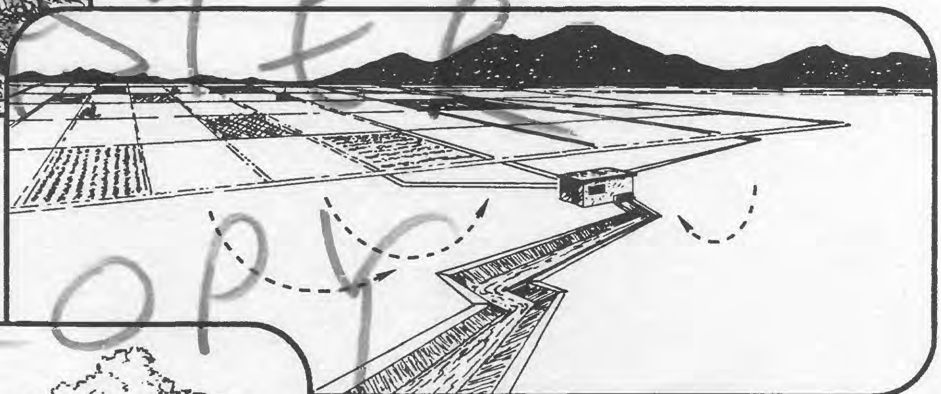
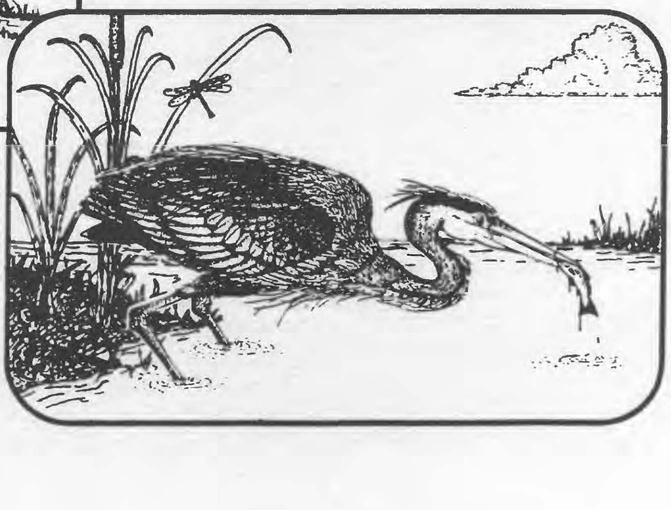
Reconnaissance Investigation of Water Quality, Bottom Sediment, and Biota Associated with Irrigation Drainage in the Gunnison and Uncompahgre River Basins and at Sweitzer Lake, West-Central Colorado, 1988-89



U.S. Geological Survey
Water-Resources Investigations Report 91-4103



U.S. Geological Survey
U.S. Fish and Wildlife Service
U.S. Bureau of Reclamation

RECONNAISSANCE INVESTIGATION OF WATER QUALITY, BOTTOM SEDIMENT, AND BIOTA ASSOCIATED WITH IRRIGATION DRAINAGE IN THE GUNNISON AND UNCOMPAHGRE RIVER BASINS AND AT SWEITZER LAKE, WEST-CENTRAL COLORADO, 1988-89

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U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 91-4103

Prepared in cooperation with the

U.S. FISH AND WILDLIFE SERVICE and the

U.S. BUREAU OF RECLAMATION

Denver, Colorado
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U.S. DEPARTMENT OF THE INTERIOR

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U.S. GEOLOGICAL SURVEY

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CONVERSION FACTORS AND ABBREVIATED WATER-QUALITY UNITS

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)	0.0631	liter per second
inch (in.)	25.4	millimeter
inch per year (in/yr)	25.4	millimeter per year
liter (L)	0.26417	gallon
mile (mi)	1.609	kilometer
millimeter (mm)	0.03937	inch
ounce (oz)	28.35	gram
pound (lb)	0.4536	kilogram
square mile (mi^2)	2.590	square kilometer
ton	0.9072	metric ton

Temperature in degree Celsius (°C) may be converted to degree Fahrenheit (°F) by use of the following formula:

$$°F = 9/5(°C)+32$$

Temperature in degree Fahrenheit (°F) may be converted to degree Celsius (°C) by use of the following formula:

$$°C = 5/9(°F-32)$$

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

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

RECONNAISSANCE INVESTIGATION OF WATER QUALITY, BOTTOM SEDIMENT, AND BIOTA ASSOCIATED WITH IRRIGATION DRAINAGE IN THE GUNNISON AND UNCOMPAHGRE RIVER BASINS AND AT SWEITZER LAKE, WEST-CENTRAL COLORADO, 1988-89

By David L. Butler, Richard P. Krueger, Barbara Campbell Osmundson, Andrew L. Thompson, and Steven K. McCall

ABSTRACT

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. This report describes the results of a reconnaissance investigation done during 1988-89 of the Uncompahgre Project, located in west-central Colorado. Water, bottom sediment, and biota samples were collected in the Gunnison and Uncompahgre River basins, and at Sweitzer Lake to identify potential water-quality problems that could be associated with the Uncompahgre Project. The Uncompahgre Project was selected for a reconnaissance investigation because unusually large selenium concentrations have been reported in the Gunnison River downstream from the project and in fish from Sweitzer Lake.

Irrigation drainage from the Uncompahgre Project area contributes dissolved solids, sodium, sulfate, nitrite plus nitrate, selenium, boron, and uranium to the Gunnison and Uncompahgre Rivers. Selenium concentrations in some of the water samples collected from both rivers exceeded U.S. Environmental Protection Agency criteria for protection of aquatic life and the concentrations may be of concern for fish and waterfowl because of food-chain biocentration. The largest concentration of selenium from the Gunnison River was 10 micrograms per liter in a sample collected in July 1988 upstream from Escalante Creek. The largest selenium concentrations in the Uncompahgre River were in samples collected at Delta; concentrations were 33 micrograms per liter in November 1987 and 34 micrograms per liter in January 1988. The insecticide parathion was detected at concentrations exceeding the criteria for protection of aquatic life in both the Gunnison and Uncompahgre Rivers in samples collected in July 1988.

Irrigation-drainage water discharging into Sweitzer Lake contributes dissolved solids, sodium, sulfate, nitrite plus nitrate, and selenium to the lake during the nonirrigation season. The maximum concentrations of dissolved solids, sodium, sulfate, selenium, boron, and uranium were in samples collected during January and March 1988 from the Garnet Canal diversion at Sweitzer Lake; selected maximum constituent concentrations were: 12,700 milligrams per liter of dissolved solids, 320 micrograms per liter of selenium, 800 micrograms per liter of boron, and 64 micrograms per liter of uranium. Water in the Garnet Canal during the nonirrigation season probably is irrigation-drainage water.

Concentrations of selenium in four sets of water samples collected in Sweitzer Lake ranged from 10 to 25 micrograms per liter. The selenium concentrations in all water samples collected at Sweitzer Lake exceeded criteria for protection of aquatic life. Mercury was detected in water samples collected from the lake and from inflow into the lake in July 1988.

Concentrations of selenium in bottom-sediment samples collected from the Gunnison and Uncompahgre Rivers were slightly greater than baseline concentrations for soils in the Western United States. There was substantially more selenium in bottom sediments from Sweitzer Lake; the selenium concentration was 41 micrograms per gram in a sample collected in January 1988.

Selenium concentrations in fish and avian food items at Sweitzer Lake may be large enough for fish and wildlife to accumulate harmful amounts of selenium through biomagnification of selenium in the food chain. Selenium concentrations in all whole-body fish samples from Sweitzer Lake exceeded the 85th-percentile concentration of the National Contaminants Biomonitoring Program. The maximum selenium concentration was 50 micrograms per gram dry weight in a carp sample from Sweitzer Lake. The maximum recommended daily intake of selenium for humans could be exceeded by eating catfish from Sweitzer Lake; three ounces of catfish fillet had about 502 micrograms of selenium.

Concentrations of selenium in many whole-body samples from the Gunnison and Uncompahgre Rivers and three tributaries of the Uncompahgre River exceeded the 85th-percentile concentration of the National Contaminants Biomonitoring Program. The maximum selenium concentration in a fish sample collected from streams was 10.5 micrograms per gram dry weight in a carp collected from Dry Creek, a tributary of the Uncompahgre River.

Selenium concentrations in bird livers, whole-body birds, and eggs collected at Sweitzer Lake and the Escalante State Wildlife Area were equal, and some of the selenium concentrations indicate significant exposure to selenium. The maximum selenium concentration in a bird sample was about 84 micrograms per gram dry weight in the liver of a western grebe collected at Sweitzer Lake.

Most other trace-element concentrations were less than baseline concentrations or less than concentrations that might be harmful to fish and wildlife. There were concentrations of cadmium, copper, mercury, and zinc in some biota samples that exceeded background concentrations. Large concentrations of mercury were reported in two common merganser livers collected at the Escalante State Wildlife Area.

DDE was detected in all biota samples that were analyzed for organic compounds. The maximum DDE concentration was 110 micrograms per gram wet weight in a whole-body killdeer that probably accumulated the DDE in its wintering areas outside of Colorado. Toxaphene was detected in 12 biota samples. Concentrations of the herbicide dacthal in three fish samples exceeded the maximum dacthal concentration reported by the National Pesticide Monitoring Program.

The Colorado River downstream from the Gunnison River provides habitat for endangered fish and birds. The Uncompahgre Project area is a major source of selenium to the Gunnison River; the effects of the selenium on the endangered fish and birds are not known.

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 19 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 19 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 1989. 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 fiscal year 1988:

California:	Sacramento Refuge Complex
California-Oregon:	Klamath Basin Refuge Complex
Colorado:	Gunnison and Uncompahgre River basins and Sweitzer Lake
	Pine River Project
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 Geological Survey, U.S. Fish and Wildlife Service, and U.S. Bureau of Reclamation 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 Gunnison and Uncompahgre Rivers and Sweitzer Lake (fig. 1) were selected for a reconnaissance investigation because selenium concentrations in the Gunnison River at a U.S. Geological Survey gaging station located downstream from the U.S. Bureau of Reclamation's Uncompahgre Project exceeded background selenium concentrations for major rivers in the United States (Smith and others, 1987). The U.S. Bureau of Reclamation previously had identified the Uncompahgre Project area as a large contributor of salinity to the Upper Colorado River Basin, and the geologic formation that contributes a large part of the salinity also was a likely source of selenium. The Uncompahgre Project area has characteristics such as alkaline and potentially seleniferous soils, low precipitation, and high evaporation that can be indicators of possible problems associated with irrigation drainage (Sylvester and others, 1988). Also, the State of Colorado had reported large concentrations of selenium in fish collected from Sweitzer Lake, a small reservoir near Delta.

Purpose and Scope

The purpose of this report is to describe the results of the reconnaissance investigation of the Gunnison and Uncompahgre Rivers and of Sweitzer Lake. The report describes concentrations of selected trace elements and pesticides in water, bottom sediment, and biota and compares the analytical

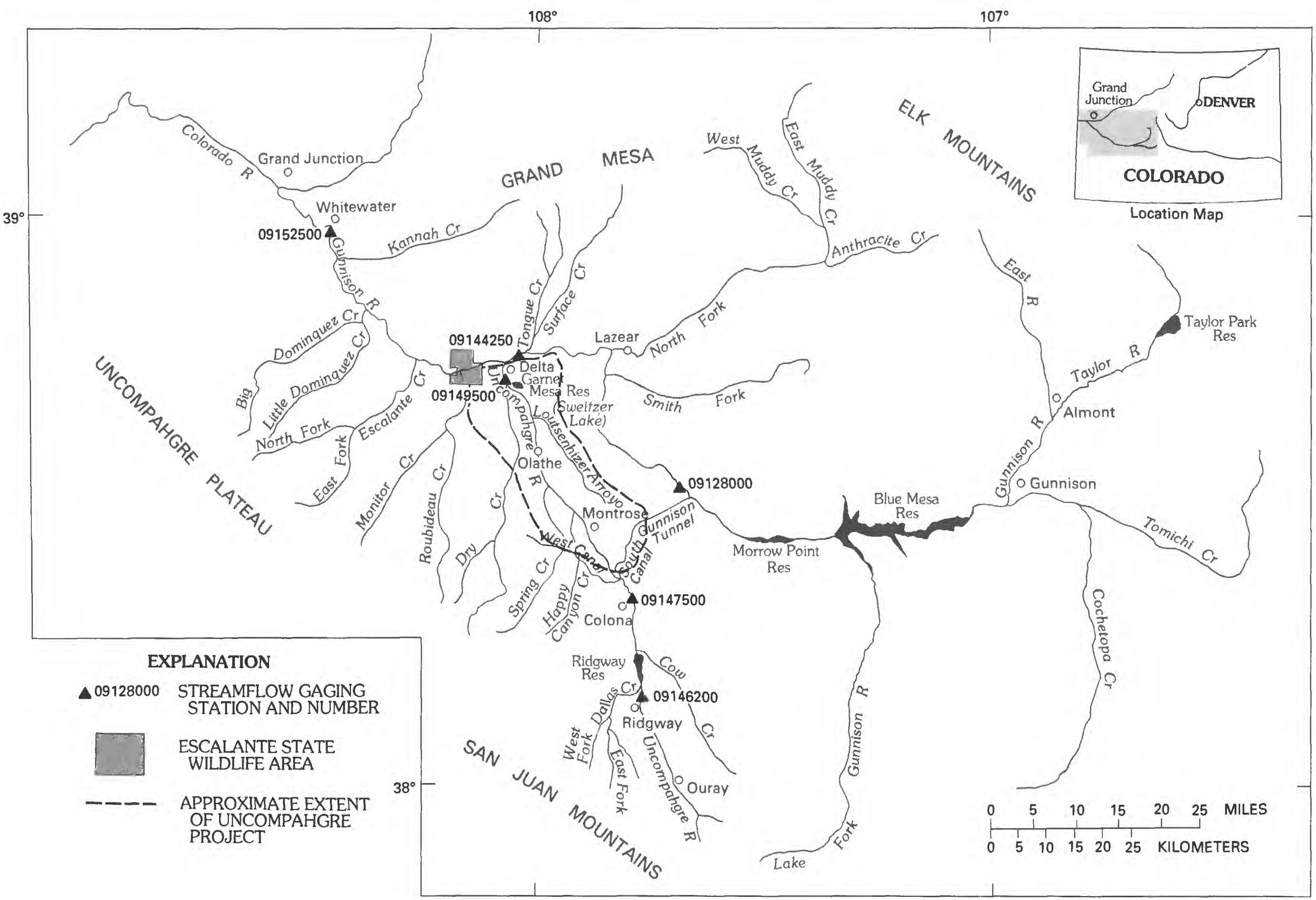

Figure 1.--Location and major features of Gunnison and Uncompahgre River basins.

results to various guidelines and baseline information. The results in this report are intended for use by the DOI in determining whether irrigation drainage from the Uncompahgre Project 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 uses.

Water samples were collected at three sites on the Gunnison River and at two sites on the Uncompahgre River. Water samples also were collected in Sweitzer Lake, from two ditches that flow into the lake, and from the outflow from the lake. Bottom-sediment samples were collected at two sites on the Gunnison River, at two sites on the Uncompahgre River, and from Sweitzer Lake. Fish, invertebrates, and aquatic plants were collected at three sites on the Gunnison River and at two sites on the Uncompahgre River. Biota samples also were collected at Sweitzer Lake and from three tributaries of the Uncompahgre River. Bird and egg samples were collected at Sweitzer Lake and at the Escalante State Wildlife Area. All samples were collected from November 1987 to July 1988, except for some catfish samples collected from Sweitzer Lake in March 1989.

Acknowledgments

The authors thank Kenneth Moreland and his staff of the Colorado Division of Parks and Outdoor Recreation at Sweitzer Lake for their cooperation and useful information. The authors also thank Frederick Hill and other personnel of the Colorado Division of Wildlife for their data for Sweitzer Lake and the information about fish and wildlife resources in the study area.

DESCRIPTION OF STUDY AREA

Location

The study area is located in the lower Gunnison and Uncompahgre River basins in west-central Colorado (fig. 1), primarily in the Uncompahgre River valley between Colona and Delta. The Gunnison River forms the northern boundary of irrigated areas (fig. 2) served by the Uncompahgre Project. The study area extends a short distance downstream from Delta along the Gunnison River to include the Escalante State Wildlife Area (fig. 1), located west of Delta. Garnet Mesa Reservoir, located about 2 mi southeast of Delta (fig. 1), more commonly is called Sweitzer Lake and will be referred to as Sweitzer Lake in this report.

History

The Uncompahgre River valley was inhabited by Indians prior to the arrival of settlers, who came into the area in the late 1800's. The initial impetus for settling in the region was mining in the mountain areas south and east of the study area. Concurrently, ranches and farms were established in the river valleys along with the towns of Montrose, Olathe, and Delta. By 1890, about 30,000 acres of land were irrigated with water diverted from the

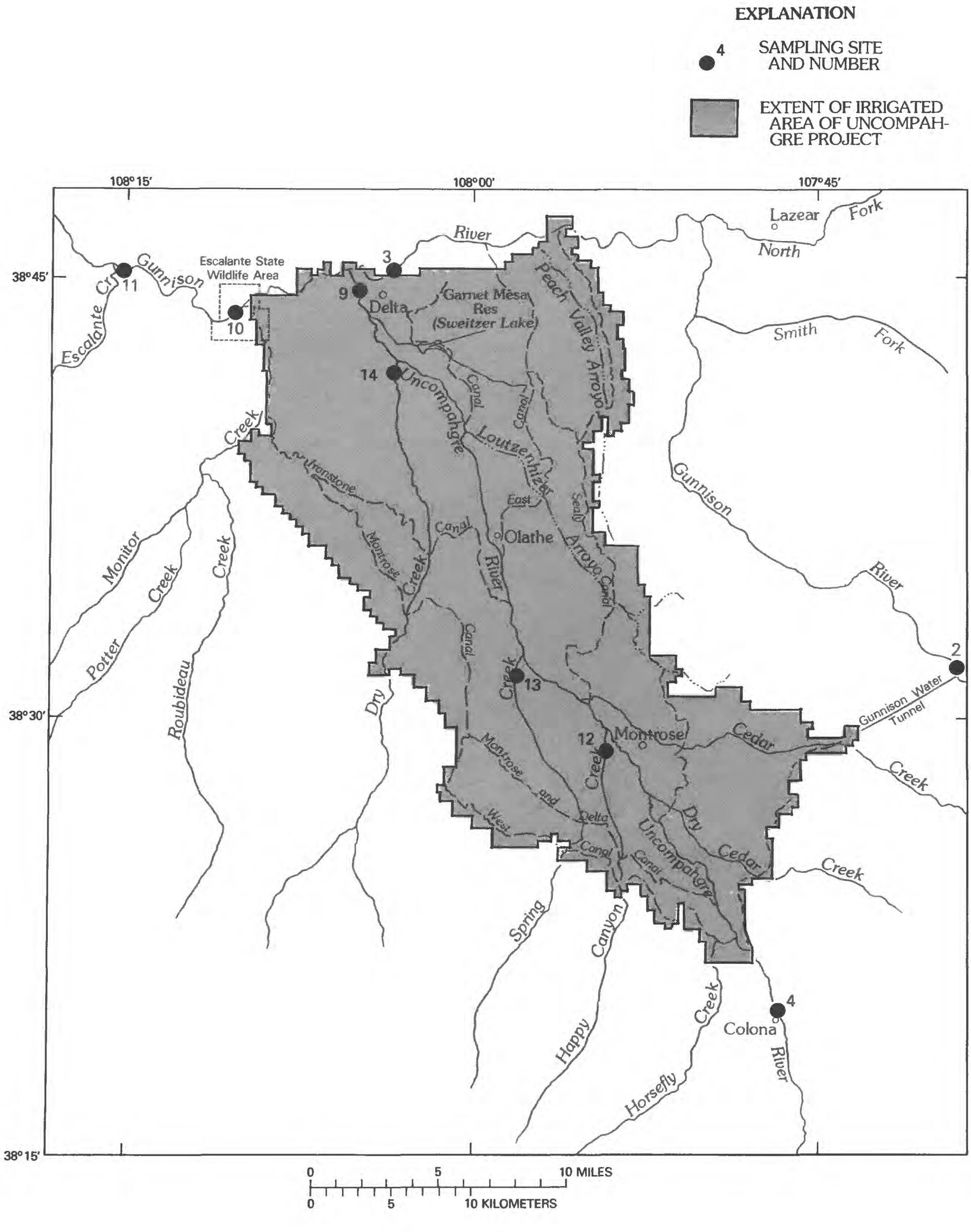

Figure 2.--Location of sampling sites on streams and extent of irrigated area.

Uncompahgre River (U.S. Bureau of Reclamation, 1984). More water was needed to supply the arable lands in the valley, so the State of Colorado started construction of a tunnel from the Gunnison River in 1901. The State was unable to complete the tunnel and asked for aid from the newly established Reclamation Service. The Gunnison Tunnel (fig. 1) was completed in 1909 and a diversion dam was completed on the Gunnison River in 1912. This reclamation project was called the Uncompahgre Project and was one of the first Federal reclamation projects (U.S. Bureau of Reclamation, 1984). New canals were constructed and existing canals were acquired and improved where needed and included in the project. The operation and maintenance of the project was transferred from the U.S. Bureau of Reclamation to the Uncompahgre Valley Water User's Association in 1932.

Taylor Park Reservoir (fig. 1), completed in 1937, has a storage capacity of 106,200 acre-ft on the Taylor River, a headwater tributary of the Gunnison River. The reservoir was built to supply dependable flows in the river during summer and fall and is part of the Uncompahgre Project. Blue Mesa Reservoir (storage capacity 940,800 acre-ft, 111,200 acre-ft of which is dead storage) was completed in 1965 on the Gunnison River upstream from the Gunnison Tunnel Diversion (fig. 1). That reservoir is part of the U.S. Bureau of Reclamation's Colorado River Storage Project. In 1987, Ridgway Reservoir (fig. 1) was completed on the Uncompahgre River between Ridgway and Colona. Ridgway Reservoir (storage capacity 84,590 acre-ft) is part of the U.S. Bureau of Reclamation's Dallas Creek Project, and 10,300 acre-ft of water from that project is used to augment irrigation supplies to the Uncompahgre Project.

Sweitzer Lake was built in 1954 on land donated to the State of Colorado with the condition that a reservoir be built for recreation. The lake, a State park operated by the Colorado Division of Parks and Outdoor Recreation, primarily is used for boating, picnicking, fishing, and limited bird hunting. The Colorado Division of Wildlife has responsibility for the fishery in the lake. In 1974, the Division of Wildlife decided to stop stocking the lake because of suspected selenium problems. A warning sign was posted at the lake in 1977 advising people not to eat fish caught from the lake. The Division of Wildlife restocked 1,000 catfish in Sweitzer Lake in 1984.

Physiography and Climate

The Uncompahgre River valley is about 1 mi wide at Colona and about 5 to 7 mi wide between Montrose and Delta. Elevation ranges from about 4,900 ft at Delta to about 5,900 ft at Colona. The area west of the river is a series of terraces separated by small valleys eroded by tributaries of the Uncompahgre River. The terraces are stream deposits and outwash remnants. The land east of the river is characterized by rolling terrain formed by erosion of the Mancos Shale. Sweitzer Lake is in a minor depression on Garnet Mesa, about 100 ft above the Uncompahgre River.

Climate in the Uncompahgre Valley downstream from Colona is semi-arid and varies with elevation. The valley is dry with generally low humidity; the annual class A pan evaporation at Montrose is about 58 in. Annual precipitation (1951-80) ranges from 8 in. at Delta to about 12 in. at Colona (U.S. Geological Survey, 1984). Annual snowfall in the Uncompahgre

Valley is about 20 to 30 in., and most winters have snow cover on the ground only for short periods. Precipitation increases with increasing elevation to almost 40 in. on Grand Mesa north of Delta and in the San Juan Mountains southwest of Ouray. Winters are cool with occasional sub-zero temperatures, but severe cold is not typical. Summers are quite hot, and afternoon temperatures frequently exceed 90 °F. The growing season varies from 112 to 148 days in the river valley.

Geology

The following discussion about geology in the study area was summarized from Meeks (1950) and Brooks and Ackerman (1985). Geologic maps for the study area are in reports by Williams (1964) and Tweto and others (1976). The major structural feature near the study area is the Uncompahgre uplift, an anticline plunging northwest and southeast. This feature forms the Uncompahgre Plateau shown in figure 1.

Most of the irrigated land west of the Uncompahgre River is composed of soils and outcrops derived from alluvial deposits of Quaternary age and the Dakota Sandstone of Cretaceous age. The alluvial deposits are valley-fill material composed of clay, sand, gravel, and cobbles and glacial outwash material composed of sand, gravel, cobbles, and boulders. The Dakota Sandstone consists of sedimentary deposits of sandstone, shale, and coal. Underlying the Dakota Sandstone is the Morrison Formation of Jurassic age, which is exposed in a few canyons on the west side of the valley. The Morrison Formation is composed of mudstone, sandstone, and siltstone.

Much of the irrigated land east of the Uncompahgre River is composed of soils and outcrops of the Mancos Shale of Cretaceous age. The Mancos Shale is a gray marine shale that has thin beds of sandstone and siltstone and contains gypsum. Compared to other sedimentary rocks, shales often are enriched in certain trace elements, including arsenic, boron, chromium, mercury, selenium, uranium, vanadium, and zinc (Brownlow, 1979). The Mancos Shale is exposed in a few areas west of the river. There also are scattered alluvial deposits east of the river. Soils and surface deposits around Sweitzer Lake and deposits underlying the lake primarily were derived from the Mancos Shale.

Soils and Land Use

Soils in the Uncompahgre River valley are separated into four major types: terrace or mesa soils, Mancos soils, floodplain soils, and Dakota soils (U.S. Bureau of Reclamation, 1984). About 60 percent of irrigated land served by the Uncompahgre Project is on mesa soils, mostly west of the Uncompahgre River. Mesa soils were derived from terrace deposits and are mostly medium textured and have a low salt content. Mesa soils are productive and extensively farmed.

Soils derived from Mancos Shale (also called adobe soils) compose about 34 percent of the irrigated area and are mostly east of the Uncompahgre River. Mancos soil is calcareous, medium to fine texture, and has a maximum depth of

20 ft. Some Mancos soils are not arable because they contain too much salt to be productive. Floodplain soils compose about 3 percent of irrigated area and are located along the Uncompahgre River. They are varied in texture and are underlain by gravels and the Mancos Shale. Floodplain soils have variable salt content dependent on the parent material. Soils derived from the Dakota Sandstone compose about 3 percent of the irrigated lands, are located west of Montrose, are relatively shallow, and have low salt content. Because of the dry climate and sparse vegetation, organic content of most soil in the study area is small, and the soils have not been leached to any great depth in nonirrigated areas. Therefore, parent soils in the study area have retained the salinity and chemical composition of the parent rocks.

Land use in the Uncompahgre River valley between Colona and Delta primarily is agricultural. Crops grown in the valley include cash crops such as onions, beans, and barley; feed crops such as alfalfa, corn, grasses, hay, and small grains; and fruit orchards. Croplands often are interspersed with natural or uncultivated areas, especially east of the river. Natural vegetation is sparse and consists of desert shrubs such as sagebrush and saltbush, and pinyon and juniper along valley fringes. There is riparian habitat along the Gunnison and Uncompahgre Rivers. There are urban areas around Montrose, Olathe, and Delta. Populations in 1980 were 8,722 for Montrose; 1,262 for Olathe; and 3,931 for Delta (U.S. Bureau of Reclamation, 1984).

Fish and Wildlife Resources

There are three State wildlife areas located in the study area managed by the Colorado Division of Wildlife. The largest is the Escalante State Wildlife Area, which has a total area of about 7,600 acres consisting of several tracts of land along the Gunnison River west of Delta and some land in lower Escalante Creek canyon and in the upper Roubideau Creek basin (Michael Stone, Colorado Division of Wildlife, Montrose, Colo., oral commun., 1989). Only the lower tracts along the Gunnison River are shown in figures 1 and 2 because they are the only parts of the wildlife area that could be affected by irrigation drainage. This area provides habitat for a variety of waterbirds, upland birds, small game, and big game. The Escalante State Wildlife Area frequently is used for waterfowl and upland bird hunting. Golden eagles and great blue herons nest in the lower section.

The Billy Creek State Wildlife Area, a small area about 2 mi south of Colona along the Uncompahgre River, is managed for deer and elk habitat. Chipeta Lakes State Wildlife Area, located about 3 mi south of Montrose along the Uncompahgre River, consists of small ponds that are stocked with trout by the State and is managed as a put-and-take trout fishery.

The Gunnison River upstream from the confluence with the North Fork (fig. 1) is an excellent cold-water fishery for brown and rainbow trout. Between the North Fork and Delta, the Gunnison River supports a fairly good trout fishery, but has more carp and suckers than the reach upstream from the North Fork. Downstream from Delta, carp and suckers are the primary fish species in the Gunnison River, and the primary game fish is channel catfish. Few trout are present in the river downstream from Delta.

The Uncompahgre River between Colona and Montrose supports trout, suckers, and fathead minnows. A large number of trout are present in the river at Montrose, but many of the trout came from the Gunnison River through the Gunnison Tunnel and the South Canal. Downstream from Montrose, the primary fish in the Uncompahgre River are carp, suckers, and roundtail chub.

Two reservoirs are located in the Uncompahgre River basin. Sweitzer Lake is used by fishermen in the summer and by waterfowl hunters in the fall. The lake supports large populations of green sunfish and carp and a small population of channel catfish. Ridgway Reservoir (fig. 1) was constructed by the U.S. Bureau of Reclamation in 1987 and is managed by the Colorado Division of Parks and Outdoor Recreation. The reservoir supports a cold-water trout fishery and is a popular area for boating, fishing, and camping.

The Federally endangered Colorado squawfish and the razorback sucker, a candidate species for listing as endangered, have been identified from the Colorado and Gunnison Rivers downstream from the Uncompahgre Project area. Those species possibly could be present upstream in the study area, but their presence has not been documented. Other endangered species, such as the bald eagle, peregrine falcon, and whooping crane, may visit the area seasonally. Bald eagles are common winter visitors and can be observed roosting near open water. Peregrine falcons are known to nest near the study area and could pass through the area while hunting or migrating. Whooping cranes pass through the area during spring and fall migration and commonly are mixed with flocks of sandhill cranes. Cranes are known to stop at small stock ponds and agricultural fields in the Uncompahgre Valley during their migration; however, the cranes apparently use the area only for brief periods, and there has never been a documented nesting attempt by cranes in the Uncompahgre Valley.

HYDROLOGIC SETTING

The hydrologic system in the study area consists of the Gunnison and Uncompahgre Rivers and their tributaries, Sweitzer Lake, the irrigation system of the Uncompahgre Project, and upstream reservoirs (figs. 1 and 3). Ground water also is a component of the hydrologic system; shallow aquifers may discharge to streams, canals, and Sweitzer Lake.

Streams

The Gunnison River, which drains about 8,000 mi^2, is formed by the confluence of the East and Taylor Rivers at Almont, flows south and then west to northwest to Delta, and then northwest from Delta to its confluence with the Colorado River at Grand Junction (fig. 1). Headwaters of the Gunnison River are in the Elk Mountains (fig. 1).

Most of the irrigated land in the study area is drained by the Uncompahgre River (fig. 2). The headwaters of the Uncompahgre River are in the San Juan Mountains south of Ouray (fig. 1); the river flows north to northwest to its confluence with the Gunnison River at Delta. The river drains 1,115 mi^2; about 60 percent of the drainage basin is between Colona and Delta. Stream discharge from the Uncompahgre River, part of which is

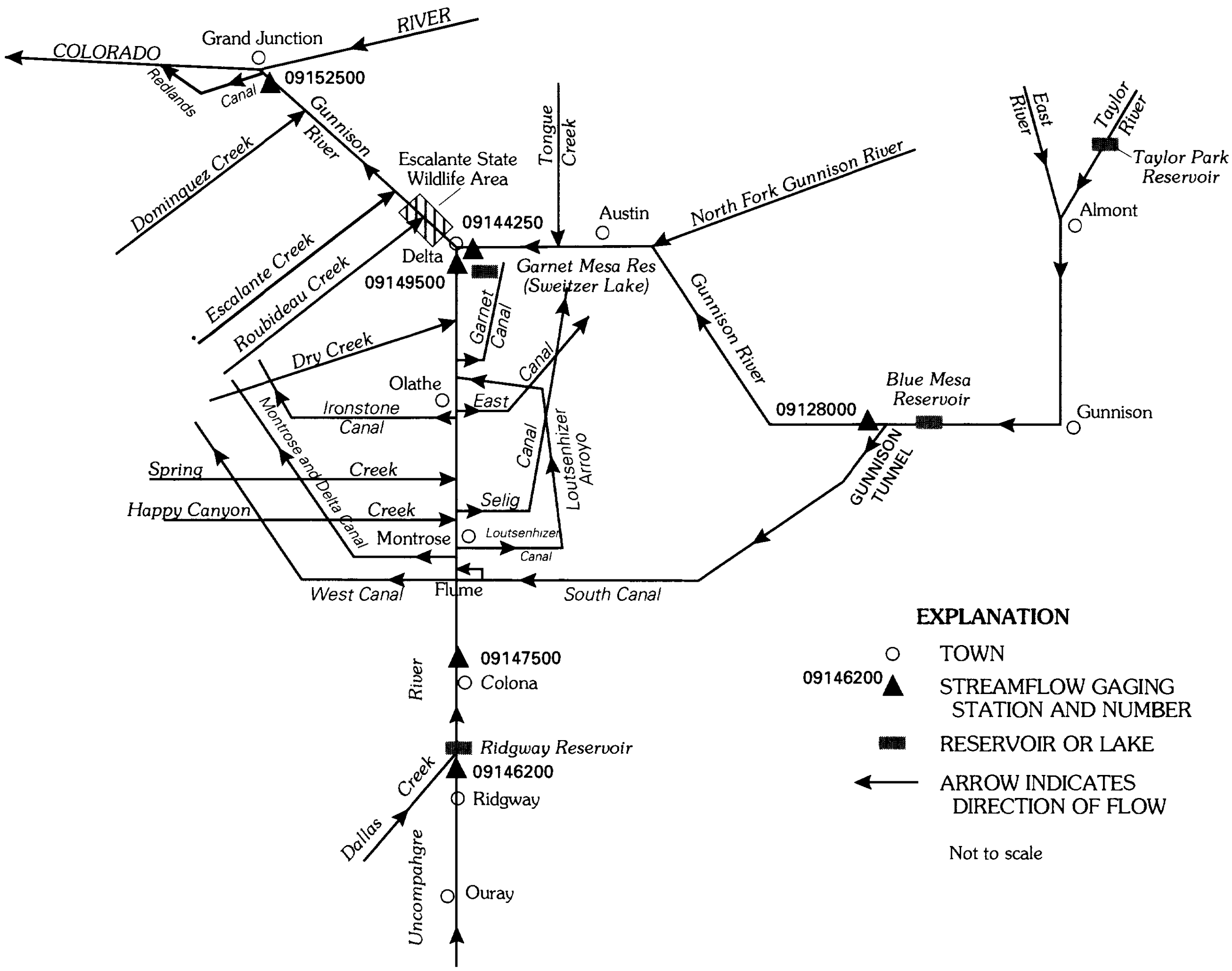

Figure 3.--Schematic diagram of major streams, tributaries, reservoirs, and canals and movement of water.

water diverted from the Gunnison River, accounted for about 12 percent of the stream discharge from the Gunnison River basin recorded at streamflow-gaging station (hereinafter referred to as gaging station) 09152500 (fig. 1) for water years 1939-88.

Downstream from the Smith Fork (fig. 1) to Grand Junction, the State of Colorado has classified the Gunnison River for cold-water fishery, recreation, domestic and municipal water supplies, and agricultural use (Colorado Department of Health, 1988). The Gunnison River is not used for domestic and municipal water supplies in Delta, and normally is not used for municipal water supplies in the Grand Junction area. The river is used as a backup water supply for the Grand Junction water-supply system, but usually only in drought years. Grand Junction last used the Gunnison River as a major water source in 1977. The Gunnison River is considered a Gold-Medal trout stream in a reach upstream from the Smith Fork to Morrow Point Reservoir (fig. 1). The largest use of water from the Gunnison River downstream from Delta is for the Redlands Canal (fig. 3), which diverts water from the river 2 mi upstream from Grand Junction. Most of the water diverted for the Redlands Canal is for operation of a small powerplant.

The Uncompahgre River downstream from Colona is used for agricultural irrigation, but not for domestic or municipal water supplies. The river is classified for agricultural uses and recreation by the State of Colorado (Colorado Department of Health, 1988). Downstream from Montrose, the river presently (1989) is not classified as a viable fishery by the Colorado Department of Health because of problems from previous metal pollution from headwater areas, warm stream temperatures in summer, and fluctuating stream discharge and sediment associated with irrigation practices.

Less than normal snowmelt runoff and reservoir operations affected stream discharge in the Gunnison and Uncompahgre Rivers in water year 1988. Stream discharge of the Gunnison River has been partially regulated since 1937 by Taylor Park Reservoir and much more regulated since 1965 by Blue Mesa Reservoir. Stream discharge in the Uncompahgre River during water year 1988 was affected by the filling of Ridgway Reservoir that began in the fall of 1986.

The annual stream discharge of the Gunnison River at Delta (gaging station 09144250 in figs 1 and 3) in water year 1988 was about 55 percent of the average annual stream discharge for water years 1977-87. This gaging station has only operated since May 1976. To compare stream discharge in 1988 to the average stream discharge for water years 1966-87, the stream-discharge record for Gunnison River near Grand Junction (gaging station 09152500, figs. 1 and 3) was used. Water years 1966-87 were used as the long-term period because those years represent stream discharge in the river since completion of Blue Mesa Reservoir. The annual stream discharge for gaging station 09152500 in water year 1988 was about 71 percent of the average annual stream discharge for water years 1966-87. The daily mean stream discharges from October to about mid April in water year 1988 were about equal to the average daily mean stream discharges for water years 1966-87 (fig. 4). Releases from Blue Mesa Reservoir were not increased substantially in spring and summer of 1988 because of less than normal snowmelt runoff into the reservoir. The monthly mean stream discharges in May, June, and July of 1988 were only about 35 to 40 percent of the long-term average monthly mean stream discharges for those months for water years 1966-87.

Natural runoff in the Uncompahgre River basin upstream from Ridgway Reservoir is represented by the stream-discharge record for Uncompahgre River at Ridgway (gaging station 09146200 in fig. 1). The annual stream discharge at Ridgway for water year 1988 was about 80 percent of the average annual discharge for the period of record (water years 1959-87). Stream discharge for Uncompahgre River at Colona (gaging station 09147500 in fig. 1) during water year 1988 was primarily dependent on releases from Ridgway Reservoir. The annual stream discharge at Colona for water year 1988 was only about 53 percent of the average annual stream discharge for the period of record (water years 1913-87). Stream discharge was greatly decreased during spring runoff in 1988 compared to the long-term average (fig. 5). Monthly mean stream discharge in May 1988 was only about 27 percent of the average monthly mean discharge for May, and stream discharge in June was only about 34 percent of the average monthly mean discharge for June.

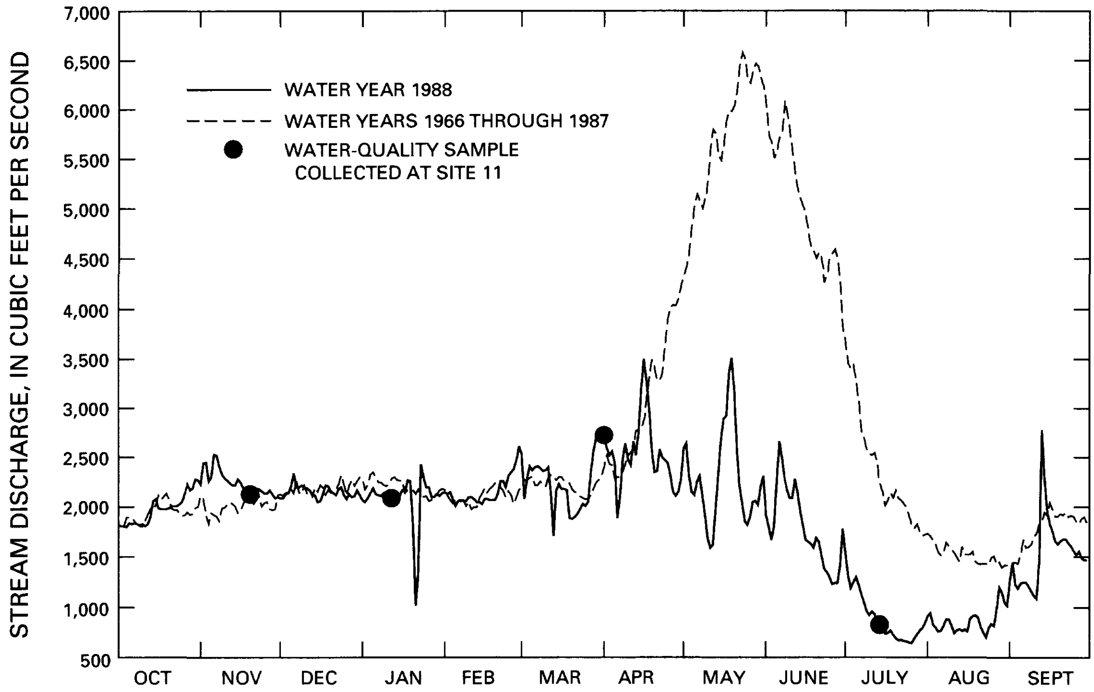

Figure 4.--Daily mean stream discharge for water year 1988, average daily mean stream discharge for water years 1966-87 at streamflow gaging station 09152500, Gunnison River near Grand Junction, and dates when water-quality samples were collected at site 11.

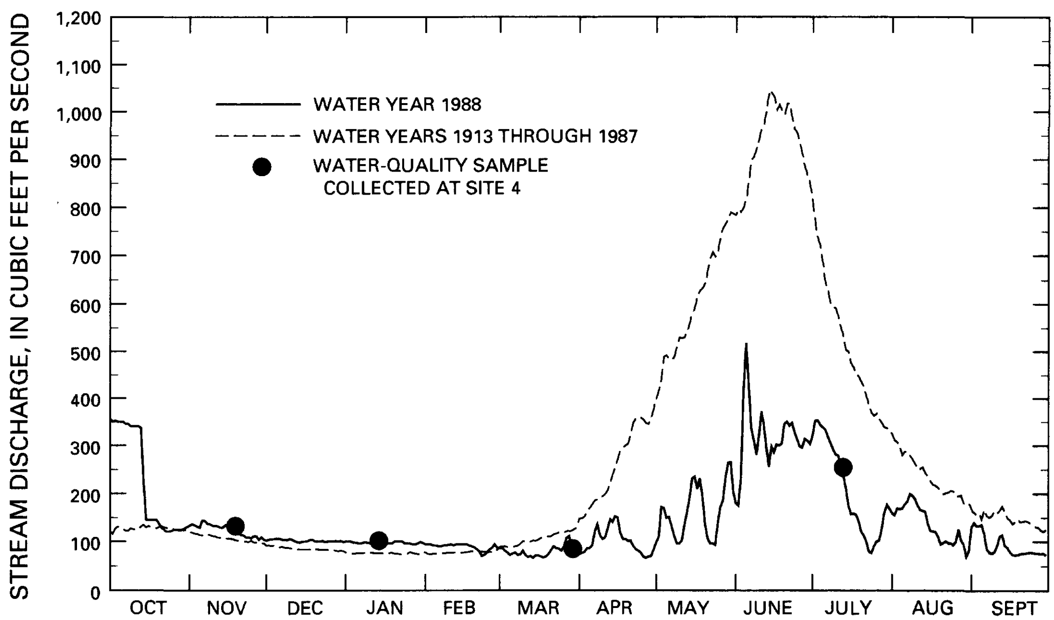

Figure 5.--Daily mean stream discharge for water year 1988, average daily mean stream discharge for water years 1913-87, and dates when water-quality samples were collected at streamflow gaging station 09147500, Uncompahgre River at Colona (site 4).

Stream discharge for the Uncompahgre River at Delta (gaging station 09149500 in fig. 1) during water year 1988 was affected by natural runoff during winter and spring, irrigation diversions and return flows during summer, and by the filling of Ridgway Reservoir. The annual stream discharge for water year 1988 at gaging station 09149500 was only about 67 percent of the average annual stream discharge for water years 1939-87. Compared to the long-term stream-discharge record, stream discharge at gaging station 09149500 from October through mid-April was about normal, and stream discharge from May through August generally was less than normal (fig. 6) in water year 1988. During May, June, and July, the monthly mean stream discharges were less than 50 percent of the long-term average monthly mean stream discharges for corresponding months for water years 1939-87. Much of the decrease in stream discharge in the Uncompahgre River at Delta during May through July 1988 can be attributed to storage of water in Ridgway Reservoir.

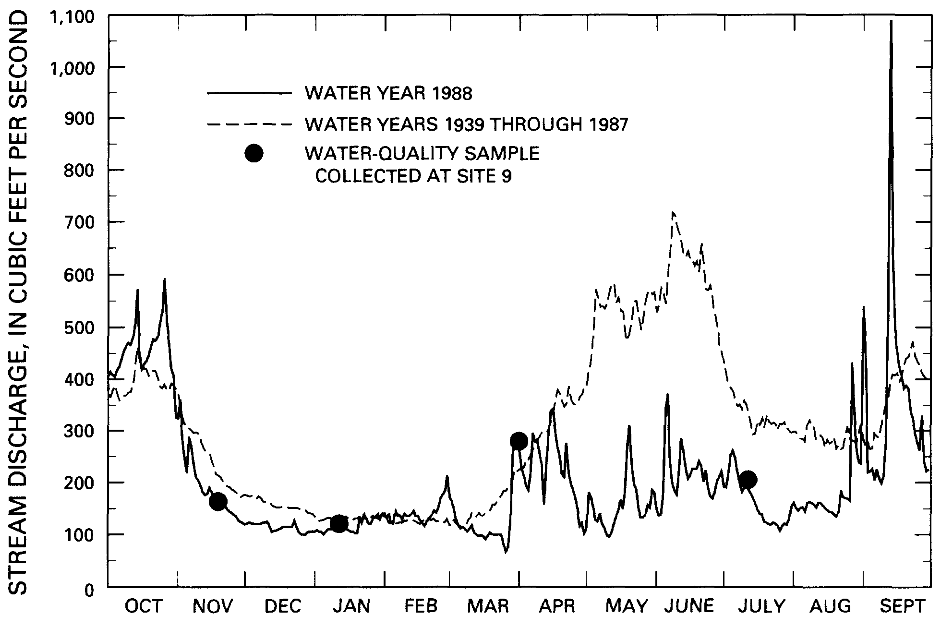

Figure 6.--Daily mean stream discharge for water year 1988, average daily mean stream discharge for water years 1939-87, and dates when water-quality samples were collected at streamflow gaging station 09149500, Uncompahgre River at Delta (site 9).

Although most of the data collection for the reconnaissance investigation was done during a relatively dry year (water year 1988), the data collection was at the end of an unusually wet hydrologic period in the Gunnison and Uncompahgre River basins. Annual mean stream discharges in water years

1982-87 exceeded the average annual mean stream discharge for water years 1939-88 for the Uncompahgre River at Delta (gaging station 09149500) (fig. 7). A similar pattern occurred for the water years 1982-87 for the Gunnison River near Grand Junction (gaging station 09152500). Water years 1983-85 had three of the five largest annual stream discharges for the period of record for both gaging stations.

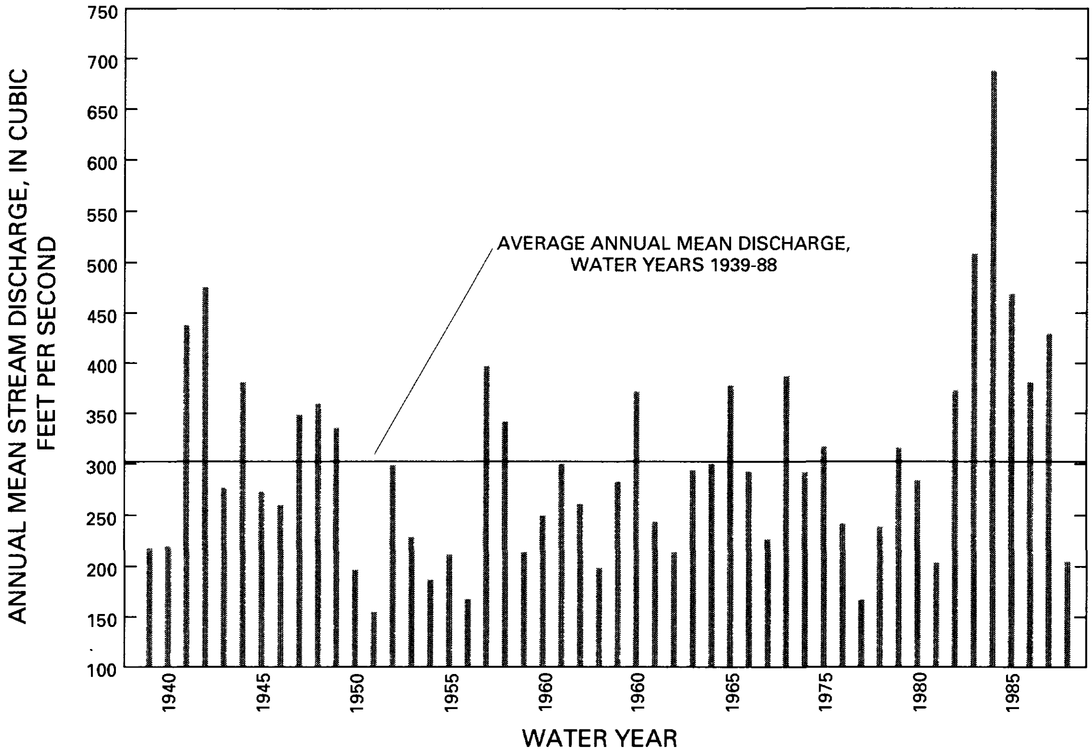

Figure 7.--Annual mean stream discharge at streamflow gaging station 09149500, Uncompahgre River at Delta, water years 1939-88.

Uncompahgre Project

The primary hydrologic features of the Uncompahgre Project are shown in figure 3. These features include Taylor Park Reservoir, Gunnison Tunnel, and the canals. There are many other smaller canals, laterals, and drains that are part of the irrigation supply and drainage system. The extent of irrigated lands shown in figure 2 is about 187,880 acres, of which about 94,000 acres are actually irrigated. The Uncompahgre Project furnishes water to about 86,000 acres (U.S. Bureau of Reclamation, 1984); the other 8,000 irrigated acres receive non-project water. An irrigated area of 94,000 acres comprises about 21 percent of the Uncompahgre River drainage basin between Colona and Delta.

The primary source of water to the Uncompahgre Project is the Gunnison River. Taylor Park Reservoir provides about 50,000 acre-ft of storage for the project in the upper Gunnison River basin. Water from the Gunnison River is diverted downstream from Blue Mesa Reservoir through the Gunnison Tunnel (capacity 1,135 ft^3/s) into the South Canal (figs. 2 and 3). In water year 1988, 399,186 acre-ft of water was diverted through the Gunnison Tunnel (James Hokit, Uncompahgre Valley Water User's Association, oral commun., 1988). There are laterals and direct diversions from the South Canal to irrigate areas east of Montrose, but most of the water in the South Canal flows to the Uncompahgre River. The South Canal has a capacity of 800 ft^3/s at its terminus at the Uncompahgre River. There, water is carried by flume across the river into the West Canal (capacity 175 ft^3/s), the remainder discharges into the Uncompahgre River to augment flow for downstream diversions to the six canals (Montrose and Delta, Loutsenhizer, Selig, Ironstone, East, and Garnet) shown in figure 3. There is considerable reuse or rediversion of irrigation water by the downstream canals, such as East and Garnet Canals. The streamflow in the Uncompahgre River often is minimal during summer immediately downstream from the diversion for the East Canal at Olathe; therefore, the Garnet Canal, which supplies water to Sweitzer Lake, diverts water that primarily might be return flow from upstream irrigated lands.

During this study, water diversion through the Gunnison Tunnel was stopped October 31, 1987, and started again on April 5, 1988. Water is maintained in some of the canals during winter for livestock watering. Water flows through about 70 percent of the system at a maximum flow of about 20-percent capacity during winter (U.S. Bureau of Reclamation, 1984).

Because most of the facilities of the Uncompahgre Project were built before 1915, most are old and in need of repair. More than 80 percent of the canal and lateral structures were constructed of timber (U.S. Bureau of Reclamation, 1984). Currently (1989), more than 90 percent of the canals and laterals are not lined, which results in conveyance losses in the distribution system.

Much of the irrigation drainage and return flow from lands east of the Uncompahgre River discharge into the Uncompahgre River. However, tailwater and part of the surface return flow and subsurface drainage from areas served by the Selig, East, and Garnet Canals discharge into the Gunnison River between Delta and Peach Valley Arroyo (fig. 2) through drainage canals, ditches, and natural drainages. Much of the irrigation drainage from lands on the west side of the Uncompahgre Valley also discharge into the Uncompahgre River. However, some tailwater and irrigation drainage from the Montrose and Delta and Ironstone canals discharge into the Gunnison River downstream from Delta through Roubideau Creek and a few small drainages.

Sweitzer Lake

Sweitzer Lake has a storage capacity of 1,330 acre-ft and a surface area of 135 acres. The maximum depth is 28 ft. According to park personnel at Sweitzer Lake State Park, the lake usually is full, and water flows over the spillway at the dam. Apparently, there is sufficient surface and subsurface inflow to keep the lake full or almost full throughout the year. Surface inflow primarily is from a diversion ditch off the Garnet Canal on the east side of the lake and from a small drainage ditch at the southwest end of the lake (fig. 8). The State has water shares for the Garnet Canal and during irrigation season can divert water into the lake from the Garnet Canal. During the nonirrigation season (November through March), the diversion on the Uncompahgre River for the Garnet Canal is closed. A small quantity of water continues to flow through the Garnet Canal during the nonirrigation season from irrigation drainage and seepage into the canal. The headgate on the diversion ditch usually is open throughout the year; therefore, there usually is a continuous flow through the diversion ditch into the lake. There was water flowing in the Garnet diversion ditch during every visit by project personnel during the reconnaissance investigation. The maximum discharge measured or estimated in the Garnet diversion ditch was about 1.5 ft^3/s. The continuous flow of water from the canal into the lake has been occurring only since installation of a new headgate during the mid 1980's on the diversion structure at the lake (Kenneth Moreland, Colorado Division of Parks and Outdoor Recreation, oral commun., 1989). Apparently, the old headgate was silted in much of the time, and no surface water would flow into the lake. Since installation of the new headgate, there may be considerably more flushing of the lake than in previous years. There may be small quantities of drainage into the lake from nearby irrigated fields; and, because the lake is in a minor depression, there could be shallow ground-water discharge into the lake. The quantity of subsurface inflow into the lake is not known.

Outflow from Sweitzer Lake is over the spillway into a small, grass- and brush-choked channel. Apparently, water in the outflow channel infiltrates into alluvium and does not flow to the Uncompahgre River at the surface. Water was observed flowing over the spillway during visits to the lake by project personnel (November 1987 to August 1988) except during a visit in late March. On rare occasions, water has been released from the lake through a bottom outlet, but that outlet was not used during the period of the reconnaissance investigation.

Ground Water

In the Uncompahgre River valley, aquifers in alluvial material and in the Dakota Sandstone are the most used, primarily for livestock watering or for domestic use in rural areas without access to a municipal water system. Well yields as large as 750 gal/min have been reported from a well completed in alluvial material (Brooks and Ackerman, 1985). Alluvial ground water is hydraulically connected to the Uncompahgre River and to canals. Most of the ground water used in the valley is west of the Uncompahgre River. East of the river, the alluvial material is not as suitable as a water supply because there are fewer gravel beds and more shale in the material (Meeks, 1950). Shallow wells east of the river may be in lenses of sand and gravel or broken shale that store drainage from irrigated fields and seepage from canals, laterals, and ditches (Meeks, 1950). Alluvial ground water can be more saline than nearby surface water; much of the increased salinity might be from leaching of salts by irrigation drainage.

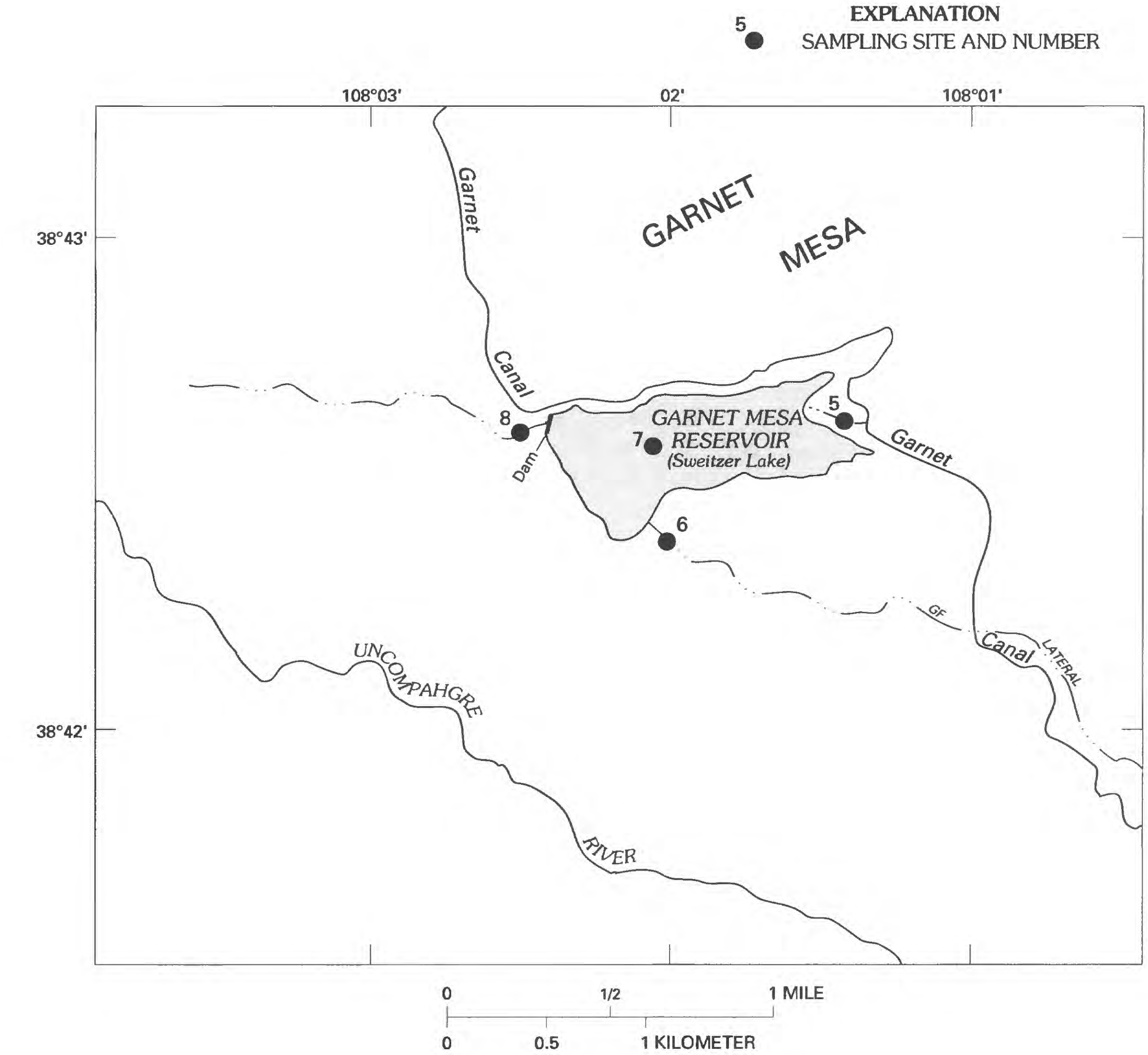

Figure 8.--Location of sampling sites at Sweitzer Lake.

Bedrock aquifers in the study area have limited use, primarily for livestock watering. Yields from wells completed in the Dakota Sandstone ranged from 1 to 22 gal/min. Aquifers in the Mancos Shale generally do not produce sufficient quantities of water for most uses. Water production in wells in the Mancos Shale often is erratic, and the water often is highly mineralized. The weathered and fractured layers of the Mancos Shale may contain water that is recharged by the irrigation system. Use of such water would be limited because of poor quality. There are a few wells completed in aquifers of the Morrison Formation west of Montrose, but water from that formation has limited use in the study area.

Salinity studies of the Uncompahgre Project area (U.S. Bureau of Reclamation, 1984) determined that most of the increase in salt load (equivalent to dissolved-solids load) in the Uncompahgre River through the study area was caused by surface water entering the shallow ground-water system and dissolving salts from the soil and underlying shale. The shallow ground water then flows through weathered and fractured shale or through sand and gravel layers and discharges into canals, into natural drainages, or directly into the Gunnison River or the Uncompahgre River. A large percentage of the recharge to the ground-water system is from deep percolation of applied irrigation water and distribution-system losses (U.S. Bureau of Reclamation, 1984). Although only about 38 percent of the irrigated area served by the Uncompahgre Project is located on the east side of the valley, 64 percent of the salt-load increase came from project lands on the east side (U.S. Bureau of Reclamation, 1984). Virtually all of the salt loading from irrigated areas on the east side of the valley was caused by surface water dissolving salt from adobe (Mancos) soils or from weathered and fractured shale layers in the Mancos Shale. The water in the Mancos Shale had an estimated salinity concentration (or dissolved-solids concentration) of 4,500 mg/L (U.S. Bureau of Reclamation, 1984).

PREVIOUS INVESTIGATIONS

Water-quality data were collected in the Uncompahgre Project area primarily to study and monitor salinity; much of the long-term data available are major-ion and dissolved-solids data for stream sites. Trace-element data were collected at two sites on the Gunnison River and two sites on the Uncompahgre River. There are no data available for pesticide concentrations in the study area. Ground-water use in the project area is quite limited; consequently, few water-quality analyses are available. Geochemical data for soils were available for irrigated areas near Delta and Grand Junction. The few biological data were collected from Sweitzer Lake, Ridgway Reservoir, and the Uncompahgre River downstream from Ridgway Reservoir.

Water-Quality Data

Streams

The U.S. Geological Survey collected major-ion and dissolved-solids data from 1959-63 at sites on the Gunnison River between the North Fork confluence and Delta. The only trace-element data collected were for boron. Mean dissolved-solids concentration (80 samples) was 488 mg/L, and boron concentrations ranged from 50 to 150 μg/L (8 samples). The Colorado Department of Health collected trace-element data for the Gunnison and Uncompahgre Rivers at Delta and for the Uncompahgre River at Ridgway; these data are summarized in table 1. The overall collection period for the data listed in table 1 is 1968-88. The data were retrieved from the storage and retrieval (STORET) part of the U.S. Environmental Protection Agency's Water Quality Control Information System. The longest term and most comprehensive water-quality data-collection site in the Gunnison River basin is at the gaging station near Grand Junction (station 09152500 in fig. 1). The U.S. Geological Survey has collected major-ion, dissolved-solids, and iron data since 1931 at that station. Mean dissolved-solids concentration (1931-88) was 1,006 mg/L and was a mixed-cation sulfate water type. In 1975, the station was included in the U.S. Geological Survey's National Stream Quality Accounting Network, and comprehensive trace-element data have been collected on a routine basis for that program. Selected trace-element data are listed in table 2, and the dissolved-selenium concentrations are plotted in figure 9. The apparent trend of decreasing selenium concentrations at station 09152500 might have been caused by greater than average stream discharge of the Gunnison River from 1983-87. The overall collection period for the data listed in table 2 is 1975-88, except for boron, which is 1951-79.

Table 1.--*Summary of selected total trace-element concentrations for Gunnison River at Delta, Uncompahgre River at Ridgway, and Uncompahgre River at Delta*

[Analyses by Colorado Department of Health; concentrations are in micrograms per liter; concentrations were reported as total or total recoverable. Data-collection period is 1968-88.]

Constituent	Number of samples	Median	Maximum	Minimum
	GUNNISON RIVER AT DELTA			
Arsenic	49	0	93	0
Boron	58	60	210	0
Cadmium	100	.3	3.0	0
Chromium	7	0	6	0
Copper	97	5	24	0
Lead	100	5	42	0
Mercury	9	.5	.5	.5
Molybdenum	18	0	18	0
Nickel	7	50	100	0
Selenium	56	0	10	0
Zinc	113	10	450	0
	UNCOMPAHGRE RIVER AT RIDGWAY			
Arsenic	96	10	20	0
Boron	47	40	190	0
Cadmium	98	.31	3.7	0
Chromium	7	0	6	0
Copper	95	28	360	0
Lead	101	7	260	0
Mercury	8	.5	.5	.5
Molybdenum	17	0	15	0
Nickel	7	50	100	0
Selenium	38	0	5	0
Zinc	100	120	480	0

Table 1.--*Summary of selected total trace-element concentrations for Gunnison River at Delta, Uncompahgre River at Ridgway, and Uncompahgre River at Delta*--Continued

Constituent	Number of samples	Median	Maximum	Minimum
	UNCOMPAHGRE RIVER AT DELTA			
Arsenic	101	10	105	0
Boron	69	170	540	0
Cadmium	131	.3	11.1	0
Chromium	10	0	10	0
Copper	171	8	120	0
Lead	177	9	160	0
Mercury	7	.5	.5	.5
Molybdenum	23	0	20	0
Nickel	7	50	100	0
Selenium	103	15	52	0
Zinc	205	20	410	0

Table 2.--*Summary of selected trace-element concentrations for streamflow gaging station 09152500, Gunnison River near Grand Junction*

[Sample collection and analyses by the U.S. Geological Survey; concentrations are for dissolved constituents unless noted; concentrations are in micrograms per liter; <, less than; ND, concentration reported as not detected; --, not determined. Data-collection period is 1975-88, except for boron, which is 1951-79.]

Constituent	Number of samples	Median	Maximum	Minimum
Arsenic	55	1	7	<1
Arsenic, total	28	2	5	<1
Boron	173	140	350	0
Cadmium	54	<1	10	0 and ND
Copper	54	2	23	<2 and ND
Lead	54	3	71	0 and ND
Mercury	53	--	<.5	<.1
Mercury, total	25	--	<.5	<.1
Selenium	54	7	25	<1
Selenium, total	27	10	21	4
Vanadium	25	<6	15	<1
Zinc	55	10	82	3 and ND

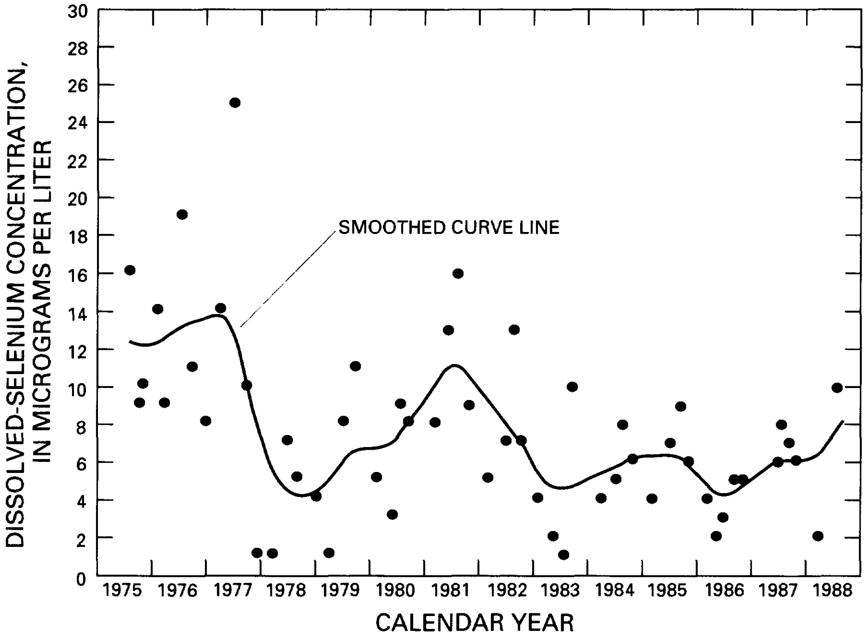

Figure 9.--Concentrations of dissolved selenium at streamflow gaging station 09152500, Gunnison River near Grand Junction, 1975-88.

The water and salinity (dissolved-solids load) budget of the Uncompahgre River from Colona to Delta is described in a report by the U.S. Bureau of Reclamation (1984). That report discusses the quantity and sources of the salt-load increase in the river in the Uncompahgre Project area. The U.S. Geological Survey collected major-ion, dissolved-solids, and boron data at the Uncompahgre River at Delta (gaging station 09149500) from 1958 to 1980. Mean dissolved-solids concentration (120 samples) was 1,498 mg/L, concentrations ranged from 485 to 2,530 mg/L, and most samples were a mixed-cation sulfate water type. Boron concentrations ranged from 0 to 450 μg/L. The Colorado Department of Health also has collected selected trace-element data for the Uncompahgre River at Delta and Ridgway (table 1).

Water-quality data for the tributaries and canals in the study area are sparce. The U.S. Geological Survey collected water-quality data at two sites on Spring Creek (fig. 1) from 1977 to 1981. One site was upstream from the West Canal and, therefore, upstream from irrigated areas. The other site was near the mouth of Spring Creek and was downstream from irrigated land on the west side of the Uncompahgre Valley. The site near the mouth had greater concentrations of dissolved solids and nitrite plus nitrate than the upstream site. Except for boron, trace-element concentrations at the sites were about equal, and the concentrations were small. Maximum concentrations of selected trace elements (both sites) for Spring Creek were: arsenic, 2 μg/L; mercury, 0.1 μg/L; selenium, 3 μg/L; and zinc, 53 μg/L. The Colorado Division of Wildlife collected two samples for selenium analysis in 1974 from Loutsenhizer Arroyo; both samples had less than 10 μg/L of selenium.

Sweitzer Lake

Water-quality data for Sweitzer Lake were collected only for short-term studies. Sweitzer Lake was sampled by the U.S. Geological Survey in August 1973 as part of a lake survey in Colorado (Britton and Wentz, 1980). Dissolved-selenium concentrations were 14 μg/L near the surface and 6 μg/L in a sample collected near the lake bottom. Other trace-element concentrations were small. The Colorado Division of Wildlife reported selenium concentrations that ranged from less than 10 to 80 μg/L in six samples (Colorado Division of Wildlife, written commun., 1987) collected in 1974 from the lake. The U.S. Bureau of Reclamation collected selenium data in 1978 from Sweitzer Lake and from three inflow drains, including the diversion ditch off the Garnet Canal. Five sets of samples were collected from July to October 1978 for dissolved- and total-selenium analyses. The largest concentrations of selenium were in samples collected during August, and less selenium was reported in samples collected in September and October. Selenium concentrations ranged from less than 5 to 45 μg/L in the lake and from less than 5 to 25 μg/L in the drains.

Ground Water

Ground-water quality pertaining to salinity in the Uncompahgre River valley is briefly discussed in Meeks (1950). The salinity study of the Uncompahgre Project by the U.S. Bureau of Reclamation describes ground-water quality in relation to salt loading from project lands. Water-quality data for aquifers in the lower Gunnison River basin are reported by Brooks and Ackerman (1985); some of those data are applicable to the study area. A computer retrieval of ground-water-quality data collected by the U.S. Geological Survey had 14 sites in the Uncompahgre River valley north of Colona that had chemical analyses for alluvial aquifers and aquifers in the Dakota Sandstone. Selected water-quality data for alluvial and Dakota Sandstone aquifers are summarized in table 3. The water-quality data in table 3 were collected from 1974 to 1982. The maximum selenium concentration reported in table 3 was for a water sample from a well located about 2 mi north of Sweitzer Lake.

Water-quality data collected by the U.S. Geological Survey for samples representing water in the Mancos Shale in west-central Colorado are summarized in table 4. The data summarized in table 4 are for samples collected at 12 sites from 1974 to 1980. The sample that had 100 μg/L of selenium (table 4) was not collected in the study area; the sample came from a spring located about 45 mi southwest of Montrose on the west side of the Uncompahgre Plateau (fig. 1).

Table 3.--*Summary of selected water-quality data for samples collected from alluvial aquifers and aquifers in the Dakota Sandstone in the Uncompahgre River valley*

[Analyses by U.S. Geological Survey; concentrations are in micrograms per liter, except for dissolved solids and nitrate as nitrogen, which are in milligrams per liter; all constituents are dissolved unless noted; <, less than; --, not determined. Data-collection period is 1974-82]

Constituent	Number of samples	Median	Maximum	Minimum
Dissolved solids	14	1,080	12,400	347
Nitrate as nitrogen	14	.12	20	.00
Arsenic	7	1	270	<1
Arsenic, total	5	3	3	2
Boron	12	260	12,000	50
Cadmium	6	--	<2	0
Chromium	6	10	10	0
Copper	6	1	6	<1
Iron	14	120	1,800	<10
Lead	6	1	2	0
Manganese	14	21	1,300	<10
Mercury	6	--	<.1	0
Selenium	7	<1	21	0
Selenium, total	5	5	15	<1
Silver	6	--	<1	0
Zinc	6	20	300	5

In 1986, the U.S. Bureau of Reclamation sampled water flowing from an abandoned gas well located along the banks of the Gunnison River a few miles upstream from Delta. The volume of water flowing from the well was small and fluctuated considerably. The water was a brine that had large concentrations of arsenic, boron, lead, mercury, selenium, strontium, and vanadium. Source of water from this well is unknown.

Soil and Bottom-Sediment Data

Geochemical data for soils in the Delta and Grand Junction areas were available from the U.S. Geological Survey (T.F. Harms, U.S. Geological Survey, written commun., 1988). Only certain elements were analyzed in those samples, and selenium was not determined in the soil samples from the Delta area. There were geochemical data for certain elements for 28 soil samples that were collected from irrigated areas in the Grand Valley (Grand Junction area, fig. 1). Soils and climate in the Grand Valley are similar to soils and climate in the Delta area. A statistical summary of the geochemical data for the soil samples is listed in table 5. Two rock samples from the Mancos Shale (one near Delta and one near Grand Junction) had 3 and 2 μg/g selenium

(Anderson and others, 1961). Two soil samples collected by the U.S. Bureau of Reclamation in 1978 at Sweitzer Lake had 0.12 and 0.24 μg/g selenium reported as soluble selenate.

Table 4.--*Summary of selected water-quality data for samples collected from the Mancos Shale in west-central Colorado*

[Analyses by U.S. Geological Survey; concentrations are in micrograms per liter, except for dissolved solids and nitrate nitrogen, which are in milligrams per liter; all constituents are dissolved unless noted; ND, not detected; <, less than; --, not determined. Data-collection period is 1974-80]

Constituent	Number of samples	Median	Maximum	Minimum
Dissolved solids	13	1,810	8,220	306
Nitrate as nitrogen	12	2.0	8.4	.03
Arsenic	8	2	5	<1
Arsenic, total	2	--	2	1
Boron	9	330	1,000	<20
Cadmium	6	<2	3	ND
Cobalt	6	--	ND	ND
Copper	6	3	43	ND
Iron	13	50	2,100	<10
Lead	6	5	10	ND
Mercury	6	<.1	<.1	<.1
Nickel	6	2.5	6	<2
Selenium	8	8	100	<1
Selenium, total	2	--	16	1
Zinc	6	30	4,200	<20

The only sites where bottom-material samples from streams were collected were at the two sites on Spring Creek. The U.S. Geological Survey collected three samples at each site during 1977-81. All samples had selenium concentrations reported as 0 μg/g (reporting limit probably was 1 μg/g). The mean concentrations of selected trace elements for the three samples collected at the site near the mouth of Spring Creek (downstream from irrigation drainage) were: arsenic, 5 μg/g; copper, 2 μg/g; lead, 10 μg/g; mercury, 0.01 μg/g; vanadium, 2 μg/g; and zinc, 20 μg/g. The Colorado Division of Wildlife reported 305 μg/g of selenium in a bottom-sediment sample collected from Sweitzer Lake in 1974 (Colorado Division of Wildlife, written commun., 1987).

Biological Data

The Colorado Division of Wildlife collected data in 1974 and 1977 from Sweitzer Lake (Colorado Division of Wildlife, written commun., 1987). The lake was sampled because of suspected problems related to selenium in water

Table 5.--*Geochemical data for selected trace elements in soils in irrigated areas near Delta and in the Grand Valley*

[Data from T.F. Harms, U.S. Geological Survey, Branch of Exploration Geochemistry, written commun., 1988; concentrations are in micrograms per gram; <, less than]

Trace element	Median	Range
	SOILS NEAR DELTA, 16 SAMPLES	
Arsenic	9	8-60
Cadmium	<1	<1-2
Copper	13	8-18
Mercury	.04	.03-.09
	SOILS IN THE GRAND VALLEY, 28 SAMPLES	
Arsenic	14	0.26-91
Mercury	.04	.02-.20
Selenium	.15	<.1-.692
Uranium	3.73	3.06-4.48
Zinc	122	71-141

and fish and because of concerns for human consumption of fish from the lake. The Colorado Division of Wildlife reported large selenium concentrations in fish samples. A summary of mean selenium concentrations is listed in table 6. Maximum concentrations (dry weight) of selenium in individual samples were 243 μg/g in flesh samples and 255 μg/g in liver samples; both concentrations were in samples from flannelmouth suckers collected in 1974. The mean selenium concentration in three crayfish was 122 μg/g dry weight and in five aquatic plant samples was 200 μg/g dry weight.

Table 6.--*Mean selenium concentrations in flesh and liver samples in fish from Sweitzer Lake, 1974 and 1977*

[Data from the Colorado Division of Wildlife, written commun., 1987; concentrations are in micrograms per gram dry weight; -- indicates no data]

Species	Mean selenium concentration			
	Flesh		Liver	
	1974	1977	1974	1977
Channel catfish	96	64	75	74
Green sunfish	129	100	154	103
Carp	--	79	--	--
Bullhead	109	48	87	81
Flannelmouth sucker	141	--	185	--
White sucker	128	95	147	--
Longnose sucker	--	99	--	--
Chub	--	84	--	--

The U.S. Fish and Wildlife Service collected 12 fish samples, including 6 trout, from Ridgway Reservoir and the Uncompahgre River downstream from Ridgway Reservoir in 1987-88. The fish were analyzed for trace elements, and results are listed in table 7. In at least one of the fish samples, concentrations of arsenic, cadmium, copper, lead, and selenium exceeded the 85th-percentile concentration (Lowe and others, 1985) for fish samples collected in 1980-81 for the National Contaminants Biomonitoring Program (NCBP). The NCBP 85th percentile for arsenic was exceeded in two samples. Cadmium concentrations in 10 of the 12 samples listed in table 7 exceeded the NCBP 85th percentile for cadmium. All concentrations of copper (table 7) exceeded the 85th percentile for copper (0.9 μg/g wet weight or 3.6 μg/g dry weight at 75 percent moisture). The lead concentration of 20 μg/g dry weight (4.3 μg/g wet weight) in a white sucker collected from the Uncompahgre River was much larger than the NCBP 85th-percentile concentration of 0.25 μg/g wet weight (1.0 μg/g dry weight at 75 percent moisture). The NCBP 85th percentile for selenium (0.77 μg/g wet weight or 2.8 μg/g dry weight at 75 percent moisture) was exceeded in all six trout samples. Zinc concentrations in seven of the fish samples exceeded the NCBP mean concentration for zinc, but none of the zinc concentrations exceeded the 85th-percentile concentration of 160 μg/g dry weight. Mine drainage into the Uncompahgre River upstream from Ridgway Reservoir is the most likely source of the trace elements. All mercury concentrations were less than the NCBP 85th-percentile concentration (0.18 μg/g wet weight or 0.72 μg/g dry weight at 75 percent moisture).

Table 7.--*Selected trace-element data for whole-body fish samples collected from the Uncompahgre River and Ridgway Reservoir in 1987-88*

[Analyses by U.S. Fish and Wildlife Service; concentrations are in micrograms per gram dry weight; <, less than; numbers in parentheses are the 85th-percentile concentrations in dry weight of the National Contaminants Biomonitoring Program. The 85th percentiles were reported in wet-weight concentrations and were converted to dry-weight concentrations at 75-percent moisture]

Species	Year	Aluminum	Arsenic (0.88)	Cadmium (0.24)	Chromium	Copper (3.6)	Lead (1.0)	Mercury (0.72)	Molybdenum	Nickel	Selenium (2.84)	Zinc (160)
					RIDGWAY RESERVOIR							
Brown trout	1988	12	0.30	<2.0	<1.0	8.2	<4	0.15	<1.0	<1	4.0	99.8
Rainbow trout	1987	547	.93	.48	<2.0	6.4	<.5	.35	.2	.5	3.4	90.8
Rainbow trout	1988	290	.40	<2.0	2.0	10	<4	.16	<1.0	<1	6.0	133
White sucker	1987	464	.38	.49	<2.0	5.8	<.5	.09	.3	.6	2.7	57.3
White sucker	1988	310	.30	.40	3.0	5.9	<4	.18	<1.0	<1	1.6	59.1
					UNCOMPAHGRE RIVER BELOW RIDGWAY RESERVOIR							
Brown trout	1987	4	.37	.40	<2.0	14.8	<.5	.12	.2	.4	4.1	89.5
Brown trout	1988	220	.30	.60	2.0	19.5	<4	.12	<1.0	<1	4.6	109
Rainbow trout	1988	200	.70	1.3	2.0	19	<4	.10	<1.0	<1	2.9	142
White sucker	1987	190	.30	.30	<2.0	4.8	<.5	.21	.3	.6	1.8	83
White sucker	1988	1,740	2.2	1.2	10	20	20	.08	<1.0	4.0	1.9	145
Mottled sculpin	1987	210	.34	.66	<2.0	6.0	.6	.08	.2	.6	2.2	131
Mottled sculpin	1988	321	.40	1.3	3.1	8.4	<4	.08	<1.0	2.0	2.8	150

SAMPLE COLLECTION AND ANALYSIS

Objectives

The general objective of this reconnaissance investigation was to determine if selenium, other trace elements, and pesticides were present in water, bottom sediment, and biota in and downstream from the Uncompahgre Project area. Constituent concentrations were compared to guidelines for environmental quality or natural background concentrations. A specific objective was a general reconnaissance to determine if the project area was contributing potentially harmful chemical constituents and compounds to the Gunnison and Uncompahgre Rivers. Another objective was to substantiate the large selenium concentrations previously reported in water, bottom sediment, and fish from Sweitzer Lake.

A standard set of chemical constituents (table 8) for analysis in each medium were developed by the DOI Task Group for use in all irrigation-drainage studies to afford comparability of data among the study areas. At water-quality collection sites, water temperature, pH, specific conductance, and dissolved oxygen were measured. Stream discharge was determined at the sites on the Gunnison and Uncompahgre Rivers and at inflow and outflow sites at Sweitzer Lake. Instantaneous stream discharge was determined at sites with gaging stations from the stage record and from stage-discharge rating tables. Pesticide compounds selected for analysis were based on pesticide usage in each study area. In the Uncompahgre Valley, organophosphate and carbamate pesticides and the herbicide 2,4-D (table 8) were selected based on discussions with agricultural extension agents and farm-supply businesses in the area.

A primary objective of the biological sampling was to identify possible bioaccumulation of contaminants within different trophic levels. Biota selected from lower trophic levels (invertebrates and plants) represent possible food sources for either fish or migratory birds that were most likely to be present at study-area locations. Consistency in species composition of samples among sites was attempted so that direct comparisons of data could be made between areas. Consistency among species could not always be achieved because of habitat variability and because sufficient numbers of organisms for adequate biomass for analysis could not always be collected.

Bird and egg samples of the following species were collected during this study: Canada geese, common mergansers, mallards, blue-winged teal, western grebes, eared grebes, coots, sora rails, Gambel's quail, bobwhite quail, killdeer, red-winged blackbirds, and yellow-headed blackbirds. Fish species collected include: brown trout, rainbow trout, channel catfish, green sunfish, flannelmouth suckers, white suckers, bluehead suckers, carp, roundtail chubs, red shiners, speckled dace, fathead minnows, and mottled sculpin. Invertebrate species collected were crayfish and snails, and various insects. Aquatic plants and filamentous algae samples also were collected.

Table 8.--*Water-quality constituents analyzed in water, bottom sediment, and biota samples*

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

Water		Bottom sediment		Biota	
Inorganic	Pesticides	Inorganic	Pesticides	Inorganic	Pesticides
Hardness	2,4-D	Arsenic	PCN	Aluminum	β-BHC
Calcium	2,4-DP	Barium	PCB	Antimony	α-Chlordane
Magnesium	Silvex	Beryllium	Aldrin	Arsenic	γ-Chlordane
Sodium	2,4,5-T	Bismuth	Chlordane	Barium	Dacthal
Potassium	Diazinion	Boron	DDD	Beryllium	p,p'-DDD
Alkalinity	Disyston	Cadmium	DDE	Boron	p,p'-DDE
Sulfate	Ethion	Cerium	DDT	Cadmium	p,p'-DDT
Chloride	Malathion	Chromium	Dieldrin	Chromium	Dieldrin
Dissolved solids	Methyl parathion	Cobalt	Endosulfan	Copper	Endrin
	Methyl trithion	Copper	Endrin	Iron	HCB
Nitrite plus nitrate	Parathion	Europium	Heptachlor	Lead	Heptachlor epoxide
	Trithion	Gallium	Heptachlor epoxide	Magnesium	
Arsenic	Aldicarb	Gold		Manganese	trans-Nonachlor
Boron	Carbofuran	Holmium	Lindane	Mercury	Oxychlordane
Cadmium	Methomyl	Lanthanum	Mirex	Molybdenum	PCB's
Chromium	Oxamyl	Lead	Perthane	Nickel	Toxaphene
Copper	Propham	Lithium	Toxaphene	Selenium	
Lead	Sevin	Manganese		Silver	
Mercury		Mercury		Strontium	
Molybdenum		Molybdenum		Thallium	
Selenium		Neodymium		Tin	
Vanadium		Nickel		Vanadium	
Zinc		Niobium		Zinc	
Uranium		Scandium			
		Selenium			
		Silver			
		Strontium			
		Tantalum			
		Thorium			
		Tin			
		Uranium			
		Vanadium			
		Ytterbium			
		Yttrium			
		Zinc			

Sampling Sites and Schedule of Sample Collection

Water-quality samples for inorganic analysis were collected from the Gunnison and Uncompahgre Rivers, Sweitzer Lake, and inflow to and outflow from Sweitzer Lake (table 9). Water sampling was done in four surveys (table 10) to define seasonal change in water chemistry and in trace-element concentrations. Samples were collected in November (2 to 3 weeks after the irrigation season ended); in January (during a period of cold weather that had stable, low-flow conditions), and in late March (one week prior to start of the irrigation season). Samples also were collected in July during the irrigation season.

Table 9.--*Sampling sites and types of samples collected*

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

Site number (figs. 2 and 8)	Site name	Water		Bottom sediment		Biota	
		Inorganic	Pesticides	Inorganic	Pesticides	Inorganic	Pesticides
2	Gunnison River below Gunnison Tunnel (09128000)	X	--	--	--	X	X
3	Gunnison River at Delta (09144250)	X	--	X	--	X	X
4	Uncompahgre River at Colona (09147500)	X	--	X	--	X	--
5	Garnet Canal diversion at Sweitzer Lake	X	X	--	--	--	--
6	Drainage ditch at Sweitzer Lake	X	--	--	--	--	--
7	Sweitzer Lake	X	X	X	X	X	X
8	Outflow from Sweitzer Lake	X	--	--	--	--	--
9	Uncompahgre River at Delta (09149500)	X	X	X	--	X	X
10	Gunnison River at Escalante State Wildlife Area	--	--	--	--	X	X
11	Gunnison River upstream from Escalante Creek	X	X	X	X	--	--
12	Happy Canyon Creek near mouth	--	--	--	--	X	X
13	Spring Creek near mouth	--	--	--	--	X	X
14	Dry Creek near mouth	--	--	--	--	X	X

Table 10.--*Sample-collection schedule for water, bottom sediment, and biota, November 1987 and January, March, and July 1988*

Sample medium and analysis	Months samples were collected
Water, inorganic	November, January, March, July
Water, pesticides	July
Bottom sediment, inorganic	November, January
Bottom sediment, pesticides	November, January
Birds, inorganic	May, June, July
Birds, pesticides	May, June, July
Eggs, inorganic	May, June, July
Eggs, pesticides	May, June, July
Fish, inorganic	July[1]
Fish, pesticides	July
Invertebrates, inorganic	July
Plants, inorganic	July

[1]Fish samples also were collected at Sweitzer Lake in March 1989.

Water-quality samples were collected at three sites on the Gunnison River and two sites on the Uncompahgre River (table 9; fig. 2). One site on each stream was selected as a background site and was located upstream from all lands receiving irrigation water from the Uncompahgre Project. Site 2 (Gunnison River below Gunnison Tunnel) is the background site for the Gunnison River, and water quality at site 2 is equivalent to the quality of the water diverted into the Gunnison Tunnel. Water quality of the Gunnison River immediately upstream from the confluence of the Uncompahgre River at Delta was sampled at site 3 (Gunnison River at Delta). There is irrigation drainage and tailwater from project lands that discharge into the Gunnison River upstream from site 3; however, there also is irrigation drainage and return flow from the Smith Fork basin, from the North Fork basin, and from irrigated land on the north side of the Gunnison River. The outflow site downstream from the entire project area is at site 11, (Gunnison River upstream from Escalante Creek). Site 11 was the nearest site to the Escalante State Wildlife Area where the Gunnison River could be sampled, and samples collected at site 11 represent the quality of water flowing through the Escalante State Wildlife Area (site 10). Much of the inflow into the Gunnison River between the mouth of the Uncompahgre River at Delta and site 11 is from Roubideau Creek, which was estimated to contribute less than 5 percent of the stream discharge of the Gunnison River at site 11.

The background sampling site for the Uncompahgre River was at site 4 (Uncompahgre River at Colona) (fig. 2). Site 9 (Uncompahgre River at Delta) is the outflow sampling site for the Uncompahgre River and is located about 1.1 mi upstream from the confluence with the Gunnison River near Delta. Water-quality differences between sites 4 and 9 could be attributed to several factors. During the nonirrigation season (November through March), irrigation drainage and shallow ground-water discharge probably have the largest effect on water quality of the river. Runoff in tributaries, such as Happy Canyon, Spring, and Dry Creeks (figs. 1 and 2), can affect water quality of the Uncompahgre River during periods of peak snowmelt, which occur from March to May depending on weather conditions. After the snowmelt season, stream discharge in these tributaries upstream from irrigated areas is small, and during the irrigation season most of the water discharged from the tributaries into the Uncompahgre River is irrigation return flow. During the irrigation season, the Uncompahgre River at the South Canal terminus (figs. 1 and 2) will be a mixture of water diverted from the Gunnison River and water in the Uncompahgre River upstream from the South Canal. Downstream from the South Canal, the quality of water in the river is altered by canal diversions, irrigation return flows, and subsurface drainage.

Water samples for inorganic analysis were collected at four sites at Sweitzer Lake (fig. 8); site 5 (Garnet Canal diversion at Sweitzer Lake) is a diversion ditch from the Garnet Canal into the lake; site 6 is a drainage ditch from fields south of the lake; site 7 is Sweitzer Lake; and site 8 is the outflow from the lake. Sites 5 and 6 were the only two ditches that had water flowing into the lake during the initial reconnaissance of sites in July 1987. Water samples were collected from Sweitzer Lake from near the surface and from near the lake bottom near the middle of the lake when possible. In January, the sample was collected near the dam because of safety considerations regarding the ice on the lake and was a composite of water sampled at three depths. An additional water sample was collected near the dam in March from the deepest area in the lake to obtain a sample from a water layer that had almost zero dissolved-oxygen concentration and a much larger specific conductance than the water layer immediately above it. The anaerobic water layer was not thick enough at the mid-lake site to collect a water sample that was representative of the anaerobic layer.

Water samples for pesticide analysis were collected in July (table 10) at stream sites that were downstream from irrigation drainage on the Gunnison River (site 11) and on the Uncompahgre River (site 9), and at Sweitzer Lake (sites 5 and 7). These samples were collected during the period when pesticides normally are applied in the study area.

Bottom-sediment samples for inorganic analysis were collected at sites 3 and 11 on the Gunnison River, at site 9 on the Uncompahgre River, and at Sweitzer Lake (table 9). Site 4 on the Uncompahgre River at Colona also was sampled because concentrations of heavy metals in bottom sediments in the Uncompahgre River may be greater than baseline concentrations because of more than 100 years of metal mining and associated mine drainage in the headwaters of the river. The Uncompahgre River upstream from Ridgway (fig. 1) has been severely affected by heavy metal pollution (Wentz, 1974). The extent of the metal pollution downstream from Ridgway into the study area was uncertain. The Gunnison River upstream from Escalante Creek (site 11) and Sweitzer Lake (site 7) were the only sites sampled for pesticides (table 9) in bottom sediment. Bottom-sediment samples were scheduled to be collected only in November, when maximum accumulation of potential contaminants from irrigation drainage was expected to occur; however, a malfunctioning bottom-sediment sampler prevented collection of a bottom-sediment sample from a mid-lake location at Sweitzer Lake. Therefore, the sample collected in November was collected from bottom sediment at the south (inflow) end of the lake in shallow water. In January, a second bottom-sediment sample in the lake was collected about 25 ft from the lake bank near the dam (table 10).

Biota sampling sites were selected to determine maximum concentrations of contaminants associated with irrigation drainage. Biota sampling sites were selected based on inflow and outflow of irrigation drainage water and the availability of biota. Biota sampling on the Gunnison and Uncompahgre Rivers was done at or as near as possible to the water-quality sampling sites on these rivers.

Sites on the Gunnison River (sites 2, 3, and 10), the Uncompahgre River (sites 4 and 9), and at Sweitzer Lake (site 7) were sampled for fish, invertebrates, and plants during July (table 9). Fish, macroinvertebrates, plants, and plankton were collected when maximum growth rates, maximum water temperature, and exposure to irrigation water were occurring. Biota sampling site 10 was considered equivalent to water-quality site 11 on the Gunnison River. Three tributaries of the Uncompahgre River, Happy Canyon Creek (site 12), Spring Creek (site 13), and Dry Creek (site 14) were sampled for biota because they represented major paths for irrigation drainage from farmlands on the west side of the valley. Because water-quality sampling during 1987-88 indicated that maximum selenium concentrations in Sweitzer Lake may occur in late winter or early spring, additional fish samples were collected from the lake in March 1989 (table 10).

Birds and eggs were collected from the Sweitzer Lake area and from the Escalante State Wildlife Area (site 10) during May, June, and July (table 10). That sampling period was selected based on availability of pre-fledgling birds and bird eggs. Because pre-fledglings generally are confined to a local area until they fledge, trace elements and pesticides in their tissue are obtained from food and water in the area where the birds are reared. An attempt was made to collect pre-fledglings immediately before fledging because older birds would have been exposed to any contaminants present in the area for a longer time period than younger birds. Such collections were not always possible because of time limitations in the sampling effort and considerable predation on young birds. Although 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. Therefore, early collection to ensure that representative egg samples were available for contaminant analysis outweighed the loss of pathological information related to developmental abnormalities.

Sampling Methods

All samples were collected using standard techniques. Water-quality samples for the river sites were collected using depth-integrating samplers and methods described by Edwards and Glysson (1988). At sites that had small discharge (sites 5, 6, and 8), depths were too shallow to use samplers, and representative point samples from the centroid of flow were collected using 3-L bottles. Water samples for pesticides were collected from the centroid of flow, when possible, by using the glass sample bottles furnished by the water-quality laboratory. Samples were processed for analysis according to instructions in the Water Quality Laboratory Services Catalog (U.S. Geological Survey, 1986).

The bottom-sediment sample from Sweitzer Lake collected in November was composited from several samples spooned from shallow areas on the south side of the lake. The availability of fine bottom sediment at the stream sites was limited; therefore, bottom-sediment samples were scooped from areas of deposition using stainless-steel spoons and were composited in a bucket. Bottom sediment was mixed in the bucket, and subsamples were taken for inorganic analysis and for pesticide analysis where applicable. The lake was resampled in January using an Ekman dredge.

Biological samples were collected by the U.S. Fish and Wildlife Service using standard equipment and techniques (U.S. Fish and Wildlife Service, 1986 and 1990). Birds were shot using steel shot, and livers were removed using stainless-steel dissecting equipment. Based on the literature, 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). Dissecting equipment was cleansed using water, soap, and solvent (U.S. Fish and Wildlife Service, 1990) prior to removal of each liver. Bird livers were placed in chemically cleansed jars, weighed, and frozen. Livers from each bird group were sometimes composited with two or three livers into one sample.

After locating nests, bird eggs were removed, the egg volume was determined by water displacement, and 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.

Fish were collected using electroshocking equipment and seine or gill nets. Fish were rinsed, weighed, measured for length, and immediately frozen on dry ice until storage in a freezer. Whole-body samples were composited by species into groups of three or more fish as dictated by the DOI sampling protocol. Fish for analyses of inorganic contaminants were frozen in plastic bags. Fish samples for analyses of pesticides were wrapped in aluminum foil and placed in plastic bags.

Stream invertebrates were collected using a kick screen, and lake invertebrates were collected using a sweep net. Because this was a reconnaissance-level study, several easily identifiable invertebrate groups were combined to obtain sufficient biomass for analysis. Vascular plants and algae were collected by hand. These samples were placed in chemically cleansed jars, weighed, and frozen. Algae samples contained green algae (Chlorophyta) and blue-green algae (Cyanophyta), and plankton samples consisted of phytoplankton and zooplankton.

Analytical Support

Analyses of water samples for major constituents and trace elements (except uranium) were done by the U.S. Geological Survey's National Water Quality Laboratory in Arvada, Colorado, using analytical methods described in Fishman and Friedman (1989). Uranium analyses were done by a private laboratory, contracted by the U.S. Geological Survey, using a method described in Thatcher and others (1977). Pesticide analyses of water and bottom-sediment samples also were done by the National Water Quality Laboratory using methods described by Wershaw and others (1987). Improvements were made in analysis of carbamates in water at the laboratory, and the reporting level for the samples collected for this study was 0.5 μg/L instead of 2.0 μg/L as stated in Wershaw and others (1987). In addition, a method was initiated at the laboratory in 1988 that can be used to determine carbamate concentrations much smaller than 0.5 μg/L in samples where positive identification of target compounds was made (S.M. Johnson, U.S. Geological Survey, written commun., 1988).

Inorganic analyses of bottom-sediment samples were done 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 sieved 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).

Biological samples were analyzed by Hazelton Laboratories America, Inc., in Madison, Wisconsin, and the Environmental Trace Substances Research Center in Columbia, Missouri[1]. Those laboratories were contracted by the U.S. Fish and Wildlife Services's Patuxent Analytical Control Facility in Patuxent, Maryland. Biological samples were analyzed for the constituents listed in table 8. Most trace elements were analyzed by inductively coupled argon-plasma/atomic-absorption spectrometry after complete digestion of the sample with strong acids. Arsenic and selenium were analyzed by hydride-generation atomic absorption, and mercury was analyzed using flameless cold-vapor atomic absorption. Biological samples scanned for pesticide residues were analyzed using solvent extraction followed by electron-capture gas chromatography.

DISCUSSION OF RESULTS

Water-Quality Results

Analytical results for stream samples were examined to identify effects of the Uncompahgre Project on water quality of the Gunnison and Uncompahgre Rivers and to determine if potentially harmful concentrations of trace elements or pesticides were present at the downstream sites. Analytical results for the sites at Sweitzer Lake were examined to determine if selenium, other trace elements, or pesticides were present in potentially harmful concentrations. Water-quality properties and analytical results of inorganic constituents are reported in table 16, and results for pesticides are in table 17 in the "Supplemental Data" section at the back of the report.

Constituent concentrations were compared to water-quality standards established by the Water Quality Control Commission of the State of Colorado (Colorado Department of Health, 1988). The State has classified streams and

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[1]The use of trade names in this report does not constitute endorsement by the U.S. Geological Survey or the U.S. Fish and Wildlife Service.

lakes in Colorado according to present or potential water uses. Major streams are separated into stream segments, and standards determined for each stream segment. The water-quality standards were derived to protect the classified uses of each segment; therefore, standards may be different for stream segments for the same stream. The standard applied to a particular constituent could be based on U.S. Environmental Protection Agency drinking-water standards (U.S. Environmental Protection Agency, 1986), standards for agricultural use, or standards based on protection of aquatic life. The water-use classifications and associated water-quality standards of selected constituents for stream segments of the Gunnison and the Uncompahgre Rivers within the study area and for Sweitzer Lake are listed in table 11. The State standards in table 11 for cadmium, copper, lead, mercury, and zinc are based on criteria for protection of aquatic life that were derived from acute or chronic toxicity data (Colorado Department of Health, 1988). Except for the lower Uncompahgre River, the selenium standards are based on the drinking-water standard (10 μg/L) or the standard for agricultural use (20 μg/L).

Table 11.--*Water-use classifications and water-quality standards for selected constituents of the Colorado Department of Health, Water Quality Control Commission, for the Gunnison and Uncompahgre Rivers and for Sweitzer Lake*

[Classification codes: R1, recreation with primary body contact, such as swimming; R2, recreation, secondary contact; A, agricultural, suitable for irrigation of crops and as drinking water for livestock; CW1, class 1 cold-water (water temperature seldom exceeds 20 degrees Celsius) aquatic life and able to sustain a wide variety of cold-water biota, including sensitive species; WW1, same as CW1 only for warm-water aquatic life; WW2, class 2 warm-water aquatic life but not capable of sustaining a wide variety of warm-water biota. WW2 standards protect only biota normally living in the water; D, domestic water supply; concentrations are in micrograms per liter, except for sulfate, chloride, and nitrate, which are in milligrams per liter; --, standards for constituent not applicable for water-use classifications]

Stream section or water body	Classifications	Sulfate	Chloride	Nitrate	Arsenic	Boron	Cadmium	Chromium	Copper	Lead	Mercury	Selenium	Zinc
Gunnison River from Smith Fork confluence to confluence with Uncompahgre River	R2, A CW1, D	250	250	10	50	750	0.4	50	12	5	0.05	10	50
Gunnison River from confluence with Uncompahgre River to mouth	R2, A CW1, D	250	250	10	50	750	3	100	20	33	.05	20	110
Uncompahgre River from Ouray to 2 miles south of Montrose	R2, A CW1	--	--	--	50	750	.4	100	65	40	.05	20	225
Uncompahgre River from 2 miles south of Montrose to the mouth	R2, A WW2	--	--	--	50	750	5	100	30	50	.05	35	100
Sweitzer Lake	R1, A, WW1	--	--	--	50	750	1	100	10	25	.05	20	50

The State standard for selenium for the lower Uncompahgre River of 35 μg/L (table 11) is much greater than selenium criteria for protection of aquatic life suggested by the U.S. Environmental Protection Agency (1987) and by Lemly and Smith (1987). The U.S. Environmental Protection Agency (1987) chronic criterion is a 4-day average selenium concentration that should not exceed 5 μg/L more than once every 3 years and the acute criterion is a 1-hour average selenium concentration that should not exceed 20 μg/L more than once every 3 years. Lemly and Smith (1987) reported that selenium concentrations in water greater than 2 to 5 μg/L might cause reproductive failure or mortality in fish and waterfowl because of food-chain bioaccumulation.

The Statewide standard for uranium (for domestic water supplies) is 40 pCi/L (about 59 μg/L) (Colorado Department of Health, 1988). There are standards for a few of the pesticides in water; for protection of aquatic life, the standard is 0.10 μg/L of malathion, 0.04 μg/L of parathion; for domestic water supplies, standards are 100 μg/L for 2,4-D and 10 μg/L for 2,4,5-T (Colorado Department of Health, 1988).

Gunnison River

Concentrations of dissolved solids (fig. 10), sodium, sulfate, selenium (fig. 11), boron, and uranium (fig. 12) in the Gunnison River generally were greater at site 3 (at Delta) than at site 2 (below the Gunnison Tunnel) and concentrations also were greater at site 11 (upstream from Escalante Creek) than at site 3. Increases in constituent concentrations between sites 2 and 3 can be attributed to numerous sources and include inflow from the Smith Fork, inflow from the North Fork, inflow from areas north of the Gunnison River between the North Fork confluence and Delta that are drained by streams such as Tongue Creek, and irrigation drainage from the Uncompahgre Project. Irrigation drainage from the Uncompahgre Project into the Gunnison River between sites 2 and 3 occurs in the stream reach between Peach Valley Arroyo (fig. 2) and site 3. This reconnaissance investigation did not separate the effects of irrigation drainage from the Uncompahgre Project on water quality of the Gunnison River between sites 2 and 3 from the effects of upstream tributaries. The Smith Fork, North Fork, and Tongue Creek drain irrigated areas outside the Uncompahgre Project area. There also are other potential sources of trace elements, such as coal mines, in the North Fork basin.

Most increases of constituent concentrations in the Gunnison River between sites 3 and 11 can be attributed to water discharging from the Uncompahgre River and Roubideau Creek (fig. 2). Much of the irrigation drainage from the Uncompahgre Project discharges into the Uncompahgre River. Constituent loads for the four sets of samples collected from the Gunnison and Uncompahgre Rivers were examined to approximate the constituent loading of the Uncompahgre River to the Gunnison River. The difference (gain) in constituent loads between sites 3 and 11 was compared to the constituent loads at site 9 (Uncompahgre River at Delta). Generally, at least 50 percent of the increase of dissolved-solids, sodium, sulfate, chloride, boron, selenium, and uranium loads between sites 3 and 11 was accounted for in the Uncompahgre River at site 9.

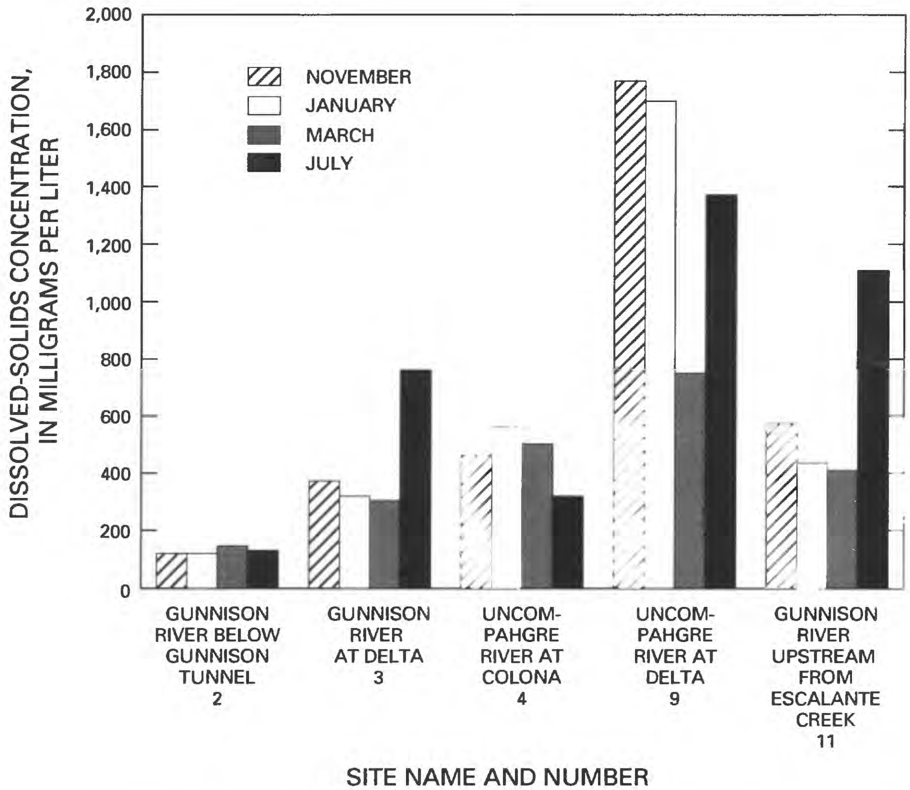

Figure 10.--Dissolved-solids concentrations in the Gunnison and Uncompahgre Rivers, November 1987 and January, March, and July 1988.

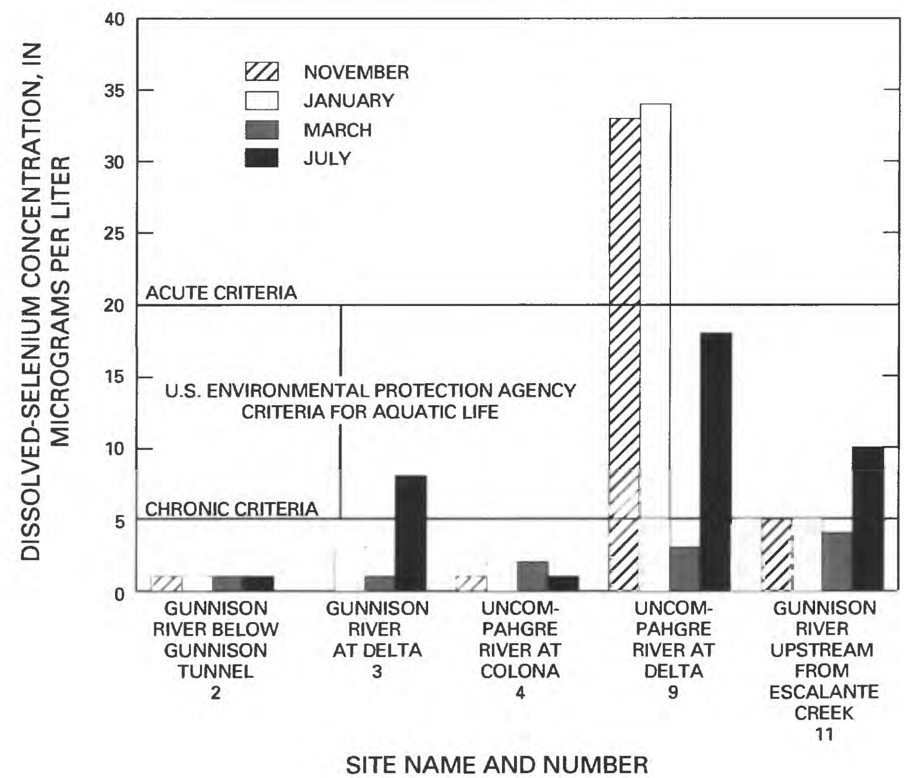

Figure 11.--Concentrations of dissolved selenium in the Gunnison and Uncompahgre Rivers, November 1987 and January, March, and July 1988.

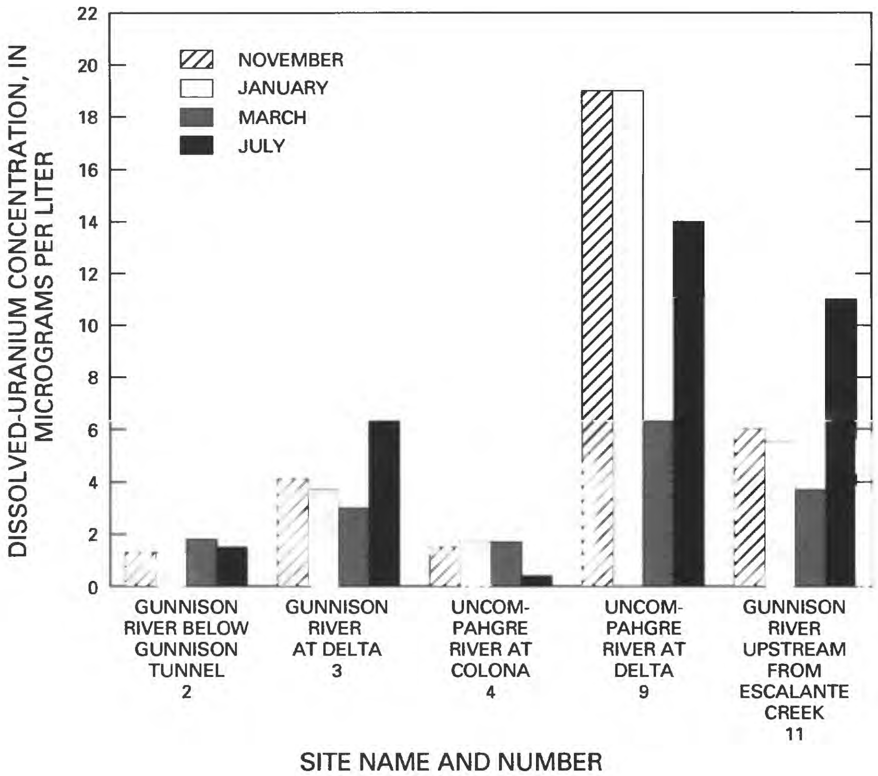

Figure 12.--Concentrations of dissolved uranium in the Gunnison and Uncompahgre Rivers, November 1987 and January, March, and July 1988.

The sulfate concentration at site 3 exceeded the drinking-water standard of 250 mg/L in July. The sulfate concentrations at site 11 exceeded the standard in November and July. The only trace-element concentrations in the Gunnison River exceeding State standards were the mercury concentration of 0.6 µg/L in the sample collected in July at site 2 and the lead concentration of 35 µg/L in the sample collected in November at site 3. The standard for mercury is 0.05 µg/L (table 11), but because the analytical reporting limit was 0.1 µg/L, mercury concentrations reported as less than 0.1 µg/L (table 16) could have exceeded the standard. A selenium concentration of 13 µg/L was reported for the sample collected at site 3 in November, which would exceed the State standard for selenium for that reach of the Gunnison River. However, that selenium result seemed to be questionable after an analysis of selenium loads, other constituent concentrations, and the selenium concentrations in November at site 11 and at gaging station 09152500. Therefore, the selenium analysis for the sample collected at site 3 in November was not used. The maximum selenium concentration in the Gunnison River was 10 µg/L in the sample collected at site 11 in July 1988.

Although selenium concentrations in the Gunnison River did not exceed State standards, the concentrations in samples collected in July 1988 at site 3 (8 µg/L) and site 11 (10 µg/L) exceeded the U.S. Environmental Protection Agency's criterion of 5 µg/L for chronic exposure. The selenium concentrations in samples collected in November 1987 and January 1988 at site 11 were equal to 5 µg/L.

Samples collected in November, January, and March from the Gunnison River were collected at normal stream discharges (fig. 4) and the sample collected in July was collected at less than normal stream discharge. The largest concentrations of many constituents in the samples collected at sites 3 and 11 occurred in July, when small releases from Blue Mesa Reservoir resulted in less dilution of constituent concentrations by upstream water.

Site 2 (below the Gunnison Tunnel) was considered the reference site for the Gunnison River. Many trace-element concentrations, including selenium, were near or less than reporting limits in the samples collected at site 2 (table 16). For comparison to the selenium data for site 11, dissolved-selenium concentrations at gaging station 09152500 near Grand Junction were 2 µg/L in April 1988, 10 µg/L in August 1988, and 8 µg/L in September 1988 (fig. 9).

Pesticide concentrations in the Gunnison River at site 11 were not unusual except for the organophosphate insecticide parathion. The parathion concentration of 0.18 µg/L (table 17) exceeds the standard of 0.04 µg/L for protection of aquatic life. Some of the parathion in the Gunnison River at site 11 came from the Uncompahgre River based on the parathion concentration at site 9 of 0.33 µg/L (table 17). Acute toxicity to certain invertebrates was reported for parathion concentrations as small as 0.4 µg/L (U.S. Environmental Protection Agency, 1986). Parathion does not persist in water in substantial concentrations and does not accumulate in biota to toxic amounts. There was no positive identification of carbamates (the last six pesticides, aldicarb through sevin, listed in table 17) in the sample collected at site 11.

Uncompahgre River

Most concentrations of dissolved solids (fig. 10), major ions (especially sodium and sulfate), nitrite plus nitrate, selenium (fig. 11), boron, and uranium (fig. 12) in the Uncompahgre River were larger at site 9 (Delta) than at site 4 (Colona) (table 16). Most of the increases in constituent concentrations between sites 4 and 9 probably can be attributed to irrigation drainage from the Uncompahgre Project area. A comparison of constituent loads for the four sets of samples for sites 4 and 9 indicate that, for most of the samples, at least 75 percent of the dissolved-solids, magnesium, sodium, sulfate, nitrite plus nitrate, selenium, boron, and uranium loads at site 9 can be attributed to inflow between sites 4 and 9. For example, on November 18, the Uncompahgre River gained 638 tons of dissolved solids between sites 4 and 9, which is 79 percent of the dissolved-solids load at site 9 for that day. A large quantity of selenium is contributed to the river from the project area; for example, on November 18 the Uncompahgre River gained about 29 lbs of selenium between sites 4 and 9, which is about 98 percent of the selenium load at site 9 for that day. Most of the inflow between sites 4 and 9 during the sampling periods in November, January, and July was irrigation drainage and return flow from the Uncompahgre Project. A substantial part of the inflow in March was snowmelt runoff from tributaries, however, snowmelt runoff tends to dilute constituent concentrations. The nitrite plus nitrate concentration for site 4 in January (25 mg/L) seemed anomolous, but there were cattle-feeding areas adjacent to and upstream from site 4 during the winter.

Only three constituent concentrations in the Uncompahgre River exceeded Colorado water-quality standards for the classified uses of the river (table 11). The mercury concentrations in samples collected in March at sites 4 and 9 (table 16) exceeded the State standards (0.05 μg/L). The sulfate concentration for site 4 for January exceeded State standards. The sulfate concentrations for site 9 exceeded the drinking-water standard of 250 mg/L (U.S. Environmental Protection Agency, 1986), however, the Uncompahgre River at site 9 is not classified by the State for use as a domestic water supply.

Selenium concentrations in the Uncompahgre River at site 9 did not exceed the Colorado standard of 35 μg/L for the lower Uncomphagre River. However, the selenium concentrations in the samples collected in November 1987 (33 μg/L), January 1988 (34 μg/L), and in July 1988 (18 μg/L) exceeded the chronic criterion for protection of aquatic life (5 μg/L), and the concentrations in the samples collected in November and January also exceeded the acute criterion for protection of aquatic life (20 μg/L).

The hydrographs for the Uncompahgre River shown in figures 5 and 6 indicate that the samples collected in November and January represent average hydrologic conditions, but that the samples collected in July were collected at stream discharges considerably less than the long-term stream discharge. A number of constituent concentrations for site 9 were considerably less in March than in the samples collected in November, January, and July at this site (figs. 10 through 12 and table 16). The sample collected in March at site 9 was during a runoff period (fig. 6), and probably most of the increase in stream discharge between site 4 and site 9 in late March was snowmelt from tributaries (such as Spring and Dry Creeks). Dissolved-solids and major-ion concentrations had less seasonal variation than would be expected at site 4 because of the effect of Ridgway Reservoir.

The parathion concentration of 0.33 μg/L in the sample collected in July at site 9 substantially exceeded the criterion of 0.04 μg/L for protection of aquatic life. Methyl parathion also was detected in that sample.

Sweitzer Lake

Concentrations of dissolved solids (fig. 13), major ions, particularly sodium, sulfate, magnesium, and nitrite plus nitrate, and selenium (fig. 14) increased in Sweitzer Lake (site 7) during the nonirrigation season (November through March) based on the samples collected in November, January, and March (table 16). The concentrations shown in figures 13 through 15 for Sweitzer Lake for November and July are averages of the two samples collected during those months, and the concentrations shown for March are the averages of the concentrations in the samples collected at depths of 1 and 19 ft (table 16). Concentrations of boron (table 16) and uranium (fig. 15) did not increase substantially during the nonirrigation season. Constituent concentrations increased in Sweitzer Lake during the nonirrigation season because much of the inflow into the lake probably was irrigation-drainage water. The maximum constituent concentrations for the four sets of samples collected for this study were in March. Specific-conductance measurements of Sweitzer Lake on May 10 (range from 2,830 to 2,900 μS/cm) were slightly less than the specific-conductance measurements made in March. Constituent concentrations probably are diluted during the irrigation season (April through October) by irrigation water diverted from the Uncompahgre River. Constituent concentrations in the four sets of samples collected from Sweitzer Lake (site 7) generally were smallest in November (table 16), at the end of the irrigation season.

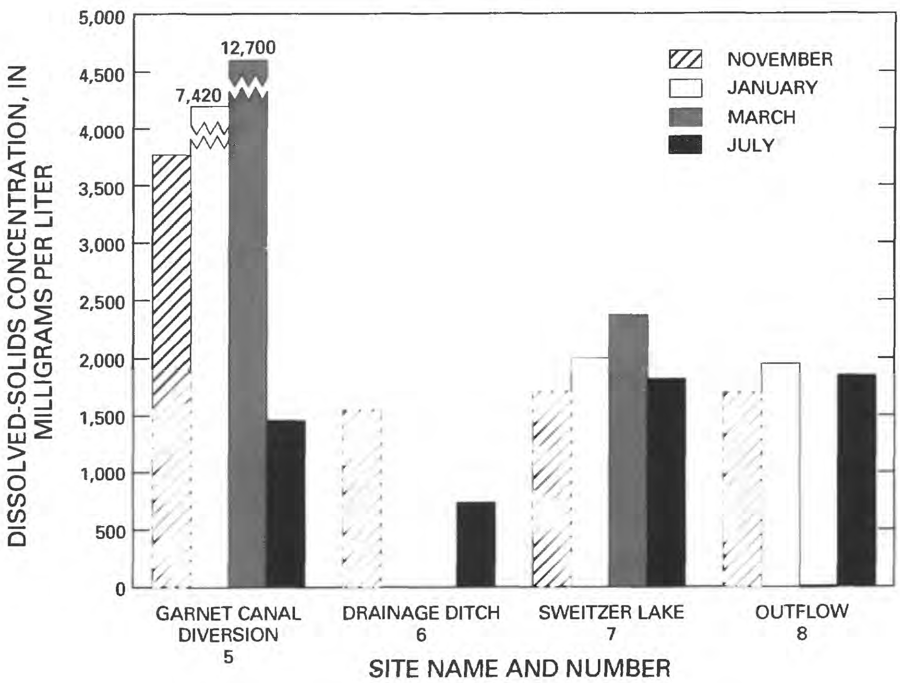

Figure 13.--Dissolved-solids concentrations for sites at Sweitzer Lake, November 1987 and January, March, and July 1988 (no bar indicates no sample collected).

Site 5, the diversion from the Garnet Canal into Sweitzer Lake, had the largest concentrations of dissolved solids, major ions, and several trace elements in the samples collected for this reconnaissance investigation. The water sampled at site 5 during November through March is irrigation drainage and shallow ground-water discharge intercepted by the Garnet Canal. The concentration of dissolved solids was 12,700 mg/L; sodium was 2,900 mg/L; and sulfate was 7,500 mg/L in late March (table 16), about 1 week before the Gunnison Tunnel diversion was opened. The sample collected in March at site 5 had the maximum concentrations of selenium (320 µg/L), boron (800 µg/L), vanadium (14 µg/L), and uranium (64 µg/L) for samples collected during this reconnaissance.

Water samples collected in November at site 6 had substantially smaller concentrations of dissolved solids (fig. 13), sodium, sulfate (table 16), and selenium (fig. 14) than did the water samples collected at site 5 on the same

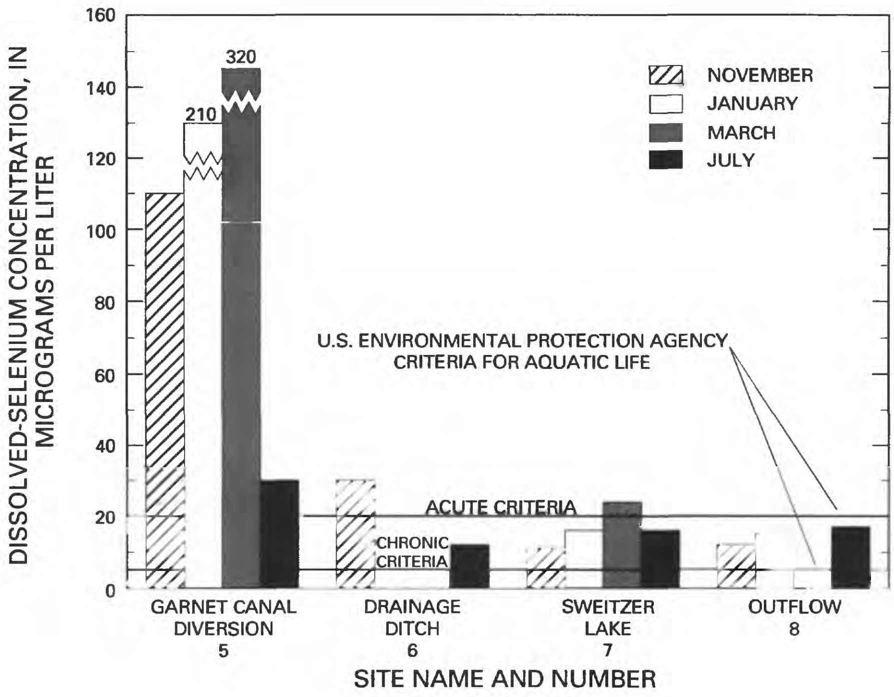

Figure 14.--Concentrations of dissolved selenium for sites at Sweitzer Lake, November 1987 and January, March, and July 1988 (no bar indicates no sample collected).

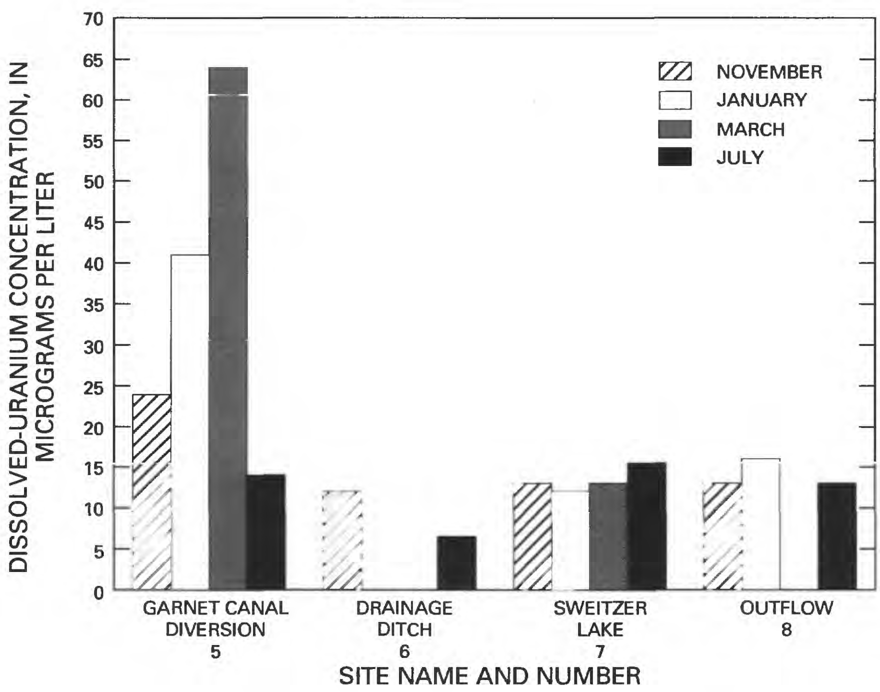

Figure 15.--Concentrations of dissolved uranium for sites at Sweitzer Lake, November 1987 and January, March, and July 1988 (no bar indicates no sample collected).

day. The drainage ditch into the lake at site 6 probably receives water from the GF lateral (fig. 8), which is a lateral from the East Canal, and water at site 6 may be surface runoff and shallow drainage from nearby fields. There was no flow at site 6 during the January and March sampling visits.

Selenium concentrations in the three samples collected in March 1988 from Sweitzer Lake (site 7 in table 16) exceeded the Colorado State water-quality standard of 20 μg/L for Sweitzer Lake (table 11). However, the selenium concentrations in all samples collected from the lake exceeded the U.S. Environmental Protection Agency's chronic criterion for protection of aquatic life (5 μg/L). Selenium concentrations in the samples collected from the lake in March also exceeded the acute criterion for protection of aquatic life (20 μg/L). The State of Colorado does not apply water-quality standards to irrigation canals; therefore, there are no State standards for selenium for sites 5, 6, and 8. However, selenium concentrations in all samples collected at those sites were greater than 5 μg/L; selenium concentrations in all samples collected at site 5 were greater than 20 μg/L. Mercury was detected in the samples collected in July 1988 (table 16) from Sweitzer Lake and in the samples collected from both inflow sites (sites 5 and 6) and from the outflow site (site 8).

In Sweitzer Lake, specific-conductance profiles indicated little change in specific conductance from the surface to about the 20-ft depth, and dissolved-solids concentrations in samples collected at the 1 and near 20-ft depths were about equal during each of the four sampling surveys. The lake was not thermally stratified at the time of sample collection in November, January, and March. The lake was thermally stratified in July, and the dissolved-oxygen concentration at the 20-ft depth was 0.2 mg/L.

A sample was collected from Sweitzer Lake near the dam (sample collected March 30 at site 7 at a depth of 27 ft in table 16) from an anaerobic water layer. Dissolved-solids, major-ion, nitrite plus nitrate, selenium, boron, and uranium concentrations were considerably larger in this sample than in the samples collected on the same day at the 1- and 19-ft depths (table 16). Comparison of concentrations of constituents in the sample from the anaerobic layer to the average concentrations for the same constituents in water samples from the Garnet Canal (samples collected from November to March at site 5) indicates that most of the water at the lake bottom was canal water or irrigation-drainage water. The lake was not thermally stratified on March 30; therefore, a chemocline may have formed in the lake during the winter. If water that was sampled during November, January, and March in the diversion ditch from the Garnet Canal (site 5) is assumed to be irrigation-drainage water, then the irrigation-drainage water had much larger dissolved-solids concentrations than the lake water. Therefore, the denser irrigation-drainage water would sink to the lake bottom and would accumulate during the winter. On May 10, specific-conductance and dissolved-oxygen were measured in the deepest part of the lake near the dam. The dissolved-oxygen concentration near the lake bottom was 5 mg/L, and specific conductance near the lake surface and near the bottom was about 2,900 μS/cm. These measurements indicate that the anaerobic layer and the chemocline were not present, implying that the lake had mixed sometime in April or early May.

The pesticide sample collected in July at site 5 (the Garnet Canal diversion) had detectable concentrations of 2,4-D, parathion, and carbofuran (table 17). The sample from Sweitzer Lake had parathion detected at the reporting limit of 0.01 μg/L. Parathion concentrations at Sweitzer Lake were considerably smaller than parathion concentrations in the Gunnison and Uncompahgre Rivers.

Excluding the sample collected near the lake bottom in March, the selenium concentrations in Sweitzer Lake (site 7) reported for this reconnaissance investigation were less than the largest concentrations reported by previous studies of Sweitzer Lake (80 μg/L by the Colorado Division of Wildlife in 1974 and 45 μg/L by the U.S. Bureau of Reclamation in 1978). There may be more flushing of the lake since the mid-1980's because of the installation of the new headgate on the Garnet Canal. The water quality of Sweitzer Lake described in this report probably will not change in the near future as long as the current (1989) operation of the lake continues, which features a nearly continuous surface inflow into the lake.

Bottom-Sediment Results

Six bottom-sediment samples were collected for trace-element analysis; trace-element concentrations in the less than 0.0625-mm size fraction and the less than 2-mm size fraction are listed in table 18. Three samples were collected for analysis of a standard suite of chlorinated insecticides plus PCN and PCB; these data are listed in table 19. (Tables 18 and 19 are in the "Supplemental Data" section at the back of the report.) The trace-element data were compared to baseline geochemical data for soils for the Western United States (Shacklette and Boerngen, 1984) and to bottom-sediment data collected for the nine initial DOI irrigation-drainage reconnaissance studies (Severson and others, 1987) (table 12). The data for soils from Shacklette and Boerngen (1984) represents analyses of the less than 2-mm size fraction, and the data from Severson and others (1987) represents analyses of the less than 0.0625-mm size fraction. The baselines for soil listed in table 12 were not in Shacklette and Boerngen (1984), but were computed from the information presented in that report. Only the range of values for the DOI irrigation-drainage studies was reported by Severson and others (1987). The results in this report also can be compared to the data for soils near Delta and in the Grand Valley (Grand Junction area in fig. 1); those data were summarized in table 5 in the "Previous Investigations" section of this report.

There were no major differences between trace-element concentrations (table 18) in bottom-sediment samples collected from the Gunnison River at site 3 (Delta) and at site 11 (upstream from Escalante Creek). The selenium concentrations were slightly greater than the upper baseline for soil (table 12) and the boron concentrations were less than the lower baseline for soil at both sites. Boron concentrations reported in table 12 are not directly comparable to the boron concentrations reported for this study. The soils data represent analyses for total boron, whereas the bottom-sediment samples collected for this study were analyzed only for boron that was hot-water extractable. The selenium concentrations for sites 3 and 11 were greater than selenium concentrations in the Grand Valley soils (table 5). Uranium concentration in bottom-sediment samples collected at sites 3 and 11 (table 18) were less than the minimum uranium concentration of 3.0 μg/g reported for the nine initial DOI reconnaissance investigations (table 12). The uranium concentrations also were less than the median uranium concentration of 3.73 μg/g for the 28 samples from the Grand Valley (table 5).

Table 12.--*Baseline geochemical data for soils in the Western United States and for bottom-sediment samples collected for nine irrigation-drainage reconnaissance investigations*

[Soil data for the Western United States modified from Shacklette and Boerngen (1984); bottom-sediment data were summarized by Severson and others (1987) for nine irrigation drainage reconnaissance investigations in the Western United States during 1986-87; baseline is the 95-percent expected range; all concentrations are in micrograms per gram; <, less than; --, no data]

Trace element	Soils in Western United States			Bottom-sediment samples, 1986-87
	Geometric mean	Range	Baseline	Range
Arsenic	5.5	<0.1-97	1.4-22	2.4-31
Barium	580	70-5,000	200-1,700	310-990
Beryllium	.68	<1-15	.13-3.6	1.0-2.0
Boron	23	<20-300	5.8-91	.6-210
Cadmium	--	--	--	--
Chromium	41	3-2,000	8.5-200	20-210
Cobalt	7.1	<3-50	1.8-28	6.0-28
Copper	21	2-300	4.9-90	10-110
Lead	17	<10-700	5.2-55	9.0-52
Lithium	22	5-130	8.8-55	22-180
Manganese	380	30-5,000	97-1,500	200-3,000
Mercury	.046	<.01-4.6	.0085-.25	<.02-18
Molybdenum	.85	<3-7	.18-4.0	<2-40
Nickel	15	<5-700	3.4-66	11-170
Selenium	.23	<.1-4.3	.039-1.4	<.1-85
Strontium	200	10-3,000	43-933	170-920
Thorium	9.1	2.4-31	4.1-20	<4.7-18.6
Uranium	2.5	.68-7.9	1.2-5.3	3.0-56
Vanadium	70	7-500	18-270	36-210
Zinc	55	10-2,100	17-180	49-510

The organochlorine compounds DDD and DDE were detected in the Gunnison River at small concentrations in the sample collected at site 11 (table 19). The DDE concentration of 2.8 μg/kg for site 11 was the largest pesticide concentration in the bottom-sediment samples collected for this study. Chlordane and dieldrin also were detected in the sample from site 11.

There were larger concentrations of most trace elements including arsenic, copper, lead, and zinc in bottom sediment collected from the Uncompahgre River at site 4 (Colona) than in bottom sediment collected from site 9 (Delta) (table 18). The lead concentrations in the sample collected at site 4 exceeded the upper baseline (table 12) for Western United States soils and exceeded the maximum lead concentration reported for the nine initial reconnaissance investigations. Also, the zinc concentration for site 4 exceeded the upper baseline for soils, but was within the range of zinc concentrations for the nine reconnaissance investigations. The sample collected at site 9 had the smallest concentrations of several trace elements including chromium, nickel, vanadium, and zinc reported for the six bottom-sediment samples collected for this study. Selenium concentrations in bottom-sediment samples from the Uncompahgre River were slightly greater than the upper baseline for Western United States soils and were within the range of selenium concentrations reported for the nine initial reconnaissance investigations (table 12). The selenium concentrations in bottom sediment from the Uncompahgre and Gunnison Rivers were approximately equal.

Selenium concentrations in both bottom-sediment samples collected from Sweitzer Lake (table 18) were substantially greater than the upper baseline for soils in the Western United States. However, the selenium concentrations are less than the largest selenium concentration in bottom sediments reported for the nine initial reconnaissance investigations (85 μg/g). There were substantial differences in concentrations of barium, lead, selenium, and uranium between the two bottom-sediment samples collected at Sweitzer Lake. The bottom-sediment sample collected near the dam in January probably was more representative of bottom sediment in Sweitzer Lake than the sample collected near the south shore in November. The sample collected near the dam had greater selenium and uranium concentrations (table 18) than the sample collected near the south shore. The uranium concentrations for the sample collected near the dam exceeded the upper baseline for Western United States soils (table 12). The larger lead concentrations in the sample collected near the dam may be attributed to the proximity of a boat dock, where gasoline may be a source of lead. The bottom-sediment samples from Sweitzer Lake generally had greater concentrations of chromium, nickel, selenium, and uranium and smaller manganese concentrations than the bottom-sediment samples from the rivers. Small concentrations of DDD, DDE, and dieldrin were detected in the bottom-sediment samples collected from Sweitzer Lake; the maximum concentration was 0.8 μg/kg of DDE (table 19).

Differences in trace-element concentrations between size fractions for the six bottom-sediment samples collected for this study generally were not large (table 18), but there were exceptions. Selenium concentrations were greater in the less than 2-mm size fraction than in the less than 0.0625-mm size fraction in five of the six samples, and the magnitude of the differences was variable. The largest difference in selenium concentrations between size fractions was in the sample collected in November from Sweitzer Lake near the south shore. The selenium concentration in the less than 2-mm size fraction was 18 μg/g compared to 8.6 μg/g in the less than 0.0625-mm size fraction. Concentrations of manganese in the less than 2-mm size fraction for the bottom-sediment samples collected from the Uncompahgre River were about 25 percent greater than in the less than 0.0625-mm size fraction.

Biota Results

Analytical results for the biota samples are listed in tables 20 through 24 in the "Supplemental Data" section at the back of the report. Trace elements listed in the tables are expressed as dry-weight concentrations. To express these data as wet-weight concentrations for comparison to toxicological data, multiply the dry-weight concentration by the factor (1 minus the percent moisture content of the sample expressed as a decimal). For example, a dry-weight concentration of 25.2 μg/g for a sample that has 64.3 percent moisture is equivalent to a wet-weight concentration of about 9.0 μg/g [25.2 multiplied by (1-0.643)].

Wildlife Observations

Onsite observations and collections of biota began in the first week of May 1988 and concluded in July. Observations indicated that there were few waterfowl nests along the Gunnison River at Escalante State Wildlife Area and at Sweitzer Lake. Nesting along the Gunnison River was most successful for Canada geese. Several mallard nests were found that did not produce young because of predation. Only two active mallard nests were located at Escalante State Wildlife Area during this study, and eggs were sampled from those nests. Other birds such as killdeer, sandpipers, great blue herons, and blackbirds seem to have good nesting success at the Escalante State Wildlife Area. The heron rookery had young birds in early May; however, despite numerous visits under the rookery, no abandoned young or prey remains were collected. Killdeer and sandpipers were always present on the gravel bars of the Gunnison River. Coots were not seen at the wildlife area.

A mixture of waterbirds, shorebirds, and other species were present during each visit to Sweitzer Lake. In late May, more than 20 blackbird nests containing eggs were located. Coots had suitable habitat at the lake for nesting, but only a single coot nest that had eggs was located. Eggs judged to be less than a week old were collected from the coot nest. Killdeer seemed to be defending territories on the alkali flats along the shore, but only one killdeer nest was found in late June. Although excellent habitat for bird nesting is present at Sweitzer Lake, relatively few birds were observed nesting at the lake during the study. There were four western grebes present at Sweitzer Lake for more than two months. Two grebes were collected on July 19, and these two birds were assumed to be the grebes that had been present since May.

Reasons for the lack of use of nesting habitat at the lake are not known. The Escalante State Wildlife Area and Sweitzer Lake are used as a staging area for migrating waterfowl in the spring and fall. Large numbers of ducks and geese use the Gunnison River in the vicinity of the wildlife area and Sweitzer Lake as a temporary stopover, but most tend to migrate out of the study area prior to nesting.

The largest diversity of fish species was in the Gunnison River at the Escalante State Wildlife Area, where 12 species were observed (chemical analysis were done for 8 species). The species most frequently observed were suckers, carp, roundtail chub, and fathead minnows. There was a similar mixture of species in the Gunnison River at Delta. A few trout were observed in the Gunnison River at Delta and at the wildlife area. The fish species most frequently observed in the Uncompahgre River at Colona were trout, suckers, and mottled sculpin. Carp, suckers, and roundtail chub were the most frequently observed species in the Uncompahgre River at Delta.

Two river otters (a mother with her young) were observed along the Gunnison River near the Escalante State Wildlife Area. Historically, otters were native to the study area, and the Colorado Division of Wildlife considers the otters a threatened species and is attempting to reintroduce otters in the Gunnison River basin. River otters have been reintroduced in the Black Canyon of the Gunnison River, which is the reach immediately downstream from the Gunnison Tunnel diversion (near gaging station 09128000 in fig. 1 or site 2 in fig. 2). It is not known where the otters at the Escalante State Wildlife Area originated.

Data Interpretation

Many chemical, physical, biological, and physiological factors affect the toxicity of environmental contaminants to biological 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 into the organism. Depending on concentration, the effects can be beneficial to the organism, have subtle biochemical changes, or be lethal. Biological and physiological factors affecting toxicity include species, age, sex, and physiological state of the organism. Interpretation of contaminant concentrations in biota is difficult, complex, and in many instances, may not be possible using data collected from field studies. One of the best methods for interpretating contaminant data is by comparison with data collected from other field studies and laboratory studies.

Concentrations of inorganic trace elements in biological samples are extremely variable. Such data can be interpreted by comparison to available literature to determine if concentrations exceed background concentrations or exceed concentrations that may be harmful to fish and wildlife. One of the most frequently used literature sources is the National Contaminant Biomonitoring Program (NCBP) of the U.S. Fish and Wildlife Service. Lowe and others (1985) reported the 85th-percentile concentration for arsenic, cadmium, copper, lead, mercury, selenium, and zinc for fish samples collected in 1980-81 throughout the United States. The 85th percentile has been established by NCBP as an arbitrary concentration for distinguishing whole-body fish samples that have large concentrations of the seven trace elements. The 85th percentile has no meaning with respect to potential hazards to fishery resources or to regulatory statutes. The 85th-percentile concentrations in Lowe and others (1985) were reported as wet-weight concentrations. For ease of comparison with the biota data listed in tables 20 through 23, which are dry-weight concentrations, the wet-weight concentrations reported by Lowe and others (1985) were converted to dry-weight concentrations by assuming an average moisture content of 75 percent. Fish samples collected for this reconnaissance had moisture contents ranging from 61 to 84 percent; therefore, the NCBP concentrations converted to dry-weight concentrations using 75-percent moisture should be considered estimates. For example, the 85th percentile for selenium of 0.71 μg/g wet weight (Lowe and others, 1985) was converted to about 2.8 μg/g dry weight using 75-percent moisture [0.71 divided by (1-0.75)].

Interpretation of some trace-element data for biota samples collected for the reconnaissance investigation was not possible. Biota samples were analyzed at two laboratories, and some trace-element data from one of the laboratories had reporting limits that exceeded background concentrations. For example, the reporting limits for cadmium, copper, and lead for many of the whole-body fish samples were several times greater than the NCBP 85th percentile; therefore, interpretation of the sample concentrations was not possible.

Inorganic Trace Elements

Generally, concentrations of chromium, nickel, strontium, tin, and vanadium were less than analytical reporting limits; however, a few concentrations exceeded reporting limits. Background information on those trace elements is very limited, but some concentrations exceeded concentrations reported in the literature. For example, tin was detected in some of the bird samples collected at the Escalante State Wildlife Area (site 10 in table 20). Several tin concentrations in fish from various sites were much greater than background concentrations of 2.0 to 21.6 μg/g dry weight reported by Jenkins (1980). The significance of the tin is not known. Nickel was detected in a few biota samples; for example, an immature, pre-fledgling Canada goose sample collected at site 10 had a nickel concentration of 106 μg/g dry weight. That concentration was much larger than the nickel concentrations (3.3 to 75.7 μg/g dry weight) reported by Cain and Pafford (1981) in livers of mallard ducklings that died of nickel toxicity within 60 days of birth.

Except for selenium, cadmium, copper, mercury, and zinc, other trace-element concentrations either were all less than reporting limits or were determined to be representative of background concentrations listed in the literature. There were many concentrations of selenium and a sufficient number of concentrations of cadmium, copper, mercury, and zinc in biota samples that exceeded various guidelines to warrant further discussion of those trace elements.

Selenium in biota, Sweitzer Lake

Selenium concentrations in fish, invertebrate, and aquatic plant samples were greater in samples collected from Sweitzer Lake (table 23) than in samples collected from the streams (tables 20-22). The much larger selenium concentrations in fish from Sweitzer Lake are readily apparent in figure 16 and table 13. All the selenium concentrations in fish collected from the lake exceeded the NCBP 85th-percentile concentration of 2.8 μg/g dry weight at 75-percent moisture (0.71 μg/g wet weight). Selenium concentrations were large in all fish species regardless of trophic level (table 13). For example, selenium concentrations (dry weight) in whole-body fish samples (table 23) were 32.4 μg/g in a channel catfish, 39.0 μg/g in a black bullhead, 22.0 and

39.0 µg/g in suckers, 25.8 to 50.0 µg/g in carp, and 15.2 and 25.1 µg/g in green sunfish. The selenium concentrations in whole-body fish samples (about 15.2 to 50.0 µg/g) were about 1,000 to 3,000 times greater than selenium concentrations in the water (15-17 µg/L in July) at Sweitzer Lake, which indicates that selenium is bioconcentrated through the food chain. Baumann and Gillespie (1986) reported that bioaccumulation of selenium in bluegill resulted in selenium concentrations 1,000 times higher in the ovaries of bluegill than in the water from which the fish were collected. They suggest that bluegills with a selenium concentration of about 7.94 µg/g wet weight (about 32 µg/g dry weight) in their ovaries transferred this selenium to their offspring, which resulted in larvae with edema.

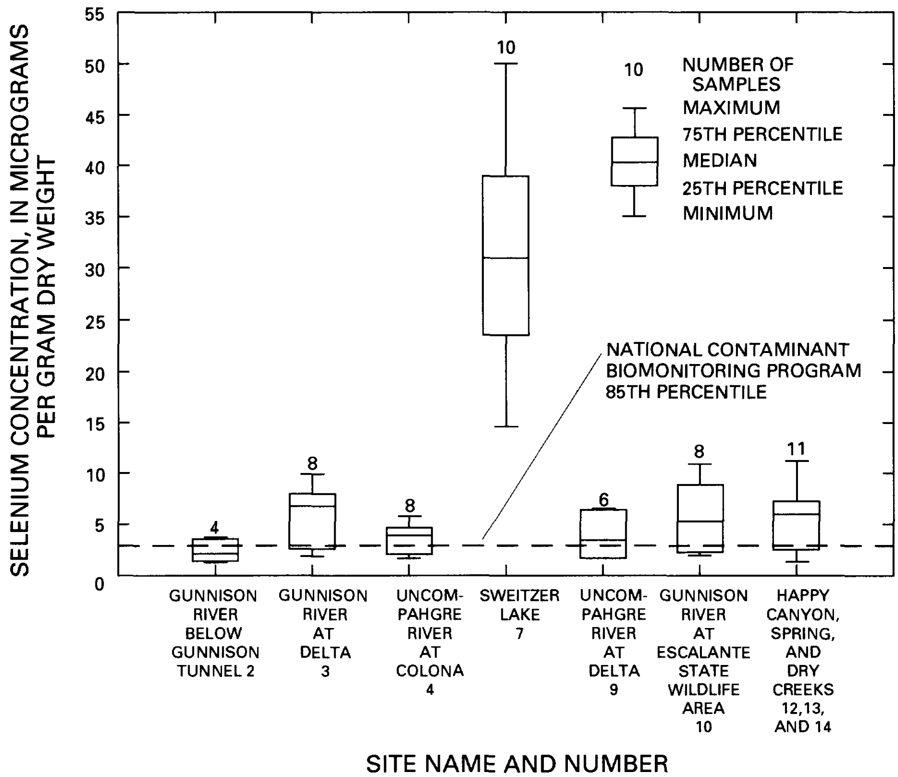

Figure 16.--Summary statistics of selenium concentrations in whole-body fish samples.

The presence of a large population of green sunfish and carp of various ages in Sweitzer Lake indicated that the two species may have adapted to selenium in the lake. However, the populations of fish species once present in the lake, such as suckers, are minimal, indicating that selenium may have affected their survival. Channel catfish have been stocked in Sweitzer Lake, but there was no evidence of catfish reproduction in the lake.

Table 13.--*Range of concentrations of selected trace elements in composite whole-body fish samples*

[Concentrations are in micrograms per gram, dry weight; n, number of samples; ND, not detected; number in parenthesis by element is the 85th-percentile concentration for the National Contaminant Biomonitoring Program, 1980-81; --, no data]

Trace Element	Gunnison River below Gunnison Tunnel (Site 2)			Gunnison River at Delta (Site 3)		
	Large predators n=3	Bottom feeders n=0	Small omnivores n=1	Large predators n=2	Bottom feeders n=2	Small omnivores n=4
Arsenic (0.88)	0.16-.44	--	0.08	0.04-0.09	0.05-0.06	0.05-.30
Copper (3.6)	ND	--	ND	ND	ND	ND
Mercury (0.72)	ND-.27	--	.28	.21-.32	.24-.60	.21-.39
Selenium (2.8)	1.5-2.4	--	3.5	3.5-6.4	1.8-2.2	6.5-9.5
Zinc (160)	42.9-81.3	--	105	113-113	48.8-172	72.5-170

Trace Element	Uncompahgre River at Colona (Site 4)			Sweitzer Lake (Site 7)		
	Large predators n=3	Bottom feeders n=3	Small omnivores n=2	Large predators n=3	Bottom feeders n=6	Small omnivores n=1
Arsenic (0.88)	ND-.30	ND-.40	ND-.30	ND-.03	ND	ND
Copper (3.6)	6.6-14.1	3.3-6.8	3.0-7.5	ND	ND-5.0	2.1
Mercury (0.72)	.06-.08	.08-.19	.04-.06	.11-.12	ND-.06	ND
Selenium (2.8)	3.3-3.5	1.7-5.3	2.6-4.4	15.2-32.4	22.0-50.0	39.0
Zinc (160)	76.4-112	66.1-89.9	101-220	87.2-99.5	90.7-270	109

Trace element	Uncompahgre River at Delta (Site 9)			Gunnison River at Escalante State Wildlife Area (Site 10)		
	Large predators n=1	Bottom feeders n=4	Small omnivores n=1	Large predators n=3	Bottom feeders n=4	Small omnivores n=4
Arsenic (0.88)	.18	.05-.08	.03	.06-.44	.07-.10	.04-.07
Copper (3.6)	ND	ND-25.3	ND	ND-9.4	ND	ND
Mercury (0.72)	.95	.24-.30	.21	.14-.62	.16-.21	.12-.17
Selenium (2.8)	ND	ND-6.0	5.7	1.9-7.9	2.5-10.3	4.8-8.1
Zinc (160)	75.5	56.4-227	118	56.1-114	42.0-266	74.1-137

Trace element	Happy Canyon, Spring, and Dry Creeks (Sites 12, 13, and 14)		
	Large predators n=3	Bottom feeders n=4	Small omnivores n=4
Arsenic (0.88)	.09-.13	.08-.42	.09-.21
Copper (3.6)	ND-15.3	ND-11.2	ND
Mercury (0.72)	.19-.63	.24-.59	.14-.23
Selenium (2.8)	5.4-8.3	1.3-10.5	4.1-6.8
Zinc (160)	47.5-122	58.2-232	101-135

Different body parts from channel catfish were analyzed to assess differential accumulation of selenium. The largest mean concentrations were in kidney tissues, followed by livers, eggs, axial muscle tissues, and stomach tissues (fig. 17). Sager and Cofield (1984) reported a similar pattern of selenium concentrations in four fish species; in order of decreasing selenium concentrations, these were: liver, female reproductive tissue, axial muscles, and male reproductive tissue.

Aquatic invertebrate samples from Sweitzer Lake had selenium concentrations of 26.7 and 29.8 µg/g dry weight. The algae sample collected from Sweitzer Lake had a selenium concentration of 12.8 µg/g dry weight (table 23), which is in the range of concentrations reported for algae collected at the Kesterson National Wildlife Refuge in California, where reproduction problems in birds have been documented (Ohlendorf and others, 1986). Selenium concentrations in aquatic plants from Sweitzer Lake ranged from 7.9 to 12.8 μg/g dry weight (table 14), and there was a selenium concentration of 35.3 μg/g dry weight in a composite plankton sample (table 23). Although these selenium concentrations were less than selenium concentrations for similar biota at Kesterson National Wildlife Refuge (Ohlendorf and others, 1986), the selenium in the food chain at Sweitzer Lake may be of concern. Lemly and Smith (1987) stated that 3 to 5 μg/g dry weight of selenium in food may cause reproductive failure or mortality in fish and waterfowl by food-chain bioconcentration (also discussed in Cumbie and Van Horn, 1978; Heinz and others, 1987; Lemly, 1987). Coughlan and Velte (1989) report that consumption by striped bass of red shiners that had 38 μg/g dry weight of selenium resulted in elevated selenium concentrations in muscle, modified behavior, decreased physiological condition, histological damage to the liver and kidney, and death of all fish within 78 days.

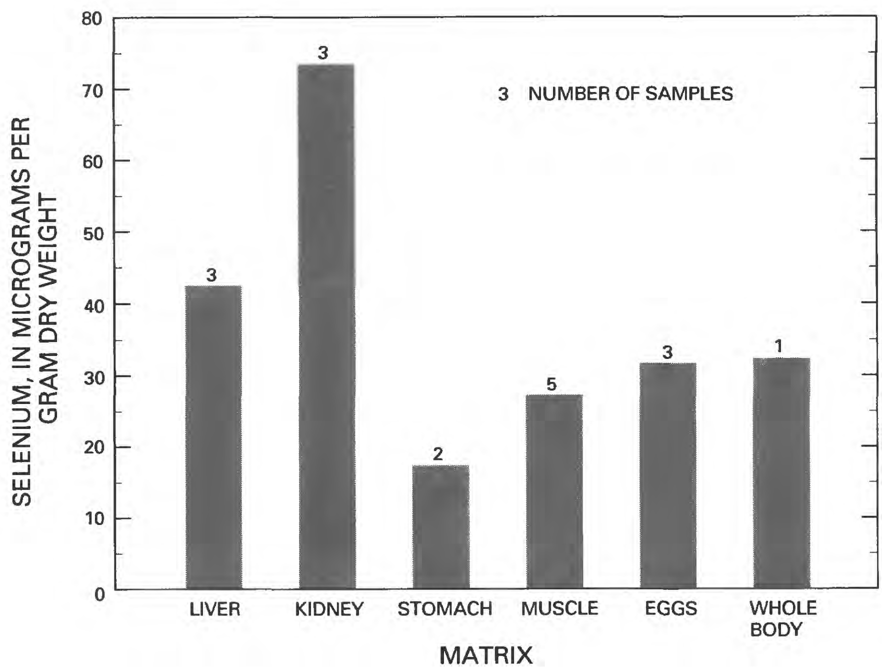

Figure 17.--Mean concentrations of selenium in channel catfish samples from Sweitzer Lake (site 7).

A sign is posted at Sweitzer Lake warning anglers not to eat fish caught from the lake. The lake supports considerable fishing use, and many anglers keep their catch. The average selenium concentration of the five catfish

Table 14.--*Range of concentrations of selected trace elements in invertebrate and aquatic plant samples*

[Concentrations are in micrograms per gram dry weight; n, number of samples; ND, not detected; aq., aquatic; inv., invertebrate; --, no data]

Trace element	Gunnison River below Gunnison Tunnel (Site 2)		Gunnison River at Delta (Site 3)		Uncompahgre River at Colona (Site 4)		Sweitzer Lake (Site 7)	
	Aq. inv. n=1	Aq. plant n=2	Aq. inv. n=2	Aq. plant n=1	Aq. inv. n=2	Aq. plant n=2	Aq. inv. n=2	Aq. plant n=4
Arsenic	2.6	3.0-4.2	2.8-7.5	6.7	3.1-6.0	11.0-13.0	11.5-12.0	.41-12.0
Copper	28.6	ND	ND-92.7	ND	56.1-76.4	20.0-62.5	26.4-50.0	ND
Mercury	.20	ND	ND-.24	.34	.04-.14	.02-.03	ND-.30	ND
Selenium	1.2	1.2-2.2	5.6-6.8	.70	3.1-4.7	.49-1.4	26.7-29.8	7.9-12.8
Zinc	85.1	87.9-114	92.3-96.4	70.5	386-433	124-231	126-202	10.8-44.5

Trace element	Uncompahgre River at Delta (Site 9)		Gunnison River at Escalante State Wildlife Area (Site 10)		Happy Canyon, Spring, and Dry Creeks (Sites 12, 13, 14)	
	Aq. inv. n=1	Aq. plant n=2	Aq. inv. n=1	Aq. plant n=2	Aq. inv. n=1	Aq. plant n=5
Arsenic	2.8	3.6-9.6	2.3	3.6-7.8	9.1	2.3-9.0
Copper	117	ND-22.5	77.6	17.2-44.9	ND	ND-21.9
Mercury	ND	ND-.38	ND	ND	ND	ND
Selenium	4.1	1.7-4.4	4.8	1.7-3.4	2.8	ND-1.0
Zinc	77.4	88.2-425	68.3	76.1-88.2	119	49.0-96.3

muscle samples collected in March 1989 (table 23) was about 28 μg/g, or about 5.9 μg/g wet weight (average percent moisture was about 79 percent). One large catfish provided about 547 g of filet meat (from both sides); that filet meat would contain about 3,230 μg (5.9 μg/g times 547 g) of selenium. Human consumption of 3 ounces of that filet meat would result in consumption of about 502 μg of selenium. Levander (1984) suggested a maximum daily selenium intake of 500 μg for adults and 200 μg for children. Shamberger (1981) suggested a maximum average daily intake of 200 μg of selenium for adults.

Bird samples also had relatively large concentrations of selenium (figs. 18 and 19; table 15), which may be expected because of the selenium concentrations in avian food items. Selenium concentrations in invertebrate and aquatic plant samples exceeded the concentration range of 4 to 8 μg/g dry weight of selenium (as selenomethionine) that Heinz and others (1989) reported as causing reproductive impairment for mallards. However, Smith and others (1988) reported that black-crowned night herons were less sensitive than mallards to the toxic effects of selenium, and there was no difference in hatching success between birds fed control diets and 10 μg/g of selenium (as selenomethionine) diets.

Western grebe livers had larger selenium concentrations (about 72 and 84 μg/g dry weight) than livers of other bird species collected at Sweitzer Lake (tables 15 and 23). These concentrations are in the range of selenium concentrations in bird livers from Kesterson National Wildlife Refuge (Ohlendorf and others, 1986). Fish are an important dietary component for western grebes, which probably accounts for the large selenium concentrations in the western grebe livers and the eared grebe whole-body sample (table 23). Also, the two western grebes may have been at Sweitzer Lake for more than 2 months when they were collected in July. Avian livers with more than 20 μg/g wet weight (about 69 μg/g dry weight) for selenium indicated significant exposure to selenium (G.H. Heinz, U.S. Fish and Wildlife Service, oral commun., 1990), and could be considered as an indication of a possible health threat to the bird.

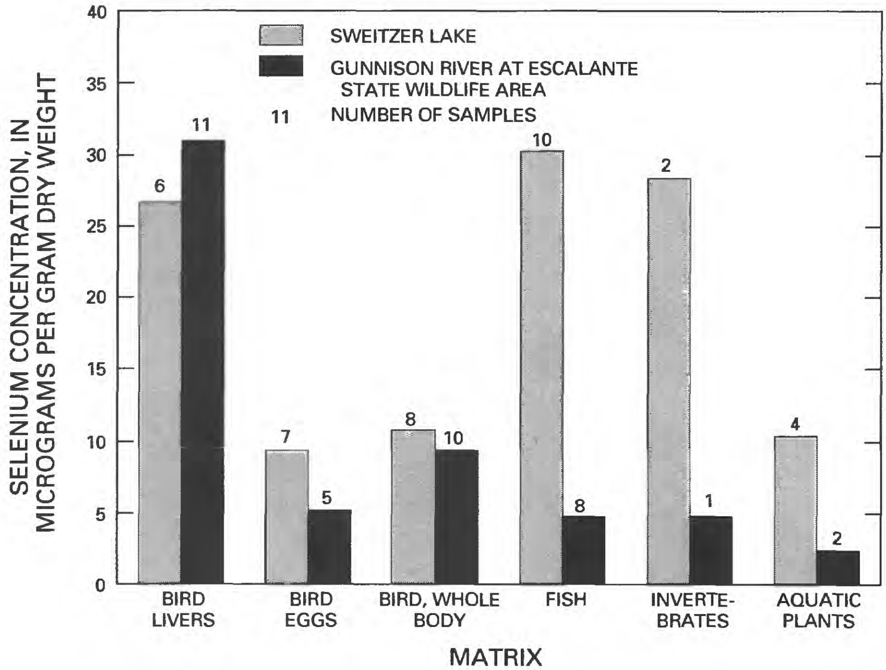

Figure 18.--Mean concentrations of selenium in biota samples from Sweitzer Lake (site 7) and the Gunnison River at Escalante State Wildlife Area (site 10).

Selenium concentrations greater than 5 µg/g wet weight (about 17 µg/g dry weight at 71 percent moisture) in bird eggs will be cause for concern until the chemical forms (selenomethionine is the most toxic) of selenium ingested by birds is known (G.H. Heinz, U.S. Fish and Wildlife Service, oral commun., 1990). Also, if selenium concentrations in eggs are greater than 1 µg/g wet weight (about 3.5 µg/g dry weight at 71 percent moisture) reproductive success needs to be examined (G.H. Heinz, U.S. Fish and Wildlife Service, oral commun., 1990). Selenium concentrations in eggs collected at Sweitzer Lake (table 23; fig. 19) ranged from 4.1 to 17.6 µg/g dry weight. No deformities were observed in birds collected from Sweitzer Lake; however, the limited number of eggs collected were less than one-half of the way through incubation, which is too early to detect abnormalities in embryos. Selenium concentrations in the coot egg, the red-winged blackbird egg, and in one of the yellow-headed blackbird eggs collected at Sweitzer Lake (table 23) exceeded the selenium concentration of 10 µg/g that decreased productivity and duckling survival (Hoffman and Heinz, 1988). The selenium concentrations in those three eggs were within the range of concentrations (9.1 to 81.4 µg/g dry weight) reported by Ohlendorf and others (1986) in eggs at Kesterson National Wildlife Refuge, where abnormalities in embryos were detected.

DuBowy (1989) calculated a bioconcentration factor of about 1,430 for selenium from surface water to waterfowl breast muscle. Using that factor, a selenium concentration in Sweitzer Lake of 11 µg/L (surface-water sample from Sweitzer Lake in November 1987; table 16) would correspond to a selenium concentration of approximately 16 µg/g wet weight in waterfowl breast muscle.

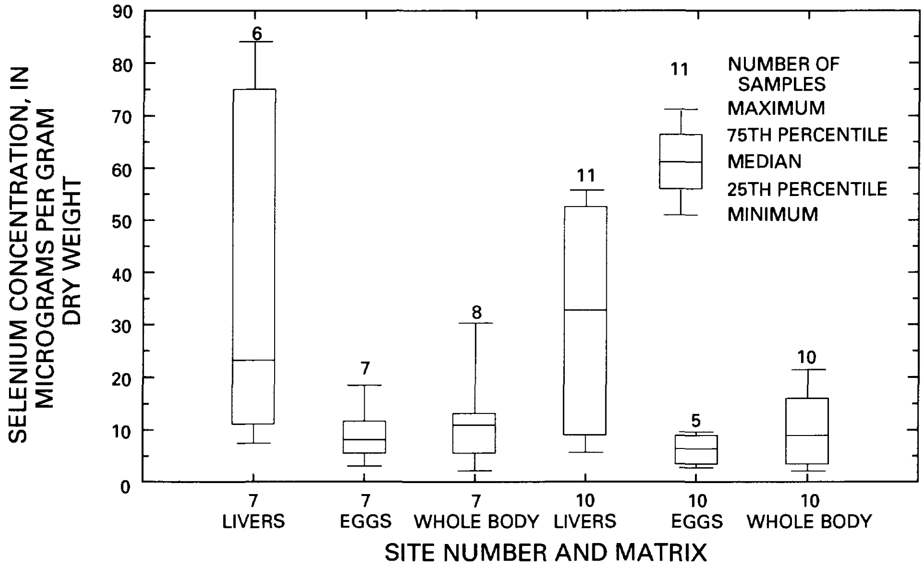

Figure 19.--Summary statistics of selenium concentrations in bird samples from Sweitzer Lake (site 7) and the Gunnison River at Escalante State Wildlife Area (site 10).

Table 15.--*Range of concentrations of selected trace elements in composite samples of bird livers from Sweitzer Lake and the Gunnison River at Escalante State Wildlife Area*

[Concentrations are in micrograms per gram dry weight; ND, not detected; n, number of samples]

Trace element	Sweitzer Lake (Site 7)			Gunnison River at Escalante State Wildlife Area (Site 10)		
	Western grebe n=2	Killdeer n=2	Coot n=2	Mallard n=4	Common merganser n=3	Killdeer n=3
Cadmium	ND	3.5-4.2	ND	ND-2.9	ND	ND-3.
Copper	14.7-27.6	20.6-20.6	19.6-26.3	29.5-51.7	12.6-35.3	14.6-24.1
Mercury	1.7-4.1	.20-.28	.42-.43	.33-.90	22.7-42.3	.38-.4
Selenium	72.1-83.6	9.0-25.4	12.2-21.1	9.2-32.6	37.2-52.4	33.0-54.2
Zinc	99.2-143	98.7-103	163-175	107-159	98.6-117	88.7-95.3

This concentration is 16 times the maximum recommended selenium concentration of 1 μg/g wet weight in edible tissue (Fan and others, 1988). No duck or goose samples were submitted for analysis during this study to determine actual selenium concentrations in bird tissue that would be consumed by humans.

One sample of young voles collected at Sweitzer Lake had a selenium concentration of 4.3 μg/g dry weight (table 23). This concentration was in the lower range of selenium concentrations in voles at Kesterson National Wildlife Refuge (Ohlendorf, 1989), where selenium toxicity was a problem.

Selenium in biota, Gunnison and Uncompahgre Rivers and tributaries

Selenium concentrations in fish, invertebrate, and aquatic plant samples were comparable between samples collected from the Gunnison River at Delta (site 3) and at the Escalante State Wildlife Area (site 10). Selenium concentrations in fish collected from the Gunnison River can be compared in figure 16 and in table 13. Selenium concentrations in biota samples collected at Sweitzer Lake (site 7) and at the Gunnison River at Escalante State Wildlife Area (site 10) can be compared in figures 18 and 19. Selenium concentrations in invertebrate and aquatic plant samples collected from the Gunnison River are summarized in table 14.

Selenium concentrations in fish samples collected from the Gunnison River at Escalante State Wildlife Area ranged from 1.9 μg/g dry weight in a roundtail chub to 10.3 μg/g dry weight in a carp (table 20). Carp, fathead minnows, and green sunfish had the largest selenium concentrations of the eight fish species analyzed. Non-parametric statistical tests (significance level of 0.05) indicated that selenium concentrations were significantly less in fish collected at the wildlife area (site 10) than in fish collected at Sweitzer Lake (site 7). However, five of the eight fish samples collected at the wildlife area (table 20) had selenium concentrations greater than the NCBP 85th-percentile concentration of 2.8 μg/g dry weight.

Selenium concentrations in fish samples collected from the Gunnison River at Delta (site 3) and at Escalante State Wildlife Area (site 10) were not significantly different (significance level of 0.05). Selenium concentrations in fish collected from the Gunnison River at Delta ranged from 1.8 μg/g dry weight in a white sucker sample to 9.5 μg/g dry weight in a fathead minnow sample (table 20). A leopard frog sample collected at Delta had a concentration of 8.2 μg/g dry weight.

Background selenium concentrations in biota for the Gunnison River may be represented by the samples collected at the reference site, Gunnison River below the Gunnison Tunnel (site 2). Biota samples collected at this site contained less selenium (table 20) than biota at the downstream sites. This corresponded to small concentrations of selenium (less than 1 μg/L) in water samples collected at the same site (table 16). The average selenium concentration in the four fish samples collected below the Gunnison Tunnel was 2.4 μg/g dry weight.

There were no significant differences (significance level of 0.05) in selenium concentrations of bird livers, eggs, and whole-body samples between Sweitzer Lake and the Gunnison River at Escalante State Wildlife Area (figs. 18 and 19; tables 15, 20, and 23). Selenium concentrations in whole-body bird samples collected at the wildlife area (site 10) ranged from 3.3 µg/g dry weight in an immature Canada goose to 19.6 µg/g dry weight in an immature mallard (table 20). Selenium concentrations in bird liver samples ranged from 6.5 µg/g dry weight in an immature Canada goose to 54.2 µg/g dry weight in a killdeer. Selenium concentrations in eggs ranged from 2.8 µg/g dry weight in a Canada goose egg to 8.6 µg/g dry weight in a red-winged blackbird egg (table 20). Because of the close proximity of locations, birds collected from the Escalante State Wildlife Area also may have foraged at Sweitzer Lake where they may have accumulated selenium. Although selenium concentrations in fish, invertebrates, and aquatic plants collected at the wildlife area were less than the selenium concentrations at Sweitzer Lake (fig. 18), the concentrations in water and avian food items (including fish) may be large enough to cause problems due to food-chain biomagnification. Selenium concentrations in birds from the wildlife area indicate considerable exposure to selenium, and impairment of reproduction could have occurred because concentrations were similar to those found by Ohlendorf and others, 1986; Heinz and others, 1987; Heinz and others, 1989. No embryo deformities were detected in samples collected at the Escalante State Wildlife Area, but eggs were collected before they were one-half of the way through incubation. External morphology of young killdeer, blackbird, and waterfowl samples appeared normal.

Selenium concentrations in fish samples collected from the Uncompahgre River [at Colona (site 4) and at Delta (site 9)] were significantly (significance level of 0.05) less than selenium concentrations in fish samples from the Gunnison River at sites 3 and 10 (tables 13 and 14, fig. 16). Selenium concentrations in fish samples collected from the Uncompahgre River ranged from less than 1.5 µg/g dry weight in a flannelmouth sucker to 6 µg/g dry weight, also in a flannelmouth sucker (table 21). Selenium concentrations in eight fish samples from the Uncompahgre River exceeded the 1980-81 NCBP 85th-percentile concentration of 2.8 µg/g dry weight. There was no significant difference (significance level of 0.05) between selenium concentrations in fish samples collected at Colona (site 4) and fish samples collected at Delta (site 9). Selenium concentrations in fish collected at Colona and Delta (table 21) were not substantially greater than the selenium concentrations in fish samples collected upstream from the Uncompahgre Project area at Ridgway Reservoir and from the Uncompahgre River downstream from Ridgway Reservoir (table 7).

Selenium concentrations in fish samples collected from Happy Canyon Creek (site 12), Spring Creek (site 13), and Dry Creek (site 14) were not significantly different (significance level of 0.05) than selenium concentrations in fish samples collected from the Uncompahgre River (fig. 16; tables 13, 21, and 22). Selenium concentrations in fish samples collected at the three tributary sites ranged from 1.3 µg/g dry weight in a composite sucker sample to 10.5 µg/g dry weight in a carp sample collected from Dry Creek (table 22). Eight fish samples from the tributary streams had selenium concentrations exceeding the 1980-81 NCBP 85th-percentile concentration of 2.8 µg/g dry weight for selenium. Selenium concentrations in invertebrate and aquatic plant samples collected at the three tributary sites seem to be comparable to those samples collected from the Uncompahgre River. Selenium concentrations were less than 2.4 μg/g dry weight (table 22) in the five aquatic plant samples collected from the three tributaries.

The effects of irrigation drainage on fish in the Gunnison and Uncompahgre Rivers and the three tributaries are not known. Selenium and other trace-element concentrations may not be sufficiently large to cause direct mortality, although selenium concentrations may be sufficient to affect reproduction. The transport of selenium from the Gunnison River basin into the Colorado River may be of concern for endangered fish in the Colorado River.

Cadmium

Four cadmium concentrations in fish collected from the Uncompahgre River at Colona (site 4 in table 21) are slightly larger than the NCBP's 85th percentile of 0.24 μg/g dry weight and are slightly larger than concentrations of cadmium in fish collected from a relatively uncontaminated part of Palestine Lake in Indiana (Murphy and others, 1978). Murphy and others (1978) stated that average cadmium concentrations for fish from relatively uncontaminated aquatic ecosystems ranged from 0.08 to 0.38 μg/g dry weight. In addition, several other sources (Lovett and others, 1972; Hammons and others, 1978; Jenkins, 1980; May and McKinney, 1981) listed background concentrations of cadmium in fish that exceeded the cadmium concentrations in fish collected at site 4.

Cadmium was detected in the livers of four adult killdeer, two each from Sweitzer Lake (site 7) and the Escalante State Wildlife Area (site 10), and one adult mallard from the wildlife area (tables 15, 20, and 23). These concentrations are greater than cadmium concentrations in livers of one-year-old mallard ducks that were fed 2 μg/g cadmium for 30 to 60 days, but were less than the cadmium concentrations in livers of mallards fed the same diet for 90 days (White and Finley, 1978). Although no adverse affects were observed in bird groups fed 2 and 20 μg/g of cadmium, birds in both study groups accumulated cadmium in the liver at concentrations similar to the concentrations in their diets and in the kidney at concentrations about 2.5 times the concentrations in their diets (White and Finley, 1978). Cadmium concentrations in invertebrate and aquatic plant samples collected at site 4 were within the ranges listed by Jenkins (1980) and Hammons and others (1978) for cadmium concentrations in aquatic organisms.

Copper

Copper was detected in 17 of 55 whole-body fish samples (tables 20-23), including all the samples collected at Uncompahgre River at Colona (site 4 in table 21). The range of concentrations is summarized in table 13. Thirteen samples had copper concentrations that exceeded the NCBP 85th percentile for copper of 3.6 μg/g dry weight (Lowe and others, 1985). Those samples were collected from the Gunnison River at Escalante State Wildlife Area (site 10), at both sampling sites on the Uncompahgre River (sites 4 and 9), from Happy Canyon, Spring, and Dry Creeks (sites 12, 13, and 14), and from Sweitzer Lake (site 7). The maximum concentration of copper in a whole-body fish sample was 25.3 µg/g in a carp collected at Uncompahgre River at Delta (site 9 in table 21). Similar to cadmium, there were large differences in reporting limits for copper by the two laboratories.

In the 17 whole-body fish samples with detected copper, concentrations were similar to copper concentrations in juvenile rainbow trout exposed to 30 and 58 µg/L copper for 7, 14, and 21 days (Dixon and Sprague, 1981). The rainbow trout did not exhibit lethal effects in that study. At the 30 µg/L level of exposure, the fish may have attained equilibrium with copper at a concentration of approximately 10 to 11 µg/g dry weight (whole-body) within the 7 to 21 day period (Dixon and Sprague, 1981). Copper concentrations in the fish samples also were similar to copper concentrations in bluegill tissues (gill, liver, and kidney) from fish that were exposed to 3, 12, and 21 µg/L of copper for 2 years (Benoit, 1975). Benoit (1975) stated that larval growth of bluegills was not significantly decreased.

Most copper concentrations in bird liver samples collected at the Escalante State Wildlife Area (site 10 in table 20) and at Sweitzer Lake (table 23) did not exceed background concentrations reported by Beck (1961) and Jackson (1977). However, a single whole-body yellow-headed blackbird (immature, pre-fledgling) collected at Sweitzer Lake had a copper concentration of 258 µg/g dry weight (table 23). This concentration is much larger than background concentrations for copper reported in the literature (Beck, 1961; Jackson, 1977). Henderson and Winterfield (1975) reported normal bird liver copper concentration to be between 3 and 26 µg/g.

Mercury

Elemental mercury and its compounds have no known normal metabolic function. The presence of mercury compounds in the cells of living organisms represents contamination from natural and anthropogenic sources; all such contamination must be regarded as undesirable and potentially hazardous (National Research Council, 1978).

Mercury was detected in most fish collected for this study (table 13); however, in all but one sample, the concentration was less than the NCBP 85th percentile of 0.72 µg/g dry weight (0.18 µg/g wet weight; Lowe and others, 1985). A comparison among sampling sites for mercury concentrations in whole-body fish samples is shown in figure 20. The only fish sample that exceeded the NCBP 85th-percentile concentration was a roundtail chub collected from the Uncompahgre River at Delta (site 9 in table 21), which had a mercury concentration of 0.95 µg/g dry weight. This fish was 400 mm in length and probably more than 7 years old (Vanicek and Kramer, 1969). Older predatory fish, such as this roundtail chub, consistently have elevated concentrations of mercury that were aquired from natural processes rather than from anthropogenic activities (Eisler, 1987).

Because the upper Uncompahgre River basin was extensively mined for gold and other metals, mercury contamination in the river was suspected. However, the biota data indicate that mercury is not a major concern in the Uncompahgre River, at least downstream from Colona (site 4). One-half of the fish samples from Sweitzer Lake (site 7) had mercury concentrations less than analytical reporting limits, and all other mercury concentrations for fish were less than 0.20 μg/g dry weight (table 23). Most mercury concentrations in invertebrate and aquatic plant samples were equal to or less than reporting limits (table 14).

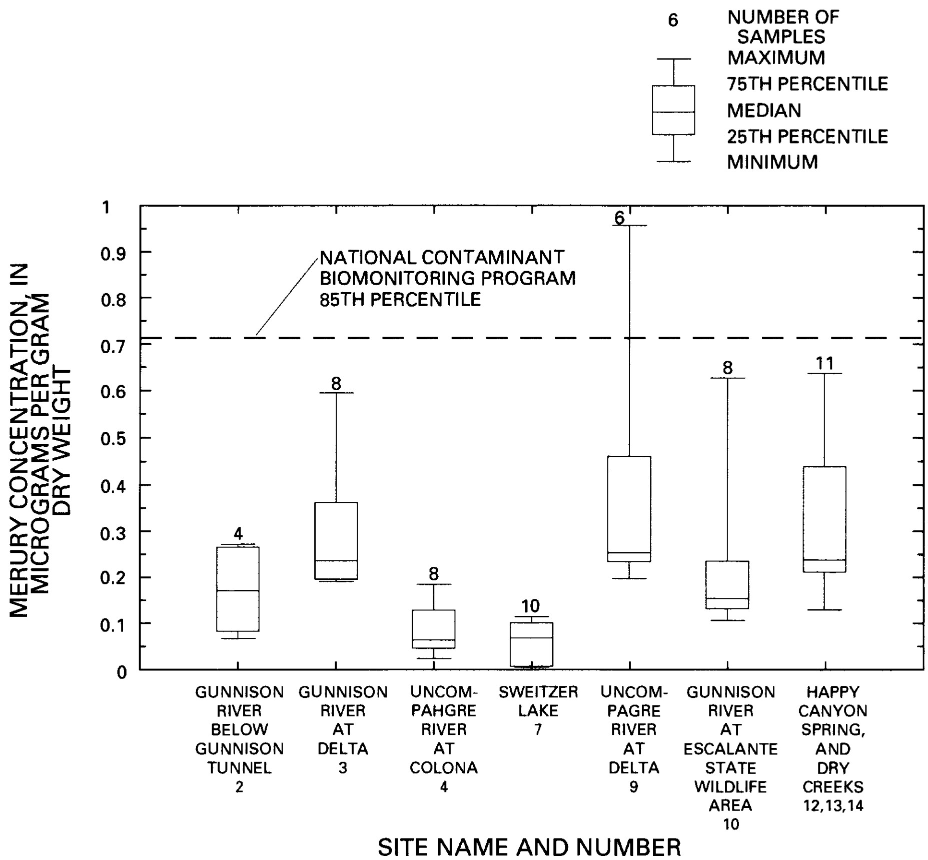

Figure 20.--Summary statistics of mercury concentrations in whole-body fish samples.

Concentrations of mercury in birds collected for this study were variable. Mercury concentrations ranged from less than 0.06 μg/g dry weight in a whole-body, immature Canada goose sample to 42.3 μg/g in the liver of a common merganser; both samples were collected at the Escalante State Wildlife Area (site 10 in table 20). Mercury concentrations in whole-body bird samples were less than 1 μg/g dry weight, except in an eared grebe from Sweitzer Lake that had 2.6 μg/g dry weight (table 23). Generally, the largest mercury concentrations occur in bird species that eat fish or other aquatic organisms, and concentrations are highest in kidney and liver tissues, although the concentration of mercury in a particular bird is substantially modified by food preference and availability and by migratory paths (National Research Council, 1978; Delbek and others, 1984). Those patterns were evident in this study. Concentrations of mercury in young-of-the-year birds were less than

1 μg/g, and only in the adults of the higher trophic level species (western grebes and common mergansers) was mercury detected in larger concentrations. The source of mercury in those birds may or may not be in the Uncompahgre Project area because of the mobility of the birds and because mercury concentrations are cumulative.

Mercury toxicity varies widely among various species of birds. Birds that were experimentally killed by methylmercury poisoning had mercury concentrations in liver ranging from 17 μg/g dry weight in red-tailed hawks to 70 μg/g in jackdaws; there were intermediate concentrations in pheasants, kestrels, and magpies (Solonen and Lodenius, 1984). Experimentally poisoned grey herons were unusually resistant to mercury; lethal doses produced mercury concentrations in livers of 415 to 752 μg/g dry weight (Van der Molen and others, 1982). The mercury concentrations of 22.7 and 42.3 μg/g dry weight in the livers of two common mergansers collected at Escalante State Wildlife Area (site 10 in table 20) may be less than the toxicity threshold for those birds. Also, the two common merganser livers that had large mercury concentrations had relatively large selenium concentrations (table 20). The antagonistic effects between mercury and selenium may diminish the toxicological effects of mercury in the birds.

A major concern regarding mercury in fish and wildlife is potential effects on human health. Mercury in humans causes teratogenic, mutagenic, and carcinogenic effects; the fetus is the most sensitive life stage (National Research Council, 1978; Chang, 1979; Khera, 1979; Elhassani, 1983; Greener and Kochen, 1983; Clarkson and others, 1984; U.S. Environmental Protection Agency, 1985). The U.S. Food and Drug Administration's action level for mercury in seafood is 1.0 μg/g wet weight (U.S. Food and Drug Administration, 1978). Some studies indicate that this concentration may be too large for the consumption of freshwater fish (U.S. Environmental Protection Agency, 1985). All fish samples collected in the study area had mercury concentrations less than 1.0 μg/g wet weight.

Zinc

Eleven of the 55 whole-body fish samples (tables 20-23) collected from the study area had zinc concentrations exceeding the NCBP 85th-percentile concentration of 160 μg/g dry weight. The maximum zinc concentration in fish was 270 μg/g in a carp collected from Sweitzer Lake (table 23). No distinct areal patterns of zinc concentrations in fish are apparent. Eight of the samples that exceeded the NCBP 85th-percentile concentration for zinc were carp (tables 20-23), and the other three were small omnivorous fish. Carp have a tendency to accumulate more zinc than other fish species (Lowe and others, 1985), and omnivorous species tend to accumulate more zinc than carnivorous fish (Mathis and Cummins, 1973; Brown and Chow, 1977; Murphy and others, 1978). Most zinc concentrations in fish samples collected from the study area are less than concentrations found in industrial and agricultural areas by Brown and Chow, 1977; Murphy and others, 1978; Adams and others, 1980; and Vinikour and others, 1980.

Pesticides and Polychlorinated Biphenyl (PCB) Residues

Thirty-five biota samples were analyzed for pesticide and PCB residues. The organic compound p,p'-DDE, which is the most persistent degradation product of p,p'-DDT, was detected in all these samples in at least trace concentrations (table 24). DDE residues in fish ranged from 0.01 to 1.0 μg/g wet weight. The National Pesticide Monitoring Program (NPMP)[2] mean DDE concentration in fish collected during 1980-81 was 0.20 μg/g wet weight (Schmitt and others 1985), and the maximum value was 2.57 μg/g wet weight. Fish samples collected from Spring and Dry Creek (sites 13 and 14) had DDE concentrations of 1.0 and 0.71 μg/g DDE wet weight (table 24), which are several times greater than the NPMP mean concentration. The presence of very small concentrations of p,p'-DDD (another degradation compound of DDT) and p,p'-DDT (the parent compound) in these same samples reflects the breakdown process of DDT that occurs over time. DDT use was banned in the United States in 1972. Schmitt (1989) reported that the mean concentration of total DDT (DDT, DDD and DDE) in fish has continued to decline from about 1 μg/g in 1970 to 0.25 μg/g in 1984, and that the percentage of total DDT composed of DDE has increased steadily from 48 percent in 1970 to 73 percent in 1984.

Compared to DDE data from the literature, p,p'-DDE concentrations in killdeer adults, chicks and eggs were relatively large. Killdeer adults collected from Sweitzer Lake (site 7) and from the Escalante State Wildlife Area (site 10) had DDE concentrations ranging from 2.9 to 110 μg/g wet weight (table 24). Killdeer collected from the wildlife area had 0.36 to 28 μg/g wet weight of DDE, and a killdeer egg sample collected from Sweitzer Lake had 11.0 μg/g wet weight of DDE. White and others (1983) reported that dowitchers on their wintering grounds along the south Texas coast had accumulated DDE residues as large as 68 μg/g wet weight (whole body residues), which are concentrations known to cause reproductive problems in other avian species (Longcore and others, 1971; Stickel, 1973; Longcore and Stendell, 1977). DeWeese and others (1986) reported a DDE concentration of 58.8 μg/g in the carcass fat of a killdeer adult collected during 1980 and suggested that DDE concentration could be lethal if 15 to 20 percent of the DDE stored in fat was rapidly mobilized to the brain. The DDE concentration of 110 μg/g wet weight in the killdeer collected at Sweitzer Lake may have been lethal to the bird. DeWeese and others (1986) also suggested that DDE concentrations greater than 3 μg/g wet weight in avian prey species may be sufficient to inhibit the normal reproduction of raptor species (including peregrine falcons), which occasionally feed on them.

Of the fish-eating bird species analyzed for pesticide residues, DDE concentrations were 1.7 and 7.6 μg/g wet weight in carcasses of two western grebes collected from Sweitzer Lake and 2.6 μg/g wet weight in a common merganser collected from the Escalante State Wildlife Area (table 24). As for fish, smaller concentrations of DDD and DDT also were detected in some of the bird samples containing DDE. DeWeese and others (1986) stated that insectivorous animals living in areas treated with one DDT application contained large proportions of DDT (compared to other DDT metabolites) from

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[2]The National Pesticide Monitoring Program, as it was referred to prior to 1984, is now known as the National Contaminants Biomonitoring Program (NCBP).

several months to about 2 years. DeWeese and others (1986) also suggested that parts of the southwestern United States and unidentified locations in Latin American countries are likely sources of DDE contamination in western migratory birds.

Toxaphene residues were detected in four fish and eight bird samples (whole body) collected during this study (table 24). Schmitt and others (1985) noted that toxaphene was the most used insecticide in the United States, partly because DDT was banned in 1972. Toxaphene was restricted in 1982 and was banned in 1986 by the U.S. Environmental Protection Agency; however, toxaphene is extremely persistent in soil and water (Eisler and Jacknow, 1985). Toxaphene residues in fish samples collected for this study ranged from not detected to 0.92 μg/g wet weight in a carp from Dry Creek (site 14). The 1980-81 NPMP mean toxaphene concentration in fish was 0.27 μg/g wet weight, and the maximum concentration was 21.0 μg/g wet weight (Schmitt and others 1985). Mayer and Mehrle (1977) reported that toxaphene residues in excess of 0.4 to 0.6 μg/g may be hazardous to fish health, and Eisler and Jacknow (1985) suggested that such concentrations should be considered as evidence of possible environmental contamination. The toxaphene concentration of 0.92 μg/g wet weight in the carp sample collected from Dry Creek (site 14) is greater than that range. However, the toxaphene concentrations were less than the U.S. Food and Drug Administration's action level of 5.0 μg/g wet weight in fish (U.S. Environmental Protection Agency, 1980).

Toxaphene concentrations in bird samples ranged from not detected to 2.7 μg/g wet weight in a western grebe collected at Sweitzer Lake (site 7 in table 24). White and others (1983) reported toxaphene residues as great as 3 μg/g in carcasses of fish-eating birds and suggested that these concentrations were probably not biologically significant because birds, unlike fish, readily metabolize and excrete toxaphene.

The herbicide dacthal was detected in six fish samples, and the maximum concentration (0.4 μg/g wet weight) reported for the NPMP samples collected in 1980-81 was exceeded in three of the fish samples. The three samples (table 24) were collected from the Gunnison River at Delta (site 3), Happy Canyon Creek (site 12), and Dry Creek (site 14). The NPMP mean dacthal concentration for fish was less than 0.01 μg/g wet weight (Schmitt and others, 1985). The largest dacthal concentrations reported by Schmitt and others (1985) were in regions that were intensively farmed. Dacthal is a popular broad-spectrum herbicide registered for use on ornamentals, turf, and certain vegetable and field crops (Schmitt and others, 1985), and is used in the Uncompahgre Valley.

PCB's were detected in 10 biota samples collected from the study area. The largest PCB concentrations (table 24) were 3.1 μg/g wet weight in a western grebe collected at Sweitzer Lake (site 7) and 2.7 μg/g wet weight in a common merganser collected at the Escalante State Wildlife Area (site 10). These concentrations are less than the concentrations known to cause reproductive problems or decreased survival of birds (Eisler, 1986) and also are less than the U.S. Food and Drug Administration's tolerance concentration for PCB's in poultry of 5 μg/g wet weight for human consumption (Eisler, 1986, p. 33).

Small concentrations of other organochlorine pesticides, including β-BHC, dieldrin, heptachlor epoxide, and oxychlordane, were detected in killdeer adults and chicks collected from Escalante State Wildlife Area (site 10 in table 24). Those concentrations were about equal to the concentrations in killdeer collected during 1980 in the Western United States (DeWeese and others, 1986). Killdeer probably accumulated residues of these pesticides on their wintering grounds outside the study area because only trace concentrations were detected in fish samples.

CORRELATION OF CONSTITUENTS AMONG WATER, BOTTOM SEDIMENT, AND BIOTA

The most obvious correlation of constituent concentrations among sampling media was for concentrations of selenium in the samples collected at Sweitzer Lake. Selenium is ubiquitous in water, bottom sediment, and biota at the lake. No distinct correlation of selenium among sampling media was determined for stream samples. Although selenium concentrations in water samples from the Uncompahgre River at Delta (site 9) were usually larger than in water samples from other stream sites (fig. 11), the bottom sediment and biota in samples collected at site 9 did not have larger selenium concentrations than samples collected at other stream sites.

No other distinct correlations of constituent concentrations among all three sampling media were evident. The bottom-sediment sample collected from the Uncompahgre River at Colona (site 4) had larger concentrations of copper, lead, and zinc than bottom sediment from other sites (table 18), however, the water samples collected at Colona (table 16) did not have larger concentrations of those trace elements compared to other sites. Copper concentrations exceeded baseline concentrations in bottom-sediment and biota samples collected at Colona. The maximum zinc concentrations in bottom-sediment samples (table 18) and invertebrate and aquatic plant samples (table 14) collected in the study area were from the Uncompahgre River at Colona (site 4). However, water and fish samples (tables 16 and 21) from Colona did not have large zinc concentrations compared to other water and fish samples from the study area.

SUMMARY AND CONCLUSIONS

In 1985, the U.S. Department of the Interior initiated a program to identify the nature and extent of irrigation-induced water-quality problems that might exist in the Western United States. An inter-bureau Task Group identified areas in 13 States that warranted reconnaissance-level field investigations. These investigations were to determine whether irrigation drainage has caused or has the potential to cause harmful effects on human health, fish, and wildlife or may adversely affect the suitability of water for beneficial uses.

In 1987, the U.S. Bureau of Reclamation's Uncompahgre Project in the lower Gunnison River basin in west-central Colorado was selected for a reconnaissance investigation. The irrigated area served by the project is in the Uncompahgre River valley between Colona and Delta. The U.S. Bureau of Reclamation had identified the Uncompahgre Project as a significant source of salinity in the Upper Colorado River Basin. The geologic formation (Mancos

Shale) that was a primary source of salt loading from the Uncompahgre Project also can be a source of potentially harmful trace elements such as selenium. Water-quality data collected since 1975 for the Gunnison River downstream from the Uncompahgre Project indicated that selenium concentrations in the river exceeded background selenium concentrations for major rivers in the United States. There also was concern about selenium in Sweitzer Lake, a small man-made lake near Delta. The State of Colorado had reported large concentrations of selenium in fish collected from the lake, and in 1977 a warning sign was posted advising people not to eat fish caught from Sweitzer Lake.

Water samples for analyses of major ions and selected trace elements were collected from the Gunnison River, Uncompahgre River, and at Sweitzer Lake in November, January, March, and July during 1987-88. Bottom-sediment samples (analyses of trace elements and organochlorine pesticides) were collected at stream sites in November 1987 and from Sweitzer Lake in November 1987 and January 1988. Fish, invertebrate, and aquatic plant samples were collected at stream sites and at Sweitzer Lake in July 1988. Bird and egg samples were collected in May through July 1988. Additional fish samples were collected from Sweitzer Lake in March 1989 for inorganic analyses of fish tissue and various organs.

Irrigation drainage from the Uncompahgre Project area is contributing substantial quantities of dissolved solids, sodium, sulfate, nitrite plus nitrate, selenium, boron, and uranium to the Gunnison and Uncompahgre Rivers. The Uncompahgre River may be contributing more than 50 percent of the increase of those constituent loads in the Gunnison River between Delta and Escalante Creek. The reconnaissance investigation did not determine the effects of irrigation drainage from the Uncompahgre Project on water quality of the Gunnison River upstream from Delta.

Although selenium concentrations in the Gunnison and Uncompahgre Rivers were less than Colorado State standards, selenium concentrations in some of the water samples collected from both rivers exceeded U.S. Environmental Protection Agency criteria for the protection of aquatic life. The selenium concentrations in the Gunnison and Uncompahgre Rivers may be of concern for fish and waterfowl because of food-chain bioconcentration. The maximum selenium concentrations in the Gunnison River were in samples collected in July 1988 during low stream discharge; concentrations were 8 μg/L at Delta and 10 μg/L upstream from Escalante Creek. The largest selenium concentrations in the Uncompahgre River at Delta were 33 and 34 μg/L in samples collected in November 1987 and January 1988. By comparison, the maximum selenium concentration in the Uncompahgre River at Colona, upstream from the Uncompahgre Project, was only 2 μg/L. Most of the inflow into the Uncompahgre River between Colona and Delta in November and January might be irrigation drainage.

Parathion concentrations in water samples collected from the Gunnison and Uncompahgre Rivers in July 1988 exceeded the criteria of 0.04 μg/L for protection of aquatic life. The parathion concentrations were 0.18 μg/L in the Gunnison River upstream from Escalante Creek and 0.33 μg/L in the Uncompahgre River at Delta. Both sites are downstream from extensive agricultural areas of the Uncompahgre Project.

Concentrations of dissolved solids, sodium, sulfate, nitrite plus nitrate, and selenium increased during the nonirrigation season (November through March) in Sweitzer Lake, when most of the inflow into the lake probably was irrigation-drainage water. Water sampled from the Garnet Canal diversion at Sweitzer Lake during the nonirrigation season was irrigation-drainage water or shallow ground water. Maximum constituent concentrations in Sweitzer Lake were in the samples collected in late March 1988; minimum constituent concentrations generally were in the samples collected in November 1987 at the end of the irrigation season. Average in-lake selenium concentrations were 11 μg/L in November, 16 μg/L in January, 24 μg/L in March, and 16 μg/L in July and the corresponding selenium concentrations in samples from the Garnet Canal diversion were 110 μg/L, 210 μg/L, 320 μg/L, and 30 μg/L. The sample collected from the Garnet Canal diversion in March also had the maximum concentrations of several other constituents, including 12,700 mg/L of dissolved solids, 7,500 mg/L of sulfate, 800 μg/L of boron, and 64 μg/L of uranium.

The selenium concentrations in all water samples collected from Sweitzer Lake and at two inflow sites exceeded U.S. Environmental Protection Agency criteria for the protection of aquatic life. The four water samples from the Garnet Canal diversion at Sweitzer Lake exceeded the chronic (5 μg/L) and the acute (20 μg/L) criteria. The selenium concentrations in Sweitzer Lake are sufficient to cause reproductive and mortality problems for fish and waterfowl because of food-chain bioconcentration. The Colorado State standard for selenium for Sweitzer Lake (20 μg/L) was exceeded in the lake samples collected in March 1988. Mercury was detected in all samples collected in July 1988 from Sweitzer Lake and from inflows into the lake.

The selenium concentrations in the lake water reported for this study generally were less than selenium concentrations reported by studies of Sweitzer Lake in the 1970's. Since the mid-1980's, there usually was a continuous surface inflow into the lake, and perhaps there has been more flushing of the lake since the mid-1980's than during the 1970's.

Selenium concentrations in bottom sediment from the Gunnison and Uncompahgre Rivers ranged from 1.5 to 4.0 μg/g, which is slightly greater than the baseline concentration for soil in the Western United States. Bottom sediment from Sweitzer Lake had much more selenium, and the maximum concentration was 41 μg/g. The only other trace elements exceeding the soil's baseline concentration were lead and zinc in the sample collected from the Uncompahgre River at Colona and uranium in a sample collected at Sweitzer Lake.

Except for selenium, cadmium, copper, mercury, and zinc, most trace-element concentrations in biota did not exceed the National Contaminant Biomonitoring Program's (NCBP) 85th percentile-concentration for fish or other background concentrations and guidelines available in the literature. Some analyses of trace elements in biota samples had reporting limits that exceeded background concentrations, and no information could be derived from such data.

Fish, invertebrate, and aquatic plant samples collected at Sweitzer Lake have substantially larger selenium concentrations than samples collected at the stream sites. All whole-body fish samples from the lake had selenium concentrations exceeding the NCBP 85th percentile. The maximum concentration in a whole-body fish sample was 50 µg/g in a carp sample. Based on analyses of channel catfish samples, there is differential accumulation of selenium in fish organs and tissue. Although fish from Sweitzer Lake had selenium concentrations that could be detrimental to their health and reproduction, the presence of large numbers of green sunfish and carp of various ages in the lake indicate that the two species may have adapted to the selenium in the lake. However, populations of fish species once found in Sweitzer Lake, such as suckers, are minimal, indicating that perhaps selenium may have affected their survival. Based on the selenium concentrations in water and in fish samples, there is a bioconcentration factor of about 1,000 to 3,000 from water to fish in Sweitzer Lake.

The selenium concentrations in avian food items at Sweitzer Lake were equal to or less than selenium concentrations in avian food items at Kesterson National Wildlife Refuge, where reproductive problems in birds caused by selenium have been documented. Selenium concentrations in food items at Sweitzer Lake may be sufficient for fish and wildlife to bioconcentrate harmful quantities of selenium.

Selenium concentrations in fish samples from Sweitzer Lake may be of concern for human consumption. The average selenium concentration in five samples of catfish muscle (fillets) was about 28 µg/g dry weight. Ingestion of 3 ounces of the meat would result in an intake of about 502 µg of selenium. The recommended maximum daily intake for an adult of 500 µg for selenium could be exceeded by eating channel catfish caught from Sweitzer Lake. No waterfowl breast tissue was sampled, but the selenium concentrations in water samples from Sweitzer Lake indicate that waterfowl could accumulate more than 1 µg/g of selenium in tissue, which would exceed the recommended limit for human consumption.

Some of the bird and egg samples collected at Sweitzer Lake had relatively large concentrations of selenium. Maximum selenium concentrations in bird samples from Sweitzer Lake were about 72 and 84 µg/g dry weight in livers from two western grebes. Three bird eggs had more than 10 µg/g dry weight of selenium, which could cause reproductive problems.

Selenium concentrations in bird and egg samples collected at the Escalante State Wildlife Area and at Sweitzer Lake were not significantly different. The maximum selenium concentration in a whole-body sample from the wildlife area was 19.6 µg/g in an immature mallard, and the maximum selenium concentration in a liver sample was 54.2 µg/g in a killdeer. Selenium concentrations in some of the bird samples collected at the Escalante State Wildlife Area indicate significant exposure to selenium based on information in the literature.

Many whole-body fish samples from the Gunnison and Uncompahgre Rivers and three tributaries of the Uncompahgre River had selenium concentrations exceeding the NCBP 85th percentile-concentration for selenium. The maximum selenium concentration in a fish sample from a stream was 10.5 µg/g dry weight in a carp collected from Dry Creek. Selenium concentrations in fish from the Uncompahgre River were significantly less than the selenium concentrations in fish collected from the Gunnison River at Delta and the Escalante State Wildlife Area.

Cadmium was detected in five bird livers collected in the study area. Copper was detected in about one third of the fish samples, and 13 copper concentrations exceeded the NCBP 85th percentile-concentration. The maximum copper concentration reported in a fish sample was 25.3 µg/g dry weight in a carp sample collected from the Uncompahgre River at Delta.

Mercury concentrations in fish and in whole-body bird samples were similar to background concentrations reported in the literature. Liver samples from two common mergansers collected at the Escalante State Wildlife Area had 22.7 µg/g and 42.3 µg/g dry weight of mercury. The common mergangers may not have accumulated the mercury from the study area because migratory birds can accumulate mercury in other areas, such as their wintering grounds.

Zinc concentrations in 11 fish samples from several sampling sites exceeded the NCBP 85th percentile, and 8 of those samples were carp. The maximum concentration was 270 µg/g dry weight of zinc in a carp collected from Sweitzer Lake.

DDE was detected in all biota samples that were analyzed for organic compounds. The maximum DDE concentration in a fish sample was 1.0 µg/g wet weight in a brown trout collected from Spring Creek. Some bird samples had potentially harmful concentrations of DDE. Maximum DDE concentrations were 110 µg/g wet weight in a whole-body killdeer sample and 11.0 µg/g in a killdeer egg. Both of those samples were from Sweitzer Lake. The source of DDE residues in killdeer is probably their wintering grounds outside of Colorado.

Toxaphene was detected in four fish and eight bird samples. The maximum toxaphene concentration was 0.92 µg/g wet weight in a carp from Dry Creek. The herbicide dacthal was detected in six fish samples, including a fish sample from the three tributary streams of the Uncompahgre River. Three of the dacthal concentrations exceeded the maximum dacthal concentration of 0.4 µg/g wet weight reported by the National Pesticide Monitoring Program.

Results of the reconnaissance investigation indicated that the Uncompahgre Project area is a major source of selenium to the Gunnison River, which discharges into the Colorado River at Grand Junction. The Colorado River downstream from the Gunnison River provides habitat for three Federally endangered fish species and one candidate species soon to be listed. Also, the lower Gunnison River basin and the Colorado River basin downstream from the study area provide wintering habitat for bald eagles and staging habitat for whooping cranes. The diet of both of these endangered bird species include fish from the Gunnison and Colorado Rivers. The effects of the selenium from the Uncompahgre Project area to the endangered fish and birds are not known.

Selenium concentrations in water, bottom sediment, and biota were relatively large in samples collected at Sweitzer Lake. However, no adverse effects to biota were observed during the reconnaissance investigation. Relatively few birds were nesting at the lake. Other wetlands in the Uncompahgre Project area may be utilized by birds for nesting. Selenium concentrations in birds and in diet items at other wetlands were not determined for the reconnaissance investigation.

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SUPPLEMENTAL DATA

Table 16.--*Water-quality properties and inorganic-constituent concentrations in water samples collected from the Gunnison and Uncompahgre Rivers and Sweitzer Lake*

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

Site number (figs. 2 and 8)	Site name	Date	Streamflow, instantaneous (ft^3/s)	Sampling depth (ft)	Specific conductance (µS/cm)	pH (standard units)	Water temperature (°C)	Oxygen, dissolved (mg/L)
2	Gunnison River below Gunnison Tunnel	11-18-87	1,470	--	185	8.1	8.5	9.7
		01-13-88	1,560	--	196	8.5	3.0	11.1
		03-29-88	1,610	--	242	8.1	3.5	10.1
		07-12-88	356	--	211	8.2	10.0	8.6
3	Gunnison River at Delta	11-19-87	1,700	--	570	8.3	4.5	12.1
		01-11-88	1,940	--	520	8.6	3.0	11.9
		03-31-88	2,150	--	480	8.6	5.0	11.3
		07-13-88	420	--	1,060	8.3	19.5	7.7
4	Uncompahgre River at Colona	11-18-87	148	--	725	8.3	3.0	11.5
		01-13-88	93	--	835	8.4	.0	12.0
		03-29-88	84	--	770	8.3	3.0	11.4
		07-12-88	237	--	505	8.3	13.5	9.8
5	Garnet Canal diversion at Sweitzer Lake	11-17-87	E1.0	--	4,500	8.5	4.0	13.6
		01-11-88	.75	--	8,600	8.1	.0	--
		03-30-88	.22	--	13,600	8.3	5.0	12.4
		07-11-88	1.3	--	1,760	8.0	17.5	7.9
6	Drainage ditch at Sweitzer Lake	11-17-87	E.20	--	1,970	8.4	4.0	10.6
		07-11-88	1.4	--	1,030	8.2	19.5	8.3
7	Sweitzer Lake	11-17-87	--	1.0	2,170	8.4	7.5	9.7
		11-17-87	--	20	2,160	8.4	7.0	8.6
		01-14-88	--	--	2,560	8.3	--	--
		03-30-88	--	1.0	2,990	8.5	7.5	9.2
		03-30-88	--	19	2,980	8.5	6.5	2.5
		03-30-88	--	27	8,160	7.9	5.0	.0
		07-13-88	--	1.0	2,280	8.4	24.0	8.4
		07-13-88	--	20	2,270	8.3	15.0	.2
8	Outflow from Sweitzer Lake	11-17-87	E1.4	--	2,170	8.5	7.5	9.8
		01-11-88	E.80	--	2,600	8.7	1.5	12.4
		07-11-88	2.1	--	2,290	8.4	26.0	7.9
9	Uncompahgre River at Delta	11-18-87	172	--	2,140	8.4	4.5	11.4
		01-11-88	129	--	2,260	8.5	.5	12.7
		03-31-88	296	--	1,120	8.4	4.0	11.0
		07-14-88	178	--	1,690	8.1	16.5	7.7
11	Gunnison River upstream from Escalante Creek	11-19-87	E1,920	--	840	8.3	4.0	12.8
		01-11-88	E2,060	--	705	8.6	3.0	12.0
		03-31-88	E2,600	--	590	8.4	3.0	10.8
		07-13-88	E650	--	1,370	8.3	24.0	10.7

Table 16.--*Water-quality properties and inorganic-constituent concentrations in water samples collected from the Gunnison and Uncompahgre Rivers and Sweitzer Lake*--Continued

Site number (figs. 2 and 8)	Date	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 $CaCO_3$)
2	11-18-87	104	85	25	5.4	4.9	0.2	1.8	72
	01-13-88	103	90	27	5.6	4.7	.2	1.7	80
	03-29-88	96	100	28	7.6	7.2	.3	1.8	85
	07-12-88	96	96	27	6.9	6.5	.3	1.5	81
3	11-19-87	109	230	55	22	31	.9	2.7	109
	01-11-88	107	200	49	19	26	.8	4.5	109
	03-31-88	106	190	49	17	26	.8	2.2	111
	07-13-88	101	410	97	41	66	1	4.4	152
4	11-18-87	106	350	110	19	24	.6	3.9	122
	01-13-88	103	390	120	21	32	.7	2.7	57
	03-29-88	107	340	99	22	32	.8	2.8	134
	07-12-88	118	230	72	12	16	.5	1.9	97
5	11-17-87	127	1,100	240	130	660	9	9.0	174
	01-11-88	--	1,600	280	220	1,300	14	15	419
	03-30-88	125	2,300	310	380	2,900	27	16	505
	07-11-88	100	690	180	59	130	2	4.8	175
6	11-17-87	98	750	190	68	170	3	4.4	111
	07-11-88	109	430	120	32	63	1	2.9	138
7	11-17-87	98	640	140	71	210	4	23	130
	11-17-87	86	640	140	71	200	4	5.1	131
	01-14-88	--	630	140	69	290	5	5.9	150
	03-30-88	95	800	170	92	320	5	6.5	159
	03-30-88	25	980	210	110	350	5	7.1	159
	03-30-88	0	1,800	260	280	1,400	15	12	282
	07-13-88	122	730	160	80	280	5	6.1	115
	07-13-88	2	770	170	83	280	4	6.1	116
8	11-17-87	99	670	150	72	210	4	6.2	130
	01-11-88	109	670	140	79	250	4	5.5	90
	07-11-88	118	770	170	84	260	4	5.9	112
9	11-18-87	104	820	190	83	160	3	0.50	113
	01-11-88	108	820	200	79	160	3	4.5	61
	03-31-88	101	430	110	38	76	2	3.2	141
	07-14-88	95	760	210	58	110	2	3.7	205
11	11-19-87	114	330	84	30	49	1	3.0	133
	01-11-88	108	280	70	25	38	1	2.8	124
	03-31-88	96	260	69	22	33	.9	2.4	114
	07-13-88	152	600	160	49	83	2	4.2	177

Table 16.--*Water-quality properties and inorganic-constituent concentrations in water samples collected from the Gunnison and Uncompahgre Rivers and Sweitzer Lake*--Continued

Site number (figs. 2 and 8)	Date	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Solids, residue at 180 °C, dissolved (mg/L)	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)
2	11-18-87	19	1.3	121	<0.10	1	10	1	<1
	01-13-88	17	.90	121	.27	2	<10	<1	<1
	03-29-88	33	2.7	147	<.10	1	10	<1	<1
	07-12-88	26	1.1	131	<.10	1	10	<1	<1
3	11-19-87	170	5.6	373	.28	1	50	<1	1
	01-11-88	140	3.9	319	.20	1	40	<1	<1
	03-31-88	130	4.5	303	.18	1	40	<1	<1
	07-13-88	420	10	762	.61	3	110	<1	<1
4	11-18-87	250	18	461	.16	1	40	<1	1
	01-13-88	290	4.4	560	25	2	50	<1	<1
	03-29-88	240	5.3	502	.19	2	50	<1	<1
	07-12-88	140	2.7	319	.15	2	30	<1	<1
5	11-17-87	2,300	57	3,770	15.0	1	350	<1	2
	01-11-88	4,900	98	7,420	42.0	<1	550	<1	5
	03-30-88	7,500	200	12,700	--	<1	800	<1	<1
	07-11-88	820	12	1,460	--	1	180	<1	1
6	11-17-87	890	18	1,550	3.0	<1	190	<1	2
	07-11-88	390	6.0	736	1.1	1	90	<1	<1
7	11-17-87	1,000	20	1,710	.32	2	210	<1	<1
	11-17-87	1,100	20	1,710	.31	2	200	<1	<1
	01-14-88	1,200	19	2,000	.99	1	200	<1	<1
	03-30-88	1,400	21	2,380	2.1	1	240	<1	1
	03-30-88	1,500	20	2,360	2.0	1	240	<1	<1
	03-30-88	4,300	110	6,990	18.0	<1	390	<1	1
	07-13-88	1,200	22	1,830	.20	2	210	<1	1
	07-13-88	1,200	21	1,820	.21	2	200	1	<1
8	11-17-87	1,000	20	1,700	.30	2	210	<1	1
	01-11-88	1,300	21	1,950	.96	1	220	<1	1
	07-11-88	1,100	21	1,850	.24	1	200	1	<1
9	11-18-87	900	18	1,770	3.8	1	250	<1	2
	01-11-88	1,000	17	1,780	3.6	1	240	1	1
	03-31-88	400	7.7	751	1.3	1	100	<1	<1
	07-14-88	760	12	1,370	4.0	2	190	<1	1
11	11-19-87	300	8.6	575	.87	1	80	<1	<1
	01-11-88	220	5.1	434	.59	1	60	<1	<1
	03-31-88	170	.30	409	.45	1	60	<1	<1
	07-13-88	600	11	1,100	2.7	2	150	<1	1

Table 16.--*Water-quality properties and inorganic-constituent concentrations in water samples collected from the Gunnison and Uncompahgre Rivers and Sweitzer Lake*--Continued

Site number (figs. 2 and 8)	Date	Copper, dis-solved (µg/L as Cu)	Lead, dis-solved (µg/L as Pu)	Mercury, dis-solved (µg/L as Hg)	Molyb-denum, dissolved (µg/L as Mo)	Selenium, dis-solved (µg/L as Se)	Vanadium, dis-solved (µg/L as V)	Zinc, dis-solved (µg/L as Zn)	Uranium, natural, dissolved (µg/L as U)
2	11-18-87	1	<5	<0.1	<1	<1	1	5	1.3
	01-13-88	1	<5	<.1	1	<1	<1	<3	1.3
	03-29-88	6	6	<.1	2	<1	2	10	1.8
	07-12-88	2	<5	.6	<1	<1	1	<3	1.5
3	11-19-87	4	35	<.1	1	--	<1	12	4.1
	01-11-88	2	<5	<.1	1	3	<1	3	3.7
	03-31-88	3	<5	<.1	<1	<1	2	<10	3.0
	07-13-88	5	<5	<.1	2	8	2	10	6.3
4	11-18-87	5	<5	<.1	1	1	<1	18	1.5
	01-13-88	4	<5	<.1	3	2	<1	17	1.7
	03-29-88	6	<5	1.7	1	2	1	8	1.7
	07-12-88	6	6	<.1	1	1	<1	8	.4
5	11-17-87	<1	<5	<.1	4	110	<1	10	24
	01-11-88	5	<5	<.1	1	210	3	20	41
	03-30-88	2	<5	<.1	4	320	14	20	64
	07-11-88	2	<5	.2	5	30	3	6	14
6	11-17-87	<1	<5	<.1	3	31	1	7	12
	07-11-88	3	<5	.4	3	12	2	3	6.5
7	11-17-87	<1	<5	<.1	4	11	<1	<10	13
	11-17-87	2	<5	<.1	5	10	<1	<10	13
	01-14-88	3	<5	<.1	5	16	<1	<10	12
	03-30-88	1	<5	<.1	5	23	1	10	12
	03-30-88	<1	<5	<.1	6	25	1	<10	14
	03-30-88	2	<5	<.1	7	170	7	20	29
	07-13-88	2	<5	.7	6	17	1	<10	16
	07-13-88	1	<5	.2	6	15	1	<10	15
8	11-17-87	<1	<5	<.1	4	12	<1	<10	13
	01-11-88	4	<5	<.1	5	15	<1	10	16
	07-11-88	2	<5	.3	7	17	1	20	13
9	11-18-87	3	<5	<0.1	4	33	1	10	19
	01-11-88	2	<5	<.1	3	34	<1	10	19
	03-31-88	4	<5	.1	1	2	2	<10	6.3
	07-14-88	4	<5	<.1	5	18	3	15	14
11	11-19-87	4	12	<.1	1	5	1	6	6.0
	01-11-88	6	8	<.1	1	5	<1	9	5.5
	03-31-88	2	<5	<.1	1	4	2	20	3.7
	07-13-88	5	<5	<.1	3	10	3	7	11

Table 17.--*Pesticide concentrations in water samples collected from the Gunnison and Uncompahgre Rivers and Sweitzer Lake*

[Analyses by U.S. Geological Survey; all concentrations are in micrograms per liter; <, less than; --, no data]

Site number (figs. 2 and 8)	Site name	Date	2,4-D, total	2,4-DP, total	Silvex, total	2,4,5-T, total
5	Garnet canal diversion at Sweitzer Lake	07-11-88	0.13	<0.01	<0.01	<0.01
7	Sweitzer Lake	07-13-88	--	--	--	--
9	Uncompahgre River at Delta	07-14-88	--	--	--	--
11	Gunnison River upstream from Escalante Creek	07-13-88	--	--	--	--

Site number (figs. 2 and 8)	Date	Diaz-inion, total	Disys-ton, total	Ethion, total	Mala-thion, total	Methyl para-thion, total	Methyl tri-thion, total	Para-thion, total
5	07-11-88	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.04
7	07-13-88	<.01	<.01	<.01	<.01	<.01	<.01	.01
9	07-14-88	<.01	<.01	<.01	<.01	.03	<.01	.33
11	07-13-88	<.01	<.01	<.01	.01	.03	<.01	.18

Site number (figs. 2 and 8)	Date	Tri-thion, total	Aldi-carb (Temik), total	Carbo-furan (Furadan), total	Metho-myl, total	Oxamyl, total	Propham, total	Sevin (Car-baryl), total
5	07-11-88	<0.01	<0.5	0.09	<0.5	<0.5	<0.5	<0.5
7	07-13-88	<.01	<.5	<.5	<.5	<.5	<.5	<.5
9	07-14-88	<.01	<.5	<.5	<.5	<.5	<.5	<.5
11	07-13-88	<.01	<.5	<.5	<.5	<.5	<.5	<.5

Table 18.--*Trace-element concentrations in bottom-sediment samples collected from the Gunnison and Uncompahgre Rivers and Sweitzer Lake*

[Analyses by U.S. Geological Survey; values are total concentrations in micrograms per gram; <, less than; <0.0625, less than 0.0625 millimeter size fraction; <2.0, less than 2.0-millimeter size fraction]

Trace element	Concentrations at indicated sites (site numbers from figs. 2 and 8)											
	Gunnison River at Delta (Site 3) 11-19-87		Uncompahgre River at Colona (Site 4) 11-18-87		Sweitzer Lake (Site 7)				Uncompahgre River at Delta (Site 9) 11-18-87		Gunnison River upstream from Escalante Creek (Site 11) 11-19-87	
					11-17-87		01-14-88					
	<0.0625	<2.0	<0.0625	<2.0	<0.0625	<2.0	<0.0625	<2.0	<0.0625	<2.0	<0.0625	<2.0
Arsenic	8.9	8.1	16	12	12	12	6.6	5.9	8.4	4.9	8.2	7.2
Barium	610	640	600	740	770	1,100	480	450	520	670	720	740
Beryllium	2	2	2	2	2	1	1	1	<1	1	1	1
Bismuth	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Boron	1.4	1.3	.9	.8	1.3	1.3	1.7	1.9	1.2	.9	1.0	.7
Cadmium	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Cerium	68	65	63	60	46	42	48	39	44	35	72	53
Chromium	51	49	47	35	64	60	59	46	35	23	49	34
Cobalt	11	12	12	13	10	10	11	9	7	9	11	10
Copper	26	23	69	55	24	18	26	21	18	18	22	15
Europium	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Gallium	14	13	13	16	12	12	12	11	9	9	12	11
Gold	<8	<8	<8	<8	<8	<8	<8	<8	<8	<8	<8	<8
Holmium	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4	<4
Lanthanum	39	38	36	36	30	28	31	25	27	29	42	32
Lead	26	29	66	59	23	21	46	37	24	25	32	26
Lithium	35	33	37	31	36	34	41	33	26	25	32	26
Manganese	580	620	580	730	280	260	370	310	360	460	580	520
Mercury	.04	.02	.04	.02	<.02	.02	.04	<.02	.04	<.02	.02	.02
Molybdenum	<2	<2	4	3	6	7	4	3	<2	<2	<2	<2
Neodymium	37	30	30	30	25	21	24	19	22	21	36	26
Nickel	20	21	21	17	31	30	27	21	14	10	18	13
Niobium	8	5	7	7	6	5	7	5	5	5	7	6
Scandium	8	8	9	9	8	8	8	7	6	5	8	7
Selenium	2.3	4.0	1.9	3.0	8.6	18	41	40	2.2	2.3	1.5	2.0
Silver	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Strontium	330	370	340	580	630	680	610	500	250	380	290	320
Tantalum	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40	<40
Thorium	10	10	10	10	9	12	9	8	8	7	12	8
Tin	10	<10	10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Uranium	1.1	1.7	2.1	2.3	4.1	3.5	9.9	7.6	1.6	1.3	1.5	1.0
Vanadium	100	97	120	130	140	150	130	110	79	73	110	84
Ytterbium	2	2	2	2	2	2	2	2	2	2	3	2
Yttrium	22	20	19	19	18	17	17	14	15	13	22	16
Zinc	110	100	300	270	110	96	120	96	88	84	110	87

Table 19.--*Pesticide concentrations in bottom-sediment samples collected from the Gunnison River and Sweitzer Lake*

[Analyses by U.S. Geological Survey; all concentrations are in micrograms per kilogram]

Site number (figs. 2 and 8)	Site name	Date	PCN, total	PCB, total	Aldrin, total	Chlordane, total	DDD, total	DDE, total	DDT, total
7	Sweitzer Lake	11-17-87	<1.0	<1	<0.1	<1.0	<0.4	0.2	<0.1
		01-14-88	<1.0	<1	<.1	<1.0	.3	.8	<.3
11	Gunnison River upstream from Escalante Creek	11-19-87	<1.0	<1	<.1	1.0	.5	2.8	<.1

Site number (figs. 2 and 8)	Date	Dieldrin, total	Endosulfan, total	Endrin, total	Heptachlor, total	Heptachlor epoxide, total	Lindane, total	Mirex, total	Perthane, total	Toxaphene, total
7	11-17-87	0.3	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1.00	<10
	01-14-88	.1	<.1	<.1	<.1	<.1	<.1	<.1	<1.00	<10
11	11-19-87	.3	<.1	<.1	<.1	<.1	<.1	<.1	<1.00	<10

Table 20.--*Trace-element concentrations in biota, Gunnison River sites (sites 2, 3, and 10)*

[Analyses by U.S. Fish and Wildlife Service; concentrations are in micrograms per gram dry weight; aq., aquatic; inv., invertebrates; imm., immature; fish matrix are whole-body samples; <, less than; site 2, Gunnison River below Gunnison Tunnel; site 3, Gunnison River at Delta; site 10, Gunnison River at Escalante State Wildlife Area]

Site number (fig. 2)	Matrix	Species	Date	Percent moisture	Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium
2	Fish	Brown trout	07-12-88	72.6	<36.5	0.13	0.16	<18.2	<1.8	<18.2	<1.8
2	Fish	Rainbow trout	07-12-88	66.0	35.3	.14	.28	<14.7	<1.5	<14.7	<1.5
2	Fish	Rainbow trout	07-12-88	73.3	86.1	.16	.44	<18.7	<1.9	<18.7	<1.9
2	Fish	Speckled dace	07-12-88	66.1	<29.5	<.07	.08	31.9	<1.5	<14.8	<1.5
2	Aq. inv.	Composite	07-12-88	83.2	815	<.15	2.6	64.3	<3.0	<29.8	<3.0
2	Aq. plant	Unknown	07-12-88	90.9	2,710	.53	4.2	156	<5.5	60.4	<5.5
2	Aq. plant	Unknown	07-12-88	91.5	2,590	<.30	3.0	102	<5.9	<58.8	<5.9
3	Fish	Brown trout	07-12-88	68.4	<31.6	<.08	.09	<15.8	<1.6	<15.8	<1.6
3	Fish	Green sunfish	07-12-88	75.1	<40.2	<.10	.04	<20.1	<2.0	<20.1	<2.0
3	Fish	Red shiner	07-12-88	72.6	<36.5	<.09	.05	<18.3	<1.8	<18.3	<1.8
3	Fish	Carp	07-12-88	77.3	<44.0	<.11	.06	<22.0	<2.2	<22.0	<2.2
3	Fish	Fathead minnow	07-12-88	75.9	519	<.10	.16	<20.7	<2.1	<20.7	<2.1
3	Fish	Speckled dace	07-12-88	80.0	115	<.13	.30	<25.0	<2.5	<25.0	<2.5
3	Fish	White sucker	07-12-88	66.2	<29.6	<.07	.05	<14.8	<1.5	<14.8	<1.5
3	Fish	Mottled sculpin	07-12-88	72.4	39.9	<.09	.08	<18.1	<1.8	<18.1	<1.8
3	Aq. inv.	Crayfish	07-12-88	78.0	591	.15	2.8	80.9	<2.3	<22.7	<2.3
3	Aq. inv.	Composite	07-12-88	85.7	2,860	.42	7.5	62.2	<3.5	<35.0	<3.5
3	Aq. plant	Unknown	07-12-88	85.1	4,320	.93	6.7	87.2	<3.4	114.0	<3.4
3	Whole body	Frog	07-12-88	81.7	355	<.14	.11	<27.3	<2.7	<27.3	<2.7
10	Liver	Mallard	05-26-88	70.0	<33.3	<.08	.02	<16.7	<1.7	<16.7	<1.7
10	Liver	Mallard	05-31-88	67.5	<30.8	<.08	.03	<15.4	<1.5	<15.4	<1.5
10	Liver	Mallard	06-24-88	73.9	<38.3	.27	.04	<19.2	<1.9	<19.2	<1.9
10	Liver	Mallard	06-24-88	68.7	<32.0	<.08	.06	<16.0	<1.6	<32.0	2.9
10	Liver	Common merganser	05-13-88	71.4	<35.0	<.09	<.02	<17.5	<1.8	<17.5	<1.8

Table 20.--*Trace-element concentrations in biota, Gunnison River sites (sites 2, 3, and 10)*--Continued

Site number (fig. 2)	Matrix	Species	Date	Chromium	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Molybdenum
2	Fish	Brown trout	07-12-88	<3.6	<9.1	358	<36.5	949	6.93	0.27	<18.2
2	Fish	Rainbow trout	07-12-88	<2.9	<7.4	124	<29.4	735	19.1	.11	<14.7
2	Fish	Rainbow trout	07-12-88	<3.8	<9.4	187	<37.5	974	31.5	<.09	<18.7
2	Fish	Speckled dace	07-12-88	<3.0	<7.4	333	<29.5	1,090	38.6	.28	<14.8
2	Aq. inv.	Composite	07-12-88	<6.0	28.6	1,020	<59.5	1,370	288	.20	<29.8
2	Aq. plant	Unknown	07-12-88	<11.0	<27.5	3,140	<110	2,970	1,540	<.28	<54.9
2	Aq. plant	Unknown	07-12-88	<11.8	<29.4	4,740	<118	3,180	1,310	<.29	<58.8
3	Fish	Brown trout	07-12-88	<3.2	<7.9	88.6	<31.6	1,010	6.33	.21	<15.8
3	Fish	Green sunfish	07-12-88	<4.0	<10.0	100	<40.2	1,810	21.3	.32	<20.1
3	Fish	Red shiner	07-12-88	<3.6	<9.1	128	<36.9	1,310	15.7	.25	<18.3
3	Fish	Carp	07-12-88	<4.4	<11.0	163	<44.0	1,280	12.8	.60	<22.0
3	Fish	Fathead minnow	07-12-88	<4.2	<10.4	979	<41.5	1,910	41.1	.21	<20.7
3	Fish	Speckled dace	07-12-88	<5.0	<12.5	250	<50.0	1,450	21.5	.38	<25.0
3	Fish	White sucker	07-12-88	<3.0	<7.4	97.6	<29.6	1,010	15.1	.24	<14.8
3	Fish	Mottled sculpin	07-12-88	<3.6	<9.1	127	<36.2	1,450	27.9	.22	<18.1
3	Aq. inv.	Crayfish	07-12-88	<4.6	92.7	977	<45.5	3,050	145	<.11	<2.7
3	Aq. inv.	Composite	07-12-88	<7.0	<17.5	5,550	<69.9	3,360	620	.24	<35.0
3	Aq. plant	Unknown	07-12-88	<6.7	<16.8	8,660	<67.1	8,190	671	.34	<33.6
3	Whole body	Frog	07-12-88	<5.5	20.2	639	<54.6	1,800	20.8	<.14	<27.3
10	Liver	Mallard	05-26-88	<3.3	51.7	3,500	<33.3	600	14.3	.90	<16.7
10	Liver	Mallard	05-31-88	<3.1	36.6	2,970	<30.8	862	19.4	.51	<15.4
10	Liver	Mallard	06-24-88	<3.8	29.5	3,690	<38.3	805	17.6	.33	<19.2
10	Liver	Mallard	06-24-88	<3.2	47.9	2,890	<32.0	671	15.7	.82	<16.0
10	Liver	Common merganser	05-13-88	<3.5	35.3	5,660	<35.0	769	16.4	22.7	<17.5

Site number (fig. 2)	Matrix	Species	Date	Nickel	Selenium	Silver	Strontium	Thallium	Tin	Vanadium	Zinc
2	Fish	Brown trout	07-12-88	21.9	2.2	<18.2	4.01	<0.37	<18.2	<18.2	73.4
2	Fish	Rainbow trout	07-12-88	<11.8	2.4	<14.7	5.00	<.29	<14.7	<14.7	42.9
2	Fish	Rainbow trout	07-12-88	<15.0	1.5	<18.7	15.4	<.37	<18.7	<18.7	81.3
2	Fish	Speckled dace	07-12-88	<11.8	3.5	<14.8	71.7	.29	23.9	<14.8	105
2	Aq. inv.	Composite	07-12-88	<23.9	1.2	<29.8	95.8	<.60	<29.8	<29.8	85.1
2	Aq. plant	Unknown	07-12-88	<44.0	2.2	<54.9	91.2	<1.1	<54.9	<54.9	87.9
2	Aq. plant	Unknown	07-12-88	<47.1	1.2	<58.8	64.7	<1.2	<58.8	<58.8	114
3	Fish	Brown trout	07-12-88	<12.7	3.5	<15.8	39.9	<.32	<15.8	<15.8	113
3	Fish	Green sunfish	07-12-88	<16.1	6.4	<20.1	138	<.40	<20.1	<20.1	113
3	Fish	Red shiner	07-12-88	<14.6	7.7	<18.3	80.7	<.37	32.5	<18.3	166
3	Fish	Carp	07-12-88	<17.6	2.2	<22.0	48.9	<.44	<22.0	<22.0	172
3	Fish	Fathead minnow	07-12-88	<16.6	9.5	<20.7	82.6	<.41	22.8	<20.7	149
3	Fish	Speckled dace	07-12-88	<20.0	6.5	<25.0	112	<.50	<25.0	<25.0	170
3	Fish	White sucker	07-12-88	<11.8	1.8	<14.8	55.0	<.30	<14.8	<14.8	48.8
3	Fish	Mottled sculpin	07-12-88	<14.5	6.5	<18.1	98.9	<.36	<18.1	<18.1	72.5
3	Aq. inv.	Crayfish	07-12-88	<18.2	6.8	<22.7	659	<.45	<22.7	<22.7	95.4
3	Aq. inv.	Composite	07-12-88	<28.0	5.6	<35.0	74.8	<.70	<35.0	<35.0	92.3
3	Aq. plant	Unknown	07-12-88	<26.8	.70	<33.6	186	<.67	<33.6	<33.6	70.5
3	Whole body	Frog	07-12-88	<21.8	8.2	<27.3	109	<.55	<27.3	<27.3	105
10	Liver	Mallard	05-26-88	<13.3	31.0	<16.7	<3.33	<.33	<16.7	<16.7	10[illegible]
10	Liver	Mallard	05-31-88	<12.3	32.6	<15.4	<3.08	<.31	<15.4	<15.4	107
10	Liver	Mallard	06-24-88	<15.3	9.2	<19.2	<3.83	<.38	<19.2	<19.2	159
10	Liver	Mallard	06-24-88	<12.8	23.0	<16.0	<3.20	<.32	<16.0	<16.0	108
10	Liver	Common merganser	05-13-88	<14.0	52.4	<17.5	<3.50	<.35	<17.5	<17.5	98.6

Table 20.--*Trace-element concentrations in biota, Gunnison River sites (sites 2, 3, and 10)*--Continued

Site number (fig. 2)	Matrix	Species	Date	Percent moisture	Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium
10	Liver	Common merganser	06-03-88	68.3	<31.5	<0.08	<0.02	<15.8	<1.6	<15.8	<1.6
10	Liver	Canada goose-imm.	05-09-88	75.2	<40.3	<.10	.04	<20.2	<2.0	<20.2	<2.0
10	Liver	Canada goose-imm.	05-16-88	75.2	<40.3	<.10	.04	<20.2	<2.0	<20.2	<2.0
10	Liver	Killdeer	05-31-88	69.1	<32.4	<.08	.06	<16.2	<1.6	<16.2	2.6
10	Liver	Killdeer	06-03-88	70.5	<33.9	<.08	<.02	<16.9	<1.7	<16.9	<1.7
10	Liver	Killdeer	06-03-88	67.9	<31.2	<.08	.04	<15.6	<1.6	<15.6	3.4
10	Egg	Mallard	05-20-88	67.9	<31.2	<.08	<.02	<15.6	<1.6	<15.6	<1.6
10	Egg	Canada goose	05-20-88	63.7	<27.6	<.07	.04	<13.8	<1.4	<13.8	<1.4
10	Egg	Canada goose	05-20-88	63.8	<27.6	<.07	.04	<13.8	<1.4	<13.8	<1.4
10	Egg	Red-winged blackbird	05-26-88	79.1	<47.8	<.12	.04	<23.9	<2.4	<23.9	<2.4
10	Egg	Red-winged blackbird	05-26-88	81.5	<54.1	<.14	.04	<27.0	<2.7	<27.0	<2.7
10	Whole body	Mallard-imm.	05-09-88	75.0	92.0	.56	.08	<20.0	<2.0	<20.0	<2.0
10	Whole body	Canada goose-imm.	05-03-88	63.7	<27.6	<.07	.09	<13.8	<1.4	<13.8	<1.4
10	Whole body	Canada goose-imm.	05-05-88	58.6	<24.2	<.06	.08	<12.1	<1.2	<12.1	<1.2
10	Whole body	Killdeer-imm.	05-09-88	76.8	608	1.2	.29	<21.6	<2.2	<21.6	<2.2

Site number (fig. 2)	Matrix	Species	Date	Chromium	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Molybdenum
10	Liver	Common merganser	06-03-88	<3.2	12.6	9,240	<31.5	757	24.3	42.3	<15.8
10	Liver	Canada goose-imm.	05-09-88	<4.0	48.0	536	<40.4	776	12.9	<.10	<20.2
10	Liver	Canada goose-imm.	05-16-88	12.9	44.8	577	<40.3	806	16.1	<.10	<20.2
10	Liver	Killdeer	05-31-88	<3.2	14.6	615	<32.4	809	15.9	.39	<16.2
10	Liver	Killdeer	06-03-88	<3.4	24.1	1,330	<33.9	780	16.3	.48	<16.9
10	Liver	Killdeer	06-03-88	<3.1	16.8	847	<31.2	748	16.2	.38	<15.6
10	Egg	Mallard	05-20-88	3.1	<7.8	90.3	<31.2	374	<4.67	.11	<15.6
10	Egg	Canada goose	05-20-88	<2.8	<6.9	71.6	<27.6	413	<4.13	<.07	<13.8
10	Egg	Canada goose	05-20-88	<2.8	<6.9	737	<27.6	1,020	34.5	<.07	<13.8
10	Egg	Red-winged blackbird	05-26-88	<4.8	<12.0	120	<47.8	<478	<7.18	<.12	<23.9
10	Egg	Red-winged blackbird	05-26-88	<5.4	<13.5	114	<54.1	<541	<8.11	<.14	<27.0
10	Whole body	Mallard-imm.	05-09-88	<4.0	14.4	488	<40.0	1,120	16.8	.26	<20.0
10	Whole body	Canada goose-imm.	05-03-88	<2.8	<6.9	129	<27.6	579	<4.13	<.07	<13.8
10	Whole body	Canada goose-imm.	05-05-88	<2.4	74.6	104	<24.2	411	<3.62	<.06	<12.1
10	Whole body	Killdeer-imm.	05-09-88	<4.3	<10.8	608	<43.1	1,250	27.2	.14	<21.6

Site number (fig. 2)	Matrix	Species	Date	Nickel	Selenium	Silver	Strontium	Thallium	Tin	Vanadium	Zinc
10	Liver	Common merganser	06-03-88	<12.6	37.2	<15.8	<3.2	<0.32	<15.8	<15.8	117
10	Liver	Canada goose-imm.	05-09-88	<16.1	6.5	<20.2	<4.0	<.40	<20.2	<20.2	145
10	Liver	Canada goose-imm.	05-16-88	<16.1	8.5	<20.2	<4.0	<.40	<20.2	<20.2	152
10	Liver	Killdeer	05-31-88	<12.9	33.0	<16.2	<3.2	<.32	<16.2	<16.2	88.7
10	Liver	Killdeer	06-03-88	<13.6	52.9	<16.9	<3.4	.34	<16.9	<16.9	95.3
10	Liver	Killdeer	06-03-88	<12.5	54.2	<15.6	<3.1	<.31	<15.6	<15.6	90.3
10	Egg	Mallard	05-20-88	<12.5	5.9	<15.6	10.6	<.31	<15.6	<15.6	57.3
10	Egg	Canada goose	05-20-88	<11.0	2.8	<13.8	6.9	<.28	<13.8	<13.8	66.9
10	Egg	Canada goose	05-20-88	<11.0	3.3	<13.8	38.1	<.28	35.1	<13.8	64.6
10	Egg	Red-winged blackbird	05-26-88	<19.1	8.1	<23.9	9.1	<.48	<23.9	<23.9	60.8
10	Egg	Red-winged blackbird	05-26-88	<21.6	8.6	<27.0	11.9	<.54	<27.0	<27.0	74.6
10	Whole body	Mallard-imm.	05-09-88	<16.0	19.6	<20.0	67.2	<.40	<20.0	<20.0	112
10	Whole body	Canada goose-imm.	05-03-88	<11.0	3.3	<13.8	25.1	<.28	<13.8	<13.8	62.0
10	Whole body	Canada goose-imm.	05-05-88	106	3.4	<12.1	12.6	<.24	<12.1	<12.1	89.6
10	Whole body	Killdeer-imm.	05-09-88	<17.2	8.6	<21.6	63.8	<.43	51.3	<21.6	81.5

Table 20.--*Trace-element concentrations in biota, Gunnison River sites (sites 2, 3, and 10)*--Continued

Site number (fig. 2)	Matrix	Species	Date	Percent moisture	Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium
10	Whole body	Killdeer-imm.	05-16-88	75.4	<40.6	0.17	0.04	<20.3	<2.0	<20.3	<2.0
10	Whole body	Killdeer-imm.	05-26-88	78.9	408	.33	.16	<23.7	<2.4	<23.7	<2.4
10	Whole body	Killdeer-imm.	05-26-88	77.6	107	.38	.18	<22.3	<2.2	<22.3	<2.2
10	Whole body	Killdeer-imm.	05-31-88	77.5	151	<.11	.11	<22.2	<2.2	<22.2	<2.2
10	Whole body	Killdeer-imm.	05-31-88	75.2	109	.25	.05	<20.2	<2.0	<20.2	<2.0
10	Whole body	Sora rail	05-20-88	65.0	<28.6	.16	.08	<14.3	<1.4	<14.3	<1.4
10	Fish	Brown trout	07-11-88	69.7	627	.14	.13	<16.5	<1.6	<16.5	<1.6
10	Fish	Green sunfish	07-11-88	73.5	279	<.09	.06	<18.9	<1.9	<18.9	<1.9
10	Fish	Roundtail chub	07-11-88	69.0	174	.17	.44	<16.1	<1.6	<16.1	<1.6
10	Fish	Carp	07-11-88	69.0	<32.3	.13	.07	<16.1	<1.6	<16.1	<1.6
10	Fish	Fathead minnow	07-11-88	75.2	117	<.10	.07	<20.2	<2.0	<20.2	<2.0
10	Fish	Speckled dace	07-11-88	64.3	202	<.07	.04	<14.0	<1.4	<14.0	<1.4
10	Fish	Flannelmouth sucker	07-11-88	60.7	38.2	.07	.10	<12.7	<1.3	<12.7	<1.3
10	Fish	Mottled sculpin	07-11-88	71.8	181	<.09	.05	<17.7	<1.8	<17.7	<1.8
10	Aq. inv.	Crayfish	07-11-88	71.4	410	<.09	2.3	33.1	<1.7	<17.2	<1.7
10	Aq. plant	Algae	07-11-88	76.2	8,950	.42	7.8	117	<2.1	<21.0	<2.1
10	Aq. plant	Unknown	07-11-88	82.4	2,270	.30	3.6	93.8	<2.8	122	<2.8

Site number (fig. 2)	Matrix	Species	Date	Chromium	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Molybdenum
10	Whole body	Killdeer-imm.	05-16-88	<4.1	<10.2	244	<40.6	1,340	6.5	0.19	<20.3
10	Whole body	Killdeer-imm.	05-26-88	<4.7	<11.8	180	<47.4	806	<7.1	.24	<23.7
10	Whole body	Killdeer-imm.	05-26-88	<4.5	<11.2	442	<44.6	1,210	15.6	.43	<22.3
10	Whole body	Killdeer-imm.	05-31-88	<4.4	<11.1	533	<44.4	1,420	37.3	.36	<22.2
10	Whole body	Killdeer-imm.	05-31-88	<4.0	<10.1	411	<40.3	1,250	28.2	.20	<20.2
10	Whole body	Sora rail	05-20-88	<2.9	10.0	246	<28.6	943	8.3	.73	<14.3
10	Fish	Brown trout	07-11-88	<3.3	<8.2	248	<33.0	990	10.9	.25	<16.5
10	Fish	Green sunfish	07-11-88	<3.8	9.4	408	<37.7	1,660	20.8	.14	<18.9
10	Fish	Roundtail chub	07-11-88	<3.2	<8.1	310	<32.3	871	25.2	.62	<16.1
10	Fish	Carp	07-11-88	<3.2	<8.1	284	<32.3	1,190	12.6	.16	<16.1
10	Fish	Fathead minnow	07-11-88	<4.0	<10.1	266	<40.3	1,410	20.2	.12	<20.2
10	Fish	Speckled dace	07-11-88	<2.8	<7.0	308	<28.0	1,200	25.2	.17	<14.0
10	Fish	Flannelmouth sucker	07-11-88	<2.5	<6.4	160	<25.4	764	14.8	.21	<12.7
10	Fish	Mottled sculpin	07-11-88	<3.6	<8.9	394	<35.5	1,560	36.2	.14	<17.7
10	Aq. inv.	Crayfish	07-11-88	<3.4	77.6	552	<34.5	2,040	106	<.09	<17.2
10	Aq. plant	Algae	07-11-88	15.5	17.2	8,660	<42.0	6,010	2,100	<.10	<21.0
10	Aq. plant	Unknown	07-11-88	<5.7	44.9	3,300	<56.8	6,880	1,220	<.14	<28.4

Table 20.--*Trace-element concentrations in biota, Gunnison River sites (sites 2, 3, and 10)*--Continued

Site number (fig. 2)	Matrix	Species	Date	Nickel	Selenium	Silver	Strontium	Thallium	Tin	Vanadium	Zinc
10	Whole body	Killdeer-imm.	05-16-88	<16.3	16.3	<20.3	56.1	<0.41	<20.3	<20.3	112
10	Whole body	Killdeer-imm.	05-26-88	<18.9	8.1	<23.7	17.1	<.47	<23.7	<23.7	132
10	Whole body	Killdeer-imm.	05-26-88	<17.9	6.2	<22.3	49.1	<.45	46.9	<22.3	82.1
10	Whole body	Killdeer-imm.	05-31-88	<17.8	10.7	<22.2	52.0	.44	38.2	<22.2	104
10	Whole body	Killdeer-imm.	05-31-88	<16.1	15.3	<20.2	44.0	<.40	37.5	<20.2	97.6
10	Whole body	Sora rail	05-20-88	<11.4	2.3	<14.3	26.6	<.29	<14.3	<14.3	101
10	Fish	Brown trout	07-11-88	<13.2	2.0	<16.5	25.4	<.33	<16.5	<16.5	64.0
10	Fish	Green sunfish	07-11-88	<15.1	7.9	<18.9	104	<.38	<18.9	<18.9	114
10	Fish	Roundtail chub	07-11-88	<12.9	1.9	<16.1	21.9	<.32	<16.1	<16.1	56.1
10	Fish	Carp	07-11-88	<12.9	10.3	<16.1	127	<.32	17.1	<16.1	266
10	Fish	Fathead minnow	07-11-88	<16.1	8.1	<20.2	78.2	<.41	<20.2	<20.2	130
10	Fish	Speckled dace	07-11-88	<11.2	4.8	<14.0	106	<.28	17.6	<14.0	137
10	Fish	Flannelmouth sucker	07-11-88	<10.2	2.5	<12.7	36.9	<.25	<12.7	<12.7	42.0
10	Fish	Mottled sculpin	07-11-88	<14.2	5.0	<17.7	120	<.35	25.5	<17.7	74.1
10	Aq. inv.	Crayfish	07-11-88	<13.8	4.8	<17.2	486	<.34	<17.2	<17.2	68.3
10	Aq. plant	Algae	07-11-88	<16.8	1.7	<21.0	393	<.42	<21.0	25.6	88.2
10	Aq. plant	Unknown	07-11-88	<22.7	3.4	<28.4	618	<.57	<28.4	<28.4	76.1

Table 21.--*Trace-element concentrations in biota, Uncompahgre River sites (sites 4 and 9)*

[Analyses by U.S. Fish and Wildlife Service; concentrations in micrograms per gram dry weight; aq., aquatic; inv., invertebrates; <, less than; --, no data; site 4, Uncompahgre River at Colona; site 9, Uncompahgre River at Delta]

Site number (fig. 2)	Matrix	Species	Date	Percent moisture	Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium
4	Fish	Brown trout	11-15-87	76.9	110	--	0.30	2.2	<0.10	<2.0	0.23
4	Fish	Brown trout	07-13-88	72.8	25.0	--	<.20	.49	<.10	<2.0	<.20
4	Fish	Rainbow trout	07-13-88	75.1	100	--	<.20	1.6	<.10	<2.0	<.20
4	Fish	Flannelmouth sucker	07-13-88	72.7	220	--	.40	12.3	<.10	<2.0	.50
4	Fish	White sucker	11-15-87	76.4	120	--	.10	3.4	.10	<2.0	.45
4	Fish	Bluehead sucker	07-13-88	71.1	230	--	<.20	4.6	<.10	<2.0	.30
4	Fish	Mottled sculpin	11-15-87	84.3	150	--	.30	4.0	<.10	<2.0	.98
4	Fish	Mottled sculpin	07-13-88	76.4	87.0	--	<.20	3.1	<.10	<2.0	<.20
4	Aq. inv.	Composite	11-15-87	96.3	4,780	--	6.0	83.0	.20	15.0	5.5
4	Aq. inv.	Composite	07-13-88	84.9	4,500	--	3.1	121	.20	3.0	6.3
4	Aq. plant	Filamanteous algae	11-15-87	90.7	5,710	--	13.0	56.2	.20	74.0	2.2
4	Aq. plant	Filamanteous algae	07-13-88	79.7	9,720	--	11.0	209	.38	12.0	1.0
9	Fish	Roundtail chub	07-12-88	72.6	179	<.091	.18	<18.2	<1.8	<18.2	<1.8
9	Fish	Carp	07-12-88	71.9	96.1	<.089	.08	<17.8	<1.8	<17.8	<1.8
9	Fish	Speckled dace	07-12-88	66.6	35.9	<.075	.03	<15.0	<1.5	<15.0	<1.5
9	Fish	Flannelmouth sucker	07-12-88	70.2	<33.6	<.084	.07	<16.8	<1.7	<16.8	<1.7
9	Fish	Flannelmouth sucker	07-12-88	61.2	77.3	<.064	.08	<12.9	<1.3	<12.9	<1.3
9	Fish	Flannelmouth sucker	07-12-88	66.0	85.3	<.074	.05	<14.7	<1.5	<14.7	<1.5
9	Aq. inv.	Crayfish	07-12-88	73.0	474	.200	2.8	33.3	<1.9	<18.5	<1.9
9	Aq. plant	Unknown	07-12-88	88.5	626	.600	3.6	<43.5	<4.4	<43.5	<43.5
9	Aq. plant	Algae	07-12-88	79.6	6,130	.745	9.6	136	<2.4	43.1	<2.4

Site number (fig. 2)	Matrix	Species	Date	Chromium	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Molybdenum
4	Fish	Brown trout	11-15-87	<2.0	14.1	163	<0.5	1,180	63.0	0.06	0.2
4	Fish	Brown trout	07-13-88	<1.0	6.6	84	<4.0	908	10.0	.07	<1.0
4	Fish	Rainbow trout	07-13-88	2.0	11.0	236	<4.0	987	22.7	.08	<1.0
4	Fish	Flannelmouth sucker	07-13-88	3.0	4.3	840	<4.0	1,100	34.3	.19	<1.0
4	Fish	White sucker	11-15-87	<2.0	6.8	166	<.50	1,430	36.0	.08	.3
4	Fish	Bluehead sucker	07-13-88	1.0	3.3	658	<4.0	1,110	36.8	.16	<1.0
4	Fish	Mottled sculpin	11-15-87	<2.0	7.5	165	<.5	1,460	51.0	.04	<3.0
4	Fish	Mottled sculpin	07-13-88	3.0	3.0	257	<4.0	1,190	33.1	.06	<1.0
4	Aq. inv.	Composite	11-15-87	5.0	76.4	3,610	13.0	2,460	1,610	.14	.6
4	Aq. inv.	Composite	07-13-88	7.7	56.1	7,110	10.0	2,490	865	.04	<1.0
4	Aq. plant	Filamanteous algae	11-15-87	7.2	62.5	5,560	10.0	3,470	831	.03	1.0
4	Aq. plant	Filamanteous algae	07-13-88	26.0	20.0	28,500	17.0	4,730	693	.02	<3.0
9	Fish	Roundtail chub	07-12-88	<3.6	<9.1	3,520	<36.5	1,090	30.3	.95	<18.2
9	Fish	Carp	07-12-88	<3.6	25.3	302	<35.6	1,100	14.9	.30	<17.8
9	Fish	Speckled dace	07-12-88	<3.0	<7.5	189	<29.9	1,200	19.5	.21	<15.0
9	Fish	Flannelmouth sucker	07-12-88	<3.4	<8.4	339	<33.6	1,340	21.5	.24	<16.8
9	Fish	Flannelmouth sucker	07-12-88	<2.6	<6.4	168	<25.8	928	19.8	.25	<12.9
9	Fish	Flannelmouth sucker	07-12-88	<2.9	<7.4	238	<29.4	1,060	19.1	.26	<14.7
9	Aq. inv.	Crayfish	07-12-88	<3.7	117	722	<37.0	2,555	116	<.09	<18.5
9	Aq.plant	Unknown	07-12-88	<.70	<21.7	956	<87.0	3,740	78.3	<.22	<43.5
9	Aq.plant	Algae	07-12-88	12.2	22.5	10,200	<49.0	7,650	603	.38	<24.5

Table 21.--*Trace-element concentrations in biota, Uncompahgre River sites (sites 4 and 9)*--Continued

Site number (fig. 2)	Matrix	Species	Date	Nickel	Sele-nium	Silver	Stron-tium	Thal-lium	Tin	Vana-dium	Zinc
4	Fish	Brown trout	11-15-87	0.83	3.3	<1.0	37.5	<0.30	--	0.30	112
4	Fish	Brown trout	07-13-88	<1.0	3.5	<2.0	21.6	<5.0	--	<.30	79.3
4	Fish	Rainbow trout	07-13-88	<1.0	3.5	<2.0	20.4	<5.0	--	.60	76.4
4	Fish	Flannelmouth sucker	07-13-88	<1.0	1.7	<2.0	36.7	<5.0	--	2.40	89.9
4	Fish	White sucker	11-15-87	.40	5.3	<1.0	69.4	<.30	--	.33	83.0
4	Fish	Bluehead sucker	07-13-88	<1.0	1.8	<2.0	59.9	<5.0	--	2.10	66.1
4	Fish	Mottled sculpin	11-15-87	.40	2.6	<1.0	122	<.30	--	.53	220
4	Fish	Mottled sculpin	07-13-88	2.0	4.4	<2.0	87.1	<5.0	--	.91	101
4	Aq. inv.	Composite	11-15-87	6.8	3.1	<1.0	108	2.7	--	13.6	433
4	Aq. inv.	Composite	07-13-88	8.1	4.7	<2.0	98.2	<5.0	--	20.0	386
4	Aq. plant	Filamanteous algae	11-15-87	6.3	1.4	<1.0	178	<2.0	--	17.6	231
4	Aq. plant	Filamanteous algae	07-13-88	14.0	.49	<2.0	145	<6.0	--	76.2	124
9	Fish	Roundtail chub	07-12-88	<14.6	<1.8	<18.2	55.1	<.36	<18.2	<18.2	75.5
9	Fish	Carp	07-12-88	<14.2	3.9	<17.8	70.8	<.36	<17.8	<17.8	227
9	Fish	Speckled dace	07-12-88	<12.0	5.7	<15.0	140	<.30	<15.0	<15.0	118
9	Fish	Flannelmouth sucker	07-12-88	<13.4	6.0	<16.8	72.8	<.34	<16.8	<16.8	76.8
9	Fish	Flannelmouth sucker	07-12-88	<10.3	1.5	<12.9	57.2	<.26	<12.9	<12.9	56.4
9	Fish	Flannelmouth sucker	07-12-88	<11.8	<1.5	<14.7	76.8	<.29	<14.7	<14.7	65.0
9	Aq. inv.	Crayfish	07-12-88	<14.8	4.1	<18.5	689	<.37	18.9	<18.5	77.4
9	Aq. plant	Unknown	07-12-88	<34.8	1.7	<43.5	328	<.87	54.8	<43.5	425
9	Aq. plant	Algae	07-12-88	<19.6	4.4	<24.5	355	<.49	<24.5	<24.5	88.2

Table 22.--*Trace-element concentrations in biota, tributary sites (sites 12, 13, and 14)*

[Analyses by U.S. Fish and Wildlife Service; concentrations in micrograms per gram dry weight; aq., aquatic; inv., invertebrates; fish matrix is a whole-body sample; <, less than; site 12, Happy Canyon Creek near mouth; site 13, Spring Creek near mouth; site 14, Dry Creek near mouth]

Site number (fig. 2)	Matrix	Species	Date	Percent moisture	Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium
12	Fish	Brown trout	07-14-88	68.5	<31.7	0.09	0.09	<15.9	<1.6	<15.9	<1.6
12	Fish	Sucker composite	07-14-88	71.6	81.0	.12	.16	<17.6	<1.8	<17.6	<1.8
12	Fish	Mottled sculpin	07-14-88	69.3	<32.6	.19	.15	<16.3	<1.6	<16.3	<1.6
12	Aq. inv.	Composite	07-14-88	89.3	4,260	.71	9.1	104	<4.7	<46.7	<4.7
12	Aq. plant	Algae	07-14-88	84.5	2,350	.70	6.4	57.4	<3.2	110	<3.2
12	Aq. plant	Unknown	07-14-88	84.0	1,340	.41	2.3	43.8	<3.1	248	<3.1
13	Fish	Brown trout	07-14-88	71.2	<34.7	<.09	.12	<17.4	<1.7	<17.4	<1.7
13	Fish	Speckled dace	07-14-88	70.7	154	<.08	.21	<17.7	<1.7	<17.1	<1.7
13	Fish	Sucker composite	07-14-88	68.2	53.5	.08	.17	<15.7	<1.6	<15.7	<1.6
13	Fish	Mottled sculpin	07-14-88	73.4	<37.6	<.09	.09	<18.8	<1.9	<18.8	<1.9
13	Aq. plant	Algae	07-14-88	78.5	4,790	.61	7.4	127	<2.3	88.8	<2.3
14	Fish	Roundtail chub	07-14-88	68.0	<31.2	<.08	.13	<15.6	<1.6	<15.6	<1.6
14	Fish	Carp	07-14-88	68.7	<31.9	<.08	.08	<16.0	<1.6	<16.0	<1.6
14	Fish	Speckled dace	07-14-88	64.9	37.0	<.07	.14	<14.2	<1.4	<14.2	<1.4
14	Fish	Flannelmouth sucker	07-14-88	66.5	152	.10	.42	<14.9	<1.5	<14.9	<1.5
14	Aq. plant	Algae	07-14-88	80.9	6,490	.56	9.0	127	<2.6	73.3	<2.6
14	Aq. plant	Unknown	07-14-88	80.1	4,230	.58	5.1	135	<2.5	<25.1	<2.5

Site number (fig. 2)	Matrix	Species	Date	Chromium	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Molybdenum
12	Fish	Brown trout	07-14-88	<3.17	10.5	95	<31.7	1,110	<4.76	0.19	<15.9
12	Fish	Sucker composite	07-14-88	<3.52	<8.8	215	<35.2	1,580	30.6	.40	<17.6
12	Fish	Mottled sculpin	07-14-88	3.58	<8.1	169	<32.6	1,400	27.4	.14	<16.3
12	Aq. inv.	Composite	07-14-88	<9.35	<23.4	11,500	<93.5	4,210	899	<.23	<46.7
12	Aq. plant	Algae	07-14-88	<6.45	<16.1	4,210	<64.5	3,100	432	<.16	<32.3
12	Aq. plant	Unknown	07-14-88	<6.25	<15.6	2,480	<62.5	3,060	530	<.16	<31.3
13	Fish	Brown trout	07-14-88	<3.47	15.3	108	<34.7	1,220	6.94	.44	<17.4
13	Fish	Speckled dace	07-14-88	<3.41	<8.5	246	<34.1	1,190	18.1	.22	<17.1
13	Fish	Sucker Composite	07-14-88	<3.14	<7.9	160	<31.4	1,230	32.1	.33	<15.7
13	Fish	Mottled sculpin	07-14-88	<3.76	<9.4	132	<37.6	1,350	21.1	.23	<18.8
13	Aq. plant	Algae	07-14-88	8.84	21.9	6,840	<46.5	3,770	1,000	<.12	<23.2
14	Fish	Rountail chub	07-14-88	<3.12	<7.8	175	<31.2	719	<4.69	.63	<15.6
14	Fish	Carp	07-14-88	<3.19	11.2	233	<31.9	1,280	17.6	.24	<16.0
14	Fish	Speckled dace	07-14-88	<2.85	<7.1	157	<28.5	1,280	18.2	.23	<14.2
14	Fish	Flannelmouth sucker	07-14-88	2.99	<7.5	242	<29.9	1,070	29.3	.59	<14.9
14	Aq. plant	Algae	07-14-88	9.42	21.5	7,960	<52.4	5,920	984	<.13	<25.2
14	Aq. plant	Unknown	07-14-88	9.55	18.6	6,380	<50.3	4,420	429	<.13	<25.1

Table 22.--*Trace-element concentrations in biota, tributary sites (sites 12, 13, and 14)*--Continued

Site number (fig. 2)	Matrix	Species	Date	Nickel	Sele-nium	Silver	Stron-tium	Thal-lium	Tin	Vana-dium	Zinc
12	Fish	Brown trout	07-14-88	<12.7	5.4	<15.9	65.1	<0.32	<15.9	<15.9	122
12	Fish	Sucker composite	07-14-88	<14.1	2.1	<17.6	138	<.35	<17.6	<17.6	91.9
12	Fish	Mottled sculpin	07-14-88	<13.0	4.2	<16.3	125	<.33	42.0	<16.3	109
12	Aq. inv.	Composite	07-14-88	<37.4	2.8	<46.7	358	<.94	<46.7	<46.7	119
12	Aq. plant	Algae	07-14-88	<25.8	.60	<32.3	118	<.65	<32.3	<32.3	49.0
12	Aq. plant	Unknown	07-14-88	<25.0	<.63	<31.3	113	<.63	<31.3	<31.3	64.4
13	Fish	Brown trout	07-14-88	<13.9	8.3	<17.4	78.8	<.35	<17.4	<17.4	122
13	Fish	Speckled dace	07-14-88	<13.6	4.1	<17.1	75.8	<.34	20.1	<17.1	118
13	Fish	Sucker composite	07-14-88	<12.6	1.3	<15.7	85.2	<.31	<15.7	<15.7	70.8
13	Fish	Mottled sculpin	07-14-88	<15.0	6.8	<18.8	93.6	<.38	27.4	<18.8	101
13	Aq. plant	Algae	07-14-88	<18.6	<2.4	<23.2	173	<.47	<23.2	<23.2	96.3
14	Fish	Roundtail chub	07-14-88	<12.5	<5.6	<15.6	7.5	<.31	<15.6	<15.6	47.5
14	Fish	Carp	07-14-88	<12.8	10.5	<16.0	128	<.32	<16.0	<16.0	232
14	Fish	Speckled dace	07-14-88	<11.4	6.3	<14.2	142	<.28	17.9	<14.2	135
14	Fish	Flannelmouth sucker	07-14-88	<11.9	2.4	<14.9	72.8	<.30	<14.9	<14.9	58.2
14	Aq. plant	Algae	07-14-88	<20.9	1.0	<26.2	452	<.52	<26.2	<26.2	84.3
14	Aq. plant	Unknown	07-14-88	<20.1	1.0	<25.1	250	<.50	<25.1	<25.1	74.4

Table 23.--*Trace-element concentrations in biota at Sweitzer Lake (site 7)*

[Analyses by U.S. Fish and Wildlife Service; concentrations in micrograms per gram dry weight; bb, blackbird; imm., immature; aq., aquatic; inv., invertebrates; fish matrix is a whole-body sample; <, less than; --, no data]

Matrix	Species	Date	Percent moisture	Alum-inum	Anti-mony	Arse-nic	Bar-ium	Beryl-lium	Boron	Cad-mium
Liver	Western grebe	07-19-88	74.9	<39.8	<0.10	<0.02	<19.9	<2.0	<19.9	<2.0
Liver	Western grebe	07-19-88	71.4	<35.0	<.09	<.02	<17.5	<1.8	<17.5	<1.8
Liver	Killdeer	06-23-88	68.5	<31.8	<.08	.02	<15.9	<1.6	<15.9	3.5
Liver	Killdeer	06-23-88	68.9	<32.2	<.08	.06	<16.1	<1.6	<16.1	4.2
Liver	Coot	06-23-88	70.4	<33.8	<.08	.07	<16.9	<1.7	<16.9	<1.7
Liver	Coot	06-23-88	73.0	<37.0	<.09	.04	<18.5	<1.8	<18.5	<1.8
Egg	Killdeer	06-23-88	72.2	<36.0	<.09	.02	<18.0	<1.8	<18.0	<1.8
Egg	Killdeer	06-23-88	72.2	<37.2	<.09	.05	<18.6	<1.9	<18.6	<1.9
Egg	Coot	06-22-88	74.7	<39.5	<.10	.02	<19.8	<2.0	<19.8	<2.0
Egg	Red-winged bb	05-24-88	79.0	<47.6	--	--	<23.8	<2.4	<23.8	<2.4
Egg	Yellow-headed bb	05-24-88	78.8	<47.2	<.12	.06	<23.6	<2.4	<23.6	<2.4
Egg	Yellow-headed bb	06-22-88	81.7	<54.6	<.14	.03	<27.3	<2.7	<27.3	<2.7
Egg	Bobwhite quail	06-22-88	66.2	<29.6	<.07	.03	<14.8	<1.5	<14.8	<1.5
Whole body	Eared grebe	05-12-88	62.1	<26.4	<.07	<.01	<13.2	<1.3	<13.2	<1.3
Whole body	Killdeer	06-01-88	68.0	175	.09	.14	<15.6	<1.6	<15.6	<1.6
Whole body	Red-winged bb-imm.	06-01-88	84.3	<63.7	.61	<.03	<31.8	<3.2	<31.8	<3.2
Whole body	Yellow-headed bb-imm.	06-22-88	70.4	<33.8	<.09	<.02	<16.9	<1.7	<16.9	<1.7
Whole body	Yellow-headed bb-imm.	06-22-88	74.4	<39.1	<.10	<.02	<19.5	<2.0	<19.5	<2.0
Whole body	Yellow-headed bb-imm.	06-22-88	72.1	<35.8	<.09	.09	<17.9	<1.8	<17.9	<1.8
Whole body	Yellow-headed bb-imm.	06-22-88	72.6	<36.5	<.09	<.02	<18.2	<1.8	<18.2	<1.8
Whole body	Sora rail-imm.	05-12-88	63.7	88.2	.10	.10	<13.8	<1.4	<13.8	<1.4
Liver	Channel catfish	03-16-89	77.3	16.0	--	<.20	.20	<.10	<2.0	.30
Liver	Channel catfish	03-16-89	76.8	3.0	--	<.20	<.10	<.10	<2.0	<.20
Liver	Channel catfish	03-16-89	78.1	7.0	--	<.20	<.10	<.10	<2.0	<.20
Kidney	Channel catfish	03-16-89	77.9	20.0	--	<.20	.50	<.10	<2.0	.64

Matrix	Species	Date	Chro-mium	Copper	Iron	Lead	Mag-nesium	Manga-nese	Mer-cury	Molyb-denum
Liver	Western grebe	07-19-88	<4.0	14.7	3,350	<39.8	717	12.0	4.1	<19.9
Liver	Western grebe	07-19-88	<3.5	27.6	2,680	<35.0	664	12.6	1.7	<17.5
Liver	Killdeer	06-23-88	<3.2	20.6	860	<31.8	794	16.5	.20	<15.9
Liver	Killdeer	06-23-88	<3.2	20.6	810	<32.2	836	19.0	.28	<16.1
Liver	Coot	06-23-88	<3.4	26.3	3,410	<33.8	743	12.2	.43	<16.9
Liver	Coot	06-23-88	<3.7	19.6	2,390	<37.0	704	8.5	.42	<18.5
Egg	Killdeer	06-23-88	<3.6	11.2	144	<36.0	611	<5.4	.26	<18.0
Egg	Killdeer	06-23-88	<3.7	<9.3	119	<37.2	632	<5.6	.31	<18.6
Egg	Coot	06-22-88	<4.0	<9.9	90.9	<39.5	435	<5.9	.38	<19.8
Egg	Red-winged bb	05-24-88	<4.8	<11.9	171	<47.6	<476	<7.1	--	<23.8
Egg	Yellow-headed bb	05-24-88	<4.7	<11.8	113	<47.2	<472	<7.1	--	<23.6
Egg	Yellow-headed bb	06-22-88	<5.5	<13.7	126	<54.6	<546	<8.2	<.14	<27.3
Egg	Bobwhite quail	06-22-88	<3.0	<7.4	62.1	<29.6	325	<4.4	<.07	<14.8
Whole body	Eared grebe	05-12-88	9.2	10.8	398	<26.4	1,130	4.0	2.6	<13.2
Whole body	Killdeer	06-01-88	<3.1	17.8	419	<31.2	1,220	9.1	.39	<15.6
Whole body	Red-winged bb-imm.	06-01-88	<6.4	<15.9	191	<63.7	892	<9.6	<.16	<31.8
Whole body	Yellow-headed bb-imm.	06-22-88	<3.4	<8.4	203	<33.8	1,450	<5.1	.13	<16.9
Whole body	Yellow-headed bb-imm.	06-22-88	<3.9	15.6	211	<39.1	1,130	<5.9	<.10	<19.5
Whole body	Yellow-headed bb-imm.	06-22-88	<3.6	258	229	<35.8	1,110	5.4	.14	<17.9
Whole body	Yellow-headed bb-imm.	06-22-88	<3.6	16.8	245	<36.5	1,090	9.5	.10	<18.2
Whole body	Sora rail-imm.	05-12-88	<2.8	8.0	350	<27.6	964	14.0	.84	<13.8
Liver	Channel catfish	03-16-89	<1.0	32.2	202	<4.0	906	6.9	.03	<1.0
Liver	Channel catfish	03-16-89	<1.0	20.9	379	<4.0	833	3.6	.03	<1.0
Liver	Channel catfish	03-16-89	<1.0	20.0	715	<4.0	764	3.7	.03	<1.0
Kidney	Channel catfish	03-16-89	<1.0	3.3	468	<4.0	748	3.1	.03	<1.0

Table 23.--*Trace-element concentrations in biota at Sweitzer Lake (site 7)*--Continued

Matrix	Species	Date	Nickel	Sele-nium	Silver	Stron-tium	Thal-lium	Tin	Vana-dium	Zinc
Liver	Western grebe	07-19-88	<15.9	72.1	<19.9	<4.0	<0.40	<19.9	<19.9	99.2
Liver	Western grebe	07-19-88	<14.0	83.6	<17.5	<3.5	<.35	<17.5	<17.5	143
Liver	Killdeer	06-23-88	<12.7	25.4	<15.9	<3.2	<.32	<15.9	<15.9	98.7
Liver	Killdeer	06-23-88	<12.9	9.0	<16.1	<3.2	<.33	<16.1	<16.1	103
Liver	Coot	06-23-88	<13.5	12.2	<16.9	<3.4	<.34	<16.9	<16.9	175
Liver	Coot	06-23-88	<14.8	21.1	<18.5	<3.7	<.38	<18.5	<18.5	163
Egg	Killdeer	06-23-88	<14.4	7.6	<18.0	31.3	<.36	<18.0	<18.0	70.5
Egg	Killdeer	06-23-88	<14.9	5.6	<18.6	29.0	<.37	<18.6	<18.6	65.8
Egg	Coot	06-22-88	<15.8	11.1	<19.8	17.8	<.40	<19.8	<19.8	65.6
Egg	Red-winged bb	05-24-88	<19.0	17.6	<23.8	24.8	<.48	<23.8	<23.8	83.8
Egg	Yellow-headed bb	05-24-88	<18.9	8.0	<23.6	12.3	.47	<23.6	<23.6	65.1
Egg	Yellow-headed bb	06-22-88	<21.9	11.5	<27.3	20.2	<.55	<27.3	<27.3	76.5
Egg	Bobwhite quail	06-22-88	<11.8	4.1	<14.8	9.2	<.30	<14.8	<14.8	60.1
Whole body	Eared grebe	05-12-88	<10.6	29.3	<13.2	39.0	<.26	<13.2	<13.2	90.2
Whole body	Killdeer	06-01-88	<12.5	3.4	<15.6	45.6	.31	<15.6	<15.6	134
Whole body	Red-winged bb-imm.	06-01-88	<25.5	12.7	<31.8	59.2	.64	<31.8	<31.8	104
Whole body	Yellow-headed bb-imm.	06-22-88	<13.5	12.8	<16.9	67.6	<.34	<16.9	<16.9	124
Whole body	Yellow-headed bb-imm.	06-22-88	<15.6	10.2	<19.5	52.0	<.39	<19.5	<19.5	127
Whole body	Yellow-headed bb-imm.	06-22-88	69.9	9.3	<17.9	47.0	<.36	<17.9	<17.9	245
Whole body	Yellow-headed bb-imm.	06-22-88	<14.6	11.3	<18.2	62.8	<.37	<18.2	<18.2	114
Whole body	Sora rail-imm.	05-12-88	<11.0	4.4	<13.8	38.0	<.28	<13.8	<13.8	71.9
Liver	Channel catfish	03-16-89	<2.0	47.0	<2.0	1.4	<4.0	--	1.4	120
Liver	Channel catfish	03-16-89	<2.0	40.0	<2.0	1.3	<4.0	--	2.3	117
Liver	Channel catfish	03-16-89	<2.0	41.0	<2.0	1.6	<4.0	--	2.0	115
Kidney	Channel catfish	03-16-89	<2.0	77.0	<2.0	3.6	<4.0	--	3.2	89.7

Matrix	Species	Date	Percent moisture	Alum-inum	Anti-mony	Arse-nic	Bar-ium	Beryl-lium	Boron	Cad-mium
Kidney	Channel catfish	03-16-89	82.4	7.0	--	<0.20	0.20	<0.10	<2.0	<0.20
Kidney	Channel catfish	03-16-89	78.6	8.0	--	<.20	.10	<.10	<2.0	<.20
Stomach	Channel catfish	03-16-89	73.4	45.0	--	<.20	1.0	<.10	<2.0	<.20
Stomach	Channel catfish	03-16-89	75.6	975	--	<.20	53.9	<.10	3.0	<.20
Muscle	Channel catfish	03-16-89	77.2	4.0	--	<.20	<.10	<.10	<2.0	<.20
Muscle	Channel catfish	03-16-89	77.6	<4.0	--	<.20	<.10	<.10	<2.0	<.30
Muscle	Channel catfish	03-16-89	78.6	3.0	--	<.20	<.10	<.10	<2.0	<.20
Muscle	Channel catfish	03-16-89	81.2	11.0	--	<.20	.20	<.10	<2.0	<.20
Muscle	Channel catfish	03-16-89	81.0	5.0	--	<.20	<.10	<.10	<2.0	<.20
Eggs	Channel catfish	03-16-89	61.1	<3.0	--	<.20	<.10	<.10	<2.0	<.20
Eggs	Channel catfish	03-16-89	61.5	<3.0	--	<.20	.20	<.10	<2.0	<.20
Eggs	Channel catfish	03-16-89	64.1	<3.0	--	<.20	.10	<.10	<2.0	<.20
Fish	Channel catfish	07-19-88	77.8	<45.0	<0.11	<.02	<22.5	<2.3	<22.5	<2.3
Fish	Green sunfish	07-19-88	75.0	<40.0	<.10	.03	<20.0	<2.0	<20.0	<2.0
Fish	Green sunfish	07-19-88	72.9	<36.9	<.09	<.02	<18.4	<1.8	<18.4	<1.8

Table 23.--*Trace-element concentrations in biota at Sweitzer Lake (site 7)*--Continued

Matrix	Species	Date	Chromium	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Molybdenum
Kidney	Channel catfish	03-16-89	<1.0	4.1	491	<4.0	797	2.80	0.03	<1.0
Kidney	Channel catfish	03-16-89	<1.0	3.7	517	<4.0	672	2.40	.04	<1.0
Stomach	Channel catfish	03-16-89	2.0	1.4	90.0	<4.0	1,460	10.0	.03	<1.0
Stomach	Channel catfish	03-16-89	4.0	37.9	968	<4.0	2,900	82.7	.01	<1.0
Muscle	Channel catfish	03-16-89	<1.0	.78	18.0	<4.0	906	.70	.04	<1.0
Muscle	Channel catfish	03-16-89	<1.0	1.5	19.0	<5.0	934	.60	.04	<1.0
Muscle	Channel catfish	03-16-89	<1.0	2.0	21.0	<4.0	957	.88	.04	<1.0
Muscle	Channel catfish	03-16-89	<1.0	2.2	39.0	<4.0	1,070	2.70	.07	<1.0
Muscle	Channel catfish	03-16-89	<1.0	1.4	19.0	<4.0	1,040	1.20	.07	<1.0
Eggs	Channel catfish	03-16-89	<1.0	3.6	61.0	<4.0	1,280	8.10	<.01	<1.0
Eggs	Channel catfish	03-16-89	<1.0	3.7	54.0	<4.0	1,170	6.50	<.01	<1.0
Eggs	Channel catfish	03-16-89	<1.0	4.4	89.0	<4.0	1,270	3.50	.01	<1.0
Fish	Channel catfish	07-19-88	<4.5	<11.3	248	<45.0	1,620	<6.76	.11	<22.5
Fish	Green sunfish	07-19-88	<4.0	<10.0	104	<40.0	1,080	<6.00	.12	<20.0
Fish	Green sunfish	07-19-88	<3.7	<9.2	55.4	<36.9	1,290	<5.54	.11	<18.4

Matrix	Species	Date	Nickel	Selenium	Silver	Strontium	Thallium	Tin	Vanadium	Zinc
Kidney	Channel catfish	03-16-89	<2.0	78.0	<2.0	4.8	<4.0	--	5.4	105
Kidney	Channel catfish	03-16-89	<2.0	66.0	<2.0	3.4	<4.0	--	4.7	83.1
Stomach	Channel catfish	03-16-89	<2.0	27.0	<2.0	150	<4.0	--	.40	88.6
Stomach	Channel catfish	03-16-89	3.0	7.8	<2.0	1,050	<4.0	--	3.9	81.3
Muscle	Channel catfish	03-16-89	<2.0	25.0	<2.0	1.1	<4.0	--	<.30	23.0
Muscle	Channel catfish	03-16-89	<2.0	31.0	<2.0	1.4	<4.0	--	<.30	28.1
Muscle	Channel catfish	03-16-89	<2.0	22.0	<2.0	1.6	<4.0	--	<.30	25.3
Muscle	Channel catfish	03-16-89	<2.0	31.0	<2.0	2.6	<4.0	--	<.30	35.8
Muscle	Channel catfish	03-16-89	<2.0	29.0	<2.0	1.7	<4.0	--	<.30	27.5
Eggs	Channel catfish	03-16-89	<2.0	32.0	<2.0	15.1	<4.0	--	<.30	197
Eggs	Channel catfish	03-16-89	<2.0	32.0	<2.0	16.5	<4.0	--	<.30	189
Eggs	Channel catfish	03-16-89	<2.0	31.0	<2.0	11.0	<4.0	--	<.30	305
Fish	Channel catfish	07-19-88	<18.0	32.4	<22.5	162	<.46	<22.5	<22.5	99.5
Fish	Green sunfish	07-19-88	<16.0	15.2	<20.0	46.0	<.40	<20.0	<20.0	87.2
Fish	Green sunfish	07-19-88	<14.8	25.1	<18.4	95.6	<.37	<18.4	<18.4	87.8

Matrix	Species	Date	Percent moisture	Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium
Fish	Carp	07-19-88	70.0	46.7	<0.08	<0.02	<16.7	<1.7	<16.7	<1.7
Fish	Carp	07-19-88	70.6	<34.0	<.08	<.02	<17.0	<1.7	<17.0	<1.7
Fish	Carp	03-16-89	80.0	220	--	<.20	4.0	<.10	<2.0	<.20
Fish	Carp	03-16-89	75.4	413	--	<.20	4.3	<.10	<2.0	<.20
Fish	Black bullhead	03-16-89	83.7	449	--	<.20	7.4	<.10	<2.0	<.20
Fish	Flannelmouth sucker	03-16-89	79.5	65.0	--	<.20	2.3	<.10	<2.0	<.20
Fish	White sucker	07-19-88	74.9	120	<.10	<.02	<19.9	<2.0	<19.9	<2.0
Aq. inv.	Composite	07-19-88	94.0	1,380	.65	11.5	<83.3	<8.3	<83.3	<8.3
Aq. inv.	Composite	07-19-88	87.9	7,160	.60	12.0	108	<4.1	<41.3	<4.1
Aq. plant	Algae	07-19-88	88.3	1,850	.23	12.0	66.7	<4.3	128	<4.3
Aq. plant	Wigeon grass	07-19-88	87.3	157	1.1	.41	<39.4	<3.9	198	<3.9
Aq. plant	Unknown	07-19-88	86.4	794	.38	1.2	<36.8	<3.7	241	<3.7
Aq. plant	Unknown	07-19-88	82.7	1,850	.79	4.9	63.0	<2.9	459	<2.9
Plankton	Composite	07-19-88	96.6	<294	<.74	6.1	<147	<14.7	<147	<14.7
Whole body	Vole-imm.	05-24-88	79.1	<47.8	<.12	.04	<23.9	<2.4	<23.9	2.4

Table 23.--*Trace-element concentrations in biota at Sweitzer Lake (site 7)*--Continued

Matrix	Species	Date	Chromium	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Molybdenum
Fish	Carp	07-19-88	<3.3	<8.3	293	<33.3	1,330	10.3	<0.08	<16.7
Fish	Carp	07-19-88	<3.4	<8.5	160	<34.0	1,160	7.82	<.08	<17.0
Fish	Carp	03-16-89	<1.0	5.0	230	<4.0	1,770	10.0	.01	<1.0
Fish	Carp	03-16-89	1.0	3.0	352	<4.0	1,490	10.0	<.01	<1.0
Fish	Black bullhead	03-16-89	3.0	22.1	474	<4.0	1,920	13.0	<.01	<1.0
Fish	Flannelmouth sucker	03-16-89	<1.0	3.0	97.5	<4.0	1,630	12.0	.06	<1.0
Fish	White sucker	07-19-88	<4.0	<10.0	402	<39.8	2,110	19.1	<.08	<19.9
Aq. inv.	Composite	07-19-88	<16.7	50.0	8,580	<167	7,000	777	<.42	<83.3
Aq. inv.	Composite	07-19-88	8.3	26.4	16,900	<82.6	9,170	244	.30	<41.3
Aq. plant	Algae	07-19-88	<8.6	<21.4	5,110	<85.5	6,320	156	<.21	<42.7
Aq. plant	Wigeon grass	07-19-88	<7.9	<19.7	402	<78.7	5,590	269	<.20	<39.4
Aq. plant	Unknown	07-19-88	<7.4	<18.4	1,400	<73.5	6,250	254	<.18	<36.8
Aq. plant	Unknown	07-19-88	<5.8	<14.4	3,920	<57.8	7,920	601	<.14	<28.9
Plankton	Composite	07-19-88	<29.4	<73.5	853	<294	<2,940	79.4	<.74	<147
Whole body	Vole-imm.	05-24-88	<4.8	12.4	383	<47.8	1,240	<7.18	.18	<23.9

Matrix	Species	Date	Nickel	Selenium	Silver	Strontium	Thallium	Tin	Vanadium	Zinc
Fish	Carp	07-19-88	<13.3	31.0	<16.7	176	<0.33	<16.7	<16.7	264
Fish	Carp	07-19-88	<13.6	25.8	<17.0	124	<.34	17.7	<17.0	259
Fish	Carp	03-16-89	<2.0	40.0	<2.0	206	<4.0	--	0.9	270
Fish	Carp	03-16-89	<2.0	50.0	<2.0	185	<4.0	--	1.8	212
Fish	Black bullhead	03-16-89	3.0	39.0	<2.0	202	<4.0	--	2.2	109
Fish	Flannelmouth sucker	03-16-89	<2.0	22.0	<2.0	115	<4.0	--	.5	90.7
Fish	White sucker	07-19-88	<15.9	39.0	<19.9	214	<.40	<19.9	<19.9	90.8
Aq. inv.	Composite	07-19-88	<66.7	26.7	<83.3	1,160	<1.7	<83.3	<83.3	202
Aq. inv.	Composite	07-19-88	<33.0	29.8	<41.3	339	1.7	<41.3	<41.3	126
Aq. plant	Algae	07-19-88	<34.2	12.8	<42.7	404	<.85	<42.7	<42.7	35.9
Aq. plant	Wigeon grass	07-19-88	<31.5	7.9	<39.4	305	<.79	<39.4	<39.4	30.7
Aq. plant	Unknown	07-19-88	<29.4	12.5	<36.8	443	<.74	<36.8	<36.8	10.8
Aq. plant	Unknown	07-19-88	<23.1	9.2	<28.9	601	<.58	<28.9	<28.9	44.5
Plankton	Composite	07-19-88	<118	35.3	<147	168	<2.9	<147	<147	153
Whole body	Vole-imm.	05-24-88	<19.1	4.3	<23.9	25.8	<.48	37.8	<23.9	109

Table 24.--*Concentrations of organic compounds in biota*

[Analyses by U.S. Fish and Wildlife Service; concentrations in micrograms per gram wet weight; imm., immature; bb, blackbird]

Site number (figs. 2 and 8)	Matrix	Species	β-BHC	α-Chlordane	γ-Chlordane	Dacthal	p,p'-DDD	p,p'-DDE	p,p'-DDT	Dieldrin
2	Whole body	Rainbow trout	<.01	<.01	<.01	<.01	<.01	0.01	<.01	<.01
3	Whole body	Carp	<.01	<.01	<.01	0.24	0.01	.27	<.01	0.03
3	Whole body	Carp	0.01	<.01	<.01	.50	<.01	.05	<.01	.01
7	Egg	Yellow-headed bb	<.01	<.01	<.01	<.01	<.01	1.4	<.01	<.01
7	Egg	Yellow-headed bb	<.01	<.01	<.01	<.01	.01	.05	.02	<.01
7	Egg	Coot	<.01	<.01	<.01	<.01	<.01	.30	.02	<.01
7	Egg	Killdeer	.01	<.01	<.01	<.01	<.01	11.0	<.01	.05
7	Egg	Gambles quail	<.01	<.01	<.01	<.01	<.01	.02	<.01	<.01
7	Whole body	Western grebe	.01	0.02	0.02	<.01	.31	1.7	<.01	.02
7	Whole body	Western grebe	.07	.07	.04	<.01	.61	7.6	.09	.09
7	Whole body	Killdeer	<.01	<.01	<.01	<.01	<.01	2.9	<.01	.20
7	Whole body	Killdeer	.05	.03	.01	<.01	<.01	110.0	.12	.13
7	Whole body	Coot	<.01	<.01	<.01	<.01	<.01	.03	<.01	<.01
7	Whole body	Coot	<.01	<.01	<.01	<.01	<.01	.27	<.01	<.01
7	Whole body	Yellow-headed bb-imm.	<.01	<.01	<.01	<.01	<.01	.03	<.01	<.01
7	Whole body	Yellow-headed bb-imm.	<.01	<.01	<.01	<.01	<.01	.03	<.01	<.01
7	Whole body	Carp	<.01	<.01	<.01	<.01	<.01	.10	<.01	<.01
9	Whole body	Carp	<.01	<.01	<.01	.26	.02	.30	.05	<.01
10	Egg	Mallard	<.01	<.01	<.01	<.01	<.01	.27	.01	.01
10	Egg	Canada goose	<.01	<.01	<.01	<.01	<.01	.01	<.01	<.01
10	Egg	Canada goose	<.01	<.01	<.01	<.01	<.01	.02	<.01	<.01
10	Whole body	Mallard-imm.	<.01	<.01	<.01	<.01	<.01	.22	.01	.01
10	Whole body	Mallard	<.01	<.01	<.01	<.01	<.01	.25	<.01	.01

Table 24.--*Concentrations of organic compounds in biota*--Continued

Site number (figs. 2 and 8)	Matrix	Species	Endrin	HCB	Hepta-chlor epoxide	trans-Non-achlor	Oxy-chlor-dane	PCB	Toxa-phene
2	Whole body	Rainbow trout	<.01	<.01	<.01	<.01	<.01	<.05	<.05
3	Whole body	Carp	<.01	0.01	0.02	0.01	<.01	0.06	0.33
3	Whole body	Carp	<.01	<.01	<.01	<.01	<.01	.21	
7	Egg	Yellow-headed bb	<.01	<.01	<.01	<.01	<.01	<.05	<.05
7	Egg	Yellow-headed bb	<.01	<.01	<.01	<.01	<.01	<.05	<.05
7	Egg	Coot	<.01	<.01	<.01	<.01	<.01	<.05	<.05
7	Egg	Killdeer	<.01	<.01	.03	.02	.02	<.05	<.05
7	Egg	Gambles quail	<.01	<.01	<.01	<.01	<.01	<.05	<.05
7	Whole body	Western grebe	<.01	.02	.06	.11	0.01	.64	1.2
7	Whole body	Western grebe	<.01	.03	<.01	.18	.02	3.1	2.7
7	Whole body	Killdeer	<.01	<.01	.03	.01	.01	<.05	<.05
7	Whole body	Killdeer	0.02	.03	.09	.03	.05	.14	1.5
7	Whole body	Coot	<.01	<.01	<.01	<.01	<.01	<.05	<.05
7	Whole body	Coot	<.01	<.01	<.01	<.01	<.01	<.05	<.05
7	Whole body	Yellow-headed bb-imm.	<.01	<.01	<.01	<.01	<.01	<.05	<.05
7	Whole body	Yellow-headed bb-imm.	<.01	<.01	<.01	<.01	<.01	<.05	<.05
7	Whole body	Carp	<.01	<.01	<.01	<.01	<.01	<.05	<.05
9	Whole body	Carp	.02	.01	.02	.02	<.01	.08	.51
10	Egg	Mallard	<.01	<.01	<.01	<.01	<.01	<.05	<.05
10	Egg	Canada goose	<.01	<.01	<.01	<.01	<.01	<.05	<.05
10	Egg	Canada goose	<.01	<.01	<.01	<.01	<.01	<.05	<.05
10	Whole body	Mallard-imm.	<.01	<.01	<.01	<.01	<.01	<.05	<.05
10	Whole body	Mallard	<.01	.01	<.01	<.01	.01	.08	.06

Site number (figs. 2 and 8)	Matrix	Species	β-BHC	α-Chlor-dane	γ-Chlor-dane	Dac-thal	p,p'-DDD	p,p'-DDE	p,p'-DDT	Diel-drin
10	Whole body	Mallard	<.01	<.01	<.01	<.01	0.01	0.67	0.04	0.02
10	Whole body	Common merganser	<.01	<.01	<.01	<.01	<.01	2.6	.04	.04
10	Whole body	Canada goose-imm.	<.01	<.01	<.01	<.01	<.01	.01	<.01	<.01
10	Whole body	Canada goose-imm.	<.01	<.01	<.01	<.01	<.01	.01	<.01	<.01
10	Whole body	Killdeer	0.01	0.01	0.02	<.01	.03	5.6	.07	.68
10	Whole body	Killdeer	<.01	.01	<.01	<.01	<.01	5.6	<.01	.52
10	Whole body	Killdeer-imm.	.05	.01	.01	<.01	<.01	28.0	<.01	.82
10	Whole body	Killdeer-imm.	.31	.01	<.01	<.01	<.01	7.1	<.01	.03
10	Whole body	Killdeer-imm.	<.01	<.01	<.01	<.01	<.01	.36	<.01	.03
12	Whole body	Brown trout	<.01	<.01	<.01	1.30	<.01	.05	<.01	.01
13	Whole body	Brown trout	<.01	<.01	<.01	.10	.03	1.0	.09	.05
14	Whole body	Carp	<.01	.01	.02	.94	.07	.71	.05	.05

Table 24.--*Concentrations of organic compounds in biota*--Continued

Site number (figs. 2 and 8)	Matrix	Species	Endrin	HCB	Hepta-chlor epoxide	trans-Non-achlor	Oxy-chlor-dane	PCB	Toxa-phene
10	Whole body	Mallard	<.01	0.01	0.01	0.01	0.01	<.05	0.17
10	Whole body	Common merganser	<.01	.09	<.01	.02	.05	2.7	.57
10	Whole body	Canada goose-imm.	<.01	<.01	<.01	<.01	<.01	<.05	<.05
10	Whole body	Canada goose-imm.	<.01	<.01	<.01	<.01	<.01	<.05	<.05
10	Whole body	Killdeer	<.01	.04	.09	.05	.04	.13	.86
10	Whole body	Killdeer	<.01	.01	.33	.03	.07	.08	.78
10	Whole body	Killdeer-imm.	<.01	.08	1.9	.07	.25	<.05	<.05
10	Whole body	Killdeer-imm.	<.01	<.01	.03	.02	.02	<.05	<.05
10	Whole body	Killdeer-imm.	<.01	<.01	<.01	<.01	<.01	<.05	<.05
12	Whole body	Brown trout	<.01	<.01	<.01	<.01	<.01	<.05	<.05
13	Whole body	Brown trout	<.01	<.01	<.01	<.01	<.01	<.01	.27
14	Whole body	Carp	0.02	.01	.03	.03	.01	<.05	.92

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