# COLDWATER CREEK WATERSHED

## VOLUME I: FINAL REPORT

# TOXIC AGENT STUDY

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EAST-WEST GATEWAY COORDINATING COUNCIL
METROPOLITAN ST. LOUIS SEWER DISTRICT

The preparation of this report was funded through a grant provided by the U.S. Environmental Protection Agency under Section 208 of Public Law 92-500.

JANUARY 1983

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# ACKNOWLEDGEMENTS

The Study Team acknowledges the assistance provided in the preparation of the Final Report by the following Toxic Steering Committee members: Greg Knauer, Chairman; Warren Bunch; Pete Dignan; Dorothy Heinze; Michael Lacy; Mike Richter; James Grant; and Walter Zollman.

Clarence Klassen, Environmental Consultant to East-West Gateway, also provided invaluable assistance.

# 1. EXECUTIVE SUMMARY

There has been much attention focused on the industrial waste pretreatment program developed by the United States Environmental Protection Agency (U.S. EPA). The principal problem confronting regulatory agencies in implementing this program is the identification of toxic materials in receiving waters and the determination of the probable entry pathways. Although detailed evaluation of in-stream water quality and the determination of pollutant pathways can be complex, adequate problem identification is basic to the development of a sound management strategy to control toxic pollutants.

In 1976, the U.S. EPA established a list of 129 priority pollutants, or substances considered to be hazardous. This list is continually updated and revised by the Agency. Three of the original 129 pollutants have been eliminated from the list. The current list of 126 priority pollutants provided the basis for data collection and control evaluations in this study.

The primary goal of the Toxic Agent Study was to develop and execute methodologies, including a toxic agent budget, for a specific urban watershed to enable evaluation of management strategies for the control of waterborne priority pollutants. The budget, an inventory or mass balance of toxic materials, defines the movement of priority pollutants into, within, and out

of the urban watershed. A complimentary objective was the development of a model work plan for preparing a budget which would be applicable to many watersheds throughout the nation. The field monitoring program developed involved sampling and analysis of the stream under various runoff conditions. Monitoring results were used to verify budget methodology and to investigate water quality criteria violations.

The study team was composed of staff from East-West Gateway Coordinating Council (EWGCC) and the Metropolitan St. Louis Sewer District (MSD). A technical steering committee comprised of members representing industry, consulting engineers, environmental groups, various government agencies, and the Regional Water Quality Board was also involved in overseeing the major activities of the study. Also involved in the overseeing activities were representatives from the Missouri Department of Natural Resources and U.S. Environmental Protection Agency (Region VII).

The Coldwater Creek watershed, located within northwest St. Louis County, was selected as an appropriate study area. The overall size of the watershed is approximately 43 square miles. Major land uses within this area include residential, commercial, industrial and transportation. High density strip commercial areas are found along Lindbergh Boulevard and St. Charles Rock Road. Lambert-St. Louis International Airport is located completely within the watershed and a large industrial complex is adjacent to the airport. The Coldwater Creek watershed was ideal for developing a toxic agent budget because of the mix of

land uses and the existence of several NPDES point source discharges into the creek.

The development of the Toxic Agent Budget Methodology was the first significant study output. The Budget Methodology (reproduced in Appendix A) presented in outline form all of the major steps and considerations needed to develop a toxic agent budget. This Methodology, therefore, serves as a model work plan which is applicable to many urban watersheds throughout our nation.

The Final Report represents a compilation of all previous study reports, findings and conclusions. Separate reports were prepared for the Budget Methodology (model work plan), the Study Area Inventory and the Water Quality Monitoring Strategy. Another study report produced during the study was the User's Guide for the Water Quality Evaluation Procedure. Due to the general lack of consistency and information available for establishing in-stream water quality criteria for priority pollutants, it was necessary to develop a Water Quality Evaluation Procedure. The evaluation consists of a series of decision tables which identify minimum, limited and maximum exposure levels in a water environment for each of the 126 priority pollutants. This unique decision-making process presents a systematic approach to the establishment of in-stream water quality criteria for priority pollutants (for a more detailed discussion see Chapter 7).

During the six-month monitoring program of Coldwater Creek, 30 metallic and organic priority pollutants were detected in stream, sediment and precipitation samples. Pollutants detected

included metals, volatile organic compounds, phthalate esters, pesticides, phenols, cyanide and polynuclear aromatic hydrocarbons (PAH).

A toxic agent budget was developed to evaluate the movement, distribution and ultimate fate of priority pollutants detected within the watershed. Land use patterns, industrial, commercial and residential activities were evaluated to correlate sampling results with potential source contributions.

In the Coldwater Creek watershed, motor vehicle traffic and airport activities appear to be dominant sources for lead and phenols. Industrial operations and residential/commercial area runoff contribute metals, volatile organic compounds and phthalate esters. Lawn care and pest control activities are primarily responsible for the pesticides measured, and roadway asphalt and fuel combustion are principal sources of PAH compounds.

Dry and wet weather concentrations of priority pollutants measured in Coldwater Creek indicate that only chromium, copper, lead, cyanide and endosulfan may at times exceed selected criteria for preservation of aquatic life.

Major study conclusions are:

1. The watershed evaluated in the study, Coldwater Creek, located in north St. Louis County, Missouri, is relatively free of priority pollutant contamination (based on study sampling results).

2. The methodology developed and utilized during the study can be successfully applied to any urban watershed to assess water quality problems and to identify pollution sources which require implementation of appropriate control strategy.

3. An exact mass balance (budget) of toxics entering and leaving a defined watershed is not economically nor technically feasible due to present lack of record keeping

requirements by users, generators and transporters of these substances.

4. Water quality criteria for designated uses of specific receiving waters must be developed to insure adequate environmental protection.

5. Water quality monitoring at strategic locations is essential to the identification of pollution problems and control of toxic agent discharges.

6. There is a need for standardization of U.S. EPA analytical procedures, detection limits and reporting of results.

7. Nonpoint sources contribute excessive pollutant concentrations during storm runoff but may not cause measurable toxicity effects due to short retention time within Coldwater Creek.

8. The publicly owned treatment works (POTW) has the greatest water quality impact on Coldwater Creek.

9. Based on the sampling results, the most cost-effective pollution control method for Coldwater Creek appears to be contributory source control (i.e., controlling commercial/industrial dischargers to the POTW).

10. A selective revokement and/or consolidation of overlapping pollution control regulations is needed.

11. Air pollution is a source of priority pollutants contained in stormwater runoff.

# 2. INTRODUCTION

In man's attempt to create a better standard of living, the number and type of toxic materials used for product manufacturing and service activities have been increasing each year. The general public has developed concern for the use of toxic substances (materials and/or wastes) and their potential effect on man and his environment. Toxic substances, especially those contained in wastes, can enter the air, water and soil. Toxic substances can be hazardous to human health by inhalation, ingestion or contact. Animals, likewise, are subject to these same hazards. Aquatic life can be adversely affected in their water environment. Toxics can become involved in man's food chain through impacts on animal and aquatic life.

The potential hazards from toxic substance exposure in industry, from manufacturing activities and spills, must also be considered. The workplace, because of the concentration and duration of exposure to toxic substances, can be one of the most significant means of human exposure.

Toxics in varying concentrations can find their way into either surface or ground water from runoff. They can be transported in surface runoff from agricultural and urban areas, by direct discharges from industrial facilities or through municipal sewer and treatment systems.

Approaches for the control of toxics use two recognized philosophies. The first is a "no risk" strategy which attempts to eliminate all potential environmental hazards, i.e., no pollutant discharge. A second approach is "risk assessment" which involves the determination of which materials are too hazardous under specific environmental conditions, and what others may be suitable for certain selected uses with a calculated risk.

The focus of this study is on the development of a management strategy based on the concept of risk assessment. Recognizing that there are no clear-cut and practical concepts with which to evaluate the risks associated with toxic material use, the elements of this subject must be weighed objectively. A critical step in the development of control strategies is the establishment of in-stream water quality criteria. This study utilizes the association of water quality criteria with risk assessment concepts. An innovative series of decision-making matrixes were used to correlate these considerations.

## A. STUDY GOALS AND OBJECTIVES

One of the priorities of the St. Louis 208 Water Quality Management Plan was the development of a comprehensive management strategy to control toxic material discharge within watersheds. The first step in the development of such a strategy was an assessment of the potential toxic material problems within a particular watershed.

A primary objective of this study was to develop and execute methodologies, including a toxic agent budget, for the analysis

of waterborne toxics within a typical urban watershed. The toxic agent budget would attempt to identify the movement of toxic materials into, within and out of the Coldwater Creek Watershed in north St. Louis County. The term budget refers to the mass balance (entering-leaving) of toxic substances within a watershed. Toxic substances considered in this study are the priority pollutants identified in 40 CFR Part 403, "General Pretreatment Regulations for Existing and New Sources of Pollution." The input of priority pollutants from various land use activities and point source discharges was estimated. Once a toxic agent budget was developed on a watershed basis, a framework would exist to enable U.S. EPA to develop sound management decisions concerning the effectiveness of toxic pollutant control strategies in the water environment.

To achieve the overall goal of the study, several study techniques were developed. First, a model work plan for a toxic agent budget in an urban watershed was prepared. With modifications as needed, this work plan was designed to be applicable to any urban watershed in the nation. Second, a site specific monitoring strategy for the field sampling of toxic pollutants was developed. This monitoring program was necessary in order to verify and correlate actual priority pollutant concentrations with the toxic agent budget estimates. Finally, a water quality evaluation procedure was designed to develop pragmatic water quality criteria for exposure/risk assessments.

## B. STUDY TEAM

A study team made up of EWGCC staff and MSD staff was formed to develop the toxic agent budget. Also participating in the study was a technical steering committee composed of representatives from private engineering firms, government agencies, industry, concerned citizens, and the Regional Water Quality Board (Figure 1). EWGCC and MSD provided the major study products to the Steering Committee for review and comment. In this manner, revisions in the study plan were initiated by the Steering Committee.

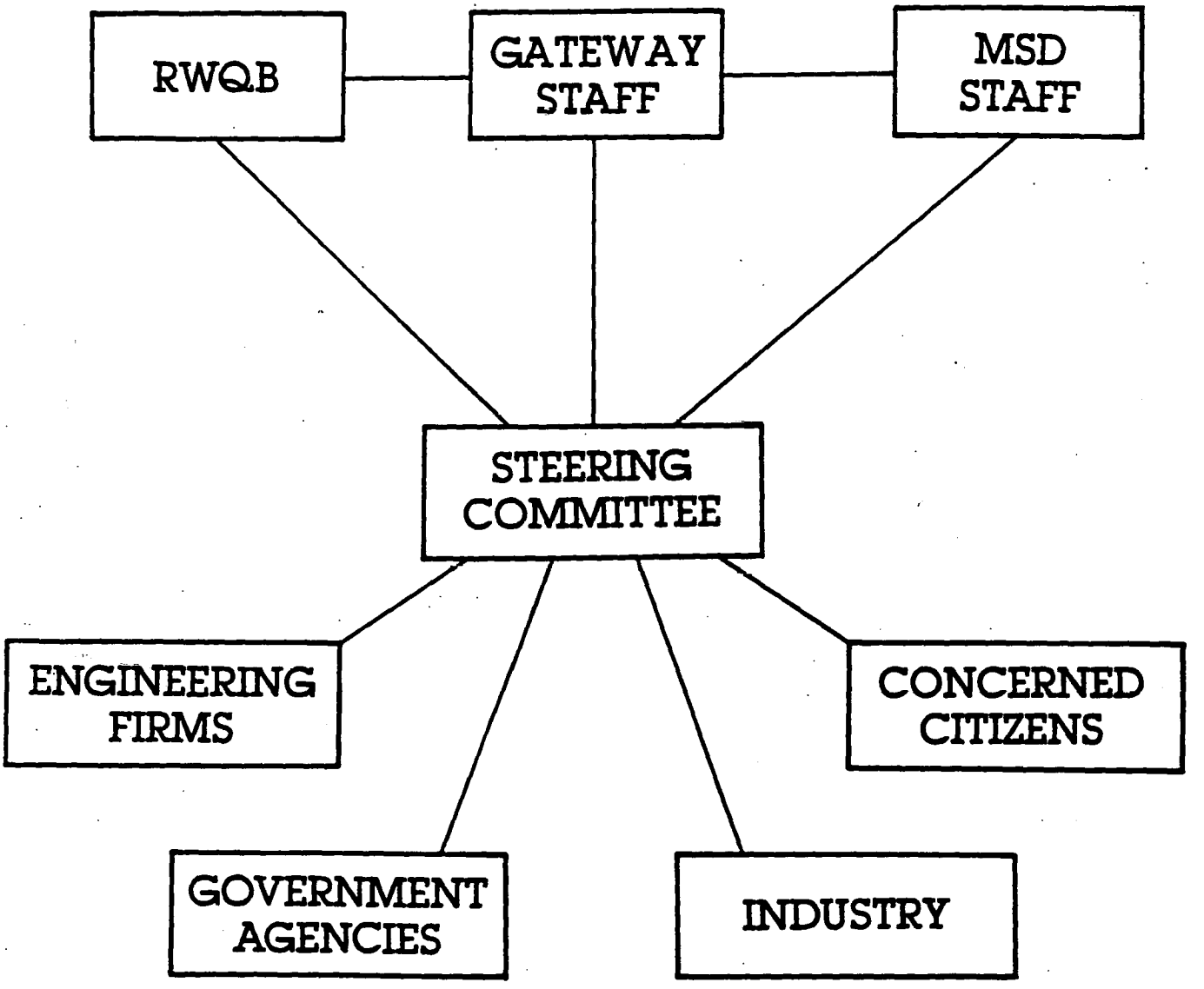
EWGCC staff retained the responsibility for the management and direction of the study and the development of the toxic agent budget. MSD was responsible for assisting in project planning and designing methodologies for the study. MSD staff provided technical direction and assistance and was responsible for many of the technical outputs and innovations developed during the study. Besides its project management duties, EWGCC was also responsible for developing interim reports and the preparation of the final report.

## C. STUDY PROCESS

One of the major tasks of the study was to develop a model work plan which would be applicable to many watersheds throughout the nation. The Toxic Agent Budget Methodology, prepared in outline form, sets forth the considerations necessary to establish a toxic agent budget for any watershed. The tasks/activities covered in the outline are as follows: inventory of the

FIGURE 1

STUDY TEAM ORGANIZATION

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study area; toxic information source location and identification; development of the toxic agent budget; establishment of the monitoring strategy and correlation of findings with the budget; development of criteria for water quality evaluation; and evaluation of control strategies.

The Toxic Agent Budget Methodology outlines the major subjects examined in this study to develop a Toxic Agent Budget for the Coldwater Creek watershed. The major aspects and findings of each study task have been summarized in the remainder of this report. The complete budget methodology outline, including all headings, subheadings and listings, is included in Appendix A.

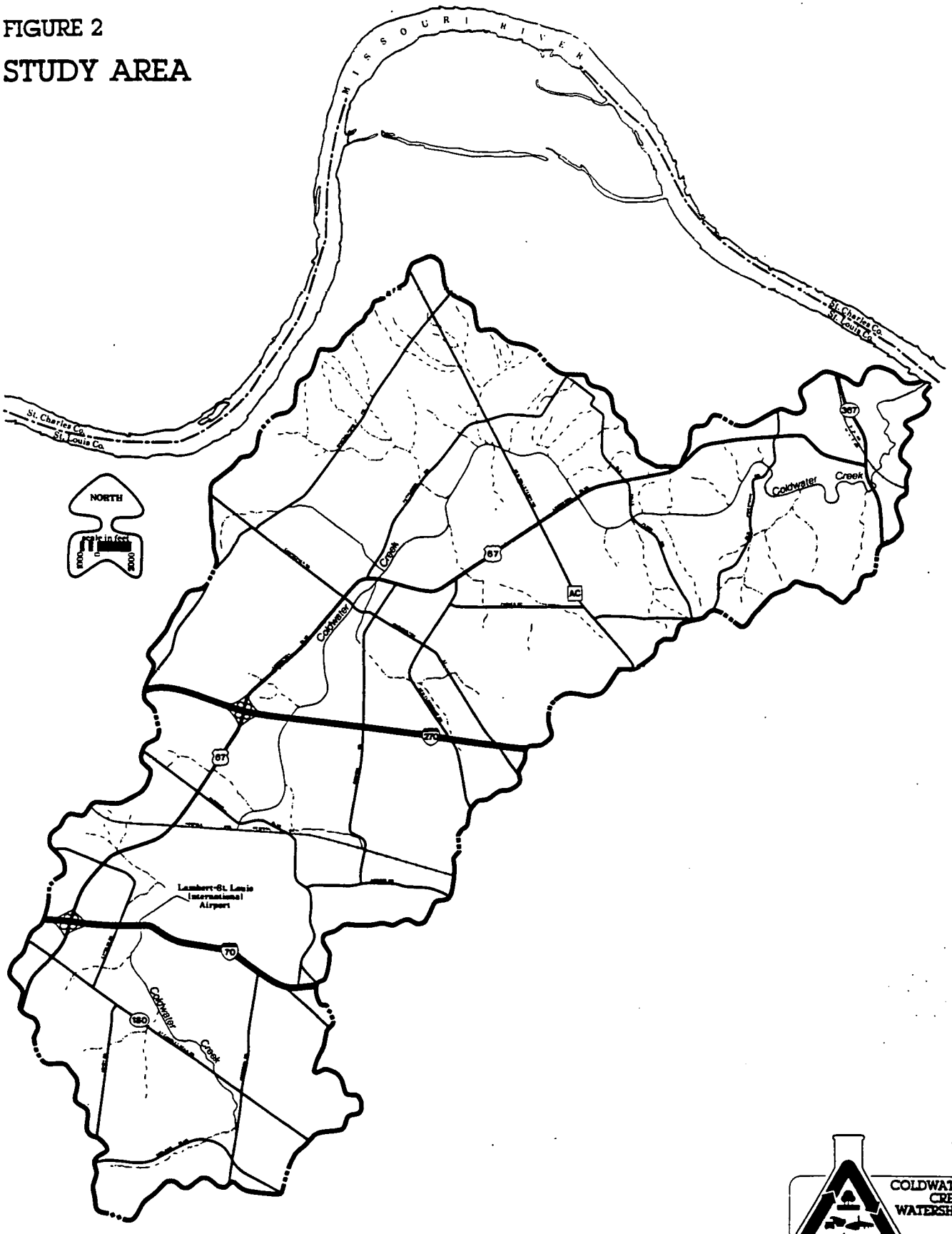
## D. STUDY AREA

All of the Coldwater Creek watershed lies within St. Louis County. It is located to the north and west of the City of St. Louis and contains the City-owned Lambert-St. Louis International Airport (Lambert Airport). The overall size of the watershed is approximately 43 square miles (Figure 2). On the north and west the watershed is bordered by unincorporated St. Louis County and the community of Bridgeton; to the east by Ferguson and Belridge; and to the south by the community of Olivette. Part or all of 18 communities are contained within the watershed.

The primary land uses within this area are residential, commercial, industrial and transportation. Older residential areas are concentrated along the southern and eastern borders, while more recent residential activity is found in the north and northwestern portions. High density strip commercial areas are

FIGURE 2

# STUDY AREA

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along Lindbergh Boulevard and St. Charles Rock Road. Industrial activity is concentrated near the center of the basin, just north of Lambert-St. Louis International Airport. This industrial complex is the second largest employment center in the St. Louis metropolitan area. Major industrial activities include aircraft manufacturing, two automobile assembly or parts facilities, and a diesel railroad engine assembly plant.

A 25 million gallon per day (MGD) sewage treatment plant operated by MSD is located in the downstream portion of the watershed. The plant is operating at its rated capacity and provides secondary wastewater treatment using the activated sludge process with anaerobic sludge digestion and disposal of digested sludge to on-site lagoons. The plant treats liquid wastes discharged by all residential, commercial and industrial sources in the watershed.

# 3. STUDY AREA INVENTORY

## A. PHYSICAL CHARACTERISTICS

### Topography

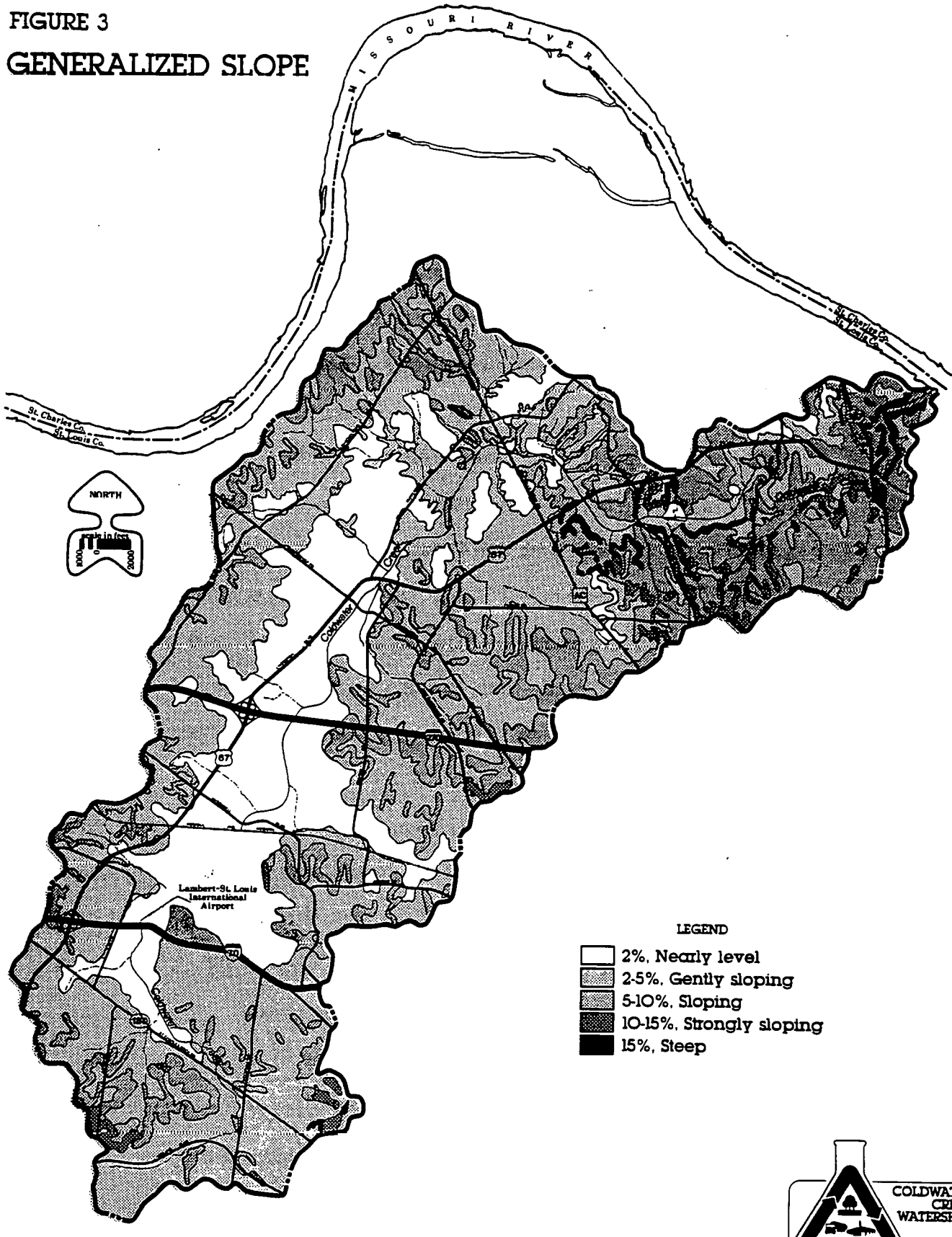
A shallow, oval-shaped depression called the Florissant Basin is the predominant physiographic feature of the Coldwater Creek watershed (Figure 3). It is approximately 10 miles long on its north-south axis and 3 1/2 miles wide on its east-west axis. The basin is bounded on the north and west by the bluffs of the Missouri River, and on the south and east by rolling uplands. Coldwater Creek flows through the entire basin. The slopes of the basin are less than 5 percent and the elevations range from 480 to 620 feet above sea level. This nearly level and featureless topography reflects what was once a lake, formed during glacial times when the drainage from the basin was temporarily blocked.

Outside the Florissant Basin, hilly and dissected uplands are found along Coldwater Creek. Slopes are more pronounced in this area and sometimes are greater than 15 percent. This type of relief is visible at New Halls Ferry Road, south of Lindbergh Boulevard and to the east beyond Old Jamestown Road.

The highest point in the watershed, 720 feet above sea level, is located in the southwest near Ashby Road, and the lowest point, approximately 400 feet above sea level, is located at the confluence of Coldwater Creek and the Missouri River.

FIGURE 3

# GENERALIZED SLOPE

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## Drainage Pattern

The Coldwater Creek watershed consists of an elongated basin sloping from the southwest toward the northeast where it joins the Missouri River. The main stem of Coldwater Creek flows in a general north and east direction from Lackland Road in Overland to the Missouri River near Cora Island.

The main channel of Coldwater Creek is an unpaved drainageway, however, the channels of some branches in Overland and Florissant have been lined with concrete. Beginning 2000 feet north of Interstate 70 the creek is channeled underneath Lambert-St. Louis International Airport and is brought to the surface in the Hazelwood industrial area.

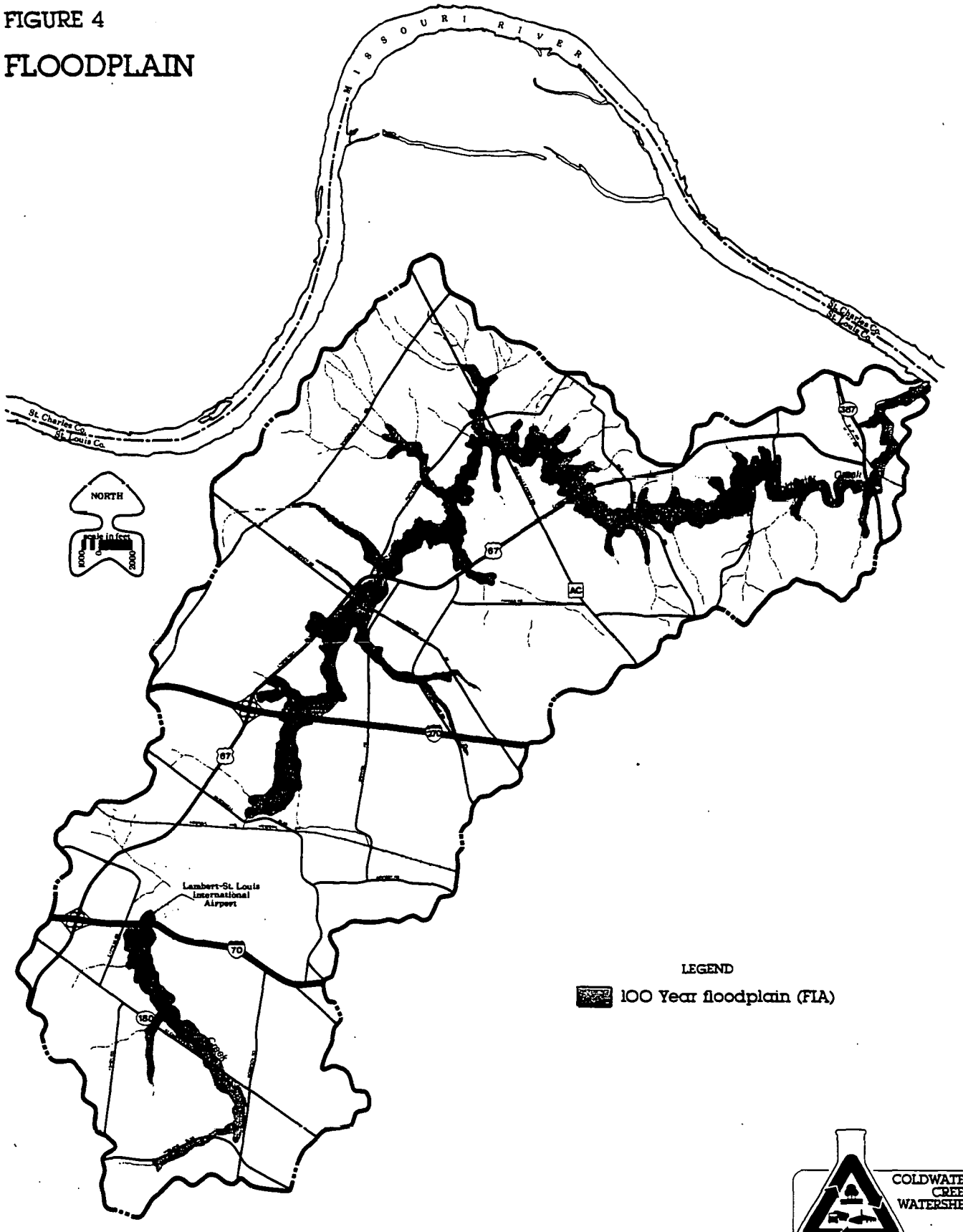
Although the normal drainage pattern has been disrupted by urbanization, the basic pattern can be classified as dendritic. This pattern is visible in the high silt loess areas in the northern part of the watershed. Along the Missouri River bluffs, two other patterns are evident. Adjacent to the northern ridge-line, numerous parallel tributaries enter the main stem within an area less than one mile wide. A pinnate pattern appears in several locations northwest of Shackelford Road and northeast of New Halls Ferry Road. This pattern consists of closely spaced branches with deep gullies, giving a feather-like appearance.

## Flood Plain

The boundaries of the 100-year frequency flood plain are delineated in Figure 4. The boundaries are based on the Flood Insurance Administration's map of the flood plain for the main

FIGURE 4

# FLOODPLAIN

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stem and selected tributaries. Built-up areas in the flood plain represent a potential source of water pollutants.

Geology

The bedrock in St. Louis County are composed of essentially flat lying sedimentary formations primarily consisting of limestone and dolomite. A slight regional northeast dip has been modified by several northwest-southeast trending folds or flexures and by a broad, irregularly shaped structural basin known as the Florissant Basin.

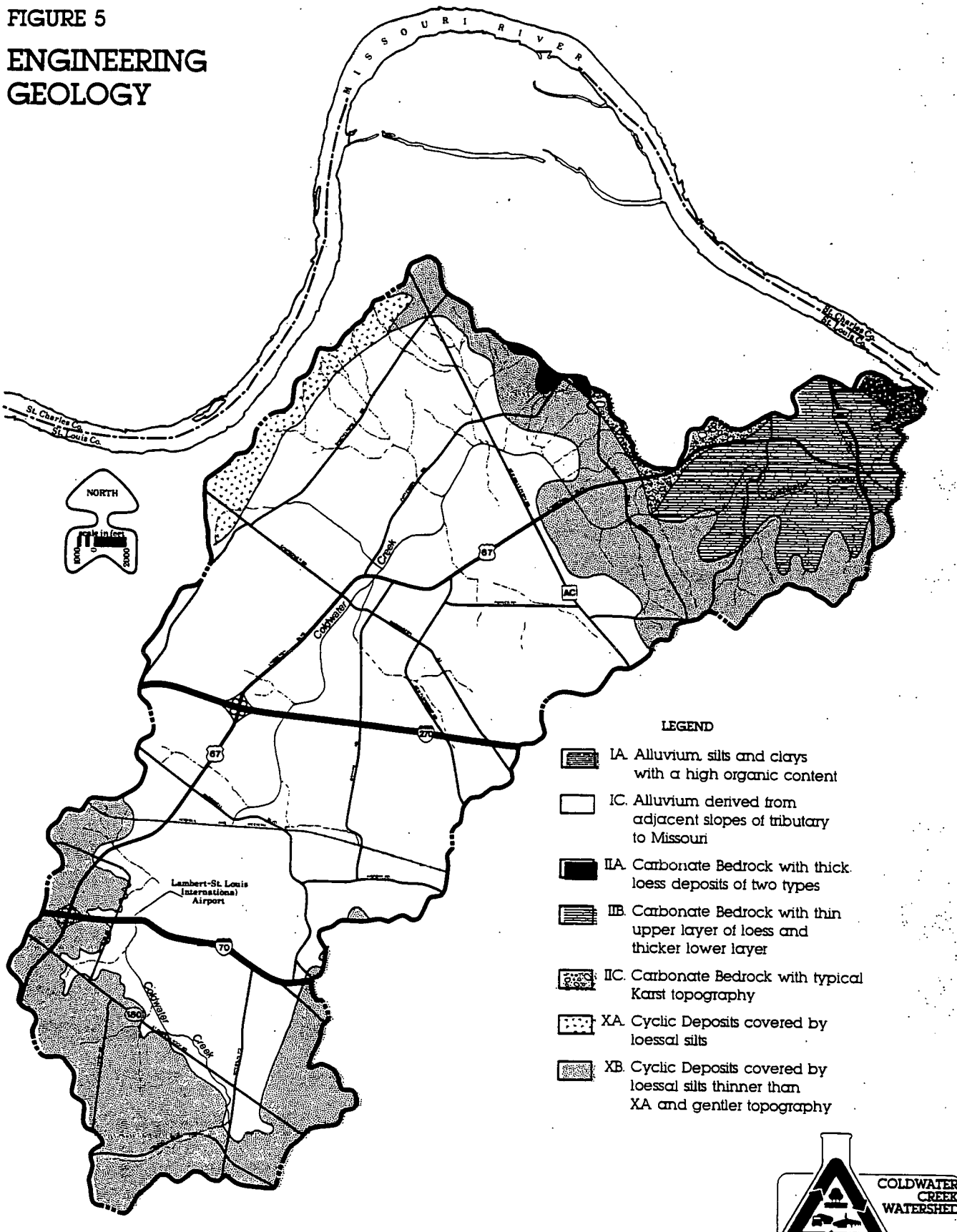
Except for those areas with alluvial materials, the majority of the bedrock formations have been covered by extensive deposits of wind blown silt (loess). It was derived from the flood plains of the Missouri and Mississippi Rivers after the retreat of the glaciers.

The geologic units found in Coldwater Creek are presented in Figure 5. These units have been developed according to the topography, soil, drainage, and engineering properties of the overlying soils. The unit definitions were established by the Missouri Geological Survey.

I-a Alluvial Material. The thickest alluvium in the major river valleys is mapped as I-a. The composition is heterogeneous, generally consisting of stratified sand, silt, and clay, with beds of gravel and lenses of organic materials. Engineering problems encountered in this unit are generally related to the variability of the strength and permeability of the soil, high water table, and flood hazard potential. This unit is found

FIGURE 5

# ENGINEERING GEOLOGY

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adjacent to the confluence of Coldwater Creek and the Missouri River.

I-c Alluvial Material. This unit includes materials deposited under standing water or lake bottoms (a lacastrine environment). The majority of the study area is underlain by this geologic unit, and it is known as the Florissant Basin. The deposits include fine sand, silt, clay and organic sediment up to 100 feet thick. These deposits were covered by a layer of loess which ranges between 5 and 25 feet thick. Because of the nature of the underlying bedrock and the type of soil present, the internal drainage is poorly developed.

II-a Limestone Formations. Unit II-a forms a narrow band of bluffs and ridgetops found along the northern boundary of the watershed. Here the limestone bedrock is covered by two layers of very thick (15-30 feet) loess deposits. The upper layer is composed of a uniform silt with low-clay content and high vertical permeability. Below this layer is a low-clay loess (Roxana) which has lower vertical and horizontal permeability. Moisture collects at the contact point of the layers.

The main engineering problem in unit II-a is soil creep which occurs on the steeper slopes (20 percent or greater). The movement is gradual but is intensified along the slide planes between the loesses or at the top of the bedrock.

II-b Limestone Formation. Unit II-b is also limestone bedrock covered by two layers of loess deposits. The upper layer of low-clay loess is relatively thin and mantles the predominant high-clay loess below.

The most serious engineering problem is slope failure, generally soil creep, which may increase in rate of movement until slides take place. This unit occurs east of Jamestown Road in the northeast portion of the watershed.

II-c Limestone Formation. Unit II-c denotes areas where the solution features of the underlying bedrock are not masked by the overlying soils. These areas contain Karst (sinkhole) topography. The most serious engineering problem encountered in Unit II-c is the tendency for soil creep to occur along the sides of a sinkhole. It is present in a small area near Vaile Road along the northern boundary of the watershed.

X-a Cyclic Deposits, Predominantly Shales, With Some Sandstone and Limestone Formations. It is a narrow band of cyclic bedrock covered by two layers of loess. The upper layer is Peoria loess which is silt-rich and 20 to 30 feet thick and Roxana loess is the lower, clay-rich and 30 to 50 feet thick. At the contact point, moisture in the soil is high and a potential slide plane can be formed. Where the bedrock is shale, the potential for a slide also increases. This unit is found adjacent to the northwest boundary of the watershed and is parallel to the Missouri River bluffs.

X-b Cyclic Deposits, Predominantly Shales with Some Sandstone and Limestone Formation. Where the overlying Peoria loess is relatively thin, the engineering properties of the Roxana loess, particularly slope stability and water retention, become most important. Unit X-b denotes areas where this situation has developed over the Pennsylvanian formations. The major problem is

related to the slope stability of the overburden and bedrock. The shale and clay shales become weak when exposed to the atmosphere and slopes are unstable when too steep or saturated.

Unit X-b is the second largest geologic unit in the watershed. It is present south of the Florissant Basin and also extends across the northern portion of the watershed.

## B. LAND USE CHARACTERISTICS

For this study, the existing land uses of the Coldwater Creek watershed were originally delineated on a map with a scale of one inch representing 2000 feet. A generalized version of this map is shown in Figure 6.

### Industrial

The majority of industrial and associated activity in the watershed is in an area bounded by I-270, I-70, Lindbergh Boulevard and Graham Road. This area is adjacent to Lambert-St. Louis International Airport and is the second largest employment center in the entire St. Louis metropolitan area. The dominant industries include aircraft manufacturing, automobile assembling, automobile parts manufacturing, and assembling diesel railroad engines. Smaller concentrations of industrial activity can be found along Lindbergh Boulevard and St. Charles Rock Road.

From the regulated flow records of MSD, 150 industrial and associated activities in the watershed were identified (Figure 7). The activities were grouped into the following categories: paper and allied products manufacturing; printing; lumber and

FIGURE 6

# GENERALIZED LAND USE

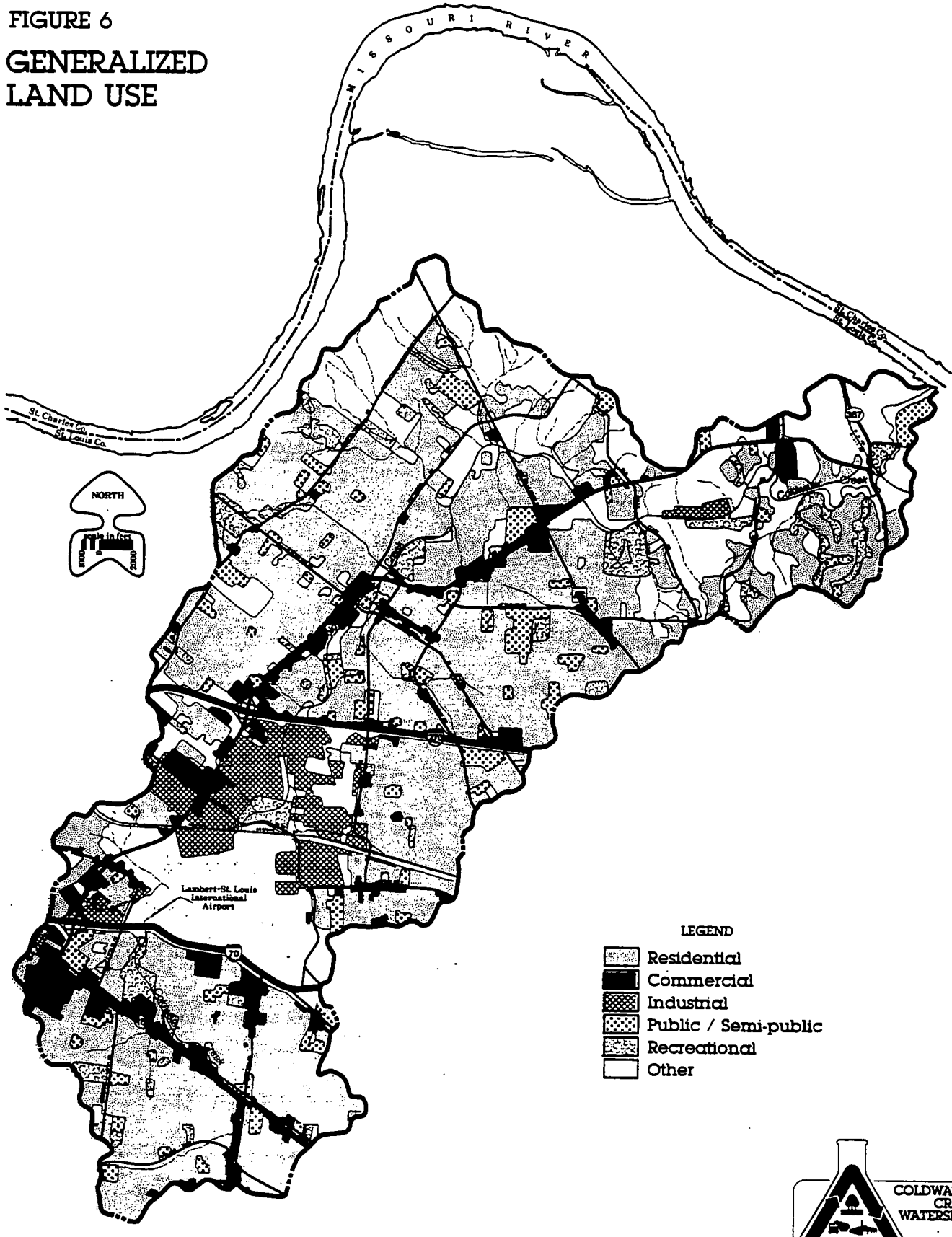


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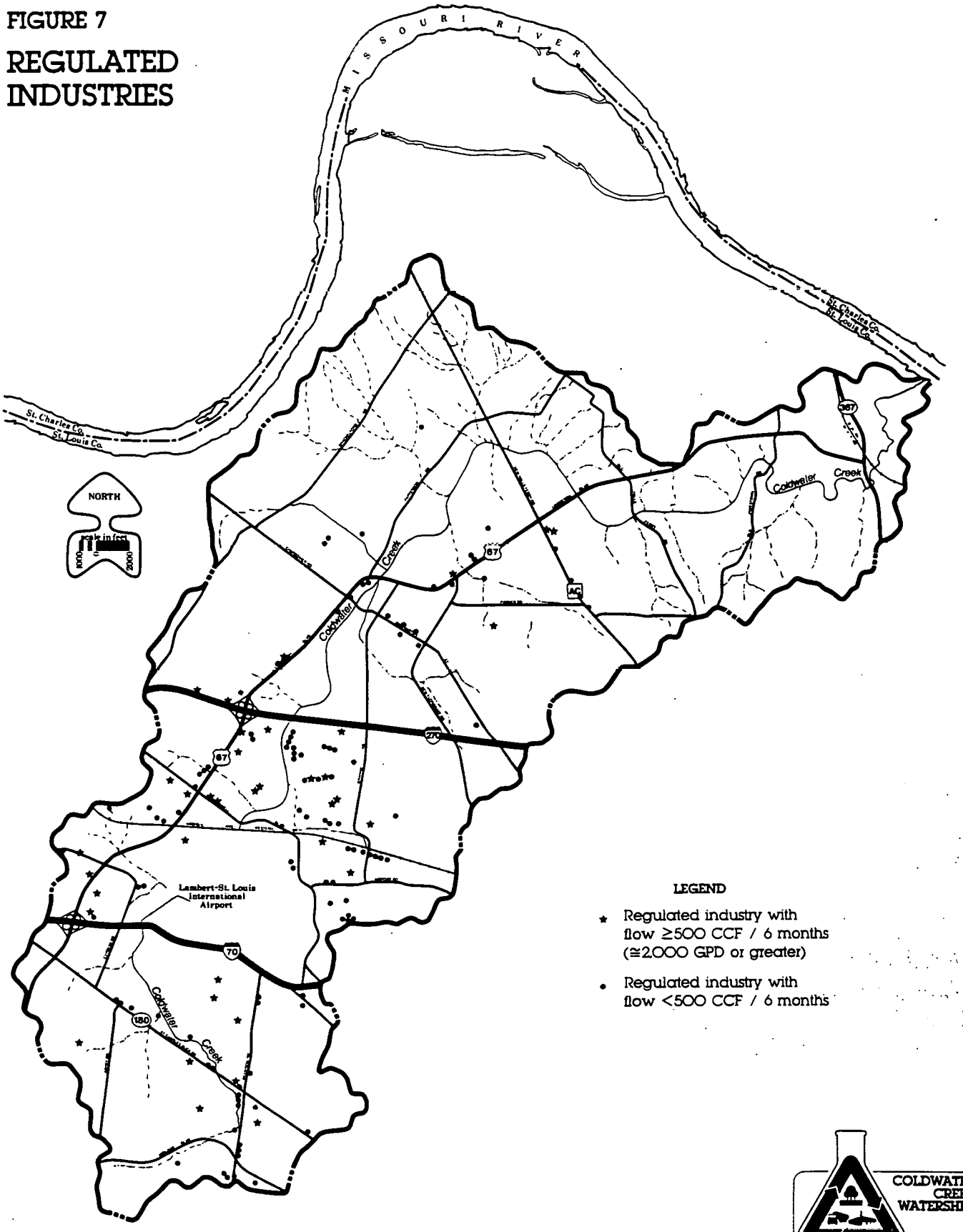
FIGURE 7

# REGULATED INDUSTRIES

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wood products; chemical manufacturing; fabricated metal products manufacturing; machinery manufacturing; medical and dental instruments manufacturing; and laundries and dry cleaning establishments.

Industries which have a National Pollutant Discharge Elimination System (NPDES) permit to discharge wastewater directly into Coldwater Creek and its tributaries are an automobile assembly plant, an aircraft manufacturing plant, and an automobile parts manufacturing plant.

Commercial

The pattern of commercial activity is both linear and concentrated. High density strip commercial areas are found along St. Charles Rock Road and Lindbergh Boulevard. A large hotel complex serving air travelers is adjacent to Lambert Airport. South of the airport at the intersection of Lindbergh Boulevard and St. Charles Rock Road, is the Northwest Plaza Shopping Center. Another commercial center is Jamestown Mall in the northeast portion of the watershed.

Agricultural

Land in agricultural use was concentrated in the extreme north and northeast portions of the watershed. Specific agricultural activities were not delineated.

## Recreation

There are no major parks in the southern part of the Coldwater Creek watershed, however, small municipal parks are scattered throughout the residential areas. Musik Park on Graham Road is the only park south of I-270. The St. Ann Golf Course on Ashby Road is the largest tract of recreational land in the southern part of the watershed. Parks in the northern section include St. Louis County's Howdershell Park in Hazelwood, the undeveloped Fort Bellefontaine Park, and the Paddock Estates Golf Club. Within the City of Florissant are St. Ferdinand Park, Kock Park, and Florissant Valley Park.

## Residential

Residential activity is the dominant land use in the study area. Residential areas built prior to World War II are evident south of I-270. The majority of the residences in Hazelwood-Florissant area have been constructed since World War II. An exception is in the center of the City of Florissant. In the north and northeast portion of the watershed are more recent subdivision developments.

## Transportation

The study area contains a number of major roads and railroads as well as a large concentration of transportation activity associated with the Lambert Airport. The major roads are St. Charles Rock Road, I-70, I-270, New Halls Ferry Road, U.S. Route 67, and Lindbergh Boulevard. North of Lambert Airport only 10

highways cross the main stem of Coldwater Creek, while south of the airport 25 crossings occur within 4 miles.

Two railroad bridges cross the main stem of the creek immediately north of Lambert Airport. One crossing is within the aircraft manufacturing complex, at the point where the creek surfaces from its underground channel. Another is a spur of the same railroad approximately one-half mile north of the first crossing which services an automobile assembly plant. Immediately east of Lewis and Clark Boulevard, a third railroad bridge crosses the main stem approximately one mile south of the mouth of Coldwater Creek.

Utilities

Activities associated with telephone, electric, and natural gas service are present in the watershed. These include: telephone equipment offices/garages and a switching center; electrical substations and truck repair centers; and an underground natural gas storage center and customer service office.

In the study area are the MSD-St. James Estates and the MSD-Coldwater Creek sewage treatment plants. Both have NPDES permits for discharge into Coldwater Creek. The Coldwater Creek plant is a 25 MGD sewage treatment facility and is presently operating at its rated capacity. It provides secondary wastewater treatment using an activated sludge process with anaerobic sludge digestion and the disposal of digested sludge to on-site lagoons. The plant treats liquid wastes discharged by all residential, commercial and industrial sources in the watershed.

Extractive

Mining and quarrying activities do not occur in the study area.

## C. HYDROLOGICAL CHARACTERISTICS

### Surface Water

The source of Coldwater Creek is surface runoff from rainfall. No known springs feed the creek. Published daily flow records for Coldwater Creek could not be found. The State Geological Survey estimated mean flow at 91 cubic feet per second (cfs) and the 7-day, 10-year low flow at 56 cfs.

The Missouri Department of Natural Resources in its current water quality standards has designated classifications and uses for segments of Coldwater Creek. From the Lambert Airport to Old Halls Ferry Road (just upstream from the Coldwater Creek Sewage Treatment Plant), it is identified as a protected stream. In a protected stream, discharges to the creek other than non-contaminated cooling water are prohibited. The remainder of the stream has been classified as a class P stream. A class P stream is defined as one which "maintains permanent flow even in drought periods."

For the downstream portion of the creek, the only use designated by the State of Missouri is as a source for industrial processing or cooling water. No other beneficial water uses of the creek were identified.

Groundwater

The Coldwater Creek watershed is underlain by Osage/Mississippian limestone deposits in the upland areas and glacial and alluvium deposits along the Missouri River. The Osage/Mississippian deposits are capable of producing groundwater in the range of 50,000-100,000 gallons per day per square mile, while the flood plain deposits are capable of producing in excess of 500,000 gallons per day per square mile. Very little ground water is used in this area except for some individual water supplies and some minor industrial usage.

## D. BIOLOGICAL INVENTORY

### Terrestrial Flora and Fauna

Of the present vegetative cover in the Coldwater Creek watershed, approximately 80 percent is closely associated with urban-suburban development. It consists primarily of bluegrass lawn interspersed with ornamental trees and shrubs, plus shade trees planted along the streets and lot lines. The remainder of the watershed vegetation is primarily associated with the common agricultural activities of Missouri.

For the 19 identified tree species, one of their preferred habitats is rich alluvial soil near streams. The majority of the species present, such as Silver Maple (Acer saccharinum) or Red Oak (Querus rubra), are commonly used as shade trees for private residences, and two species, the Red Bud (Cercis canadensis) and the Dogwood (Cornus florida), are used as ornamental trees. The

seeds of the Hickory (Carya sp) and of the Pecan (Carya illinoensis) are often harvested by man and, along with the Black Walnut (Juglans nigra), supply a high percentage of the autumn and winter food of the local wildlife.

One of the species of trees is considered to be threatened. Although it is a common species in most residential areas, the American Elm (Ulmus americana) is presently under intensive pressure from the epidemic Dutch Elm disease and is therefore considered to be an endangered species.

Six shrub and vine species are present in the watershed. Two species of shrub, Buck Brush (Symphoricarpus orbiculatus) and Elderberry (Sambucus canadensis) bear fruits which provide late summer/early autumn food supplies for the local wildlife. The Elderberry is often cultivated and hybridized, its fruit being used in jams and wines which have a commercial value.

Buck Brush and one of the vines, Poison Ivy (Rhus radicans), are classified as weed species. Poison Ivy is a persistent, poisonous species, with juices which cause a characteristic blistering of the skin upon contact. Both of these weed species readily invade diversified habitats, including recently cleared areas and waste grounds.

In the watershed, 62 species of herbs were found. These species are a primary food source for some birds, reptiles, and amphibians, and for almost all of the herbivorous mammals. Along with the shrubs, these herbs provide suitable nesting materials for birds and rodents, as well as being a good source of cover

for all small animals. The herbs are also a food source and breeding ground for many insects, both pestilent and beneficial.

Of the herbs, 23 are considered to be weeds. Many of these species have escaped from cultivation, and most will invade waste grounds and newly cleared areas, although a few are found only in relatively undisturbed areas. Several of the weeds are poisonous, most notably the Star of Bethlehem (Ornithogalum umbellatum), Pokeweed (Phytolacca americana), and Spotted Water Hemlock (Cicuta maculata).

One herb species is considered to be threatened. Because of its medicinal value, Golden Seal (Hydrastis canadensis) was heavily used in the middle of this century, and it has not regained its former stability within the Missouri plant communities.

Seventeen species of amphibians are considered to be likely permanent inhabitants of the Coldwater Creek watershed. Four species of toad, eight species of frog, and five species of salamander are included. Many of the amphibians live in cultivated grounds readily, showing a high degree of tolerance to man's influences upon the environment.

A single amphibian species which may exist within the watershed is considered to be endangered. The Eastern Wood Frog (Rana sylvatica sylvatica) requires a mesic forest habitat similar to that available in the lower reaches of the watershed, but it has not been collected in the area.

Coldwater Creek watershed provides suitable habitat for at least 29 species of reptiles, of which 9 have been positively

identified within the area, and 2 have been tentatively recorded. The reptilian species include 11 species of turtle, 15 species of snake, and 4 species of lizard. There is one rare species, the Alligator Snapping Turtle (Macrochelys temmincki), for which there is adequate habitat in the watershed, however, the species has not been recorded.

The reptiles actually collected at the watershed are mostly terrestrial, are known to be tolerant of moderately cultivated areas, and are adapting to the presence of man. Other species occur in this area simply because they have been artificially introduced, as two species of Box Turtles have been.

Within the Coldwater Creek watershed, 31 species of birds were observed. Several of the species present are known to have great tolerance to man's alteration of the environment, even to the point of preferring man-made to natural environments. Other species, such as ducks and Kingfisher, are commonly thought to avoid areas where man's influence on the environment is great.

Ninety-nine species of birds are likely to use the watershed for brief periods of time during migration. Of these, the double breasted cormorant, the Henslow's sparrow, the Osprey and the Peregrine falcon are considered to be rare or endangered.

Twenty-three species of mammals are likely to be present in the watershed of Coldwater Creek. The herbivorous mammals play an important role in controlling plant communities through browsing and seed dispersal. The bat species is primarily insectivorous, and aid in insect pest control. Some of the carnivorous mammals control populations of smaller pest mammals. In

addition to these wildlife species, there are other mammals which must be taken into consideration, primarily dogs and cats which stray from private residences in the area.

A recent U.S. Fish & Wildlife Service investigation conducted for the Army Corps of Engineers, Coldwater Creek, Missouri: Draft Reconaissance of September 1981, indicated that the following Federally designated endangered species occur in the study area: Indiana Bat (Myotis sodalis), Gray Bat (Myotis grisescens), Bald Eagle (Haliaetus leucocephalus), and Peregrine Falcon (Falco peregrinus).

Aquatic Flora and Fauna

A qualitative survey of the benthic fauna of Coldwater Creek was performed on March 11, 1981. Samples were taken at six sites along the creek using either a Serber sampler, Eleman grab or Ponar grab method, depending upon the substrate. The sites corresponded to the stream sampling sites.

An extremely low diversity of aquatic organisms was found due to the late winter date of the sampling. The dominant class in Coldwater Creek was the Tubificidae. Tubificid worms, members of the Oligochaetes group, have been widely acclaimed as pollution indicators since the mid-1940s. These worms require a minimal amount of oxygen to survive and are often found in large numbers in septic ooze or soft mud.

Chironomids, particularly those of the Chironomus genus, are also considered to be pollution tolerant organisms and were present in the stream. Known as bloodworms because of their

bright red color, these Dipterans will build tubes of sludge in sewage deposits. The presence of their larvae usually indicates that an area in a stream is in the first stages of recovery, and that oxygen content is beginning to increase slightly.

Sampling of aquatic fauna in Coldwater Creek has been conducted in August of 1981 by the U.S. Fish and Wildlife Service for the Army Corps of Engineers. Preliminary results indicate that only pollution tolerant species are present in the creek. Seven of the eight stream stations sampled during the Toxic Monitoring Study were chosen as seining sites. Fauna collected at the seven sites were as follows: 200 fathead minnows, 2 gold shiners, 1 red shiner, 1 black bullhead, 1 carp and 2 bluegill.

Demographics

Population estimates for the Coldwater Creek watershed were obtained from the St. Louis, Missouri Water Quality Management Plan (208 Plan, May 1978) and from the St. Louis County Water Pollution Control Study (Phase II Study, September 1973). These estimates were compared to projections by the St. Louis County Department of Planning (Analysis of Five Watersheds, August 31, 1976) and were found to agree within three percent. More recent data from the St. Louis County Population estimates of April 1980 and the Missouri Department of Natural Resources Population Estimates of July 1980 were examined and coordinated with the other studies to determine final population figures. In the Coldwater Creek watershed, the year 2000 projected population is 188,825.

The population in the Coldwater Creek Watershed is expected to increase moderately through the year 2000 (Table 1). Population projections made in the late '60s and early '70s had estimated somewhat higher figures. Because of the decreasing growth rate throughout the nation in recent years and the decrease in the size of the family units observed in this study area, the higher figures from the St. Louis Water Quality 208 Plan were revised to reflect the anticipated continuation of this trend.

## E. METEOROLOGICAL INFLUENCES

Except on a micro basis, the climate throughout the St. Louis area is rather homogeneous. The St. Louis weather is a modified continental influenced climate with four distinct seasons. A notable point about St. Louis weather is the variable conditions encountered within any season. These variable conditions are caused by the weather-creating air masses which meet over this region. From the south comes the warm, moist air of the Gulf of Mexico; and the cold air masses originate in Canada. Winters are brisk, but seldom severe. Summers are quite warm, often uncomfortably so when coupled with high humidity.

For the St. Louis area the normal annual precipitation, based on the average for the period 1941-1970, is a little over 35 inches. The three winter months are the dryest, averaging about six inches of precipitation. The spring months of April through June are usually the wettest with normal total precipitation of nearly 12 inches.

TABLE 1

POPULATION ESTIMATES
COLDWATER CREEK WATERSHED

| Year | 208 Report* | Dept. of Planning** |
|---|---|---|
| 1970 | 167,869 | 176,673 |
| 1975 | 171,396 | |
| 1980 | 176,046 | |
| 1985 | 180,235 | |
| 1990 | 183,996 | |
| 1995 | 186,771 | 191,690 |
| 2000 | 188,825 | |

*Figures from St. Louis, Missouri Water Quality Management Plan (208 Report), May 1978

**Figures from "Analysis of Five Watersheds," Department of Planning, St. Louis County, Missouri, 1976

NOTE: The above figures have been reviewed and coordinated with data from: 1) St. Louis County Population Estimates, April, 1980; and 2) Missouri Department of Natural Resources Population Estimates, July 1980.

Since 1930, snowfall has averaged less than 20 inches per winter season and the amount has varied from a mere 0.7 of an inch in 1931-32 to a record 67.6 inches in 1911-12. Normally, snowfall of one inch or more is received five to ten days per year.

Thunderstorms occur on the average between 40 to 50 days per year. During any year, there are usually a few thunderstorms that can be classified as severe storms with hail and damaging winds. During the entire period of record only four tornadoes have produced extensive damage and loss of life in St. Louis: May 27, 1896, September 29, 1927, February 19, 1959, and January 24, 1967.

In the spring, the last temperature as low as 32 degrees F has occurred as early as March 8th and as late as May 10th. The first occurrence of a freezing temperature in the fall has happened as early as September 28th and as late as November 27th. The number of days between the last freezing temperature in the spring and the first such temperature in the fall can range from 150 to almost 230 days.

The long-term record for St. Louis (since 1871) indicates that maximum temperatures of 90 degrees Farenheit (F) or higher occur an average of 35 to 40 days per year. The highest temperature on record was 115 degrees F on July 14, 1954 at Lambert Airport.

Records since 1871 show that on an average of two to three days per year temperatures drop to zero degrees F or below. In

most years, the daily maximum temperature remains as cold as 32 degrees F or lower less than 20 to 25 days.

For the St. Louis area, the average relative humidity is 70 percent. December has the highest monthly average, 77 percent, while April, with 66 percent, is the lowest.

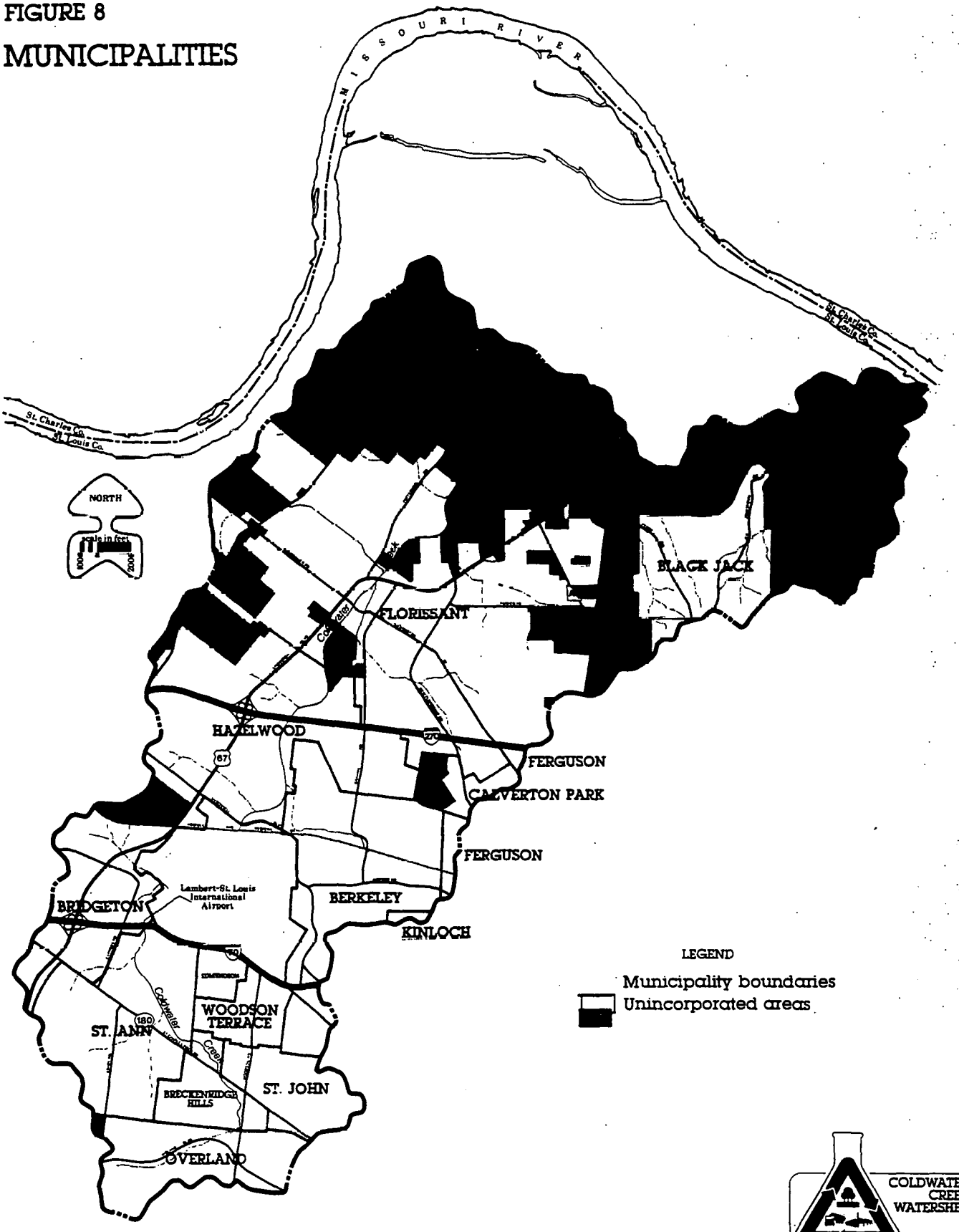
The highest average wind speed was recorded during the month of March, 11.9 miles per hour. The highest average speed occurs from December through April, while the month of August has the lowest. During the majority of the year, south is the prevailing wind direction, but in December through April, the prevailing directions are northwest and west-northwest.

## F. GOVERNMENTAL JURISDICTIONS AND AGENCIES

All of the Coldwater Creek watershed lies within St. Louis County. It is located to the north and west of the City of St. Louis and contains the City-owned Lambert-St. Louis International Airport. On the north and west the watershed is bordered by unincorporated St. Louis County and the community of Bridgeton; to the east by Ferguson and Belridge; and to the south by the community of Olivette. Contained within the watershed are part or all of the following communities: Black Jack, Florissant, Hazelwood, Ferguson, Calverton Park, Kinloch, Berkeley, Bridgeton, Bridgeton Terrace, St. Ann, Edmundson, Woodson Terrace, Maryridge, St. John, Breckenridge Hills, Overland, Charlack, and Sycamore Hills. Figure 8 shows the boundaries of these municipalities.

FIGURE 8

# MUNICIPALITIES




EAST-WEST GATEWAY COORDINATING COUNCIL

The pattern of land in public and semi-public use is related to population size and density. Public facilities are dispersed throughout the study area. Few facilities are located in the more recently developed northeast portion of the watershed. Public and semi-public activities present include: grade and high schools; churches and associated structures; cemeteries; a hospital; and community and county government offices and structures. One important activity is the provision of fire protection services, whether by a community or a cooperative district. Three fire stations are north of I-270 while the remainder are along Lindbergh Boulevard, Hanley Road and St. Charles Rock Road. A religious facility and a boarding school adjacent to the creek both have NPDES permits.

# 4. TOXIC INFORMATION SOURCES

## A. PRIORITY POLLUTANT INFORMATION SOURCES

The steps necessary to identify sources of priority pollutant information and to survey priority pollutants in the Coldwater Creek Watershed are described herein and presented in outline form in Appendix A.

Lists of toxic and hazardous pollutants have been developed by federal agencies and departments (U.S. EPA, U.S. DOT); out-of-court settlements; and an abstract service (Table 2). For this study, the list of 126 priority pollutants developed by EPA was used (Table 3).

TABLE 2

SOURCES OF TOXIC AGENT LISTINGS

| AGENCY | TITLE |
|---|---|
| U.S. EPA | Priority Pollutants |
| U.S. EPA | Hazardous Waste Designation |
| U.S. EPA | Hazardous Air Pollutants |
| U.S. EPA | Pesticide Tolerance Designation |
| U.S. EPA | Registered Chemicals |
| U.S. DOT | Hazardous Materials |
| NRDC vs. U.S. EPA | Consent Decree |
| American Chemical Society | Chemical Abstract Service |

A toxic agent is considered by U.S. EPA to be a pollutant or combination of pollutants including disease causing agents, which after discharge and upon exposure, through ingestion, inhalation or assimilation into any organism either directly or

TABLE 3
U.S. EPA PRIORITY POLLUTANTS

Antimony
Arsenic
Asebstos
Beryllium
Cadmium
Chromium
Copper
Cyanide
Lead
Mercury
Nickel
Selenium
Silver
Thallium
Zinc
Acrolein
Aldrin
Chlorodane
DDD
DDE
DDT
Dieldrin
Endosulfan Alpha
Endosulfan Beta
Endosulfan Sulfate
Endrin
Endrin Aldehyde
Heptachlor
Heptachlor Epoxide
Alpha BHC
Beta BHC
Delta BHC
Gamma BHC
Isophorone
TCDD
Toxaphene
PCB 1242
PCB 1254
PCB 1221
PCB 1232
PCB 1248
PCB 1260
PCB 1016
2-Chloronaphthalene
Methyl Chloride
Methylene Chloride
Chloroform
Tetrachloromethane

Chloroethane
1,1 Dichloroethane
1,2 Dichloroethane
1,1,1 Trichloroethane
1,1,2 Trichloroethane
1,1,2,2 Tetrachloroethane
Hexachloroethane
Chloroethene
1,1 Dichloroethane
1,2 Trans Dichloroethane
Tetrachloroethene
Trichloroethene
1,2 Dichloropropane
1,3 Dichloropropane
Hexachlorobutadiene
Hexachlorocyclopentadiene
Bromomethane
Bromodichloromethane
Dibromochloromethane
Tribromomethane
Dichlorodifluoromethane*
Trichlorofluoromethane*
Bis(2-chloromethyl)Ether*
Bis(2-chloroisopropyl)Ether
2 Chloroethyl Vinyl Ether
4 Chlorophenyl Phenyl Ether
4 Bromphenyl Phenyl Ether
Bis(2-chloroethoxy)Methane
Benzene
Chlorobenzene
1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
1,2,4-Trichlorobenzene
Hexochlorobenzene
Ethylbenzene
Nitrobenzene
Toluene
2,4-Dinitrotoluene
2,6-Dinitrotoluene
Phenol
2-Chlorophenol
2,4-Dichlorophenol
2,4,6-Trichlorophenol
Pentrachlorophenol
2-Nitrophenol
4-Nitrophenol
2,4-Dinitrophenol

*U.S. EPA no longer considers this substance a priority pollutant (1981).

TABLE 3
(Continued)

2,4-Dimethyl Phenol
P-Chloro-M-Cresol
4,6-Dinitro-O-Cresol
Dimethyl Phthalate
Diethyl Phthalate
Di-n-butyl Phthalate
Di-n-octyl Phthalate
Bis(2-ethyl hexyl) Phthalate
Butyl Bertyl Benzl Phthalate
Acenaphthene
Acenaphthylene
Fluorene
Naphthalene
Anthracene
Fluoranthene

Phenanthrene
Benzo(a)Anthracene
Benzo(k)Fluorathene
Chrysene
Pyrene
Benzo(ghi)Perylene
Benzo(a)Pyrene
Di Benzo(a)Anthracene
Indeno(1,2,3-cd) Pyrene
Dimethyl Nitrosamine
Diphenyl Nitrosamine
Di-n-propyl Nitrosamine
Benzidine
3,3$^{1}$-Dichlorobenzidine
1,2-Diphenylhydrazine
Acrylonitrile

indirectly cause death, disease, cancer, genetic mutations, physiological malfunctions (including malfunctions in reproduction), and/or physical deformations in such organisms and their offspring. It also is any substance that causes toxic effects after concentration in a food chain or in combination with other substances.

A telephone survey of sources of toxic material information was conducted in the Fall of 1981. Appendix B contains responses of federal, state and local agencies. These other sources of toxic pollutant information have provided valuable data concerning environmental and health effects of these pollutants. Many of EPA's 126 priority pollutants are also included on these lists.

The three pollutants removed from the initial list of 129 are: dichlorodifluoromethane, trichlorofluoromethane and bis(2-chloromethyl)ether.

Information on federal government toxicity designation was found in Proposed Criteria for Water Quality, EPA 1973; Quality Criteria for Water, EPA 1976; and "Final Water Quality Documents," Federal Register, November 28, 1980. Pretreatment regulations and the NPDES permits are now administered by the Department of Natural Resources for the State of Missouri. Copies of the NPDES permits allowing discharge into Coldwater Creek are on file with that agency. These permits address conventional pollutants and some heavy metals. Limitations for organic priority pollutants are not included.

The State of Missouri Water Quality Standards do not have any specific in-stream water quality criteria for protected streams or streams designated for industrial use such as Coldwater Creek. Only the general criteria for all state waters are applicable. These criteria mandate that all waters of the state shall be:

1. Free from substances in sufficient amounts to cause the formation of putrescent, unsightly or harmful bottom deposits or interfere with beneficial uses;

2. Free from oil, scum and floating debris in sufficient amounts to be unsightly or interfere with beneficial uses;

3. Free from substances in sufficient amounts to cause unslightly color or turbidity, offensive odor or taste, or interfere with beneficial uses; and

4. Free from substances or conditions that have a harmful effect on human, animal, or aquatic life.

For this study, the use of Coldwater Creek has been identified for the propagation of aquatic life. The State of Missouri standards for this classification are presented in Table 4.

The St. Louis, Missouri Water Quality Management Plan (208 Plan), East-West Gateway Coordinating Council, 1978, was completed prior to the adoption of final stream standards by the State of Missouri. Recommended classifications of streams were developed based upon expected uses and designated desirable in-stream water quality levels for each of the classifications. The lower segments of Coldwater Creek, below Old Halls Ferry Road, were determined to be non-conforming to the standards recommended by the 208 Plan for alkalinity, ammonia, fecal coliform, iron, oil, phenols, phosphate and zinc.

TABLE 4

MAXIMUM LIMITATIONS BY SPECIFIC USE
FROM THE MISSOURI DEPARTMENT OF NATURAL RESOURCES

| Priority Pollutants | Water Use | |
|---|---|---|
| | Propagation of Aquatic Life (ug/l)* | Drinking Water Supply (ug/l) |
| Arsenic | 50 | 50 |
| Beryllium | 1100 | -- |
| Cadmium | 12 | 10 |
| Chromium | 100 | 50 |
| Copper | 20 | 1000 |
| Cyanide (free) | 5 | -- |
| Lead | 50 | 50 |
| Mercury | .05 | 2 |
| Nickel | 100 | -- |
| Selenium | -- | 10 |
| Silver | -- | 50 |
| Zinc | 100 | 5000 |
| Phenol | -- | 1 |

*Toxic Agent Study Team and Steering Committee designated this use for Coldwater Creek.

ug/l--micrograms per liter of water.

SOURCE: 10 CSR 20-7.031, Water Quality Standards, Missouri Department of Natural Resources, 1981.

Recent water quality data are available from MSD for many of the conventional pollutant parameters. The information about priority pollutants is limited to heavy metals. In past years, the heavy metals information has indicated occasional violations of the standards set for drinking water.

In Source of Toxic Pollutants Found in Influents to Sewage Treatment Plants by U.S. EPA, actual sampling data for the priority pollutants was presented. Relatively few toxic pollutants were found in the sources (tap water, residential, commercial, and industrial influents), and many were at low concentrations. For the Coldwater Creek sewage treatment plant, only 33 of the priority pollutants were observed in the influent.

The following professional literature were also consulted for information about priority pollutants: Environmental Engineering; Journal of the Water Pollution Control Federation; Journal of the Air Pollution Control Association; and Environmental Research and Technology.

## B. TOXIC INFORMATION SOURCES FOR COLDWATER CREEK

A general inventory of toxic pollutant information was reviewed for applicability to the Coldwater Creek study area. Specific source documents were utilized in the development of project water quality criteria. Also, detailed toxic pollutant references were used to identify environmental and human health impacts of these pollutants. These sources are discussed in the paragraphs below.

In Fate of Priority Pollutants in Publicly Owned Treatment Works, Burns and Roe presented the results of a two-plant pilot study for U.S. EPA (1979) designed to determine model operational parameters. Outputs from this study were used to determine the occurrence and fate of priority pollutants at 40 strategically located publicly owned treatment works (POTW). Because these two plants had different proportions of industrial flow, the relationship between industrial contributions and priority pollutant levels in POTW influents was examined. Analytical and logistical factors of fielding samples were tested to determine the optimum field methodologies and also to ascertain the feasibility of studying other aspects of POTW operations.

An Arthur D. Little study in 1979 for U.S. EPA compared relative source strengths for residential, commercial and industrial contributions of priority pollutants with publicly owned treatment plant influents. A service area in each of four U.S. cities was studied in detail. St. Louis and the Coldwater Creek sewage treatment plant were selected for study. In each city, representative sampling of source categories was conducted and the data was analyzed by source category, frequency of occurrence, concentration of sources, and impact on treatment plant influent. For St. Louis, the wastewater inflow distribution was assigned at 80 percent residential, 9 percent commercial, and 11 percent industrial.

A priority pollutant analysis was prepared for MSD by Sverdrup and Parcel in 1980 which identified influent and effuent concentrations for the four MSD sewage treatment plants, including the

Coldwater Creek plant. The day-to-day variations of the organic priority pollutants was examined thrugh three-day samples. Concentrations of stream pollutants were reported as components of the treatment plant effluent.

In a U.S. EPA contracted report, Water Quality Analyses--Ten Area-Specific Dilution Studies, 1979, SCS Engineers described water quality investigations conducted for 10 selected geographic areas. St. Louis was one of the areas examined, and in this area, Coldwater Creek was chosen to be studied. Study methodology and input detail were presented. The purpose of the study was to identify those areas and specific pollutants which may cause problems because water quality goals (criteria) for toxic pollutants might not be attainable, even with best available technology (BAT).

The 1981 draft reconnaissance report from the St. Louis District of the Army Corps of Engineers discusses the findings of a reconnaissance study of flooding and related problems opportunities in the Coldwater Creek watershed. An inventory of the physical, social, economic and environmental characteristics of the watershed was performed. Flooding and associated problems along the creek were investigated as were various potential flood damage reduction measures.

Point and nonpoint source information for the watershed were inventoried as part of the development of the overall Toxic Agent Budget. The NPDES permits were used to construct point source inputs into Coldwater Creek. To analyze the impacts of

the MSD Coldwater Creek treatment plant effluent, MSD pretreatment information was reviewed. Both the NPDES permits and the pretreatment data were used to map industrial and commercial land use activities within the watershed.

To determine if any toxic discharges had occurred or could occur in the watershed, the records of the Emergency Response Center, the Marine Safety Office and various EPA divisions were examined. Dry and wet weather depositions of toxic substances from air quality point sources were assembled from information provided by the St. Louis County Department of Health and MoDNR files.

# 5. WATER QUALITY MONITORING

## A. MONITORING STRATEGY

### Sampling Points

To link pollutant runoff and land use types, eight sampling sites were selected in the Coldwater Creek Watershed. The site locations are shown in Figure 9. The site selections were based on accessibility, drainage patterns, land use, size of drainage area and location of potential sources of priority pollutants (e.g., industrial plants, wastewater treatment plants, etc.).

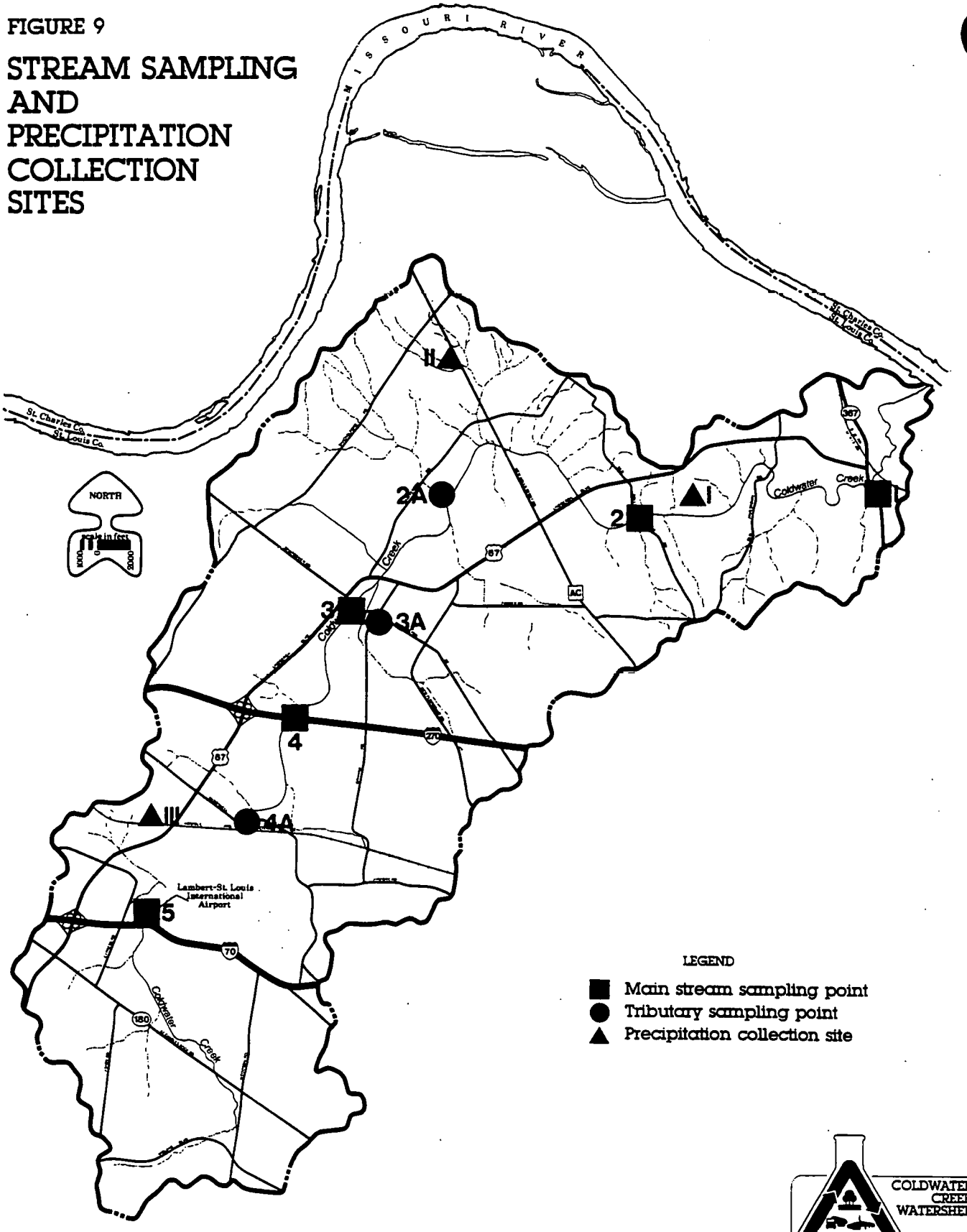
Monitoring sites were located at bridges which pass over Coldwater Creek or its tributaries. This facilitated sample collection by allowing rapid access and provided greater safety for the sample collectors. A brief description of the sites and selection criteria is presented below. The major sites were designated by numbers only and minor sites by numbers and the letter "A":

Site 1 Coldwater Creek at Highway 367. This site was near the mouth of Coldwater Creek and results from this site helped to determine the contribution of priority pollutants contained in the MSD Coldwater Creek Treatment Plant effluent. The 25 MGD sewage treatment plant provides secondary treatment using activated sludge process with anaerobic sludge digestion and disposal of sludge to lagoons. This sampling site was located approximately three miles downstream from the treatment plant outfall. The bridge site was selected for sample point accessibility and to avoid Missouri River backwater influence.

Site 2 Coldwater Creek at Old Halls Ferry Road. This site was located upstream from MSD's treatment plant. This station, in combination with Site 1, allowed a comparison

FIGURE 9

# STREAM SAMPLING AND PRECIPITATION COLLECTION SITES



of the priority pollutants being discharged through the Coldwater Creek wastewater treatment plant with those from upstream sources.

Site 2A Unnamed tributary at intersection of Patterson and Lawnview Roads. This was a minor site that was selected to determine the pollutant loading from a generally new residential area and an agricultural area. The site permitted sampling of the most undisturbed area available in the entire watershed.

Site 3 Coldwater Creek at St. Denis Road. This site allowed an assessment of the large drainage area between Sites 2 and 4. The site also provided background information for the input of two major tributaries. The drainage area between this site and Site 4 was predominantly residential.

Site 3A Fountain Creek at St. Denis Road. This minor site was selected to determine the inputs from a well established suburban area. Since the runoff was from suburban areas only, it provided invaluable background data for comparison of priority pollutants from other land uses in Coldwater Creek.

Site 4 Coldwater Creek at Dunn Road. This site was directly below the major industrial complex within the Coldwater Creek watershed, and it enabled an evaluation of the industrial component of the priority pollutant budget.

Site 4A Coldwater Creek at McDonnell Blvd. Although located on the main stem, this was considered a minor sampling station. It was located just below the Lambert-St. Louis International Airport. This site allowed an assessment of pollutant contributions from the runoff of a major air terminal facility.

Site 5 Coldwater Creek at Airport Access Road. This site was located upstream from the airport. It provided a dual function of background data for the airport and industrial complex evaluation and also augmented the data collected from Site 4 since an older commercial/residential area contributed runoff above this point.

The eight sites represented the best available network of monitoring sites for both toxic budget verification and sampling practicality.

The records of the Missouri Geological Survey showed there were only two wells in the watershed and both were more than 500

feet deep. These wells did not satisfy the shallow, 25 feet or less, well criteria established by the study team. A spring was found in the northeastern portion of the watershed on the property of the Missouri Hills Home for Boys. It was near the mouth of Coldwater Creek and was productive only during wet conditions and was accessible only when the Missouri River was low. For this reason, the spring was sampled as a groundwater site. The other well site was a well 375 feet deep which was located on the Kavanough family farm in the northwestern portion of the watershed.

In addition to the eight stream monitoring sites, three precipitation collection sites were located in the upper, central and lower portions of the watershed (see Figure 9). The precipitation sites were:

Site I MSD Coldwater Creek Sewage Treatment Plant at 13798 Old Halls Ferry Road in Black Jack, Missouri. This site was in the lower portion of the watershed.

Site II Florissant Fire Station at 605 St. Catherine in Florissant, Missouri. This site was in the central sector of the watershed.

Site III Robertson Fire Station at 355 Fairview Road in Robertson, Missouri. This site was in the upper part of the watershed.

These locations provided information on the rate of rainfall and the quality of precipitation entering the watershed during the three monitored storm events.

After the stream sampling sites were surveyed to record the cross sectional area, MSD staff painted gauges on the bridge abutments using the zero gauge datum provided by United States Geological Survey (USGS). These sites became rated flow stations. The zero level could be as much as one foot below the

actual streambed level because the USGS measurements took into account a scouring effect. Lines were painted in fluorescent yellow at one tenth of a foot intervals and were numbered at foot intervals. These gauges were to be used by the sampling crew to determine when samples were to be collected and to estimate runoff volume for pollutant quantity calculations.

Sampling Procedure

The time space for this study was based on several factors. These factors included: project deadlines, financial limitations, personnel availability, seasonal considerations, and statistical reliability requirements. The length of the monitoring time period was based primarily on the U.S. EPA required project completion deadline of May 1982. Subsequently, the deadline was extended to January 1983. Because a full year of sampling was not feasible, sampling during the spring and summer of 1981 was chosen. This six month period, April through September, offered the widest range of weather conditions in the St. Louis area (spring floods to low flow conditions).

The eight sampling points were selected to reflect potential pollutant sources in the watershed. Five of these sites were considered major stream sampling points and the remainder were identified as minor sites. To reduce collection and analysis costs, minor sites were sampled less frequently during storm events.

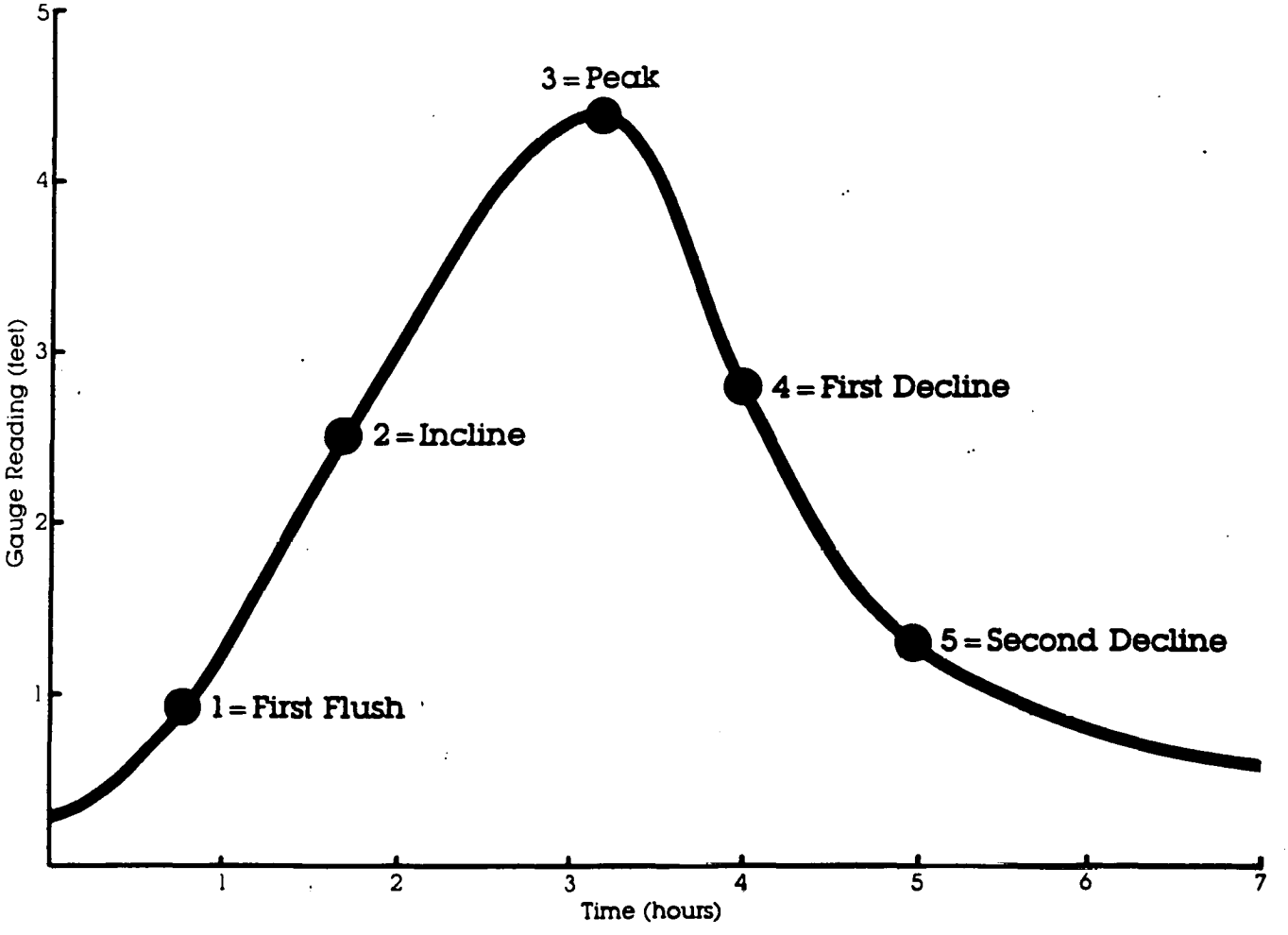
All samples were gathered by staff from EWGCC and MSD. The priority pollutant analyses were performed by the U.S. EPA contract laboratories. A technical consultant coordinated the storm sampling logistics.

To provide the most complete information using the funds available, the frequency of sampling at these sites was as often and under as many runoff conditions as possible. The sampling at the stream monitoring sites in Coldwater Creek was done during storm and dry weather conditions. At all eight stream stations, dry weather water quality sampling was conducted once a month from April through September. At the beginning and the end of the dry weather sampling period, sediment samples were collected. The sites were also sampled during three storm events which took place during the six month period. Rainfall at the three precipitation sites was collected once during each of the three storm events for which stormwater sampling was conducted. Both groundwater sources were sampled in April and September.

The dry weather sampling occurred regardless of the previous day's weather conditions. The wet weather sampling took place during storm events with an attempt to capture a rainfall with an intensity of 0.25 inches or greater per hour. A storm sampling event had to be preceded by at least two days with no precipitation to allow for a buildup of pollutants on urban land surfaces.

Five phases of sampling were involved in the water sampling during a storm event (Figure 10). The first flush sample was taken at all sites as soon as a rise in the water level of the creek due to storm runoff was observed. The incline sample was taken at all upstream major sites (Sites 3, 4 and 5) about one-half hour after the first flush and after an additional rise of one foot. The peak sample was taken at all sites immediately after the stream water level started to fall from its maximum

FIGURE 10
SAMPLING PHASES




COLDWATER CREEK WATERSHED
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height. The first decline sample was taken at all major sites one hour after the peak sample was taken. To reflect the longer incline and decline periods portrayed on the hydrograph for the downstream sites and the distance from suspected priority pollutant sources, the sampling procedure differed for the downstream sites. To sample runoff from the entire upstream area, a second decline sample was taken at two hours after the peak sample at Sites 1 and 2.

Type of Sampling

Storm sampling at the major sites involved the collection of four grab samples per storm. Two grab samples per storm event were collected at the minor sites. All samples for the storm events were collected by lowering a one gallon stainless steel bucket into the middle of the stream from the bridge. The temperature of the water was measured and the contents of the bucket were swirled prior to pouring the water into the sample containers.

Dry weather samples were gathered once a month from each sample site. Samples were collected at the well sites in April and September. Water samples at the stream sites were collected by lowering a stainless steel bucket from the top of the bridge. In addition, sediment samples were obtained at the beginning and end of the study period by scooping some of the streambed deposits at each site into a one quart glass jar. At the well site, water was collected from a spigot which had been running for at

least 15 minutes. Water from the spring was collected by dipping a bucket into the pool formed at the spring outlet.

A numbering system was developed to uniquely identify each sample collected. The label on each sampling container carried a six digit code which was based on the following format: VQxxyy, where VQ was an U.S. EPA identifier, xx represented two numbers indicating the type of event, and yy represented two numbers indicating the location and type of sample.

The yy designation varied with the type of sample collected (i.e., stream, precipitation or well). For the stream samples, the first digit in the yy series indicated the site location of the sample collection.

The specific sampling protocol for each priority pollutant analytical group was:

1. Cyanide. One quart of sample for cyanide analysis was to be collected in a plastic cubitainer. Oxidizing agents, such as chlorine, decompose many cyanides. Therefore, at time of collection, samples were stabilized against such agents. For this purpose, 5 ml. of 6 N sodium hydroxide was added to each cubitainer. The sealed sample bottle was to be maintained at 4 degrees C and kept out of direct light during transport and storage prior to analysis.

2. Phenolics. Samples to be analyzed for phenol were to be collected in 1 quart plastic cubitainers. Preservation of the sample was to be accomplished with 10 ml per cubitainer of a working solution of 100 ml phosphoric acid plus 100 grams of copper sulfate, diluted to 1 liter. Samples were to be maintained at 4 degrees C during transport and storage. The sample was to be kept out of direct light during the period prior to analysis.

3. Extractable Organics. Samples for extractable organics were collected in a single one gallon glass jug cleaned by the Laboratory Organics Section at U.S. EPA. The bottle was cleaned with hot soapy (lab glassware soap) water and rinsed in sequence with deionized water, acetone, hexane and methylene chloride. The lid on these jugs was equipped with a Teflon liner and had been previously rinsed with

methylene chloride. Samples were to be maintained at 4 degrees C during transport and storage.

4. Volatile Organics. Samples for volatile organics analysis were to be collected in two 40 ml screw cap glass vials. The U.S. EPA laboratory prepared the glass vials by baking the bottles at 150 degrees C for the minimum of one hour and stored them in cubitainers with carbon filters. Each container was slowly filled to overflowing. The container was carefully set on a level surface. The septum (Teflon side down) was placed on the convex sample meniscus. The sample was sealed with the screw cap. To insure that the sample has been properly sealed, the sample was inverted and the lid was lightly tapped on a solid surface. The absence of entrapped air bubbles indicated a proper seal. If air bubbles were present, the bottle was opened, additional sample was added, and resealed. The sample remained hermetically sealed until it was analyzed. The vials were placed in a dry cubitainer with a carbon filter and maintained at 4 degrees C during transport and storage prior to analysis.

5. Total Metals. Samples analyzed for total metals were collected in one quart plastic cubitainers. Samples were maintained at 4 degrees C during transport and storage.

The technical consultant recommended a list of equipment necessary to perform stormwater sampling. Using this list as a guide, EWGCC staff purchased eight sets of equipment, one for each person assigned to a sampling site. Each person received the following:

1. One life jacket
2. One high visibility (orange) plastic rainsuit
3. Four traffic safety cones
4. One waterproof flashlight
5. 50 feet of nylon rope
6. One one-gallon stainless steel bucket with 30-feet of 1/8" diameter nylon rope attached
7. One clipboard
8. One grease pencil
9. One "beeper" communications device
10. One roll reflecting tape
11. One thermometer
12. One duffle bag
13. One manual provided by consultant

Equipment was placed in duffle bags and assigned to the sampling personnel for each site. To allow for timely access, sampling personnel kept these materials in their possession throughout the duration of the study.

Sampling containers required for the priority pollutant analyses were obtained from the U.S. EPA laboratory in Kansas City. Each storm event required 29 one-gallon glass jugs, 87 cubitainers, 58 40-ml glass vials and 15 coolers. EWGCC staff transported these containers to the Coldwater Creek sewage treatment plant, labeled the containers appropriately and placed the labeled bottles in assigned coolers.

Within 48 hours after collection, the technical consultant delivered all samples to the Region VII U.S. EPA laboratory in Kansas City, Mo. The U.S. EPA contract laboratories were responsible for the lab analysis protocol.

Review of Sampling Methodology

This field sampling methodology had advantages and disadvantages. The major advantage of this particular sampling methodology was the relative low cost to operate the system. For the Coldwater Creek study, sample collectors were drawn from the staffs of EWGCC and MSD. The coordination of the field operations and the insurance of compliance with U.S. EPA sampling protocol was performed by a consultant retained by EWGCC. The consultant also obtained the services of a 24-hour private weather forecasting company. Close coordination between the consultant and the forecasting company helped in the decision-making process of

"go" or "no go" for sampling and the mobilization of the field samplers.

This type of program can be installed and made operational in a short period of time in comparison to other methods (e.g., fixed monitors), especially if lengthy procurement procedures have to be considered.

This system also allows flexibility in site selection. Land use and point source criteria were important aspects of site selection in this study. Several sampling sites initially identified in the study were moved to improve accessibility or to satisfy site selection criteria.

Several disadvantages of this field sampling methodology were identified. The greatest difficulty was communicating with the sampling crew who were located along 15 miles of stream. Activities in the field were coordinated by the technical and weather consultants through the use of a beeper communications device and a series of beep codes for specific actions which were sometimes difficult to comprehend.

A field-related problem was the hazardous working conditions encountered by the sampling crew. Many of the sampling sites were located on narrow highway bridges which were subject to heavy local traffic. Sampling from these bridges at night was at times unsafe and difficult.

## B. SAMPLING RESULTS

Samples collected during the monitoring period were analyzed by U.S. EPA contract laboratories using extraction procedures,

standard gas chromatography - mass spectrometry (GC-MS) and atomic absorption (AA) methods. Thirty metallic and organic priority pollutants were detected in stream, sediment, and precipitation samples. They are presented in Table 5.

The concentration range of priority pollutants detected is presented in Figures 11, 12 and 13 for stream, precipitation and sediment sampling. With the exception of zinc (a soil component), no priority pollutants were detected in groundwater samples collected at the two well sites.

In general, the metals and organic compounds identified were measured during both dry and wet weather stream sampling. The exceptions were nickel and toluene which were only detected in the storm samples. Of all the organic compounds, phenols and phthalate esters were the most continuously detected. Pesticides were detected only during the storm events. For metals and phenols, storm sample concentrations were consistently higher than concentrations in dry weather samples. Aside from phenols, the most frequently measured concentrations of organic compounds were at or below the confidence level of the analytical method used. Confidence levels were 5 micrograms per liter (ug/l) for pesticides and 10 ug/l for other organics. Although these levels appear high in light of the sensitivity of the analytical methods, the protocol for sampling and the analysis employed by U.S. EPA contract laboratories apparently precluded greater accuracy.

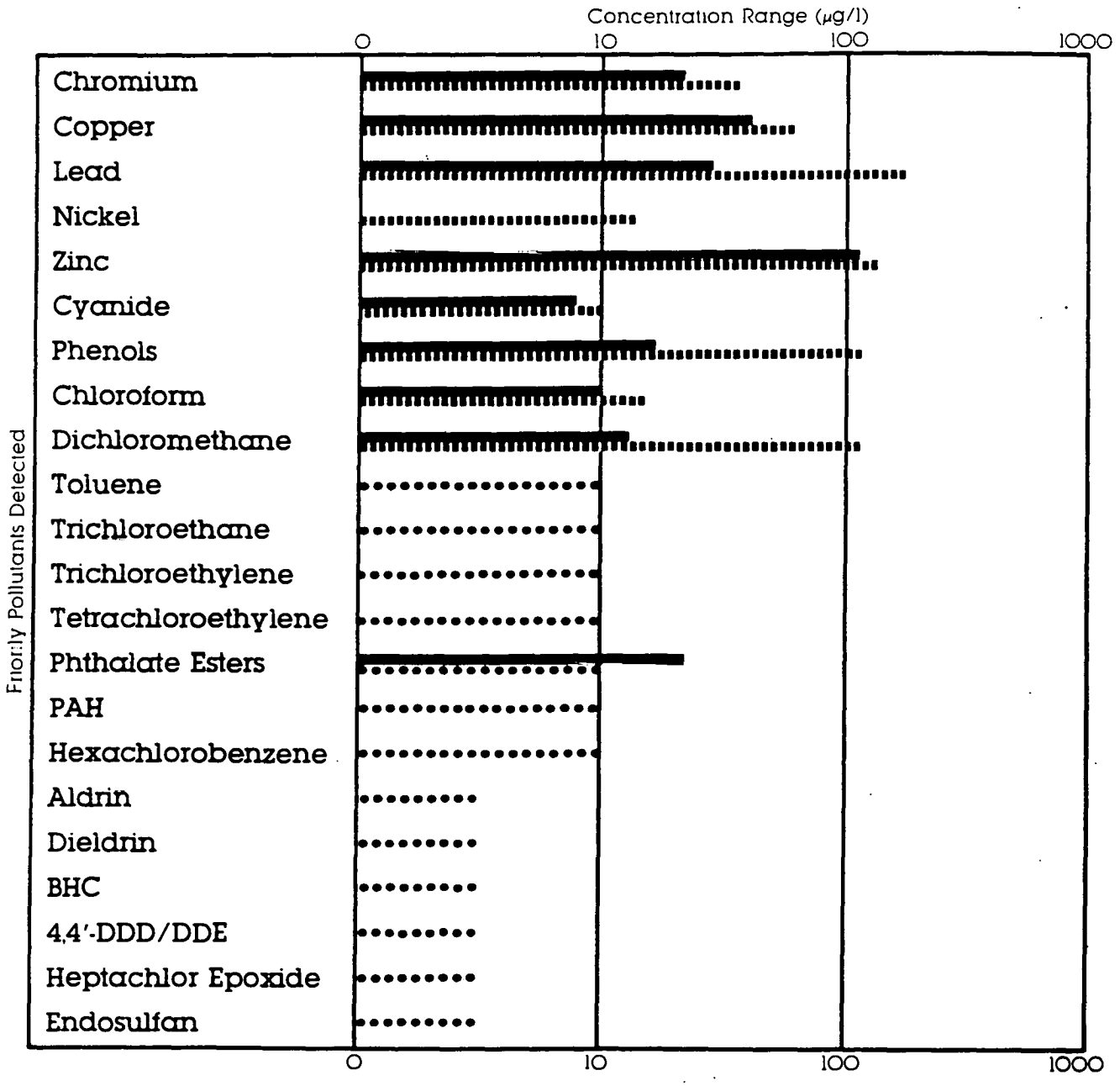
TABLE 5

PRIORITY POLLUTANTS DETECTED
IN COLDWATER CREEK

| | |
|---|---|
| METALS: | Chromium<br>Copper<br>Nickel<br>Lead<br>Zinc |
| EXTRACTABLE ORGANICS: | Cyanide<br>Phenols |
| VOLATILE ORGANICS: | Chloroform<br>Dichloromethane (methylene chloride)<br>Tetrachloroethylene<br>Toluene<br>Trichloroethane<br>Trichloroethylene |
| BASE/NEUTRAL ORGANICS: | Phthalate Esters<br>Bis(2-ethyl hexyl)phthalate<br>Butyl benzyl phthalate<br>Diethyl phthalate<br>Di-n-butyl phthalate<br>Polynuclear Aromatic Hydrocarbons (PAH)<br>Pyrene<br>Fluoranthene<br>Anthracene-Phenanthene<br>Chrysene<br>Benzo(a)anthracene<br>Hexachlorobenzene (HCB) |
| PESTICIDES: | Alpha, Beta, Delta, Gamma Benzylhexachloride (BHC)<br>Aldrin<br>Dieldrin<br>Heptachlor Epoxide<br>Endosulfan<br>4,4'-dichlorodiphenyldichloroethane (DDD/DDE) |

FIGURE 11

## CONCENTRATION RANGE OF PRIORITY POLLUTANTS: STREAM SAMPLES




**LEGEND**

- Wet Weather Sampling
- Dry Weather Sampling
- Concentration measured at or below the detection confidence level

COLDWATER CREEK WATERSHED
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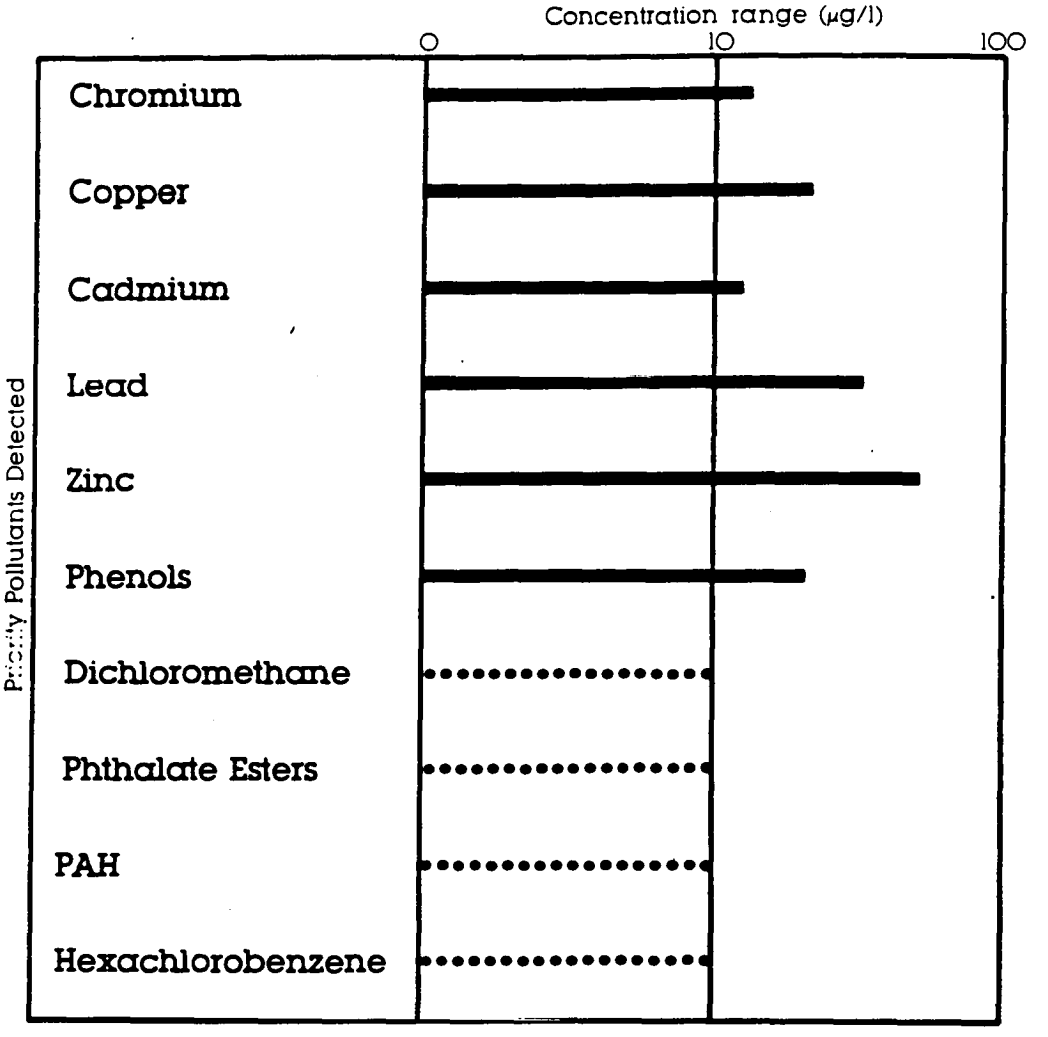
FIGURE 12

CONCENTRATION RANGE OF PRIORITY POLLUTANTS: PRECIPITATATION SAMPLES



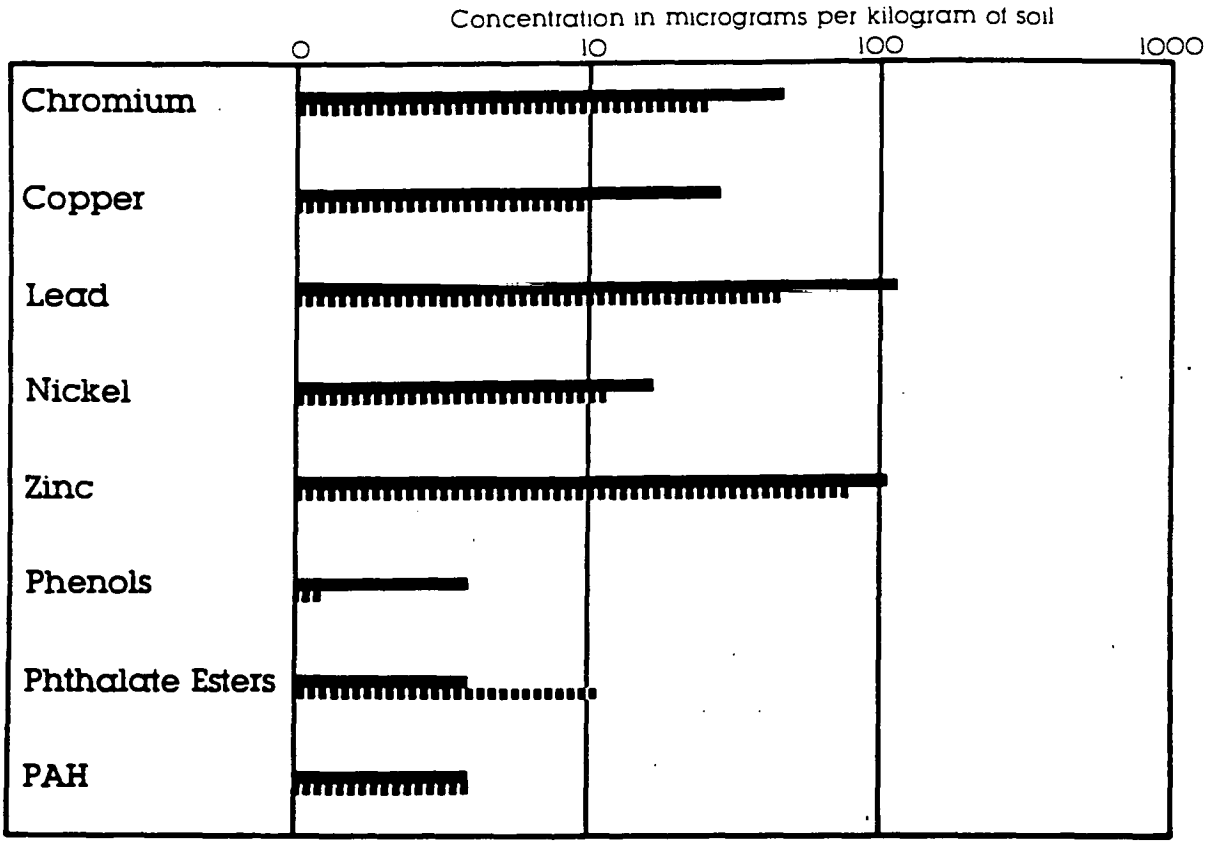

LEGEND

●●●●● Dotted lines indicate concentration measured at or below the detection confidence level

COLDWATER CREEK WATERSHED
TOXIC AGENT STUDY

FIGURE 13

CONCENTRATION RANGE OF PRIORITY POLLUTANTS: SEDIMENT SAMPLES




LEGEND

April Samples

September Samples

COLDWATER CREEK WATERSHED TOXIC AGENT STUDY

The discrepancy between detection limits and reported concentrations often posed a problem in the interpretation of analysis results, particularly where the selected water quality criteria for protection of aquatic life were below the analytical confidence levels. For example, aquatic life protection criteria for dieldrin has been set at .0019 ug/l, while analytical results specified detected levels at or less than 5 ug/l.

In Coldwater Creek sediment samples, metals, phenols, phthalate esters and PAH compounds were detected at all sampling sites. In general, concentrations of those pollutants were higher in April samples than samples collected in September.

Analysis of precipitation samples collected during the study's three storm events revealed the presence of phenols, metals, phthalate esters, PAH and a common solvent compound, methylene chloride.

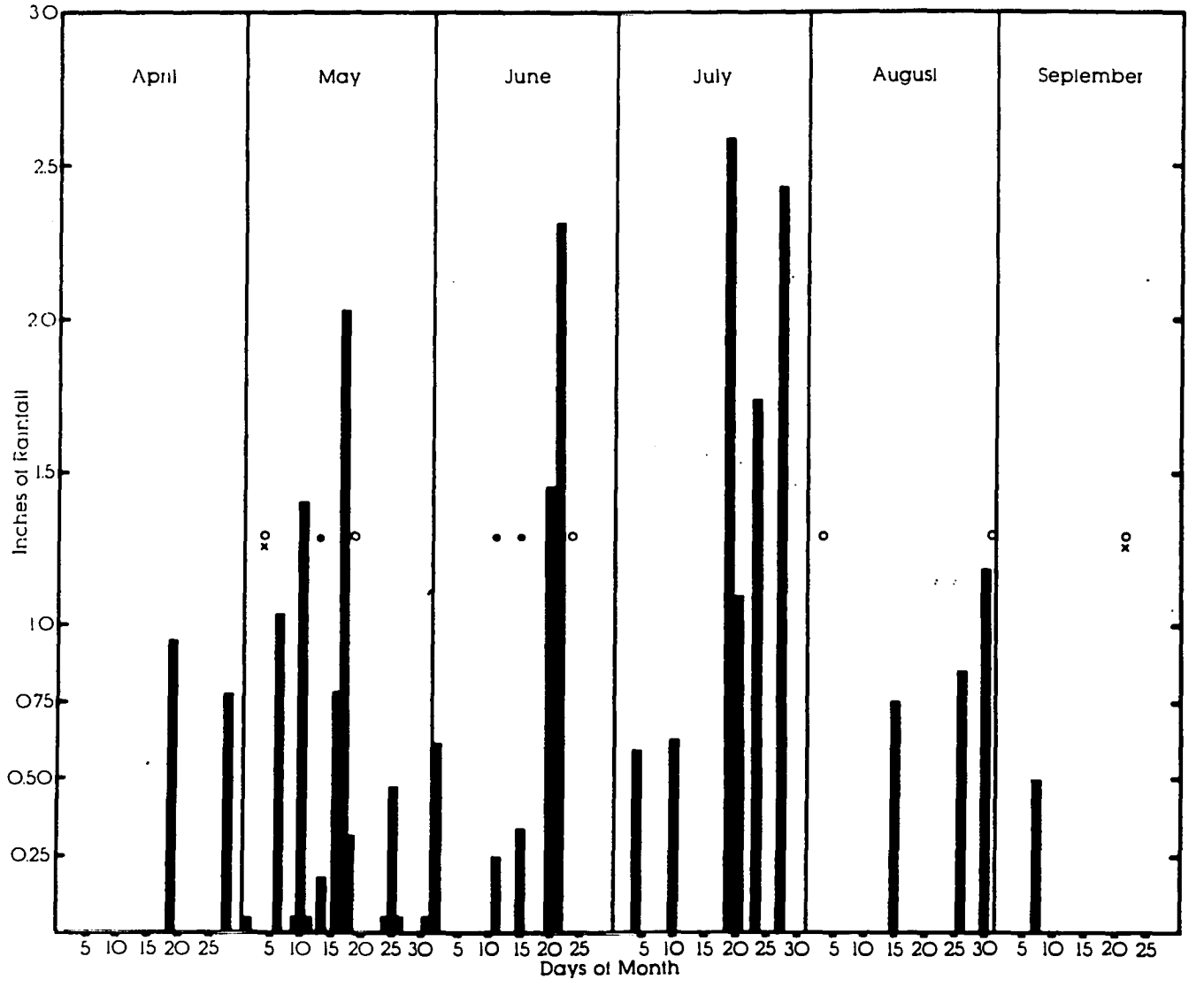
In the watershed well samples, no pesticides or other organic compounds and no heavy metals, aside from zinc, were detected.

## Precipitation Recorded During the Sampling Period

Daily precipitation patterns during the study period had a significant effect on sampling results, as shown in Figure 14. Throughout the study, most of the dry weather sampling times were preceded by rainstorms of considerable intensity, ranging from 0.76 to 2.43 inches of rainfall. A rainfall of 1.4 inches preceded the May storm sampling event, Storm 1, recorded at 0.17 inches. However, both the June storm events sampled (Storms 2 and 3) were not preceded by intense rainstorms. Storm 3 was

FIGURE 14

PRECIPITATION INTENSITIES DURING STREAM SAMPLING PERIODS
(Calendar Year 1981 — Station: Lambert International Airport)




## LEGEND

- • Wet weather samples collected: 5/13/81, 6/11/81, 6/15/81
- ○ Dry weather samples collected: 5/4/81, 5/19/81, 6/23/81, 8/3/81, 8/31/81, 9/21/81
- × Sediment samples collected: 5/4/81 and 9/21/81

COLDWATER CREEK WATERSHED
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recorded at 0.34 inches of precipitation, and Storm 2 at 0.25 inches. Sampling results from the three storm events are closely correlated with the pattern of precipitation intensity. Storm 3 generally showed the highest concentrations of all priority pollutants measured in the creek during wet weather and the most continuous measurements of compounds detected followed in turn by Storm 2 and then Storm 1. Pesticides and other organic compounds detected during Storms 2 and 3 were not measured during Storm 1. Priority pollutant levels which might have been measured during Storm 1 were apparently diminished by the 1.4 inches of rainfall which occurred three days before sampling was conducted. This mechanism may also have diminished concentrations of priority pollutants measured in dry weather stream samples during the monitoring period.

# 6. TOXIC AGENT BUDGET

The purpose of the toxic agent budget is to describe the movement, distribution and fate of priority pollutants in the watershed. The budget is based on the concept of a chemical mass balance:

| Inflow mass of chemical substance | = | Outflow mass of chemical substance | + | Loss due to mass transfer and/or chemical reaction | + | Mass of chemical substance accumulated |
|---|---|---|---|---|---|---|

The toxic agent budget developed for Coldwater Creek is directed towards the 30 priority pollutants detected in the course of the monitoring program. Although a quantitative mass balance was beyond the scope of this study, the budget assesses the modes by which priority pollutants enter the watershed; their use, generation and movement within the study area; and the various mechanisms by which they are ultimately removed and/or degraded by natural processes. Reflecting land use patterns in the watershed, potential pollutant sources were defined and relative source-strengths evaluated for correlation with sampling results. The methodology applied in developing the toxic agent budget is contained in Appendix A.

## A. MOVEMENT, DISTRIBUTION AND FATE OF POLLUTANTS IN THE COLDWATER CREEK WATERSHED

Priority pollutants in the Coldwater Creek watershed are an integral part of our daily lives, moving within a complex pattern of use and release to the air, water and soil. Motor vehicles and airplanes and the commercial and industrial activities which maintain them contribute a major portion of watershed pollutants. Smaller contributions from consumer products used in the home and in commercial establishments--disinfectants, detergents, solvents, paints, plastics, pesticides--are uncontrolled and numerous. Industrial processes within the watershed involve well-controlled but large scale use and generation of priority pollutants. Direct discharges of water containing priority pollutants are made by point sources, such as sewage treatment plants. Indirect or non-point discharges are made by sources such as lawn care and agricultural area runoff. Surface water runoff and precipitation are the primary mechanisms by which pollutants present in the watershed are deposited into the receiving water. Figures 15 and 16 identify the location of point and non-point sources in the Coldwater Creek study area.

### Toxics Entering the Study Area

By volume, transportation sources comprise the most significant mode for priority pollutants entering Coldwater Creek. The U.S. Department of Transportation (U.S. DOT) estimates concerning the transportation of hazardous materials assign the following mode distribution:[1]

FIGURE 15

# POINT POLLUTION SOURCES

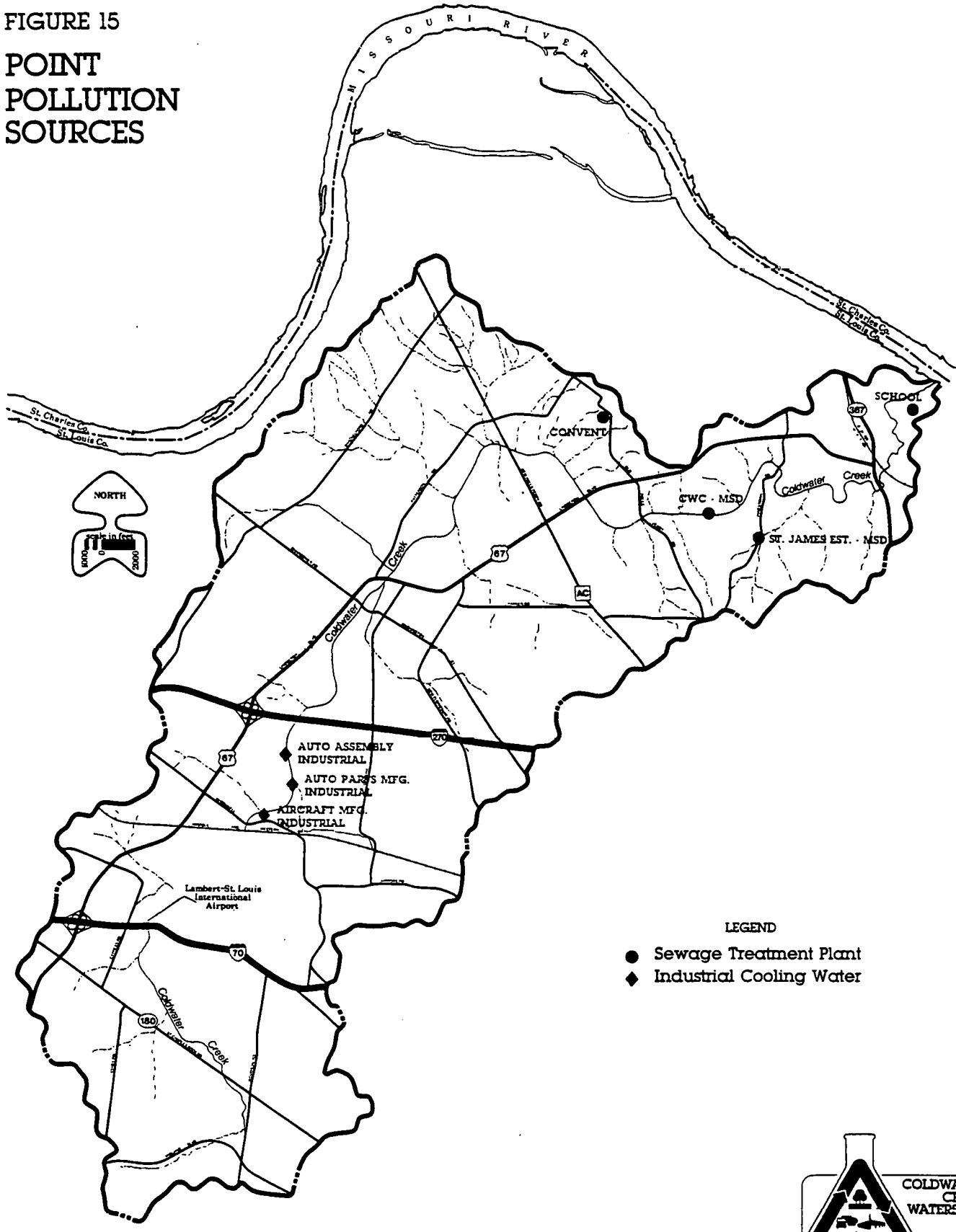
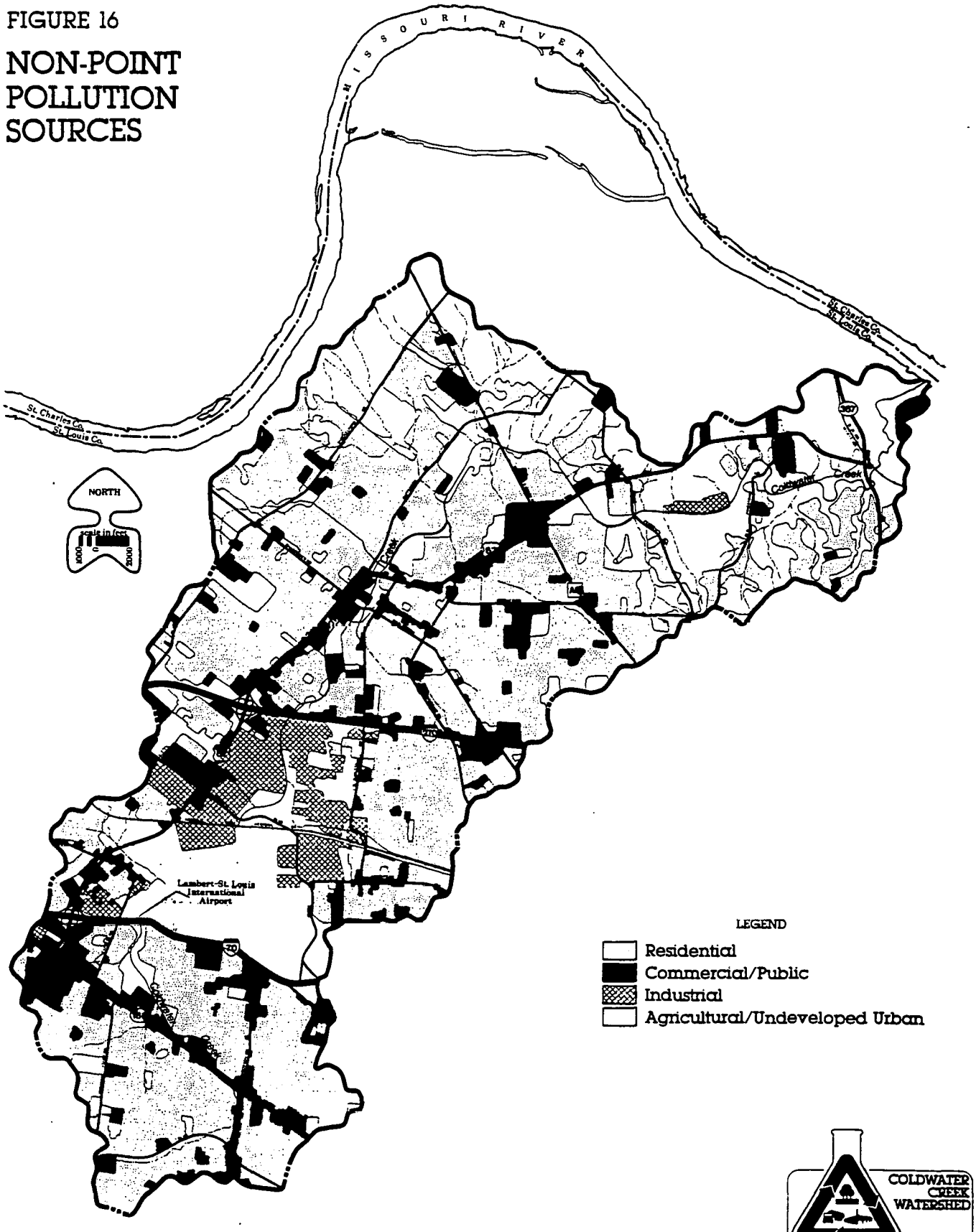


FIGURE 16

# NON-POINT POLLUTION SOURCES




COLDWATER CREEK WATERSHED
TOXIC AGENT STUDY

EAST-WEST GATEWAY COORDINATING COUNCIL

| Mode | Percent of Total Quantity Shipped |
|---|---|
| Motor Carriers | 29% |
| Railroads | 7% |
| Liquid Products Pipelines | 47% |
| Water Carriers | 17% |

U.S. DOT records indicate that crude oil and refined petroleum products account for about 85 percent of hazardous materials transported. Liquid product pipelines transport the largest volume of petroleum products, motor carriers the next largest. Transportation of chemical products is about evenly distributed between railroad and motor carriers.

Although no statistics are available specifically for the St. Louis area, it can be inferred from the above that fuel and other petroleum products, supplying the greatest volume of priority pollutants, are transported into the Coldwater Creek watershed via truck and pipeline. Chemicals and consumer products are primarily transported by truck and railroad car. This has been confirmed by observation of commodity transport and delivery within the study area. Air transportation is an additional commercial mode of entry for small quantities of chemicals and products containing priority pollutants. Although estimation of the quantities of chemicals transported into the watershed as raw materials or for product formulations is beyond the scope of this study, some rough estimates of fuel use and related products can be made.

Each month, 14 million gallons of jet fuel (25 percent gasoline, 75 percent kerosene) and large quantities of gasoline,

lubricants, detergents and cleaning solvents are delivered by pipeline and tank truck to Lambert Airport near the southern end of the watershed. Approximately 120 gasoline and automotive service stations are located throughout the study area and handle an average petroleum throughput of 50,000 gallons per month per station, or collectively, over 72 million gallons annually. Approximately half the gasoline received and sold in the area contains lead. About 300 pounds of commercial detergents and 400-500 gallons of degreasing solvents per year are delivered to each automotive service station operating within the watershed.

Spills from transportation accidents are another mode of pollutant entry into the Coldwater Creek study area. A railroad industry study correlating major spills for 1973 with type of carrier reported the following distribution:[2]

| Type of Carrier | Percent of Total Spills |
|---|---|
| Air | 0.6 |
| Marine | 0.2 |
| Rail | 5.4 |
| Highway | 72.4 |
| Pipeline | 21.4 |

A Battelle Memorial Institute study for U.S. EPA derived probabilities for spillage of hazardous materials by mode.[3] Probability estimates were based upon the number of accidents in 1968 related to hazardous material in a specific year compared with the total number of chemical shipments. For rail, the probability was estimated at 0.0011, or roughly one accident in 1,000 shipments. For trucks, the probability estimate of 0.019 would equal approximately 1 accident in every 55 shipments. In the

same study, a priority ranking of 257 hazardous substances based upon their properties, annual quantities produced and shipped and spillage probabilities by most frequent mode, phenol (one of the priority pollutants most frequently detected in Coldwater Creek) ranked as first among the top 15 hazardous chemicals in the United States.

Another major mode of transport and distribution of fuel and petroleum products are motor vehicles which travel over 3 million vehicle miles per day within the watershed. Of fuel and oil spills within the study area recorded by local fire districts and the U.S. Coast Guard, those from motor vehicle accidents are the greatest in number. Aside from fuel spills, the daily inflow of motor vehicles to the Coldwater Creek area releases priority pollutants to the ambient air and roadway surfaces. These include lead and toluene as fuel components, phenols and heavy metals in automotive fluids, and polynuclear aromatic hydrocarbons (PAH) from fuel combustion and tire, brake lining and asphalt erosion products.[4]

Hydrological flow of surface water is the most important transport mechanism for all priority pollutants detected in Coldwater Creek. As pollutants enter the watershed they are released to the environment, the movement of water in soil and on asphalt and concrete surfaces eventually transports them to the creek. Depending on the water table configuration, groundwater or subsurface flow can be a transport mode for aquatic pollutants. In Coldwater Creek this mechanism has not yet been identified.

Meteorological processes can also introduce significant amounts of pollutants into receiving waters through dry and wet deposition of particulate and gaseous compounds contained in the ambient air. Analysis of the composition of urban aerosols in St. Louis and other cities has confirmed the presence of a variety of priority pollutants, particularly lead, zinc and other heavy metals, commonly used volatile organic compounds and PAH.[5,6,7] Air emission sources operating within the watershed include the following:

Motor vehicles
Aircraft
Industrial/commercial process emissions
Incinerators
Industrial equipment
Lawn and garden equipment
Agricultural activities
Gasoline marketing

During dry weather, suspended fine particulate matter and organic vapors can be transported within air masses and can eventually settle out by gravity or by turbulent mixing into soil and surface water. During wet weather, both particulate and gaseous compounds are washed out of the air to become components of runoff water. In this way, precipitation can be a direct mode of entry for pollutants. This mechanism has been identified in Coldwater Creek by precipitation sampling results.

## Use and Generation of Priority Pollutants Within the Study Area

An Arthur D. Little (ADL) study for U.S. EPA in 1979 compared relative source strengths for residential, commercial and industrial contributions of priority pollutants with treatment plant

influents in four U.S. cities.[8] The Coldwater Creek Sewage Treatment Plant was one of the plants selected for the study. In each city, representative sampling of source categories was conducted. For the City of St. Louis, the wastewater inflow distribution was assigned at 80 percent residential, 9 percent commercial and 11 percent industrial. From flow distribution and known pollutant loadings, a contribution fraction was derived for each pollutant. The ADL study served as a reference for priority pollutant source designations in the Coldwater Creek study.

Industrial Use and Generation. Industrial activity in the watershed is primarily concentrated in an area north of Lambert Airport. Industrial processes operating within this area are automobile and aircraft fabrication, brake fluid manufacturing and formulation of motor oils and additives, surface coating and painting, metal finishing and electroplating, corrugated box and package manufacturing, printing and packaging operations, chemicals distribution and asphalt refining.

Metal finishing and the large-scale use of plastics and plasticizers, inks, dyes, fuels, pesticides and preservatives involve the use and generation of virtually all priority pollutants measured in Coldwater Creek. Fugitive process emissions and evaporative losses are released from surface coating, painting and degreasing operations. Industrial diesel engine emissions, cleaning operations and spills from storage containers, loading operations, leaking valves, pipes and fittings contribute to pollutant load on and around industrial sites in the watershed.

The annual industrial/commercial water usage in the Coldwater Creek area is 2.6 million Ccf (hundred cubic feet) or approximately 5.3 million gallons per day. Water loss to the environment can be 10 percent or more.

Under NPDES permits, aircraft manufacturing and automobile assembly plants directly discharge non-contact cooling water, stormwater, cooling water from welding operations, boiler blowdown water and wastewater treatment pond overflow at a combined average dry weather flow rate of 1.5 million gallons per day. Of the industrial firms in the watershed, nine are registered under the hazardous waste manifest system as generators. Generic types and quantities of wastes generated and transported out of the watershed are listed below.

| Waste Type | Quantity in Kkg* |
|---|---|
| Acid waste (pickle liquor) | 11,079.28 |
| Alkalis | 6,720.59 |
| Empty containers | 120.35 |
| Oils (industrial) | 1,575.66 |
| PCBs (contaminated oils) | .20 |
| Paint sludge (contains lead and other heavy metals) | 160.71 |
| Poisons (U.S. DOT) | 3.11 |
| Halogenated solvents | 511.86 |
| Non-halogenated solvents | 986.39 |
| Toxic metals from plating | 55.16 |
| Toxic metals (other than plating or paint sludge) | 7,142.67 |
| Miscellaneous waste | 27.25 |
| Waste oil | 8.70 |
| Contaminated debris (spillage clean-up, contaminated soil/paper/trash/building debris, etc.) | 2,594.28 |
| GRAND TOTAL | 30,986.37 |

*1000 kilograms

Commercial Use and Generation. Commercial generators and users of priority pollutants within the watershed are the Lambert Airport, approximately 120 gasoline and automotive service stations, numerous shopping centers, 35 dry cleaners and laundromats, commercial storage and bulk loading facilities, commercial printers, metal finishers and photographic supply firms.

Lambert Airport is a major surface transportation activity center. As noted earlier in this report, of 35 roadway crossings of the stream, 25 are south of the airport, at or above Sampling Site 5 and only 10 are north of the airport along the remaining 11.5 miles of Coldwater Creek. In addition to extensive roadway runoff, the creek receives drainage from a major shopping center south of the airport, from airport parking fields and from 138 acres of runway. Aircraft emissions to the atmosphere of a wide range of organic compounds has been estimated to be approximately 1400 tons per day. Total daily St. Louis County organic (hydrocarbon) emissions are approximately 22,000 tons.[9]

Both evaporative emissions and spills associated with gasoline marketing and automotive service and clean-up contribute significantly to runoff water. Wasted gasoline, automotive grease and oils, as well as detergents and degreasing solvents, become part of the commercial area drainage water.

Aside from the airport parking fields, the watershed has two major shopping centers with extensive parking areas draining into Coldwater Creek. Parking lots act as collection surfaces for motor vehicle pollutants. Previous sampling of parking lot

runoff by MSD has confirmed the presence of elevated levels of phenols, lead and other heavy metals.

Dry cleaners operating in the area release an average of 11 kilograms per day each of volatile organic compounds, primarily perchloroethylene, which has been detected in stream samples. Overall, commercial sources of priority pollutants are primarily concentrated in the area south of the airport and north of the industrial complex.

Motor vehicle traffic distributed throughout the watershed releases particulate lead into the air from combustion exhaust emissions and resuspension of road dust. Particulate lead which has settled out on road surfaces and surrounding soil is washed off and drained into the creek from areas with the heaviest concentration of traffic. Sampling results for lead in Coldwater Creek has confirmed this pattern, with highest stormwater lead concentrations measured at Sampling Site 5 which receives drainage from the Northwest Plaza shopping center parking fields and a dense highway network.

Roadway runoff is also a source of polynuclear aromatic hydrocarbon compounds (PAH) derived from fuel combustion, asphalt deterioration and spills of automotive oils and greases.

Residential Use and Generation. Residential and commercial use of a variety of consumer products provides a highly variable but significant contribution of priority pollutants in most areas of the watershed. In 1980, a literature research report published by U.S. EPA's Municipal Environmental Research Laboratory identified toxic chemicals in common household and commercial

products.[10] Many consumer products commonly used both inside and outside the home contain priority pollutant chemicals detected in areas of the creek which provide residential area drainage. Chief among these are phenols, chloroform, tetrachloroethylene, trichloroethane, phthalate esters and the more common heavy metals--zinc, chromium, nickel, copper, lead and cadmium. With approximately 55,625 household units and 178,000 residents of the watershed, about 21.6 million gallons of domestic water is used each day. Water loss, or that quantity not returned for sewage treatment, has been estimated nationally at between eight and ten percent.[11] A significant portion of "lost" domestic wastewater carrying its priority pollutant load becomes part of residential area runoff. Studies of priority pollutants in domestic wastewater have established residential sources as significant contributors to surface water priority pollutant levels.[12,13,14]

Lawn care and pest control activities on approximately 23,000 total acres of residential, commercial and public land in the watershed introduce persistent pesticide compounds to the receiving water. Application of herbicides and insecticides to 2700 acres of agricutural land in the northern portion of the watershed is an additional potential source of the pesticide compounds detected. A 1978 survey of pesticide use in Missouri reported that 29 percent of all farmland (planted and unplanted) applied herbicides, 6 percent applied insecticides and 1 percent

applied fungicides. Application rates varied between 0.5 and 3 pounds (dry) per acre.[15]

Waste Treatment Facilities. Waste treatment and disposal facilities are another source category for release of priority pollutants within the Coldwater Creek area. This category includes municipal sewage treatment, industrial wastewater pretreatment and solid waste incineration.

The principal wastewater treatment facility in the watershed is the Coldwater Creek municipal sewage treatment plant (STP), discharging 25 million gallons per day into Coldwater Creek upstream of Site 1. At this rate of discharge, the treatment plant appears to be the dominant source affecting downstream water quality. A priority pollutant analysis prepared for MSD in 1980 by Sverdrup and Parcel identified influent and effluent concentrations for the Coldwater Creek STP. Concentrations of stream pollutants measured in the present study--chromium, copper, nickel, lead, zinc, phenols, phthalate esters and volatile organic compounds--were reported as components of the treatment plant effluent. In a previous study by Sverdrup and Parcel for U.S. EPA, the range and variability of sewage treatment process efficiency with respect to individual priority pollutants was described.[16] Stabilized sludge from the treatment process containing concentrated amounts of metallic priority pollutants is kept in four five-acre sludge lagoons near the plant.

Effluent from two smaller residential wastewater treatment systems are directly discharged to Coldwater Creek under NPDES permits at locations indicated previously (Figure 15).

Several industrial wastewater retention and pretreatment facilities are located within the industrial complex area near Sampling Site 4. The largest of these facilities discharge effluent containing priority pollutants directly into Coldwater Creek. In addition, waste and wastewater storage and treatment activities on industrial sites in the area affect surrounding soil and water quality due to nonspecific discharge or accidental release.

Twenty hospital and commercial refuse incinerators, with rated capacities between 100 and 1000 pounds per hour and operating at a maximum of six hours per day, are located between stream Sampling Sites 3 and 1. Incinerators are known to contribute zinc, lead, cadmium and other heavy metals to ambient air levels. Long-term studies of the contribution of refuse incineration to the elemental composition of urban aerosols have indicated that incineration sources can account for major localized fractions of ambient zinc, lead and cadmium.[17]

Storage and Loading Facilities. Community and commercial storage and bulk loading facilities such as school district bus depots, transfer stations and warehouses can also be included as generators of priority pollutants in the watershed. Spillage and leaks from these facilities constitute a localized release or generation of priority pollutants. In addition to a chemical distribution company with loading operations adjacent to Coldwater Creek, petroleum products, aircraft, natural gas and railroad companies all maintain storage and loading facilities near the creek itself and at other locations in the watershed.

Table 6 lists potential contributions of detected priority pollutants from the sources described above. The approximate location of source inputs to Coldwater Creek is described in the following section.

Movement Out of the Study Area

The movement of priority pollutants out of the Coldwater Creek watershed is accomplished through four principal modes: transportation, on-site industrial transformations, hydrological outflow, and natural transformations in the environment.

Land transportation is the primary mode of transport for commodities and wastes leaving the watershed. Brake and lighting fluids, lubricating oils and oil additives, chemicals and compressed gases are transported by railroad and truck tank cars for distribution outside of the area. Machine and diesel engine parts, automobile, truck and aircraft components, finished metal products and a variety of packaging and photographic materials are shipped out of the watershed by truck. Air transport is also used for shipping smaller quantities of products or parts.

Industrial refuse and hazardous wastes on the manifest system are hauled by truck for disposal in licensed disposal facilities, principally landfills located outside the study area. Other wastes are treated on site in clarifiers, large oxidation ponds, oil separator tanks and neutralization basins before disposal or reuse of water.

Priority pollutants also leave the watershed by hydrologic flow, transported in surface runoff water to the Missouri River

TABLE 6
POTENTIAL CONTRIBUTIONS OF PRIORITY POLLUTANTS

| Sources | Priority Pollutants Used/Generated |
|---|---|
| Roads/Parking Lots | Lead (Pb), zinc (Zn), chromium (Cr), copper (Cu), phenols, PAH |
| Gasoline/Automotive Service Stations | Pb, Cr, Zn, Cu, phenols, toluene, degreasing solvents |
| Dry Cleaners/Laundromats | Tetrachloroethylene, phenols |
| Commercial Printing/ Photo Supply | Tetrachloroethylene, toluene, methylene chloride, phthalate esters, nickel (Ni) |
| Residential/Commercial Area Drainage | Pb, Cr, Cu, Zn, Ni, phenols, tetrachloroethylene, chloroform, trichloroethane, trichloroethene, methylene chloride, phthalate esters |
| Cooling Water Discharge | Zn, Cr, Cu, phenols |
| Industrial Wastewater Treatment | Pb, Zn, Cu, Cr, Ni, phenols |
| Painting/Surface Coating | Pb, Cr, Zn, toluene, organic solvents, other metals |
| Metal Finishing/Electroplating | Cr, Zn, Ni, Cu, cyanide, organic solvents, other metals |
| Corrugated Box/Package Manufacturing | Phenols, phthalate esters, organic solvents, Pb, Cr |
| Brake Fluid Manufacturing | Pb, Cr, phenols |
| Asphalt Refining | PAH, organic solvents |
| Diesel Locomotive Rebuilding | Phenols, Zn, Pb, toluene, degreasing solvents |
| Automotive/Aircraft Fabrication | Phenols, cyanide, Pb, Zn, Cr, Cu, Ni, organic solvents, phthalate esters, other metals |
| Airport Operations | Pb, Zn, Cr, Cu, Ni, phenols, toluene, degreasing solvents, PAH |
| Refuse Incineration | Zn, Cd, Pb, Cr, Cu, PAH |
| Residential/Commercial Pesticide Use | Aldrin, dieldrin, heptachlor epoxide, endosulfan, BHC, DDD, DDE, HCB |

via Coldwater Creek or removed along the way by evaporation from water and soil and transpiration by surface vegetation.

Evapotranspiration is a combination of evaporation from soil and water surfaces and uptake by growing vegetation and is an important transformation and removal mode for certain priority pollutants in runoff water. Transpiration considerably reduces runoff water as vegetation takes up water from the soil and discharges water vapor to the atmosphere. Total transpiration in an area depends on the depth and extent of vegetative ground cover. The uptake and retention of organic and inorganic substances varies with plant species. Since, for the most part, Coldwater Creek itself is bordered by dense vegetation, transpiration plays a significant role in the transformation and removal of priority pollutants from water draining into the Creek. Evaporation from water and land surfaces depends on ambient temperature, humidity and wind velocity. Evaporation from land surfaces also depends on soil characteristics which affect the infiltration, absorption and percolation of chemical substances into surface layers. In soils that are in contact with a free water surface, evaporation occurs at a greater rate. In the Coldwater Creek drainage basin, a predominance of permeable alluvial material, a mix of stratified sand, silt, clay and organic sediment, establishes evaporation from soil surfaces as an important removal mechanism.

Natural Removal Mechanisms. As a dynamic system, the natural environment is continually absorbing a variety of substances produced by both natural and man-made sources. These substances

travel through air, water and soil, reacting and being changed or degraded by physical, chemical and biological processes. Acting individually or collectively, these processes work to remove pollutants from the environment.

Priority pollutants move through the water system by flow or convection and disperse by diffusion or mixing, often traveling from one environmental compartment--air, water, soil or biota--to another. The transport mechanisms from one compartment to another, acting throughout the water system, determine the overall effect of priority pollutants on water quality in the system. The extent to which a particular chemical becomes distributed among the environmental compartments is expressed by the "partition coefficient." The partition coefficient depends upon a compound's molecular structure.

Physical processes which transport and ultimately remove priority pollutants from the Coldwater Creek drainage basin include volatilization, sorption, solvation, advection and dispersion. Volatile substances, such as the organic solvent compounds measured in this study, vaporize upon release to the atmosphere or gradually volatize from a water system. Water solubility is a key element in the breakdown of chemicals in the environment. Substances, such as cyanide, which are water soluble, dissolve in surface water. Relatively insoluble substances, such as phthalate esters, can be adsorbed or absorbed by suspended particles or sediment and transported downstream by surface water or sediment flow. Sediment flow itself can become a continuous

mode of transport for insoluble pollutants, such as heavy metals and PAH compounds.

Whether dissolved or adsorbed by particulate matter, priority pollutants are transported from their point of origin by the mass motion of air, water and sediment and dispersed by currents and turbulent mixing. Dispersion continually dilutes pollutant concentrations throughout the watershed.

Chemical processes which act to remove priority pollutants from the environment include coagulation, complexation, precipitation and ion exchange reactions. These reactions change physical and chemical characteristics and often the solubility and mobility of chemical compounds in the watershed. Ion exchange is a particularly significant chemical change occurring most frequently in muddy waters and sediment. The extent of this reaction depends largely on chemical compound and soil type. Metallic compounds, in particular, are subject to this removal mechanism.

The principal chemical reactions which break down or degrade priority pollutants in the environment are oxidation, hydrolysis, and photolysis. Oxidation is the reaction of a compound with oxygen and occurs in both air and water. Oxygen's free radical action and solubility in water make it a prime reactant in the natural environment. Oxidation breaks down molecular structures and forms other reactive species such as peroxides and epoxides which further react and degrade. Hydrolysis is the reaction of chemical compounds with water molecule components, hydroxyl and

hydrogen ions and depends largely upon temperature and pH (relative acidity). Hydrolysis, the main dissipating reaction in the water environment, is a reaction which degrades a compound by replacing a less easily degradable molecular component with a more easily degradable one.

Many priority pollutants, such as pesticides and PAH compounds, undergo photolysis, or sunlight-induced photochemical reactions. These reactions in the natural environment continually destroy and recreate in different forms a wide range of chemical species. Sunlight energy initiates the decomposition of organic and inorganic compounds in the air and water.

In the water environment, interactive and synergistic effects occur between the natural oxidizer, ozone ($O_3$), and the natural photolyzer, the sun. Sunlight, therefore, plays an important role in transforming chemicals in the environment.

Priority pollutants detected in Coldwater Creek which are degraded and removed by chemical processes are primarily phenols, cyanide and PAH compounds.

Biological processes which transfer and remove priority pollutants from the watershed are biodegradation and bioaccumulation. Microorganisms deactivate toxic substances by natural metabolic processes. Biometabolism is essentially a detoxification process by which an organism converts low water-soluble substances into more water-soluble substances that can be excreted. There are a great diversity of biological species, metabolic rates and types of substances which can be degraded by this mechanism. The rate of transformation by micro-organisms

depends on factors such as temperature, oxygen availability, light and pH. Biometabolism usually results in detoxifying a chemical substance with respect to aquatic life. A notable exception, or "reverse detoxification," is the biometabolism of aldrin to dieldrin, a more persistent and more toxic compound.

Bioconcentration, or the tendency of an organism to accumulate a chemical substance, is a selective process unique to various biological and chemical species. The "bioconcentration factor" establishes the hazard potential (or inability to be metabolized) of a chemical to a living species. The bioconcentration factor for a chemical compound has been found to be closely correlated with solubility and partition coefficient. The partition coefficient is an indicator of the mobility of a chemical species from one environmental compartment to another. A high partition coefficient is usually correlated with a low water solubility and a high lipid or fat solubility which promotes retention of the chemical within the organism. Bioaccumulation often leads to biomagnification, a sequential increase in the concentration of a chemical in going from one biological food level to another. This is a particularly important mechanism for many pesticides, including DDT and its related forms, DDD and DDE, detected in the Coldwater Creek study.

Priority pollutants detected in Coldwater Creek which can be biodegraded are aldrin, endosulfan, benzyl hexachloride (BHC), heptachlor epoxide, the organic solvent compounds (methylene chloride, chloroform, toluene, trichloroethane, trichloroethylene, tetrachloroethylene), phenols, PAH compounds and

phthalate esters to a limited extent. Those pollutants which can potentially bioaccumulate within living species in the watershed include all the detected metals except nickel (i.e., chromium, copper, lead and zinc), aldrin/ dieldrin, 4,4'-DDD/DDE, heptachlor epoxide, hexachlorobenzene (HCB), phthalate esters and PAH compounds to some degree.

A key aspect of the biodegradation and bioaccumulation potential of a pollutant is its persistence. U.S. EPA's 126 priority pollutants have been ranked according to their persistence in the water environment based upon their physical and chemical properties.[18] The use of this ranking in the Coldwater Creek water quality criteria evaluation process is described in Chapter 7. A description of persistence ranking can be found in Appendix E. Of the priority pollutants detected in Coldwater Creek, the metals, pesticides, phthalate esters, HCB and PAH compounds were ranked at the top of the persistence scale due to their non-volatile and accumulative properties. Cyanide and the volatile organics were ranked as "non-persistent" and "low persistence," respectively.

References consulted in assessing the fate of priority pollutants in the watershed are listed as references 19 through 22 in the Bibliography, Appendix G.

## B. CORRELATION OF SAMPLING RESULTS WITH SOURCE CONTRIBUTION

The results of U.S. EPA laboratory analyses of the stream, precipitation, sediment and well samples collected were correlated with existing sources at each sampling site. All potential

point and area sources at each of the five major sites were evaluated to allow a qualitative assessment of source contribution to measured pollutants. Sampling data from the three minor sampling sites 2A, 3A and 4A, allowed comparison of new and old residential area runoff characteristics and differentiation of airport and industrial complex contributions. Priority pollutants measured at two of the minor sites, located on tributaries of the creek, were treated as tributary source inputs.

The variability and diversity of area source contributions and the confidentiality maintained by industrial operations within the watershed precluded a detailed quantitative assessment of source strength and contribution in this study. Source designations presented here, however, can be used as a guide if more intensive investigations are considered necessary.

In Table 7, priority pollutants measured are correlated with potential source contributions at each site. The table demonstrates the effects of land use in the watershed on runoff characteristics. Sampling Site 5, drainage from a dense traffic network and from commercial and residential areas, provides pollutant loading to the upstream portion of the creek. Above Sampling Site 4, priority pollutant contributions are added from industrial point sources and from airport and industrial area runoff. Drainage from a large commercial and residential area contributes additional priority pollutants measured at Sampling Sites 3 and 2. Above Sampling Site 1, a large point source discharge from the municipal sewage treatment plant and runoff from commercial and residential areas contribute to the water quality measured at that site.

TABLE 7
CORRELATION OF PRIORITY POLLUTANTS WITH SOURCE CONTRIBUTIONS

| Sampling Point | Stream Miles | Upstream Activities | Potential Pollutants Contributed | Pollutants Measured |
|---|---|---|---|---|
| | 18.0 | Shopping center parking lots | Lead (Pb), zinc (Zn), chromium (Cr), phenols, PAH | |
| | | Dry cleaners/laundries | Tetrachloroethylene, phenols | |
| | | Printing/photographic supply | Phthalate esters, toluene, other organic solvents, Zn, Cr, Cu, Pb, Nickel (Ni) | |
| | | Gasoline/automotive service stations | Pb, Cr, Copper (Cu), Zn, phenols, toluene | |
| | | Commercial metal finishing | Cr, Cu, Zn, cyanide (CN), organic solvents | |
| | | Residential area drainage | Cu, Cr, Ni, Pb, phenols, phthalates | |
| | | Lawn care/pest control | Pesticide compounds, Cn, HCB | |
| | 15.5 | Airport parking fields | Pb, Zn, Cr, phenols, PAH | |
| Site 5 | 15.0 | Roadway runoff | Pb, Zn, Cr, phenols, PAH | Zn, Pb, Cr, Cu, Ni, CN, phenols, phthalates, PAH, BHC, dieldrin, chloroform, methylene chloride, tetrachloroethylene |
| | 14.8 | Military training center | Phenols, Zn, Cr, Cu, Pb, Ni, HCB | |
| | 14.0 | International air terminal facility (fueling/cleaning/flight activities) | Zn, Cr, Cu, Pb, Ni, phenols, PAH, phthalates, toluene, organic solvents | |
| | | Pest control | Pesticide compounds | |
| Site 4A | 13.5 | Roadway runoff | Pb, Zn, Cr, phenols, PAH | Cr, Cu, Zn, Pb, Ni, CN, phenols, phthalates, PAH, BHC, dieldrin, 4,4'-DDD/DDE, heptachlor epoxide, chloroform, tetrachloroethylene |

TABLE 7
(Continued)

| Sampling Point | Stream Miles | Upstream Activities | Potential Pollutants Contributed | Pollutants Measured |
|---|---|---|---|---|
| | | Aircraft and automobile manufacturing | Zn, Cr, Cu, Ni, Pb, CN, organic solvents, phthalates | |
| | | Metal finishing/electroplating | Zn, Cr, Cu, Ni, cyanide (CN) | |
| | | Painting/coating | Pb, Cr, Zn, phthalates, organic solvents | |
| | | Boiler cooling water discharge | Zn, Cr, Cu, phenols | |
| | | Package manufacturing | Phthalates, phenols, organic solvents | |
| | | Automotive fluids formulation | Cr, Cu, Pb, Zn, organic solvents | |
| | | Pest Control | Pesticide compounds, CN, HCB | |
| Site 4 | 12.0 | Roadway runoff | Pb, Zn, Cr, phenols, PAH | Cr, Cu, Zn, Pb, Ni, CN, phenols, phthalates, PAH, BHC, dieldrin, 4,4'-DDD/DDE, heptachlor epoxide, chloroform, tetrachloroethylene, toluene |
| | | Gasoline/automotive service stations | Pb, Cr, Cu, Zn, phenols, toluene | |
| | 11.0 | Dry cleaners/laundromats | Tetrachloroethylene, phenols | |
| | | Refuse incineration | Zn, Pb, PAH, cadmium (Cd), Cu, Cr | |
| | | Lawn care/pest control | Pesticide compounds, HCB, CN | |
| | | Older residential area runoff | Cu, Pb, Cr, Zn, phenols, phthalates, CN | |
| Site 3 | 10.0 | Roadway runoff | Pb, Zn, Cr, phenols, PAH | Cu, Cr, Pb, Zn, Ni, CN, phenols, dichloromethane, phthalates, chloroform, trichloroethane, trichloroethylene, tetrachloroethylene, toluene, HCB, dieldrin, 4,4'-DDD/DDE |

TABLE 7
(Continued)

| Sampling Point | Stream Miles | Upstream Activities | Potential Pollutants Contributed | Pollutants Measured |
|---|---|---|---|---|
| | 5.0 | Municipal STP effluent discharge | Zn, Cr, Cu, Ni, Pb, organic solvents, CN, phenols, phthalates | |
| | 2.5 | Residential STP effluent discharge | Zn, Cr, Cu, Ni, Pb, phthalates, CN, phenols | |
| | | Residential area runoff | Cu, Pb, Cr, Zn, Ni, phenols, phthalates, organic solvents | |
| | | Shopping center parking lots | Pb, Cr, Cu, Zn, phenols, toluene | |
| | | Agriculture/lawn care/pest control | Pesticide compounds, CN, HCB | |
| Site 1 | 1.5 | Roadway runoff | Pb, Zn, Cr, phenols, PAH | Zn, Cu, Cr, Pb, Ni, CN, phenols, phthalates, methylene chloride, trichloroethane, tetrachloroethylene, toluene, HCB, aldrin, dieldrin |

No pesticides or PAH compounds were detected during dry weather stream sampling.

Metallic and organic priority pollutants identified in dry weather sediment sampling are presented in Figures 30 and 31, at the end of this chapter. As expected, the same group of metals detected in stream sampling were measured in the creek sediment. Organic pollutants detected were primarily phthalate esters, PAH compounds and phenols. In general, sediment samples collected in April contained higher priority pollutant concentrations than the September samples. The frequency and intensity of storm events during the sampling period suggests a scouring mechanism and movement of sediment deposits from their original location.

Phenols and phthalates were detected in highest concentrations in the sediment at residential Site 3 followed by Site 1 downstream from the sewage treatment plant. PAH compounds were highest at Sites 5 and 3, downstream from roadway runoff sources. Location of the highest metal concentrations in the sediment varied significantly. The wave motion character of advective sediment flow has been accurately described and measured. This phenomenon could account for much of the lack of direct correlation between source location and sediment concentration measured.

## Wet Weather Sampling

Representative storm event stream sample results are presented in Figures 32 through 46. The remaining wet weather sampling data collected is contained in Appendix C.

In general, higher concentrations of all detected metals were measured during the storm events and there were more continuous measurements of volatile organic compounds and phthalate esters at all sites, compared with the dry weather samples. PAH compounds, pesticides and hexachlorobenzene (HCB), a component of wood preservatives, were all detected during storm event sampling.

In general, pesticides were detected most frequently in runoff from residential areas, particularly at tributary Site 3A in the central portion of the watershed. During the second storm event, however, pesticide compounds were detected at all stream sampling sites.

The highest concentrations of lead were consistently detected at Sampling Site 5, below major roadway and parking areas, followed by concentrations at industrial/airport Sampling Site 4. The heavy metals were highest at Site 4 and Site 1, downstream from the municipal STP effluent discharge. Phenols, following a similar pattern to lead, were highest at Sites 4 and 5. Volatile organic compounds were detected most frequently downstream from the airport and industrial areas. Pesticides were primarily detected in residential and commercial area runoff. PAH compounds were detected only at Sites 5 and 4 during the storm events, confirming their origins from roadway and airport runoff sources.

Precipitation Sampling

Precipitation sampled in the watershed during the three storm events is represented in Figures 47 through 49. Of the priority

pollutant metals detected (zinc, copper, chromium, lead and cadmium), the highest levels were measured at precipitation Sampling Site II, in the center of the watershed. Refuse incineration sources are centered in the general area of this sampling site. A direct source correlation between incineration and measured ambient air concentrations of priority pollutant metals, as described in Part A of this chapter, has been established by several investigators. This correlation was confirmed for the Coldwater Creek study area by the observation that high levels of cadmium (19 micrograms per liter) were detected only during precipitation sampling at Site II, not anywhere else during the study. Ambient air cadmium, in particular, has been directly related to incinerator sources. Priority pollutant metals were also measured in samples at precipitation Site III near the industrial complex area.

Detection of PAH compounds in precipitation samples at precipitation Sites II and III can also be correlated with direct combustion sources, such as incinerators and internal combustion engines.

The detection of dichloromethane (methylene chloride) in the precipitation samples is consistent with May-June 1980 St. Louis measurements of ambient air concentrations as high as 6.4 micrograms per cubic meter.

Phenols were measured during all three storm events at all precipitation sampling sites, with highest concentrations consistently measured at Site III in the industrial area of the watershed.

In two storm events, phthalate esters were detected at Precipitation Site I, located in a primarily residential area of the watershed.

Precipitation sampling results, in general, appear to be consistent with aerosol sampling conducted in St. Louis and elsewhere in the nation. They confirm that air pollution sources contribute to priority pollutant levels measured in urban area runoff.

## Groundwater Sampling

Aside from low-moderate levels of zinc, no priority pollutants were detected in ground water samples collected at the two well sites. The source of zinc measured was considered to be the loess, or windblown silt deposits, which comprise the soil covering limestone bedrock in the area of the well sampling sites.

## Minor Site Comparisons

Minor Site 2A, located on a tributary of Coldwater Creek, was selected in order to observe pollutant loading characteristics from a newer residential area with some agricultural activity. The location of minor Site 3A, also on a tributary, provided an assessment of runoff from an older residential and highly commercialized suburban area. Major Sampling Site 3 was selected to measure pollutants in the large residential/commercial drainage area between Sampling Sites 2 and 4, and it provided background information for the tributary sites.

In dry weather sampling, no distinguishing characteristics were noted between the newer and older residential sites for both metallic and organic priority pollutants. Pollutant concentrations were generally higher at major Site 3 than at the upstream and downstream tributary sites. During storm event sampling, however, priority pollutant metals were consistently higher at the older residential site (3A), as were phenols and cyanide. Overall, there were more organic priority pollutants measured in runoff at Site 3A than were measured at Site 2A, the newer residential site. This observation is consistent with land use patterns in the minor site areas. Greater residential and commercial density in the drainage area for Site 3A, as well as other factors such as greater metal corrosion, can account for the comparatively higher levels of priority pollutants in stormwater runoff measured at this sampling site.

Comparison of major/minor Site 2 and major/minor Site 3 showed that higher concentrations of all pollutants detected generally occurred at the major, or nontributary, sampling sites. The exceptions were pesticides, which were generally detected in greater number and with greater frequency in storm samples from the tributary sites, particularly Site 3A.

Priority pollutant contributions to the creek from the two tributaries monitored at minor sites 2A and 3A were measured in all sampling modes. During dry weather, contributions were primarily phenols, zinc, lead and phthalate esters, with occasional contributions of organic solvent compounds. During storm event sampling, chromium, copper and nickel were also detected along

with pesticides and other organic compounds. These findings confirm the source strength and significance of residential and commercial area runoff with respect to those priority pollutants detected in Coldwater Creek.

Although not a tributary measurement site, minor Site 4A was selected for special purpose monitoring of the creek. Located just downstream from the Lambert Airport, Site 4A was designated as a background site to differentiate and characterize priority pollutant loadings from airport and industrial activities. A comparison of sampling results from Sites 5, 4A and 4 was useful during the study in evaluating runoff and discharges from these areas.

During dry and wet weather monitoring at Site 4A, sampling results were consistent for some pollutants and variable for others. No unique pattern emerged with respect to type or quantity of contributions from airport and industrial complex areas. At specific times, each area was observed to add a major contribution to measured pollutant levels downstream. During dry weather, the heavy metals detected tended to be slightly higher at the airport drainage site, while phenol contributions were generally higher at the industrial complex site. Aside from lead, heavy metal concentrations at both sites were consistently greater than concentrations measured upstream at Sampling Site 5.

In wet weather sampling, measured levels of phenols, chromium, copper and nickel were higher at industrial Site 4 with higher concentrations of lead and zinc measured upstream at the airport site. Cyanide, phthalate esters, PAH and all the organic solvent

compounds identified in both wet and dry sampling were detected with approximately the same frequency at Site 4A as at Site 4. Measured concentrations, however, were often higher at the industrial site. These observations underscore the basic source similarity between airport and industrial activities along Coldwater Creek.

Pesticides were detected at Site 4A only during Storm 3, the most intense of the storm events, when the same compounds were detected at all other sampling sites along the creek.

Dominant Sources for Pollutants Measured

Certain general patterns emerged from correlation of sampling results with source locations in the watershed.

Traffic sources were found to be the primary contributors of lead in the watershed, as measured lead levels correlated closely with transportation activity. Industrial and residential sources were secondary but significant contributors. Dominant sources of zinc, chromium, copper and nickel were manufacturing activities followed closely by transportation, commercial and residential area sources.

Phenols followed the same source pattern. Cyanide contributions also appeared to be predominantly from manufacturing sources, followed by residential and commercial source contributions reflected in levels measured downstream from the municipal STP discharge. Phthalate esters were associated with all land use activities. Analysis of sediment samples, however, indicated

residential and commercial area runoff as a primary source, followed by industrial activities in the industrial complex area. Dominant sources of volatile organic compounds were shown to be industrial and airport activities, followed closely by residential and commercial area drainage.

Polynuclear aromatic hydrcarbons (PAH) measured in the watershed were directly correlated with traffic source emissions and asphalt erosion products. Residential and commercial lawn care and pest control sources appeared principal contributors of pesticide compounds measured.

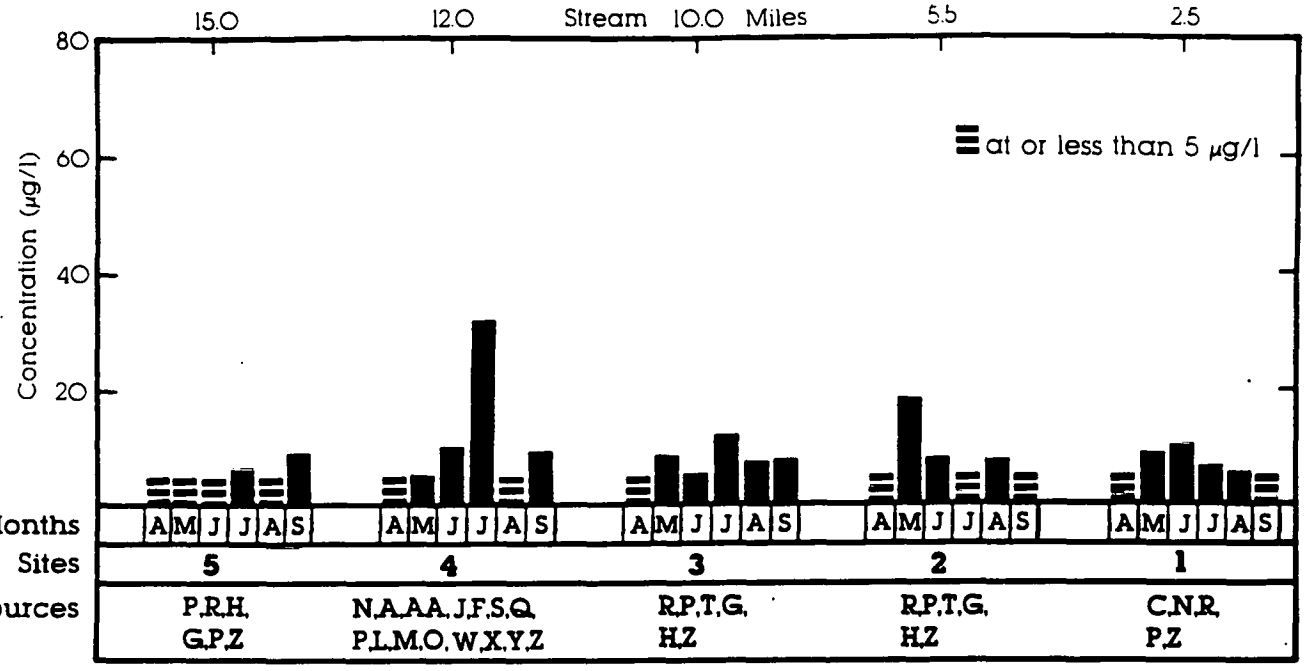
Overall, point source discharges into Coldwater Creek were found to be significant contributors to water quality measurements, but non-point sources, collectively, appeared to match and often exceed point source contributions for most of the priority pollutants detected.

References cited in this chapter can be found in the Bibliography in Appendix G.

FIGURE 17

Dry Weather Sampling

**PHENOLS**




## LIST OF SOURCE SYMBOLS

| Symbol | Source |
|---|---|
| A | Airport activities |
| AA | Automotive/aircraft fabrication |
| B | Agricultural use of pesticides (insecticide, herbicide) |
| BB | Commercial/residential use of pesticides (insecticide, herbicide, fungicide, rodenticide) |
| C | Municipal Sewage Treatment Plant |
| D | Dry cleaning |
| E | Industrial solvent use |
| F | Brake/lighting fluid manufacturing |
| G | Gasoline marketing |
| H | Automotive service/leasing/washing |
| I | Refuse incinerator emissions |
| J | Chemical distribution |
| K | Surface coating/painting operations |
| L | Corrugated box/package manufacturing |
| M | Metal finishing/electroplating |
| N | Direct discharge (NPDES permits) |
| O | Compounding of motor oils/additives/grease/anti-freeze |
| OO | Asphalt refining process |
| P | Commercial area/parking lot draining |
| Q | Fuel oil/chemical spills |
| R | Residential area drainage |
| S | On-site storage of priority pollutants |
| T | Tributary contribution |
| U | Printing/packaging operations |
| V | Motor vehicle exhaust emissions |
| W | Industrial wastewater treatment facility |
| X | Diesel locomotive rebuilding |
| Y | Military training facility |
| Z | Direct roadway wash-off at sampling site |

COLDWATER CREEK WATERSHED
TOXIC AGENT STUDY

**FIGURE 18**

Dry Weather Sampling

**ZINC**

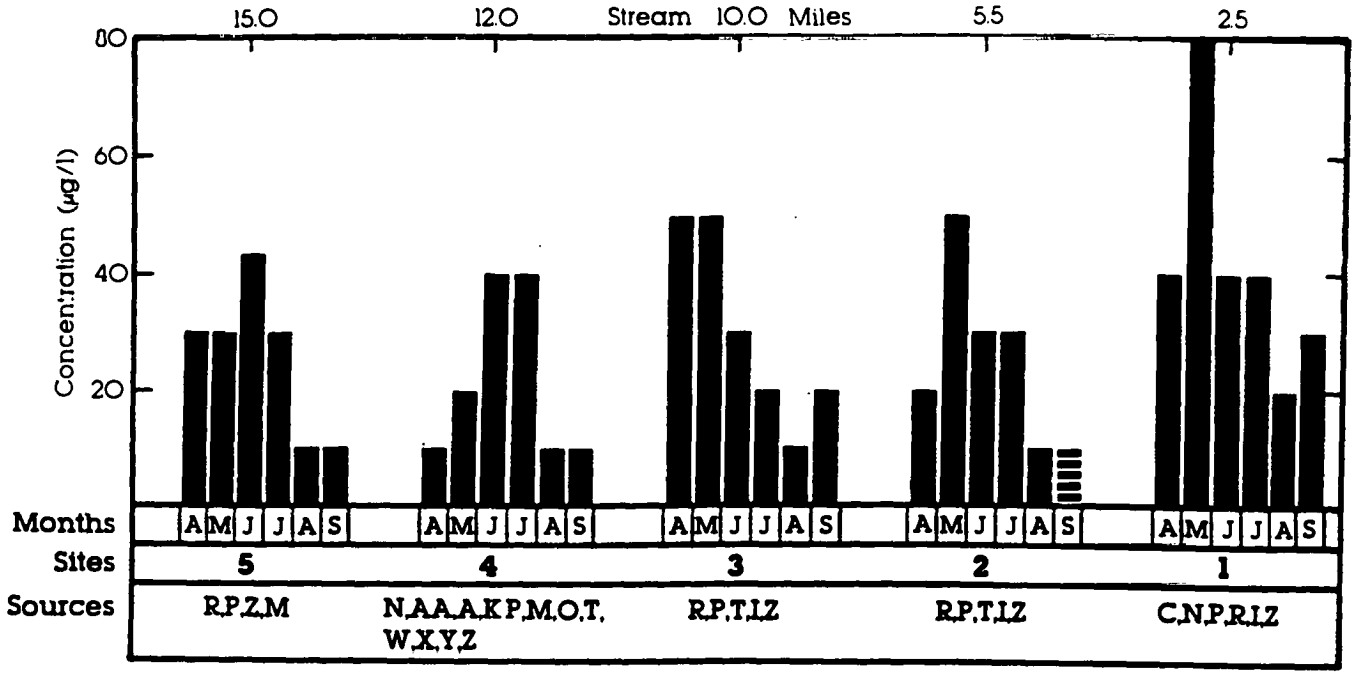
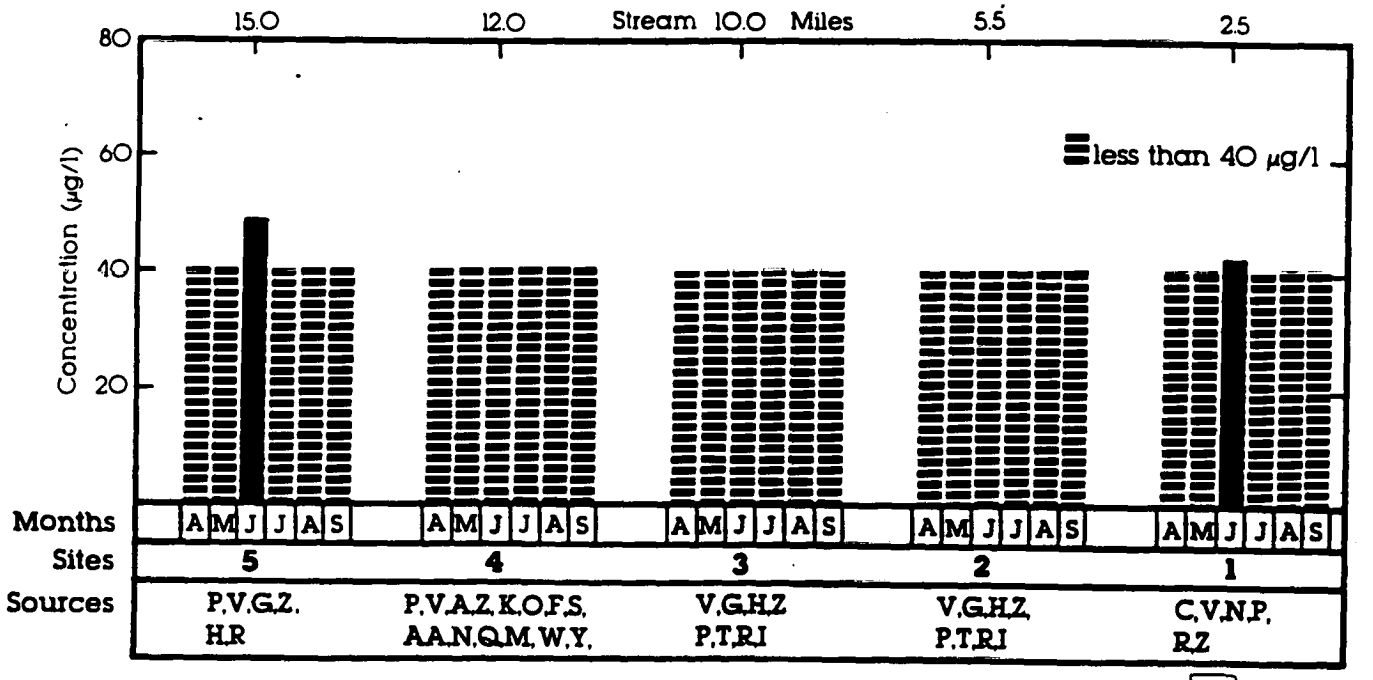



**FIGURE 19**

Dry Weather Sampling

**LEAD**




COLDWATER CREEK WATERSHED
TOXIC AGENT STUDY

FIGURE 20

Dry Weather Sampling

**TETRACHLOROETHYLENE**

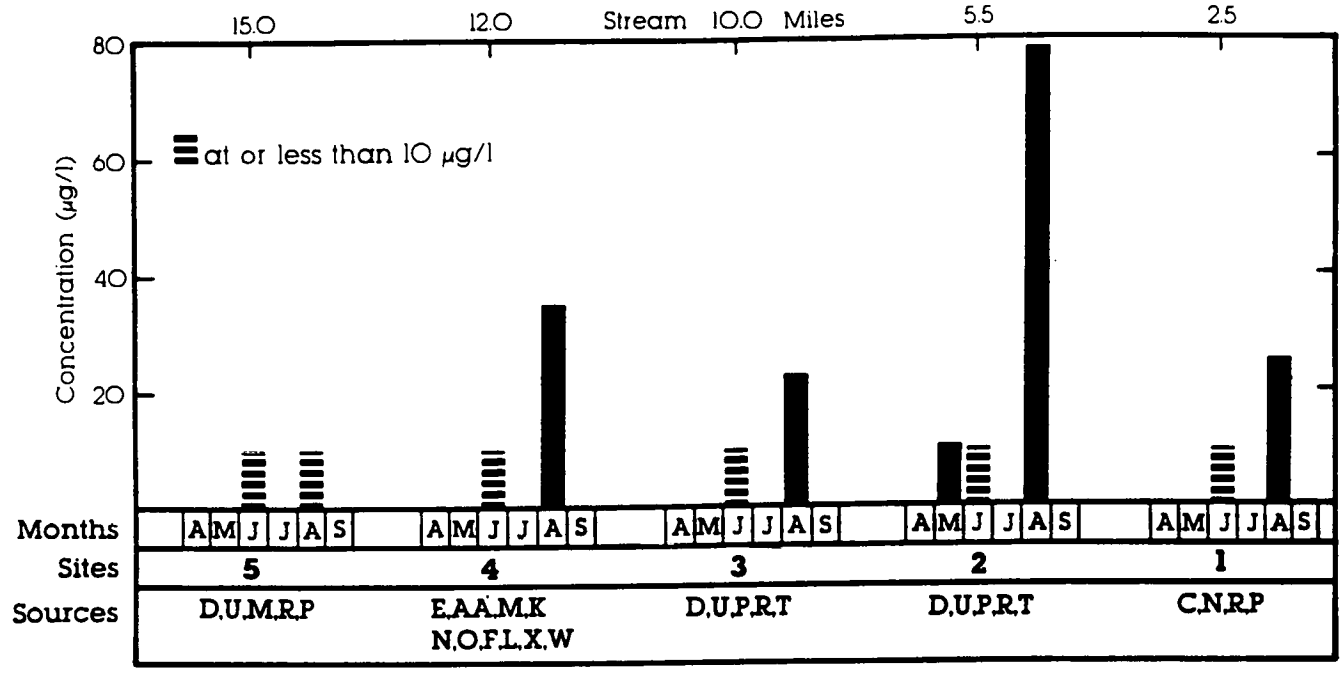
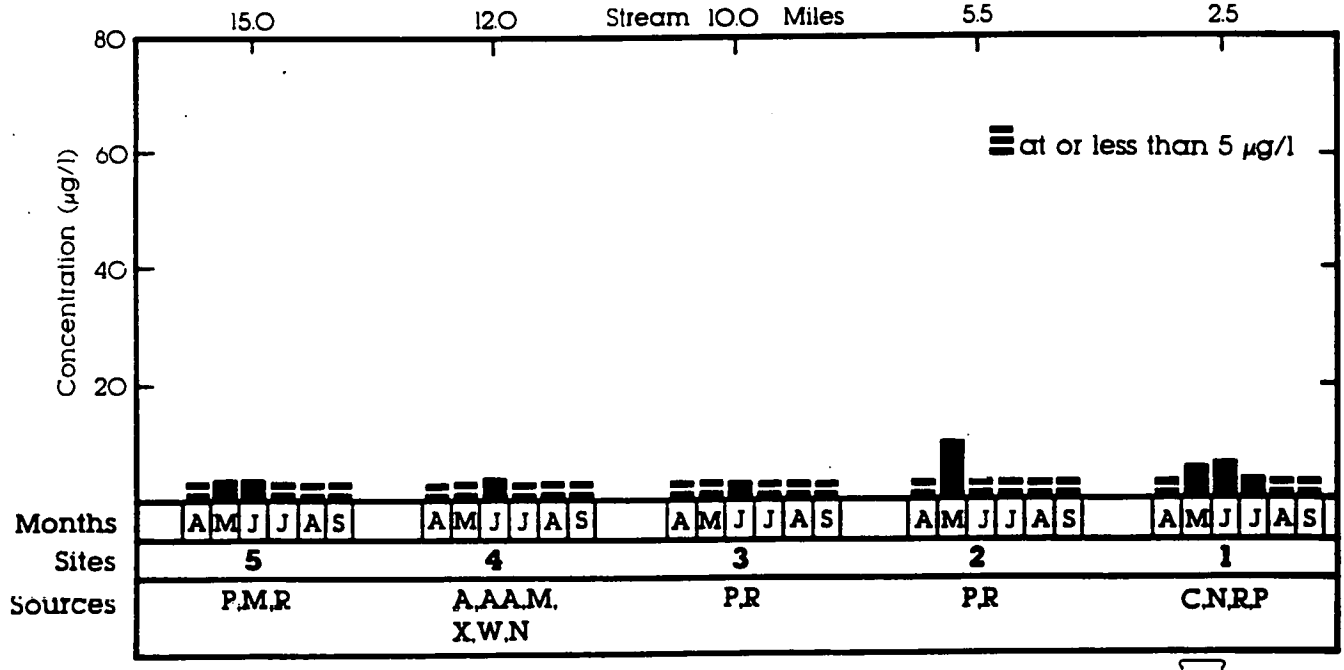



FIGURE 21

Dry Weather Sampling

**CYANIDE**




COLDWATER CREEK WATERSHED
TOXIC AGENT STUDY

FIGURE 22

Dry Weather Sampling

CHLOROFORM

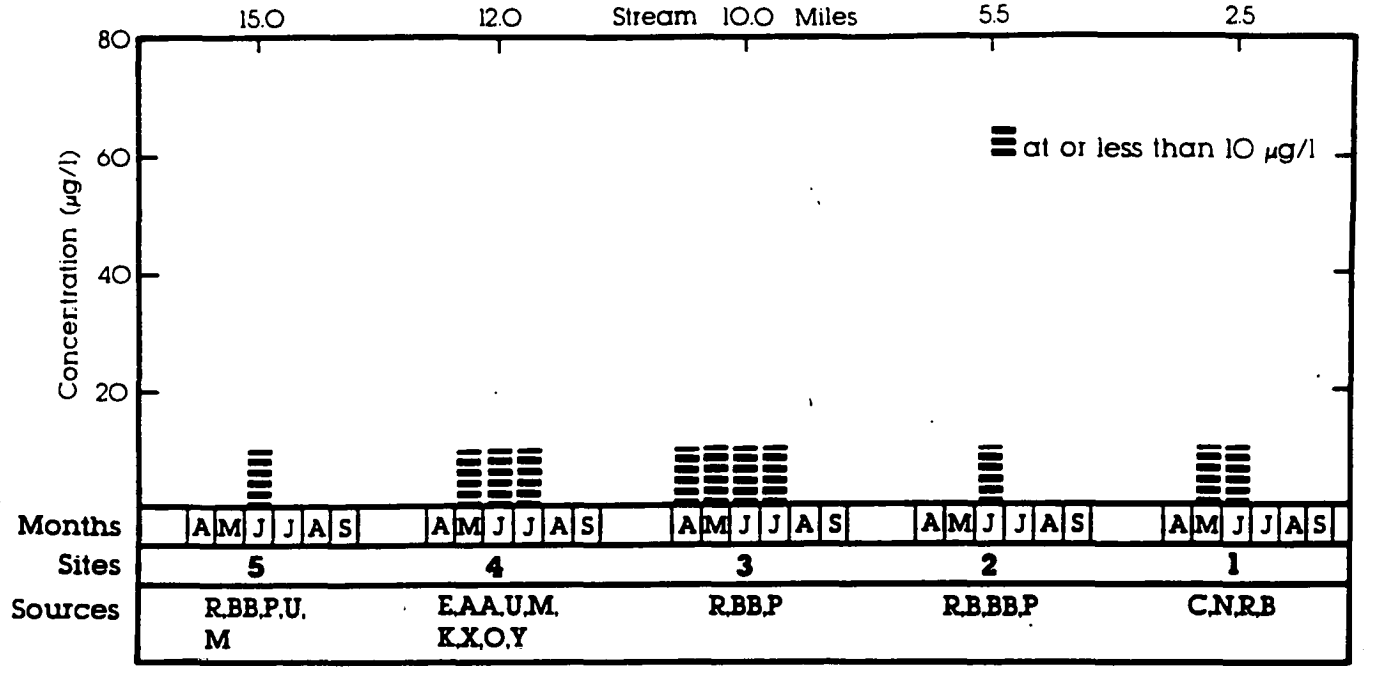
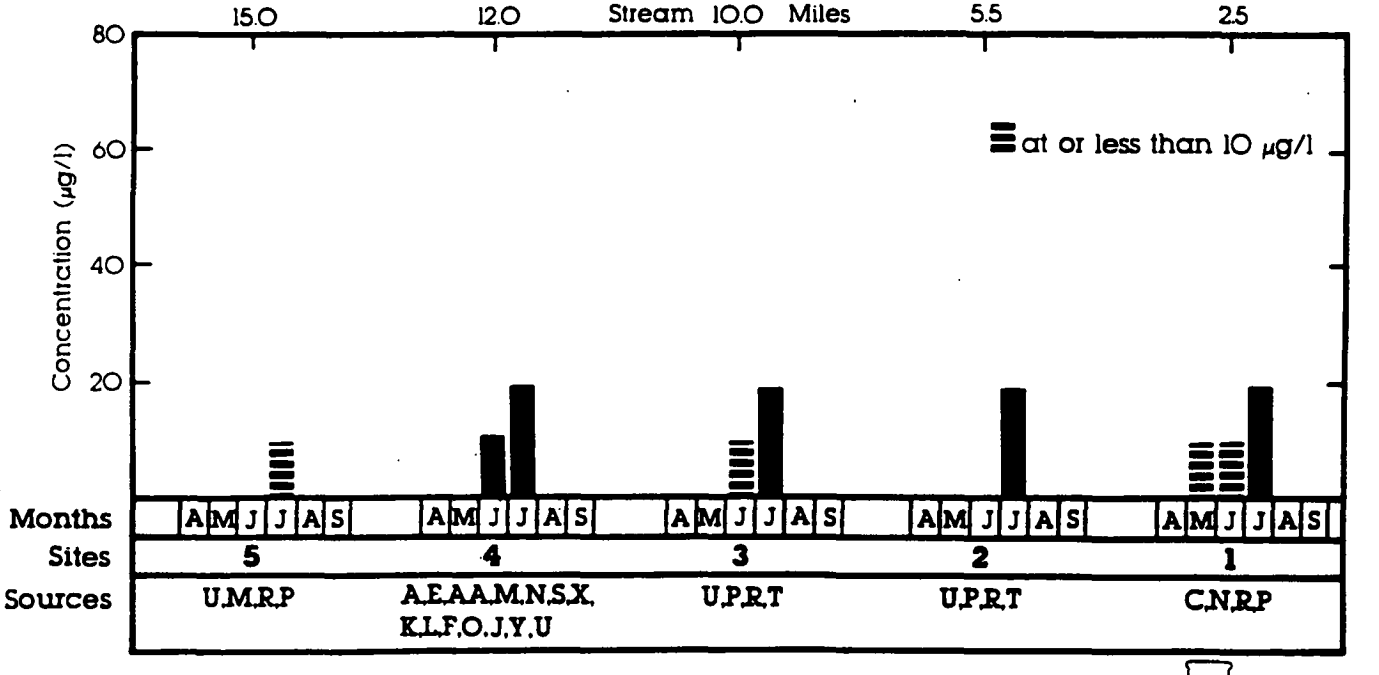



FIGURE 23

Dry Weather Sampling

METHYLENE CHLORIDE




COLDWATER CREEK WATERSHED

TOXIC AGENT STUDY

FIGURE 24

Dry Weather Sampling

TRICHLOROETHANE

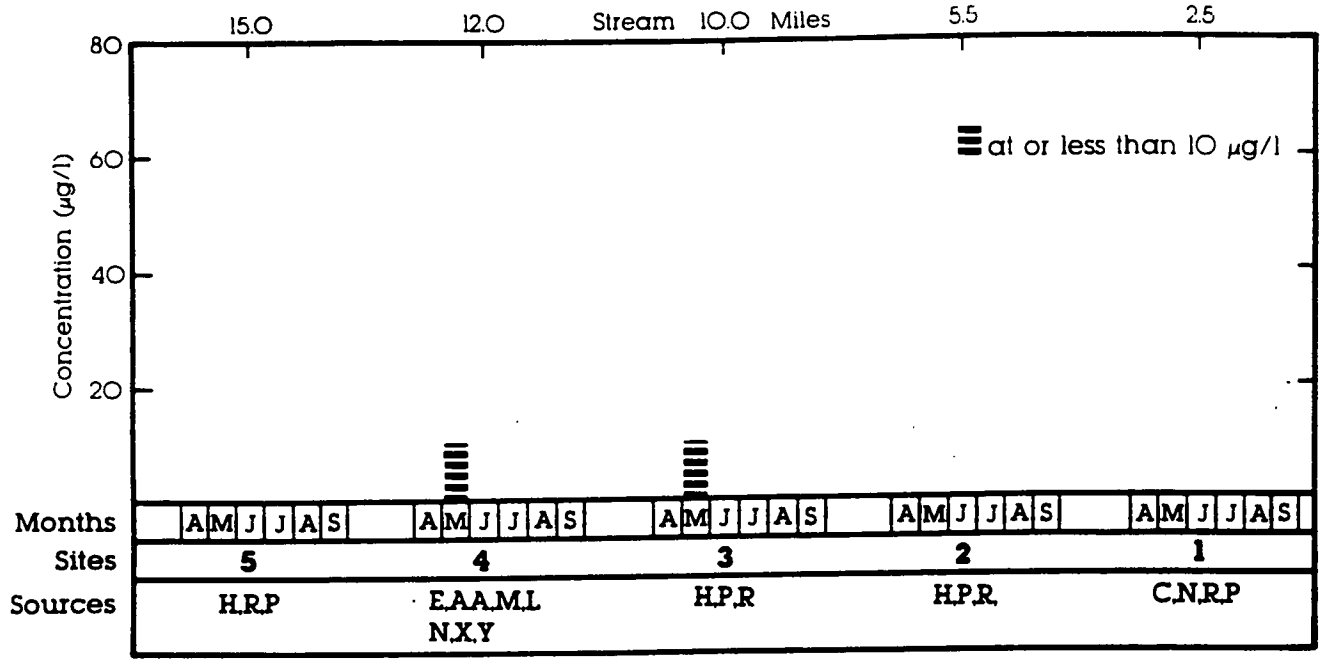
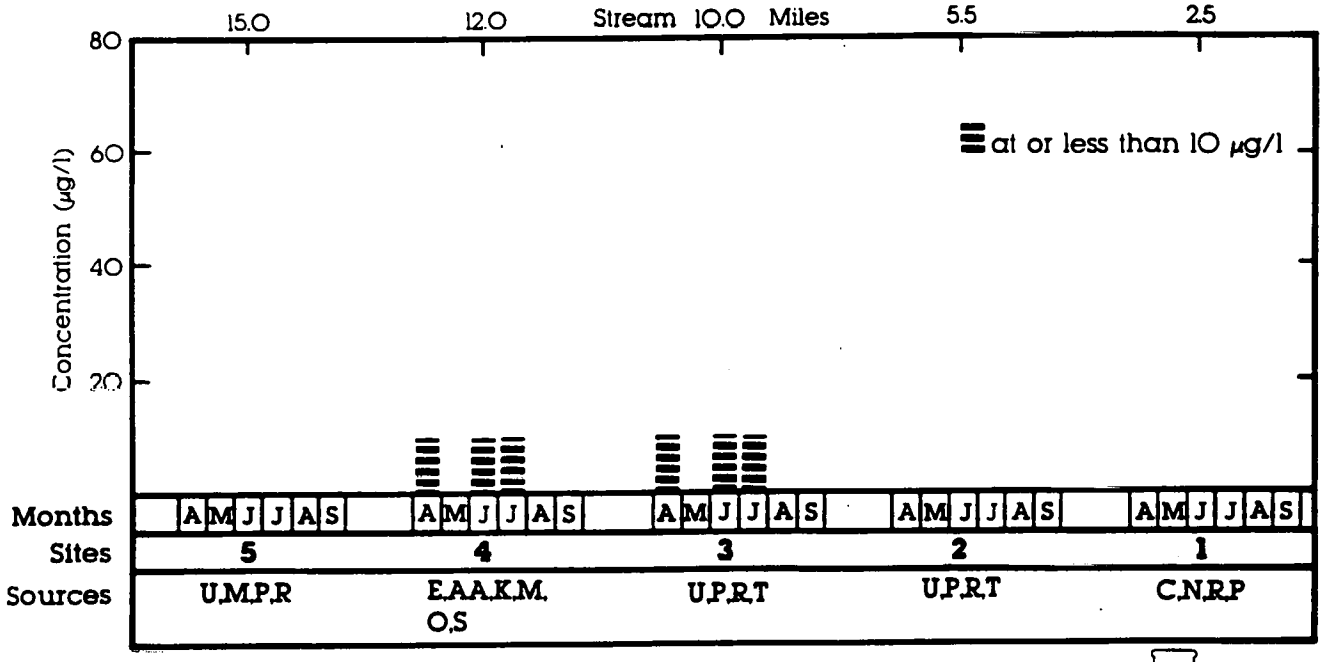



FIGURE 25

Dry Weather Sampling

TRICHLOROETHYLENE




COLDWATER CREEK WATERSHED

TOXIC AGENT STUDY

FIGURE 26

Dry Weather Sampling

**BIS (2 ETHYL HEXYL) PHTHALATE**

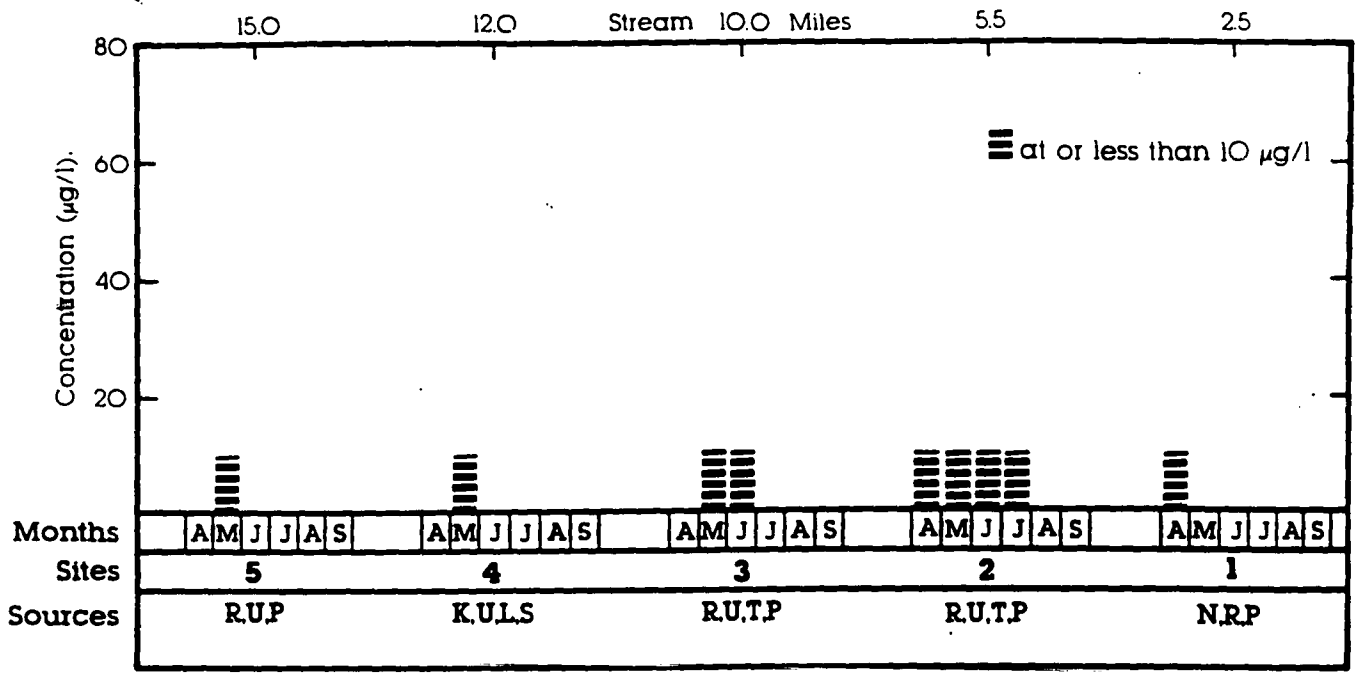
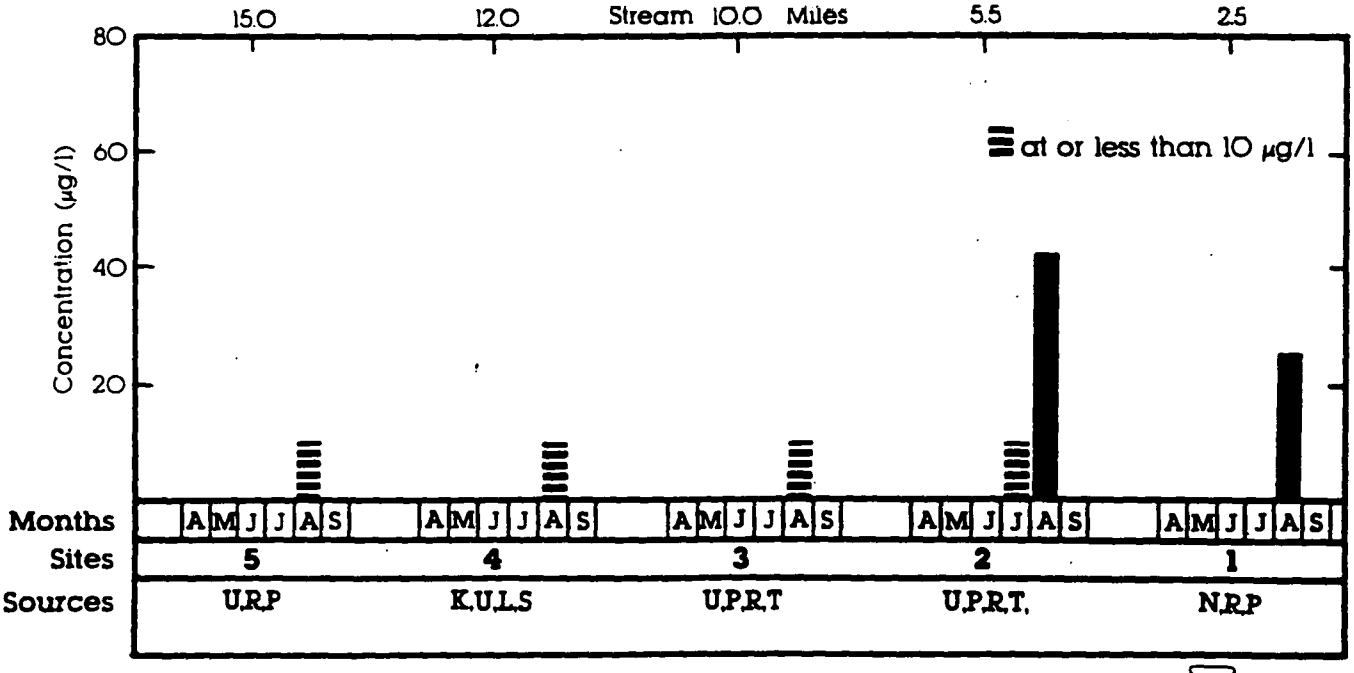



FIGURE 27

Dry Weather Sampling

**BUTYL BENZYL PHTHALATE**




COLDWATER CREEK WATERSHED

TOXIC AGENT STUDY

FIGURE 28

Dry Weather Sampling

**DIETHYL PHTHALATE**

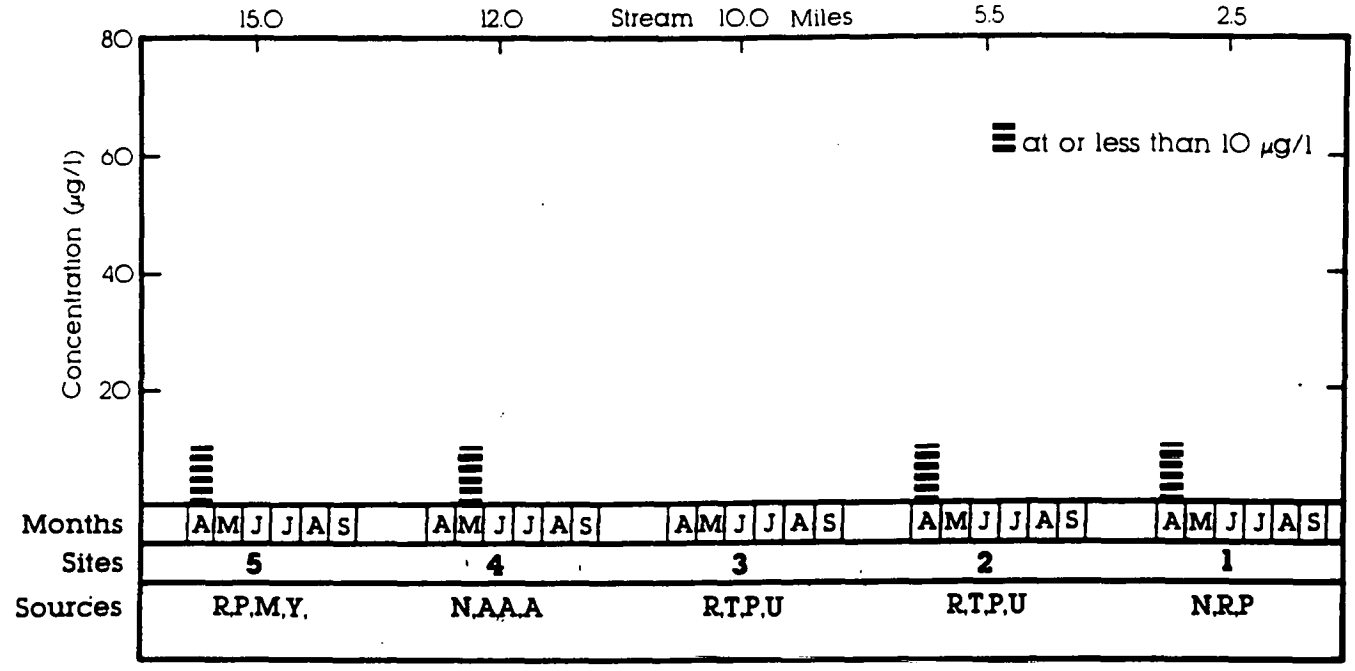
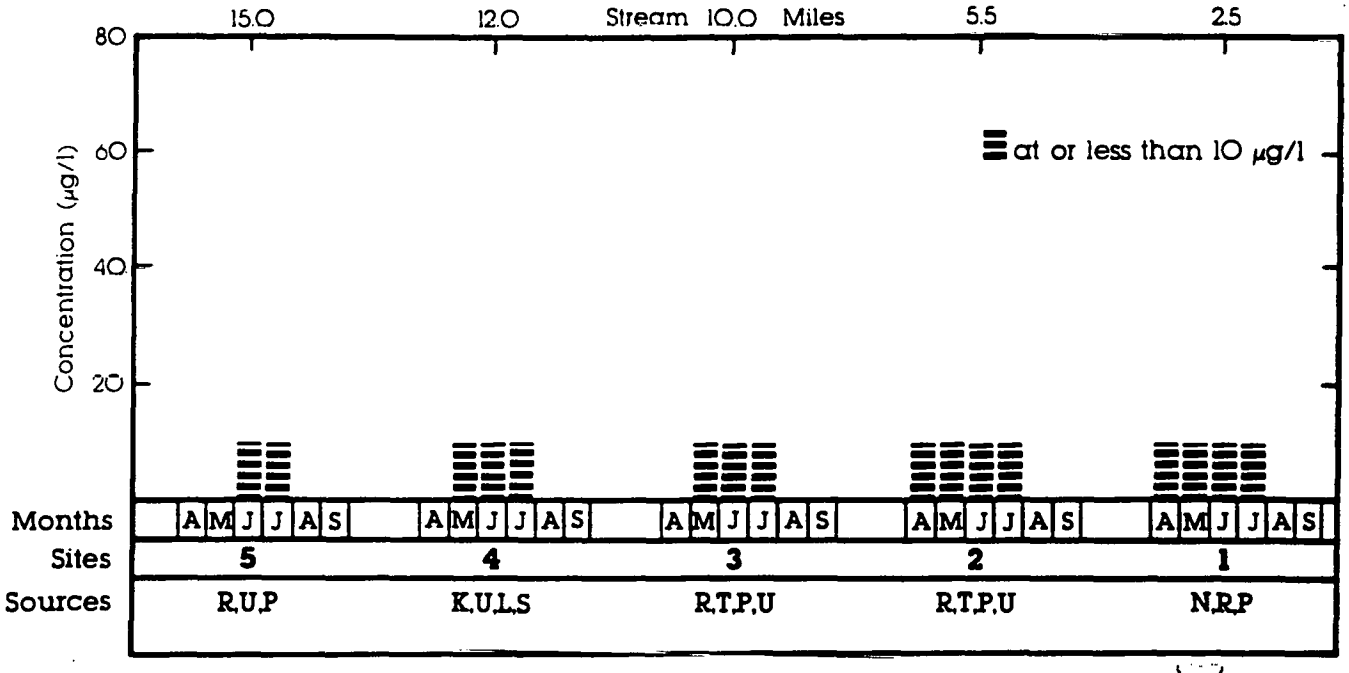



FIGURE 29

Dry Weather Sampling

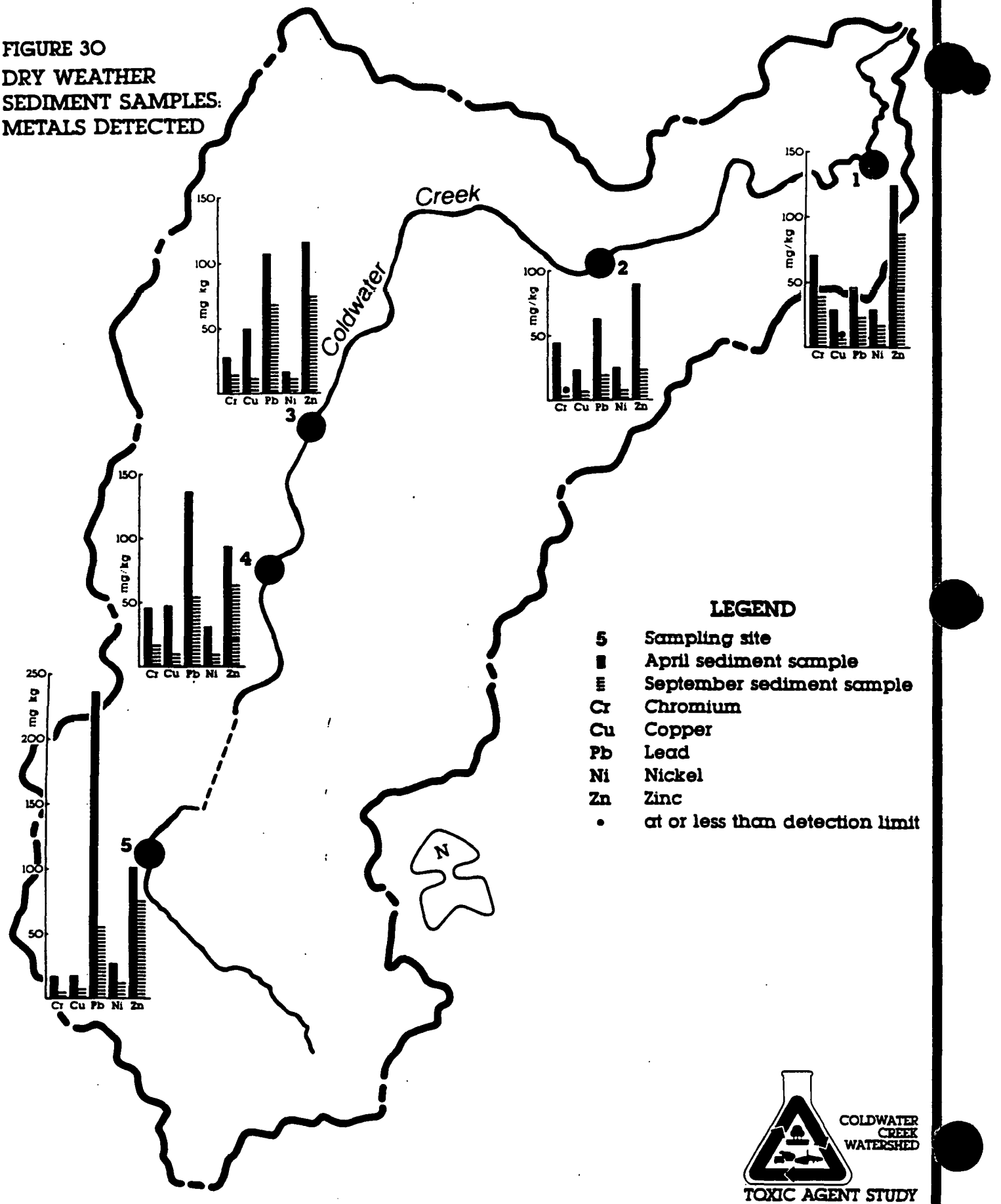
**DI-n-BUTYL PHTHALATE**




COLDWATER CREEK WATERSHED

TOXIC AGENT STUDY

FIGURE 30
DRY WEATHER
SEDIMENT SAMPLES:
METALS DETECTED




**LEGEND**

| | |
|---|---|
| 5 | Sampling site |
| ▮ | April sediment sample |
| ≣ | September sediment sample |
| Cr | Chromium |
| Cu | Copper |
| Pb | Lead |
| Ni | Nickel |
| Zn | Zinc |
| • | at or less than detection limit |

COLDWATER CREEK WATERSHED
TOXIC AGENT STUDY

FIGURE 31
DRY WEATHER
SEDIMENT SAMPLES:
ORGANIC
COMPOUNDS
DETECTED

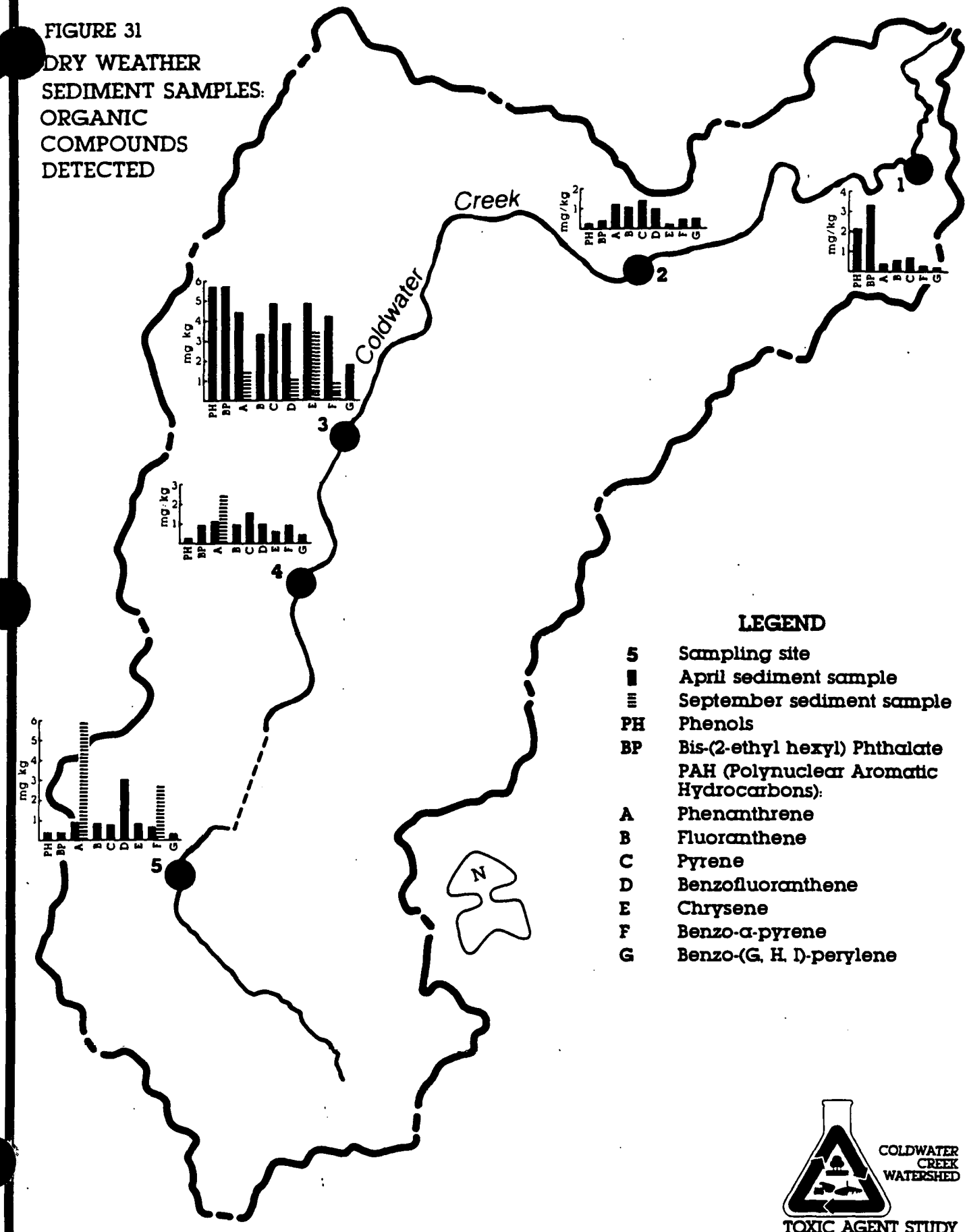


FIGURE 32

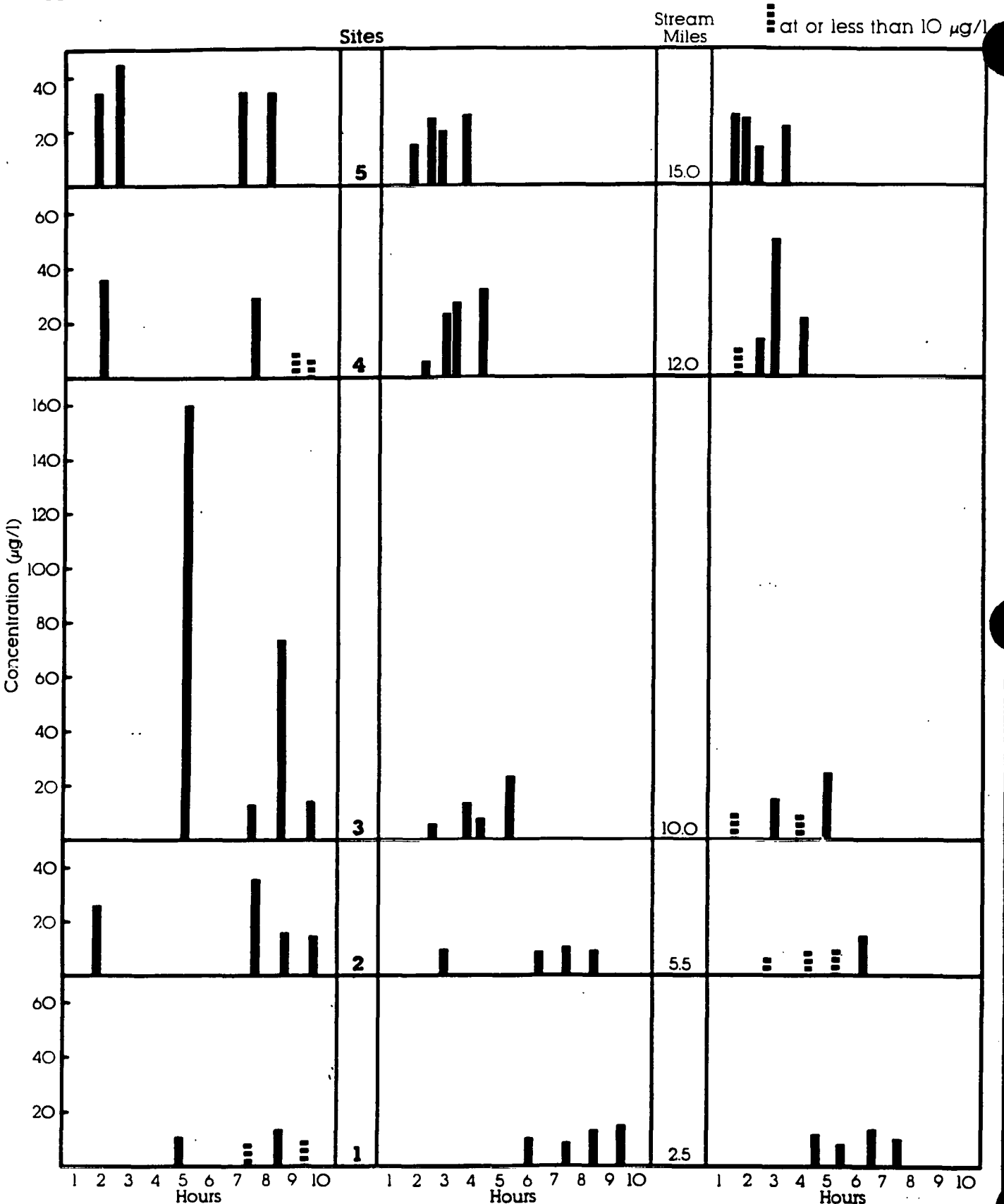

Sites
Stream Miles
at or less than 10 µg/l
Concentration (µg/l)
5
4
3
2
1
15.0
12.0
10.0
5.5
2.5
Hours
PHENOLS
Storm #1
(May 13, 1981)
PHENOLS
Storm #2
(June 11, 1981)
PHENOLS
Storm #3
(June 15, 1981)

FIGURE 33

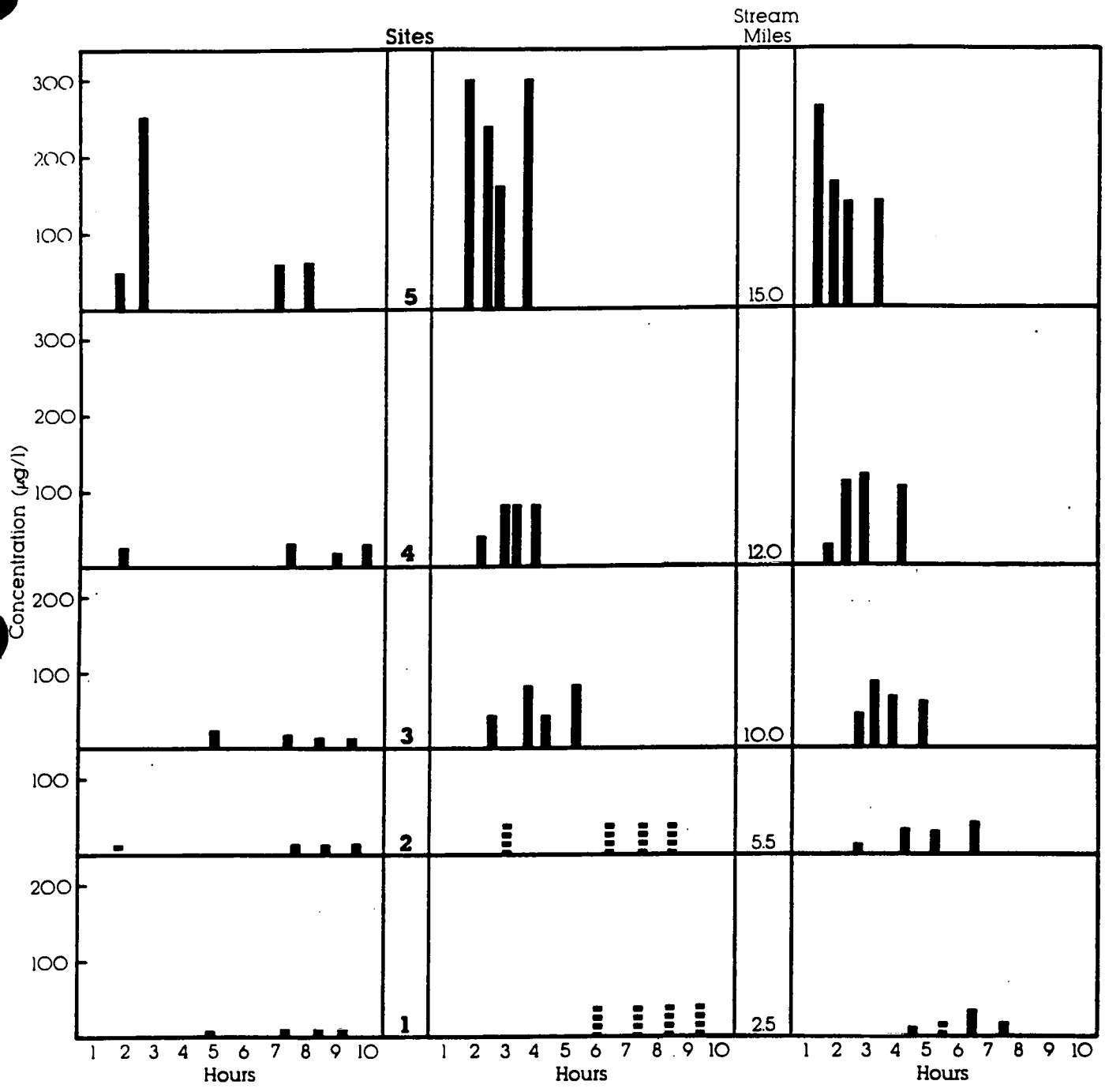
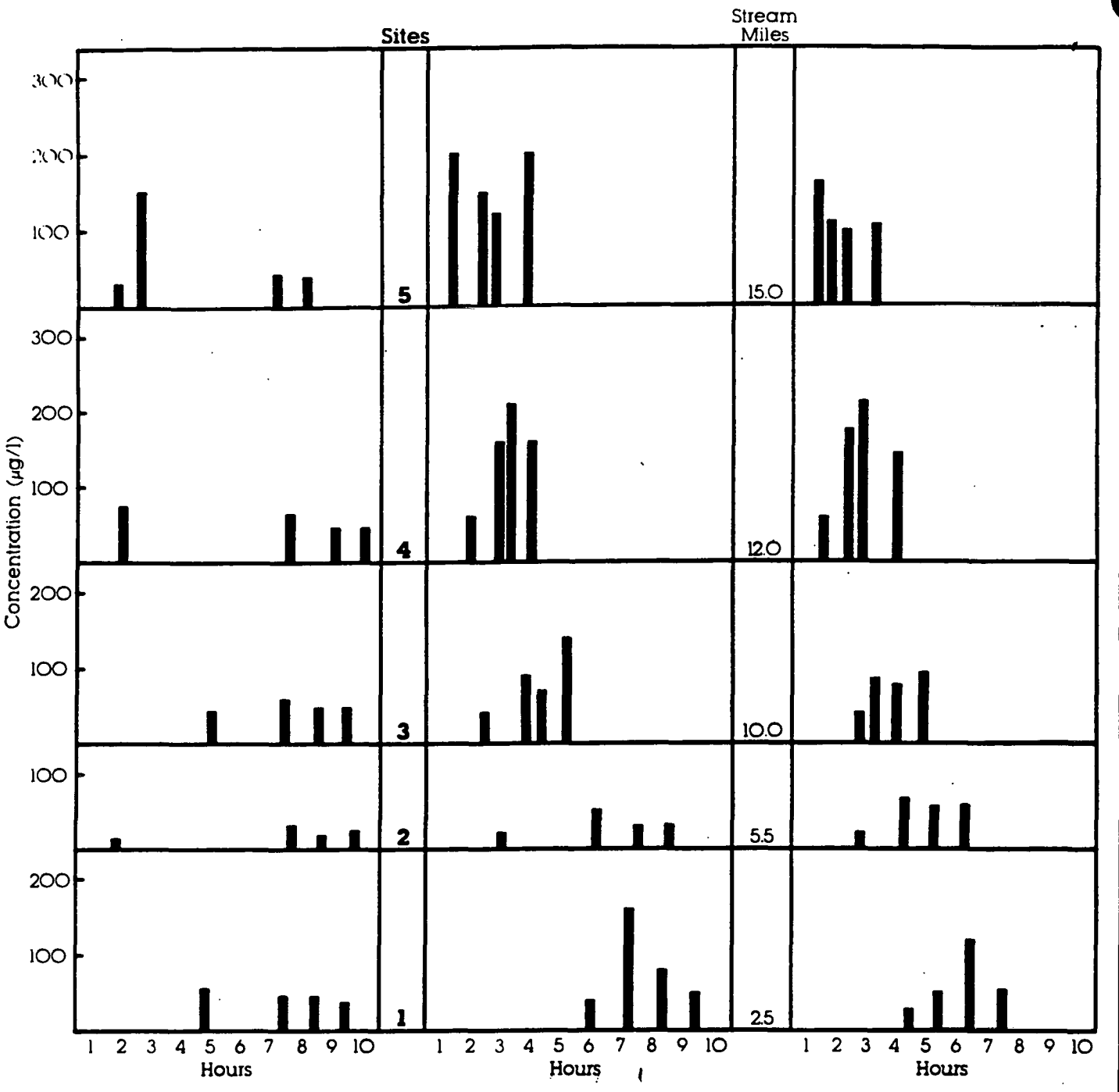

Sites
Stream Miles
Concentration (µg/l)
300
200
100
5
15.0
4
12.0
3
10.0
2
5.5
1
2.5
1 2 3 4 5 6 7 8 9 10
Hours
LEAD
Storm #1
(May 13, 1981)
LEAD
Storm #2
(June 11, 1981)
LEAD
Storm #3
(June 15, 1981)
at or less than 5 µg/l
at or less than 40 µg/l
at or less than 20 µg/l

FIGURE 34



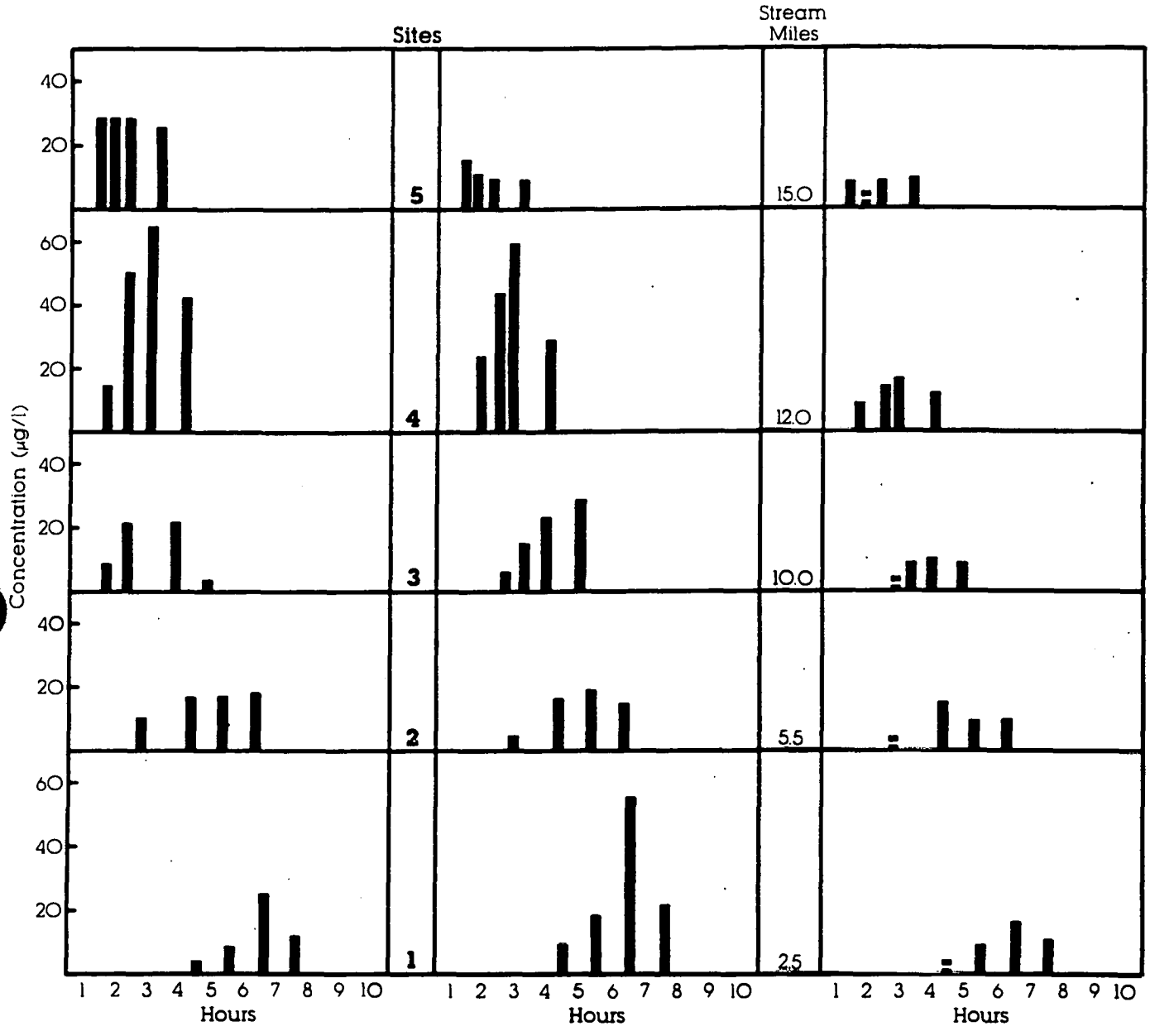

**ZINC**
Storm #1
(May 13, 1981)

**ZINC**
Storm #2
(June 11, 1981)

**ZINC**
Storm #3
(June 15, 1981)

COLDWATER CREEK WATERSHED
TOXIC AGENT STUDY

FIGURE 35 FIGURE 36 FIGURE 37




**COPPER**
Storm #3
(June 15, 1981)

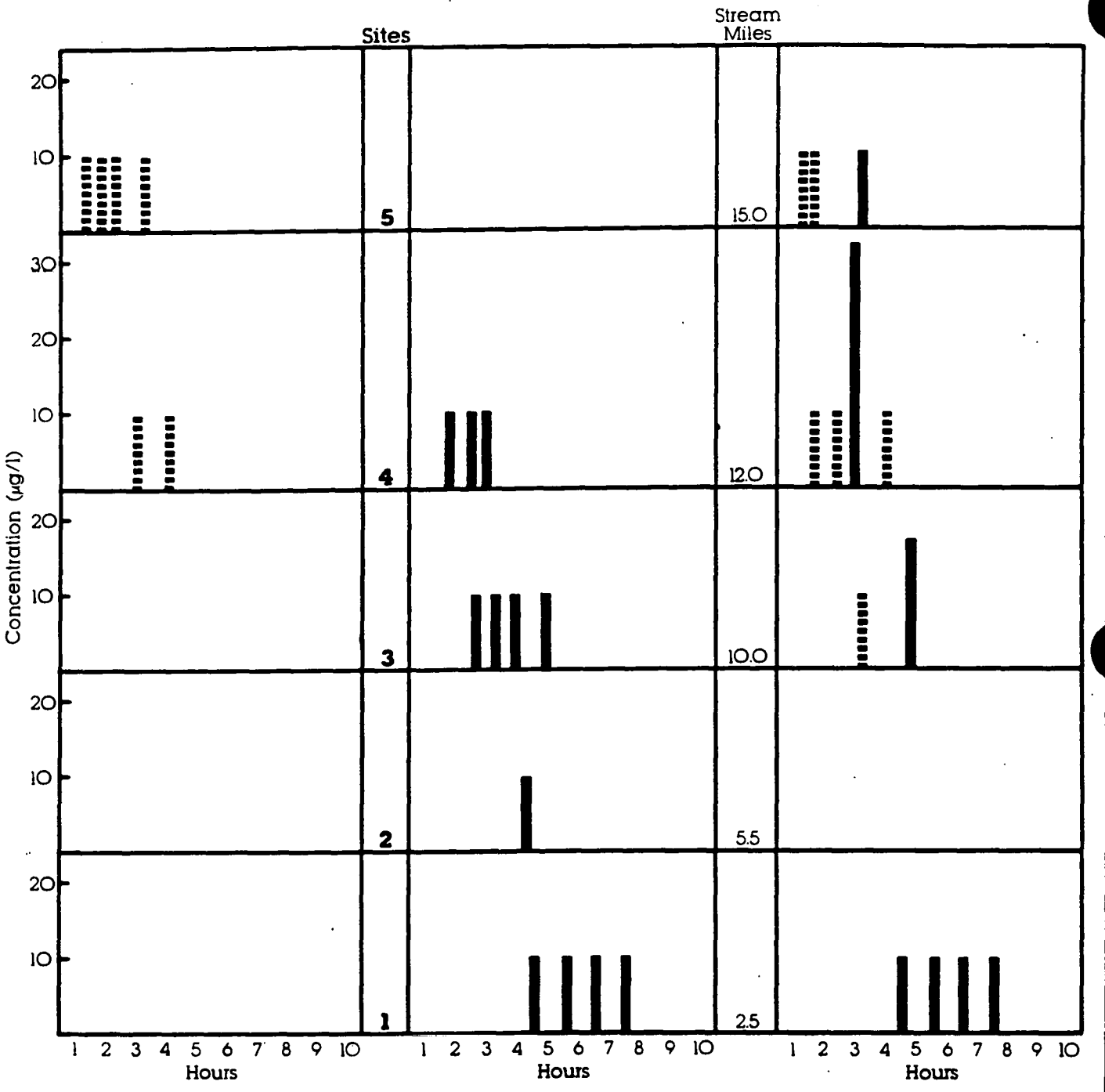
**CHROMIUM**
Storm #3
(June 15, 1981)

**NICKEL**
Storm #3
(June 15, 1981)

= at or less than 5 µg/l

COLDWATER CREEK WATERSHED
TOXIC AGENT STUDY

FIGURE 38 FIGURE 39 FIGURE 40




**POLYNUCLEAR AROMATIC HYDROCARBONS (P.A.H.)***
Storm #3
(June 15, 1981)

**METHYLENE CHLORIDE**
Storm #3
(June 15, 1981)

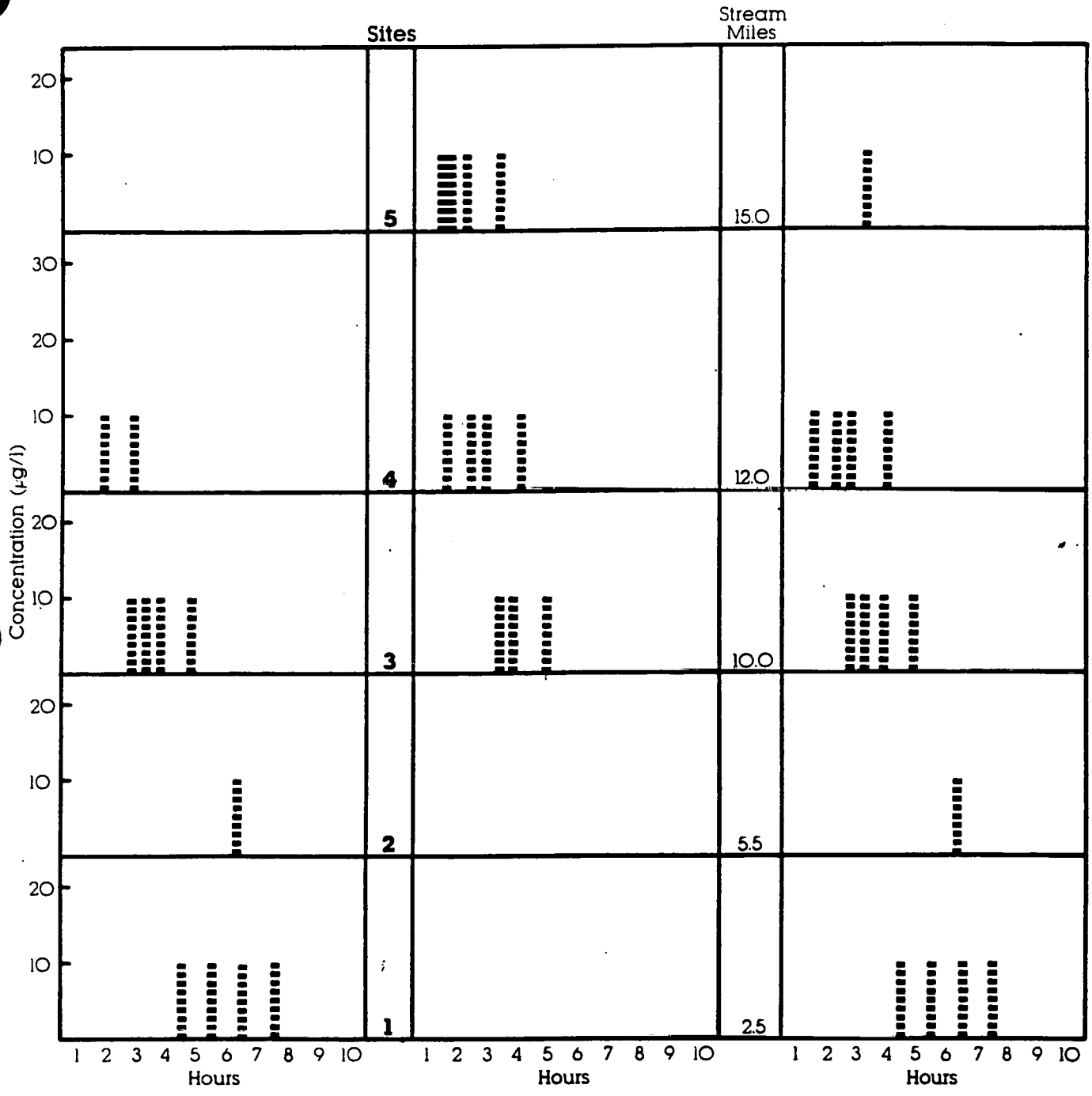
**CHLOROFORM**
Storm #3
(June 15, 1981)

▪ at or less than 10 µg/l

*P.A.H. Acenaphthene, Fluoranthene, Anthracene-Phenanthracene, Pyrene

COLDWATER CREEK WATERSHED
TOXIC AGENT STUDY

FIGURE 41 FIGURE 42 FIGURE 43




**DIETHYL PHTHALATE**
Storm #3
(June 15, 1981)

**DI-n-BUTYL PHTHALATE**
Storm #3
(June 15, 1981)

**BIS (2-ETHYL HEXYL) PHTHALATE**
Storm #3
(June 15, 1981)

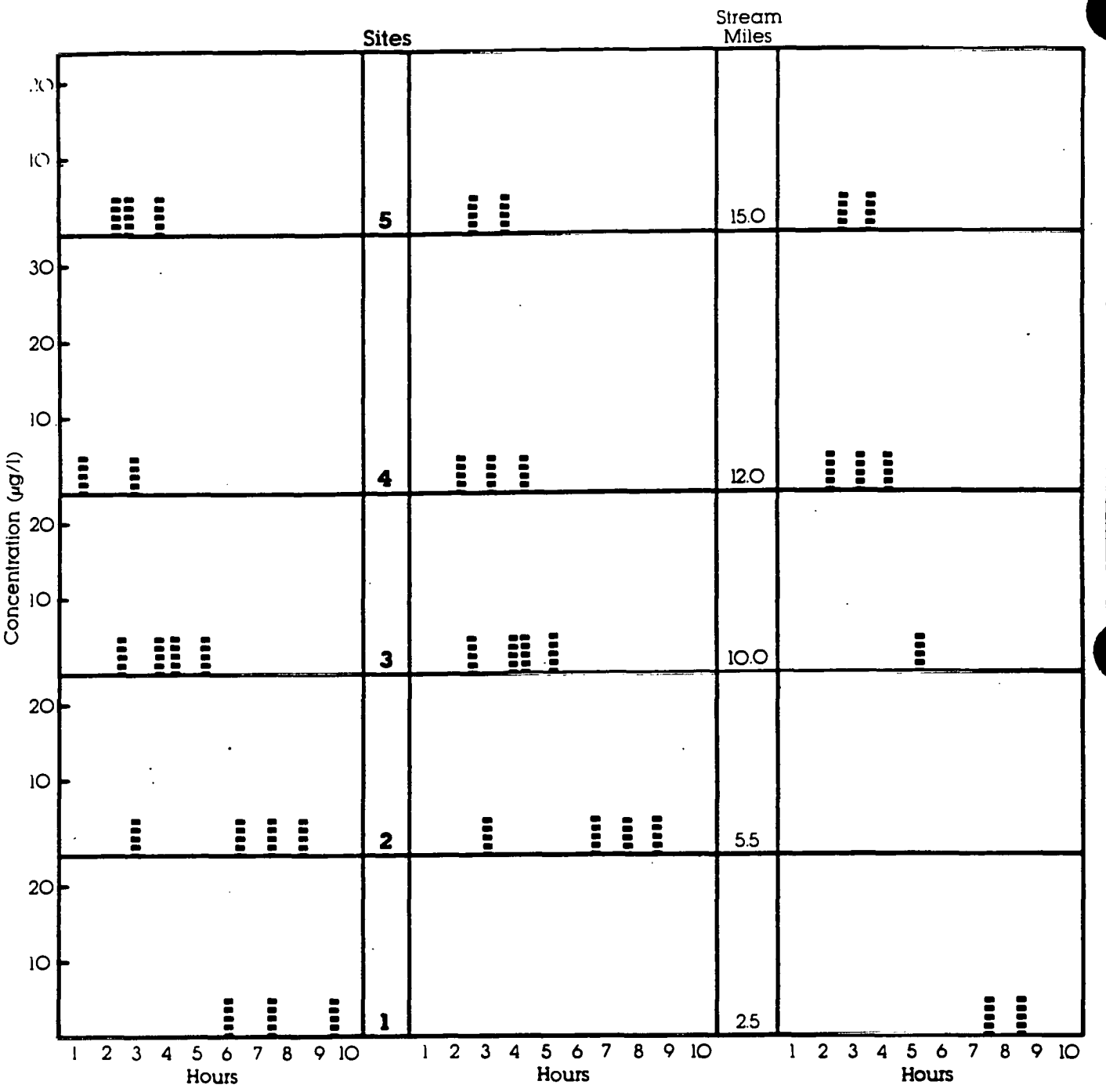
▪ at or less than 10 µg/l

COLDWATER CREEK WATERSHED
TOXIC AGENT STUDY

FIGURE 44

FIGURE 45

FIGURE 46




**ALPHA-BHC**
Storm #2
(June 11, 1981)

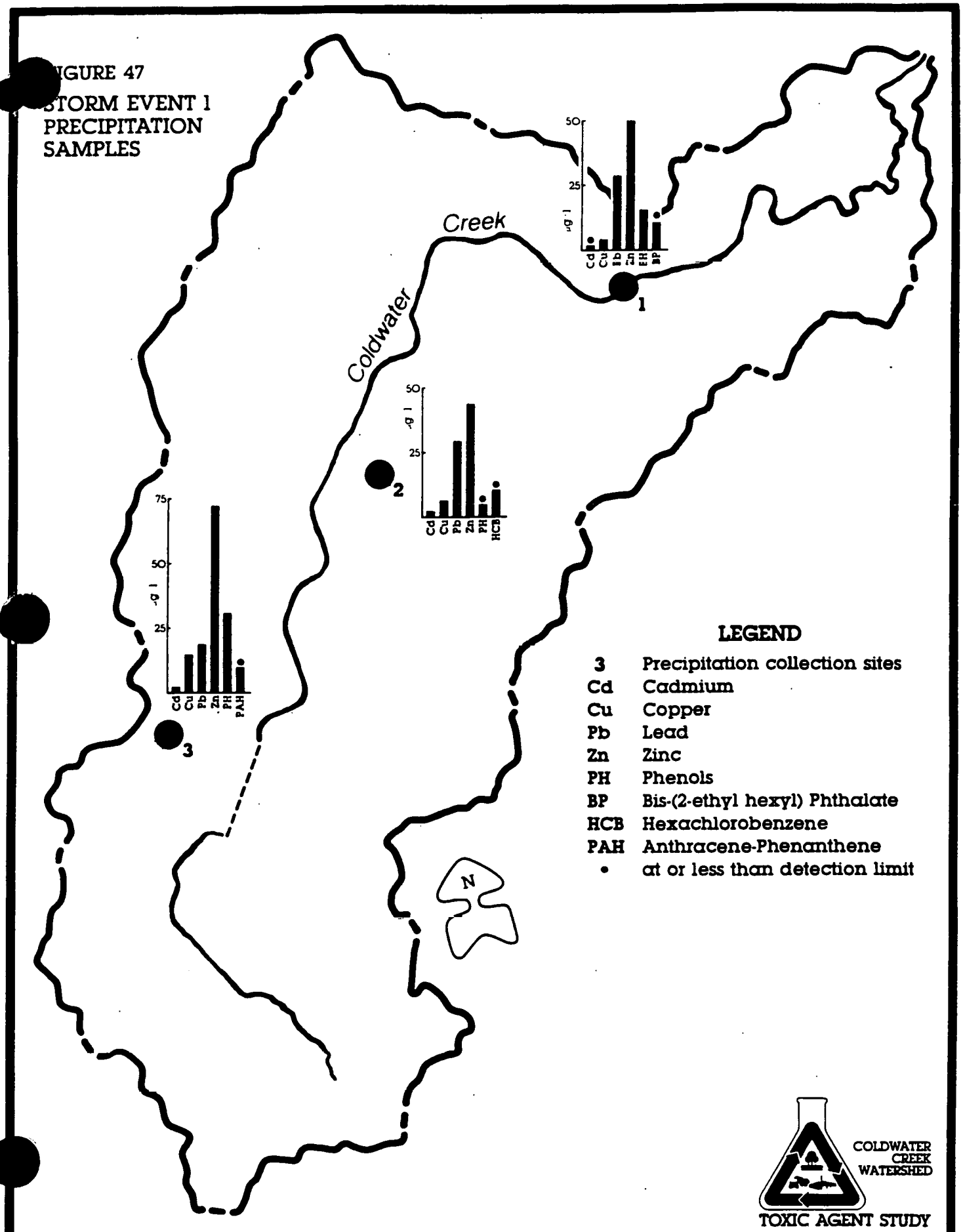
**GAMMA-BHC**
Storm #2
(June 11, 1981)

**DIELDRIN**
Storm #2
(June 11, 1981)

at or less than 5 µg/l

COLDWATER CREEK WATERSHED
TOXIC AGENT STUDY

FIGURE 47
STORM EVENT 1
PRECIPITATION
SAMPLES



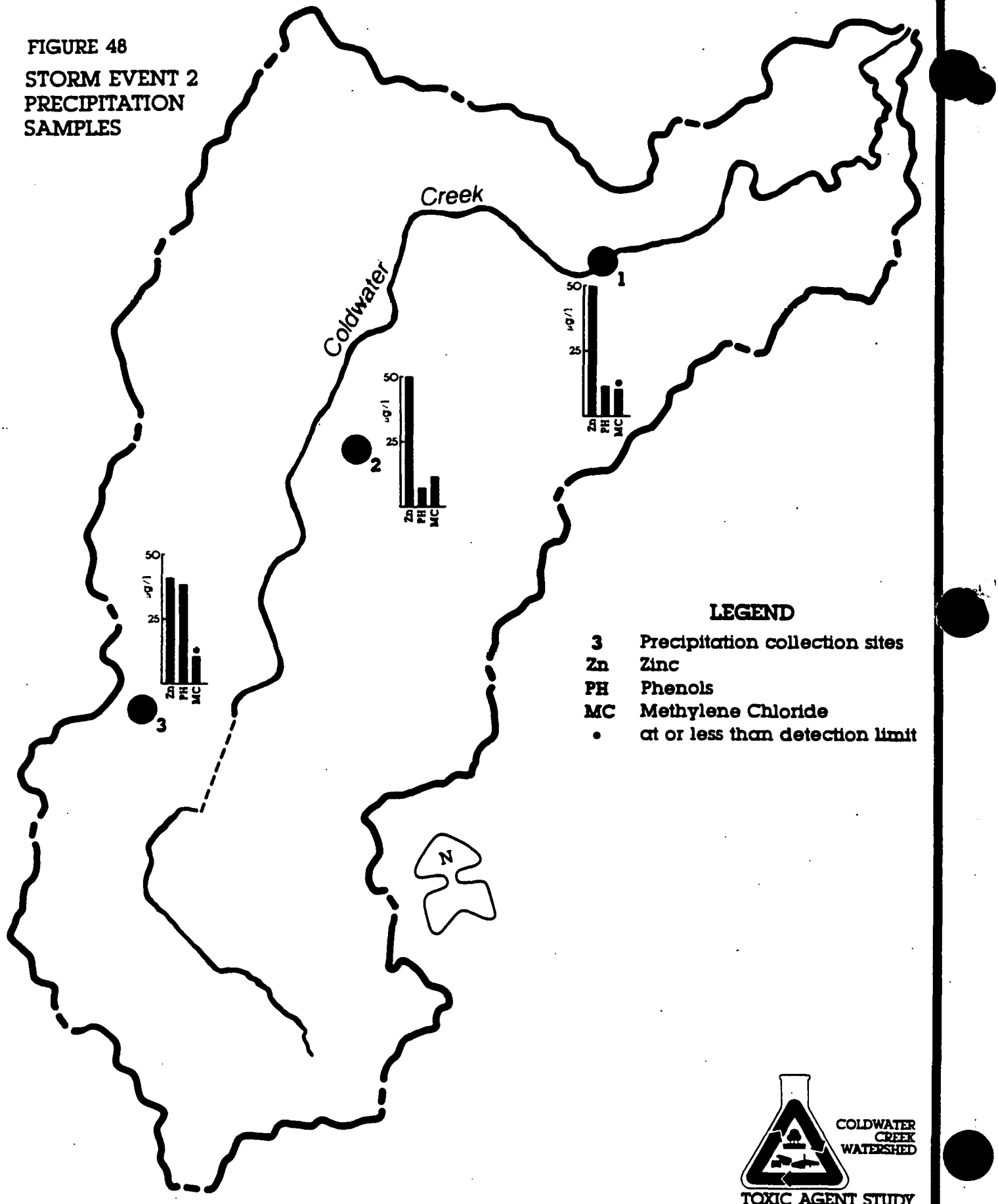

**LEGEND**

| | |
|---|---|
| 3 | Precipitation collection sites |
| Cd | Cadmium |
| Cu | Copper |
| Pb | Lead |
| Zn | Zinc |
| PH | Phenols |
| BP | Bis-(2-ethyl hexyl) Phthalate |
| HCB | Hexachlorobenzene |
| PAH | Anthracene-Phenanthene |
| • | at or less than detection limit |

COLDWATER CREEK WATERSHED
TOXIC AGENT STUDY

FIGURE 48

STORM EVENT 2
PRECIPITATION
SAMPLES

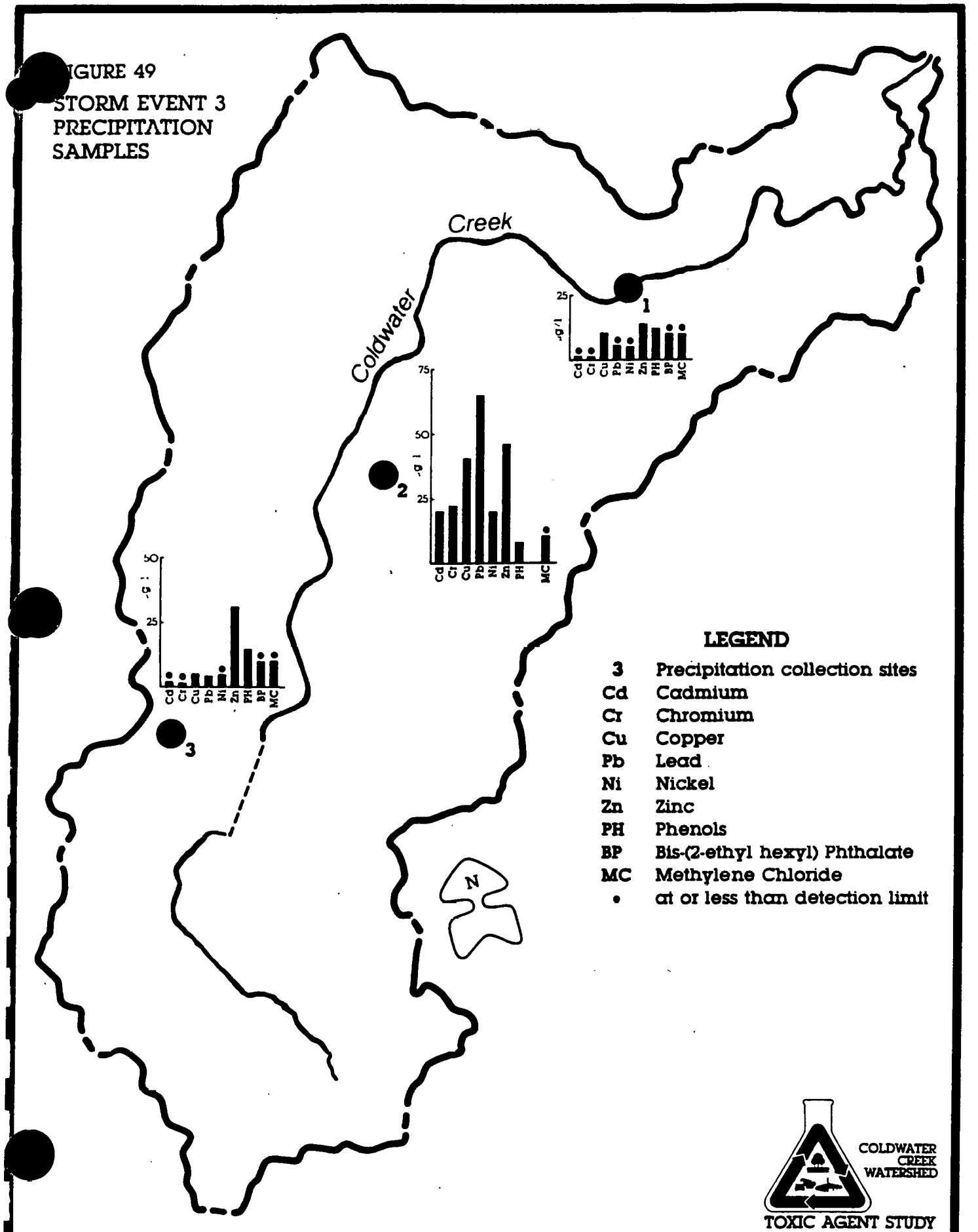



**LEGEND**

| | |
|---|---|
| 3 | Precipitation collection sites |
| Zn | Zinc |
| PH | Phenols |
| MC | Methylene Chloride |
| • | at or less than detection limit |

COLDWATER CREEK WATERSHED
TOXIC AGENT STUDY

FIGURE 49
STORM EVENT 3
PRECIPITATION
SAMPLES




**LEGEND**

| | |
|---|---|
| 3 | Precipitation collection sites |
| Cd | Cadmium |
| Cr | Chromium |
| Cu | Copper |
| Pb | Lead |
| Ni | Nickel |
| Zn | Zinc |
| PH | Phenols |
| BP | Bis-(2-ethyl hexyl) Phthalate |
| MC | Methylene Chloride |
| • | at or less than detection limit |

COLDWATER CREEK WATERSHED
TOXIC AGENT STUDY

# 7. EVALUATION CRITERIA ASSESSMENT

This chapter is divided into three sections. In the first, the environmental effects of the priority pollutants detected in Coldwater Creek are discussed. The second section examines the decision-making process developed during the course of the study to establish water quality criteria for these priority pollutants. The last section presents the water quality criteria developed for the 25 priority pollutants found in Coldwater Creek.

## A. ENVIRONMENTAL AND BIOLOGICAL EFFECTS

The biological effects of the priority pollutants detected in Coldwater Creek is discussed below. The documents consulted for each pollutant are identified by a number. This list of documents can be found in Appendix G. The level and detail of information varies with each of the toxic agents. When possible, four areas of description were applied to each toxic material. They were: biological effect; toxicity; criteria; and environmental fate.

Biological effect relates to how a particular chemical affects biological processes. These include:

Bioconcentration Factors - uptake factors for a substance directly absorbed from the concentration in the water.

Bioaccumulation - identifies to what extent and how a particular substance accumulates in a particular organism.

Biotransformation - describes a process that would alter a substance through biological processes, with an enzyme as the catalyst.

Biodegradation - describes the process which breaks down a particular substance through biological means.

Toxicity is the property of a chemical to induce a harmful response in living organisms.

Criteria are the levels of pollutants that affect the suitability of water for a given use.

Environmental fate is an identification of the various physical, chemical and biological pathways that influence existence of a chemical in the aquatic system. The various processes reviewed included: volatilization; hydrolysis; photolysis; sorption; and oxidation.

A review of the environmental fate indicates what physical/chemical processes are important to a particular substance in Coldwater Creek. For example, if volatilization is an important physical process which causes rapid elimination of toluene in solution, then less emphasis should be placed on control of this pollutant in the water environment, with more emphasis in the air environment. This is in contrast to a chemical which is more persistent in the aquatic environment and more toxic to aquatic life.

Twenty-five priority pollutants were found in Coldwater Creek during the wet and dry sampling events. The physical properties, the human health effects and the environmental effects of these pollutants are described below.

Aldrin[23, 24, 25, 26, 27, 28]

Aldrin is a chlorinated hydrocarbon which is used as a pesticide. It is easily transformed to dieldrin.

Biological Effect. Bioconcentration factors of aldrin in both the terrestrial and aquatic environment range from 1 X $10^3$ to 1 X $10^4$. In short time periods, biouptake may be an important process. Since aldrin is quite rapidly converted to dieldrin in the environment, significant bioaccumulation of Aldrin through food chains probably does not occur. The low bioconcentration factors may be due to the large amount of dieldrin found in the test organisms which originally was aldrin.

Bioconcentration can also occur through contact with water containing aldrin. The bioconcentration factors for fish species after three days of testing ranged from 260-460; for Daphnia, 1800-9100; and for mosquito larve, 970-1100.

Toxicity. The U.S. Fish and Wildlife Service has conducted bioassays to identify lethal aldrin concentrations for several fish species.

TABLE 8
LETHAL ALDRIN TOXICITY TO COMMON AQUATIC SPECIES

| Organism | 96 Hour Lethal Concentration For 50% of Test Organisms* |
|---|---|
| Channel Catfish | 53 ug/l |
| Black Bullhead | 19 ug/l |
| Bluegill | 6.2 ug/l |

*95% confidence interval

Toxicity was not appreciably modified by variations of temperature (2-18°C) or water hardness (40-135 ppm).

Criteria. Maximum concentrations for the protection of aquatic life are: for acute toxicity, 0.53 ug/liter(1) and for chronic toxicity, 0.0019 ug/liter(1). For humans, for maximum protection, the recommended concentration in water is zero.

Aldrin is a suspected carcinogen. Estimated risk levels of contracting cancer, as stated in the Federal Register of November 28, 1980, are: $10^{-5}$ at 0.74 ng/l; $10^{-6}$ at 0.0974 ng/l; and $10^{-7}$ at 0.0074 ng/l.

These exposure levels are primarily determined from the consumption of aquatic organisms in which bioconcentration has already occurred.

Environmental Fate. Volatilization is probably the most important physical process for aldrin, with its half life considered in terms of days. The most active processes are bioaccumulation and biodegradation. Photolysis, oxidation and hydrolysis do not appear to be important. Sorption may be important over time, when significant biological activity is lacking.

## Dieldrin[23, 24, 27, 28]

Dieldrin is a chlorinated hydrocarbon which is used as a pesticide and is persistent in the environment.

Biological Effect. In various organisms the bioconcentration factors for dieldrin ranged from $1 \times 10^2$ to $1 \times 10^4$. Results of microcosm experiments suggest the following bioconcentration

factors: for algae, 1 X $10^3$; for snails, 8 X $10^4$; and for fish, 4.5 X $10^3$.

Toxicity. Dieldrin is a suspected carcinogen. In a bioassay performed by the U.S. Fish and Wildlife Service, the 96 hour LCSO at 95 percent confidence interval for channel catfish was between 19 and 45 ug/l, and for bluegill was between 3.1 and 11 ug/l. Toxicity was doubled for bluegill where temperature was raised from 7 degrees Centigrade to 29 degrees Centigrade. Water hardness did not appear to affect toxicity.

Criteria. Protection of aquatic life values are .07 ug/l for acute and .0069 ug/l for chronic. For humans, the recommended concentration in water for maximum protection is zero. Estimated risk levels established for dieldrin are: $10^{-5}$ for .71 ng/l, $10^{-6}$ for .071 ng/l, and $10^{-7}$ for .0071 ug/l (Federal Register, 45:231:79325). Exposure levels are primarily from consumption of aquatic organisms in which bioconcentration has already occurred.

Environmental Fate. Processes important in the fate of dieldrin are volatilization, sorption, and bioaccumulation. Those processes which are not considered important to the fate of dieldrin include photolysis, oxidation, hydrolysis, and bioaccumulation, although the latter may be the ultimate loss process of the sediment.

## Cyanide[23, 24, 25, 29]

Cyanides are defined as organic or inorganic compounds which contain the CN group.

Biological Effect. In biological systems, hydrogen cyanide interferes with enzymes associated with cellular oxidation. Either this material is quickly metabolized, or the organism is killed. Metal cyanide complexes have demonstrated the ability to bioaccumulate in fish, although the metal cyanides are less toxic than hydrogen cyanide.

Hydrogen cyanide and metallocyanide complexes are all subject to biodegradation in almost all organisms at low concentrations.

Toxicity. No data exist to suggest that cyanide produces such irreversible effects as mutagenesis, teratogensis or cancer (Federal Register, Vol. 44, No. 144, 43667).

Criteria. For the protection of aquatic life the standards are: to avoid acute toxicity, 1.4 ug/l; and to reduce chronic toxicity, 17.0 ug/l. The average daily intake limit for humans is 8.4 mg/day, assuming 2 liters of water consumed, a 70 kilogram person, a safety factor of 100, and cyanide concentration in the water at 4.16 mg/l.

Environmental Effect. Free hydrogen cyanide (HCN) is very reactive; it occurs rarely in nature. Hydrogen cyanide is very soluble in all proportions in water and is quite volatile. The cyanide ion joins with a variety of metals and forms insoluble metal cyanides. Inorganic cyanides hydrolyze in water and form ammonia and bicarbonate ions. Organic compounds which have a cyanide group as a constituent are nitrites. The nitrites are much less toxic than free hydrogen cyanide or the metal cyanides, and nitrites with low molecular weight have a fate similar to hydrogen cyanide.

Volatilization and biodegradation are the dominant processes affecting hydrogen cyanide and the nitrites. At a pH of 10 most of the free cyanide will be in the form of HCN which is quite volatile. The simple metal cyanides are insoluble and tend to accumulate in streambed sediments. Complex metallocyanides are transported in solution by the water column.

Cyanide is unlikely to become a widespread environmental pollutant because of its low degree of persistence in the biosphere. Well controlled attempts to show cumulative toxic effects of cyanide have not been successful.

Endosulfan[23, 24, 25, 27]

Endosulfan is a chlorinated hydrocarbon which is used as a pesticide. It occurs in an alpha and a beta isomer.

Biological Effect. The most toxic potential effect of endosulfan to man is central nervous system (CNS) toxicity. At very high levels of acute exposure, humans will show CNS symptoms and may die.

In microcosm studies, it was found that the beta isomer was metabolically transformed to the alpha isomer which then oxidized and became endosulfan sulfate.

Bioconcentration factors are presented in Table 9. It appears that generally endosulfan sulfate is more persistent and bioaccumulates more than endosulfan isomers.

TABLE 9
ENDOSULFAN BIOCONCENTRATION FACTORS

| Organism | Alpha Isomer | Beta Isomer | Sulfate |
|---|---|---|---|
| Algae | 17-999 | 44-3863 | 223-1654 |
| Snail | 1336-5763 | 8174-39457 | 5457-29430 |
| Mosquito | 218-831 | 1245-1508 | 210-763 |
| Fish | 30-304 | 90-388 | 935-1741 |

The U.S. Fish and Wildlife Service have performed fish bioassays and found that the 96 hour lethal concentration of endosulfan which would kill 50 percent of the test organisms, was 1.5 ug/l for channel catfish and 1.2 ug/l for bluegill.

Overall, data for aquatic systems are limited. No data exist to indicate that endosulfan produces such irreversible effects as mutagenesis, teratogenesis, or cancer (Federal Register, Vol. 44, No. 144, 43675).

Criteria. Criteria for the protection of aquatic life are: acute, 0.22 ug/l; and chronic, 0.042 ug/l.

To protect human health from the toxic characteristics of endosulfan (from the ingestion of contaminated aquatic organisms), the ambient water criterion was determined by the U.S. EPA to be 159 ug/l (Federal Register, Vol. 45, No. 231, 79334).

Environmental Fate. Environmental processes important in the degradation of endosulfan are photolysis, hydrolysis, and sorption. Processes which are less important include oxidation, bioaccumulation, and biotransformation.

DDD and DDE[23, 24, 27]

DDD is a chlorinated hydrocarbon used as a pesticide. Chemically it is a close relative to DDE and DDT, which are other well known organochlorinated pesticides.

Biological Effect. Bioconcentration is an important fate process for DDD in aquatic systems. Bioconcentration factors range from $10^3$ to $10^5$ and elimination from organisms is twice as slow as other common pesticides (i.e., dieldrin, heptochlor epoxide, endrin).

Biotransformation is slow and of limited value in degradation of DDD.

Toxicity. For protection of freshwater aquatic life, the acute toxicity of DDD has been noted at 0.6 ug/l. No information was available concerning chronic toxicity.

Criteria. DDD and DDE falls in the category of DDT and its metabolites, with the guidelines established as being 0.0010 ug/l for a 24-hour average and should not exceed 1.1 ug/l at any one time (Federal Register, Vol. 45; 231; 79311).

For DDE, acute toxicity for freshwater aquatic life occurs at 1,050 ug/l. No information was available for chronic toxicity.

With DDT and its metabolites having the potential of being carcinogenic, risk levels have been established (Table 10).

TABLE 10
DDT AND METABOLITES HUMAN RISK LEVELS

| | RISK LEVELS | | |
|---|---|---|---|
| | $10^{-5}$ | $10^{-6}$ | $10^{-7}$ |
| Contaminated aquatic organisms (with or without water) | 0.24 ng/l | 0.024 ng/l | 0.0024 ng/l |

Environmental Fate. Two processes are important in the degradation of DDD and DDE--sorption and bioaccumulation.

Sorption occurs both on sediments and biota, with 20 years of sediment accumulation having been recorded.

The strong bioconcentration rates plus slow depuration indicates that bioaccumulation is important to the overall degradation of DDD and DDE.

## Heptachlor Epoxide[23, 24, 30]

Heptachlor epoxide is a metabolic byproduct of the pesticide Heptachlor. It is a chlorinated hydrocarbon.

Biological Effect. Bioconcentration of heptachlor epoxide does occur. Concentration factors (CF) for three species are in Table 11.

TABLE 11
HEPTACHLOR EPOXIDE BIOCONCENTRATION

| Organism | (CF) |
|---|---|
| Alga | $2 \times 10^3$ |
| Snail | $8 \times 10^4$ |
| Fish | $6 \times 10^3$ |

Bioaccumulation is low to moderate, with a half-life for heptachlor epoxide being eliminated was about 2 days in mussels that showed a concentration factor of 1700 and then transferred to clean water.

Toxicity. No information obtained.

Criteria. No information obtained.

Environmental Fate. Little is known concerning the fate of heptachlor epoxide in the aquatic environment. Heptachlor epoxide is resistent to chemical and biological change. Sorption and bioaccumulation are not appreciable but may be the only important mechanism for ridding the aquatic environment of this chemical.

## Hexachlorbenzene[23, 24, 31]

Hexachlorbenzene is a very persistent chlorinated hydrocarbon and is used as a fungicide and as a solvent in industrial processes.

Biological Effect. Hexachlorobenzene has a high affinity for lipophilic materials. However, the source of the majority of hexachlorobenzene found in aquatic organisms is aqueous rather than dietary (bioconcentration instead of bioaccumulation).

Bioconcentration factors for various organisms are: algae, 1 to 4 X $10^4$; snail, 1.3 to 2.6 X $10^3$; and fish, 1 to 2.2 X $10^3$.

Toxicity. The U.S. Fish and Wildlife Service has conducted bioassays for hexachlorobenzene and found that the 96 hour lethal concentration which killed 50 percent of the test organisms was: 25 ug/l for channel catfish; 13 ug/l for bluegill, and 17 ug/l for redear sunfish. Hexachlorobenzene has little or no cumulative toxicity. Flowthrough bioassays have demonstrated that sublethal effects are very prominent at concentrations considerably below the acute lethal levels.

Criteria. No criteria for acute or chronic levels were found. No risk levels have established. No information for carcinogenic, teratogenic or mutagenic effects is available.

Environmental Fate. Although information is insufficient to permit assessment of a most probable fate, indications are that sorption and bioaccumulation are the most important.

Polynuclear Aromatic Hydrocarbons (PAH)[23, 24, 27, 32]

PAHs are compounds which consist of substituted and unsubstituted aromatic rings.

Biological Effect. Very competitive with the physical processes are the effects of bioaccumulation and biodegradation. In terms of bioaccumulation, PAHs which have less than 4 benzene rings are readily metabolized and eliminated as conjugated metabolites. Bioaccumulation is not as important of a fate as biotransformation. It is known to occur in bacteria, invertebrates and mammals. Biotransformation by bacteria is especially prevalant in those areas acclimated to the presence of PAHs.

Toxicity. There is not enough information to establish criteria (Federal Register 45:231:79339).

Criteria. The human health risk levels for contracting cancer through the consumption of either contaminated aquatic organisms or water are presented in Table 12 (Federal Register 45:231:79339).

TABLE 12
PAH Human Risk Levels

| SOURCE | $10^{-5}$ | $10^{-6}$ | $10^{-7}$ |
|---|---|---|---|
| Contaminated aquatic organisms and water | 28 ng/l | 2.8 ng/l | 0.28 ng/l |
| Contaminated aquatic organisms only | 311 ng/l | 31.1 ng/l | 3.11 ng/l |

Environmental Fate. While an accurate assessment of a most probable fate is not possible due to insufficient evidence, the most important processes appear to be photolysis and sorption.

## Phenol[23, 24, 27]

Phenol is basically a benzene ring with a hydroxyl group attached at one position in the ring.

Biological Effect. Biodegradation of phenol has been observed in both laboratory and field studies. The primary degradation activity has been monitored in microbial populations. *In situ* investigation of phenol-degrading activity of bacteria exhibited a removal rate of phenol at approximately 30 ug/l per hour from samples having original concentrations of 125 mg/l.

Criteria. Criteria for the protection of freshwater organisms has been established as 10,200 ug/l for acute toxicity and 2,560 ug/l for chronic toxicity (Federal Register 45:231,79338).

The criteria for the protection of human health is 3.5 mg/l.

Environmental Fate. Photoxidation and metal-catalyzed oxidation are the two primary destructive forces acting upon phenol in the physical environment, with the most evident pathway being photoxidation.

Phthalate Esters (Butyl, Benzyl and Diethyl)[23, 24, 27, 33]

Phthalate esters are present in the environment from anthropogenic and perhaps natural sources. They are used as pesticizers, primarily in the production of polyvinyl chloride resins which are found in a wide variety of industrial, textile, and packaging materials. Residues in surface waters appear to be correlated with drainage from industrial or heavily populated areas.

Biological Effect. Most phthalate esters have a relatively high octanol/water partition coefficient of 2.12, indicating that they are lipophilic. Accumulation factors for phthalate esters by aquatic organisms after seven days are reported to be 350-3900 times the concentration of the substance in water. No specific information is available for butyl, benzyl and diethyl forms.

A number of studies indicate that fish and aquatic life can metabolize phthalate esters. Bioaccumulation, biotransformation, and biodegradation are all considered to make a substantial contribution to fate processes, but their degree of influence on the ultimate fate of phthalate esters is unclear.

Criteria. For the protection of aquatic life, acute and chronic criteria of 940 ug/l and 3 ug/l, respectively, have been established. The acute and chronic concentrations do not specify which phthalate ester was utilized to develop the concentrations listed (Federal Register 45:231:79339).

The diethyl phthalate criteria to protect human health is 350 mg/l for the combination of contaminated aquatic organisms and water and 1.8 mg/l for contaminated aquatic organisms alone.

Environmental Fate. The two transport mechanisms most likely to affect phthalate esters in aquatic environments are absorption onto suspended solids and particulate matter, and complexation with natural organic substances.

## Trichloroethane (Methyl Chloroform)[23, 24, 27, 34]

Trichloroethane belongs to the chemical group identified as halogenated aliphatic hydrocarbons. It is used for the production of tetraethyl lead, vinyl chloride, and as an industrial solvent.

Biological Effect. Octanol/water coefficients indicate that bioaccumulation of trichloroethane in adipose tissues is possible, but is not an important mechanism. There is no information on biotransformation, and biodegradation studies indicate that for compounds in this group, biochemical degradation is very slow.

Criteria. To prevent aquatic life, criteria has been established at 18,000 ug/l for acute and 9400 ug/l for chronic toxicity (Federal Register 45:231:79328).

For the protection of human health, the criteria for 1,1,1 trichloroethane are 18.4 mg/l for combinations of contaminated aquatic organisms and water and 1.03 g/l for contaminated aquatic organisms alone. The ambient water concentration for 1,1,2 trichloroethane should be zero because the compound is a suspected

carcinogen. The risk levels of contracting cancer are presented in Table 13.

TABLE 13
1,1,2 TRICHLOROETHANE RISK LEVELS

| SOURCE | $10^{-5}$ | $10^{-6}$ | $10^{-7}$ |
|---|---|---|---|
| Contaminated aquatic organisms and water | 6.0 ug/l | 0.6 ug/l | 0.06 ug/l |
| Contaminated aquatic organisms | 418.0 ug/l | 41.8 ug/l | 4.18 ug/l |

Environmental Fate. Volatilization is the primary transport process for removal of trichloroethane from aquatic systems. With intermittent stirring at a concentrated rate of 1 mg/l, the time required for a 50 percent depletion rate was determined to be 90 minutes.

Chloroform (Trichloromethane)[23, 24, 27, 35]

Chloroform belongs to the chemical group identified as halogenated aliphatic hydrocarbons. It can be used as a chemical solvent and is an intermediate step in the production of refrigerents and plastics.

Biological Effect. Bioaccummulation is weak, and biotransformation/biodegradation are unimportant for removal of chloroform from aquatic systems.

Criteria. For the protection of aquatic life, criteria has been established as 28,900 ug/l for acute toxicity and 1240 ug/l for chronic toxicity (Federal Register 45:231:79331).

Chloroform is a suspected carcinogen. The risk levels are presented in Table 14.

TABLE 14
CHLOROFORM RISK LEVELS

| SOURCE | $10^{-5}$ | $10^{-6}$ | $10^{-7}$ |
|---|---|---|---|
| Contaminated aquatic organisms and water | 1.90 | 0.19 | 0.019 |
| Contaminated aquatic organisms only | 157 | 15.7 | 1.57 |

Environmental Fate. Volatilization is the major transport process for removal of chloroform from aquatic systems. With intermittent stirring at a concentration of 1 mg/l, the time required for 50 percent depletion was slightly greater than 90 minutes.

## Dichloromethane (Methylene Chloride)[23, 24, 25, 26, 27]

Dichloromethane belongs to the chemical group identified as halogenated aliphatic hydrocarbons. It is used for the production of tetraethyl lead, vinyl chloride and as an industrial solvent.

Biological Effect. Octanol/water partition coefficients indicate that dichloromethane is not highly lipophilic and probably would not exhibit a significant tendency to bioaccumulate. There is no information concerning biotransformation.

Environmental Fate. From aquatic systems, volatization (evaporation) is the primary transport process for removal of dichloromethane. With minimal stirring at a concentration of 1 mg/l, a 50 percent depletion rate was determined to be 90 minutes.

## Tetrachloroethene (Tetrachloroethylene)[23, 24, 27, 36]

Tetrachloroethene belongs to the chemical group identified as halogenated aliphatic hydrocarbons. It is used as a solvent in the dry cleaning industry.

Biological Effect. The octanol/water partition coefficient for this compound indicates that it has the potential to bioaccumulate. The maximum increase in concentration from water to the top of the food chain has been indicated at 100-fold (from $0.5 \times 10^{-9}$ in water to $50 \times 10^{-9}$ in tissue). Although evidence of slight bioaccumulation exists, there is no evidence for biomagnification. There is evidence of tetrachlorethylene in human tissue at the ug/l level, but this is considered background.

There is little evidence to indicate biotransformation other than tetrachloroethene may be metabolized by higher organisms to trichloroaetic acid.

Criteria. To protect aquatic life, the acute toxicity criteria has been set at 5280 ug/l and the chronic is 840 ug/l (Federal Register 45:231:79340).

As tetrachloroethylene is a suspected carcinogen, human risk levels have been established and are presented in Table 15.

TABLE 15
TETRACHLOROETHYLENE RISK LEVELS

| SOURCE | $10^{-5}$ | $10^{-6}$ | $10^{-7}$ |
|---|---|---|---|
| Contaminated aquatic organisms and water | 8 mg/l | 0.8 mg/l | 0.08 mg/l |
| Contaminated aquatic organisms | 88.5 mg/l | 8.85 mg/l | 0.88 mg/l |

Environmental Fate. Volatilization is the primary transport process for removal of tetrachloroethylene from aquatic systems. With intermittent stirring at a concentration of 1 mg/l, the time required for 50 percent depletion was greater than 90 minutes.

Hexachlorocyclohexane (Alpha, Beta, and Delta-BHC Isomers)[23,24,27]

Hexachlorocyclohexanes are chlorinated hydrocarbons used as pesticides, especially the gamma isomer also known as lindane, which is transformed to the alpha-, beta-, or delta-isomers.

Biological Effect. Bioconcentration factors vary among the isomers within a range of 10-500, depending on the isomer and organism. Report concentrations are in Table 16.

TABLE 16
BHC CONCENTRATION FACTORS

| Organism | Concentration Factor |
|---|---|
| Shrimp | 80 |
| Pinfish | 480 |
| Oysters | 130 |
| Mussels | 100 |

Bioaccumulation studies indicate a strong tendency for the BHC to decrease rapidly in the organism studied once the source of BHC was removed.

Criteria. For a mixture of BHC isomers acute toxicity is indicated at concentrations as low as 100 ug/l. No data is available for chronic toxicity (Federal Register 45:231, November 28, 1980).

BHC isomers are suspected carcinogens. Not enough information is known concerning the delta isomer to evaluate a risk factor. Risk factors for the alpha- and beta-isomers are presented in Table 17.

TABLE 17
BHC HUMAN RISK LEVELS

| Source | $10^{-5}$ | | $10^{-6}$ | | $10^{-7}$ | |
|---|---|---|---|---|---|---|
| | a | b | a | b | a | b |
| Contaminated Aquatic Organisms and Water | 92ng/l | 163ng/l | 9.2ng/l | 16.3ng/l | 0.92ng/l | 1.63ng/l |
| Contaminated Aquatic Organisms Only | 310ng/l | 547ng/l | 31 ng/l | 54.7ng/l | 3.1 ng/l | 5.47ng/l |

Environmental Fate. Sorption onto particulates with subsequent deposition and transformation in anaerobic systems appears to be the most important fate for BHC. Little information is available concerning environmental fate, and what is available is not definitive.

## Toluene[23, 24, 25, 26, 27]

Toluene is a methylated benzene ring.

Biological Effect. No information was found indicating that toluene bioaccumulates. In general, compounds with high

solubilities, such as toluene, have little potential for aquatic bioaccumulation.

Toluene is transformed microbially by oxidation and metabolic reactions to acetic acid and pyruvic acid. In mammals, it then reacts with glycine and is further transformed to hippuric acid which is rapidly excreted.

Criteria. Acute toxicity to freshwater aquatic life occurs at concentrations as low as 17,500 ug/l. No information was available for chronic toxicity. In Table 18, the criteria for protection of human health are displayed (Federal Register 45:231 November 28, 1980).

TABLE 18
TOLUENE HUMAN HEALTH CRITERIA

| Source | Levels |
|---|---|
| Contaminated aquatic organisms and water | 14.3 mg/l |
| Contaminated aquatic organisms only | 424 mg/l |

Environmental Fate. Volatilization appears to be the major route of removal for toluene from aquatic environments. Atmospheric photo-oxidation probably subordinates all other fate processes.

## Copper[23, 24, 37, 38, 39, 40, 41, 42]

Biological Effect. Copper is an essential, but minor, nutrient in aquatic plants and animals. It plays a major role in chlorophyll synthesis, and is used in several other metabolic

cycles, often as an oxygen carrier. Copper is absorbed from the surrounding environment by plants, and ingested in the food supply by fish, although some absorption also occurs. Unpolluted surface waters usually contain 1-10 mg copper/l.

Since copper is an essential element, bioconcentration occurs in most living materials. Bioconcentration factors in freshwater range from $10^2$ for algae and fish to $10^5$ for mollusks. No biotransformation is known to occur.

Toxicity. Although levels of copper near 25 mg/l are not ordinarily toxic to fish, concentrations much less than this can have adverse affects on crustaceans and other invertebrates. The most sensitive species to acute effects of copper is Daphnia pulicaia, for which the lowest acute effects occur at 7.24 mg Cu/l water. Other daphnid species are also extremely sensitive to copper, as is the scud (Gammarus sp.) Salmonid fishes are acutely sensitive to copper at levels near 60 mg/l. Bluegills (Lepomis macrodirus) are the most resistant fish species, with symptoms of acute toxicity appearing at 10,200 mg copper/l. Young fish exhibit lower tolerance than adults when exposed to copper.

Levels of copper near 3.3 mg/l for extended periods of time can prevent spawning of the fathead minnow, and brook trout have a no-chronic effect level of 3.9 mg copper/l. The bluegill has a no-chronic effect level of copper at approximately 21 mg/l. The Northern Pike has a high tolerance for chronic copper exposure, showing chronic effects at 60.4 mg/l.

Often fishes will avoid an area of high copper concentration. Salmon, for example, avoid copper at concentrations as low as 4 mg/l.

Copper is toxic to plants at approximately the same concentrations as it is to animals. Symptoms of toxicosis include inhibition of photosynthesis and stunted growth. There is little evidence that would indicate a mutagenic, teratogenic or carcinogenic role for copper in human metabolism.

Criteria. The criteria for copper has been changed from 0.1 x 96 LC50 for a sensitive resident species to a 24 hour average of 5.6 mg/l, with concentrations never exceeding e(0.94 ln (hardness)-1.23). These levels are based on aquatic animal sensitivity, and it is assumed that plants are also protected at this level. At various hardness levels, the maximum copper concentration should not exceed the values listed in the following table.

TABLE 19
COPPER CONCENTRATION

| Hardness (mg/l) | Copper Concentration (ug/l) |
|---|---|
| 50 | 12 |
| 100 | 22 |
| 200 | 43 |

Environmental Fate. The primary physical process important in removing copper from the aquatic environment is sorption. Copper attaches to hydrous iron, manganese oxides, and day particles, causing precipitation. Copper also complexes with organic and inorganic liquids.

Chromium[23, 24, 43, 44, 45, 46, 47, 48]

Biological Effect. Chromium is required in the nutrition of both aquatic plants and aquatic animals. It is absorbed directly from the surrounding environment and from food ingestion. Bioconcentration factors range from $10^2$-$10^4$, and decrease as tropic levels increase. It is used in transport systems and as an enzyme catalyst in various reactions.

Toxicity. Although bluegills can tolerate 45 mg chromium/l for 20 days in hardwater, they suffer the effects of acute chromium poisoning within 6 to 84 hours of exposure to 104 mg chromium/l as $CrO_3$. The 96-hour LC50's range from 3.33 mg/l for guppies in softwater to 133 mg/l for bluegills in hardwater. The 96-hour low safe concentration for fathead minnows has been approximated at 1.0 mg chromium/l, while that for salmonids is a much lower 0.2 mg/l.

Daphnia magna shows few chronic effects when exposed to 0.33 mg chromium/l in softwater, although reproduction is slightly impaired. The approximate safe level for chinook salmon is 0.2 mg chromium/l. Chromium exhibits a cumulative toxicity to rainbow trout and to the other salmonid fishes.

Chromium levels, which have been shown to inhibit algal growth, are 0.03 to 64.0 mg chromium/l, although 0.03 mg chromium/l can serve as a stimulatory chromium concentration. A 0.2 to 0.4 mg chromium/l level causes a 50 percent reduction in diatom growth. Hexavalent chromium acts as an inhibitor of photosynthesis in aquatic plants, thus producing harmful effects.

Although there is no indication to point to chromium as an overall carcinogen, there is a known correlation between inhaled hexavalent chromium and instances of lung cancer in cases of occupational exposure. No such correlation has been shown between skin cancer and dermal exposure, nor other types of cancers and exposures.

Criteria. Most European countries have adopted a criterion for chromium as 0.05 mg/l in natural waters to protect aquatic life. Criteria for chromium deals with both forms--Cr (VI), hexavalent and Cr (III), trivalent. The criterion for Cr (VI) is 0.29 ug/l for 24-hour average and should not exceed 21 ug/l at any one time. For Cr (III), the criterion is 0.44 ug/l for 24 hour average and should not be exceeded according to the hardness (Table 20).

Environmental Fate. Cr(III) is easily hydrolyzed and precipitates as chromium hydroxide. Cr(VI) is soluble and tends to remain in solution.

TABLE 20
CHROMIUM CONCENTRATION

$e^{(1.08(\ln(\text{hardness}))+3.48)}$, where:

| Hardness (mg/l) | Cr(III) (ug/l) |
|---|---|
| 50 | 2,200 |
| 100 | 4,700 |
| 200 | 9,900 |

Lead[23, 24, 49, 50, 51, 52, 53, 54]

Biological Effect. Lead does not serve any beneficial role in aquatic plant and animal metabolism. It is absorbed from the

surrounding environment and, in the animals, ingested as part of the food supply. It accumulates primarily in the bones of fishes and is thus not a particular hazard to humans via the food chain. Bioconcentration of lead occurs at a factor of $10^2$-$10^3$ and decreases as the trophic level increases. Methylation occurs by microbes, which cause volatile compounds to form, releasing lead compounds from sediments to aqueous environment.

Toxicity. The toxicity of lead is affected by water hardness, as shown by the tolerance in hardwaters by the fathead minnow (Pimephales promelas) to 31 times the amount of lead which produces sensitivity in soft waters.

The most acutely sensitive animal to lead is the scud, and the least sensitive animals tend to be the benthic insects. Salmonid fishes are also highly sensitive to lead, and Daphnia magna shows impaired growth when exposed to low lead concentrations. Daphnia magna shows effects of chronic lead poisoning at levels near 120 mg/l in hardwater, and rainbow trout are affected at 850 mg/l in hardwater and 31 mg/l in soft water. Snails are the most sensitive species to chronic lead toxicosis, developing symptoms at levels as low as 25 mg/l.

Acute toxicoses in freshwater alga can occur at 500 mg lead/liter. Adverse effects on plants are not likely to occur at levels desinged to protect aquatic animal life.

Lead has been shown to act as a carcinogen in rats and in mice. It is believed to be carcinogenic to most animals. It also exhibits teratogenic effects on chick embryods and on rodents at levels of 25 to 70 mg lead/kg feed. It does not seem

to produce the same teratogenic effects in sheep and cattle as it does in other animals. Lead is not known to be teratogenic.

Criteria. THE EPA recommended criteria for lead in water to protect aquatic life is determined using the factor of hardness, which has been shown to affect toxicity. The maximum allowable 24-hour average level of the lead is $e^{(2.35(\ln(\text{hardness}))-9.48)}$, with the lead concentration in the water never exceeding the concentration equal to $e^{(1.22(\ln(\text{hardness}))-0.47)}$. Table 21 shows the results of the relationship at three levels of hardness.

TABLE 21
LEAD CONCENTRATION

| Hardness (mg/l) | 24-hour Average (ug/l) | Not to Exceed (mg/l) |
|---|---|---|
| 50 | 0.75 | 74 |
| 100 | 3.80 | 170 |
| 200 | 20 | 400 |

Environmental Fate. The primary physical process controlling lead in the environment is sorption to fine sediments. At pH less than 7.0, lead forms complexes and increases its affinity for clays and fine sands.

## Zinc[23, 24, 47, 55, 56, 57, 58, 59, 60, 61]

Biological Effect. Zinc is an essential nutrient to all aquatic animals and plants, and is utilized in respiratory and photosynthetic processes, as well as other enzymatic reactions and nucleic acid synthesis. Because of the difficulties of measuring intake or output of animals which exist in solution no

minimum requirements have been designated for aquatic life, nor have accurate measurements been made of the flux of zinc in the organisms in aquatic systems. Bioconcentration factors range from $10^3$ in fish to $10^5$ in invertebrates and plants.

Toxicity. The toxicity of zinc in aquatic systems is affected by several physical factors, including water hardness, pH, and ionic strength. Zinc is less toxic in hard waters than in soft acidic waters because of its solubility in acids. Hardness tends to be the best single chemical parameter used in determining the toxicity of zinc to aquatic life, although chronic toxicity effects are not as strongly affected by this as the effects of acute toxicity.

Few tests have been performed in order to determine the chronic toxicity of zinc to aquatic organisms, although many acute level tests have been made. The ranges of acute toxicity are from 90 mg zinc/l to 58,100 mg zinc/liter. Acute toxicity will cause cellular breakdown in the gills of fish, and clog the gills with mucous, which creates an impermeable barrier to oxygen so that the fish will suffocate. Chronic toxicity will not disturb the gills, but causes histological changes in other organs of the body, reducing growth and naturation and results in a general enfeeblement.

Within species, different zinc compounds may have highly different levels of toxicity. This is well represented by zinc toxicities of the bluegill sunfish (Lepomis macrochirus). As the sulfate, zinc is completely lethal to bluegill fry in three days at 235 mg/l, but as the phosphate zinc causes no death after 4

days. Changes in water pH, hardness, or temperature can produce similar effects.

Of all animals tested, Daphnia magna was shown to have symptoms of acute toxicosis at 100 mg/l to 655 mg/l when hardness is increased. Chronic tests showed extreme sensitivity, with toxic threshold level that may be as low as 47 mg/l Chinook salmon have a higher threshhold level at 371 mg/l, and acute toxicity can be observed at less than 700 mg/l. Rainbow trout have chronic toxicity symptoms at greater than 277 mg/l, with acute symptoms noticed at less than 380 mg/l. Brook trout have a chronic threshold of 852 mg/l, and an acute threshhold of 2000 mg/l. The fathead minnow suffers from chronic zinc excess at levels greater than 106 mg/l, and shows signs of acute toxicosis at levels greater than 600 mg/l. The flagfish, which can tolerate up to 1500 mg/l zinc before showing signs of acute toxicity, will exhibit signs of chronic zinc toxicity when exposed to 47 mg/l.

These are aquatic plants which may have higher sensitivities to zinc than the lowest value noted in animal tests. The green alga, Selenastrum capricornutum has been recorded as being highly sensitive to zinc at concentratins as low as 30 mg/l, but this information is contradicted in other literature. Most plants tolerate zinc at levels well above the 47 mg/l minimal chronic threshold noted above, and therefore the criteria is based on the needs of aquatic animal life.

Criteria. The criteria has recently been altered from being 1/100 of the 96 hrs LC50 for sensitive resident species to 47

mg/l as a 24-hour average, as this is the lowest concentration known above which there may be hazardous effects. Zinc concentrations should not exceed e(0.83 n(hardness))+1.95), which would relate as shown in Table 22.

TABLE 22
ZINC CONCENTRATION

| Hardness (mg/l) | Zinc (ug/l) |
|---|---|
| 50 | 180 |
| 100 | 320 |
| 200 | 570 |

Environmental Fate. The most important physical process controlling the fate of zinc in the aquatic environment is sorption. This occurs with hydrous metal oxides, clay particles and organic material.

## Nickel[23, 24, 62, 63, 64, 65]

Biological Effect. Nickel is commonly found at concentrations less than 1 ug/l in natural waterways. Nickel toxicity is much higher in soft water than hard water. The level of sensitivity of aquatic organisms to nickel varies, with cladocerans being the most sensitive and benthic insects the least sensitive. Nickel can activate several enzymatic systems.

Toxicity. Daphnia magna exhibits symptoms of acute toxicosis at 510 ug/l in soft water. The rockbase exhibits acute toxicosis at 2480 ug/l in soft water, while the stonefly is sensitive at levels near 33,500 ug/l. An unspecified salmonid fish exhibited acute nickel toxicosis in hard water at 35,000 ug/l, while

the banded killifish showed acute toxic effects at 46,200 ug/l in hard water. Chronic effects are experienced by Daphnia magna at 14.8 ug/l and by fathead minnows at 530 ug/l, with the hardness conditions in these tests being unspecified.

Algae should remain relatively unaffected at levels of nickel which are not deleterious to aquatic animals. A reduction in algal growth is caused by 100-700 ug nickel/l. Of special concern is a reduction in diatom diversity, though not community size, in the presence of 2 ug/l nickel.

Criteria. Due to the dependence of toxicity on hardness, the U.S. EPA recommended criterion utilizing the local hardness in termination of safe levels. The 24-hour average nickel concentration should not exceed the value equal to e(0.76 ln (hardness) + 1.06), with concentration during the 24-hour period never exceeding the value equal to e(0.76 ln (hardness) + 4.02).

Environmental Fate. The primary physical process controlling nickel in the environment is sorption to fine sediments. All pH less than 7.0, nickel increases its affinity for clays and fine sands.

## B. WATER QUALITY CRITERIA EVALUATION

To select minimum, limited, and maximum exposure levels for the 25 priority pollutants detected in Coldwater Creek, a series of question and response tables were developed. The Water Quality Criteria Evaluation procedure has two divisions: the Pollutant/Water Quality Evaluation; and the Criteria Assignment. The decision-making and selection process developed, presents a

systematic approach to the establishment of water quality criteria for priority pollutants. This approach is applicable to other environmental control issues and is flexible in the selection of justifiable criteria. A full discussion of the terms used and methodology employed can be found in Appendix D.

The Pollutant/Water Quality Evaluation has two sections: the identification of the sensitivity of the receiving water and the material characteristics. The sensitivity of the receiving water is determined by the answers to a set of questions about the type of receiving water, the most sensitive use of the receiving water, and the predominant use of the land surrounding the stream. Each question has several possible responses. A table of sensitivity values selected for these varying responses is consulted. The Receiving Water Sensitivity Rating is calculated by placing the values assigned to the different responses in the formula below:

$$\text{sensitivity rating} = \text{type value} + (3 \times \text{use value}) + \text{location value}$$

In the material control section, another series of questions and response tables are presented. The major questions concern the presence and persistence of the chemical material in the area, the toxicity of this material to man, the toxicity of this material to aquatic life, and the commercial importance of the material. Each major set of questions has an individual decision table. Also included in the Appendix are the decision tables and a discussion of the pollutant persistence, Appendix E. The particular response indicates at what point the table should be

entered and which actions are to be taken. Positive and negative point values are assigned to each question. After the addition and subtraction of indicated values are completed, a material control rating for a specific priority pollutant is obtained.

To determine the appropriate exposure level (in-stream pollutant criteria) for the specific receiving water and particular priority pollutant, the Criteria Assignment table is consulted. Within this table are values for the Receiving Water Sensitivity Rating and the Material Control Rating values. The range of values presented identify a specific action to be taken. The actions can include setting criteria at a limited exposure level or suggesting additional research as needed to obtain information on the unknowns.

C. TOXIC AGENT STUDY CRITERIA

In-stream pollutant criteria was then developed for the identified priority pollutants using the methodology described above. The following definitions were created for the Toxic Agent Study.

The minimum exposure level is in-stream pollutant critera set below the level at which any adverse environmental effects have been demonstrated. The limited exposure level is in-stream pollutant criteria set at 50 percent of the acute toxicity limit of the most sensitive indigenous species; not to exceed the chronic limit for more than 48 hours. The maximum exposure level is in-stream pollutant criteria set at 75 percent of the acute toxicity

of the most sensitive indigenous species; not to exceed the chronic limit for more than 96 hours.

Acute toxicity involves a stimulus severe enough to rapidly induce an adverse biological response. In aquatic tests, a response observed within 48 hours is typically considered an acute test, with the death of a test organism being the most common effect observed. Chronic toxicity involves a stimulus that lingers or continues for a long period of time and typically induces a biological response of slow progress and long continuance.

The percentages in the study exposure levels and the U.S. EPA acute criteria for the protection of freshwater aquatic life were used to calculate the study exposure levels and specific criteria (Table 23). The range of concentration, the U.S. EPA acute and chronic criteria, and the calculated study criteria for the detected priority pollutants are presented in Table 24.

Using the EWGCC/MSD study criteria and the storm and dry weather sampling results, only 11 priority pollutants appear to be of concern in Coldwater Creek. These are: chromium, copper, lead, cyanide, aldrin, dieldrin, gamma BHC, heptachlor epoxide, endosulfan, 4,4'DDD, and 4,4'DDE. These will be discussed further in Chapter 8.

The method used in this study to specify water quality criteria for Coldwater Creek appears to have a logical and justifiable basis. This approach can be applied to other study areas to plot the direction of water pollution control efforts.

TABLE 23

IDENTIFIED POLLUTANTS EXPOSURE LEVELS

| Priority Pollutants Detected in Coldwater Creek | EWGCC/MSD Study Exposure Level |
|---|---|
| Chromium | Limited |
| Copper | Limited |
| Lead | Limited |
| Nickel | Limited |
| Zinc | Limited |
| Cyanide | Minimum |
| Phenols | Limited |
| Chloroform | Minimum |
| Dichloromethane | Minimum |
| Tetrachloroethylene | Minimum |
| Toluene | Limited |
| Trichloroethane | Minimum |
| Trichloroethylene | Limited |
| Bis(2 ethyl hexyl) Phthalate | Limited |
| Butyl Benzl Phthalate | Limited |
| Diethyl Phthalate | Limited |
| Di-n-butyl Phthalate | Limited |
| Polynuclear Aromatic Hydrocarbons (PAH) | Limited |
| Alpha BHC | Maximum |
| Beta BHC | Maximum |
| Gamma BHC | Maximum |
| Delta BHC | Maximum |
| Aldrin | Minimum |
| Dieldrin | Minimum |
| Heptachlor Epoxide | Minimum |
| Endosulfan | Limited |
| 4,4$^{1}$ DDD | Limited |
| 4,4$^{1}$ DDE | Minimum |
| Hexachlorobenzene | Limited |

TABLE 24

PRIORITY POLLUTANTS
WATER QUALITY CRITERIA

| Priority Pollutants Detected in Coldwater Creek | Concentration Detected (ug/l) Storm | Dry | Aquatic Life Criteria (ug/l)[a] Acute | Chronic | EWG/MSD Study Criteria (ug/l) |
|---|---|---|---|---|---|
| Chromium | ≤10- 58 | ≤10- 40 | 21 | .29 | 10.5 (Not to exceed .29 ug/l for 48 hours) |
| Copper | ≤1- 80 | ≤20- 64 | 43 | 5.6[b] | 21.5 (Not to exceed 5.6 ug/l for 48 hours) |
| Lead | ≤1-300 | ≤40- 50 | 400 | | 200 (Not to exceed 20 ug/l for 48 hours) |
| Nickel | ≤5- 20 | N.D. | 3100 | | 1550 (Not to exceed 160 ug/l for 48 hours) |
| Zinc | 12-212 | 10-140 | 570 | 47[b] | 285 (Not to exceed 47 ug/l for 48 hours) |
| Cyanide | ≤3- 10 | ≤3- 9 | 521 | 3.5[b] | 3.5 |
| Phenols | 10-160 | ≤5- 32 | 10,200 | 2,560 | 5,100 (Not to exceed 2560 ug/l for 48 hours) |

a U.S. Environmental Protection Agency , "Water Quality Criteria Documents: Availability," Federal Register, Vol. 45 (November 28, 1980), pp. 79318-79379.

b A 24-hour average.

N.D. Not detected

TABLE 24
(Continued)

| Priority Pollutants Detected in Coldwater Creek | Concentration Detected (ug/l) Storm | Dry | Aquatic Life Criteria (ug/l)[a] Acute | Chronic | EWG/MSD Study Criteria (ug/l) |
|---|---|---|---|---|---|
| Chloroform | ≤10- 26 | 10 | 28,900 | 1,240[c] | 1,240 |
| Dichloromethane | 10-140 | ≤10- 19 | 11,000 | | 11,000 |
| Tetrachloroethylene | 10 | ≤10- 78 | 5,280 | 840 | 840 |
| Toluene | 10 | N.D. | 17,500 | | 8,750 (No data) |
| Trichloroethane | 10 | 10 | 18,000 | 9,400 | 9,400 |
| Trichloroethylene | 10 | 10 | 45,000 | d | 22,500 (No data) |
| Bis(2-ethyl hexyl) Phthalate | ≤10 | ≤10 | 940 | 3 | 470 (Not to exceed 3 ug/l for 48 hours) |
| Butyl Benzyl Phthalate | ≤10 | ≤10- 43 | 940 | 3 | 470 (Not to exceed 3 ug/l for 48 hours) |
| Diethyl Phthalate | ≤10 | ≤10- 43 | 940 | 3 | 470 (Not to exceed 3 ug/l for 48 hours) |

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a U.S. Environmental Protection Agency , "Water Quality Criteria Documents: Availability," Federal Register, Vol. 45 (November 28, 1980), pp. 79318-79379.

c 27 day LC 50 values.

d No data are available concerning chronic toxicity but adverse behavioral effects occur to one species at concentrations as low as 21.900 ug/l.

N.D. Not detected

TABLE 24
(Continued)

| Priority Pollutants Detected in Coldwater Creek | Concentration Detected (ug/l) Storm | Dry | Aquatic Life Criteria (ug/l)[a] Acute | Chronic | EWG/MSD Study Criteria (ug/l) |
|---|---|---|---|---|---|
| Di-n-butyl Phthalate | ≤10 | ≤10 | 940 | 3 | 470 (Not to exceed 3 ug/l for 48 hours) |
| Polynuclear Aromatic Hydrocarbons (PAH) | ≤10 | N.D. | 1700 | 520 | 850 |
| Alpha BHC | ≤5 | .4 | 100 | | 75 (No data) |
| Beta BHC | ≤5 | .4 | 100 | N.D. | 75 (No data) |
| Gamma BHC | ≤5 | N.D. | 2 | .08[b] | 1.5 (Not to exceed .08 ug/l for 96 hours) |
| Delta BHC | ≤5 | .2 | 100 | | 75 (No data) |
| Aldrin | ≤5 | N.D. | 3 | N.D. | 3 |
| Dieldrin | ≤5 | N.D. | 2.5 | .0019[b] | .0019 |
| Heptachlor Epoxide | ≤5 | N.D. | .52 | .0038[b] | .0038 |
| Endosulfan | N.D. | .2 | .22 | .056[b] | .11 (Not to exceed .056 ug/l for 48 hours) |

a U.S. Environmental Protection Agency , "Water Quality Criteria Documents: Availability," Federal Register, Vol. 45 (November 28, 1980), pp. 79318-79379.

b A 24-hour average.

N.D. Not detected

TABLE 24
(Continued)

| Priority Pollutants Detected in Coldwater Creek | Concentration Detected (ug/l) Storm | Dry | Aquatic Life Criteria (ug/l)[a] Acute | Chronic | EWG/MSD Study Criteria (ug/l) |
|---|---|---|---|---|---|
| 4,4' DDD | ≤5 | N.D. | .06 | .001[b] | .03 (Not to exceed .001 ug/l for 48 hours). |
| 4,4' DDE | ≤5 | N.D. | 1,050 | .001[b] | .001 |
| Hexachlorobenzene | ≤10 | N.D. | 250 | e | 125 (No data) |

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a U.S. Environmental Protection Agency , "Water Quality Criteria Documents: Availability," Federal Register, Vol. 45 (November 28, 1980), pp. 79318-79379.

b A 24-hour average.

e No data are available concerning the chronic toxicity of the more toxic of the chlorinated benzenes to sensitive freshwater aquatic life but toxicity occurs at concentrations as low as 50 ug/l for a fish species exposed for 7.5 days.

N.D. Not detected

# 8. CONTROL STRATEGY EVALUATION

This chapter is divided into two major sections. The first section outlines the existing major toxic material control legislation and describes in detail the toxic-related specifics of the Clean Water Act of 1977 and its amendments. The U.S. EPA rules, regulations and functions related to the Clean Water Act are discussed. Also included in this section is a brief description of other federal laws and agencies which may impact existing U.S. EPA toxic programs and policies.

The second section addresses the effectiveness of existing federal toxic programs. A list of potential water quality problems based on criteria/concentration comparisons for Coldwater Creek is included. These water quality problems are referenced as to probable sources. An analysis of the regulatory effectiveness of existing toxic laws and related management programs for controlling the potential priority pollutant problems in the Coldwater Creek watershed is also presented.

## A. TOXIC CONTROL LEGISLATION

### Clean Water Act and Amendments

On October 18, 1972, the United States Congress passed the Federal Water Pollution Control Act Amendments (FWPCA) which then became Public Law 92-500. Considered by water quality experts to be one of the most complex and comprehensive pollution

affect industrial discharges. By July 1, 1984, industries must have installed the best available technology (BAT) for the control of toxic pollutants and best conventional technology (BCT) for the control of conventional pollutants. Those priority pollutants to be controlled by BAT are listed in Table 3, Chapter 4.

Both the FWPCA and the CWA empower the U.S. EPA with the authority to promulgate rules and regulations governing the implementation of the NPDES program. The Federal water law also gives U.S. EPA the authority to set effluent limitations for both conventional and toxic pollutants. The CWA of 1977 gives special authority to U.S. EPA for the establishment of a pretreatment program for the purpose of monitoring and controlling industrial dischargers into publicly owned treatment works. Currently, the NPDES and the pretreatment program are the two major management and enforcement mechanisms available to U.S. EPA for the control of toxic pollutants contained in wastewater discharges.

In addition to controlling private, municipal and industrial discharges, the FWPCA of 1972 authorized major research and demonstration programs to evaluate the impact of pollutants from urban and agricultural runoff, acid mine drainage and other non-point sources. Utilizing this statutory authority, U.S. EPA has authorized grants for special research and demonstration projects in these areas. The Toxic Agent Study was funded through a U.S. EPA planning grant to investigate the relative magnitude of point and non-point sources of toxic pollutants on a receiving stream. This study has provided valuable information concerning

the efficiency of current NPDES and pretreatment programs in the control of toxic pollutants. Although the federal water laws authorize major research and planning in the area of non-point source pollution, very few rules and regulations have been promulgated by the agency regarding control measures for non-point pollution sources.

Another important area of the FWPCA and the CWA is the establishment of water quality standards. The water laws grant U.S. EPA the authority to establish in-stream water quality standards as related to conventional and toxic pollutants. Standards are to be revised periodically to coordinate closely with major statutory goals and deadlines. Adherence to all water quality standards will measure the effectiveness of effluent limitations and pretreatment programs. States may adopt the federal standards or more stringent standards, but they may not allow less stringent standards. Currently, U.S. EPA has adopted water quality standards for conventional pollutants. Water quality standards for all of the 126 priority pollutants have not been set but guidelines for in-stream water quality criteria have been developed for some of the priority pollutants (Development Documents). Once guidelines have been promulgated for all 126 priority pollutants, water quality standards can be established.

Supportive Programs

There are currently 24 federal statutes related to the regulation of toxic substances. Eighteen separate federal agencies

draw their authority from these statutes for monitoring, controlling, and investigating toxic materials. All of these federal statutes and/or agencies impact in varying degrees the U.S. EPA functions and its list of 126 priority pollutants. The major federal law which directly affects the Clean Water Act and Amendments as related to toxic materials is the Toxic Substance Control Act (TSCA). The following sections are brief descriptions of environment-related and health related federal laws and programs which can influence priority pollutant designations.

Environment-Related Programs. The Toxic Substances Control Act authorizes U.S. EPA to obtain data from industry on the production, use and health effects of toxic chemicals, and any other data that U.S. EPA may deem necessary for toxic control investigations. If U.S. EPA determines an unreasonable risk or hazard to human health or the environment, the Agency may regulate the manufacture, processing, distribution in commerce, use and disposal of a toxic substance. Pesticides, tobacco, nuclear material, firearms and ammunition are exempted from the Act since these substances are regulated by other laws.

The U.S. EPA may require processors or manufacturers of potentially detrimental chemicals to conduct tests on the chemicals. Testing involves the evaluation of the following chemical characteristics:

1. Acute and/or chronic toxicity;
2. Health and/or environmental effects which can include carcinogenic, mutagenic, behavioral and synergistic effects.

Under TSCA, if a chemical contains a toxic contaminant as the result of a certain manufacturing process, U.S. EPA can require a process change to eliminate the toxic substance.

TSCA impacts the toxic control strategy in two important ways. First, TSCA directs U.S. EPA to use other laws administered by U.S. EPA to protect the public from risks associated with toxic substances which are not covered under TSCA. Such regulatory action may involve the CWA of 1977. Second, the testing of chemical substances for health and environmental effects by the manufacturer may require revision to the 126 priority pollutant list. Primarily such revisions could be anticipated to be adding rather than eliminating substances.

The Resource Conservation and Recovery Act of 1976 (RCRA) is another major environmental law enacted by Congress which may influence the toxic control strategy and future U.S. EPA directions. This law amends the Solid Waste Disposal Act to provide for five major elements of a comprehensive solid waste management program:

1. U.S. EPA is granted authority to regulate hazardous waste.
2. The Act establishes a program to eliminate open dumping.
3. Financial and technical assistance is authorized for improving solid waste management programs.
4. The Act establishes rural solid waste management programs.
5. RCRA gives authority to U.S. EPA for conducting research and demonstration projects.

The element of RCRA which directly affects the U.S. EPA priority pollutant issue is its hazardous waste regulatory program. RCRA directs EPA to identify which wastes are hazardous, and in

what quantities, qualities, concentrations and forms of disposal these wastes become a threat to health or environment. Additionally, RCRA empowers U.S. EPA to issue standards for generators and transporters of hazardous wastes, including recordkeeping practices, labeling appropriate containers, use of a manifest system and reporting of quantities and disposition of materials.

In terms of constructing a toxic agent budget, the manifest system could provide valuable information in regards to the movement of toxic waste through a watershed. Also, the hazardous waste identification process of the U.S. EPA can provide additional information for adding or deleting substances to the 126 priority pollutant list. The manifest system can also provide valuable information of toxic substance spill potential.

The Office of Pesticides Programs is within the U.S. EPA. This office is responsible for implementing the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) and certain provisions of the Federal Food, Drug and Cosmetic Act (FDCA). This office coordinates all agency programs concerning pesticides management and regulations, including the establishment of tolerance levels for pesticides residues in or on food, registration and reregistration of pesticides, monitoring of pesticide levels in food, humans, and non-target fish and wildlife, and the preparation of guidelines and standards for product development to insure effective control programs. Additional responsibilities of the Office of Pesticides include establishing pesticide tolerance levels and use management, laboratory audit and special registrations.

The U.S. Coast Guard and the U.S. Department of Transportation are two agencies involved in the monitoring of hazardous material transportation. The Coast Guard administers the Bulk Liquid Hazardous Cargoes Act. The Coast Guard monitors hazardous material shipments by barge on all navigable inland and coastal waters. The Act provides emergency response to spills of oil and hazardous substances and notification to Captain of Port of the existence of hazardous conditions aboard vessels.

The U.S. Department of Transportation is responsible for issuing and enforcing regulations ensuring the safe transportation of hazardous materials by all modes of transportation. The exception is bulk shipments by water which is the responsibility of the U.S. Coast Guard.

Both of these agencies can provide information for constructing a toxic agent budget, particularly for spill potential of hazardous materials moving through the watershed.

Health-Related Programs. The Consumers Product Safety Commission has the authority to administer two programs which address toxic substances. Through the Consumers Product Safety Act of 1973, the Federal Hazardous Substance Act of 1960, Poison Prevention Packaging Act of 1970, and the Flammable Fabrics Act provide the statutory authority for the Acute Chemical Hazards Program and the Chronic Chemical Hazards Program. The Consumers Product Safety Commission administers both programs. The Acute Program is concerned with those products which have immediate injurious effects, while the Chronic Program is concerned with

reducing consumer exposure to products which contribute to adverse health effects occurring sometime after repeated exposure. The Consumers Product Safety Commission already has taken action on some classes of materials detected in the Coldwater Creek study, e.g., benzene, formaldehyde, lead and hexane. Both programs have application in controlling the movements of toxics within a watershed by identifying the substances, setting priorities, evaluating risks, and determining regulatory and non-regulatory methods for reducing and eliminating risks.

The National Cancer Institute is a section within the National Institute of Health (NIH) which is a division within the Department of Health and Human Services. The Institute identifies environmental carcinogens, establishes and measures relationships between carcinogens and the incidence of cancer, and operates educational programs to reduce cancer. Studies include examining the relationships between fluorides and generalized cancers; the presence of chlorine in water and increase in cancer rates; and industrial hazards and cancer. These toxic investigations can provide additional information for U.S. EPA in developing the list of 126 Priority Pollutants.

Four other agencies involved in the research of toxic effects of chemicals on human health and the environment are: the National Center of Toxicological Research, the National Institute of Environmental Health Science, the National Institute for Occupational Safety and Health (NIOSH) and the Occupational Safety and Health Administration (OSHA).

The National Center of Toxicological Research is a joint venture of the Food and Drug Administration and U.S. EPA, to help provide a better understanding of relationships of chemicals in the environment and possible adverse effects. An advanced scientific program for toxicological experimentation has been developed. The Center maintains its own research laboratory and other related facilities. Principally, it conducts research in toxic related areas which include carcinogenesis, mutagenesis, and teratogenesis, plus experiments in other related fields.

The National Institute of Environmental Health Science, an agency of the Department of Health and Human Services, has the broadest responsibility among Federal agencies for support of research in the areas of effects of chemicals and physical environmental agents on human health and the training of manpower. Programs exist for the development of Toxicity Testing Systems, genetic toxicology, risk assessment, pharmakinetics (concerned with study of the ratio of mechanisms, uptake and storage of persistent compounds) and excretion of environmental agents, chronic organic toxicity, epidemiology, and environmental chemistry.

The National Institute for Occupational Safety and Health (NIOSH) is a division of the Public Health Service. Its principal activity involves research to eliminate on-the-job hazards and to insure the health and safety of the work force. One of the primary areas of research is to determine acute and chronic toxicology of new and existing industrial chemicals in the work place. Other activities include criteria documentation and

standard development, and publishing "Registry of Toxic Effects of Chemical Substances."

The Occupational Safety and Health Administration, an agency which is within the Department of Labor, is responsible for administering and enforcing the Occupational Safety and Health Act of 1970 (OSHA). Toxic related activities of this agency include identification, classification and regulation of toxic materials which pose a potential carcinogenic risk in the work place.

All four of these agencies develop research information and toxicological data which can influence decision-making of U.S. EPA to expand or contract the Priority Pollutant list.

Other agencies involved in regulating hazardous materials or toxic waste are described in Appendix F.

## B. EFFECTIVENESS OF EXISTING PROGRAMS

### Potential Water Quality Problems

When the concentration ranges of the priority pollutants detected were compared to the EWG-MSD Toxic Agent Study criteria, four heavy metals and possibly seven organic compounds (pesticides) were observed to be in violation of selected study criteria (Table 25). Due to detection limit problems experienced during the analysis of samples, it was not possible to be certain that the seven pesticides detected during the storm event and dry samples were in violation of the study criteria. The concentration ranges, probable pathways and sources of the problem priority pollutants are discussed below.

TABLE 25
PRIORITY POLLUTANTS WHICH EXCEED STUDY CRITERIA

| Priority Pollutant | Concentration* Range Detected (ug/l) Storm | Dry | EWG-MSD Study Criteria (ug/l) |
|---|---|---|---|
| Chromium | ≤10-58 | ≤10-40 | 10.5 (Not to exceed .29 ug/l for 48 hours) |
| Copper | ≤1-80 | ≤20-40 | 21.5 (Not to exceed 5.6 ug/l for 48 hours) |
| Lead | ≤1-300 | <40-50 | 200 (Not to exceed 20 ug/l for 48 hours) |
| Cyanide | ≤3-10 | ≤3-9 | 3.5 |
| Gamma BHC | ≤5 | N.D. | 1.5 (Not to exceed .08 ug/l for 96 hours) |
| Aldrin | ≤5 | N.D. | 3 |
| Dieldrin | ≤5 | N.D. | .0019 |
| Heptachlor Epoxide | ≤5 | N.D. | .0038 |
| Endosulfan | N.D. | .2 | .11 (Not to exceed .056 ug/l for 48 hours) |
| 4,4' DDD | ≤5 | N.D. | .03 (Not to exceed .001 ug/l for 48 hours) |
| 4,4' DDE | ≤5 | N.D. | .001 |

N.D. = Not detected.

*Less than or equal signs (≤) indicate the sampling analysis confidence limits.

Heavy Metals

Chromium. The EWGCC-MSD study criteria developed for chromium was 10.5 ug/l (not to exceed .29 ug/l for 48 hours).

For the first storm event (May 13, 1981), the short-term criteria was exceeded by 1.5 ug/l during the incline phase at Site 5 and by 1.5 ug/l during the second decline phase at Site 1. Duration was not long, therefore, no adverse environmental impact would be expected.

During the second storm event (June 11, 1981), the concentrations detected for chromium were greater than the study criteria at Sites 5, 4, 3, and 1. The concentrations ranged from 20 ug/l at Sites 4, 3 and 1, to 40 ug/l during the incline phase at Site 5. At Site 4, the concentrations in the incline and peak phases were all 30 ug/l, while the concentration of the decline phase was measured at 20 ug/l. Both concentrations for the incline and decline phases at Site 3 were 20 ug/l. At Site 1, concentrations of 30 ug/l were detected during the peak and first decline phases. The second decline phase concentration was 20 ug/l.

The concentrations of chromium detected at all 5 sampling sites during the third storm event (June 15, 1981) were greater than the short-term study criteria of 10.5 ug/l. The concentrations ranged from 12 ug/l at Site 3 to 58 ug/l in the peak phase at Site 4. At Site 5, a concentration of 16 ug/l was measured during the first flush phase. For Site 4, the concentrations ranged between 25 ug/l to 58 ug/l. The concentrations measured at Site 3 included 15 ug/l in the incline and 20 ug/l during the peak, while the decline phase was 12 ug/l. For Site 2, the concentrations detected during the peak, first decline, and second decline were 16 ug/l, 19 ug/l and 15 ug/l, respectively. The concentration measured during the peak was 19 ug/l and during

the second decline was 23 ug/l. At Site 1, the concentration ranged from 18 ug/l to 56 ug/l.

The short term study criteria for chromium was exceeded during dry weather sampling only in September at Sites 5 and 3. The concentrations detected were 30 ug/l and 40 ug/l, respectively.

Probable sources and pathways for chromium entering Coldwater Creek for Sites 5, 3, and 2 are: drainage from parking lots, shopping centers, automobile services stations, and drainage from residential/commercial land use areas. Industrial operations and associated activities are concentrated near Site 4. These operations include aircraft manufacturing, automobile fabrication, brake fluid manufacturing, painting and metal finishing. Other activities associated with these industrial operations are cooling water discharge, on-site chemical storage, and industrial wastewater treatment. Airport operations (fueling/cleaning/flight) also occur in the vicinity of Site 4. Probable sources of chromium at Site 1 include municipal sewage treatment plant, and drainage from commercial parking lot areas.

Copper. The study criteria developed for copper was 21.5 ug/l (not to exceed 5.6 ug/l for 48 hours).

During the first storm event, the incline phase concentration at Site 5 was at the study criteria.

The concentrations detected at Sites 5, 4 and 3 during the second storm event were greater than the study criteria. The concentrations ranged from 40 ug/l at Sites 5, 4, and 3 to 60 ug/l at Site 4 (incline and peak phases). All the sampling phase concentrations at Site 5 were at 40 ug/l. The decline phase at

Site 4 was 40 ug/l. The concentrations incline and decline phases at Site 4 were both measured at 40 ug/l.

In the third storm event, the concentrations of copper at Sites 5, 4, 3, and 1 were more than the study criteria. The concentrations ranged from 21.5 ug/l at Site 3 (incline and peak phases) to 64 ug/l at Site 4 (peak phase). At Site 5, a concentration of 29 ug/l was detected during the first flush incline and peak phases, while 25 ug/l was measured at the decline phase. The incline phase concentration at Site 4 was 50 ug/l, and the decline phase concentration was 42 ug/l. For Site 1, the first decline phase was 25 ug/l.

Dry weather samples of copper for the month of June were measured at Sites 2 and 1 at 50 ug/l and 64 ug/l, respectively.

Potential sources of copper in the area of Site 5 are drainage from residential/commercial areas and commercial metal finishing activities. In the vicinity of Site 4, industrial activities and associated operations which are probable sources of copper include automobile fabrication, aircraft manufacturing, cooling water discharge, and industrial wastewater treatment processes. For both Sites 3 and 2, potential non-point sources are contributions from residential/commercial land use area drainage. Within the area of Site 1, the municipal sewage treatment plant, direct discharges under the NPDES program and drainage from residential/commercial areas are probable sources.

Lead. The short-term study criteria developed for lead was 200 ug/l (not to exceed 20 ug/l for 48 hours).

During the storm event of May 13, 1981, the concentration of lead detected at Site 5 during the incline phase was 245 ug/l.

In the second storm event, the concentrations at Site 5 again were greater than the study criteria. The concentration at the first flush phase was 300 ug/l. For both the incline and decline phases, the concentration was 240 ug/l.

The concentrations of lead measured during the third storm event was 260 ug/l during the first flush phase at Site 5, which was probably due to parking lot runoff.

The concentrations of lead detected during the dry weather sampling did not exceed the established criteria.

Probable sources and/or pathways of lead in the area of Site 5 are runoff from parking lots, drainage from residential/commercial land use areas, roadway washoff, and motor vehicles emissions. Other sources at Site 5 include automobile service and gasoline service stations.

Cyanide. The study criteria for cyanide is 3.5 ug/l.

During the first storm event, cyanide concentrations were greater than the criteria at three sampling sites. At Site 5 the incline and peak phases were 4 ug/l. The first flush and incline phases at Site 4 had concentrations of cyanide at 4 ug/l. The Site 1 peak, first decline, and second decline, concentrations were 5 ug/l, 7 ug/l, and 6 ug/l.

The concentrations of cyanide during the second storm event were greater than the study criteria at Site 1. The first flush phase concentration was 4 ug/l more and the peak phase was 6 ug/l.

The concentrations at Site 1 also exceeded the study criteria during the third storm event. All of the concentrations of cyanide detected during sampling phases were over the study criteria. The first flush phase was 5 ug/l, peak phase was 8 ug/l, first decline was 10 ug/l, and second decline was 7 ug/l.

During the May dry weather sampling, the concentrations detected at Sites 5, 2 and 1 were greater than the cyanide study criteria established. The Site 5 concentration was 4 ug/l, Site 2 was 9 ug/l, and Site 1 was 6 ug/l. In June dry weather samples, cyanide concentrations detected at Sites 5 and 4 were 4 ug/l. The Site 1 concentration was 7 ug/l. The concentration at Site 1 in the July dry weather sampling was 4 ug/l.

Probable sources for cyanide at Site 5 are commercial metal finishing and drainage from residential/commercial land use areas. In the area of Site 4 potential sources are industrial operations and associated activities, including automobile fabrication, aircraft manufacturing, and industrial metal finishing. The on-site storage of cyanide and industrial wastewater treatment processes are also a part of the industrial activities. The probable source of cyanide at Site 2 is drainage from residential/commercial areas. The municipal sewage treatment plant and the drainage from residential/commercial land use activities are probable sources within the vicinity of Site 1.

Organic Compounds (Pesticides)

Due to problems with detection limit confidence levels experienced during the samples analyses by the U.S. EPA contract

laboratories, it was not possible to be certain that the six pesticides detected during the storm events were in violation of their study criteria (Table 25). Only one pesticide compound was detected during the dry weather sampling process. In the following paragraphs, the storm event sampling phase, the dry weather sampling, and the probable sources of these seven pesticides are discussed.

Aldrin. During the second storm event, aldrin was detected during the peak phase at Site 1. In the third storm event, it was also found at Site 1 during the first decline phase.

Dieldrin. This pesticide was identified in the second storm event at Sites 5, 4, 3 and 1. At Site 5, dieldrin concentrations were found in the peak and decline phases. For Site 4, first flush, peak and decline phases all had concentrations of dieldrin. The peak phase at Site 3 also contained this compound. Both the peak and second decline phase at Site 1 were found to have dieldrin concentrations.

Gamma-BHC. During the second storm event, gamma-BHC was found at all of the sampling sites. The compound was detected at Site 5 in the incline, peak and decline phases. The first flush and peak phases at Site 4 contained gamma-BHC. This pesticide was found in all of the sampling phases at the remaining sampling sites.

Heptachlor Epoxide. In the second storm event, this pesticide was detected in the peak phase at Site 4.

Endosulfan. This compound was detected in the April dry weather sampling at Site 1 and the concentration was .2 ug/l.

Endosulfan is an insecticide used wth vegetable crops. The criteria excursion is assumed to be associated with the preparation of land for commercial agriculture activities and home gardens.

4,4'-DDD. During the second storm event, 4,4'-DDD was identified at Site 4, first flush phase; Site 3, peak and decline phases; and Site 2, first flush phase.

4,4'-DDE. The second storm event showed 4,4'-DDE in the second decline phase at Site 2.

Potential Sources. Probable source of these pesticides in the area of Sites 4, 5, and 1 is the commercial/residential use of pesticides. Agricultural, commercial and residential uses of pesticides are the potential sources within the vicinity of Sites 2 and 1.

## Regulatory Analysis

Potential strategies for controlling toxic materials in Coldwater Creek watershed, and those applicable to implementation in other urban watersheds, fall into four major categories:

1. The enforcement of existing regulations
2. The modification or enhancement of existing regulations to make them more inclusive
3. The creation of new regulatory controls where needed through legislative means
4. Selective revokement of redundant regulations

The applicability of these major control strategies will be discussed with respect to controlling chromium, lead, copper, cyanide and endosulfan. MoDNR has previously adopted in-stream water quality criteria for these five priority pollutants. The

two sets of criteria for each of the five priority pollutants, as they relate to possible control strategy options will also be described below.

Lead. The EWGCC/MSD short term criteria for protecting indigenous aquatic species was selected to be 200 ug/l as compared to the MoDNR aquatic criteria of 50 ug/l. The sampling results indicate that all EWGCC/MSD criteria violations occurred at Site 5 only during storm events. This suggests contributions from nonpoint sources. The major factors involved in these criteria violations are the location of large area parking lots and the proximity of Interstate 70. The highway and many of the parking lots have direct pipe discharges into Coldwater Creek. Site 5 is also located at the upper end of the watershed which would help to account for the violations since downstream sampling points would have increased flow volumes and tend to dilute lead readings. The highest lead reading for Site 5 was during the second storm event on a first flush sample (300 ug/l). This reading translates into total lead loading rate of 78.0 mg/sec with a hydrograph cycle of 3 hours and 15 minutes.

The control strategy which would be most appropriate for diminishing the lead violation would be the modification or enhancement of existing regulations. A complete ban on leaded gasoline would obviously lead to immediate improvement, and with the growing use of unleaded gasoline, this may eventually, over time, eliminate all lead violations. The federal unleaded gasoline requirements, therefore, would need enhancement, or at the very least, enforcement of existing regulations. An interim

strategy which may help to reduce lead concentration would be to use vacuum street sweepers for both street and parking lot surfaces. The removal of street and parking lot grit and sediment would lower lead levels since lead is closely associated with particulate matter. Vacuum street sweeping would have to occur, based on accepted practice, at a twice-a-week frequency in order to be effective. This control measure may be cost-prohibitive since street sweeping is relatively expensive.

Chromium. The aquatic EWGCC/MSD short-term criteria selected for chromium is 10.5 ug/l as compared to the MoDNR criteria of 100 ug/l. Although none of the sampling results violated the MoDNR aquatic life criteria, major EWGCC/MSD criteria violations occurred during storm events and were recorded at all major sites. Site 1 recorded a high concentration of 56 ug/l during storm 3 a on the first decline sample. This reading equals a total loading rate of 103.2 milligrams/second (mg/sec) with a hydrograph phase of 5 hours. Of this total, approximately 51 percent, or 52.7 mg/sec, is contributed by the Coldwater Creek sewage treatment plant. The industrial cooling tower discharges located above Sampling Site 4 are estimated to contribute less than 15 percent, or approximately 15.6 mg/sec. However, industrial cooling water discharges may have a significant impact on Site 4 criteria excedences. (Site 4 had the highest reading, 58 ug/l, during Storm 3.) The remaining portion is thought to originate in commercial and residential runoff.

The major source for chromium at Site 1 would appear to be the Coldwater Creek sewage treatment plant. A more stringent

application of existing regulations under MSD's pretreatment program or a new NPDES permit with stricter chromium limitations are possible strategies. The most cost-effective means of achieving the reduction would be by tighter control on sources discharging to the publicly owned treatment works. Such control would eliminate chromium violations using EWGCC/MSD aquatic criteria. Also, to eliminate Site 4 criteria violations, modifications to the existing NPDES industrial cooling water permits may be required. However, under current MoDNR aquatic life criteria for chromium and from the study's sampling results, there are no violations of MoDNR chromium criteria.

Copper. The EWGCC/MSD short-term criteria selected for copper is 21.5 ug/l which approximately equals the MoDNR aquatic life criteria of 20 ug/l. Violations for both EWGCC/MSD and MoDNR criteria occurred principally during storm events. Criteria violations were distributed over all of the sampling sites, however, Site 4 consistently had the higher concentration levels and frequency of violation. Site 4 recorded the highest storm concentration of 64 ug/l during Storm 3 on the peak sample. This reading equals a peak loading rate of 25.6 mg/sec with a hydrograph phase of 3 hours. It is considered that industrial cooling water contributions above Site 4 equal 14.6 mg/sec, or approximately 57 percent, of the peak copper loading rate at Site 4.

During dry weather, only two violations occurred and both of these appeared during the June sampling at Sites 1 and 2. Site 1 had a June reading of 64 ug/l which translates into a loading

rate of 6.08 kg/day flowing past Site 1. The Coldwater Creek sewage treatment plant can contribute as high a loading rate as 14.35 kg/day, which could account for all of the copper loading at Site 1.

The major sources for copper appear to be the industrial cooling water discharges and the Coldwater Creek sewage treatment plant effluent. During wet weather, non-point sources, such as parking lot and commercial area runoff, may also influence upstream sites.

Since both wet weather and dry weather violations are related in part to the point source discharges, a modification of existing permits and standards may be required to meet the EWGCC/MSD aquatic life criteria. Such permit revisions could possibly require the specific cooling water permitted discharges to stagger discharges from various cooling towers and also attenuate the flows from these towers. Further, improved copper removal efficiency at the Coldwater Creek sewage treatment plant may be cost prohibitive and a detailed survey and adjustment of industrial pretreatment for copper may be in order.

Cyanide. The EWGCC/MSD criteria for cyanide is 3.5 ug/l for the protection of aquatic life. The study criteria compares favorably to the MoDNR criteria of 5 ug/l. EWGCC/MSD criteria violations were present during both wet and dry weather sampling. During wet weather sampling, the most frequent and highest concentrations were located at Site 1. Storm 3 produced the highest reading at Site 1, 10 ug/l, on the first decline sample. This concentration level equals a peak cyanide loading rate of

18.5 mg/sec with a hydrograph phase of 5 hours flowing past Site 1 at that point. The Coldwater Creek sewage treatment plant can contribute as high a loading rate as 112.6 mg/sec which obviously accounts for a high percentage of the concentrations measured at Site 1.

During dry weather, EWGCC/MSD criteria violations generally were detected at Site 1. Some minor excursions (4 ug/1 readings) occurred at Sites 4 and 5, but most frequent violations (three out of six monthly samples) were detected at Site 1. The June dry weather reading of 7.0 ug/1 was the highest concentration for Site 1. This figure translates into a cyanide loading rate of 0.665 kg/day. As in the wet weather sampling, the Coldwater Creek sewage treatment plant appears to be the major source of cyanide at Site 1.

Two major sources of cyanide are metal finishing operations and pesticides. Minor metal finishing operations are located in the upper part of the watershed, above the airport, which could impact results from Sites 5 and 4 during wet weather. Also, these metal finishing operations could be contributing cyanide concentrations to the Coldwater Creek sewage treatment plant. Such commercial discharges may need further investigation and control if study criteria is to be achieved.

Another source of cyanide is from the manufacture and use of pesticides. Use of pesticides range from the home and garden to large scale commercial agricultural application in the northwestern part of the watershed. These uses are apparently as significant in terms of in-stream effects as the Coldwater Creek

STP discharge and related commercial operations. A tightening of pretreatment requirements may be required to meet the EWGCC/MSD study criteria.

Endosulfan. The EWGCC/MSD short-term criteria for the protection of aquatic life is 0.11 ug/l as compared to the MoDNR aquatic life criteria of 0.003 ug/l. However, since MoDNR has not designated the use of Coldwater Creek to be aquatic life propagation, the 0.003 ug/l standard does not apply.

The sampling results indicate that the EWGCC/MSD short-term criteria were exceeded only during the dry weather monthly sample of April. The endosulfan concentration of 0.22 ug/l occurred at Site 1, and this reading approximated a daily loading of 0.021 kg/day. This sample is indicative of early spring pesticide applications for home garden and commercial agriculture use.

To correct this seasonal criteria violation, some form of pesticide application control may be necessary. Although one monthly dry weather sampling violation does not constitute a total verification of a persistent pesticide problem, further research in this area may be required.

# 9. CONCLUSIONS

The major objective of the Toxic Agent Study was to develop and execute methodologies, including a toxic agent budget, for the analysis of waterborne toxics within a typical urban watershed. Based on the information developed in this study, current management strategies for the control of priority pollutants could then be evaluated. A second objective was to develop a model work plan for conducting a toxic agent study which would be applicable to other watersheds. Included in the study was the implementation of a field sampling program and design of a water quality criteria selection procedure essential to the evaluation of water pollution control effectiveness. Outlined below are the major conclusions formulated as a result of the study. A brief explanation and justification of each conclusion is included.

1. The watershed evaluated in the study, Coldwater Creek, located in north St. Louis County, Missouri, is relatively free of priority pollutant contamination (based on study sampling results).

In 1980, U.S. EPA estimated that Coldwater Creek was one of 20 worst polluted streams in the nation, based on types of industries with NPDES permits. The Toxic Agent Study revealed that only four priority pollutants (chromium, lead, cyanide and

copper) were consistently in violation of EWGCC/MSD water quality criteria. One insecticide (endosulfan) was detected in excess of short-term study criteria in one dry weather monthly sample. The study results indicate that Coldwater Creek is not polluted by significant quantities of toxic agents.

2. The methodology developed and utilized during the study can be successfully applied to any urban watershed to assess water quality problems and to identify pollution sources which require implementation of appropriate control strategy.

The major elements of the study, i.e., study area definition, field monitoring, water quality criteria selection, and pollutant source identification, are essential to a successful evaluation of toxics entry modes and water quality control needs. The potential pollutants must be identified, probable sources located, and actual concentrations measured and compared to water quality criteria. The selection of appropriate water quality criteria appears to be the most essential element in the control strategy evaluation process.

3. An exact mass balance (budget) of toxics entering and leaving a defined watershed is not economically nor technically feasible due to present lack of record keeping requirements by users, generators and transporters of these substances.

The lack of existing information on potential toxic agent sources presented a difficult problem. For example, transportation source information is, at best, generalized. As related to the trucking industry, there is no information or record keeping

required as to the quantity and type of toxic substance hauled, stored or distributed in a particular area.

4. Water quality criteria for designated uses of specific receiving waters must be developed to insure adequate environmental protection.

One area in which information is obviously lacking is that of in-stream water quality criteria for the 126 priority pollutants. In order to resolve this problem, a unique decision table methodology for selecting appropriate criteria was developed for the Toxic Agent Study. This criteria setting procedure involved development of a series of decision table matrices which establish priority pollutant criteria based on designated uses of a receiving water and toxicity of substance being evaluated. This criteria setting procedure takes into consideration site-specific factors such as land use, stream characteristics and material toxicity, uses, and economic significance. Water quality criteria are a necessary element for measuring the effectiveness of control strategies.

5. Water quality monitoring at strategic locations is essential to the identification of pollution problems and control of toxic agent discharges.

A field monitoring program is necessary for determining water quality violations, particularly as related to priority pollutants. A carefully designed and implemented sampling program will lead to the most cost-effective control strategy for both point and nonpoint source priority pollutants.

6. There is a need for standardization of U.S. EPA analytical procedures, detection limits and reporting of results.

The sampling of Coldwater Creek and analysis of collected samples by U.S. EPA contract laboratories presented data recording and reporting problems that need to be resolved by U.S. EPA. The first major problem area is that of detection limits. Each of the various U.S. EPA labs utilized seem to have differing detection limits for the same priority pollutant. The second major area is the establishment of consistent analytical protocol. Analytical protocol for detection was changed during the course of this study and made the quantification of priority pollutants difficult for budget calculations.

7. Nonpoint sources contribute excessive pollutant concentrations during storm runoff but may not cause measurable toxicity effects due to short retention time within Coldwater Creek.

Nonpoint sources were found to have a significant impact on water quality. For example, lead violations were detected only at Site 5 and only during storm events. These lead violations are definitely correlated to transportation related sources since many parking lots and an interstate highway drain into Site 5. Such nonpoint pollution source impacts may not have measurable toxicity effects since the storm events are of relatively short duration and runoff is rapid. During storm events, time of travel from the headwaters of Coldwater Creek to its mouth is about 10 hours.

8. The publicly owned treatment works (POTW) has the greatest water quality impact on Coldwater Creek.

The wet and dry weather sampling results emphasized the impact of the Coldwater Creek sewage treatment plant has on the lower section of Coldwater Creek. During low flow period, the treatment plant effluent represents a high percentage (80 percent) of the total stream flow below the plant. Obviously, this point source is of greater priority than upstream nonpoint sources which affect the water quality for short durations. Reducing priority pollutant concentrations from the POTW would create the greatest water quality benefit for Coldwater Creek in its lower reach.

9. Based on the sampling results, the most cost-effective pollution control method for Coldwater Creek appears to be contributory source control (i.e., controlling commercial/industrial dischargers to the POTW).

Noted excursions above selected water quality criteria could be corrected by controlling point source discharges or by regulating contributory discharges through the point source. For example, copper violations could be diminished by tightening enforcement of pretreatment standards at the industrial source. This is more cost-effective than installing expensive copper removal technology at the Coldwater Creek sewage treatment plant.

10. A selective revokement and/or consolidation of overlapping pollution control regulations is needed.

One overlap observed was related to the establishment of toxicity of priority pollutants. Currently, there are many

agencies involved in determining the toxicity of new materials. These analyses may impact the list of 126 priority pollutants. Clearly, U.S. EPA needs to be the lead agency for toxicity analysis as related to the priority pollutant list.

11. Air pollution is a source of priority pollutants contained in stormwater runoff.

The analysis of precipitation samples revealed that heavy metals and certain organic compounds were prevalent in the atmosphere and were being washed out during storm events. The complex relationship between air quality and water quality needs to be investigated further.

| STANDARD TITLE PAGE FOR TECHNICAL REPORTS | 1. Report No. EWG-TS-0450(I).15.0 | 3. Recipient's Catalog No. |
|---|---|---|
| Title and Subtitle: Toxic Agent Study Volume I: Final Report | | 5. Report Date: January 1983 |
| | | 6. Performing Organization Code |
| 7 Author(s): Michael Coulson, Carol Lawrence, Wileen Sweet, Bernard Rains, Gregory Knauer | | 8. Performing Organization Rept. No. EWG-TS-0450(I).15.0 |
| 9 Performing Organization Name and Address: East-West Gateway Coordinating Council, 112 North 4th Street, Suite 1200, St. Louis, MO 63102 | | 10. Project/Task/Work Unit No. 3442-3443 |
| | | 11. Contract/Grant No. PO07064-01 |
| 12. Sponsoring Agency Name and Address: Environmental Protection Agency, 324 East 11th Street, Kansas City, MO | | 13. Type of Report & Period Covered: Final |
| | | 14. Sponsoring Agency Code |

15 Supplementary Notes

16 Abstracts

This report presents for the Coldwater Creek watershed an inventory of existing conditions and methodology employed in the water quality sampling, findings of the toxic agent budget (mass balance of priority pollutants), water quality criteria developed, and priority pollutant control strategies. Study methodology can be applied to other urban watersheds in the nation.

17 Key Words and Document Analysis. (a). Descriptors

17b. Identifiers/Open-Ended Terms

COSATI Field/Group

| 18. Distribution Statement | 19. Security Class (This Report) | 21. No. of Pages |
|---|---|---|
| East-West Gateway Coordinating Council, 112 North 4th Street, Suite 1200, St. Louis, MO 63102 | UNCLASSIFIED | 195 |
| | 20. Security Class. (This Page) UNCLASSIFIED | 22. Price |

Form CFSTI-35 (4-70)

# FUSRAP Document Management System

Year: 00
ID: 2787
Further Info? ☐

Operating Unit: St. Louis Sites
Site:
Area:
MARKS Number: FN:1110-1-8100g

Primary Document Type: Site Management
Secondary Document Type: Reference Documents

Subject or Title: East-West Gateway Coordinating Council Coldwater Creek Toxic Agent Study dated January 1993

Author/Originator:
Company: East West Gateway C
Date: 1/1/1983

Recipient (s):
Company (-ies):
Version: Final

Original's Location: Central Files
Document Format: Paper
Confidential File? ☐

Include in which AR(s)?

- ☑ North County
- ☐ Madison
- ☐ Downtown
- ☐ Iowa

Comments:
SAIC number:
Bechtel ID:

ETL: 1.6
Filed in Volume: 1