            |
| Isopropylether             | 10.6                                                       | -                                                      | 3.20                                                     | 500,000                               | VC            |
| Methyl Mercury             | 3.4                                                        | -                                                      | 0.0014                                                   | 0.012                                 | W             |
| Toluene                    | 1.6                                                        | -                                                      | 0.06                                                     | 1270.0                                | WCC           |
| m,p-Xylene                 | 3.4                                                        | -                                                      | 0.07                                                     | 200.0                                 | VC            |
| O-Xylene                   | 2.3                                                        | -                                                      | 0.08                                                     | 1.0                                   | VC            |
| Butylate                   | 308.0                                                      | -                                                      | 5.9                                                      | 360.0                                 | AC            |
| Cycloate                   | 251.0                                                      | -                                                      | 8.6                                                      | 260.0                                 | AC            |
| EPTC                       | 156.0                                                      | -                                                      | 13.6                                                     | 1450.0                                | ICI           |
| Molinate                   | 127.0                                                      | -                                                      | 13.0                                                     | 18.0                                  | AC            |
| Pebulate                   | 78.0                                                       | -                                                      | 3.0                                                      | 210.0                                 | ICI           |
| Vernolate                  | 176.0                                                      | -                                                      | 5.7                                                      | 23.0                                  | AC            |

Chemical and Biological Data

Table 6-18 lists  $K_{oc}$  values used to calculate water chemical concentrations from sediment concentrations. Also listed are log octanol-water partition coefficients ( $\log K_{ow}$ ). When  $K_{oc}$  values were unknown,  $\log K_{ow}$  or water solubility (S) were used to calculate  $K_{oc}$  with the following equations:

$$\log K_{oc} = 0.544 \log K_{ow} + 1.377 \quad (\text{Equation 6-4})$$

(Staples et al. 1985)

$$\log K_{ow} = -0.800 \log S(\text{mg/L}) + 4.158 \quad (\text{Equation 6-5})$$

(Staples et al. 1985)

Table 6-19 lists the parameters used to run the Ranking Model. Geometric mean BCF values are given for all reported freshwater fish species in the respective U.S. EPA Ambient Water Quality Criteria Documents and ICI (1989) for thiocarbamate herbicides. Only BCF values resulting from laboratory studies of at least 28 days duration (U.S. EPA 1985) were used. When BCF values were not available from respective Water Quality Criteria Documents or other sources, the following equation was used to calculate the BCF:

$$\log BCF = \log K_{ow} - 1.32 \quad (\text{Equation 6-6})$$

(McCarty 1986)

Ecological impacts were estimated from geometric mean BCF values for all reported freshwater fish. The following equation was used to determine organism tissue concentrations:

$$BCF = C_{\text{organism}} / C_{\text{water}} \quad (\text{Equation 6-7})$$



TABLE 6-18 CALCULATED AND MEASURED LOG K<sub>OW</sub> AND K<sub>OC</sub> VALUES

| Chemicals                  | Log K <sub>ow</sub> | Source | K <sub>oc</sub> | Source |
|----------------------------|---------------------|--------|-----------------|--------|
| Acetone                    | -0.24               | CF     | 18.0            | CF     |
| Benzene                    | 2.13                | V      | 343.3           | V,S    |
| Benzoic Acid               | 1.87                | CF     | 247.9           | CF,S   |
| Bis(2-ethylhexyl)phthalate | 5.11                | CF     | 87420.0         | CF     |
| 2-Butanone                 | 0.26                | V      | 33.0            | V,S    |
| Carbon Disulfide           | 0.852               | V      | 69.3            | V,S    |
| Chlorobenzene              | 2.84                | V      | 835.5           | V,S    |
| Methyl Mercury             | 6.253               | W,M    | 60066.5         | W,M,S  |
| Toluene                    | 2.69                | V      | 692.4           | V,S    |
| m,p-Xylene                 | 3.15                | V      | 1232.0          | V,S    |
| o-Xylene                   | 2.77                | V      | 765.4           | V,S    |
| Butylate                   | 2.835               | F,S    | 1304.0          | ICI    |
| Cycloate                   | 2.614               | F,S    | 729.0           | ICI    |
| EPTC                       | 2.099               | F,S    | 286.0           | ICI    |
| Molinate                   | 1.836               | F,S    | 244.0           | ICI    |
| Pebulate                   | 2.587               | F,S    | 657.0           | ICI    |
| Vernolate                  | 2.534               | F,S    | 766.0           | ICI    |

CF ChemFate (1991).

V Verschueren (1983).

W Table 5, U.S. EPA Ambient Water Quality Criteria Document.

M Equation 1-4, McCarty (1986).

F Fang (1975).

S Equation 1-2 or 1-3, Staples et al. (1985).

ICI ICI (1989).

TABLE 6-19 INPUT PARAMETERS FOR THE RANKING MODEL

| <u>Chemical</u> | <u>Detection Ratio<br/>(Detected/Total)</u> | <u>BCF</u> | <u>Source</u> | <u>TQ (Mean Water<br/>Conc. / Chronic<br/>Toxic Endpoint)</u> |
|-----------------|---------------------------------------------|------------|---------------|---------------------------------------------------------------|
| Aluminum        | 9/14                                        | 82.5       | W             | 34.94                                                         |
| Antimony        | 1/14                                        | 1.0        | B             | $3.75 \times 10^{-2}$                                         |
| Arsenic         | 10/14                                       | 1.9        | W             | $3.13 \times 10^{-2}$                                         |
| Barium          | 11/14                                       | 100.0      | ATS           | $1.83 \times 10^{-3}$                                         |
| Beryllium       | 11/14                                       | 20.0       | B             | 0.26                                                          |
| Cadmium         | 6/14                                        | 407.4      | W             | 10.78                                                         |
| Chromium        | 11/14                                       | 1.7        | W             | 0.38                                                          |
| Copper          | 11/14                                       | 17.0       | W             | 2.66                                                          |
| Lead            | 7/14                                        | 42.0       | W             | 0.98                                                          |
| Mercury (total) | 14/14                                       | 16786.0    | W             | 34.17                                                         |
| Nickel          | 11/14                                       | 23.7       | W             | 0.10                                                          |
| Selenium        | 7/14                                        | 64.5       | W             | 0.06                                                          |
| Vanadium        | 10/14                                       | 10.0       | B             | 0.14                                                          |
| Zinc            | 11/14                                       | 397.1      | W             | 2.20                                                          |

W = Table 5, Respective Ambient Water Quality Criteria Document.

ATS = ATSDR (1989).

B = Bodek et al. (1988).

CF = ChemFate (1991).

V = Kow value from Verschueren (1983).

M = Equation 1-4, McCarty (1986).

ICI = ICI (1989).

The reader should note that acetone is carried through the model only for completeness. Acetone was not detected in water, and the modeled concentration is far higher than would be expected under any circumstances. This is an artifact of the modeling process itself, and results should not be construed as actual or projected concentrations. In fact, acetone is likely spurious in this data set; measured concentrations may be due to laboratory contamination.

TABLE 6-19 (Cont.)

| <u>Chemical</u>                 | <u>Detection Ratio<br/>(Detected/Total)</u> | <u>BCF</u> | <u>Source</u> | <u>TQ (Mean Water<br/>Conc. / Chronic<br/>Toxic Endpoint)</u> |
|---------------------------------|---------------------------------------------|------------|---------------|---------------------------------------------------------------|
| Acetone                         | 9/14                                        | 0.389      | CF            | 0.70                                                          |
| Benzene                         | 2/14                                        | 6.5        | V,M           | $6.79 \times 10^{-4}$                                         |
| Benzoic Acid                    | 5/14                                        | 14.1       | CF            | $1.9 \times 10^{-4}$                                          |
| Bis(2-ethylhexyl)-<br>phthalate | 4/14                                        | 1175.0     | CF            | $5.0 \times 10^{-3}$                                          |
| 2-Butanone                      | 6/14                                        | 0.087      | V,M           | $3.5 \times 10^{-5}$                                          |
| Carbon Disulfide                | 1/14                                        | 0.34       | V,M           | $2.05 \times 10^{-3}$                                         |
| Chlorobenzene                   | 4/14                                        | 33.1       | V,M           | $8.2 \times 10^{-5}$                                          |
| Methyl Mercury                  | 7/13                                        | 29806.4    | W             | 0.008                                                         |
| Butylate                        | 7/14                                        | 235.0      | ICI           | 0.016                                                         |
| Cycloate                        | 6/14                                        | 169.0      | ICI           | 0.033                                                         |
| EPTC                            | 9/14                                        | 72.0       | ICI           | $9.4 \times 10^{-3}$                                          |
| Molinate                        | 8/14                                        | 16.0       | ICI           | 0.72                                                          |
| Pebulate                        | 3/14                                        | 60.0       | ICI           | 0.014                                                         |
| Toluene                         | 3/14                                        | 23.4       | V,M           | $4.7 \times 10^{-5}$                                          |
| Vernolate                       | 5/14                                        | 160.0      | ICI           | 0.25                                                          |
| m,p-Xylene                      | 2/14                                        | 75.9       | V,M           | $3.5 \times 10^{-4}$                                          |
| o-Xylene                        | 2/14                                        | 28.2       | V,M           |                                                               |

3 10 0222

where

$C_{\text{organism}}$  = Concentration of contaminant in the organism ( $\mu\text{g/kg}$ )

$C_{\text{water}}$  = Concentration of contaminant in the water ( $\mu\text{g/L}$ )

Table 6-19 also lists the detection frequency for each chemical (number of detections above background divided by the total number sampled) and the TQ (mean water concentration divided by the chronic toxicity endpoint). Frequency of detection estimates included "J" values.

#### 6.2.1.4 Screening Model Results

The results of application of the screening model to identified TCL compounds, TAL metals, and the thiocarbamates are presented in Figure 6-4. Of the 33 compounds and elements, five metals and methyl mercury were identified by the screening technique as potential contaminants of concern. These compounds are as follows:

- . Inorganic mercury
- . Zinc
- . Aluminum
- . Cadmium
- . Methyl Mercury
- . Copper

None of the other identified organic compounds (including all of the thiocarbamates) were identified as potential contaminants of concern in this initial screen.

It should be recognized that this screening procedure is not a risk assessment, and serves to exclude from concern only those compounds for which sufficient information is available. The compounds that were excluded by this screening procedure were determined to justify

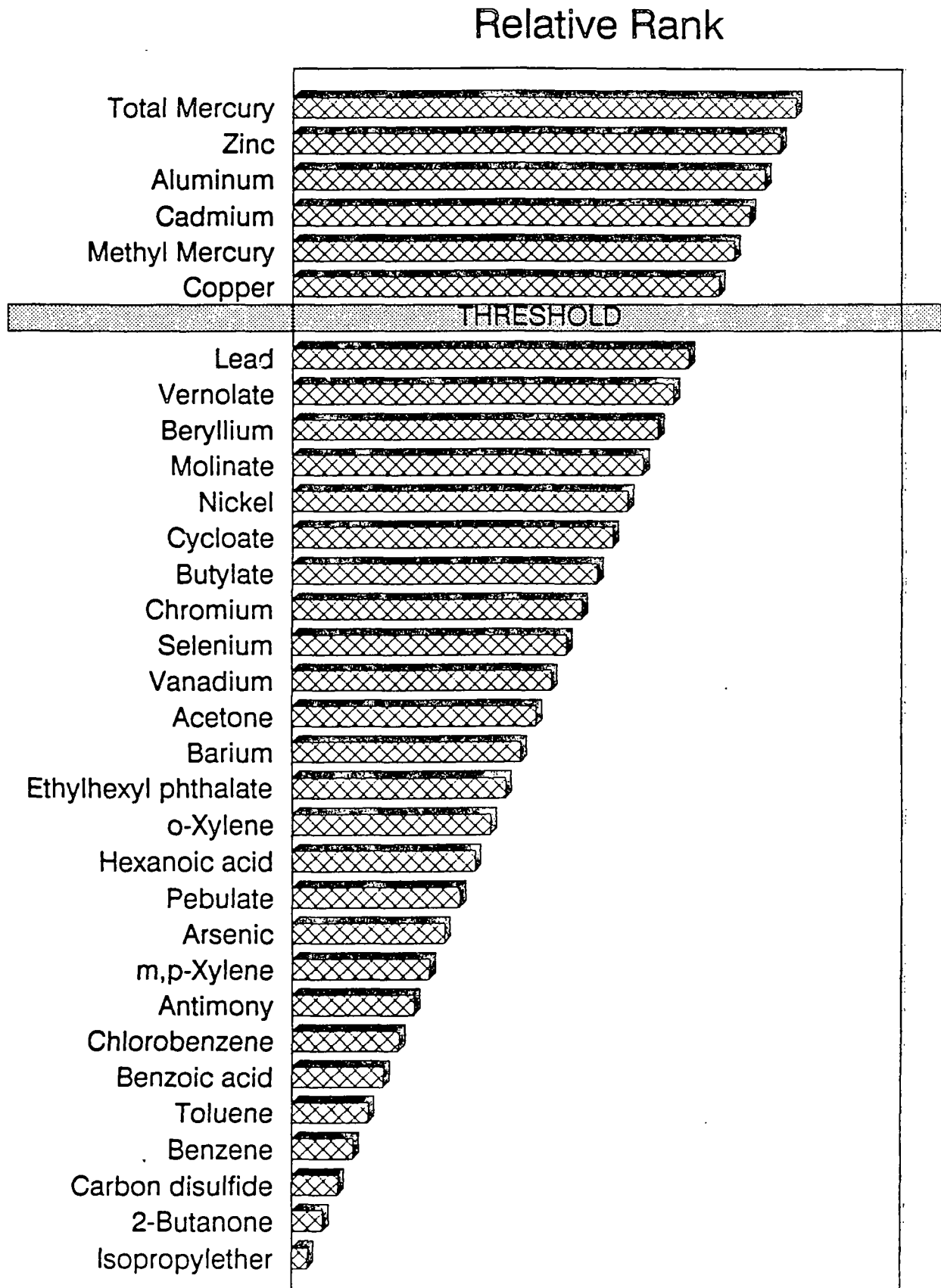


Figure 6-4. Results of Stage I Potential COC Screening Model.

no further investigation; those that were not excluded were investigated further. The metals and methyl mercury which were not excluded have passed this coarse screening procedure, but any assessment or assignment of "risk" could not be made from these data.

#### 6.2.1.5 Conclusions--Stage I Ecological Risk Evaluation

Based on the preliminary contaminant ranking screening model, the following compounds were identified as potential contaminants of concern:

- . inorganic mercury
- . methyl mercury
- . cadmium
- . copper
- . zinc
- . aluminum

During Stage II field activities, additional chemical and mineralogical data were collected. Assessment of these data led to reconsideration of identified compounds as potential contaminants of concern. As discussed in Chapter 5, it was determined that the following compounds were not considered as potential contaminants of concern:

- . aluminum
- . thiocarbamates

A detailed discussion of this decision process is provided in Chapter 5.

Therefore, after the Stage I preliminary ecological risk screening and subsequent Stage II chemical and mineralogical analyses, the only remaining potential contaminants of concern were:

- . cadmium
- . copper
- . zinc
- . mercury
- . methyl mercury

Consequently, Stage III biota collection, sampling, and ecological risk evaluations focus on the impact of mercury to the Cold Creek Swamp ecosystem.

#### 6.2.2 Stage II Ecological Risk Evaluation

A goal of the Stage II field activities program was to generate sufficient data develop an ecological risk evaluation methodology that could be used to focus Stage III field data collection (Figure 6-1). The Stage II risk evaluation methodology that was developed considered receptors of concern and exposure pathways within the Cold Creek Swamp ecosystem. Two models were developed. One model examined potential receptors of concern. This model was utilized primarily to ascertain which biota could be sampled most effectively for tissue body burdens of bioaccumulative mercury. Some taxa (for example, alligators and water birds) could be evaluated with low uncertainty without destructive sampling once a calibrated, data-driven model of mercury behavior in Cold Creek Swamp was available. Thus, the other model examined potential mercury body burdens and associated risks to receptors of concern based on the Stage II data. The following sections discuss the Stage II Ecological Risk Evaluation.

##### 6.2.2.1 Receptors of Concern Screening Model

Ecological receptors of concern for use in exposure/risk modeling were selected with an objective, semiquantitative evaluation technique. This approach applies the pairwise factor weighting technique (Dean and Nishry 1965; Canter 1977) that was previously used to screen contaminants of

concern to establish relative utility of each potential receptor of concern for ecological modeling. The factors considered as model components were as follows:

1. degree to which organisms are likely to be exposed to contaminated media,
2. trophic status,
3. habitat,
4. human uses, and
5. practicality for use in modeling relative to difficulty of field collection.

Taxa selected on this basis were recommended as analytical targets for Stage III analyses.

#### Screening Procedure

The principle of the pairwise comparison technique (PCT) (Dean and Nishry 1965; Canter 1977) is to simplify the decision-making process into individual components so that a numerical score can be developed for each candidate ecological receptor based on pertinent information (factors). A discussion of the methodology of the PCT was presented in Section 6.2.1.2.

Based upon assessment of the PCT, final factor weights were assigned as follows: site use = 0.2333, trophic status = 0.2000, habitat = 0.2667, human use = 0.2333, and practicality = 0.0667, indicating that habitat is the most important (because it drives bioaccessibility to mercury), site use and human use are tied as next in importance (because of exposure concerns and protected species issues), trophic status is of slightly lower importance (although still a key parameter), and practicality is least important. This evaluation is robust with respect to assumptions, and conclusions would not change unless assumptions were varied substantially.



## Representative Taxa

Representative taxa for input to the model were selected from among those characteristic of the Cold Creek Swamp ecosystem. Of the large number of species present or potentially present, representative species were selected from each model component to encompass a range of input parameters. This procedure allows tractable modeling for ROC selection, assures that the full diversity of environmental responses is incorporated in the evaluation, and provides potential surrogate taxa for investigation if primary taxa are unavailable.

Five input factors were included in the model (Table 6-20). Each factor incorporates a rank scale for characterizing taxa by potential contaminant exposure (Site Use, Trophic Status, and Habitat factors), human use or "value" (Human Use Status factor), and potential utility for Phase III investigation (Study Practicality factor). Each factor scale ranges from high (most likely candidate for inclusion in Phase III investigations) to low (least likely candidate). Factors reflect different biological aspects which in part determine the potential value of the taxon for further study. Factor 1 (Site Use) ranges from 1 (year-round resident) to 2 (individuals present in Cold Creek Swamp only part of the year, or which habitually spend time out of the swamp ecosystem), as potential exposure generally is driven by spatial and temporal correlation between biotic tissue and environmental media. Taxa whose individuals spend most of their time outside Cold Creek Swamp are of little interest, as any contaminant exposure would be driven primarily by external concentrations. The PCT weighting for Site Use was 0.2333.

Factor 2 (Trophic Status) reflects the potential for food web biomagnification of mercury. While there is substantial debate over the reality of biomagnification versus simple size-and-age based uptake (Huckabee et al. 1979), this factor actually serves as a surrogate for either, because taxa included as carnivores are generally larger and longer lived than those included as herbivores. Trophic Status received a PCT weight of 0.2000.

TABLE 6-20 FACTOR SCORES AND FINAL RANKING OF RECEPTORS OF CONCERN. FACTOR WEIGHTS USED ARE: SITE USE = 0.2333, TOPHIC STATUS = 0.2000, HABITAT = 0.2667, HUMAN USE = 0.2333, AND PRACTICALITY = 0.0667. IN EACH CASE, LOWER SCORES ARE PREFERABLE.

| Taxon                  | Factor Scores           |                               |                        |                          |                             | Final Rank |
|------------------------|-------------------------|-------------------------------|------------------------|--------------------------|-----------------------------|------------|
|                        | Site Use <sup>(a)</sup> | Trophic Status <sup>(b)</sup> | Habitat <sup>(c)</sup> | Human Use <sup>(d)</sup> | Practicality <sup>(e)</sup> |            |
| Frogs (Ranidae)        | 1                       | 1                             | 1                      | 2                        | 1                           | 1          |
| Large mouth bass       | 1                       | 1                             | 1                      | 2                        | 1                           | 2          |
| American alligator     | 1                       | 1                             | 1                      | 1                        | 4                           | 3          |
| Common snapping turtle | 1                       | 1                             | 1                      | 2                        | 2                           | 4          |
| Cottonmouth            | 1                       | 1                             | 1                      | 3                        | 1                           | 5          |
| Nerodia                | 1                       | 1                             | 1                      | 3                        | 1                           | 6          |
| Crayfish               | 1                       | 2                             | 1                      | 2                        | 2                           | 7          |
| Mosquito fish          | 1                       | 1                             | 1                      | 4                        | 1                           | 8          |
| Carp                   | 1                       | 2                             | 1                      | 3                        | 1                           | 9          |
| River cooter           | 1                       | 3                             | 1                      | 2                        | 2                           | 10         |
| Mink                   | 2                       | 1                             | 1                      | 2                        | 3                           | 11         |
| Thamnophis             | 1                       | 1                             | 2                      | 3                        | 1                           | 12         |
| Golden shiner          | 1                       | 3                             | 1                      | 3                        | 1                           | 13         |
| Dace                   | 1                       | 2                             | 1                      | 4                        | 1                           | 14         |
| Painted turtle         | 1                       | 2                             | 1                      | 4                        | 2                           | 15         |
| Annelids               | 1                       | 2                             | 1                      | 4                        | 3                           | 16         |
| Other crustaceans      | 1                       | 2                             | 1                      | 4                        | 3                           | 17         |
| Muskrat                | 1                       | 3                             | 2                      | 2                        | 2                           | 18         |
| Beaver                 | 1                       | 3                             | 2                      | 2                        | 3                           | 19         |
| Crustaceans            | 1                       | 3                             | 1                      | 4                        | 3                           | 20         |
| Molluscs               | 1                       | 3                             | 1                      | 4                        | 3                           | 21         |
| Heron & Egret          | 2                       | 1                             | 2                      | 3                        | 3                           | 22         |
| Waterfowl              | 2                       | 2                             | 2                      | 2                        | 3                           | 23         |
| Chironomids            | 2                       | 2                             | 1                      | 4                        | 3                           | 24         |
| Raccoon                | 2                       | 2                             | 3                      | 2                        | 3                           | 25         |
| Tent caterpillars      | 2                       | 3                             | 3                      | 4                        | 3                           | 26         |

- (a) Site Use ranges from 1 (year-round resident) to 2 (individuals present in Cold Creek Swamp only part of the year, or which habitually spend time out of the swamp ecosystem).
- (b) Trophic status ranges from 1 (top carnivore) to 3 (primary producer/consumer).
- (c) Habitat ranges from 1 (fully aquatic) to 3 (fully terrestrial).
- (d) Human Use ranges from 1 (endangered or threatened species) to 4 (non-use or nuisance species).
- (e) Practicality ranges from 1 (abundant, easy to collect) to 4 (rare, difficult or impractical to collect).

Factor 3 (Habitat) ranges from 1 (fully aquatic) to 3 (fully terrestrial). While there is measurable total mercury in terrestrial soils, the aquatic sediments generally exhibit considerably higher mercury concentration. Because the swamp thalweg is the major route of mercury transport in the Cold Creek drainage basin, concern is focused on species inhabiting flood areas. Habitat received a PCT weight of 0.2667.

Factor 4 (Human Use) is a value scale ranging from 1 (endangered or threatened species) to 4 (non-use or nuisance species). Cold Creek Swamp is largely private property, and access is limited. Human use of the area is minimal and is limited primarily to trespassers. However, the natural resource value of the swamp is partly due to its potential for human use. Therefore, taxa of greatest concern are those that have regulatory standing or which serve as game or harvest species. The latter category includes furbearers and some turtles (harvested for food) in addition to regulated mammals, birds, and fin- and shell-fishes. Human Use received a PCT weight of 0.2333.

Factor 5 (Practicality) reflects the utility of particular taxa for sampling and analysis. Likely candidates for study are common, easy to sample, and simple to process and analyze. Unlikely candidates include those that would require specialized sampling, permitting, or capture of species with regulatory standing. There is sufficient redundancy in the swamp ecosystem as reflected in the ROC model to provide surrogate taxa for species of special concern. Practicality received a PCT weight of 0.0667.

Taxa included in the rank analysis do not include those characteristic of the detritus compartment (primarily microbes and meiofauna) or primary producers. Mercury in the more toxic, bioaccumulative methylated forms is not sequestered to high concentrations in plants, microbes, or animals functioning low in the food web (Eisler 1987). Taxa of concern from the

technical and regulatory viewpoints are those large organisms that feed higher in the trophic web. These organisms and their trophic intermediates are included in the ROC rank model analysis.

The top-ranked nine taxa and suitable surrogates were recommended as candidates for further investigation in the Stage III biota collection program. There appears to be a threshold in the rank analysis after the ninth taxon, which reflects a change from basically aquatic carnivores to semi-aquatic or omnivorous taxa. While this threshold provides a somewhat arbitrary demarcation, the taxa and surrogates that were recommended were considered to offer sufficient resources for successful sampling and study.

#### Selected Receptors Based on Modeling

Individual receptor ranks are presented as final rank in Table 6-20. The most highly ranked nine taxa are those that were considered to be most likely to accumulate and be impacted by mercury in the Cold Creek Swamp ecosystem. Furthermore, these taxa are those with the most intensive human uses, and can be readily sampled and evaluated for further study. The ecology of receptor taxa is discussed below, emphasizing the characteristics that determine their identification by the model.

- . Frogs (Ranidae) are aquatic carnivores as adults and aquatic herbivores/detritivores as larvae. Ranids are larger, longer lived, and more closely tied to the aquatic food web than hylids, although as strict carnivores, hylids are suitable surrogates for sampling. Other surrogate taxa include various other aquatic amphibians such as amphiuma (Amphiumidae) and sirens (Sirenidae).

- . Largemouth bass (Micropterus salmoides) is a large, long-lived carnivorous gamefish species and is therefore an ideal taxon for investigating potential bioaccumulation of mercury. Surrogate taxa include sunfishes (Centrarchidae), pickerels (Esox), and other gars (Lepisosteus).
- . American Alligator (Alligator mississippiensis) is a carnivorous aquatic species on the federal threatened/endangered species list. It ranked 1 on all factors except practicality, as surrogate species are easily available and destructive sampling is neither necessary nor recommended. Acceptable surrogate species are the other ROC reptiles, discussed below.
- . Common snapping turtle (Chelydra serpentina) is a large, long-lived aquatic carnivore. It is the only species of snapping turtle that was observed in Cold Creek Swamp during the three field observation periods. The other member of the family (the alligator snapping turtle, Macroclemys temmincki) is unlikely to be found in this habitat, preferring large river systems. The ephemeral nature of much of the open water in Cold Creek Swamp makes it likely that snapping turtles, especially larger, older individuals, are not lifelong residents, but may travel into and out of the swamp over the course of years. Thus, the snapping turtle was not considered to be an ideal candidate for sampling. Surrogate species included other aquatic carnivorous turtles, especially soft-shelled turtles, Trionychidae.
- . Cottonmouth (Agkistrodon piscivorous) are carnivorous and aquatic, easily sampled and processed. These taxa were considered to be among the most likely accumulators of mercury in this environment, and served as reasonable surrogates for the alligator.

- . Crayfish (Asticidae) are polytrophic aquatic invertebrates which play important roles in aquatic food webs of the Gulf Coast (Costanza et al. 1983).
- . Mosquitofish (Pimephales) are small aquatic carnivores feeding lower in the food web than the largemouth bass. While not likely to be key accumulators of mercury, their role in the food web makes them trophically important. A number of forage fish species of similar habits occur in suitable habitat in Cold Creek Swamp, and all were considered to be acceptable species for sampling.
- . Carp (Cyprinus carpio) is a large aquatic omnivore. Feeding at the lower end of the food web, carp are again not likely to represent maximal mercury accumulations. However, their longevity and relatively large size render them of some value in assessing mercury fate in the ecosystem. Other depersal forage fish serve as acceptable surrogate taxa.

#### 6.2.2.2 Stage II Ecological Risk Characterization Model

##### Exposure Pathways

Cold Creek Swamp is characteristic of typical Gulf Coast wetland ecosystems. High productivity, great diversity, and abundance characterize the biota, while seasonality, hydrodynamics, and such external forces as proximity to the Mobile River and potentially catastrophic storms complicate the physicochemical environment (Costanza et al. 1983). For modeling purposes, the swamp trophic system has been conceptualized as an aggregated interactive hierarchy (Figure 6-5). This conceptual food web model makes exposure and risk modeling tractable, and renders sparse existing data on contaminant uptake useful.

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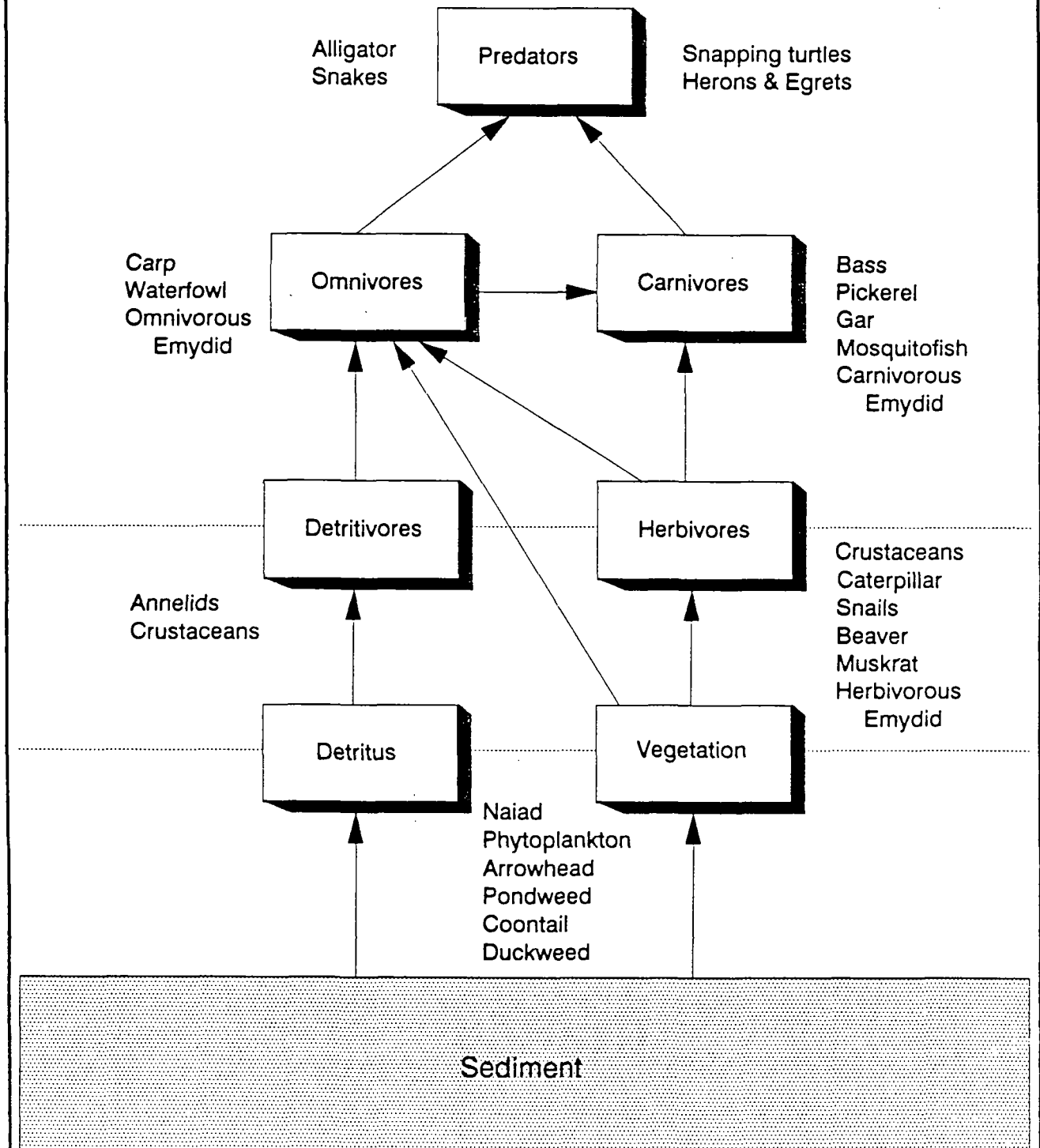


Figure 6-5. Food-web used for Stage II Ecological Exposure/Risk Modeling at Cold Creek Swamp.

The conceptual Cold Creek Swamp food web model is sufficiently general for realistic evaluation of contaminant fate, while allowing exploration of effects on particular representative species. Figure 6-5 illustrates the general model and the representative taxa for which it is currently configured. While the illustrated taxa are representative of and important to the swamp ecosystem, additional taxa can be considered with minimal modification of model parameters. For example, adding glossy ibis to the "Predator" compartment or evaluating ibises in place of herons and egrets would simply involve accounting for feeding differences among these taxa, apportioned into appropriate food compartments (ibises concentrate their feeding on the "Carnivore" compartment to a greater degree; see Kushlan 1978). In a similar fashion, other specific taxa can be incorporated into the general trophic web analysis.

In general, exposure to mercury in aquatic ecosystems is associated with both direct uptake of dissolved compound from the water column and with uptake from contaminated food (Sorensen et al. 1990). At the top end of the trophic web, food routes dominate total exposure. At lower trophic levels, dissolved and food-based intakes are of approximately equivalent magnitude (Huckabee et al. 1979).

Much information is available on mercury processes associated with individual organisms versus whole ecosystems (for example, Tejning 1967; Fimreite and Reynolds 1973; McKim et al. 1976; Rodgers and Beamish 1983). Available information indicates that methylated forms of mercury are most toxic and most bioavailable, and that mercury taken up in inorganic form can be sequestered in tissue in methylated forms. Literature is conflicting on the proportion of methylated mercury in tissue. However, mercury sequestered in tissue is generally more bioavailable than that in abiotic media, and the model accounts for this empirically by employing bioaccumulation factors which incorporate this parameter implicitly.

In general, the conceptualizations of the Cold Creek Swamp ecosystem and mercury processes are similar to available information on similar ecosystems (Costanza et al. 1983) and on mercury fate and effects (Muntau and Baudo 1984). The recommended ROC do not differ substantially from



those recommended by natural resources trustees (Preliminary Natural Resources Survey). Thus, the overall analysis is soundly grounded in both the technical literature and existing site-specific data, and fits the current regulatory framework.

#### Potential Risks to Biota Based on Partitioning Model

Predicted concentrations of methyl mercury in interstitial water presented in Table 5-6 could represent potential risks to the Cold Creek ecosystem. No criteria or standards exist for interstitial water, and direct exposure to key receptors in the Cold Creek Swamp ecosystem occurs via the water column. While it is beyond the scope of the present study to estimate water column concentrations of mercury, criteria do exist for this medium. Ambient water quality criteria (U.S. EPA 1984) for mercury were established at 0.012 µg/L based on methyl mercury water concentrations that would result in whole-body fish concentrations, which exceeded the Food and Drug Administration (FDA) action level of 1.0 mg/kg. The FDA action level is established for the protection of humans eating fish, and is based on bioaccumulation. McKim et al. (1976) studied the long-term effects of methyl mercury on brook trout and found no adverse effects on reproduction, growth, or survival in fish with body burdens above the FDA action limit. Since fish that contain mercury concentrations at the FDA limit do not exhibit adverse effects, bioaccumulation of mercury into ecological food webs is the primary concern for Cold Creek Swamp, and is expected to drive the final risk characterization (see preliminary ecological modeling, this section).

As briefly discussed earlier, modeled preliminary concentrations shown in Table 5-6 represent interstitial or pore water. Exposure modeling requires not only partitioning (as discussed in this document), but also estimated movement of the pore water through the sediment-water interface and into surface water. Bloom (1989) presented surface water concentrations of both inorganic and methyl mercury in a mercury-polluted urban lake (Onandaga Lake, Syracuse, New York). These concentrations (6.6 ng/L and 4.0 ng/L, respectively) are three orders of magnitude less than those

estimated for Cold Creek Swamp pore water (Table 5-6). This difference probably represents the diffusion of pore water through the sediment-water interface, and mixing with surface water. In Cold Creek Swamp, surface hydrodynamics are largely driven by stormflow and dilution is likely to be greater.

### Stage II Ecological Exposure/Risk Modeling

Further support identification of receptors for Stage III field investigations, organism body burdens were projected by modeling mercury behavior in the Cold Creek Swamp ecosystem. The Stage II modeling exercise is a necessary adjunct to the field data collection efforts for several reasons: (1) no tissue analyses were available for top predators from previous data collection efforts; (2) it is more cost-effective to collect data around a model framework than to attempt universal sampling without a conceptual guide; (3) successful modeling assures understanding of environmental processes; and (4) modeling allows easy and less expensive exploration of environmental costs and benefits of various risk management options. This Stage II assessment was used to guide Stage III data collection. A revised detailed risk assessment was conducted after Stage III as discussed in Section 6.2.3 below. For the detailed Baseline Risk Characterization, the model was revised to reflect biological detail and run and calibrated with updated site-specific input parameters. The exposure/risk food-web model (Figure 6-5) was designed as an equilibrium trophic-level simulation to define major ecological compartments represented at Cold Creek Swamp. The purpose of this model is to drive defensible predictive extrapolation from data collected in Stage II to unsampled ecological compartments (e.g., top predators). The product is required for evaluation of potential risks of mercury contamination and to assist in design of appropriate sampling methodologies for Stage III. The goals of this modeling effort were development of a model that is sufficiently streamlined to eliminate unnecessary Stage III sampling and to retain sufficient predictive power and accuracy to adequately describe

the complex ecosystem of the swamp. Validation of this model indicates that even though the model is conceptually simple, both predictive power and optimization of Stage III studies have been achieved.

Preliminary simulations of the ecological exposure/risk food-web model (Figure 6-5) were performed using the ranges of values presented in Table 6-21. Primary food-web transfers were simulated by partitioning of total mercury from the abiotic matrix (sediment) to primary organic matrices (detritus and vegetation) using appropriate bioaccumulation factors (BAFs; ratio of consumer tissue concentrations to source concentrations). The empirical BAFs were derived from peer-reviewed literature. It is important to note that these BAFs are not the same as water column BCFs. BAFs incorporate the binding, aging, and sorption processes that control bioavailability. BCFs are measured as uptake of unbound dissolved compound across membranes, and these parameters typically differ by many orders of magnitude.

Since detritus in Cold Creek Swamp is derived primarily from vegetation, mercury concentrations in detritus were assumed to equal vegetation concentrations. This is a conservative estimate because some organo-mercury would be expected to leach from detritus during decomposition. Each successive transfer in the food web is driven by dietary fraction and BAF ranges specific to the consumer and food source. For example, since carnivores consume both herbivores and omnivores, each of these sources is weighted with respect to fraction of the diet comprised by each. In this specific instance, BAF ranges were assumed to be equivalent because uptake from tissues of herbivores and omnivores would not be expected to differ markedly. Three BAF ranges were used in the model. The first represents accumulation from the abiotic medium to biotic matrices; the second, accumulation from vegetation and detritus to consumers; and the third, accumulation from animal tissues to tissues of consumers. Each consumer compartment was calibrated with specific dietary fraction ranges appropriate to the organisms represented.

TABLE 6-21 PARAMETER RANGES USED IN THE STAGE II ECOLOGICAL EXPOSURE/  
RISK MODEL

| Transfer                    | Range     | Reference                                                                                                                                   |
|-----------------------------|-----------|---------------------------------------------------------------------------------------------------------------------------------------------|
| <b>BAFs:</b>                |           |                                                                                                                                             |
| Abiotic → Primary Organic   | 0.02-0.08 | Muntau and Baudo 1984                                                                                                                       |
| Primary Organic → Consumers | 2.20-3.40 | Muntau and Baudo 1984                                                                                                                       |
|                             |           | Huckabee et al. 1979                                                                                                                        |
| Animal Tissues → Consumers  | 1.60-2.80 | Vermeer et al. 1973                                                                                                                         |
| <b>Dietary Fractions:</b>   |           |                                                                                                                                             |
| Detritivores → Omnivores    | 0.1-0.4   | Dietary Fractions were varied arbitrarily over a broad parameter range to provide the most comprehensive evaluation a range of model output |
| Vegetation → Omnivores      | 0.2-0.8   |                                                                                                                                             |
| Herbivores → Omnivores      | 0.1-0.4   |                                                                                                                                             |
| Herbivores → Carnivores     | 0.2-0.8   |                                                                                                                                             |
| Omnivores → Carnivores      | 0.2-0.8   |                                                                                                                                             |
| Omnivores → Top Predators   | 0.2-0.8   |                                                                                                                                             |
| Carnivores → Top Predators  | 0.2-0.8   |                                                                                                                                             |

Stage II model simulations were conducted by running the model 500 times for each section of the swamp (upper, middle, lower) using stochastic (random) selection of values for each parameter within defined ranges. The model algorithms were coded in Microsoft Q basic for ease of manipulation and simplicity of verification. Language intrinsic random number selection procedures were employed for stochastic variation of parameters. Output data analysis verified that each parameter had been appropriately and randomly varied throughout the simulations. The parameters which were varied stochastically are BAF and dietary fraction. Model results were analyzed statistically to determine mean and range of predictions for each compartment in the model. The purpose of stochastic simulation was to define the range of model output as a method for coping with predictive uncertainty.

Stage II model input parameters are summarized in Table 6-21. Bioaccumulation factors were calculated from information provided in the few available freshwater ecosystem-level studies of mercury dynamics. Sediment concentrations input to the model were the geometric mean of total mercury concentrations from all "B" samples (top 4 in. of sediment column, intended to characterize bioaccessible sediments from each segment of Cold Creek Swamp). These values are 33.85, 53.34, and 36.22 ppm (dry weight basis) for the Upper, Middle, and Lower swamp zones, respectively. A wet weight to dry weight ratio of 10 was assumed as a first approximation.

#### Stage II Ecological Exposure/Risk Model Results

Based on the results of the Stage II modeling effort, projections for the Stage III field effort were proposed. Figure 6-6 summarizes the results of 1500 total model runs. Based on this simulation, it was concluded that carnivorous species and top predators are likely to acquire the greatest body burdens of mercury in Cold Creek Swamp. Figure 6-7 presents some toxic endpoints for mercury body burdens from the general literature. The Figure 6-7 data are discussed in detail in Section 6.2.3.2. In general, comparison of Figures 6-6 and 6-7

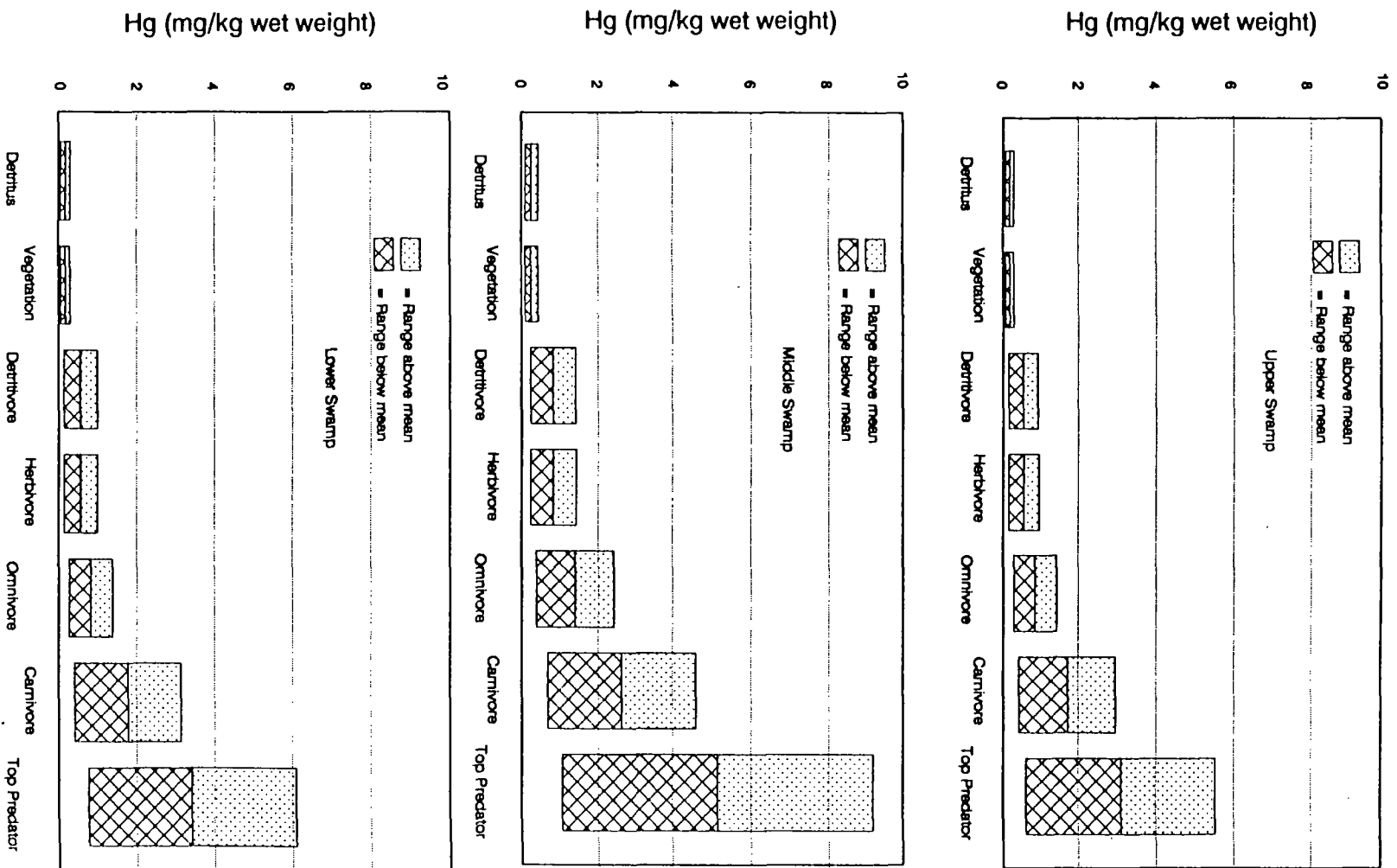
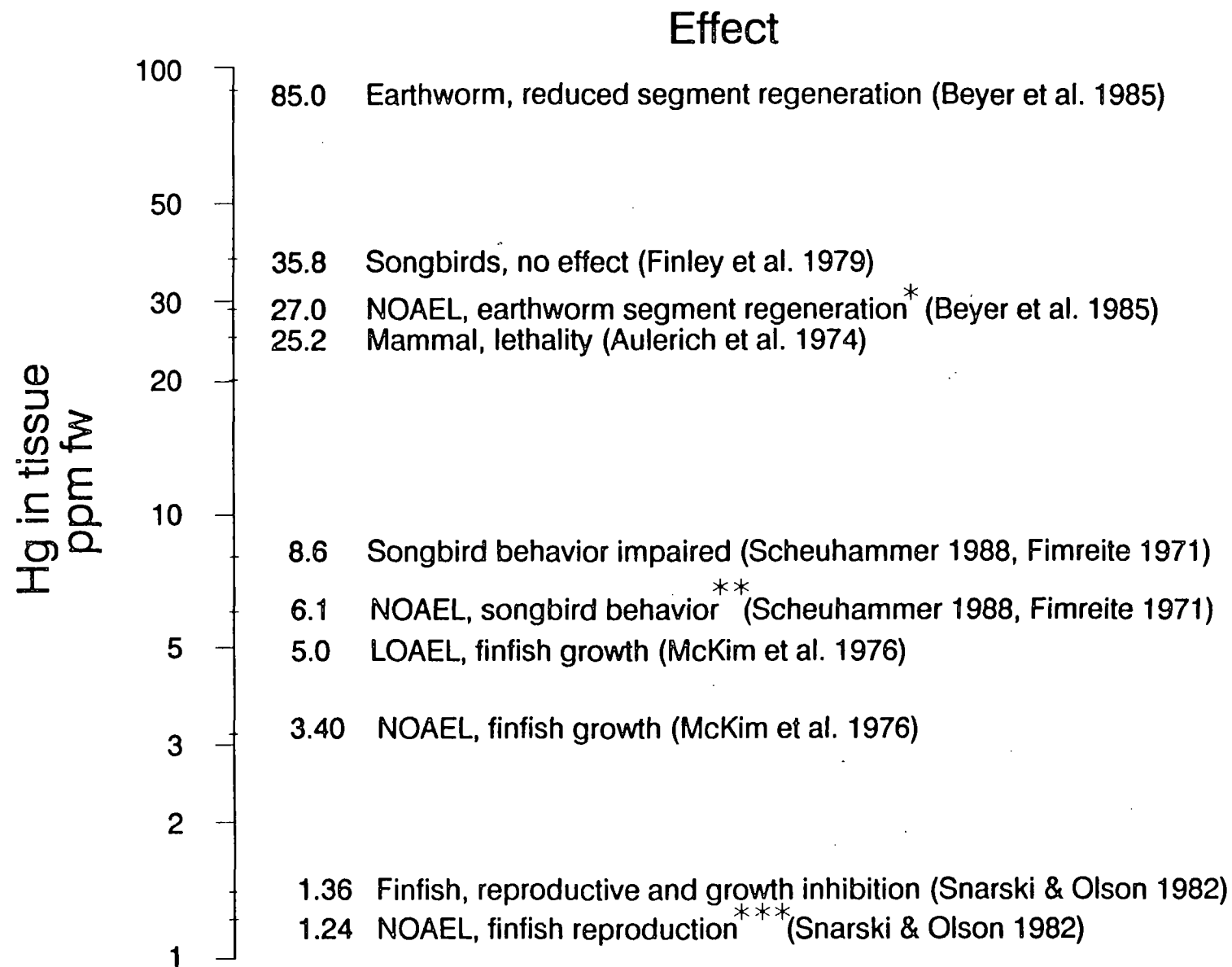


Figure 6-6. Stage II ecological exposure model stochastic predictions.



\* Criterion for invertebrate effects HI.

\*\* Criterion for avian, mammalian effects HI.

\*\*\* Criterion for fish, reptile, amphibian effects HI.

**Figure 6-7. Selected mercury toxicity reference values (TRVs) for Cold Creek Swamp biota.**



suggests that only carnivores and top predators have the potential to acquire body burdens of toxicological concern. This conclusion also supports recommendations for taxa to be sampled in Stage III. On both the rank comparison basis and on a toxicological simulation basis, carnivores (fish and frogs) and top predators (alligators, snakes, turtles) provide the most valuable, interpretable, and integrated information regarding potential effects of mercury contamination in Cold Creek Swamp.

The only site-specific data that were available to validate output of this preliminary model at the time between Stage II and Stage III field work were tissue concentration for fish, crayfish, and annelids available from previous biota studies (Section 1.2.3). Lepomids (referred to as "predators" in the 1988 RI Report) are included in the present model as carnivores, one trophic level below top predators, along with Gambusia, an insectivorous fish. The range of quantifiable values for mercury in these taxa was 0.3 to 1.9 ppm wet weight. Table 6-22 presents results of Stage II modeling by receptor categories. Receptor categories having higher ranks are expected to have higher body burdens of mercury are, therefore, of greatest concern and will be emphasized for further study. Some receptors receiving lower ranks are intermediate in the swamp food web and will be sampled as appropriate.

The simulation projections reported above were intended primarily to identify those receptors that are most productive and cost-effective for Stage III field sampling. Additional data collection (Stage III), additional model development, and additional information acquisition were necessary before risk projections could be made that constituted validated, applicable risk estimates. These issues were addressed in the baseline ecological risk evaluation developed subsequent to Stage III field work. The following section addresses the baseline ecological risk evaluation.



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TABLE 6-22 ECOLOGICAL MODEL STOCHASTIC PREDICTIONS

| <u>Trophic Level</u> | <u>Tissue Concentrations</u><br>(mg/kg wet weight) |             |                |
|----------------------|----------------------------------------------------|-------------|----------------|
|                      | <u>Minimum</u>                                     | <u>Mean</u> | <u>Maximum</u> |
| LOWER SWAMP          |                                                    |             |                |
| Detritus             | 0.07                                               | 0.19        | 0.30           |
| Vegetation           | 0.07                                               | 0.18        | 0.30           |
| Detritivore          | 0.15                                               | 0.53        | 1.00           |
| Herbivore            | 0.16                                               | 0.51        | 0.99           |
| Omnivore             | 0.28                                               | 0.81        | 1.64           |
| Carnivore            | 0.43                                               | 1.46        | 3.14           |
| Predator             | 0.78                                               | 2.51        | 6.09           |
| MIDDLE SWAMP         |                                                    |             |                |
| Detritus             | 0.10                                               | 0.27        | 0.44           |
| Vegetation           | 0.10                                               | 0.27        | 0.44           |
| Detritivore          | 0.25                                               | 0.76        | 1.43           |
| Herbivore            | 0.25                                               | 0.76        | 1.44           |
| Omnivore             | 0.40                                               | 1.21        | 2.42           |
| Carnivore            | 0.69                                               | 2.15        | 4.57           |
| Predator             | 1.08                                               | 3.72        | 9.21           |
| UPPER SWAMP          |                                                    |             |                |
| Detritus             | 0.06                                               | 0.17        | 0.28           |
| Vegetation           | 0.06                                               | 0.17        | 0.28           |
| Detritivore          | 0.15                                               | 0.48        | 0.92           |
| Herbivore            | 0.15                                               | 0.47        | 0.95           |
| Omnivore             | 0.28                                               | 0.77        | 1.41           |
| Carnivore            | 0.41                                               | 1.38        | 2.96           |
| Predator             | 0.61                                               | 2.38        | 5.59           |

### 6.2.3 Baseline Ecological Risk Evaluation

At the conclusion of Stage III field activities and analyses, a significant body of data was available for use in developing a comprehensive Baseline Ecological Risk Evaluation (Figure 6-1). The Baseline Ecological Risk Evaluation considered all of the analytical and observational data as well as all of the modeling efforts conducted in Stages I and II.

The Baseline Ecological Risk Evaluation consisted of three separate but related steps: (1) exposure assessment, (2) toxicity or hazard assessment, and (3) risk characterization. A baseline ecological risk assessment for Cold Creek Swamp, based on collected during Stage I, Stage II, and Stage III, is presented in this section.

#### 6.2.3.1 Exposure Assessment

Based on the preliminary ecological risk screening (Section 6.2.1), the human health risk assessment (Section 6.1), and the additional chemical and mineralogical analyses (Chapter 5), the only identified contaminants of concern at Cold Creek Swamp are inorganic mercury ( $\text{Hg}^{2+}$ ) and methyl mercury ( $\text{CH}_3\text{Hg}^+$ ), and the divalent metals cadmium, copper, and zinc.

Based on a site-specific analysis (Section 5.1.2), it has been found that SEM/AVS ratios for cadmium, copper, and zinc are substantially less than one in Cold Creek Swamp. For this reason, toxic effects due to these metals are not expected to occur.

Section 5.1.3.1 addressed the physical characteristics of mercuric sulfide, an extremely insoluble chemical which is expected to be the dominant form of mercury in Cold Creek Swamp sediments because of the reducing environment and the availability of AVS (Section 5.1.2.1). This environmental fate does not eliminate a possible hazard to biota because of methylation processes discussed in Sections 5.1.3.2 and 5.2.1.

These processes may convert relatively unavailable inorganic mercury into more bioavailable forms which may be reflected in tissue body burdens in biotic receptors.

As discussed in Section 5.1.3.2, Bartlett and Craig (1981) noted significant correlations between total and methyl mercury and organic carbon and silt in British estuarine sediments. Data from the June (Stage II) and October 1991 (Stage III) Cold Creek Swamp sampling programs have been similarly analyzed, by area of the swamp and across the total swamp (Table 6-23). Methylation of mercury is a microbial process dependent upon both access to inorganic mercury and a substrate which supports bacterial growth. Methylating bacteria use organic carbon associated with water and sediment as a carbon source, and as such, laboratory measured total organic carbon (TOC) can be used as a surrogate for bacterial activity. When TOC is low, conversion of inorganic mercury to methyl mercury proceeds slowly (Winfrey and Rudd 1990; Rudd et al. 1983). Consequently, TOC concentrations are generally proportional to methyl mercury concentrations assuming inorganic mercury is present in quantities sufficient to not limit the reaction. Strong correlations between organic carbon and methyl mercury are found throughout Cold Creek Swamp ( $R^2 = 0.57-0.81$ ; Table 6-23).

Cold Creek Swamp data (Table 6-23) show a dissimilarity between both the Upper and Lower swamp zones and Middle Swamp Zone. Correlations between total mercury and methyl mercury are significant in Upper and Lower swamp zones (P-value = 0.016 and 0.004, respectively) but not significant in the middle swamp (P = 0.258). These observations are consistent with the hypothesis of an erosional Middle Swamp Zone and depositional Upper and Lower swamp zones because some areas within the middle swamp have elevated total mercury but insufficient organic carbon to activate bacterial growth and concurrent methyl mercury production. Because the Upper and Lower swamp zones are depositional, all forms of mercury can be expected to correlate well with organic carbon (which has numerous sorption sites) found in this type of environment.

TABLE 6-23 PEARSON CORRELATIONS OF TOTAL AND METHYL MERCURY WITH SEDIMENT ORGANIC CARBON AND SILT IN COLD CREEK SWAMP AND BRITISH ESTUARINE SEDIMENTS

| Relationship                        | British(b)<br>Sediments | Correlation Coefficient <sup>(a)</sup> |           |           |           |
|-------------------------------------|-------------------------|----------------------------------------|-----------|-----------|-----------|
|                                     |                         | Cold Creek Swamp                       |           |           | Total     |
|                                     |                         | Upper                                  | Middle    | Lower     |           |
| total mercury : methyl mercury      | 0.76 (47)               | 0.68 (12)                              | 0.35 (12) | 0.63 (19) | 0.37 (43) |
| methyl mercury : organic carbon     | 0.55 (47)               | 0.61 (12)                              | 0.81 (12) | 0.57 (19) | 0.66 (43) |
| total mercury : organic carbon      | 0.77 (47)               | 0.41 (12)                              | 0.17 (12) | 0.54 (19) | 0.21 (43) |
| total mercury : silt <sup>(c)</sup> | 0.94 (47)               | ---                                    | ---       | ---       | 0.53 (8)  |

(a) Numbers in parentheses are N.

(b) From Bartlett and Craig (1981).

(c) Bartlett and Craig (1981) defined silt as the fraction less than 0.0625 mm, which this report has been defined as both clay and silt (Appendix X), and data presented above for Cold Creek Swamp represent both clay and silt for more reasonable comparisons.

Total organic carbon serves a dual purpose in the swamp environment, as a substrate for bacterial growth with subsequent methylation and as a sorptive surface for both methyl and total mercury (Section 5.3.1.3). Sediment organic carbon and clay/silt provide many active sorption sites for these forms of mercury and many other metals, thereby serving as repositories for these chemicals.

Because the toxicity assessment and risk characterization are based on total (not methyl) mercury associated with sediment (this approach incorporates implicitly methylation and enhanced bioavailability), no attempt to further characterize dissolved vs. sorbed methyl mercury has been performed in this exposure assessment. If needed, sorptive data exist to estimate dissolved and sorbed total and methyl mercury to both clay and organic carbon.

#### 6.2.3.2 Toxicity Assessment

##### 6.2.3.2.1 Examination of Toxicity Reference Values

Toxicity reference values (TRVs) were developed from available literature to provide a basis for comparison of Cold Creek Swamp biota exposure to potentially hazardous levels of mercury. Tissue concentration (body burden) levels were identified for key receptors in the Cold Creek Swamp ecosystem: birds, mammals, amphibians, reptiles, and invertebrates. Toxicity data are lacking for reptiles and amphibians. A sensitive endpoint for finfishes [a no observed adverse effects level (NOAEL) for reproduction and growth] was identified for application to poikilotherm (cold-blooded) vertebrates in general. Direct toxicity information is available for mammals and birds. Earthworms, the most thoroughly studied invertebrates, have the best available body-burden-based toxicity information for this receptor category.

A selection of the most scientifically sound TRVs is presented in Table 6-24. Endpoints selected as hazard levels for Cold Creek Swamp biota are also identified in Figure 6-7. In general, a lowest observed

TABLE 6-24 TOXICITY REFERENCE VALUES (TRVs) USED IN COLD CREEK SWAMP ECOLOGICAL RISK EVALUATION

| Organism        | Tissue Concentration                                       | Effect                                                      | Reference                                       |
|-----------------|------------------------------------------------------------|-------------------------------------------------------------|-------------------------------------------------|
| Fathead Minnows | 1.24 µg/g                                                  | NOAEL                                                       | Snarski and Olson 1982                          |
|                 | 1.31 µg/g                                                  | growth retardation                                          | Snarski and Olson 1982                          |
|                 | 1.36 µg/g                                                  | LOAEL, chronic reproductive inhibition - growth retardation | Snarski and Olson 1982                          |
|                 | 4.18 µg/g                                                  | lethality                                                   | Snarski and Olson 1982                          |
| Brook Trout     | 3.4 µg/g                                                   | NOAEL                                                       | McKim et al. 1976                               |
|                 | 9.5 µg/g                                                   | chronic lethality                                           | McKim et al. 1976                               |
|                 | 18.4 µg/g<br>(muscle values converted to whole-body value) | acute lethality                                             | McKim et al. 1976                               |
|                 | 5 µg/g                                                     | lowest effect chronic                                       | McKim et al. 1976                               |
| Fathead Minnows | 1.47 Hg/g                                                  | no effect                                                   | Olson et al. 1975 as cited in McKim et al. 1976 |
| Rainbow Trout   | 10 mg Hg/kg                                                | LOAEL reduction in growth and final weight                  | Rodgers and Beamish 1982                        |
| Earthworm       | 27 ppm                                                     | NOAEL                                                       | Beyer et al. 1985                               |
|                 | 85 ppm                                                     | reduced regenerative ability                                | Beyer et al. 1985                               |
| Mink            | 25.2 ppm                                                   | lethality                                                   | Aulerich et al. 1974                            |
|                 | 0.12 ppm                                                   | NOAEL (1 mink)                                              | Aulerich et al. 1974                            |

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TABLE 6-24 (Cont.)

| Organism    | Tissue Concentration | Effect              | Reference                                     |
|-------------|----------------------|---------------------|-----------------------------------------------|
| Goshawk     | 45 ppm MeHg          | lethality           | Borg et al. 1970                              |
|             | 39 ppm MeHg          | lethality (1 bird)  | Borg et al. 1970                              |
| Zebra Finch | 6.1                  | NOAEL, asymptomatic | Scheuhammer 1988                              |
|             | 8.6                  | impaired            | conversion from liver<br>to whole-body values |
|             | 14.6                 | lethality           | from Fimreite 1971<br>in Nriagu 1979          |
| Songbirds   | 35.8                 | NOAEL               | Finley et al. 1979                            |

adverse effects level (LOAEL), where available, was selected. Such information (the lowest concentration exhibiting adverse or measurable effects) provides the soundest basis for risk assessment. Where necessary, the NOAEL concentrations have been used (Figure 6-7). Risk management decisions based on the latter data are more uncertain, because the actual effects level has not been identified. However, NOAEL-based reference values are conservative, because they are below the range of concentrations causing observable toxic effects. In the following table and paragraphs, a brief discussion of the best toxicity data is presented which reviews and identifies selection endpoints.

### Fish

McKim et al. (1976) exposed, over a 144 week period, three generations of brook trout to various concentrations of methylmercuric chloride (MMC). Mean water concentrations included 2.93, 0.93, 0.29, 0.09, and 0.03 and <0.010 (control)  $\mu\text{g Hg/liter}$ . The NOEL was 3.4 mg/kg (tissue-whole body), chronic lethality was 9.5 mg/kg (tissue-whole body), and acute lethality 18.4 mg/kg muscle.

Similar values were found by Olson et al. (1975) with fathead minnows. Over a 48 week period, the fish were exposed to MMC concentrations ranging from 0.018 to 0.247  $\mu\text{g liter}$ . The lowest concentration (0.018  $\mu\text{g/L}$ ) resulted in no effect on survival, and was associated with whole body tissue concentrations of 1.47  $\mu\text{g/g}$ .

Snarski and Olson (1982) also worked with fathead minnows exposing the fish to  $\text{HgCl}_2$  concentrations. Results included an LOAEL of 0.26  $\mu\text{g/L}$  (water concentration) for reproduction and growth retardation and a residue value of 1.36 mg/kg.

Rodgers and Beamish (1982) dosed rainbow trout with MMC in food. Trout were fed at a rate of 2 percent of their body weight. A significant difference in body weights was found between the 0 and 75 Hg/kg diets, resulting in a LOAEL, for reduced growth, at tissue levels of 10 mg/kg.



## Mammals

### Mink

Aulerich et al. (1974) fed mink diets containing inorganic mercury. Weight loss resulted from a concentration of 10 ppm. A daily dose level of 0.81 mg/kg/day was established as the NOEL. Skeletal muscle concentrations were measured at 0.12 ppm.

Methyl mercury concentrations of 5 ppm in diet resulted in lethality, and tissue levels of 25.2 ppm.

## Birds

A number of generic screening values are available from the tertiary literature (e.g., Eisler 1987). For this site-specific analysis, the primary literature has been scanned to obtain the most directly applicable toxic values available. Scheuhammer (1988), in a 77-day study, fed zebra finch diets containing various concentrations of MMC. No effect was seen at dietary levels of 0.88 mg/kg/bw/day. An LOAEL, based on increased (25 percent) mortality, and neurological impairment (40 percent) was observed at 1.75 mg/kg bw/day. Mercury tissue levels in livers of asymptomatic, impaired, and dead organisms were: 30.5, 43.1 and 73. The liver values converted into whole body concentrations of 6.1, 8.6 and 14.6 respectively, using the liver to whole body conversion factor from Fimreite (1971) as cited in Nriago (1979).

An additional value for songbirds for organic mercury was reported by Finley et al. (1979). The average whole body concentration in birds not visibly affected was 35.8 ppm mercury.

### Raptors

To evaluate the effects of secondary methyl mercury in predatory birds, Borg et al. (1970) exposed goshawks to mercury in a diet of chicken muscle and liver at a concentration of 13 ppm, and muscle alone at a concentration of 10 ppm. Lethality was observed with both diets, with resulting goshawk MeHg skeletal muscle concentrations of 45 and 39 ppm.

### Annelids

Beyer et al. (1985) exposed earthworms to various concentrations of MMC in soil. After an initial exposure of 6 weeks, posterior segments were removed. The worms were returned to control and treated soils, and later measured for segment regeneration and mercury tissue concentration. Segment regenerative ability was not affected at worm tissue levels of 27 ppm, but significantly reduced at 85 ppm.

#### 6.2.3.2.2 Selected Endpoints

From the available data on mercury toxicity, the following TRVs were identified and employed to characterize ecological risk in Cold Creek Swamp (Figure 6-7):

- . 1.24 ppm for poikilothermic vertebrates (based on NOAEL for reproduction in finfish)
- . 6.1 ppm for birds (NOAEL for behavioral effects)
- . 27.0 ppm for invertebrates (based on NOAEL for segment regeneration in earthworms)

#### 6.2.3.3 Risk Characterization (Stage III)

To provide an assessment of ecological risks, organism body burdens have been projected by modeling mercury behavior in the Cold Creek Swamp ecosystem. The modeling exercise is a necessary adjunct to the field data collection efforts for several reasons:

1. Tissue analyses on top predators have been conducted only for snakes, to avoid having to sample protected reptiles and birds.
2. It was more cost-effective to collect data around a model framework than to attempt universal sampling without a conceptual guide.
3. Successful modeling guides understanding of environmental processes.
4. Modeling allows easy and less expensive exploration of environmental costs and benefits of various risk management options.

The revised exposure/risk food-web model (Figure 6-8) was designed as an equilibrium trophic-level simulation to define major ecological compartments represented at Cold Creek Swamp. The purpose of this model is to drive defensible predictive extrapolation from collected data to unsampled ecological compartments (e.g., avian top predators, alligators). The product is required for evaluation of potential risks of mercury contamination. Validation of this model indicates that even though the model is conceptually simple, predictive power is satisfactory.

Simulations of the ecological exposure/risk food-web model (Figure 6-8) were performed using stochastic variation of parameters around the values presented in Table 6-25. Primary food-web transfers were simulated by

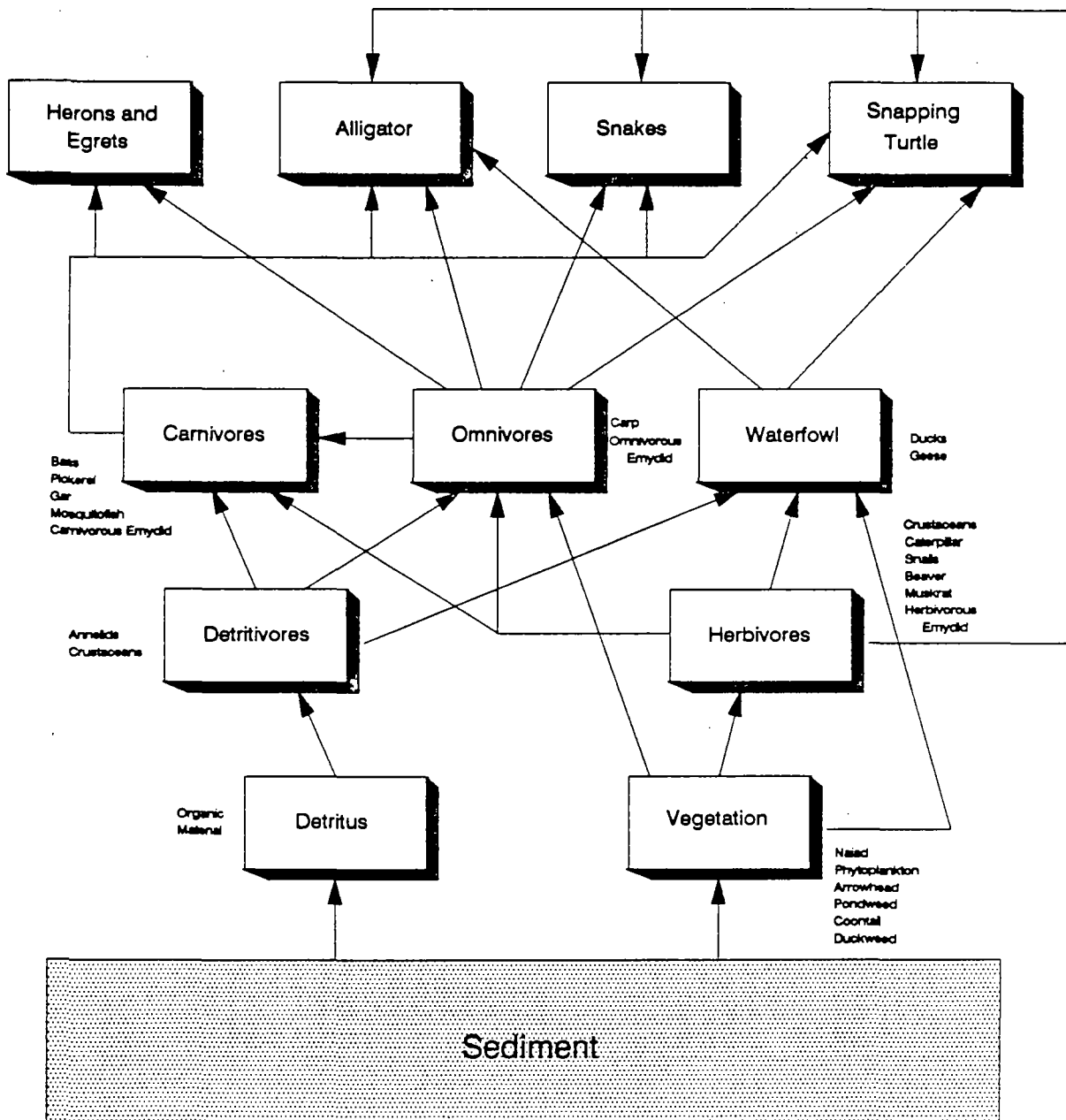


Figure 6-8. Stage III Ecological Exposure/Risk Model for Cold Creek Swamp.

TABLE 6-25 PARAMETER RANGES USED IN THE STAGE II ECOLOGICAL EXPOSURE/RISK MODEL

| Transfer           |                       | Range from Literature | Reference                                                                             | Calibrated Range or Mean |
|--------------------|-----------------------|-----------------------|---------------------------------------------------------------------------------------|--------------------------|
| BAFs:              |                       |                       |                                                                                       |                          |
| Abiotic            | => Primary Organic    | 0.02-0.08             | Muntau and Baudo 1984                                                                 | 0.012-0.014              |
| Primary Organic    | => Primary Consumers  | 2.20-3.40             | Muntau and Baudo 1984<br>Huckabee et al. 1973                                         | 1.60-2.40                |
| Primary consumer   | => Secondary Consumer | 1.60-2.80             | Vermeer et al. 1973                                                                   | 1.10-1.40                |
| Secondary Consumer | => Top Predator       | 1.60-2.80             | Vermeer et al. 1973                                                                   | 1.60-1.60                |
| DIETARY FRACTIONS  |                       |                       |                                                                                       |                          |
| Detritus           | => Detritivores       | --                    | Dietary fractions were varied around means which best represent local site conditions | 1.000                    |
| Vegetation         | => Herbivores         | --                    |                                                                                       | 1.000                    |
| Detritivores       | => Omnivores          | --                    |                                                                                       | 0.333                    |
| Herbivores         | => Omnivores          | --                    |                                                                                       | 0.333                    |
| Vegetation         | => Omnivores          | --                    |                                                                                       | 0.333                    |
| Vegetation         | => Waterfowl          | --                    |                                                                                       | 0.223                    |
| Detritus           | => Waterfowl          | --                    |                                                                                       | 0.111                    |
| Herbivores         | => Waterfowl          | --                    |                                                                                       | 0.111                    |
| Offsite            | => Waterfowl          | --                    |                                                                                       | 0.500                    |
| Herbivores         | => Carnivores         | --                    |                                                                                       | 0.167                    |
| Omnivores          | => Carnivores         | --                    |                                                                                       | 0.666                    |
| Detritivores       | => Carnivores         | --                    |                                                                                       | 0.167                    |
| Omnivores          | => Alligators         | --                    |                                                                                       | 0.167                    |
| Carnivores         | => Alligators         | --                    |                                                                                       | 0.167                    |
| Herbivores         | => Alligators         | --                    |                                                                                       | 0.167                    |
| Waterfowl          | => Alligators         | --                    |                                                                                       | 0.167                    |
| Offsite            | => Alligators         | --                    |                                                                                       | 0.333                    |
| Omnivores          | => Snakes             | --                    |                                                                                       | 0.250                    |
| Carnivores         | => Snakes             | --                    |                                                                                       | 0.250                    |
| Herbivores         | => Snakes             | --                    |                                                                                       | 0.250                    |
| Offsite            | => Snakes             | --                    |                                                                                       | 0.250                    |
| Omnivores          | => Snapping Turtles   | --                    |                                                                                       | 0.306                    |
| Carnivores         | => Snapping Turtles   | --                    |                                                                                       | 0.306                    |
| Waterfowl          | => Snapping Turtles   | --                    |                                                                                       | 0.083                    |
| Herbivores         | => Snapping Turtles   | --                    |                                                                                       | 0.306                    |
| Omnivores          | => Herons & Egrets    | --                    |                                                                                       | 0.250                    |
| Carnivores         | => Herons & Egrets    | --                    |                                                                                       | 0.250                    |
| Offsite            | => Herons & Egrets    | --                    |                                                                                       | 0.500                    |

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partitioning of total mercury from the abiotic matrix (sediment) to primary organic matrices (detritus and vegetation) using appropriate bio-accumulation factors (BAFs--ratio of consumer tissue concentrations to source concentrations). The BAFs employed in this modeling effort were originally derived from peer-reviewed literature and then adjusted during the model calibration phase so that the model best predicts the tissue concentration data collected during this study. It is important to note that these BAFs are not the same as classical water column BCFs, since they are ratios of tissue concentration to sediment concentration, not water concentration. These BAFs implicitly incorporate the binding, aging, and sorption processes which control bioavailability.

Since detritus in Cold Creek Swamp is derived primarily from vegetation, mercury concentrations in detritus were assumed to equal vegetation concentrations. This is a conservative estimate because some organo-mercury would be expected to leach from detritus during decomposition. Each successive transfer in the food-web is driven by dietary fraction and BAF ranges specific to the consumer and food source. For example, since carnivores consume both herbivores and omnivores, each of these sources is weighted with respect to fraction of the diet comprised by each. In this specific instance, BAFs were assumed to be equivalent because uptake from tissues of herbivores and omnivores would not be expected to differ markedly. In addition, organisms that do not spend all of their time in the swamp were assumed to feed offsite (no mercury contamination) some portion of the time. Four BAF ranges were used in the model, one for each of the generalized trophic levels. The first represents accumulation from the abiotic medium to vegetation and detritus; the second, accumulation from vegetation and detritus to primary consumers; the third, accumulation from primary consumers to secondary consumers; and the last, accumulation to top predators. Each consumer compartment was calibrated with specific dietary fraction ranges appropriate to the organisms represented.

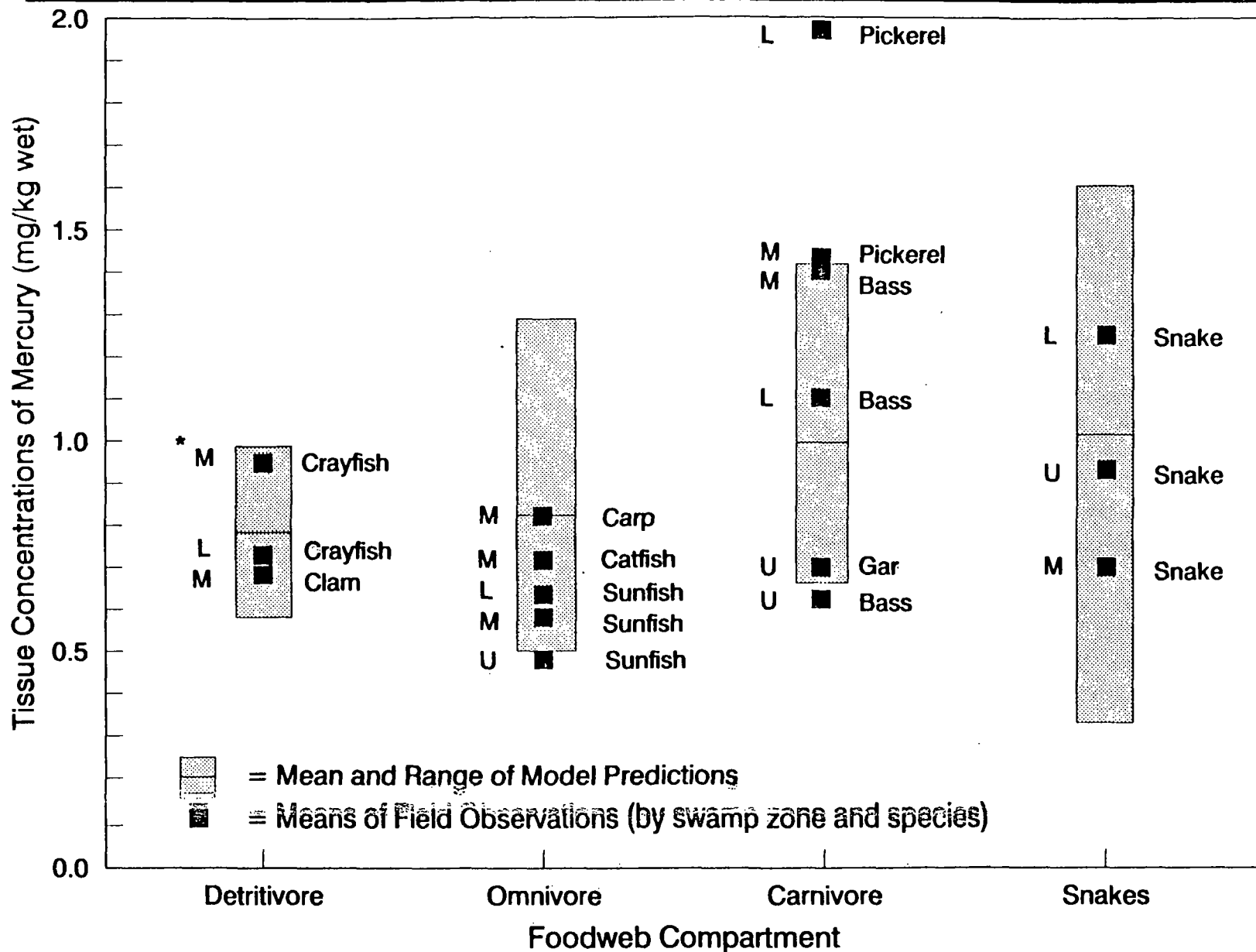
The model was calibrated by adjusting BAFs and dietary proportions until model output best matched observations from field data. The model parameters presented in Table 6-25 are those which were generated during model calibration and were used for the simulations discussed below. Since no statistically significant differences were observed between concentrations of mercury in tissues from organisms collected from various portions of the swamp (Section 4.5), the swamp was treated as a whole for modeling purposes. A comparison of model output with the calibration dataset is provided in Figure 6-9.

For modeling purposes, sediment concentrations of mercury were calculated as the area-weighted concentration of the entire swamp on the assumption that any given organism has an equal probability of occurrence in any portion of the swamp. As a simplistic example, if 5 acres have a concentration of 0.2 mg/kg and 3 acres have a concentration of 0.4 mg/kg, the area-weighted concentration of mercury is:

$$\frac{(5 \text{ acres} * 0.2 \text{ mg/kg}) + (3 \text{ acres} * 0.4 \text{ mg/kg})}{(5 \text{ acres} + 3 \text{ acres})} = 0.275 \text{ mg/kg}$$

The calculated area-weighted sediment mercury concentration which was used in the ecological model was 29.8 mg/kg.

Model simulations were conducted by running the model 500 times using stochastic (random) selection of values for each parameter within the defined ranges presented in Table 6-25. The model algorithms were coded in Microsoft Qbasic for ease of manipulation and simplicity of verification. Language intrinsic random number selection procedures were employed for stochastic variation of parameters. Output data analysis verified that each parameter had been appropriately and randomly varied throughout the simulations. The parameters that were varied stochastically are BAF and dietary fraction. Model results were analyzed statistically to determine mean and range of predictions for each compartment in the model. The purpose of stochastic simulation was to define the range of model output as a method for coping with predictive uncertainty.



\* U=Upper Swamp, M=Middle Swamp, L=Lower Swamp

Figure 6-9. Comparison of Stage III model calibration with Stage III field observations.



### Uncertainty Analysis

Several sources of uncertainty are present in the comprehensive risk characterization. These have been addressed by providing evaluations over a range of input and output parameters to ascertain sensitivity and increase confidence in conclusions. For toxicological endpoints, appropriate reference values were selected from among a range of scientifically credible studies. For contaminants and receptors of concern selection, a number of key factors were used to prevent single parameters from driving possibly spurious or uncertain selection. Risk characterization output was based on stochastic simulation and on a comprehensive data collection effort. Thus, certainty of conclusions is maximized as quantitative sensitivity and uncertainty is known in each case. The model was calibrated using site-specific data, and thus central tendencies and uncertainties reflect the real-world conditions in Cold Creek Swamp. Conclusions based on risk modeling and data analysis are well validated and of low uncertainty.

### Stage III Ecological Risk/Exposure Model Results

Predicted tissue concentrations for biota based on this model for baseline conditions are shown in Table 6-26. Graphical presentation of these data is shown in Figure 6-10.

Risks associated with predicted and observed tissue concentrations for Cold Creek Swamp can be quantified using hazard indices (HI) defined in Equation 6-9:

$$HI = (\text{predicted or observed tissue concentration} / \text{appropriate criterion})$$

Equation 6-9

TABLE 6-26 MODELED BASELINE MERCURY TISSUE CONCENTRATION (mg/kg wet wt.)

| <u>Organism</u> | <u>5th<br/>Percentile</u> | <u>Mean</u> | <u>95th<br/>Percentile</u> | <u>Standard<br/>Deviation</u> | <u>Mean<br/>HI</u> |
|-----------------|---------------------------|-------------|----------------------------|-------------------------------|--------------------|
| Alligator       | 0.50                      | 0.79        | 1.06                       | 0.17                          | 0.64               |
| Carnivore       | 0.79                      | 0.99        | 1.23                       | 0.14                          | 0.80               |
| Detritivore     | 0.62                      | 0.77        | 0.92                       | 0.09                          | 0.03               |
| Detritus        | 0.36                      | 0.39        | 0.41                       | 0.02                          | --                 |
| Herbivore       | 0.63                      | 0.77        | 0.94                       | 0.09                          | 0.62               |
| Heron, Egret    | 0.31                      | 0.74        | 1.16                       | 0.25                          | 0.12               |
| Omnivore        | 0.62                      | 0.81        | 1.02                       | 0.12                          | 0.65               |
| Snake           | 0.72                      | 1.01        | 1.34                       | 0.19                          | 0.81               |
| Snapping Turtle | 1.04                      | 1.31        | 1.60                       | 0.17                          | 1.05               |
| Vegetation      | 0.36                      | 0.39        | 0.41                       | 0.02                          | --                 |
| Water Bird      | 0.19                      | 0.42        | 0.66                       | 0.14                          | 0.07               |

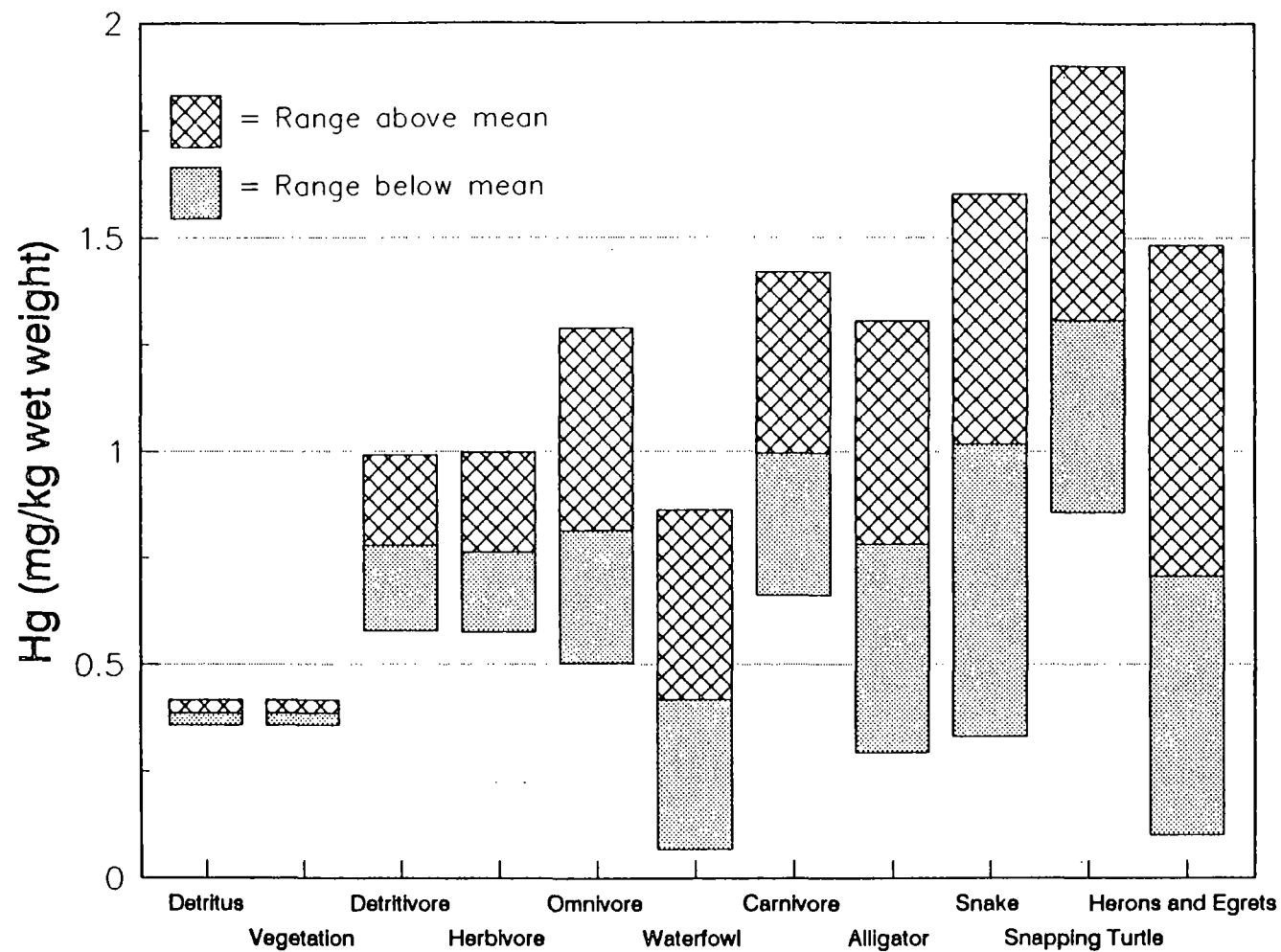


Figure 6-10. Modeled mercury body burdens for Cold Creek Swamp biota (based on Stage III Ecological Risk/Exposure Model).

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where the appropriate criterion is that found in Section 6.2.2. For example, the predicted upper 95th percentile for the alligator under baseline conditions is 1.06 mg/kg (Table 6-26), and the appropriate criterion is 1.24 mg/kg wet (Figure 6-7); therefore, the HI is:

$$\frac{1.06 \text{ mg/kg}}{1.24 \text{ mg/kg}} = 0.85$$

On this basis, modeled baseline swamp-wide risks to ecological receptors associated with mercury are shown graphically in Figure 6-11. Model results suggest that certain resident ecological receptors including snakes and snapping turtles (and likely similar predatory species) may be at risk. In addition, carnivorous fish have modeled HIs very close to one and may be considered at potential risk. It is significant that herons, egrets, waterfowl, and the alligator are not projected to be at potential risk due to exposure to Cold Creek Swamp contaminants.

Model results were generally confirmed by Stage III field samples (Figure 6-12). This is true on both an individual sample basis (Table 6-27) and when the swamp is considered on a zone basis or as a whole (Table 6-28). Examination of Table 6-28 reveals the inability to separate zones of the swamp for either mercury concentrations or hazard indices (Section 4.5). On average, body burdens in all receptors swampwide were less than 1.0. Within calculated variability (one standard deviation), one receptor category (carnivorous fish) has body burdens reflecting hazard indices greater than 1.0.

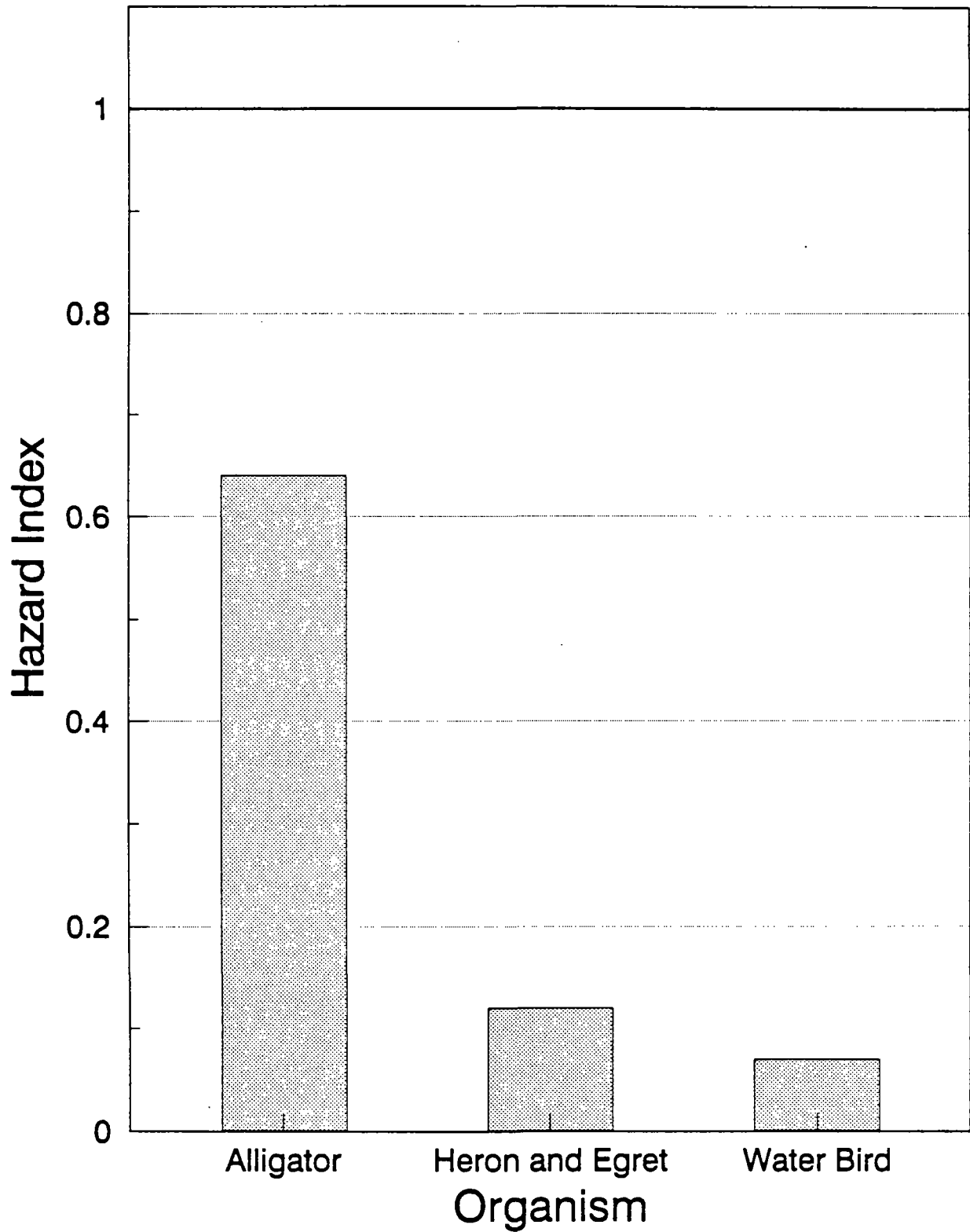


Figure 6-11. Calculated hazard indices for Cold Creek Swamp biota based on mean modeled modeled tissue mercury concentrations (Stage III Ecological Risk/Exposure Model).

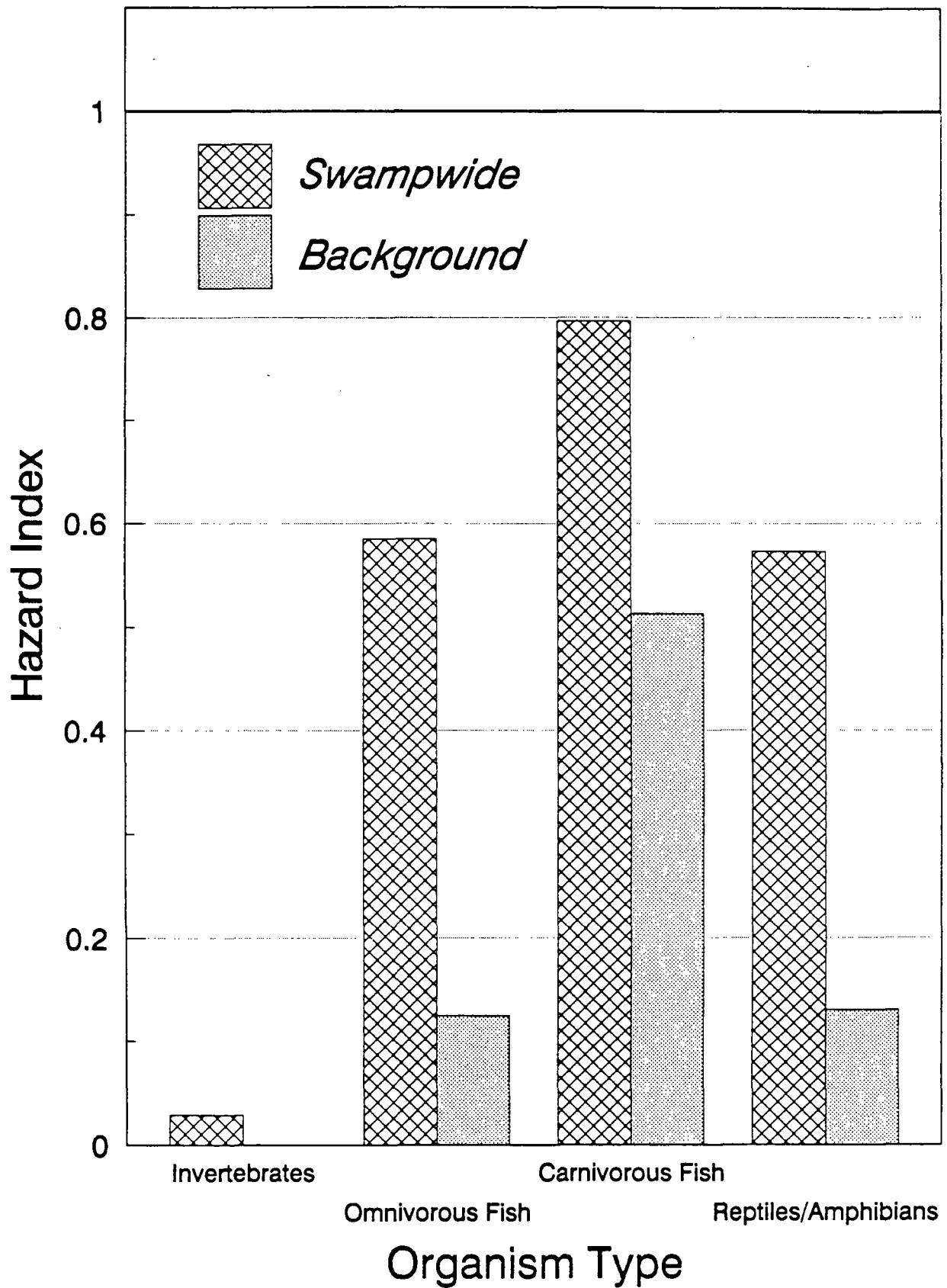


Figure 6-12. Average hazard indices for Cold Creek Swamp biota based on actual mercury body burden concentrations (Stage III biota analyses).

TABLE 6-27. ANALYTICAL RESULTS, TOXIC ENDPOINTS AND HAZARD INDICES FOR STAGE III BIOTA SAMPLES

| SAMPLE DESIGNATION | SAMPLE DESCRIPTION | TROPHIC LEVEL | TOTAL MERCURY (mg/kg) (wet weight) | LIPIDS (%) | LENGTH (mm) | WEIGHT (gm) | TOXIC ENDPOINT (mg/kg) | HAZARD INDEX (HI) |
|--------------------|--------------------|---------------|------------------------------------|------------|-------------|-------------|------------------------|-------------------|
| FINFISH SAMPLES    |                    |               |                                    |            |             |             |                        |                   |
| F-U-1              | SPOTTED GAR        | P             | 0.71                               | 2.1        | 259         | 38          | 1.24                   | 0.57              |
| F-U-2              | SPOTTED GAR        | P             | 0.69                               | 1.6        | 250         | 37          | 1.24                   | 0.56              |
| F-U-3              | BOWFIN             | C             | 0.64                               | 0.22       | 241         | 127         | 1.24                   | 0.52              |
| F-U-4              | REDEAR SUNFISH     | C             | 0.62                               | 0.94       | 142         | 59          | 1.24                   | 0.50              |
| F-U-5              | LARGEMOUTH BASS    | P             | 0.30                               | 0.35       | 191         | 81          | 1.24                   | 0.24              |
| F-U-6              | LARGEMOUTH BASS    | P             | 0.64                               | 0.41       | 203         | 87          | 1.24                   | 0.52              |
| F-U-7              | LARGEMOUTH BASS    | P             | 0.93                               | 0.075      | 146         | 34          | 1.24                   | 0.75              |
| F-U-8              | GOLDEN SHINER      | PC            | 0.29                               | 0.80       | 160         | 38          | 1.24                   | 0.23              |
| F-U-9              | GOLDEN SHINER      | PC            | 1.0                                | 0.61       | 135         | 22          | 1.24                   | 0.81              |
| F-U-10             | BLUEGILL           | C             | 0.14                               | 0.98       | 175         | 101         | 1.24                   | 0.11              |
| F-M-1              | BOWFIN             | C             | 0.91                               | 0.28       | 305         | 269         | 1.24                   | 0.73              |
| F-M-2              | LARGEMOUTH BASS    | P             | 1.4                                | 1.4        | 287         | 298         | 1.24                   | 1.13              |
| F-M-3              | LARGEMOUTH BASS    | P             | 1.4                                | 1.5        | 298         | 371         | 1.24                   | 1.13              |
| F-M-4              | REDFIN PICKEREL    | P             | 1.5                                | 7.1        | 187         | 38          | 1.24                   | 1.21              |
| F-M-5              | REDFIN PICKEREL    | P             | 0.65                               | 1.1        | 196         | 46          | 1.24                   | 0.52              |
| F-M-6              | CHAIN PICKEREL     | P             | 2.8                                | 0.54       | 190         | 31          | 1.24                   | 2.26              |
| F-M-7              | CHAIN PICKEREL     | P             | 0.81                               | 0.37       | 271         | 124         | 1.24                   | 0.65              |
| F-M-8              | COMMON CARP        | PC            | 0.82                               | 0.10       | 266         | 245         | 1.24                   | 0.66              |
| F-M-9              | GOLDEN SHINER      | PC            | 0.81                               | 1.1        | 131         | 21          | 1.24                   | 0.65              |
| F-M-10             | YELLOW BULLHEAD    | PC            | 0.71                               | 0.19       | 165         | 54          | 1.24                   | 0.57              |
| F-L-1              | AMERICAN EEL       | C             | 0.43                               | 5.3        | 600         | 517         | 1.24                   | 0.35              |
| F-L-2              | CHAIN PICKEREL     | P             | 1.5                                | 0.93       | 325         | 188         | 1.24                   | 1.21              |
| F-L-3              | CHAIN PICKEREL     | P             | 1.8                                | 0.81       | 343         | 208         | 1.24                   | 1.45              |
| F-L-4              | CHAIN PICKEREL     | P             | 3.5                                | 1.4        | 262         | 119         | 1.24                   | 2.82              |
| F-L-5              | REDFIN PICKEREL    | P             | 2.3                                | 1.7        | 261         | 126         | 1.24                   | 1.85              |
| F-L-6              | REDFIN PICKEREL    | P             | 0.69                               | 1.1        | 212         | 61          | 1.24                   | 0.56              |
| F-L-7              | LONGEAR SUNFISH    | C             | 1.4                                | 0.33       | 104         | 21          | 1.24                   | 1.13              |
| F-L-8              | LONGEAR SUNFISH    | C             | 1.1                                | 0.13       | 101         | 22          | 1.24                   | 0.89              |
| F-L-9              | LARGEMOUTH BASS    | P             | 1.1                                | 0.23       | 126         | 21          | 1.24                   | 0.89              |
| F-L-10             | WARMOUTH           | C             | 0.58                               | 4.0        | 132         | 43          | 1.24                   | 0.47              |

## NOTES:

- (1) SEE FIGURE 2-10 FOR SAMPLE LOCATIONS.
- (2) SAMPLES WERE COLLECTED 7-11 OCTOBER 1991.
- (3) MERCURY ANALYSES ARE REPORTED ON A WHOLE BODY BASIS AS TOTAL MERCURY.

## LEGEND:

|                       |                           |                             |
|-----------------------|---------------------------|-----------------------------|
| P = PREDATOR          | U = UPPER ZONE            | BP = BACKGROUND POND        |
| C = CARNIVORE         | M = MIDDLE ZONE           | BS = BACKGROUND STREAM      |
| PC = PRIMARY CONSUMER | L = LOWER ZONE            | BCM = COMPOSITE SAMPLE SITE |
| F = FINFISH           | H = HERPTILE/INVERTEBRATE |                             |
| NA = NOT APPLICABLE   | NR = NOT REPORTED         |                             |

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TABLE 6-27. (CONTINUED)

| SAMPLE<br>DESIGNATION         | SAMPLE<br>DESCRIPTION     | TROPHIC<br>LEVEL | TOTAL MERCURY<br>mg/kg<br>(wet weight) | LIPIDS<br>% | LENGTH<br>(mm) | WEIGHT<br>(gm) | TOXIC<br>ENDPOINT<br>(mg/kg) | HAZARD<br>INDEX<br>(HI) |
|-------------------------------|---------------------------|------------------|----------------------------------------|-------------|----------------|----------------|------------------------------|-------------------------|
| HERPTILE/INVERTEBRATE SAMPLES |                           |                  |                                        |             |                |                |                              |                         |
| H1-U-1                        | COTTONMOUTH SNAKE         | P                | 0.93                                   | 0.62        | NR             | 51             | 1.24                         | 0.75                    |
| H1-U-2                        | AMPHIUMA (TWO-TOED)       | C                | 0.41                                   | 1.4         | 580            | 197            | 1.24                         | 0.33                    |
| H1-U-3                        | BRONZE FROG               | C                | 0.73                                   | 2.0         | 70             | 33             | 1.24                         | 0.59                    |
| H1-U-4                        | SOUTHERN TOAD             | C                | 0.19                                   | 0.57        | 63             | 19             | 1.24                         | 0.15                    |
| H1-U-5                        | FROG (COMPOSITE OF 11)    | C                | 1.6                                    | 0.15        | NA             | NA             | 1.24                         | 1.29                    |
| H1-M-1                        | BANDED WATER SNAKE        | P                | 0.70                                   | 0.98        | 630            | 103            | 1.24                         | 0.56                    |
| H1-M-2                        | CLAMS                     | PC               | 0.68                                   | 0.46        | NA             | NA             | 27                           | 0.03                    |
| H1-M-3                        | BRONZE FROG               | C                | 0.54                                   | 0.33        | 70             | 27             | 1.24                         | 0.44                    |
| H1-M-4                        | BRONZE FROG               | C                | 0.58                                   | 0.35        | 67             | 25             | 1.24                         | 0.47                    |
| H1-M-5                        | CRAYFISH (COMPOSITE OF 3) | PC               | 0.95                                   | 6.5         | NA             | NA             | 27                           | 0.04                    |
| H1-M-7                        | BRONZE FROG               | C                | 0.55                                   | 0.12        | 41             | 8              | 1.24                         | 0.44                    |
| H1-L-1                        | COTTONMOUTH SNAKE         | P                | 1.6                                    | 2.6         | 660            | 253            | 1.24                         | 1.29                    |
| H1-L-2                        | COTTONMOUTH SNAKE         | P                | 0.90                                   | 2.7         | 770            | 339            | 1.24                         | 0.73                    |
| H1-L-3                        | CRAYFISH (COMPOSITE OF 5) | PC               | 0.74                                   | 0.49        | NA             | NA             | 27                           | 0.03                    |
| H1-L-4                        | BRONZE FROG               | C                | 0.24                                   | 0.84        | 630            | 103            | 1.24                         | 0.19                    |
| H1-L-5                        | FROG (COMPOSITE OF 2)     | C                | 0.16                                   | 3.9         | NA             | NA             | 1.24                         | 0.13                    |

## NOTES:

- (1) SEE FIGURE 2-10 FOR SAMPLE LOCATIONS.  
 (2) SAMPLES WERE COLLECTED 7-11 OCTOBER 1991.  
 (3) MERCURY ANALYSES ARE REPORTED ON A WHOLE BODY BASIS AS TOTAL MERCURY.

## LEGEND:

|                       |                           |                             |
|-----------------------|---------------------------|-----------------------------|
| P = PREDATOR          | U = UPPER ZONE            | BP = BACKGROUND POND        |
| C = CARNIVORE         | M = MIDDLE ZONE           | BS = BACKGROUND STREAM      |
| PC = PRIMARY CONSUMER | L = LOWER ZONE            | BCM = COMPOSITE SAMPLE SITE |
| F = FINFISH           | H = HERPTILE/INVERTEBRATE |                             |
| NA = NOT APPLICABLE   | NR = NOT REPORTED         |                             |



TABLE 6-27. (CONTINUED)

| SAMPLE<br>DESIGNATION | SAMPLE<br>DESCRIPTION | TROPHIC<br>LEVEL | TOTAL MERCURY<br>mg/kg<br>(wet weight) | LIPIDS<br>% | LENGTH<br>(mm) | WEIGHT<br>(gm) | TOXIC<br>ENDPOINT<br>(mg/kg) | HAZARD<br>INDEX<br>(HI) |
|-----------------------|-----------------------|------------------|----------------------------------------|-------------|----------------|----------------|------------------------------|-------------------------|
| BACKGROUND SAMPLES    |                       |                  |                                        |             |                |                |                              |                         |
| F-BP-1                | LARGEMOUTH BASS       | P                | 1.5                                    | 1.5         | 454            | 1480           | 1.24                         | 1.21                    |
| F-BP-2                | BROWN BULLHEAD        | PC               | 0.04                                   | 1.2         | 308            | 347            | 1.24                         | 0.03                    |
| F-BP-3                | COMMON CARP           | PC               | 0.12                                   | 1.5         | 264            | 281            | 1.24                         | 0.10                    |
| F-BP-4                | CHAIN PICKEREL        | P                | 0.56                                   | 1.2         | 255            | 82             | 1.24                         | 0.45                    |
| F-BP-5                | SPOTTED GAR           | P                | 0.42                                   | 0.72        | 431            | 212            | 1.24                         | 0.34                    |
| F-BS-1                | LAKE CHUBSUCKER       | PC               | 0.17                                   | 0.29        | 244            | 223            | 1.24                         | 0.14                    |
| F-BS-2                | LARGEMOUTH BASS       | P                | 0.38                                   | 1.2         | 282            | 261            | 1.24                         | 0.31                    |
| F-BS-3                | LARGEMOUTH BASS       | P                | 0.50                                   | 0.58        | 223            | 132            | 1.24                         | 0.40                    |
| F-BS-4                | REDFIN PICKEREL       | P                | 0.46                                   | 0.66        | 231            | 78             | 1.24                         | 0.37                    |
| F-BS-5                | YELLOW BULLHEAD       | PC               | 0.29                                   | 0.16        | 178            | 59             | 1.24                         | 0.23                    |
| H1-B-1                | COTTONMOUTH SNAKE     | P                | 0.66                                   | 0.23        | 630            | 135            | 1.24                         | 0.53                    |
| H1-B-2                | LEOPARD FROG          | C                | 0.02                                   | 0.68        | 86             | 60             | 1.24                         | 0.02                    |
| H1-B-3                | LEOPARD FROG          | C                | 0.04                                   | 0.84        | 86             | 60             | 1.24                         | 0.03                    |
| H1-B-4                | BRONZE FROG           | C                | 0.03                                   | 2.4         | 59             | 24             | 1.24                         | 0.02                    |
| H1-B-5                | BRONZE FROG           | C                | 0.06                                   | 2.4         | 57             | 17             | 1.24                         | 0.05                    |
| COMPOSITE SAMPLES     |                       |                  |                                        |             |                |                |                              |                         |
| BCM1                  | SPOTTED SUNFISH (5)   | C                | 0.42                                   | 1.5         | NA             | NA             | 1.24                         | 0.34                    |
| BCM2                  | BLUEGILL (5)          | C                | 0.73                                   | 2.2         | NA             | NA             | 1.24                         | 0.59                    |
| BCM3                  | BLUEGILL (5)          | C                | 0.72                                   | 1.1         | NA             | NA             | 1.24                         | 0.58                    |
| BCM4                  | SPOTTED SUNFISH (5)   | C                | 0.44                                   | 2.4         | NA             | NA             | 1.24                         | 0.35                    |
| BCM5                  | BLUEGILL (5)          | C                | 0.46                                   | 1.6         | NA             | NA             | 1.24                         | 0.37                    |
| BCM6                  | BLUEGILL (5)          | C                | 0.12                                   | 2.0         | NA             | NA             | 1.24                         | 0.10                    |
| BCM7                  | BLUEGILL (5)          | C                | 0.18                                   | 1.2         | NA             | NA             | 1.24                         | 0.15                    |

## NOTES:

- (1) SEE FIGURE 2-10 FOR SAMPLE LOCATIONS.  
 (2) SAMPLES WERE COLLECTED 7-11 OCTOBER 1991.  
 (3) MERCURY ANALYSES ARE REPORTED ON A WHOLE BODY BASIS AS TOTAL MERCURY.

## LEGEND:

|                       |                           |                             |
|-----------------------|---------------------------|-----------------------------|
| P = PREDATOR          | U = UPPER ZONE            | BP = BACKGROUND POND        |
| C = CARNIVORE         | M = MIDDLE ZONE           | BS = BACKGROUND STREAM      |
| PC = PRIMARY CONSUMER | L = LOWER ZONE            | BCM = COMPOSITE SAMPLE SITE |
| F = FINFISH           | H = HERPTILE/INVERTEBRATE |                             |
| NA = NOT APPLICABLE   | NR = NOT REPORTED         |                             |

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TABLE 6-28 SUMMARY OF AVERAGE CONCENTRATIONS AND HAZARD INDICES BY SWAMP ZONE, BASED ON STAGE III BIOLOGICAL SAMPLES

| Swamp Zone          | No. of<br>Observations | Mercury (mg/Kg) |           | Toxicity<br>Endpoint (mg/Kg) | Hazard Index |           |
|---------------------|------------------------|-----------------|-----------|------------------------------|--------------|-----------|
|                     |                        | Avg. Conc.      | Std. Dev. |                              | Avg. Value   | Std. Dev. |
| Upper Swamp         |                        |                 |           |                              |              |           |
| Invertebrates       | 0                      | -               | -         | -                            | -            | -         |
| Omnivorous fish     | 2                      | 0.65            | 0.50      | 1.24                         | 0.52         | 0.41      |
| Carnivorous fish    | 10                     | 0.58            | 0.23      | 1.24                         | 0.47         | 0.19      |
| Reptiles/amphibians | 5                      | 0.77            | 0.54      | 1.24                         | 0.62         | 0.44      |
| Middle Swamp        |                        |                 |           |                              |              |           |
| Invertebrates       | 2                      | 0.81            | 0.19      | 27.00                        | 0.03         | 0.01      |
| Omnivorous fish     | 3                      | 0.78            | 0.06      | 1.24                         | 0.63         | 0.05      |
| Carnivorous fish    | 9                      | 1.18            | 0.71      | 1.24                         | 0.95         | 0.57      |
| Reptiles/amphibians | 4                      | 0.59            | 0.07      | 1.24                         | 0.48         | 0.06      |
| Lower Swamp         |                        |                 |           |                              |              |           |
| Invertebrates       | 1                      | 0.74            | -         | 27.00                        | 0.027        | -         |
| Omnivorous fish     | 0                      | -               | -         | -                            | -            | -         |
| Carnivorous fish    | 13                     | 1.17            | 0.96      | 1.24                         | 0.94         | 0.77      |
| Reptiles/amphibians | 4                      | 0.75            | 0.65      | 1.24                         | 0.61         | 0.52      |
| Whole Swamp         |                        |                 |           |                              |              |           |
| Invertebrates       | 3                      | 0.79            | 0.14      | 27.00                        | 0.03         | 0.01      |
| Omnivorous fish     | 5                      | 0.73            | 0.27      | 1.24                         | 0.59         | 0.21      |
| Carnivorous fish    | 32                     | 0.99            | 0.76      | 1.24                         | 0.80         | 0.61      |
| Reptiles/amphibians | 13                     | 0.71            | 0.46      | 1.24                         | 0.57         | 0.37      |
| Background          |                        |                 |           |                              |              |           |
| Invertebrates       | 0                      | -               | -         | -                            | -            | -         |
| Omnivorous fish     | 4                      | 0.15            | 0.11      | 1.24                         | 0.13         | 0.08      |
| Carnivorous fish    | 6                      | 0.64            | 0.43      | 1.24                         | 0.51         | 0.35      |
| Reptiles/amphibians | 5                      | 0.16            | 0.28      | 1.24                         | 0.13         | 0.23      |

REFERENCES  
CHAPTER 6

- Agency for Toxic Substances and Disease Registry (ATSDR). Toxicology Profiles. U.S. Public Health Service, in collaboration with the U.S. EPA. Department of Health and Human Services. Oak Ridge National Laboratory, Tennessee.
- Aulerich, R.J., R.K. Ringer, and S. Iwamoto. 1974. Effects of dietary mercury on mink. Arch. Environ. Contam. Toxicol. 2(1):43-51.
- Bartlett, P.D., and P.J. Craig. 1981. Total mercury and methyl mercury levels in British Estuarine Sediments-II. Wat. Res. 15:37-47.
- BCM Engineers, Inc. 1989. Heavy Metal Levels in Cold Creek Swamp Biota. Prepared for AKZO Chemicals, Inc. June.
- Beyer, W.N., E. Cromartie, and G.B. Moment. 1985. Accumulation of methylmercury in the earthworm Eisenia foetida, and its effect on regeneration. Bull. Environ. Contam. Toxicol. 35:157-162.
- Bloom, N. 1989. Determination of picogram levels of methylmercury by aqueous phase ethylation, followed by cryogenic gas chromatography with cold vapor atomic fluorescence detection. Can. J. Aquat. Sci. 46:1131-1140.
- Bodek, I., W.J. Lyman, W.F. Reehl, and D.H. Rosenblatt, eds. 1988. Environmental Inorganic Chemistry: Properties, Processes, and Estimation Methods. Pergamon Press, Elmsford, New York.
- Borg, K., K. Erne, E. Hanko, and H. Wanntorp. 1970. Experimental secondary methyl mercury poisoning in the goshawk Accipiter G. gentilis L. Environ. Pollut. 1:91-104.
- Canter, L.W. 1977. Environmental Impact Assessment. pp. 220-232. McGraw-Hill Book Company, New York.
- Chapman, P.M. 1989. Current approachse to developing sediment quality criteria. Environ. Toxicol. Chem. 8:589-599.
- ChemFate (Chemical Fate Computer Database). 1991. Syracuse Research Corporation Environmental Fate Data Base.
- Costanza, R., C. Wiell, S.G. Leibowitz, J.R. Fruci, L.M. Bahr Jr., and J.W. Day Jr. 1983. Ecological Models of the Mississippi Delta Plain Region. FWS/OBS-82/68. U.S. Fish and Wildlife Service, Washington, D.C.
- Dean, B.V., and M.J. Nishry. 1965. Scoring and profitability models for evaluating and selecting engineering projects. J. Operations Soc. Am. 13(4):550-569.

- EA Engineering, Science, and Technology. 1985. Vanadium: Environmental and Community Health Impact. Internal Report AP137D. January.
- Eisler, R. 1987. Mercury hazards to fish, wildlife and invertebrates. U.S. Fish and Wildlife Service Biological Report 85.
- Fang, S.C. 1975. Thiocarbamates, in *Herbicides: Chemistry, Degradation, and Mode of Action, Volume I* (P.C. Kearney and D.D. Kaufman, eds.). Marcel Dekker, Inc., New York.
- Fimreite, M., and L.M. Reynolds. 1973. Mercury contamination of fish in northeastern Ontario. *J. Wildl. Manage.* 37:62-68.
- Finley, M.L., W.H. Stickel, and R.E. Christensen. 1979. Mercury residues in tissues of dead and surviving birds fed methylmercury. *Bull. Environ. Contam. Toxicol.* 21:105-110.
- Halfon, E., and M.G. Reggiani. 1986. Notes on ranking chemicals for environmental hazard. *Environ. Sci. Technol.* 20(11):1173-1179.
- Huckabee, J.W., J.W. Elwood, and S.G. Hildebrand. 1979. Accumulation of mercury in freshwater biota, in *The Biochemistry of Mercury in the Environment* (J.O. Nriagu, ed.), pp. 277-302. Elsevier/North Holland Biomedical Press, New York.
- ICI America, Inc. 1989. Internal Report. Richmond, California.
- Kushlam, J. 1978. Feeding ecology of wading birds, in *Wading Birds* (A. Sprunt IV, J.C. Ogden, and S. Winkler, eds.), pp. 249-297. National Audubon Society Research Report No. 7.
- McCarty, L.E. 1986. The relationship between aquatic toxicity QSARs and bioconcentration for some organic chemicals. *Environ. Toxicol. Chem.* 5:1071-1082.
- McKim, J.M., G.F. Olson, G.W. Holcombe, and E.P. Hunt. 1976. Long-term effects of methylmercuric chloride on three generations of brook trout (*Salvelinus fontinalis*): Toxicity, accumulation, distribution, and elimination. *J. Res. Board Can.* 33:2726-39.
- Muntau, L., and R. Bando. 1984. A case study on the fate of heavy metals: Lake Maggiore, Italy, in *Toxic Contamination in Large Lakes, Volume III* (N.W. Schmidtke, ed.), pp. 319-325. Lewis Publishers, Ann Arbor, Michigan.
- National Academy of Sciences (NAS). 1978. An assessment of mercury in the environment. NAS, Washington, D.C.
- Nriagu, J.O., ed. 1979. *The Biogeochemistry of Mercury in the Environment*. Elsevier/North Holland Biomedical Press, Amsterdam. 696 pp.

- Rodgers, D.W., and F.W.H. Beamish. 1982. Dynamics of dietary methylmercury in rainbow trout, Salmo gairdneri. *Aquatic Toxicology* 2:271-290.
- Rodgers, D.W., and F.W.H. Beamish. 1983. Water quality modifies uptake of waterborne methyl mercury by rainbow trout. *Can. J. Fish. Aquat. Sci.* 40:824-838.
- Rudd, J.W.M., M.A. Turner, A. Furutani, A.L. Swick, and B.E. Swick. 1983. The English-Wabigoun River system: II. *Can. J. Fish. Aquat. Sci.* 40:2206-2217.
- Scheuhammer, A.M. 1988. Chronic dietary toxicity of methylmercury in the zebra finch, Poephila guttata.
- Snarski, V.M., and G.F. Olson. 1982. Chronic toxicity and bioaccumulation of mercuric chloride in the fathead minnow (Pimephales promelas). *Aquatic Toxicology* 2:143-156.
- Sorensen, J.A., G.A. Glass, K.W. Schmidt, J.K. Huber, and G.R. Rapp, Jr. 1990. Airborne mercury deposition and watershed characteristics in relation to mercury concentrations in water, sediments, plankton, and fish of 80 northern Minnesota lakes. *Environ. Sci. Technol.* 24:1716-1727.
- Staples, C.A., K.L. Dickson, J.H. Rodgers, Jr., and F.Y. Saleh. 1985. A model for predicting the influence of suspended sediments on the bioavailability of neutral organic chemicals in the water compartment, in *Aquatic Toxicology and Hazard Assessment: Seventh Symposium, ASTM STP 854* (R.D. Cardwell, R. Purdy, and R.C. Bahner, eds.), pp. 417-428. American Society for Testing and Materials, Philadelphia, Pennsylvania.
- Tejning, S. 1967. Mercury in pheasants deriving from seed grain dressed with methyl and ethyl mercury compounds. *Oikos* 18:334-344.
- U.S. Environmental Protection Agency (EPA). 1984. Ambient Water Quality Criteria for Mercury. EPA 440/5-84-026.
- U.S. Environmental Protection Agency (EPA). 1985. Guidelines for Deriving Numerical Water Quality Criteria for the Protection of Aquatic Organisms and Their Uses. PB85-227049. Office of Research and Development, Duluth, Minnesota.
- U.S. Environmental Protection Agency (EPA). 1987. Aquatic Information Retrieval System (AQUIRE). U.S. EPA Chemical Information Service.
- U.S. Environmental Protection Agency (EPA). 1989. Sediment Toxicity Assessment through Evaluation of the Toxicity of Interstitial Water. EPA/600/D-89/173.
- U.S. Environmental Protection Agency (EPA). 1991a. Interim Guidance for Dermal Exposure Assessment. Review Draft. Office of Research and Development, March 1991. EPA/600/8-91/011A.

- U.S. Environmental Protection Agency (EPA). 1991b. Health Effects Assessment Summary Tables (HEAST). Annual FY-1991 (January 1991). Office of Emergency and Remedial Response and the Office of Research and Development, Washington, D.C.
- U.S. Environmental Protection Agency (EPA). 1992. Integrated Risk Information System (IRIS). U.S. EPA Environmental Criteria and Assessment Office, Cincinnati, Ohio.
- U.S. Environmental Protection Agency (EPA). n.d. Health Assessment Document. Office of Health and Environmental Assessment, Washington, D.C.
- Van Deer Kooij, L.A., D. Van De Meent, C.J. Van Leeuwen, and W.A. Bruggeman. 1991. Deriving quality criteria for water and sediment from the results of aquatic toxicity tests and product standards: Application of the equilibrium partitioning method. Water Resour. 6:697-705.
- Vermeer, K., F.A.S. Armstrong, and D.R.M. Hatch. 1973. Mercury in aquatic birds at Clay Lake, Western Ontario. J. Wildl. Manage. 37:58-61.
- Verschuieren, K. 1983. Handbook of Environmental Data on Organic Chemicals. Second Edition. Van Nostrand Reinhold, New York.
- Winfrey, M.R., and J.W.M. Rudd. 1990. Environmental factors affecting the formation of methylmercury in low pH lakes. Environ. Toxicol. Chem. 9:853-869.

## 7. CONCLUSIONS AND RECOMMENDATIONS

### 7.1 CONCLUSIONS

In response to a request from EPA and pursuant to comments from USFWS and NOAA on the 1988 RI Report for the Cold Creek/LeMoyne Superfund site, a Supplemental RI/FS was initiated in May 1990. The Supplemental RI/FS focused on investigation of the nature and extent of contamination, and potential human health and ecological risks at the Cold Creek Swamp Operable Unit of the Cold Creek/LeMoyne site.

A three-stage field data collection program was conducted between February and October 1991. A total of 140 soil/sediment samples, 80 surficial sediment samples, 6 surface water samples, and 58 biota samples were collected and analyzed for a wide range of parameters, as described in Chapter 3. Assessment of these data, in conjunction with site observations, and human health and ecological risk modeling were used to establish risk levels associated with baseline conditions at the site.

The following sections summarize:

1. Identification of contaminants of concern
2. Identification of contaminant transport findings
3. Baseline human health and ecological risk evaluations

#### 7.1.1 Contaminants of Concern

##### Stage I

At the conclusion of Stage I field work, data associated with the nature of environmental contamination in Cold Creek Swamp media were examined. These data were used for a preliminary screening of risk to human health and ecological receptors in the swamp ecosystem.

The human health risk screening indicated that, for the established exposure scenarios, there were no contaminants of concern for human health (Section 6.1).

The preliminary ecological risk screening examined site contaminants with respect to concentration, detection ratio, bioaccumulation factor, and toxicity quotient to develop a chemical ranking model. Based on the results of the chemical ranking model, the following compounds were identified as potential contaminants of concern (Section 6.2.1):

- . inorganic mercury
- . methyl mercury
- . aluminum
- . cadmium
- . copper
- . zinc

In addition, although the preliminary risk model did not identify thiocarbamates as contaminants of concern, regulatory agencies directed that they be retained for further consideration.

## Stage II

In Stage II, additional chemical and mineralogical analyses were conducted on soil/sediment and surficial sediment samples to further investigate contaminants identified in Stage I on the basis of these additional data. The only contaminant that was determined to be a contaminant of concern was mercury (Section 5.1).

Review of Stage II findings and recommendations by EPA, USFWS, and NOAA concurred that mercury was, in fact, a potential contaminant of concern. Since mineralogical data were not yet available at the time of the Stage II meeting with EPA, no decision could be made as to whether aluminum would be considered a contaminant of concern. Furthermore, because the AVS data from Stage II were unusable, the regulatory agencies



could not determine whether cadmium, copper, and zinc were potential contaminants of concern. Consequently, an additional round of AVS-SEM analyses was included in the Stage III field program.

### Stage III

Stage III field work focused primarily on assessment of mercury in biota samples. In addition, a second round of AVS-SEM samples were taken. These data confirmed that cadmium, copper, and zinc do not represent a risk to ecological receptors and, therefore, are not contaminants of concern (Section 5.1.2). Subsequent to Stage III, results from the Stage II mineralogical survey were available. These data indicated that elevated aluminum concentrations in Cold Creek Swamp are of natural origin, and in the lower swamp, primarily associated with high aluminum oxide content of Mobile River sediments that have been deposited in the lower swamp through flooding events and that aluminum is not a contaminant of concern (Section 5.1.1). Another activity performed in Stage III was a reassessment of thiocarbamate risk based on TOC data obtained during Stage III. This reassessment confirmed that thiocarbamates are not a contaminant of concern at Cold Creek Swamp (Section 5.1.4).

### Summary

At the conclusion of the three-stage sampling program and the human health and ecological risk modeling, it was determined that mercury is the only contaminant of concern with respect to risk considerations for ecological receptors. There were no identified contaminants of concern for human health risk.

#### 7.1.2 Contaminant Transport

Assessment of contaminant transport mechanisms indicated that major mercury transport pathways within the Cold Creek Swamp ecosystem were:

- . Chemical transformation (methylation-demethylation)
- . Sediment/surface-water transport

High mercury concentrations in sediments are localized primarily within an area of the upper swamp near the former discharge location. Other pathways that were examined included ground-water transport and airborne transport.

#### 7.1.3 Risk Assessment

Risk assessment activities at this site included a human health risk assessment and an ecological risk evaluation.

##### Human Health

A preliminary human health risk screen was conducted during Stage I to identify potential human health risk contaminants of concern. The findings of this study were that there were no human health contaminants of concern, based on the exposure scenarios used in the model. A comprehensive human health risk assessment incorporating all Stage I, Stage II, and Stage III data was conducted at the conclusion of Stage III. The findings of this study were that there were no contaminants of concern with respect to human health based on the exposure scenarios inherent in the risk model (Section 6.1).

##### Ecological

A three-stage ecological risk evaluation process was used. In Stage I, a chemical ranking model that used contaminant concentrations, detection ratios, bioconcentration factors, and toxicity quotients was used to screen the potential contaminants of concern (Section 6.2).

The ecological receptors of concern were selected during Stage II based on site use, trophic status, habitat, human use, and practicality of sampling. An ecological model was developed to predict mercury body burdens in ecological receptors using bioaccumulation factors, trophic status, and food web interactions (Section 6.2.2). The model was initially validated with biota analysis data available from previous studies (1988 RI and 1989 BCM study).

Subsequent to Stage III data analysis, a Baseline Ecological Risk Evaluation was developed using all data from Stage I, Stage II, and Stage III and from previous site studies. The components of the Baseline Ecological Risk Evaluation were:

- . Exposure Assessment
- . Toxicity Assessment
- . Risk Assessment

The findings of the Baseline Ecological Risk Evaluation were that levels of mercury in Cold Creek Swamp sediments pose a potential risk to some receptors. On average, hazard indices for all swamp biota are less than one. However, for some individuals at higher trophic levels, hazard indices between 1 and 2 were obtained, and one individual had a hazard index value of 2.8. Ecological receptors with the higher elevated mercury body burdens were carnivorous fish and predatory herptiles. This finding is consistent with expectations based on understanding of the biological behavior of mercury (Section 5.1.3). Body burden elevations were not considered to be a concern in a number of key receptors, including omnivorous, herbivorous, and detritivorous aquatic species, waterfowl, herons and egrets, or the alligator.

## 7.2 RECOMMENDATIONS

### 7.2.1 Recommendations for Subsequent Activities

The findings of the Baseline Ecological Risk Evaluation indicate that neither human nor ecological receptors are at substantial risk for mercury exposure in Cold Creek Swamp, but that elevated mercury concentrations are present in sediments and some biota. Based on these findings, it is recommended that a Feasibility Study be conducted to investigate potential remediation scenarios and the potential effect of different options. An important consideration when investigating potential remedial alternatives is to ensure that negative environmental impacts associated with implementation of proposed remedial actions do not outweigh projected benefits.

### 7.2.2 Recommended Remedial Action Objectives

The following remedial action objectives are proposed:

- . Ascertain potential for natural recovery within the swamp ecosystem under "no action" and "limited action" scenarios.
- . Develop, evaluate, and implement, as necessary, measures to address mercury concentrations in bioaccessible sediments and/or biota. As part of the remedial alternative evaluation process, ensure that negative environmental impacts associated with remedial measures considered do not outweigh benefits associated with exposure reduction.

These remedial action objectives will serve as the basis for establishment of site remediation objectives in the Feasibility Study.