RECONNAISSANCE INVESTIGATION OF WATER QUALITY, BOTTOM SEDIMENT, AND BIOTA ASSOCIATED WITH IRRIGATION DRAINAGE IN THE PINE RIVER PROJECT AREA, SOUTHERN UTE INDIAN RESERVATION, SOUTHWESTERN COLORADO AND NORTHWESTERN NEW MEXICO, 1988-89

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FIGURES

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CONVERSION FACTORS AND RELATED INFORMATION

Multiply	By	To obtain
acre	4,047	square meter
acre-foot (acre-ft)	1,233	cubic meter
cubic foot per second (ft^3/s)	0.028317	cubic meter per second
foot (ft)	0.3048	meter
gallon per minute (gal/min)	0.06309	liter per second
gram (g)	0.03527	ounce
inch (in.)	25.40	millimeter (mm)
liter (L)	0.26427	gallon
mile (mi)	1.609	kilometer
milligram (mg)	35.27	ounce
millimeter (mm)	0.03937	inch
square mile (mi^2)	2.589	square kilometer
ton per day	0.9072	metric ton per day

Temperature in degree Celsius (°C) may be converted to degree Fahrenheit (°F) by using the following equation:

$$°F = 9/5\ (°C) + 32.$$

Temperature in degree Fahrenheit (°F) may be converted to degree Celsius (°C) by using the following equation:

$$°C = 5/9\ (°F-32).$$

The following terms and abbreviations also are used in this report:

milligram per kilogram (mg/kg)
milligram per liter (mg/L)
microgram per liter (µg/L)
microgram per gram (µg/g)
microgram per kilogram (µg/kg)
microsiemens per centimeter at 25 degrees Celsius (µS/cm)

2,4-D	2,4-dichlorophenoxy-acetic acid
2,4-DP	2-(2,4-dichlorophenoxy) propionic acid
2,4,5-T	2,4,5-trichlorophenoxy-acetic acid
PCN's	polychlorinated naphthalenes
PCB's	polychlorinated biphenyls
DDD	1,1-dichloro -2,2-bis (p-chlorophenyl) ethane
DDE	dichloro diphenyl dichloroethylene
DDT	dichloro diphenyl trichloroethane
BHC	benzene hexachloride
HCB	hexachlorobenzene

National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

TABLES

Reconnaissance Investigation of Water Quality, Bottom Sediment, and Biota Associated with Irrigation Drainage in the Pine River Project Area, Southern Ute Indian Reservation, Southwestern Colorado and Northwestern New Mexico, 1988-89

By David L. Butler, Richard P. Krueger, Barbara Campbell Osmundson, Andrew L. Thompson, James J. Formea, *and* Donald W. Wickman

Abstract

The U.S. Department of the Interior has completed 20 reconnaissance investigations in the Western United States to determine if irrigation drainage has the potential to affect human health, fish, and wildlife or has adversely affected the suitability of water for other beneficial uses. A reconnaissance investigation of the Pine River Project, which is drained primarily by the Los Pinos River (also known as the Pine River) in southwestern Colorado, was initiated in 1988. Water, bottom sediment, and biota were sampled and analyzed during 1988-89 to determine if selenium or other potentially harmful constituents were present in the Pine River Project area. Soil and plant samples were collected from the Oxford Tract in 1989 to determine the magnitude and variability of selenium on the tract. The Oxford Tract is a block of Indian land where problems concerning human health and livestock caused by selenium poisoning have been documented.

Irrigation drainage does not seem to be a major source of dissolved solids to streams in the Pine River Project area. The maximum dissolved-solids concentration in the Los Pinos River was 156 milligrams per liter; concentrations in tributaries and other streams receiving irrigation drainage ranged from 89 to 1,090 milligrams per liter. Concentrations of manganese in 25 samples and mercury in 1 sample exceeded the maximum recommended level in the U.S. Environmental Protection Agency drinking-water regulations. Ground water from nonirrigation sources may be contributing manganese to streams. The maximum concentration of mercury in a water sample was 2.3 micrograms per liter from the reference site on the Los Pinos River. The concentration of selenium exceeded the maximum-contaminant level (50 micrograms per liter) in only one surface-water sample. Concentrations of selenium in 12 surface-water samples exceeded the U.S. Environmental Protection Agency's chronic criterion for selenium for protection of aquatic life (5 micrograms per liter). The maximum selenium concentration in a surface-water sample was 94 micrograms per liter from Rock Creek on the Oxford Tract, an area known to have large selenium concentrations in ground water. Irrigation drainage probably is contributing some of the selenium to Rock Creek and other streams in the Pine River Project area. Selenium concentrations in the Los Pinos River and in Navajo Reservoir were less than or equal to 1 microgram per liter.

Selenium concentrations in 8 of 10 ground-water samples collected at 5 sites were much larger than 50 micrograms per liter. The maximum concentration was 4,800 micrograms per liter in a sample from a well located in a nonirrigated area west of the Pine River Project. Water levels measured in two wells near irrigated areas indicate a definite connection between irrigation application and shallow ground water in parts of the Pine River Project area.

Trace-element concentrations in bottom sediment in the Pine River Project area generally were within baselines for soils and within concentration ranges reported for previous reconnaissance investigations. All selenium concentrations determined in bottom-sediment samples were less than 1 microgram per gram.

Results of analyses of soil samples from the Oxford Tract indicated that areas previously or presently (1989) irrigated had significantly greater concentrations of total selenium and extractable selenium in soil than did areas that were never irrigated. Total-selenium concentrations in 66 plant samples collected on the Oxford Tract were extremely variable; the maximum concentration was 1,500 milligrams per kilogram in a snakeweed sample. A number of forage plant samples, including alfalfa, had large total-selenium con-

centrations. One alfalfa sample had 180 milligrams per kilogram of selenium.

Selenium is the trace element of greatest concern in biota in the Pine River Project area. Most of the whole-body fish samples had selenium concentrations that exceeded the National Contaminant Biomonitoring Program 85th percentile; however, concentrations were less than the selenium concentrations known to cause reproductive problems in fish. There was no significant difference between selenium concentrations in whole-body fish samples collected upstream and downstream from irrigated areas. Selenium concentrations in aquatic plants, aquatic invertebrates, and small mammals may be sufficiently large to be of concern because of possible food-chain bioconcentration. Maximum concentrations of selenium were 10.2 micrograms per gram dry weight in an aquatic insect sample and 23 micrograms per gram dry weight in a prairie dog sample.

Bird samples collected at two wetland sites on the Oxford Tract had significantly larger selenium concentrations than bird samples collected at two wetland sites along the Los Pinos River. Maximum selenium concentrations in bird samples collected on the Oxford Tract were 50.0 micrograms per gram dry weight in a liver sample and 49.0 micrograms per gram dry weight in a whole-body sample. Two samples of mallard breast tissue collected on the Oxford Tract had selenium concentrations that exceeded guidelines for human consumption. The primary source of recharge to the wetlands on the Oxford Tract is irrigation water.

Cadmium concentrations in about 30 percent of whole-body fish samples and copper concentrations in nearly one half of whole-body fish samples exceeded the National Contaminant Biomonitoring Program 85th percentiles of 0.05 and 1.0 microgram per gram wet weight, respectively. However, these concentrations are considered too small to have toxic effects. There was no significant difference between copper concentrations in whole-body fish samples collected upstream and downstream from irrigated areas. Two whole-body fish samples had lead concentrations that exceeded the 85th percentile for lead (0.22 microgram per gram wet weight) and also exceeded a guideline for lead in foods consumed by humans.

Concentrations of mercury in 16 whole-body fish samples collected in the Pine River Project area during 1988-89 exceeded the 85th percentile for mercury (0.17 microgram per gram wet weight). Ten of these samples were collected from Navajo Reservoir. The maximum mercury concentration in whole-body fish samples was 1.3 micrograms per gram dry weight in a channel catfish from the Los Pinos River at La Boca and in a common carp from the Piedra River arm of Navajo Reservoir. Nine whole-body fish samples and one channel-catfish fillet sample had mercury concentrations that equalled or exceeded 0.25 microgram per gram wet weight, which is a guideline for consumption of fish by pregnant women. The only organochlorine pesticides detected in fish and bird samples were p,p'-DDE and mirex. Organochlorine pesticide concentrations were less than adverse-effect levels reported in the literature.

INTRODUCTION

During the last several years, there has been increasing concern about the quality of irrigation drainage and its potential harmful effects on human health, fish, and wildlife. Concentrations of selenium greater than water-quality criteria for the protection of aquatic life (U.S. Environmental Protection Agency, 1987) have been detected in subsurface drainage from irrigated land in the western part of the San Joaquin Valley in California. In 1983, incidences of mortality, birth defects, and reproductive failures in waterfowl were discovered by the U.S. Fish and Wildlife Service at the Kesterson National Wildlife Refuge in the western San Joaquin Valley, where irrigation drainage was impounded. In addition, potentially toxic trace elements and pesticide residues have been detected in other areas in Western States that receive irrigation drainage.

Because of concerns expressed by the U.S. Congress, the U.S. Department of the Interior (DOI) started a program in late 1985 to identify the nature and extent of irrigation-induced water-quality problems that might exist in the Western States. In October 1985, an interbureau group known as the "Task Group on Irrigation Drainage" was formed within the DOI. The Task Group subsequently prepared a comprehensive plan for reviewing irrigation-drainage concerns for which the DOI may have responsibility.

The DOI developed a management strategy and the Task Group prepared a comprehensive plan for reviewing irrigation-drainage concerns. Initially, the Task Group identified 20 locations in 13 States that warranted reconnaissance-level field investigations. These locations relate to three specific areas of DOI responsibilities: (1) irrigation or drainage facilities constructed or managed by the DOI, (2) national wildlife refuges managed by the DOI, and (3) other migratory-bird or endangered-species management areas that receive water from DOI-funded projects.

Nine of the 20 locations were selected for reconnaissance investigations during 1986-87. The nine areas are:

Arizona-California:	Lower Colorado-Gila River Valley area
California:	Salton Sea area
	Tulare Lake Bed area
Montana:	Sun River Reclamation Project area
	Milk River Reclamation Project area
Nevada:	Stillwater Wildlife Management area
Texas:	Lower Rio Grande-Laguna Atascosa National Wildlife Refuge area
Utah:	Middle Green River basin area
Wyoming:	Kendrick Reclamation Project area

In 1988, reports for seven of the reconnaissance investigations were published. Reports for the remaining two areas were published in 1990. Based on results of the first nine reconnaissance investigations, four detailed studies were initiated in 1988: Salton Sea area, Stillwater Wildlife Management area, Middle Green River basin area, and the Kendrick Reclamation Project area. Eleven more reconnaissance investigations were initiated in 1988:

California:	Sacramento Refuge Complex
California-Oregon:	Klamath Basin Refuge Complex
Colorado:	Gunnison and Uncompahgre River basins and Sweitzer Lake
	Pine River Project area
Colorado-Kansas:	Middle Arkansas River Basin
Idaho:	American Falls Reservoir
New Mexico:	Middle Rio Grande Project and Bosque del Apache National Wildlife Refuge
Oregon:	Malheur National Wildlife Refuge
South Dakota:	Angostura Reclamation Unit
	Belle Fourche Reclamation Project
Wyoming:	Riverton Reclamation Project

All studies are done by interbureau teams composed of a scientist from the U.S. Geological Survey as team leader, with additional U.S. Geological Survey, U.S. Fish and Wildlife Service, U.S. Bureau of Reclamation, and U.S. Bureau of Indian Affairs scientists representing several different disciplines. The reconnaissance investigations are directed toward determining whether irrigation drainage: (1) has caused or has the potential to cause significant harmful effects on human health, fish, and wildlife; or (2) may adversely affect the suitability of water for other beneficial uses.

The U.S. Bureau of Reclamation's Pine River Project furnishes water for irrigation of Indian and non-Indian land within parts of the Southern Ute Reservation in southwestern Colorado. The source of the irrigation water is the Los Pinos River, also known as the Pine River from which the Project derives its name. Problems associated with large concentrations of selenium in ground water and in vegetation and forage crops have been reported in parts of the Pine River Project area. In the 1960's, a case of selenium poisoning of humans attributed to drinking well water containing very large concentrations of selenium was documented (Beath, 1962). The selenium poisoning occurred on the Oxford Tract, a block of Indian land within the Project area. Since the selenium poisoning, agricultural use of the Oxford Tract by the Southern Ute Tribe has been limited. Also, selenium poisoning of livestock and horses has been reported on the reservation for many years; two such cases were reported in 1987. A reconnaissance investigation was started in 1988 to determine if irrigation drainage was affecting water quality, bottom sediment, and biota in the Pine River Project area.

Purpose and Scope

This report describes the results of the reconnaissance investigation of the Pine River Project area. Specific objectives of the reconnaissance investigation are to:

(1) Describe concentrations of selenium and other trace elements and selected pesticides in water, bottom sediment, and biota in streams and reservoirs that receive irrigation drainage from the Project area.

(2) Identify potentially harmful concentrations of trace elements and pesticides and document whether concentrations are the result of irrigation drainage.

(3) Document large selenium concentrations in ground water and identify if there is a connection between irrigation application and shallow ground water.

(4) Describe the magnitude and variability of selenium concentrations in soil and in plants on the Oxford Tract, and document whether irrigation practices have affected selenium concentrations.

Results of the water, bottom-sediment, and biota sampling and analysis are intended to help the DOI determine whether irrigation drainage has caused or has the potential to cause harmful effects on humans, fish, and wildlife, or has impaired the suitability of the water for beneficial use. The selenium results for soil and plants are to be used by the U.S. Bureau of Indian Affairs and the Southern Ute Tribe to help determine if the Oxford Tract could be restored to beneficial use and what management techniques would be needed to do so.

Water, bottom-sediment, and biota samples were collected from November 1988 to July 1989 from streams that drain irrigated areas of the Pine River Project. Samples also were collected from Navajo Reservoir. Samples were analyzed for selected trace elements, including selenium, and pesticides. Ground-water samples were collected at five sites in concentrated seleniferous areas during 1989. Constituent concentrations were compared to various water-quality criteria and values from the literature to identify potential problems associated with contaminants in the Project area. Water levels were measured at wells in irrigated and nonirrigated areas. Soil and plant samples were collected on the Oxford Tract in August 1989 for selenium analysis.

Acknowledgments

The authors thank George Knoll, an employee of the Southern Ute Tribe, for his assistance during the study. The authors also thank members of the Southern Ute Tribe who assisted the U.S. Fish and Wildlife Service with the biota sampling and also thank the various property owners who allowed access to their wells for sampling or measuring water levels. The authors also thank David Grey of the U.S. Geological Survey for assisting with collection of water samples and Philip Alcon of the U.S. Bureau of Reclamation for collection and compilation of water-level data.

DESCRIPTION OF PINE RIVER PROJECT AREA

Location

The Pine River Project furnishes water to irrigate land in southeast La Plata County and southwest Archuleta County in southwestern Colorado (fig. 1). Most of the irrigated land that receives water from the Project is within the general boundary of the Southern Ute Indian Reservation, centered around the Los Pinos River. The reconnaissance investigation of the Pine River Project area extended beyond the boundary of the irrigated area shown on figure 1 to include streams that receive irrigation drainage from Project land (such as the Florida River and Salt Creek) and to include streams that were used as reference sites (such as the Piedra River). The Los Pinos River arm and Piedra River arm of Navajo Reservoir (fig. 1) also were included in the reconnaissance investigation of the Pine River Project area. The Los Pinos River arm of Navajo Reservoir is in northern New Mexico (fig. 1).

History

Settlement in the Los Pinos River Valley was coincident with the discovery of gold and the mining boom during the late 1860's in the San Juan Mountains north of the Pine River Project area. The influx of miners into the Ute Indian Reservation caused considerable friction and open warfare between miners and the Indians. The Ute Indian Reservation was first defined by the treaty of 1868. In 1874, the United States bought 3 million acres of land from the Ute Indians north of the boundary line shown in figure 1. Other acts and agreements in 1880, 1882, and 1895 decreased the size of the reservation to its present boundaries. The opening of the reservation to homesteading in 1899 increased the settlement of the Indian lands and resulted in a checkerboard pattern of Indian and non-Indian lands on the reservation. In 1938, land within the reservation that had not been homesteaded (about 200,000 acres) was returned to the Southern Ute Tribe.

Irrigation in the Los Pinos River valley began in 1877, when small ditches were constructed along the river for use by the Indian agency and a few small farms. The Southern Utes had priority use of water, which caused shortages of water for other lands in the area in years when there was insufficient flow in the Los Pinos River to meet irrigation requirements. Investigations concerning storage of snowmelt for irrigation have been conducted since the 1920's by the Office of Indian Affairs (former name of the U.S. Bureau of Indian Affairs) and by the U.S. Bureau of Reclamation. In 1934, the Pine River Project was turned over to the U.S. Bureau of Reclamation for planning and construction. The Pine River Project was approved for construction in 1937, and construction of Vallecito Reservoir (fig. 1) was completed in 1941.

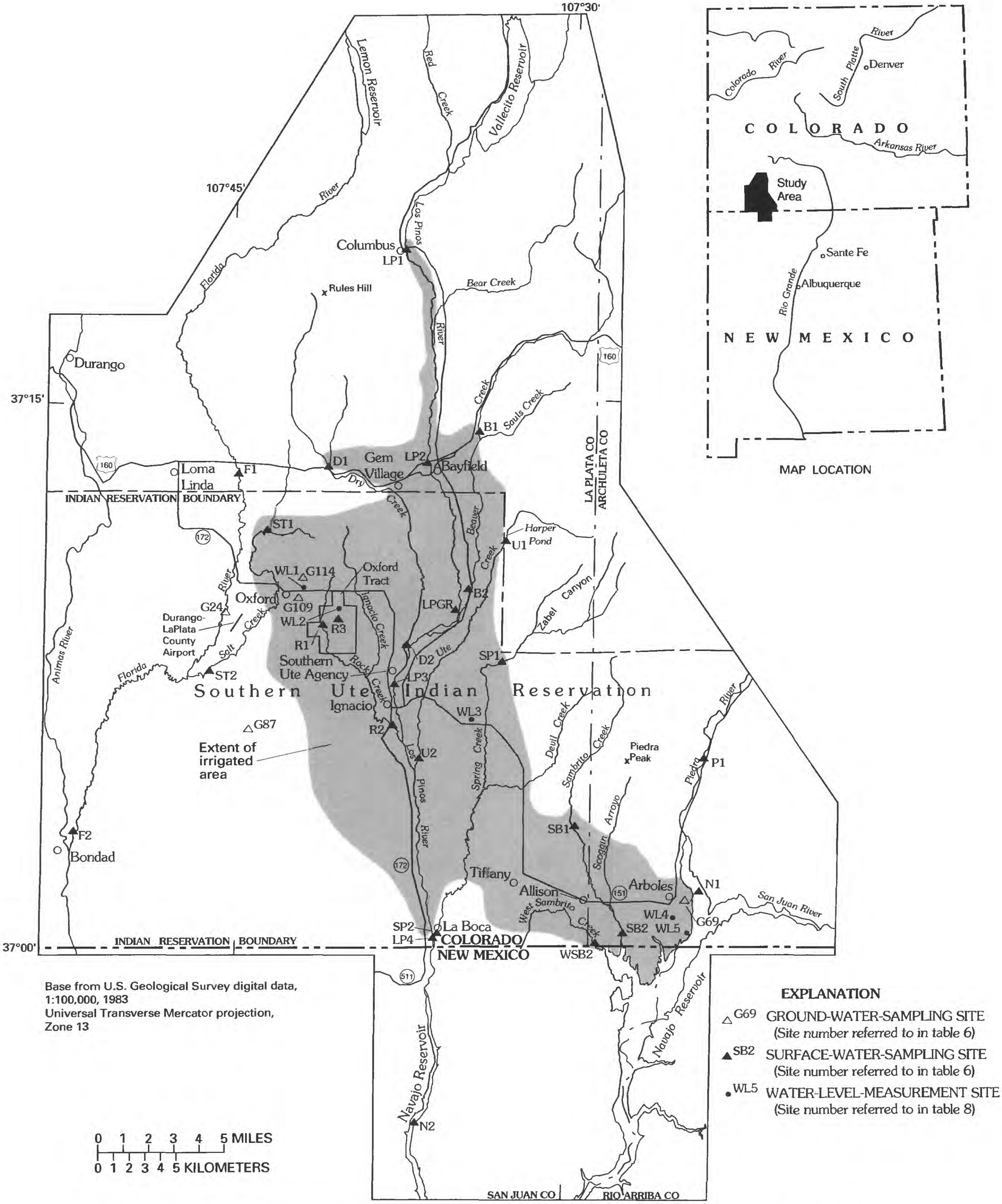

Figure 1. Extent of irrigated area, primary features, and location of data-collection sites in the Pine River Project area, Southern Ute Indian Reservation, southwestern Colorado and northwestern New Mexico, 1988-89.

Distribution facilities were not included as part of the original Project.

Physiography and Climate

The Pine River Project area is in the extreme eastern part of the Colorado Plateau physiographic province in a transition zone between the San Juan Mountains (north of Vallecito Reservoir in fig. 1) and the semiarid lowlands. Much of the irrigated land is on rolling terrain within small drainage basins that are separated by low ridges. Elevation decreases from north to south, and most of the irrigated land is between 6,200 and 6,800 ft. Elevation of the irrigated area ranges from 6,100 ft at Navajo Reservoir to about 7,300 ft at Columbus (fig. 1).

Climate in the Pine River Project area is continental, with cool to occasionally cold winters and warm summers. Minimum temperatures in winter are occasionally below 0°F. Summers are characterized by warm days with maximum temperatures in the 80's to low 90's and cool nights. The annual mean temperature is about 46°F, and extremes range from -38°F to 101°F. The growing season is relatively short and averages about 110 days at Ignacio.

The irrigated areas of the Pine River Project are considered semiarid and receive 12 to 16 in. of precipitation per year. Based on reservoir-evaporation studies for southwestern Colorado by the U.S. Bureau of Reclamation, the annual evaporation in the Project area is about 35 to 40 in. Precipitation increases quite rapidly south to north with increasing elevation. The mean annual precipitation for 1951-80 was about 14 in. at Ignacio and 26 in. at Vallecito Reservoir. The wettest months are August, when precipitation is from thunderstorms, and October, when precipitation is from frontal storms. During 1989, a drought occurred in southwestern Colorado, and the spring was very dry. At Ignacio, monthly precipitation was only 3 percent of normal in April and 20 percent of normal in May, and no precipitation fell in June.

Geology

The Pine River Project area is in the extreme northern part of the San Juan Basin, a structural depression of sedimentary rocks roughly circular in shape, located in northwestern New Mexico, southwestern Colorado, and northeastern Arizona. Stratigraphic units dip southwest toward the center of the structural basin in New Mexico (Brooks, 1985).

Stratigraphic units in the study area consist of bedrock and unconsolidated rocks. Descriptions of geologic units primarily are from Zapp (1949), Steven and others (1974), Brogden and others (1979), and Brooks (1985). Irrigated areas are located on sedimentary rocks of Tertiary age, terrace deposits of Quaternary age, and flood plain alluvium that are underlain by sedimentary bedrock units of Cretaceous age. The largest area of irrigated land is on soil and outcrops derived from the Tertiary San Jose Formation, which includes most of the irrigated area west of the Los Pinos River Valley and south of Dry Creek, the lower Spring Creek basin, and all irrigated areas in the Tiffany and Arboles areas (fig. 1). Irrigated areas along the northern boundary of the Project area, in much of the Ute and Beaver Creek basins, and in the upper Spring Creek basin are on soils and outcrops derived from the Tertiary Animas Formation. There are scattered terrace deposits in the Project area, and flood-plain alluvium is present in the larger stream valleys, including the Los Pinos and the Florida Rivers. Alluvial deposits also are present along Dry, Beaver, and Spring Creeks.

The Animas Formation is conglomerate interbedded with variegated shale, sandstone, and breccia. The unit has volcanic material, including andesite pebbles, and has a maximum thickness of about 1,400 ft. The San Jose Formation is interbedded conglomerate, shale, and sandstone. The unit has abundant volcanic material, including andesite pebbles. The proportion of volcanic material and sandstone decreases southward. The maximum thickness is about 2,500 ft. The volcanic material may be a substantial source of selenium in the San Jose Formation and Animas Formation. Volcanic plumes are enriched in selenium (Herring, 1991). The sediments of the San Jose Formation and Animas Formation were deposited during times of significant volcanic activity in the San Juan Mountains north of the area. Terrace deposits are unconsolidated, poorly sorted clay, silt, sand, gravel, and boulders. The terrace deposits are remnants of alluvial fans and older stream valleys. Alluvium in the present-day flood plains is semi- to unconsolidated silt, sand, gravel, pebbles, cobbles, and boulders and is poorly sorted.

Except for the Fruitland Formation of Cretaceous age, other stratigraphic units will not be discussed because they probably have little effect on the hydrology or water quality of irrigated areas in the Pine River Project area. The Fruitland Formation, which is exposed north and east of the Pine River Project area, is interbedded sandstone, shale, and coal. The unit has been mined for coal in areas where it outcrops. Within the Project area, the coal beds in the Fruitland Formation generally are about 2,000 to 3,000 ft below the land surface.

Soils and Land Use

Soils in the Pine River Project area have been mapped into three types (U.S. Soil Conservation Service, written commun., 1985). Most of the irrigated areas are in the Arboles-Bayfield-Zyme unit, which consists of soils on mesas, upland valleys, and foothills. These soils were formed in alluvium and residuum derived from shale and sandstone. The Arboles-Bayfield-Zyme soils are shallow to deep, well drained, and are on gently sloping to steep slopes. The surface and subsurface layers consist of clay, silty clay, or clay loam. These soils have low to moderate salt content. Part of the Arboles-Bayfield-Zyme unit consists of rock outcrops of sandstone and shale.

A second soil type is the Zyme-rock outcrop unit, which consists of soils on hills, terraces, and ridges. This unit is mapped only in small areas along the northern part of irrigated areas in the Tiffany and Allison area and in the La Boca area. Zyme soils were formed in residuum from shale on gently sloping to steep slopes, are shallow to deep, and are well drained. Much of the surface and subsurface layers are clay loam, and some soil in this group consists of cobbly loam or fine sandy loam. The Zyme soils have low to moderate salt content. About 20 percent of this soil unit is sandstone rock outcrops on cliffs, ridges, and breaks.

The third soil type mapped in the Pine River Project area is the Pescar-Tefton-Fluvaquents unit, which consists of soils of river valleys. This unit is mapped along the Los Pinos River alluvial valley from Vallecito Reservoir to the State line. These soils were formed in various alluvial material on almost level to gently sloping land. The alluvial soils are deep, somewhat poorly drained, and are composed of loam, sandy loam, and cobbly loam over sand, gravel, and sandy loam. Soils in this unit have low salt content.

The Pine River Project area consists of intermingled Indian and non-Indian lands. Irrigation primarily is used for alfalfa, irrigated pasture, and also for wheat, oats, and barley. The U.S. Bureau of Indian Affairs reported that 13,106 acres of irrigated crops, which had a value of about 1 million dollars, were produced on the Indian lands within the Project area in 1989. Nonirrigated crops include winter wheat, beans, barley, and oats. Much of the nonirrigated areas are dryland areas of sagebrush, other desert shrubs, and grasses used for grazing livestock. Woodlands of pinyon and juniper are interspersed with irrigated and nonirrigated areas throughout the study area. Willows, cottonwoods, rushes, and grasses grow in the Los Pinos River Valley.

In recent years, rural-residential development has been increasing in the Pine River Project area, especially in the vicinity of Bayfield and Ignacio. Many residences have small irrigated pastures for raising livestock. Recreation is an important industry in southwestern Colorado, although recreational activities near the Project area are limited to Vallecito and Navajo Reservoirs. Both reservoirs are very popular during the summer for fishing and water-sport activities. Since 1985, gas-well drilling has increased substantially throughout the Project area. Methane gas is being extracted from coal beds of the Fruitland Formation by de-watering the coal bed. The wells are located in irrigated and nonirrigated areas on Indian and non-Indian land; most of the wells are on non-Indian land. Most of the waste water from the gas wells is disposed of in deep re-injection wells.

Fish and Wildlife Resources

Estimates of wildlife resources on lands of the Southern Ute Tribe were considered representative of the Pine River Project area because most of the Project area is within the general boundary of the Southern Ute Indian Reservation. The wildlife biologist for the Southern Ute Tribe provided estimates and information of wildlife resources on Indian land (Samuel Diswood, Southern Ute Tribe, oral commun., 1990).

About 300 elk winter on tribal land and migrate to higher elevation areas in summer. About 100 elk reside in the Florida River area throughout the year. About 500 deer live in the Project area, many of which migrate onto the reservation area during winter. An aerial survey in 1990 counted 313 deer within the Project area. About 5 to 10 mountain lions and 5 black bear are on tribal lands. Game birds found in the study area include pheasants, mourning doves, quail, and waterfowl. Wetland areas associated with agricultural water or natural drainages provide nesting and staging areas for waterfowl and migratory birds. Common raptors found in the area include redtail hawks, Swainson's hawks, rough-legged hawks, northern harriers, American kestrels, and great-horned owls. About 10 to 20 bald eagles and 15 to 25 golden eagles winter in the Project area.

During biota sampling for this reconnaissance investigation, the U.S. Fish and Wildlife Service collected rainbow and brown trout from the Los Pinos River, Florida River, Salt Creek, Rock Creek, Dry Creek, Beaver Creek, and Spring Creek. Most of the trout in tributary streams probably came from the Los

Pinos River through canals and ditches. The Los Pinos River has the most utilized trout fishery within the Southern Ute Indian Reservation. Channel catfish and bullheads also were collected from the Los Pinos River and Rock Creek. Carp were collected from the Los Pinos River, Dry Creek, and Rock Creek.

The only State wildlife area located within the Pine River Project area is the Navajo State Wildlife Area, which is an area of 600 acres located at the northern end of Navajo Reservoir in the lower Sambrito Creek basin (fig. 1). About 1,000 ducks and 100 to 150 geese have staged at the wildlife area in the past (Michael Zginer, Colorado Division of Wildlife, oral commun., 1990). The wildlife area has not had much use by waterfowl in recent years, averaging about 40 to 60 ducks per day. In 1990, there were about 10 pairs of ducks and 2 or 3 pairs of geese that nested at the wildlife area (Richard Fentzlaff, Colorado Division of Wildlife, oral commun., 1990). Elk presence on the Navajo State Wildlife Area is sporadic, and about 10 to 15 deer reside there throughout the year. Game species in Navajo Reservoir include brown trout, rainbow trout, northern pike, bass, crappie, channel catfish, bullhead, and carp.

HYDROLOGIC SETTING

The hydrologic system in the Pine River Project area consists of all streams draining the Project area between the Florida River and the Piedra River (fig. 1), the irrigation system, and the ground-water system. Most of the irrigated area is drained by the Los Pinos River, which discharges into Navajo Reservoir. The southeastern part of the irrigated area is drained by small streams, such as Sambrito Creek, which discharge into Navajo Reservoir. A schematic diagram of the general surface-water flow system is shown in figure 2. All surface and subsurface discharge from the Project area is toward the San Juan River. Most of the irrigation drainage from the Project area is into Navajo Reservoir, but some irrigation drainage discharges into the Florida River.

Streams

Headwaters of the Los Pinos River, which drains about 570 mi^2, are in the San Juan Mountains about 20 mi northeast of Vallecito Reservoir (fig. 1). From Vallecito Reservoir, the Los Pinos River flows generally south to Navajo Reservoir. The high-water line of Navajo Reservoir is about 2 mi south of streamflow-gaging station 09354500, Los Pinos River at La Boca (site LP4 in fig. 1). The Florida River heads in the San Juan Mountains about 12 mi north of Lemon Reservoir and flows generally south and southwest to the confluence with the Animas River at Bondad (fig. 1).

Most of the irrigation drainage and return flow into the Los Pinos River is transported by tributaries, such as Rock, Dry, Beaver, Ute, and Spring Creeks. Some irrigated area in the Oxford area is drained by Salt Creek, which is tributary to the Florida River. The Florida River is a tributary of the Animas River, which discharges into the San Juan River downstream from Navajo Reservoir in northern New Mexico (fig. 2). Irrigated areas in the southeastern part of the Pine River Project area drain directly into Navajo Reservoir through natural drainages such as Sambrito Creek and West Sambrito Creek.

Annual mean stream discharge for water year 1989 was 77 percent of the average annual mean stream discharge for water years 1952-88 at streamflow-gaging station 09354500, Los Pinos River at La Boca (fig. 3). Below normal snowmelt runoff and reservoir operations resulted in smaller stream discharge in the Los Pinos River in water year 1989. Stream discharge of the Los Pinos River has been regulated since 1941 by Vallecito Reservoir.

Spring runoff in the Los Pinos River at streamflow-gaging station 09354500, Los Pinos River at La Boca, occurred in March and early April in water year 1989 (fig. 3); in most years, spring runoff occurs in May and June. The monthly mean stream discharge for March 1989 had the third largest monthly mean stream discharge for March for the period of record for gaging station 09354500. Stream discharge from late April to mid-July was substantially less than normal in water year 1989 in the Los Pinos River. Based on the annual mean stream discharges for water years 1952-89 (fig. 4), water year 1989 was the second consecutive year of less than normal stream discharge in the Los Pinos River after 5 years of greater than normal stream discharge. That pattern of stream discharge also was true for streamflow-gaging station 09349800, Piedra River near Arboles, which is an unregulated stream.

Irrigation drainage sustains year-round flow in several small streams flowing through the Pine River Project area that otherwise would be intermittent or ephemeral. All the larger tributary streams between Salt Creek and Sambrito Creek (fig. 1) are perennial downstream from irrigated areas. A typical seasonal distribution of stream discharge for small streams draining irrigated areas is represented by the stream-discharge record for streamflow-gaging station 09355000, Spring Creek at La Boca (fig. 5). Irrigation drainage sustains flow during the winter. There normally is a minor peak discharge in March in response to snowmelt runoff in the drainage basin. Most of the

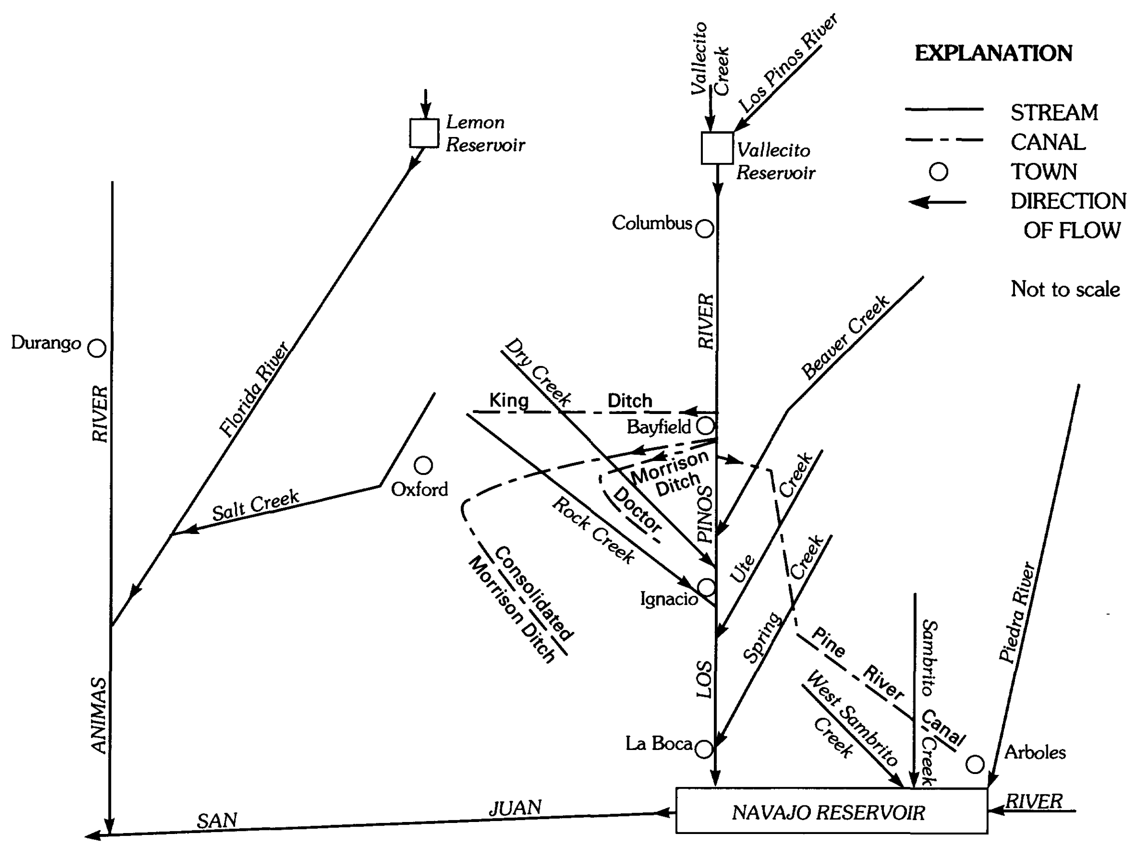

Figure 2. Major streams, tributaries, reservoirs, canals, and movement of water.

stream discharge from mid-April through October is irrigation return flow, and the peaks during that period were caused by intense rainstorms (fig. 5).

The annual mean stream discharge in Spring Creek at streamflow-gaging station 09355000 in water year 1989 was 103 percent of the average annual mean stream discharge for water years 1951-88. Dry conditions in the spring affected irrigation practices, which is evident by comparison of the daily mean discharges during May 1989 to the average daily mean stream discharges for May for the long-term record (fig. 5). Unusually large quantities of water were used early in the season because of drought conditions. There were 5 days between July 26 and August 2, 1989, when the daily mean stream discharge exceeded 120 ft^3/s because of rainstorms. The maximum daily mean stream discharge was 253 ft^3/s on August 1. The large discharge peaks are not shown in figure 5 so that more definition of the hydrographs for the rest of the year could be shown.

Irrigation System

The Pine River Project consists of Vallecito Reservoir (capacity 129,700 acre-ft), which was constructed by the U.S. Bureau of Reclamation to furnish supplemental water to about 54,000 acres of Indian and non-Indian land. Vallecito Reservoir is operated and maintained by the Pine River Irrigation District. The irrigation system is shown in the schematic diagram in figure 2, and the approximate extent of irrigated land is shown in figure 1. Only part of the land shown within the boundary of the irrigated area in figure 1 is actually irrigated. The irrigated area consists of about 13,000 acres of Indian land on the Southern Ute Indian Reservation and about 41,000 acres of non-Indian land. The Indian and non-Indian lands are interspersed throughout the Pine River Project area and are not delineated in figure 1.

Most of the irrigated non-Indian lands are part of the Pine River Irrigation District, and the distribution systems in the district are owned and operated by about 50 different ditch companies. In 1989, the Pine River Irrigation District diverted about 135,000 acre-ft of water, of which about 33,000 acre-ft were distribution

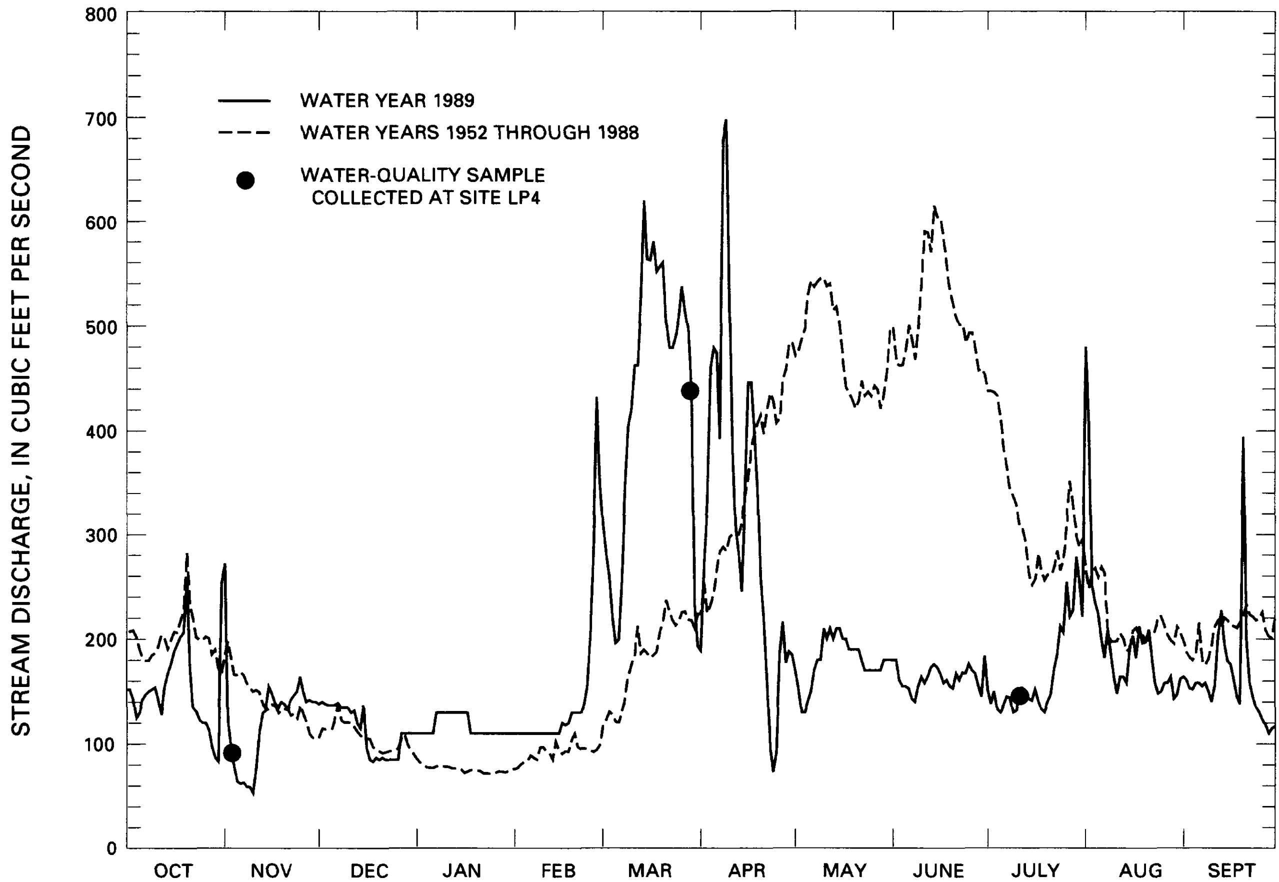

Figure 3. Daily mean stream discharge for water year 1989, average daily mean stream discharge for water years 1952-88, and dates when water-quality samples were collected at streamflow-gaging station 09354500, Los Pinos River at La Boca (site LP4).

system and evaporation losses (Joseph Brown, Pine River Irrigation District, oral commun., 1990). All Indian and some non-Indian land is served by the Pine River Indian Irrigation Project. The U.S. Bureau of Indian Affairs owns, operates, and maintains all canals, laterals, and ditches of the Pine River Indian Irrigation Project. During 1989, the Pine River Indian Irrigation Project diverted about 52,000 acre-ft of water.

Almost all irrigation water for the Pine River Irrigation District and the Pine River Indian Irrigation Project is diverted from the Los Pinos River; much of the water is diverted in the Bayfield area (fig. 2). The major canals and ditches are shown in figure 2; there are numerous canals, laterals, and ditches not shown. There also are irrigation diversions from tributary streams, but almost all of that water is return flow or tailwater from upstream areas in the Pine River Project.

Most irrigation water in the Pine River Project area is applied by flood irrigation. There are a few sprinkler-irrigation systems. According to estimates by the U.S. Soil Conservation Service, irrigation efficiency in the Project area is about 25 percent. The low irrigation efficiency is the result of using flood irrigation on soils with low infiltration rates. Deep percolation of applied water and distribution system losses recharge shallow aquifers in the irrigated areas. There are no subsurface drains and only a few surface drains built in the Project area. Irrigation drainage probably discharges from small-scale flow systems into the numerous streams, gullies, and washes dissecting the area. Some shallow ground water from irrigated areas probably discharges into the Los Pinos River alluvium. During the nonirrigation season, much of the flow in the small streams in the Project area probably is subsurface irrigation drainage, and during the irrigation season most of the flow is surface return flow.

Water for irrigation usually is diverted into the irrigation systems from mid-April through October. During this reconnaissance investigation (November 1988 to August 1989), water diversion into most canals was discontinued by late October 1988 and began again

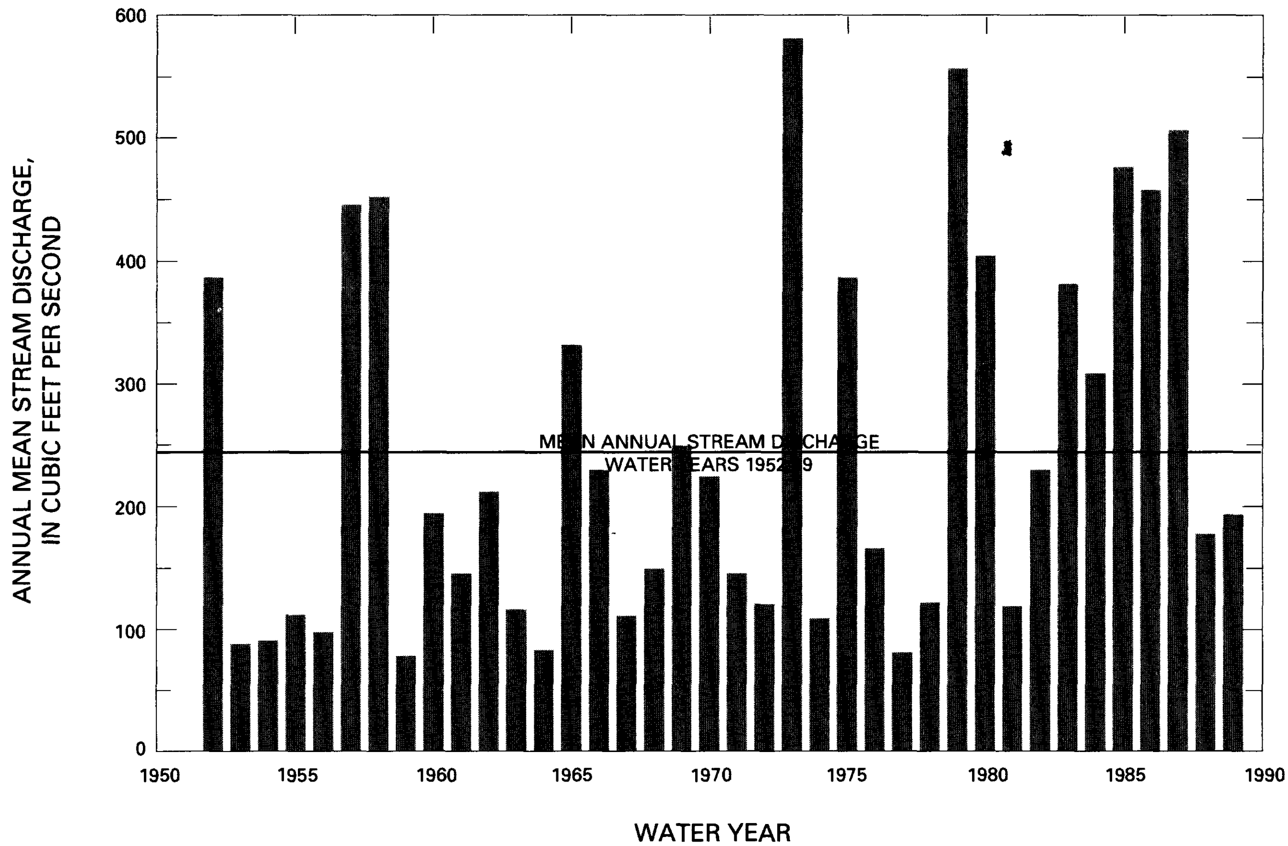

Figure 4. Annual mean stream discharge at streamflow-gaging station 09354500, Los Pinos River at La Boca (site LP4), water years 1952-89.

in mid-April 1989. Water is sometimes diverted into canals during the winter for livestock watering.

Ground Water

The Pine River Project area is near the recharge areas in the northern part of the San Juan structural basin; therefore, the direction of ground-water flow (regional scale) from the Project area is to the south toward the San Juan River. Water is present in sandstone and shale aquifers in Cretaceous and Tertiary deposits and in alluvial deposits on the Southern Ute Indian Reservation (Brogden and others, 1979). The sandstones mostly are fine to coarse grained, are cemented with calcium carbonate, and generally have small permeability and small well yields. The sandstone aquifers often are separated by as much as 100 ft of shale (Brogden and others, 1979).

The largest well yields in the Pine River Project area are from shallow aquifers in alluvial and terrace deposits and from sandstone aquifers in the San Jose Formation and Animas Formation; these aquifers are extensively used for domestic purposes and for livestock water. Alluvial aquifers are present in the Los Pinos, Florida, and the Piedra River valleys and have a maximum thickness of 50 ft and well yields of 5 to 25 gal/min. Alluvial aquifers are recharged by streams, precipitation, and irrigation water (Brogden and Giles, 1976). Alluvial aquifers in the Los Pinos River valley also may receive some ground-water discharge from the San Jose Formation and Animas Formation.

Terrace deposits generally have well yields of 5 to 10 gal/min, and, because they often are saturated only in the lower part, terrace deposits are not always a reliable water supply. Springs and seeps are present in the Project area on hillsides where coarse, permeable, saturated material overlies clay and shale. Irrigation may be the primary source of recharge to some of the terrace deposits.

Well yields as great as 75 gal/min have been reported for aquifers in the San Jose Formation and Animas Formation (Brogden and Giles, 1976), but yields of 1 to 10 gal/min are more common. Groundwater occurrence in the San Jose Formation and Animas Formation may be controlled by distribution of

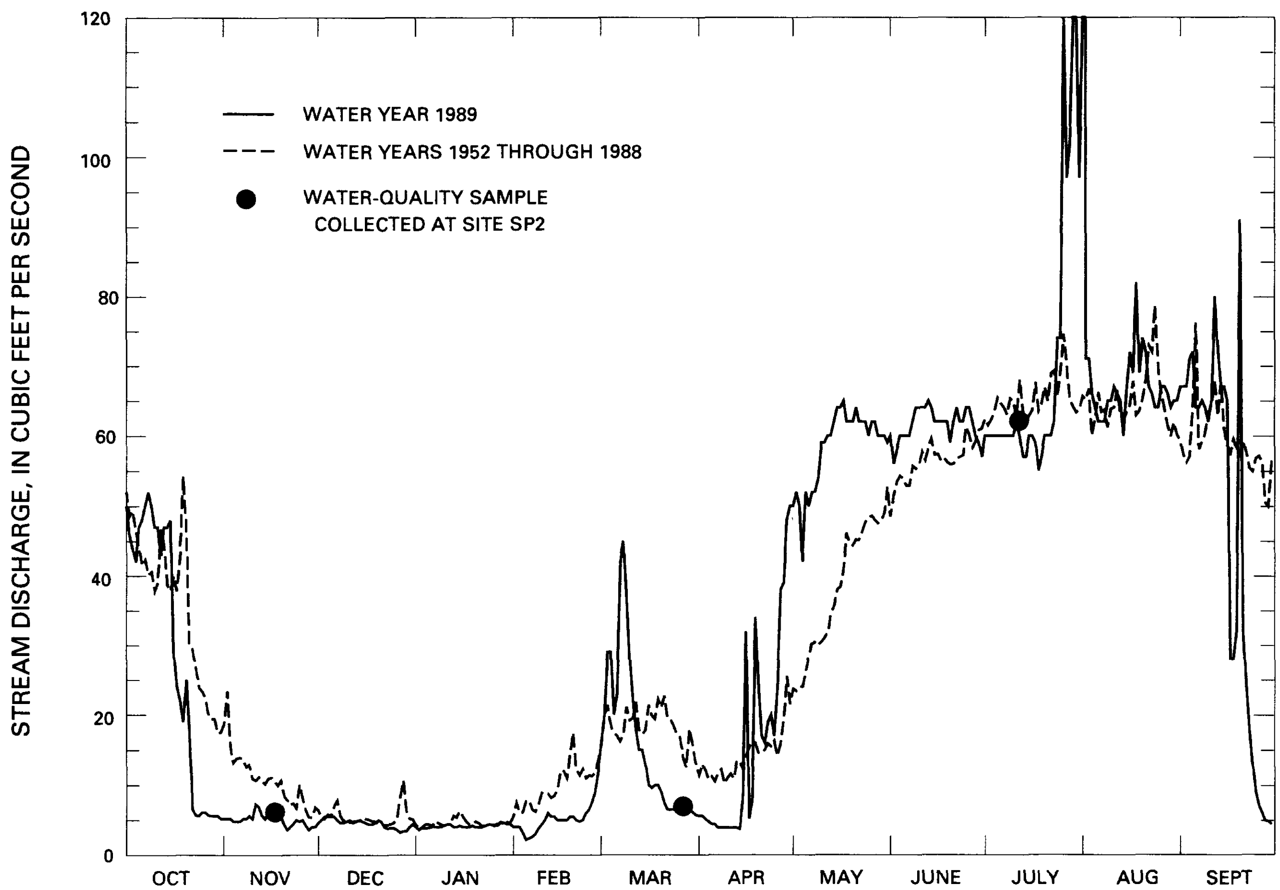

Figure 5. Daily mean stream discharge for water year 1989, average daily mean stream discharge for water years 1952-88, and dates when water-quality samples were collected at streamflow-gaging station 09355000, Spring Creek at La Boca (site SP2).

sandstone, which is the result of the original depositional extent of sandstone in the formations (Stone and others, 1983). Many of the aquifers in the San Jose Formation and Animas Formation may be part of small- or intermediate-scale flow systems of perched water and may not be part of the regional ground-water system in the San Juan Basin. Distribution system losses, deep percolation from irrigation application, and precipitation are sources of recharge to shallow aquifers. The total contribution by the irrigation system to recharge of water in the San Jose Formation and Animas Formation is not known.

There may be sources of minerals in sandstone in the stratigraphic units, but most dissolved solids and trace elements probably were derived at interfaces with adjacent confining shale layers. The dissolution of minerals could be increased by interbedding of shale and sandstone. Volcanic material from the San Juan Mountains may be a source of some trace elements, such as selenium, in the San Jose Formation and Animas Formation. Because of the interbedded nature of the stratigraphic units, wells penetrating the same aquifer may produce water from different rock types. Therefore, aquifers in the San Jose Formation and Animas Formation can have highly variable water quality.

PREVIOUS INVESTIGATIONS

Selenium has been recognized as a problem in water, soil, livestock feed, and rangeland on parts of the Southern Ute Indian Reservation for many years. The case of selenium poisoning in humans in the 1960's (Beath, 1962) focused attention on the large selenium concentrations in ground water in parts of the reservation. Agricultural problems on the reservation relating to selenium have been examined by the U.S. Bureau of Indian Affairs and by the Southern Ute Tribe in reports such as Heaney (1983). Some water-quality data have been collected for streams and ground water in the study area, but contaminant data for bottom sediment, soil, and biota collected prior to 1988 were very limited for the Pine River Project area.

Water-Quality Data

Streams

During 1969-73, the U.S. Geological Survey collected monthly water-quality data at streamflow-gaging stations on the Los Pinos, Piedra, and the San Juan Rivers. Those data were primarily major ion and dissolved-solids analyses to determine water quality of the inflow into Navajo Reservoir. During 1973-75, the U.S. Geological Survey investigated water quality of the Southern Ute Indian Reservation (Hutchinson and Brogden, 1976). Data were collected during that study from 48 surface-water sites, including sites located in or adjacent to the Pine River Project area, for major ions, nitrate, arsenic, boron, iron, manganese, and selenium. The U.S. Geological Survey also collected water-quality data in coal-leasing areas immediately north of the Southern Ute Indian Reservation (Brooks, 1985; Butler, 1986). Selected trace-element data collected from streams in the Project area by the U.S. Geological Survey are summarized in table 1. Most of the data summarized in table 1 were collected from 1973-85. The maximum selenium concentration listed in table 1 of 45 μg/L was for a sample collected from Rock Creek in 1981.

The Colorado Department of Health has collected total trace-element data for the Los Pinos and the Florida Rivers (table 2). Mean selenium concentrations were small, and the maximum selenium concentration was 8 μg/L for the Los Pinos River at La Boca. A water-quality study of the entire San Juan River basin (Colorado Department of Health, 1975) primarily was concerned with water-quality standards in relation to pollution sources.

Water quality of the Los Pinos River between Bayfield and Ignacio was studied by Mehs (1987) for the Southern Ute Tribe. Six sites were sampled during 1987 to provide information concerning the effectiveness of the Bayfield sanitation plant and to determine if pesticides, fertilizers, or heavy metals were affecting the Los Pinos River. The conclusion of that study was that no significant water-quality problems were indicated (Mehs, 1987).

The U.S. Geological Survey also collected water-quality data during 1988-89 in the Pine River Project area that were not collected for the reconnaissance investigation. Those data were collected as part of the U.S. Geological Survey's cooperative data-collection program (hereinafter referred to as the USGS cooperative program). Samples were collected at six sites on streams within the study area of the reconnaissance investigation; site F1 on the Florida River, sites

Table 1. Summary of trace-element data for streams in the Pine River Project area

[Analyses by U.S. Geological Survey; constituents are dissolved unless otherwise noted; concentrations in micrograms per liter; <, less than; ND, not detected; --, not determined]

Trace element	Number of samples	Median	Maximum	Minimum
SEVEN SITES ON THE LOS PINOS RIVER				
Arsenic, total	6	1	6	<1
Boron	6	--	30	7
Iron	7	70	190	30
Manganese	7	30	800	<10
Selenium, total	6	1	4	<1
TWENTY-SEVEN SITES ON TRIBUTARY AND OTHER STREAMS				
Arsenic	15	2	4	<1
Arsenic, total	14	1	5	<1
Boron	37	20	120	0
Cadmium	1	--	0	--
Iron	36	60	1,200	ND
Lead	8	<1	4	<1
Manganese	29	60	610	5
Selenium	22	2	45	<1
Selenium, total	13	3	25	<1
Zinc	8	15	20	6

Table 2. Summary of trace-element data collected by the Colorado Department of Health for streams in the Pine River Project area

[Data retrieved from the storage and retrieval (STORET) part of the U.S. Environmental Protection Agency's Water Quality Control Information System; all constituents are totals; concentrations in micrograms per liter; <, less than]

Trace element	Number of samples	Mean	Maximum	Minimum
		LOS PINOS RIVER AT LA BOCA		
Arsenic	43	1.7	10	0
Boron	44	35	160	0
Mercury	9	<.5	.5	<.5
Selenium	37	1.1	8	0
Zinc	107	20	800	0
		FLORIDA RIVER AT HIGHWAY 160		
Arsenic	31	.97	12	0
Boron	26	20	170	0
Selenium	18	.83	6	0
Zinc	30	6.7	90	0
		FLORIDA RIVER AT MOUTH		
Arsenic	36	1.9	10	0
Boron	34	31	110	0
Mercury	33	.41	.5	.25
Selenium	25	2.0	6	0
Zinc	81	25	480	0

LP2, LP3, and LP4 on the Los Pinos River, site SP2 on Spring Creek, and site P1 on the Piedra River (fig. 1). Samples were analyzed for major ions, nitrogen and phosphorus species, total trace elements and dissolved boron, and six herbicides. The trace-element data are summarized in table 3. The total-iron concentration in five samples exceeded 1,000 µg/L, which is the aquatic-life criteria for chronic effects of total iron (U.S. Environmental Protection Agency, 1986). The maximum total-iron concentration of 13,000 µg/L (table 3) was at site SP2 on Spring Creek. The two samples that had selenium detected were collected at site SP2.

The herbicide analyses for samples collected for the USGS cooperative program were for the same six herbicides that were analyzed in samples collected for the reconnaissance investigation during 1988-89. Therefore, the herbicide data collected for the USGS cooperative program were included with the herbicide data collected for the reconnaissance investigation (table 19 in the "Supplemental Data" section at the back of the report) and will be discussed later in the report. Also, a bottom-sediment sample was collected for pesticide analysis for the USGS cooperative program at site LP4 on the Los Pinos River in December 1988. Those data are included with the bottom-sediment data collected for the reconnaissance investigation in November 1988 (table 22 in the "Supplemental Data" section at the back of the report).

Ground Water

The case of selenium poisoning in humans documented by Beath (1962) involved the Evenson family, who developed classic symptoms of selenium poisoning. The Evenson homestead was located on the Oxford Tract at site WL2 (fig. 1). The Oxford Tract is a 2.75 mi^2 block of Indian land located southeast of Oxford (fig. 1). Beath (1962) stated that the family was poisoned by drinking water from a 140-ft deep well that contained 9,000 µg/L of selenium. Livestock also had symptoms of selenium poisoning. The homestead and the well have been abandoned since the 1960's. Since the selenium poisoning of the Evenson family, the Oxford Tract has been used sparingly for short-term dryland grazing, and only about 400 acres of the tract are irrigated, which is about one-third of the area previously irrigated. At times, livestock have exhibited symptoms of selenium poisoning after grazing on the tract.

During a water-quality inventory of the Southern Ute Indian Reservation by the U.S. Geological Survey

Table 3. Summary of total trace-element and dissolved-boron data for surface-water samples collected in the Pine River Project area in 1988-89 for the U.S. Geological Survey's cooperative data-collection program

[Analyses by U.S. Geological Survey; constituents are totals unless noted; number detected is the number of samples with concentrations equal to or greater than analytical reporting limits; concentrations in micrograms per liter; <, less than; --, not determined]

Trace element	Number of samples	Number detected	Median	Maximum	Minimum
Arsenic	12	2	<1	2	<1
Boron, dissolved	12	8	15	30	<10
Cadmium	11	1	<1	1	<1
Chromium	11	5	<1	8	<1
Copper	11	11	11	37	4
Iron	11	11	560	13,000	60
Lead[1]	11	7	--	13	1
Manganese	11	11	60	390	20
Mercury	11	0	<.1	<.1	<.1
Molybdenum	4	3	--	8	<1
Selenium	12	2	<1	8	<1
Zinc	11	8	20	60	<10

[1]Reporting limit for lead analysis changed from 5 micrograms per liter to 1 microgram per liter during the sample-collection period.

in 1973-75, samples were collected at 265 ground-water sites throughout the reservation. The Pine River Project area occupies about the central one-third of the reservation. The analytical data collected for that study are listed in Hutchinson and Brogden (1976), and an interpretative report was done by Brogden and others (1979). Ground-water-quality data for areas north and east of the reservation have been collected in other studies, such as Brooks (1985) and Butler (1986). Chemical data for ground water, including aquifers of the San Jose Formation and Animas Formation, were collected in part of La Plata County north of the reservation by Brogden and Giles (1976). There have been regional ground-water studies of the San Juan basin, such as Lyford (1979) and Stone and others (1983).

Trace-element data for ground water in the Pine River Project area are summarized in table 4. Most of the samples summarized in table 4 were collected from aquifers in alluvial deposits or aquifers in the San Jose Formation and Animas Formation during 1973-75 by Hutchinson and Brogden (1976). The data summarized in table 4 were collected within the general area bounded by the Animas and the Piedra Rivers and between Highway 160 and the New Mexico State line. Selenium data were retrieved from the U.S. Geological Survey's National Water Information System (NWIS) for ground-water sites north of the Southern Ute Indian Reservation and were compared to selenium concentrations for ground-water sites on the reservation. Selenium concentrations in ground water were much smaller north of the reservation. In the area north of the reservation, only 1 of the 36 ground-water samples had a selenium concentration greater than 10 µg/L.

Table 4. Summary of selected trace-element data for ground-water samples collected in the Pine River Project area

[Analyses by U.S. Geological Survey; constituents are dissolved unless otherwise noted; concentrations in micrograms per liter; <, less than]

Trace element	Number of samples	Median	Maximum	Minimum
Arsenic	90	<1	18	0
Arsenic, total	115	1	61	<1
Boron	185	40	1,100	0
Iron	192	30	5,400	0
Manganese	114	<10	5,500	6
Selenium	95	8	13,000	<1
Selenium, total	115	4	700	<1

Brogden and others (1979) delineated two areas on the Southern Ute Indian Reservation where many selenium concentrations in ground water exceeded 10 µg/L. The larger of the two areas was in the central part of the reservation between the Florida River and Spring Creek (fig. 1). Five samples collected in that area had dissolved selenium concentrations exceeding 1,000 μg/L, and the maximum concentration was 13,000 μg/L in a sample from the San Jose Formation at site G87 (fig. 1). The other area that had large selenium concentrations was a relatively small area in the vicinity of Arboles, near Navajo Reservoir. The concentrations of selenium among sites were extremely variable, even within the areas having large selenium concentrations. Wells that had selenium concentrations exceeding 10 μg/L had depths ranging from 10 to 300 ft. According to Brogden and others (1979), the selenium apparently is associated with water in the San Jose Formation and Animas Formation or water that had discharged from those formations into alluvial aquifers. The selenium may be associated with volcanic material in the San Jose Formation and Animas Formation because both formations contain fragments of andesite and rhyolite. In addition to selenium, there were numerous concentrations of dissolved solids, sulfate, chloride, fluoride, nitrate, iron, and manganese that exceeded U.S. Environmental Protection Agency drinking-water regulations (Brogden and others, 1979).

The Oxford Tract near the abandoned Evenson homestead was investigated by the U.S. Geological Survey and the U.S. Bureau of Indian Affairs during 1975 (Brogden and others, 1979). A test well (site WL2 in fig. 1) was drilled 85 ft east of the Evenson domestic well. The test well was 500 ft deep, and water was encountered at 35 ft. Selenium concentrations in six water samples collected from the test well ranged from 90 to 540 μg/L, which are much less than the 9,000 μg/L of selenium reported by Beath (1962) in water from the domestic well.

Soil and Bottom-Sediment Data

Only a few soil samples were collected in the Pine River Project area for which there were geochemical data in the computer files of the U.S. Geological Survey (T.F. Harms, U.S. Geological Survey, written commun., 1988). The geochemical analyses of those samples did not include selenium or other trace elements of interest to the reconnaissance investigation. Rock samples collected during drilling of the Oxford test hole in 1975 were analyzed for selenium, and the results are reported in Brodgen and others (1979). Selenium was present in shales and fine-grained silty sandstone from the test hole. Selenium concentrations in the rock samples ranged from less than detection limits (0.1 μg/g) at the 2-ft depth to 3.6 μg/g at the 42-ft depth. Generally, selenium concentrations were less than 0.4 μg/g between 2 and 27 ft and were greater than 0.4 μg/g at depths greater than 27 ft (Brogden and others, 1979). The U.S. Bureau of Indian Affairs collected soil samples from 4 depth zones at 11 sites on the Oxford Tract during 1975. Selenium concentrations in the soil samples ranged from a trace to 10.0 μg/g. At 8 of the 11 sites, selenium concentrations in soil increased with depth. The maximum concentration of 10 μg/g was from soil samples collected from the deepest zone (36-48 in.) at two sites. No data for trace elements in bottom sediment in streams or in lakes were located for the Project area.

Biological Data

During the study of the Oxford Tract in 1975, the U.S. Bureau of Indian Affairs collected two fish from a small pond south of the Evenson homestead (Brogden and others, 1979). Selenium concentrations in the fish were 3 μg/g and 0.49 μg/g.

The U.S. Fish and Wildlife Service conducted a pre-reconnaissance investigation on June 28-29, 1988, in the Pine River Project area. Fish, aquatic plants, and aquatic invertebrates were collected at seven stream sites, and prairie dogs were collected on the Oxford Tract; the samples were analyzed for trace elements. The data collected for the pre-reconnaissance investigation are listed in table 23 in the "Supplemental Data" section at the back of this report and are discussed with the biota data collected for the reconnaissance investigation in the "Biota Results" section.

SAMPLE COLLECTION AND ANALYSIS

Objectives

The objective of surface-water and bottom-sediment sampling for the reconnaissance investigation was to determine if the Pine River Project area was contributing potentially harmful chemical elements and compounds to the Los Pinos River, other streams, and reservoirs that receive irrigation drainage and return flow. Problem areas were to be identified where trace-element concentrations in water exceeded drinking-water regulations, criteria for protection of aquatic life, or criteria for agricultural use. Trace-element concentrations in bottom sediment were compared to background concentrations for soils in the Western United States.

Another objective of the sampling program was to resample selected ground-water sites that had large selenium concentrations in samples that were collected in the 1970's by Hutchinson and Brogden (1976). A secondary objective related to ground water was to document a connection between irrigation application and shallow ground water in the Pine River Project area.

A list of chemical constituents was developed by the DOI Task Group for use in all irrigation drainage studies to afford comparability of data among the study areas. The chemical constituents analyzed in water, bottom-sediment, and biota samples are listed in table 5. Herbicide compounds selected for analysis in water were based on usage in the Pine River Project area and were limited to the six compounds listed in table 5.

One objective of the soil and plant sampling on the Oxford Tract was to determine the magnitude and variability of selenium concentrations in soil and plants on the tract. A second objective was to determine if irrigation practices have affected selenium concentrations by sampling soil in areas never irrigated, previously irrigated, and presently (1989) irrigated.

A primary objective of the biological sampling was to determine contaminant concentrations within different trophic levels and whether any contaminants are of concern to fish and wildlife. Biota selected from lower trophic levels (aquatic plants and invertebrates) represented possible food sources for either fish or migratory birds that were likely to be present in the Pine River Project area. Contaminant concentrations in lower trophic levels were examined for potential problems regarding food-chain bioaccumulation. Consistency in species composition of samples among sites was attempted so that direct comparisons of data could be made between areas. However, consistency among species could not always be achieved because of habitat variability and because of insufficient numbers of organisms to obtain an adequate biomass for analysis.

Sampling Sites and Schedule of Sample Collection

Samples for inorganic analysis were collected at 19 stream sites, 2 sites on Navajo Reservoir, and 5 ground-water sites for the reconnaissance investigation of the Pine River Project area during 1988-89 (table 6). All sampling sites are shown in figure 1. Streams were sampled three times (table 7) to define seasonal changes in water chemistry and trace-element concentrations.

Three sites on the Los Pinos River were sampled for inorganic constituents during the reconnaissance investigation (table 6). Site LP1 at Columbus is upstream from nearly all irrigated areas and is a reference for water quality of the Los Pinos River. Site LP2 at Bayfield is near the major irrigation diversions and site LP4 at La Boca is the outflow site on the Los Pinos River and is downstream from all irrigation drainage in the Los Pinos River basin, except for the Spring Creek basin.

Major pathways of irrigation drainage and return flow are represented by the sampling sites on tributaries of the Los Pinos River (Rock, Dry, Beaver, Ute, and Spring Creeks) and on Salt Creek, which is tributary to the Florida River. The Florida River at Bondad (site F2) was sampled because of potential effects from the Pine River Project, although most effects from irrigation drainage to the Florida River are likely to be from the Florida Project, another Federal irrigation Project. West Sambrito and Sambrito Creeks represent major pathways for irrigation drainage directly into Navajo fig. 1). On all tributary streams except West Sambrito Creek, two sites were sampled to determine irrigation effects on water quality. A reference site upstream from most irrigated areas and a site near the mouth were sampled. The upstream sites on Salt (site ST1), Rock (site R1), Ute (site U1), Spring (site SP1), and Sambrito (site SB1) Creeks are downstream from small areas of irrigated land, a canal, or a lateral; therefore, samples from those sites may have been affected by small quantities of irrigation-drainage water or return flow. Upstream from irrigated areas, natural runoff in those streams is small, and the streams may not have flow all year. The upstream site for Beaver Creek (site B1) and Dry Creek (site D1) probably are representative of water quality that was not affected by irrigation from the Pine River Project. Because the entire West Sambrito Creek basin is downstream from relatively large areas of irrigated land, a control site was not sampled for this stream.

Navajo Reservoir was included in the reconnaissance investigation because most irrigation drainage and return flow from the Project area ultimately discharges into the reservoir. Water samples were collected once, in November 1988, from the Piedra River arm (site N1) and the Los Pinos River arm (site N2) of Navajo Reservoir. The Piedra River arm is a reference site that is not affected by irrigation drainage from the Pine River Project.

Water samples for herbicide analysis were collected during the reconnaissance investigation in July 1989 (table 7) at selected stream sites downstream from irrigated areas (table 6). The herbicide samples were collected in summer because that was during or after the time when herbicides were normally applied in the Pine River Project area.

Water-quality samples for inorganic analyses were collected at five ground-water sites (table 6 and fig. 1) that had large selenium concentrations reported

Table 5. Chemical constituents analyzed in water, bottom-sediment, and biota samples

[All constituents reported as total except inorganic constituents in water, which were reported as dissolved]

Water		Bottom sediment		Biota	
Inorganic	**Herbicides**	**Inorganic**	**Pesticides**	**Inorganic**	**Pesticides**
Hardness	2, 4-D	Arsenic	PCN's	Aluminum	Aldrin
Calcium	2, 4-DP	Barium	PCB's	Arsenic	α-BHC
Magnesium	Silvex	Beryllium	Aldrin	Barium	β-BHC
Sodium	2, 4, 5-T	Bismuth	Chlordane	Beryllium	γ-BHC
Potassium	Dicamba	Cadmium	DDD	Boron	α-Chlordane
Alkalinity	Picloram	Cerium	DDE	Cadmium	γ-Chlordane
Sulfate		Chromium	DDT	Chromium	o,p'-DDE
Chloride		Cobalt	Dieldrin	Copper	p,p'-DDE
Fluoride		Copper	Endosulfan	Iron	o,p'-DDD
Dissolved solids		Europium	Endrin	Lead	p,p'-DDD
Nitrite plus nitrate		Gallium	Heptachlor	Magnesium	o,p'-DDT
Arsenic		Gold	Heptachlor epoxide	Manganese	p,p'-DDT
Boron		Holmium	Lindane	Mercury	Dieldrin
Cadmium		Lanthanum	Mirex	Nickel	Endrin
Chromium		Lead	Perthane	Selenium	HCB
Copper		Lithium	Toxaphene	Strontium	Heptachlor
Iron		Manganese		Vanadium	Heptachlor epoxide
Lead		Mercury		Zinc	Lindane
Manganese		Molybdenum			Mirex
Mercury		Neodymium			cis-Nonachlor
Molybdenum		Nickel			trans-Nonachlor
Selenium		Niobium			Oxychlordane
Vanadium		Scandium			Toxaphene
Zinc		Selenium			
Uranium		Silver			
		Strontium			
		Tantalum			
		Thorium			
		Tin			
		Uranium			
		Vanadium			
		Ytterbium			
		Yttrium			
		Zinc			

Table 6. Sampling sites and type of samples collected for the reconnaissance investigation during 1988-89

[Number in parentheses by site name is U.S. Geological Survey streamflow-gaging station number, if applicable; X, sampled for the reconnaissance investigation; --, not sampled]

Site number (fig. 1)	Site name	Water		Bottom sediment		Biota	
		Inorganic	Herbicides	Inorganic	Pesticides	Inorganic	Pesticides
F2	Florida River at Bondad (09363200)	X	--	X	X	X	--
ST1	Salt Creek north of Oxford	X	--	--	--	X	--
ST2	Salt Creek near mouth	X	X	X	X	X	--
R1	Rock Creek on the Oxford Tract, near Oxford	X	--	--	--	X	X
R2	Rock Creek at Highway 172 at Ignacio	X	X	X	X	X	--
R3	Wetland site on Oxford Tract, Rock Creek basin	--	--	--	--	X	X
D1	Dry Creek at Highway 160	X	--	--	--	X	--
D2	Dry Creek near mouth, near Southern Ute Agency	X	X	--	--	X	--
LP1	Los Pinos River at Columbus	X	--	--	--	X	--
LP2	Los Pinos River at Bayfield	X	--	--	--	X	--
LPGR	Gravel pit along Los Pinos River northeast of Ignacio	--	--	--	--	X	X
LP3	Los Pinos River at Ignacio (09354000)	--	--	--	--	X	X
LP4	Los Pinos River at La Boca (09354500)	X	X	--	--	X	X
B1	Beaver Creek upstream from Sauls Creek, near Bayfield	X	--	--	--	X	--
B2	Beaver Creek near mouth	X	X	X	X	X	--
U1	Ute Creek at Harper Pond, near Bayfield	X	--	--	--	X	--
U2	Ute Creek near mouth	X	X	X	X	X	--
SP1	Spring Creek near Pine River Canal, near Bayfield	X	--	--	--	X	--
SP2	Spring Creek at La Boca	X	X	X	X	X	--
WSB2	West Sambrito Creek at mouth	X	X	X	X	X	--
SB1	Sambrito Creek near Pine River Canal	X	--	--	--	X	--
SB2	Sambrito Creek at mouth	X	X	X	X	X	--
P1	Piedra River near Arboles (09349800)	--	--	--	--	X	--
N1	Navajo Reservoir, Piedra River arm, near Arboles	X	--	X	X	X	--
N2	Navajo Reservoir, Los Pinos River arm, near La Boca	X	--	X	X	X	X
G24	Spring at Durango-La Plata County Airport	X	--	--	--	--	--
G69	Howard Massey well, near Arboles	X	--	--	--	--	--
G87	Steve Waters well, south of Durango-La Plata County Airport	X	--	--	--	--	--
G109	Betty Lamke well, at Oxford	X	--	--	--	--	--
G114	Mike McManus well, near Oxford	X	--	--	--	--	--

Table 7. Schedule for collection of water, bottom-sediment, soil, plant, and biota samples for the reconnaissance investigation, November 1988 to August 1989

Sample medium and type of analysis	Months in which samples were collected
Surface water, inorganic	November, March, July
Surface water, herbicides	July
Ground water, inorganic	March, August
Bottom sediment, inorganic	November
Bottom sediment, pesticides	November
Soil and plants[1]	August
Fish, inorganic	November, December, March, April, July
Fish, pesticides	November, June
Aquatic plants, inorganic	November, April, July
Invertebrates and zooplankton, inorganic	November, April, July
Birds, inorganic	May, June, July
Birds, pesticides	May, June
Eggs, inorganic	May, June
Eggs, pesticides	May, June

[1]Sampled only on the Oxford Tract, for selenium analyses.

by Hutchinson and Brogden (1976). Water levels were measured at five wells (table 8 and fig. 1) in an attempt to document a connection between irrigation application and shallow ground water in the Pine River Project area. The water in wells WL1, WL3, and WL5 was expected to be affected by irrigation. Water in well WL4 was not expected to be affected by irrigation, and it was uncertain if water in well WL2 would be affected by irrigation.

Bottom-sediment samples for inorganic and chlorinated pesticide analyses (table 5) were collected for the reconnaissance investigation at eight stream sites and from the Piedra River and the Los Pinos arms of Navajo Reservoir (table 6). Bottom sediment was sampled in November 1988 (table 7), when maximum accumulation of potential contaminants from irrigation drainage was expected to occur.

Soil samples were collected at 100 sites on the Oxford Tract in August 1989. The sites were on varying slopes, aspects, and terrain and included areas never irrigated, previously irrigated, and presently (1989) irrigated. A surface soil sample (0-to 4-in. depth) was collected at each site. At 45 sites, an additional soil sample was collected at 10- to 14-in. depth, and 5 sites had additional samples collected at 22- to 26-in. depth. Twenty soil samples also were collected under known selenium-accumulating plants such as astragalus, gumweed, and snakeweed. Sixty-six plant tissue samples were collected at 45 of the soil-sampling sites. Plant samples were collected as close as possible to the soil-sampling location, but because of problems

Table 8. Wells where water levels were measured in 1988-89

[Latitude and longitude expressed in degrees-minutes-seconds]

Site number (fig.1)	Latitude	Longitude	Location description
WL1	37-10-17	107-41-57	Mike McManus, new well, near Oxford
WL2	37-09-34	107-40-41	Oxford test hole, Oxford Tract
WL3	37-06-31	107-34-07	Gayle Cloud well, east of Ignacio
WL4	37-01-10	107-25-05	Fisher well, near Arboles
WL5	37-00-33	107-24-35	Colorado Department of Parks well, at Navajo Reservoir

with obtaining sufficient material for analysis, not all plant samples were collected at the exact location of the soil sample. The plant samples consisted of the stems and leaves.

Soil samples were analyzed for total selenium and for extractable selenium. The extractable selenium was assumed to approximate the part of selenium in the soil that could be readily absorbed and assimilated by plants. The plant samples were analyzed only for total selenium.

Biota sampling sites were selected to determine maximum contaminant concentrations associated with irrigation drainage. Biota sampling sites were selected relative to inflow and outflow of irrigation-drain water and on the availability of biota. Biota samples generally were collected from streams at or near the water-quality sampling sites (table 6). Stream and reservoir sites were scheduled to be sampled for fish, aquatic plants, and aquatic invertebrates during November, April, and July. Fish species collected include: brown trout, rainbow trout, northern pike, channel catfish, bullheads, flannelmouth suckers, white suckers, bluehead suckers, carp, roundtail chubs, speckled dace, longnose dace, and mottled sculpin. Aquatic-invertebrate species collected were crayfish, snails, and various insects, and zooplankton also were collected. Aquatic invertebrates were not found during the November sampling survey. Aquatic plants were collected whenever they were available.

Bird samples were collected at four wetland sites: sites R1 and R3 on the Oxford Tract, at a gravel pit (site LPGR) along the Los Pinos River about 4.5 mi northeast of Ignacio, and at ponds along the Los Pinos River about 1 mi upstream from site LP4 (fig. 1). There was an insignificant quantity of inflow between the ponds along the Los Pinos River and site LP4; thus, water quality at the two sites was considered equivalent.

The following bird species were collected during the reconnaissance investigation in 1989: mallards, red-winged blackbirds, yellow-headed blackbirds, American bittern, and common snipe. The sampling period was based on availability of pre-fledgling birds and bird eggs. Because pre-fledglings generally are confined to a given locale until they fledge, trace elements and pesticides in their tissues may be obtained from food and water in the area where the birds were reared. However, adult females can pass organochlorine pesticides and some trace elements to their eggs and brood. An attempt was made to collect pre-fledglings immediately before fledging because older pre-fledged birds would be exposed for a longer time period than younger birds to any contaminants present in the area. Such collections were not always possible because of time limitations in the sampling effort, and because of considerable predatory activity on young birds, which decreased the availability of samples. Unfortunately, developmental abnormalities among embryos in bird eggs cannot be detected before the egg has reached one-half term (Ohlendorf and others, 1986). Eggs were collected as soon as they were discovered because of the high risk of predatory loss of eggs and to ensure that representative egg samples were available for contaminant analysis.

Sampling Methods

At stream sites, stream discharge, specific conductance, pH, water temperature, and dissolved oxygen were measured. Instantaneous stream discharge was determined at sites that had streamflow-gaging stations from the stage record and from stage-discharge rating tables; otherwise, stream discharge was measured using standard techniques of the U.S. Geological Survey (Rantz and others, 1982).

Water-quality samples were collected at stream sites using depth-integrating samplers and methods described by Ward and Harr (1990). Where stream depths were too shallow to use samplers, representative water samples were collected from the centroid of flow or from several verticals across the stream using sample bottles. Water samples for pesticides were collected from the centroid of flow when possible using sample bottles furnished by the National Water Quality Laboratory of the U.S. Geological Survey. Water samples from Navajo Reservoir were collected using a standard water-sampling bottle. Ground-water samples were collected from either household faucets or pumps. The systems were allowed to flush before the samples were collected into 3-L plastic bottles.

The availability of fine bottom sediment at the stream sites was limited to pools or to backwater areas. Samples were scooped from areas of deposition using stainless-steel spoons and were composited in a bucket. Bottom sediment in Navajo Reservoir was collected using an Ekman grab sampler (Britton and Greeson, 1988). Bottom-sediment samples were mixed in the bucket, and subsamples were taken for inorganic analysis and for pesticide analysis where applicable.

Soil samples were collected using a soil auger. Samples were placed in soil-sampling storage bags for shipment to the laboratory. Plant samples were handpicked and placed in paper bags.

Biological samples were collected by the U.S. Fish and Wildlife Service using standard equipment and techniques (U.S. Fish and Wildlife Service, 1986; 1990b). Fish were collected using electroshocking equipment and seine or gill nets. Fish were rinsed, weighed, and measured for length and were immediately frozen on dry ice until stored in a freezer. Whole-body samples were composited by species into groups of three or more fish as specified by the DOI sampling protocol. Fillet samples, or edible parts used to determine human health concerns, were taken from individual fish and were not composited. Fish samples for analyses of organic compounds were wrapped in aluminum foil, placed in plastic bags, and frozen on dry ice until storage in a freezer. Fish for analyses of inorganic constituents were frozen in plastic bags.

Vascular plants and algae were collected by handpicking. These samples were placed in chemically-cleansed jars, weighed, and frozen. Algae samples (macroscopic, colonial attached algae) probably contained green algae (Chlorophyta) and blue-green algae (Cyanophyta). Plankton samples (microscopic, free floating in the water column) consisted of phytoplankton and zooplankton and were collected using a plankton tow. Stream invertebrates were collected using a kick screen, and lake plankton were collected using a plankton tow. Because this was a reconnaissance-level study, several easily identifiable invertebrate groups were combined to obtain sufficient biomass for analysis. Crayfish were collected when present.

Birds were shot using steel shot, and livers and muscle tissue were removed using stainless-steel dissecting equipment. Based on a literature review, bird liver was determined to be the best organ for a general trace-element scan, although other organs may be better indicators for specific elements, such as kidney for cadmium and bone for lead. The collecting apparatus was cleansed between sampling sites, and dissecting equipment was cleansed prior to removal of each liver. Bird livers and muscle tissue were placed in chemically cleansed jars, weighed, and frozen. Livers from similar bird species were sometimes composited with two to four livers constituting one sample.

After locating nests, bird eggs were removed and the egg volume was determined by water displacement. The eggs were cracked open to examine embryos for developmental abnormalities. After examination, eggs were placed in chemically cleansed jars, weighed, and frozen. Small eggs were composited to provide sufficient biomass for analysis.

Analytical Support

Analyses of water samples for major constituents and trace elements (table 5), except for uranium, were done by the U.S. Geological Survey's National Water Quality Laboratory in Arvada, Colorado. Analytical methods are described in Fishman and Friedman (1989), and laboratory quality-assurance methods are described in Jones (1987). Uranium was analyzed using a method described in Thatcher and others (1977) by a private laboratory contracted by the U.S. Geological Survey. Herbicides in water and pesticides in bottom-sediment samples (table 5) were analyzed by the National Water Quality Laboratory using methods described by Wershaw and others (1987).

Bottom-sediment samples were analyzed for trace elements by the U.S. Geological Survey's Branch of Exploration Geochemistry Laboratory in Lakewood, Colorado. The samples were dry sieved at the laboratory through a 2-mm screen. The samples then were split, and one split was seived through a 0.0625-mm screen. Both size fractions, less than 2 mm and less than 0.0625 mm, were analyzed for trace elements. Analytical methods for bottom-sediment analyses are described by Severson and others (1987).

The soil and plant samples collected by the U.S. Bureau of Indian Affairs were analyzed for selenium by the soil laboratory at Colorado State University in Fort Collins, Colorado. Samples for total-selenium analysis were digested using nitric, perchloric, and hydrochloric acids. Extractable selenium in the soil samples was the fraction of selenium in the soil removed by AB-DTPA extracting solution. AB-DTPA is a chelating agent used by the soil laboratory on calcareous soils to extract metals, nitrates, and potassium (Soltanpour and Schwab, 1977). The AB-DTPA extractable selenium in soil is not necessarily equivalent to the biologically available selenium to plants, which may be dependent on other factors such as chemical forms of the selenium, nature of the soil, and type of plant. Generally, the extractable-selenium concentrations determined using AB-DTPA solution or using hot water are about the same, but the concentration may be less using cold water (Soltanpour and Workman, 1980). The AB-DTPA soil extracts were acidified using hydrochloric acid prior to analysis. Selenium concentrations in the acid extracts were determined using inductively coupled plasma atomic-emission spectrometry with hydride generation. The detection limit for the extract analysis was 0.5 µg/L, resulting in a reporting limit for the original soil and plant samples of 0.25 mg/kg for total selenium and 0.01 mg/kg for extractable selenium.

Biological samples were analyzed by Hazelton Laboratories America, Inc., in Madison, Wisconsin, and the Environmental Trace Substances Research Center in Columbia, Missouri. Those laboratories were contracted by the U.S. Fish and Wildlife Services' Patuxent Analytical Control Facility (PACF) in Patuxent, Maryland. Biological samples were analyzed for the constituents listed in table 5. Most trace elements in biota samples were analyzed using inductively coupled argon-plasma atomic-absorption spectrometry after complete digestion of the sample with strong acids. Arsenic and selenium in biota samples were analyzed using hydride-generation atomic absorption, and mercury was analyzed by flameless cold-vapor atomic absorption. Analyses of pesticide residues in biota samples consisted of solvent extraction and electron-capture gas chromatography. All analytical data from the laboratories were reviewed by the PACF. Quality-assurance procedures included sample spikes, duplicates, and blanks.

DISCUSSION OF RESULTS

Surface-Water Quality

Water-quality measurements and analyses for the samples collected at surface-water sites for the reconnaissance investigation of the Pine River Project area are listed in table 18. Analyses for all the herbicide samples collected in the Project area during 1988-89 are listed in table 19. Tables 18 and 19 are in the "Supplemental Data" section at the back of the report.

Guidelines for Interpretation of Water-Quality Data

Water-quality data collected in the Pine River Project area during 1988-89 were compared to U.S. Environmental Protection Agency drinking-water regulations (U.S. Environmental Protection Agency, 1988a; 1988b; 1991) and aquatic-life criteria (U.S. Environmental Protection Agency, 1986; 1987). Water-quality data also were compared to Colorado agricultural-use criteria (Colorado Department of Health, 1989). The comparisons were used to determine if constituent concentrations in water samples may adversely affect the suitability of water for domestic use, have adverse effects to aquatic life, or affect the suitability of the water for agricultural use. Drinking-water regulations (table 9) that are a maximum contaminant level (MCL) are legally enforceable; regulations that are a secondary maximum contaminant level (SMCL) are not legally enforceable.

The U.S. Environmental Protection Agency's aquatic-life criteria (table 9) were established to protect aquatic organisms from chronic or acute effects from exposure to potentially toxic trace elements. Chronic criteria are for protection of aquatic organisms from adverse effects such as reproductive problems or decreased growth caused by long-term exposure to a trace element. Acute criteria are for protection of aquatic organisms from lethal effects and are based on toxicity data. The agricultural-use criteria (table 9) are applied to surface water in Colorado that is used or is considered suitable for irrigation of crops grown in Colorado and is not hazardous as drinking water for livestock (Colorado Department of Health, 1989).

The number of surface-water samples collected for the reconnaissance investigation of the Pine River Project area that had constituent concentrations exceeding the various guidelines are summarized in table 10. The aquatic-life criteria for cadmium, copper, lead, and zinc (table 9) are computed using equations that are based on water hardness. A water hardness of 150 mg/L was used to compute the aquatic-life criteria for those four trace elements listed in table 9. The water hardness of individual samples, which ranged from 40 to 340 mg/L (table 18), was used for determination of the number of samples that exceeded aquatic-life criteria that are listed in table 10.

Many streams in Colorado have been classified by the State (Colorado Department of Health, 1989) according to various beneficial-use categories, and include domestic use, recreational use, protection of aquatic life, and agricultural use. The State adopted the U.S. Environmental Protection Agency drinking-water regulations and aquatic-life criteria to develop State water-quality standards. However, not every stream in Colorado has State standards for trace elements because of the use classifications assigned to the stream, or the standards have not been determined. In the Pine River Project area, Salt, Rock, Dry, West Sambrito, and Sambrito Creeks do not have State water-quality standards for trace elements (Colorado Department of Health, 1986). Therefore, the information in table 10 was used for evaluation of the water-quality data for the reconnaissance investigation, and table 10 was not based on the Colorado stream-classification system.

The surface-water-quality data also were evaluated by comparing constituent concentrations in samples collected at reference sites and at sites upstream from irrigated areas to constituent concentrations in samples collected at sites downstream from irrigated areas. Those comparisons may indicate if irrigation drainage was affecting water quality of streams in the Pine River Project area. The comparative information was used in conjunction with the drinking-water regulations and water-quality criteria to determine if irrigation drainage was contributing potentially harmful constituents to water in the Pine River Project area.

Table 9. Drinking-water regulations and aquatic-life criteria of the U.S. Environmental Protection Agency and agricultural-use criteria of the State of Colorado

[MCL, maximum contaminant level (enforceable); SMCL, secondary maximum contaminant level (not enforceable); chronic criteria are for protection of aquatic life from adverse affects such as reproductive problems caused by long-term exposure; acute criteria are for protection of aquatic life from lethal effects; mg/L, milligrams per liter; µg/L, micrograms per liter; --, no value]

Constituent	Drinking-water regulations		Aquatic-life criteria[4]		Agricultural-use criteria[6]
	MCL[1,2]	SMCL[3]	Chronic	Acute	
Sulfate (mg/L)	--	250	--	--	--
Chloride (mg/L)	--	250	--	--	--
Dissolved solids (mg/L)	--	500	--	--	--
Nitrate (mg/L)	10	--	--	--	100
Arsenic (µg/L)	50	--	190	360	100
Boron (µg/L)	--	--	--	--	750
Cadmium (µg/L)	5	--	[a]2	[a]6	10
Chromium (µg/L)	100	--	11	16	100
Copper (µg/L)	--	1,000	[a]17	[a]26	200
Iron (µg/L)	--	300	1,000	--	--
Lead (µg/L)	50	--	[a]5	[a]137	100
Manganese (µg/L)	--	50	--	--	--
Mercury (µg/L)	2	--	.012	2.4	--
Selenium (µg/L)	50	--	[5]5	[5]20	20
Zinc (µg/L)	--	5,000	[a]149	[a]165	2,000

[a]Criteria are based on water hardness. Values were computed using a water hardness of 150 milligrams per liter.

References cited in preceeding table are indicated by numbers in column headings, and the complete references are listed in the "References" section at the back of the report.

1. U.S. Environmental Protection Agency, 1988a. (MCL's for nitrate, arsenic, lead, and mercury)
2. U.S. Environmental Protection Agency, 1991. (MCL's for cadmium, chromium, and selenium)
3. U.S. Environmental Protection Agency, 1988b.
4. U.S. Environmental Protection Agency, 1986.
5. U.S. Environmental Protection Agency, 1987.
6. Colorado Department of Health, 1989.

Table 10. Number of surface-water samples collected for the reconnaissance investigation that had constituent concentrations that exceeded drinking-water regulations and aquatic-life criteria of the U.S. Environmental Protection Agency and exceeded agricultural-use criteria of the State of Colorado

[MCL, maximum contaminant level; SMCL, secondary maximum contaminant level; number of samples is 59; --, no applicable regulation or criteria]

Constituent	Drinking-water regulations		Aquatic-life criteria		Agricultural-use criteria
	MCL	SMCL	Chronic	Acute	
Sulfate	--	2	--	--	--
Chloride	--	0	--	--	--
Dissolved solids	--	12	--	--	--
Nitrate[1]	0	--	--	--	0
Arsenic	0	--	0	0	0
Boron	--	--	--	--	0
Cadmium	0	--	[a]2	0	0
Chromium	0	--	0	0	0
Copper	--	0	0	0	0
Iron	--	0	0	--	--
Lead	0	--	[b]1	0	0
Manganese	--	25	--	--	--
Mercury	1	--	(c)	0	--
Selenium	1	--	12	2	2
Zinc	--	0	0	0	0

[1]Concentrations of nitrite plus nitrate as nitrogen compared to regulations and criteria for nitrate.

[a]The chronic criterion for cadmium for some sites was less than the analytical reporting limit of 1 microgram per liter for cadmium.

[b]The reporting limit for lead analyses was 5 micrograms per liter for samples collected in November 1988 and March 1989, which was greater than the chronic criterion for lead for several sites.

[(c)]Number of samples that exceeded criterion cannot be determined; the reporting limit for mercury analysis was 0.1 microgram per liter, which exceeds the chronic criterion of 0.012 microgram per liter for mercury.

Dissolved Solids and Major Constituents

Dissolved-solids (fig. 6) and major-constituent concentrations (table 18) were similar in the Los Pinos River at Columbus (site LP1) and at Bayfield (site LP2) for the samples collected in November 1988, March 1989, and July 1989. Dissolved-solids and some major-constituent concentrations were greater in the Los Pinos River at La Boca (site LP4) than at site LP2, particularly for the samples collected in November 1988 and July 1989. Water quality of the Los Pinos River is affected by reservoir operations, natural ground-water discharge, rainstorm and snowmelt runoff, irrigation diversions, and irrigation drainage and surface return flow. Snowmelt runoff and resulting dilution was the primary reason that dissolved-solids concentrations were similar in the Los Pinos River in March 1989 (fig. 6). The large difference in stream discharge at the sampling sites on the Los Pinos River in July (fig. 6) was caused by irrigation diversions and by large fluctuations in the discharge from Vallecito Reservoir during the 2 days that samples were collected. Dissolved-solids concentrations were less than 100 mg/L in the water diverted from the Los Pinos River for irrigation based on the samples collected at site LP2 (table 18).

The Piedra River near Arboles (site P1) was used as a reference site. Dissolved-solids concentrations in samples collected at site P1 for the USGS cooperative program during 1988-89 were larger than dissolved-solids concentrations in the Los Pinos River at La Boca (site LP4). A comparison of dissolved-solids data collected by the U.S. Geological Survey during 1969-73 at sites P1 and LP4 indicates the same relation. Mean dissolved-solids concentrations were 189 mg/L (24 sam-

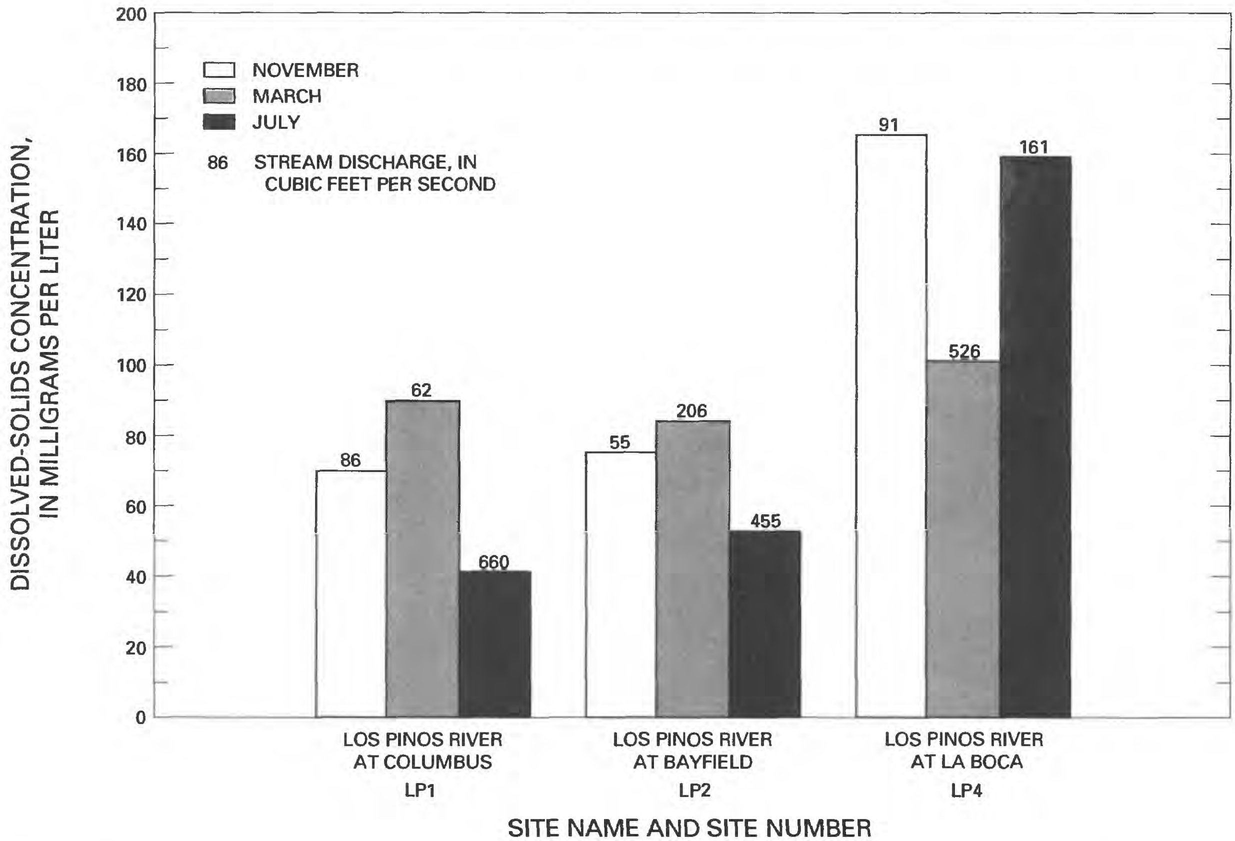

Figure 6. Dissolved-solids concentrations in the Los Pinos River, November 1988 and March and July 1989.

ples) in the Piedra River at site P1 and 137 mg/L (25 samples) in the Los Pinos River at site LP4.

Dissolved-solids concentrations in tributary streams of the Los Pinos River and the other streams draining irrigated areas of the Pine River Project area ranged from 89 mg/L at the upstream site on Salt Creek (site ST1) in July 1989 to 1,090 mg/L at West Sambrito Creek at the mouth (site WSB2) in March 1989 (table 18). Water quality in tributaries may be affected by natural ground-water discharge, irrigation drainage, surface return flow, snowmelt runoff, and rainstorms. Water samples collected in November 1988 from tributary streams probably represented various mixtures of surface return flow, irrigation drainage, and natural flow. Based on comparisons of stream discharge and dissolved-solids concentrations between upstream and downstream sites (table 18), much of the gain of stream discharge in Salt, Rock, and Dry Creeks during the sample collection in November 1988 was return flow and tailwater from canals and laterals.

Generally, base-flow conditions were sampled for most tributaries for the pre-irrigation sampling in late March 1989, and most of the water at downstream sites probably was comprised of irrigation drainage. There may have been small quantities of snowmelt runoff in Spring and Sambrito Creeks, and most of the water in Beaver Creek during the sampling period in March 1989 was snowmelt runoff. The source of snowmelt runoff to the streams during late March 1989 was from higher elevation areas of the drainage basins upstream from the irrigated areas. Because of unusually warm weather that began in mid-February, all snow in lowland areas, including the irrigated areas, had melted by early March. In July 1989, most of the water in the tributary streams was irrigation return flow or tailwater. Because of the dilution effect of the canal water, dissolved-solids and major-ion concentrations generally were smaller in July 1989 than in November 1988 and March 1989 (table 18).

Using dissolved solids as a general indicator of water quality, the possible effects of irrigation drainage on water quality of streams in the Pine River Project area were examined. There was no indication of substantial effects of irrigation on dissolved-solids concentrations in streams in the Project area. Dissolved-solids concentrations in the Los Pinos River (fig. 6) indicate there may be small effects on water quality of the river between Bayfield (site LP2) and La Boca (site LP4). In the smaller streams that were sampled, differences in the dissolved-solids concentrations between upstream sites and downstream sites were variable. Dissolved-solids concentrations were about equal between the upstream and downstream site on Salt, Rock (fig. 7), and Ute Creeks (table 18) in the samples collected in March 1989. If most of the inflow in March 1989 into Salt, Rock, and Ute Creeks between the upstream and downstream sites was irrigation drainage, then irrigation drainage did not substantially affect dissolved-solids concentrations in those streams. In Dry Creek (fig. 7), the dissolved-solids concentration was smaller at the downstream site (D2) than at the upstream site (D1) in March 1989. Stream discharge in Sambrito Creek may have been at base flow in November 1988, and dissolved-solids concentrations increased about 28 percent between the upstream site (SB1) and the downstream site (SB2).

The secondary maximum contaminant level (SMCL) for dissolved solids was exceeded in 12 samples collected in the Pine River Project area (table 10). The SMCL for sulfate was exceeded in two samples collected from West Sambrito Creek at mouth (site WSB2).

Trace Elements

Many trace-element concentrations in samples collected from the Pine River Project area (table 18) were equal to or less than analytical reporting limits. A statistical summary of trace-element data is listed in table 11. The only trace-element concentrations that exceeded the U.S. Environmental Protection Agency drinking-water regulations or aquatic-life criteria or Colorado agricultural-use criteria (tables 9 and 10) to

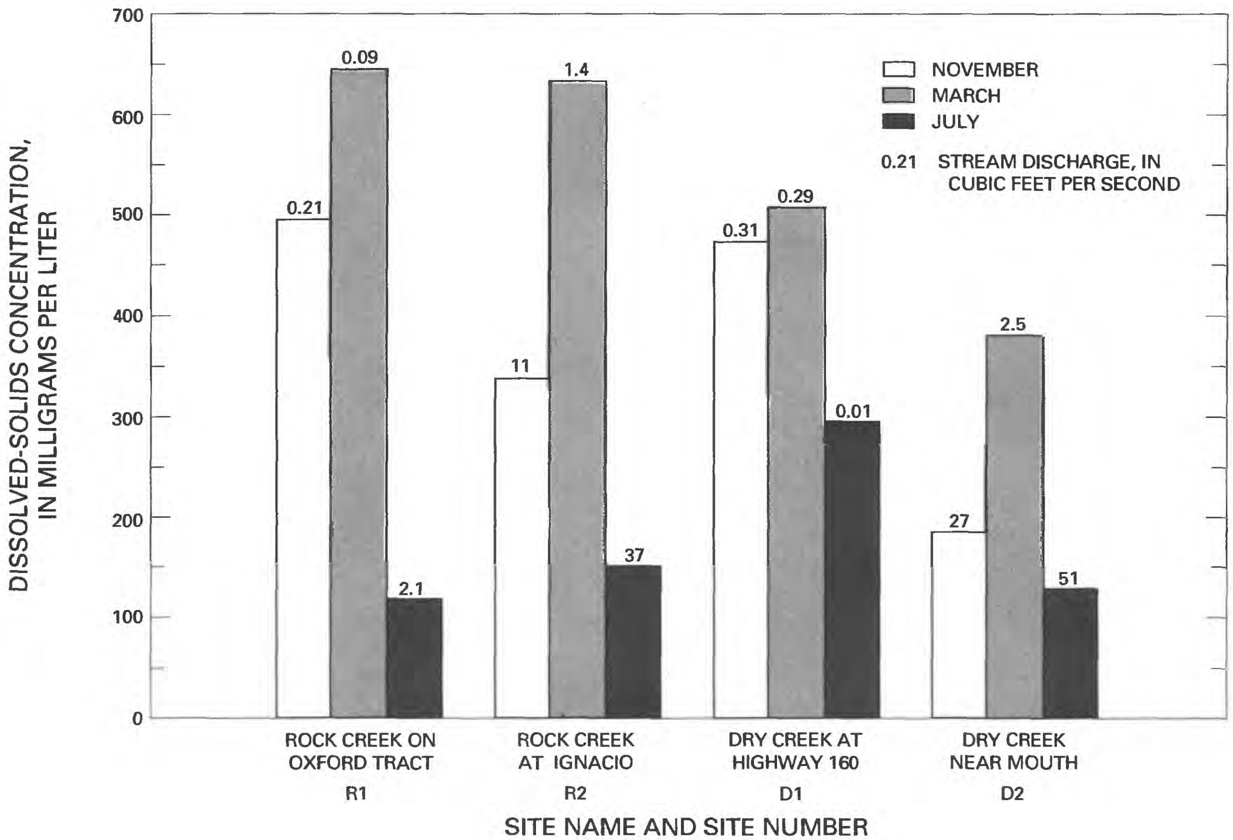

Figure 7. *Dissolved-solids concentrations in Rock and Dry Creeks, November 1988 and March and July 1989.*

Table 11. Statistical summary of trace-element concentrations in surface-water samples collected for the reconnaissance investigation, 1988-89

[Analyses by U.S. Geological Survey; number detected is the number of samples with concentrations equal to or greater than analytical reporting limits; concentrations in micrograms per liter; <, less than]

Trace element	Number of samples	Number detected	Median	Maximum	Minimum
Arsenic	59	26	<1	2	<1
Boron	59	49	20	60	<10
Cadmium	59	6	<1	4	<1
Chromium	59	3	<1	3	<1
Copper	59	59	2	10	1
Iron	59	58	32	220	<3
Lead[1]	59	10	<5	5	<1
Manganese	59	59	37	1,000	3
Mercury	59	9	<.1	2.3	<.1
Molybdenum	59	21	<1	10	<1
Selenium	59	33	1	94	<1
Uranium	31	29	1.4	7.2	<.40
Vanadium	59	40	1	3	<1
Zinc	59	49	5	63	<3

[1]Reporting limit for lead analysis for all samples collected in November 1988 and March 1989 (40 samples) was 5 micrograms per liter; the reporting limit for the samples collected in July 1989 (19 samples) was 1 microgram per liter.

warrant further discussion were cadmium, lead, manganese, mercury, and selenium. Those elements will be discussed further in this section of the report.

Cadmium

Cadmium exceeded the chronic aquatic-life criteria in samples collected in November 1988 from Rock Creek at Ignacio (site R2) and West Sambrito Creek at mouth (site WSB2). Cadmium also was detected (reporting limit of 1 μg/L) in four other samples (tables 11 and 18), but concentrations did not exceed aquatic-life criteria. Five of the six samples that had cadmium detected were collected in November 1988, after the irrigation season. The five sites that had detected cadmium are downstream from irrigated areas of the Pine River Project; however, it is uncertain if irrigation drainage was the source of cadmium. Cadmium was not detected in samples collected from the Los Pinos River (table 18). The analytical reporting limit for cadmium exceeded the chronic aquatic-life criteria for cadmium for samples with small water-hardness concentrations, including all the samples collected from the Los Pinos River at Columbus (site LP1) and at Bayfield (site LP2).

Lead

The sample collected from the Los Pinos River at La Boca (site LP4) in March 1989 had a lead concentration of 5 μg/L, which exceeded the hardness-based chronic aquatic-life criteria of about 2 μg/L. However, the reporting limit for lead analysis was 5 μg/L for all water samples collected in November 1988 and in March 1989 for the reconnaissance investigation; 5 μg/L is greater than the chronic aquatic-life criteria for 29 samples collected during those months, based on the water hardness of the individual samples. Nine of the 10 samples with lead detected (table 11) were collected in July 1989 when the reporting limit for lead analysis was 1 μg/L. The maximum lead concentration in samples collected in July 1989 was 4 μg/L from Ute Creek near the mouth (site U2). None of the 19 samples collected in July 1989 had a lead concentration that exceeded the chronic aquatic-life criteria.

Manganese

Every stream sampled for the reconnaissance investigation, except the Los Pinos River and the Florida River, had at least one sample that had a manganese concentration that exceeded the SMCL of 50 µg/L (table 9). Twenty-five samples exceeded the SMCL for manganese (table 10). Manganese normally is not a toxic contaminant; the drinking-water regulation for manganese is based primarily on aesthetic qualities of water for human use. The maximum concentration of dissolved manganese was 1,000 µg/L in a sample from the upstream site on Ute Creek (site U1) (table 18).

Manganese concentrations in ground-water samples from the Southern Ute Indian Reservation commonly exceeded 50 µg/L (Hutchinson and Brogden, 1976). The primary source of manganese in streams may be local ground-water discharge, some of which may be from natural sources. Many of the largest manganese concentrations in streams were collected at the upstream sites, such as Rock Creek (site R1), Dry Creek (site D1), Ute Creek (site U1), and Spring Creek (site SP1) (table 18). Manganese concentrations in the Los Pinos River were not large. Irrigation drainage from the Project area does not seem to be contributing large quantities of manganese to streams.

Mercury

Mercury was detected in nine surface-water samples collected in the Pine River Project area during 1988-89 (table 11) at concentrations ranging from 0.1 to 2.3 µg/L (table 18). These samples exceeded the chronic aquatic-life criterion. Mercury concentrations reported as less than 0.1 µg/L (table 18) cannot be compared to the chronic aquatic-life criterion of 0.012 µg/L (table 9) because the analytical reporting limit of 0.1 µg/L is greater than the criterion concentration. The mercury concentration of 2.3 µg/L was in the sample collected on March 29, 1989, from the Los Pinos River at Columbus (site LP1) (table 18) and exceeded the MCL of 2 µg/L (table 9). The mercury concentrations in the Los Pinos River at Bayfield (site LP2) and at La Boca (site LP4) were less than 0.1 µg/L on March 29; reasons for the large mercury concentration in the sample from site LP1 are not known. Mercury was detected in the samples collected from the Los Pinos River at sites LP1 and LP2 in July 1989 (table 18). There was construction at the powerplant at Vallecito Reservoir during the year, but it is not known if that was a source of mercury to the Los Pinos River. Both samples collected from Navajo Reservoir in November 1988 had 0.2 µg/L of mercury. Mercury also was detected in samples collected in March 1989 at four sites on tributary streams.

Selenium

Selenium concentrations exceeded the maximum contaminant level for drinking water of 50 µg/L (table 9) in only one surface-water sample from the Pine River Project area (tables 10 and 18). That sample was collected from Rock Creek on the Oxford Tract (site R1) in March 1989 and had a selenium concentration of 94 µg/L. Rock Creek is not used as a domestic-water supply. The U.S. Environmental Protection Agency (1987) reported a selenium aquatic-life criterion of 5 µg/L for chronic exposure effects and 20 µg/L for acute effects. Lemly and Smith (1987) reported that selenium concentrations in water greater than 2 to 5 µg/L may cause reproductive failure or mortality in fish and waterfowl because of food-chain bioaccumulation. Twelve surface-water samples collected in the Project area had selenium concentrations greater than 5 µg/L; these samples were collected from Salt, Rock, Spring, West Sambrito, and Sambrito Creeks. Two surface-water samples had selenium concentrations greater than 20 µg/L; both samples were collected from Rock Creek on the Oxford Tract (site R1, table 18). The selenium concentrations in those two samples also exceeded the agricultural-use criterion of 20 µg/L.

The maximum selenium concentrations in surface-water samples were in samples collected from Rock Creek on the Oxford Tract (site R1, table 18). Site R1 is in an area known to have large selenium concentrations in ground water. The ground water discharging into upper Rock Creek may be from irrigation-induced sources and perhaps from naturally occurring ground water in the San Jose Formation. The selenium concentration at the downstream site on Rock Creek at Ignacio (site R2) on March 27, 1989, was 15 µg/L, compared to 94 µg/L at site R1 (table 18). Stream discharge in Rock Creek increased from 0.09 to 1.4 ft^3/s from site R1 to site R2 on March 27. There was no overland runoff in the Rock Creek basin in late March 1989; therefore, the gain in stream discharge was ground-water inflow into Rock Creek and Ignacio Creek (fig. 1). Ground water discharging into Rock Creek and Ignacio Creek probably was irrigation drainage and perhaps recharge from snowmelt that occurred in February. There were slightly larger selenium concentrations in Spring, West Sambrito, and Sambrito Creeks (maximum concentration was 9 µg/L) compared to Dry, Beaver, and Ute Creeks. There were small increases in selenium concentrations in Ute and Sambrito Creeks that probably were caused by irrigation drainage. The streams that had the larger selenium concentrations in the Project area drain parts of the same areas that Brogden and others (1979) had delineated as having large selenium concentrations in the ground water. However, the selenium concentrations in streams generally were much smaller than selenium concentrations reported in ground-water samples. Selenium concentrations were equal to or less than 1 μg/L in all samples from the Los Pinos River and from Navajo Reservoir (table 18). Therefore, irrigation drainage from the Pine River Project was not contributing substantial quantities of selenium to the Los Pinos River.

Herbicides

Eighteen samples collected in the Pine River Project area were analyzed for six herbicides (table 19). Nine samples were collected in July 1989 for the reconnaissance investigation; the other samples were collected for the USGS cooperative program. Only five herbicide concentrations were reported equal to or greater than the reporting limit (0.01 μg/L for all six compounds). All concentrations were small; the maximum concentration was 0.03 μg/L of 2,4-D in a sample from the Los Pinos River at La Boca (site LP4) and of dicamba in samples from Spring Creek at La Boca (site SP2) and Sambrito Creek at mouth (site SB2) (table 19). These concentrations are considerably less than the concentrations that may be harmful to aquatic life.

Ground Water

Water Quality

The water-quality data collected at five ground-water sites (sites on fig. 1 that begin with the prefix "G") in March and August 1989 are listed in table 18. Site G24 is a spring; the other four sites are wells. To facilitate comparison of the data collected during the reconnaissance investigation to the data collected in the 1970's, the numerical part of the site number is the same site number used in table 1 in the report by Hutchinson and Brogden (1976).

Except for the well at site G87, ground water at the sampling sites was used for domestic purposes, including drinking water. The residents at site G87 were not using the well water, except for washing or cleaning. The spring at site G24 is part of the water supply for the Durango-La Plata County Airport. Selenium concentrations in 8 of the 10 ground-water samples collected in 1989 (table 18) exceeded the maximum contaminant level (MCL) of 50 μg/L for selenium (table 9). Selenium concentrations in the two samples from site G24 were less than 50 μg/L. Concentrations of nitrite plus nitrate in the samples from sites G87 and G114 were considerably greater than the MCL of 10 mg/L for nitrate. Concentrations of chloride in samples from sites G87 and G109 exceeded the secondary maximum contaminant level of 250 mg/L for chloride (table 9).

Selected constituent concentrations in samples collected for the reconnaissance investigation in 1989 and in samples collected in the 1970's are compared in table 12. Dissolved-solids concentrations between the two periods were about equal for each site, except for site G114, which had smaller dissolved-solids concentrations in 1989 than in 1975. The concentrations of nitrite plus nitrate also were less in the samples collected in 1989 than in samples from 1975 at site G114. Samples collected in 1989 had smaller selenium concentrations than the samples collected in the 1970's at four of the five ground-water sites (table 12). The exception was site G109, which had larger dissolved-selenium concentrations in 1989 compared to the total-selenium concentration in 1974. The maximum selenium concentration reported by Hutchinson and Brogden (1976) was 13,000 μg/L at site G87; there was substantially less selenium in the two samples collected in 1989 at site G87 (4,400 and 4,800 μg/L) (table 12). However, the ground water at site G87 continues to contain far too much selenium to be considered safe for ingestion by humans or livestock.

There were not large differences among most constituent concentrations between samples collected in March 1989 and samples collected in August 1989 (table 18). At four of the five ground-water sites, selenium concentrations were larger in August than in March (tables 12 and 18). The samples collected in March preceded irrigation in the Pine River Project area. Site G24 is a spring located on a hillside in the Florida River valley, and the spring probably is recharged by irrigation water. Site G87 is in a non-irrigated area, and the other three sites are located in or near irrigated areas. The effects of irrigation on water quality of ground water at sites G69, G109, and G114 were not known. An analysis of the major-ion composition of the samples collected in 1989 indicated no evidence that a major change in water chemistry, and hence, water sources, had occurred in the aquifers from March to August 1989. As indicated earlier in the "Previous Investigations" section of this report, water quality in shallow ground water in the Project area is variable because of the varied lithology of the geologic units (Brogden and others, 1979).

Table 12. Comparison of concentrations of selected constituents in ground-water samples collected in 1989 to samples collected at the same sites during 1974-75

[Analyses by U.S. Geological Survey; concentrations are for dissolved constituents unless denoted by *, which is a concentration for total constituent; mg/L, milligrams per liter; µg/L, micrograms per liter; ND, not detected; <, less than; --, no data; data for 1974-75 are from Hutchinson and Brogden (1976)]

Site number (fig. 1)	Well depth (feet)	Water level (feet)	Date	Dissolved solids (mg/L)	Nitrite plus nitrate (mg/L)	Arsenic (µg/L)	Boron (µg/L)	Iron (µg/L)	Manganese (µg/L)	Selenium (µg/L)
G24	--	--	08-27-75	508	1.8	1	50	ND	--	130
G24	--	--	03-22-89	512	.71	<1	40	5	3	30
G24	--	--	08-22-89	490	.64	<1	30	8	4	37
G69	120	41	08-20-75	677	2.0	0	80	ND	--	220
G69	120	--	10-02-75	--	--	0	--	0	--	160
G69	120	--	03-22-89	629	1.7	<1	50	19	3	110
G69	120	--	08-23-89	578	2.8	<1	40	27	3	140
G87	159	50	06-18-74	1,630	70	0*	80	50	0	7,860
G87	159	--	07-24-75	--	--	1	--	--	--	13,000
G87	159	--	03-22-89	1,790	79	2	30	10	<10	4,400
G87	159	--	08-22-89	1,730	67	<1	20	<3	2	4,800
G109	244	Flowing	06-20-74	944	8.6	0*	50	70	0	*240
G109	244	--	03-28-89	1,100	5.7	2	30	4	13	380
G109	244	--	08-22-89	1,020	5.5	2	10	20	<10	510
G114	105	30	08-28-75	1,358	111	0	50	ND	--	170
G114	105	--	12-22-75	1,205	97	0	--	60	--	240
G114	105	--	03-22-89	836	39	8	40	<3	1	100
G114	105	--	08-22-89	727	25	6	40	20	<10	85

Water Levels

Water levels were measured in five wells (sites WL1, WL2, WL3, WL4, and WL5 in fig. 1) in an attempt to document the possible connection between irrigation application and shallow ground water in the Pine River Project area. The water levels are plotted in figures 8-12.

Well WL1 is located near irrigated areas, but the water table (fig. 8) was too shallow during the measuring period to provide useful information. Site WL2 is the test well drilled by the U.S. Geological Survey in 1975 at the Evenson homestead on the Oxford Tract (Brogden and others, 1979). When the well was drilled, the water level was 35 ft. There has been almost no irrigation on the Oxford Tract in the vicinity of the well since it was drilled, but there is irrigated land (non-Indian land) less than 0.5 mi north and west of the Oxford Tract. The water level in well WL2 slightly decreased during the irrigation season (fig. 9), indicating that irrigation on land adjacent to the tract had not affected the water level during the period of measurement. The U.S. Geological Survey and the U.S. Bureau of Indian Affairs monitored water levels in well WL2 during the late 1970's and early 1980's, and water levels at that time were slowly decreasing.

Well WL3 (fig. 10) was selected for water-level measurements because it could be affected by irrigation, and the water levels substantiated that hypothesis. Irrigation began in early May 1989, and the water level in well WL3 began to rise.

Well WL4 (fig. 11) is located in a non-irrigated area on a hilltop above Arboles and would not be affected by irrigation. Except for a minor fluctuation in August 1989, water levels in well WL4 were relatively unchanged during the measuring period.

Well WL5 is adjacent to irrigated areas at the Navajo State Park near Navajo Reservoir. The water

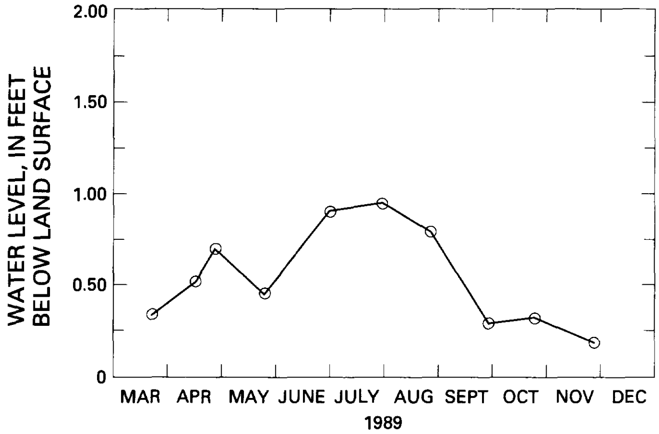

Figure 8. Water-level measurements for well WL1.

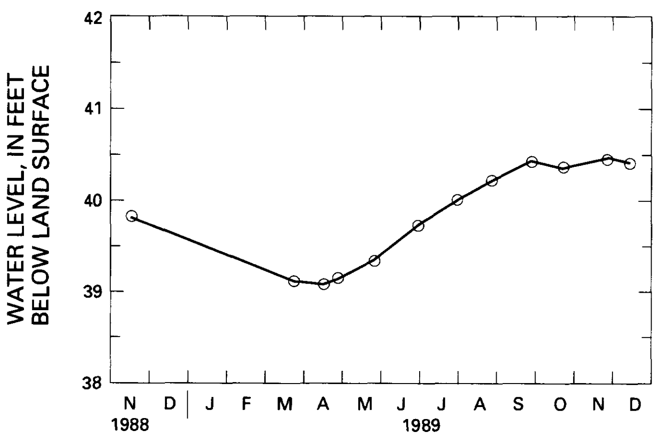

Figure 9. Water-level measurements for well WL2.

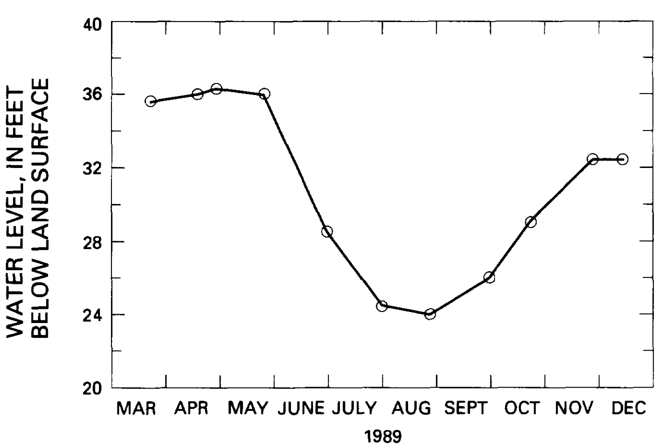

Figure 10. Water-level measurements for well WL3.

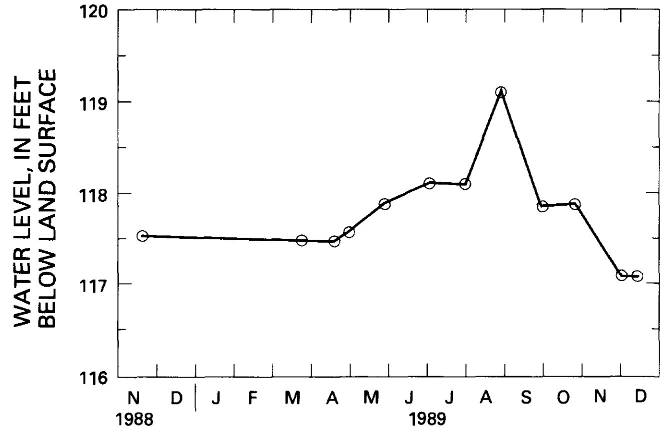

Figure 11. Water-level measurements for well WL4.

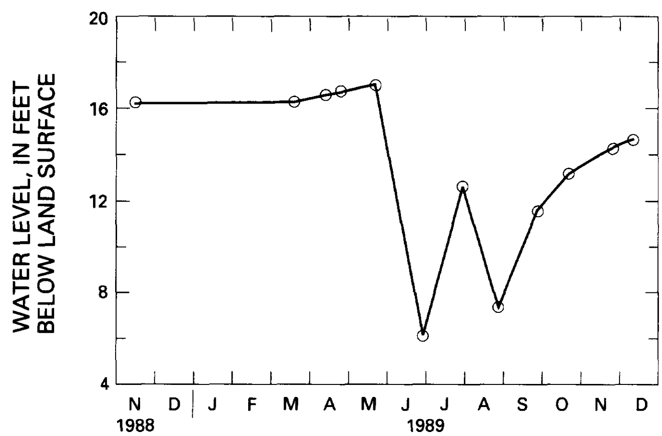

Figure 12. Water-level measurements for well WL5.

levels (fig. 12) indicate a definite rise in June 1989 that probably was caused by irrigation application at the park and to an adjacent field. The water table at site WL5 was shallow, and levels fluctuated considerably during the irrigation season (May to October), probably the result of variable amounts of water applied for irrigation.

The water-level data for wells WL3 and WL5 indicated that irrigation application has a connection to shallow ground water in parts of the Pine River Project area. Water levels rose during the irrigation season in those wells, indicating that irrigation water does recharge shallow ground water in the Project area.

Bottom Sediment

Bottom-sediment samples were collected at 10 sites for trace-element and pesticide analysis during the reconnaissance investigation, and a bottom-sediment sample for pesticide analysis was collected at Los Pinos River at La Boca (site LP4) for the USGS cooperative program. The trace-element analyses for the less than 0.0625-mm size fraction are listed in table 20 and for the less than 2-mm size fraction in table 21. The organic-compound analyses are listed in table 22. Tables 20-22 are in the "Supplemental Data" section at the back of the report. A summary of selected trace-element concentrations is listed in table 13.

Most trace-element concentrations in samples collected from the Pine River Project area (tables 20 and 21) generally were not unusual compared to soil-baseline data or bottom-sediment data from previous studies for the DOI Irrigation Drainage Program (table 14). Trace-element data for bottom sediment in the Project area were compared to the data in table 14 to identify outlier concentrations.

All manganese concentrations in both size fractions exceeded the geometric mean for soils, but none exceeded the upper baseline concentration. All selenium concentrations in bottom sediment were less than 1 μg/g and were within the baselines for soil (tables 13 and 14). All thorium concentrations in the less than 0.0625-mm size fraction (table 20) exceeded the geometric mean concentration for soils (table 14), and thorium in the samples from Spring Creek at La Boca (site SP2) and West Sambrito Creek at the mouth (site WSB2) exceeded the upper baseline value of 20 μg/g. Uranium concentrations in the less than 0.0625-mm size fraction at four sites (table 20) exceeded the upper baseline value of 5.3 μg/g for soils (table 14).

None of the trace-element concentrations in bottom-sediment samples from the Pine River Project area were outside the observed range for the samples collected in 1988-89 for the DOI Irrigation Drainage Program studies (table 14). Three concentrations of nickel and two concentrations of zinc in the less than 0.0625-mm size fraction (table 20) were less than the minimum concentrations reported for those elements for the DOI Irrigation Drainage Program for 1986-87. Three concentrations of thorium in the less than 0.0625-mm size fraction (table 20) exceeded the maximum thorium concentration for the DOI Irrigation Drainage Program for 1986-87.

There may be areal differences in some trace-element concentrations in bottom sediment in the Pine River Project area. West Sambrito Creek at the mouth (site WSB2) had the maximum concentration for barium, chromium, lead, nickel, and vanadium, in both size fractions (table 13). Sambrito Creek at the mouth (site SB2) and the Piedra River arm of Navajo Reservoir (site N1) also tended to have larger concentrations of some trace elements compared to other sites. These three sites are located in the southeast part of the Project area (fig. 1). Salt Creek near the mouth (site ST2) and Ute Creek near the mouth (site U2) had a number of the minimum concentrations of trace elements, particularly in the less than 0.0625-mm size fraction (table 13).

Only thorium and uranium concentrations had noteworthy differences between size fractions. Thorium and uranium were more concentrated in the less than 0.0625-mm size fraction compared to the less than 2-mm size fraction in most samples (tables 20 and 21). There were slightly larger median concentrations of chromium, copper, strontium, and zinc in the less than 0.0625-mm size fraction than in the less than 2-mm size fraction (table 13).

Only seven concentrations of organic compounds exceeded analytical reporting limits in bottom-sediment samples from the Pine River Project area (table 22). The compounds detected were chlordane and DDT or its metabolites (DDE or DDD). The only sites where organic compounds were detected in bottom sediment were Los Pinos River at La Boca (site LP4) and the two sites on Navajo Reservoir (sites N1 and N2). None of the concentrations were significant; the maximum concentrations were 1.0 μg/kg of chlordane and 0.3 μg/kg of DDD (table 22).

Selenium in Soil and Plants on the Oxford Tract

Total and extractable selenium were analyzed in 171 soil samples that were collected at 100 sites on the Oxford Tract in August 1989. Soil samples were collected in areas never irrigated, previously irrigated, and

Table 13. Summary of selected trace-element concentrations in bottom-sediment samples collected in November 1988

[Analyses by U.S. Geological Survey; concentrations in micrograms per gram; <, less than; number of samples is 10]

Trace element	Median	Maximum	Site(s)	Minimum	Site(s)
		LESS THAN 0.0625-MILLIMETER SIZE FRACTION			
Arsenic	5.0	6.2	SP2	3.8	ST2, SB2
Barium	680	1,100	WSB2	530	ST2
Cadmium	<2	<2	All sites	<2	All sites
Chromium	31	43	WSB2	25	ST2
Copper	24	27	WSB2 SB2, N1	19	U2
Lead	14.5	17	WSB2	12	R2, U2
Lithium	21.5	31	N1	16	ST2
Manganese	590	1,000	B2	450	ST2
Mercury	.04	.10	SB2	.02	ST2
Molybdenum	<2	<2	All sites	<2	All sites
Nickel	13	17	WSB2, N1	9	ST2, R2
Selenium	.5	.8	SB2	.2	ST2
Strontium	160	270	N1	120	ST2, R2, U2
Thorium	16.1	22.9	SP2	11.5	U2
Uranium	5.18	8.19	SP2	3.64	N1
Vanadium	79.5	100	WSB2, N1	58	U2
Zinc	65.5	86	N1	45	U2
		LESS THAN 2-MILLIMETER SIZE FRACTION			
Arsenic	5.65	12	B2	2.9	ST2
Barium	690	1,000	WSB2	490	R2
Cadmium	<2	<2	All sites	<2	All sites
Chromium	23.5	39	WSB2	19	B2
Copper	17.5	28	N1	12	R2, B2
Lead	13	16	WSB2	12	ST2, B2
Lithium	18	31	N1	15	F2, ST2
Manganese	625	940	R2	530	N2
Mercury	.02	.08	N1	<.02	ST2, R2, B2, U2
Molybdenum	<2	<2	All sites	<2	All sites
Nickel	12.5	18	WSB2	9	F2, ST2
Selenium	.4	.8	WSB2, N2	.2	ST2
Strontium	130	360	B2	110	U2, SP2
Thorium	9.2	12.9	WSB2	5.9	R2
Uranium	3.24	3.78	N1	2.45	U2
Vanadium	72.5	110	WSB2	58	F2, U2
Zinc	58	93	WSB2	49	ST2

Table 14. Background geochemical data for soils in the Western United States and the observed range of trace-element concentrations in bottom-sediment samples collected for the U.S. Department of Interior's Irrigation Drainage Program in 1986-87 and 1988-89

[Soil data for Western United States modified from Shacklette and Boerngen (1984); bottom-sediment data for the irrigation-drainage reconnaissance studies during 1986-87, from Severson and others (1987), are concentrations in the less than 0.0625-millimeter size fraction; bottom-sediment data for the irrigation-drainage studies during 1988-89, from Harms and others (1990), include concentrations in the less than 0.0625-millimeter and the less than 2-millimeter size fractions; baseline is the 95-percent expected range; concentrations in micrograms per gram; <, less than; --, no data]

Trace element	Soils in Western United States			Observed range of bottom-sediment data	
	Geometric mean	Observed range	Baseline	1986-87	1988-89
Arsenic	5.5	<0.1-97	1.4-22	2.4-15	0.6-120
Barium	580	70-5,000	200-1,700	310-990	67-2,200
Beryllium	0.68	<1-15	0.13-3.6	1.0-2.0	<1-3
Cadmium	--	--	--	--	<2-8
Chromium	41	3-2,000	8.5-200	20-210	3.0-330
Cobalt	7.1	<3-50	1.8-28	6.0-28	2.0-40
Copper	21	2-300	4.9-90	10-110	3.0-520
Lead	17	<10-700	5.2-55	9.0-52	<4-500
Lithium	22	5-130	8.8-55	22-180	4.0-220
Manganese	380	30-5,000	97-1,500	200-3,000	66-4,500
Mercury	0.046	<0.01-4.6	0.0085-0.25	<0.02-18	<0.02-1.0
Molybdenum	0.85	<3-7	0.18-4.0	<2-40	<2-73
Nickel	15	<5-700	3.4-66	11-170	<2-160
Selenium	0.23	<0.1-4.3	0.039-1.4	<0.1-85	<0.1-43
Strontium	200	10-3,000	43-933	170-920	59-1,600
Thorium	9.1	2.4-31	4.1-20	<4.7-18.6	<4-45
Uranium	2.5	0.68-7.9	1.2-5.3	3.0-56	0.15-21
Vanadium	70	7-500	18-270	36-210	5-310
Zinc	55	10-2,100	17-180	49-510	10-1,600

presently (1989) irrigated. Soil also was sampled at various depths at some sites; at 18 sites, samples were collected from underneath selenium-accumulating plants. A summary of the selenium results grouped by irrigation history and sample depths is listed in table 15. A soil sample was collected from a test hole from the 0- to 4-in. depth at every site, and the total-selenium concentrations for those samples are plotted in figure 13. At one site, two samples were collected from the 0- to 4-in. depth; therefore, there are 101 samples included in table 15 but only 100 sites are shown in figure 13.

An unexpected result of the soil sampling was that areas previously or presently (1989) irrigated on the Oxford Tract seemed to have more selenium (both total and extractable) in the upper soil profile (samples from the 0- to 4-in. depth) than soil in areas that were never irrigated. Some of the sites classified as previously irrigated were in areas that have not been irrigated for almost 30 years. Total-selenium concentrations were equal to or less than 0.5 mg/kg (fig. 13) and extractable-selenium concentrations were less than 0.1 mg/kg (table 15) in all soil samples collected in areas never irrigated. At some sites in never-irrigated areas, selenium-accumulating plants were present. The differences in selenium between never-irrigated and irrigated areas did not seem to be based solely on geologic or topographical differences. A non-parametric statistical test, the Mann-Whitney test, and the selenium data for soil samples from the 0- to 4-in. depth, were used to determine if there was a significant difference in selenium concentrations based on irrigation history. The significance level used for the tests was 0.05, and the total- and extractable-sele-

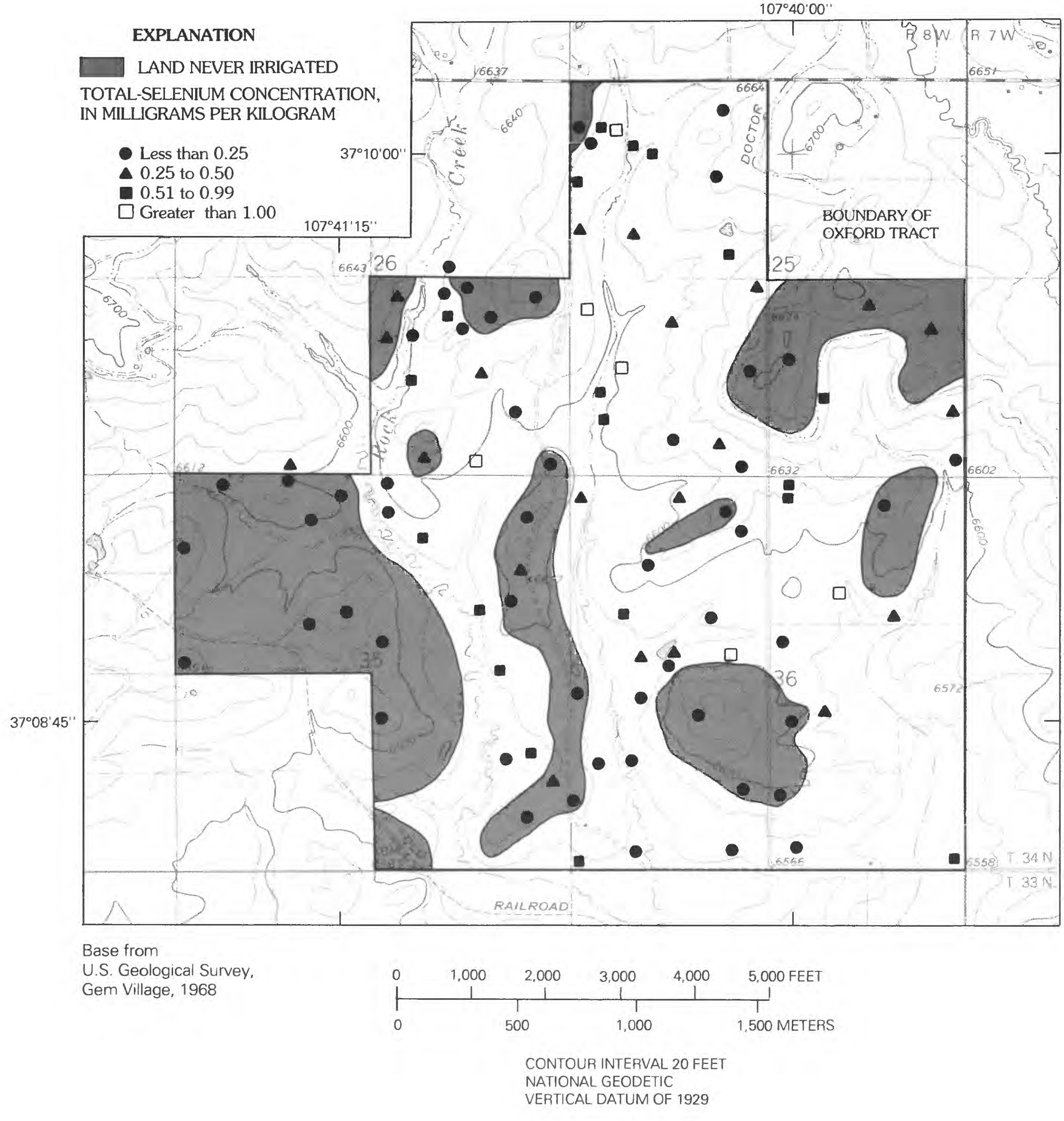

Figure 13. Total-selenium concentrations in soil samples collected at 0- to 4-inch depth on the Oxford Tract, August 1989.

Table 15. Summary of concentrations of total and extractable selenium in soil samples collected at various depths in areas never irrigated, previously irrigated, and presently irrigated on the Oxford Tract, August 1989

[Samples collected by U.S. Bureau of Indian Affairs and were analyzed by Colorado State University; concentrations in milligrams per kilogram; N, number of samples; ND, number of samples reported as less than reporting limits (0.25 milligram per kilogram for total selenium, 0.01 milligram per kilogram for extractable selenium); Max, maximum concentration; Min, minimum concentration; sample depth in inches; sample depth ACC, soil samples collected from under selenium-accumulating plants; <, less than; NC, median not computed; --, no data]

Sample depth	Never irrigated					Previously irrigated					Presently irrigated				
	N	ND	Median	Max	Min	N	ND	Median	Max	Min	N	ND	Median	Max	Min
							TOTAL-SELENIUM CONCENTRATION								
0 to 4	35	26	<0.25	0.50	<0.25	52	18	0.325	2.10	<0.25	14	5	0.325	1.31	<0.25
10 to 14	14	14	<.25	<.25	<.25	21	15	<.25	.30	<.25	10	5	.25	.54	<0.25
22 to 26	1	1	NC	<.25	<.25	4	4	<.25	<.25	<.25	0	--	--	--	--
ACC	5	2	.30	.50	<.25	13	4	.80	3.00	<.25	2	0	NC	.74	.32
All depths	55	43	<.25	.50	<.25	90	41	.25	3.00	<.25	26	10	.285	1.31	<.25
							EXTRACTABLE-SELENIUM CONCENTRATION								
0 to 4	35	5	0.02	0.09	<0.01	52	1	0.06	0.43	<0.01	14	0	0.04	0.24	0.01
10 to 14	14	3	.01	.06	<.01	21	0	.02	.06	.01	10	0	.03	.16	.01
22 to 26	1	0	NC	.05	.05	4	0	NC	.08	.01	0	--	--	--	--
ACC	5	1	.04	.06	<.01	13	1	.08	1.40	<.01	2	0	NC	.08	.03
All depths	55	9	.02	.09	<.01	90	2	.05	1.40	<.01	26	0	.03	.24	.01

nium concentrations were tested. The statistical tests were done for each of the three possible pairs of irrigation history (never irrigated versus previously irrigated, never irrigated versus presently irrigated, and previously irrigated versus presently irrigated). The never-irrigated areas had significantly less selenium in soil than either the previously-irrigated or the presently-irrigated areas. There is not an apparent explanation for that result. There was not a significant difference in selenium in soil between the previously irrigated and presently (1989) irrigated areas.

Median selenium concentrations in soil samples collected from underneath selenium-accumulating plants (astragalus, gumweed, and snakeweed) were larger than median selenium concentrations in soil samples from test holes (table 15), but the concentrations were not as great as expected. There was no distinct relation between selenium concentrations in soil collected from under the accumulating plants and selenium concentrations in soil from the test hole at the same site.

Soil samples were collected at the 0- to 4-in. depth and 10- to 14-in. depth at 45 sites. The Mann-Whitney test was used to determine if there was a significant difference in selenium concentrations between the sampling depths. The data were not separated by irrigation history for this test. Perhaps because of oxidation, concentrations of total and extractable selenium were significantly larger (significance level 0.05) in the 0- to 4-in. soil zone than in the 10- to 14-in. soil zone.

Plant tissue was sampled at 45 sites on the Oxford Tract, and a total of 66 samples were analyzed for total-selenium concentration. Total-selenium concentrations in plants were extremely variable (table 16). There were large differences in total-selenium concentrations in the same plant species from sites within short distances. Examples include total-selenium concentrations of 0.7 and 34 mg/kg in alfalfa samples collected at sites about 800 ft apart and total-selenium concentrations of 4.6 and 71 mg/kg in brome grass samples collected at sites about 900 ft apart. Large variability of selenium concentrations in alfalfa collected in the same field were noted in the Kendrick Reclamation Project in Wyoming (See and others, 1992). There also were large differences in total-selenium concentrations in different plant species at the same site. Examples include total-selenium concentrations of 2.5 mg/kg in crested wheatgrass and 140 mg/kg in astragalus at one site and total-selenium concentrations of 4.6 mg/kg in brome grass and 180 mg/kg in alfalfa at another site. The plant species sampled on the Oxford Tract were grouped into five

Table 16. Summary of total-selenium concentrations in plant-tissue samples collected from the Oxford Tract, August 1989

[Samples collected by U.S. Bureau of Indian Affairs and were analyzed by Colorado State University; concentrations in milligrams per kilogram; <, less than; --, median not computed]

Plant species	Number of samples	Median	Maximum	Minimum
Alfalfa	5	76	180	0.70
Astragalus	9	140	1,300	19
Blue gramma	1	--	<.25	<.25
Brome grass	3	19	71	4.6
Cattail	1	--	<.25	<.25
Clover, sweet	2	--	1.7	1.3
Dock	2	--	13	.90
Foxtail	1	--	2.7	2.7
Grasses, mixed	12	2.85	100	.41
Gumweed	6	30	290	5.8
Rabbitbrush	1	--	5.0	5.0
Sagebrush	3	.50	1.8	<.25
Sedges	3	1.2	1.5	.85
Snakeweed	8	13.5	1,500	.40
Sunflower	1	--	26	26
Wheatgrass, crested	4	3.35	51	2.2
Wheatgrass, western	2	--	43	13
Willow	1	--	2.5	2.5
Yarrow	1	--	8.8	8.8
All plant samples	66	13.0	1,500	<.25

general categories based on similarity of the species. The plant groups are:

Plant group	Plant species included in group
Selenium accumulators	Astragalus, gumweed, snakeweed
Crops and feed	Alfalfa, brome grass, sweet clover
Range grasses	Blue gramma, mixed grasses, crested wheat grass, western wheat grass
Wetland plants and forbs	Cattail, dock, foxtail, sedges, sunflower, willow, yarrow
Dryland shrubs	Rabbitbrush, sagebrush

Comparison of total-selenium concentrations in the five plant groups is shown in figure 14. As expected, the selenium accumulators had the largest selenium concentrations, but the crops-and-feed group also had large selenium concentrations. The variability of selenium concentrations in plants of the same species (table 16) resulted in variability of concentrations within the plant groups (fig. 14).

There was no distinct relation between concentrations of total selenium in plants to concentrations in the soil profile at many of the sites. Other factors, in addition to the selenium concentration in soil, may determine total-selenium concentrations in the plants. The relation may have been more distinct if selenium in soil from the root system and tissue from a single plant were determined.

The soil-and-plant sampling program for the Oxford Tract was designed to collect data to determine if the tract could be put back into irrigation with the assumption that irrigation would leach selenium down-

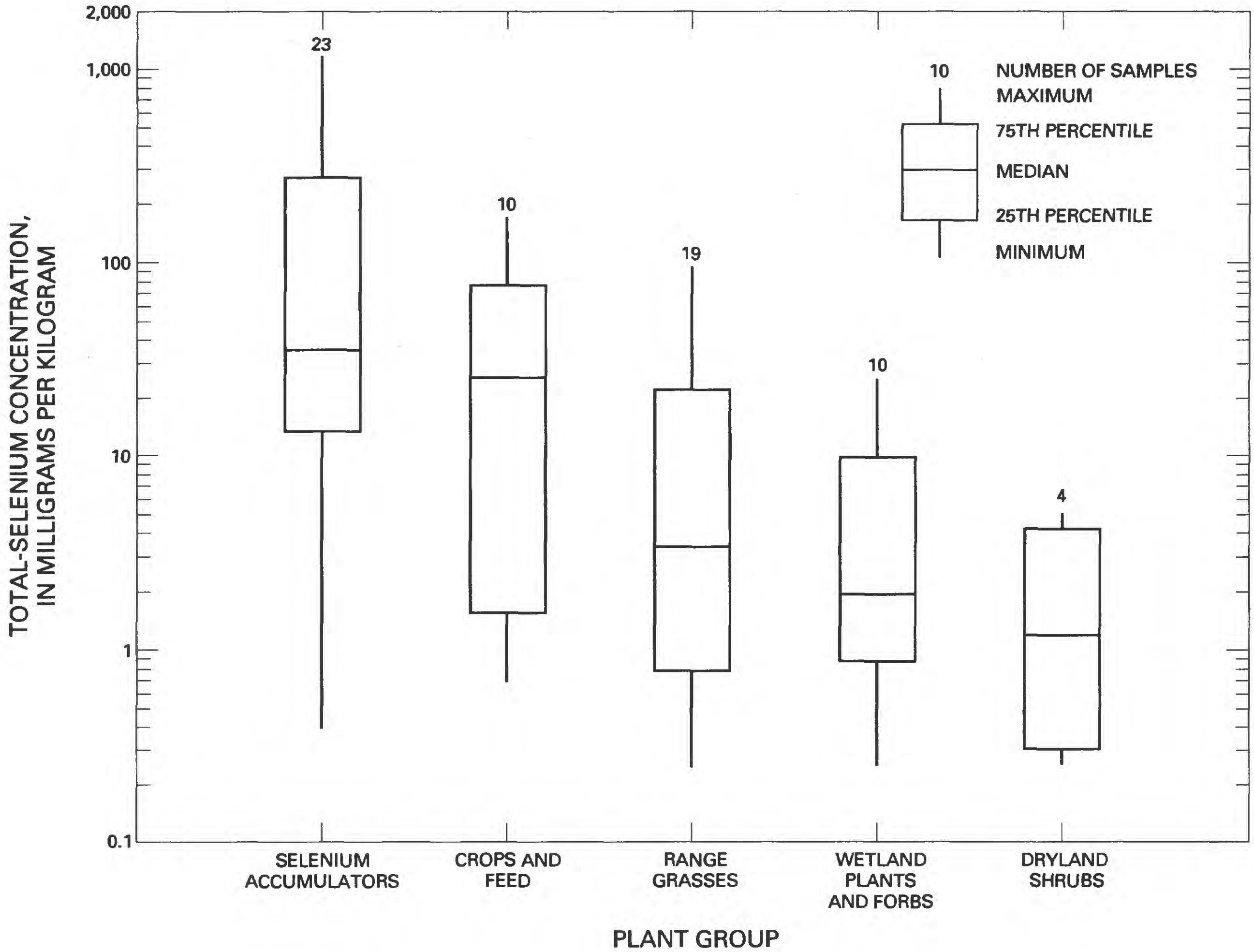

Figure 14. Total-selenium concentrations in plant samples collected on the Oxford Tract, grouped by general types.

ward in the soil. The results of the sampling program did not substantiate that hypothesis. Possibly, irrigation of plants that do not accumulate selenium, such as certain grasses, could make part of the tract useful for agriculture. Some forage species and feeds, such as alfalfa, seem to accumulate large concentrations of selenium and may not be a desirable crop to produce on parts of the Oxford Tract. If alfalfa were grown on the Oxford Tract, it potentially could be used for livestock feed if blended with other feeds that contain small quantities of selenium or sold to selenium-deficit areas.

Biota

Analytical results for biota samples collected for the DOI reconnaissance investigation from November 1988 through July 1989 are listed in tables 24-26 in the "Supplemental Data" section at the back of this report. The biota data listed in table 23, also in the "Supplemental Data" section, were collected in June 1988 by the U.S. Fish and Wildlife Service as a pre-reconnaissance investigation of the Pine River Project. These data provide additional trace-element information for biota in the Project area.

Trace-element concentrations are expressed as dry-weight concentrations in the tables. To compare these data with data in the literature, the concentrations sometimes need to be expressed as wet weight, which can be obtained by multiplying the dry-weight concentration by a factor "1 minus the percent moisture content of the sample converted to a decimal." For example, a dry-weight concentration of 15.7 μg/g for a sample that had a moisture content of 72.6 percent is equivalent to a wet-weight concentration of about 4.3 μg/g [15.7 times (1- 0.726)].

Data Interpretation

Numerous chemical, physical, and biological factors affect the toxicity of environmental contaminants to living organisms. Chemical and physical factors include contaminant type, chemical species or form, water temperature, hardness, pH, dissolved oxygen, salinity, and multiple-chemical exposure (antagonism and synergism). Also affecting toxicity are duration of exposure, quantity of contaminant, and pathways of the contaminant from the environment to the organism. Some trace elements are beneficial to organisms at small concentrations but may be toxic at larger concentrations. Biological and physiological factors affecting toxicity include species, age, sex, and physiological state of the organism. Such factors tend to complicate the interpretation of biological data collected for field studies. One of the best methods for interpreting contaminant data is by comparison with data from other field and laboratory studies.

Concentrations of inorganic trace elements in biological samples are extremely variable. Data can be interpreted by comparison to available literature to determine if constituent concentrations in biota samples exceed concentrations that may be harmful to fish and wildlife or exceed guidelines for human consumption. A frequently used literature source for interpreting contaminant data for fish samples is the National Contaminant Biomonitoring Program (NCBP) of the U.S. Fish and Wildlife Service. Schmitt and Brumbaugh (1990) reported the 85th-percentile concentration for arsenic, cadmium, copper, lead, mercury, selenium, and zinc for fish samples collected during 1976-84 at sites throughout the United States. The 85th percentile has been established by NCBP as an arbitrary concentration for identifying sites where whole-body fish samples have relatively large concentrations of one or more of the seven trace elements. The 85th percentile is not necessarily an indicator of potential hazards to fishery resources or to be used in place of regulatory statutes. Concentrations listed by Schmitt and Brumbaugh (1990) are wet-weight concentrations, therefore, the dry-weight concentrations listed in tables 23 and 24 for the seven trace elements were converted to wet-weight concentrations to facilitate comparison to the 85th-percentile concentrations. The NCBP also has collected data for organochlorine pesticides (Schmitt and others, 1990).

The NCBP 85th percentile was reported for several sampling periods for 1976-84 (Schmitt and Brumbaugh, 1990). The most recent compilation was for fish samples collected during 1984. The 85th percentiles reported for 1984 are used in this report. Previous DOI reconnaissance investigations used 85th percentiles based on earlier NCBP sampling periods. In the reconnaissance investigation of the Gunnison and Uncompahgre River basins, Colorado (Butler and others, 1991), the NCBP 85th percentiles for 1980-81 were used. The 85th-percentile concentrations for the seven trace elements for the two sampling periods, 1980-81 and 1984, are shown in table 17. The number of whole-body fish samples collected in the Pine River Project area that exceeded the NCBP 85th percentiles for 1984 also are listed in table 17.

Trace-element concentrations in whole-body fish samples collected upstream and downstream from irrigated areas were compared to determine if irrigation drainage may be affecting trace-element concentra-

Table 17. National Contaminant Biomonitoring Program (NCBP) 85th-percentile concentrations for 1980-81 and 1984, and the number of whole-body fish samples collected in the Pine River Project area that exceeded the 85th percentiles for 1984

[Concentrations in micrograms per gram wet weight; 85th-percentile concentrations from Schmitt and Brumbaugh (1990); number of whole-body fish samples collected in June 1988 was 23 and from November 1988 to July 1989 was 153]

Trace element	NCBP 85th percentile concentration		Number of exceedances	
	1980-81	1984	June 1988	November 1988-July 1989
Arsenic	0.22	0.27	1	2
Cadmium	.06	.05	0	46
Copper	.9	1.0	3	75
Lead	.25	.22	0	2
Mercury	.17	.17	2	14
Selenium	.71	.73	20	104
Zinc	40.1	34.2	12	51

tions in biota. Samples collected from streams that had an upstream and a downstream sampling site (Salt, Rock, Dry, Beaver, Ute, Spring, and Sambrito Creeks) were separated into two data sets. All samples collected at the upstream sites were in one data set (48 samples), and all samples collected at the downstream sites were in a second data set (67 samples). The Mann-Whitney statistical test was used to determine if there was a significant difference (significance level 0.05) between trace-element concentrations in whole-body fish samples collected upstream and downstream from irrigation drainage.

Many of the trace-element and organochlorine pesticide concentrations in biota samples collected in the Pine River Project area were less than analytical reporting limits. A complicating factor for data interpretation is that biota samples were analyzed by two laboratories, and reporting limits for some trace elements were not the same. Also, some trace-element concentrations were reported as "less than values" which were actually greater than the concentrations from the literature used for data interpretation.

Aluminum, arsenic, cadmium, copper, lead, mercury, selenium, and zinc concentrations in some biota samples exceeded concentrations of concern reported in the literature, or were sufficiently large to warrant further discussion. The only organochlorine pesticides detected in biota samples were p,p'-DDE and mirex, and are discussed briefly. Selenium is the trace element of greatest concern in biological samples collected from the Pine River Project area; therefore, selenium will be discussed first.

Selenium

Fish

Selenium concentrations in whole-body fish collected for the pre-reconnaissance investigation in June 1988 at seven sites (table 23) ranged from 1.5 μg/g dry weight in two sucker samples from the Piedra River (site P1) to 17.1 μg/g dry weight in a speckled dace from Rock Creek at Ignacio (site R2). Selenium concentrations in 20 of the 23 whole-body fish samples collected in June 1988 exceeded the NCBP 85th percentile for 1984 (table 17), and mean selenium concentrations for all sites (fig. 15) exceeded the 85th percentile. However, selenium concentrations in whole-body fish samples were less than the selenium concentration of 7.94 μg/g wet weight (about 32 μg/g dry weight) reported by Gillespie and Baumann (1986) known to cause reproductive problems in bluegills. The Mann-Whitney test was used (significance level of 0.05) to determine if there were significant differences in mean selenium concentrations among different trophic levels (fig. 16). There are 153 whole-body fish samples listed in table 24, but only 151 samples are shown in figure 16 (for November 1988 to July 1989). Two of the whole-body fish samples are not included in figure 16 because the samples were composites of different fish species. Each pair of trophic levels were tested, omnivores versus predators, omnivores versus bottom feeders, and predators versus bottom feeders. Omnivores (dace, minnows, and sculpin) had significantly greater selenium concentrations than either the predators (trout and roundtail chubs) or the bottom feeders (suckers and carp).

Whole-body fish samples were collected for the reconnaissance investigation from November 1988 to July 1989 at 23 sites (table 24) in the Pine River Project area. Selenium concentrations ranged from 0.92 μg/g dry weight in a flannelmouth sucker from the Los Pinos River at Ignacio (site LP3) to 16.0 μg/g dry weight in a fathead minnow collected from Salt Creek near the mouth (site ST2). Selenium concentrations exceeded the NCBP 85th percentile in about 68 percent of whole-body fish samples (table 17). All whole-body fish samples collected from Salt Creek (sites ST1 and ST2), Rock Creek (sites R1 and R2), West Sambrito Creek (site WSB2), and Sambrito Creek (sites SB1 and SB2) exceeded the NCBP 85th percentile for selenium. In contrast, none of the whole-body fish samples collected at the two upstream sites on the Los Pinos River (sites LP1 and LP2) had selenium concentrations exceeding the NCBP 85th percentile. The mean selenium concentration in whole-body fish samples exceeded the NCBP 85th percentile at every site (fig. 17) except for the Los Pinos River at Columbus (site LP1), Los Pinos River at Bayfield (site LP2), and both sampling sites on Navajo Reservoir (sites N1 and N2). There was no significant difference ($p=0.86$) in selenium concentrations between whole-body fish samples collected upstream and downstream from irrigated areas. No selenium concentrations in whole-body fish samples exceeded the concentration of 7.94 μg/g wet weight that caused reproductive problems in bluegills (Gillespie and Baumann, 1986).

Selenium was analyzed in different tissue types from a channel catfish collected from Rock Creek at Ignacio (site R2) (fig. 18). The fillet of that sample had a concentration of 0.34 μg/g wet weight (1.7 μg/g dry weight in table 24), which was less than the maximum recommended selenium concentration of 1 μg/g wet weight in edible tissue for human consumption (Fan and others, 1988). The other tissue samples of the catfish had considerably more selenium than the fillet (fig. 18). Sager and Cofield (1984) reported larger sele-

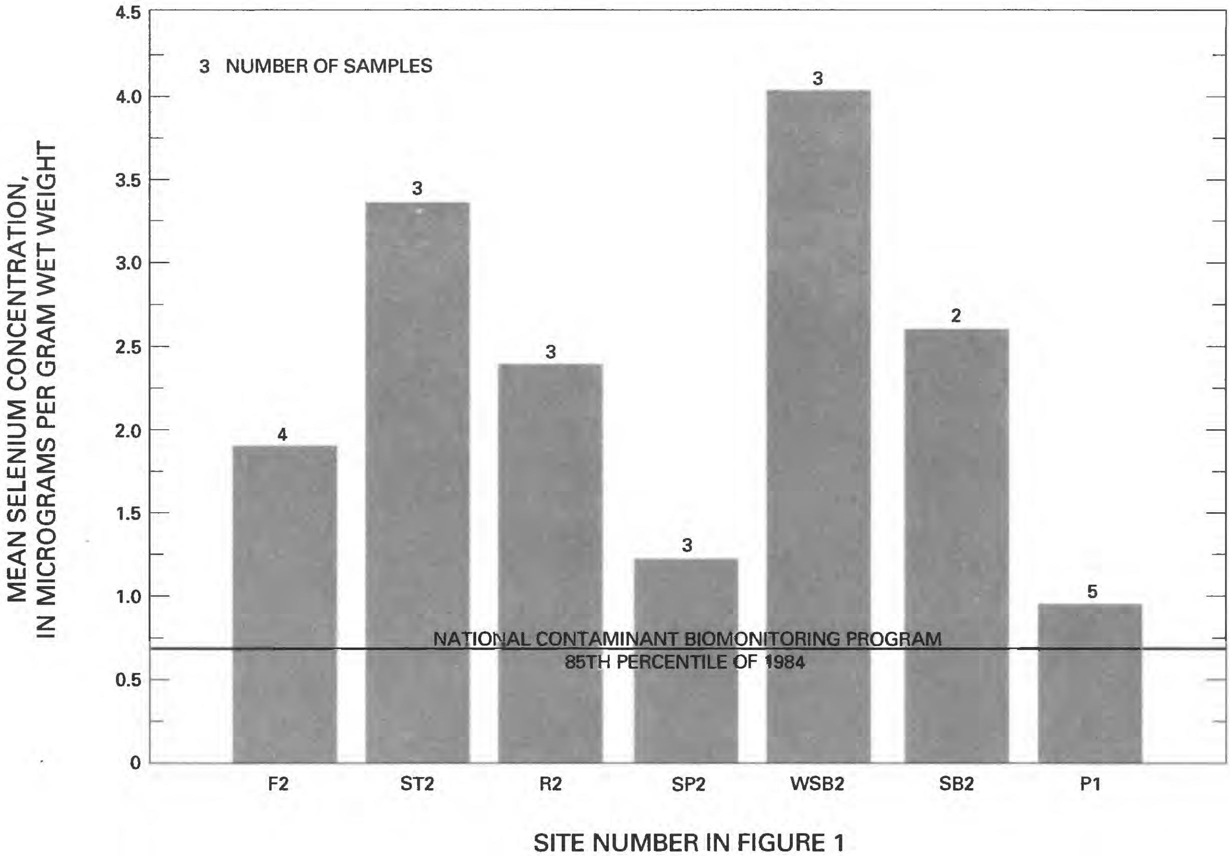

Figure 15. Mean selenium concentrations in whole-body fish samples collected at seven sites in June 1988.

nium concentrations in liver and reproductive tissue than in muscle of channel catfish.

Aquatic Plants

Selenium concentrations in six aquatic-plant samples collected in the pre-reconnaissance investigation in June 1988 (table 23) ranged from 0.75 μg/g dry weight in a sample from Sambrito Creek at the mouth (site SB2) to 6.7 μg/g dry weight in a sample from Rock Creek at Ignacio (site R2). The selenium in samples from Rock Creek and Salt Creek (site ST2) exceeded the range of 3 to 5 μg/g dry weight that Lemly and Smith (1987) stated may cause reproductive failure or mortality in fish and waterfowl through food-chain bioconcentration. The aquatic-plant sample collected in June 1988 from the Florida River (site F2) had a selenium concentration within the range of 3 to 5 μg/g dry weight reported by Lemly and Smith (1987).

Aquatic-plant samples collected from November 1988 to July 1989 at 20 sites in the Pine River Project area (table 24) generally had smaller selenium concentrations than the samples collected in June 1988. Dry-weight concentrations ranged from 0.20 μg/g in an algae sample from the Los Pinos River at Columbus (site LP1) to 4.2 μg/g in an aquatic plant sample from West Sambrito Creek at the mouth (site WSB2). Six aquatic-plant samples collected from November 1988 to July 1989 (at six different sites) had selenium concentrations within the range of 3 to 5 μg/g dry weight that Lemly and Smith (1987) reported may cause reproductive problems. One sample of filamentous algae collected from the west marsh on the Oxford Tract (site R1) had a selenium concentration of 7.3 μg/g dry weight (table 25), which exceeds the range of 3 to 5 μg/g dry weight and may be of concern for fish and waterfowl.

Aquatic Invertebrates

Selenium concentrations in aquatic invertebrates collected for the pre-reconnaissance investigation in June 1988 (table 23) ranged from 1.1 μg/g dry weight in a crayfish sample from the Piedra River (site P1) to 10.2 μg/g dry weight in a composite sample (mostly aquatic insects) from the Florida River (site F2). For

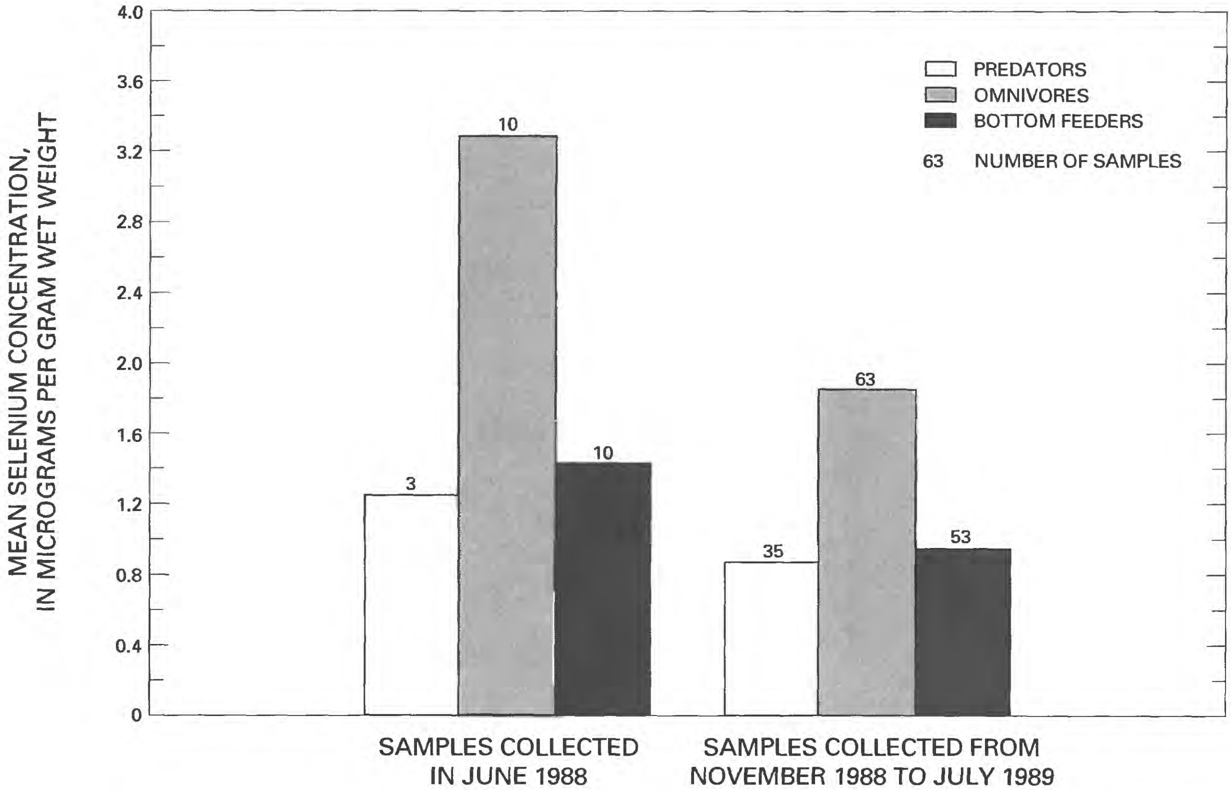

Figure 16. Mean selenium concentrations in whole-body fish samples collected in June 1988 and from November 1988 to July 1989, separated by trophic levels.

samples collected in June 1988, the median selenium concentration was 4.5 µg/g dry weight for crayfish and 7.0 µg/g dry weight for composited aquatic insects. As with aquatic plants, there may be problems associated with selenium toxicity to fish and waterfowl by food-chain bioconcentration in areas where selenium concentrations in aquatic invertebrates are in the range of 3 to 5 µg/g dry weight (Lemly and Smith, 1987). Selenium concentrations of 4 to 8 µg/g dry weight in aquatic plants and in aquatic invertebrates caused reproductive impairment in mallards (Heinz and others, 1989). Hamilton and others (1990) report that, after a 90-day exposure, survival was decreased in chinook salmon fed more than 9.6 µg/g dry weight of selenium, and growth was diminished in fish fed more than 5.3 µg/g dry weight of selenium.

Crayfish samples collected for the reconnaissance investigation (table 24) had selenium concentrations ranging from 0.83 µg/g dry weight at the Los Pinos River at Ignacio (site LP3) to 4.5 µg/g dry weight at Rock Creek near Oxford (site R1). Nine of 20 sites had crayfish samples with a selenium concentration of at least 3.0 µg/g dry weight. Crayfish generally had smaller selenium concentrations than aquatic insects; however, fish and waterfowl probably consume more aquatic insects than crayfish. Crayfish were sampled more intensively than aquatic insects in the Pine River Project area because they were ubiquitous and easier to collect than aquatic insects.

Birds (Oxford Tract)

The source of water to the west marsh on the Oxford Tract (fig. 19) is Rock Creek. Stream site R1 (fig. 1) is near the center of the west marsh; therefore, site R1 also was used for the identification number for the west marsh in figure 1 and in table 25.

Bird and egg samples collected from the west marsh on the Oxford Tract had substantially smaller selenium concentrations (fig. 20 and table 25) than samples collected from the east marsh (site R3). Selenium concentrations in liver samples collected from the west marsh ranged from 6.8 µg/g dry weight in a yellow-headed blackbird liver to 21.2 µg/g dry weight in an immature mallard liver (table 25). Dry-weight selenium concentrations in eggs from the west marsh

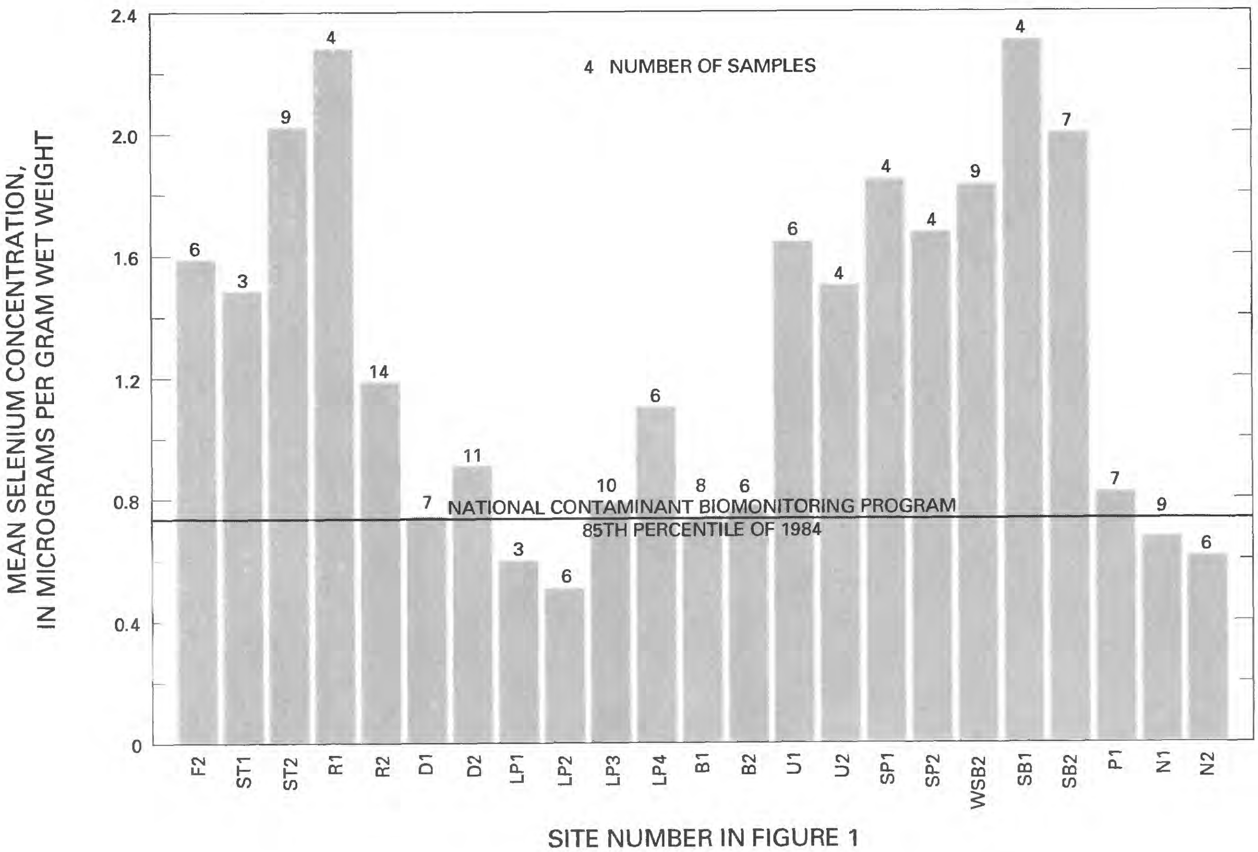

Figure 17. Mean selenium concentrations in whole-body fish samples collected at 23 sites, November 1988 to July 1989.

ranged from 2.4 µg/g in a mallard egg to 5.3 µg/g in a yellow-headed blackbird egg. Whole-body samples of yellow-headed blackbirds had relatively large selenium concentrations of 16.4 µg/g and 16.9 µg/g dry weight. A sample of immature mallard breast tissue from the west marsh contained 6.3 µg/g dry weight of selenium or about 1.6 µg/g wet weight. That concentration is greater than the maximum selenium concentration of 1 µg/g wet weight recommended in food for human consumption (Fan and others, 1988).

The source of water to the east marsh on the Oxford Tract (site R3; fig. 1) is shallow ground water that may be recharged by irrigation drainage from areas north of the Oxford Tract (D.W. Wickman, U.S. Bureau of Indian Affairs, Southern Ute Agency, oral commun., 1991). The extent of the east marsh is shown in figure 19. Whole body, liver, and breast samples from birds collected at the east marsh had selenium concentrations that ranged from 10.0 to 50.0 µg/g dry weight. The selenium concentrations in whole-body and liver samples from the east marsh were significantly (significance level 0.05) larger than in similar bird tissue samples collected at the west marsh and at wetland sites along the Los Pinos River (fig. 20; table 25). The red-winged blackbird egg listed in table 25 with a moisture content of only 28.3 percent was excluded from figure 20 and was not used for statistical testing because the sample may not have been representative. Selenium concentrations of 50.0 and 34.8 µg/g dry weight in livers from an immature mallard and an adult mallard from the east marsh were in the range of selenium concentrations in duck and coot livers at Kesterson National Wildlife Refuge where reproductive problems were reported (Ohlendorf and others, 1986). Selenium concentrations in bird livers usually are less than 12 to 16 µg/g dry weight in areas without selenium contamination (Blus and others, 1977; Haseltine and others, 1981; King and others, 1983). Skorupa and others (1990) reported a median selenium concentration of 5.6 µg/g dry weight in livers of breeding waterbirds collected at non-marine background sites. They also reported that mean selenium concentrations exceeding 30 µg/g dry weight usually are associated with biological risk. Two whole-body bird samples from the east marsh had unusually large selenium concentrations;

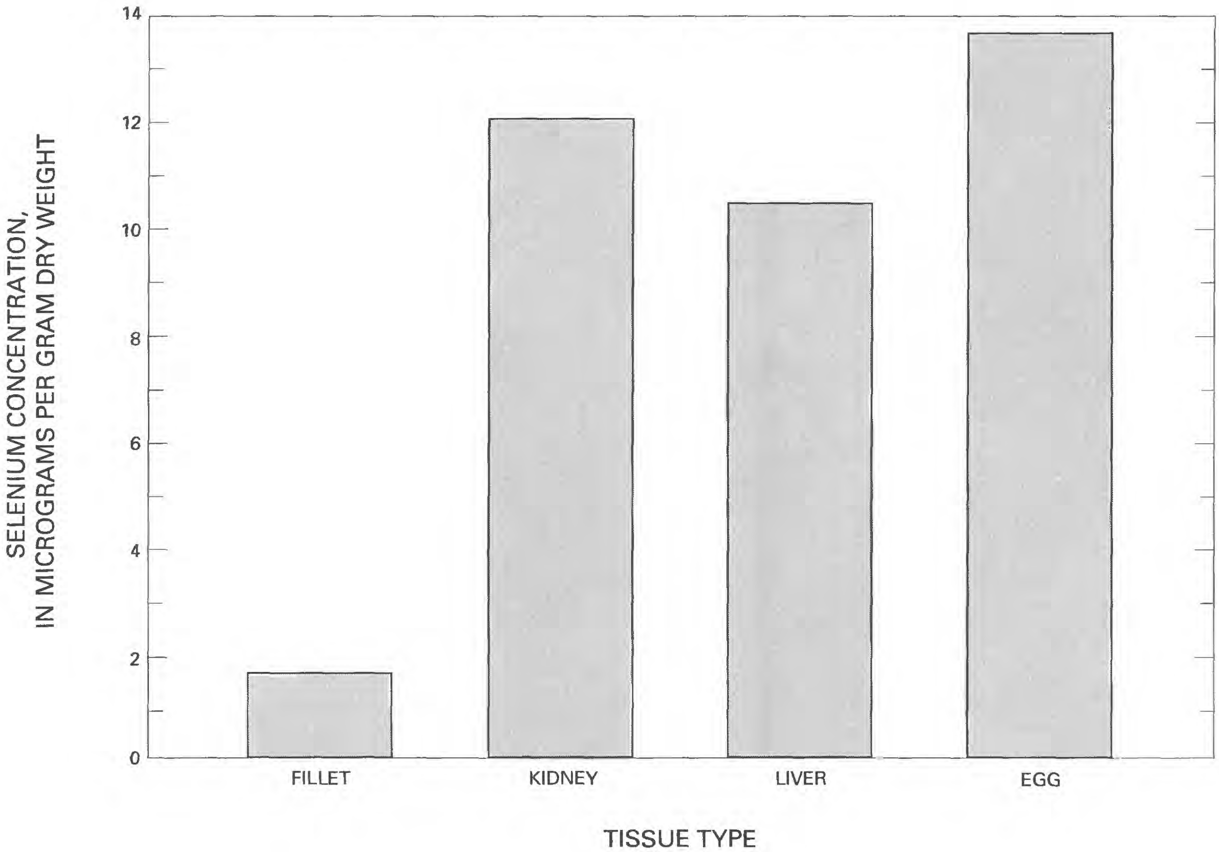

Figure 18. Selenium concentrations in tissue samples from a channel catfish collected from Rock Creek at Ignacio (site R2) on April 3, 1989.

27.5 µg/g dry weight in a young red-winged blackbird and 49.0 µg/g dry weight in a young meadowlark.

Selenium concentrations in three mallard eggs collected from the east marsh (table 25) ranged from 6.5 to 8.4 µg/g dry weight, and a snipe egg collected from the east marsh had a selenium concentration of 13.0 µg/g dry weight. Eggs with selenium concentrations greater than 1 µg/g wet weight (about 3.5 µg/g dry weight at 71 percent moisture) may indicate decreased reproductive success (G.H. Heinz, U.S. Fish and Wildlife Service, oral commun., 1990). Selenium concentrations less than 3 µg/g dry weight in eggs are not associated with biological risk; however, concentrations between 3 and 20 µg/g dry weight cannot be interpreted with confidence without detailed field studies of reproductive performance (U.S. Fish and Wildlife Service, 1990a). No embryo deformities were observed in bird eggs collected for this study.

A mallard breast sample collected from the east marsh on the Oxford Tract had a selenium concentration of 10.0 µg/g dry weight or 2.4 µg/g wet weight. This concentration is 2.4 times the maximum recommended selenium concentration of 1 µg/g wet weight in edible tissue for human consumption (Levander, 1983; Fan and others, 1988).

Birds, Los Pinos River wetlands

Selenium concentrations in bird and egg samples collected from the two wetland sampling sites along the Los Pinos River (site LPGR and near site LP4 on fig. 1) were much smaller than selenium concentrations in bird and egg samples from the east marsh on the Oxford Tract (fig. 20; table 25) and generally were smaller than the selenium concentrations in bird and egg samples from the west marsh. Blackbird livers had selenium concentrations ranging from 4.2 µg/g dry weight to 5.4 µg/g dry weight. Selenium concentrations in egg samples ranged from 2.0 µg/g dry weight in two blackbird eggs from site LPGR to 5.3 µg/g dry weight in a bittern egg from the wetland site north of site LP4 near La Boca. The median selenium concentration for the 12 bird eggs collected at sites LPGR and LP4 is 2.9 µg/g dry weight. Mean selenium concentrations less than 3 µg/g dry weight in eggs and 10 µg/g dry weight in livers usually are not associated with bio-

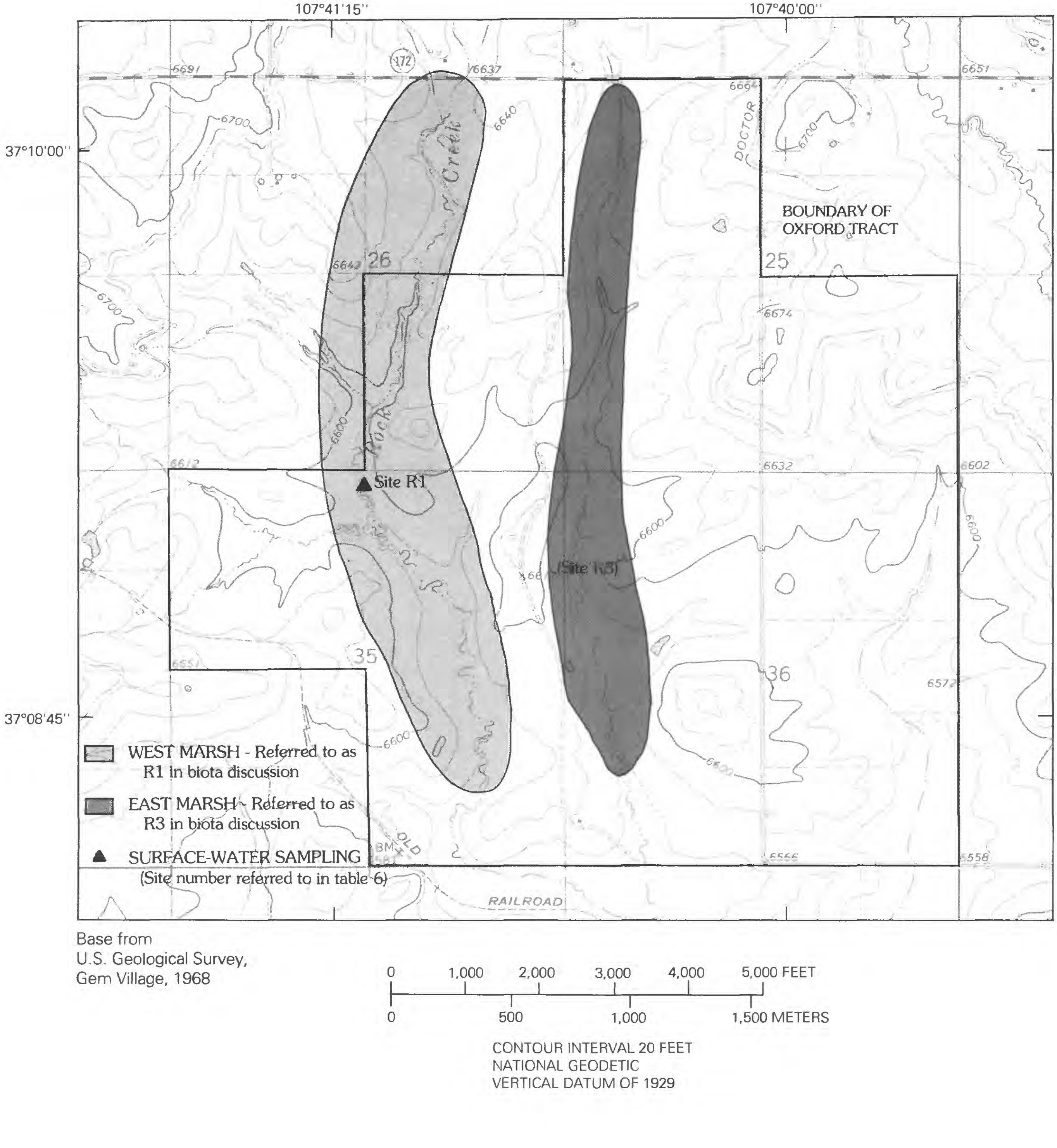

Figure 19. Extent of the west marsh and the east marsh on the Oxford Tract.

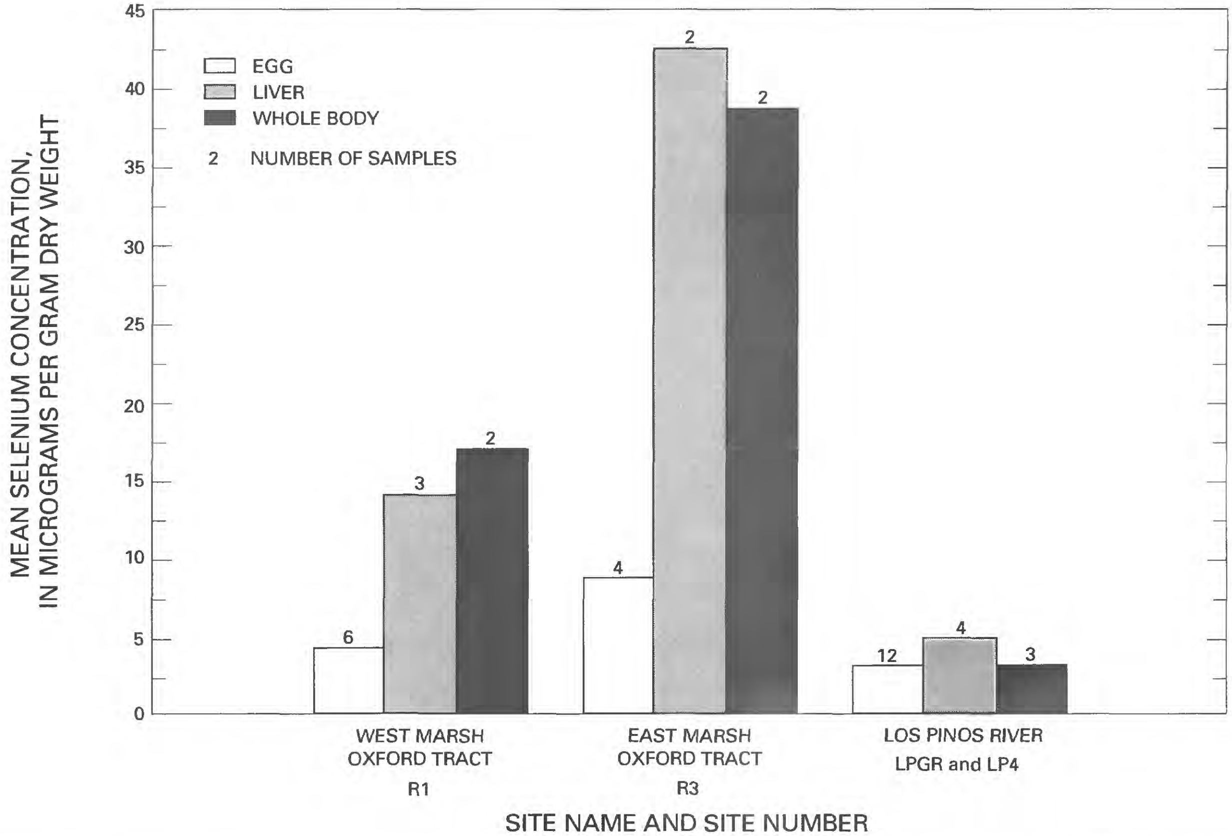

Figure 20. Mean selenium concentrations in bird tissue samples collected at wetland sites in the Pine River Project area, May-July 1989.

logical risk (U.S. Fish and Wildlife Service, 1990a). These data indicate that there has not been significant selenium contamination along the Los Pinos River.

Mammals

Selenium concentrations in six whole-body prairie dog samples (table 23) collected on the Oxford Tract in June 1988 ranged from 4.5 µg/g dry weight to 23.0 µg/g dry weight, and the median concentration was 11.5 µg/g dry weight. These concentrations are about the same as the selenium concentrations in vole and mouse samples collected at Kesterson National Wildlife Refuge (Clark, 1987). The prairie dogs probably accumulated selenium from ingesting selenium accumulating plants such as snakeweed (gutierrzia) and milkvetch (astragalus) that are present on the Oxford Tract. Large selenium concentrations in plants on the Oxford Tract were discussed previously in this report. The selenium concentrations in the prairie dogs may be of concern because prairie dogs are major food sources for resident bald eagles and migratory raptors. A whole-body muskrat sample collected at the wetland site along the Los Pinos River near La Boca (site LP4) (table 25) had a relatively small selenium concentration of 1.3 µg/g dry weight.

Aluminum

There was a large range of aluminum concentrations in whole-body fish samples. Samples collected for the pre-reconnaissance investigation in June 1988 had aluminum concentrations ranging from less than 38.2 to 2,290 µg/g dry weight (table 23), and samples collected for the reconnaissance investigation from November 1988 to July 1989 had aluminum concentrations ranging from 4.0 to 5,810 µg/g dry weight (table 24). Precision of aluminum analyses of whole-body fish is poor, and the concentrations had large variability because the gastrointestinal tract contents in fish contain extremely variable concentrations of aluminum, which can cause variable results in the whole-body samples. In addition, toxicity of aluminum to fish is much greater in acidic water that has a pH less than 5.5 (Cleveland and others, 1986; Hunn and others, 1987; Kane and Rabeni, 1987). Water samples collected at biological sampling sites during this study had values of pH that ranged from 7.4 to 9.1 (table 18). Aluminum concentrations were significantly greater (p=0.01) in whole-body fish collected upstream from irrigation than in samples collected downstream from irrigation.

Aquatic-plant and aquatic-invertebrate samples had large aluminum concentrations (tables 23 and 24). Aluminum concentrations in aquatic plants (including filamentous algae samples) ranged from 2,530 to 32,100 µg/g dry weight; concentrations in aquatic invertebrates ranged from 196 to 2,730 µg/g dry weight. Aluminum concentrations in phytoplankton and zooplankton ranged from 1,230 to 13,700 µg/g dry weight. Aluminum concentrations in bird samples were larger in the whole-body samples than in the liver or breast tissue samples (table 25), which may be caused by concentration of aluminum in the gastrointestinal tract. Aluminum was detected in only one bird egg sample. Because aluminum is much more toxic in acidic water, the aluminum concentrations in biota in the Pine River Project area were not considered a concern to fish and wildlife.

Arsenic

Arsenic concentrations in whole-body fish collected for the pre-reconnaissance investigation in June 1988 ranged from 0.12 to 4.6 µg/g dry weight (table 23). One whole-body fish sample collected in June 1988 had an arsenic concentration greater than the NCBP 85th percentile (table 17). That sample was a speckled dace collected from the Piedra River (site P1, table 23) that had an arsenic concentration of 4.6 µg/g dry weight (about 1.1 µg/g wet weight). Only two fish collected for the reconnaissance investigation from November 1988 to July 1989 had arsenic concentrations larger than the NCBP 85th percentile (table 17); a bluehead sucker collected from the Florida River (site F2) (table 24) had an arsenic concentration of 0.9 µg/g dry weight (0.29 µg/g wet weight), and a brown trout collected from Spring Creek at La Boca (site SP2) had a concentration of 0.9 µg/g dry weight (0.31 µg/g wet weight). Moore and Ramamoorthy (1984) reported that arsenic concentrations generally range from less than 0.1 to 0.4 µg/g wet weight in fish collected from unpolluted or mildly contaminated water. Eisler (1988) reported arsenic concentrations of 1.3 to 5 µg/g wet weight in aquatic organisms may have adverse effects. No biota samples collected in the Project area exceeded 1.3 µg/g wet weight selenium. Sorensen and others (1985) recommended arsenic concentrations less than 0.5 µg/g dry weight in fish as a permissible level for human consumption. However, Phillips and others (1982) suggested an arsenic concentration of about 24 µg/g dry weight as permissible in edible tissue of fish. Five whole-body fish samples collected in June 1988 and 17 samples collected from November 1988 to July 1989 had arsenic concentrations exceeding 0.5 µg/g dry weight, but none exceeded 24 µg/g dry weight. Based on the Mann-Whitney test, there was no significant difference (p=0.51) between arsenic concentrations in whole-body fish collected upstream and downstream from irrigated areas of the Pine River Project.

Arsenic concentrations in aquatic-plant samples collected in the Pine River Project area in June 1988 (table 23) ranged from 3.6 to 15.4 µg/g dry weight. Arsenic concentrations in aquatic-plant samples collected for the reconnaissance investigation (November 1988 to July 1989) ranged from 0.9 to 20 µg/g dry weight (table 24). These arsenic concentrations were similar to or less than the background concentrations discussed by Moore and Ramamoorthy (1984) and by the National Research Council (1977). Arsenic concentrations in aquatic-invertebrate samples (insects and crayfish) collected in June 1988 ranged from 1.0 to 4.2 µg/g dry weight (table 23), and arsenic concentrations in aquatic invertebrates collected for the reconnaissance investigation ranged from 0.5 to 2.7 µg/g dry weight (table 24). These concentrations are within the range (0.5 to 20 µg/g dry weight) reported by Moore and Ramamoorthy (1984) for an unpolluted environment.

All arsenic concentrations in bird egg and tissue samples (table 25) were less than reporting limits (0.1 µg/g dry weight) except for one yellow-headed blackbird liver and two mallard eggs collected along the Los Pinos River near La Boca (LP4, table 25). The arsenic concentration in these three samples was 0.2 µg/g dry weight, which is much less than the range for arsenic concentrations (2 to 10 µg/g wet weight) in bird livers and kidneys that exceed background concentrations (Goede, 1985).

Cadmium

All cadmium concentrations in fish samples collected in the Pine River Project area for the pre-reconnaissance investigation in June 1988 (table 23) were less than analytical reporting limits for cadmium. About 30 percent of all whole-body fish samples from November 1988 and July 1989 (table 24) had cadmium concentrations that exceeded the NCBP 85th percentile of 0.06 µg/g wet weight (table 17). At least one-half of the whole-body fish samples collected at sites ST2, B1, SB1, SB2, N1, and N2 had cadmium concentrations that exceeded the NCBP 85th percentile. However, 33 percent of whole-body fish samples had cadmium concentrations reported as less than 0.2 to less than 0.5 μg/g dry weight. It is not known if cadmium concentrations in those samples exceeded the NCBP 85th percentile. Cadmium concentrations in 13 whole-body fish samples collected at seven sites exceeded the range (0.08 to 0.38 μg/g dry weight) reported by Murphy and others (1978) that was indicative of relatively uncontaminated aquatic systems. Schmitt and Brumbaugh (1990) stated that common carp seem to accumulate cadmium more readily than other fish species and reported a maximum cadmium concentration of 0.22 μg/g wet weight in a common carp. Several of the largest cadmium concentrations in fish from the Project area were in common carp samples collected from Navajo Reservoir (sites N1 and N2) (table 24). Three of those samples had cadmium concentrations that ranged from 0.22 to 0.27 μg/g wet weight.

All cadmium concentrations in aquatic-plant and aquatic-invertebrate samples collected in June 1988 were less than analytical reporting limits (table 23). Cadmium concentrations in aquatic-plant samples collected in June 1988 and for the reconnaissance investigation (November 1988 to July 1989) (table 24) were about equal to or less than cadmium concentrations of 0.6 to 6.7 μg/g dry weight reported in the literature (Moore and Ramamoorthy, 1984; Eisler, 1985a; Schroeder and others, 1988; Stephens and others, 1988). The cadmium concentrations in crayfish collected in the Pine River Project area ranged from less than reporting limits to 0.6 μg/g dry weight. These concentrations were less than the background cadmium concentrations in crayfish of 1.3 Lg/g dry weight reported in the literature (Giesy and others, 1980).

Cadmium concentrations were less than reporting limits (0.2 to 0.3 μg/g dry weight) in all bird egg, whole body, and breast tissue samples (table 25). The cadmium concentration in the liver from an adult mallard collected from the east marsh on the Oxford Tract was 6.4 μg/g dry weight (2.1 μg/g wet weight) and is equal to the cadmium concentration in the liver of a mallard fed 2 μg/g of cadmium per day for 90 days that resulted in no toxic effects (White and Finley, 1978). Eisler (1985a) reported that cadmium concentrations that exceeded 10 mg/kg (10 μg/g) wet weight in vertebrate kidney or liver or 2.0 mg/kg (2.0 μg/g) wet weight in the whole body are evidence of probable cadmium contamination. Cadmium concentrations in vertebrate (fish and birds) samples collected in the Pine River Project area were less than those concentrations.

Copper

Three whole-body fish samples collected for the pre-reconnaissance investigation in June 1988 (table 23) had copper concentrations greater than the NCBP 85th percentile of 1.0 μg/g wet weight. Seventy-five of 153 whole-body fish samples collected for the reconnaissance investigation (November 1988 to July 1989) (table 24) had copper concentrations equal to or greater than the NCBP 85th percentile. There were differences in mean copper concentrations in whole-body fish samples grouped by trophic level (fig. 21). Predatory fish had a larger mean copper concentration than omnivores or bottom feeders (fig. 21), but the mean concentrations for predators and bottom feeders are not statistically different based on a Mann-Whitney test (significance level 0.05). Brown trout, a large predatory species, had the largest mean copper concentration (7.8 μg/g dry weight or about 2.1 μg/g wet weight). The maximum copper concentration in a whole-body fish sample collected in June 1988 was 18.4 μg/g dry weight in a sucker from West Sambrito Creek (site WSB2, table 23). For samples collected from November 1988 to July 1989, the maximum copper concentration was 18.0 μg/g dry weight in a brown trout collected upstream from the irrigated area at site B1 on Beaver Creek (table 24). The copper concentrations in whole-body fish samples probably were not sufficiently large to cause toxic effects on fish based on the concentrations in fish muscle tissue listed in Moore and Ramamoorthy (1984). There was no significant difference ($p=0.53$) between copper concentrations in whole-body fish samples collected upstream from and downstream from the irrigated area.

Copper concentrations in aquatic plants ranged from 4.7 to 30.6 μg/g dry weight and in aquatic invertebrates from 20.9 to 190 μg/g dry weight (tables 23 and 24). These concentrations were within the ranges of concentrations of 10 to 100 μg/g dry weight for aquatic plants and 5 to 200 μg/g dry weight for aquatic invertebrates in polluted freshwater (Moore and Ramamoorthy, 1984). Accumulation of copper in aquatic plants and in aquatic invertebrates often is species dependent, and there is no evidence that indicates bioconcentration through the food chain (Moore and Ramamoorthy, 1984).

Copper concentrations in bird samples (table 25) were typical of copper concentrations reported in the literature (Beck, 1961; Klasing, 1990). The largest concentrations of copper in bird livers were 111 and 103 μg/g dry weight in livers from two immature mallards collected at the west marsh on the Oxford Tract (site R1 in table 25). According to Underwood (1977),

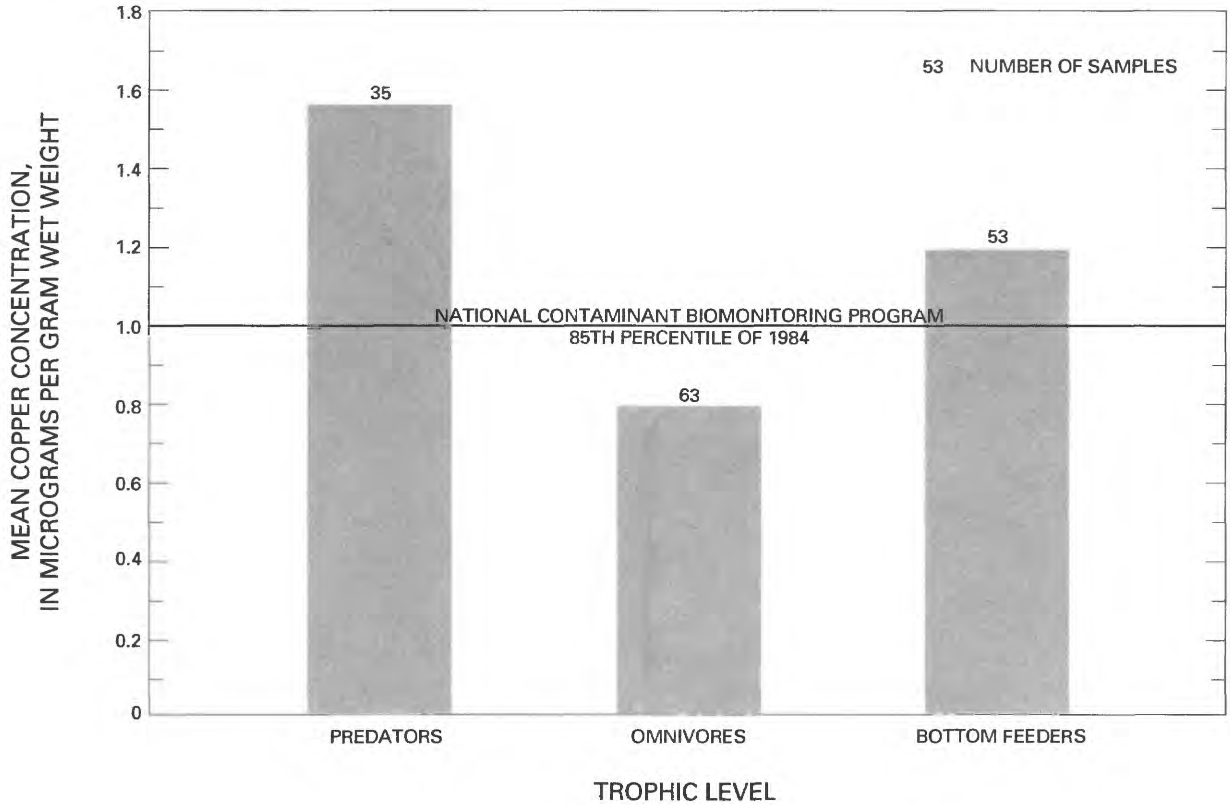

Figure 21. Mean copper concentrations in whole-body fish samples collected from November 1988 to July 1989, separated by trophic levels.

ducks have larger copper concentrations in their livers than do other bird species. The mean concentration in livers of normal adult ducks was 153 μg/g dry weight. Human consumption of 100 g of the two mallard livers from the west marsh would result in ingestion of about 3 to 4 mg of copper. This is less than the 10-mg occasional dose that the National Research Council considers "probably safe for adult humans" (National Research Council, 1989). Two mallard breast samples collected on the Oxford Tract had copper concentrations of 18 and 19.2 μg/g dry weight (table 25). Human consumption of 100 g of the breast tissue would result in ingestion of less than 1 mg of copper.

Lead

Four whole-body fish samples collected for the reconnaissance investigation (table 24) had detectable concentrations of lead. Two of these samples exceeded the NCBP 85th-percentile concentration of 0.22 μg/g wet weight (table 17); a bluehead sucker from the upper site on Beaver Creek (site B1) had a lead concentration of 2.0 μg/g dry weight (0.45 μg/g wet weight), and a bullhead from the Los Pinos River arm of Navajo Reservoir (site N2) had a concentration of 2.1 μg/g dry weight (0.41 μg/g wet weight). The other two whole-body fish samples with lead exceeding reporting limits were collected from Dry Creek (sites D1 and D2) (table 24). Because of the large number of lead concentrations reported as less than reporting limits, statistical testing of upstream and downstream affects of irrigation to whole-body fish samples was not done.

The World Health Organization (1972) established a lead concentration of 0.3 μg/g wet weight in foods as a guideline for human consumption. The two whole-body fish samples discussed previously from sites B1 and N2 exceeded this guideline. Many of the samples were analyzed for lead using inductively coupled argon-plasma spectrometry (reporting limit 4 µg/g dry weight) rather than atomic absorption (reporting limit 0.5 µg/g dry weight). Therefore, interpretation of most of the lead data cannot be done because the analytical reporting limits for many of the fish samples were greater than the NCBP 85th percentile and the World Health Organization human health guideline.

The lead concentrations in aquatic plants (tables 23 and 24) were relatively small based on information in the literature (Knowlton and others, 1983; Moore and Ramamoorthy, 1984; Thompson and Krueger, 1990). All lead concentrations in aquatic-invertebrate samples were less than reporting limits except for a concentration of 0.7 µg/g dry weight in the sample collected from Rock Creek near Oxford (site R1) (table 24).

A whole-body sample of a prairie dog collected on the Oxford Tract in June 1988 had a lead concentration of 99 µg/g dry weight (table 23). Prairie dogs were collected using a small caliber rifle firing lead bullets. This was the only prairie dog sample or biota sample collected in June 1988 with a detectable lead concentration and is considered suspect.

Mercury

Generally, biota samples collected in the Pine River Project area had relatively small concentrations of mercury compared to the concentrations in biota in the Gunnison and Uncompahgre River basins and Sweitzer Lake in Colorado (Butler and others, 1991). Mercury concentrations in biota samples in the Pine River Project area also were much smaller than those reported for biota in the San Luis Valley in Colorado for 1986-89 (Thompson and Krueger, 1990).

Two whole-body fish samples collected for the pre-reconnaissance investigation in June 1988 had mercury concentrations that exceeded the 1984 NCBP 85th percentile (table 17). These two mercury concentrations were 0.26 µg/g wet weight (1.1 µg/g dry weight) in a carp sample collected from Rock Creek at Ignacio (site R2) and 0.27 µg/g wet weight (1.0 µg/g dry weight) in a flannelmouth sucker collected from the Piedra River (site P1) (table 23). Fourteen of 153 whole-body fish samples (about 9.2 percent) collected for the reconnaissance investigation (table 24) had mercury concentrations greater than the NCBP 85th percentile. The following stream sites had one whole-body fish sample that had a mercury concentration larger than the NCBP 85th percentile: Rock Creek at Ignacio (site R2), both sites on Beaver Creek (sites B1 and B2), and the Piedra River near Arboles (site P1).

Mean mercury concentrations in whole-body fish samples collected for the reconnaissance investigation are summarized in figure 22. The maximum mercury concentration in a whole-body fish sample was 1.3 µg/g dry weight in channel catfish from the Los Pinos River at La Boca (site LP4) and in a common carp from the Piedra River arm of Navajo Reservoir (site N1) (table 24).

Many of the larger mercury concentrations in fish samples were in samples from Navajo Reservoir. Five of the nine whole-body fish samples collected from the Piedra River arm of Navajo Reservoir (site N1) (table 24) and five of the six fish samples collected from the Los Pinos River arm of Navajo Reservoir (site N2) had mercury concentrations that exceeded the NCBP 85th percentile. The mean mercury concentration for whole-body fish samples from sites N1 and N2 exceeded the NCBP 85th percentile (fig. 22). Some studies have indicated that mercury accumulation in fish is facilitated by reservoirs because reservoirs provide conditions conducive to methylation of mercury, which facilitates mercury uptake by biota (Bodaly and others, 1984; Phillips and others, 1987; Stokes and Wren, 1987). The mercury concentrations in the fish samples were much smaller than the whole body mercury concentration of 5 µg/g wet weight proposed by the U.S. Environmental Protection Agency (1985) for the protection of brook trout (a species that is quite sensitive to mercury).

There was no significant difference ($p=0.44$) between mercury concentrations in whole-body fish samples collected upstream and downstream from irrigation drainage (samples from the seven streams used for the Mann-Whitney test). However, the mean mercury concentration for whole-body fish from the upstream site on Rock Creek (site R1) is less than the mean concentration for whole-body fish from the downstream site (site R2) (fig. 22).

An action level of 1 µg/g wet weight is reported by the U.S. Food and Drug Administration (1978) as the maximum allowable mercury concentration in fish and seafood to be consumed by humans. The National Research Council (1978) reported that humans in the United States should not consume fish with mercury concentrations greater than 0.5 µg/g wet weight. All mercury concentrations in fish samples from the Pine River Project area were less than these guidelines. Khera (1979) recommended that pregnant women should not consume fish or seafood having more than 0.25 µg/g wet weight of mercury. Mercury concentrations in two whole-body fish samples collected in June 1988 and mercury concentrations in seven whole-body fish samples and in a channel-catfish fillet collected from November 1988 to July 1989 were equal to or

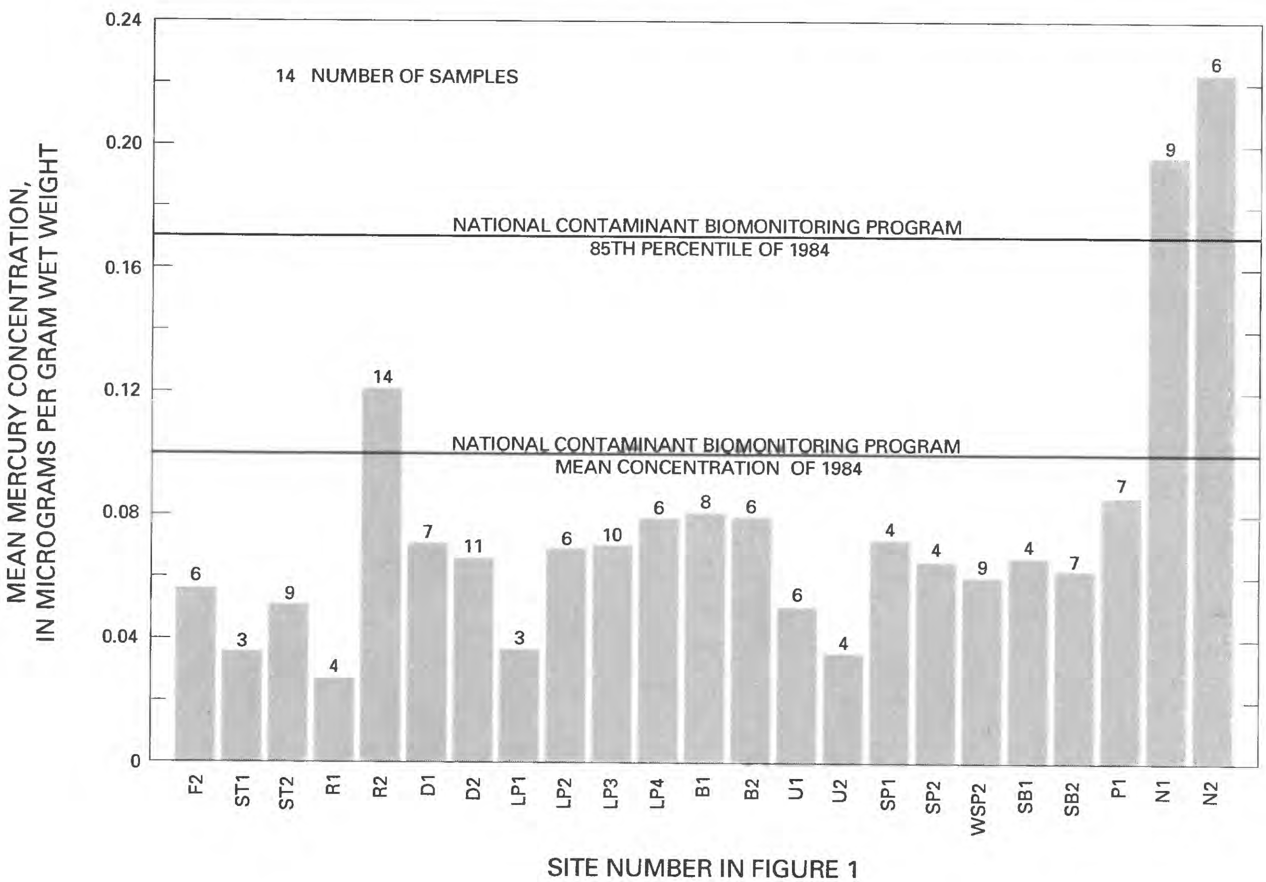

Figure 22. Mean mercury concentrations in whole-body fish samples collected at 23 sites, November 1988 to July 1989.

greater than Khera's guideline. The channel-catfish fillet was collected from Rock Creek at Ignacio (site R2) and had a mercury concentration of 2.1 µg/g dry weight (0.42 µg/g wet weight).

Aquatic-plant, aquatic-invertebrate, and plankton samples collected in June 1988 (table 23) and from November 1988 to July 1989 (table 24) had mercury concentrations less than 0.1 µg/g wet weight, which is the maximum mercury concentration in diet items recommended by Eisler (1987) for protection of sensitive birds. Except for the mercury concentration of 0.27 µg/g dry weight (0.06 µg/g wet weight) in a crayfish collected from the Florida River (site F2) in June 1988 (table 23), mercury concentrations in aquatic invertebrates were within the range (0.0 to 0.05 µg/g wet weight) reported by Hildebrand and others (1980) as occurring in freshwater invertebrates from relatively uncontaminated environments.

All mercury concentrations in bird eggs (table 25) were less than the concentration of 0.9 µg/g wet weight that Eisler (1987) reported as possibly having adverse reproductive effects among sensitive avian species. All mercury concentrations in bird livers were much smaller than the concentrations reported in the literature as being hazardous to bird health (Fimreite and Karsted, 1971; Keoman and others, 1971; Finley and others, 1979). The mercury concentrations in two samples of mallard breast tissue collected on the Oxford Tract (table 25) were less than the 1 µg/g wet-weight concentration that Lindsay and Dimmick (1983) reported as a guideline for mercury for human consumption of duck tissue.

The maximum mercury concentration in a mammal was 0.76 µg/g dry weight (0.22 µg/g wet weight) in a prairie dog collected from the Oxford Tract on June 28, 1988 (table 23). This mercury concentration is greater than the 0.1 µg/g wet-weight concentration in diet items recommended by Eisler (1987) for protection of birds and small mammals. Prairie dogs are a prey base for migrating raptors, including bald eagles.

Zinc

Zinc concentrations in 12 (about 52 percent) of the whole-body fish samples collected for the prereconnaissance investigation in June 1988 and in 51 (about 33 percent) of the whole-body fish samples collected for the reconnaissance investigation (November 1988 to July 1989) exceeded the NCBP 85th percentile of 34.2 µg/g wet weight. All zinc concentrations in common carp exceeded the NCBP 85th percentile. In the Pine River Project area, zinc concentrations in fish samples were species dependent and did not seem to be affected by either trophic level or feeding habits. Common carp had much larger zinc concentrations than other fish species. Lowe and others (1985) stated that carp tend to accumulate much more zinc than other fish species. The mean zinc concentration in common carp collected from 1976 to 1981 for the NCBP was 63.4 µg/g wet weight, compared to the mean zinc concentration of 16.5 µg/g wet weight for all other species (Lowe and others, 1985). The mean zinc concentration in common carp collected for the reconnaissance investigation was 68 µg/g wet weight, compared to 27 µg/g wet weight in all other fish species. Mean zinc concentrations for fathead minnow (about 37 µg/g wet weight) and speckled dace (about 38 µg/g wet weight) exceeded the NCBP 85th percentile. Zinc concentrations in whole-body fish samples were significantly greater ($p=0.024$) in samples collected upstream from irrigated areas than in samples collected downstream from irrigated areas.

Zinc concentrations in aquatic plants collected from polluted freshwater generally range from 100 to 500 µg/g dry weight (Moore and Ramamoorthy, 1984). Concentrations of zinc in most aquatic-plant samples collected in the Pine River Project area in June 1988 (table 23) and for the reconnaissance investigation (table 24) were less than 100 µg/g dry weight, and only a few samples had zinc concentrations between 100 and 500 µg/g dry weight. Zinc concentrations in all aquatic-invertebrate samples collected in the Pine River Project area (tables 23 and 24) were similar to background zinc concentrations for crayfish reported by Anderson and Brower (1978) and Giesy and others (1980).

Zinc concentrations in tissues of birds collected in the Pine River Project area (table 25) were comparable to zinc concentrations in normal bird populations reported in the literature (Gasaway and Buss, 1972; Gochfield and Burger, 1987; Klasing, 1990). Mean wet-weight zinc concentrations were 10.5 µg/g for blackbird eggs, 15.5 µg/g for mallard eggs, 23.6 µg/g for blackbird livers, and 29.0 µg/g for mallard livers. The egg sample of 28.3 percent moisture collected at site R1 (table 25) was not used to compute the mean concentration for blackbird eggs.

Organochlorine Pesticides

Only two organochlorine pesticides were detected in whole-body fish and bird samples collected in the Pine River Project area (table 26). Mirex was detected in a snipe egg, and p,p'-DDE was detected in two whole-body fish samples and five bird samples (two whole body and three egg samples). The concentrations of p,p'-DDE, a DDT metabolite, in the two carp samples were only 0.04 and 0.03 µg/g wet weight (table 26), and are less than the NCBP mean concentration 0.2 µg/g wet weight (Schmitt and others, 1990). The maximum concentration of p,p'-DDE in bird samples was 0.49 µg/g wet weight in a redwinged blackbird egg from site LPGR along the Los Pinos River. That concentration is not at a level of concern according to the literature (Stickel, 1973; White and others, 1983; DeWeese and others, 1986; Butler and others, 1991).

Mirex was banned by the U.S. Environmental Protection Agency in 1978 because of damage to fish and wildlife resources in the southeastern United States and in the Great Lakes area (Eisler, 1985b). However, birds are relatively resistant to mirex. Grackles fed 2,250 mg of mirex had a 50 percent mortality in 5 days (Stickel and others, 1973). The snipe egg that contained detectable mirex (0.12 µg/g wet weight) was collected from the Oxford Tract (table 26). This concentration would not be fatal or have adverse effects to birds; however, this sample does indicate that mirex is still found in the environment despite being banned for 11 years (as of 1989).

SUMMARY

A reconnaissance investigation of the Pine River Project area in southwestern Colorado was conducted during 1988-89 to determine the quality of irrigation drainage and to assess whether the drainage has significantly affected human health, fish, and wildlife or has adversely affected the suitability of water for other beneficial uses. The source of water to the Pine River Project is the Los Pinos River, also called the Pine River. The Project furnishes water for irrigation of Indian and non-Indian land within the general boundary of the Southern Ute Indian Reservation. Problems with selenium in water and in livestock feed on parts of the Reservation have been documented for many years.

A case of human selenium poisoning from ground water that occurred on the Oxford Tract, a block of Indian land on the reservation, has been documented.

Dissolved-solids and major-constituent concentrations in the Los Pinos River were larger at La Boca (downstream from irrigation) than at Bayfield (upstream from irrigation). The maximum dissolved-solids concentration in the Los Pinos River was 156 mg/L. Dissolved-solids concentrations in tributaries of the Los Pinos River and other streams draining irrigated areas ranged from 89 to 1,090 mg/L, and concentrations varied between sites and with time of year. Irrigation drainage into most streams during low-flow periods did not seem to have a substantial effect on dissolved-solids and major-ion concentrations. The secondary maximum contaminant level (SMCL) for dissolved solids in drinking water was exceeded in 12 samples, and the SMCL for sulfate was exceeded in 2 samples collected in the Pine River Project area.

Median concentrations of most trace elements in water samples were near analytical reporting limits. The only trace elements that had concentrations exceeding drinking-water regulations, aquatic-life criteria, or agricultural-use criteria were cadmium, lead, manganese, mercury, and selenium. Cadmium was detected in six samples collected at five different sites in the Project area, and the maximum concentration was 4 μg/L in a sample from Rock Creek at Ignacio. Cadmium exceeded the chronic aquatic-life criterion in two surface-water samples; one sample was from Rock Creek at Ignacio, the other sample was from West Sambrito Creek at the mouth. One sample exceeded the chronic aquatic-life criterion for lead, which was collected from the Los Pinos River at La Boca.

Every stream sampled for the reconnaissance investigation, except the Los Pinos and the Florida Rivers, had at least one sample that had a manganese concentration that exceeded the SMCL of 50 μg/L. The maximum concentration of manganese was 1,000 μg/L in a sample from the upstream site on Ute Creek. A number of the largest manganese concentrations were at sites upstream from most irrigated areas; therefore, irrigation drainage may not be a significant source of manganese in the Pine River Project area.

Mercury was detected in nine samples collected in the Pine River Project area at concentrations that ranged from 0.1 to 2.3 μg/L. Mercury concentrations greater than 0.012 μg/L exceed the chronic criterion for protection of aquatic life. The maximum concentration of mercury (2.3 μg/L) was in a sample collected in March 1989 from the Los Pinos River at Columbus, upstream from the irrigated area. The mercury concentration in that sample exceeded the maximum contaminant level (MCL) of 2 μg/L for mercury in drinking water. Downstream from irrigation, mercury concentrations were 0.2 μg/L in water samples collected from the Piedra River arm and Los Pinos River arm of Navajo Reservoir in November 1988.

The only selenium concentration in a surface-water sample exceeding the MCL for selenium in drinking water (50 μg/L) was collected from Rock Creek on the Oxford Tract in late March 1989. Rock Creek is not used for domestic water supplies. Selenium concentrations in 12 surface-water samples exceeded 5 μg/L, which is the U.S. Environmental Protection Agency's chronic criterion for selenium for protection of aquatic life. Surface-water samples that had selenium concentrations exceeding 5 μg/L were collected from Salt, Rock, Spring, West Sambrito, and Sambrito Creeks. Only two surface-water samples had selenium concentrations greater than 20 μg/L, which is the acute aquatic-life criterion and the State agricultural-use criterion for selenium. Both samples were collected from Rock Creek on the Oxford Tract.

The maximum selenium concentration was 94 μg/L in a sample collected in March 1989 from Rock Creek on the Oxford Tract, an area known to have large selenium concentrations in ground water. Irrigation drainage probably is a source of some of the selenium in tributary streams in the Project area. Selenium concentrations in all samples from the Los Pinos River were equal to or less than 1 μg/L; irrigation drainage was not contributing large quantities of selenium to the Los Pinos River.

Only five concentrations of herbicides were equal to or greater than 0.01 μg/L in the 18 samples collected in the Pine River Project area in 1988-89, and those concentrations were considerably less than the levels harmful to aquatic life. The maximum herbicide concentrations were 0.03 μg/L of 2,4-D and 0.03 μg/L of dicamba.

Selenium concentrations in ground-water samples collected at four sites in 1989 substantially exceeded the MCL of 50 μg/L for selenium in drinking water. The maximum selenium concentration in a ground-water sample was 4,800 μg/L in a sample from a well located in a nonirrigated area west of the Pine River Project. The samples collected in 1989 had smaller selenium concentrations than samples collected during the 1970's at four of the five ground-water sites. Nitrite plus nitrate concentrations in two wells were much greater than the MCL of 10 mg/L for nitrate in drinking water.

Water levels in two wells adjacent to irrigated land in the Pine River Project area rose during the irrigation season in 1989, indicating that irrigation water does recharge shallow ground water in the Project area. Water levels in a well on the Oxford Tract were relatively unchanged during the monitoring period.

Trace-element concentrations in bottom sediment collected in the Pine River Project area generally were within the baselines for soils in the Western United States and within concentration ranges reported from previous DOI reconnaissance investigations. All selenium concentrations were less than 1 μg/g. Two thorium and four uranium concentrations exceeded the upper soil baseline.

Results of the soil sampling on the Oxford Tract indicated that areas previously or presently (1989) irrigated had significantly greater concentrations of total and extractable selenium than soil in areas that were never irrigated. These results are based on selenium concentrations in soil samples collected from the 0- to 4-in. depth at 100 sites. The differences in selenium between irrigated areas and areas that were never irrigated did not seem to be based solely on geologic or topographical differences. Concentrations of total and extractable selenium were significantly larger in soil samples from 0- to 4-in. depth than in soil samples from 10- to 14-in. depth.

Total-selenium concentrations in 66 plant tissue samples collected on the Oxford Tract were extremely variable; the median concentration was 13 mg/kg, and the maximum concentration was 1,500 mg/kg in a snakeweed sample. Selenium accumulating plants had the largest selenium concentrations, but a number of samples of crop-and-feed plants, such as alfalfa, also had large selenium concentrations. One alfalfa sample contained 180 mg/kg of selenium. The soil and plant data collected for the Oxford Tract did not support the initial hypothesis that irrigation would leach selenium downward in the soil.

Selenium was the trace element of greatest concern in biota samples collected in the Pine River Project area during 1988-89. Selenium concentrations in whole-body fish samples exceeded the National Contaminant Biomonitoring Program (NCBP) 85th percentile in 20 of 23 samples collected in June 1988 and in about 68 percent of the samples collected for the reconnaissance investigation (November 1988 through July 1989). However, all selenium concentrations in fish samples were less than the concentrations known to cause reproductive problems in bluegills. The maximum selenium concentration in a whole-body fish sample was 17.1 μg/g dry weight in a sample from Rock Creek at Ignacio. There was no significant difference (significance level 0.05) between selenium concentrations in whole-body fish samples collected upstream and downstream from irrigation drainage. Omnivorous fish species had significantly greater selenium concentrations than either bottom feeders or predators.

Three aquatic-plant samples collected in June 1988 had selenium concentrations that could cause reproductive problems in fish and waterfowl through food-chain bioconcentration. The maximum selenium concentration in aquatic plants was 6.7 μg/g dry weight in a sample from Rock Creek at Ignacio. Crayfish collected at nine sites from November 1988 through July 1989 had selenium concentrations that could be of concern to fish and wildlife through food-chain bioconcentration. The maximum selenium concentration in an aquatic-insect sample was 10.2 μg/g dry weight in a sample from the Florida River at Bondad. Aquatic insects tended to have larger selenium concentrations than crayfish, and would be more readily available as a food source to fish and birds; therefore, aquatic insects provide a greater risk of selenium bioaccumulation through the food chain.

Four wetland sites in the Pine River Project area were sampled for birds; two sites on the Oxford Tract and two sites along the Los Pinos River. Concentrations of selenium in birds collected on the Oxford Tract indicate probable contamination by selenium, especially at the east marsh site. Irrigation water is a primary source of recharge to the wetlands on the Oxford Tract. Selenium concentrations in liver and whole-body samples of birds were significantly greater in samples from the east marsh than in samples from the other three wetland sites. Maximum selenium concentrations in bird-tissue samples (all from the east marsh) include: 50.0 μg/g dry weight in a liver sample; 49.0 μg/g dry weight in a whole-body sample; and 13.0 μg/g dry weight in an egg sample. Selenium in bird-tissue samples from the east marsh are sufficiently large to cause reproductive problems based on information in the literature. Two samples of mallard breast tissue collected on the Oxford Tract had selenium concentrations that exceeded the recommended guideline for human consumption. Selenium concentrations in bird samples from the two wetland sites along the Los Pinos River were much smaller than the selenium concentrations in bird samples from the Oxford Tract. Selenium in the birds from wetlands along the Los Pinos River should not be of concern.

The selenium concentrations in six prairie dog samples collected in June 1988 on the Oxford Tract ranged from 4.5 to 23.0 μg/g dry weight. Selenium in prairie dogs may be of concern because the prairie dogs are a major food source for bald eagles and other migrating raptors.

Arsenic concentrations in three whole-body fish samples collected in the Pine River Project area exceeded the NCBP 85th percentile of 1984 for arsenic. There was no significant difference between arsenic concentrations in whole-body fish samples collected upstream and downstream from irrigated areas. Arsenic concentrations in biota in the Project area are not of concern based on information in the literature. Cadmium concentrations in about 30 percent of whole-body fish samples exceeded the NCBP 85th percentile of 1984 for cadmium (0.06 μg/g wet weight). Several of the largest cadmium concentrations in fish were in carp samples from Navajo Reservoir. Cadmium concentrations in fish and bird samples were less than concentrations that indicate probable cadmium contamination.

About one half of the whole-body fish samples collected for the reconnaissance investigation had copper concentrations that exceeded the NCBP 85th percentile for copper (1.0 μg/g wet weight). There was no significant difference between copper concentrations in whole-body fish samples collected upstream and downstream from irrigated areas. Predatory fish such as brown trout had larger copper concentrations than omnivores and bottom feeders. The copper concentrations in fish in the Pine River Project area probably were not sufficiently large to cause toxic effects. Copper concentrations in aquatic-plant and aquatic-invertebrate samples generally were within the range of concentrations found in similar species in polluted freshwater.

Two whole-body fish samples, one from the upper site on Beaver Creek and one from the Los Pinos River arm of Navajo Reservoir, had lead concentrations that exceeded the NCBP 85th percentile of 1984 for lead (0.22 μg/g wet weight). Lead concentrations in the two samples also exceeded a guideline for lead in food for human consumption.

Two whole-body fish samples collected in June 1988 and 14 whole-body fish samples collected for the reconnaissance investigation (November 1988 through July 1989) had mercury concentrations that exceeded the NCBP 85th percentile (0.17 μg/g wet weight). Ten of those samples were collected from Navajo Reservoir. The maximum mercury concentration in a whole-body fish sample was 1.3 μg/g dry weight in a channel catfish sample from the Los Pinos River at La Boca, and in a common carp sample from the Piedra River arm of Navajo Reservoir. A channel-catfish fillet collected from Rock Creek at Ignacio had a mercury concentration of 2.1 μg/g dry weight. There was no significant difference between mercury concentrations in whole-body fish samples collected upstream and downstream from irrigated areas of the Pine River Project. Mercury concentrations in fish samples were less than two guidelines established for mercury in food consumed by humans. However, 10 fish samples had mercury concentrations that exceeded a guideline (0.25 μg/g wet weight) for consumption of fish by pregnant women. Mercury concentrations in bird samples were less than adverse-effect levels documented in the literature.

Except for common carp, zinc concentrations in fish samples from the Pine River Project area were comparable to zinc concentrations considered to be normal in fish. Zinc concentrations in common carp were much larger than zinc concentrations in other fish species, and all zinc concentrations in common carp exceeded the NCBP 85th percentile for zinc.

The only organochlorine pesticides detected in fish and bird samples were p,p'-DDE and mirex. Seven biota samples contained p,p'-DDE, but the concentrations were not large. Mirex was detected in a snipe egg from the Oxford Tract at a concentration of 0.12 μg/g wet weight. The organochlorine pesticide concentrations in biota throughout the Project area were less than adverse-effect levels reported in the literature.

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SUPPLEMENTAL DATA

Table 18. Water-quality properties and inorganic-constituent concentrations in water samples

[Analyses by U.S. Geological Survey; ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; mg/L, milligrams per liter; tons/d, tons per day; µg/L, micrograms per liter; <, less than; --, no data]

Site number (fig. 1)	Site name	Date	Time	Discharge, instantaneous (ft^3/s)	Specific conductance (µS/cm)	pH (standard units)
F2	Florida River at Bondad	11-14-88	1520	39	460	8.5
F2		03-30-89	0900	309	240	8.1
F2		07-12-89	1530	42	379	8.6
ST1	Salt Creek north of Oxford	11-14-88	1310	.30	735	8.8
ST1		03-27-89	1330	.26	1,010	8.4
ST1		07-11-89	1600	8.7	146	8.1
ST2	Salt Creek near mouth	11-14-88	1400	3.9	342	8.4
ST2		03-27-89	1230	1.0	1,030	8.6
ST2		07-12-89	1410	13	224	8.3
R1	Rock Creek on the Oxford Tract,	11-16-88	0810	.21	785	8.3
R1	near Oxford	03-27-89	1440	.09	1,010	9.1
R1		07-10-89	1230	2.1	176	8.0
R2	Rock Creek at Highway 172, at	11-16-88	0930	11	516	8.3
R2	Ignacio	03-27-89	1530	1.4	968	8.5
R2		07-10-89	1330	37	212	8.4
D1	Dry Creek at Highway 160	11-15-88	0800	.31	720	8.3
D1		03-28-89	0740	.29	794	8.2
D1		07-10-89	1600	.01	502	7.8
D2	Dry Creek near mouth, near	11-15-88	0900	27	283	8.3
D2	Southern Ute Agency	03-28-89	1430	3.5	608	8.5
D2		07-10-89	1500	51	196	7.9
LP1	Los Pinos River at Columbus	11-03-88	0900	86	99	8.3
LP1		03-29-89	1410	62	140	8.4
LP1		07-12-89	0830	660	83	7.4
LP2	Los Pinos River at Bayfield	11-03-88	1030	55	113	7.8
LP2		03-29-89	1300	206	133	8.6
LP2		07-12-89	0950	455	90	7.6
LP4	Los Pinos River at La Boca	11-03-88	1200	91	253	8.2
LP4		03-29-89	1150	526	156	8.1
LP4		07-11-89	1340	161	259	8.8
B1	Beaver Creek upstream from	11-15-88	1030	1.9	352	8.4
B1	Sauls Creek, near Bayfield	03-28-89	0820	54	136	7.9
B1		07-12-89	1100	.36	376	8.2

Table 18. Water-quality properties and inorganic-constituent concentrations in water samples--Continued

Site number (fig. 1)	Date	Water temperature (°C)	Oxygen, dissolved (mg/L)	Oxygen, dissolved (percent saturation)	Hardness, total (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Sodium adsorption ratio	Potassium, dissolved (mg/L as K)	Alkalinity, lab (mg/L as $CaCO_3$)
F2	11-14-88	8.0	9.7	103	190	57	11	27	0.9	2.1	191
F2	03-30-89	5.0	9.9	96	120	39	6.1	5.0	.2	1.2	110
F2	07-12-89	25.5	8.0	121	150	46	9.2	24	.9	2.9	165
ST1	11-14-88	8.5	13.6	150	200	61	12	95	3	1.7	245
ST1	03-27-89	15.0	11.8	151	220	65	15	150	5	1.8	303
ST1	07-11-89	23.0	6.6	99	57	18	2.9	7.8	.5	1.2	61
ST2	11-14-88	7.0	9.9	104	100	31	5.5	32	1	3.5	116
ST2	03-27-89	13.5	10.3	126	180	53	12	170	6	4.3	297
ST2	07-12-89	25.0	6.4	98	85	27	4.3	14	.7	3.8	98
R1	11-16-88	.5	11.7	103	150	46	9.6	120	4	3.9	226
R1	03-27-89	16.0	--	--	150	43	11	190	7	2.5	246
R1	07-10-89	21.0	6.6	94	70	22	3.6	10	.5	1.4	75
R2	11-16-88	.5	10.3	90	130	39	8.0	58	2	3.9	137
R2	03-27-89	18.0	9.0	122	200	55	14	150	5	3.8	273
R2	07-10-89	25.0	7.1	109	81	25	4.4	12	.6	3.0	95
D1	11-15-88	2.5	9.6	92	180	50	13	110	4	2.3	333
D1	03-28-89	1.5	10.1	93	250	75	16	93	3	1.5	344
D1	07-10-89	26.5	--	--	140	44	7.9	53	2	1.3	209
D2	11-15-88	3.5	9.8	95	110	33	6.3	26	1	1.9	120
D2	03-28-89	18.0	7.8	105	180	52	12	69	2	2.0	243
D2	07-10-89	24.5	6.4	98	85	27	4.2	8.5	.4	1.5	91
LP1	11-03-88	8.0	9.0	99	47	15	2.3	1.6	.1	.90	45
LP1	03-29-89	9.5	9.3	106	70	23	3.0	1.9	.1	.90	66
LP1	07-12-89	12.0	8.4	101	40	13	1.9	1.3	.1	.70	36
LP2	11-03-88	8.0	9.1	99	56	18	2.7	2.3	.1	1.1	53
LP2	03-29-89	7.5	10.4	112	66	21	3.3	2.1	.1	.90	61
LP2	07-12-89	13.5	8.1	99	44	14	2.1	1.4	.1	.70	40
LP4	11-03-88	9.5	9.8	108	100	32	5.3	16	.7	1.6	111
LP4	03-29-89	8.0	9.3	98	71	22	3.8	4.6	.2	1.1	69
LP4	07-11-89	25.0	7.2	109	100	32	5.3	13	.6	2.4	118
B1	11-15-88	3.5	10.1	99	160	46	11	19	.7	1.5	155
B1	03-28-89	2.0	9.7	90	64	18	4.6	4.9	.3	1.4	53
B1	07-12-89	21.5	7.7	112	160	45	11	25	.9	1.6	170

Table 18. Water-quality properties and inorganic-constituent concentrations in water samples--Continued

Site number (fig. 1)	Date	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Solids residue at 180°C, dissolved (mg/L)	Solids dissolved (ton/d)	Nitrogen, NO_2 + NO_3 dissolved (mg/L as N)	Arsenic, dissolved (µg/L as As)	Boron, dissolved (µg/L as B)	Cadmium, dissolved (µg/L as Cd)	Chromium, dissolved (µg/L as Cr)
F2	11-14-88	37	12	0.2	277	29.2	0.24	<1	20	2	<1
F2	03-30-89	18	2.5	.1	141	118	<.10	<1	10	<1	<1
F2	07-12-89	19	9.1	.2	217	24.6	<.10	1	30	<1	<1
ST1	11-14-88	100	17	.3	445	.36	.46	<1	10	<1	<1
ST1	03-27-89	170	37	.3	631	.44	.21	<1	20	<1	<1
ST1	07-11-89	10	1.6	.2	89	2.09	<.10	<1	<10	<1	<1
ST2	11-14-88	45	12	.2	207	2.18	<.10	<1	<10	<1	<1
ST2	03-27-89	160	61	.4	622	1.68	<.10	<1	20	<1	<1
ST2	07-12-89	13	4.5	.3	152	5.21	<.10	1	10	<1	<1
R1	11-16-88	110	32	.4	476	.27	.34	<1	20	<1	<1
R1	03-27-89	180	66	.5	620	.15	.24	1	20	<1	<1
R1	07-1089	10	2.2	.2	113	.64	<.10	1	10	<1	<1
R2	11-16-88	95	17	.2	319	9.73	<.10	<1	10	4	<1
R2	03-27-89	180	35	.4	609	2.30	<.10	<1	20	<1	<1
R2	07-10-89	6.0	4.5	.2	146	14.6	<.10	1	20	<1	<1
D1	11-15-88	53	19	.4	452	.38	<.10	<1	40	<1	<1
D1	03-28-89	48	20	.4	487	.38	<.10	<1	30	<1	<1
D1	07-10-89	27	6.5	.3	281	.01	<.10	1	20	<1	<1
D2	11-15-88	28	4.9	.2	176	12.7	<.10	1	<10	<1	<1
D2	03-28-89	58	11	.3	364	3.44	<.10	<1	20	<1	<1
D2	07-10-89	7.0	.90	.2	119	16.4	<.10	1	30	<1	<1
LP1	11-03-88	5.8	.40	.2	65	15.1	<.10	<1	<10	<1	<1
LP1	03-29-89	8.6	.70	.3	84	14.1	<.10	<1	<10	<1	<1
LP1	07-12-89	5.0	.30	.2	40	71.3	<.10	<1	<10	<1	<1
LP2	11-03-88	7.0	.70	.2	70	10.4	<.10	<1	<10	<1	<1
LP2	03-29-89	10	.50	.3	78	43.4	<.10	<1	<10	<1	<1
LP2	07-12-89	5.0	.30	.2	49	60.2	<.10	<1	<10	<1	<1
LP4	11-03-88	18	2.5	.2	156	38.3	<.10	<1	10	<1	<1
LP4	03-29-89	15	1.1	.3	94	133	<.10	<1	<10	<1	3
LP4	07-11-89	11	2.0	.3	150	65.2	<.10	1	20	<1	<1
B1	11-15-88	37	3.0	.2	218	1.12	<.10	<1	20	<1	<1
B1	03-28-89	16	1.0	.1	97	14.1	<.10	<1	<1	<1	3
B1	07-12-89	30	3.1	.3	218	.21	<.10	<1	30	<1	<1

Table 18. Water-quality properties and inorganic-constituent concentrations in water samples--Continued

Site number (fig. 1)	Date	Copper, dissol-ved (µg/L as Cu)	Iron, dissol-ved (µg/L as Fe)	Lead, dissol-ved (µg/L as Pb)	Manga-nese, dissol-ved (µg/L as Mn)	Mercury, dissol-ved (µg/L as Hg)	Molyb-denum, dissol-ved (µg/L as Mo)	Sele-nium, dissol-ved (µg/L as Se)	Vana-dium, dissol-ved (µg/L as V)	Zinc, dissol-ved (µg/L as Zn)	Urani-um natural, dissol-ved (µg/L as U)
F2	11-14-88	2	7	<5	11	<0.1	<1	2	1	6	--
F2	03-30-89	2	38	<5	23	<.1	<1	<1	<1	4	1.7
F2	07-12-89	2	20	1	11	<.1	<1	2	2	<3	--
ST1	11-14-88	2	17	<5	66	<.1	<1	7	1	9	--
ST1	03-27-89	2	12	<5	59	<.1	<1	7	<1	19	4.3
ST1	07-11-89	1	48	<1	13	<.1	1	<1	<1	20	.80
ST2	11-14-88	2	26	<5	18	<.1	2	3	1	13	--
ST2	03-27-89	7	6	<5	60	.1	<1	15	1	4	4.2
ST2	07-12-89	1	74	<1	14	<.1	<1	<1	2	36	1.3
R1	11-16-88	2	42	<5	210	<.1	1	33	1	7	--
R1	03-27-89	7	130	<5	59	.2	<1	94	3	24	3.7
R1	07-10-89	6	160	1	37	<.1	<1	3	1	6	.90
R2	11-16-88	3	220	<5	70	<.1	1	3	1	63	--
R2	03-27-89	2	33	<5	59	<.1	<1	15	1	6	4.8
R2	07-10-89	10	74	1	27	<.1	<1	1	1	5	1.4
D1	11-15-88	4	48	<5	240	<.1	<1	<1	1	56	--
D1	03-28-89	2	19	<5	450	<.1	<1	<1	<1	9	1.4
D1	07-10-89	5	15	1	290	<.1	<1	<1	<1	5	--
D2	11-15-88	2	29	<5	57	<.1	<1	<1	2	4	--
D2	03-28-89	4	13	<5	40	<.1	<1	2	1	3	2.6
D2	07-10-89	7	41	2	11	<.1	<1	<1	<1	<3	.80
LP1	11-03-88	2	13	<5	8	<.1	<1	<1	<1	8	--
LP1	03-29-89	3	80	<5	7	2.3	<1	<1	<1	9	.60
LP1	07-12-89	5	6	1	3	.5	<1	<1	<1	<3	.50
LP2	11-03-88	2	16	<5	13	<.1	<1	<1	<1	6	--
LP2	03-29-89	1	79	<5	8	<.1	<1	<1	<1	<3	.60
LP2	07-12-89	2	9	<1	5	.3	<1	<1	<1	6	--
LP4	11-03-88	2	16	<5	24	<.1	1	1	1	4	--
LP4	03-29-89	3	160	5	14	<.1	<1	<1	<1	<3	.60
LP4	07-11-89	2	68	<1	16	<.1	<1	<1	<1	4	3.2
B1	11-15-88	1	11	<5	30	<.1	1	<1	1	3	--
B1	03-28-89	3	120	<5	13	<.1	<1	<1	2	4	<.40
B1	07-12-89	1	10	<1	14	<.1	<1	<1	1	4	--

Table 18. Water-quality properties and inorganic-constituent concentrations in water samples--Continued

Site number (fig. 1)	Site name	Date	Time	Discharge instantaneous (ft³/s)	Specific conductance (µS/cm)	pH (standard units)	Water temperature (°C)
B2	Beaver Creek near mouth	11-15-88	1300	8.8	438	8.4	7.0
B2		03-28-89	1000	65	164	7.9	4.5
B2		07-12-89	1140	16	304	8.0	21.0
U1	Ute Creek at Harper Pond, near Bayfield	11-15-88	1210	.17	867	8.3	3.0
U1		03-28-89	1100	.09	850	8.0	2.0
U1		07-11-89	1500	.25	584	8.2	23.0
U2	Ute Creek near mouth	11-15-88	1350	2.2	745	8.6	8.5
U2		03-28-89	1230	.72	920	8.6	16.0
U2		07-12-89	1240	15	296	8.5	22.5
SP1	Spring Creek near Pine River Canal, near Bayfield	11-16-88	1230	.28	774	7.8	8.0
SP1		03-28-89	1130	1.3	233	7.9	8.5
SP1		07-11-89	1120	1.2	390	8.1	20.0
SP2	Spring Creek at La Boca	11-16-88	1050	6.5	1,030	8.2	1.0
SP2		03-28-89	1400	6.1	948	8.3	18.0
SP2		07-11-89	1250	60	311	8.3	22.0
WSB2	West Sambrito Creek at mouth	11-16-88	1300	.84	1,460	8.2	5.5
WSB2		03-29-89	1030	.10	1,670	8.3	12.0
WSB2		07-11-89	0850	14	262	8.0	17.5
SB1	Sambrito Creek near Pine River Canal	11-17-88	0830	.04	763	8.2	3.0
SB1		03-29-89	0840	.54	224	8.0	6.0
SB1		07-11-89	1040	.20	372	8.3	19.0
SB2	Sambrito Creek at mouth	11-17-88	0900	1.6	922	8.5	2.5
SB2		03-29-89	0930	1.5	796	8.6	8.0
SB2		07-11-89	0930	13	352	8.3	18.0
N1	Navajo Reservoir, Piedra River arm, near Arboles	11-02-88	0940	--	259	8.3	--
N2	Navajo Reservoir, Los Pinos River arm, near La Boca	11-02-88	1330	--	265	8.5	--
G24	Spring at Durango-La Plata County Airport	03-22-89	0830	--	834	7.5	8.0
G24		08-22-89	1230	--	924	7.4	15.0
G69	Howard Massey well, near Arboles	03-22-89	1300	--	1,020	7.4	14.0
G69		08-23-89	1000	--	1,030	7.5	15.0
G87	Steve Waters well, south of Durango-La Plata	03-22-89	0940	--	3,240	8.1	10.0
G87	County Airport	08-22-89	1145	--	2,960	8.0	18.0
G109	Betty Lamke well, at Oxford	03-28-89	1800	--	1,820	7.9	8.5
G109		08-22-89	1900	--	1,850	7.9	17.0
G114	Mike McManus well, near Oxford	03-22-89	1030	--	1,310	8.0	11.5
G114		08-22-89	1100	--	1,150	8.0	14.0

Table 18. Water-quality properties and inorganic-constituent concentrations in water samples--Continued

Site number (fig. 1)	Date	Oxygen, dissolved (mg/L)	Oxygen, dissolved (percent saturation)	Hardness, total (mg/L as $CaCO_3$)	Calcium, dissolved (mg/L as Ca)	Magnesium, dissolved (mg/L as Mg)	Sodium, dissolved (mg/L as Na)	Sodium adsorption ratio	Potassium, dissolved (mg/L as K)	Alkalinity, lab (mg/L as $CaCO_3$)	Sulfate, dissolved (mg/L as SO_4)
B2	11-15-88	9.6	102	170	71	11	28	1	1.7	197	31
B2	03-28-89	10.0	98	73	51	5.0	7.3	.4	1.4	67	23
B2	07-12-89	7.6	108	130	40	7.1	16	.6	2.4	142	17
U1	11-15-88	9.1	88	340	76	36	88	2	3.4	382	100
U1	03-28-89	9.0	84	330	77	34	82	2	2.6	371	120
U1	07-11-89	5.8	87	210	49	21	47	1	2.1	263	50
U2	11-15-88	9.1	99	200	57	15	90	3	2.6	279	99
U2	03-28-89	6.1	78	210	56	17	140	4	2.7	290	170
U2	07-12-89	7.4	108	110	35	6.2	22	.9	2.5	135	20
SP1	11-16-88	9.5	102	320	100	16	60	2	2.0	337	70
SP1	03-28-89	9.3	101	92	29	4.8	12	.6	2.9	93	22
SP1	07-11-89	7.5	105	150	47	7.2	27	1	4.4	170	27
SP2	11-16-88	11.2	98	290	80	22	140	4	3.0	319	220
SP2	03-28-89	7.9	105	240	68	18	140	4	3.1	290	200
SP2	07-11-89	6.8	97	110	33	6.5	26	1	3.4	129	27
WSB2	11-16-88	10.7	106	310	86	23	190	5	3.8	341	330
WSB2	03-29-89	10.5	123	330	92	25	260	6	5.0	338	420
WSB2	07-11-89	7.4	96	92	28	5.3	19	.9	3.5	104	23
SB1	11-17-88	9.5	90	270	84	14	78	2	1.4	327	79
SB1	03-29-89	9.5	96	93	31	3.8	13	.6	2.8	104	18
SB1	07-11-89	8.8	119	140	46	6.8	27	1	3.0	171	24
SB2	11-17-88	10.5	97	250	72	17	130	4	1.5	344	130
SB2	03-29-89	10.3	109	210	62	14	110	3	2.1	309	110
SB2	07-11-89	8.2	108	110	35	6.6	31	1	2.9	153	28
N1	11-02-88	8.1	--	100	31	6.4	14	.6	2.0	79	46
N2	11-02-88	9.5	--	98	30	5.6	19	.9	1.6	109	28
G24	03-22-89	5.4	58	270	85	14	95	3	1.2	394	48
G24	08-22-89	--	--	270	87	14	95	2	1.2	361	52
G69	03-22-89	5.5	67	230	71	13	140	4	2.0	318	150
G69	08-23-89	--	--	280	84	17	110	3	2.1	309	150
G87	03-22-89	3.1	35	78	30	.80	560	29	.90	60	150
G87	08-22-89	--	--	75	29	.73	550	28	.90	65	150
G109	03-28-89	1.9	21	68	24	1.9	390	22	1.3	382	160
G109	08-22-89	--	--	67	24	1.8	380	20	1.5	398	170
G114	03-22-89	2.2	26	58	22	.77	270	16	.90	351	90
G114	08-22-89	--	--	53	20	.70	260	16	1.0	376	89

Table 18. Water-quality properties and inorganic-constituent concentrations in water samples--Continued

Site number (fig. 1)	Date	Chloride, dissolved (mg/L as Cl)	Fluoride, dissolved (mg/L as F)	Solids residue at 180°C dissolved (mg/L)	Solids, dissolved (ton/d)	Nitrogen, NO_2+ NO_3 dissolved (mg/L as N)	Arsenic, dissolved (µg/L as As)	Boron, dissolved (µg/L as B)	Cadmium, dissolved (µg/L as Cd)	Chromium, dissolved (µg/L as Cr)	Copper, dissolved (µg/L as Cu)
B2	11-15-88	3.8	0.2	235	5.58	<0.10	<1	20	2	<1	1
B2	03-28-89	1.6	.1	156	27.4	<.10	<1	10	<1	<1	3
B2	07-12-89	1.9	.3	178	7.88	<.10	1	30	<1	<1	2
U1	11-15-88	10	.4	541	.25	<.10	<1	30	<1	<1	1
U1	03-28-89	7.8	.4	554	.13	<.10	1	30	<1	<1	2
U1	07-11-89	3.2	.4	340	.23	<.10	2	60	<1	<1	1
U2	11-15-88	12	.4	430	2.55	<.10	1	30	2	<1	2
U2	03-28-89	19	.4	572	1.11	<.10	1	30	<1	<1	2
U2	07-12-89	2.5	.3	176	7.13	<.10	1	20	<1	<1	4
SP1	11-16-88	9.7	.3	457	.35	.34	<1	30	<1	<1	1
SP1	03-28-89	4.1	.1	152	.53	<.10	1	20	<1	<1	5
SP1	07-11-89	4.4	.3	229	.71	.11	1	20	<1	<1	4
SP2	11-16-88	19	.7	701	12.3	<.10	<1	30	<1	<1	2
SP2	03-28-89	15	.4	619	10.2	<.10	1	30	<1	<1	3
SP2	07-11-89	3.8	.3	198	32.1	<.10	1	20	<1	<1	5
WSB2	11-16-88	63	.4	974	2.21	<.10	<1	40	4	<1	2
WSB2	03-29-89	96	.9	1,090	.29	<.10	1	30	<1	<1	3
WSB2	07-11-89	5.0	.3	162	6.34	<.10	1	30	2	<1	2
SB1	11-17-88	8.5	.5	450	.05	<.10	<1	30	<1	<1	2
SB1	03-29-89	2.5	.3	139	.20	<.10	1	20	<1	<1	4
SB1	07-11-89	2.7	.3	--	.11	<.10	1	20	<1	<1	2
SB2	11-17-88	13	.6	576	2.49	.38	1	40	<1	<1	1
SB2	03-29-89	10	1.1	492	1.99	<.10	1	40	<1	1	3
SB2	07-11-89	3.5	.4	207	7.38	<.10	1	30	<1	<1	5
N1	11-02-88	2.0	.1	166	.0	<.10	<1	20	<1	<1	3
N2	11-02-88	2.8	.2	162	.0	<.10	<1	10	<1	<1	3
G24	03-22-89	23	.4	512	.0	.71	<1	40	<1	<1	10
G24	08-22-89	25	.3	490	.0	.64	<1	30	<1	1	6
G69	03-22-89	46	1.1	629	.0	1.7	<1	50	<1	<1	3
G69	08-23-89	49	1.0	578	.0	2.8	<1	40	<1	1	2
G87	03-22-89	650	2.8	1,790	.0	79	2	30	1	<1	8
G87	08-22-89	610	2.7	1,730	.0	67	<1	20	<1	<1	18
G109	03-28-89	260	1.2	1,100	.0	5.7	2	30	<1	<1	20
G109	08-22-89	230	1.2	1,020	.0	5.5	2	10	<1	<1	14
G114	03-22-89	62	.9	836	.0	39	8	40	<1	<1	3
G114	08-22-89	42	.9	727	.0	25	6	40	<1	2	4

Table 18. Water-quality properties and inorganic-constituent concentrations in water samples--Continued

Site number (fig. 1)	Date	Iron, dissolved (µg/L as Fe)	Lead, dissolved (µg/L as Pb)	Manganese, dissolved (µg/L as Mn)	Mercury, dissolved (µg/L as Hg)	Molybdenum, dissolved (µg/L as Mo)	Selenium, dissolved (µg/L as Se)	Vanadium, dissolved (µg/L as V)	Zinc, dissolved (µg/L as Zn)	Uranium natural, dissolved (µg/L as U)
B2	11-15-88	<3	<5	73	<0.1	1	<1	1	4	--
B2	03-28-89	120	<5	12	.1	<1	3	2	<3	<0.40
B2	07-12-89	42	1	45	<.1	<1	<1	1	10	--
U1	11-15-88	27	<5	730	<.1	<1	<1	2	4	--
U1	03-28-89	120	<5	1,000	<.1	<1	<1	2	12	2.6
U1	07-11-89	40	<1	140	<.1	1	<1	1	40	--
U2	11-15-88	4	<5	53	<.1	2	3	2	4	--
U2	03-28-89	9	<5	62	<.1	<1	5	1	9	4.6
U2	07-12-89	52	4	14	<.1	<1	<1	2	5	--
SP1	11-16-88	7	<5	590	<.1	1	9	1	5	--
SP1	03-28-89	100	<5	51	<.1	<1	1	2	6	.60
SP1	07-11-89	58	<1	100	<.1	1	2	<1	14	1.3
SP2	11-16-88	14	<5	54	<.1	2	6	2	4	--
SP2	03-28-89	18	<5	29	<.1	<1	5	2	<3	4.9
SP2	07-11-89	92	<1	10	<.1	<1	1	1	7	1.1
WSB2	11-16-88	3	<5	160	<.1	2	7	1	4	--
WSB2	03-29-89	16	<5	210	.1	1	8	2	<3	6.9
WSB2	07-11-89	82	<1	17	<.1	<1	1	<1	6	7.2
SB1	11-17-88	10	<5	49	<.1	2	3	2	4	--
SB1	03-29-89	96	<5	8	<.1	<1	1	2	4	.50
SB1	07-11-89	36	<1	35	<.1	1	1	<1	42	1.8
SB2	11-17-88	8	<5	81	<.1	3	6	2	5	--
SB2	03-29-89	32	<5	65	<.1	1	6	2	<3	5.0
SB2	07-11-89	75	1	14	<.1	4	2	<1	<3	1.3
N1	11-02-88	16	<5	12	.2	2	<1	2	5	--
N2	11-02-88	38	<5	37	.2	10	1	<1	7	--
G24	03-22-89	5	<5	3	<.1	<1	30	<1	50	4.3
G24	08-22-89	8	3	4	<.1	<1	37	<1	16	6.3
G69	03-22-89	19	<5	3	<.1	2	110	<1	10	5.5
G69	08-23-89	27	<1	3	<.1	3	140	<1	14	10
G87	03-22-89	10	<5	<10	<.1	45	4,400	19	30	<.40
G87	08-22-89	<3	<1	2	--	46	4,800	10	59	.60
G109	03-28-89	4	9	13	.2	39	380	7	13	14
G109	08-22-89	20	<1	<10	<.1	22	510	4	10	22
G114	03-22-89	<3	<5	1	<.1	10	100	8	34	19
G114	08-22-89	20	<1	<10	.1	13	85	3	60	24

Table 19. Concentrations of herbicides in water samples

[Analyses by U.S. Geological Survey; concentrations in micrograms per liter; <, less than; all constituent concentrations are totals]

Site number (figure 1)	Site name	Date	2,4-D	2,4-DP	Silvex	2,4,5-T	Dicamba	Picloram
F1	Florida River at County	03-31-89	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
F1	Road 510, near Oxford	06-06-89	<.01	<.01	<.01	<.01	<.01	<.01
ST2	Salt Creek near mouth	07-12-89	<.01	<.01	<.01	<.01	<.01	<.01
R2	Rock Creek at Highway 172, at Ignacio	07-10-89	<.01	<.01	<.01	<.01	<.01	.01
D2	Dry Creek near mouth, near Southern Ute Agency	07-10-89	<.01	<.01	<.01	<.01	<.01	<.01
LP2	Los Pinos River at Bayfield	02-16-89	<.01	<.01	<.01	<.01	<.01	<.01
LP3	Los Pinos River at Ignacio	02-16-89	<.01	<.01	<.01	<.01	<.01	<.01
LP3		06-19-89	<.01	<.01	<.01	<.01	<.01	<.01
LP4	Los Pinos River at La Boca	12-06-88	<.01	<.01	<.01	<.01	<.01	<.01
LP4		06-20-89	<.01	<.01	<.01	<.01	<.01	<.01
LP4		07-11-89	.03	<.01	<.01	<.01	<.01	<.01
B2	Beaver Creek near mouth	07-12-89	<.01	<.01	<.01	<.01	<.01	<.01
U2	Ute Creek near mouth	07-12-89	<.01	<.01	<.01	<.01	<.01	<.01
SP2	Spring Creek at La Boca	07-11-89	<.01	<.01	<.01	.01	.03	<.01
WSB2	West Sambrito Creek at mouth	07-11-89	<.01	<.01	<.01	<.01	<.01	<.01
SB2	Sambrito Creek at mouth	07-11-89	<.01	<.01	<.01	<.01	.03	<.01
P1	Piedra River near Arboles	12-07-88	<.01	<.01	<.01	<.01	<.01	<.01
P1		05-16-89	<.01	<.01	<.01	<.01	<.01	<.01

Table 20. Trace-element concentrations in the less than 0.0625-millimeter size fraction in bottom-sediment samples

[Analyses by U.S. Geological Survey; concentrations in micrograms per gram; <, less than]

Site number (fig. 1)	Site name	Date	Arsenic	Barium	Beryllium	Bismuth	Cadmium	Cerium	Chromium
F2	Florida River at Bondad	11-14-88	4.4	720	2	<10	<2	84	30
ST2	Salt Creek near mouth	11-14-88	3.8	530	1	<10	<2	63	25
R2	Rock Creek at Highway 172, at Ignacio	11-16-88	5.4	540	1	<10	<2	73	29
B2	Beaver Creek near mouth	11-15-88	4.8	730	1	<10	<2	66	32
U2	Ute Creek near mouth	11-15-88	4.6	580	1	<10	<2	55	29
SP2	Spring Creek at La Boca	11-16-88	6.2	1,000	2	<10	<2	76	39
WSB2	West Sambrito Creek at mouth	11-16-88	5.8	1,100	2	<10	<2	73	43
SB2	Sambrito Creek at mouth	11-17-88	3.8	890	2	<10	<2	65	41
N1	Navajo Reservoir, Piedra River arm, near Arboles	11-02-88	5.2	620	2	<10	<2	61	38
N2	Navajo Reservoir, Los Pinos River arm, near La Boca	11-02-88	5.6	640	2	<10	<2	62	28

Site number (fig. 1)	Date	Cobalt	Copper	Europium	Gallium	Gold	Holmium	Lanthanum	Lead	Lithium	Manganese	Mercury	Molybdenum	Neodymium
F2	11-14-88	11	25	<2	15	<8	<4	44	16	18	570	0.06	<2	38
ST2	11-14-88	8	20	<2	11	<8	<4	32	13	16	450	.02	<2	29
R2	11-16-88	9	20	<2	11	<8	<4	37	12	17	630	.04	<2	35
B2	11-15-88	10	22	<2	13	<8	<4	35	14	21	1,000	.04	<2	32
U2	11-15-88	8	19	<2	10	<8	<4	29	12	18	610	.04	<2	28
SP2	11-16-88	10	24	<2	13	<8	<4	40	15	22	540	.04	<2	36
WSB2	11-16-88	13	27	<2	15	<8	<4	39	17	25	790	.04	<2	37
SB2	11-17-88	10	27	<2	13	<8	<4	35	16	24	610	.10	<2	32
N1	11-02-88	13	27	<2	16	<8	<4	34	13	31	520	.06	<2	31
N2	11-02-88	10	24	<2	14	<8	<4	32	15	23	550	.06	<2	30

Site number (fig. 1)	Date	Nickel	Niobium	Scandium	Selenium	Silver	Strontium	Tantalum	Thorium	Tin	Uranium	Vanadium	Ytterbium	Ytrium	Zinc
F2	11-14-88	11	7	8	0.4	<2	160	<40	18.9	<10	5.07	71	2	20	61
ST2	11-14-88	9	6	5	.2	<2	120	<40	13.4	<10	4.41	66	2	15	48
R2	11-16-88	9	7	5	.5	<2	120	<40	17.8	<10	5.62	74	2	17	50
B2	11-15-88	12	7	6	.3	<2	210	<40	15.7	<10	5.29	78	2	18	65
U2	11-15-88	10	4	5	.4	<2	120	<40	11.5	<10	5.06	58	2	16	45
SP2	11-16-88	14	8	7	.5	<2	160	<40	22.9	<10	8.19	90	3	21	66
WSB2	11-16-88	17	8	8	.7	<2	160	<40	21.0	<10	6.43	100	2	22	85
SB2	11-17-88	15	6	7	.8	<2	170	<40	16.5	<10	5.38	90	2	19	74
N1	11-02-88	17	7	10	.7	<2	270	<40	11.7	<10	3.64	100	2	21	86
N2	11-02-88	15	6	8	.6	<2	130	<40	11.9	<10	4.07	81	2	18	67

Table 21. Trace-element concentrations in the less than 2-millimeter size fraction in bottom-sediment samples

[Analyses by U.S. Geological Survey; concentrations in micrograms per gram; <, less than]

Site number (fig. 1)	Site name	Date	Arsenic	Barium	Beryllium	Bismuth	Cadmium	Cerium	Chromium
F2	Florida River at Bondad	11-14-88	4.8	810	2	<10	<2	67	22
ST2	Salt Creek near mouth	11-14-88	2.9	520	1	<10	<2	56	21
R2	Rock Creek at Highway 172, at Ignacio	11-16-88	4.9	490	1	<10	<2	58	21
B2	Beaver Creek near mouth	11-15-88	12	880	1	<10	<2	61	19
U2	Ute Creek near mouth	11-15-88	6.5	550	1	<10	<2	42	21
SP2	Spring Creek at La Boca	11-16-88	6.4	760	1	<10	<2	47	25
WSB2	West Sambrito Creek at mouth	11-16-88	8.5	1,000	2	<10	<2	55	39
SB2	Sambrito Creek at mouth	11-17-88	6.4	870	2	<10	<2	53	36
N1	Navajo Reservoir, Piedra River arm, near Arboles	11-02-88	4.6	620	2	<10	<2	61	36
N2	Navajo Reservoir, Los Pinos River arm, near La Boca	11-02-88	3.7	580	2	<10	<2	56	35

Site number (fig. 1)	Date	Cobalt	Copper	Europium	Gallium	Gold	Holmium	Lanthanum	Lead	Lithium	Manganese	Mercury	Molybdenum	Neodymium
F2	11-14-88	10	19	<2	15	<8	<4	35	15	15	540	0.02	<2	31
ST2	11-14-88	10	16	<2	11	<8	<4	29	12	15	550	<.02	<2	27
R2	11-16-88	14	12	<2	10	<8	<4	28	13	16	940	<.02	<2	29
B2	11-15-88	11	12	<2	13	<8	<4	34	12	17	820	<.02	<2	29
U2	11-15-88	10	14	<2	9	<8	<4	22	13	18	620	<.02	<2	22
SP2	11-16-88	10	14	<2	11	<8	<4	24	13	18	640	.02	<2	25
WSB2	11-16-88	14	21	<2	15	<8	<4	28	16	25	640	.04	<2	31
SB2	11-17-88	11	19	<2	13	<8	<4	27	15	24	630	.02	<2	30
N1	11-02-88	13	28	<2	16	<8	<4	35	14	31	550	.08	<2	31
N2	11-02-88	10	22	<2	13	<8	<4	29	13	22	530	.04	<2	28

Site number (fig. 1)	Date	Nickel	Niobium	Scandium	Selenium	Silver	Strontium	Tantalum	Thorium	Tin	Uranium	Vanadium	Ytterbium	Yttrium	Zinc
F2	11-14-88	9	4	6	0.3	<2	150	<40	12.0	<10	3.15	58	2	15	55
ST2	11-14-88	9	5	5	.2	<2	120	<40	8.7	<10	2.57	63	2	14	49
R2	11-16-88	10	4	5	.4	<2	130	<40	5.9	<10	2.73	65	2	17	50
B2	11-15-88	12	6	5	.4	<2	360	<40	8.5	<10	3.34	72	2	17	59
U2	11-15-88	12	4	4	.3	<2	110	<40	8.8	<10	2.45	58	1	14	51
SP2	11-16-88	13	<4	5	.3	<2	110	<40	7.7	<10	2.91	73	1	17	57
WSB2	11-16-88	18	6	8	.8	<2	120	<40	12.9	<10	3.60	110	2	21	93
SB2	11-17-88	16	5	7	.6	<2	130	<40	10.2	<10	3.44	100	2	21	77
N1	11-02-88	17	8	11	.7	<2	280	<40	9.5	<10	3.78	99	2	21	84
N2	11-02-88	14	6	7	.8	<2	130	<40	11.0	<10	3.32	76	2	17	70

Table 22. Concentrations of organic compounds in bottom-sediment samples

[Analyses by U.S. Geological Survey; concentrations in micrograms per kilogram; <, less than; all constituent concentrations are totals]

Site number (fig. 1)	Site name	Date	PCN	PCB	Aldrin	Chlordane	DDD
F2	Florida River at Bondad	11-14-88	<1.0	<1	<0.1	<1.0	<0.1
ST2	Salt Creek near mouth	11-14-88	<1.0	<1	<.1	<1.0	<.1
R2	Rock Creek at Highway 172, at Ignacio	11-16-88	<1.0	<1	<.1	<1.0	<.1
LP4	Los Pinos River at La Boca	12-06-88	<1.0	<1	<.1	1.0	.3
B2	Beaver Creek near mouth	11-15-88	<1.0	<1	<.1	<1.0	<.1
U2	Ute Creek near mouth	11-15-88	<1.0	<1	<.1	<1.0	<.1
SP2	Spring Creek at La Boca	11-16-88	<1.0	<1	<.1	<1.0	<.1
WSB2	West Sambrito Creek at mouth	11-16-88	<1.0	<1	<.1	<1.0	<.1
SB2	Sambrito Creek at mouth	11-17-88	<1.0	<1	<.1	<1.0	<.1
N1	Navajo Reservoir, Piedra River arm, near Arboles	11-02-88	<1.0	<1	<.1	<1.0	<.1
N2	Navajo Reservoir, Los Pinos River arm, near La Boca	11-02-88	<1.0	<1	<.1	1.0	.1

Site number (fig. 1)	Date	DDE	DDT	Dieldrin	Endosulfan	Endrin	Heptachlor	Heptachlor epoxide	Lindane	Mirex	Perthane	Toxaphene
F2	11-14-88	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1.0	<10
ST2	11-14-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<1.0	<10
R2	11-16-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<1.0	<10
LP4	12-06-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<1.0	<10
B2	11-15-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<1.0	<10
U2	11-15-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<1.0	<10
SP2	11-16-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<1.0	<10
WSB2	11-16-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<1.0	<10
SB2	11-17-88	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<1.0	<10
N1	11-02-88	.2	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<1.0	<10
N2	11-02-88	.1	.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<1.0	<10

Table 23. Trace-element concentrations in fish, aquatic-plant, aquatic-invertebrate, and prairie dog samples collected in June 1988

[Analyses by U.S. Fish and Wildlife Service; concentrations in micrograms per gram dry weight; mean length in millimeters; all fish and mammal samples are whole-body samples; aq., aquatic; inv., invertebrates; <, less than; --, no data]

Site number (fig. 1)	Matrix	Species	Date	Mean length	Number in sample	Percent moisture	Aluminum	Arsenic	Barium	Beryllium	Boron
F2	Fish	Sucker composite	06-28-88	410	4	68.8	205	0.27	17.3	<1.6	<16
F2	Fish	Mottled sculpin	06-28-88	100	4	71.2	53	.17	23.3	<1.8	<18
F2	Fish	Roundtail chub	06-28-88	120	10	76.5	46	.29	<19.2	<1.9	<19
F2	Fish	Common carp	06-28-88	460	2	68.4	113	.32	19.3	<1.8	<18
F2	Aq. plants	Not determined	06-28-88	--	--	77.0	6,430	3.6	553	<2.2	25
F2	Aq. inv.	Crayfish	06-28-88	--	--	77.2	382	2.2	379	<2.2	<22
F2	Aq. inv.	Composite	06-28-88	--	--	87.3	2,730	2.4	254	<3.9	<39
ST2	Fish	Sucker composite	06-28-88	130	12	77.0	287	.24	25.2	<2.2	<22
ST2	Fish	Speckled dace	06-28-88	70	30	71.3	300	.19	42.2	<1.7	<17
ST2	Fish	Fathead minnow	06-28-88	65	9	76.6	2,290	.74	180	<2.1	<21
ST2	Aq. plants	Not determined	06-28-88	--	--	89.6	5,630	3.9	367	<4.8	84
ST2	Aq. inv.	Crayfish	06-28-88	--	--	75.4	854	1.5	650	<2.0	<20
ST2	Aq. inv.	Composite	06-28-88	--	--	94.3	947	3.9	<88	<8.8	<88
R2	Fish	Sucker composite	06-28-88	334	2	67.8	71.4	.36	<15.6	<1.6	<16
R2	Fish	Speckled dace	06-28-88	--	--	70.2	63.8	.16	34.2	<1.7	<17
R2	Fish	Common carp	06-28-88	565	2	76.0	<41.7	.41	<20.8	<2.1	<21
R2	Aq. plants	Not determined	06-28-88	--	--	98.5	5,930	13.3	507	<33	<333
R2	Aq. inv.	Crayfish	06-28-88	--	--	74.4	625	1.0	398	<2.0	<20
Oxford	Mammal	Prairie dog	06-28-88	--	1	76.5	153	.23	25.1	<2.1	<21
Tract	Mammal	Prairie dog	06-28-88	--	1	68.9	35.4	.17	21.9	<1.6	<16
	Mammal	Prairie dog	06-28-88	--	1	77.2	175	.11	71.5	4.8	<22
	Mammal	Prairie dog	06-28-88	--	1	80.1	307	.20	31.7	<2.5	<25
	Mammal	Prairie dog	06-28-88	--	1	71.7	113	.07	18.0	<1.8	<18
	Mammal	Prairie dog	06-28-88	--	1	76.0	154	.05	45.0	<2.1	<21
SP2	Fish	Brown trout	06-28-88	--	1	73.8	<38.2	.12	<19.1	<1.9	<19
SP2	Fish	Bluehead sucker	06-28-88	--	1	78.9	223	.72	36.5	<2.4	<24
SP2	Fish	Fathead minnow	06-28-88	--	10	80.1	95.5	.33	83.9	<2.5	<25
SP2	Aq. inv.	Crayfish	06-28-88	--	--	79.5	922	1.3	482	<2.4	<24
SP2	Aq. inv.	Composite	06-28-88	--	--	84.7	673	1.5	36.6	<3.3	<33

Table 23. Trace-element concentrations in fish, aquatic-plant, aquatic-invertebrate, and prairie dog samples collected in June 1988--Continued

Site number (fig. 1)	Matrix	Species	Date	Cadmium	Chromium	Copper	Iron	Lead	Magnesium	Manganese	Mercury
F2	Fish	Sucker composite	06-28-88	<1.6	3.9	<8.1	330	<32	962	32.4	0.25
F2	Fish	Mottled sculpin	06-28-88	<1.8	<3.5	<8.8	265	<35	1,380	32.9	.34
F2	Fish	Roundtail chub	06-28-88	<1.9	<3.8	<9.6	130	<38	958	6.9	.46
F2	Fish	Common carp	06-28-88	<1.8	6.2	<9.1	349	<36	1,160	25.8	.38
F2	Aq. plants	Not determined	06-28-88	<2.2	14.3	20.9	8,260	<44	2,390	1,390	.12
F2	Aq. inv.	Crayfish	06-28-88	<2.2	<4.4	89.5	386	<44	1,670	130	.27
F2	Aq. inv.	Composite	06-28-88	<3.9	<7.9	39.4	2,570	<79	1,650	850	.23
ST2	Fish	Sucker composite	06-28-88	<2.2	<4.4	<10.9	430	<44	1,300	40.4	.18
ST2	Fish	Speckled dace	06-28-88	<1.7	7.3	<8.7	331	<35	1,290	36.2	.29
ST2	Fish	Fathead minnow	06-28-88	<2.1	<4.3	<10.7	2,450	<43	1,880	154	.36
ST2	Aq. plants	Not determined	06-28-88	<4.8	11.5	26.9	9,330	<96	1,920	2,600	<.24
ST2	Aq. inv.	Crayfish	06-28-88	<2.0	<4.1	123	736	<41	1,750	393	.15
ST2	Aq. inv.	Composite	06-28-88	<8.8	<17.5	<43.9	1,210	<175	<1,750	289	.60
R2	Fish	Sucker composite	06-28-88	<1.6	<3.1	<7.8	177	<31	714	25.5	.20
R2	Fish	Speckled dace	06-28-88	<1.7	<3.4	<8.4	141	<34	1,310	29.2	.31
R2	Fish	Common carp	06-28-88	<2.1	<4.2	<10.4	250	<42	1,330	17.1	1.1
R2	Aq. plants	Not determined	06-28-88	<33	<66.7	<167	11,500	<667	<6,670	6,460	<1.7
R2	Aq. inv.	Crayfish	06-28-88	<2.0	<3.9	118	598	<39	1,950	270	.19
Oxford	Mammal	Prairie dog	06-28-88	<2.1	<4.3	10.6	421	<43	1,570	20.9	.11
Tract	Mammal	Prairie dog	06-28-88	<1.6	<3.2	9.0	190	<32	1,350	7.1	<.08
	Mammal	Prairie dog	06-28-88	<2.2	<4.4	39.9	627	<44	2,940	34.6	.18
	Mammal	Prairie dog	06-28-88	<2.5	<5.0	17.1	477	<50	1,710	42.2	<.13
	Mammal	Prairie dog	06-28-88	<1.8	<3.5	<8.8	396	<35	1,130	15.2	.76
	Mammal	Prairie dog	06-28-88	<2.1	<4.2	<10.4	446	99	1,670	17.1	<.11
SP2	Fish	Brown trout	06-28-88	<1.9	<3.8	<9.5	45.8	<38	1,260	12.6	.27
SP2	Fish	Bluehead sucker	06-28-88	<2.4	<4.7	<11.9	412	<47	1,520	54.5	.18
SP2	Fish	Fathead minnow	06-28-88	<2.5	<5.0	<12.6	246	<50	1,660	29.6	.50
SP2	Aq. inv.	Crayfish	06-28-88	<2.4	<4.9	190	1,060	<49	2,340	331	.19
SP2	Aq. inv.	Composite	06-28-88	<3.3	<6.5	24.2	745	<65	719	142	.47

Table 23. Trace-element concentrations in fish, aquatic-plant, aquatic-invertebrate, and prairie dog samples collected in June 1988--Continued

Site number (fig. 1)	Matrix	Species	Date	Nickel	Selenium	Strontium	Vanadium	Zinc
F2	Fish	Sucker composite	06-28-88	<13	4.2	49.4	<16	63.1
F2	Fish	Mottled sculpin	06-28-88	<14	9.9	131	<18	95.4
F2	Fish	Roundtail chub	06-28-88	<15	7.3	23.8	<19	95.8
F2	Fish	Common carp	06-28-88	<15	5.8	123	<18	333
F2	Aq. plants	Not determined	06-28-88	<17	3.5	347	<22	48.3
F2	Aq. inv.	Crayfish	06-28-88	<18	4.8	706	<22	83.8
F2	Aq. inv.	Composite	06-28-88	<32	10.2	148	<39	141
ST2	Fish	Sucker composite	06-28-88	<17	10.0	75.7	<22	91.7
ST2	Fish	Speckled dace	06-28-88	<14	15.7	141	<17	203
ST2	Fish	Fathead minnow	06-28-88	<17	12.8	194	<21	191
ST2	Aq. plants	Not determined	06-28-88	<39	5.8	158	<48	64.4
ST2	Aq. inv.	Crayfish	06-28-88	<16	4.5	1,120	<20	82.9
ST2	Aq. inv.	Composite	06-28-88	<70	7.0	42.1	<88	98.2
R2	Fish	Sucker composite	06-28-88	<12	2.2	13.4	<16	37.3
R2	Fish	Speckled dace	06-28-88	<13	17.1	148	<17	157
R2	Fish	Common carp	06-28-88	<17	5.0	104	<21	458
R2	Aq. plants	Not determined	06-28-88	<267	6.7	220	<333	<133
R2	Aq. inv.	Crayfish	06-28-88	<16	5.1	977	<20	78.5
Oxford	Mammal	Prairie dog	06-28-88	<17	23.0	99.6	<21	114
Tract	Mammal	Prairie dog	06-28-88	<13	7.4	70.7	<16	95.8
	Mammal	Prairie dog	06-28-88	<18	8.8	372	<22	130
	Mammal	Prairie dog	06-28-88	<20	4.5	136	<25	91.0
	Mammal	Prairie dog	06-28-88	<14	21.6	73.1	<18	88.0
	Mammal	Prairie dog	06-28-88	<17	14.2	155	<21	115
SP2	Fish	Brown trout	06-28-88	<15	3.4	70.2	<19	174
SP2	Fish	Bluehead sucker	06-28-88	<19	7.1	175	<24	117
SP2	Fish	Fathead minnow	06-28-88	<20	6.0	170	<25	231
SP2	Aq. inv.	Crayfish	06-28-88	<20	3.4	1,100	<24	90.2
SP2	Aq. inv.	Composite	06-28-88	<26	7.2	19.6	<33	113

Table 23. Trace-element concentrations in fish, aquatic-plant, aquatic-invertebrate, and prairie dog samples collected in June 1988--Continued

Site number (fig. 1)	Matrix	Species	Date	Mean length	Number in sample	Percent moisture	Aluminum	Arsenic	Barium	Beryllium	Boron
WSB2	Fish	Sucker composite	06-29-88	--	4	74.5	208	0.46	34.1	<2.0	<20
WSB2	Fish	Speckled dace	06-29-88	--	--	68.6	204	.29	24.2	<1.6	<16
WSB2	Fish	Fathead minnow	06-29-88	--	--	76.6	423	.41	79.9	<2.1	<21
WSB2	Aq. plants	Not determined	06-29-88	--	--	77.1	7,820	15.4	498	<2.2	<22
WSB2	Aq. inv.	Crayfish	06-29-88	--	--	77.9	213	1.7	252	<2.3	<23
SB2	Fish	Sucker composite	06-29-88	--	--	74.7	446	.56	54.9	<2.0	<20
SB2	Fish	Speckled dace	06-29-88	--	20	68.6	51	.30	18.8	<1.6	<16
SB2	Aq. plants	Not determined	06-29-88	--	--	73.5	2,790	3.6	257	<1.9	31
SB2	Aq. inv.	Crayfish	06-29-88	--	5	77.8	378	1.7	216	<2.3	<23
SB2	Aq. inv.	Composite	06-29-88	--	--	86.6	1,250	4.2	308	<3.7	<37
P1	Fish	Brown trout	06-29-88	186	6	75.9	<41.5	.23	<20.8	<2.1	<21
P1	Fish	Flannelmouth sucker	06-29-88	520	1	73.0	159	.50	<18.6	<1.9	<19
P1	Fish	Sucker composite	06-29-88	226	7	72.5	149	.59	<18.2	<1.8	<18
P1	Fish	Mottled sculpin	06-29-88	--	30	78.0	63.6	.37	<22.7	<2.3	<23
P1	Fish	Speckled dace	06-29-88	--	23	76.3	<42.2	4.6	<21.1	<2.1	<21
P1	Aq. plants	Not determined	06-29-88	--	--	82.9	7,190	4.6	161	<2.9	56
P1	Aq. inv.	Crayfish	06-29-88	--	--	73.0	196	1.5	107	<1.9	<19
P1	Aq. inv.	Composite	06-29-88	--	--	85.8	592	1.9	<35.2	<3.5	<35

Table 23. Trace-element concentrations in fish, aquatic-plant, aquatic-invertebrate, and prairie dog samples collected in June 1988--Continued

Site number (fig. 1)	Matrix	Species	Date	Cadmium	Chromium	Copper	Iron	Lead	Magnesium	Manganese	Mercury
WSB2	Fish	Sucker composite	06-29-88	<2.0	5.1	18.4	573	<39	1,960	55.7	0.38
WSB2	Fish	Speckled dace	06-29-88	<1.6	<3.2	<8.0	424	<32	1,110	24.2	.22
WSB2	Fish	Fathead minnow	06-29-88	<2.1	<4.3	12.0	560	<43	1,880	47.9	.21
WSB2	Aq. plants	Not determined	06-29-88	<2.2	33.6	30.6	21,000	<44	2,230	2,070	<.11
WSB2	Aq. inv.	Crayfish	06-29-88	<2.3	<4.5	174	443	<45	1,760	128	.11
SB2	Fish	Sucker composite	06-29-88	<2.0	<4.0	14.6	739	<40	1,620	80.2	<.10
SB2	Fish	Speckled dace	06-29-88	<1.6	<3.2	<8.0	156	<32	1,110	24.5	.27
SB2	Aq. plants	Not determined	06-29-88	<1.9	<3.8	12.8	6,720	<38	1,060	1,350	<.10
SB2	Aq. inv.	Crayfish	06-29-88	<2.3	<4.5	150	477	<45	1,670	118	.14
SB2	Aq. inv.	Composite	06-29-88	<3.7	<7.5	20.9	1,940	<75	1,040	1,160	.37
P1	Fish	Brown trout	06-29-88	<2.1	<4.2	<10.4	112	<42	1,160	7.9	.10
P1	Fish	Flannelmouth sucker	06-29-88	<3.9	<3.7	<9.3	570	<37	1,070	33.0	1.0
P1	Fish	Sucker composite	06-29-88	<1.8	<3.6	<9.1	473	<36	1,160	45.8	.09
P1	Fish	Mottled sculpin	06-29-88	<2.3	<4.5	<11.4	191	<45	1,500	47.7	<.11
P1	Fish	Speckled dace	06-29-88	<2.1	<4.2	<10.5	203	<42	1,390	22.8	.19
P1	Aq. plants	Not determined	06-29-88	<2.9	14.6	22.2	19,100	<59	4,970	860	.42
P1	Aq. inv.	Crayfish	06-29-88	<1.9	<3.7	83.0	393	<37	1,180	105	.16
P1	Aq. inv.	Composite	06-29-88	<3.5	<7.0	43.0	1,180	<70	2,040	174	.20

Table 23. Trace-element concentrations in fish, aquatic-plant, aquatic-invertebrate, and prairie dog samples collected in June 1988--Continued

Site number (fig. 1)	Matrix	Species	Date	Nickel	Selenium	Strontium	Vanadium	Zinc
WSB2	Fish	Sucker composite	06-29-88	<16	11.8	176	<20	109
WSB2	Fish	Speckled dace	06-29-88	<13	15.6	103	<16	147
WSB2	Fish	Fathead minnow	06-29-88	<17	17.1	201	<21	216
WSB2	Aq. plants	Not determined	06-29-88	23	1.3	114	23	103
WSB2	Aq. inv.	Crayfish	06-29-88	<18	5.9	873	<23	89.6
SB2	Fish	Sucker composite	06-29-88	<16	5.1	185	<20	98.8
SB2	Fish	Speckled dace	06-29-88	<13	12.1	141	<16	145
SB2	Aq. plants	Not determined	06-29-88	<15	.75	108	<19	34.0
SB2	Aq. inv.	Crayfish	06-29-88	<18	3.6	766	<23	91.4
SB2	Aq. inv.	Composite	06-29-88	<30	6.7	60.4	<37	119
P1	Fish	Brown trout	06-29-88	<17	3.3	29.9	<21	144
P1	Fish	Flannelmouth sucker	06-29-88	<15	1.5	23.3	<19	55.2
P1	Fish	Sucker composite	06-29-88	<15	1.5	60.7	<18	62.2
P1	Fish	Mottled sculpin	06-29-88	<18	7.3	112	<23	99.1
P1	Fish	Speckled dace	06-29-88	<17	5.5	106	<21	162
P1	Aq. plants	Not determined	06-29-88	<23	1.2	93.6	<29	67.2
P1	Aq. inv.	Crayfish	06-29-88	<15	1.1	626	<19	83.7
P1	Aq. inv.	Composite	06-29-88	<28	2.8	33.1	<35	196

Table 24. Trace-element concentrations in fish, aquatic-plant, and aquatic-invertebrate samples, November 1988-July 1989

[Analyses by U.S. Fish and Wildlife Service; concentrations in micrograms per gram dry weight; mean length in millimeters; all fish samples are whole-body samples unless noted otherwise; aq., aquatic; inv., invertebrates; ch., channel; <, less than; --, no data]

Site number (fig. 1)	Matrix	Species	Date	Mean length	Number in sample	Percent moisture	Aluminum	Arsenic	Barium	Beryllium	Boron
F2	Fish	Rainbow trout	11-16-88	390	1	70.9	110	<0.2	8.4	<0.01	<2
F2	Fish	Rainbow trout	07-18-89	320	1	71.2	21.0	<.2	2.4	<.1	<2
F2	Fish	White sucker	11-16-88	290	1	76.5	91.5	.3	11.8	<.01	<2
F2	Fish	Bluehead sucker	04-04-89	393	3	68.4	399	.6	9.0	<.1	<2
F2	Fish	Bluehead sucker	07-08-89	264	5	68.3	747	.9	87.9	<.1	<2
F2	Fish	Speckled dace	07-18-89	100	11	64.0	38.0	<.2	47.8	<.1	<2
F2	Aq. plants	Not determined	11-16-88	--	--	90.3	8,020	1.8	375	.4	8.7
F2	Aq. plants	Not determined	07-18-89	--	--	86.7	5,730	2.4	383	.2	81
F2	Aq. inv.	Crayfish	07-18-89	100	12	80.9	635	2.7	347	<.1	3
ST1	Fish	White sucker	04-06-89	204	4	76.5	344	<.2	18.9	<.1	<2
ST1	Fish	White sucker	07-19-89	250	1	71.4	465	<.2	13.6	<.1	<2
ST1	Fish	Speckled dace	07-19-89	80	7	69.1	230	<.2	17.3	<.1	<2
ST1	Aq. plants	Not determined	11-15-88	--	--	83.5	11,200	2.0	690	.7	70
ST1	Aq. inv.	Crayfish	04-06-89	60	3	72.8	1,290	1.1	612	<.1	<2
ST1	Aq. inv.	Crayfish	07-19-89	60	15	74.1	1,020	1.3	448	<.1	<2
ST2	Fish	Brown trout	11-15-88	260	1	71.5	8.8	<.2	2.8	<.01	<2
ST2	Fish	White sucker	11-15-88	180	2	78.0	145	<.2	28.4	<.01	<2
ST2	Fish	White sucker	07-18-89	170	3	75.7	1,240	.2	43.9	<.1	<2
ST2	Fish	Speckled dace	11-15-88	64	10	74.6	194	.2	31.9	.01	<2
ST2	Fish	Speckled dace	04-04-89	70	10	80.1	230	.2	30.9	<.1	<2
ST2	Fish	Speckled dace	07-18-89	80	28	70.1	110	<.2	25.2	<.1	<2
ST2	Fish	Fathead minnow	11-15-88	62	9	78.3	2,360	.5	169	.07	<2
ST2	Fish	Fathead minnow	04-04-89	50	7	80.3	1,630	.3	184	<.1	<2
ST2	Fish	Composite sucker	04-04-89	90	5	77.4	300	<.2	27.6	<.1	<2
ST2	Aq. plants	Not determined	11-15-88	--	--	86.5	8,390	2.2	282	.58	11
ST2	Aq. plants	Not determined	04-04-89	--	--	75.7	28,300	2.7	1,690	1.0	13
ST2	Aq. plants	Not determined	07-18-89	--	--	90.3	15,500	2.8	408	.41	93
ST2	Aq. inv.	Crayfish	04-04-89	--	7	74.1	2,150	1.2	818	<.1	<2
ST2	Aq. inv.	Crayfish	07-18-89	80	12	77.0	1,560	1.2	657	<.1	3
R1	Fish	White sucker	04-05-89	209	4	76.5	180	<.2	11.2	<.1	<2
R1	Fish	Speckled dace	04-05-89	70	25	73.7	280	.2	22.9	<.1	<2
R1	Fish	Fathead minnow	04-06-89	50	20	80.2	789	.3	90.3	<.1	<2
R1	Fish	Fathead minnow	07-19-89	60	21	76.2	5,810	1.0	132	.1	<2
R1	Aq. plants	Not determined	11-15-88	--	--	83.8	15,200	3.0	626	.97	<2
R1	Aq. plants	Not determined	04-06-89	--	--	78.4	11,800	.9	127	.33	7
R1	Aq. plants	Not determined	07-19-89	--	--	88.5	4,290	1.7	423	<.1	5
R1	Aq. inv.	Composite	11-15-88	--	--	89.6	933	.6	13.6	.04	<2
R1	Aq. inv.	Crayfish	04-03-89	--	1	74.9	2,140	1.5	582	<.1	<2
R1	Aq. inv.	Crayfish	07-19-89	80	6	74.6	1,400	1.0	437	<.1	<2

Table 24. Trace-element concentrations in fish, aquatic-plant, and aquatic-invertebrate samples, November 1988-July 1989--Continued

Site number (fig. 1)	Matrix	Species	Date	Cadmium	Chromium	Copper	Iron	Lead	Magnesium	Manganese	Mercury
F2	Fish	Rainbow trout	11-16-88	0.10	4.6	5.1	131	<0.5	1,050	17.0	0.27
F2	Fish	Rainbow trout	07-18-89	<.2	1.0	4.7	59	<4	806	3.2	.27
F2	Fish	White sucker	11-16-88	.20	3.7	3.0	150	<.5	1,150	33.2	.21
F2	Fish	Bluehead sucker	04-04-89	.3	1.0	3.4	385	<4	827	43.4	.09
F2	Fish	Bluehead sucker	07-08-89	.3	<1.0	4.9	750	<4	1,080	95.7	.06
F2	Fish	Speckled dace	07-18-89	<.2	<1.0	2.1	71	<4	911	10.0	.22
F2	Aq. plants	Not determined	11-16-88	.20	34.0	11.2	8,670	19	2,260	660	.02
F2	Aq. plants	Not determined	07-18-89	.4	8.2	7.2	5,500	<4	2,670	1,160	.03
F2	Aq. inv.	Crayfish	07-18-89	.2	<1.0	80.2	408	<4	1,530	105	.12
ST1	Fish	White sucker	04-06-89	<.2	2.0	4.9	346	<4	1,320	46.3	.11
ST1	Fish	White sucker	07-19-89	<.2	1.0	4.3	500	<4	1,060	24.0	.15
ST1	Fish	Speckled dace	07-19-89	<.2	<1.0	1.6	194	<4	1,030	19.0	.14
ST1	Aq. plants	Not determined	11-15-88	.20	15.0	10.8	10,400	17	2,490	3,750	.03
ST1	Aq. inv.	Crayfish	04-06-89	<.2	2.0	118	900	<4	1,610	519	.07
ST1	Aq. inv.	Crayfish	07-19-89	.2	2.0	120	793	<4	1,420	172	.05
ST2	Fish	Brown trout	11-15-88	.21	2.6	3.4	44.1	<.5	914	5.0	.43
ST2	Fish	White sucker	11-15-88	.16	2.2	6.5	203	<.5	1,600	52.1	.17
ST2	Fish	White sucker	07-18-89	<.2	2.0	3.7	1,080	<4	1,420	52.5	.12
ST2	Fish	Speckled dace	11-15-88	.28	1.9	3.4	162	<.5	1,270	29.8	.22
ST2	Fish	Speckled dace	04-04-89	.3	3.5	2.8	209	<4	1,290	23.0	.22
ST2	Fish	Speckled dace	07-18-89	.2	<.9	1.5	121	<.5	859	14.0	.21
ST2	Fish	Fathead minnow	11-15-88	.31	2.0	4.9	1,540	<.6	1,600	108	.21
ST2	Fish	Fathead minnow	04-04-89	.2	3.9	4.1	997	<4	1,490	133	.09
ST2	Fish	Composite sucker	04-04-89	<.2	1.0	3.5	238	<4	1,440	54.0	.19
ST2	Aq. plants	Not determined	11-15-88	.65	27.4	9.2	10,300	16	1,820	1,070	.02
ST2	Aq. plants	Not determined	04-04-89	.2	34.0	12.0	32,300	10	3,740	1,890	.03
ST2	Aq. plants	Not determined	07-18-89	.5	11.0	11.0	10,600	5	3,800	1,930	.05
ST2	Aq. inv.	Crayfish	04-04-89	.3	3.0	152	1,270	<4	1,540	464	.06
ST2	Aq. inv.	Crayfish	07-18-89	<.2	2.0	100	1,060	<4	1,490	206	.07
R1	Fish	White sucker	04-05-89	<.2	2.0	6.2	195	<4	1,320	33.2	.13
R1	Fish	Speckled dace	04-05-89	<.4	4.6	3.0	267	<7	1,300	31.0	.18
R1	Fish	Fathead minnow	04-06-89	.4	3.9	3.9	536	<5	1,410	53.4	.09
R1	Fish	Fathead minnow	07-19-89	<.2	6.5	7.9	3,510	<4	1,790	274	.09
R1	Aq. plants	Not determined	11-15-88	1.7	9.2	13.6	15,300	25	2,530	2,720	.03
R1	Aq. plants	Not determined	04-06-89	.5	15.0	4.7	5,910	<4	1,790	652	.06
R1	Aq. plants	Not determined	07-19-89	<.4	5.1	7.4	3,870	<5	1,730	4,360	.02
R1	Aq. inv.	Composite	11-15-88	.06	3.1	41.7	667	.7	970	59.2	.08
R1	Aq. inv.	Crayfish	04-03-89	.3	3.6	120	1,690	<4	1,620	1,520	.06
R1	Aq. inv.	Crayfish	07-19-89	.2	2.0	82.9	842	<4	1,570	384	.05

Table 24. Trace-element concentrations in fish, aquatic-plant, and aquatic-invertebrate samples, November 1988-July 1989--Continued

Site number (fig. 1)	Matrix	Species	Date	Nickel	Selenium	Strontium	Vanadium	Zinc
F2	Fish	Rainbow trout	11-16-88	3.7	7.6	35.1	<0.3	96.7
F2	Fish	Rainbow trout	07-18-89	<2.0	7.6	11.7	<.3	96.3
F2	Fish	White sucker	11-16-88	2.0	5.2	50.0	.5	61.3
F2	Fish	Bluehead sucker	04-04-89	1.0	.94	44.5	.7	84.5
F2	Fish	Bluehead sucker	07-08-89	<2.0	1.9	78.2	1.8	88.9
F2	Fish	Speckled dace	07-18-89	<2.0	8.9	77.7	<.3	102
F2	Aq. plants	Not determined	11-16-88	18.0	.89	209	12.0	29.3
F2	Aq. plants	Not determined	07-18-89	5.0	3.0	332	8.2	22.0
F2	Aq. inv.	Crayfish	07-18-89	<2.0	3.9	688	1.0	60.6
ST1	Fish	White sucker	04-06-89	<1.0	4.7	104	.7	76.2
ST1	Fish	White sucker	07-19-89	<2.0	4.9	53.5	1.1	66.9
ST1	Fish	Speckled dace	07-19-89	<2.0	6.8	81.5	.4	117
ST1	Aq. plants	Not determined	11-15-88	13.0	2.4	143	19.0	128
ST1	Aq. inv.	Crayfish	04-06-89	2.0	2.3	1,110	2.4	58.1
ST1	Aq. inv.	Crayfish	07-19-89	2.0	2.2	843	1.7	60.0
ST2	Fish	Brown trout	11-15-88	1.9	6.0	49.5	<.3	137
ST2	Fish	White sucker	11-15-88	1.7	8.3	153	.4	89.0
ST2	Fish	White sucker	07-18-89	<2.0	7.0	126	2.6	72.1
ST2	Fish	Speckled dace	11-15-88	2.8	8.5	122	.4	136
ST2	Fish	Speckled dace	04-04-89	2.0	10.7	134	.3	151
ST2	Fish	Speckled dace	07-18-89	<2.0	9.3	84.4	<.3	111
ST2	Fish	Fathead minnow	11-15-88	2.0	7.6	145	3.2	217
ST2	Fish	Fathead minnow	04-04-89	2.0	16.0	164	2.6	190
ST2	Fish	Composite sucker	04-04-89	<1.0	6.6	133	.6	112
ST2	Aq. plants	Not determined	11-15-88	17.0	.83	93.1	16.0	55.8
ST2	Aq. plants	Not determined	04-04-89	18.0	3.0	472	78.0	81.2
ST2	Aq. plants	Not determined	07-18-89	5.8	1.7	162	23.0	50.2
ST2	Aq. inv.	Crayfish	04-04-89	3.0	3.7	902	3.4	59.9
ST2	Aq. inv.	Crayfish	07-18-89	<2.0	3.0	1,000	2.6	60.6
R1	Fish	White sucker	04-05-89	1.0	9.5	76.8	.5	76.4
R1	Fish	Speckled dace	04-05-89	17.0	8.5	138	.6	152
R1	Fish	Fathead minnow	04-06-89	2.0	11.0	125	1.5	181
R1	Fish	Fathead minnow	07-19-89	3.0	11.0	120	9.1	152
R1	Aq. plants	Not determined	11-15-88	9.6	2.7	131	23.0	62.8
R1	Aq. plants	Not determined	04-06-89	7.3	1.3	50.6	18.0	44.5
R1	Aq. plants	Not determined	07-19-89	3.0	2.2	169	7.4	46.5
R1	Aq. inv.	Composite	11-15-88	.6	2.7	7.5	1.5	98.0
R1	Aq. inv.	Crayfish	04-03-89	3.0	3.5	793	4.6	60.7
R1	Aq. inv.	Crayfish	07-19-89	2.0	4.5	1,110	2.3	61.3

Table 24. Trace-element concentrations in fish, aquatic-plant, and aquatic-invertebrate samples, November 1988-July 1989--Continued

Site number (fig. 1)	Matrix	Species	Date	Mean length	Number in sample	Percent moisture	Aluminum	Arsenic	Barium	Beryllium	Boron
R2	Fish	Brown trout	11-14-88	265	4	72.0	25.0	<0.2	2.6	<.01	<2
R2	Fish	Brown trout	04-03-89	345	1	72.8	51.0	<.1	2.3	<.1	<2
R2	Fish	Brown trout	07-17-89	245	2	70.3	5.0	<.2	1.9	<.1	<2
R2	Fish	Ch. catfish	07-17-89	--	--	70.6	190	.2	17.8	<.1	<2
R2	Fish	Ch. catfish, fillet	07-17-89	500	2	77.6	25.0	<.2	.2	<.1	<2
R2	Fish	Bullhead	07-18-89	269	4	78.3	65.1	.2	15.8	<.01	<2
R2	Fish	Bullhead	07-17-89	268	3	80.0	41.0	.3	19.7	<.1	<2
R2	Fish	White sucker	04-03-89	345	4	77.0	110	<.2	8.4	<.1	<2
R2	Fish	White sucker	07-17-89	392	3	75.4	230	.2	14.0	<.1	<2
R2	Fish	Composite sucker	11-14-88	367	3	77.4	251	.3	17.3	<.01	<2
R2	Fish	Speckled dace	11-14-88	87	12	77.3	481	.4	29.8	.01	<2
R2	Fish	Common carp	04-03-89	387	3	76.4	336	<.2	18.8	<.1	<2
R2	Fish	Common carp	07-17-89	500	1	63.2	4.0	.5	5.5	<.1	<2
R2	Fish	Fathead minnow	04-03-89	70	40	79.6	2,110	.5	77.2	<.1	<2
R2	Fish	Fathead minnow	07-17-89	70	20	81.4	429	.2	72.9	<.1	<2
R2	Fish	Ch. catfish, fillet	04-03-89	--	1	79.8	20.0	<.2	.69	<.1	<2
R2	Fish	Ch. catfish, kidney	04-03-89	--	1	83.2	30.0	<.2	.73	<.1	<2
R2	Fish	Ch. catfish, liver	04-03-89	--	1	80.1	30.0	<.2	.2	<.1	<2
R2	Fish	Ch. catfish, eggs	04-03-89	--	--	73.4	<10.0	<.2	1.7	<.1	<2
R2	Aq. plants	Not determined	04-06-89	--	--	86.5	32,100	20.0	448	1.6	26
R2	Aq. plants	Not determined	07-17-89	--	--	86.1	4,010	.9	331	<.1	209
R2	Aq. inv.	Crayfish	04-03-89	--	1	74.9	1,350	.9	506	.1	<2
R2	Aq. inv.	Crayfish	07-17-89	--	11	80.7	1,120	1.1	266	<.1	3
D1	Fish	Bluehead sucker	04-05-89	100	3	79.6	971	.3	48.4	<.1	<2
D1	Fish	Sucker composite	11-16-88	--	--	78.5	1,350	.3	43.1	.03	<2
D1	Fish	Speckled dace	11-16-88	--	--	76.0	490	.2	40.7	.02	<2
D1	Fish	Speckled dace	04-05-89	55	48	76.8	801	.2	44.5	<.1	<2
D1	Fish	Speckled dace	07-19-89	60	25	73.0	311	<.2	41.2	<.1	<2
D1	Fish	Fathead minnow	11-16-88	--	--	79.0	3,000	.8	217	.09	<2
D1	Fish	Fathead minnow	04-05-89	60	50	79.3	5,760	.9	213	.1	<2
D1	Aq. plants	Not determined	11-16-88	--	--	85.1	15,800	3.1	483	.9	<2
D1	Aq. inv.	Crayfish	07-19-89	80	6	78.3	1,340	.9	439	<.1	<2

Table 24. Trace-element concentrations in fish, aquatic-plant, and aquatic-invertebrate samples, November 1988-July 1989--Continued

Site number (fig. 1)	Matrix	Species	Date	Cadmium	Chromium	Copper	Iron	Lead	Magnesium	Manganese	Mercury
R2	Fish	Brown trout	11-14-88	0.10	2.9	5.8	63.9	<0.5	976	7.7	0.26
R2	Fish	Brown trout	04-03-89	<.2	1.0	6.2	87.0	<4	1,060	4.2	.56
R2	Fish	Brown trout	07-17-89	<.2	1.0	5.2	43.0	<4	828	2.9	.52
R2	Fish	Ch. catfish	07-17-89	<.2	1.0	7.0	212	<4	745	17.0	.34
R2	Fish	Ch. catfish, fillet	07-17-89	<.2	<.9	.84	26.0	<4	929	.87	.61
R2	Fish	Bullhead	07-18-89	.19	4.1	3.6	152	<.5	1,330	17.4	.54
R2	Fish	Bullhead	07-17-89	<.2	1.0	11.0	143	<4	1,360	11.0	.55
R2	Fish	White sucker	04-03-89	<.2	2.0	4.2	191	<4	1,310	25.0	.38
R2	Fish	White sucker	07-17-89	.2	<1.0	4.1	447	<4	1,180	33.3	.65
R2	Fish	Composite sucker	11-14-88	.21	3.8	4.1	231	<.5	1,290	52.7	.42
R2	Fish	Speckled dace	11-14-88	.11	1.2	3.2	419	<.5	1,470	41.6	.15
R2	Fish	Common carp	04-03-89	<.2	1.0	4.4	369	<4	1,420	24.0	.53
R2	Fish	Common carp	07-17-89	.8	<1.0	3.3	97.1	<4	667	4.0	.81
R2	Fish	Fathead minnow	04-03-89	<.2	4.3	4.4	1,410	<5	1,540	55.8	.38
R2	Fish	Fathead minnow	07-17-89	<.2	<1.0	5.5	359	<4	1,490	32.5	.65
R2	Fish	Ch. catfish, fillet	04-03-89	<.2	1.0	2.0	52.0	<4	857	1.8	2.1
R2	Fish	Ch. catfish, kidney	04-03-89	8.0	3.5	3.5	560	<4	610	3.9	1.2
R2	Fish	Ch. catfish, liver	04-03-89	1.5	1.0	34.4	830	<4	624	5.3	1.9
R2	Fish	Ch. catfish, eggs	04-03-89	<.2	<1.0	4.1	150	<4	1,130	15.0	.12
R2	Aq. plants	Not determined	04-06-89	1.5	18.0	13.0	20,900	10	3,580	1,750	.05
R2	Aq. plants	Not determined	07-17-89	.6	6.7	14.0	3,280	<4	2,580	2,980	.02
R2	Aq. inv.	Crayfish	04-03-89	<.3	3.0	134	890	<6	1,590	679	.06
R2	Aq. inv.	Crayfish	07-17-89	.2	2.0	109	806	<4	1,560	250	.07
D1	Fish	Bluehead sucker	04-05-89	<.2	3.0	11.0	770	<4	1,720	85.4	.27
D1	Fish	Sucker composite	11-16-88	.17	2.2	6.8	855	1	1,720	91.4	.33
D1	Fish	Speckled dace	11-16-88	.36	6.1	3.6	388	<.5	1,390	47.8	.39
D1	Fish	Speckled dace	04-05-89	<.3	5.4	4.0	585	<5	1,500	87.6	.42
D1	Fish	Speckled dace	07-19-89	<.2	<1.0	3.0	232	<4	1,270	31.0	.37
D1	Fish	Fathead minnow	11-16-88	.19	2.5	4.8	1,950	<.6	1,640	142	.18
D1	Fish	Fathead minnow	04-05-89	<.2	6.3	5.5	3,570	<4	1,910	212	.23
D1	Aq. plants	Not determined	11-16-88	.10	5.7	19.0	19,100	23	3,310	2,540	.03
D1	Aq. inv.	Crayfish	07-19-89	<.2	1.0	151	807	<4	1,670	244	.13

Table 24. Trace-element concentrations in fish, aquatic-plant, and aquatic-invertebrate samples, November 1988-July 1989--Continued

Site number (fig. 1)	Matrix	Species	Date	Nickel	Selenium	Strontium	Vanadium	Zinc
R2	Fish	Brown trout	11-14-88	0.93	5.4	41.7	<0.3	115
R2	Fish	Brown trout	04-03-89	<1.0	6.7	51.2	<.3	105
R2	Fish	Brown trout	07-17-89	<2.0	5.9	13.5	<.3	98.2
R2	Fish	Ch. catfish	07-17-89	<2.0	3.0	66.5	.4	43.5
R2	Fish	Ch. catfish, fillet	07-17-89	<2.0	2.6	1.3	<.3	23.0
R2	Fish	Bullhead	07-18-89	4.6	3.5	129	.6	83.0
R2	Fish	Bullhead	07-17-89	<2.0	4.0	96.9	.6	81.3
R2	Fish	White sucker	04-03-89	<1.0	5.4	98.4	.4	64.3
R2	Fish	White sucker	07-17-89	<2.0	4.2	68.2	.9	58.4
R2	Fish	Composite sucker	11-14-88	4.8	5.0	94.9	<.3	67.2
R2	Fish	Speckled dace	11-14-88	.50	6.0	137	.8	123
R2	Fish	Common carp	04-03-89	<1.0	4.8	140	.8	180
R2	Fish	Common carp	07-17-89	<2.0	3.3	27.7	<.3	352
R2	Fish	Fathead minnow	04-03-89	2.0	6.6	125	3.2	159
R2	Fish	Fathead minnow	07-17-89	<2.0	6.6	112	.9	162
R2	Fish	Ch. catfish, fillet	04-03-89	<1.0	1.7	1.5	<.3	26.0
R2	Fish	Ch. catfish, kidney	04-03-89	3.0	12.0	2.6	7.1	81.2
R2	Fish	Ch. catfish, liver	04-03-89	<1.0	10.3	.88	2.1	124
R2	Fish	Ch. catfish, eggs	04-03-89	<1.0	13.5	10.7	.5	360
R2	Aq. plants	Not determined	04-06-89	12.0	3.9	255	46.9	91.3
R2	Aq. plants	Not determined	07-17-89	4.0	1.8	127	7.0	40.7
R2	Aq. inv.	Crayfish	04-03-89	6.9	3.5	770	2.3	59.7
R2	Aq. inv.	Crayfish	07-17-89	<2.0	3.9	685	2.2	65.1
D1	Fish	Bluehead sucker	04-05-89	<1.0	2.8	278	1.6	145
D1	Fish	Sucker composite	11-16-88	1.2	2.3	276	2.0	124
D1	Fish	Speckled dace	11-16-88	6.5	3.5	280	.9	229
D1	Fish	Speckled dace	04-05-89	7.1	3.7	300	1.2	224
D1	Fish	Speckled dace	07-19-89	<2.0	3.4	250	.5	209
D1	Fish	Fathead minnow	11-16-88	1.4	3.7	247	4.0	214
D1	Fish	Fathead minnow	04-05-89	3.0	3.8	284	7.6	187
D1	Aq. plants	Not determined	11-16-88	6.1	.77	739	20.0	66.2
D1	Aq. inv.	Crayfish	07-19-89	<2.0	1.2	1,590	1.8	66.4

Table 24. Trace-element concentrations in fish, aquatic-plant, and aquatic-invertebrate samples, November 1988-July 1989--Continued

Site number (fig. 1)	Matrix	Species	Date	Mean length	Number in sample	Percent moisture	Aluminum	Arsenic	Barium	Beryllium	Boron
D2	Fish	Brown trout	11-16-88	281	5	76.8	36.0	<0.2	2.5	<0.01	<2
D2	Fish	Brown trout	04-05-89	320	1	77.3	26.0	.1	1.6	<.1	<2
D2	Fish	Brown trout	07-17-89	373	3	72.6	15.0	.3	3.1	<.1	<2
D2	Fish	White sucker	11-16-88	238	6	77.1	320	.3	20.4	<.01	<2
D2	Fish	White sucker	04-05-89	201	8	74.3	140	<.2	12.0	<.1	<2
D2	Fish	Bluehead sucker	11-16-88	251	5	72.8	1,140	.4	29.3	<.02	<2
D2	Fish	Bluehead sucker	07-17-89	323	2	67.6	1,560	.5	33.5	<.1	<2
D2	Fish	Speckled dace	11-16-88	80	4	72.9	427	.2	21.1	.02	<2
D2	Fish	Speckled dace	04-05-89	60	25	76.0	160	.2	14.5	<.1	<2
D2	Fish	Speckled dace	07-17-89	80	19	74.5	150	<.2	21.6	<.1	<2
D2	Fish	Common carp	07-17-89	585	1	79.1	280	<.2	20.3	<.1	<2
D2	Aq. plants	Not determined	07-19-89	--	--	82.9	7,650	2.2	293	.3	160
D2	Aq. inv.	Crayfish	04-03-89	--	2	70.2	1,210	.5	514	.1	<2
D2	Aq. inv.	Crayfish	07-19-89	60	7	74.7	1,190	.8	290	<.1	5
LP1	Fish	Rainbow trout	04-05-89	310	2	72.6	110	.2	7.3	<.1	<2
LP1	Fish	Mottled sculpin	11-30-88	81	15	77.9	105	.4	15.5	<.01	<2
LP1	Fish	Mottled sculpin	04-05-89	90	24	79.7	100	.3	14.3	<.1	<2
LP1	Aq. plants	Algae	04-05-89	--	--	98.9	6,060	6.5	91.9	.3	15
LP2	Fish	Rainbow trout	11-16-88	390	3	71.9	351	.2	10.0	.03	<2
LP2	Fish	Rainbow trout-fillet	04-04-89	--	2	75.1	<10	.2	.87	<.1	<2
LP2	Fish	Brown trout	11-16-88	357	3	73.7	26.0	.3	1.9	<.01	<2
LP2	Fish	Brown trout	04-04-89	355	3	73.7	100	.5	3.7	<.1	<2
LP2	Fish	Brown trout	07-19-89	325	1	72.9	130	<.2	3.7	<.1	<2
LP2	Fish	Mottled sculpin	04-04-89	93	2	77.5	354	.2	15.9	<.1	<2
LP2	Fish	Mottled sculpin	07-19-89	85	20	78.6	170	<.2	10.9	<.1	<2
LP2	Aq. plants	Not determined	04-05-89	--	--	84.3	6,260	4.2	230	.6	<2
LP2	Aq. inv.	Crayfish	07-19-89	--	3	78.6	856	1.5	203	<.1	<2
LP3	Fish	Rainbow trout	07-17-89	370	2	73.1	130	<.2	5.7	<.1	<2
LP3	Fish	Brown trout	11-14-88	418	3	77.6	7.1	.8	2.1	<.01	<2
LP3	Fish	Brown trout	07-17-89	320	1	73.7	11.0	<.2	1.1	<.1	<2
LP3	Fish	Flannelmouth sucker	11-14-88	450	3	70.5	678	.4	24.6	.02	<2
LP3	Fish	Flannelmouth sucker	07-17-89	435	2	65.9	506	.2	16.1	<.1	<2
LP3	Fish	White sucker	04-03-89	375	2	72.6	200	.3	14.1	<.1	<2
LP3	Fish	Mottled sculpin	11-14-88	78	12	76.2	179	.4	23.9	<.01	<2
LP3	Fish	Mottled sculpin	04-03-89	70	5	78.0	240	.3	15.6	<.1	<2
LP3	Fish	Mottled sculpin	07-17-89	90	11	73.9	94.0	<.2	16.0	<.1	<2
LP3	Fish	Speckled dace	07-17-89	70	6	69.0	71.0	<.2	28.0	<.1	<2
LP3	Aq. plants	Not determined	07-17-89	--	--	87.5	3,980	1.3	255	.2	89
LP3	Aq. inv.	Crayfish	04-03-89	--	3	72.8	660	.7	398	.1	<2
LP3	Aq. inv.	Crayfish	07-17-89	--	--	75.6	820	1.1	305	<.1	<2

Table 24. Trace-element concentrations in fish, aquatic-plant, and aquatic-invertebrate samples, November 1988-July 1989--Continued

Site number (fig. 1)	Matrix	Species	Date	Cadmium	Chromium	Copper	Iron	Lead	Magnesium	Manganese	Mercury
D2	Fish	Brown trout	11-16-88	0.10	2.9	12.1	97.5	<0.5	1,140	8.3	0.46
D2	Fish	Brown trout	04-05-89	<.5	3.7	6.6	103	<6	989	6.5	.45
D2	Fish	Brown trout	07-17-89	<.2	<.9	7.9	62.0	<4	857	4.4	.38
D2	Fish	White sucker	11-16-88	.15	1.5	5.3	407	<.5	1,440	60.5	.22
D2	Fish	White sucker	04-05-89	<.2	3.7	8.3	205	<4	1,230	42.5	.18
D2	Fish	Bluehead sucker	11-16-88	.07	2.6	3.3	754	.7	1,150	93.0	.09
D2	Fish	Bluehead sucker	07-17-89	<.2	3.7	4.4	1,250	<4	1,140	93.4	.10
D2	Fish	Speckled dace	11-16-88	.29	2.4	2.5	307	<.5	1,240	42.2	.15
D2	Fish	Speckled dace	04-05-89	<.2	3.8	2.8	165	<4	1,250	28.0	.15
D2	Fish	Speckled dace	07-17-89	<.2	<1.0	.97	202	<4	1,070	24.0	.17
D2	Fish	Common carp	07-17-89	.3	2.0	5.5	314	<4	1,310	19.0	.71
D2	Aq. plants	Not determined	07-19-89	<.3	22.0	8.7	10,200	7	3,250	1,660	.03
D2	Aq. inv.	Crayfish	04-03-89	<.2	2.0	99.4	710	<4	2,010	733	.06
D2	Aq. inv.	Crayfish	07-19-89	<.2	2.0	86.7	817	<4	1,580	211	.05
LP1	Fish	Rainbow trout	04-05-89	<.3	3.0	4.1	217	<5	1,010	54.0	.16
LP1	Fish	Mottled sculpin	11-30-88	.36	1.4	4.6	151	<.6	1,320	84.8	.17
LP1	Fish	Mottled sculpin	04-05-89	.3	2.0	3.2	160	<4	1,270	84.0	.15
LP1	Aq. plants	Algae	04-05-89	<.5	16.0	8.2	4,310	<9	2,700	467	.04
LP2	Fish	Rainbow trout	11-16-88	.18	12.0	6.2	516	<.5	999	76.6	.34
LP2	Fish	Rainbow trout-fillet	04-04-89	<.3	2.0	1.0	20.0	<4	1,000	1.3	.29
LP2	Fish	Brown trout	11-16-88	.20	5.0	7.8	104	<.5	1,030	14.5	.33
LP2	Fish	Brown trout	04-04-89	<.2	3.1	10.0	178	<4	1,040	29.0	.36
LP2	Fish	Brown trout	07-19-89	<.2	<1.0	16.0	187	<4	863	20.1	.19
LP2	Fish	Mottled sculpin	04-04-89	<.2	3.2	2.9	299	<4	1,600	47.0	.22
LP2	Fish	Mottled sculpin	07-19-89	<.2	1.0	2.5	252	<4	1,220	45.5	.16
LP2	Aq. plants	Not determined	04-05-89	1.1	15.0	12.3	15,100	8	2,430	3,120	.05
LP2	Aq. inv.	Crayfish	07-19-89	.4	2.0	85.8	1,540	<4	1,640	498	.12
LP3	Fish	Rainbow trout	07-17-89	<.2	<1.0	2.3	162	<4	953	41.7	.26
LP3	Fish	Brown trout	11-14-88	.08	3.2	8.4	118	<.5	1,170	4.8	.42
LP3	Fish	Brown trout	07-17-89	<.2	1.0	5.2	76.0	<4	964	3.2	.36
LP3	Fish	Flannelmouth sucker	11-14-88	.28	3.1	2.8	757	<.5	1,040	108	.36
LP3	Fish	Flannelmouth sucker	07-17-89	<.2	1.0	2.0	513	<4	797	41.6	.23
LP3	Fish	White sucker	04-03-89	<.2	2.0	3.5	267	<4	1,060	47.5	.21
LP3	Fish	Mottled sculpin	11-14-88	.18	1.9	2.4	209	<.5	1,200	108	.16
LP3	Fish	Mottled sculpin	04-03-89	<.5	3.6	2.6	228	<8	1,120	95.6	.12
LP3	Fish	Mottled sculpin	07-17-89	<.2	1.0	2.3	104	<4	1,120	61.7	.15
LP3	Fish	Speckled dace	07-17-89	<.2	<1.0	.84	108	<4	1,130	28.2	.31
LP3	Aq. plants	Not determined	07-17-89	1.8	4.8	6.9	4,070	<4	2,550	1,980	.02
LP3	Aq. inv.	Crayfish	04-03-89	<.2	1.0	64.8	550	<4	1,710	344	.10
LP3	Aq. inv.	Crayfish	07-17-89	<.2	1.0	84.0	501	<4	1,540	183	.08

Table 24. Trace-element concentrations in fish, aquatic-plant, and aquatic-invertebrate samples, November 1988-July 1989--Continued

Site number (fig. 1)	Matrix	Species	Date	Nickel	Selenium	Strontium	Vanadium	Zinc
D2	Fish	Brown trout	11-16-88	1.0	3.5	47.3	<0.3	161
D2	Fish	Brown trout	04-05-89	3.0	3.5	22.2	.7	118
D2	Fish	Brown trout	07-17-89	<2.0	3.2	20.1	<.3	76.5
D2	Fish	White sucker	11-16-88	1.2	2.5	102	.7	75.7
D2	Fish	White sucker	04-05-89	2.0	1.9	82.0	.4	63.2
D2	Fish	Bluehead sucker	11-16-88	1.4	2.3	81.0	1.7	54.7
D2	Fish	Bluehead sucker	07-17-89	<2.0	1.6	65.0	3.0	51.2
D2	Fish	Speckled dace	11-16-88	1.1	4.9	89.9	.7	119
D2	Fish	Speckled dace	04-05-89	2.0	6.8	103	<.3	128
D2	Fish	Speckled dace	07-17-89	<2.0	6.5	86.4	.5	130
D2	Fish	Common carp	07-17-89	<2.0	3.7	87.9	.7	221
D2	Aq. plants	Not determined	07-19-89	12.0	.83	145	16.0	58.8
D2	Aq. inv.	Crayfish	04-03-89	2.0	1.4	933	1.9	66.8
D2	Aq. inv.	Crayfish	07-19-89	2.0	1.5	636	2.2	60.0
LP1	Fish	Rainbow trout	04-05-89	2.0	1.5	13.3	<.3	82.6
LP1	Fish	Mottled sculpin	11-30-88	1.0	3.1	70.8	.5	100
LP1	Fish	Mottled sculpin	04-05-89	<1.0	3.3	64.8	.5	89.6
LP1	Aq. plants	Algae	04-05-89	19.0	.20	62.4	9.5	48.0
LP2	Fish	Rainbow trout	11-16-88	8.4	1.4	18.4	.6	71.8
LP2	Fish	Rainbow trout-fillet	04-04-89	9.7	1.0	.66	<.3	15.0
LP2	Fish	Brown trout	11-16-88	5.8	1.7	22.8	<.3	109
LP2	Fish	Brown trout	04-04-89	1.0	2.1	28.0	.3	107
LP2	Fish	Brown trout	07-19-89	<2.0	1.6	13.4	.4	87.5
LP2	Fish	Mottled sculpin	04-04-89	3.6	2.2	61.4	1.0	85.8
LP2	Fish	Mottled sculpin	07-19-89	<2.0	3.1	54.2	.8	60.9
LP2	Aq. plants	Not determined	04-05-89	11.0	.60	47.9	16.0	103
LP2	Aq. inv.	Crayfish	07-19-89	<2.0	1.0	430	1.7	68.1
LP3	Fish	Rainbow trout	07-17-89	<2.0	1.9	19.3	<.3	63.2
LP3	Fish	Brown trout	11-14-88	.97	2.1	37.1	<.3	123
LP3	Fish	Brown trout	07-17-89	<2.0	2.8	15.0	<.3	126
LP3	Fish	Flannelmouth sucker	11-14-88	1.5	.92	57.3	1.5	54.7
LP3	Fish	Flannelmouth sucker	07-17-89	<2.0	1.4	27.8	1.1	37.0
LP3	Fish	White sucker	04-03-89	<1.0	2.5	62.4	.5	60.2
LP3	Fish	Mottled sculpin	11-14-88	1.3	3.9	103	.9	75.8
LP3	Fish	Mottled sculpin	04-03-89	3.0	4.2	85.3	1.2	70.0
LP3	Fish	Mottled sculpin	07-17-89	<2.0	4.9	83.7	.5	61.9
LP3	Fish	Speckled dace	07-17-89	<2.0	6.0	99.5	.3	123
LP3	Aq. plants	Not determined	07-17-89	3.0	.77	136	6.2	60.4
LP3	Aq. inv.	Crayfish	04-03-89	<1.0	.83	690	1.8	57.0
LP3	Aq. inv.	Crayfish	07-17-89	<2.0	1.4	540	1.3	68.3

Table 24. Trace-element concentrations in fish, aquatic-plant, and aquatic-invertebrate samples, November 1988-July 1989--Continued

Site number (fig. 1)	Matrix	Species	Date	Mean length	Number in sample	Percent moisture	Aluminum	Arsenic	Barium	Beryllium	Boron
LP4	Fish	Brown trout	11-30-88	423	3	76.1	17.0	0.8	1.7	<0.01	<2
LP4	Fish	Ch. catfish-fillet	07-19-89	470	2	78.9	8.0	<.2	.2	<.1	<2
LP4	Fish	Ch. catfish	07-19-89	420	1	72.1	230	<.2	15.8	<.1	<2
LP4	Fish	Flannelmouth sucker	04-04-89	427	3	69.6	82.0	.3	9.3	<.1	<2
LP4	Fish	Flannelmouth sucker	07-19-89	360	4	68.1	313	.2	93.6	<.1	<2
LP4	Fish	White sucker	04-04-89	320	4	71.7	180	.3	18.8	<.1	<2
LP4	Fish	Speckled dace	07-19-89	80	8	66.9	210	<.2	93.1	<.1	<2
LP4	Aq. plants	Not determined	11-30-88	--	--	88.0	4,840	3.8	654	.4	140
LP4	Aq. inv.	Crayfish	07-17-89	--	--	75.3	978	1.1	276	<.1	5
B1	Fish	Brown trout	04-05-89	440	1	75.2	97.0	<.2	8.4	<.1	<2
B1	Fish	White sucker	07-19-89	355	2	77.3	3,090	.5	50.7	.2	<2
B1	Fish	Bluehead sucker	11-17-88	88	16	77.5	5,210	1.0	83.5	.2	<2
B1	Fish	Bluehead sucker	04-05-89	144	1	76.3	1,830	.7	49.4	<.1	<2
B1	Fish	Speckled dace	11-17-88	60	10	78.0	550	.5	44.4	.02	<2
B1	Fish	Speckled dace	07-19-89	60	40	74.1	398	<.2	45.9	<.1	<2
B1	Fish	Fathead minnow	11-17-88	40	20	77.4	3,390	.9	150	.1	<2
B1	Fish	Composite species	04-05-89	50	10	78.0	773	.4	72.6	<.1	<2
B1	Aq. plants	Not determined	11-17-88	--	--	92.0	12,000	4.2	313	.8	11
B1	Aq. inv.	Crayfish	04-05-89	40	3	74.6	1,430	1.1	639	<.1	<2
B1	Aq. inv.	Crayfish	07-19-89	80	11	77.0	1,620	1.3	601	<.1	<2
B2	Fish	Brown trout	11-17-88	--	--	71.3	29.0	.6	4.5	<.01	<2
B2	Fish	Brown trout	04-05-89	250	1	75.2	57.0	.2	2.6	<.1	<2
B2	Fish	Brown trout	07-18-89	445	1	69.5	14.0	<.2	.81	<.1	<2
B2	Fish	Bluehead sucker	07-18-89	298	5	73.4	2,360	.6	45.6	<.1	<2
B2	Fish	Sucker composite	04-05-89	245	3	74.9	524	.2	23.6	<.1	<2
B2	Fish	Speckled dace	07-18-89	80	8	69.0	341	<.2	22.4	<.1	<2
B2	Aq. inv.	Crayfish	04-04-89	--	4	72.8	970	.6	262	<.1	<3
B2	Aq. inv.	Crayfish	07-18-89	60	11	78.6	1,160	1.6	326	<.1	<2
U1	Fish	Bluehead sucker	04-05-89	100	3	76.7	503	.2	27.8	<.1	<2
U1	Fish	Sucker composite	11-15-88	118	4	76.2	316	.3	22.3	.01	<2
U1	Fish	Speckled dace	11-15-88	75	25	70.9	116	.3	17.4	<.01	<2
U1	Fish	Speckled dace	04-05-89	80	50	72.5	160	.3	17.1	<.1	<2
U1	Fish	Speckled dace	07-19-89	70	17	71.0	804	<.2	23.1	.1	<2
U1	Fish	Fathead minnow	04-05-89	60	18	76.9	1,140	.4	62.0	<.1	<2
U1	Aq. plants	Not determined	11-15-88	--	--	83.0	9,040	3.8	347	.77	69
U1	Aq. inv.	Crayfish	04-05-89	46	5	71.2	1,720	1.1	370	.1	2
U1	Aq. inv.	Crayfish	07-19-89	70	8	72.3	1,570	1.5	361	<.1	2
U2	Fish	Sucker composite	04-05-89	80	6	76.8	388	.4	19.7	<.1	<2
U2	Fish	Speckled dace	11-15-88	--	60	77.8	2,180	.97	84.7	.08	<2
U2	Fish	Speckled dace	04-05-89	70	28	75.1	439	<.2	19.1	<.1	<2
U2	Fish	Speckled dace	07-19-89	50	55	73.8	110	<.2	14.7	<.1	<2
U2	Aq. plants	Not determined	11-15-88	--	--	67.0	4,910	3.7	271	.44	4
U2	Aq. inv.	Crayfish	04-06-89	60	13	73.2	1,450	1.6	403	.1	<2
U2	Aq. inv.	Crayfish	07-20-89	70	6	73.0	1,080	2.2	241	<.1	3

Table 24. Trace-element concentrations in fish, aquatic-plant, and aquatic-invertebrate samples, November 1988-July 1989--Continued

Site number (fig. 1)	Matrix	Species	Date	Cadmium	Chromium	Copper	Iron	Lead	Magnesium	Manganese	Mercury
LP4	Fish	Brown trout	11-30-88	0.12	3.1	6.3	105	<0.5	1,160	4.4	0.56
LP4	Fish	Ch. catfish-fillet	07-19-89	<.2	1.0	1.4	27.0	<4	1,050	.91	.40
LP4	Fish	Ch. catfish	07-19-89	<.2	2.0	2.8	281	<4	893	19.5	1.3
LP4	Fish	Flannelmouth sucker	04-04-89	<.2	<1.0	2.3	160	<4	752	25.0	.18
LP4	Fish	Flannelmouth sucker	07-19-89	<.2	1.0	5.5	350	<4	895	45.1	.14
LP4	Fish	White sucker	04-04-89	<.2	3.0	3.9	217	<4	1,130	54.2	.16
LP4	Fish	Speckled dace	07-19-89	<.2	<1.0	.86	289	<4	1,000	42.8	.28
LP4	Aq. plants	Not determined	11-30-88	3.5	18.9	10.2	9,100	7	1,710	3,940	.02
LP4	Aq. inv.	Crayfish	07-17-89	<.2	2.0	68.6	573	<4	1,610	341	.07
B1	Fish	Brown trout	04-05-89	<.2	3.0	18.0	145	<5	1,070	14.0	.92
B1	Fish	White sucker	07-19-89	<.2	4.2	3.6	2,420	<4	1,770	93.0	.54
B1	Fish	Bluehead sucker	11-17-88	.27	5.1	6.4	3,200	2.0	1,860	178	.13
B1	Fish	Bluehead sucker	04-05-89	.3	5.3	4.2	1,740	<4	1,450	64.2	.12
B1	Fish	Speckled dace	11-17-88	.49	4.1	3.9	484	<.5	1,300	47.6	.38
B1	Fish	Speckled dace	07-19-89	.2	<1.0	2.7	304	<4	1,260	29.1	.26
B1	Fish	Fathead minnow	11-17-88	.46	2.9	5.6	1,970	<.6	1,590	88.3	.12
B1	Fish	Composite species	04-05-89	<.3	3.2	3.6	664	<5	1,370	39.3	.21
B1	Aq. plants	Not determined	11-17-88	.20	38.5	18.4	17,100	19	2,600	1,560	.04
B1	Aq. inv.	Crayfish	04-05-89	.3	3.6	186	1,330	<5	1,810	822	.18
B1	Aq. inv.	Crayfish	07-19-89	.2	3.0	155	1,340	<4	2,450	172	.10
B2	Fish	Brown trout	11-17-88	.14	2.3	6.7	106	<.5	919	9.2	.38
B2	Fish	Brown trout	04-05-89	<.2	3.5	4.9	95.0	<4	1,070	7.5	.18
B2	Fish	Brown trout	07-18-89	<.2	<1.0	6.3	55.0	<4	853	2.7	.57
B2	Fish	Bluehead sucker	07-18-89	<.2	4.1	8.1	1,440	<4	1,410	107	.14
B2	Fish	Sucker composite	04-05-89	<.2	5.2	3.7	468	<5	1,360	74.5	.16
B2	Fish	Speckled dace	07-18-89	<.2	<1.0	4.1	313	<4	1,060	32.7	.23
B2	Aq. inv.	Crayfish	04-04-89	.5	3.0	90.5	570	<6	860	485	.09
B2	Aq. inv.	Crayfish	07-18-89	.4	3.1	138	993	<4	1,760	164	.09
U1	Fish	Bluehead sucker	04-05-89	<.2	1.0	4.4	349	<4	1,400	49.9	.09
U1	Fish	Sucker composite	11-15-88	.17	2.2	6.8	270	<.5	1,470	53.5	.19
U1	Fish	Speckled dace	11-15-88	.18	1.1	2.7	146	<.5	1,070	17.3	.19
U1	Fish	Speckled dace	04-05-89	<.2	2.0	2.6	265	<4	1,240	20.0	.25
U1	Fish	Speckled dace	07-19-89	.2	1.0	2.1	619	<4	1,090	34.7	.22
U1	Fish	Fathead minnow	04-05-89	<.3	5.9	4.3	713	<6	1,340	49.9	.20
U1	Aq. plants	Not determined	11-15-88	.82	9.3	16.5	12,600	19	2,140	1,580	.04
U1	Aq. inv.	Crayfish	04-05-89	.3	2.0	127	1,110	<4	1,920	769	.06
U1	Aq. inv.	Crayfish	07-19-89	.3	3.4	134	1,060	<4	1,990	306	.06
U2	Fish	Sucker composite	04-05-89	<.2	2.0	4.5	319	<4	1,500	60.5	.13
U2	Fish	Speckled dace	11-15-88	.21	2.3	4.9	1,450	<.6	1,540	121	.15
U2	Fish	Speckled dace	04-05-89	<.2	3.6	3.0	314	<5	1,290	31.7	.14
U2	Fish	Speckled dace	07-19-89	<.2	<.9	2.7	140	<4	1,100	15.0	.17
U2	Aq. plants	Not determined	11-15-88	.29	24.7	7.5	9,640	8.0	1,370	722	.01
U2	Aq. inv.	Crayfish	04-06-89	.3	3.0	127	1,180	<4	1,760	595	.05
U2	Aq. inv.	Crayfish	07-20-89	.4	3.3	114	679	<4	1,430	141	.06

Table 24. Trace-element concentrations in fish, aquatic-plant, and aquatic-invertebrate samples, November 1988-July 1989--Continued

Site number (fig. 1)	Matrix	Species	Date	Nickel	Selenium	Strontium	Vanadium	Zinc
LP4	Fish	Brown trout	11-30-88	1.7	1.8	37.6	<0.3	143
LP4	Fish	Ch. catfish-fillet	07-19-89	<2.0	2.1	1.1	<.3	24.0
LP4	Fish	Ch. catfish	07-19-89	<2.0	3.3	63.9	.7	49.5
LP4	Fish	Flannelmouth sucker	04-04-89	<1.0	2.4	27.5	.6	42.8
LP4	Fish	Flannelmouth sucker	07-19-89	<2.0	2.6	47.5	.8	41.4
LP4	Fish	White sucker	04-04-89	<1.0	2.8	81.6	.6	54.8
LP4	Fish	Speckled dace	07-19-89	<2.0	8.7	87.6	.7	103
LP4	Aq. plants	Not determined	11-30-88	14.0	1.5	156	14.0	36.6
LP4	Aq. inv.	Crayfish	07-17-89	<2.0	3.2	713	1.7	65.1
B1	Fish	Brown trout	04-05-89	3.0	4.2	74.0	.6	120
B1	Fish	White sucker	07-19-89	2.0	2.6	116	6.4	82.6
B1	Fish	Bluehead sucker	11-17-88	3.1	1.9	202	8.7	101
B1	Fish	Bluehead sucker	04-05-89	3.0	2.2	152	5.2	93.6
B1	Fish	Speckled dace	11-17-88	4.9	4.4	153	1.2	224
B1	Fish	Speckled dace	07-19-89	<2.0	4.4	135	.8	190
B1	Fish	Fathead minnow	11-17-88	2.8	3.1	139	5.7	144
B1	Fish	Composite species	04-05-89	5.1	2.9	142	1.7	178
B1	Aq. plants	Not determined	11-17-88	21.0	.82	146	30.0	53.4
B1	Aq. inv.	Crayfish	04-05-89	2.0	1.3	973	2.7	55.2
B1	Aq. inv.	Crayfish	07-19-89	<2.0	1.2	1,180	3.3	57.3
B2	Fish	Brown trout	11-17-88	.94	2.4	26.1	<.3	116
B2	Fish	Brown trout	04-05-89	3.0	2.7	48.4	<.3	153
B2	Fish	Brown trout	07-18-89	<2.0	2.7	9.9	<.3	59.1
B2	Fish	Bluehead sucker	07-18-89	2.0	1.8	87.9	4.2	68.2
B2	Fish	Sucker composite	04-05-89	4.7	1.8	108	1.3	66.1
B2	Fish	Speckled dace	07-18-89	<2.0	5.8	83.0	.8	130
B2	Aq. inv.	Crayfish	04-04-89	2.0	1.4	402	2.3	32.5
B2	Aq. inv.	Crayfish	07-18-89	<2.0	1.3	635	3.0	63.2
U1	Fish	Bluehead sucker	04-05-89	<1.0	4.8	126	1.1	99.1
U1	Fish	Sucker composite	11-15-88	1.1	3.6	130	.6	84.9
U1	Fish	Speckled dace	11-15-88	.79	6.9	115	.3	127
U1	Fish	Speckled dace	04-05-89	<1.0	7.3	142	.6	140
U1	Fish	Speckled dace	07-19-89	<2.0	9.8	111	1.5	127
U1	Fish	Fathead minnow	04-05-89	9.7	6.4	118	2.2	152
U1	Aq. plants	Not determined	11-15-88	13.0	1.2	109	21.0	50.8
U1	Aq. inv.	Crayfish	04-05-89	2.0	2.0	1,080	3.7	59.0
U1	Aq. inv.	Crayfish	07-19-89	3.0	2.0	957	3.2	58.9
U2	Fish	Sucker composite	04-05-89	2.0	2.3	128	.9	98.9
U2	Fish	Speckled dace	11-15-88	2.0	3.6	103	4.1	132
U2	Fish	Speckled dace	04-05-89	5.4	9.2	115	.8	139
U2	Fish	Speckled dace	07-19-89	<2.0	9.4	84.2	<.3	104
U2	Aq. plants	Not determined	11-15-88	15.0	1.2	157	16.0	28.2
U2	Aq. inv.	Crayfish	04-06-89	3.0	3.3	875	3.3	61.9
U2	Aq. inv.	Crayfish	07-20-89	2.0	2.9	560	2.2	56.7

Table 24. Trace-element concentrations in fish, aquatic-plant, and aquatic-invertebrate samples, November 1988-July 1989--Continued

Site number (fig. 1)	Matrix	Species	Date	Mean length	Number in sample	Percent moisture	Aluminum	Arsenic	Barium	Beryllium	Boron
SP1	Fish	Bluehead sucker	04-05-89	27	9	77.1	959	0.4	36.7	<0.1	<2
SP1	Fish	Speckled dace	11-15-88	60	12	73.2	96.7	<.2	19.7	<.01	<2
SP1	Fish	Speckled dace	04-05-89	50	30	72.8	150	<.2	15.3	<.1	<2
SP1	Fish	Speckled dace	07-19-89	110	19	71.5	220	<.2	25.1	<.1	<2
SP1	Aq. plants	Not determined	11-15-88	--	--	84.5	9,010	7.3	337	.74	<2
SP1	Aq. plants	Not determined	11-15-88	--	--	86.7	9,030	3.6	323	.73	<2
SP1	Aq. plants	Not determined	07-19-89	--	--	90.2	5,640	2.2	326	.2	198
SP1	Aq. inv.	Crayfish	04-05-89	50	8	71.5	2,460	1.1	401	.2	<2
SP1	Aq. inv.	Crayfish	07-19-89	110	4	72.6	1,080	1.5	177	<.1	<2
SP2	Fish	Brown trout	07-19-89	420	1	65.4	20.0	.9	.6	<.1	<2
SP2	Fish	White sucker	11-15-88	279	4	74.8	46.4	.3	20.0	<.01	<2
SP2	Fish	Speckled dace	07-19-89	50	31	69.6	190	.2	18.5	<.1	<2
SP2	Fish	Fathead minnow	04-05-89	50	40	78.9	1,890	.6	99.1	<.1	<2
SP2	Aq. plants	Algae	07-19-89	--	--	87.7	12,100	3.2	275	.49	52
SP2	Aq. inv.	Crayfish	04-04-89	--	8	72.4	990	1.6	331	<.1	<2
SP2	Aq. inv.	Crayfish	07-19-89	--	15	77.2	1,160	1.6	229	<.1	2
WSB2	Fish	White sucker	11-17-88	188	6	77.1	241	.3	25.9	.01	<2
WSB2	Fish	White sucker	04-05-89	198	3	77.2	120	<.2	24.5	<.1	<2
WSB2	Fish	White sucker	07-18-89	190	3	74.7	415	.3	24.9	<.1	<2
WSB2	Fish	Speckled dace	11-17-89	90	3	71.5	31.0	.2	23.2	<.01	<2
WSB2	Fish	Speckled dace	04-05-89	70	50	72.0	250	<.2	16.5	<.1	<2
WSB2	Fish	Speckled dace	07-18-89	90	7	66.0	344	.2	18.6	<.1	<2
WSB2	Fish	Fathead minnow	11-17-88	50	17	72.6	217	.2	24.7	<.01	<2
WSB2	Fish	Fathead minnow	04-05-89	40	13	75.0	1,650	.5	52.0	<.1	<2
WSB2	Fish	Fathead minnow	07-18-89	70	25	77.5	1,110	.3	39.3	<.1	<2
WSB2	Aq. plants	Not determined	11-17-88	--	--	88.4	8,270	2.9	446	.63	7.5
WSB2	Aq. plants	Not determined	07-18-89	--	--	90.1	16,000	3.1	527	.5	57
WSB2	Aq. inv.	Crayfish	04-05-89	50	16	72.8	2,120	1.6	400	.2	<2
WSB2	Aq. inv.	Crayfish	07-18-89	90	10	73.4	2,010	2.0	322	<.1	3
SB1	Fish	Speckled dace	11-16-88	70	11	71.1	145	.3	27.7	<.01	<2
SB1	Fish	Speckled dace	04-05-89	70	50	72.9	160	.3	18.1	<.1	<2
SB1	Fish	Speckled dace	07-18-89	70	10	67.3	190	<.2	17.3	<.1	<2
SB1	Fish	Composite species	11-16-88	71	6	76.3	47.1	.2	23.5	<.01	<2
SB1	Aq. plants	Not determined	11-16-88	--	--	62.8	6,240	3.3	650	.59	<2
SB1	Aq. plants	Not determined	11-16-88	--	--	82.8	7,810	2.8	497	.61	3
SB1	Aq. plants	Not determined	07-19-89	--	--	94.8	7,910	2.6	258	.4	5
SB1	Aq. inv.	Crayfish	04-05-89	57	6	72.8	2,000	1.6	430	.1	<2
SB1	Aq. inv.	Crayfish	07-19-89	80	11	70.4	1,760	2.0	285	<.1	3

Table 24. Trace-element concentrations in fish, aquatic-plant, and aquatic-invertebrate samples, November 1988-July 1989--Continued

Site number (fig. 1)	Matrix	Species	Date	Cadmium	Chromium	Copper	Iron	Lead	Magnesium	Manganese	Mercury
SP1	Fish	Bluehead sucker	04-05-89	<0.4	6.9	9.9	740	<8	1,410	60.8	0.08
SP1	Fish	Speckled dace	11-15-88	.12	1.9	3.0	117	<.5	1,180	27.3	.39
SP1	Fish	Speckled dace	04-05-89	.3	4.1	3.2	212	<4	1,170	19.0	.13
SP1	Fish	Speckled dace	07-19-89	<.2	<1.0	1.6	235	<4	1,180	38.7	.45
SP1	Aq. plants	Not determined	11-15-88	.67	17.0	18.6	11,800	17	2,190	2,590	.05
SP1	Aq. plants	Not determined	11-15-88	.46	6.6	16.4	12,400	19	2,370	965	.04
SP1	Aq. plants	Not determined	07-19-89	.5	6.3	10.0	4,330	<4	3,550	5,070	.04
SP1	Aq. inv.	Crayfish	04-05-89	.4	3.2	176	1,710	<5	1,900	732	.06
SP1	Aq. inv.	Crayfish	07-19-89	.3	1.0	110	668	<4	1,500	490	.13
SP2	Fish	Brown trout	07-19-89	<.2	<1.0	4.0	53.0	<4	775	1.5	.25
SP2	Fish	White sucker	11-15-88	.12	1.2	3.5	106	<.5	1,190	26.1	.25
SP2	Fish	Speckled dace	07-19-89	.2	<1.0	5.2	251	<4	1,110	16.0	.21
SP2	Fish	Fathead minnow	04-05-89	.2	3.0	4.7	1,150	<4	1,590	53.2	.18
SP2	Aq. plants	Algae	07-19-89	.8	17.0	13.0	9,650	6	2,370	492	.04
SP2	Aq. inv.	Crayfish	04-04-89	.4	2.0	105	800	<4	1,650	585	.12
SP2	Aq. inv.	Crayfish	07-19-89	.4	2.0	182	751	<4	2,000	97.1	.09
WSB2	Fish	White sucker	11-17-88	.11	.83	4.4	204	<.5	1,370	46.5	.19
WSB2	Fish	White sucker	04-05-89	<.2	1.0	5.1	145	<4	1,500	42.4	.19
WSB2	Fish	White sucker	07-18-89	<.2	<.9	3.0	331	<4	1,300	32.4	.15
WSB2	Fish	Speckled dace	11-17-89	.38	1.1	2.9	84.7	<4	1,160	10.2	.32
WSB2	Fish	Speckled dace	04-05-89	<.2	3.4	2.9	233	<5	1,240	18.0	.25
WSB2	Fish	Speckled dace	07-18-89	<.2	21.0	1.5	435	<4	850	20.3	.19
WSB2	Fish	Fathead minnow	11-17-88	.39	1.6	2.9	251	<4	1,290	20.9	.33
WSB2	Fish	Fathead minnow	04-05-89	<.2	5.9	4.3	1,110	<4	1,390	101	.17
WSB2	Fish	Fathead minnow	07-18-89	<.2	2.0	5.0	726	<4	1,300	40.8	.26
WSB2	Aq. plants	Not determined	11-17-88	.24	11.0	12.8	10,800	16	2,360	1,440	.03
WSB2	Aq. plants	Not determined	07-18-89	<.3	19.0	15.0	19,600	8	3,340	1,050	.03
WSB2	Aq. inv.	Crayfish	04-05-89	<.2	3.7	138	1,240	<4	1,750	556	.07
WSB2	Aq. inv.	Crayfish	07-18-89	.3	3.7	105	1,170	<4	1,470	180	.07
SB1	Fish	Speckled dace	11-16-88	.22	2.3	2.7	137	<.5	1,080	15.9	.23
SB1	Fish	Speckled dace	04-05-89	.2	2.0	2.9	173	<4	1,200	19.0	.25
SB1	Fish	Speckled dace	07-18-89	<.2	<.9	2.4	165	<4	937	18.7	.25
SB1	Fish	Composite species	11-16-88	.23	1.0	4.7	90.9	<.5	1,330	13.9	.21
SB1	Aq. plants	Not determined	11-16-88	1.3	16.0	11.6	10,100	10	1,820	759	.05
SB1	Aq. plants	Not determined	11-16-88	.36	12.0	11.3	10,500	15	2,140	1,780	.11
SB1	Aq. plants	Not determined	07-19-89	.4	13.0	17.0	7,730	6	2,080	690	.03
SB1	Aq. inv.	Crayfish	04-05-89	<.2	4.1	138	1,140	<4	1,710	542	.10
SB1	Aq. inv.	Crayfish	07-19-89	.2	7.5	110	936	<4	1,640	160	.08

Table 24. Trace-element concentrations in fish, aquatic-plant, and aquatic-invertebrate samples, November 1988-July 1989--Continued

Site number (fig. 1)	Matrix	Species	Date	Nickel	Selenium	Strontium	Vanadium	Zinc
SP1	Fish	Bluehead sucker	04-05-89	5.0	5.1	118	2.2	115
SP1	Fish	Speckled dace	11-15-88	.95	7.3	138	<.3	146
SP1	Fish	Speckled dace	04-05-89	2.0	8.9	122	.4	133
SP1	Fish	Speckled dace	07-19-89	<2.0	7.0	145	.5	133
SP1	Aq. plants	Not determined	11-15-88	16.0	2.1	170	20.0	78.3
SP1	Aq. plants	Not determined	11-15-88	10.0	1.4	215	17.0	96.7
SP1	Aq. plants	Not determined	07-19-89	5.4	3.3	249	10.0	142
SP1	Aq. inv.	Crayfish	04-05-89	3.0	3.1	909	3.9	60.6
SP1	Aq. inv.	Crayfish	07-19-89	2.0	2.8	944	1.9	67.0
SP2	Fish	Brown trout	07-19-89	<2.0	1.2	12.5	<.3	104
SP2	Fish	White sucker	11-15-88	.6	3.5	104	<.3	63.9
SP2	Fish	Speckled dace	07-19-89	<2.0	12.0	122	.4	102
SP2	Fish	Fathead minnow	04-05-89	2.0	8.2	131	3.4	174
SP2	Aq. plants	Algae	07-19-89	10.0	1.6	116	21.0	48.5
SP2	Aq. inv.	Crayfish	04-04-89	1.0	2.6	766	2.5	59.8
SP2	Aq. inv.	Crayfish	07-19-89	3.0	2.9	937	2.4	68.2
WSB2	Fish	White sucker	11-17-88	.75	4.3	128	.4	81.1
WSB2	Fish	White sucker	04-05-89	<1.0	6.3	144	<.3	71.0
WSB2	Fish	White sucker	07-18-89	<2.0	3.9	116	.9	63.4
WSB2	Fish	Speckled dace	11-17-89	.6	7.6	129	<.3	145
WSB2	Fish	Speckled dace	04-05-89	4.4	11.7	131	.6	147
WSB2	Fish	Speckled dace	07-18-89	9.9	6.2	79.1	.8	99.5
WSB2	Fish	Fathead minnow	11-17-88	1.0	4.2	95.0	.5	161
WSB2	Fish	Fathead minnow	04-05-89	3.0	10.0	109	3.0	139
WSB2	Fish	Fathead minnow	07-18-89	<2.0	8.1	79.3	2.0	123
WSB2	Aq. plants	Not determined	11-17-88	9.7	4.2	636	17.0	41.2
WSB2	Aq. plants	Not determined	07-18-89	11.0	1.6	132	30.0	67.5
WSB2	Aq. inv.	Crayfish	04-05-89	3.0	3.6	843	3.7	59.0
WSB2	Aq. inv.	Crayfish	07-18-89	2.0	2.4	853	3.4	54.5
SB1	Fish	Speckled dace	11-16-88	1.4	10.0	135	.7	127
SB1	Fish	Speckled dace	04-05-89	1.0	9.5	156	.3	136
SB1	Fish	Speckled dace	07-18-89	<2.0	7.8	103	.4	101
SB1	Fish	Composite species	11-16-88	.5	4.8	134	<.3	212
SB1	Aq. plants	Not determined	11-16-88	13.0	1.0	400	18.0	46.5
SB1	Aq. plants	Not determined	11-16-88	11.0	3.1	701	18.0	42.9
SB1	Aq. plants	Not determined	07-19-89	9.5	2.8	105	15.0	67.3
SB1	Aq. inv.	Crayfish	04-05-89	3.0	2.1	1,300	4.2	66.9
SB1	Aq. inv.	Crayfish	07-19-89	<2.0	2.2	1,040	3.1	55.9

Table 24. Trace-element concentrations in fish, aquatic-plant, and aquatic-invertebrate samples, November 1988-July 1989--Continued

Site number (fig. 1)	Matrix	Species	Date	Mean length	Number in sample	Percent moisture	Aluminum	Arsenic	Barium	Beryllium	Boron
SB2	Fish	White sucker	04-05-89	320	2	73.9	93.0	<0.2	16.3	<0.1	<2
SB2	Fish	White sucker	07-18-89	207	3	73.2	740	.5	22.8	<.1	<2
SB2	Fish	Speckled dace	11-16-88	70	35	73.3	216	.3	25.4	.01	<2
SB2	Fish	Speckled dace	04-05-89	80	40	70.9	381	.2	19.5	<.1	<2
SB2	Fish	Fathead minnow	11-16-88	20	45	76.5	1,760	.7	102	.07	<2
SB2	Fish	Fathead minnow	04-05-89	60	25	74.4	685	.3	44.6	<.1	<2
SB2	Fish	Fathead minnow	07-18-89	60	30	72.0	1,430	.3	24.6	<.1	<2
SB2	Aq. plants	Not determined	11-16-88	--	--	85.6	7,860	3.2	352	.41	<2
SB2	Aq. plants	Not determined	07-18-89	--	--	88.7	4,570	1.2	229	.2	276
SB2	Aq. inv.	Crayfish	04-05-89	50	6	71.8	1,630	1.4	296	<.1	<2
SB2	Aq. inv.	Crayfish	07-18-89	80	20	75.4	1,060	2.4	229	<.1	2
P1	Fish	Flannelmouth sucker	04-04-89	435	1	77.0	57.0	.5	9.2	<.1	<2
P1	Fish	White sucker	12-01-88	355	1	74.8	42.7	.3	12.7	<.01	<2
P1	Fish	Bluehead sucker	04-04-89	355	2	73.9	337	.5	9.0	<.1	<2
P1	Fish	Bluehead sucker	07-18-89	229	5	70.5	68.0	.2	9.6	<.1	<2
P1	Fish	Mottled sculpin	12-01-88	70	13	78.9	370	.4	25.6	.01	<2
P1	Fish	Mottled sculpin	04-04-89	90	14	81.2	180	.3	13.8	<.1	<2
P1	Fish	Mottled sculpin	07-18-89	80	24	79.0	63.0	.3	11.6	<.1	<2
P1	Aq. plants	Not determined	12-01-88	--	--	82.5	9,110	8.5	330	.85	2
P1	Aq. inv.	Crayfish	07-18-89	80	4	76.0	507	2.2	93.3	<.1	4
N1	Fish	Northern pike	11-02-88	620	3	76.1	43.6	.4	4.6	<.01	<2
N1	Fish	Ch. catfish	06-08-89	432	3	69.0	290	<.2	4.3	<.1	<2
N1	Fish	Bullhead	11-02-88	238	6	79.7	1,290	.4	27.8	.04	<2
N1	Fish	Bullhead	03-29-89	230	4	79.3	410	.2	20.9	<.1	<2
N1	Fish	Bullhead	06-08-89	230	4	75.7	552	<.2	20.5	<.1	<2
N1	Fish	Sucker composite	11-02-88	457	3	73.2	116	.2	8.7	<.01	<2
N1	Fish	Common carp	11-02-88	450	3	74.8	211	.5	16.8	<.01	<2
N1	Fish	Common carp	03-29-89	495	2	77.8	491	.3	14.0	<.1	<2
N1	Fish	Common carp	06-08-89	443	3	73.4	270	.5	12.2	<.1	<2
N1	Aq. plants	Plankton	11-02-88	--	--	97.9	13,700	3.0	111	.50	8.1
N1	Aq. plants	Plankton	06-08-89	--	--	98.9	1,230	1.4	28.2	<.1	2.0
N2	Fish	Brown trout-eggs	11-01-88	--	--	67.4	44.9	<.1	.69	<.01	<2
N2	Fish	Ch. catfish	03-28-89	525	2	70.4	120	<.2	6.2	<.1	<2
N2	Fish	Bullhead	11-01-88	257	3	80.4	2,510	.4	66.2	.09	<2
N2	Fish	Bullhead	07-18-89	247	3	80.4	312	.3	19.2	<.1	<2
N2	Fish	Common carp	11-01-88	513	3	71.9	139	.6	15.7	<.01	<2
N2	Fish	Common carp	03-28-89	460	2	75.8	100	.7	10.3	<.1	<2
N2	Fish	Common carp	07-18-89	477	3	73.1	140	.4	14.4	<.1	<2
N2	Aq. plants	Plankton	11-01-88	--	--	92.6	8,180	2.0	132	.25	4
N2	Aq. plants	Plankton	06-07-89	--	--	97.0	3,860	1.4	134	.1	<2

Table 24. Trace-element concentrations in fish, aquatic-plant, and aquatic-invertebrate samples, November 1988-July 1989--Continued

Site number (fig. 1)	Matrix	Species	Date	Cadmium	Chromium	Copper	Iron	Lead	Magnesium	Manganese	Mercury
SB2	Fish	White sucker	04-05-89	<0.2	<1.0	7.5	141	<4	1,170	28.0	0.24
SB2	Fish	White sucker	07-18-89	<.2	1.0	3.4	512	<4	836	35.7	.18
SB2	Fish	Speckled dace	11-16-88	.20	3.3	3.1	189	<.5	1,160	19.8	.28
SB2	Fish	Speckled dace	04-05-89	.2	3.2	3.2	271	<4	1,240	23.0	.31
SB2	Fish	Fathead minnow	11-16-88	.42	2.6	4.9	1,340	<.6	1,390	75.5	.16
SB2	Fish	Fathead minnow	04-05-89	<.2	3.0	3.9	432	<5	1,340	27.0	.24
SB2	Fish	Fathead minnow	07-18-89	.5	2.0	3.9	873	<4	1,310	38.0	.24
SB2	Aq. plants	Not determined	11-16-88	.95	19.0	15.8	9,140	8.6	2,150	990	.03
SB2	Aq. plants	Not determined	07-18-89	<.3	7.1	8.1	3,680	<4	3,310	1,330	.02
SB2	Aq. inv.	Crayfish	04-05-89	<.2	2.0	74.8	720	<4	996	582	.09
SB2	Aq. inv.	Crayfish	07-18-89	.4	2.0	102	767	<4	1,430	172	.07
P1	Fish	Flannelmouth sucker	04-04-89	.3	3.0	5.3	220	<5	1,170	17.0	1.2
P1	Fish	White sucker	12-01-88	.08	.59	3.5	90.6	<.5	1,520	30.6	.33
P1	Fish	Bluehead sucker	04-04-89	.3	2.0	5.0	633	<4	1,060	31.0	.21
P1	Fish	Bluehead sucker	07-18-89	<.2	<1.0	2.3	107	<4	1,070	24.7	.24
P1	Fish	Mottled sculpin	12-01-88	.31	1.4	3.2	325	<.5	1,380	44.0	.19
P1	Fish	Mottled sculpin	04-04-89	.2	2.0	3.2	196	<4	1,340	43.4	.23
P1	Fish	Mottled sculpin	07-18-89	<.2	<1.0	2.6	118	<4	1,310	36.2	.28
P1	Aq. plants	Not determined	12-01-88	.63	21.6	18.6	17,400	19	2,550	461	.03
P1	Aq. inv.	Crayfish	07-18-89	.6	1.0	63.8	536	<4	1,090	181	.09
N1	Fish	Northern pike	11-02-88	.11	.30	1.8	90.5	<.5	1,320	13.1	.61
N1	Fish	Ch. catfish	06-08-89	<.2	<1.0	1.1	245	<4	754	9.2	.51
N1	Fish	Bullhead	11-02-88	.29	2.3	4.1	919	<.5	1,610	46.4	.78
N1	Fish	Bullhead	03-29-89	.2	3.0	4.9	390	<4	1,470	17.0	.78
N1	Fish	Bullhead	06-08-89	<.2	2.0	4.4	447	<4	1,270	22.9	.81
N1	Fish	Sucker composite	11-02-88	.27	2.0	2.5	152	<.5	1,370	18.6	.72
N1	Fish	Common carp	11-02-88	.65	2.1	5.4	267	<.5	1,270	16.1	.76
N1	Fish	Common carp	03-29-89	1.2	2.0	5.9	440	<4	1,310	17.0	1.3
N1	Fish	Common carp	06-08-89	.4	1.0	12.0	274	<4	969	9.5	.94
N1	Aq. plants	Plankton	11-02-88	.90	12.0	15.9	9,840	15	3,150	217	.04
N1	Aq. plants	Plankton	06-08-89	.7	1.0	10.0	1,010	<4	1,510	73.6	.11
N2	Fish	Brown trout-eggs	11-01-88	<.05	2.0	10.9	81.7	<.5	1,360	4.7	.04
N2	Fish	Ch. catfish	03-28-89	<.2	<1.0	1.5	140	<4	793	13.0	.71
N2	Fish	Bullhead	11-01-88	.15	3.0	7.2	1,410	2.1	2,100	60.9	.83
N2	Fish	Bullhead	07-18-89	<.2	2.0	3.3	296	<4	1,440	19.7	.93
N2	Fish	Common carp	11-01-88	.77	.78	3.6	222	<.5	1,240	12.6	1.0
N2	Fish	Common carp	03-28-89	.94	<1.0	4.2	177	<4	1,160	11.0	1.1
N2	Fish	Common carp	07-18-89	.4	<1.0	4.1	202	<4	1,060	10.0	.86
N2	Aq. plants	Plankton	11-01-88	1.2	7.5	28.2	4,010	13.0	1,830	156	.11
N2	Aq. plants	Plankton	06-07-89	1.1	3.0	9.3	2,540	<4	1,810	220	.17

Table 24. Trace-element concentrations in fish, aquatic-plant, and aquatic-invertebrate samples, November 1988-July 1989--Continued

Site number (fig. 1)	Matrix	Species	Date	Nickel	Selenium	Strontium	Vanadium	Zinc
SB2	Fish	White sucker	04-05-89	<1.0	4.8	122	0.3	59.4
SB2	Fish	White sucker	07-18-89	<2.0	4.3	27.7	1.4	41.5
SB2	Fish	Speckled dace	11-16-88	4.8	7.8	150	.6	144
SB2	Fish	Speckled dace	04-05-89	1.0	10.8	164	.6	136
SB2	Fish	Fathead minnow	11-16-88	3.4	5.7	153	3.5	160
SB2	Fish	Fathead minnow	04-05-89	4.3	8.6	115	1.3	148
SB2	Fish	Fathead minnow	07-18-89	<2.0	9.9	89.5	2.8	117
SB2	Aq. plants	Not determined	11-16-88	16.0	2.6	318	18.0	56.0
SB2	Aq. plants	Not determined	07-18-89	4.0	2.4	164	9.0	32.6
SB2	Aq. inv.	Crayfish	04-05-89	<1.0	3.4	574	2.2	31.8
SB2	Aq. inv.	Crayfish	07-18-89	<2.0	3.9	877	2.3	56.6
P1	Fish	Flannelmouth sucker	04-04-89	2.0	2.4	53.9	.7	58.3
P1	Fish	White sucker	12-01-88	<.2	1.8	113	.4	52.7
P1	Fish	Bluehead sucker	04-04-89	<1.0	1.7	54.7	1.4	55.4
P1	Fish	Bluehead sucker	07-18-89	<2.0	2.2	48.3	<.3	50.4
P1	Fish	Mottled sculpin	12-01-88	1.5	5.1	124	1.6	98.5
P1	Fish	Mottled sculpin	04-04-89	2.0	6.7	111	1.2	99.9
P1	Fish	Mottled sculpin	07-18-89	<2.0	6.4	94.4	.7	85.3
P1	Aq. plants	Not determined	12-01-88	19.0	.50	74.5	33.0	61.8
P1	Aq. inv.	Crayfish	07-18-89	<2.0	1.5	600	1.4	60.5
N1	Fish	Northern pike	11-02-88	<.2	2.2	55.6	<.3	136
N1	Fish	Ch. catfish	06-08-89	<2.0	2.3	33.3	.6	44.2
N1	Fish	Bullhead	11-02-88	1.9	1.8	119	2.8	94.1
N1	Fish	Bullhead	03-29-89	1.0	1.8	133	1.4	92.5
N1	Fish	Bullhead	06-08-89	<2.0	2.1	89.0	1.8	74.2
N1	Fish	Sucker composite	11-02-88	1.1	1.5	53.7	.4	68.3
N1	Fish	Common carp	11-02-88	2.1	2.9	94.0	.8	288
N1	Fish	Common carp	03-29-89	<1.0	4.9	92.3	1.2	313
N1	Fish	Common carp	06-08-89	<2.0	4.2	52.0	.8	177
N1	Aq. plants	Plankton	11-02-88	14.0	1.7	108	27.0	62.0
N1	Aq. plants	Plankton	06-08-89	<2.0	2.1	64.7	2.1	73.3
N2	Fish	Brown trout-eggs	11-01-88	<.3	6.2	5.5	<.3	84.3
N2	Fish	Ch. catfish	03-28-89	<1.0	1.6	56.5	.5	47.1
N2	Fish	Bullhead	11-01-88	1.6	1.4	242	3.9	92.1
N2	Fish	Bullhead	07-18-89	<2.0	2.1	103	1.1	81.5
N2	Fish	Common carp	11-01-88	.50	3.2	107	.6	321
N2	Fish	Common carp	03-28-89	<1.0	2.7	79.1	.4	222
N2	Fish	Common carp	07-18-89	<2.0	3.2	71.4	.3	225
N2	Aq. plants	Plankton	11-01-88	3.1	2.6	344	10.0	98.2
N2	Aq. plants	Plankton	06-07-89	<2.0	2.7	358	5.0	84.0

Table 25. Trace-element concentrations in bird, algae, and muskrat samples collected at four wetland sites, May-July 1989

[Analyses by U.S. Fish and Wildlife Service; concentrations in micrograms per gram dry weight; yh., yellow headed; rw., red winged; pre., prefledgling; nst., nestling; imm., immature; ad., adult <, less than; --, no data]

Site number (fig. 1)	Species	Sample type	Date	Number in sample	Percent moisture	Aluminum	Arsenic	Barium	Beryllium	Boron
R1	Yh. blackbird	Egg	05-22-89	3	81.4	<3.0	<0.1	6.3	<0.1	<2
R1	Yh. blackbird	Egg	05-22-89	4	83.7	<3.0	<.1	8.7	<.1	<2
R1	Yh. blackbird	Egg	05-22-89	18	83.2	<3.0	<.1	5.8	<.1	<2
R1	Yh. blackbird	Egg	05-22-89	6	84.8	<3.0	<.1	5.1	<.1	<2
R1	Yh. blackbird, ad.	Liver	05-22-89	4	74.4	11.0	<.1	1.5	<.1	<2
R1	Yh. blackbird, pre.	Whole body	06-06-89	2	72.2	130	<.1	13.1	<.1	<2
R1	Yh. blackbird, nst.	Whole body	06-06-89	2	78.1	160	<.1	13.6	<.1	<2
R1	Mallard	Egg	05-23-89	1	69.8	<3.0	<.1	28.6	<.1	<2
R1	Mallard	Egg	05-23-89	1	69.2	<3.0	<.1	24.2	<.1	<2
R1	Mallard, imm.	Liver	07-17-89	1	66.4	<3.0	<.1	.1	<.1	<2
R1	Mallard, imm.	Liver	07-17-89	1	69.6	<3.0	<.1	.4	<.1	<2
R1	Mallard, imm.	Breast	07-17-89	1	75.4	<3.0	<.1	.2	<.09	<2
R1	Algae composite	--	05-24-89	--	98.0	25,000	3.5	462	.93	3
R3	Rw. blackbird	Egg	06-06-89	1	28.3	13.0	<.1	29.4	<.1	<2
R3	Rw. blackbird, nst.	Whole body	06-06-89	2	77.2	130	<.1	17.1	<.1	<2
R3	Meadowlark, pre.	Whole body	07-17-89	1	74.0	210	<.1	15.0	<.1	<2
R3	Snipe	Egg	05-22-89	6	74.3	<3.0	<.1	5.3	<.1	<2
R3	Mallard	Egg	05-22-89	1	67.9	<3.0	<.1	20.5	<.1	<2
R3	Mallard	Egg	05-22-89	1	68.2	<3.0	<.1	26.8	<.1	<2
R3	Mallard	Egg	05-22-89	1	69.7	<3.0	<.1	37.3	<.1	<2
R3	Mallard, imm.	Liver	07-07-89	1	73.3	4.0	<.1	1.5	<.1	<2
R3	Mallard, ad.	Liver	07-20-89	1	67.9	7.0	<.1	.3	<.1	<2
R3	Mallard, ad.	Breast	07-20-89	1	75.9	13.0	<.1	.4	<.1	<2
LPGR	Rw. blackbird	Egg	06-05-89	4	83.9	<3.0	<.1	3.5	<.1	<2
LPGR	Rw. blackbird	Egg	06-05-89	3	82.5	<3.0	<.1	7.2	<.09	<2
LPGR	Rw. blackbird	Egg	06-05-89	4	83.7	<3.0	<.1	10.8	<.09	<2
LPGR	Rw. blackbird, ad.	Liver	06-05-89	4	66.8	<3.0	<.1	.35	<.1	<2
LPGR	Algae composite	--	06-05-89	--	94.5	2,530	1.2	1,040	<.1	3

Table 25. Trace-element concentrations in bird, algae, and muskrat samples collected at four wetland sites, May-July 1989--Continued

Site number (fig. 1)	Species	Sample type	Date	Cadmium	Chromium	Copper	Iron	Lead	Magnesium	Manganese	Mercury
R1	Yh. blackbird	Egg	05-22-89	<0.3	<1.0	1.2	192	<4	361	7.0	0.05
R1	Yh. blackbird	Egg	05-22-89	<.3	<1.0	1.4	128	<4	360	5.1	.02
R1	Yh. blackbird	Egg	05-22-89	<.3	<1.0	.94	186	<4	415	5.7	.02
R1	Yh. blackbird	Egg	05-22-89	<.3	<1.0	1.2	148	<4	395	4.1	.02
R1	Yh. blackbird, ad.	Liver	05-22-89	<.3	<1.0	23.3	1,200	<4	720	11.0	.14
R1	Yh. blackbird, pre.	Whole body	06-06-89	<.2	3.0	12.0	299	<4	1,050	15.0	.06
R1	Yh. blackbird, nst.	Whole body	06-06-89	<.2	2.0	18.0	295	<4	1,030	24.9	.03
R1	Mallard	Egg	05-23-89	<.3	<1.0	3.1	116	<4	328	3.5	.09
R1	Mallard	Egg	05-23-89	<.3	<1.0	2.9	116	<4	349	3.5	.11
R1	Mallard, imm.	Liver	07-17-89	1.7	1.0	111	2,060	<4	442	7.3	.27
R1	Mallard, imm.	Liver	07-17-89	.4	2.0	103	5,360	<4	456	9.1	.26
R1	Mallard, imm.	Breast	07-17-89	<.3	<.9	18.0	293	<4	1,010	1.4	.21
R1	Algae composite	--	05-24-89	<.3	16	12.0	17,800	10	3,370	1,310	.05
R3	Rw. blackbird	Egg	06-06-89	<.3	<1.0	3.2	151	<4	646	2.8	.04
R3	Rw. blackbird, nst.	Whole body	06-06-89	<.2	2.0	11.0	264	<4	1,090	16.0	.02
R3	Meadowlark, pre.	Whole body	07-17-89	<.2	7.9	15.0	327	<4	1,260	9.7	.01
R3	Snipe	Egg	05-22-89	<.3	<1.0	2.8	124	<4	529	5.1	.75
R3	Mallard	Egg	05-22-89	<.3	<.9	3.6	116	<4	342	3.1	.05
R3	Mallard	Egg	05-22-89	<.3	<1.0	3.1	101	<4	369	3.5	.06
R3	Mallard	Egg	05-22-89	<.3	<1.0	3.5	129	<4	339	2.2	.32
R3	Mallard, imm.	Liver	07-07-89	<.3	<1.0	51.3	1,510	<4	834	33.4	.38
R3	Mallard, ad.	Liver	07-20-89	6.4	2.0	25.2	4,370	<4	703	17.0	.58
R3	Mallard, ad.	Breast	07-20-89	<.3	1.0	19.2	335	<4	1,050	2.4	.29
LPGR	Rw. blackbird	Egg	06-05-89	<.3	<1.0	3.3	190	<4	670	3.5	.13
LPGR	Rw. blackbird	Egg	06-05-89	<.3	<.9	3.1	162	<4	484	3.4	.06
LPGR	Rw. blackbird	Egg	06-05-89	<.3	<.9	11.0	201	<4	914	11.0	.15
LPGR	Rw. blackbird, ad.	Liver	06-05-89	.5	<1.0	17.0	1,200	<4	739	4.3	.39
LPGR	Algae composite	--	06-05-89	<.3	3.8	9.5	2,550	<4	2,140	276	.03

Table 25. Trace-element concentrations in bird, algae, and muskrat samples collected at four wetland sites, May-July 1989--Continued

Site number (fig. 1)	Species	Sample type	Date	Nickel	Selenium	Strontium	Vanadium	Zinc
R1	Yh. blackbird	Egg	05-22-89	<2.0	3.9	10.9	<.4	68.2
R1	Yh. blackbird	Egg	05-22-89	<2.0	5.3	12.3	<.4	55.4
R1	Yh. blackbird	Egg	05-22-89	<2.0	5.2	10.6	<.4	72.5
R1	Yh. blackbird	Egg	05-22-89	<2.0	3.7	10.1	<.4	53.5
R1	Yh. blackbird, ad.	Liver	05-22-89	<2.0	6.8	1.6	<.4	94.3
R1	Yh. blackbird, pre.	Whole body	06-06-89	<1.0	16.4	47.8	.3	100
R1	Yh. blackbird, nst.	Whole body	06-06-89	<1.0	16.9	42.7	<.3	109
R1	Mallard	Egg	05-23-89	<2.0	2.4	9.6	<.4	49.5
R1	Mallard	Egg	05-23-89	<2.0	4.9	9.2	<.4	50.2
R1	Mallard, imm.	Liver	07-17-89	<2.0	14.0	<.1	<.4	93.3
R1	Mallard, imm.	Liver	07-17-89	<2.0	21.2	.2	<.4	88.2
R1	Mallard, imm.	Breast	07-17-89	<2.0	6.3	.3	<.4	31.3
R1	Algae composite	--	05-24-89	9.2	7.3	123	28.0	62.4
R3	Rw. blackbird	Egg	06-06-89	<2.0	13.6	204	<.4	48.8
R3	Rw. blackbird, nst.	Whole body	06-06-89	<1.0	27.5	47.2	<.3	95.4
R3	Meadowlark, pre.	Whole body	07-17-89	<1.0	49.0	63.7	.4	104
R3	Snipe	Egg	05-22-89	<2.0	13.0	12.9	<.4	52.7
R3	Mallard	Egg	05-22-89	<2.0	7.9	8.2	<.4	52.3
R3	Mallard	Egg	05-22-89	<2.0	8.4	10.0	<.4	50.8
R3	Mallard	Egg	05-22-89	<2.0	6.5	18.7	<.4	59.6
R3	Mallard, imm.	Liver	07-07-89	<2.0	50.0	.98	<.4	96.2
R3	Mallard, ad.	Liver	07-20-89	<2.0	34.8	.30	<.4	100
R3	Mallard, ad.	Breast	07-20-89	<2.0	10.0	.44	<.4	34.3
LPGR	Rw. blackbird	Egg	06-05-89	<2.0	2.8	10.0	<.4	62.5
LPGR	Rw. blackbird	Egg	06-05-89	<2.0	2.0	10.4	<.4	66.3
LPGR	Rw. blackbird	Egg	06-05-89	<2.0	2.0	27.3	<.4	87.6
LPGR	Rw. blackbird, ad.	Liver	06-05-89	<2.0	4.2	.35	<.4	59.5
LPGR	Algae composite	--	06-05-89	<2.0	.20	195	4.2	19,0

Table 25. Trace-element concentrations in bird, algae, and muskrat samples collected at four wetland sites, May-July 1989--Continued

Site number (fig. 1)	Species	Sample type	Date	Number in sample	Percent moisture	Aluminum	Arsenic	Barium	Beryllium	Boron
LP4	Rw. blackbird	Egg	05-23-89	4	83.8	<3.0	<.1	6.3	<.1	<2
LP4	Rw. blackbird	Egg	05-23-89	9	82.8	<3.0	<.1	9.3	<.1	<2
LP4	Rw. blackbird	Egg	05-23-89	3	82.2	<3.0	<.1	9.5	<.1	<2
LP4	Rw. blackbird	Egg	05-23-89	4	83.0	<3.0	<.1	8.9	<.1	<2
LP4	Rw. blackbird, imm.	Whole body	06-06-89	2	72.5	52.0	<.1	16.7	<.1	3
LP4	Rw. blackbird, imm.	Whole body	06-06-89	2	71.8	93.0	<.1	20.1	<.1	3
LP4	Rw. blackbird, imm.	Whole body	06-06-89	2	70.9	110	<.1	12.5	<.1	3
LP4	Rw. blackbird, ad.	Liver	05-23-89	3	68.6	4.0	<.1	.91	<.1	<2
LP4	Rw. blackbird, ad.	Liver	05-23-89	4	71.9	<3.0	<.1	.10	<.1	<2
LP4	Yh. blackbird	Egg	05-23-89	3	83.8	<3.0	<.1	5.1	<.1	<2
LP4	Yh. blackbird	Egg	05-23-89	4	84.6	<3.0	<.1	4.9	<.1	<2
LP4	Yh. blackbird, ad.	Liver	05-23-89	3	66.2	5.0	.2	.36	<.1	<2
LP4	Mallard	Egg	05-23-89	1	69.2	<3.0	.2	32.7	<.1	<2
LP4	Mallard	Egg	05-23-89	1	69.9	<3.0	.2	45.8	<.1	<2
LP4	Bittern	Egg	06-06-89	1	80.7	<3.0	<.1	6.2	<.1	<2
LP4	Muskrat	Whole body	05-23-89	1	78.2	60.0	<.1	23.5	<.1	4

Site number (fig. 1)	Species	Sample type	Date	Cadmium	Chromium	Copper	Iron	Lead	Magnesium	Manganese	Mercury
LP4	Rw. blackbird	Egg	05-23-89	<0.3	<1.0	1.9	155	<4	365	4.0	0.05
LP4	Rw. blackbird	Egg	05-23-89	<.3	<1.0	2.6	171	<4	512	3.1	.04
LP4	Rw. blackbird	Egg	05-23-89	<.3	<1.0	1.9	164	<4	352	3.8	.05
LP4	Rw. blackbird	Egg	05-23-89	<.3	<1.0	1.5	154	<4	397	2.7	.12
LP4	Rw. blackbird, imm.	Whole body	06-06-89	<.2	1.0	9.0	206	<4	1,210	6.4	.03
LP4	Rw. blackbird, imm.	Whole body	06-06-89	<.3	3.0	9.0	294	<5	1,170	18.0	.05
LP4	Rw. blackbird, imm.	Whole body	06-06-89	<.2	5.1	92.2	337	<4	1,210	15.0	.08
LP4	Rw. blackbird, ad.	Liver	05-23-89	.6	<1.0	21.1	1,190	<4	821	5.7	.13
LP4	Rw. blackbird, ad.	Liver	05-23-89	.3	<1.0	24.8	1,590	<4	790	4.9	.23
LP4	Yh. blackbird	Egg	05-23-89	<.3	<1.0	1.1	179	<4	379	4.2	.04
LP4	Yh. blackbird	Egg	05-23-89	<.3	<1.0	1.6	115	<4	363	5.8	.04
LP4	Yh. blackbird, ad.	Liver	05-23-89	.8	1.0	31.0	2,460	<4	759	6.0	.14
LP4	Mallard	Egg	05-23-89	<.3	<1.0	2.3	187	<4	355	4.9	.22
LP4	Mallard	Egg	05-23-89	<.3	<1.0	3.0	130	<4	378	7.0	.20
LP4	Bittern	Egg	06-06-89	<.3	<1.0	4.2	118	<4	367	2.0	.92
LP4	Muskrat	Whole body	05-23-89	<.2	3.4	5.8	479	<4	1,390	118	.02

Table 25. Trace-element concentrations in bird, algae, and muskrat samples collected at four wetland sites, May-July 1989--Continued

Site number (fig. 1)	Species	Sample type	Date	Nickel	Selenium	Strontium	Vanadium	Zinc
LP4	Rw. blackbird	Egg	05-23-89	<2.0	2.9	9.1	<0.4	55.9
LP4	Rw. blackbird	Egg	05-23-89	<2.0	2.9	29.0	<.4	68.5
LP4	Rw. blackbird	Egg	05-23-89	<2.0	2.5	15.5	<.4	65.5
LP4	Rw. blackbird	Egg	05-23-89	<2.0	3.5	18.0	<.4	51.6
LP4	Rw. blackbird, imm.	Whole body	06-06-89	<1.0	2.3	53.6	<.3	90.0
LP4	Rw. blackbird, imm.	Whole body	06-06-89	3.8	3.3	66.6	<.3	92.8
LP4	Rw. blackbird, imm.	Whole body	06-06-89	1.0	3.0	51.0	<.3	95.0
LP4	Rw. blackbird, ad.	Liver	05-23-89	<2.0	5.0	.54	<.4	80.1
LP4	Rw. blackbird, ad.	Liver	05-23-89	<2.0	5.2	.10	<.4	71.3
LP4	Yh. blackbird	Egg	05-23-89	<2.0	3.9	12.6	<.4	52.5
LP4	Yh. blackbird	Egg	05-23-89	<2.0	3.5	9.4	<.4	58.0
LP4	Yh. blackbird, ad.	Liver	05-23-89	<2.0	5.4	.20	<.4	86.2
LP4	Mallard	Egg	05-23-89	<2.0	2.9	13.4	<.4	41.3
LP4	Mallard	Egg	05-23-89	<2.0	4.6	12.5	<.4	48.7
LP4	Bittern	Egg	06-06-89	<2.0	5.3	4.9	<.4	48.6
LP4	Muskrat	Whole body	05-23-89	<1.0	1.3	71.0	<.3	87.0

Table 26. Concentrations of selected pesticides and polychlorinated biphenyls (PCB's) in fish and bird samples, 1988-89

[Analyses by U.S. Fish and Wildlife Service; concentrations in micrograms per gram wet weight; ad., adult; imm., immature; rw., red winged; <, less than; --, no data]

Site number (fig.1)	Species	Sample type	Date	Mean length	Number in sample	Percent moisture	Aldrin	α BHC	β BHC	γ BHC	α Chlordane	γ Chlordane	o,p' -DDE	p,p' -DDE
R1	Mallard	Egg	05-23-89	--	1	68.2	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
R1	Mallard	Egg	05-23-89	--	1	65.6	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
R3	Mallard, imm.	Whole body	05-23-89	--	1	61.5	<.01	<.01	<.01	<.01	<.01	<.01	<.01	.02
R3	Snipe	Egg	05-23-89	--	2	73.6	<.05	<.05	<.05	<.05	<.05	<.05	<.05	.09
LPGR	Rw. blackbird, ad.	Whole body	06-05-89	--	2	66.6	<.01	<.01	<.01	<.01	<.01	<.01	<.01	.49
LP3	White sucker	Whole body	11-14-88	340	4	72.5	<.05	<.05	<.05	<.05	<.05	<.05	<.05-	<.05
LP3	Sucker, composite	Whole bodv	11-14-88	289	4	76.2	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
LP4	Mallard	Egg	06-06-89	--	1	68.7	<.05	<.05	<.05	<.05	<.05	<.05	<.05	.10
LP4	American bittern	Egg	06-06-89	--	1	80.6	<.05	<.05	<.05	<.05	<.05	<.05	<.05	.28
N2	Carp	Whole body	06-07-89	451	4	68.0	<.01	<.01	<.01	<.01	<.01	<.01	<.01	.04
N2	Carp	Whole body	06-07-89	428	4	66.7	<.01	<.01	<.01	<.01	<.01	<.01	<.01	.03

Table 26. Concentrations of selected pesticides and polychlorinated biphenyls (PCB's) in fish and bird samples, 1988-89--Continued

Site number (fig.1)	Species	Sample type	Date	o,p' -DDD	p,p' -DDD	o,p' -DDT	p,p' -DDT	Diel-drin	En-drin	HCB	Hep-ta-chlor	Hep-ta-chlor epox-ide	Lin-dane
R1	Mallard	Egg	05-23-89	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
R1	Mallard	Egg	05-23-89	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
R3	Mallard, imm.	Whole body	05-23-89	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
R3	Snipe	Egg	05-23-89	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
LPGR	Rw. blackbird, ad.	Whole body	06-05-89	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
LP3	White sucker	Whole body	11-14-88	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
LP3	Sucker, composite	Whole body	11-14-88	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
LP4	Mallard	Egg	06-06-89	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
LP4	American bittern	Egg	06-06-89	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05
N2	Carp	Whole body	06-07-89	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
N2	Carp	Whole body	06-07-89	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01

Table 26. Concentrations of selected pesticides and polychlorinated biphenyls (PCB's) in fish and bird samples, 1988-89--Continued

Site number (fig.1)	Species	Sample type	Date	Mirex	cis-Non-achlor	trans-Non-achlor	Oxy-chlor-dane	Tox-aphene	PCB
R1	Mallard	Egg	05-23-89	<0.05	<0.05	<0.05	<0.05	<0.5	<0.5
R1	Mallard	Egg	05-23-89	<.05	<.05	<.05	<.05	<.5	<.5
R3	Mallard, imm.	Whole body	05-23-89	<.01	<.01	<.01	<.01	<.1	<.1
R3	Snipe	Egg	05-23-89	.12	<.05	<.05	<.05	<.5	<.5
LPGR	Rw. blackbird, ad.	Whole body	06-05-89	<.01	<.01	<.01	<.01	<.1	<.1
LP3	White sucker	Whole body	11-14-88	<.05	<.05	<.05	<.05	<.5	<.5
LP3	Sucker, composite	Whole body	11-14-88	<.05	<.05	<.05	<.05	<.5	<.5
LP4	Mallard	Egg	06-06-89	<.05	<.05	<.05	<.05	<.5	<.5
LP4	American bittern	Egg	06-06-89	<.05	<.05	<.05	<.05	<.5	<.5
N2	Carp	Whole body	06-07-89	<.01	<.01	<.01	<.01	<.1	<.1
N2	Carp	Whole body	06-07-89	<.01	<.01	<.01	<.01	<.1	<.1

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