Reconnaissance Investigation of Water Quality, Bottom Sediment, and Biota Associated with Irrigation Drainage in the Dolores Project Area, Southwestern Colorado and Southeastern Utah, 1990-91

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CONVERSION FACTORS AND RELATED INFORMATION

Multiply	By	To obtain
acre	4,047	square meter
acre-foot (acre-ft)	1,233	cubic meter
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year
centimeter (cm)	0.3937	inch
cubic foot per second (ft^3/s)	0.028317	cubic meter per second
foot (ft)	0.3048	meter
gallon per minute (gal/min)	0.06309	liter per second
gram (g)	0.03527	ounce
inch (in.)	25.40	millimeter (mm)
kilogram (kg)	2.205	pound
liter (l)	0.26427	gallon
micrometer (µm)	0.00003937	inch
mile (mi)	1.609	kilometer
millimeter (mm)	0.03937	inch
ounce (oz)	28.35	gram
square mile (mi^2)	2.589	square kilometer
ton per day (ton/d)	0.9072	metric ton per day
ton per year (ton/yr)	0.9072	metric ton per year

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

$$°F = 9/5\ (°C) + 32.$$

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

$$°C = 5/9\ (°F-32).$$

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

microgram per gram (µg/g).

microgram per kilogram (µg/kg).

microgram per kilogram per day (µg/kg/d).

microgram per liter (µg/L).

milligram per kilogram (mg/kg).

milligram per liter (mg/L).

microsiemens per centimeter at 25 degrees Celsius (µS/cm).

2,4-D	2,4-dichlorophenoxy-acetic acid
2,4-DP	2-(2,4-dichlorophenoxy) propionic acid
2,4,5-T	2,4,5-trichlorophenoxy-acetic acid
BHC	benzene hexachloride

DDD	1,1-dichloro -2,2-bis (p-chlorophenyl) ethane
DDE	dichloro diphenyl dichloroethylene
DDT	dichloro diphenyl trichloroethane
HCB	hexachlorobenzene
PCN	polychlorinated naphthalenes
PCB	polychlorinated biphenyls

For those who wish to convert dry-weight concentrations to wet-weight concentrations for biological samples, the equation is:

$$\text{wet weight} = \text{dry weight}\ [1-(\text{percent moisture})/100].$$

GLOSSARY OF SCIENTIFIC NAMES FOR BIOLOGICAL ORGANISMS

[sp., species; --, too numerous to list]

Common name	Order/family	Genus/species
	AQUATIC PLANTS	
Coontail	Ceratophyllaceae	*Ceratophyllum* sp.
Sago pondweed	Potamogetonaceae	*Potamogeton* sp.
Horned pondweed	Naidaceae	*Zannichellia* sp.
Watercress	Brassicaceae	*Nasturtium* sp.
	AQUATIC INVERTEBRATES	
Crayfish	Decapoda/Astacidae	--
Aquatic insects	Diptera	--
	Coleoptera	--
	Hemoptera	--
	Plecoptera	--
	Ephemerotera	--
	Odonata	--
	Trichoptera	--
	FISH	
Rainbow trout	Salmonidae	*Oncorhynchus mykis*
Kokanee salmon	Salmonidae	*Oncorhynchus nerka*
Northern pike	Esocidae	*Esox lucius*
Walleye	Percidae	*Stizostedion vitreum*
Yellow perch	Percidae	*Perca flavescens*
Largemouth bass	Centrarchidae	*Micropterus salmoides*
Smallmouth bass	Centrarchidae	*Micropterus dolomieui*
Black crappie	Centrarchidae	*Pomoxis nigromaculatus*
Green sunfish	Centrarchidae	*Lepomis cyanellus*
Bluegill	Centrarchidae	*Lepomis macrochirus*
Roundtail chub	Cyprinidae	*Gila robusta*
Common carp	Cyprinidae	*Cyprinus carpio*
Fathead minnow	Cyprinidae	*Pimephales promelas*
Speckled dace	Cyprinidae	*Rhinichthys osculus*
Red shiner	Cyprinidae	*Cyprinella lutrensis*
Flannelmouth sucker	Catostomidae	*Catostomus latipinnis*
White sucker	Catostomidae	*Catostomus commersoni*
Bluehead sucker	Catostomidae	*Catostomus discobolus*
Razorback sucker	Catostomidae	*Xyrauchen texanus*
Colorado squawfish	Cyprinidae	*Ptychocheilus lucius*

GLOSSARY OF SCIENTIFIC NAMES FOR BIOLOGICAL ORGANISMS --Continued

Common name	Order/family	Genus/species
	BIRDS	
Mallard	Anatidae	*Anas platyrhynchas*
American coot	Rallidae	*Fulica americana*
Pied-billed grebe	Podicipedidae	*Aechmophorus occidentalis*
Sora rail	Rallidae	*Porzana carolina*
Red-winged blackbird	Emberizidae	*Agelaius phoenicus*
Yellow-headed blackbird	Emberizidae	*Xanthocephalus xanthocephalus*
	MAMMALS	
Muskrat		*Ondatra zibethicus*

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By David L. Butler, Richard P. Krueger, Barbara Campbell Osmundson, *and* Errol G. Jensen

Abstract

The Department of the Interior started a program in October 1985 to identify the nature and extent of irrigation-induced water-quality problems that might exist in the Western United States. Water, bottom-sediment, and biota samples were collected and analyzed for a reconnaissance investigation during 1990–91 to identify potential water-quality problems associated with irrigation drainage in the Dolores Project area in southwestern Colorado and southeastern Utah.

Concentrations of dissolved solids and sulfate exceeded secondary maximum contaminant levels for drinking water in many water samples from irrigated and nonirrigated areas. Mc Elmo Creek and the Mancos River contribute substantial dissolved-solids loads to the San Juan River.

Cadmium was detected in 19 water samples from 16 sites. Criterion to protect aquatic life from chronic exposure to cadmium was exceeded in two samples, however, these samples were collected from Summit Reservoir and Puett Reservoir, which are located outside the irrigated area served by the Dolores Project. Mercury was detected in 11 water samples at concentrations ranging from 0.1 to 1.2 micrograms per liter, and 6 of those samples were collected at sites outside of the irrigated area served by the Dolores Project.

Selenium concentrations exceeded the chronic aquatic-life criterion for selenium of 5 micrograms per liter in most water samples from Mc Elmo Creek, Navajo Wash, from newly irrigated areas, and from the Mancos River. Irrigation drainage may be the primary source of selenium to Mc Elmo Creek. The maximum selenium concentration in water was 88 micrograms per liter in Navajo Wash, which drains irrigated land on Mancos Shale in the southern end of the Montezuma Valley. Only 1 of 15 water samples collected from streams that drain the Montezuma Valley north of Mc Elmo Creek had a selenium concentration greater than 1 microgram per liter. Samples of irrigation drainwater from newly (since 1987) irrigated land in the Yellow Jacket and Cahone areas had selenium concentrations ranging from 3 to 12 micrograms per liter. Selenium concentrations in the San Juan River were 2 micrograms per liter, and selenium was not detected in water samples collected in nonirrigated areas. Concentrations of pesticides in water were less than levels harmful to aquatic life.

Except for selenium concentrations in bottom-sediment samples from four sites, trace-element concentrations in bottom sediment in the Dolores Project area were not elevated when compared to soils in the western United States. The maximum concentration of an organochlorine pesticide in bottom sediment was 5.5 micrograms per kilogram of DDD in a sample from Summit Reservoir.

Generally, selenium concentrations in biota in the Dolores Project area were greatest in samples collected from Navajo Wash, in newly irrigated areas in the Yellow Jacket and Cahone areas, and from the Mancos River basin. Selenium concentrations in aquatic plants and aquatic invertebrates were larger in samples collected in the newly irrigated areas than in the long-term irrigated areas in the Montezuma Valley. Selenium concentrations in 10 of 11 aquatic-invertebrate samples from the newly irrigated areas exceeded a

guideline for food items consumed by fish and wildlife. The maximum selenium concentration in an aquatic-invertebrate sample was 19.2 micrograms per gram dry weight in a sample from Woods Canyon, in the newly irrigated area. Selenium concentrations in whole-body suckers (all species) were larger in samples from the Mancos River than in sucker samples from the Montezuma Valley or San Juan River. Selenium concentrations in whole-body suckers were significantly higher in samples collected from the San Juan River downstream from the Dolores Project than in samples collected upstream from the project. An assessment of the effects of irrigation drainage from the Dolores Project on endangered fish, such as the Colorado squawfish (*Ptychocheilus lucius*) in the San Juan River, could not be made for the reconnaissance investigation.

Whole-body samples of fathead minnows from Woods Canyon, in the newly irrigated area, and from the Mancos River had selenium concentrations associated with adverse effects on fathead minnows. As in water samples and other biota samples, the largest selenium concentrations in speckled-dace samples from the Montezuma Valley were collected from Navajo Wash.

Selenium concentrations in bird eggs were within the range of uncertainty regarding biological significance. The largest selenium concentration in a biota sample collected in 1990 was 37.5 micrograms per gram dry weight in a mallard liver from Woods Canyon, in the newly irrigated area. Selenium concentrations ranged from 10 to 69 micrograms per gram dry weight in six bird-tissue samples collected in July 1989 within the irrigated area of the Mancos Project, upstream from the Dolores Project.

Mercury concentrations in warm-water game fish in reservoirs in the Dolores Project area may be of concern for human consumption of fish. Weekly dietary limits are most restrictive for consumption of walleye, northern pike, and bass from McPhee, Narraguinnep, Totten, Summit, and Puett Reservoirs. Chromium concentrations in biota samples were indicative of chromium contamination, although chromium concentrations in water and bottom-sediment samples were not elevated. The maximum chromium concentration in a biota sample was 440 micrograms per gram dry weight in a crayfish from the Mancos River. Some concentrations of aluminum, boron, cadmium, copper, lead, and zinc in biota exceeded background concentrations reported in the literature, but generally the concentrations were not toxicologically significant or the toxicological significance was not known. Previously mined areas in the upper Dolores River basin could have been a source of trace metals and may have been transported into the Dolores Project in the irrigation water supply.

Concentrations of organochlorine pesticides and PCB's in fish and birds in the Dolores Project area were indicative of background concentrations. Polycyclic aromatic hydrocarbons were analyzed in fish-bile samples from 10 sites, but the biological significance of the data is 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 October 1985 to identify the nature and extent of irrigation-induced water-quality problems that might exist in the Western United States. The DOI developed a management strategy and formed an interbureau group known as the "Task Group on Irrigation Drainage", which prepared a comprehensive plan for reviewing irrigation-drainage concerns for which the DOI may have responsibility.

Initially, the Task Group identified 20 areas in 13 States that warranted reconnaissance-level investigations related to three specific activities: (1) Irrigation or drainage facilities constructed or managed by the DOI, (2) national wildlife refuges managed by the DOI, and (3) other migratory-bird or endangered-species management areas that receive water from DOI-funded projects.

Nine of the 20 areas were selected for reconnaissance investigations during 1986–87:

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

On the basis of results from these investigations, four detailed studies were initiated in 1988: Salton Sea area, Stillwater Wildlife Management area, Middle Green River Basin area, and the Kendrick Reclamation Project area. Eleven more reconnaissance investigations were initiated in 1988:

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

Evaluation of results for these investigations, and a continuing evaluation of all data for the Irrigation Drainage Program, led to initiating three more detailed studies early in 1990:

California-Oregon	Klamath Basin Refuge Complex
Montana	Sun River area
Colorado	Gunnison River Basin/Grand Valley Project

In October 1990, four additional reconnaissance investigations were begun and another was started in October 1991. The study areas are:

Oregon- Nevada	Owyhee-Vale Projects
Nevada	Humboldt Wildlife Management area
Colorado	Dolores Project area
New Mexico	San Juan River area
Washington	Middle Columbia River Basin

One detailed study was started in October 1993:

New Mexico	San Juan River area

In October 1993, another reconnaissance investigation was begun:

New Mexico	Vermejo Project area

All reconnaissance investigations are conducted by interbureau study teams consisting of a scientist from the U.S. Geological Survey as team leader, with additional U.S. Geological Survey, U.S. Fish and Wildlife Service, Bureau of Reclamation, and Bureau of Indian Affairs scientists representing several different disciplines. The 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 Bureau of Reclamation's Dolores Project and areas downstream from the project were selected for a reconnaissance investigation because of possible effects on the water quality of the San Juan River by Mc Elmo Creek, which drains part of the irrigated area, and because the San Juan River downstream from Mc Elmo Creek provides habitat for threatened and endangered fish. The Bureau of Reclamation has identified the Mc Elmo Creek basin as a substantial source of dissolved solids in the Upper Colorado River Basin. Historical trace-element data indicated that there were moderate concentrations of selenium and boron in Mc Elmo Creek. The source of all irrigation water for the project is McPhee Reservoir, located on the Dolores River, and there was potential for transport of heavy metals from the Dolores River into the Dolores Project. Of particular concern was mercury accumulation in reservoirs. Mercury concentrations in some fish samples from McPhee Reservoir and from a reservoir located north of Cortez exceeded guidelines for human consumption. The Dolores Project also was chosen because the project would provide an opportunity to collect data in areas that were being irrigated for the first time.

Purpose and Scope

This report describes results of the reconnaissance investigation of the Dolores Project area. Specific objectives of the reconnaissance investigation were to:

1. Describe concentrations of selected inorganic and organic constituents in water, bottom sediment, and biota in long-term irrigated areas, in newly (since 1987) irrigated areas, and in the Mancos and San Juan Rivers.
2. Compare constituent concentrations to various guidelines and baseline information from the literature to determine if irrigation drainage from the Dolores Project is causing or has the potential to cause harmful effects to human health, fish, and wildlife.

Water, bottom-sediment, and biota samples were collected in 1990 in the Dolores Project area for the reconnaissance investigation. Samples collected in the Mc Elmo Creek basin and from Navajo Wash were used to assess water quality in the long-term irrigated area in the Montezuma Valley. Samples also were collected in selected areas north of the Montezuma Valley that were recently (since 1987) irrigated, from the Mancos and San Juan Rivers, and at reference sites located upstream from irrigated areas of the Dolores Project.

Additional data are included in the report that were not collected for the reconnaissance investigation in 1990. Results of biota sampling by the U.S. Fish and Wildlife Service in the Mancos River basin in 1989 are described in the report. Mercury data for game fish collected from reservoirs in the Dolores Project area during 1988–91 by State and Federal agencies were used to assess mercury concentrations and human consumption limits in game fish. Five fish samples collected in August 1991 for analysis of polycyclic aromatic hydrocarbons are included in the report. Selected ground-water level data collected by the Bureau of Reclamation in 1990–91 in the newly irrigated areas also are described in the report.

Acknowledgments

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DESCRIPTION OF DOLORES PROJECT AREA

Location

Irrigated areas of the Dolores Project are located in the southwestern corner of Colorado in Montezuma and Dolores Counties (fig. 1). The Dolores Project area includes the Mancos River in Colorado and extends into southeastern Utah along the San Juan River to Lake Powell (fig. 2). The Dolores Project was designated as three specific areas (fig. 1) in Bureau of Reclamation planning reports (Bureau of Reclamation, 1977a, b; 1988, 1989), and those designations will be used in this report. The first area is the Montezuma Valley, which is centered around Cortez and was irrigated by nonproject water supplied by the Montezuma Valley Irrigation Company (MVIC); this area is referred to as the MVIC area (fig. 1). The MVIC area will receive supplemental irrigation water from the Dolores Project. The second area is referred to as the Dove Creek area and consists of the five irrigated areas shown in figure 1 between Yellow Jacket Canyon and Monument Creek. The third area is referred to as the Towaoc area and consists of the irrigated areas shown in figure 1 on the southwestern flanks of Sleeping Ute Mountain on the Ute Mountain Ute Reservation. Part of the Dove Creek area was irrigated during 1990, and none of the Towaoc area was irrigated in 1990.

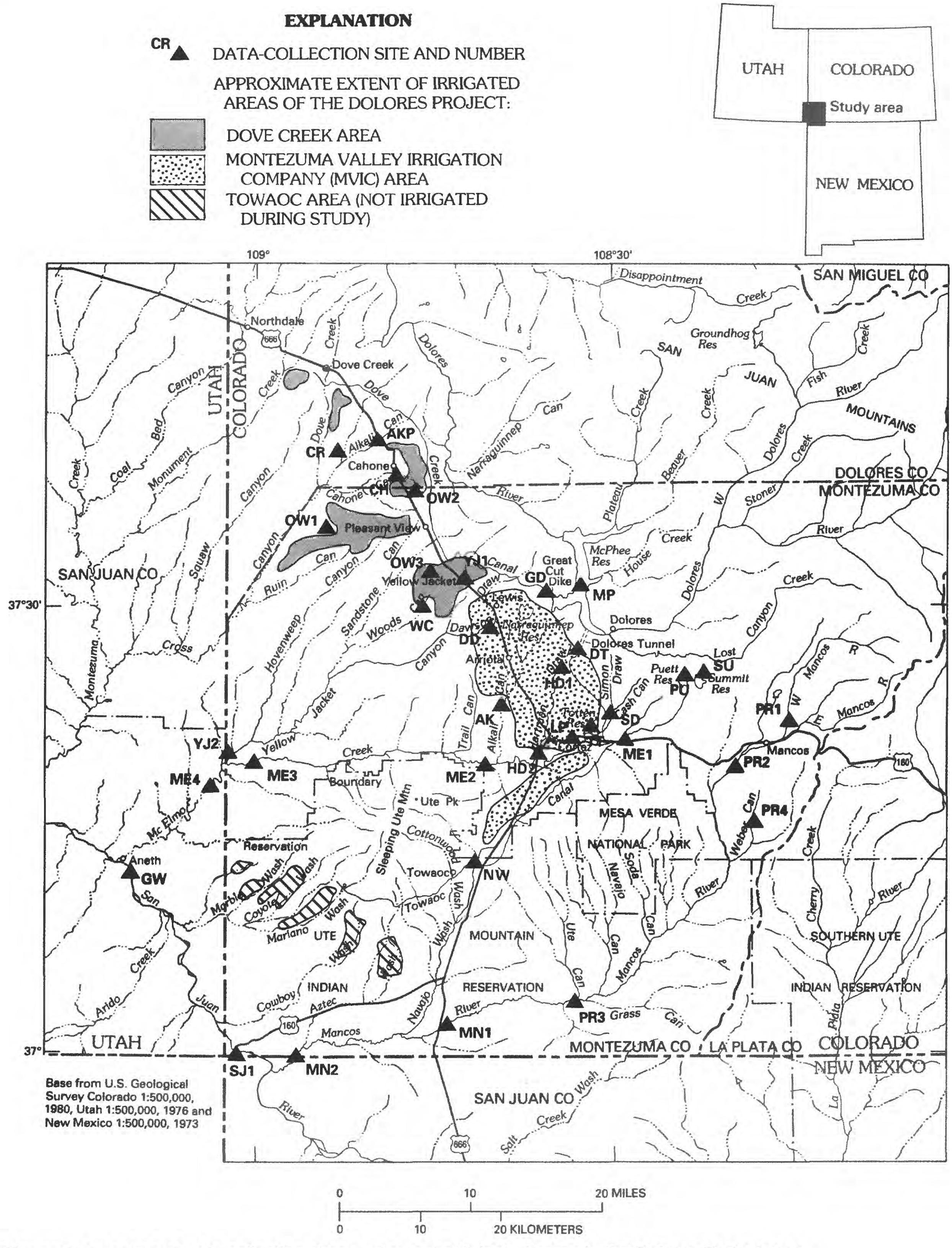

Figure 1. Location of data-collection sites and extent of irrigated areas in the Dolores Project area.

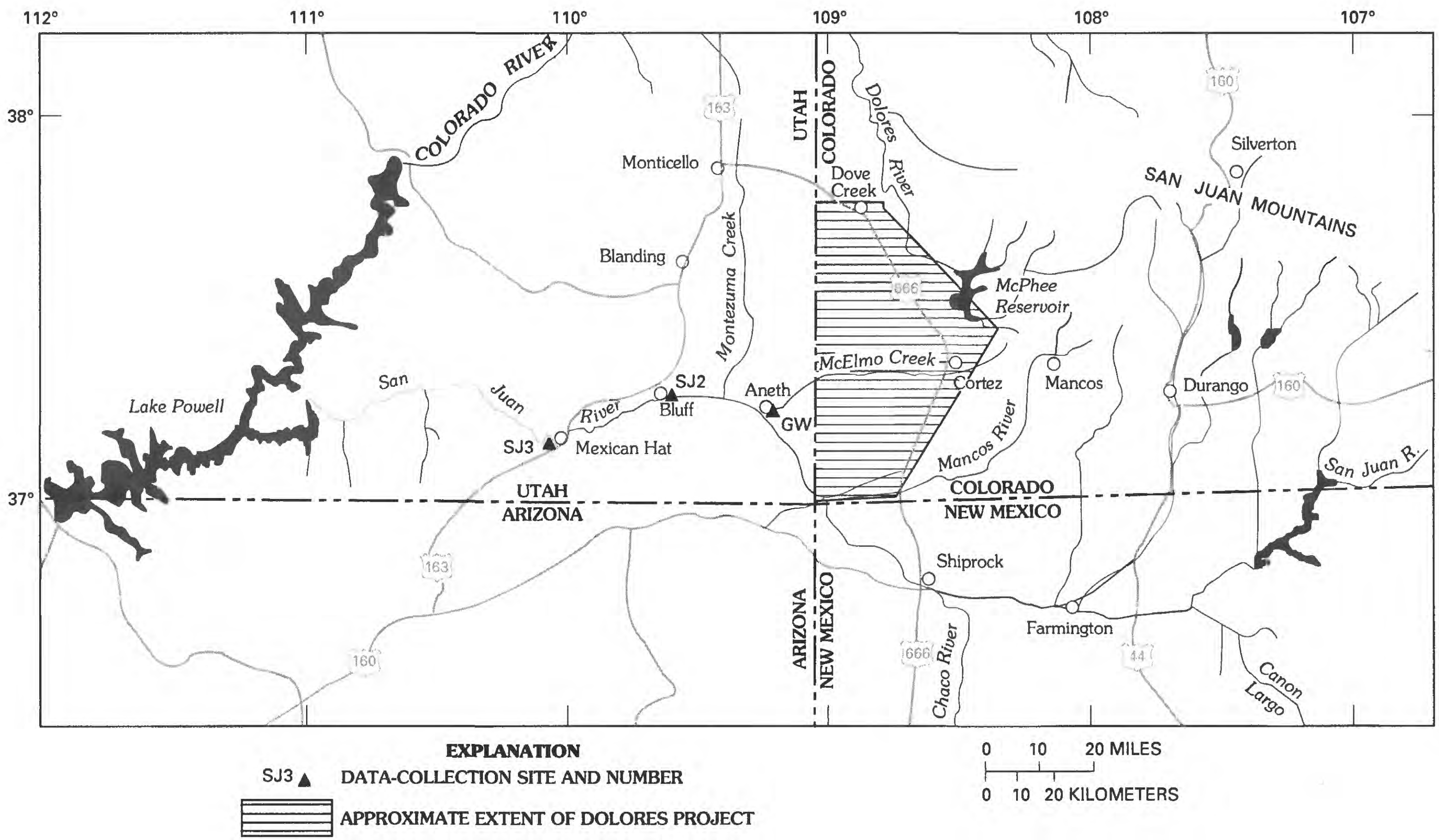

Figure 2. General location of the Dolores Project area and location of data-collection sites in Utah.

History

The presence of many Indian ruins in southwestern Colorado (such as in Mesa Verde National Park) indicates that the Dolores Project area was inhabited for many years prior to the arrival of miners and settlers in the 1870's and 1880's. The Ute Indian Reservation was first formally defined by a treaty in 1868. Between 1870 and 1895, the reservation size was decreased by several enactments. In 1895, the Ute Indian Reservation was divided into the Ute Mountain Ute Reservation and Southern Ute Indian Reservation. Irrigation began in the 1880's in the Montezuma Valley. A tunnel and canal system was built by private concerns to transport water from the Dolores River into the area for irrigation; the tunnel was completed in 1889. There were several owners of the irrigation company during the next 30 years prior to the Montezuma Valley Irrigation Company. There was adequate precipitation for dryland farming in nonirrigated areas of northern Montezuma Valley and in the Dove Creek area. Stockmen were using the Dove Creek area as early as 1878. Much of the sagebrush cover was burned, and the Dove Creek area was used exclusively for cattle until 1915, when farming began in the area under the Homestead Act. Dryland farming developed slowly in the area until roads and transportation improved, and then developed rapidly after 1938. Almost all tillable land that was productive by dryland farming was utilized. Agricultural development on the Ute Mountain Ute Reservation has been limited to one small farm and to cattle and sheep grazing.

Physiography and Climate

The Dolores Project area is located in the Colorado Plateau physiographic province. The area is in a transition zone between the foothills on the southwest flank of the San Juan Mountains (fig. 2) and the mesa and canyon country to the south and west. The Montezuma Valley centered around Cortez is a broad, relatively flat valley. Irrigated areas in the Montezuma Valley are on gently rolling terrain dissected by numerous, shallow streams and swales. South of Mc Elmo Creek, the irrigated lands are on fan and flood-plain deposits of ephemeral streams flowing off the Mesa Verde escarpment. The upland areas consist of foothills and low mountains. The drainage divide that separates the Dolores River basin from the Mc Elmo Creek basin is quite low, and elevations range from about 7,200 to 7,800 ft. Much of the area to the west is desert land featuring high mesas incised by deep canyons. The Dove Creek area of the Dolores Project is on a broad plateau that slopes gently south and is incised by numerous deep canyons. The Towaoc area of the Dolores Project is on the southern and southwestern side of Sleeping Ute Mountain on gently sloping terrain intersected by numerous gullies and deep arroyos. Land to be irrigated in the Towaoc area northwestern of Mariano Wash (fig. 1) is on long fans extending southwest from Sleeping Ute Mountain; project lands southeast of Mariano Wash are in alluvial valleys eroded into shale. The Mancos River flows through a deep canyon on the eastern and southern side of Mesa Verde National Park, and then flows into a broad, open valley. There are numerous small washes and gullies in this area.

A major feature in the Dolores Project area is Sleeping Ute Mountain located southwest of Cortez. Elevation in the project area ranges from about 4,400 ft at the San Juan River in Utah to almost 10,000 ft on Sleeping Ute Mountain. The elevation of Cortez is about 6,200 ft. Elevation of the Mc Elmo Creek basin ranges from about 4,600 to 8,500 ft. Elevation of the area south of Sleeping Ute Mountain in the Mancos River Valley ranges from about 5,000 to 5,500 ft. To the north of Cortez, elevation gradually increases to almost 7,000 ft at Dove Creek.

The Dolores Project area has a continental, semiarid climate. Annual precipitation (1951–80) in the Montezuma Valley area is about 11 to 14 in.; in the area to the north toward Dove Creek about 12 to 16 in.; and at lower elevations of western Mc Elmo Creek drainage about 8 to 12 in. Annual precipitation at lower elevations of the Ute Mountain Ute Reservation is 8 to 10 in. The mean annual precipitation was 12.72 in. at Cortez and 18.07 in. at Dolores for 1951–80 (National Oceanic and Atmospheric Administration, 1990). The wettest months are August and October, the driest month is June. Summer precipitation is characterized by thunderstorms that may have brief, heavy rains. The annual precipitation for calendar year 1990 was slightly above normal (compared to 1951–80) in the Dolores Project area based on precipitation data for Cortez, Mesa Verde National Park, Dolores, and Northdale (fig. 1) (National Oceanic and Atmospheric Administration, 1990). The pan evaporation at the McPhee Reservoir site (elevation 6,900 ft) was estimated by the Bureau of Reclamation (1977a) to be 42 in. for the growing season (April through October).

The Dolores Project area usually has warm to hot summers and cool winters. Lower elevation areas frequently have daytime summer temperatures exceeding 90°F. Winters are characterized by mild days and cold nights (12 to 15°F). The mean annual temperature for 1951–80 was 48.8°F at Cortez, 50.0°F at Mesa Verde National Park, and 45.1°F at Northdale. Temperature extremes in the Cortez area are -25°F to about 100°F. The frost free period in the Mc Elmo Creek area ranges from about 133 to 141 days (Bureau of Reclamation, 1981), is slightly longer in the lower Mancos River Valley, and is shorter in the Dove Creek area (about 110 to 120 days). The irrigation season usually begins in late April and ends in October.

Geology

The geologic map of the Cortez 1:250,000 quadrangle is in Haynes and others (1972). Irwin (1966) described the geology of the Ute Mountain Ute Reservation. Large-scale geologic studies of the San Juan Basin and Paradox Basin include all or parts of the Dolores Project area, and other geologic studies have been done, such as Whitfield and others (1983). Geology of the Mc Elmo Salinity Control Unit is described in reports by Bureau of Reclamation (1981, 1988). Geldon (1985) described the geology in the Cottonwood Wash area (fig. 1) near Towaoc on the Ute Mountain Ute Reservation.

The Mc Elmo Creek basin is in the Four Corners structural platform of the Colorado Plateau province. The area has been folded and faulted to some extent. The exposed bedrock primarily is sedimentary rocks of Jurassic through Cretaceous age and some igneous rocks of Tertiary age. Most of the irrigated land in the MVIC area is underlain by the Mancos Shale and Dakota Sandstone of Cretaceous age. There are extensive surficial deposits of eolian material between Cortez and Dove Creek. Much of the irrigated area in the northern Montezuma Valley and Dove Creek area is on soils derived from eolian deposits. The eolian deposits are red-brown loess consisting of unconsolidated silt and sand. In many canyons, the Morrison Formation and other sedimentary formations of Jurassic age crop out. For example, the Morrison Formation crops out in the Mc Elmo Creek Canyon downstream from Cortez, in Yellow Jacket Canyon downstream from Dawson Draw, and along the San Juan River. Sleeping Ute Mountain consists of igneous rocks of Cretaceous and Tertiary age.

The Mancos Shale is a dark gray marine shale that has thin beds of sandstone and limestone. In much of the Dolores Project area, the Mancos Shale is overlain by surficial materials. The formation was named in 1899 for the outcrops along the Mancos River Valley near the town of Mancos (Irwin, 1966). The Bureau of Reclamation has identified the Mancos Shale as a significant contributor of salinity to the Colorado River from other Bureau of Reclamation projects in western Colorado, such as the Uncompahgre Project and the Grand Valley Project. The Mancos Shale also was identified as a significant source of selenium in irrigated areas in the middle Green River basin in Utah (Stephens and others, 1988; 1992). The Dakota Sandstone is interbedded sandstone, shale, and coal and forms the caprock seen along the top of many of the canyons. The Morrison Formation is variegated shale, sandstone, and mudstone deposits. Some members of the Morrison Formation contain uranium and vanadium, which were mined.

There are other sedimentary rocks exposed along Mesa Verde National Park and Sleeping Ute Mountain. Alluvium of Quaternary age is present in larger stream valleys, including Mc Elmo Creek and the Mancos River. There are various alluvial deposits around Sleeping Ute Mountain, including talus, colluvium, and pediments.

Soils and Land Use

Soils

Soils were extensively studied by the Bureau of Reclamation for the Dolores Project (Bureau of Reclamation, 1977b; 1988). Two major soil types are described; the gray soils and the red soils. The gray soils are alluvial in origin, and parent rocks were comprised of shale and sandstone from the Mancos Shale and the Mesaverde Formation. Gray soils often are underlain by shale. The Bureau of Reclamation (1988) described two types of gray soils, flood-plain soils and fan soils. Flood-plain soils were formed by alluvial deposition, primarily along Mc Elmo Creek. Flood-plain soils have a sandy loam to silty clay texture, and dissolved-solids concentrations in soil extracts ranged from 550 to 12,000 mg/L (Bureau of Reclamation, 1988). Fan soils are formed by slope wash and colluvial processes and have a loamy sand to silty clay texture. Dissolved-solids concentrations in soil extracts from fan soils ranged from 525 to 8,600 mg/L. The Bureau of Reclamation (1977b) reported that the gray soils have about 8 times more potential salt loading than do the red soils. Gray soils have limited profile development, have low permeability, and are erodible. In some areas of the MVIC, there are problems with irrigation on gray soils because of salinity and poor drainage. Gray soils are present in the southern and southeastern parts of Montezuma Valley (generally south of Mc Elmo Creek), and in the eastern Towaoc area (east of Cowboy Wash). Soils along the lower Mancos River Valley on the Ute Mountain Ute Reservation are similar to the gray soils because the Mancos Shale is extensive in this area.

The red soils are residual soils derived from eolian deposits. Red soils are loam to clay loam in texture, have moderate depths over sandstone and shale, and have moderate to high permeability. The northeastern part of the MVIC area has a mixture of red and gray soils, but generally has loam to clay loam red soil overlying silty clay gray soil. Dissolved-solids concentrations in soil extracts from the northeastern part of the MVIC area ranged from 250 to 4,000 mg/L (Bureau of Reclamation, 1988). Runoff and deep percolation from red soils often enter areas where gray soils are present. Red soils are predominant in the MVIC area north of Mc Elmo Creek and west of Highway 666 (fig. 1). All irrigated land in the Dove Creek area is on red soils. Red soils also are present in the Towaoc area west of Cowboy Wash.

Land Use

The primary economic activity in the Dolores Project area is agriculture and its related services. Agricultural uses are concentrated on livestock grazing, feed crops, and rangeland. Primary crops are alfalfa, hay, pasture, small grains, feed corn, and some vegetables and fruit. Historically, dryland farming in the Dove Creek area produced pinto beans, alfalfa, and wheat. Prior to 1993, the primary land use on the Ute Mountain Ute Reservation was for cattle and sheep grazing. Along the Mancos River, the Ute Mountain Ute Tribe irrigates about 200 to 300 acres for growing cattle feed and pasture; however, the largest agricultural development on the reservation will occur when water is delivered to the Towaoc area by the Dolores Project.

The Dolores Project area has a small population. The following population statistics are from the 1990 census (Rand McNally and Company, 1993). Montezuma County had a population of 18,672. The only area that may be considered an urban area is Cortez (population 7,284). The other towns are small farming communities, such as Dove Creek (population 643) and Dolores (population 866). Towaoc, headquarters of the Ute Mountain Ute Tribe, had a population of 700.

Oil and gas drilling have historically been an important economic factor and source of employment in the Four Corners area. There is little drilling activity and no uranium or coal activity in Montezuma County (U.S. Bureau of Land Management, Durango, Colorado, oral commun., 1989). Metal mining, primarily for gold and silver, began in the upper Dolores River basin in the 1870's. Presently (1993), there are no gold-mining activities in the basin. Mine drainage could be a potential source of heavy metals in the irrigation water supply from the Dolores River. Recreation and tourism have become an important part of the economy in the region. The Dolores Project area is adjacent to many attractions, and tourism has increased steadily in the last few years. McPhee Reservoir attracts people for recreation, such as fishing and boating.

Natural vegetation in the Dolores Project area is dominated by pinyon pine and juniper, which are scattered throughout the area, and sagebrush. In lower, drier areas, salt shrubs such as greasewood are present. Higher and wetter areas grade into oak brush and pine forests. Vegetation is relatively sparse on lower areas of the Ute Mountain Ute Reservation. The valley bottoms have pasture interspersed with brush and marshes. Along streams, riparian vegetation is predominately cottonwood and boxelder trees interspersed with dense brush and shrubs.

Fish and Wildlife Resources

There are several fish and wildlife resource areas within the Dolores Project area that could be affected by irrigation. The State of Colorado manages several State wildlife areas of nongame and game species of fish and wildlife. State wildlife areas in the project area are Narraguinnep Reservoir, Totten Reservoir, and the Dolores River downstream from McPhee Reservoir. Wildlife enhancement for the Dolores Project was planned in Dawson Draw (fig. 1).

Narraguinnep and Totten Reservoirs contain a variety of warm-water game fish and are used as waterfowl nesting and resting areas. The Dolores River downstream from McPhee Dam is an excellent coldwater trout fishery, and the Dolores River Canyon has mule deer, elk, and wild turkey. The canyon area also provides a wintering area for waterfowl because of warm water downstream from the dam during winter. There are numerous small ponds and wetlands in the MVIC and Dove Creek areas that are used by migratory waterfowl. Fish and wildlife resource areas are very limited at low elevations on the Ute Mountain Ute Reservation. The Mancos River is not considered an important fishery; however, the river is one of the few streams in Colorado populated only by native fish species. Wetland areas are limited in the Towaoc area, and there is little utilization of this area by migratory waterfowl.

Recently (1987), endangered fish species have been documented in the San Juan River from near Shiprock, New Mexico to Lake Powell (fig. 2). The federally listed endangered Colorado squawfish (*Ptychocheilus lucius*) was identified in 1987 and 1988 in the San Juan River (Meyer and Moretti, 1988; Roberts and Moretti, 1989). Young-of-the-year fish were seined from the river, indicating that Colorado squawfish reproduced in the San Juan River. Adult razorback suckers, another federally listed endangered species, were captured in the San Juan arm of Lake Powell.

Two endangered birds, the bald eagle and the peregrine falcon, are present in the Dolores Project area. Bald eagles winter in Colorado and typically roost near open water where they feed on fish. Fish are a potential source of contamination to bald eagles. There is at least one pair of peregrine falcons nesting in the Mesa Verde National Park area; these falcons probably feed on other birds in the Dolores Project area. There are two federally listed endangered plants occurring in or near irrigated areas, the Mancos milkvetch (*Astragalus humillimus*) and the Mesa Verde cactus (*Sclerocatus mesae-verdae*). In addition, three candidate plant species for listing as endangered species are found in the project area.

In May 1991, fish consumption advisories were posted by the Colorado Division of Wildlife, in cooperation with the Colorado Department of Health, at McPhee and Narraguinnep Reservoirs. The advisories were posted because some warm-water game fish, such as walleye, northern pike, and bass from the reservoirs had elevated concentrations of mercury. The mercury concentrations did not pose an acute hazard, but there was concern about chronic, long-term exposure to small amounts of mercury, especially for children and pregnant women (Colorado Department of Health, 1992).

HYDROLOGIC SETTING

The hydrologic system of the Dolores Project area is complex and includes two major tributaries of the Colorado River (fig. 2), the Dolores River (source of irrigation water) and the San Juan River (receives all irrigation drainage and return flow). The San Juan River upstream from the confluence of the Mancos River to downstream from the confluence of Mc Elmo Creek, the Mancos River, Mc Elmo Creek, and tributaries are included in the hydrologic system. Also included in the hydrologic system are the canyons north of the Mc Elmo Creek basin that drain into Montezuma Creek, which discharges to the San Juan River in Utah (fig. 1). A general schematic of the surface-water system is shown in figure 3. The irrigation systems and ground water are other components of the hydrologic system of the Dolores Project area.

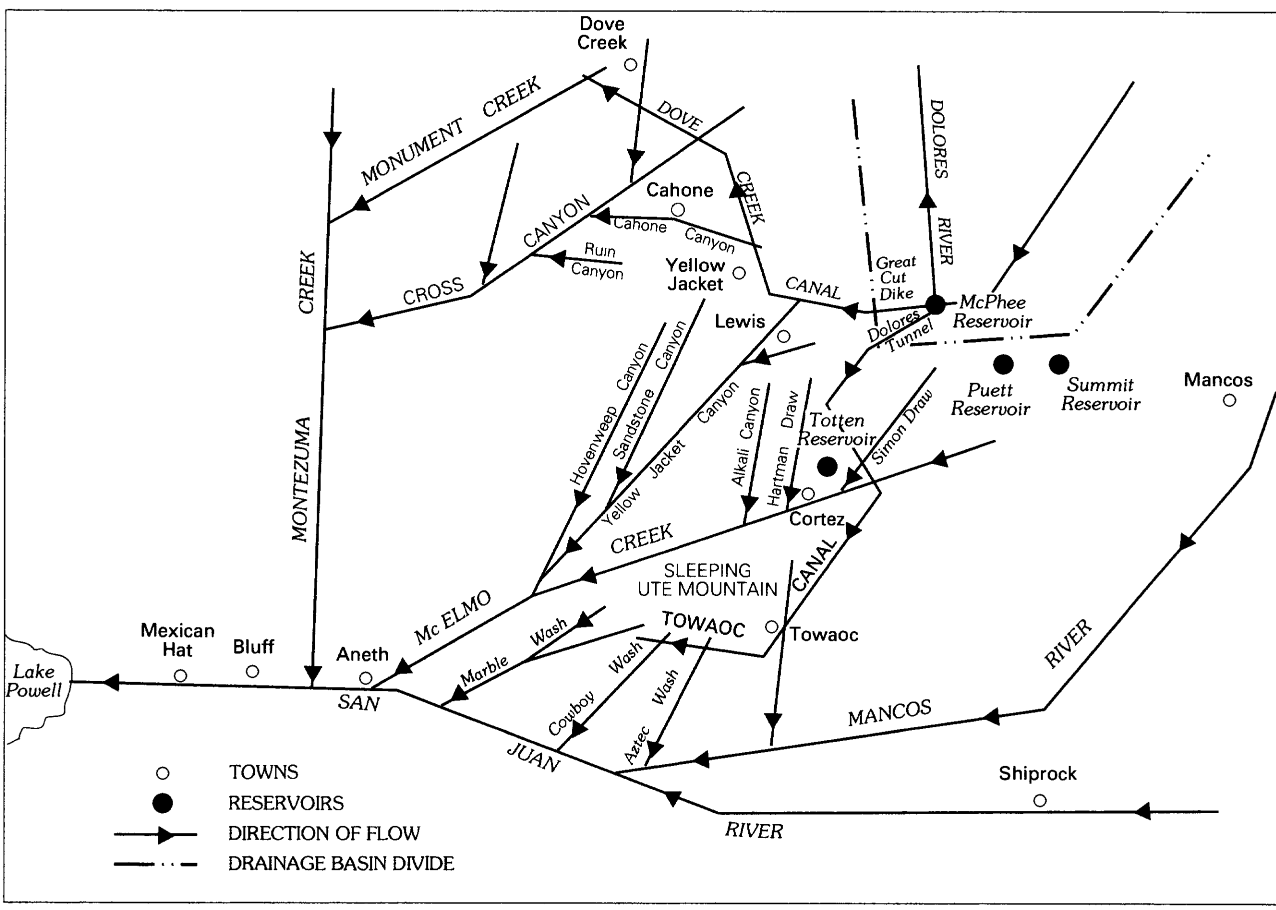

Figure 3. Major streams, tributaries, reservoirs, canals, and movement of water in the Dolores Project area.

Surface Water

The San Juan River drains about 24,600 mi^2 and heads in the San Juan Mountains about 100 mi east of Cortez, flowing generally west to southwest to Lake Powell in Utah (fig. 2). The U.S. Geological Survey operates a streamflow-gaging station at Mexican Hat, Utah (gaging station 09379500; site SJ3 in fig. 2), and that station is the most downstream gaging station on the river. The drainage area upstream from gaging station 09379500 is about 23,000 mi^2. The average annual mean discharge for water years 1962–89 was 2,258 ft^3/s. The flow regime of the San Juan River has been altered since completion of Navajo Reservoir in 1962. Based on information from the U.S. Department of the Interior (1989), the San Juan River accounted for about 15 percent of the inflow into Lake Powell for water years 1976–87. Except for rainfall-induced peaks during the summer, stream discharge of the San Juan River generally was less than normal (compared to water years 1962–89) prior to and during the reconnaissance investigation in 1990 (fig. 4). Water year 1990 was the third consecutive year of less-than normal stream discharge in the San Juan River at gaging station 09379500 (fig. 5); the annual mean discharge for water year 1990 was only 47 percent of the average annual mean discharge for water years 1962–89. The U.S. Geological Survey has operated a gaging station at Four Corners (gaging station 09371010; site SJ1 in fig. 1) since 1978. The drainage area upstream from that gaging station is 14,600 mi^2. The average annual mean discharge for water years 1978–89 was 2,684 ft^3/s, which is about 94 percent of the average annual mean discharge (2,858 ft^3/s) at gaging station 09379500 for the same period. That small difference of annual stream discharges indicates that runoff per unit drainage area in the San Juan River basin between the two gaging stations is small.

The Dolores River originates in the San Juan Mountains northeast of the Dolores Project area, flows southwest, and then turns abruptly at the town of Dolores to flow northwest to its confluence with the Colorado River about 75 mi north of Dove Creek (fig. 2). The U.S. Geological Survey has operated a streamflow-gaging station at Dolores (drainage area 504 mi^2), immediately upstream from McPhee Reservoir, since 1922. The average annual mean discharge for the Dolores River at Dolores for water years 1922–89 was 445 ft^3/s.

Mc Elmo Creek drains 702 mi^2 and heads on the low drainage divide northeast of Cortez and flows generally west to the San Juan River at Aneth, Utah (fig. 2). The U.S. Geological Survey operated two streamflow-gaging stations on Mc Elmo Creek, gaging station 09371500 (at site ME2 in fig. 1) and gaging station 09372000 (at site ME3 in fig. 1). Gaging station 09372000 near the Colorado-Utah State line (drainage area 346 mi^2) has been operated since 1951. The hydrograph for the period of record for gaging station 09372000 (fig. 6) does not indicate a distinct seasonal pattern, which is atypical of streams in this area. Much of the stream discharge in Mc Elmo Creek is return flow and irrigation drainage from the MVIC area. Stream discharge in Mc Elmo Creek was less than normal (water years 1952–89) from October 1989 to June 1990 and at or greater than normal from July to November 1990 (fig. 6). The large discharge peaks in the summer of 1990 were caused by thunderstorms and rainstorms. The annual mean discharge at gaging station 09372000 for water year 1990 was about 74 percent of the average annual mean discharge for water years 1952–89.

The Mancos River drains about 795 mi^2 and heads into the San Juan Mountains northeast of the town of Mancos (fig. 1) at elevations above 10,000 ft. The river flows southwest to south to its confluence with the San Juan River south of the Colorado-New Mexico State line. The confluence is a few miles upstream from streamflow-gaging station 09371010 on the San Juan River. Stream-discharge data have been collected for the Mancos River at Highway 666 at gaging station 09371000 (at site MN1 in fig. 1) (drainage area 526 mi^2). The headwater areas of the Mancos River are considerably higher than the headwater areas of Mc Elmo Creek, therefore, snowmelt runoff normally is substantially greater in the Mancos River basin. Also, there is no transbasin import of water into the Mancos River basin as there is in the Mc Elmo Creek basin. The mean annual discharge for water year 1990 was only 20 percent of the average mean annual discharge for water years 1952–89 at gaging station 09371000, primarily because spring runoff was much less than normal in 1990.

A hydrologic study of Cottonwood Wash (drainage area 16 mi^2), a tributary of Navajo Wash, was done by Geldon (1985). Stream discharge of Cottonwood Wash probably is typical of intermittent washes and streams in the Dolores Project area that are not affected by irrigation drainage. The average annual mean discharge (water years 1980–82) was less than 0.2 ft^3/s, and there often was no flow in the wash during the summer.

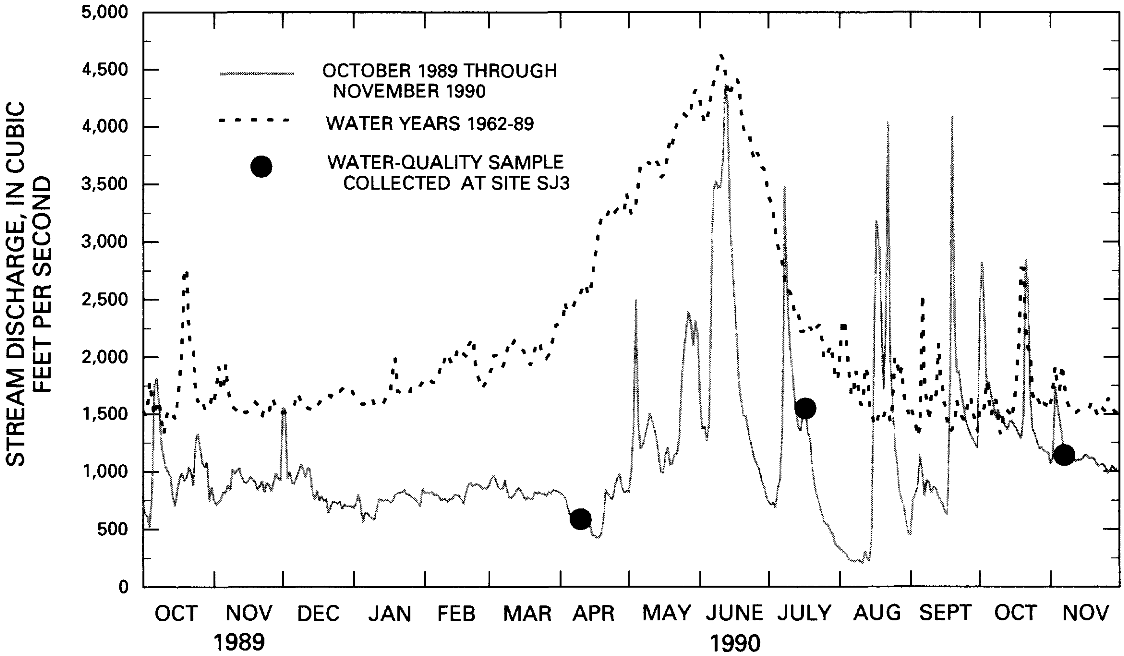

Figure 4. Daily mean stream discharge for October 1989 through November 1990, average daily mean stream discharge for water years 1962–89, and dates when water-quality samples were collected at streamflow-gaging station 09379500, San Juan River at Mexican Hat, Utah (site SJ3).

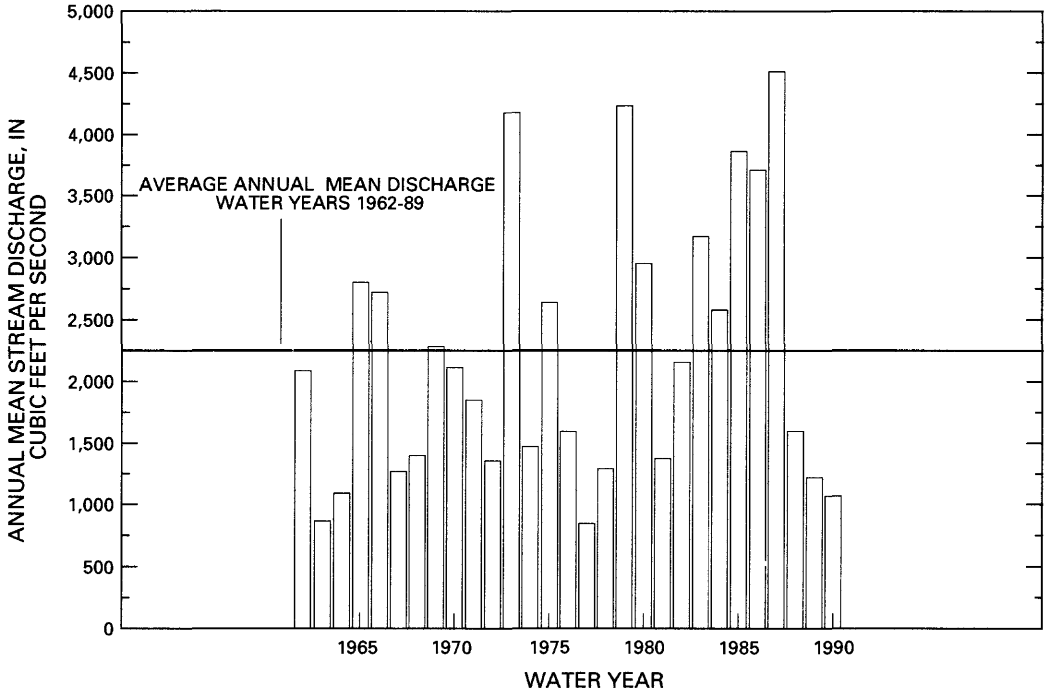

Figure 5. Annual mean stream discharge at streamflow-gaging station 09379500, San Juan River at Mexican Hat, Utah (site SJ3), water years 1962–90.

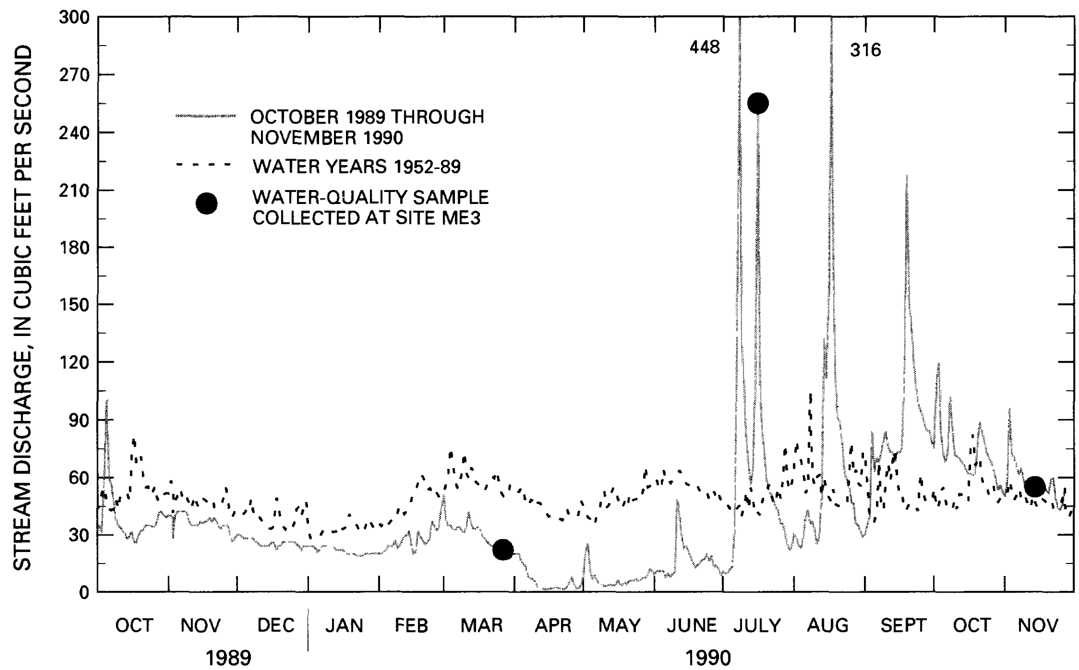

Figure 6. Daily mean stream discharge for October 1989 through November 1990, average daily mean stream discharge for water years 1952–89, and dates when water-quality samples were collected at streamflow-gaging station 09372000, Mc Elmo Creek near the Colorado-Utah State line (site ME3).

Irrigation Projects

Four irrigation projects will be described in this section. Most of the discussion is about the Dolores Project. Brief descriptions also are given for the Ute Mountain Ute Irrigation Project, the Mancos Project, and the Summit Irrigation District.

Dolores Project

The Dolores Project develops water from the Dolores River for irrigation, municipal and industrial use, power production, recreation, and fish and wildlife enhancement. Other project purposes include flood control, salinity control, and cultural resources mitigation. The MVIC furnishes water to about 37,500 acres, and the Dolores Project supplies supplemental water to the MVIC system for irrigation of 26,300 acres. There are 11,200 acres of land served by MVIC that will not receive project water because the soils were classified as unsuitable for irrigation (Bureau of Reclamation, 1977a). The Dolores Project will irrigate 27,920 acres in the Dove Creek area and 7,500 acres in the Towaoc area (fig. 1). The Dove Creek and Towaoc areas will be irrigated for the first time. Through August 1991, about 18,000 acres in the Dove Creek area had been brought into irrigation as sections of the Dove Creek Canal and laterals were completed.

The Dolores Water Conservancy District (DWCD) is responsible for general operation and administration of all project facilities. The Bureau of Reclamation and DWCD signed an agreement in 1985 for DWCD to operate and maintain the project with Bureau of Reclamation supervision. The MVIC will continue to administer its system, including the salinity-control modifications to be built for the Dolores Project. The Ute Mountain Ute Tribe will be responsible for operation and maintenance of the canals and laterals to the Towaoc area.

The primary components of the Dolores Project include McPhee Reservoir (capacity 381,000 acre-ft), the Dolores Tunnel, Great Cut Dike, Dove Creek Canal, Towaoc Canal, and six pumping plants. Other components include laterals, power plants, drainage facilities, and salinity-control features (canal lining and pipe laterals). Major features are shown in relation to the hydrologic system in the schematic in figure 3. McPhee Reservoir was completed in 1984. The Dolores Tunnel replaces the old tunnel from the Dolores River operated by MVIC. Water from McPhee Reservoir is transported through the Great Cut Dike into the Dove Creek Canal and into the northern part of the MVIC system. The Dove Creek Canal and laterals in the Dove Creek area were completed by August 1991. Water deliveries from the Dove Creek Canal began in the Cahone and Yellow Jacket areas in 1987, and delivery of the supplemental water to the MVIC system began in 1988. Water deliveries to the Dove Creek area and the acreage of newly irrigated land for 1987–90 are summarized in table 1. Since completion of the Dove Creek Canal in 1991, irrigation in the Dove Creek area has gradually increased as the distribution system was completed and more farmers began using Dolores Project water. As of September 1993, there was about 7,000 acre-ft of project water yet to be utilized in the Dove Creek area.

Table 1. Water delivery and irrigated acreage in the Dove Creek area of the Dolores Project, 1987–90

Year	Water delivered (acre-feet)	Irrigated acreage (acres)
1987	2,100	1,050
1988	8,800	4,400
1989	16,000	8,000
1990	26,600	13,300
Full allocation	54,300	27,920

The Towaoc Canal, completed in September 1993, will serve the newly irrigated land in the Towaoc area on the Ute Mountain Ute Reservation and serves part of the MVIC service area. Some laterals and center pivots were in use in 1993 in the Towaoc area, and about 1,000 acres were irrigated. Completion of laterals on the Ute Mountain Ute Reservation is planned in 1994.

Narraguinnep and Totten Reservoirs (fig. 1) are storage reservoirs from the old MVIC system. Narraguinnep Reservoir (capacity 19,000 acre-ft) is an off-stream reservoir located about 10 mi north-northwest of Cortez and was supplied by the old MVIC tunnel and canal system. Totten Reservoir (capacity 3,000 acre-ft), located northeast of Cortez, will no longer be used by the MVIC system for storage of water for irrigation supplies once the Towaoc Canal and Rocky Ford lateral are completed. Totten Reservoir will be kept as a fishery, and 800 acre-ft of water from McPhee Reservoir are reserved for maintenance of water storage in Totten Reservoir.

Once completed, the Dolores Project will provide an average of 90,900 acre-ft/yr of water from the Dolores River basin (from McPhee Reservoir) for irrigation in the San Juan River basin and 8,700 acre-ft/yr of water for municipal and industrial uses. The average annual irrigation allocations for the project are 13,700 acre-ft of supplemental water for the MVIC system, 54,300 acre-ft to the Dove Creek area, and 22,900 acre-ft to the Towaoc area (Bureau of Reclamation, 1977a). The MVIC will continue to receive its historical diversion of Dolores River water because MVIC water rights are senior to all project water rights. In an agreement with DWCD, MVIC will limit their demand to enable the project to have an adequate water supply; in exchange, the MVIC will receive the supplemental project water (13,700 acre-ft/yr) to alleviate late-season shortages that were common pre-project occurrences. The average annual diversion through the old MVIC Tunnel from 1928–73 was about 105,000 acre-ft (Bureau of Reclamation, 1977a).

The MVIC will continue to use its gravity distribution system, which is old, and many of the canals and laterals are incised into shale. None of the MVIC distribution system was lined; however, part of the MVIC system will be replaced or rehabilitated for the salinity-control features of the Dolores Project. Sections of three laterals and canals were abandoned when the Towaoc Canal was built. Two ditches in the southern MVIC area were abandoned, and that area is now served by buried pipe laterals from the Towaoc Canal. The remaining salinity control work for the Dolores Project is lining 9.3 mi of laterals in the northern MVIC area, and that work is expected to be completed by 1995.

The irrigation method used in most of the MVIC area is flood irrigation. Irrigators often have applied excess water early in the year during spring runoff to store sufficient soil moisture for use by crops during the late-season dry period when water supply often is insufficient. With the supplemental water from the Dolores Project, there will be more water available for late season use.

The Dove Creek and Towaoc Canals are open, earth-lined canals. Water is distributed from these canals through pressurized pipe laterals to sprinkler systems. Pressure is supplied by pumping plants in the Dove Creek area and by gravity in the Towaoc area.

Irrigation drainage in the MVIC area primarily is diffuse discharge into natural pathways, mostly ephemeral and intermittent streams, canyons, and arroyos. There are drainage problems in part of the MVIC area because of shallow depths to bedrock, low soil permeability, topography, and lack of natural drainages. Drainage facilities are limited in the MVIC system, and drainage facilities will not be constructed in the MVIC area for the Dolores Project. Surface return flow, natural runoff, and diffuse ground water (irrigation drainage) discharge into Mc Elmo Creek or its tributaries, such as Hartman Draw, Alkali Canyon, Trail Canyon, Yellow Jacket Canyon, and Dawson Draw (fig. 1). Irrigation drainage and return flow from the extreme southern MVIC area discharges into Navajo Wash, which is tributary to the Mancos River.

As part of the Mc Elmo Unit Salinity Control Program, the Bureau of Reclamation (1981) estimated that return flow was about 35 percent of water applied in the MVIC area. If MVIC diverted their full allocation of water and received 13,700 acre-ft/yr of supplemental water, return flow would be about 50,500 acre-ft/yr. The salt load pickup from the Mc Elmo Creek basin is estimated at 117,900 tons/yr based on the latest project modifications (Bureau of Reclamation, 1989). Salt loading to the San Juan River from the Mc Elmo Creek basin is the result of distribution-system seepage and deep percolation of applied water that dissolves salts from soils and from the weathered zone of the Mancos Shale.

In the Dove Creek area (newly irrigated areas north of Yellow Jacket Canyon), drainage generally is not expected to be a problem except in low areas (Bureau of Reclamation, 1977b). Irrigation is or will be on ridge lands of rolling plateaus dissected by numerous swales and drainage pathways. All irrigation drainage is into Yellow Jacket, Hovenweep, Cross, and Squaw Canyons and into Monument Creek, or their tributaries (fig. 1). Natural drainage is expected to remove all excess surface water. Ground water is expected to accumulate in the low areas and swales, at the end of long slopes, and in isolated hillside seep areas where sandstone bedrock crops out at the surface. The low areas do not have sufficient subsurface drainage to remove the water because depths to sandstone or shale barriers often are shallow. The Bureau of Reclamation plans to install 24 mi of deep pipe drains in the Dove Creek area to control the subsurface drainage and to protect low areas. The natural drainages will be used as collectors and outlets. The estimated volume of return flow is about 10,920 acre-ft/yr from the Dove Creek area (Bureau of Reclamation, 1977b).

Land to be irrigated in the Towaoc area is on relatively smooth, long, continuous slopes separated by major washes. Major washes are shown in figure 1 and include Aztec, Cowboy, Mariano, Coyote, and Marble Washes. Aztec Wash is tributary to the Mancos River; the other washes are tributary to the San Juan River. The washes are ephermal and have channels 10 to 50 ft deep in their lower reaches. There are numerous washes and gullies tributary to the main washes that should provide adequate surface drainage.

The subsurface drainage in the Towaoc area varies because of different soils and bedrock (Bureau of Reclamation, 1977b). West of Mariano Wash, the areas to be irrigated are on red soils underlain by Dakota Sandstone. Pipe drains should provide adequate subsurface drainage west of Mariano Wash. The outlet and collectors would be the natural drainages, which in this area are eroded to the sandstone bedrock. Areas to be irrigated in Aztec Wash and Cowboy Wash are on gray soil underlain by Mancos Shale bedrock. The bottom of the natural drains are fine-textured gray soils, and the drains tend to constrict toward their lower ends. In addition to the pipe drains, the Towaoc area also will have a piped outlet system. The Bureau of Reclamation estimates that 49 mi of deep pipe drains will be built in the Towaoc area.

The estimated volume of return flow would be about 4,930 acre-ft/yr from the Towaoc area (Bureau of Reclamation, 1977b). An estimated 30,000 tons/yr of salt would enter into the San Juan River for the first 6 years of irrigation in the Towaoc area, and the salt load would average 12,600 tons/yr for 100 years. The dissolved-solids concentration is predicted to increase from 127 mg/L in applied water to 2,470 mg/L in return flows from the Towaoc area (Bureau of Reclamation, 1977b). Rapid leaching is expected in the red-soil areas west of Mariano Wash, and good quality return flows are expected after initial leaching.

Ute Mountain Ute Irrigation Project

The Ute Mountain Ute Irrigation Project consists of a single farm that irrigates land along the Mancos River immediately west of Highway 666. The project was planned to irrigate 563 acres, but has never irrigated more than 290 acres, and 205 acres were irrigated in 1988. Water for the Ute Mountain Ute Irrigation Project is diverted from the Mancos River about 2 mi upstream from Highway 666 into a unlined ditch that runs north of the river. Water is applied by flood irrigation to fields of alfalfa, sudan grass, oats, and pasture. Drainage is through the natural pathways to the Mancos River. Surface runoff has not been measured or estimated; however, there may be little, if any, runoff from irrigated areas during a significant part of the irrigation season because of the limited water supply to this project. There are periods during the summer when there is no flow in the Mancos River upstream from the diversion.

Further development and expansion of this irrigation project is greatly restricted by several constraints and is not likely to occur. Constraints include limited water supply, topography, nonarable soils, and archaeological mitigation.

Mancos Project

The Mancos Project irrigates land in the Mancos River basin upstream from the Dolores Project area. Facilities built by the Bureau of Reclamation for the Mancos Project were for supplemental irrigation supply and for domestic water for the town of Mancos, the rural Mancos area, and for Mesa Verde National Park. The general extent of the irrigated area of the Mancos Project is in the vicinity of the town of Mancos (fig. 1). The irrigated area is about 13,746 acres; 11,683 acres were actually irrigated in 1981. Primary crops are alfalfa, hay, pasture, wheat, oats, barley, and feed corn. Storage is in Jackson Gulch Reservoir (capacity 9,980 acre-ft), located about 4 mi north of the town of Mancos (fig. 1). The reservoir was built in 1950 by the Bureau of Reclamation. Parts of the distribution system were built before 1900.

The irrigated areas are in the Mancos River Valley to the east side of Mesa Verde National Park and in Weber Canyon (fig. 1). Some of the irrigated land is on alluvial areas, but the entire area in underlain by Mancos Shale. Drainage from the area is through the natural drainages and subsurface flow to the Mancos River. The effects of irrigation drainage from the Mancos Project on water quality of the Mancos River have not been studied.

Summit Irrigation District

The Summit Irrigation District is a private company that provides water for about 4,600 acres in the upper Mc Elmo Creek basin, upstream from the MVIC service area. The irrigated areas are located near and west of Summit and Puett Reservoirs (fig. 1). The district diverts water from the Dolores River basin from Lost Canyon Creek into Summit Reservoir.

The Summit Irrigation District has similar physiography, climate, geology, and soils as the Montezuma Valley. The irrigated area is at a slightly greater elevation (about 7,000 ft) than the Montezuma Valley; therefore, the area probably has a shorter growing season and receives more precipitation than Cortez. Crops are alfalfa, small grains, and pasture. The irrigated land is mostly on soils derived from the Dakota Sandstone and to a lesser extent, the Mancos Shale. Effects on water quality in the Mc Elmo Creek basin by irrigation drainage from the Summit District land are not known.

Ground Water

Ground water is present in several unconsolidated alluvial deposits (colluvium, pediments, stream alluvium) and in confined bedrock units. The aquifers in alluvial deposits have the best potential yields. In the Towaoc area (Geldon, 1985), yields as great as 50 to 100 gal/min were reported in talus and pediment deposits, but yields had large seasonal variation. The quantity of water stored in alluvial deposits also was quite variable. Geldon (1985) reported that bedrock in the area consisted of fine-grained material such as claystone, shales, sandstones, and mudstones, and although bedrock aquifers might contain considerable quantities of water, yields in these aquifers are insufficient for development.

Irwin (1966) described ground water on the Ute Mountain Ute Reservation and stated that the Mancos Shale is not a good aquifer because of low permeability and storage. Because the shale is thick and extensive, development of water supplies from ground water would be difficult. Yields from sandstone aquifers in the Dakota Sandstone were quite small on the Ute Mountain Ute Reservation, and limestone beds were too thin in the area to be major aquifers (Irwin, 1966). At the regional scale, water in shallow aquifers flows toward the canyons and tributaries of the San Juan River. Water in deeper bedrock aquifers flows toward the San Juan River (Whitfield and others, 1983).

The Bureau of Reclamation drilled about 70 wells from 1977–80 for ground-water investigations in the Mc Elmo Creek basin (Bureau of Reclamation, 1988). Ground water was present in surficial materials consisting of colluvium, gravels, and weathered shale and in the Dakota Sandstone. Ground-water flow generally was toward Mc Elmo Creek, and ground water in all areas seemed to be recharged by deep percolation from irrigation (Bureau of Reclamation, 1988).

Ground-water use in the Dolores Project area for domestic supplies is not significant. Spring water from the Cottonwood Wash basin was used to augment supplies for Towaoc. Towaoc now receives municipal water from the Cortez water-treatment plant. There are scattered water wells in rural areas that may be used for domestic and livestock water supplies, but the number of wells is not large nor is the water use significant when compared to the surface-water supplies.

PREVIOUS INVESTIGATIONS

The Bureau of Reclamation has done extensive hydrologic, water-supply, irrigation-drainage, geologic, and soils investigations for planning reports and for environmental impact statements for the Dolores Project (Bureau of Reclamation, 1977a,b, 1988, 1989). The Bureau of Reclamation also has investigated water quality of the Mc Elmo Creek basin for the Mc Elmo Creek Unit of the Colorado River Water Quality Improvement Program (Bureau of Reclamation, 1981). The Mc Elmo Creek Unit, a salinity control project, is now a feature of the Dolores Project (Bureau of Reclamation, 1988, 1989). Many geologic and mineral-related (uranium, coal, oil, and natural gas) studies have been done in the Four Corners area (such as Fassett and Hinds, 1971; Ridgley and others, 1978).

Studies related to uranium generally were outside of the Dolores Project because the major economic deposits are outside the area. The U.S. Geological Survey and other investigators have done numerous geologic and ground-water investigations in the San Juan basin (Stone and others, 1983; Weir and others, 1983; Whitfield and others, 1983). Many of the studies of the San Juan basin were in New Mexico or in coal areas in Colorado, east of the Dolores Project area.

Other than the studies done by the Bureau of Reclamation, investigations specific to the Dolores Project area are limited. Geldon (1985) discussed water supply for Towaoc and the geohydrology of the Cottonwood Wash basin, a tributary to Navajo Wash. Water supply and geology of the Ute Mountain Ute Reservation was investigated by Irwin (1966). An inventory of soil and rangeland on the Reservation was reported by the Bureau of Indian Affairs (1965). The Colorado Department of Game, Fish, and Parks (former name of the Colorado Division of Wildlife) surveyed the upper Dolores River basin from 1960 to 1968 to address contamination problems caused by tailings ponds and a sulfuric acid plant (State of Colorado, 1968). The Bureau of Reclamation has done recent investigations in the Dolores River basin concerning sources of mercury. Recently (since about 1987), there have been several biological investigations in the Dolores Project area by the Colorado Division of Wildlife, Bureau of Reclamation, the U.S. Fish and Wildlife Service, and the National Park Service.

Water-Quality Data

Surface Water

Water-quality data collected in the Mc Elmo Creek basin by the Bureau of Reclamation were for studies of salt loading, and trace-element data were not collected. The U.S. Geological Survey collected trace-element data between 1977–81 at streamflow-gaging station 09372000, Mc Elmo Creek near the Colorado-Utah State line (site ME3 in fig. 1), and those data are summarized in table 2. A computer retrieval from the U.S. Environmental Protection Agency's Storage and Retrieval system (STORET) located 60 selenium analyses of water samples collected from Mc Elmo Creek west of Cortez. These selenium data were collected by the Colorado Department of Health; the median concentration was 5 µg/L and the maximum concentration was 20 µg/L. Trace-element data for tributaries of Mc Elmo Creek are very limited. The U.S. Bureau of Land Management collected three samples from Yellow Jacket Canyon in 1983 and 1984 (Dennis Murphy, U.S. Bureau of Land Management, written commun., 1989). Selenium concentrations in those three samples were 4, 2, and 10 µg/L, and concentrations of arsenic, cadmium, mercury, silver, and zinc were about equal to or less than analytical reporting limits.

Table 2. Median and maximum concentrations of trace elements in water samples collected at streamflow-gaging station 09372000, Mc Elmo Creek near the Colorado-Utah State line (site ME3)

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

Trace element	Number of samples	Median	Maximum
Arsenic	15	1	3
Arsenic, total	8	2	10
Barium	15	30	200
Boron	46	200	310
Cadmium	15	<2	6
Cadmium, total	8	<2	1
Chromium	15	<20	20
Copper	15	<20	20
Iron	45	30	370
Lead	15	<10	5
Manganese	15	110	280
Mercury, total	8	<.1	.3
Molybdenum	15	2	14
Nickel	15	3	15
Selenium	15	7	15
Selenium, total	8	4	33
Vanadium	15	<6	14
Zinc	15	14	50
Zinc, total	8	30	760

The U.S. Geological Survey collected a single water sample from near the bottom (48-ft depth) of Narraguinnep Reservoir in July 1990. Concentrations of trace elements, including selenium, were not large, and many concentrations were less than analytical reporting limits.

Trace-element data were collected in the Mancos River basin. Except for the data collected by Geldon (1985) in the Navajo Wash basin, almost all of the data were collected upstream from the Dolores Project area (upstream from site MN1 in fig. 1). The U.S. Geological Survey collected water-quality data at the streamflow-gaging station at site MN1, but almost all the trace-element data were for iron and manganese. One sample had analyses for selenium; the concentration of total selenium was 7 µg/L, and dissolved selenium was

3 µg/L. Trace-element data were collected by the Colorado Department of Health from the Mancos River near Mancos; concentrations of arsenic (37 samples) ranged from 0 to 10 µg/L, and selenium concentrations (24 samples) ranged from 0 to 5 µg/L. Mercury was not detected in the nine samples that were analyzed for mercury. The maximum selenium concentration for a surface-water site reported by Geldon (1985) was 8 µg/L at Navajo Wash near the mouth.

The U.S. Geological Survey collected trace-element data for the San Juan River at streamflow-gaging stations 09371010 (site SJ1 in fig. 1) and 09379500 (site SJ3 in fig. 2). These data are summarized in table 3. Most of the data for gaging station 09371010 were collected during 1977–81, and for gaging station 09379500 during 1975–89. A retrieval from STORET for the San Juan River from Four Corners to Lake Powell located limited trace-element data collected by other agencies. There were 42 selenium analyses for the San Juan River near Four Corners collected by the Colorado Department of Health; the median concentration was 0 µg/L, and the maximum concentration was 14 µg/L. The Utah Department of Health has collected water-quality data for the San Juan River near the confluence with Montezuma Creek, Utah (fig. 2). Median concentrations of arsenic, cadmium, lead, selenium, and zinc were 0 µg/L (number of samples ranged from 31 to 42). The maximum concentration of selenium was 16 µg/L for the samples collected from the San Juan River at Montezuma Creek, and seven concentrations exceeded 5 µg/L.

Trace-element data were collected by the Bureau of Reclamation in the Dolores River basin during 1969–75 and from the Dolores River at Dolores since 1979. Arsenic, cadmium, and lead concentrations generally were equal to or less than analytical reporting limits, and most samples had less than 2 µg/L of selenium. Mercury has been detected consistently in the water samples collected at Dolores, and several samples had total-mercury concentrations of 1 to 2 µg/L.

Table 3. Median and maximum concentrations of trace elements in water samples collected at streamflow-gaging stations 09371010, San Juan River at Four Corners (site SJ1), and 09379500, San Juan River at Mexican Hat, Utah (site SJ3)

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

Trace element	Gaging station 09371010			Gaging station 09379500		
	Number of samples	Median	Maximum	Number of samples	Median	Maximum
Arsenic	15	1	3	64	1	5
Arsenic, total	10	2	40	32	3	180
Barium	15	80	200	43	94	500
Boron	46	90	290	144	80	520
Cadmium	15	<2	4	64	<1	4
Cadmium, total	10	<2	9	33	<20	20
Chromium	15	<10	10	64	<1	10
Copper	15	3	18	64	3	11
Iron	46	20	120	59	15	410
Lead	15	<10	27	63	1	63
Manganese	25	3	30	61	<10	190
Mercury	13	<.1	.2	64	<.1	2.4
Mercury, total	10	<.1	.8	31	.1	2.2
Molybdenum	13	<10	4	30	<10	10
Nickel	15	<2	3	36	1	10
Selenium	15	2	6	64	2	7
Selenium, total	10	3	9	32	3	27
Vanadium	13	<6	1	31	<6	6
Zinc	15	9	30	64	20	430
Zinc, total	10	60	8,800	33	70	1,700

The only pesticide data for water for the Dolores Project area were three samples collected from the San Juan River at Mexican Hat, Utah in 1977, 1978, and 1982. These samples were analyzed for organophosphate and phenoxyacid herbicides and organochlorine insecticides. The only pesticide detected was diazinon (concentration 0.01 µg/L) in one sample.

Ground Water

Trace-element data for shallow ground water in the Dolores Project area are limited. A retrieval from the U.S. Geological Survey's National Water Information System (NWIS) located 17 samples that have dissolved-selenium data. The median dissolved-selenium concentration was 5 µg/L, and the maximum concentration was 13 µg/L in samples from an alluvial spring near Sleeping Ute Mountain and from a spring in the Mancos Shale in the Navajo Wash basin upstream from Towaoc. A sample from an alluvial well (depth 65 ft) in Navajo Wash south of Towaoc had 12 µg/L of dissolved selenium. These data also were reported by Geldon (1985). The retrieval from NWIS also located two samples collected in 1973 from wells in the Dakota Sandstone in the Dove Creek area. Total-selenium concentrations in the samples were 36 µg/L for a well located near Yellow Jacket and 2 µg/L for a well located about 5.5 mi west-northwest of Pleasant View. Based on a NWIS retrieval of selenium data for the Dakota Sandstone for a five-county area, the selenium concentration of 36 µg/L is not typical of selenium concentrations in water samples from the Dakota Sandstone in southwestern Colorado.

The Bureau of Reclamation collected water samples from 35 shallow wells in the MVIC area in 1978–80 (Bureau of Reclamation, 1988). The samples were analyzed for major ions and dissolved solids, but not for trace elements. The mean dissolved-solids concentration for 16 wells in red soil areas was 3,014 mg/L, and the mean concentration for 19 wells in gray soil areas was 9,338 mg/L (Bureau of Reclamation, 1988). Ground water in red soil areas was a calcium magnesium sulfate type, and ground water in gray soil areas was a sodium magnesium sulfate type (Bureau of Reclamation, 1988).

In 1986, the Bureau of Reclamation started drilling an observation-well network in areas to be irrigated in the Dove Creek area. These were shallow wells, generally less than 20-ft deep. The purpose of the wells was to monitor water levels in newly irrigated areas to identify areas where installation of subsurface drains may be needed. Through 1991, the Bureau of Reclamation had collected water-level data from 49 wells. During 1991, 41 wells were monitored, and 23 were dry most or all of the year. Sixteen wells had water levels less than 5 ft below land surface, and 12 wells had water levels greater than 10 ft below land surface (Kenneth J. Ouellette, Bureau of Reclamation, written commun., 1992).

Soil and Bottom-Sediment Data

The Bureau of Reclamation has collected considerable soil data for the Dolores Project for classification of the soils regarding suitability for irrigation. Prior to 1987, soil analyses were physical tests and tests for salinity. In 1987, the Bureau of Reclamation collected soil samples at four locations in Dawson Draw (near site DD in fig. 1) for trace-element analyses (table 4). The maximum selenium concentration of 17.1 µg/g for Dawson Draw soil samples (table 4) seems to be an anomaly when compared to selenium concentrations in the other soil samples collected in 1987 and to selenium concentrations in bottom sediment collected in 1990. In 1989, the Bureau of Reclamation collected soil samples for selenium analysis in areas to be irrigated on the Ute Mountain Ute Reservation. Samples were collected at various depths at two sites near Aztec Wash (gray soil), one site near Mariano Wash (red soil), one site between Coyote and Marble Washes (red soil), and at two sites near Marble Wash (red soil). Selenium concentrations in the samples from gray soil ranged from 0.2 to 1.3 µg/g, and concentrations in samples from the red soil areas ranged from 0.1 to 0.6 µg/g. The soil sample that had 1.3 µg/g selenium was collected at a depth of 42- to 58-in. at one of the sites near Aztec Wash.

Table 4. Maximum and minimum concentrations of selected trace elements in four soil samples from Dawson Draw (near site DD)

[Analyses by Bureau of Reclamation; concentrations in milligrams per kilogram; <, less than]

Trace element	Maximum	Minimum
Arsenic	5.6	3.6
Lead	17	14
Mercury	.08	<.02
Selenium	17.1	.4
Zinc	86	45

The U.S. Geological Survey has collected bottom-sediment data in the Dolores Project area. Seven bottom-sediment samples were collected at Mc Elmo Creek near the Colorado-Utah State line (site ME3 in fig. 1) during 1978–81, and four samples were collected from the San Juan River at Four Corners (site SJ1 in fig. 1) during 1977–79 for trace-element analyses. The range of trace-element concentrations for these samples are summarized in table 5. The U.S. Geological Survey, in cooperation with the Bureau of Reclamation's Dolores River Water Quality study, collected a core sample of bottom sediment from Narraguinnep Reservoir in July 1990. The purpose of the core sampling was to determine if there were periods when irrigation water, diverted from the Dolores River for storage in Narraguinnep Reservoir, had high concentrations of mercury or other trace elements. Trace-element concentrations in the core sample are listed in table 6. Organochlorine insecticides and PCB's were not detected in two bottom-sediment samples collected in 1979 and 1981 from the San Juan River at Mexican Hat, Utah (site SJ3 in fig. 2).

Biological Data

The U.S. Fish and Wildlife Service collected biological data in 1988 in the Dolores Project area, and those data are summarized in tables 7 and 8. The U.S. Fish and Wildlife Service also collected biota data in 1989 for a field-screening study of the Mancos River basin, and this information is discussed in the next section.

Table 5. Range of trace-element concentrations in bottom-sediment samples collected at Mc Elmo Creek near the Colorado-Utah State line (site ME3) and at San Juan River at Four Corners (site SJ1)

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

Trace element	Mc Elmo Creek	San Juan River
Arsenic	0–5	1–6
Barium	40–900	30–50
Beryllium	0–10	0–0
Cadmium	0–1	0–<1
Chromium	2–20	1–10
Copper	5–10	0–4
Lead	0–20	0–8
Manganese	160–560	120–200
Mercury	0–.04	0–.01
Molybdenum	1–17	0–3
Nickel	0–20	0–2
Selenium	0–2	0–0
Zinc	7–50	10–30

Mancos River Field-Screening Study

Fish and wildlife resources in the Mancos Project area for which the DOI has Federal trusteeship include migratory waterfowl and endangered fish. The Mancos River at the confluence with the San Juan River is an important staging area for the endangered Colorado squawfish and the razorback sucker. The roundtail chub and the flannelmouth sucker are candidate species for Federal listing as endangered and are present in the Mancos River along much of its length.

In July 1989, the U.S. Fish and Wildlife Service did a field-screening study of the Mancos River to determine if selenium and other trace elements from irrigation drainage from the Mancos Project were at

Table 6. Concentrations of trace elements in seven sections of a core sample of bottom sediment collected from Narraguinnep Reservoir, July 1990

[Analyses by U.S. Geological Survey; sample interval in centimeters; concentrations in micrograms per gram]

Sample interval	Arsenic	Barium	Cadmium	Chromium	Copper	Lead	Mercury	Selenium	Zinc
0–6	10	270	1	10	20	30	0.05	1	90
6–12	10	300	2	20	30	40	.05	1	130
12–18	10	280	2	10	30	60	.05	1	180
18–24	11	290	1	10	30	40	.04	1	120
24–30	7	230	1	9	20	30	.05	1	100
30–36	10	290	1	10	30	40	.05	1	180
36–42	9	240	1	10	20	30	.03	1	90

Table 7. Trace-element data for biota samples collected in the Dolores Project area in May and June 1988

[Analyses by U.S. Fish and Wildlife Service; wb., whole body; <, less than; inv., invertebrates; values are range of concentrations, in micrograms per gram dry weight; single value indicates all concentrations were equal to one concentration]

Location	Sample matrix	Number of samples	Aluminum	Arsenic	Barium	Beryllium	Boron
Dolores River	Fish, wb.	3	75–997	<0.10–0.36	5.6–16.4	<0.05	<3.0
McPhee Reservoir	Fish, wb.	3	33–130	<.10–.49	4.8–9.6	<.05	<3.0
Narraguinnep Reservoir	Fish, wb.	3	29–1,040	<.10–.20	3.4–16.0	<.05	<3.0
Totten Reservoir	Fish, wb.	3	67–298	<.10–.40	1.7–6.6	<.05	<3.0
Dawson Draw	Algae	4	11,800–23,800	3.3–5.5	132–271	.45–.92	5.0–65
	Aquatic inv.	5	784–7,800	1.3–2.4	59–141	<.05–.32	<3.0
	Fish, wb.	7	160–710	<.10–.20	6.1–22.6	<.05	<3.0
	Canada goose, liver	3	3–5	<.20	<.05–.09	<.05	<3.0
	Mallard, liver	3	4–8	<.20	.10–.38	<.05	<3.0

Location	Cadmium	Chromium	Copper	Iron	Lead	Magnesium	Manganese
Dolores River	0.08–0.40	1.0–6.0	3.6–7.9	101–622	0.10–0.69	933–1,300	24.6–35.2
McPhee Reservoir	.04–.07	2.0–5.4	.5–3.0	102–180	<.10	1,180–1,380	9.9–35.4
Narraguinnep Reservoir	.04–.15	1.0–5.2	.9–28.0	79.6–672	<.10–.52	1,140–1,490	3.1–32.3
Totten Reservoir	.03–.04	1.0–2.0	1.1–64.6	120–407	<.10–.60	758–1,810	3.1–13.0
Dawson Draw	.15–1.0	10.0–18.0	5.8–16.0	11,300–13,100	3.8–12.0	4,720–6,740	1,050–5,840
	.08–.31	3.0–8.0	14.0–95.7	610–5,970	.57–4.5	1,820–2,180	229–1,880
	.03–.38	<1.0–4.4	2.1–5.3	160–507	.20–.64	1,060–1,330	23.4–72.4
	.05–.08	<1.0–1.0	52.7–65.0	523–1,670	<.10–.20	761–819	11.0–18.0
	.41–.95	<1.0	67.0–110	3,070–5,300	.30–.56	699–760	17.0–25.7

Location	Mercury	Molybdenum	Nickel	Selenium	Strontium	Vanadium	Zinc
Dolores River	0.27–0.31	<0.5	2.0–3.0	3.0–6.1	30.2–72.6	<1–1	44–109
McPhee Reservoir	.93–1.5	<.5	2.0–3.0	1.5–2.1	29.2–91.9	<1	47–107
Narraguinnep Reservoir	.69–2.6	<.5–2.0	2.0–3.0	1.4–2.1	44.3–97.4	<1–2	41–68
Totten Reservoir	.09–.46	<.5–.9	<2.0–2.0	1.4–2.0	32.3–109	<1–1	55–200
Dawson Draw	.02–.05	<1.0–2.0	6.0–14	.57–3.4	90.1–1,010	18–28	46–67
	.05–.13	<.5–2.0	2.0–7.5	.93–1.8	45.4–639	1–10	60–96
	.18–.50	<.5–.6	2.0–3.0	1.1–4.6	64.2–83.3	<1–1	31–140
	.05–.09	.9–1.0	<2.0–2.0	2.9–3.2	.20–.57	<1	155–190
	.37–1.7	3.2–7.4	<2.0–2.0	11.0–14.6	.40–.62	<1	109–155

Table 8. Selected trace-element data for fish samples collected in the Dolores Project area in December 1988

[Samples collected by U.S. Fish and Wildlife Service and analyzed by the Bureau of Reclamation; concentrations in micrograms per gram dry weight; <, less than; single value listed for one sample]

Location	Sample matrix	Number of samples	Range of concentrations			
			Cadmium	Lead	Mercury	Selenium
Dolores River	Fillet	1	0.02	<0.07	0.31	3.0
	Whole body	2	.19–.37	.10–.20	.16–.26	7.1–8.9
McPhee Reservoir	Fillet	2	<.01–.04	.07–.33	1.5–2.7	1.8–2.2
	Whole body	3	.04–.08	.07–.21	.44–1.5	2.4–2.5
Narraguinnep Reservoir	Fillet	3	<.01–.01	<.07–<.07	4.8–6.4	2.8–3.0
	Liver	1	.13	.10	2.8	6.6
	Kidney	1	.67	.10	5.1	8.0
	Skin	1	.10	.68	.89	2.1
	Whole body	1	<.01	.10	1.9	2.6

levels of concern in water, bottom sediment, aquatic plants, aquatic invertebrates, fish, and birds. Samples were collected at four sites on the Mancos River (fig. 1): the West Mancos River upstream from the town of Mancos (site PR1); the Mancos River downstream from the town of Mancos (site PR2); the Mancos River near Ute Canyon, south of Mesa Verde National Park (site PR3); and the Mancos River at the Colorado-New Mexico State line (site MN2) (fig. 1).

In 1989, an attempt was made to collect aquatic plants, aquatic invertebrates, and fish at each of the four Mancos River sites. The West Mancos River at site PR1 is a clear stream that has stable, cobble substrate and an abundant assortment of aquatic invertebrates. Rainbow trout, brook trout, and mottled sculpin are the principal fish species in the West Mancos River. The West Mancos River loses water downstream from site PR1 by irrigation diversions. Most of the diversions for the Mancos Project are upstream from the town of Mancos.

At site PR2, the Mancos River was turbid, and sediment covered the bottom of the river. Small aquatic invertebrates were uncommon; crayfish were the most common aquatic invertebrate. Rainbow trout are rarely found in this stream reach, and bluehead suckers, speckled dace, and fathead minnows are the dominant species.

Downstream from Weber Canyon (fig. 1), a tributary of the Mancos River that receives irrigation return flow from the Mancos Project, water in the Mancos River during the summer consists primarily of irrigation return flow and ground water. Severe thunderstorms produce flash floods that regularly flush the canyon. Sampling site PR3 is upstream from Ute Canyon on the Ute Mountain Ute Reservation (fig. 1). The Mancos River in the vicinity of site PR3 is turbid, and the aquatic invertebrate population is limited to crayfish. The only two species of fish found at site PR3 in 1989 were native flannelmouth suckers and roundtail chubs. Roundtail chubs were a significant percentage of the fish population in this reach of the river. Stream discharge in the Mancos River in 1989 was unusually low, and the river had no flow for more than 20 mi from near Ute Canyon downstream to the mouth of the river. During the following 3 years (1990–1992), the river had a year-round flow.

During the field-screening study, samples were collected on the Mancos River at site MN2 (fig. 1), which also was a sampling site for the reconnaissance investigation in 1990. Fish collected at site MN2 in 1989 were in an isolated pool that was about 100 ft long and as much as 5 ft deep. The catfish collected at site MN2 probably were trapped in the pool after moving upstream from the San Juan River. Fish movement in the Mancos River is impeded by a 12-ft-high irrigation diversion structure 1 mi upstream from the Highway 666 bridge (fig. 1).

Water and sediment samples for bioassay analysis were collected from each of the four Mancos River sites and were analyzed by the University of Minnesota Cooperative Fish and Wildlife Research Unit. The bioassay results indicated no chronic or acute toxicity in the analyses done on water fleas (*Daphnia magna*), fathead minnows (*Pimephales promelas*), and midge larvae (*Chironomus tetans*).

Unfiltered, acidified water samples from each of the Mancos River sites were analyzed by Hazelton Laboratories American, Inc., in Madison, Wisconsin. Selenium was detected at sites PR1, PR3, and MN2 at concentrations of 2 μg/L (table 9).

Selenium concentrations in aquatic biota

The only trace element of concern in the biota samples collected for the field-screening study was selenium. Selenium concentrations were notably higher in biota from the Mancos River for site MN2 than for sites PR1, PR2, and PR3 (table 9). Lemly and Smith (1987) recommended that 3 µg/g dry weight selenium be used as the toxic threshold in food items that may be consumed by fish and wildlife. Selenium concentrations in aquatic plants collected at the upper sites, PR1 and PR2, were 0.4 µg/g dry weight (table 9) and are less than the suggested dietary guideline of 3 µg/g. Aquatic plants were not collected at sites PR3 and MN2 because turbid water conditions inhibited plant growth. Selenium concentrations in aquatic-

Table 9. Trace-element concentrations in water, bottom-sediment, and biota samples collected in the Mancos River basin, July 1, 1989

[Analysis by U.S. Fish and Wildlife Service; --, no data; aq., aquatic; inv., invertebrates; fm., flannelmouth; rw., red winged; fish and bird matrices are whole-body samples; length in millimeters; concentrations in micrograms per gram dry weight, except concentrations for water samples, which are in micrograms per liter; <, less than]

Matrix	Species	Mean length	Number in sample	Percent moisture	Aluminum	Arsenic	Barium
WEST MANCOS RIVER ABOVE MANCOS (SITE PR1)							
Water	--	--	--	--	447	--	42
Sediment	Composite	--	--	32.8	9,590	3.9	115
Aq. plant	Algae	--	--	56.8	13,100	4.5	169
Aq. inv.	Composite	--	1	92.8	3,340	1.6	134
Fish	Rainbow trout	219	1	75.1	1,010	.5	10.7
Fish	Mottled sculpin	110	7	77.3	290	.4	15.2
MANCOS RIVER DOWNSTREAM FROM MANCOS, UPSTREAM FROM WEBER CANYON (SITE PR2)							
Water	--	--	--	--	419	--	70
Sediment	Composite	--	--	83.9	20,000	5.4	231
Aq. plant	Sago pondweed	--	--	89.9	607	1.1	85.1
Aq. inv.	Crayfish	120	5	76.5	421	1.2	73.4
Fish	Rainbow trout	278	1	71.4	<3	.4	.32
Fish	Bluehead sucker	196	5	79.4	445	.4	13.8
Fish	Speckled dace	90	35	71.5	12	<.2	6.9
MANCOS RIVER NEAR UTE CANYON (SITE PR3)							
Water	--	--	--	--	18,200	--	140
Sediment	Composite	--	--	41.8	10,300	4.5	164
Aq. inv.	Crayfish	125	6	69.3	1,040	1.3	78.4
Fish	Fm. sucker	360	2	76.2	438	.3	11.9
Fish	Roundtail chub	380	1	71.3	11	<.2	1.5
MANCOS RIVER NEAR COLORADO-NEW MEXICO STATE LINE (SITE MN2)							
Water	--	--	--	--	2,940	--	110
Sediment	Composite	--	--	22.2	5,280	7.7	412
Aq. inv.	Crayfish	--	17	74.5	1,710	1.7	61.9
Fish	Channel catfish	298	2	82.8	180	.3	6.1
Fish	Fm. sucker	269	5	70.9	20	.2	3.0
Fish	Speckled dace	80	7	64.8	57	<.2	4.8
POND IN THE MANCOS VALLEY, WEBER CANYON DRAINAGE (SITE PR4)							
Bird	Killdeer	--	1	71.4	523	<.2	22.7
Liver	Killdeer	--	1	67.9	15	<.2	.42
Liver	Mallard	--	1	71.7	<3	<.2	.40
Liver	Mallard	--	1	69.7	<3	<.2	.20
Liver	Ruddy duck	--	2	73.3	<3	<.2	.10
Liver	Rw. blackbird	--	1	68.7	<3	<.2	.20

Table 9. Trace-element concentrations in water, bottom-sediment, and biota samples collected in the Mancos River basin, July 1, 1989--Continued

Matrix	Species	Percent moisture	Beryl-lium	Boron	Cadmium	Copper	Iron	Lead	Magne-sium
WEST MANCOS RIVER ABOVE MANCOS (SITE PR1)									
Water	--	--	--	210	--	<13	315	<15	3.5
Sediment	Composite	32.8	0.43	3	0.3	17.0	12,200	68	1,800
Aq. plant	Algae	56.8	.62	4	.3	29.9	14,300	28	2,600
Aq. inv.	Composite	92.8	<.1	3	2.1	60.1	5,030	35	1,930
Fish	Rainbow trout	75.1	<.1	3	<.2	10.0	895	<4	1,060
Fish	Mottled sculpin	77.3	<.1	2	<.2	4.1	273	<4	1,430
MANCOS RIVER DOWNSTREAM FROM MANCOS, UPSTREAM FROM WEBER CANYON (SITE PR2)									
Water	--	--	--	54	--	14	505	<15	28
Sediment	Composite	83.9	.81	9.2	.7	149	18,500	16	4,420
Aq. plant	Sago pondweed	89.9	<.1	393	5.0	19.0	836	14	3,870
Aq. inv.	Crayfish	76.5	<.1	4	.5	219	311	<4	1,770
Fish	Rainbow trout	71.4	<.1	2	<.2	3.5	42	<4	786
Fish	Bluehead sucker	79.4	<.1	3	.2	4.8	352	<4	1,420
Fish	Speckled dace	71.5	<.1	3	<.2	3.0	67	<4	1,200
MANCOS RIVER NEAR UTE CANYON (SITE PR3)									
Water	--	--	--	154	--	24	13,100	30	152
Sediment	Composite	41.8	.49	6	<.2	21.0	14,400	10	7,600
Aq. inv.	Crayfish	69.3	<.1	4	<.2	200	698	<4	4,200
Fish	Fm. sucker	76.2	<.1	3	<.3	4.5	1,240	<5	1,570
Fish	Roundtail chub	71.3	<.1	2	<.2	1.8	70	<4	893
MANCOS RIVER NEAR COLORADO-NEW MEXICO STATE LINE (SITE MN2)									
Water	--	--	--	376	--	<13	2,920	<15	104
Sediment	Composite	22.2	.33	2	.3	6.4	22,600	16	3,130
Aq. inv.	Crayfish	74.5	<.1	5	.4	104	1,200	<4	3,420
Fish	Channel catfish	82.8	<.1	2	<.2	4.6	257	4	--
Fish	Fm. sucker	70.9	<.1	2	<.2	5.4	62	<4	1,020
Fish	Speckled dace	64.8	<.1	<2	<.2	5.4	62	<4	1,040
POND IN THE MANCOS VALLEY, WEBER CANYON DRAINAGE (SITE PR4)									
Bird	Killdeer	71.4	<.1	3	<.2	8.3	549	<4	1,480
Liver	Killdeer	67.9	<.1	<2	.7	16.0	628	<4	709
Liver	Mallard	71.7	<.1	<2	2.0	14.0	4,140	<4	477
Liver	Mallard	69.7	<.1	<2	1.4	43.1	5,000	<4	609
Liver	Ruddy duck	73.3	<.1	<2	<.2	29.1	411	<4	803
Liver	Rw. blackbird	68.7	<.1	<2	.5	22.0	1,140	<4	801

Table 9. Trace-element concentrations in water, bottom-sediment, and biota samples collected in the Mancos River basin, July 1, 1989--Continued

Matrix	Species	Percent moisture	Manga-nese	Mercury	Molyb-denum	Nickel	Sele-nium	Stron-tium	Vana-dium	Zinc
WEST MANCOS RIVER ABOVE MANCOS (SITE PR1)										
Water	--	--	18	--	--	<20	2	198	--	38
Sediment	Composite	32.8	364	<0.01	--	5.8	.20	41.1	19	61.0
Aq. plant	Algae	56.8	543	.05	<2	14	.40	45.3	18	69.8
Aq. inv.	Composite	92.8	983	.06	<1	4.6	2.0	32.7	5.8	261
Fish	Rainbow trout	75.1	59.0	.10	<1	5.2	3.5	19.0	1.8	85.6
Fish	Mottled sculpin	77.3	93.1	.14	<1	2.0	4.0	92.2	.8	88.4
MANCOS RIVER DOWNSTREAM FROM MANCOS, UPSTREAM FROM WEBER CANYON (SITE PR2)										
Water	--	--	88	--	--	<20	<1	768	--	207
Sediment	Composite	83.9	469	.02	<2	18	1.3	155	29	109
Aq. plant	Sago pondweed	89.9	1,590	.65	5	4.4	.40	272	1.0	52.0
Aq. inv.	Crayfish	76.5	137	.07	<1	2.0	.89	462	.7	70.7
Fish	Rainbow trout	71.4	1.5	.12	<1	<1	2.5	4.2	<.3	52.9
Fish	Bluehead sucker	79.4	51.6	.06	<1	2	1.5	73.5	.7	84.4
Fish	Speckled dace	71.5	16.0	.19	<1	<1	5.1	80.5	<.3	148
MANCOS RIVER NEAR UTE CANYON (SITE PR3)										
Water	--	--	202	--	--	22	2	2,940	--	60
Sediment	Composite	41.8	365	.02	--	12	.91	148	21	50.6
Aq. inv.	Crayfish	69.3	145	.09	<1	2	2.2	777	1.8	63.0
Fish	Fm. sucker	76.2	64.9	.38	<1	5.6	3.8	84.0	1.1	84.2
Fish	Roundtail chub	71.3	2.7	1.3	<1	<1	4.4	32.4	<.3	56.0
MANCOS RIVER NEAR COLORADO-NEW MEXICO STATE LINE (SITE MN2)										
Water	--	--	152	--	--	<20	2	2,120	--	81
Sediment	Composite	22.2	275	<.01	<3	7.7	.81	128	18	43.8
Aq. inv.	Crayfish	74.5	94.7	.11	<1	4	9.9	710	3.9	62.3
Fish	Channel catfish	82.8	12.0	.66	<1	<1	5.7	104	.5	96.3
Fish	Fm. sucker	70.9	9.6	.12	<1	<1	7.0	65.4	<.3	49.6
Fish	Speckled dace	64.8	8.6	.18	<1	<1	11.0	119	<.3	117
POND IN THE MANCOS VALLEY, WEBER CANYON DRAINAGE (SITE PR4)										
Bird	Killdeer	71.4	11	.06	<1	<2	20.9	57.0	1.2	95.9
Liver	Killdeer	67.9	14	.13	3	<2	25.7	.68	<.3	80.9
Liver	Mallard	71.7	7.1	.22	5	<2	33.3	.3	<.3	103
Liver	Mallard	69.7	9.2	.15	4	<2	25.3	.2	<.3	157
Liver	Ruddy duck	73.3	12	.01	2	<2	69.0	.69	<.3	11.3
Liver	Rw. blackbird	68.7	4.8	.23	4	<2	10.0	.1	<.3	82.9

invertebrate samples ranged from 0.89 μg/g dry weight at site PR2 to 9.9 μg/g dry weight in a crayfish sample collected at site MN2 (table 9). The concentration of 9.9 μg/g dry weight is more than 3 times higher than the dietary guideline of 3 μg/g suggested by Lemly and Smith (1987).

Fish species collected for the field-screening study varied by site because of major changes in stream habitat through the sampled reach of the Mancos River. Therefore, comparisons of selenium in similar species between sites could not be made. Generally, the selenium concentrations in fish collected in the lower reach of the Mancos River (sites PR3 and MN2) were higher than in fish from the upper reaches at sites PR1 and PR2. Selenium concentrations in nine of the ten whole-body fish samples collected from the Mancos River exceeded the National Contaminant Biomonitoring Program (NCBP) 85th percentile of 0.73 μg/g wet weight (Schmitt and Brumbaugh, 1990) for selenium. The selenium concentrations in six fish samples equaled or exceeded the selenium concentration of 4 μg/g dry weight that Lemly (1993) recommended as being the level of concern for overall health and reproductive vigor of freshwater fish. The highest selenium concentration in fish at each site was in the smallest species, speckled dace or mottled sculpin. These smaller fish often are consumed by higher trophic species.

Selenium concentrations in birds

Birds were collected from a small farm pond and wetland area in the lower part of the Mancos Project at site PR4 (fig. 1). This pond and wetland complex received irrigation supply water from laterals and irrigation return flow from an adjoining field. However, the supply water in the lower part of the project is return flow from upstream irrigated areas. Ponds and wetlands are not common in the Mancos River basin; however, the ponds and wetlands that are present attract a large number of waterfowl and shorebirds. About 20 young-of-year American coots and several young mallards were observed at site PR4. The presence of the young birds indicates that waterfowl are reproducing at sites that have available nesting habitat.

As with fish samples, selenium was the element of concern in bird samples. Concentrations of selenium in bird-tissue samples ranged from 10 μg/g dry weight in a red-winged blackbird liver to 69 μg/g dry weight in a composite sample of two sub-adult ruddy duck livers (table 9). J.P. Skorupa (U.S. Fish and Wildlife Service, written commun., 1993) reported that baseline mean selenium concentrations rarely exceed 10 μg/g dry weight in bird livers. All bird-liver samples collected at site PR4 (table 9) had selenium concentrations that equaled or exceeded 10 μg/g dry weight. All birds collected at site PR4 were immature or were adults that were brooding young, which indicates that the selenium in these birds was obtained at this site.

J.P. Skorupa (U.S. Fish and Wildlife Service, written commun., 1993) reported a high risk of adverse biological effects when mean selenium concentrations of a population exceeds 30 μg/g dry weight in bird livers. J.P. Skorupa also suggested that where mean selenium concentrations are between 10 and 30 μg/g dry weight in livers, additional studies of reproductive performance are needed for conclusive interpretation of biological significance. Selenium concentrations in all bird samples collected at site PR4 equaled or exceeded those concentrations of concern. The selenium concentrations in birds from site PR4 indicate that there is a source of selenium available at this site and that bioaccumulation of selenium in birds was occurring. The concentration of selenium in birds represents a level of concern, and additional studies in the upper Mancos River basin would be required to determine whether selenium is causing deformities or affecting reproductive rates.

SAMPLE COLLECTION AND ANALYSIS

Objectives

One objective of surface-water and bottom-sediment sampling for the reconnaissance investigation was to determine concentrations of trace elements and pesticides in water and bottom sediment in streams draining long-term irrigated areas in the MVIC area. Another objective was to collect water and bottom-sediment data in newly irrigated areas in the Dove Creek area, and a third objective was to collect data for the Mancos and San Juan Rivers upstream from and downstream from the Dolores Project. Problem areas were to be identified where trace-element concentrations in water exceeded drinking-water regulations, criteria for protection of aquatic life, or criteria for agricultural use. Water and bottom-sediment data collected in irrigated areas were compared to data collected at reference sites to determine if irrigation drainage was contributing potentially harmful constituents to streams and reservoirs. Trace-element concentrations in bottom sediment were compared to trace-element concentrations in soils in the Western United States.

A standard set of chemical constituents was analyzed in water and bottom-sediment samples collected for the reconnaissance investigation. The list of constituents was developed by the DOI Task Group for use in all irrigation drainage studies to enable comparison of data among the reconnaissance investigations. The constituents for analysis in each medium are listed in table 10. Pesticide compounds selected for analysis in water and bottom sediment (table 10) were based on past or present usage in the Dolores Project area.

A primary objective of the biological sampling was to determine if trace-element concentrations in biota were of concern and to identify the potential for contaminant bioaccumulation within different trophic levels. Biota selected from lower trophic levels (aquatic plants and aquatic invertebrates) represented possible food sources for either fish or migratory birds that were most likely to be present in the Dolores

Table 10. Constituents analyzed in water, bottom-sediment, and biota samples

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

Water		Bottom sediment		Biota	
Inorganic	Pesticides	Inorganic	Pesticides	Inorganic	Pesticides
Hardness	2,4-D	Arsenic	PCN	Aluminum	alpha-BHC
Calcium	2,4-DP	Barium	PCB	Arsenic	beta-BHC
Magnesium	Silvex	Beryllium	Aldrin	Barium	gamma-BHC
Sodium	2,4,5-T	Bismuth	Chlordane	Beryllium	alpha-Chlordane
Potassium	Dicamba	Cadmium	DDD	Boron	gamma-Chlordane
Sulfate	Picloram	Cerium	DDE	Cadmium	o,p'-DDE
Chloride	DEF	Chromium	DDT	Chromium	p,p'-DDE
Alkalinity	Diazinon	Cobalt	Dieldrin	Copper	o,p'-DDD
Fluoride	Disyston	Copper	Endosulfan	Iron	p,p'-DDD
Dissolved solids	Ethion	Europium	Endrin	Lead	o,p'-DDT
Nitrite	Malathion	Gallium	Heptachlor	Magnesium	p,p'-DDT
Nitrite plus nitrate as N	Methyl parathion	Gold	Heptachlor epoxide	Manganese	Dieldrin
	Methyl trithion	Holmium	Lindane	Mercury	Endrin
Ammonia	Parathion	Lanthanum	Mirex	Nickel	HCB
Orthophosphorus	Phorate	Lead	Perthane	Selenium	Heptachlor epoxide
Arsenic	Trithion	Lithium	Toxaphene	Strontium	Mirex
Boron		Manganese		Vanadium	cis-Nonachlor
Cadmium		Mercury		Zinc	trans-Nonachlor
Chromium		Molybdenum			Oxychlordane
Copper		Neodymium			Toxaphene
Lead		Nickel			PCB
Mercury		Niobium			
Molybdenum		Scandium			
Selenium		Selenium			
Vanadium		Silver			
Zinc		Strontium			
Uranium, total		Tantalum			
		Thorium			
		Tin			
		Uranium			
		Vanadium			
		Ytterbium			
		Yttrium			
		Zinc			

Project area. Consistency in species composition of samples among sites was attempted so that direct comparisons of data could be made between sites and areas. Consistency among species could not always be achieved because of habitat variability and because of insufficient numbers of organisms to obtain an adequate biomass for analysis.

Sampling Sites and Schedule of Sample Collection

Water-quality samples for inorganic analysis were collected at 19 stream sites, 2 sites representing irrigation water from McPhee Reservoir, 3 reservoirs, and 4 ground-water sites for the reconnaissance investigation of the Dolores Project area during 1990 (table 11). All sampling sites are shown in figures 1 and 2. Streams were sampled three times (table 12) during 1990 to document seasonal differences in water chemistry and in trace-element concentrations. Water samples for inorganic analyses were collected from reservoirs only in the pre-irrigation (April) and post-irrigation (November) seasons.

Four sites on Mc Elmo Creek were sampled for the reconnaissance investigation (table 11). Site ME1 is upstream from MVIC irrigated areas and is a reference site relative to the MVIC area. Site ME2 is downstream from most of the irrigated land within the MVIC area. Site ME3 was sampled to determine effects from irrigation along Mc Elmo Creek downstream from Cortez (non project irrigation). Site ME4 is the outflow site for Mc Elmo Creek and is downstream from all irrigated areas. Major pathways of irrigation drainage and return flow from the MVIC area are represented by the sampling sites on tributaries of Mc Elmo Creek. The sampling sites are Hartman Draw (sites HD1 and HD2), Alkali Wash (site AK), Dawson Draw (site DD), and the lower site on Yellow Jacket Canyon (site YJ2). Navajo Wash (site NW), tributary to the Mancos River, is a pathway for irrigation drainage from the extreme southern part of the MVIC area. Water samples also were collected from Totten Reservoir (site TT), which is located in the MVIC area. Summit Reservoir (site SU), Puett Reservoir (site PU), and Simon Draw (site SD) are reference sites for the MVIC area. Water quality of all irrigation source water from McPhee Reservoir into the MVIC area and to the newly irrigated areas was sampled at the outlets of the Dolores Tunnel (site DT) and the Great Cut Dike (site GD).

Selection of sampling sites in newly irrigated areas or areas yet to be irrigated was restricted because the many small arroyos and washes draining those areas did not have flow. The upper site on Yellow Jacket Canyon (site YJ1) and the sites on Woods Canyon (site WC) and Cahone Canyon (site CH) are downstream from newly irrigated areas that were being irrigated during 1990. Water samples collected at those sites were from irrigation drainage from land that has been irrigated less than 3 years. The site on Cross Canyon (site CR) is a reference site (upstream from irrigated land) for the Dove Creek area because irrigation had not begun in 1990 in the basin upstream from site CR. The three observation wells (sites OW1, OW2, and OW3) are located in newly irrigated areas, and water samples from those wells probably were from shallow irrigation drainage that had collected in low areas. There was no flow in streams and washes draining land to be irrigated on the Ute Mountain Ute Reservation other than in the Mancos River (sites MN1 and MN2).

Two sites were selected on the San Juan River for water sampling. Site SJ1 (fig. 1) is downstream from the Mancos River and upstream from Mc Elmo Creek. Site SJ3 (fig. 2) is downstream from the Dolores Project and is the outflow from the San Juan River into Lake Powell (fig. 2). The San Juan River upstream from the Mancos River was sampled for the reconnaissance investigation of the San Juan basin in northern New Mexico. Site GW at Aneth, Utah (fig. 2) is a seep area along the San Juan River Valley. Samples from site GW are from ground water discharging from bedrock through an abandoned gas well. Water from the seep area discharges into the San Juan River.

Water samples for pesticide analysis were collected at 12 stream sites and 2 reservoir sites (table 11) in July 1990 (table 12). The pesticide samples were collected in summer during or after the time when pesticides normally are applied in the Dolores Project area.

Bottom-sediment samples for inorganic and chlorinated pesticide analyses were collected at 18 sites (table 11). The samples were collected in November 1990 (table 12), when maximum accumulation of potential contaminants from irrigation drainage was expected.

Biota sampling sites were selected to determine maximum contaminant concentrations associated with irrigation drainage. Biota sampling sites were selected relative to inflow and outflow of irrigation drainage and based on the availability of biota. Biota samples generally were collected from streams at or near the water-quality sampling sites (table 11). Stream sites were scheduled to be sampled for aquatic plants, aquatic invertebrates, and fish during April, July, and November (table 12). Fish samples also were collected from the San Juan River at Bluff (site SJ2) in July 1990, and from McPhee Reservoir (site MP).

Table 11. Sampling sites and type of samples collected for the reconnaissance investigation during 1990

[MVIC, Montezuma Valley Irrigation Company; X, sampled for the reconnaissance investigation; --, not sampled]

Site number (figs. 1, 2)	Site name	Water		Bottom Sediment		Biota	
		Inorganic	Pesticides	Inorganic	Pesticides	Inorganic	Pesticides
			MVIC AREA				
ME1	Mc Elmo Creek at Highway 160, near Cortez	X	--	--	--	X	--
ME2	Mc Elmo Creek downstream from Alkali Canyon	X	X	X	X	X	X
ME3	Mc Elmo Creek upstream from Yellow Jacket Canyon	X	--	X	X	X	--
ME4	Mc Elmo Creek downstream from Yellow Jacket Canyon	X	X	X	X	X	X
DT	Dolores Tunnel outflow	X	--	--	--	--	--
GD	Great Cut Dike outflow	X	--	--	--	--	--
MP	McPhee Reservoir	--	--	--	--	X	--
SU	Summit Reservoir	X	X	X	X	X	--
PU	Puett Reservoir	X	--	X	X	X	--
TT	Totten Reservoir	X	X	X	X	X	X
LP	Leighton Pond	--	--	--	--	X	X
SD	Simon Draw downstream from Cash Canyon	X	X	X	X	X	--
HD1	Hartman Draw near Lebanon	X	--	--	--	X	--
HD2	Hartman Draw near mouth, at Cortez	X	X	X	X	X	X
AK	Alkali Canyon downstream from Narraguinnep Canyon	X	X	X	X	X	X
DD	Dawson Draw near Lewis	X	X	X	X	X	X
YJ2	Yellow Jacket Canyon at mouth	X	X	X	X	X	--
NW	Navajo Wash near Towaoc	X	X	X	X	X	--
			DOVE CREEK AREA				
YJ1	Tributary of Yellow Jacket Canyon at Highway 666	X	--	--	--	X	--
WC	Woods Canyon near Yellow Jacket	X	--	X	X	X	--
CH	Cahone Canyon at Highway 666	X	X	X	X	X	--
CR	Cross Canyon upstream from Alkali Canyon	X	--	X	X	X	--
AKP	Pond in Alkali Canyon, in Cross Canyon basin	--	--	--	--	X	X
OW1	Observation well 7.5 miles west of Pleasant View	X	--	--	--	--	--
OW2	Observation well 2.5 miles southeast of Cahone	X	--	--	--	--	--
OW3	Observation well 3.2 miles west of Yellow Jacket	X	--	--	--	--	--
			MANCOS AND SAN JUAN RIVERS				
MN1	Mancos River at Highway 666	X	--	--	--	X	--
MN2	Mancos River at Colorado-New Mexico State line	X	X	X	X	X	X
SJ1	San Juan River at Four Corners	X	X	X	X	X	--
SJ2	San Juan River near Bluff, Utah	--	--	--	--	X	--
SJ3	San Juan River at Mexican Hat, Utah	X	X	X	X	X	--
GW	Seep area along San Juan River at Aneth, Utah	X	--	--	--	--	--

Table 12. Collection schedule of water, bottom-sediment, and biota samples for the reconnaissance investigation during 1990

Sample medium and type of analysis	Months in which samples were collected
Streams, inorganic	March, April, July, November
Reservoirs, inorganic	April, November
Streams and reservoirs, pesticides	July
McPhee Reservoir outflow, inorganic	May, August
Bottom sediment, inorganic	November
Bottom sediment, pesticides	November
Fish, streams, inorganic	April, July, November
Fish, reservoirs, inorganic	April, May, June, November
Fish, pesticides	June, July
Aquatic plants, inorganic	April, July, November
Aquatic invertebrates, inorganic	April, July, November
Birds, inorganic	May, July
Birds, pesticides	May, July
Eggs, inorganic	May, July
Eggs, pesticides	May, July

Aquatic plants collected were algae, coontail, sago pondweed, horned pondweed, and watercress. Aquatic-invertebrate species collected were crayfish, snails, aquatic insects, and zooplankton. Fish species collected included: rainbow trout, kokanee salmon, northern pike, channel catfish, walleye, largemouth bass, smallmouth bass, yellow perch, black crappie, green sunfish, flannelmouth suckers, white suckers, bluehead suckers, common carp, roundtail chubs, bluegill, speckled dace, red shiners, and fathead minnows.

Bird samples were collected at Totten Reservoir (site TT), Leighton Pond (site LP), Dawson Draw (site DD), a pond in Woods Canyon (site WC), and a pond in Alkali Canyon (site AKP, in the Cross Canyon drainage basin). Birds and eggs were collected during May and July in 1990 (table 12). Bird species collected during the reconnaissance investigation were: mallard, red-winged blackbird, yellow-headed blackbird, American coot, sora rail, and pied-billed grebe. The sampling period was selected based on availability of pre-fledgling birds and bird eggs. Because pre-fledglings generally are confined to a given locale until they fledge, trace elements and pesticides in their tissue may be obtained from food and water in the area where the birds are reared, although females can pass some trace elements and organochlorine pesticides to eggs. An attempt was made to collect pre-fledglings immediately before fledging because older birds would be exposed to contaminants present in the area for a longer period than younger birds. These bird collections were not always possible because of time limitations in the sampling effort and because of considerable predatory activity 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 of eggs in the Dolores Project area. 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

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

Water-quality samples were collected at stream sites using depth-integrating samplers and methods described by Ward and Harr (1990). Where stream depths were too shallow to use samplers, representative water samples were collected from the centroid of flow or from several verticals across the stream using sample-collection bottles. Water samples for pesticides were collected from the centroid of flow when possible, using sample bottles furnished by the National Water Quality Laboratory of the U.S. Geological Survey. Water samples from reservoirs were collected using a Van Dorn sampler. Ground-water samples were collected using a bailer.

The availability of fine bottom sediment at many stream sites was limited to pools or backwater areas. Bottom-sediment samples were collected from areas of deposition using a BMH-53 sampler (Edwards and Glysson, 1988), and were composited in a stainless-steel bucket using a stainless-steel spoon. Bottom sediment in reservoirs was collected using an Ekman grab sampler (Britton and Greeson, 1988). Bottom-sediment samples were composited in the bucket, and subsamples were taken for inorganic and pesticide analyses.

Quality-assurance samples were collected for water and bottom-sediment sampling. Water samples analyzed for quality assurance (all collected in the field) included six deionized water blanks, three sequential duplicate samples, and three split samples. The quality-assurance water samples were analyzed for the inorganic constituents in water listed in table 10. Bottom-sediment samples analyzed for quality assurance included one duplicate sample, one split sample, and a soil sample used as an internal standard by the laboratory. The bottom-sediment samples were analyzed for the inorganic constituents listed in table 10.

Biological samples were collected by the U.S. Fish and Wildlife Service using standard equipment and techniques (U.S. Fish and Wildlife Service, 1986, 1990). 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 stored in a freezer. Whole-body samples were composited by species into groups of three or more fish as directed by the DOI sampling protocol. Fillet and egg samples were taken from individual fish and were not composited. Fish for analysis of inorganic contaminants were frozen in plastic bags. Fish samples for analysis of organic compounds were wrapped in aluminum foil and placed in plastic bags.

Vascular plants and algae were collected by handpicking. These samples were placed in chemically cleansed jars, weighed, and frozen. Algae samples probably contained green algae (Chlorophyta) and blue-green algae (Cyanophyta), and plankton samples consisted of phytoplankton and zooplankton. Stream invertebrates were collected using a kick screen, and lake plankton samples were collected using a plankton tow. Several easily identifiable invertebrate groups were combined to obtain sufficient biomass for analysis. Crayfish were collected when present.

Birds were shot using steel shot, and livers were removed using stainless-steel dissecting equipment. Based on the literature (Ohlendorf, 1993), 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 with water and soap and rinsed with distilled water and benzene prior to removal of each liver. Bird livers and muscle tissue were placed in chemically cleansed jars, weighed, and frozen. Livers from each bird group were sometimes composited, which resulted in two or three livers constituting one sample.

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

Analytical Support

Analyses of water samples for major constituents and trace elements, except uranium, were done by the U.S. Geological Survey National Water Quality Laboratory in Arvada, Colorado. Analytical methods are described in Fishman and Friedman (1989) and laboratory quality-assurance methods are described in Jones (1987). Analysis for uranium was done using a method described in Thatcher and others (1977) by a private laboratory contracted by the U.S. Geological Survey. Analysis for pesticides in water and bottom-sediment samples (table 10) was done by the National Water Quality Laboratory, using methods described by Wershaw and others (1987).

Bottom-sediment samples were analyzed for trace elements by the U.S. Geological Survey 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 (1991).

Biological samples were analyzed by Hazelton Laboratories America, Inc., in Madison, Wisconsin, and by the Environmental Trace Substances Research Center in Columbia, Missouri. These laboratories were contracted by the U.S. Fish and Wildlife Service Patuxent Analytical Control Facility in Laurel, Maryland. Biological samples were analyzed for the constituents listed in table 10. Analyses for most trace elements in biota samples were done using inductively coupled argon-plasma atomic-absorption spectrometry after complete digestion of the sample by strong acids. Analysis for arsenic and selenium in biota samples was done using hydride-generation atomic-absorption spectrometry, and analysis for mercury was done using flameless cold-vapor atomic-absorption spectrometry. Analysis for pesticide residues in biota samples consisted of solvent extraction and electron-capture gas chromatography.

DISCUSSION OF RESULTS

Water Quality

Inorganic data collected for the reconnaissance investigation of the Dolores Project area are listed in table 22. Pesticide data for water samples are listed in table 23. Tables 22 and 23 are in the "Supplemental Data" section at the back of the report.

Guidelines for Interpretation of Water-Quality Data

Water-quality data collected in the Dolores Project area during 1990 were compared to U.S. Environmental Protection Agency drinking-water regulations (U.S. Environmental Protection Agency, 1988a,b, 1991) and aquatic-life criteria (U.S. Environmental Protection Agency, 1986, 1987). Water-quality data also were compared to Colorado agricultural-use criteria (Colorado Department of Health, 1989). The comparisons were used to determine if constituent concentrations in water samples may adversely affect the suitability of water for domestic use, have adverse effects on aquatic life, or affect the suitability of the water for agricultural use. Drinking-water regulations (table 13) that are a maximum contaminant level (MCL) are legally enforceable; regulations that are a secondary maximum contaminant level (SMCL) are advisory recommendations and are not legally enforceable.

Aquatic-life criteria (table 13) of the U.S. Environmental Protection Agency were established to protect aquatic organisms from chronic or acute effects from exposure to potentially toxic trace elements. Chronic criteria are for protection of aquatic organisms from adverse effects, such as reproductive problems or decreased growth caused by long-term exposure to the trace element. Acute criteria are for protection of aquatic organisms from lethal effects and are based on toxicity data. The agricultural-use criteria (table 13) apply to water in Colorado that is used or considered suitable for irrigation of crops grown in Colorado and

Table 13. Drinking-water regulations and aquatic-life criteria of the U.S. Environmental Protection Agency and agricultural-use criteria of the State of Colorado

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

Constituent	Drinking-water regulations		Aquatic-life criteria[4]		Agricultural-use criteria[6]
	MCL[1,2]	SMCL[3]	Chronic	Acute	
Sulfate (mg/L)	--	250	--	--	--
Chloride (mg/L)	--	250	--	--	--
Dissolved solids (mg/L)	--	500	--	--	--
Nitrate (mg/L)	10	--	--	--	100
Arsenic (µg/L)	50	--	190	360	100
Boron (µg/L)	--	--	--	--	750
Cadmium (µg/L)	5	--	[a]4	[a]24	10
Chromium (µg/L)	100	--	11	16	100
Copper (µg/L)	--	1,000	[a]47	[a]81	200
Lead (µg/L)	50	--	[a]25	[a]633	100
Mercury (µg/L)	2	--	.012	2.4	--
Selenium (µg/L)	50	--	[5]5	[5]20	20
Zinc (µg/L)	--	5,000	[a]414	[a]458	2,000

[a]Criteria are based on water hardness. Values were computed using a water hardness of 500 milligrams per liter.

References are indicated by the following numbers:

[1]U.S. Environmental Protection Agency, 1988a (MCL for nitrate, arsenic, lead, and mercury).

[2]U.S. Environmental Protection Agency, 1991 (MCL for cadmium, chromium, and selenium).

[3]U.S. Environmental Protection Agency, 1988b.

[4]U.S. Environmental Protection Agency, 1986.

[5]U.S. Environmental Protection Agency, 1987.

[6]Colorado Department of Health, 1989.

that is not hazardous as drinking water for livestock (Colorado Department of Health, 1989). Three of the water-quality sites are located in Utah (sites ME4, SJ3, and GW); however, the Colorado agricultural-use criteria were used for comparison to the water-quality data collected in Utah for the reconnaissance investigation. Except for selenium, the agricultural-use criteria for Utah (Utah Department of Health, 1988) are the same as those listed in table 13. The selenium criterion for agricultural use in Utah is 50 μg/L (Utah Department of Health, 1988) instead of 20 μg/L; that difference in the selenium criterion did not affect interpretation of results.

The number of water samples collected in the Dolores Project area that had constituent concentrations exceeding the various guidelines are summarized in table 14. The aquatic-life criteria for cadmium, copper, lead, and zinc (table 13) were computed using equations based on water hardness. A water hardness of 500 mg/L was used to compute the aquatic-life criteria listed in table 13 for those four trace elements. The water hardness of individual samples, which ranged from 52 to 3,200 mg/L (table 22), was used for determination of the number of samples listed in table 14 that exceeded aquatic-life criteria.

Many streams in Colorado have been classified by the State according to various beneficial-use categories and include domestic use, recreational use, protection of aquatic life, and agricultural use (Colorado Department of Health, 1989). The State adopted the drinking-water regulations and aquatic-life criteria of the U.S. Environmental Protection Agency to develop State water-quality standards. However, not all streams in Colorado have State numeric standards for trace elements because of the use classifications assigned to the stream or because the standards have not been determined. In the Dolores Project area, only

Table 14. Number of water samples collected in the Dolores Project area that had constituent concentrations exceeding drinking-water regulations and aquatic-life criteria of the U.S. Environmental Protection Agency and exceeded agricultural-use criteria of the State of Colorado

[MCL, maximum contaminant level; SMCL, secondary maximum contaminant level; number of samples is 79; --, no applicable regulation or criterion]

Constituent	Drinking-water regulations		Aquatic-life criteria		Agricultural use
	MCL	SMCL	Chronic	Acute	
Sulfate	--	58	--	--	--
Chloride	--	6	--	--	--
Dissolved solids	--	63	--	--	--
Nitrate[1]	2	--	--	--	0
Arsenic	0	--	0	0	0
Boron	--	--	--	--	0
Cadmium	0	--	[2]2	0	0
Chromium	0	--	0	0	0
Copper	--	0	0	0	0
Lead	0	--	0	0	0
Mercury	0	--	[3]11	0	--
Selenium	1	--	19	1	1
Zinc	--	0	0	0	0

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

[2]The chronic criterion for cadmium for three samples from Summit Reservoir was less than the analytical reporting limit of 1 microgram per liter for cadmium.

[3]Number of samples that exceeded criterion may be greater; the reporting limit for mercury was 0.1 microgram per liter; the chronic criterion for mercury was 0.012 microgram per liter.

Mc Elmo Creek, the Mancos River, and the San Juan River have State water-quality standards for trace elements (Colorado Department of Health, 1986). Therefore, readers are advised that the information in table 14 used for evaluation of the water-quality data was not based on the State stream-classification system.

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

Dissolved Solids and Major Constituents

The water samples collected in the Dolores Project area were characterized by large dissolved-solids and sulfate concentrations compared to drinking-water regulations (tables 13 and 14). Concentrations in many samples exceeded the secondary maximum contaminant level (SMCL) for dissolved solids and sulfate (table 14). Samples that exceeded the SMCL's were collected at sites in the long-term irrigated area of the MVIC, in newly irrigated areas, and in non-irrigated areas. Only 16 of 79 water samples had dissolved-solids concentrations less than 500 mg/L; those samples were collected at the two outflow sites from McPhee Reservoir (sites GD and DT), Summit, Puett, and Totten Reservoirs (sites SU, PU, and TT), and the San Juan River at Four Corners (site SJ1 in table 22).

Most samples collected from streams in the MVIC area had dissolved-solids concentrations greater than 1,000 mg/L, and all samples collected in the MVIC area during the pre-irrigation season (late March and April) in 1990 had concentrations greater than 1,500 mg/L except for the sample from Yellow Jacket Canyon at the mouth (site YJ2 in table 22). Almost all samples collected at sites in irrigated areas of the MVIC had dissolved-solids and sulfate concentrations exceeding the SMCL for those constituents. The concentration of nitrite plus nitrate as nitrogen (17.0 mg/L) in the sample collected at Navajo Wash (site NW) in March exceeded the MCL for nitrate of 10 mg/L (table 13). None of the streams or reservoirs in the MVIC area where drinking-water regulations were exceeded are used for municipal or domestic water supplies.

The maximum dissolved-solids concentration in a water sample collected downstream from irrigation drainage was 5,850 mg/L in the sample collected in March from Navajo Wash (site NW) (table 22). Water in Navajo Wash in March probably was irrigation drainage from gray (Mancos) soils in the southern MVIC area. Irrigation drainage from MVIC areas north of Mc Elmo Creek into Hartman Draw (sites HD1 and HD2), Alkali Canyon (site AK), Dawson Draw (site DD), and lower Yellow Jacket Canyon (site YJ2) had smaller dissolved-solids concentrations than Navajo Wash in the samples collected in the pre-irrigation season. The irrigated areas north of Mc Elmo Creek have more red soil than areas south of the creek, and red soils have less salt than gray soils (Bureau of Reclamation, 1988). Water samples from reference sites on Mc Elmo Creek at Highway 160 (site ME1) and Simon Draw (site SD) had dissolved-solids concentrations similar to dissolved-solids concentrations in streams draining irrigated land in the MVIC service area. However, stream discharge at sites ME1 and SD was considerably less than in the streams draining irrigated areas, and consequently, dissolved-solids loads were much less at reference sites than at sites downstream from irrigated areas.

Dissolved-solids concentrations in irrigation drain water diverted from McPhee Reservoir were about 160 mg/L based on samples collected in May and in August from the Dolores Tunnel (site DT) and Great Cut Dike (site GD) (table 22). This concentration is much less than the dissolved-solids concentrations in Mc Elmo Creek and other streams draining the MVIC area, indicating a substantial increase of dissolved-solids concentration in irrigation drain water. Water samples collected from the Dolores Tunnel and the Great Cut Dike were a calcium bicarbonate type (assuming most of the alkalinity was bicarbonate at the pH of the samples); water samples from Mc Elmo Creek and tributary streams were a mixed cation sulfate type.

In the Dove Creek area (newly irrigated areas between Yellow Jacket Canyon and the town of Dove Creek), water samples collected from a small tributary of upper Yellow Jacket Canyon (site YJ1), Woods Canyon (site WC), and Cahone Canyon (site CH) probably consisted of irrigation drainage from newly irrigated areas (since 1987). No sample was collected at site WC in July because there was no flow at this site, although there was irrigation in the drainage basin upstream from the site. In 1990, there was no irrigation upstream from site CR in Cross Canyon; therefore, site CR was a reference site for the Dove Creek area. On October 30, 1990, water samples were collected from three shallow observation wells (sites OW1, OW2, and OW3) that were used by the Bureau of Reclamation to monitor ground-water levels.

Concentrations of dissolved solids and sulfate exceeded drinking-water regulations (table 13) in all samples collected at stream sites in the Dove Creek area (table 22); however, none of these streams are used for domestic water supplies. The seasonal variation of dissolved-solids concentrations (table 22) in upper Yellow Jacket Canyon (site YJ1) and Cahone Canyon (site CH) are indicative of irrigation effects. The lack of seasonal variation of dissolved-solids and major-ion concentrations in Cross Canyon (site CR) (table 22) indicates that the water at site CR in 1990 probably was natural ground-water discharge. Although dissolved-solids concentrations in the irrigation drainage from the Dove Creek area are similar to the concentrations in drainage in the MVIC area, the stream discharges, and subsequently the dissolved-solids loads, are much smaller in the Dove Creek area than in the MVIC area (table 22). As more land is brought into irrigation, the amount of irrigation return flow and drainage probably will increase in the Dove Creek area.

Sulfate comprised a large percentage of the anion composition of samples collected in the Dove Creek area, but the cation composition varied. The cation composition primarily was calcium in the tributary of Yellow Jacket Canyon, mixed calcium and magnesium in Woods Canyon, and magnesium in Cahone Canyon.

Dissolved-solids and major-ion concentrations in samples from three observation wells (sites OW1, OW2, and OW3) in the Dove Creek area were variable. Site OW1 is located in a tributary drainage of Cross Canyon in an area where irrigation began in the summer of 1990. The sample from site OW1 had less dissolved solids than other samples from the Dove Creek area. Site OW2 is located in the Cahone Canyon drainage upstream from site CH (fig. 1), and the dissolved-solids concentration and water composition for water samples collected in the fall of 1990 at sites OW2 and CH were similar (table 22). Site OW3 is in a tributary drainage of Sandstone Canyon and is located about 2.5 mi northeast of site WC. Concentrations of dissolved solids and major ions in samples collected in the fall of 1990 at sites OW3 and WC were about equal (table 22).

Monthly measurements of water levels during 1990–91 (J.P. Alcon, Bureau of Reclamation, written commun., 1992) in the three sampled observation wells are shown in figure 7. The rise in water levels in well OW1 in 1991 compared to 1990 was caused by increased irrigation of nearby land in 1991. The water levels in wells OW2 and OW3 did not change substantially until after the spring of 1991, when the water level in both wells decreased about 3 ft by September (fig. 7).

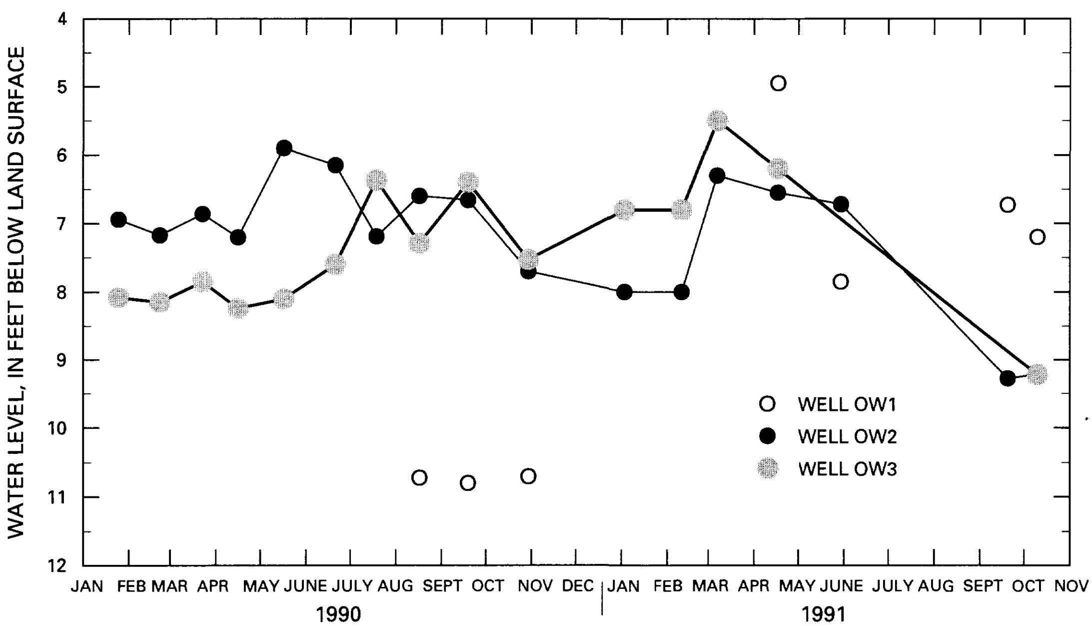

Figure 7. Water-level measurements for wells OW1, OW2, and OW3, January 1990–October 1991.

Dissolved-solids and sulfate concentrations in all samples from the Mancos River (sites MN1 and MN2 in table 22) exceeded the SMCL for those constituents (table 13). The lower Mancos River is not used for water supplies. Dissolved-solids concentrations in the Mancos River were greater than 1,000 mg/L, and water samples were a mixed cation sulfate water type. The washes draining land to be irrigated in the Towaoc area had no flow during the reconnaissance investigation in 1990.

The dissolved-solids and sulfate concentrations in the sample collected in July from the San Juan River at Four Corners (site SJ1) exceeded the SMCL (table 13) for those constituents. Dissolved-solids concentrations in the three samples collected from the San Juan River at Mexican Hat (site SJ3 in table 22) exceeded the SMCL for dissolved solids, and the sulfate concentrations in the three samples equaled or exceeded the SMCL for sulfate. The San Juan River is used for water supplies for the small towns of Aneth, Montezuma Creek, Bluff, and Mexican Hat in Utah (fig. 2).

The water samples collected from the San Juan River were a calcium sodium sulfate type, and most constituent concentrations were slightly greater at Mexican Hat (site SJ3) than at Four Corners (site SJ1). The gain in dissolved-solids load of 2,040 tons/d between sites SJ1 and SJ3 on July 17 (table 22) primarily was caused by inflow from Mc Elmo Creek (site ME4, table 22), which consisted of irrigation return flow from the MVIC area and runoff caused by thunderstorms. The Mancos River also may contribute large quantities of dissolved solids to the San Juan River. The confluence of the Mancos and San Juan Rivers is about 3 mi upstream from site SJ1, and site MN2 on the Mancos River is about 2 mi upstream from the confluence (fig. 1). For the samples collected on July 17, the dissolved-solids load at site MN2 accounted for about 14 percent of the dissolved-solids load at site SJ1, and for samples collected on November 6 and 7, the dissolved-solids load at site MN2 accounted for about 10 percent of the load at site SJ1. The three water samples collected from the seep area at Aneth, Utah (site GW in table 22) had dissolved-solids concentrations that ranged from 8,210 to 8,730 mg/L, and about 75 percent of the dissolved solids was comprised of sodium chloride. Data for site GW indicate that ground water could be a source of dissolved solids and other constituents to the San Juan River downstream from the Dolores Project.

Trace Elements

Many trace-element concentrations in samples collected from the Dolores Project area (table 22) were equal to or less than analytical reporting limits. A statistical summary of trace-element data is listed in table 15. The only trace-element concentrations that exceeded the drinking-water regulations or aquatic-life criteria of the U.S. Environmental Protection Agency or the Colorado agricultural-use criteria (table 13) were cadmium, mercury, and selenium (table 14).

Table 15. Statistical summary of trace-element concentrations in water samples collected in the Dolores Project area in 1990

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

Trace element	Number of samples	Number of detections	Median	Maximum	Minimum
Arsenic	79	41	1	12	<1
Boron	79	75	110	720	<10
Cadmium	79	19	<1	4	<1
Chromium	79	22	<1	4	<1
Copper	79	72	1	15	<1
Lead	79	9	<1	3	<1
Mercury	79	11	<1	1.2	<.1
Molybdenum	79	50	1	16	<1
Selenium	79	36	<1	88	<1
Vanadium	79	60	2	48	<1
Zinc	79	46	4	35	<3
Uranium	77	66	5.0	45	<1.0

Cadmium

Cadmium was detected (reporting limit 1 µg/L) in 19 samples (table 15) collected at 16 sites; however, only two concentrations of cadmium exceeded the chronic criterion for aquatic life based on water hardness of individual samples. The cadmium concentration of 2 µg/L in the near-surface sample collected in November from Summit Reservoir (site SU, table 22) exceeded the hardness-based criterion of about 1 µg/L for that sample. The cadmium concentration of 4 µg/L in the near-bottom sample collected in November from Puett Reservoir (site PU) exceeded the hardness-based criterion of about 2 μg/L for that sample. Summit and Puett Reservoirs are reference sites located outside the MVIC area. Cadmium was detected in at least one water sample from most of the sites within the MVIC service area and in three of the six water samples collected from the San Juan River. The only part of the Dolores Project area where cadmium was not detected in water samples was the Dove Creek area. Mine drainage in the upper Dolores River basin may have been a potential source of cadmium in the irrigation water diverted from the Dolores River basin.

Mercury

Mercury was detected (reporting limit 0.1 μg/L) in 11 water samples (table 15) collected at 9 sites in the Dolores Project area during 1990 at concentrations ranging from 0.1 to 1.2 μg/L (table 22). The maximum mercury concentration of 1.2 μg/L was in the sample collected in July from the seep area along the San Juan River at Aneth, Utah (site GW) (table 22). All samples in which mercury was detected exceeded the chronic criterion for mercury (0.012 μg/L); however, mercury concentrations reported as less than 0.1 μg/L (table 22) cannot be compared to the chronic criterion because 0.1 μg/L is greater than the criterion concentration. In the newly irrigated areas, mercury was detected in one sample from Cahone Canyon and in the samples from wells OW2 and OW3. Six of the 11 samples in which mercury was detected were collected at reference sites, which are outside irrigated areas of the Dolores Project. Mercury was not detected in the outflow from McPhee Reservoir (sites DT and GD) nor was mercury detected in samples from the San Juan River.

The mercury data collected for the reconnaissance investigation represent the dissolved mercury in water because the samples were filtered through 0.45 μm filters prior to analysis. Mercury concentrations in unfiltered water samples can be greater than the concentrations in filtered samples because fluvial transport of some trace elements, including mercury, is dominated by the suspended-sediment phase (Hem, 1985; Horowitz, 1991). Although dissolved mercury was not detected in outflow from McPhee Reservoir (four samples), mercury transport into the Dolores Project area could occur on the suspended sediment in the water. As with cadmium, the mined areas in the upper Dolores River basin could be a source of mercury to the Dolores River and, subsequently, to the irrigation water diverted into the Dolores Project area.

Selenium

Selenium was detected (reporting limit 1 μg/L) in 36 water samples (table 15) collected at 15 sites. Selenium concentrations in water samples collected at stream sites in 1990 are plotted in figures 8 and 9. The

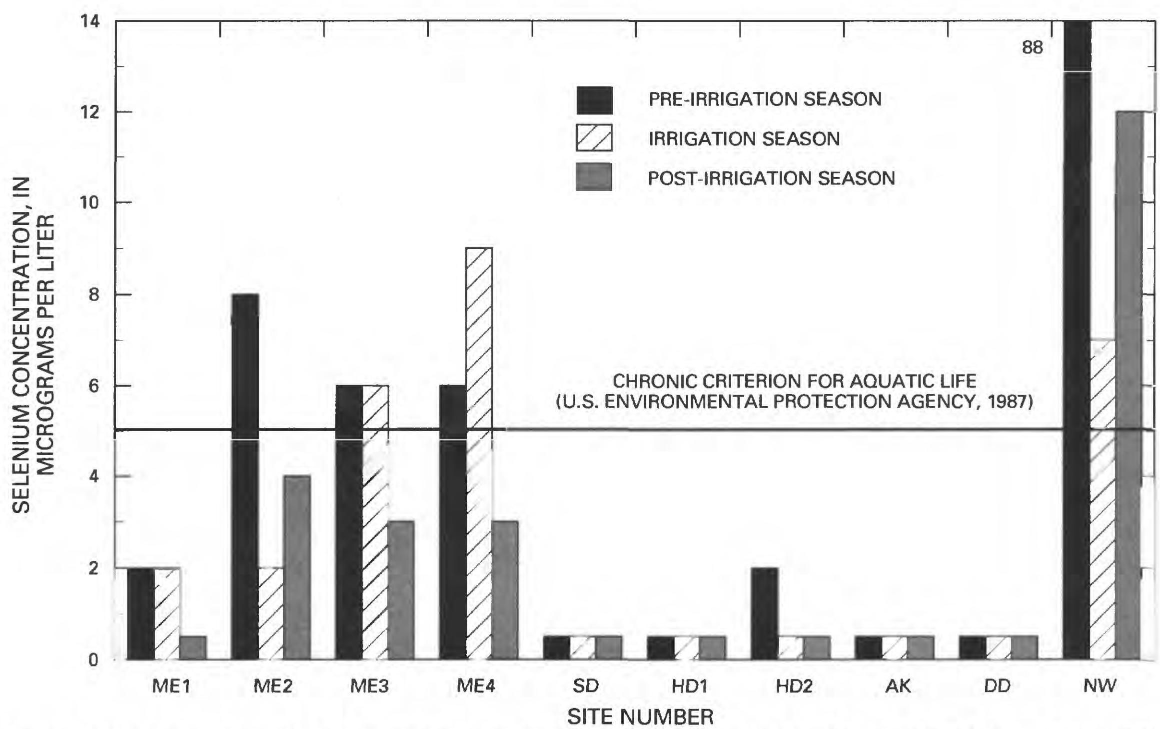

Figure 8. Concentrations of selenium in surface-water samples from Mc Elmo Creek (ME), Simon Draw (SD), Hartman Draw (HD), Alkali Canyon (AK), Dawson Draw (DD), and Navajo Wash (NW) in 1990. (Concentrations plotted as 0.5 were reported as less than 1 microgram per liter.)

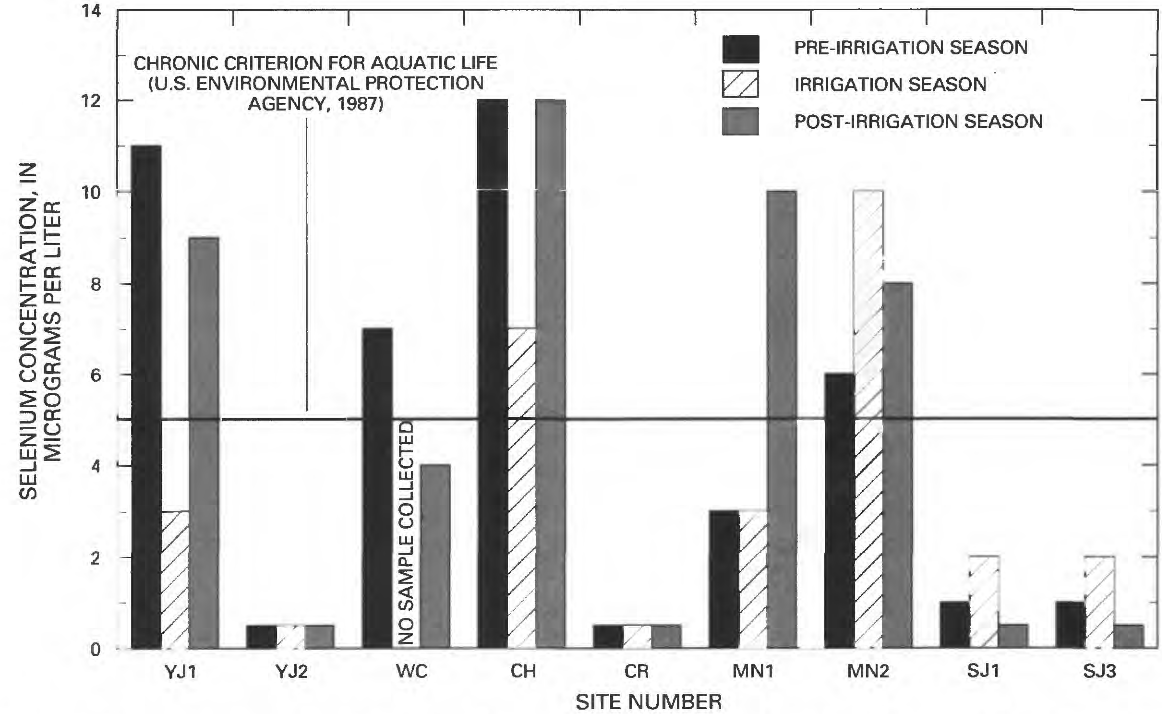

Figure 9. Concentrations of selenium in surface-water samples from Yellow Jacket Canyon (YJ), Woods Canyon (WC), Cahone Canyon (CH), Cross Canyon (CR), the Mancos River (MN), and the San Juan River (SJ) in 1990. (Concentrations plotted as 0.5 were reported as less than 1 microgram per liter.)

samples plotted for the pre-irrigation season were collected in late March and early April, samples for the irrigation season were collected in July, and samples for the post-irrigation season were collected in November. Only one selenium concentration was greater than 1 μg/L in the samples collected from outflow from McPhee Reservoir (sites DT and GD), from reservoirs (sites SU, PU, and TT), or at ground-water sites (sites OW1, OW2, OW3, and GW). That one sample was collected at site OW1 and had a selenium concentration of 7 μg/L (table 22). Therefore, selenium concentrations for those nine sites were not plotted.

The only selenium concentration in a water sample from the Dolores Project area that exceeded the MCL for selenium (50 μg/L) was 88 μg/L in a sample collected in March 1990 from Navajo Wash (site NW) (fig. 8). Navajo Wash is not used for domestic water supplies. The selenium concentration in 18 water samples from streams (figs. 8 and 9) and in the sample from well OW1 (table 22) exceeded the chronic aquatic-life criterion of 5 μg/L. Lemly and Smith (1987) reported that selenium concentrations greater than 2 to 5 μg/L in water may cause reproductive failure or mortality in fish and waterfowl because of food-chain bioaccumulation. The selenium concentration in the sample collected in March at site NW also was the only concentration that exceeded the acute aquatic-life criterion and the agricultural-use criterion of 20 μg/L.

Selenium was detected in all samples from Mc Elmo Creek that were collected within or downstream from the MVIC area (sites ME2, ME3, and ME4) at concentrations that ranged from 2 to 9 μg/L (fig. 8). Concentrations of selenium in 5 of the 10 samples collected at sites ME2, ME3, and ME4 (table 22) exceeded the chronic aquatic-life criterion. Based on selenium-load calculations using the stream-discharge and selenium data for Mc Elmo Creek, almost all the selenium in Mc Elmo Creek came from areas downstream from site ME1. Irrigation water from McPhee Reservoir (sites DT and GD) had selenium concentrations less than 1 μg/L (table 22).

There were distinct differences in selenium concentrations in tributary streams that drain the MVIC area. Selenium concentrations in samples from Navajo Wash (site NW) (fig. 8) were much larger than the concentrations in samples from Hartman Draw (sites HD1 and HD2), Alkali Canyon (site AK), Dawson Draw (site DD), and lower Yellow Jacket Canyon (site YJ2) (figs. 8 and 9). Selenium was detected in only 1 of the 15 samples collected from the sites on tributaries draining MVIC areas north of Mc Elmo Creek. The sample collected in the pre-irrigation season from Hartman

Draw near the mouth (site HD2) had 2 µg/L of selenium. Navajo Wash drains irrigated areas on gray (Mancos) soils south of Cortez; the streams north of Mc Elmo Creek drain irrigated areas on red soils or mixed red and gray soils. If selenium concentrations in Navajo Wash are typical of selenium concentrations in irrigation drainwater from gray-soil areas south of Mc Elmo Creek, then irrigation drainage from gray-soil areas may be the primary source of selenium to Mc Elmo Creek.

In contrast to the northern MVIC area, selenium was detected (range of concentrations 3 to 12 µg/L) in all samples from the Dove Creek area that were collected from upper Yellow Jacket Canyon (site YJ1), Woods Canyon (site WC), and Cahone Canyon (site CH) (fig. 9 and table 22). Those three sites are downstream from newly irrigated areas (since 1987). The selenium concentration in six of the eight samples from sites YJ1, WC, and CH exceeded the chronic aquatic-life criterion of 5 µg/L. Water samples collected at the three sites during the pre- and post-irrigation seasons probably were comprised of shallow irrigation drainage from newly irrigated areas. There was a small amount of surface return flow in Cahone Canyon at site CH in July. Stream discharges measured at sites YJ1, WC, and CH were less than 0.25 ft^3/s; consequently, selenium loads in the newly irrigated areas were very small. Selenium was not detected in samples from Cross Canyon (site CR), the reference site for the Dove Creek area (fig. 9).

Irrigated land is on red soils throughout the Dove Creek area. Possibly, the long-term irrigation and the high application rates may have leached most of the soluble selenium from soils in the northern MVIC area, but in the Dove Creek area, the soluble selenium has not been leached from the soil. Selenium analyses have not been done on red soils from the Dove Creek area; however, the Bureau of Reclamation collected selenium data for red soils in the western part of the Towaoc area. Selenium concentrations in these soil samples ranged from 0.1 to 0.6 µg/g, indicating that there is some selenium in red soils that have never been irrigated. The selenium concentrations in the water samples collected in 1990 at sites YJ1, WC, and CH may be indicative of selenium concentrations in irrigation drainage from red soils under initial leaching conditions.

The Mancos River drains extensive areas of Mancos Shale. Selenium in water samples from the Mancos River ranged from 3 to 10 µg/L (sites MN1 and MN2 in fig. 9 and table 22). Selenium sources in the Mancos River basin include irrigation drainage from the Mancos Project, located upstream from the Dolores Project; irrigation drainage from the MVIC area discharging from Navajo Wash; and natural sources. Despite low stream discharge during 1990, selenium concentrations in the San Juan River (sites SJ1 and SJ3) did not exceed 2 µg/L (fig. 9). Because selenium concentrations at sites SJ1 and SJ3 were equal for the three sampling surveys in 1990, outflow from the Dolores Project area did not have a measurable effect on selenium concentrations in water in the San Juan River.

Other trace elements

The only samples that had arsenic concentrations greater than 3 µg/L were collected at the ground-water site at Aneth, Utah (site GW); concentrations were 11 and 12 µg/L (table 22). Water at site GW discharges into the San Juan River. The maximum boron concentration of 720 µg/L (table 15) was in the sample collected from Navajo Wash during the pre-irrigation season. That sample also had the maximum selenium concentration. Boron concentrations in Mc Elmo Creek downstream from the MVIC area (sites ME2, ME3, and ME4) ranged from 110 to 260 µg/L, compared to boron concentrations equal to or less than 20 µg/L in irrigation water from McPhee Reservoir (sites DT and GD; table 22). Analogous to dissolved solids and selenium, irrigation drainage from the MVIC area apparently is a source of boron to Mc Elmo Creek. Copper concentrations did not exceed water-quality guidelines (table 14). The maximum copper concentration of 15 µg/L (table 15) was in the sample collected in July 1990 from the San Juan River at Four Corners (site SJ1). Thunderstorm runoff upstream from site SJ1 may have been the source of copper. Thunderstorm runoff also may have been the cause of the slightly larger molybdenum concentrations in Mc Elmo Creek at sites ME3 and ME4 in July (table 22).

The largest vanadium concentrations were in samples of ground water from reference sites, site GW at Aneth, Utah, and site CR in Cross Canyon. The maximum vanadium concentration of 48 µg/L (table 15) was in the sample collected at site GW in November 1990 (table 22). There were distinct seasonal differences of vanadium concentrations in stream samples. The median vanadium concentrations were less than 1 µg/L for pre-irrigation-season samples, 6 µg/L for the irrigation-season samples, and 1 µg/L for the post-irrigation-season samples. The maximum uranium concentration of 45 µg/L (table 15) was in the sample collected during the pre-irrigation season from Navajo Wash, the same sample that had the maximum selenium and boron concentrations. However, a number of the larger uranium concentrations were collected at reference sites, such as site ME1 on Mc Elmo Creek and site GW (table 22). There was a weak correlation between selenium and uranium concentrations for water samples collected in irrigated areas; the Spearman correlation coefficient was 0.65.

Pesticides

Fourteen samples collected in the Dolores Project area were analyzed for 6 herbicides (the first six compounds listed in table 23) and 10 organophosphate insecticides. The analytical reporting limit for all the compounds listed in table 23 was 0.01 μg/L. The herbicides 2,4-D and dicamba were detected in most samples, and picloram was detected in five samples. The maximum pesticide concentration was 0.20 μg/L of 2,4-D for the downstream site on the Mancos River (site MN2) (table 23). Only one organophosphate insecticide was detected; malathion was reported at 0.01 μg/L in the sample from the lower site on Hartman Draw (site HD2). The pesticide concentrations in water samples were considerably less than the concentrations that may be harmful to aquatic life.

Bottom Sediment

Bottom-sediment samples were collected at 18 sites for trace-element and pesticide analysis during the reconnaissance investigation. The trace-element analyses for the less than 0.0625-mm size fraction are listed in table 24 and for the less than 2-mm size fraction in table 25. The pesticide analyses are listed in table 26. Tables 24–26 are in the "Supplemental Data" section at the back of the report. A statistical summary of selected trace-element concentrations in bottom sediment is listed in table 16.

Table 16. Statistical summary of selected trace-element concentrations in bottom-sediment samples collected in the Dolores Project area in November 1990

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

Trace element	Median	Maximum	Minimum
LESS THAN 0.0625-MILLIMETER SIZE FRACTION			
Arsenic	4.8	7.8	3.4
Barium	515	1,900	400
Beryllium	1	2	1
Cadmium	<2	<2	<2
Chromium	40	68	29
Copper	19	25	11
Lead	16	20	13
Lithium	34	54	21
Manganese	485	670	290
Mercury	.04	.10	<.02
Molybdenum	<2	6	<2
Nickel	18	30	10
Selenium	.5	4.3	.1
Strontium	240	720	130
Thorium	13.1	21.1	8.7
Uranium	5.0	10.3	3.7
Vanadium	60	140	49
Zinc	60	100	36
LESS THAN 2-MILLIMETER SIZE FRACTION			
Arsenic	4.0	8.5	1.9
Barium	470	1,300	140
Beryllium	1	2	<1
Cadmium	<2	<2	<2
Chromium	24	70	3
Copper	11	28	3
Lead	14	28	7
Lithium	24	61	11
Manganese	390	540	220
Mercury	.02	.08	<.02
Molybdenum	<2	3	<2
Nickel	11	31	2
Selenium	.4	3.6	<.1
Strontium	170	440	64
Thorium	6.0	15.2	1.3
Uranium	2.2	5.0	.74
Vanadium	38	150	10
Zinc	40	110	12

Most trace-element concentrations in samples collected from the Dolores Project area (tables 24 and 25) were not elevated compared to soil-baseline data or bottom-sediment data from previous reconnaissance investigations for the DOI Irrigation Drainage Program (table 17). The bottom-sediment data in table 17 were based on trace-element concentrations in 255 samples collected from 19 areas in the Western United States from 1986–88 (Severson and others, 1991). Trace-element data for bottom sediment in the project area were compared to the data in table 17 to identify outlier concentrations.

Median concentrations in the less than 0.0625-mm size fraction for most of the trace elements in bottom sediment (table 16) were similar to the geometric mean-concentrations for soils in the Western United States (table 17). Median concentrations in the less than 2-mm size fraction for almost all of the trace elements were less than the geometric means for soils.

Table 17. Background geochemical data for soils in the Western United States and the observed range of trace-element concentrations in bottom-sediment samples collected for the U.S. Department of the Interior's Irrigation Drainage Program from 1986–88

[Soil data for Western United States modified from Shacklette and Boerngen (1984); baseline is the 95-percent expected range; bottom-sediment data for the irrigation-drainage reconnaissance studies from Severson and others (1991); coarse fraction is the less than 2-millimeter size fraction; fine fraction is the less than 0.0625-millimeter size fraction; concentrations in micrograms per gram; <, less than; --, not reported]

Trace element	Soils in Western United States			Range of concentrations for bottom-sediment data	
	Geometric mean	Range	Baseline	Fine fraction	Coarse fraction
Arsenic	5.5	<0.1–97	1.4–22	0.6–120	0.6–59
Barium	580	70–5,000	200–1,700	32–2,200	56–1,900
Beryllium	.68	<1–15	.13–3.6	<1.0–3.0	<1.0–3.0
Chromium	41	3–2,000	8.5–200	20–330	1.0–300
Cobalt	7.1	<3–50	1.8–28	4.0–40	2.0–39
Copper	21	2–300	4.9–90	5.0–520	3.0–180
Lead	17	<10–700	5.2–55	<4.0–500	<4.0–250
Lithium	22	5–130	8.8–55	10–220	4.0–200
Manganese	380	30–5,000	97–1,500	66–4,500	80–2,100
Mercury	.046	<.01–4.6	.0085–.25	<.02–18	<.02–20
Molybdenum	.85	<3–7	.18–4.0	<2–73	<2–54
Nickel	15	<5–700	3.4–66	8.0–170	<2–160
Selenium	.23	<.1–4.3	.039–1.4	<.1–85	<.1–120
Strontium	200	10–3,000	43–930	59–1,600	69–1,400
Thorium	9.1	2.4–31	4.1–20	<4.0–47	<4.0–24
Uranium	2.5	.68–7.9	1.2–5.3	--	--
Vanadium	70	7–500	18–270	20–310	5.0–220
Zinc	55	10–2,100	17–180	23–1,600	10–860

One concentration of barium, two concentrations of lithium, and two concentrations of molybdenum (tables 24 and 25) were slightly greater than the upper baseline for soils. Six concentrations of selenium were greater than the upper baseline for soils (1.4 µg/g). The selenium concentrations in both size fractions (tables 24 and 25) in bottom sediment from Cahone Canyon (site CH) and from the downstream site on the Mancos River (site MN2) exceeded 1.4 µg/g. The selenium concentration in the less than 0.0625-mm size fraction (table 24) in bottom sediment from Woods Canyon (site WC) and from Navajo Wash (site NW) exceeded 1.4 µg/g. These four sites also had some of the larger selenium concentrations in water samples. The maximum concentrations of selenium in both size fractions (table 16) were in the sample collected from Cahone Canyon (site CH). There were two concentrations of thorium that exceeded the upper baseline for soils (20 µg/g), and six concentrations of uranium that exceeded the upper baseline for soils (5.3 µg/g); all those concentrations were in samples of the less than 0.0625-size fraction (table 24).

The trace-element data for the Dolores Project area (tables 24 and 25) were compared to the range of trace-element concentrations in bottom sediment collected for previous DOI irrigation-drainage reconnaissance investigations (table 17). The bottom-sediment data in table 24 were compared to the range of concentrations for the fine size fraction listed in table 17, and the data in table 25 were compared to the range of concentrations for the coarse size fraction listed in table 17. Trace-element concentrations in both size fractions in bottom sediment from the Dolores Project area did not exceed maximum concentrations for the previous DOI investigations. The strontium concentration of 64 µg/g in the less than 2-mm size fraction for Hartman Draw near the mouth (site HD2 in table 25) was smaller than the minimum concentration for the coarse size fraction (table 17) reported by Severson and others (1991).

A number of concentrations of chromium, copper, lithium, manganese, nickel, thorium, uranium, vanadium, and zinc were smaller in the less than 2-mm size fraction than in the less than 0.0625-mm size fraction (tables 24 and 25). Some of the largest concentrations of several trace elements in bottom sediment were in samples from the three reservoirs (sites SU, PU, and TT) and the Mancos River (site MN2). Mercury was an element of concern in the Dolores Project area because of possible bioaccumulation through the food chain that could result in undesirable mercury concentrations in game fish. The only sites that had concentrations of mercury exceeding 0.04 µg/g in bottom sediment were Summit Reservoir (site SU) and Puett Reservoir (site PU) (tables 24 and 25).

Six pesticides were detected in bottom-sediment samples collected in the Dolores Project area (table 26). The compounds detected were aldrin, chlordane, DDD, DDE, DDT, and dieldrin. DDE was detected in 10 of the 18 bottom-sediment samples collected in the Dolores Project area. The maximum concentration of a pesticide in bottom sediment was 5.5 µg/kg of DDD in the sample from Summit Reservoir (site SU, table 26), a reference site located outside irrigated areas of the Dolores Project. The largest pesticide concentrations were in samples collected at Summit Reservoir, Totten Reservoir (site TT), and Simon Draw (site SD). Those sites are located in the same general area northeast of Cortez (fig. 1).

Biota

Data Interpretation

Many chemical, physical, and biological factors affect the toxicity of environmental contaminants to biological organisms. Chemical and physical factors include contaminant type, chemical species or form, pH, water temperature, dissolved oxygen, hardness, salinity, and multiple-chemical exposure (antagonism and synergism). Duration of exposure, quantity of contaminant, and exposure pathways from the environment to the organism also affect toxicity. Some trace elements are beneficial to organisms at small concentrations but may be toxic at larger concentrations. Biological and physiological factors affecting toxicity include species, age, sex, and health of the organism. Interpretation of contaminant concentrations in biota is difficult and complex and, in many cases, may not be possible using only data collected in field studies. One of the best methods for interpreting 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. These data can be interpreted by comparison to available literature to determine if constituent concentrations in biota samples exceed concentrations that may be harmful to fish and wildlife or exceed guidelines for human consumption. A frequently used index for interpreting contaminant data for fish samples is the National Contaminant Biomonitoring Program (NCBP) of the U.S. Fish and Wildlife Service. Schmitt and Brumbaugh (1990) reported the 85th-percentile concentrations for arsenic, cadmium, copper, lead, mercury, selenium, and zinc for fish samples collected during 1976–84 throughout the United States. The 85th percentile has been established by NCBP as an arbitrary concentration for distinguishing whole-body fish samples that have relatively large concentrations for the seven trace elements. The 85th percentile is not necessarily an indicator of potential hazards to fishery resources nor can it be used in place of regulatory standards. The NCBP means and percentiles were calculated using combined fish species, and it should be noted that there can be significant differences in selenium accumulation between species (Lemly, 1993). Nevertheless, NCBP data are still useful for comparison purposes. Concentrations listed in Schmitt and Brumbaugh (1990) are wet-weight concentrations; therefore, the dry-weight concentrations listed in table 27 for the seven trace elements were converted to wet-weight concentrations in the text to facilitate comparison to the 85th-percentile concentrations. (Tables 27–29 are in the "Supplemental Data" section at the back of the report). The NCBP also has collected data for organochlorine pesticides (Schmitt and others, 1990).

The NCBP 85th percentile was reported for several years within the sampling period, 1976–84 (Schmitt and Brumbaugh, 1990). The most recent compilation was for fish samples collected during 1984, and the 85th percentiles reported for 1984 are used in this report. Previous DOI reconnaissance investigations used 85th percentiles based on earlier compilation periods. The 85th-percentile concentrations for the seven trace elements and the number of whole-body fish samples collected in the Dolores Project area that exceeded the 85th percentiles for 1984 are listed in table 18.

Biota samples were collected from the MVIC area and the Dove Creek area to compare effects from long-term irrigation to the effects from new irrigation.

Table 18. National Contaminant Biomonitoring Program (NCBP) 85th-percentile concentrations for 1984 and the number of whole-body fish samples collected in the Dolores Project area that exceeded the 85th percentile for 1984

[Concentrations in micrograms per gram wet weight; NCBP 85th, NCBP 85th-percentile concentrations from Schmitt and Brumbaugh (1990); MVIC, Montezuma Valley Irrigation Company; N, total number of fish samples collected in April, July, and November 1990; numbers in parentheses are the number of exceedances expressed as a percentage of total number of samples in each group]

Trace element	NCBP 85th	Number of samples exceeding 1984 NCBP 85th percentile					
		Total (N=181)	MVIC area streams (N=100)	Dove Creek area (N=3)	Mancos River (N=17)	San Juan River (N=31)	Reservoirs (N=30)
Arsenic	0.27	7	7 (7.0)	0	0	0	0
Cadmium	.05	63	51[1] (51.0)	2 (66.7)	3[1] (17.6)	2[1] (6.5)	5 (16.7)
Copper	1.0	83	48 (48.0)	1 (33.3)	13 (76.5)	16[1] (51.6)	5 (16.7)
Lead	.22	40	19[1] (19.0)	0	6[1] (35.3)	15[1] (48.4)	0
Mercury	.17	29	11 (11.0)	0	1 (5.9)	0	17 (56.7)
Selenium	.73	79	46 (46.0)	3 (100.0)	15 (88.2)	14 (45.2)	1 (3.3)
Zinc	34.20	44	32 (32.0)	2 (66.7)	3 (17.6)	6 (19.4)	1 (3.3)

[1]Some fish samples had reporting limits greater than the NCBP 85th percentile.

In addition, biota samples were collected from the Mancos River to provide reference data for the Towaoc area, which will be irrigated in the future with water from the Dolores Project.

All drainage from the Dolores Project eventually discharges into the San Juan River. The San Juan River is habitat for two endangered fish species, the Colorado squawfish (*Ptychocheilus lucius*) and the razorback sucker (*Xyrauchen texanus*). A total of four adult Colorado squawfish were found in the San Juan River in 1988 (Platania, 1990), three in New Mexico and the fourth in Utah near the Four-Corners area. Nineteen young-of-year Colorado squawfish were found during 1987 and 1988. Six squawfish were located close to the confluence of Montezuma Creek and the San Juan River, two squawfish were in New Mexico near the confluence of the San Juan River and Mancos River (3 mi upstream from and 0.5 mi downstream from the confluence), and the remaining squawfish were located in the lower 24 river miles (downstream from Grand Gulch). In 1987, 18 adult razorback suckers were found in the San Juan River arm of Lake Powell. In 1988, 10 adult razorback suckers were captured in the mouth of the San Juan River at Lake Powell in Utah.

Trace-element concentrations in nonendangered fish species collected at three sites on the San Juan River were used to indicate potential exposures to endangered fish species. Trace-element concentrations in flannelmouth sucker and bluehead sucker tissues may be indicative of selenium concentrations in the endangered razorback sucker, and concentrations in channel catfish may be indicative of selenium concentrations in Colorado squawfish. However, caution is advised when applying toxicity information across taxonomic groups. Trace-element concentrations in aquatic plant, aquatic invertebrate, and fish prey species may be indicative of possible dietary exposure through the food-web pathway.

Although biota samples were analyzed for an array of trace elements, major emphasis was placed on selenium, which has been associated with some irrigated areas in the Western United States. Also, mercury concentrations were emphasized because of concern about the transport of heavy metals from the Dolores River into the study area, especially into the reservoirs. The analytical results for the biological samples are listed in table 27. All elements for which toxicological information is readily available are discussed in the following "Trace Elements" section. Concentrations of other elements listed in table 27 are presented as background information for future studies.

Trace Elements

Selenium in aquatic plants

Fifty-four algae and aquatic-plant samples were collected in the Dolores Project area for trace-element analysis. Thirty-three of these samples were collected from streams in the MVIC area, one from a pond in the MVIC area, and 13 samples were collected from streams in the Dove Creek area. Three samples were collected from the San Juan River, and four were collected from reservoirs. Geometric mean selenium concentrations were calculated for vegetation samples (table 19) after excluding reference sites upstream from irrigation; Cross Canyon (site CR) from the Dove Creek area, and site ME1 on Mc Elmo Creek and Simon Draw (site SD) from the MVIC area. The geometric mean selenium concentrations in aquatic-plant and algae samples from the four areas were; 0.74 µg/g dry weight for streams in the MVIC area, 2.7 µg/g dry weight for the Dove Creek area, 0.63 µg/g dry weight for the San Juan River, and 0.45 µg/g dry weight for the reservoirs (table 19). The geometric mean selenium concentration for six aquatic-plant and algae samples collected from MVIC reference sites (sites ME1 and SD) was 1.0 µg/g dry weight (standard deviation 1.6). Thus, there was no apparent difference in selenium concentrations in aquatic plants and algae from sites within the irrigated MVIC area and reference sites.

Table 19. Statistical summary of selenium concentrations in selected biota samples collected in the Dolores Project area in 1990

[Concentrations in micrograms per gram dry weight; MVIC, Montezuma Valley Irrigation Company; N, number of samples; GM, geometric mean; GD, geometric deviation; --, statistic not computed; data for reference sites not included in statistics for Dove Creek and MVIC areas]

Statistic	Aquatic plants and algae	Aquatic invertebrates	Fathead minnows	Speckled dace	Suckers	Carp
			MVIC AREA STREAMS			
N	27	23	19	17	44	5
GM	.74	1.7	3.4	4.9	1.5	4.2
GD	1.9	2.2	1.7	1.4	1.9	1.2
Maximum	4.3	9.3	11.0	8.7	9.3	5.2
Minimum	.30	.62	1.4	2.8	.49	3.7
			DOVE CREEK AREA			
N	9	11	3	0	0	0
GM	2.7	7.8	22.3	--	--	--
GD	1.7	2.0	1.2	--	--	--
Maximum	6.4	19.2	26.4	--	--	--
Minimum	1.3	2.0	18.4	--	--	--
			MANCOS RIVER			
N	0	5	2	1	8	3
GM	--	3.7	10.4	5.5	4.3	6.8
GD	--	2.2	1.5	--	1.7	1.4
Maximum	--	11.2	14.0	--	7.6	9.8
Minimum	--	1.8	7.7	--	1.7	5.4
			SAN JUAN RIVER			
N	3	1	0	3	20	4
GM	.63	2.5	--	4.0	1.7	2.8
GD	1.4	--	--	1.3	1.6	2.2
Maximum	.94	--	--	5.1	4.2	5.3
Minimum	.46	--	--	2.9	.61	.92
			RESERVOIRS			
N	4	5	0	0	4	0
GM	.45	.66	--	--	1.3	--
GD	1.4	1.1	--	--	1.1	--
Maximum	.60	.83	--	--	1.4	--
Minimum	.30	.60	--	--	1.2	--

Four aquatic-plant and algae samples collected at the reference site for the Dove Creek area (Cross Canyon at site CR) had a geometric mean selenium concentration of 1.3 µg/g dry weight (standard deviation 3.0), compared to the geometric mean of 2.7 µg/g dry weight for the irrigated sites. The Dove Creek area had higher selenium concentrations in vegetation than did the MVIC area (fig. 10, table 19).

Lemly and Smith (1987) and Lemly (1993) recommended that 3 µg/g dry weight selenium be used as the toxic threshold for selenium transferred to consumer species of fish and wildlife through aquatic food chains. Only 5 of the 54 vegetation samples exceeded 3 µg/g dry weight selenium (table 27). One algae sample collected in Navajo Wash (site NW) in the MVIC area contained 4.3 µg/g dry weight selenium. In the Dove Creek area, one vegetation sample collected in Cahone Canyon contained 6.4 µg/g dry weight selenium, one sample from the Cross Canyon reference site contained 4.0 µg/g dry weight selenium, and two samples from Woods Canyon contained 3.3 and 5.8 µg/g dry weight selenium.

Selenium in aquatic invertebrates

A total of 29 crayfish, 3 snail, 1 earthworm, and 21 other aquatic-invertebrate (aquatic insects) samples were collected within the Dolores Project study area (table 27). After combining all invertebrate species, and excluding reference sites upstream from the irrigated areas (sites ME1, SD, and CR), geometric mean selenium concentrations were calculated for invertebrates from the MVIC and Dove Creek areas, the Mancos and San Juan Rivers, and reservoirs within the Dolores Project area (table 19, fig. 10). For MVIC streams, the geometric mean selenium concentration for 23 aquatic-invertebrate samples was 1.7 µg/g dry weight. The geometric mean selenium concentration for 5 aquatic-invertebrate samples (excluding the earthworm sample from site ME1) from MVIC reference sites (sites ME1 and SD) was 1.8 (standard deviation 1.6). Thus, there was no apparent difference in geometric mean selenium concentrations in aquatic invertebrates between the irrigated and the non-irrigated MVIC areas.

Of the aquatic-invertebrate samples from the MVIC area, the five samples collected from Navajo Wash (site NW) contained from 3.3 to 9.3 µg/g dry weight selenium (table 27), and these concentrations

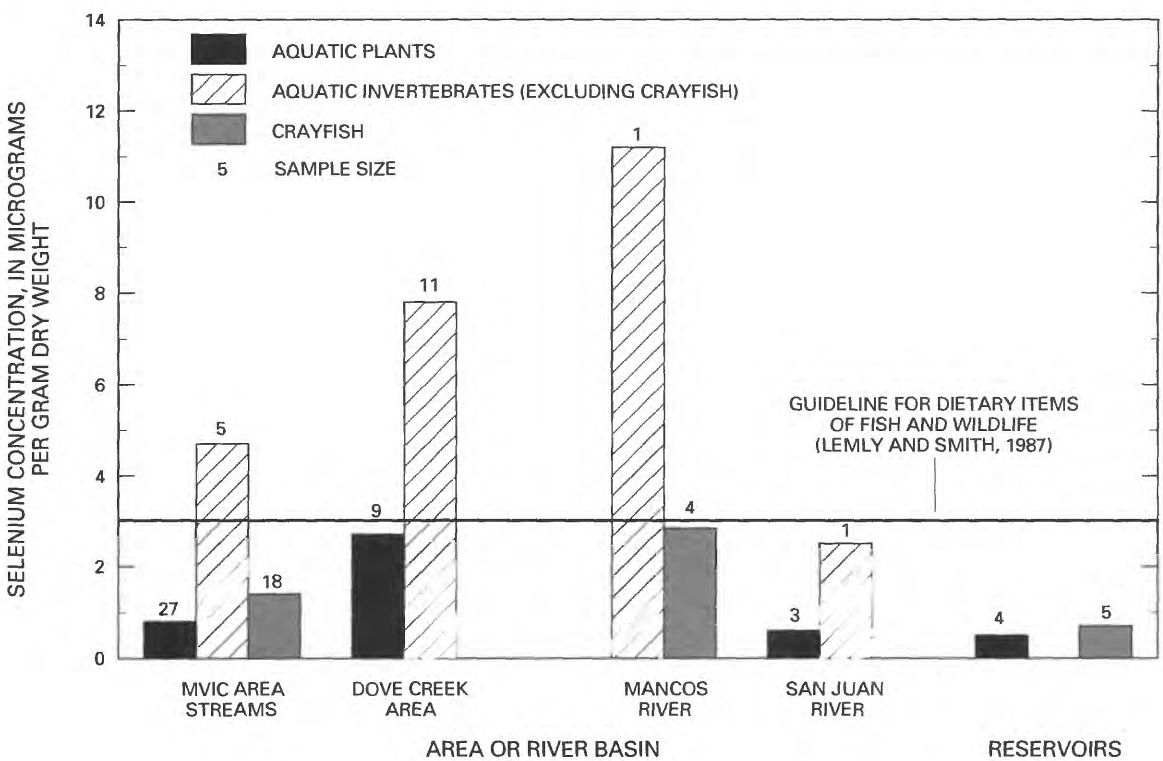

Figure 10. Geometric mean selenium concentrations in dietary items of fish and wildlife. (No bar indicates no data. MVIC, Montezuma Valley Irrigation Company. Means for MVIC and Dove Creek areas do not include data from reference sites.)

exceed the dietary guideline concentration of 3 μg/g dry weight selenium for protection of fish and wildlife resources (Lemly and Smith, 1987; Lemly, 1993). One aquatic-invertebrate sample collected from lower Yellow Jacket Canyon (site YJ2) contained 3.1 μg/g dry weight selenium (table 27). A crayfish sample from Mc Elmo Creek (site ME3), contained 3.7 μg/g dry weight selenium. An earthworm sample collected from the water at site ME1 on Mc Elmo Creek (fig. 1) contained 21 μg/g dry weight selenium (table 27). Although earthworms are not typically considered aquatic invertebrates, they are a potential food source for fish and birds. The selenium concentration exceeded the dietary guideline of 3 μg/g dry weight selenium (Lemly and Smith, 1987; Lemly, 1993) by seven times. Another aquatic-invertebrate sample collected at site ME1 contained 3.4 μg/g dry weight selenium (table 27). It is noteworthy that surface-water samples collected from Navajo Wash and Mc Elmo Creek also contained the highest selenium concentrations of the sampled drainages within the MVIC area (table 22, fig. 8).

The geometric mean selenium concentration for aquatic-invertebrate samples from the Dove Creek area (excluding the reference site CR) was 7.8 μg/g dry weight (table 19, fig. 10). Ten of the 11 aquatic-invertebrate samples collected from the Dove Creek area exceeded the dietary guideline concentration of 3 μg/g dry weight selenium (table 27). Aquatic invertebrates from upper Yellow Jacket Canyon (site YJ1) contained 10 and 15.7 μg/g dry weight selenium (table 27). Aquatic invertebrates from Cahone Canyon (site CH) contained 7.4, 11.2, and 6.7 μg/g dry weight selenium. All aquatic-invertebrate samples from the pond at Woods Canyon (site WC) contained relatively high selenium concentrations of 9.6, 13.4, and 19.2 μg/g dry weight selenium (table 27). Also, two of the three snail samples collected from site WC exceeded the dietary guideline of 3 μg/g dry weight selenium, containing 3.7 and 3.9 μg/g dry weight selenium. The geometric mean selenium concentration for three aquatic-invertebrate samples from the Dove Creek area reference site upstream from irrigation (site CR) was 4.1 μg/g dry weight (standard deviation 1.7), and was lower than the mean calculated for invertebrates collected from the irrigated area (7.8 μg/g dry weight). Two aquatic-invertebrate samples from reference site CR contained 5.0 and 6.1 μg/g dry weight selenium. As with aquatic-plant samples, aquatic-invertebrate samples collected from the Dove Creek area had higher selenium concentrations than the MVIC area (table 19, fig. 10).

The geometric mean selenium concentration for five aquatic-invertebrate samples collected from the Mancos River was 3.7 μg/g dry weight (table 19), and two samples exceeded the 3 μg/g dry weight selenium dietary guideline (Lemly, 1993) at concentrations of 6.7 and 11.2 μg/g dry weight (table 27). The aquatic-invertebrate sample collected from the San Juan River (site SJ1) contained 2.5 μg/g dry weight selenium (tables 19 and 27).

The geometric mean selenium concentration for the five crayfish samples collected from the reservoirs was 0.66 μg/g dry weight (table 19, fig. 10), and was lower than the geometric mean concentration for crayfish collected from MVIC streams. Eight zooplankton samples collected in the reservoirs contained from 0.4 to 2.9 μg/g selenium dry weight, less than the 3 μg/g dry weight selenium dietary guideline concentration.

Selenium in fish

Seventy-eight suckers were collected within the Dolores Project area. Geometric mean selenium concentrations in whole-body sucker samples are compared in table 19 and figure 11. The geometric mean selenium concentration for 44 suckers collected from MVIC streams (excluding two reference site samples) was only 1.5 μg/g dry weight. The geometric mean selenium concentration for two bluehead sucker samples collected from Simon Draw (site SD), a MVIC ref-

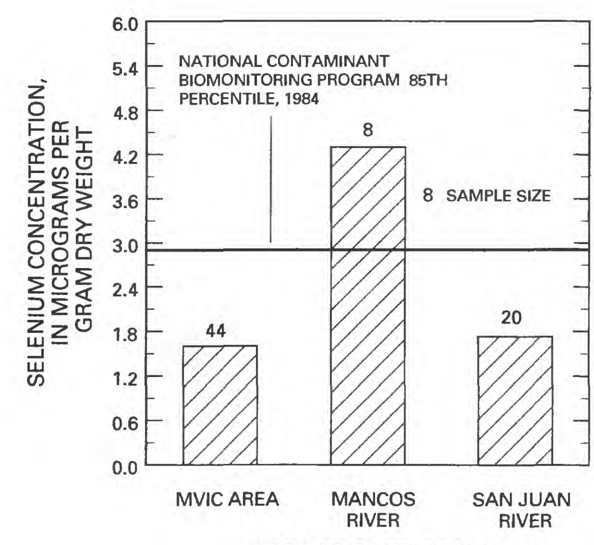

Figure 11. Geometric mean selenium concentrations in whole-body sucker samples collected from streams. (MVIC, Montezuma Valley Irrigation Company.)

erence site upstream from irrigation, was 1.6 µg/g dry weight (standard deviation 1.1), comparable to the mean for fish collected from the irrigated MVIC area. Only 4 of the 46 sucker samples from the MVIC area contained selenium concentrations that exceeded the 1984 NCBP 85th-percentile concentration of 0.73 µg/g wet weight (Schmitt and Brumbaugh, 1990) (tables 18 and 27). Geometric mean selenium concentrations in whole-body sucker samples collected from the different MVIC streams are compared in figure 12. One sucker sample collected from site ME3 contained 3.6 µg/g dry weight selenium (0.81 µg/g wet weight), and another sucker sample collected from site ME4 contained 3.0 µg/g dry weight selenium (0.78 µg/g wet weight) (table 27). Both sucker samples collected from site NW contained relatively high selenium concentrations of 7.2 µg/g dry weight selenium (1.5 µg/g wet weight) and 9.3 µg/g dry weight (1.6 µg/g wet weight). These concentrations not only exceed the 1984 NCBP 85th percentile, but also exceed the concentration of 4 µg/g dry weight selenium concentration that Lemly (1993) recommended to be a whole-body concentration of concern for the overall health and reproductive vigor of freshwater fish. The pattern of selenium concentrations in sucker samples from MVIC drainages correlates well with the pattern of selenium concentrations in surface water samples from the same drainages (figs. 8 and 12).

The geometric mean selenium concentration for four sucker samples collected from the reservoirs was 1.3 µg/g dry weight selenium. This mean selenium concentration is similar to the mean concentration for suckers collected from MVIC streams (fig. 11).

Seven of the eight sucker samples collected from the Mancos River exceeded the 1984 NCBP 85th percentile (Schmitt and Brumbaugh, 1990) (tables 18 and 27), and four of these samples exceeded the 4 µg/g dry weight selenium concentration of concern (Lemly, 1993). The four samples contained 6.5, 4.8, 7.6, and 7.6 µg/g dry weight selenium (table 27).

Selenium concentrations in the 20 sucker samples collected from the San Juan River were lower than those collected from the Mancos River (fig. 11, table 19). The mean selenium concentration for suckers collected at site SJ1 was 1.62 µg/g dry weight selenium (standard deviation 1.14) and for site SJ3 was

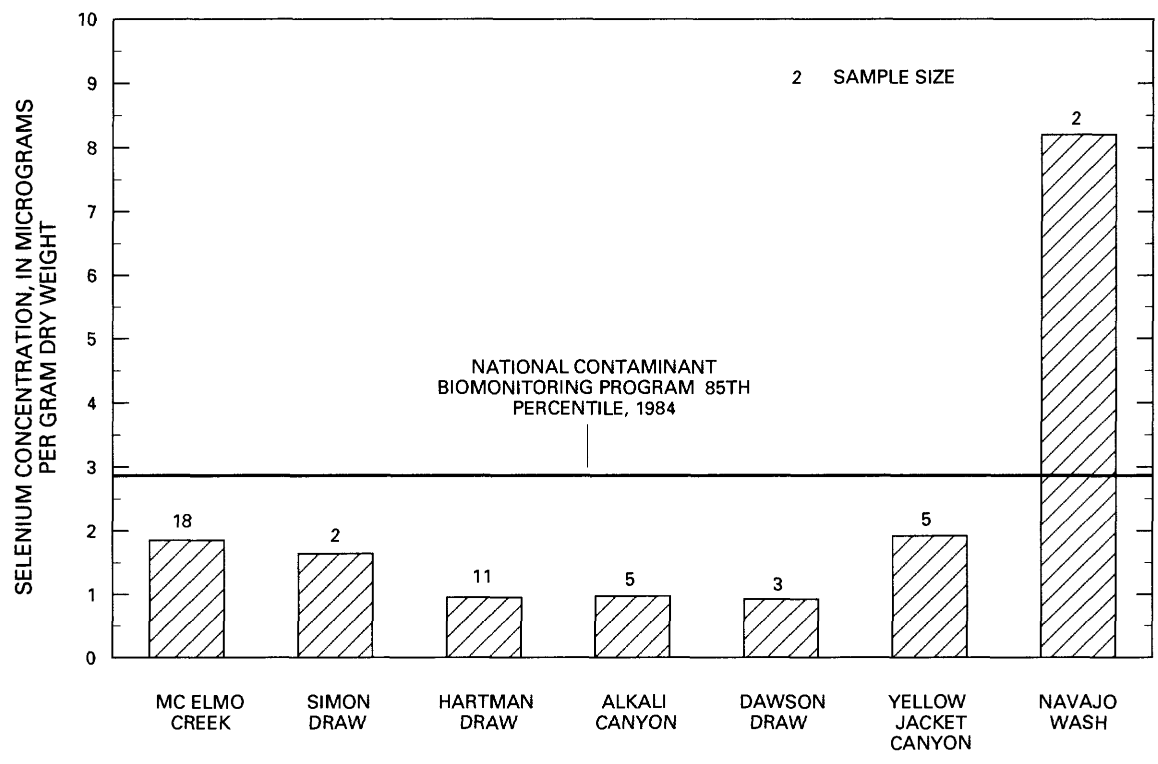

Figure 12. Geometric mean selenium concentrations in whole-body sucker samples collected from streams draining the MVIC (Montezuma Valley Irrigation Company) area.

2.23 µg/g dry weight selenium (standard deviation 0.59). Based on a Mann-Whitney U-test (Iman and Conover, 1983), suckers from site SJ3 had significantly higher selenium concentrations (p=0.034) than those collected from site SJ1 (table 27). Apparently, suckers at site SJ3 accumulated more selenium than suckers at site SJ1, although selenium concentrations in surface-water samples were not different between the two sites (fig. 9, table 22). However, accumulation of selenium through the food chain usually is the major pathway of uptake for fish and wildlife species of higher trophic levels, rather than uptake directly from the water (Lemly 1985; 1993).

One sucker sample collected from site SJ1 contained 4.2 µg/g dry weight selenium (0.92 µg/g wet weight) (table 27), which exceeds the 1984 NCBP 85th-percentile concentration (Schmitt and Brumbaugh, 1990) and the 4 µg/g dry weight selenium concentration of concern for whole-body fish (Lemly, 1993). Selenium concentrations in two sucker samples from site SJ3 exceeded the 1984 NCBP 85th percentile (Schmitt and Brumbaugh, 1990).

Twelve carp samples were collected within the Dolores Project area (table 27). Five carp from Mc Elmo Creek (collected at sites ME3 and ME4) had a geometric mean selenium concentration of 4.2 µg/g dry weight, three carp from the Mancos River had a geometric mean selenium concentration of 6.8 µg/g dry weight, and four carp from the San Juan River had a geometric mean selenium concentration of 2.8 µg/g dry weight (table 19). Eleven of the twelve carp samples contained selenium concentrations that exceeded the 1984 NCBP 85th-percentile (Schmitt and Brumbaugh, 1990) (table 27), and six of these carp samples also exceeded the 4 µg/g dry weight selenium concentration of concern in whole-body fish (Lemly,1993).

Twenty-eight fathead minnow samples were collected within the Dolores Project area (table 27). The geometric mean selenium concentration for 19 fathead minnow samples collected from the MVIC area streams (excluding reference sites ME1 and SD) was 3.4 µg/g dry weight (table 19). The geometric mean selenium concentration for 4 fathead minnow samples collected from MVIC reference sites (sites ME1 and SD) was 4.3 µg/g dry weight (standard deviation 1.3), which is comparable to selenium concentrations in fathead minnows collected within the irrigated MVIC area. Fifteen of the 23 fathead minnow samples from the MVIC area had selenium concentrations that exceeded the 1984 NCBP 85th percentile (Schmitt and Brumbaugh, 1990) (table 27), and 10 of these samples equaled or exceeded the 4 µg/g dry weight selenium concentration of concern in whole-body fish (Lemly, 1993). Of the streams in the MVIC area, Mc Elmo Creek (sites ME1-ME4) and lower Yellow Jacket Canyon (site YJ2) had the highest selenium concentrations in fathead minnows.

Researchers commonly use fathead minnows in laboratory toxicity studies. Ogle and Knight (1989) reported that a whole-body selenium concentration of 6 µg/g dry weight slowed the growth in juvenile and adult fathead minnows. Schultz and Hermanutz (1990) reported reproductive failure at a whole-body selenium concentration of 8 µg/g dry weight. One fathead minnow sample collected from site YJ2 contained 11 µg/g dry weight selenium (table 27), which exceeded known toxicity concentrations to fathead minnows.

Selenium concentrations in three fathead minnow samples collected from the pond in Woods Canyon (site WC) in the Dove Creek area ranged from 18.4 to 26.4 µg/g dry weight, with a geometric mean selenium concentration of 22.3 µg/g dry weight (tables 19 and 27). The selenium concentrations in these samples greatly exceeded those associated with toxic effects for fathead minnows (Ogle and Knight, 1989; Schultz and Hermanutz 1990). As was the case with aquatic-plant and aquatic-invertebrate samples, selenium concentrations were considerably higher in fathead minnows collected from the Dove Creek area compared to those from the MVIC area. Selenium concentrations also were relatively high in the fathead minnow samples collected in the Mancos River, at concentrations of 7.7 and 14 µg/g dry weight (table 27).

Of the 18 speckled dace samples collected within the MVIC area (including the sample from site ME1), 17 contained selenium concentrations that exceeded the 1984 NCBP 85th-percentile (Schmitt and Brumbaugh, 1990), and 14 equaled or exceeded the 4 µg/g dry weight selenium concentration of concern (Lemly, 1993). As with other biota, the highest selenium concentration in a speckled dace sample from the MVIC area was collected from Navajo Wash at site NW (concentration 8.7 µg/g dry weight; table 27). The geometric mean selenium concentration for 17 speckled dace samples collected within the MVIC service area was 4.9 µg/g dry weight (table 19). The only speckled dace sample collected from a MVIC area reference site was from Mc Elmo Creek at site ME1, and that sample had 6.4 µg/g dry weight selenium. One speckled dace sample collected in the Mancos River contained 5.5 µg/g dry weight selenium, and three speckled dace samples collected from the San Juan River had a geometric mean selenium concentration of 4.0 µg/g dry weight (table 19 and 27), and individual samples exceeding the concentration of concern.

A few piscivorous fish were collected from streams and rivers within the Dolores Project area. Four samples were collected from streams in the MVIC area. A bullhead sample containing 3.0 μg/g dry weight selenium and a green sunfish sample containing 5.0 μg/g dry weight selenium were collected at site ME3. Two samples of green sunfish were collected at site HD1, and each contained 1.3 μg/g dry weight selenium (table 27). The selenium concentration of 5.0 μg/g dry weight exceeds the 4 μg/g dry weight concentration of concern (Lemly, 1993), but is less than the 12 μg/g dry weight concentration that Lemly and Smith (1987) associated with reproductive failure in warmwater fishes. Members of the sunfish family are especially sensitive to selenium (Cumbie and Van Horn, 1978; Lemly, 1985; 1993).

A roundtail chub sample collected from the Mancos River at site MN2 contained 5.4 μg/g dry weight selenium (table 27), exceeding the 4 μg/g dry weight concentration of concern for whole-body fish (Lemly, 1993). Three of four whole-body channel catfish samples collected from three sites on the San Juan River contained selenium concentrations (table 27) exceeding the concentration of concern. A fillet sample containing 2.2 μg/g dry weight selenium and a channel catfish-liver sample containing 5.8 μg/g dry weight selenium were collected at site SJ1. These concentrations are less than the concentrations of concern for fish health—12 μg/g dry weight selenium in the liver and 8 μg/g dry weight selenium in fillets (Lemly, 1993).

Selenium concentrations in piscivorous fish samples collected from McPhee, Summit, Puett, and Totten Reservoirs contained relatively low selenium concentrations compared to stream sites. The selenium concentration of 4.2 μg/g dry weight (1.0 μg/g wet weight) in a whole-body roundtail chub sample from McPhee Reservoir (site MP) (table 27) was the only selenium concentration in a piscivorous fish from reservoirs that exceeded the 1984 NCBP 85th percentile (Schmitt and Brumbaugh, 1990) and also exceeded the 4 μg/g dry weight selenium concentration of concern for whole-body fish. All selenium concentrations in fillet and in fish egg samples were less than selenium concentrations of concern of 8 μg/g dry weight for fillets and 10 μg/g dry weight for eggs (Lemly, 1993).

Selenium in birds

Thirty bird samples were collected within the Dolores Project area (table 27); of these, 15 were eggs, 9 were livers, and 6 were whole-body samples. Three of the five collection sites are within the MVIC area; Dawson Draw (site DD), Leighton Pond (site LP), and Totten Reservoir (site TT) (fig. 1). Two collection sites are located within the Dove Creek area, at a pond (site AKP) in the Alkali Canyon drainage, a tributary to Cross Canyon, and the pond in Woods Canyon (site WC). Geometric mean selenium concentrations were calculated for all of the bird-liver and egg samples collected in the entire Dolores Project area. The geometric mean selenium concentration was 3.6 μg/g dry weight (standard deviation 2.0) for egg samples and 6.0 μg/g dry weight (standard deviation 2.4) for liver samples. J.P. Skorupa (U.S. Fish and Wildlife Service, written commun., 1993) reported that baseline geometric mean selenium concentrations rarely exceeded 3 μg/g dry weight selenium in eggs and 10 μg/g dry weight selenium in livers, and warned that there is a high risk of adverse biological effects when population mean selenium concentrations exceed 20 μg/g dry weight in eggs and 30 μg/g dry weight in livers. Skorupa also suggested that if population geometric means were between 3 and 20 μg/g dry weight selenium in eggs and between 10 and 30 μg/g dry weight selenium in livers, associated studies of reproductive performance would be needed for conclusive interpretation of biological significance. The mean selenium concentration of 3.6 μg/g dry weight for bird eggs collected from the Dolores Project area is within the range of uncertainty for bird eggs. The mean selenium concentration of 6.0 μg/g dry weight for bird livers from the Dolores Project area is less than the baseline selenium concentration of 10 μg/g dry weight (J.P. Skorupa, U.S. Fish and Wildlife Service, written commun., 1993). The highest selenium concentration detected in bird-tissue samples was in a mallard liver collected in Woods Canyon (table 27), which contained 37.5 μg/g dry weight selenium (10.5 μg/g wet weight), and a coot egg sample collected from the pond in Alkali Canyon (site AKP), which contained 18.5 μg/g dry weight selenium (4.5 μg/g wet weight). Gary Heinz (U.S. Fish and Wildlife Service, written commun., 1993) and Lemly (1993) suggested that selenium concentrations exceeding 10 μg/g wet weight in bird livers are potentially harmful to bird health and that concentrations greater than 3 μg/g wet weight in livers of laying females may be associated with reproductive impairment. No deformities were found in the field, upon examination of egg contents, or in the collected birds. All food items (aquatic invertebrates and aquatic plants) collected at the five bird-sampling sites had selenium concentrations less than the dietary concentration of concern of 3 μg/g dry weight (Lemly and Smith, 1987; Lemly, 1993), except for Woods Canyon (site WC), which had high selenium concentrations in food items and in bird-tissue samples.

In summary, selenium concentrations in biota collected from the Dove Creek area often exceeded selenium concentrations in biota collected from the MVIC area. As discussed previously in the report, the long-term irrigation and high application rates in the northern MVIC area may have leached most of the soluble selenium from the red soil areas, but in the Dove Creek area, the soluble selenium may not be leached from the soil because the area had been irrigated less than 3 years. Within the MVIC area, biota samples containing the highest selenium concentrations often were from Navajo Wash. Navajo Wash drains irrigated areas on gray, seleniferous (Mancos) soils south of Cortez, which could account for the higher selenium concentrations in water, sediment, and biota samples. Streams north of Mc Elmo Creek drain irrigated areas on mixed red and gray soils or on red soils. Selenium concentrations in biota (crayfish and fish) collected from reservoirs usually were much lower than in biota collected from streams.

Biota samples collected from the Mancos River generally had relatively high selenium concentrations, especially when compared to biota samples collected from the San Juan River. That result was not surprising because the Mancos River drains extensive areas of Mancos Shale. Higher streamflow in the San Juan River dilutes incoming selenium from tributary streams. However, fish collected from the San Juan River often contained selenium concentrations that exceeded the concentration of concern of 4 μg/g dry weight. Selenium concentrations in suckers collected from the San Juan River at site SJ3 had significantly higher selenium concentrations than in suckers collected from site SJ1. Additional studies would be needed to assess the potential effects of irrigation drainage from the Dolores Project to endangered fish species in the San Juan River. Young-of-year Colorado squawfish were found near the confluence of the San Juan River and the Mancos River. Selenium concentrations are relatively high in the Mancos River. Juvenile fish often are quite susceptible to selenium toxicity (Hodson and others, 1980; Hunn and others, 1987; Hamilton and others, 1990), therefore, there is a potential risk to these endangered fish. The amount of selenium in the Mancos River contributed by irrigation drainage has not been fully investigated.

Mercury

Mercury concentrations that exceeded analytical reporting limits in aquatic plants collected within the Dolores Project area ranged from 0.01 to 0.08 μg/g dry weight (table 27), except for one algal sample from site HD1 that contained 0.26 μg/g dry weight mercury (0.03 wet weight). There seemed to be no differences among sites in mercury concentrations in aquatic plants in the Dolores Project area. All mercury concentrations in aquatic-plant samples were less than 0.1 μg/g wet weight, which is a dietary guideline not to be exceeded for the protection of sensitive species of birds (Eisler, 1987a).

The geometric mean mercury concentration for 20 crayfish samples collected from streams in the MVIC area was 0.09 μg/g dry weight (geometric deviation 1.52) and was slightly lower than the geometric mean mercury concentration in 5 crayfish samples collected from the reservoirs of 0.12 μg/g dry weight (standard deviation 0.10). The geometric mean mercury concentration in eight non-crayfish aquatic-invertebrate samples from the MVIC area (excluding the earthworm collected at site ME1) was 0.15 μg/L dry weight (geometric deviation 1.51), which is about 1.7 times greater than the geometric mean mercury concentration in crayfish samples. The geometric mean mercury concentration is 0.06 μg/g dry weight (geometric deviation 2.13) for the 11 aquatic-invertebrate samples (other than crayfish) collected from the Dove Creek area. An invertebrate sample collected from the Mancos River at site MN1 (fig. 1) contained 0.84 μg/g dry weight mercury (0.12 μg/g wet weight) (table 27), and was the only mercury concentration that exceeded the dietary guideline concentration of 0.1 μg/g wet weight for the protection of birds (Eisler, 1987a). Hildebrand and others (1980) suggested that invertebrates with mercury concentrations of 0.05 μg/g wet weight or less are indicative of uncontaminated environments and that concentrations equal to or greater than 1 to 4 μg/g wet weight are indicative of contaminated environments. All mercury concentrations in aquatic-invertebrate samples from the Dolores Project area were much less than 1 μg/g wet weight. Zooplankton samples collected from four MVIC area reservoirs (sites MP, SU, PU, and TT) also contained low mercury concentrations that ranged from 0.05 to 0.37 μg/g dry weight (less than 0.008 μg/g wet weight) (table 27).

Twenty-nine of the 181 whole-body fish samples collected in the Dolores Project area contained mercury concentrations greater than the 1984 NCBP 85th-percentile concentration of 0.17 μg/g wet weight (0.65 μg/g dry weight at 75-percent moisture) (Schmitt and Brumbaugh, 1990) (table 18). Seventeen of those 29 samples were collected from McPhee, Summit, Puett, and Totten Reservoirs, 11 were collected from streams in the MVIC area (sites ME3, ME4, HD2, AK, DD, and YJ2), and one sample was collected from the Mancos River. Eisler (1987a) recommended that total mercury concentrations in food items for sensitive species of birds not exceed 0.1 µg/g wet weight; mercury concentrations in the 73 fish samples exceeded that guideline. However, the mercury concentrations in all whole-body fish samples were much less than the whole-body concentration of 5 µg/g wet weight mercury proposed by the U.S. Environmental Protection Agency (1985) for the protection of brook trout (one of the species most sensitive to mercury).

The highest mercury concentrations in fish were in warm-water game species, especially walleye, smallmouth bass, and northern pike collected from the four reservoirs in or adjacent to the MVIC area (fig. 13). Mercury accumulation in fish is thought to be facilitated by reservoirs where conditions are conducive to methylation of mercury, which increases mercury uptake by biota (Bodaly and others, 1984; Phillips and others, 1987; Stokes and Wren, 1987). Other researchers have found that mercury accumulation increases with fish length (age) and also seems to vary from species to species (Eisler, 1987a; Phillips and others, 1987; Wiener and others, 1990).

An action level of 1 µg/g wet weight was suggested by the U.S. Food and Drug Administration (1978) as the maximum allowable mercury concentration in fish and seafood to be consumed by humans. The National Research Council (1978) suggested that humans in the United States should not consume fish that had mercury concentrations greater than 0.5 µg/g wet weight. Eleven fillet and whole-body fish samples had mercury concentrations that exceeded 0.5 µg/g wet weight mercury, and all the samples were collected from reservoirs. Kahn (1971) recommended that pregnant women should not consume fish or seafood having more than 0.25 µg/g wet weight mercury. Twenty two of the 23 fillet and whole-body fish samples that had mercury concentrations exceeding 0.25 µg/g wet weight were collected from the reservoirs. McPhee and Narraguinnep Reservoirs were posted in May 1991 advising anglers of elevated mercury concentrations in fish and suggesting limits for human consumption (Colorado Department of Health, 1992).

Recommended weekly maximum amounts of fish that could safely be consumed by an adult, a child under the age of 9, and a pregnant woman, as prescribed by the Colorado Department of Health, are listed in table 20. The risk assessment used for the calculation of weekly consumption rates in table 20 is based on the U.S. Environmental Protection Agency's reference dose of 0.3 µg/kg/d for adults and children based on a lifetime daily dose at which no adverse

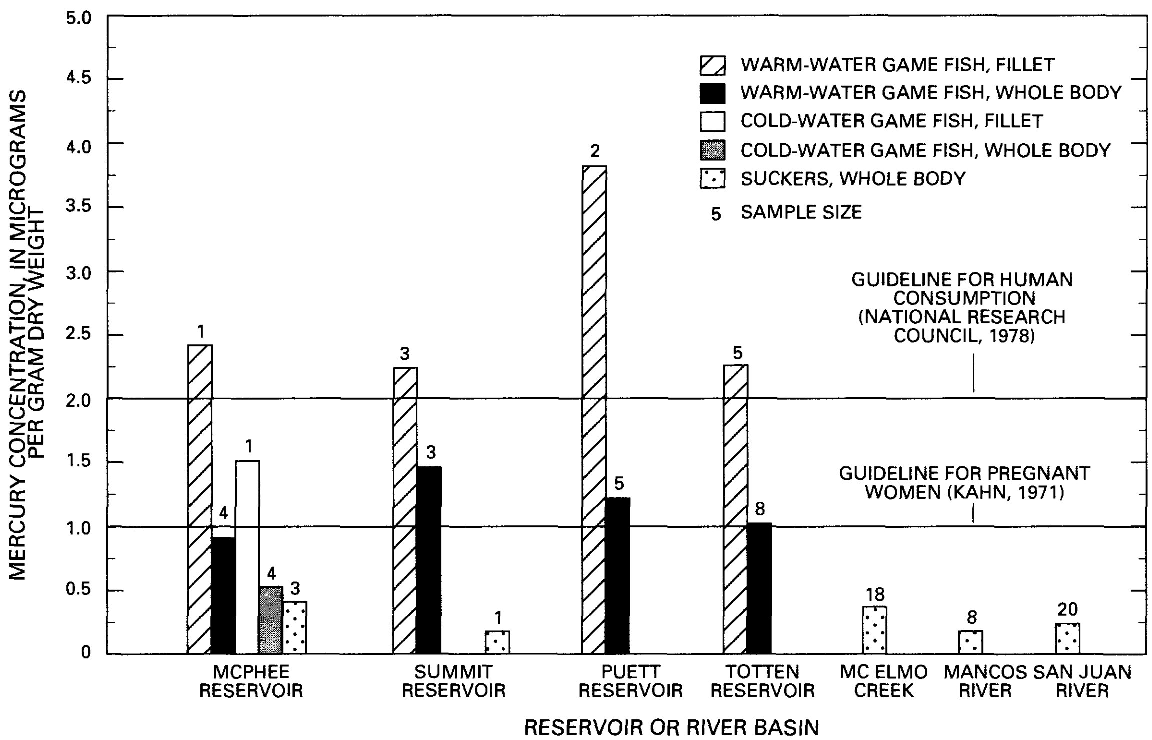

Figure 13. Geometric mean mercury concentrations in fillet and whole-body fish samples. Warm-water game fish included northern pike, walleye, bluegill, black crappie, smallmouth bass, largemouth bass, and yellow perch. Cold-water game fish included rainbow trout and kokanee salmon. (No bar indicates no data. Consumption guidelines computed from wet-weight concentrations using 75 percent moisture.)

Table 20. Mean mercury concentrations in fillets of game fish collected in the Dolores Project area, 1988–91, and recommended human consumption limits

[Fish samples collected and analyzed by U.S. Fish and Wildlife Service, Bureau of Reclamation, and Colorado Division of Wildlife (Michael Japhet, Colorado Division of Wildlife, written commun., 1992); mean concentrations in micrograms per gram wet weight; NS, number of samples; NF, total number of fish composited in samples; consumption limits based on a reference dose of 0.3 microgram mercury per kilogram body weight per day for adults and children and 0.075 microgram mercury per kilogram body weight per day for women who are pregnant, nursing, or planning to become pregnant (Michael P. Wilson, Colorado Department of Health, written commun., 1992)]

Site	Species	NS	NF	Mean	Recommended consumption limit, in ounces per week		
					70-kilogram adult	18-kilogram child[1]	60-kilogram pregnant woman[1]
Dolores River	Brown trout	1	6	0.31	17	4	4
McPhee Reservoir	Kokanee salmon	2	13	.09	58	15	12
	Rainbow trout	4	18	.24	22	6	5
	Yellow perch	2	18	.21	25	6	5
	Smallmouth bass	2	10	.29	18	5	4
	Largemouth bass	3	10	.61	8	2	2
	Black crappie	1	9	.53	10	3	2
Narraguinnep Reservoir	Yellow perch	2	14	.22	24	6	5
	Channel catfish	1	9	.43	12	3	3
	Northern pike	5	11	.70	7	2	2
	Walleye	4	27	1.11	0	0	0
Summit Reservoir	Smallmouth bass	3	6	.50	10	3	2
	Black crappie	1	3	.33	16	4	3
Puett Reservoir	Walleye	2	3	.87	6	2	1
Totten Reservoir	Northern pike	2	2	.38	14	3	3
	Walleye	3	3	.69	7	2	2

[1]A threshold effect level for methylmercury has not been observed. Therefore, young children and women who are pregnant, nursing, or planning to become pregnant may wish to limit their consumption to fish with mercury concentrations less than this level.

health effects are expected to occur (Colorado Department of Health, written commun., 1992). The amount of fish that can safely be consumed varied by species of fish and the site from which the fish were taken (table 20). The quantity of fish that can safely be consumed by a 70-kg adult in a week ranged from 58 oz of kokanee salmon from McPhee Reservoir to 0 oz of walleye from Narriguinnep Reservoir (table 20).

There was a large range of mercury concentrations in bird tissues collected from the Dolores Project area. The highest mercury concentrations were 1.53 μg/g dry weight (0.50 μg/g wet weight) in a whole-body yellowhead blackbird sample from Totten Reservoir (site TT) and 1.20 μg/g dry weight (0.28 μg/g wet weight) in a pied-bill grebe egg sample from Leighton Pond (site LP). There is a paucity of information relating mercury concentrations in bird tissues to toxicological effects. Heinz (1979) reported that a mercury concentration of 0.9 μg/g wet weight in mallard eggs was associated with adverse behavioral effects. All mercury concentrations in egg samples from the Dolores Project area were much less than this concentration. Finley and others (1979) suggested that concentrations of mercury in excess of 20 μg/g wet weight in bird soft tissues should be considered hazardous. Mercury concentrations in bird-liver samples from the Dolores Project area ranged from 0.10 μg/g dry weight (0.027 μg/g wet weight) to 0.44 μg/g dry weight (0.129 μg/g wet weight.

Aluminum

Aquatic-plant and aquatic-invertebrate samples collected from the Dolores Project area had relatively high aluminum concentrations compared to the other trace elements. Aluminum concentrations in aquatic plants (including algae samples) ranged from 534 µg/g dry weight in a sago pondweed sample collected from Totten Reservoir (site TT) to 23,100 µg/g dry weight in an algae sample collected from Dawson Draw (site DD) (table 27). Aluminum concentrations in aquatic-invertebrate samples ranged from 240 µg/g dry weight in a crayfish sample from Totten Reservoir (site TT) to 13,600 µg/g dry weight in an aquatic-invertebrate sample from the Mancos River (site MN1). Aluminum concentrations in zooplankton samples ranged from 1,000 µg/g dry weight in a sample from McPhee Reservoir (site MP) to 6,590 µg/g dry weight in a sample from Puett Reservoir (site PU). Sparling (1990) reported that mallard ducklings exposed to a diet of about 11,000 µg/g dry weight aluminum had stunted growth and high mortality rates; ducklings exposed to a diet of about 5,500 µg/g dry weight aluminum had stunted growth and altered behavior. Aluminum concentrations in several of the aquatic-plant and a few aquatic-invertebrate samples are potentially hazardous to young aquatic birds, such as coots and waterfowl.

Aluminum concentrations in whole-body fish were extremely variable. Aluminum concentrations in whole-body fish from the four reservoirs were substantially less than the concentrations in whole-body fish from streams in the MVIC area. Brumbaugh and Kane (1985) reported that gastrointestinal-tract contents in fish contained highly variable amounts of aluminum and caused bias and increased variability when included in whole-body samples. Because whole-body fish samples from the Dolores Project area were submitted for laboratory analyses, actual aluminum concentrations in fish without the gastrointestinal-tract contents is unknown. Thus, it is unknown if there is an aluminum problem in the Dolores Project area.

Arsenic

Arsenic concentrations in most biota samples from the Dolores Project area were within the range for unpolluted environments. Arsenic concentrations in aquatic-plant samples ranged from 0.66 µg/g dry weight in an algae sample from site YJ1 to 18.3 µg/g dry weight in an algae sample from site CR (table 27). Moore and Ramamoorthy (1984) reported that arsenic is not a significant contaminant of aquatic-plant tissues, except at local point-source discharges, and residues are low (less than 50 µg/g dry weight) in most industrial-zone water. All samples from the Dolores Project area samples contained arsenic concentrations much less than 50 µg/g dry weight. Arsenic concentrations that exceeded reporting limits in aquatic-invertebrate samples ranged from 0.2 µg/g dry weight in an aquatic-invertebrate sample from site ME1 to 2.6 µg/g dry weight arsenic in a crayfish sample from Puett Reservoir (site PU). Moore and Ramamoorthy (1984) suggested arsenic residues in aquatic-invertebrates collected from unpolluted freshwater usually ranged from less than 0.5 to 20 µg/g dry weight. Arsenic concentrations in invertebrate samples from the Dolores Project area were much less than 20 µg/g dry weight. Arsenic concentrations in zooplankton samples collected from the Dolores Project area ranged from 0.8 µg/g dry weight in a sample from Totten Reservoir (site TT) to 4.4 µg/g dry weight in a sample from Summit Reservoir (site SU) (table 27).

Arsenic in seven whole-body fish samples exceeded the 1984 NCBP 85th-percentile arsenic concentration of 0.27 µg/g wet weight (Schmitt and Brumbaugh, 1990) (table 18). Moore and Ramamoorthy (1984) suggested that arsenic concentrations ranging from less than 0.1 to 0.4 µg/g wet weight (1.6 µg/g dry weight at 75 percent moisture) in fish tissues are indicative of unpolluted to mildly contaminated water. Arsenic concentrations in three fish samples from streams in the MVIC area exceeded 0.4 µg/g wet weight; a fathead minnow sample from site ME3 had 0.63 µg/g wet weight arsenic, a flannelmouth sucker sample from site HD2 had 0.42 µg/g wet weight arsenic, and one bluehead sucker sample from site NW had 0.44 µg/g wet weight arsenic.

Eisler (1988a) suggested that arsenic concentrations of 2 to 10 µg/g wet weight in bird livers or kidneys should be considered elevated above background levels and that arsenic concentrations greater than 10 µg/g wet weight are indicative of arsenic poisoning. All arsenic concentrations in bird liver samples from the Dolores Project area were much less than these guidelines.

Boron

Eisler (1990) proposed that boron concentrations ranging from 30 to 100 µg/g wet weight in waterfowl diets may cause adverse effects. Two aquatic-plant samples contained boron concentrations that exceeded 30 µg/g wet weight (table 27). The boron concentration in a sago pondweed sample from Alkali Canyon (site AK) was 368 µg/g dry weight (about 53 µg/g wet weight) and in a pondweed sample from Cross Canyon (site CR) contained 345 µg/g dry weight (about 37 µg/g wet weight). Boron concentrations in two other aquatic-plant samples were slightly less than the 30 µg/g wet weight concentration; a sago pondweed sample from Summit Reservoir (site SU) contained 274 µg/g dry weight boron (about 28 µg/g wet weight), and a sago pondweed sample from Totten Reservoir (site TT) contained 256 µg/g dry weight boron (about 27 µg/g wet weight). All boron concentrations in aquatic-invertebrate samples were much lower than the dietary guideline for boron of 30 µg/g wet weight for waterfowl.

Saiki and May (1988) compiled data from various studies and suggested that background concentrations of boron in whole-body freshwater fish generally are less than 4.0 µg/g dry weight. Most of the boron concentrations in whole-body fish samples collected in the Dolores Project area were less than 4.0 µg/g dry weight. However, some samples from streams in the MVIC area contained boron concentrations that exceeded 4.0 µg/g dry weight. All boron concentrations in whole-body fish samples collected from reservoirs were equal to or less than 2.0 µg/g dry weight.

Cadmium

Cadmium concentrations in aquatic-plant samples from the Dolores Project area (table 27) were about equal to or less than cadmium concentrations reported in other studies (Moore and Ramamoorthy, 1984; Eisler, 1985; Schroeder and others, 1988; Stephens and others, 1988; Mueller and others, 1991). Cadmium concentrations in aquatic plants collected from the MVIC area were similar to concentrations in aquatic plants from the Dove Creek area. The highest cadmium concentration in an aquatic-plant sample was 3.7 µg/g dry weight from the San Juan River at site SJ1. Cadmium concentrations in aquatic-invertebrate samples (including crayfish) also were within background concentrations based on cadmium residues in aquatic invertebrates from other studies (Giesy and others, 1980; Moore and Ramamoorthy, 1984; Eisler, 1985). Zooplankton samples collected from the reservoirs also had relatively low cadmium concentrations and ranged from less than analytical reporting limits to 2.0 µg/g dry weight.

Cadmium concentrations in 63 whole-body fish samples exceeded the 1984 NCBP 85th-percentile concentration of 0.05 µg/g wet weight (Schmitt and Brumbaugh, 1990) (table 18). Analytical reporting limits exceeded the 85th-percentile concentration for some samples; therefore, the actual number of samples exceeding the 85th percentile is not known. Schmitt and Brumbaugh (1990) reported that common carp seem to accumulate cadmium more readily than other fish species and reported a maximum concentration of 0.22 µg/g wet weight in a common carp sample collected in 1984. Cadmium concentrations in eight whole-body fish samples from the Dolores Project area exceeded the 1984 maximum concentration, most often in sucker samples. The highest cadmium concentration in fish samples was 3.5 µg/g dry weight (1.16 wet weight) in a speckled dace sample from site ME2 (table 27). Eisler (1985) indicated that cadmium concentrations in whole-body vertebrates that exceed 2 µg/g wet weight or 10 µg/g fresh weight (same as wet weight) in the kidney or liver should be considered as evidence of probable cadmium contamination. Eisler (1985) also reported that a cadmium concentration of 5.0 µg/g wet weight (20 µg/g dry weight at 75-percent moisture) in a whole-body estuarine fish as potentially life-threatening. All cadmium concentrations in whole-body fish and organ samples from the Dolores Project area were less than these concentrations.

Cadmium concentrations were relatively low in bird samples from the Dolores Project area. All cadmium concentrations were less than guideline concentrations for vertebrates suggested by Eisler (1985) as indicative of contamination.

Chromium

Moore and Ramamoorthy (1984) reported that chromium is not a significant contaminant in aquatic-plant tissues, except at site-specific discharge points, and that concentrations in freshwater aquatic plants seldom exceed 5 µg/g dry weight. Moore and Ramamoorthy (1984) reported that chromium concentrations in freshwater aquatic plants collected from industrial sources are as much as 50 µg/g dry weight. Forty-one of the 54 aquatic-plant samples collected from the Dolores Project area contained chromium concentrations that exceeded 5 µg/g dry weight, including 32 samples from streams in the MVIC area, 6 from streams in the Dove Creek area, and 3 from the San Juan River (table 27). The highest chromium concentration in aquatic vegetation was 37 µg/g dry weight in an algae sample from site YJ2 (table 27).

Moore and Ramamoorthy (1984) reported that chromium concentrations in aquatic-invertebrate samples collected from polluted freshwater can be as much as 25 µg/g dry weight, compared to less than 5 µg/g dry weight for unpolluted water. Twelve of the 54 aquatic-invertebrate samples (including crayfish, earthworms, and snails) contained chromium concentrations that exceeded 5 µg/g dry weight, and included 6 samples from streams in the MVIC area, 3 samples from the streams in the Dove Creek area, 2 samples from the Mancos River, and 1 sample from the San Juan River (table 27). The highest chromium concentration in an aquatic-invertebrate sample was 440 µg/g dry weight in a crayfish sample collected from site MN2 on the Mancos River (table 27). Seven of the eight zooplankton samples collected from reservoirs in the MVIC area contained chromium concentrations that exceeded 5 µg/g dry weight, and the highest concentration was 25 µg/g dry weight in a zooplankton sample from McPhee Reservoir (site MP) (table 27).

Eisler (1986a) indicated that chromium concentrations exceeding 4 µg/g dry weight in organs and tissue of fish and wildlife should be viewed as presumptive evidence of chromium contamination. Forty-three of the 181 whole-body fish samples from the Dolores Project area had chromium concentrations that exceeded 4 µg/g dry weight. Of these 43 samples, 33 were collected from streams in the MVIC area, 2 were collected from streams in the Dove Creek area, 3 were collected from the Mancos River, 4 were collected from the San Juan River, and 1 sample was collected from the reservoirs. At least one of the whole-body fish samples collected at sites ME4, SD, HD2, DD, WC, MN1, SJ1, and SJ3 had chromium concentrations that exceeded 10 µg/g dry weight (table 27), which is 2.5 times the guideline concentration suggested by Eisler (1986a). Moore and Ramamoorthy (1984) reported that chromium does not normally accumulate in fish and that chromium concentrations in the muscle of freshwater fish generally are less than 0.25 µg/g wet weight. A walleye fillet sample from Totten Reservoir (site TT) had a chromium concentration of 2.6 µg/g dry weight (about 0.63 µg/g wet weight), about 2.5 times the value expected in freshwater fish muscle. All chromium concentrations in tissues of birds collected from the Dolores Project area were less than the guideline of 4 µg/g dry weight (Eisler 1986a). Chromium and other trace metals may have been transported into irrigated areas of the Dolores Project, especially into the MVIC area, in the irrigation water supply from the Dolores River basin.

Copper

Moore and Ramamoorthy (1984) reported that copper concentrations in attached species of aquatic plants inhabiting polluted water generally ranged between 10 and 100 µg/g dry weight. Copper concentrations in aquatic-plant samples from the Dolores Project area ranged from 2.2 µg/g dry weight in an algae sample from site WC to 32.9 µg/g dry weight in an algae sample from site CR (table 27). Moore and Ramamoorthy (1984) also reported that aquatic-invertebrates inhabiting polluted freshwater generally had copper concentrations of 5 to 200 µg/g dry weight. Copper concentrations in aquatic-invertebrate samples from the Dolores Project area ranged from 4 µg/g dry weight in a snail sample from site WC to 134 µg/g dry weight in a crayfish sample from site YJ2 (table 27).

Copper concentrations in 83 of 181 whole-body fish samples exceeded the 1984 NCBP 85th-percentile of 1.0 µg/g wet weight (table 18). Of these 83 samples, 48 were collected from streams in the MVIC area, 1 from a stream in the Dove Creek area, 13 from the Mancos River, 16 from the San Juan River, and 5 were from the reservoirs. Moore and Ramamoorthy (1984) reported that a toxic copper concentration in whole-body fish has not yet been determined; however, they reported that copper concentrations in muscle tissue seldom exceeded 1.0 µg/g wet weight. A copper concentration of 5.6 µg/g dry weight (1.5 µg/g wet weight) in a fillet sample taken from a flannelmouth sucker collected in the San Juan River (site SJ1) was the only fillet sample that exceeded 1.0 µg/g wet weight copper.

Lead

Lead concentrations in aquatic-plant and aquatic-invertebrate samples from the Dolores Project area were relatively low compared to other studies (Moore and Ramamoorthy, 1984; Eisler 1988b). Lead concentrations in 40 of the 181 whole-body fish samples collected in the Dolores Project area exceeded the 1984 NCBP 85th-percentile concentration of 0.22 µg/g wet weight (Schmitt and Brumbaugh, 1990) (table 18). Of these samples, 19 were collected from streams in the MVIC area, 15 were collected from the San Juan River, and 6 were collected from the Mancos River. Several samples had lead concentrations with analytical reporting limits exceeding the NCBP 85th-percentile concentration, so it is unknown if those concentrations exceeded the 85th percentile. The toxic lead concentration in whole-body fish has not yet been determined (Saiki and Palawski, 1990).

Zinc

Zinc concentrations in 44 of the 181 whole-body fish samples collected in the Dolores Project area exceeded the 1984 NCBP 85th-percentile concentration of 34.2 µg/g wet weight (Schmitt and Brumbaugh, 1990) (table 18). Of these samples, 32 were collected from streams in the MVIC area, 2 from streams in the

Dove Creek area, 3 from the Mancos River, 6 samples from the San Juan River, and 1 sample from the reservoirs. Schmitt and Brumbaugh (1990) reported that common carp apparently accumulate zinc to a greater extent than other fish species. Of the 44 whole-body fish samples that exceeded the 1984 NCBP 85th-percentile, 9 were common carp that had zinc concentrations ranging from 169 to 596 μg/g dry weight (table 27). The toxicological significance of these zinc concentrations is unknown. Saiki and Palawski (1990) reported zinc concentrations in juvenile striped bass that were as much as 170 μg/g dry weight, and none of the fish were in poor condition. Zinc concentrations in fish fillets from reservoir sites were substantially lower than concentrations in whole-body fish collected from the same sites (table 27). Whole-body fish often contain substantial amounts of contaminated material in the gastrointestinal tract (Saiki and Palawski, 1990), which could account for higher zinc concentrations in whole-body fish when compared to fillets. Zinc concentrations in fish eggs from Summit, Puett, and Totten Reservoirs (sites SU, PU, TT) (table 27) ranged from 56.2 μg/g dry weight to 217 μg/g dry weight. Evidently, zinc concentrations are deposited into the eggs of female fish.

Organochlorine Pesticides

Concentrations of organochlorine pesticides and PCBs in fish and bird samples from the Dolores Project area generally were low and within the range of background concentrations (Fleming and others, 1983; White and others, 1983; DeWeese and others, 1986; Eisler, 1986b, 1987b; Schmitt and others, 1990) (table 28). All organochlorine concentrations in fish samples from the Dolores Project area (table 28) were less than or equal to the 1984 NCBP geometric mean concentrations (table 21). The organic compound p,p'-DDE, which is the most persistent degradation product of p,p'-DDT, was the organochlorine pesticide detected most often in biota samples from the Dolores Project area (table 28).

Polycyclic Aromatic Hydrocarbons

Polycyclic aromatic hydrocarbons (PAHs) are ubiquitous in nature. Natural processes such as forest fires, microbial synthesis, and volcanic activity result in PAHs in sediment, soil, air, surface water, and plant and animal tissues (Eisler, 1987b). Anthropogenic sources of PAHs in the Four Corners area include coal-fired power plants and oil refineries that generate aromatic hydrocarbons from high temperature (greater than 700°C) pyrolysis of organic materials. These sources can produce localized areas of PAH contamination (Eisler, 1987b).

Table 21. National Contaminant Biomonitoring Program (NCBP) geometric mean concentrations of selected organochlorine pesticides and PCB's for 1984

[Concentrations in micrograms per gram wet weight; geometric mean concentrations from Schmitt and others (1990)]

Compound	NCBP geometric mean concentration
p,p'-DDE	0.19
p,p'-DDD	.06
p,p'-DDT	.03
Total DDT	.26
Heptachlor	.01
cis-chlordane	.03
trans-chlordane	.02
cis-nonachlor	.02
trans-nonachlor	.03
oxychlordane	.01
Total PCB's	.39

Fish-bile samples were collected as an indicator of PAH exposure at seven stream sites and three reservoirs within the Dolores study area (table 29). Bile is a sensitive indicator for assessing the exposure of fish to PAHs (McDonald and others, 1991). High concentrations of PAH metabolites in bile indicate actual exposure, and high concentrations of PAHs in sediment indicate a potential for exposure (Johnston and Baumann, 1989). The bile samples were analyzed for naphthalene, phenanthrene, and benzo[a]pyrene using high performance liquid chromatography and fluorescence detection by Texas A&M University Geotechnical and Environmental Research Group, a contract laboratory for the U.S. Fish and Wildlife Service. Bile samples were collected for this project because of concern levels of PAHs in fish bile samples collected during the San Juan reconnaissance investigation in the San Juan River Basin in northern New Mexico.

Of the three compounds analyzed, only benzo[a]pyrene is a known carcinogen. Benzo[a]pyrene generally is associated with anthropogenic activities such as coke production, catalytic cracking in the petroleum industry, manufacturing of asphalt, fossil fuel combustion for heating and power generation, open burning, and internal combustion engines (Eisler, 1987b). Naphthalene and phenanthrene are indicators of exposure to PAHs but are not considered to be very toxic or carcinogenic (Eisler, 1987b). Eisler (1987b) also reports that selenium can be an effective inhibitor of PAH-induced tumor development.

Eisler (1987b) reports that criteria or standards have not been promulgated for PAHs by any regulatory agency for the protection of sensitive species of aquatic organisms or wildlife. The highest concentration of PAHs was in a channel catfish collected near Four Corners on the San Juan River (site SJ1 in table 29). A flannelmouth sucker also was collected at this site, but the PAH concentrations were much lower for the sucker than for the channel catfish. Susan McDonald (Texas A and M Research Foundation, oral commun., 1993) stated that flannelmouth suckers may not be a good indicator species of PAH contamination because they tend to have much lower concentrations of PAHs than other fish species. However, in the Dolores project area, flannelmouth suckers were selected because of their widespread distribution.

At Alkali Canyon (site AK), bile was collected from five flannelmouth suckers in November 1990 (table 29). This composite bile sample had the lowest PAH concentration within the study area. Site AK was considered a control site for PAHs in the Dolores Project area and for the San Juan study area because of the low concentrations in the November samples. Five additional bile samples collected at site AK in August 1991 (table 29) had PAH values much higher than in November 1990, indicating an exposure to PAHs had occurred some time after November 1990. The five fish collected in August 1991 were collected from the same pool and were similar in size (500 mm) and weight (2,500 g) to the five fish collected in November 1990.

SUMMARY

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. The U.S. Department of the Interior (DOI) initiated a program in 1985 to identify the nature and extent of irrigation-induced water-quality problems that might exist in the Western United States. Twenty-four reconnaissance investigations were completed through 1990 to determine if irrigation drainage has significantly affected human health, fish, and wildlife or has adversely affected the suitability of water for other beneficial uses.

This report describes results of a reconnaissance investigation of the Dolores Project area in southwestern Colorado done during 1990–91. The study area extended into southeastern Utah along the lower San Juan River. The project diverts water from McPhee Reservoir, in the Dolores River basin, for irrigation and municipal supplies in the San Juan River basin. The Dolores Project furnishes supplemental water to the area served by the Montezuma Valley Irrigation Company (MVIC). The MVIC area is located primarily in the Mc Elmo Creek basin and has been irrigated since the 1880's. The project provides all the irrigation water to the newly irrigated areas (since 1987) between Yellow Jacket Canyon and Dove Creek (the Dove Creek area), and will furnish water for irrigation on the Ute Mountain Ute Reservation (the Towaoc area) by 1994. One objective of the reconnaissance investigation was to determine if there were potentially harmful concentrations of trace elements or pesticides in water, bottom sediment, and biota in the long-term irrigated areas and in areas where irrigation recently began. Another objective was to determine if there were potentially harmful concentrations of contaminants in the Mancos River and San Juan River in the project area.

Dissolved-solids and sulfate concentrations in most water samples collected for the reconnaissance investigation exceeded the secondary maximum contaminant levels for those constituents. Dissolved-solids concentrations exceeded 500 mg/L in samples collected during the pre-irrigation season from streams draining the MVIC area, the Dove Creek area, and from the Mancos River. The MVIC area is a significant source of dissolved solids to Mc Elmo Creek. Dissolved-solids loads in the streams draining the newly irrigated areas north of Yellow Jacket Canyon were much smaller than the loads in streams draining the MVIC area. The Mancos River and Mc Elmo Creek may be significant sources of dissolved solids to the San Juan River.

The only dissolved trace-element concentrations that exceeded U.S. Environmental Protection Agency drinking-water regulations, aquatic-life criteria, or Colorado agricultural-use criteria were cadmium, mercury, and selenium. Cadmium was detected in 19 water samples collected at 16 sites. The maximum cadmium concentration was 4 µg/L in a sample from Puett Reservoir collected in November 1990. Cadmium concentrations exceeded the chronic aquatic-life criterion in two water samples; one sample was from Summit Reservoir and the other sample was from Puett Reservoir. Both reservoirs are reference sites located outside irrigated areas served by the Dolores Project. Cadmium was detected in at least one water sample from most sites within the MVIC area. Mercury was detected in 11 water samples at concentrations that ranged from 0.1 to 1.2 µg/L; however, 6 of those samples were collected at reference sites. The maximum concentration of mercury was 1.2 µg/L in a sample collected outside of the irrigated area from a seep area along the San Juan River at Aneth, Utah. The source of the seep is ground-water discharge from bedrock. Mercury was not detected in samples from the San Juan River.

Although neither dissolved cadmium or dissolved mercury were detected in the four samples collected from outflow from McPhee Reservoir, transport of cadmium, mercury, and other trace elements from the Dolores River basin into the irrigated areas may be associated with suspended sediment in water. Water has been diverted from the Dolores River into the MVIC area for about 100 years. Metal mining began in the upper Dolores River basin in the 1870's, and the numerous mined areas may have been a source of trace elements to the irrigation water supply for the Dolores Project area.

Selenium was detected in 36 water samples collected at 15 sites. The only selenium concentration that exceeded the MCL for selenium in drinking water (50 μg/L) was 88 μg/L in a sample from Navajo Wash, which drains irrigated areas on Mancos Shale in the southern MVIC area. That concentration also was the maximum selenium concentration in a water sample collected in the Dolores Project area. Selenium concentrations in 18 surface-water samples and 1 ground-water sample exceeded 5 μg/L, which is the U.S. Environmental Protection Agency's chronic criterion for selenium for protection of aquatic life.

Selenium was detected in all water samples collected from Mc Elmo Creek downstream from irrigated land in the MVIC area at concentrations that ranged from 2 to 9 μg/L. Irrigation water from McPhee Reservoir had less than 1 μg/L of selenium and the selenium load in Mc Elmo Creek upstream from the MVIC area was very small, indicating that the MVIC area is the primary source of selenium to Mc Elmo Creek. If selenium concentrations in Navajo Wash are typical of selenium concentrations in irrigation drain-water from the gray-soil areas south of Mc Elmo Creek, then irrigation drainage from gray-soil areas may be the primary source of selenium to Mc Elmo Creek. Only 1 of the 15 water samples collected from streams draining the MVIC area north of Mc Elmo Creek had a selenium concentration greater than 1 μg/L.

In contrast to the northern MVIC area, selenium was detected in all water samples collected from three small streams in the newly (since 1987) irrigated areas north of the MVIC area. Long-term irrigation may have leached much of the soluble selenium from soils in the northern MVIC area, but the soluble selenium has not been leached from soils in newly irrigated areas. The selenium concentrations in samples collected in newly irrigated areas ranged from 3 to 12 μg/L and exceeded the chronic aquatic-life criterion of 5 μg/L in six of eight samples. Selenium loads in the Dove Creek area were very small because stream discharges were small (less than 0.25 ft^3/s).

Selenium concentrations in the Mancos River ranged from 3 to 10 μg/L. The Mancos Project, a Federal irrigation project in the upper Mancos River basin, may be a source of some of the selenium in the Mancos River. Concentrations of selenium in the San Juan River did not exceed 2 μg/L. Concentrations of selenium in the San Juan River at Four Corners were equal to the concentrations at Mexican Hat, Utah, for the three sampling surveys in 1990.

The herbicides 2,4-D, and dicamba were detected in most of the 14 water samples collected in the Dolores Project area in July 1990. Picloram was detected in five samples, and malathion was detected in one sample. Pesticide concentrations in water were considerably less than the levels harmful to aquatic life.

Trace-element concentrations in bottom sediment collected in the Dolores Project area generally were within the baseline ranges for soils in the Western United States and within concentration ranges reported from previous DOI reconnaissance investigations. Selenium concentrations in bottom-sediment samples from Cahone Canyon, Woods Canyon, Navajo Wash, and the Mancos River exceeded the upper baseline for soils (1.4 μg/g). Those sites also had some of the larger selenium concentrations in water samples.

Six pesticides were detected in bottom-sediment samples from the Dolores Project area. The maximum pesticide concentration in bottom sediment was 5.5 μg/kg of DDD in the sample from Summit Reservoir, which is a reference site located outside irrigated areas of the Dolores Project.

Biota data collected by the U.S. Fish and Wildlife Service for a field screening study of the Mancos River basin in July 1989, indicated elevated selenium concentrations in some biota samples collected within and downstream from the Mancos Project. Selenium concentrations in 7 of 10 whole-body fish samples equaled or exceeded 4 μg/g dry weight, which is a guideline concentration of concern for freshwater fish. Selenium concentrations ranged from 10 to 69 μg/g dry weight in six bird-tissue samples collected from a pond located within the irrigated area of the Mancos Project. The selenium concentrations in the bird samples indicate that bioaccumulation of selenium is occurring in the Mancos Project, which is upstream from the Dolores Project.

Only 5 of 54 aquatic-plant and algae samples collected in the Dolores Project area in 1990 had selenium concentrations exceeding the recommended guideline of 3 μg/g dry weight for food items consumed by fish and wildlife, and 4 of those samples were from the

Dove Creek area. Five aquatic-invertebrate samples from Navajo Wash had selenium concentrations exceeding 3 µg/g, but only three other aquatic-invertebrate samples from the MVIC area had selenium concentrations exceeding 3 µg/g. Ten of 11 aquatic-invertebrate samples from the Dove Creek area had selenium concentrations exceeding the guideline of 3 µg/g dry weight, and the maximum concentration was 19.2 µg/g dry weight in an aquatic-invertebrate sample from Woods Canyon. Geometric mean selenium concentrations for aquatic plants and aquatic invertebrates were higher for the Dove Creek area than for the MVIC area.

Geometric mean selenium concentrations were higher in suckers (whole-body samples) from the Mancos River than in suckers from the MVIC area (except for suckers from Navajo Wash) or from the San Juan River. Selenium concentrations in only 4 of 46 sucker samples from the MVIC area exceeded the 1984 NCBP 85th-percentile concentration, and two of those samples were from Navajo Wash. The selenium concentrations in sucker samples correlated with the selenium concentrations in water samples for streams in the MVIC area. Selenium concentrations in seven of eight sucker samples collected from the Mancos River exceeded the NCBP 85th-percentile concentration for selenium, and four of those concentrations exceeded 4 µg/g dry weight, which is a guideline for selenium concentrations of concern for freshwater fish.

The mean selenium concentration was significantly higher in sucker samples collected from the San Juan River at Mexican Hat, Utah, which is downstream from the Dolores Project, than in sucker samples collected in the San Juan River at Four Corners, which is upstream from most irrigation of the Dolores Project. Suckers apparently accumulated more selenium at Mexican Hat than at Four Corners, although selenium concentrations in water samples from the two sites were equal for the three sampling surveys in 1990. Juvenile Colorado squawfish have been found in the San Juan River near the Mancos River confluence, but data collected by the reconnaissance investigation are not sufficient to assess effects of irrigation drainage from the Dolores Project on endangered fish in the San Juan River.

Other fish species collected in the Dolores project area, such as common carp, fathead minnows, and speckled dace, tended to have higher selenium concentrations than suckers. Eleven of twelve common carp whole-body samples had selenium concentrations that exceeded the NCBP 85th percentile, and six of those exceeded 4 µg/g dry weight. Selenium concentrations in more than one-half of fathead minnow samples exceeded the NCBP 85th percentile. The highest selenium concentrations in fathead minnows were in samples from lower Yellow Jacket Canyon, Woods Canyon, and from the Mancos River, and the maximum concentration was 26.4 µg/g dry weight in a sample from Woods Canyon. Some fathead minnows from those basins had selenium concentrations associated with adverse effects reported in the literature. Almost all selenium concentrations in speckled dace exceeded the NCBP 85th-percentile concentration, and most concentrations exceeded the concentration of concern of 4 µg/g for whole-body fish samples. As with water samples and other biota samples, the highest selenium concentrations in speckled dace in the MVIC area were in samples from Navajo Wash.

Selenium concentrations in piscivorous fish samples from reservoirs in the Dolores Project area generally were less than the concentrations in fish samples from streams. Selenium concentrations in fillet and egg samples of piscivorous fish were less than concentrations of concern.

The geometric mean selenium concentration in 15 bird eggs (different species) collected in the Dolores Project area was 3.6 µg/g dry weight, and the mean concentration in 9 bird livers was 6.0 µg/g dry weight. The mean concentration for eggs is within the range of uncertainty for biological significance, and the mean concentration for livers is less than the mean baseline concentration of 10 µg/g dry weight. Bird-tissue samples that had the highest selenium concentrations were collected in the Dove Creek area and included 37.5 µg/g dry weight in a mallard liver from Woods Canyon, and 18.5 µg/g dry weight in a coot egg from a pond in Alkali Canyon, a tributary of Cross Canyon.

The only mercury concentrations in biota that may be of concern in the Dolores Project area are in warm-water game fish from reservoirs. Advisories were posted in 1991 at McPhee and Narraguinnep Reservoirs by the Colorado Department of Health concerning elevated mercury concentrations in game fish. Based on mercury data collected from 1988–91 and the risk assessment method used by the Colorado Department of Health, weekly human consumption guidelines were computed for adults, children, and pregnant women. The amount of fish that can safely be consumed varied by fish species and by site. The most restrictive consumption limits were for walleye, bass, and northern pike. The weekly consumption limits for adults ranged from 0 oz/week for walleye from Narraguinnep Reservoir to 58 oz/wk for kokanee salmon from McPhee Reservoir.

A few aluminum concentrations in aquatic-plant and aquatic-invertebrate samples from the Dolores Project area may be potentially hazardous to young aquatic birds, such as coots and waterfowl. Arsenic concentrations in biota were representative of unpolluted environments or were less than background concentrations. Two boron concentrations in aquatic plants and a few concentrations in whole-body fish were elevated compared to information in the literature, but boron probably is not a concern in biota in the Dolores Project area.

Cadmium concentrations in biota generally were within background concentrations reported in the literature except for a number of whole-body fish samples. Cadmium concentrations in about 50 percent of whole-body fish samples from the MVIC area exceeded the 1984 NCBP 85th percentile of 0.05 μg/g wet weight for cadmium. Eight cadmium concentrations in whole-body fish from the Dolores Project area exceeded the maximum concentration for the 1984 NCBP data of 0.22 μg/g wet weight. The maximum cadmium concentration from the Dolores Project area of 3.5 μg/g dry weight (1.16 μg/g wet weight) was in a speckled dace collected from Mc Elmo Creek downstream from Cortez. However, cadmium concentrations in fish were less than concentrations reported in the literature that indicate cadmium contamination. Although chromium concentrations in water and bottom-sediment samples from the Dolores Project area were not elevated, chromium concentrations in a significant number of aquatic-plant, aquatic-invertebrate, and whole-body fish samples from the project area are indicative of chromium contamination. The maximum chromium concentration in a biota sample was 440 μg/g dry weight in a crayfish from the lower Mancos River. Cadmium and chromium could have been transported into the Dolores Project area in the irrigation water diverted from the Dolores River basin.

Copper concentrations in 83 whole-body fish samples and lead concentrations in 41 whole-body fish samples exceeded the 1984 NCBP 85th-percentile concentrations for those trace elements. Toxic concentrations of copper and lead in fish have not been determined. Zinc concentrations in 44 whole-body fish samples exceeded the 1984 NCBP 85th percentile, and 32 of the samples were from the MVIC area. However, the toxicological significance of the zinc concentrations is not known.

Concentrations of organochlorine pesticides and PCB's in fish and birds in the Dolores Project area were within the range of background concentrations. Fish-bile samples from seven streams and three reservoirs were analyzed for 3 PAH compounds. The highest PAH concentrations were in a channel catfish from the San Juan River at Four Corners, but the biological significance of PAH concentrations are not known.

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SUPPLEMENTAL DATA

Table 22. Physical properties and inorganic constituent concentrations in water samples collected in the Dolores Project area from March through November, 1990

[ft³/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; MVIC, Montezuma Valley Irrigation Company; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than reporting limit; E, estimated; --, no data]

Site number (figs. 1, 2)	Site name	Date	Time	Stream discharge (ft³/s)	Specific conductance (µS/cm)	pH (standard units)	Water temperature (°C)
		MVIC AREA					
ME1	Mc Elmo Creek at Highway 160 near	03-27-90	1100	0.09	6,380	8.3	10.5
	Cortez	07-16-90	1930	3.1	1,430	7.5	20.0
		11-14-90	1520	E.02	6,210	8.2	6.5
ME2	Mc Elmo Creek downstream from	03-27-90	1630	19	3,490	8.8	11.5
	Alkali Canyon	07-16-90	1700	131	1,690	8.2	22.0
		07-19-90	1430	78	1,680	8.4	23.0
		11-14-90	1400	42	2,530	8.5	6.0
ME3	Mc Elmo Creek upstream from	03-27-90	1450	21	3,340	8.5	15.0
	Yellow Jacket Canyon	07-16-90	1500	272	2,000	7.6	19.0
		11-14-90	1130	56	2,570	8.4	6.0
ME4	Mc Elmo Creek downstream from	03-27-90	1230	26	3,180	8.5	13.0
	Yellow Jacket Canyon	07-16-90	1240	E300	2,490	7.7	20.0
		11-14-90	0830	67	2,360	8.3	4.0
DT	Dolores Tunnel outflow	05-15-90	0900	209	293	8.3	8.0
		08-14-90	0830	48	264	7.7	12.5
GD	Great Cut Dike outflow	05-15-90	1030	108	297	8.3	9.0
		08-14-90	0910	159	265	8.2	18.0
SU	Summit Reservoir - near-surface sample	04-17-90	1015	--	190	8.3	12.0
	near-bottom sample	04-17-90	1020	--	141	8.0	7.0
	near-surface sample	11-08-90	1015	--	126	9.0	4.5
	near-bottom sample	11-08-90	1020	--	126	8.6	4.5
PU	Puett Reservoir - near-surface sample	04-17-90	0910	--	634	8.7	12.5
	near-bottom sample	04-17-90	0915	--	626	8.9	12.5
	near-surface sample	11-08-90	1130	--	478	9.0	5.0
	near-bottom sample	11-08-90	1135	--	482	9.0	5.0

Table 22. Physical properties and inorganic constituent concentrations in water samples collected in the Dolores Project area from March through November, 1990--Continued

Site number (figs. 1, 2)	Date	Dis- solved oxygen (mg/L)	Hard- ness, total (mg/L as $CaCO_3$)	Calcium, dis- solved (mg/L as Ca)	Magne- sium, dis- solved (mg/L as Mg)	Sodium, dis- solved (mg/L as Na)	Sodium adsorp- tion ratio	Potas- sium, dis- solved (mg/L as K)	Sulfate, dis- solved (mg/L as SO_4)	Chlo- ride, dis- solved (mg/L as Cl)	Alka- linity, (mg/L as $CaCO_3$)
					MVIC AREA--Continued						
ME1	03-27-90	9.9	3,000	380	490	680	5	5.0	4,300	93	270
	07-16-90	6.6	570	130	59	95	2	6.4	670	15	85
	11-14-90	11.0	2,600	380	400	680	6	5.0	3,800	110	276
ME2	03-27-90	10.1	1,800	340	230	250	3	5.5	1,700	47	238
	07-16-90	7.1	820	200	78	87	1	5.9	830	17	196
	07-19-90	6.8	860	200	87	82	1	4.0	700	15	232
	11-14-90	11.1	1,400	300	150	140	2	4.2	1,300	27	241
ME3	03-27-90	9.1	1,700	310	220	240	3	6.0	1,900	33	208
	07-16-90	7.0	890	220	82	120	2	8.6	1,100	18	150
	11-14-90	10.9	1,300	290	150	150	2	4.6	1,300	29	252
ME4	03-27-90	9.3	1,600	290	220	240	3	6.0	1,600	46	213
	07-16-90	6.8	1,100	250	110	170	2	9.0	1,300	33	189
	11-14-90	11.1	1,300	270	150	140	2	4.4	1,200	29	252
DT	05-15-90	--	140	44	7.1	7.7	.3	2.6	31	5.7	108
	08-14-90	--	130	41	6.4	7.1	.3	1.6	30	7.3	100
GD	05-15-90	9.4	140	44	7.0	7.6	.3	1.6	30	8.8	110
	08-14-90	--	130	40	6.3	6.9	.3	1.6	24	8.3	111
SU	04-17-90	8.3	79	24	4.6	5.9	.3	1.1	32	.6	55
	04-17-90	8.4	52	15	3.5	4.8	.3	1.0	25	.6	41
	11-08-90	9.0	57	18	2.9	3.8	.2	.50	16	1.2	49
	11-08-90	9.0	60	19	3.0	3.9	.2	.60	16	1.0	49
PU	04-17-90	9.1	240	60	23	39	1	1.8	190	6.8	109
	04-17-90	9.2	240	60	23	39	1	1.9	190	6.8	109
	11-08-90	8.9	190	49	16	28	.9	1.7	120	6.3	109
	11-08-90	9.1	190	49	16	28	.9	1.8	120	7.5	110

Table 22. Physical properties and inorganic constituent concentrations in water samples collected in the Dolores Project area from March through November, 1990--Continued

Site number (figs. 1, 2)	Date	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)	Dissolved solids (mg/L)	Dissolved solids (tons per day)	Nitrogen, Nitrite dissolved (mg/L as N)	Nitrogen, NO_2+NO_3 dissolved (mg/L as N)	Nitrogen, ammonia dissolved (mg/L as N)	Orthophosphorus, dissolved (mg/L as P)	Arsenic, dissolved (μg/L as As)	Boron, dissolved (μg/L as B)
					MVIC AREA--Continued						
ME1	03-27-90	--	--	6,110	1.48	--	<0.1	--	--	<1	150
	07-16-90	--	5.1	1,030	8.62	--	.4	--	--	1	60
	11-14-90	0.4	5.7	5,550	E.30	0.01	<.1	0.03	<0.01	<1	150
ME2	03-27-90	--	--	2,740	143	--	4.7	--	--	<1	260
	07-16-90	--	12	1,350	477	--	.5	--	--	1	120
	07-19-90	--	12	1,240	261	--	.9	--	--	1	140
	11-14-90	.3	10	2,090	237	.01	2.0	.06	.10	<1	170
ME3	03-27-90	--	--	2,840	161	--	1.8	--	--	<1	230
	07-16-90	--	7.4	1,650	1,210	--	1.1	--	--	1	110
	11-14-90	.1	9.5	2,090	316	<.01	1.2	.01	.01	<1	180
ME4	03-27-90	--	--	2,540	178	--	1.8	--	--	<1	220
	07-16-90	--	8.3	2,000	1,620	--	1.8	--	--	1	150
	11-14-90	.3	9.7	1,960	354	<.01	1.2	.01	.01	<1	170
DT	05-15-90	--	--	163	91.9	--	<.1	--	--	<1	20
	08-14-90	--	4.0	157	20.4	--	<.1	--	--	1	10
GD	05-15-90	--	--	165	48.1	--	<.1	--	--	<1	20
	08-14-90	--	4.5	158	67.9	--	<.1	--	--	1	<10
SU	04-17-90	--	--	101	--	--	<.1	--	--	<1	<10
	04-17-90	--	--	74	--	--	<.1	--	--	<1	<10
	11-08-90	<.1	3.6	75	--	<.01	<.1	<.01	<.01	1	10
	11-08-90	<.1	3.6	76	--	<.01	<.1	<.01	<.01	<1	<10
PU	04-17-90	--	--	386	--	--	<.1	--	--	1	20
	04-17-90	--	--	386	--	--	<.1	--	--	1	20
	11-08-90	.1	.5	287	--	<.01	<.1	<.01	<.01	1	20
	11-08-90	.1	.5	289	--	<.01	<.1	.05	<.01	1	20

Table 22. Physical properties and inorganic constituent concentrations in water samples collected in the Dolores Project area from March through November, 1990--Continued

Site number (figs. 1, 2)	Date	Cadmium, dissolved (µg/L as Cd)	Chromium, dissolved (µg/L as Cr)	Copper, dissolved µg/L as Cu)	Lead, dissolved (µg/L as Pb)	Mercury, dissolved (µg/L as Hg)	Molybdenum, dissolved (µg/L as Mo)	Selenium, dissolved (µg/L as Se)	Vanadium, dissolved (µg/L as V)	Zinc, dissolved (µg/L as Zn)	Uranium, natural total (µg/L as U)
					MVIC AREA--Continued						
ME1	03-27-90	<1	<1	4	<1	<0.1	7	2	1	10	19
	07-16-90	2	2	3	<1	<.1	5	2	5	8	1.5
	11-14-90	<1	<1	1	<1	<.1	4	<1	4	<10	25
ME2	03-27-90	<1	1	2	<1	<.1	2	8	<1	<10	11
	07-16-90	2	<1	5	<1	<.1	4	2	6	4	6.6
	07-19-90	<1	<1	1	<1	.1	1	2	6	<3	3.4
	11-14-90	<1	1	1	<1	<.1	<1	4	1	<10	7.3
ME3	03-27-90	<1	<1	2	<1	<.1	3	6	<1	<10	8.4
	07-16-90	<1	3	2	1	<.1	13	6	6	<10	6.9
	11-14-90	1	<1	1	<1	<.1	3	3	1	<10	7.8
ME4	03-27-90	<1	<1	2	<1	<.1	4	6	<1	<10	8.3
	07-16-90	<1	1	10	<1	<.1	16	9	8	10	9.0
	11-14-90	3	<1	1	<1	<.1	1	3	1	<10	6.5
DT	05-15-90	<1	<1	4	1	<.1	2	<1	2	11	<1.0
	08-14-90	<1	<1	1	<1	<.1	<1	<1	2	10	2.4
GD	05-15-90	<1	<1	4	1	<.1	2	<1	2	9	<1.0
	08-14-90	<1	<1	2	<1	<.1	<1	<1	2	16	<1.0
SU	04-17-90	<1	<1	3	<1	<.1	<1	<1	<1	<3	<1.0
	04-17-90	<1	<1	2	<1	<.1	<1	<1	1	11	<1.0
	11-08-90	2	<1	1	<1	<.1	<1	<1	2	4	<1.0
	11-08-90	<1	<1	2	<1	<.1	<1	<1	2	4	<1.0
PU	04-17-90	<1	<1	2	<1	.1	1	<1	<1	<3	3.4
	04-17-90	<1	<1	3	<1	.1	<1	<1	<1	3	1.2
	11-08-90	2	<1	2	<1	<.1	<1	<1	2	4	<1.0
	11-08-90	4	<1	5	<1	<.1	<1	1	2	6	<1.0

Table 22. Physical properties and inorganic constituent concentrations in water samples collected in the Dolores Project area from March through November, 1990--Continued

Site number (figs. 1, 2)	Site name	Date	Time	Stream discharge (ft³/s)	Specific conduct-ance (µS/cm)	pH (standard units)	Water temp-erature (°C)
			MVIC AREA--Continued				
TT	Totten Reservoir - near-surface sample	04-17-90	1210	--	1,020	8.2	13.5
	near-bottom sample	04-17-90	1215	--	1,030	8.2	13.5
	near-surface sample	11-08-90	1250	--	758	8.2	7.5
	near-bottom sample	11-08-90	1255	--	757	8.3	7.5
SD	Simon Draw downstream from Cash Canyon	03-28-90	1340	.76	3,360	8.1	14.0
		07-18-90	1430	.64	2,710	7.9	23.5
		11-08-90	1500	.65	2,790	8.1	8.0
HD1	Hartman Draw near Lebanon	03-28-90	1230	2.4	2,570	8.0	12.0
		07-18-90	1230	4.8	1,910	8.0	20.5
		11-13-90	1400	6.5	1,880	8.1	7.0
HD2	Hartman Draw near mouth, at Cortez	03-28-90	0830	4.4	2,820	8.2	6.0
		07-18-90	0840	27	1,770	8.2	17.5
		11-13-90	1500	15	2,260	8.4	6.5
AK	Alkali Canyon downstream from Narraguinnep Canyon	03-28-90	1000	4.3	2,460	8.1	7.5
		07-18-90	1030	23	1,410	8.2	18.0
		11-09-90	0800	13	2,220	8.3	3.0
DD	Dawson Draw near Lewis	04-11-90	0730	1.9	2,090	8.1	6.5
		07-19-90	1140	15	882	8.2	21.5
		11-09-90	0900	4.5	1,400	8.1	2.5
YJ2	Yellow Jacket Canyon at mouth	03-27-90	1400	2.5	1,590	8.4	17.0
		07-16-90	1330	21	936	8.5	27.0
		11-14-90	1000	8.3	1,200	8.4	4.0
NW	Navajo Wash near Towaoc	03-28-90	0730	.87	6,880	8.4	6.0
		07-18-90	0730	19	1,380	8.1	18.0
		11-06-90	1630	9.0	2,390	8.1	6.0

Table 22. Physical properties and inorganic constituent concentrations in water samples collected in the Dolores Project area from March through November, 1990--Continued

Site number (figs. 1, 2)	Date	Dis-solved oxygen (mg/L)	Hard-ness, total (mg/L as $CaCO_3$)	Calcium, dis-solved (mg/L as Ca)	Magne-sium, dis-solved (mg/L as Mg)	Sodium, dis-solved (mg/L as Na)	Sodium adsorp-tion ratio	Potas-sium, dis-solved (mg/L as K)	Sulfate, dis-solved (mg/L as SO_4)	Chlo-ride, dis-solved (mg/L as Cl)	Alka-linity, (mg/L as $CaCO_3$)
					MVIC AREA--Continued						
TT	04-17-90	9.2	510	130	45	27	0.5	3.0	420	11	113
	04-17-90	9.2	510	130	45	26	.5	3.0	450	9.1	113
	11-08-90	7.8	370	100	29	18	.4	2.9	250	9.8	138
	11-08-90	7.8	370	100	30	19	.4	2.9	240	8.4	139
SD	03-28-90	9.0	2,000	370	250	160	2	5.5	1,800	36	287
	07-18-90	8.8	1,600	380	160	75	.8	5.1	1,400	19	331
	11-08-90	10.2	1,700	400	180	88	.9	4.3	1,500	22	295
HD1	03-28-90	8.4	1,400	330	150	82	.9	3.9	1,300	15	255
	07-18-90	7.1	1,100	280	100	46	.6	3.9	920	10	308
	11-13-90	10.0	1,100	270	96	45	.6	3.1	910	15	202
HD2	03-28-90	9.0	1,700	370	180	120	1	4.8	1,400	25	269
	07-18-90	7.2	980	250	86	54	.8	4.3	850	15	264
	11-13-90	11.4	1,400	330	130	77	.9	3.7	1,200	25	219
AK	03-28-90	9.8	1,400	310	150	100	1	4.2	1,200	18	287
	07-18-90	7.6	730	180	68	46	.7	3.9	530	13	279
	11-09-90	10.8	1,200	280	130	81	1	4.1	1,000	18	298
DD	04-11-90	8.6	1,100	230	120	120	2	5.4	1,100	18	322
	07-19-90	6.9	410	100	40	30	.6	3.7	150	17	288
	11-09-90	10.5	680	150	74	60	1	3.7	450	18	324
YJ2	03-27-90	8.1	680	120	93	110	2	5.3	570	42	249
	07-16-90	6.6	420	94	45	43	.9	5.3	240	18	264
	11-14-90	10.8	570	110	72	71	1	3.6	430	28	236
NW	03-28-90	8.7	3,200	440	500	800	6	8.7	3,700	110	358
	07-18-90	7.5	600	130	68	85	2	5.0	570	20	179
	11-06-90	9.3	1,100	210	130	160	2	5.3	1,200	33	201

Table 22. Physical properties and inorganic constituent concentrations in water samples collected in the Dolores Project area from March through November, 1990--Continued

Site number (figs. 1, 2)	Date	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)	Dissolved solids (mg/L)	Dissolved solids (tons per day)	Nitrogen, Nitrite dissolved (mg/L as N	Nitrogen, NO_2+NO_3 dissolved (mg/L as N)	Nitrogen, ammonia dissolved (mg/L as N)	Orthophosphorus, dissolved (mg/L as P)	Arsenic, dissolved (µg/L as As)	Boron, dissolved (µg/L as B)
					MVIC AREA--Continued						
TT	04-17-90	--	--	704	--	--	<0.1	--	--	1	70
	04-17-90	--	--	731	--	--	<.1	--	--	<1	70
	11-08-90	.3	6.3	499	--	<0.01	<.1	0.01	<0.01	1	60
	11-08-90	.3	6.5	491	--	<.01	<.1	.02	<.01	<1	60
SD	03-28-90	--	--	2,790	5.73	--	<.1	--	--	<1	130
	07-18-90	--	11	2,250	3.89	--	<.1	--	--	<1	170
	11-08-90	.2	10	2,380	4.18	<.01	<.1	.03	<.01	<1	140
HD1	03-28-90	--	--	2,030	13.2	--	<.1	--	--	<1	110
	07-18-90	--	14	1,560	20.2	--	<.1	--	--	1	120
	11-13-90	0.2	9.9	1,470	25.8	<.01	<.1	.02	.01	<1	80
HD2	03-28-90	--	--	2,270	27.0	--	1.7	--	--	1	160
	07-18-90	--	13	1,430	102	--	.2	--	--	1	140
	11-13-90	.3	9.5	1,910	79.9	<.01	.4	.05	.08	<1	130
AK	03-28-90	--	--	1,950	22.6	--	<.1	--	--	<1	130
	07-18-90	--	16	1,020	64.2	--	<.1	--	--	1	110
	11-09-90	.3	14	1,710	62.3	<.01	<.1	.01	<.01	<1	130
DD	04-11-90	--	--	1,790	9.18	--	<.1	--	--	1	100
	07-19-90	--	18	531	22.1	--	<.1	--	--	1	80
	11-09-90	.3	15	965	11.7	<.01	<.1	<.01	.03	1	80
YJ2	03-27-90	--	--	1,090	7.36	--	<.1	--	--	1	90
	07-16-90	--	17	621	34.9	--	<.1	--	--	2	90
	11-14-90	.3	12	869	19.5	<.01	<.1	.05	<.01	1	70
NW	03-28-90	--	--	5,850	13.7	--	17.0	--	--	<1	720
	07-18-90	--	8.8	999	51.0	--	1.0	--	--	1	140
	11-06-90	.4	7.3	1,880	45.7	.01	2.1	.01	<.01	<1	190

Table 22. Physical properties and inorganic constituent concentrations in water samples collected in the Dolores Project area from March through November, 1990--Continued

Site number (figs. 1, 2)	Date	Cadmium, dissolved (µg/L as Cd)	Chromium, dissolved (µg/L as Cr)	Copper, dissolved (µg/L as Cu)	Lead, dissolved (µg/L as Pb)	Mercury, dissolved (µg/L as Hg)	Molybdenum, dissolved (µg/L as Mo)	Selenium, dissolved (µg/L as Se)	Vanadium, dissolved (µg/L as V)	Zinc, dissolved (µg/L as Zn)	Uranium, natural total (µg/L as U)
					MVIC AREA--Continued						
TT	04-17-90	<1	<1	1	<1	0.1	1	<1	<1	<3	1.8
	04-17-90	<1	<1	2	<1	<.1	<1	<1	<1	<3	1.6
	11-08-90	<1	<1	<1	<1	<.1	<1	<1	1	7	2.3
	11-08-90	1	<1	1	<1	<.1	<1	<1	1	12	6.0
SD	03-28-90	<1	<1	1	<1	.1	2	<1	<1	<10	4.2
	07-18-90	<1	1	1	<1	<.1	2	<1	5	<10	4.7
	11-08-90	3	1	<1	<1	<.1	<1	<1	1	<10	1.4
HD1	03-28-90	<1	<1	1	<1	<.1	1	<1	<1	20	3.0
	07-18-90	2	<1	1	<1	<.1	1	<1	3	35	1.4
	11-13-90	<1	<1	1	<1	<.1	<1	<1	<1	6	3.7
HD2	03-28-90	<1	1	2	<1	<.1	1	2	<1	<10	5.3
	07-18-90	2	3	2	<1	<.1	1	<1	4	8	2.0
	11-13-90	<1	1	1	<1	<.1	<1	<1	<1	<10	--
AK	03-28-90	<1	<1	2	<1	<.1	1	<1	<1	<10	5.6
	07-18-90	1	<1	2	<1	<.1	1	<1	5	15	2.3
	11-09-90	1	<1	1	<1	<.1	<1	<1	1	<10	4.4
DD	04-11-90	<1	<1	1	<1	<.1	1	<1	3	<10	4.0
	07-19-90	<1	<1	1	<1	<.1	1	<1	8	9	<1.0
	11-09-90	<1	<1	1	<1	<.1	<1	<1	2	7	5.0
YJ2	03-27-90	<1	<1	<1	<1	<.1	<10	<1	<6	22	2.4
	07-16-90	1	<1	3	1	<.1	1	<1	11	5	2.1
	11-14-90	<1	<1	1	<1	<.1	<1	<1	1	5	1.9
NW	03-28-90	<1	<1	3	<1	<.1	5	88	1	10	45
	07-18-90	<1	<1	1	<1	<.1	1	7	6	6	5.6
	11-06-90	2	<1	1	<1	<.1	<1	12	2	<10	5.7

Table 22. Physical properties and inorganic constituent concentrations in water samples collected in the Dolores Project area from March through November, 1990--Continued

Site number (figs. 1, 2)	Site name	Date	Time	Stream discharge (ft^3/s)	Specific conductance (µS/cm)	pH (standard units)	Water temperature (°C)
		DOVE CREEK AREA					
YJ1	Tributary of Yellow Jacket Canyon at Highway 666	03-28-90	1100	0.02	3,200	8.1	6.5
		07-19-90	1100	E.01	1,480	8.1	20.0
		11-15-90	0800	E.01	3,330	7.9	.0
WC	Woods Canyon near Yellow Jacket	04-11-90	0810	.01	2,980	7.7	3.5
		11-15-90	0830	E.02	2,830	8.0	3.0
CH	Cahone Canyon at Highway 666	04-09-90	1530	.02	5,120	8.3	13.0
		07-19-90	0930	.20	2,190	8.1	16.0
		11-15-90	0945	E.05	5,040	7.8	4.0
CR	Cross Canyon upstream from Alkali Canyon	04-11-90	0930	.12	4,200	7.8	6.0
		07-19-90	0830	E.01	4,180	7.7	16.5
		11-15-90	1130	E.02	4,240	7.9	2.0
OW1	Observation well 7.5 miles west of Pleasant View	10-30-90	0930	--	1,320	7.3	12.0
OW2	Observation well 2.5 miles southeast of Cahone	10-30-90	1015	--	4,080	6.7	12.0
OW3	Observation well 3.2 miles west of Yellow Jacket	10-30-90	1100	--	3,190	6.9	14.0

Site number (figs. 1, 2)	Date	Dissolved oxygen (mg/L)	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)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Alkalinity, (mg/L as $CaCO_3$)
YJ1	03-28-90	--	1,900	490	160	140	1	2.0	1,700	85	267
	07-19-90	--	740	210	52	48	.8	3.1	570	29	179
	11-15-90	11.0	1,900	490	160	140	1	1.9	1,700	48	266
WC	04-11-90	--	1,600	360	180	170	2	1.4	1,300	140	406
	11-15-90	9.5	1,500	340	160	180	2	2.1	1,200	140	375
CH	04-09-90	11.7	1,900	400	460	360	3	3.8	2,900	210	316
	07-19-90	8.3	1,200	180	180	110	1	5.5	970	62	247
	11-15-90	9.8	2,800	380	450	350	3	4.0	2,800	200	408
CR	04-11-90	8.4	2,100	590	150	280	3	2.8	1,800	400	325
	07-19-90	4.2	2,200	620	160	260	2	3.5	1,900	380	85
	11-15-90	--	2,100	590	160	300	3	2.5	1,900	360	261
OW1	10-30-90	--	460	120	38	130	3	1.4	220	45	333
OW2	10-30-90	--	2,400	390	340	220	2	2.0	2,200	42	524
OW3	10-30-90	--	1,700	350	190	130	1	2.0	1,200	150	566

Table 22. Physical properties and inorganic constituent concentrations in water samples collected in the Dolores Project area from March through November, 1990--Continued

Site number (figs. 1, 2)	Date	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)	Dissolved solids (mg/L)	Dissolved solids (tons per day)	Nitrogen, Nitrite dissolved (mg/L as N	Nitrogen, NO_2+NO_3 dissolved (mg/L as N)	Nitrogen, ammonia dissolved (mg/L as N)	Orthophosphorus, dissolved (mg/L as P)	Arsenic, dissolved (µg/L as As)	Boron, dissolved (µg/L as B)
					DOVE CREEK AREA--Continued						
YJ1	03-28-90	--	--	2,740	0.15	--	1.3	--	--	<1	80
	07-19-90	--	11	1,040	E.03	--	2.5	--	--	1	60
	11-15-90	<0.1	15	2,750	E.07	0.03	7.5	0.03	<0.01	<1	80
WC	04-11-90	--	--	2,410	.07	--	3.1	--	--	1	100
	11-15-90	.2	20	2,280	E.12	<.01	2.1	.08	.04	<1	110
CH	04-09-90	--	--	4,520	.24	--	.1	--	--	1	180
	07-19-90	--	13	1,670	.90	--	<.1	--	--	1	130
	11-15-90	.2	11	4,440	E.60	<.01	.2	.07	.05	<1	180
CR	04-11-90	--	--	3,420	1.11	--	<.1	--	--	<1	90
	07-19-90	--	14	3,390	E.09	--	<.1	--	--	<1	140
	11-15-90	.3	14	3,480	E.19	<.01	<.1	.07	<.01	<1	90
OW1	10-30-90	.4	--	830	--	.01	17.0	<.01	<.01	<1	130
OW2	10-30-90	<.1	--	3,510	--	<.01	<.1	.20	.03	3	250
OW3	10-30-90	.6	--	2,360	--	<.01	<.1	.08	.06	2	370

Site number (figs. 1, 2)	Date	Cadmium, dissolved (µg/L as Cd)	Chromium, dissolved (µg/L as Cr)	Copper, dissolved (µg/L as Cu)	Lead, dissolved (µg/L as Pb)	Mercury, dissolved (µg/L as Hg)	Molybdenum, dissolved (µg/L as Mo)	Selenium, dissolved (µg/L as Se)	Vanadium, dissolved (µg/L as V)	Zinc, dissolved (µg/L as Zn)	Uranium, natural total (µg/L as U)
YJ1	03-28-90	<1	<1	1	<1	<0.1	1	11	1	<10	9.1
	07-19-90	<1	1	2	<1	<.1	1	3	7	12	3.4
	11-15-90	<1	2	1	<1	<.1	<1	9	3	<10	15
WC	04-11-90	<1	<1	2	<1	<.1	1	7	8	<10	16
	11-15-90	<1	<1	1	<1	<.1	1	4	6	<10	11
CH	04-09-90	<1	1	2	<1	<.1	2	12	6	10	8.4
	07-19-90	<1	<1	2	<1	.2	2	7	9	10	5.5
	11-15-90	<1	1	2	<1	<.1	1	12	9	10	11
CR	04-11-90	<1	2	<1	<1	<.1	1	<1	16	<10	6.1
	07-19-90	<1	3	1	<1	<.1	<1	<1	17	20	3.3
	11-15-90	<1	2	1	<1	.1	<1	<1	17	<10	7.0
OW1	10-30-90	<1	<1	6	<1	<.1	3	7	8	15	--
OW2	10-30-90	<1	1	<1	<1	.1	2	<1	7	20	16
OW3	10-30-90	<1	1	1	<1	.1	4	<1	10	30	17

Table 22. Physical properties and inorganic constituent concentrations in water samples collected in the Dolores Project area from March through November, 1990--Continued

Site number (figs. 1, 2)	Site name	Date	Time	Stream discharge (ft^3/s)	Specific conductance (μS/cm)	pH (standard units)	Water temperature (°C)
		MANCOS AND SAN JUAN RIVERS					
MN1	Mancos River at Highway 666	04-10-90	0900	2.9	2,380	8.3	8.0
		07-17-90	0800	16	1,540	8.3	20.0
		11-06-90	1500	17	1,850	8.1	7.5
MN2	Mancos River at Colorado-New Mexico State line	04-10-90	1000	.89	2,820	8.2	11.0
		07-17-90	1000	49	1,820	8.2	21.5
		11-06-90	1310	31	1,850	8.0	7.0
SJ1	San Juan River at Four Corners	04-10-90	1200	599	785	8.4	12.5
		07-17-90	1530	888	881	8.2	26.5
		11-07-90	1400	1,060	678	8.0	6.0
SJ3	San Juan River at Mexican Hat, Utah	04-10-90	1510	590	835	8.5	18.0
		07-17-90	1230	1,680	1,100	8.2	25.5
		11-07-90	1030	1,150	815	8.3	5.5
GW	Seep area along San Juan River at Aneth, Utah	04-10-90	1400	--	13,600	7.5	18.5
		07-17-90	1415	--	13,900	7.4	19.5
		11-07-90	1300	--	13,500	7.4	18.0

Site number (figs. 1, 2)	Date	Dissolved oxygen (mg/L)	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)	Sulfate, dissolved (mg/L as SO_4)	Chloride, dissolved (mg/L as Cl)	Alkalinity, (mg/L as $CaCO_3$)
MN1	04-10-90	8.9	1,100	220	140	170	2	4.2	1,200	21	189
	07-17-90	7.2	660	160	64	87	1	6.1	740	9.2	141
	11-06-90	10.0	860	180	100	120	2	3.9	870	19	190
MN2	04-10-90	8.5	1,300	240	160	220	3	4.9	1,400	38	200
	07-17-90	7.1	820	200	79	120	2	8.0	870	23	156
	11-06-90	10.2	850	180	98	120	2	4.2	820	21	190
SJ1	04-10-90	8.4	240	70	15	68	2	2.4	210	19	128
	07-17-90	6.1	230	75	10	81	2	4.6	280	16	144
	11-07-90	10.0	240	75	14	49	1	2.4	170	13	135
SJ3	04-10-90	9.0	280	78	21	68	2	2.6	260	22	135
	07-17-90	6.7	370	110	22	86	2	5.0	380	39	153
	11-07-90	10.2	280	80	19	66	2	2.8	250	17	137
GW	04-10-90	--	390	89	41	2,900	64	26	1,500	3,500	544
	07-17-90	--	410	94	42	2,700	58	26	1,400	3,600	558
	11-07-90	--	460	110	44	2,900	59	26	1,400	3,900	560

Table 22. Physical properties and inorganic constituent concentrations in water samples collected in the Dolores Project area from March through November, 1990--Continued

Site number (figs. 1, 2)	Date	Fluoride, dissolved (mg/L as F)	Silica, dissolved (mg/L as SiO_2)	Dissolved solids (mg/L)	Dissolved solids (tons per day)	Nitrogen, Nitrite dissolved (mg/L as N	Nitrogen, NO_2+NO_3 dissolved (mg/L as N)	Nitrogen, ammonia dissolved (mg/L as N)	Orthophosphorus, dissolved (mg/L as P)	Arsenic, dissolved (μg/L as As)	Boron, dissolved (μg/L as B)
					MANCOS AND SAN JUAN RIVERS--Continued						
MN1	04-10-90	--	--	1,870	14.6	--	<0.1	--	--	<1	110
	07-17-90	--	9.1	1,160	50.1	--	.3	--	--	1	90
	11-06-90	.1	8.3	1,420	65.2	<0.01	<.1	<0.01	<0.01	<1	90
MN2	04-10-90	--	--	2,180	5.24	--	.1	--	--	<1	140
	07-17-90	--	8.6	1,410	187	--	.8	--	--	1	150
	11-06-90	.3	6.8	1,370	115	<.01	.9	<.01	<.01	<1	110
SJ1	04-10-90	--	--	463	748	--	.3	--	--	1	60
	07-17-90	--	10	566	1,360	--	.7	--	--	1	70
	11-07-90	.3	8.6	415	1,190	<.01	.3	<.01	.03	1	60
SJ3	04-10-90	--	--	533	848	--	<.1	--	--	<1	70
	07-17-90	--	10	749	3,400	--	1.1	--	--	1	100
	11-07-90	.3	8.7	528	1,640	<.01	.5	.02	.02	1	60
GW	04-10-90	--	--	8,380	--	--	.2	--	--	12	60
	07-17-90	--	11	8,210	--	--	.3	--	--	11	430
	11-07-90	<.1	10	8,730	--	.01	.4	.26	<.01	11	450

Site number (figs. 1, 2)	Date	Cadmium, dissolved (μg/L as Cd)	Chromium, dissolved (μg/L as Cr)	Copper, dissolved (μg/L as Cu)	Lead, dissolved (μg/L as Pb)	Mercury, dissolved (μg/L as Hg)	Molybdenum, dissolved (μg/L as Mo)	Selenium, dissolved (μg/L as Se)	Vanadium, dissolved (μg/L as V)	Zinc, dissolved (μg/L as Zn)	Uranium, natural total (μg/L as U)
					MANCOS AND SAN JUAN RIVERS--Continued						
MN1	04-10-90	<1	<1	1	<1	<.1	2	3	<1	<10	6.3
	07-17-90	2	3	5	1	<.1	5	3	7	4	<1.0
	11-06-90	<1	<1	2	<1	<.1	3	10	1	6	6.4
MN2	04-10-90	<1	1	1	<1	<.1	3	6	<1	<10	6.6
	07-17-90	<1	<1	5	<1	<.1	4	10	9	7	7.6
	11-06-90	<1	<1	2	<1	<.1	<1	8	1	7	6.4
SJ1	04-10-90	2	<1	<3	<1	<.1	<10	1	<6	6	3.6
	07-17-90	1	<1	15	1	<.1	2	2	6	4	7.4
	11-07-90	<1	<1	2	<1	<.1	<1	<1	1	7	3.1
SJ3	04-10-90	<1	<1	<4	<1	<.1	<10	1	<6	10	3.3
	07-17-90	3	<1	3	<1	<.1	2	2	6	<3	8.0
	11-07-90	<1	<1	11	<1	<.1	<1	<1	2	4	4.9
GW	04-10-90	<1	<1	1	<1	.8	4	<1	13	10	13
	07-17-90	<1	4	1	3	1.2	4	<1	25	<10	9.5
	11-07-90	<1	<1	1	<4	<.1	3	<1	48	<10	13

Table 23. Pesticide concentrations in water samples collected in the Dolores Project area in July 1990

[Concentrations are totals, in micrograms per liter; <, less than reporting limit]

Site number (figs. 1, 2)	Site name	Date	Time	2,4-D	2,4,5-T	Silvex	2,4-DP
ME2	McElmo Creek downstream from Alkali Canyon	07-16-90	1700	0.18	<0.01	<0.01	<0.01
ME4	McElmo Creek downstream from Yellow Jacket Canyon	07-16-90	1240	.14	<.01	<.01	<.01
SU	Summit Reservoir	07-18-90	1330	<.01	<.01	<.01	<.01
TT	Totten Reservoir	07-18-90	1520	.03	<.01	<.01	<.01
SD	Simon Draw downstream from Cash Canyon	07-18-90	1430	.02	<.01	<.01	<.01
HD2	Hartman Draw near mouth, at Cortez	07-18-90	0840	.15	<.01	<.01	<.01
AK	Alkali Canyon downstream from Narraguinnep Canyon	07-18-90	1030	.07	<.01	<.01	<.01
DD	Dawson Draw near Lewis	07-19-90	1140	.02	<.01	<.01	<.01
YJ2	Yellow Jacket Canyon at mouth	07-16-90	1330	.03	<.01	<.01	<.01
NW	Navajo Wash near Towaoc	07-18-90	0730	<.01	<.01	<.01	<.01
CH	Cahone Canyon at Highway 666	07-19-90	0930	.04	<.01	<.01	<.01
MN2	Mancos River at Colorado-New Mexico State line	07-17-90	1000	.20	<.01	<.01	<.01
SJ1	San Juan River at Four Corners	07-17-90	1530	.02	<.01	<.01	<.01
SJ3	San Juan River at Mexican Hat, Utah	07-17-90	1230	.04	<.01	<.01	<.01

Site number (figs. 1,2)	Date	Dicamba	Picloram	DEF	Diazinon	Disyston	Ethion	Malathion	Methyl parathion	Methyl trithion	Parathion	Phorate	Trithion
ME2	07-16-90	0.04	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
ME4	07-16-90	.03	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
SU	07-18-90	.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
TT	07-18-90	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
SD	07-18-90	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
HD2	07-18-90	.03	.01	<.01	<.01	<.01	<.01	.01	<.01	<.01	<.01	<.01	<.01
AK	07-18-90	.04	.03	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
DD	07-19-90	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
YJ2	07-16-90	.03	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
NW	07-18-90	.04	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
CH	07-19-90	<.01	.08	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
MN2	07-17-90	.04	.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
SJ1	07-17-90	.03	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
SJ3	07-17-90	.03	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01

Table 24. Trace-element concentrations in the less than 0.0625-millimeter size fraction in bottom-sediment samples collected in the Dolores Project area in 1990

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

Site number (figs. 1, 2)	Site name	Date	Arsenic	Barium	Beryllium	Bismuth	Cadmium	Cerium	Chromium
ME2	McElmo Creek downstream from Alkali Canyon	11-14-90	6.8	540	1	<10	<2	60	45
ME3	McElmo Creek upstream from Yellow Jacket Canyon	11-14-90	4.1	910	1	<10	<2	61	34
ME4	McElmo Creek downstream from Yellow Jacket Canyon	11-14-90	5.2	990	1	<10	<2	63	32
SU	Summit Reservoir	11-08-90	4.8	500	2	<10	<2	80	60
PU	Puett Reservoir	11-08-90	5.9	400	2	<10	<2	72	68
TT	Totten Reservoir	11-08-90	6.1	510	1	<10	<2	53	40
SD	Simon Draw downstream from Cash Canyon	11-08-90	4.9	480	2	<10	<2	65	39
HD2	Hartman Draw near mouth, at Cortez	11-13-90	4.3	430	1	<10	<2	90	37
AK	Alkali Canyon downstream from Narraguinnep Canyon	11-09-90	5.8	480	1	<10	<2	64	43
DD	Dawson Draw near Lewis	11-09-90	4.9	520	2	<10	<2	68	47
YJ2	Yellow Jacket Canyon at mouth	11-14-90	3.7	1,900	1	<10	<2	73	39
NW	Navajo Wash near Towaoc	11-06-90	7.5	490	1	<10	<2	57	46
WC	Woods Canyon near Yellow Jacket	11-15-90	3.9	550	1	<10	<2	62	41
CH	Cahone Canyon at Highway 666	11-15-90	4.2	520	2	<10	<2	66	45
CR	Cross Canyon upstream from Alkali Canyon	11-15-90	3.4	510	2	<10	<2	57	38
MN2	Mancos River at Colorado-New Mexico State line	11-06-90	7.8	450	2	<10	<2	64	64
SJ1	San Juan River at Four Corners	11-07-90	4.2	820	1	<10	<2	86	37
SJ3	San Juan River at Mexican Hat, Utah	11-07-90	3.5	880	1	<10	<2	82	29

Table 24. Trace-element concentrations in the less than 0.0625-millimeter size fraction in bottom-sediment samples collected in the Dolores Project area in 1990 --Continued

Site number (figs. 1,2)	Date	Cobalt	Copper	Europium	Gallium	Gold	Holmium	Lanthanum	Lead	Lithium	Manganese	Mercury	Molybdenum	Neodymium
ME2	11-14-90	9	18	<2	12	<8	<4	32	16	33	490	0.04	3	28
ME3	11-14-90	7	13	<2	9	<8	<4	33	15	26	490	.02	2	28
ME4	11-14-90	8	16	<2	9	<8	<4	34	17	27	480	.02	<2	32
SU	11-08-90	12	22	<2	22	<8	<4	44	20	54	500	.10	<2	39
PU	11-08-90	10	21	<2	20	<8	<4	38	18	51	400	.08	<2	31
TT	11-08-90	9	21	<2	14	<8	<4	29	19	34	450	.04	<2	27
SD	11-08-90	10	17	<2	12	<8	<4	35	16	31	570	.04	<2	30
HD2	11-13-90	6	11	<2	8	<8	<4	46	16	22	630	.04	<2	39
AK	11-09-90	12	16	<2	12	<8	<4	33	16	34	560	<.02	2	28
DD	11-09-90	10	19	<2	14	<8	<4	34	13	37	430	.02	<2	30
YJ2	11-14-90	7	12	<2	10	<8	<4	37	19	24	640	<.02	<2	30
NW	11-06-90	9	19	<2	11	<8	<4	31	17	34	290	.04	5	28
WC	11-15-90	9	19	<2	14	<8	<4	31	16	31	670	.04	<2	27
CH	11-15-90	10	20	<2	16	<8	<4	35	16	48	510	<.02	<2	30
CR	11-15-90	8	18	<2	13	<8	<4	30	13	36	420	<.02	<2	27
MN2	11-06-90	11	25	<2	17	<8	<4	35	17	40	310	.04	6	32
SJ1	11-07-90	8	19	<2	12	<8	<4	45	18	23	410	.04	<2	37
SJ3	11-07-90	8	15	<2	11	<8	<4	43	15	21	430	<.02	<2	37

Table 24. Trace-element concentrations in the less than 0.0625-millimeter size fraction in bottom-sediment samples collected in the Dolores Project area in 1990 --Continued

Site number (figs. 1, 2)	Date	Nickel	Nio-bium	Scan-dium	Sele-nium	Silver	Stron-tium	Tanta-lum	Thor-ium	Tin	Uran-ium	Vana-dium	Ytter-bium	Yttrium	Zinc
ME2	11-14-90	20	<4	7	1.1	<2	330	<40	14.6	<5	4.3	81	2	18	75
ME3	11-14-90	13	<4	5	.4	<2	230	<40	11.3	<5	4.9	50	2	18	46
ME4	11-14-90	14	<4	6	.5	<2	240	<40	12.0	<5	5.5	55	2	19	50
SU	11-08-90	22	10	12	.5	<2	130	<40	21.1	<5	5.4	92	2	24	93
PU	11-08-90	25	9	12	.5	<2	150	<40	17.9	<5	5.5	94	1	20	93
TT	11-08-90	18	5	7	1.1	<2	450	<40	9.2	<5	3.7	62	2	15	100
SD	11-08-90	19	6	6	.5	<2	270	<40	14.9	<5	4.7	53	2	18	70
HD2	11-13-90	10	<4	5	.2	<2	140	<40	21.1	<5	10.3	50	3	24	40
AK	11-09-90	23	<4	7	.2	<2	720	<40	12.2	<5	4.4	60	2	18	58
DD	11-09-90	18	6	8	.7	<2	150	<40	16.6	<5	5.0	66	2	19	61
YJ2	11-14-90	12	<4	5	.1	<2	240	<40	--	<5	--	60	3	24	36
NW	11-06-90	24	<4	7	1.6	<2	240	<40	8.7	<5	4.9	83	2	18	77
WC	11-15-90	16	5	7	1.5	<2	190	<40	11.5	<5	4.1	53	2	19	55
CH	11-15-90	19	7	9	4.3	<2	410	<40	13.1	<5	5.1	60	2	22	65
CR	11-15-90	15	6	7	.5	<2	200	<40	12.1	<5	4.1	54	2	19	53
MN2	11-06-90	30	7	9	2.8	<2	280	<40	12.2	<5	5.2	140	2	19	100
SJ1	11-07-90	12	<4	6	.3	<2	230	<40	15.0	<5	6.4	58	2	22	54
SJ3	11-07-90	13	<4	5	.2	<2	240	<40	14.3	<5	6.2	49	2	21	52

Table 25. Trace-element concentrations in the less than 2-millimeter size fraction in bottom-sediment samples collected in the Dolores Project area in 1990

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

Site number (figs. 1, 2)	Site name	Date	Arsenic	Barium	Beryllium	Bismuth	Cadmium	Cerium	Chromium
ME2	McElmo Creek downstream from Alkali Canyon	11-14-90	5.5	390	<1	<10	<2	38	18
ME3	McElmo Creek upstream from Yellow Jacket Canyon	11-14-90	3.3	470	<1	<10	<2	21	6
ME4	McElmo Creek downstream from Yellow Jacket Canyon	11-14-90	3.9	770	<1	<10	<2	30	10
SU	Summit Reservoir	11-08-90	6.7	540	2	<10	<2	96	64
PU	Puett Reservoir	11-08-90	8.5	450	2	<10	<2	88	70
TT	Totten Reservoir	11-08-90	7.6	520	1	<10	<2	57	40
SD	Simon Draw downstream from Cash Canyon	11-08-90	4.0	330	<1	<10	<2	46	13
HD2	Hartman Draw near mouth, at Cortez	11-13-90	2.5	140	<1	<10	<2	23	7
AK	Alkali Canyon downstream from Narraguinnep Canyon	11-09-90	5.6	380	1	<10	<2	43	24
DD	Dawson Draw near Lewis	11-09-90	4.3	360	1	<10	<2	42	24
YJ2	Yellow Jacket Canyon at mouth	11-14-90	2.0	1,300	<1	<10	<2	15	3
NW	Navajo Wash near Towaoc	11-06-90	6.0	560	<1	<10	<2	43	27
WC	Woods Canyon near Yellow Jacket	11-15-90	3.3	450	1	<10	<2	44	23
CH	Cahone Canyon at Highway 666	11-15-90	4.1	470	1	<10	<2	58	36
CR	Cross Canyon upstream from Alkali Canyon	11-15-90	3.0	410	1	<10	<2	43	25
MN2	Mancos River at Colorado-New Mexico State line	11-06-90	8.3	500	1	<10	<2	65	62
SJ1	San Juan River at Four Corners	11-07-90	3.0	910	1	<10	<2	69	22
SJ3	San Juan River at Mexican Hat, Utah	11-07-90	1.9	750	<1	<10	<2	33	11

Table 25. Trace-element concentrations in the less than 2-millimeter size fraction in bottom-sediment samples collected in the Dolores Project area in 1990--Continued

Site number (figs. 1, 2)	Date	Cobalt	Copper	Europium	Gallium	Gold	Holmium	Lanthanum	Lead	Lithium	Manganese	Mercury	Molybdenum	Neodymium
ME2	11-14-90	8	7	<2	5	<8	<4	21	15	23	540	0.02	<2	20
ME3	11-14-90	4	5	<2	<4	<8	<4	13	9	15	410	<.02	<2	11
ME4	11-14-90	5	5	<2	4	<8	<4	18	8	18	370	.02	<2	15
SU	11-08-90	13	24	<2	22	<8	<4	53	28	61	540	.08	<2	44
PU	11-08-90	11	23	<2	22	<8	<4	48	25	59	410	.04	<2	39
TT	11-08-90	9	24	<2	13	<8	<4	31	21	35	420	.04	<2	30
SD	11-08-90	5	6	<2	8	<8	<4	25	10	20	270	<.02	<2	21
HD2	11-13-90	4	3	<2	<4	<8	<4	12	9	11	460	<.02	<2	10
AK	11-09-90	10	11	<2	8	<8	<4	23	14	25	500	.02	<2	22
DD	11-09-90	6	12	<2	8	<8	<4	23	14	25	280	<.02	<2	21
YJ2	11-14-90	3	3	<2	<4	<8	<4	10	7	11	230	<.02	<2	8
NW	11-06-90	8	11	<2	8	<8	<4	25	12	26	270	.02	<2	24
WC	11-15-90	6	13	<2	8	<8	<4	24	12	24	470	<.02	<2	22
CH	11-15-90	9	17	<2	13	<8	<4	32	18	42	420	.04	<2	27
CR	11-15-90	6	10	<2	9	<8	<4	23	15	27	270	.02	<2	20
MN2	11-06-90	11	28	<2	14	<8	<4	37	26	41	320	.04	3	34
SJ1	11-07-90	6	12	<2	10	<8	<4	38	15	17	340	<.02	<2	8
SJ3	11-07-90	3	5	<2	6	<8	<4	18	11	11	220	<.02	<2	5

Table 25. Trace-element concentrations in the less than 2-millimeter size fraction in bottom-sediment samples collected in the Dolores Project area in 1990--Continued

Site number (figs. 1, 2)	Date	Nickel	Niobium	Scandium	Selenium	Silver	Strontium	Tantalum	Thorium	Tin	Uranium	Vanadium	Ytterbium	Yttrium	Zinc
ME2	11-14-90	11	<4	4	0.5	<2	230	<40	5.4	<5	1.8	37	1	12	42
ME3	11-14-90	3	<4	2	.1	<2	140	<40	2.2	<5	.85	18	<1	6	20
ME4	11-14-90	4	<4	2	.1	<2	170	<40	2.9	<5	1.2	21	<1	8	26
SU	11-08-90	25	10	14	.5	<2	140	<40	15.2	<5	5.0	100	2	28	100
PU	11-08-90	26	9	13	.5	<2	170	<40	15.0	<5	4.9	110	2	24	110
TT	11-08-90	18	4	7	1.1	<2	440	<40	8.3	<5	3.1	66	2	16	110
SD	11-08-90	7	<4	3	.2	<2	200	<40	4.8	<5	1.7	25	<1	9	37
HD2	11-13-90	4	<4	<2	<.1	<2	64	<40	3.6	<5	.77	10	<1	5	15
AK	11-09-90	13	<4	4	.2	<2	400	<40	6.1	<5	2.3	39	1	12	41
DD	11-09-90	11	<4	4	.4	<2	98	<40	7.4	<5	2.0	39	1	12	39
YJ2	11-14-90	<2	<4	<2	<.1	<2	110	<40	1.3	<5	.74	10	<1	4	12
NW	11-06-90	15	<4	5	1.1	<2	240	<40	6.8	<5	2.2	57	1	14	58
WC	11-15-90	10	<4	5	1.0	<2	160	<40	5.4	<5	2.2	35	1	13	38
CH	11-15-90	16	<4	7	3.6	<2	330	<40	8.2	<5	3.6	51	2	19	56
CR	11-15-90	11	<4	5	.4	<2	130	<40	5.9	<5	2.4	37	1	13	37
MN2	11-06-90	31	5	9	2.5	<2	310	<40	10.4	<5	4.6	150	2	21	100
SJ1	11-07-90	8	<4	4	.1	<2	210	<40	8.4	<5	3.6	40	2	17	41
SJ3	11-07-90	5	<4	2	<.1	<2	150	<40	4.1	<5	1.4	20	<1	8	21

Table 26. Concentrations of organic compounds in bottom-sediment samples collected in the Dolores Project area in 1990

[Concentrations in micrograms per kilogram; <, less than detection limit]

Site number (figs. 1, 2)	Site name	Date	Time	Aldrin	Chlordane	DDE	DDD	DDT
ME2	McElmo Creek downstream from Alkali Canyon	11-14-90	1400	<0.1	<1.0	<0.1	<0.1	<0.1
ME3	McElmo Creek upstream from Yellow Jacket Canyon	11-14-90	1130	<.1	<1.0	<.1	<.1	<.1
ME4	McElmo Creek downstream from Yellow Jacket Canyon	11-14-90	0830	<.1	<1.0	<.1	<.1	<.1
SU	Summit Reservoir	11-08-90	1020	<.1	<1.0	1.5	5.5	<.1
PU	Puett Reservoir	11-08-90	1135	<.1	<1.0	.3	.1	<.1
TT	Totten Reservoir	11-08-90	1255	<.1	1.0	1.5	.6	.3
SD	Simon Draw downstream from Cash Canyon	11-08-90	1500	.6	1.0	.5	.2	.2
HD2	Hartman Draw near mouth, at Cortez	11-13-90	1500	<.1	<1.0	<.1	<.1	<.1
AK	Alkali Canyon downstream from Narraguinnep Canyon	11-09-90	0800	<.1	<1.0	<.1	<.1	.1
DD	Dawson Draw near Lewis	11-09-90	0900	<.1	<1.0	<.1	<.1	<.1
YJ2	Yellow Jacket Canyon at mouth	11-14-90	1000	<.1	<1.0	<.1	<.1	<.1
NW	Navajo Wash near Towaoc	11-06-90	1630	<.1	<1.0	.1	<.1	<.1
WC	Woods Canyon near Yellow Jacket	11-15-90	0830	<.1	<1.0	.2	<.1	<.1
CH	Cahone Canyon at Highway 666	11-15-90	0945	<.1	<1.0	.2	<.1	<.1
CR	Cross Canyon upstream from Alkali Canyon	11-15-90	1130	<.1	<1.0	.1	<.1	<.1
MN2	Mancos River at Colorado-New Mexico State line	11-06-90	1310	<.1	<1.0	.1	<.1	<.1
SJ1	San Juan River at Four Corners	11-07-90	1400	<.1	<1.0	.1	<.1	<.1
SJ3	San Juan River at Mexican Hat, Utah	11-07-90	1030	<.1	<1.0	<.1	<.1	<.1

Table 26. Concentrations of organic compounds in bottom-sediment samples collected in the Dolores Project area in 1990--Continued

Site number (figs. 1, 2)	Date	Dieldrin	Endosulfan	Endrin	Hepta-chlor	Hepta-chlor epoxide	Lindane	Methoxy-chlor	Mirex	Perthane	Toxa-phene	PCB	PCN
ME2	11-14-90	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<1.0	<10	<1	<1.0
ME3	11-14-90	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<1.0	<10	<1	<1.0
ME4	11-14-90	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<1.0	<10	<1	<1.0
SU	11-08-90	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<1.0	<10	<1	<1.0
PU	11-08-90	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<1.0	<10	<1	<1.0
TT	11-08-90	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<1.0	<10	<1	<1.0
SD	11-08-90	1.3	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<1.0	<10	<1	<1.0
HD2	11-13-90	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<1.0	<10	<1	<1.0
AK	11-09-90	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<1.0	<10	<1	<1.0
DD	11-09-90	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<1.0	<10	<1	<1.0
YJ2	11-14-90	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<1.0	<10	<1	<1.0
NW	11-06-90	.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<1.0	<10	<1	<1.0
WC	11-15-90	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<1.0	<10	<1	<1.0
CH	11-15-90	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<1.0	<10	<1	<1.0
CR	11-15-90	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<1.0	<10	<1	<1.0
MN2	11-06-90	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<1.0	<10	<1	<1.0
SJ1	11-07-90	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<1.0	<10	<1	<1.0
SJ3	11-07-90	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<.1	<1.0	<10	<1	<1.0

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990

[Analysis by U.S. Fish and Wildlife Service; site names are listed in table 11 and locations are on figures 1 and 2; aq., aquatic; --, no data; inv., invertebrate; fm., flannelmouth; yh., yellow-headed; rw., red winged; fish and bird matrices are whole-body samples; length in millimeters; comp., composite; concentrations in micrograms per gram dry weight; MVIC, Montezuma Valley Irrigation Company]

Site	Matrix	Species	Date	Length	No. in sample	Percent moisture	Aluminum	Arsenic	Barium	Beryllium
					MVIC AREA					
ME1	Aq. plant	Algae	07-11-90	--	Comp.	73.5	13,000	7.3	348	0.78
ME1	Aq. plant	Algae	11-08-90	--	Comp.	88.6	6,280	6.5	73.8	.32
ME1	Aq. inv.	Invertebrates	07-11-90	--	Comp.	76.2	250	.2	4.2	.1
ME1	Aq. inv.	Invertebrates	11-08-90	--	Comp.	72.0	1,890	.89	15.9	<.1
ME1	Aq. inv.	Earthworms	11-08-90	--	Comp.	82.2	4,110	4.4	60.4	.3
ME1	Fish	Fathead minnow	11-08-90	70	10	79.9	1,620	.3	30.5	.06
ME1	Fish	Speckled dace	11-08-90	80	10	76.7	150	<.2	2.7	<.01
ME2	Aq. plant	Algae	07-11-90	--	Comp.	81.3	16,600	3.8	194	.72
ME2	Aq. plant	Algae	11-07-90	--	Comp.	74.0	8,880	7	213	.39
ME2	Aq. inv.	Crayfish	04-01-90	80	3	67.1	1,600	1.6	78.6	<.1
ME2	Aq. inv.	Crayfish	07-11-90	80	5	73.3	878	.69	52.9	.2
ME2	Fish	Bluehead sucker	07-11-90	332	3	66.6	270	.5	5.2	.01
ME2	Fish	Bluehead sucker	11-07-90	319	5	71.9	5,980	.96	42.1	.2
ME2	Fish	Fathead minnow	07-11-90	60	7	75.2	514	.61	16.7	.02
ME2	Fish	Fm. sucker	04-04-90	433	2	72.6	1,490	.5	13.2	.05
ME2	Fish	Fm. sucker	07-11-90	440	3	69.7	453	.75	4.5	.02
ME2	Fish	Fm. sucker	11-07-90	153	2	76.0	2,760	.4	24.5	.1
ME2	Fish	Fm. sucker	11-07-90	483	3	73.2	1,850	.5	14.1	.07
ME2	Fish	Speckled dace	07-11-90	85	2	67.0	45	.4	1.5	<.01
ME3	Aq. plant	Algae	04-04-90	--	Comp.	71.9	11,400	3.7	198	.54
ME3	Aq. plant	Algae	07-11-90	--	Comp.	73.2	15,400	4.2	470	.74
ME3	Aq. plant	Algae	11-07-90	--	Comp.	77.3	4,700	3.2	145	.2
ME3	Aq. inv.	Crayfish	04-04-90	85	2	66.5	1,380	2.4	73.6	<.1
ME3	Aq. inv.	Crayfish	07-11-90	40	30	79.4	1,240	1.3	35.6	.2
ME3	Fish	Bluehead sucker	07-11-90	272	3	70.2	250	.67	4.2	<.01
ME3	Fish	Bluehead sucker	11-07-90	295	1	72.0	6,220	.96	56	.23
ME3	Fish	Bullhead	07-11-90	245	1	82.8	60	.3	2	<.01
ME3	Fish	Common carp	04-04-90	473	2	74.5	180	.5	8.6	<.01
ME3	Fish	Common carp	07-11-90	480	1	74.5	200	.5	6.3	<.01

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990 --Continued

Site	Matrix	Species	Date	Length	No. in sample	Percent moisture	Aluminum	Arsenic	Barium	Beryllium
					MVIC AREA--Continued					
ME3	Fish	Fathead minnow	04-04-90	61	5	75.7	432	0.4	5.6	0.02
ME3	Fish	Fathead minnow	07-11-90	70	8	77.6	519	.5	10.6	.02
ME3	Fish	Fathead minnow	11-07-90	60	8	80.4	1,950	3.2	22.4	.07
ME3	Fish	Fm. sucker	04-04-90	420	1	67.6	105	.4	4.7	<.01
ME3	Fish	Fm. sucker	07-11-90	417	3	67.7	110	.5	2.7	<.01
ME3	Fish	Fm. sucker	11-07-90	161	5	77.4	4,960	.5	38	.18
ME3	Fish	Fm. sucker	11-07-90	470	1	74.5	1,660	.3	14	.059
ME3	Fish	Fm. sucker	11-07-90	314	5	76.3	2,710	.4	20.4	.1
ME3	Fish	Green sunfish	07-11-90	80	1	74.8	94	.4	1.7	<.01
ME3	Fish	Red shiners	07-11-90	65	2	75.5	72	.5	6.9	<.01
ME3	Fish	Red shiners	11-07-90	75	15	72.8	46.8	<.2	5.4	<.01
ME3	Fish	Speckled dace	04-04-90	86	4	69.9	230	.3	5.1	.02
ME3	Fish	Speckled dace	07-11-90	40	12	66.6	81	.3	2.9	<.01
ME3	Fish	Speckled dace	11-07-90	80	2	79.5	462	<.2	9	.01
ME4	Aq. plant	Algae	04-04-90	--	Comp.	81.8	11,200	3.1	148	.5
ME4	Aq. plant	Algae	11-07-90	--	Comp.	71.7	12,400	3.6	169	.59
ME4	Aq. inv.	Crayfish	04-04-90	--	Comp.	69.1	1,790	2.1	97.5	<.1
ME4	Aq. inv.	Crayfish	07-11-90	100	6	70.7	691	.67	62.1	.2
ME4	Fish	Common carp	04-04-90	500	2	75.8	300	.5	9.6	.01
ME4	Fish	Common carp	07-11-90	474	1	74.6	184	.5	5.7	<.01
ME4	Fish	Common carp	11-07-90	460	2	75.8	114	<.2	6.3	<.01
ME4	Fish	Fathead minnow	04-04-90	60	4	72.4	1,240	.3	12.2	.06
ME4	Fish	Fathead minnow	07-11-90	55	4	75.9	433	.77	12.4	<.01
ME4	Fish	Fm. sucker	04-04-90	448	2	66.4	234	.3	11.3	<.01
ME4	Fish	Fm. sucker	07-11-90	392	1	66.5	82.1	.4	1.8	<.01
ME4	Fish	Fm. sucker	11-07-90	415	4	74.2	3,910	.67	42.4	.13
ME4	Fish	Fm. sucker	11-07-90	480	1	73.6	1,500	.3	13.8	.05
ME4	Fish	Fm. sucker	11-07-90	172	3	74.0	1,030	.2	21.5	.03
ME4	Fish	Red shiners	07-11-90	60	5	80.6	162	.4	2.3	<.01
MP	Aq. inv.	Crayfish	11-14-90	150	1	66.0	521	2.5	473	<.1
MP	Zooplankton	Zooplankton	04-18-90	--	Comp.	96.1	1,000	1.1	45.8	<.1
MP	Zooplankton	Zooplankton	11-14-90	--	Comp.	98.4	4,780	2.5	68.8	.2
MP	Fillet	Largemouth bass	06-07-90	320	1	75.2	2.5	.4	.63	<.01

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990 --Continued

Site	Matrix	Species	Date	Length	No. in sample	Percent moisture	Aluminum	Arsenic	Barium	Beryllium
				MVIC AREA--Continued						
MP	Fillet	Rainbow trout	11-14-90	357	1	80.3	4.5	<0.2	0.2	<0.01
MP	Fish	Fm. sucker	06-07-90	463	3	68.3	162	.4	6.7	<.01
MP	Fish	Fm. sucker	11-14-90	455	3	71.3	263	<.2	5.5	.01
MP	Fish	Green sunfish	06-07-90	175	2	77.8	48	.3	8.3	<.01
MP	Fish	Rainbow trout	04-18-90	343	5	77.5	503	.4	6.5	.02
MP	Fish	Rainbow trout	04-18-90	355	3	79.4	24	.21	.59	<.01
MP	Fish	Rainbow trout	11-07-90	382	3	77.3	254	.3	9.4	<.01
MP	Fish	Roundtail chub	06-07-90	240	1	76.3	190	.3	14.4	<.01
MP	Fish	Smallmouth bass	06-07-90	380	2	70.7	22	.63	8.3	<.01
MP	Fish	White sucker	04-18-90	445	1	67.7	200	.3	3.6	<.01
MP	Fish	Yellow perch	04-18-90	180	1	78.6	658	.3	5.8	.02
MP	Fish	Yellow perch	06-07-90	160	15	73.1	47	.3	5.3	<.01
MP	Fish	Yellow perch	11-14-90	195	3	73.0	28	<.2	9.3	<.01
MP	Fish-gutted	Kokanee salmon	10-31-90	368	4	76.7	8.3	.52	2.4	<.43
SU	Aq. plant	Sago pondweed	11-14-90	--	Comp.	89.9	2,370	1.6	108	<.1
SU	Zooplankton	Zooplankton	04-16-90	--	Comp.	92.3	3,030	1.1	56.2	<.1
SU	Zooplankton	Zooplankton	11-14-90	--	Comp.	97.8	2,070	4.4	39.9	.1
SU	Eggs	Smallmouth bass	11-14-90	--	Comp.	62.6	<.3	.2	.35	<.01
SU	Fillet	Smallmouth bass	04-16-90	258	2	79.7	16	.4	.37	<.01
SU	Fillet	Smallmouth bass	11-14-90	370	Comp.	78.3	5.6	.3	.2	<.01
SU	Fillet	Smallmouth bass	11-14-90	388	Comp.	76.3	5.4	<.2	.1	<.01
SU	Fish	Black crappie	04-16-90	200	1	85.2	71	.5	5.7	<.01
SU	Fish	Smallmouth bass	04-16-90	267	3	76.4	49	.4	6.7	<.01
SU	Fish	Smallmouth bass	11-14-90	405	2	71.8	5	<.2	4.7	<.01
SU	Fish	White sucker	04-16-90	345	2	72.0	90	.3	2.9	<.01
PU	Aq. inv.	Crayfish	05-31-90	--	2	72.8	1,990	2.6	318	.1
PU	Aq. inv.	Crayfish	11-15-90	130	12	67.4	796	1.2	205	<.1
PU	Zooplankton	Zooplankton	05-31-90	--	Comp.	96.9	6,590	4.3	130	.2
PU	Zooplankton	Zooplankton	11-15-90	--	Comp.	97.4	4,060	3.3	41.6	<.2

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990 --Continued

Site	Matrix	Species	Date	Length	No. in sample	Percent moisture	Aluminum	Arsenic	Barium	Beryllium
				MVIC AREA--Continued						
PU	Eggs	Walleye	11-15-90	725	--	61.7	0.3	0.1	0.71	<0.01
PU	Fillet	Walleye	05-31-90	665	2	82.1	4	.7	1.8	<.01
PU	Fillet	Walleye	11-15-90	725	1	73.4	4.3	<.2	.1	<.01
PU	Fish	Northern pike	05-31-90	680	1	78.5	9.3	.69	7.5	<.01
PU	Fish	Northern pike	11-15-90	600	2	79.9	76.6	<.2	14	<.01
PU	Fish	Walleye	05-31-90	540	1	75.5	11	.67	5.6	<.01
PU	Fish	Walleye	11-15-90	573	2	67.3	15	<.2	3.6	<.01
PU	Fish	Yellow perch	05-31-90	328	2	72.4	30	.3	4.8	<.01
TT	Aq. plant	Coontail	07-12-90	--	Comp.	87.2	1,040	.84	97.7	<.1
TT	Aq. plant	Sago pondweed	07-12-90	--	Comp.	89.5	534	2.3	122	<.1
TT	Aq. plant	Sago pondweed	11-15-90	--	Comp.	87.3	1,500	2.3	169	<.1
TT	Aq. inv.	Crayfish	04-17-90	109	4	74.6	704	2.1	242	<.1
TT	Aq. inv.	Crayfish	11-15-90	110	3	65.5	240	1.5	171	<.1
TT	Zooplankton	Zooplankton	04-17-90	--	Comp.	95.8	1,010	.8	118	<.1
TT	Zooplankton	Zooplankton	11-15-90	--	Comp.	98.1	2,600	3.1	41.3	.1
TT	Eggs	Northern pike	04-17-90	1,000	Comp.	66.1	5.8	.2	.32	<.01
TT	Eggs	Northern pike	11-15-90	775	Comp.	67.2	6.4	<.1	.32	<.01
TT	Eggs	Walleye	11-15-90	610	Comp.	56.5	.74	<.1	.1	<.01
TT	Fillet	Northern pike	04-18-90	1,000	1	78.3	77	<.2	.3	<.01
TT	Fillet	Northern pike	11-15-90	775	1	78.2	12	<.2	.46	<.01
TT	Fillet	Walleye	04-17-90	575	1	75.6	9.6	<.2	.32	<.01
TT	Fillet	Walleye	04-17-90	610	1	76.6	5.7	.3	<.01	<.1
TT	Fillet	Walleye	11-15-90	610	1	72.5	7.4	<.2	.1	<.01
TT	Fish	Black crappie	04-17-90	245	2	82.3	35	.3	1.6	<.01
TT	Fish	Bluegill	04-17-90	136	4	79.2	35	.4	5.4	<.01
TT	Fish	Channel catfish	04-17-90	610	1	71.8	20	<.2	10.8	<.01
TT	Fish	Northern pike	04-17-90	750	1	78.8	19	.3	.73	<.01
TT	Fish	Northern pike	11-15-90	550	1	78.1	5.3	<.2	.92	<.01
TT	Fish	Walleye	04-17-90	570	2	73.9	35	.3	1.3	<.01
TT	Fish	Walleye	11-15-90	528	2	71.4	11	<.2	1.5	.01
TT	Fish	Yellow perch	04-17-90	343	2	76.7	32	.2	4.4	<.01
TT	Fish	Yellow perch	11-15-90	200	2	79.6	105	<.2	1.8	<.01

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990 --Continued

Site	Matrix	Species	Date	Length	No. in sample	Percent moisture	Aluminum	Arsenic	Barium	Beryllium
				MVIC AREA--Continued						
TT	Bird	Yh. blackbird	07-12-90	--	4	67.2	<4	<0.1	<0.1	<0.1
TT	Bird	Yh. blackbird	07-12-90	--	1	71.0	62	<.1	2.9	<.1
TT	Eggs	Coot	05-22-90	--	3	76.0	<3	<.1	4.6	<.1
TT	Eggs	Coot	07-12-90	--	2	77.7	<3	<.1	2.3	<.09
TT	Eggs	Mallard	05-30-90	--	2	69.9	<3	<.1	12.4	<.09
TT	Egg	Mallard	05-30-90	--	1	72.5	<3	<.1	17.7	<.09
TT	Eggs	Yh. blackbird	05-30-90	--	4	83.4	3	<.1	1.5	<.1
TT	Eggs	Yh. blackbird	05-30-90	--	4	83.7	<3	<.1	1.1	<.1
TT	Liver	Coot	07-12-90	--	1	72.5	8	.34	.1	<.09
TT	Liver	Coot	07-12-90	--	1	71.4	8	.3	.2	<.1
LP	Aq. plant	Coontail	07-12-90	--	Comp.	84.5	3,530	1.2	35.5	.09
LP	Eggs	Coot	05-23-90	--	3	74.9	<3	<.1	.3	<.1
LP	Eggs	Coot	07-12-90	--	3	77.6	<3	<.1	.2	<.09
LP	Eggs	Pied-billed grebe	05-23-90	--	3	76.3	<3	<.1	<.1	<.1
LP	Eggs	Rw. blackbird	07-12-90	--	2	83.6	20	<.1	.7	<.2
LP	Eggs	Yh. blackbird	05-23-90	--	4	83.8	<3	<.1	1.2	<.1
LP	Liver	Coot	07-12-90	--	1	73.2	8	<.1	<.1	<.1
LP	Liver	Coot	07-12-90	--	1	34.2	<3	.2	<.1	<.1
LP	Liver	Coot	07-12-90	--	1	72.2	5	<.1	<.1	<.1
LP	Liver	Coot	07-12-90	--	1	72.6	6	<.1	<.1	<.1
LP	Liver	Muskrat	07-12-90	--	1	91.2	17	<.1	<.2	<.2
SD	Aq. plant	Algae	04-04-90	--	Comp.	70.3	21,300	4.8	204	1.5
SD	Aq. plant	Algae	07-10-90	--	Comp.	68.5	23,000	3.9	179	1.3
SD	Aq. plant	Algae	11-08-90	--	Comp.	85.9	13,800	4.7	99.5	.63
SD	Aq. plant	Sago pondweed	07-10-90	--	Comp.	90.8	11,700	4.6	105	.8
SD	Aq. inv.	Crayfish	04-04-90	--	12	73.0	1,990	2.2	67	.1
SD	Aq. inv.	Crayfish	07-10-90	70	24	70.7	1,810	.69	47.1	.3
SD	Aq. inv.	Invertebrates	11-08-90	--	Comp.	73.1	1,110	1.9	23.3	.1
SD	Fish	Bluehead sucker	07-10-90	70	7	73.1	4,960	1.1	33.1	.25
SD	Fish	Bluehead sucker	11-08-90	122	3	76.2	2,110	.3	12.1	.07

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990 --Continued

Site	Matrix	Species	Date	Length	No. in sample	Percent moisture	Aluminum	Arsenic	Barium	Beryllium
				MVIC AREA--Continued						
SD	Fish	Fathead minnow	04-04-90	30	25	76.7	423	0.3	6.3	0.03
SD	Fish	Fathead minnow	07-10-90	70	17	74.9	2,450	.6	18.6	.13
SD	Fish	Fathead minnow	11-08-90	60	40	77.6	1,450	.4	12.5	.06
HD1	Aq. plant	Algae	04-06-90	--	Comp.	71.1	12,000	3.8	157	.58
HD1	Aq. plant	Algae	07-11-90	--	Comp.	90.0	14,400	7.4	1,000	.67
HD1	Aq. plant	Algae	11-08-90	--	Comp.	88.1	12,800	7.1	96.3	.41
HD1	Aq. plant	Watercress	07-11-90	--	Comp.	95.2	3,530	16	84.3	.2
HD1	Aq. inv.	Crayfish	04-06-90	65	12	72.1	1,520	1.4	85	<.1
HD1	Aq. inv.	Crayfish	07-11-90	80	10	75.8	973	.86	38	.2
HD1	Fish	Bluehead sucker	04-06-90	133	5	72.7	1,040	.4	8.3	.03
HD1	Fish	Bluehead sucker	04-06-90	250	1	74.8	1,870	.62	11.7	.06
HD1	Fish	Bluehead sucker	07-11-90	120	6	71.5	1,820	1	13.9	.07
HD1	Fish	Bluehead sucker	11-08-90	146	3	75.1	6,210	1.6	35.4	.21
HD1	Fish	Fathead minnow	04-06-90	60	40	77.2	835	.4	12.5	.03
HD1	Fish	Fathead minnow	07-11-90	70	30	76.4	1,340	.73	15.6	.51
HD1	Fish	Fathead minnow	07-11-90	70	30	76.0	1,200	.7	14.1	.04
HD1	Fish	Fm. sucker	11-08-90	70	25	78.8	1,950	.4	21.8	.06
HD1	Fish	Green sunfish	04-06-90	170	1	74.2	110	<.2	1.3	<.01
HD1	Fish	Green sunfish	07-11-90	110	3	78.0	246	.4	3	<.01
HD1	Fish	Speckled dace	04-06-90	110	8	76.2	679	.3	5.8	.03
HD1	Fish	Speckled dace	07-11-90	110	5	69.8	38	.2	2.8	<.01
HD1	Fish	Speckled dace	11-08-90	92	3	76.9	223	<.2	4.5	.01
HD2	Aq. plant	Algae	04-04-90	--	Comp.	70.2	9,870	3.9	286	.42
HD2	Aq. plant	Algae	11-07-90	--	Comp.	74.1	12,700	4	202	.63
HD2	Aq. inv.	Crayfish	04-04-90	76	7	70.1	1,850	1.6	73.4	<.1
HD2	Aq. inv.	Crayfish	07-10-90	--	12	74.8	931	.53	48.6	.2
HD2	Fish	Fathead minnow	04-04-90	82	18	74.8	1,550	.5	27.6	.06
HD2	Fish	Fathead minnow	11-07-90	80	7	75.0	968	.2	13.2	.03
HD2	Fish	Fm. sucker	07-10-90	454	2	66.0	57	.3	1.3	<.01
HD2	Fish	Fm. sucker	07-10-90	430	2	69.9	3,190	1.4	54.5	.11

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990 --Continued

Site	Matrix	Species	Date	Length	No. in sample	Percent moisture	Aluminum	Arsenic	Barium	Beryllium
				MVIC AREA--Continued						
HD2	Fish	Fm. sucker	11-07-90	503	2	68.9	124	<0.2	1.5	0.03
HD2	Fish	Fm. sucker	11-07-90	170	5	71.4	441	<.2	4.3	.01
HD2	Fish	Suckers	04-04-90	467	2	68.8	48.7	.2	.24	<.1
HD2	Fish	Suckers	07-10-90	110	4	71.8	712	.67	10.8	.03
AK	Aq. plant	Algae	04-08-90	--	Comp.	72.4	16,500	3.1	218	.64
AK	Aq. plant	Algae	11-07-90	--	Comp.	73.5	11,000	4.2	161	.51
AK	Aq. plant	Coontail	07-11-90	--	Comp.	90.3	7,790	4	132	.34
AK	Aq. plant	Coontail	11-07-90	--	Comp.	84.8	9,090	6.7	145	.51
AK	Aq. plant	Sago pondweed	07-11-90	--	Comp.	85.6	6,280	1.9	68.8	.3
AK	Aq. inv.	Crayfish	04-08-90	--	4	68.9	1,700	1.6	99	<.1
AK	Aq. inv.	Crayfish	07-11-90	90	6	74.1	760	.55	48.9	.2
AK	Fish	Bluehead sucker	07-11-90	236	7	74.2	2,270	1.2	18.8	.09
AK	Fish	Fathead minnow	04-08-90	60	25	76.0	300	.3	21.4	.02
AK	Fish	Fathead minnow	07-11-90	50	25	78.8	931	.4	17.4	.03
AK	Fish	Fathead minnow	11-07-90	50	52	78.0	1,010	.3	15.6	.04
AK	Fish	Fm. sucker	04-08-90	483	2	70.1	250	.2	1	.01
AK	Fish	Fm. sucker	07-11-90	518	2	69.3	250	.6	3.3	.01
AK	Fish	Fm. sucker	11-07-90	535	2	75.3	1,170	.2	9.6	.05
AK	Fish	Fm. sucker	11-07-90	485	2	69.6	266	<.2	2.6	<.01
AK	Fish	Speckled dace	04-08-90	80	5	73.4	300	.2	4.6	.02
AK	Fish	Speckled dace	07-11-90	80	10	71.5	120	.3	3.3	<.01
AK	Fish	Speckled dace	11-07-90	80	15	71.1	59	<.2	3.9	<.02
DD	Aq. plant	Algae	04-06-90	--	Comp.	76.9	23,100	4.4	262	.88
DD	Aq. plant	Algae	07-11-90	--	Comp.	53.9	14,900	2.3	118	.69
DD	Aq. plant	Algae	11-08-90	--	Comp.	88.8	9,630	3.3	137	.36
DD	Aq. plant	Sago pondweed	11-08-90	--	Comp.	89.6	5,950	2.7	175	.3
DD	Aq. plant	Horned pondweed	07-11-90	--	Comp.	90.2	5,380	7	160	.2
DD	Aq. inv.	Crayfish	04-06-90	--	6	68.8	1,980	1.4	172	<.1
DD	Aq. inv.	Crayfish	07-11-90	70	7	78.1	481	.53	41.6	.2

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990 --Continued

Site	Matrix	Species	Date	Length	No. in sample	Percent moisture	Aluminum	Arsenic	Barium	Beryllium
					MVIC AREA--Continued					
DD	Fish	Bluehead sucker	04-06-90	70	2	72.4	250	0.3	11	0.02
DD	Fish	Bluehead sucker	07-11-90	350	1	74.1	557	.5	10.6	.02
DD	Fish	Bluehead sucker	11-08-90	88	2	76.9	80.1	.2	4.6	<.01
DD	Fish	Fathead minnow	04-06-90	50	7	75.2	536	.3	22.9	.02
DD	Fish	Fathead minnow	07-11-90	70	8	76.0	975	.4	16.7	.03
DD	Fish	Fathead minnow	11-08-90	54	17	78.1	412	<.02	18.3	.01
DD	Fish	Speckled dace	04-06-90	119	8	70.8	235	.2	6.5	.01
DD	Fish	Speckled dace	07-11-90	106	8	68.7	95.3	.3	5.8	<.01
DD	Fish	Speckled dace	11-08-90	88	10	71.6	16	<.2	5.1	<.01
DD	Bird	Rw. blackbird	07-12-90	--	1	69.3	41	<.1	3.6	<.1
DD	Bird	Sora rail	07-12-90	--	1	66.4	24	<.1	3.1	<.1
DD	Bird	Mallard	07-12-90	--	1	72.1	67	.1	11.3	<.1
DD	Eggs	Rw. blackbird	05-30-90	--	6	81.0	<3	<.1	1.4	<.09
DD	Liver	Mallard	07-12-90	--	1	73.6	<3	<.1	.1	<.1
DD	Liver	Mallard	07-12-90	--	1	70.6	<3	<.1	<.1	<.09
YJ2	Aq. plant	Algae	04-06-90	--	Comp.	85.2	9,770	3.4	163	.45
YJ2	Aq. plant	Algae	11-07-90	--	Comp.	74.5	4,720	2.6	467	.34
YJ2	Aq. inv.	Crayfish	04-06-90	40	7	75.0	1,210	1.6	134	<.1
YJ2	Aq. inv.	Crayfish	07-11-90	30	30	77.3	1,090	.64	152	.2
YJ2	Aq. inv.	Invertebrates	04-06-90	--	Comp.	85.7	3,270	.76	80.9	.1
YJ2	Aq. inv.	Invertebrates	11-07-90	--	Comp.	73.5	1,500	1.3	130	<.1
YJ2	Fish	Bluehead sucker	04-06-90	220	1	74.2	36	.5	1.6	<.01
YJ2	Fish	Bluehead sucker	11-07-90	130	2	78.6	2,470	.96	77.3	.1
YJ2	Fish	Fathead minnow	04-06-90	50	2	74.3	447	.8	9.9	.04
YJ2	Fish	Fathead minnow	11-07-90	50	23	81.4	1,730	.7	35.4	.06
YJ2	Fish	Fm. sucker	11-07-90	173	3	77.9	1,580	.4	41.6	.06
YJ2	Fish	Fm. sucker	11-07-90	330	1	76.3	436	<.2	11.1	.02
YJ2	Fish	Red shiners	11-07-90	60	14	71.5	55.8	<.2	4.3	<.01
YJ2	Fish	Speckled dace	04-06-90	60	16	71.8	280	<.2	6.1	.02
YJ2	Fish	Speckled dace	11-07-90	65	4	63.5	180	.4	9.6	.01
YJ2	Fish	Speckled dace	11-07-90	75	8	74.0	334	.99	19.3	<.1
YJ2	Fish	Suckers	07-11-90	65	7	74.9	932	.67	22.5	.05

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990 --Continued

Site	Matrix	Species	Date	Length	No. in sample	Percent moisture	Aluminum	Arsenic	Barium	Beryllium
					MVIC AREA--Continued					
NW	Aq. plant	Algae	04-04-90	--	Comp.	65.1	9,450	2.6	115	0.48
NW	Aq. plant	Algae	07-10-90	--	Comp.	87.2	10,400	4.8	102	.51
NW	Aq. inv.	Crayfish	04-04-90	--	Comp.	67.2	949	1.7	42.1	<.1
NW	Aq. inv.	Crayfish	11-06-90	--	Comp.	76.7	467	1.4	47.3	<.1
NW	Aq. inv.	Invertebrate	04-04-90	--	Comp.	85.1	6,050	1.1	40.6	.2
NW	Aq. inv.	Invertebrates	07-10-90	--	Comp.	85.1	2,570	.92	36.5	.3
NW	Aq. inv.	Invertebrates	11-06-90	--	Comp.	76.7	2,730	1.7	36.4	.1
NW	Fish	Bluehead sucker	07-10-90	40	40	84.2	2,620	.85	15.6	.1
NW	Fish	Bluehead sucker	11-06-90	100	20	78.2	6,570	2	41.6	.25
NW	Fish	Speckled dace	07-10-90	100	Comp.	63.6	353	.3	3.3	<.01
					DOVE CREEK AREA					
YJ1	Aq. plant	Algae	04-07-90	--	Comp.	86.1	3,540	.66	49.7	<.1
YJ1	Aq. plant	Watercress	07-09-90	--	Comp.	85.6	14,100	2	118	.58
YJ1	Aq. inv.	Invertebrates	04-07-90	--	Comp.	71.6	3,460	.62	33.3	.1
YJ1	Aq. inv.	Invertebrates	07-09-90	--	Comp.	80.3	4,520	.65	35.8	.31
WC	Aq. plant	Algae	04-06-90	--	Comp.	70.4	3,640	2	126	.1
WC	Aq. plant	Algae	07-12-90	--	Comp.	67.7	1,110	2	76.9	<.1
WC	Aq. plant	Algae	11-05-90	55	Comp.	70.4	3,210	3.7	151	<.1
WC	Aq. inv.	Invertebrates	04-06-90	--	Comp.	81.3	407	.63	6.2	<.1
WC	Aq. inv.	Invertebrates	11-05-90	--	Comp.	85.6	799	.9	6.8	<.1
WC	Aq. inv.	Invertebrates	07-12-90	--	Comp.	81.2	270	.68	2.7	.1
WC	Aq. inv.	Snails	04-06-90	--	Comp.	74.6	668	1.3	31.5	.2
WC	Aq. inv.	Snails	07-12-90	--	Comp.	75.4	370	.73	18	<.9
WC	Aq. inv.	Snails	11-05-90	--	Comp.	70.7	425	.94	30.6	<.1
WC	Fish	Fathead minnow	04-06-90	50	40	79.4	977	.6	8.9	.04
WC	Fish	Fathead minnow	07-12-90	70	Comp.	78.6	937	.4	8.9	.03
WC	Fish	Fathead minnow	11-05-90	--	Comp.	80.0	177	.3	9.3	.01
WC	Liver	Mallard	07-12-90	--	1	71.9	8	<.1	.2	<.1
WC	Bird	Rw. blackbird	07-12-90	--	1	70.9	30	<.1	3.6	<.09

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990 --Continued

Site	Matrix	Species	Date	Length	No. in sample	Percent moisture	Aluminum	Arsenic	Barium	Beryllium
				DOVE CREEK AREA--Continued						
CH	Aq. plant	Algae	04-03-90	--	Comp.	80.1	14,900	3	165	0.58
CH	Aq. plant	Algae	07-09-90	--	Comp.	77.7	16,300	3.5	168	.57
CH	Aq. plant	Algae	11-05-90	--	Comp.	74.1	5,210	3.2	71	.1
CH	Aq. plant	Sago pondweed	07-09-90	--	Comp.	92.7	13,500	2.8	118	.67
CH	Aq. inv.	Invertebrates	04-03-90	--	Comp.	80.0	5,990	2.2	49	.20
CH	Aq. inv.	Invertebrates	07-09-90	--	Comp.	67.9	9,630	1.5	69.5	.43
CH	Aq. inv.	Invertebrates	11-05-90	--	Comp.	67.3	819	.84	11	<.1
CR	Aq. plant	Algae	04-03-90	--	Comp.	79.1	13,700	18.3	218	.71
CR	Aq. plant	Algae	11-05-90	--	Comp.	96.6	749	2.5	197	<.1
CR	Aq. plant	Sago pondweed	07-09-90	--	Comp.	92.3	12,900	4.3	116	.53
CR	Aq. plant	Sago pondweed	11-05-90	--	Comp.	89.4	2,000	3.9	117	.1
CR	Aq. inv.	Invertebrates	04-03-90	--	Comp.	81.2	1,620	.61	13.9	<.1
CR	Aq. inv.	Invertebrates	07-09-90	--	Comp.	83.4	2,260	.68	15.9	.2
CR	Aq. inv.	Invertebrates	11-05-90	--	Comp.	79.8	313	1.9	7.1	<.1
AKP	Eggs	Coot	05-24-90	--	4	75.9	<3	<.1	1.2	<.09
AKP	Eggs	Rw. blackbird	05-24-90	--	4	83.7	<3	<.1	2	<.09
AKP	Eggs	Rw. blackbird	05-24-90	--	4	83.0	<3	<.1	1.9	<.1
				MANCOS AND SAN JUAN RIVERS						
MN1	Aq. inv.	Crayfish	04-05-90	100	1	66.5	1,730	1	75	<.1
MN1	Aq. inv.	Crayfish	07-10-90	88	6	71.3	--	.94	27	<.33
MN1	Aq. inv.	Invertebrates	04-05-90	--	Comp.	86.1	13,600	1.9	92.9	.42
MN1	Fish	Common carp	04-05-90	448	2	76.0	180	.2	11.4	.01
MN1	Fish	Common carp	07-10-90	420	1	75.7	--	<.35	9.8	<.39
MN1	Fish	Fish	07-10-90	70	15	84.2	--	<.62	9.1	<.61
MN1	Fish	Fm. sucker	04-05-90	370	1	68.9	135	.2	.47	<.01
MN1	Fish	Fm. sucker	11-06-90	400	2	72.9	210	<.29	2.8	<.34
MN1	Fish	Fm. sucker	11-06-90	175	1	76.1	340	.36	2.5	<.42
MN1	Fish	Speckled dace	04-05-90	--	Comp.	66.0	51	.3	1.3	.02
MN2	Aq. inv.	Crayfish	04-07-90	--	3	71.1	--	2	26	<.33
MN2	Aq. inv.	Crayfish	07-10-90	80	6	73.2	--	<.37	40	<.36
MN2	Fish	Common carp	04-07-90	460	1	76.1	--	<.37	5.9	<.41

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990 --Continued

Site	Matrix	Species	Date	Length	No. in sample	Percent moisture	Aluminum	Arsenic	Barium	Beryllium
MANCOS AND SAN JUAN RIVERS--Continued										
MN2	Fish	Fathead minnow	04-07-90	40	6	69.2	--	<0.32	8.3	<1.7
MN2	Fish	Fathead minnow	07-10-90	80	12	75.5	--	.91	25	<.86
MN2	Fish	Fm. sucker	04-07-90	153	5	70.8	--	<.31	3	<.34
MN2	Fish	Fm. sucker	04-07-90	225	1	72.8	--	<.32	4	<.35
MN2	Fish	Fm. sucker	11-06-90	267	7	77.6	520	.57	5.5	<.45
MN2	Fish	Fm. sucker	11-06-90	397	3	69.9	450	.66	4.6	<.31
MN2	Fish	Fm. sucker	11-06-90	327	3	75.0	620	.57	4	<.38
MN2	Fish	Red shiners	07-10-90	70	20	75.3	--	<.36	4.2	<.39
MN2	Fish	Roundtail chub	04-07-90	250	1	73.5	--	<.33	2.6	<.33
SJ1	Aq. plant	Algae	04-05-90	--	Comp.	61.7	4,600	1.2	170	<1.3
SJ1	Aq. plant	Algae	07-10-90	--	Comp.	79.7	4,400	4.3	210	<2.4
SJ1	Aq. inv.	Invertebrate	04-05-90	--	Comp.	81.1	--	<.48	53	2.6
SJ1	Fillet	Channel catfish	11-06-90	481	2	79.1	67	<.46	2.7	<.44
SJ1	Fillet	Fm. sucker	04-05-90	510	2	73.6	--	<.35	.7	<.35
SJ1	Liver	Channel catfish	11-06-90	481	1	73.1	23	<.35	<.36	<.36
SJ1	Fish	Bluehead sucker	04-05-90	358	2	66.7	--	<.28	6.4	<.29
SJ1	Fish	Bluehead sucker	07-10-90	360	2	66.5	--	.58	6.9	<.29
SJ1	Fish	Bluehead sucker	11-06-90	305	2	71.0	1,000	.64	40	<.33
SJ1	Fish	Common carp	04-05-90	425	2	73.9	--	<.34	10	<.36
SJ1	Fish	Common carp	11-06-90	395	1	72.9	51	<.36	13	<.35
SJ1	Fish	Channel catfish	07-10-90	110	1	74.0	--	<.38	4	<.62
SJ1	Fish	Fm. sucker	04-05-90	222	5	71.6	--	<.3	16	<.32
SJ1	Fish	Fm. sucker	04-05-90	493	2	71.5	--	<.32	20	<.35
SJ1	Fish	Fm. sucker	07-10-90	505	1	58.2	--	<.21	12	<.24
SJ1	Fish	Fm. sucker	11-06-90	427	3	67.1	110	.27	6.3	<.29
SJ1	Fish	Fm. sucker	11-06-90	237	4	78.2	330	.97	17	<.45
SJ1	Fish	Red shiners	07-10-90	60	40	73.3	--	<.31	5.9	<.36
SJ1	Fish	Speckled dace	04-05-90	51	4	69.0	--	<.32	11	<1.4
SJ1	Fish	Speckled dace	07-10-90	70	13	70.1	--	<.29	7.4	<.32
SJ1	Fish	Speckled dace	11-06-90	75	2	70.6	130	.27	10	<.71

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990 --Continued

Site	Matrix	Species	Date	Length	No. in sample	Percent moisture	Aluminum	Arsenic	Barium	Baryllium
				MANCOS AND SAN JUAN RIVERS--Continued						
SJ2	Fish	Bluehead sucker	06-25-90	314	5	61.7	--	<0.23	7.5	<0.26
SJ2	Fish	Common carp	06-25-90	457	3	72.4	--	<.31	3.7	<.35
SJ2	Fish	Channel catfish	06-25-90	289	1	75.2	--	<.38	1.9	<.4
SJ2	Fish	Channel catfish	06-25-90	107	1	76.0	--	<.39	7.9	<.58
SJ2	Fish	Fm. sucker	06-25-90	482	3	67.1	--	<.26	5	<.3
SJ3	Aq. plant	Algae	04-05-90	--	Comp.	74.0	5,300	.9	130	<1.7
SJ3	Fish	Bluehead sucker	04-05-90	290	2	61.9	--	<.25	20	<.29
SJ3	Fish	Bluehead sucker	06-25-90	152	4	70.3	--	<.31	9.8	<.33
SJ3	Fish	Bluehead sucker	11-06-90	245	1	72.4	560	<.3	9.9	<.34
SJ3	Fish	Common carp	06-25-90	171	1	77.5	--	<.82	7.2	<1.6
SJ3	Fish	Channel catfish	04-05-90	63	3	79.8	--	.42	5.2	<2
SJ3	Fish	Fm. sucker	04-05-90	373	2	64.9	--	<.25	14	.31
SJ3	Fish	Fm. sucker	04-05-90	380	2	72.2	--	<.35	1	<.36
SJ3	Fish	Fm. sucker	04-05-90	210	5	69.7	--	<.32	6.6	<.31
SJ3	Fish	Fm. sucker	06-25-90	395	4	64.3	--	<.24	7.6	<.28
SJ3	Fish	Fm. sucker	11-06-90	294	12	75.8	180	.43	7.5	<.4
SJ3	Fish	Fm. sucker	11-06-90	440	1	69.4	83	<.3	3.8	<.32

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990--Continued

Site	Matrix	Date	Boron	Cadmium	Chromium	Copper	Iron	Lead	Magnesium	Manganese
					MVIC AREA--Continued					
ME1	Aq. plant	07-11-90	13	1.0	22	17	15,800	18	7,650	368
ME1	Aq. plant	11-08-90	30	.9	6	11	9,230	<4	7,720	4,370
ME1	Aq. inv.	07-11-90	3	2.9	5.3	31	396	<4	968	39
ME1	Aq. inv.	11-08-90	4	2.6	7.3	18	1,760	<5	1,880	75.9
ME1	Aq. inv.	11-08-90	<3	6	5.6	14	6,290	6	4,400	73.9
ME1	Fish	11-08-90	<2	.32	2.8	4.51	819	<.8	1,850	28
ME1	Fish	11-08-90	<2	.1	.4	2.4	122	<.4	1,230	9.78
ME2	Aq. plant	07-11-90	56	.8	14	17	11,500	15	6,390	1,250
ME2	Aq. plant	11-07-90	8.6	.5	12	8.5	14,100	10	5,850	725
ME2	Aq. inv.	04-01-90	4	<.4	3	71.9	1,440	<5	3,400	314
ME2	Aq. inv.	07-11-90	4	<.3	1	67.6	575	<4	2,610	157
ME2	Fish	07-11-90	3	.34	2	3.04	254	<.8	975	44
ME2	Fish	11-07-90	5	.2	6.9	4.96	3,060	2	2,660	111
ME2	Fish	07-11-90	3	.71	4.3	5.33	387	<1	1,400	19
ME2	Fish	04-04-90	<2	.52	3.5	4.8	832	<.5	1,420	51.5
ME2	Fish	07-11-90	2	.08	2	3.02	382	.9	1,050	21
ME2	Fish	11-07-90	3	.1	3.9	4.36	1,500	1	2,270	53.1
ME2	Fish	11-07-90	<2	.1	3.9	3.71	11	1	1,670	36.8
ME2	Fish	07-11-90	<2	3.5	3.3	2.29	95	<.5	1,050	10
ME3	Aq. plant	04-04-90	12	<.4	17	7.9	8,390	10	5,600	548
ME3	Aq. plant	07-11-90	40	.5	12	16	11,700	14	6,370	783
ME3	Aq. plant	11-07-90	10	2.1	5.8	5.9	5,980	<4	3,960	289
ME3	Aq. inv.	04-04-90	3	<.4	3	81.3	893	<4	3,740	373
ME3	Aq. inv.	07-11-90	5	.4	2	79.2	812	<4	2,820	95.1
ME3	Fish	07-11-90	3	.26	4.5	4.7	263	<1	1,060	27
ME3	Fish	11-07-90	5.8	.11	6.4	4.39	3,440	2	2,710	92.5
ME3	Fish	07-11-90	<2	.01	1.2	5.8	177	<.5	1,180	4.4

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990--Continued

Site	Matrix	Date	Boron	Cadmium	Chromium	Copper	Iron	Lead	Magnesium	Manganese
					MVIC AREA--Continued					
ME3	Fish	04-04-90	<2	0.37	2	4.83	262	<0.5	1,440	13.8
ME3	Fish	07-11-90	<2	.16	2.3	4.8	273	.8	1,220	9.6
ME3	Fish	04-04-90	<2	.4	5.3	4.16	283	.5	1,430	19
ME3	Fish	07-11-90	4	.62	2.6	5.1	385	<.8	1,490	22
ME3	Fish	11-07-90	2	.37	3.1	4.08	1,030	<.7	2,100	37.7
ME3	Fish	04-04-90	<2	.11	.7	2.07	137	<.4	812	7.4
ME3	Fish	07-11-90	3	.06	1	2.3	128	.7	954	12
ME3	Fish	11-07-90	4	.1	5.1	5.03	2,510	2	2,500	63
ME3	Fish	11-07-90	<2	.06	2	3.81	866	.7	1,460	26.3
ME3	Fish	11-07-90	3	.06	2.6	3.15	1,290	1	2,050	47.1
ME3	Fish	07-11-90	2	.26	3.6	2.49	121	<.8	1,360	21
ME3	Fish	07-11-90	3	.38	9.5	4.5	148	<2	1,470	18
ME3	Fish	11-07-90	<2	.14	1.6	3.18	109	<.5	1,300	9.77
ME3	Fish	04-04-90	<2	<.3	7.2	5.85	242	<.8	1,300	24.4
ME3	Fish	07-11-90	2	.21	2	2.2	104	<.8	1,010	9.8
ME3	Fish	11-07-90	<2	.34	2.4	3.14	619	<1	1,460	26.1
ME4	Aq. plant	04-04-90	30	<.4	21	14	7,830	7	6,680	705
ME4	Aq. plant	11-07-90	9	.5	8.1	9	9,570	9	6,530	487
ME4	Aq. inv.	04-04-90	4	<.4	2	81.2	1,090	<4	3,740	289
ME4	Aq. inv.	07-11-90	5	<.3	1	65.2	456	<4	3,040	96.4
ME4	Fish	04-04-90	<2	.75	1.7	5.04	314	<.5	1,430	17
ME4	Fish	07-11-90	<2	.62	.99	7.1	263	.6	1,200	8.2
ME4	Fish	11-07-90	<2	.42	1	4.49	166	.8	1,290	9.71
ME4	Fish	04-04-90	<2	<.3	21	6.11	677	.8	1,450	45.1
ME4	Fish	07-11-90	2	.15	8.4	6.8	328	.5	1,510	19
ME4	Fish	04-04-90	<2	.26	1.3	2.1	256	<.5	856	15.1
ME4	Fish	07-11-90	<2	.14	1.9	3.1	113	<.9	792	7
ME4	Fish	11-07-90	3	.1	5.4	3.82	2,020	1	2,130	58.4
ME4	Fish	11-07-90	2	.09	1.8	2.56	758	.9	1,560	32.3
ME4	Fish	11-07-90	<2	.08	1.2	3.1	493	3.4	2,070	32.7
ME4	Fish	07-11-90	<2	.16	6.2	6.2	158	<.6	1,410	12

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990--Continued

Site	Matrix	Date	Boron	Cadmium	Chromium	Copper	Iron	Lead	Magnesium	Manganese
					MVIC AREA--Continued					
MP	Aq. inv.	11-14-90	<2	<0.3	<1	98	1,340	<4	1,980	1,700
MP	Zooplankton	04-18-90	<2	<.7	4	7.6	855	10	1,300	104
MP	Zooplankton	11-14-90	6	2	25	8.1	2,810	<10	1,570	214
MP	Fillet	06-07-90	3	.05	1.1	1.2	14	<.5	1,090	.5
MP	Fillet	11-14-90	<2	<.03	.2	1.2	34	<.4	1,220	.43
MP	Fish	06-07-90	<2	.08	1.4	2.3	153	<.5	927	18
MP	Fish	11-14-90	<2	.09	1.2	2.2	204	<.6	925	11.9
MP	Fish	06-07-90	<2	.51	1.6	3	111	<.7	1,240	6.4
MP	Fish	04-18-90	<2	.39	1	2.8	445	<.5	1,310	13
MP	Fish	04-18-90	<2	.04	1	2.1	73	<.05	1,290	2.2
MP	Fish	11-07-90	<2	.1	.68	3.12	260	<.5	1,270	15.2
MP	Fish	06-07-90	2	.72	5.1	7.7	333	<.6	1,920	23
MP	Fish	06-07-90	<2	.07	1.3	2.2	81	<.4	1,180	8.7
MP	Fish	04-18-90	<2	<.04	.52	2.69	161	<.4	769	19.5
MP	Fish	04-18-90	<2	.38	3.3	2.2	444	<.5	1,160	16
MP	Fish	06-07-90	2	.47	3.4	1.7	88	<.6	1,230	10
MP	Fish	11-14-90	<2	.1	.3	1.3	43	.7	1,530	8.7
MP	Fish-gutted	10-31-90	<5.5	<.43	<.43	5.5	56	<1.1	1,300	4.3
SU	Aq. plant	11-14-90	274	<.3	3	4.5	1,990	<4	1,780	417
SU	Zooplankton	04-16-90	<2	<.6	5.6	7.2	1,610	10	1,430	242
SU	Zooplankton	11-14-90	3	1.3	8.9	4.8	1,200	<4	1,210	121
SU	Eggs	11-14-90	<2	<.03	<.1	5.91	80	<.4	813	4.2
SU	Fillet	04-16-90	<2	.06	3	4.8	39	<.5	1,400	.75
SU	Fillet	11-14-90	<2	<.03	.2	1.1	17	<.5	1,150	.44
SU	Fillet	11-14-90	<2	<.03	.78	1.5	17	<.4	1,100	.32
SU	Fish	04-16-90	<2	<.06	2	2	312	<.5	1,480	8.3
SU	Fish	04-16-90	<2	.13	.62	2.27	96	<.4	1,420	7.6
SU	Fish	11-14-90	<2	.04	.72	2.1	49	<.5	1,190	3.99
SU	Fish	04-16-90	<2	.14	1	3.9	116	<.4	1,630	13.1

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990--Continued

Site	Matrix	Date	Boron	Cadmium	Chromium	Copper	Iron	Lead	Magnesium	Manganese
					MVIC AREA--Continued					
PU	Aq. inv.	05-31-90	2	<0.3	2	71	2,290	5	3,010	984
PU	Aq. inv.	11-15-90	<2	<.3	<1	53.5	1,170	<4	2,530	298
PU	Zooplankton	05-31-90	8.2	.5	5.5	8.1	4,260	5	2,450	280
PU	Zooplankton	11-15-90	7	<.9	19	6.2	2,320	<10	1,520	238
PU	Eggs	11-15-90	<2	<.03	.39	1.8	36	<.4	1,040	3.11
PU	Fillet	05-31-90	<2	.04	.63	2.68	37	<.5	1,230	2.7
PU	Fillet	11-15-90	<2	<.04	.3	1.7	22	<.5	891	.39
PU	Fish	05-31-90	<2	.05	<1	6	80	<.4	1,200	13
PU	Fish	11-15-90	<2	.19	1.2	8.03	127	<.5	1,390	32.3
PU	Fish	05-31-90	<2	.06	1.2	4.04	63	<.5	1,380	4.5
PU	Fish	11-15-90	<2	.06	.61	2.97	35	<.6	1,060	2.83
PU	Fish	05-31-90	<2	.1	1	4.41	61	<.5	1,270	16
TT	Aq. plant	07-12-90	21	<.3	2	7	936	<4	4,880	437
TT	Aq. plant	07-12-90	256	<.3	3.9	7.7	1,320	<4	3,080	3,350
TT	Aq. plant	11-15-90	9.5	<.3	1	4.1	1,790	<4	3,600	961
TT	Aq. inv.	04-17-90	<2	<.4	<1	34.9	737	<4	2,440	263
TT	Aq. inv.	11-15-90	<2	<.3	<1	24.5	349	<4	2,240	120
TT	Zooplankton	04-17-90	<2	<.7	9.2	9.1	762	10	2,070	627
TT	Zooplankton	11-15-90	6.6	.7	11	4.3	2,370	6	2,200	670
TT	Eggs	04-17-90	<2	.04	1	2.8	51	<.4	1,530	6.2
TT	Eggs	11-15-90	<2	<.04	.2	4.25	140	<.6	1,130	21.9
TT	Eggs	11-15-90	<2	<.03	.39	1.3	28	<.6	1,010	3.61
TT	Fillet	04-18-90	<2	.13	.49	2.45	67	<.4	1,230	.88
TT	Fillet	11-15-90	<2	.04	.2	1.1	23	<.4	1,390	3.37
TT	Fillet	04-17-90	2	.08	2.6	4.1	35	<.5	1,030	1
TT	Fillet	04-17-90	<2	<.03	.3	1.1	17	<.4	1,100	.5
TT	Fillet	11-15-90	<2	<.05	.3	1	15	<.6	1,170	.35
TT	Fish	04-17-90	<2	.03	.34	2.1	98	<.4	1,440	18
TT	Fish	04-17-90	<2	.23	1	1.7	127	<.5	1,550	13
TT	Fish	04-17-90	<2	<.04	.67	2.1	115	<.5	854	9.2
TT	Fish	04-17-90	<2	.03	2	3.11	65	<.4	1,210	5.7

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990--Continued

Site	Matrix	Date	Boron	Cadmium	Chromium	Copper	Iron	Lead	Magnesium	Manganese
MVIC AREA--Continued										
TT	Fish	11-15-90	<2	<0.03	0.2	1.3	37	<0.4	1,290	5.91
TT	Fish	04-17-90	<2	<.04	.43	1.1	51	<.5	1,160	2.9
TT	Fish	11-15-90	<2	.1	.7	.92	41	<.8	1,150	2.4
TT	Fish	04-17-90	<2	.12	2	1.7	65	<.6	1,780	6.2
TT	Fish	11-15-90	<2	<.03	.9	2.88	168	.5	1,210	8.05
TT	Bird	07-12-90	<3	.6	<1	18	1,620	<6	720	4.1
TT	Bird	07-12-90	2	<.3	3.3	8.6	367	<4	1,090	4.1
TT	Eggs	05-22-90	2	<.3	<1	1.9	122	<4	430	.8
TT	Eggs	07-12-90	2	<.3	2	3.8	96	<4	492	2.4
TT	Eggs	05-30-90	<2	<.3	<1	3.2	107	<4	390	1.9
TT	Egg	05-30-90	<2	<.3	<1	3	108	<4	392	1.7
TT	Eggs	05-30-90	<2	<.3	<1	1.7	163	<4	361	3
TT	Eggs	05-30-90	2	<.3	<1	1.1	172	<4	366	3.1
TT	Liver	07-12-90	<2	1.4	1	27	5,200	<4	632	11
TT	Liver	07-12-90	2	.5	2	21	7,760	<4	689	12
LP	Aq. plant	07-12-90	16	<.3	2.8	3.5	2,120	<4	8,660	264
LP	Eggs	05-23-90	<2	<.3	<1	2.9	137	<4	480	1.8
LP	Eggs	07-12-90	2	<.3	<1	1.3	84	<4	514	1.6
LP	Eggs	05-23-90	<2	<.3	1	2.1	127	<4	402	1.9
LP	Eggs	07-12-90	<3	<.6	<2	1	150	<7	379	3.7
LP	Eggs	05-23-90	<2	<.3	<1	1.7	186	<4	422	3.6
LP	Liver	07-12-90	5	.6	<1	15	2,880	<4	707	11
LP	Liver	07-12-90	5	<.3	<1	14	2,240	<4	771	12
LP	Liver	07-12-90	4	.6	<1	16	2,820	<4	765	15
LP	Liver	07-12-90	5	<.3	2	7.2	1,060	<4	587	8.5
LP	Liver	07-12-90	3	<.5	2	23	894	<7	800	15
SD	Aq. plant	04-04-90	6	<.4	24	11	15,900	10	7,230	2,740
SD	Aq. plant	07-10-90	13	<.3	10	10	14,300	21	6,320	1,130
SD	Aq. plant	11-08-90	11	1	11	10	8,490	7	5,880	1,500

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990--Continued

Site	Matrix	Date	Boron	Cadmium	Chromium	Copper	Iron	Lead	Magnesium	Manganese
					MVIC AREA--Continued					
SD	Aq. plant	07-10-90	18	<0.3	13	12	9,820	10	5,330	1,200
SD	Aq. inv.	04-04-90	2	<.4	2	81	1,320	<5	3,060	1,080
SD	Aq. inv.	07-10-90	4	<.3	3	84.4	925	<4	3,560	291
SD	Aq. inv.	11-08-90	<2	.4	3	36.8	1,130	<4	1,820	266
SD	Fish	07-10-90	6	.79	4.8	4.2	2,400	2.7	2,310	218
SD	Fish	11-08-90	<2	.1	2	3.41	814	<.6	1,770	82.7
SD	Fish	04-04-90	<2	.4	15.1	4.81	346	<.5	1,500	33.5
SD	Fish	07-10-90	6	1.1	5.6	5.3	1,320	<1	1,690	96.7
SD	Fish	11-08-90	<2	.1	1.5	3.42	588	.6	1,670	49.2
HD1	Aq. plant	04-06-90	2	<.4	29	8.5	12,900	10	5,290	2,210
HD1	Aq. plant	07-11-90	9.2	.5	9.8	8.1	14,600	15	5,950	1,110
HD1	Aq. plant	11-08-90	32	.6	10	6.1	13,200	10	4,310	731
HD1	Aq. plant	07-11-90	17	<.3	5	9	12,000	6	7,490	2,790
HD1	Aq. inv.	04-06-90	3	<.4	2	90.1	1,010	<4	2,590	496
HD1	Aq. inv.	07-11-90	3	<.3	2	76.9	883	<4	2,380	240
HD1	Fish	04-06-90	3	.89	4.5	3.7	760	<1.0	1,470	77.9
HD1	Fish	04-06-90	<2	<.1	6.1	3.9	1,230	<.6	1,330	103
HD1	Fish	07-11-90	3	.81	3.7	2.7	1,420	<.8	1,700	149
HD1	Fish	11-08-90	5	.1	5.3	4.25	3,160	2.3	2,570	175
HD1	Fish	04-06-90	<2	.43	5.9	8.5	619	<.5	1,560	49.7
HD1	Fish	07-11-90	3	.87	3.3	3.6	1,060	<.8	1,620	94
HD1	Fish	07-11-90	3	.75	3.2	3.3	902	<.7	1,550	87.2
HD1	Fish	11-08-90	<2	.2	2.1	3.76	1,070	.9	1,830	62.5
HD1	Fish	04-06-90	3	.45	3.3	3.15	133	<.6	1,720	47.3
HD1	Fish	07-11-90	<2	.35	1.2	4.4	231	<.5	1,580	38
HD1	Fish	04-06-90	<2	<.2	5.3	3.78	444	<.6	1,510	44
HD1	Fish	07-11-90	<2	.31	2.2	2.1	125	<.9	1,140	17
HD1	Fish	11-08-90	<2	.08	.43	2.62	244	<.3	1,350	18.9
HD2	Aq. plant	04-04-90	<2	<.4	10	11	8,120	10	6,500	2,360
HD2	Aq. plant	11-07-90	7.7	<.4	7.2	9.3	11,100	10	5,220	967

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990--Continued

Site	Matrix	Date	Boron	Cadmium	Chromium	Copper	Iron	Lead	Magnesium	Manganese
					MVIC AREA--Continued					
HD2	Aq. inv.	04-04-90	<2	<0.4	3.6	86.1	1,030	<4	2,790	237
HD2	Aq. inv.	07-10-90	4	.5	1	118	668	4	2,340	155
HD2	Fish	04-04-90	<2	<.2	16	4.9	1,020	<.7	1,720	70.3
HD2	Fish	11-07-90	<2	.17	1	2.99	540	<.6	1,320	27.3
HD2	Fish	07-10-90	<2	<.04	1.6	2.6	98	<.4	780	7.78
HD2	Fish	07-10-90	6	.76	5.8	3.74	1,970	2	1,770	122
HD2	Fish	11-07-90	<2	.1	.82	1.7	102	<1	885	15
HD2	Fish	11-07-90	<2	.1	.79	2.31	243	<.7	1,210	19.6
HD2	Fish	04-04-90	<2	<.03	<.1	2.31	107	<.4	811	18.3
HD2	Fish	07-10-90	4	1	2.8	2.5	594	<1	1,310	69.4
AK	Aq. plant	04-08-90	7	<.4	16	8.7	1,070	9	6,460	3,110
AK	Aq. plant	11-07-90	9.5	.4	10	7.5	11,100	7	4,690	1,060
AK	Aq. plant	07-11-90	33	1.1	6.8	9.9	8,130	9	7,230	10,100
AK	Aq. plant	11-07-90	5	2.5	8.4	12	9,340	7	5,540	2,010
AK	Aq. plant	07-11-90	368	.7	17	8.1	5,260	5	4,660	1,260
AK	Aq. inv.	04-08-90	<2	<.4	3.3	96.5	981	<4	2,560	673
AK	Aq. inv.	07-11-90	5	<.3	1	81.5	569	<4	2,160	177
AK	Fish	07-11-90	5	.7	4.5	4.37	1,830	2.9	1,550	239
AK	Fish	04-08-90	<2	.25	4.1	5.32	237	<.5	1,380	26.4
AK	Fish	07-11-90	3	.87	4.2	5.5	687	.8	1,640	67.2
AK	Fish	11-07-90	<2	<.3	1.6	3.67	562	<.5	1,570	34.4
AK	Fish	04-08-90	<2	.23	1.3	3.36	216	<.5	1,050	35.4
AK	Fish	07-11-90	2	.09	2	3.75	367	.6	876	24
AK	Fish	11-07-90	2	.1	1.4	3.21	688	.6	1,360	68
AK	Fish	11-07-90	<2	<.06	1.1	2.64	213	.5	955	18.8
AK	Fish	04-08-90	<2	.2	5.4	4.41	277	<.6	1,360	30.6
AK	Fish	07-11-90	3	.5	3	3	150	<.7	1,200	24
AK	Fish	11-07-90	<2	<.08	<.2	2.2	78	<1	1,130	14

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990--Continued

Site	Matrix	Date	Boron	Cadmium	Chromium	Copper	Iron	Lead	Magnesium	Manganese
					MVIC AREA--Continued					
DD	Aq. plant	04-06-90	29	<0.4	27	11	14,400	10	6,900	3,260
DD	Aq. plant	07-11-90	13	<.4	10	10	11,100	10	3,620	606
DD	Aq. plant	11-08-90	49	.7	8.9	7.8	8,570	6	4,460	2,630
DD	Aq. plant	11-08-90	9.1	<.3	5.6	10	5,410	4	4,120	5,180
DD	Aq. plant	07-11-90	140	.6	5.9	10	7,800	9	4,190	3,140
DD	Aq. inv.	04-06-90	3	<.4	3.3	71.3	1,160	<4	2,570	858
DD	Aq. inv.	07-11-90	2	.3	1	89.2	381	<4	1,790	162
DD	Fish	04-06-90	<2	<.3	12	4.5	226	<.7	1,260	31.6
DD	Fish	07-11-90	3	.68	2.5	10	584	<.5	1,240	114
DD	Fish	11-08-90	<2	.19	1	2.82	74	<.6	1,260	25.1
DD	Fish	04-06-90	<2	.33	1.3	4.21	363	<.5	1,490	28.5
DD	Fish	07-11-90	3	.79	3.3	5	745	<.7	1,460	61.5
DD	Fish	11-08-90	<2	.09	.97	3.74	295	<.5	1,420	28.9
DD	Fish	04-06-90	<2	<.1	4.2	3.83	197	<.6	1,170	19
DD	Fish	07-11-90	2	.32	2	4.14	142	<.8	1,080	15
DD	Fish	11-08-90	<2	.04	.03	1.9	60	<.4	1,100	10.3
DD	Bird	07-12-90	3	<.3	<1	8.8	269	<4	1,180	8
DD	Bird	07-12-90	2	<.4	2	6.2	304	<4	863	5.5
DD	Bird	07-12-90	3	<.3	2	11	393	<4	1,230	12
DD	Eggs	05-30-90	<2	<.3	<1	1.7	192	<4	355	2.7
DD	Liver	07-12-90	<2	2.5	<1	121	2,720	<4	629	13
DD	Liver	07-12-90	<2	4.7	<1	82.5	3,340	<4	706	16
YJ2	Aq. plant	04-06-90	42	<.4	37	18	7,260	<5	5,110	746
YJ2	Aq. plant	11-07-90	12	<.3	18	6.4	5,580	7	3,320	377
YJ2	Aq. inv.	04-06-90	<2	<.4	1.0	134	720	<5	2,530	445
YJ2	Aq. inv.	07-11-90	4	.5	1	75.3	764	<4	2,520	75.6
YJ2	Aq. inv.	04-06-90	2	<.6	6.3	18	1,610	<5	2,000	986
YJ2	Aq. inv.	11-07-90	3	2.2	4.4	86.9	1,630	<5	2,280	121
YJ2	Fish	04-06-90	<2	<.1	3.4	3.02	124	<.6	899	10
YJ2	Fish	11-07-90	4	.43	2.7	3.96	1,360	<1	2,050	89.1

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990--Continued

Site	Matrix	Date	Boron	Cadmium	Chromium	Copper	Iron	Lead	Magnesium	Manganese
					MVIC AREA--Continued					
YJ2	Fish	04-06-90	<4	0.2	<0.3	6.85	441	<1	2,650	60.6
YJ2	Fish	11-07-90	<2	.09	1.2	4.25	841	1	2,000	45.8
YJ2	Fish	11-07-90	2	.26	1.5	4.61	766	2.3	1,980	44.7
YJ2	Fish	11-07-90	<2	.05	.84	4.26	329	.5	1,160	18.3
YJ2	Fish	11-07-90	<2	.14	.62	2.78	93..	<.5	1,370	11.1
YJ2	Fish	04-06-90	<2	<.2	6.2	3	215	<.7	1,170	23
YJ2	Fish	11-07-90	<2	.19	3.9	3.69	201	<.5	1,070	13
YJ2	Fish	11-07-90	.01	.2	1.2	2.5	255	<1	1,320	19.7
YJ2	Fish	07-11-90	5	.93	4.7	3.39	753	<1	1,720	46
NW	Aq. plant	04-04-90	17	<.4	13	8.5	8,440	7	10,000	1,240
NW	Aq. plant	07-10-90	120	.7	11	11	12,100	9	6,110	633
NW	Aq. inv.	04-04-90	3.0	.4	1	84.1	497	<4	2,850	152
NW	Aq. inv.	11-06-90	2	<.4	<1	76.8	399	<4	2,440	102
NW	Aq. inv.	04-04-90	14	<.6	9.9	16	3,250	<5	4,190	488
NW	Aq. inv.	07-10-90	7.6	.7	3.3	64.5	1,860	<4	3,210	114
NW	Aq. inv.	11-06-90	3	.7	8.2	17	3,040	<4	2,070	464
NW	Fish	07-10-90	5	.57	4.8	10	1,910	2.1	2,560	45
NW	Fish	11-06-90	7.2	.28	7.8	9.24	4,140	3	4,160	95
NW	Fish	07-10-90	3	.58	4.2	4.2	312	<2	1,050	13
					DOVE CREEK AREA--Continued					
YJ1	Aq. plant	04-07-90	9.1	<.4	3.9	3.6	2,080	<4	4,470	434
YJ1	Aq. plant	07-09-90	15	<.3	12	12	9,860	10	5,770	419
YJ1	Aq. inv.	04-07-90	3	<.4	3.3	15	2,660	<4	1,740	1,170
YJ1	Aq. inv.	07-09-90	6.3	.5	5.1	29	2,710	<4	2,510	177
WC	Aq. plant	04-06-90	59	<.4	4.9	3.9	2,890	<4	8,310	2,450
WC	Aq. plant	07-12-90	83	<.3	2	2.2	1,190	4	5,170	1,730
WC	Aq. plant	11-05-90	52	<.3	2	3.3	2,580	<4	6,090	876
WC	Aq. inv.	04-06-90	<2	<.5	2	10	331	<5	1,200	372
WC	Aq. inv.	11-05-90	4	.4	3	17	500	<4	1,710	280
WC	Aq. inv.	07-12-90	2	<.3	2	16	266	<4	1,290	57.9

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990--Continued

Site	Matrix	Date	Boron	Cadmium	Chromium	Copper	Iron	Lead	Magnesium	Manganese
				DOVE CREEK AREA--Continued						
WC	Aq. inv.	04-06-90	4	0.4	2.9	12	677	<4	2,200	1,300
WC	Aq. inv.	07-12-90	<20	<3	<9	4	340	<30	1,330	499
WC	Aq. inv.	11-05-90	<2	<.3	3	9.2	335	<4	2,450	635
WC	Fish	04-06-90	<2	.64	11	12.6	663	<.5	1,820	69.7
WC	Fish	07-12-90	3	.72	4.6	3.45	665	<.9	1,820	175
WC	Fish	11-05-90	<2	.13	.63	3.5	212	<.5	1,640	47.4
WC	Liver	07-12-90	<2	<.3	2	38.5	425	<4	726	23
WC	Bird	07-12-90	2	<.3	<1	8.8	302	<4	1,090	4.9
CH	Aq. plant	04-03-90	31	<.4	14	9	9,420	8	9,750	2,600
CH	Aq. plant	07-09-90	15	.4	15	8.7	10,700	10	6,040	1,130
CH	Aq. plant	11-05-90	41	.8	4.2	5.3	3,890	<4	6,840	5,730
CH	Aq. plant	07-09-90	16	.3	11	13	9,720	10	8,830	712
CH	Aq. inv.	04-03-90	5	<.05	6.1	34.2	2,930	<5	3,890	1,330
CH	Aq. inv.	07-09-90	7.2	.6	5.1	26	5,330	7	3,300	499
CH	Aq. inv.	11-05-90	2	<.3	2	27	806	<4	1,500	152
CR	Aq. plant	04-03-90	6.3	.6	13	10	45,300	9	4,820	6,670
CR	Aq. plant	11-05-90	4	<.3	5	32.9	2,390	<4	3,660	2,100
CR	Aq. plant	07-09-90	54	<.3	9	8.7	8,660	10	6,160	12,700
CR	Aq. plant	11-05-90	345	.4	2	3.9	2,260	<4	3,960	16,400
CR	Aq. inv.	04-03-90	<2	1.5	4.9	21.7	1,040	<5	2,080	405
CR	Aq. inv.	07-09-90	3	.5	3.9	17	1,700	<4	2,060	833
CR	Aq. inv.	11-05-90	3	.4	2	13	389	<4	1,430	1,490
AKP	Eggs	05-24-90	2	<.3	<1	2.8	100	<4	536	1.7
AKP	Eggs	05-24-90	3	<.3	<1	1.8	165	<4	365	3.4
AKP	Eggs	05-24-90	<2	<.3	<1	2.1	193	<4	391	4.4
				MANCOS AND SAN JUAN RIVERS--Continued						
MN1	Aq. inv.	04-05-90	3	<.4	3	127	1,130	<5	4,550	441
MN1	Aq. inv.	07-10-90	<3.6	<.33	<1.6	73	380	<.65	2,400	170
MN1	Aq. inv.	04-05-90	12	<.5	15	16	6,620	9	4,010	410
MN1	Fish	04-05-90	<2	1	.76	4.16	237	<.5	1,610	13

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990--Continued

Site	Matrix	Date	Boron	Cadmium	Chromium	Copper	Iron	Lead	Magnesium	Manganese
				MANCOS AND SAN JUAN RIVERS--Continued						
MN1	Fish	07-10-90	<4.3	0.58	<2	2.4	150	<0.79	1,400	6.4
MN1	Fish	07-10-90	<6.7	<.61	17	6.9	710	<1.2	1,600	24
MN1	Fish	04-05-90	<2	<.04	.59	2.54	115	<.5	798	6.4
MN1	Fish	11-06-90	<4.6	<.34	<.34	4.1	160	1.4	1,400	12
MN1	Fish	11-06-90	<5.3	<.42	<.42	6.3	220	<1.1	1,900	17
MN1	Fish	04-05-90	<2.0	<.4	18	23	124	<.9	1,010	16.2
MN2	Aq. inv.	04-07-90	<3.3	.47	440	76	3,100	<.66	3,100	190
MN2	Aq. inv.	07-10-90	<4	<.36	<1.8	75	570	1	2,200	60
MN2	Fish	04-07-90	<4.1	.51	.52	7.7	290	<.82	1,900	11
MN2	Fish	04-07-90	<17	<1.7	2.2	6.5	400	23	1,800	19
MN2	Fish	07-10-90	<9.5	<.86	<4.3	8.4	2,000	1.8	2,300	37
MN2	Fish	04-07-90	<3.4	<.34	.74	6	220	<.68	1,600	14
MN2	Fish	04-07-90	<3.5	<.35	2.6	6	540	<.7	1,700	27
MN2	Fish	11-06-90	<5.4	<.45	.71	5.7	380	2.1	2,100	20
MN2	Fish	11-06-90	<4.3	<.31	.49	6.7	320	2	1,400	18
MN2	Fish	11-06-90	<4.9	<.38	.46	3.7	360	1.5	2,100	22
MN2	Fish	07-10-90	<4.3	<.39	5.4	7.5	250	<.79	1,300	11
MN2	Fish	04-07-90	<3.3	<.33	<.33	4.6	41	<.66	1,700	4.1
SJ1	Aq. plant	04-05-90	<48	<1.3	23	11	8,800	<31	2,600	410
SJ1	Aq. plant	07-10-90	130	3.7	14	--	10,000	22	5,400	690
SJ1	Aq. inv.	04-05-90	<26	<2.6	5.5	39	3,300	<5.3	2,100	93
SJ1	Fillet	11-06-90	<6	<.44	<.44	3.4	80	1.4	1,200	<4.4
SJ1	Fillet	04-05-90	<3.5	<.35	<.35	5.6	20	<.7	820	<3.5
SJ1	Liver	11-06-90	<4.8	.58	16	12	680	1.6	800	3.7
SJ1	Fish	04-05-90	<2.9	<.29	.4	3.8	320	.68	1,400	31
SJ1	Fish	07-10-90	<3.2	.65	<1.4	3	130	1.1	890	10
SJ1	Fish	11-06-90	<4.2	<.33	2.5	3.2	1,000	1.7	1,500	44
SJ1	Fish	04-05-90	<3.6	.4	.69	5.2	140	1.3	2,100	8.8
SJ1	Fish	11-06-90	<4.6	<.35	<.35	4.8	87	<.91	1,700	11
SJ1	Fish	07-10-90	<6.9	<.62	<3.1	4	150	1.4	1,200	11

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990--Continued

Site	Matrix	Date	Boron	Cadmium	Chromium	Copper	Iron	Lead	Magnesium	Manganese
				MANCOS AND SAN JUAN RIVERS--Continued						
SJ1	Fish	04-05-90	<3.2	<0.32	0.63	6.4	500	<0.64	1,600	31
SJ1	Fish	04-05-90	<3.5	<.35	1.1	6.4	380	1.4	1,300	15
SJ1	Fish	07-10-90	<2.6	<.24	<1.2	<1.2	100	1.2	850	26
SJ1	Fish	11-06-90	<3.9	<.29	.35	1.8	110	.94	1,200	16
SJ1	Fish	11-06-90	<5.7	<.45	1.4	3.8	390	1.3	1,700	26
SJ1	Fish	07-10-90	<4	<.36	9.4	5.4	170	1.2	1,200	12
SJ1	Fish	04-05-90	<14	<1.4	14	14	230	<2.9	1,500	<14
SJ1	Fish	07-10-90	<3.5	<.32	<1.6	3.1	84	<.64	980	9
SJ1	Fish	11-06-90	<20	<.71	13	6.3	290	<1.9	1,800	14
SJ2	Fish	06-25-90	<2.8	<.26	<1.3	<1.3	190	.72	850	24
SJ2	Fish	06-25-90	<3.9	<.35	<1.8	3.5	67	1.2	850	5.6
SJ2	Fish	06-25-90	<4.4	<.4	<2	<2.1	61	<.8	1,100	5.3
SJ2	Fish	06-25-90	<6.4	<.58	<2.9	<3	360	<1.2	1,400	30
SJ2	Fish	06-25-90	<3.3	<.3	<1.5	1.9	140	2.2	860	11
SJ3	Aq. plant	04-05-90	<64	<1.7	8.1	15	8,700	<42	3,800	420
SJ3	Fish	04-05-90	<2.9	<.29	.85	6.3	490	<.58	1,000	26
SJ3	Fish	06-25-90	<3.6	<.33	<1.7	4	520	1.1	1,000	40
SJ3	Fish	11-06-90	<4.3	<.34	.68	3.1	500	<.88	1,500	26
SJ3	Fish	06-25-90	<17	<1.6	<7.8	<8.1	310	<3.1	1,400	<16
SJ3	Fish	04-05-90	<20	<2	11	7	230	<4	1,700	<20
SJ3	Fish	04-05-90	<3.1	<.31	.75	5.4	290	<.63	1,200	11
SJ3	Fish	04-05-90	<3.6	<.36	<.36	2.2	20	<.71	930	<3.6
SJ3	Fish	04-05-90	<3.1	<.31	.39	4.2	300	<.62	1,400	19
SJ3	Fish	06-25-90	<3.1	<.28	<1.4	4.3	220	1	870	38
SJ3	Fish	11-06-90	<5.1	<.4	.63	2.4	180	<1	1,600	15
SJ3	Fish	11-06-90	<4.1	<.32	<.32	2.2	78	<.83	1,400	25

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990--Continued

Site	Matrix	Date	Mercury	Molybdenum	Nickel	Selenium	Strontium	Vanadium	Zinc
				MVIC AREA--Continued					
ME1	Aq. plant	07-11-90	0.04	3.9	23	1.8	241	37	58.9
ME1	Aq. plant	11-08-90	.06	2	16	1.8	194	20	46.4
ME1	Aq. inv.	07-11-90	.09	1	3	3.4	33.7	.6	263
ME1	Aq. inv.	11-08-90	.31	<1	7.7	2.6	37.7	12	98.2
ME1	Aq. inv.	11-08-90	.14	3	10	21	89.3	14	231
ME1	Fish	11-08-90	.51	<1	2.5	5.6	102	6.5	170
ME1	Fish	11-08-90	.14	<1	<.2	6.4	84.8	.4	120
ME2	Aq. plant	07-11-90	.04	1	17	1.4	338	30	73.5
ME2	Aq. plant	11-07-90	.03	<1	12	.81	491	15	42.4
ME2	Aq. inv.	04-04-90	.05	<1	3	1.1	822	3.1	63.6
ME2	Aq. inv.	07-11-90	.08	<1	3	1.4	532	1.3	64.1
ME2	Fish	07-11-90	.13	1	1.4	.83	65.4	.7	46.8
ME2	Fish	11-07-90	.17	<1	5.2	1.3	121	13	58.9
ME2	Fish	07-11-90	.23	2	2	4.8	113	1.2	152
ME2	Fish	04-04-90	.44	<1.0	1.7	1.6	76.3	2.8	48.5
ME2	Fish	07-11-90	.35	<1	1.2	1.4	52.1	.7	41.6
ME2	Fish	11-07-90	.18	<1	2.4	2.2	143	5.5	76.3
ME2	Fish	11-07-90	.53	<1	2.1	2.0	84.6	4	53.1
ME2	Fish	07-11-90	.16	<1	1.6	6.1	95.7	<.4	89.9
ME3	Aq. plant	04-04-90	.02	<2	10	.82	423	20	28
ME3	Aq. plant	07-11-90	.04	2	15	2.0	364	29	43.7
ME3	Aq. plant	11-07-90	.03	<1	6	.54	305	11	27.3
ME3	Aq. inv.	04-04-90	.05	<1	2	1.4	1,110	2.8	58.4
ME3	Aq. inv.	07-11-90	.13	<1	3	3.7	587	2	63
ME3	Fish	07-11-90	.37	2	2.5	1.8	103	.7	53.5
ME3	Fish	11-07-90	.38	<.9	4	1.7	99.7	14	40.6
ME3	Fish	07-11-90	1.20	<1	.6	3.0	55.4	<.4	61.9

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990--Continued

Site	Matrix	Date	Mercury	Molybdenum	Nickel	Selenium	Strontium	Vanadium	Zinc
				MVIC AREA--Continued					
ME3	Fish	04-04-90	0.32	<1	1.1	4.4	169	<0.3	304
ME3	Fish	07-11-90	.32	<1	1.3	5.2	117	.5	270
ME3	Fish	04-04-90	.15	<1	3	4.3	112	1.1	111
ME3	Fish	07-11-90	.38	1	1.4	5.3	162	1	170
ME3	Fish	11-07-90	.33	<1	2.1	4.4	202	5.6	177
ME3	Fish	04-04-90	.51	<1	.5	1.7	28.2	<.3	41.4
ME3	Fish	07-11-90	.41	<1	.74	1.7	76.3	<.4	50.1
ME3	Fish	11-07-90	.31	<1	3	3.6	129	9.9	82.8
ME3	Fish	11-07-90	.66	<1	1.2	2.1	81.3	3.3	56.4
ME3	Fish	11-07-90	.31	<1	1.6	2.4	161	5.2	67.3
ME3	Fish	07-11-90	.26	1	1.8	5.0	128	<.4	101
ME3	Fish	07-11-90	.30	4.5	4.7	4.6	190	<.5	144
ME3	Fish	11-07-90	1.10	<1	1	4.2	163	.4	147
ME3	Fish	04-04-90	.39	6.6	5.2	2.8	160	.9	119
ME3	Fish	07-11-90	.41	2	1.1	7.0	149	<.4	112
ME3	Fish	11-07-90	.47	<1	3.4	5.5	188	7	128
ME4	Aq. plant	04-04-90	.03	<2	12	1.2	556	19	29
ME4	Aq. plant	11-07-90	.03	<1	9.4	.87	680	17	38.1
ME4	Aq. inv.	04-04-90	.12	<1	2	1.3	1,250	3.4	59.6
ME4	Aq. inv.	07-11-90	.15	<1	3	1.8	1,230	.9	59.7
ME4	Fish	04-04-90	.49	<1	1	3.9	177	.5	169
ME4	Fish	07-11-90	.55	<1	.89	3.7	107	.5	596
ME4	Fish	11-07-90	.48	<1	1.8	3.8	145	.3	190
ME4	Fish	04-04-90	.14	6.3	13	1.4	113	2.6	93.4
ME4	Fish	07-11-90	.34	<1	4.8	5.9	182	.9	131
ME4	Fish	04-04-90	.28	<1	.75	1.5	44.3	.6	41.7
ME4	Fish	07-11-90	.23	1	1.2	1.3	46.3	<.4	41.6
ME4	Fish	11-07-90	.67	<1	3.8	2.4	91.7	7.7	51.2
ME4	Fish	11-07-90	.51	<1.0	1.7	1.9	138	3.2	54
ME4	Fish	11-07-90	.33	<.9	.92	3.0	233	2.2	91.5
ME4	Fish	07-11-90	.43	<1	3.8	5.1	171	<.4	138

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990--Continued

Site	Matrix	Date	Mercury	Molybdenum	Nickel	Selenium	Strontium	Vanadium	Zinc
				MVIC AREA--Continued					
MP	Aq. inv.	11-14-90	0.33	<1	<2	0.68	798	2.1	62.6
MP	Zooplankton	04-18-90	.07	3	3.4	2.6	104	2.1	79
MP	Zooplankton	11-14-90	.08	6	30	1.6	99.4	7.6	68.4
MP	Fillet	06-07-90	2.42	<1	.7	1.4	2.1	<.4	18
MP	Fillet	11-14-90	1.51	<1	1.1	2.4	1.7	<.3	19.7
MP	Fish	06-07-90	.44	<1	.81	1.2	41.3	.5	47.5
MP	Fish	11-14-90	.39	<1	1.5	1.4	26.7	1.8	39.5
MP	Fish	06-07-90	.88	<1	.9	1.9	82.4	<.4	76.9
MP	Fish	04-18-90	.61	<1	.69	2.5	44.5	1	127
MP	Fish	04-18-90	.90	<1	1	2.3	4.7	.7	32.4
MP	Fish	11-07-90	.41	<1	1.1	2.1	33.8	.7	118
MP	Fish	06-07-90	1.30	<1	2.6	4.2	51.2	.5	155
MP	Fish	06-07-90	2.31	<1	.75	1.9	88.3	<.4	43.4
MP	Fish	04-18-90	.39	<1	.4	1.4	24.3	.7	41.6
MP	Fish	04-18-90	.87	1	2	2.7	33.5	.8	63.2
MP	Fish	06-07-90	.44	<1	1.6	2.0	68.7	<.4	66.9
MP	Fish	11-14-90	.48	<1	1.2	2.2	111	.97	76.4
MP	Fish-gutted	10-31-90	.34	<1.1	<.43	.98	43	<.43	94
SU	Aq. plant	11-14-90	.04	1	4	.52	122	2.9	18
SU	Zooplankton	04-16-90	.08	2	3.6	1.9	125	3.5	74
SU	Zooplankton	11-14-90	.37	2	11	1.8	85.8	2.3	66
SU	Eggs	11-14-90	.09	<1	<.2	2.2	2.4	<.3	93.9
SU	Fillet	04-16-90	1.6	<1	2	1.5	2.3	<.3	18
SU	Fillet	11-14-90	2.21	<1	.86	1.4	2.1	<.3	17.7
SU	Fillet	11-14-90	3.16	<1	.5	1.2	1.2	<.3	14.7
SU	Fish	04-16-90	1.70	1	1	1.7	62	<.3	82.2
SU	Fish	04-16-90	1.06	<1	.5	1.5	88.8	<.3	63.1
SU	Fish	11-14-90	1.72	<1	.6	1.5	61.2	<.3	40.8
SU	Fish	04-16-90	.18	<1	.6	1.2	33.4	1.3	50.6

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990--Continued

Site	Matrix	Date	Mercury	Molybdenum	Nickel	Selenium	Strontium	Vanadium	Zinc
				MVIC AREA--Continued					
PU	Aq. inv.	05-31-90	0.08	<1	3	0.62	806	3.4	59.7
PU	Aq. inv.	11-15-90	.07	<1	<2	.6	671	1.3	58.6
PU	Zooplankton	05-31-90	.12	<1	5	1.8	168	9.1	64.5
PU	Zooplankton	11-15-90	.05	4	26	.4	43.8	4.9	30
PU	Eggs	11-15-90	.24	<1	<.2	2.5	.922	<.3	63.7
PU	Fillet	05-31-90	3.50	<1	.6	1.3	9.7	<.4	26.6
PU	Fillet	11-15-90	4.16	<1	<.3	1.0	.933	<.3	13.1
PU	Fish	05-31-90	.96	<1	.68	.93	57.8	<.4	153
PU	Fish	11-15-90	1.10	<1	.74	1.4	76.1	<.3	161
PU	Fish	05-31-90	2.11	<1	.8	1.0	56	<.4	40.8
PU	Fish	11-15-90	1.75	<.9	.6	.89	36.3	.7	28.2
PU	Fish	05-31-90	.53	<1	.98	1.1	71.4	<.4	53.9
TT	Aq. plant	07-12-90	.04	21	5.3	.3	295	1.7	30.7
TT	Aq. plant	07-12-90	.04	1	4	.6	143	2	29.1
TT	Aq. plant	11-15-90	.02	<1	5	.44	479	3.5	24.7
TT	Aq. inv.	04-17-90	.06	<1	1	.83	729	1.6	70.1
TT	Aq. inv.	11-15-90	.07	<1	<2	.61	713	.4	56.1
TT	Zooplankton	04-17-90	.16	4.3	6.4	2.9	106	2.2	75
TT	Zooplankton	11-15-90	.11	<1	8	1.3	69.8	9.6	41.2
TT	Eggs	04-17-90	.03	<1	.74	4.3	3.5	<.3	128
TT	Eggs	11-15-90	.07	<1	<.3	4.7	2.6	<.3	217
TT	Eggs	11-15-90	.04	<1	.83	2.7	.555	1.9	56.2
TT	Fillet	04-17-90	1.6	<1	.4	2.1	2.3	<.3	16
TT	Fillet	11-15-90	1.82	<1	<.2	1.5	32.1	<.3	18.5
TT	Fillet	04-17-90	2.95	<1	1.3	2.0	1.8	<.4	16
TT	Fillet	04-17-90	3.09	<1	.3	2.1	.599	.7	18
TT	Fillet	11-15-90	2.24	<.9	<.4	2.1	.6	<.3	12.9
TT	Fish	04-17-90	.95	<1	.2	2.5	36.8	<.3	60.7
TT	Fish	04-17-90	.62	<1	.6	2.3	84.2	<.3	86.5
TT	Fish	04-17-90	.19	<1	.5	1.0	67.8	<.3	48.4
TT	Fish	04-17-90	1.20	<1	1	1.9	31.1	<.3	138

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990--Continued

Site	Matrix	Date	Mercury	Molybdenum	Nickel	Selenium	Strontium	Vanadium	Zinc
				MVIC AREA--Continued					
TT	Fish	11-15-90	1.10	<1	<0.2	1.8	29.9	<0.3	123
TT	Fish	04-17-90	1.50	<1	.4	2.0	40.3	<.3	41.4
TT	Fish	11-15-90	1.94	<1	1.4	1.6	40.4	2.5	37.1
TT	Fish	04-17-90	.87	<1	.89	1.6	142	<.3	66.7
TT	Fish	11-15-90	.40	<1	.98	1.7	27.9	<.3	61.8
TT	Bird	07-12-90	1.53	3	<2	11	.3	<.6	72.9
TT	Bird	07-12-90	.24	<1	<2	2.7	28.9	<.4	80.7
TT	Eggs	05-22-90	.11	<1	<2	1.1	12.9	<.4	58.2
TT	Eggs	07-12-90	.82	<.9	<2	2.4	14.5	<.4	50.9
TT	Eggs	05-30-90	.15	<.9	<2	2.9	9.688	<.4	57.7
TT	Egg	05-30-90	.14	<.9	<2	2.0	8.3	<.4	50.5
TT	Eggs	05-30-90	.17	<1	<2	2.9	9	<.4	60.3
TT	Eggs	05-30-90	.08	<1	<2	4.8	.577	<.4	198
TT	Liver	07-12-90	.30	5.8	<2	5.0	.611	<.4	156
TT	Liver	07-12-90	.32	5.9	<2	1.8	8.4	<.4	51.2
LP	Aq. plant	07-12-90	.01	1	5	1.0	2,060	8.3	12
LP	Eggs	05-23-90	.10	<1	<2	2.9	14.3	<.4	57.1
LP	Eggs	07-12-90	.14	<.9	<2	3.6	11.8	<.4	52.6
LP	Eggs	05-23-90	1.20	<1	<2	5.6	5.3	<.4	50.8
LP	Eggs	07-12-90	.09	<2	<3	2.9	11	<.7	58.7
LP	Eggs	05-23-90	.07	<1	<2	5.6	13.5	<.4	71.3
LP	Liver	07-12-90	.37	3	<2	4.7	.611	<.4	167
LP	Liver	07-12-90	.28	2	<2	4.7	.755	<.4	198
LP	Liver	07-12-90	.20	3	<2	4.7	.388	<.4	173
LP	Liver	07-12-90	.10	1	<2	2.8	1	<.4	139
LP	Liver	07-12-90	.03	2	<3	3.8	1.6	<.7	173
SD	Aq. plant	04-04-90	.03	<2	19	.77	366	22	66.2
SD	Aq. plant	07-10-90	.03	<1	14	.58	239	24	58.7
SD	Aq. plant	11-08-90	.08	<1	13	1.1	324	15	60.4

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990--Continued

Site	Matrix	Date	Mercury	Molybdenum	Nickel	Selenium	Strontium	Vanadium	Zinc
				MVIC AREA--Continued					
SD	Aq. plant	07-10-90	0.03	<1	15	0.8	171	15	57
SD	Aq. inv.	04-04-90	.06	<1	4.1	1.4	524	2.6	58.3
SD	Aq. inv.	07-10-90	.07	<1	4	1.4	500	1.7	67.9
SD	Aq. inv.	11-08-90	.20	<1	5	1.1	213	1.4	71.7
SD	Fish	07-10-90	.10	<1	3.5	1.8	124	5.4	95.4
SD	Fish	11-08-90	.20	<1	2.1	1.5	121	2.5	75.8
SD	Fish	04-04-90	.16	<1	7.5	4.9	92.3	.7	189
SD	Fish	07-10-90	.16	3	3.3	3.0	90.4	3.1	164
SD	Fish	11-08-90	.22	<1	1.2	4.0	84.6	1.9	162
HD1	Aq. plant	04-06-90	.03	<2	16	.59	322	13	72.2
HD1	Aq. plant	07-11-90	.03	<1	9	.40	306	15	56.8
HD1	Aq. plant	11-08-90	.26	<1	6.5	.74	124	16	34.8
HD1	Aq. plant	07-11-90	.01	1	4	.42	260	4.8	32.1
HD1	Aq. inv.	04-06-90	.08	<1	1	.86	661	1.8	56.8
HD1	Aq. inv.	07-11-90	.08	<1	<2	.79	517	.9	71.2
HD1	Fish	04-06-90	.13	2	2.4	1.2	91.8	1.3	69.2
HD1	Fish	04-06-90	.31	2	4.3	.83	35.9	1.7	57.3
HD1	Fish	07-11-90	.11	1	2.1	.86	94.4	2.2	67.8
HD1	Fish	11-08-90	.19	<1	2.8	1.4	119	7.4	71.9
HD1	Fish	04-06-90	.16	1	2.7	3.9	85.9	1.4	156
HD1	Fish	07-11-90	.17	<1	1.9	2.5	104	1.5	163
HD1	Fish	07-11-90	.18	<1	1.5	2.6	96.9	1.2	174
HD1	Fish	11-08-90	.26	<.9	1.7	2.9	109	2.4	220
HD1	Fish	04-06-90	.50	<1	1.6	1.3	138	<.4	78.6
HD1	Fish	07-11-90	.22	<1	.86	1.3	106	<.4	89.6
HD1	Fish	04-06-90	.39	3	3.7	2.8	107	1.4	132
HD1	Fish	07-11-90	.33	2	1.5	3.2	98.2	<.4	124
HD1	Fish	11-08-90	.36	<1	.3	5.3	108	.4	133
HD2	Aq. plant	04-04-90	.02	<2	6.4	.40	1,030	14	39.3
HD2	Aq. plant	11-07-90	.03	<1	8.5	.49	468	11	42.1

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990--Continued

Site	Matrix	Date	Mercury	Molybdenum	Nickel	Selenium	Strontium	Vanadium	Zinc
				MVIC AREA--Continued					
HD2	Aq. inv.	04-04-90	0.05	<1	3	0.96	695	2.6	52.5
HD2	Aq. inv.	07-10-90	.08	<.9	3	1.0	478	1	64.9
HD2	Fish	04-04-90	.16	4.1	9.2	1.5	117	2.4	151
HD2	Fish	11-07-90	.17	<1	.4	1.6	89.6	1.1	155
HD2	Fish	07-10-90	.33	<1	.97	.54	25.5	<.4	28.9
HD2	Fish	07-10-90	.21	1	3.1	.49	79.4	4.9	58.9
HD2	Fish	11-07-90	.42	<1	2.7	.62	44.1	6	38
HD2	Fish	11-07-90	.10	<.9	1.5	.96	71.8	3	55.3
HD2	Fish	04-04-90	.49	<1	<.2	.76	36	.4	34.9
HD2	Fish	07-10-90	.74	2	1.6	.68	76.9	1.5	65.4
AK	Aq. plant	04-08-90	.01	<2	11	.54	712	19	51.3
AK	Aq. plant	11-07-90	.02	<1	9.3	.36	262	15	66.5
AK	Aq. plant	07-11-90	.05	<1	16	1.1	166	12	96.5
AK	Aq. plant	11-07-90	.02	<1	11	.43	197	12	76.5
AK	Aq. plant	07-11-90	.02	3	13	.5	128	10	76.4
AK	Aq. inv.	04-08-90	.06	<1	2	.76	675	2.3	58.3
AK	Aq. inv.	07-11-90	.08	<1	2	.79	559	.8	73.7
AK	Fish	07-11-90	.15	<1	2.4	.94	71.6	3.3	57.9
AK	Fish	04-08-90	.17	2	2.3	2.6	80.4	.8	135
AK	Fish	07-11-90	.21	1	2.7	2.9	89.8	1.3	169
AK	Fish	11-07-90	.18	<.9	.8	2.8	102	1.5	179
AK	Fish	04-08-90	.58	<1	.8	1.1	48	.5	43.6
AK	Fish	07-11-90	.51	<1	1.3	.9	39.6	.6	39.6
AK	Fish	11-07-90	.83	<1	1	1.1	68.9	1.9	55.6
AK	Fish	11-07-90	.43	<1	.94	.82	33.4	.9	44.6
AK	Fish	04-08-90	.52	3	3	4.3	118	.6	125
AK	Fish	07-11-90	.45	<1	1.6	3.1	106	.4	123
AK	Fish	11-07-90	.83	<1	<.5	4.0	96.4	.7	98.2

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990--Continued

Site	Matrix	Date	Mercury	Molybdenum	Nickel	Selenium	Strontium	Vanadium	Zinc
				MVIC AREA--Continued					
DD	Aq. plant	04-06-90	0.02	<2	16	0.88	485	27	44.7
DD	Aq. plant	07-11-90	.02	1	9.4	.41	66.7	20	43.7
DD	Aq. plant	11-08-90	.02	<1	9.1	1.6	124	13	35.4
DD	Aq. plant	11-08-90	.04	<1	7.4	.92	190	11	47
DD	Aq. plant	07-11-90	.02	1	6.6	.71	155	9.1	59.2
DD	Aq. inv.	04-06-90	.07	<1	2	.62	767	2.8	66.6
DD	Aq. inv.	07-11-90	.12	<1	3	1.1	307	.4	85.8
DD	Fish	04-06-90	.11	4.6	6.9	.64	84.9	.9	67.3
DD	Fish	07-11-90	.89	<1	1.3	1.3	59.8	1.3	45.8
DD	Fish	11-08-90	.06	<1	1.5	.88	98.3	2.2	55.1
DD	Fish	04-06-90	.35	1	.86	3.4	99.2	1.8	189
DD	Fish	07-11-90	.26	<1	1.8	3.9	88.3	1.5	137
DD	Fish	11-08-90	.39	<1	.5	3.6	100	.9	165
DD	Fish	04-06-90	.51	2	3	5.6	99.5	.8	110
DD	Fish	07-11-90	.52	1	1.2	4.4	93.5	.4	90.5
DD	Fish	11-08-90	.34	<1	<.2	6.0	86.7	<.3	90.5
DD	Bird	07-12-90	.18	<1	<2	1.5	18.7	<.4	86
DD	Bird	07-12-90	.29	1	<2	1.6	45.2	.4	63.2
DD	Bird	07-12-90	.38	<1	<2	1.7	78.1	<.4	93.1
DD	Eggs	05-30-90	.03	<1	<2	1.6	11.7	<.4	66.7
DD	Liver	07-12-90	.32	2	<2	11	.488	<.4	135
DD	Liver	07-12-90	.44	4.6	<2	9.8	.377	<.4	174
YJ2	Aq. plant	04-06-90	.02	<2	17	.3	669	11	18
YJ2	Aq. plant	11-07-90	.02	<1	11	.32	359	7.1	16
YJ2	Aq. inv.	04-06-90	.17	<1	2	1.4	1,190	1.4	64.1
YJ2	Aq. inv.	07-11-90	.20	<1	3	1.5	1,090	1.3	59.2
YJ2	Aq. inv.	04-06-90	.14	3	4.7	3.1	238	4	82.7
YJ2	Aq. inv.	11-07-90	.15	<1	4	1.8	756	8.1	55.7
YJ2	Fish	04-06-90	.50	2	2.3	.96	43.1	<.3	43.3
YJ2	Fish	11-07-90	.38	<1	2.9	2.8	235	7	83.8

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990--Continued

Site	Matrix	Date	Mercury	Molybdenum	Nickel	Selenium	Strontium	Vanadium	Zinc
				MVIC AREA--Continued					
YJ2	Fish	04-06-90	0.15	<2	0.8	11	284	1	249
YJ2	Fish	11-07-90	.33	<.9	.7	4.0	222	1.9	177
YJ2	Fish	11-07-90	.39	<1	1.5	2.4	208	2.7	88.2
YJ2	Fish	11-07-90	.76	<.9	1	1.6	73	.7	51.3
YJ2	Fish	11-07-90	.42	<1	.85	4.5	189	.92	150
YJ2	Fish	04-06-90	.39	6.2	4	6.5	187	.5	108
YJ2	Fish	07-11-90	.50	<1	2.1	7.1	190	.4	111
YJ2	Fish	11-07-90	.77	<1	3.7	6.3	218	7.4	147
YJ2	Fish	07-11-90	.27	2	2.5	2.2	192	1.5	81.6
NW	Aq. plant	04-04-90	.02	<2	12	2.6	1,400	21	33.6
NW	Aq. plant	07-10-90	.05	2	16	4.3	191	26	37.8
NW	Aq. inv.	04-04-90	.07	<1	2	4.2	764	1.9	51.2
NW	Aq. inv.	11-06-90	.06	<1	3	3.3	651	1.6	48.9
NW	Aq. inv.	04-04-90	.43	3	9.9	7.0	383	11	77.9
NW	Aq. inv.	07-10-90	.06	<1	4	5.1	426	5.1	73.4
NW	Aq. inv.	11-06-90	.09	1	11	9.3	33.9	9.5	108
NW	Fish	07-10-90	.59	<1	3.4	9.3	96.2	6.2	103
NW	Fish	11-06-90	.07	<1	6	7.2	151	18	93.9
NW	Fish	07-10-90	.17	3.6	2	8.7	110	1.2	101
				DOVE CREEK AREA--Continued					
YJ1	Aq. plant	04-07-90	.01	<1	4.8	1.3	685	4.7	16
YJ1	Aq. plant	07-09-90	.02	<1	9	2.0	188	19	37.3
YJ1	Aq. inv.	04-07-90	.08	<1	5.8	10	65.4	6	90.4
YJ1	Aq. inv.	07-09-90	.07	<1	5	15.7	34.8	5.3	121
WC	Aq. plant	04-06-90	.01	<1	4.5	5.8	866	10	12
WC	Aq. plant	07-12-90	.06	<1	3	3.3	1,770	3.8	6.7
WC	Aq. plant	11-05-90	.02	<1	3	1.8	638	6.3	9.8
WC	Aq. inv.	04-06-90	.06	2	2	13.4	21.4	1.9	64.6
WC	Aq. inv.	11-05-90	.14	<1	3	9.6	23.7	1.9	75
WC	Aq. inv.	07-12-90	.06	<1	2	19.2	17.2	<.4	71.7

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990--Continued

Site	Matrix	Date	Mercury	Molybdenum	Nickel	Selenium	Strontium	Vanadium	Zinc
				DOVE CREEK AREA--Continued					
WC	Aq. inv.	04-06-90	0.03	<0.9	3	3.7	529	3.1	22
WC	Aq. inv.	07-12-90	.02	<9	<10	3.9	620	<3	8.7
WC	Aq. inv.	11-05-90	.02	<1	<2	2.0	399	1.5	13
WC	Fish	04-06-90	.16	2	5.2	18.4	94.8	1.5	183
WC	Fish	07-12-90	.07	2	2.6	22.9	90.3	1.5	139
WC	Fish	11-05-90	.16	<1	.5	26.4	91.6	1.1	189
WC	Liver	07-12-90	.24	2	<2	37.5	2.9	<.4	143
WC	Bird	07-12-90	.19	<1	<2	7.0	11.5	<.4	75.4
CH	Aq. plant	04-03-90	.01	<2	11	2.5	1,240	18	30
CH	Aq. plant	07-09-90	.02	<1	11	2.8	804	20	32.9
CH	Aq. plant	11-05-90	.02	<1	7.5	1.7	1,150	13	17
CH	Aq. plant	07-09-90	.03	1	12	6.4	547	18	43.5
CH	Aq. inv.	04-03-90	.05	1	5.5	7.4	388	7.2	66.6
CH	Aq. inv.	07-09-90	.09	<.9	6.2	11.2	404	9.7	62.3
CH	Aq. inv.	11-05-90	.23	<1	<2	6.7	27.2	1.6	88.8
CR	Aq. plant	04-03-90	.01	<4	8.8	4.0	432	27	30
CR	Aq. plant	11-05-90	.05	<1	<2	.3	586	1.6	11
CR	Aq. plant	07-09-90	.02	1	7.9	1.9	407	17	29.8
CR	Aq. plant	11-05-90	.01	<1	4	1.2	304	6.3	20
CR	Aq. inv.	04-03-90	.28	3	3	5.0	57.4	1.9	114
CR	Aq. inv.	07-09-90	.17	<1	3	6.1	72.3	2.7	90.1
CR	Aq. inv.	11-05-90	.14	<1	3	2.3	174	2.4	58
AKP	Eggs	05-24-90	.25	<.9	<2	18.5	16.5	<.4	53.5
AKP	Eggs	05-24-90	.02	<.9	<2	4.4	11.9	<.4	59.9
AKP	Eggs	05-24-90	.11	<1	<2	9.8	11.7	<.4	68.3
				MANCOS AND SAN JUAN RIVERS--Continued					
MN1	Aq. inv.	04-05-90	.12	<1	2	2.0	1,010	3	60.5
MN1	Aq. inv.	07-10-90	.18	<.82	.81	1.8	700	1.2	47
MN1	Aq. inv.	04-05-90	.84	2	9.9	11.2	202	22	97.6
MN1	Fish	04-05-90	.46	<1	.6	5.8	167	.6	235

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990--Continued

Site	Matrix	Date	Mercury	Molybdenum	Nickel	Selenium	Strontium	Vanadium	Zinc
MANCOS AND SAN JUAN RIVERS--Continued									
MN1	Fish	07-10-90	0.84	<0.98	<0.71	5.4	210	<0.39	140
MN1	Fish	07-10-90	<.25	<1.5	6.1	4.9	100	1.8	100
MN1	Fish	04-05-90	.16	<1	.5	6.5	17.7	<.3	37.1
MN1	Fish	11-06-90	.29	<.88	<.34	1.7	63	<.34	67
MN1	Fish	11-06-90	.13	<1.1	<.42	4.8	87	<.42	71
MN1	Fish	04-05-90	.24	4.9	11	5.5	92.4	2.7	81.9
MN2	Aq. inv.	04-07-90	<.17	2.5	200	2.7	910	2.1	53
MN2	Aq. inv.	07-10-90	<.19	<.91	1.5	6.7	720	2.3	53
MN2	Fish	04-07-90	.50	<.41	<.41	9.8	190	.99	220
MN2	Fish	04-07-90	<.27	<1.7	<1.7	7.7	120	<1.7	63
MN2	Fish	07-10-90	<.31	<2.2	1.6	14	160	5.3	130
MN2	Fish	04-07-90	<.16	<.34	<.34	7.6	80	.9	43
MN2	Fish	04-07-90	<.18	.35	.42	7.6	80	1.4	70
MN2	Fish	11-06-90	.19	<1.2	<.45	3.2	120	1.2	72
MN2	Fish	11-06-90	.19	<.8	<.31	3.5	82	.74	53
MN2	Fish	11-06-90	.30	<.99	<.38	3.5	130	.92	66
MN2	Fish	07-10-90	.19	<.98	2.5	10	160	.59	170
MN2	Fish	04-07-90	.62	<.33	<.33	5.4	160	<.33	100
SJ1	Aq. plant	04-05-90	.06	<6.3	16	.46	83	11	47
SJ1	Aq. plant	07-10-90	<.24	<11	11	.57	220	19	59
SJ1	Aq. inv.	04-05-90	<.53	<2.6	13	2.5	44	6.3	95
SJ1	Fillet	11-06-90	1.00	<1.2	<.44	2.2	1.4	<.44	28
SJ1	Fillet	04-05-90	.84	<.35	<.35	2.5	3.6	<.35	14
SJ1	Liver	11-06-90	.54	<.95	6.3	5.8	.733	1.8	100
SJ1	Fish	04-05-90	.14	<.29	<.29	1.2	160	.52	55
SJ1	Fish	07-10-90	.18	<.72	<.52	.94	110	.3	210
SJ1	Fish	11-06-90	.13	<.86	.66	1.2	110	2.4	42
SJ1	Fish	04-05-90	.44	<.36	<.36	5.3	270	<.36	230
SJ1	Fish	11-06-90	.32	<.91	<.35	3.4	220	<.35	210
SJ1	Fish	07-10-90	<.19	<1.6	<1.1	4.1	93	<.62	75

Table 27. Trace-element concentrations in aquatic-plant, aquatic-invertebrate, fish, and bird samples collected in the Dolores Project area, April through November, 1990--Continued

Site	Matrix	Date	Mercury	Molybdenum	Nickel	Selenium	Strontium	Vanadium	Zinc
MANCOS AND SAN JUAN RIVERS--Continued									
SJ1	Fish	04-05-90	<0.16	<0.32	<0.32	2.2	110	0.7	62
SJ1	Fish	04-05-90	.43	<.35	<.35	1.5	56	.92	57
SJ1	Fish	07-10-90	.36	<.59	<.42	.61	140	.41	37
SJ1	Fish	11-06-90	.24	<.76	<.29	1.1	99	<.29	46
SJ1	Fish	11-06-90	.16	<1.2	<.45	4.2	130	.89	67
SJ1	Fish	07-10-90	<.17	<.9	3.3	3.5	120	<.36	150
SJ1	Fish	04-05-90	<.15	<1.4	9.6	4.3	140	<1.4	160
SJ1	Fish	07-10-90	.27	<.8	<.58	5.1	120	<.32	110
SJ1	Fish	11-06-90	.23	<1.9	4.9	2.9	190	<.71	200
SJ2	Fish	06-25-90	.18	<.64	<.46	1.3	100	.43	38
SJ2	Fish	06-25-90	.18	<.88	<.63	.92	52	<.35	42
SJ2	Fish	06-25-90	.26	<1	<.72	2.8	96	<.4	57
SJ2	Fish	06-25-90	<.19	<1.5	<1	4.4	140	.6	110
SJ2	Fish	06-25-90	.47	<.75	<.54	1.5	64	<.3	40
SJ3	Aq. plant	04-05-90	<.09	<8.3	8.7	.94	120	14	47
SJ3	Fish	04-05-90	<.13	<.29	.35	2.3	56	1.3	47
SJ3	Fish	06-25-90	.16	<.83	<.6	2.4	88	1.1	63
SJ3	Fish	11-06-90	.29	<.88	.41	2.7	100	60	60
SJ3	Fish	06-25-90	<.44	<3.9	<2.8	3.9	150	<1.6	110
SJ3	Fish	04-05-90	.31	<2	4.5	7.5	170	<2	140
SJ3	Fish	04-05-90	.17	<.31	<.31	1.9	57	.71	52
SJ3	Fish	04-05-90	.35	<.36	<.36	3.0	3.7	<.36	19
SJ3	Fish	04-05-90	<.15	<.31	<.31	1.7	120	.43	59
SJ3	Fish	06-25-90	.18	<.7	<.5	1.4	80	.36	38
SJ3	Fish	11-06-90	.28	<1	<.4	3.0	110	<.4	55
SJ3	Fish	11-06-90	.19	<.83	.19	1.7	120	<.32	45

Table 28. Concentrations of selected pesticides and polychlorinated biphenyls (PCB's) in fish and bird samples collected in the Dolores Project area in 1990

[Analyses by U.S. Fish and Wildlife Service; fm., flannelmouth; <, less than; --, no data; yh., yellow headed; rw., red winged; concentrations in micrograms per gram wet weight; length in millimeters]

Site number (fig. 1)	Matrix	Species	Date	Mean length	Number in sample	Percent moisture	alpha-BHC	beta-BHC	gamma-BHC	alpha-Chlordane	gamma-Chlordane	o, p′-DDE	p, p′-DDE	o, p′-DDD
ME2	Fish	Fm. sucker	04-04-90	418	2	72.0	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.06	<0.01
ME2	Fish	Fm. sucker	07-11-90	423	3	72.0	<.01	<.01	<.01	<.01	<.01	<.01	.04	<.01
ME2	Fish	Fm. sucker	11-07-90	448	3	--	<.01	<.01	<.01	<.01	.01	<.01	.03	<.01
ME4	Fish	Fm. sucker	04-04-90	445	2	68.5	<.01	<.01	<.01	<.01	<.01	<.01	.03	<.01
TT	Fish	Northern pike	04-17-90	605	2	78.0	<.01	<.01	<.01	<.01	<.01	<.01	.02	<.01
TT	Eggs	Coot	07-12-90	--	2	76.0	<.01	<.01	<.01	<.01	<.01	<.01	.06	<.01
TT	Eggs	Yh. blackbird	05-30-90	--	3	83.0	<.01	<.01	<.01	<.01	<.01	<.01	.17	<.01
LP	Eggs	Yh. blackbird	05-23-90	--	4	84.0	<.01	<.01	<.01	<.01	<.01	<.01	.76	<.01
HD2	Fish	Fm. sucker	04-04-90	478	2	69.5	<.01	<.01	<.01	<.01	<.01	<.01	.08	<.01
HD2	Fish	Fm. sucker	07-10-90	430	2	66.0	<.01	<.01	<.01	.02	.01	<.01	.06	.02
HD2	Fish	Fm. sucker	11-07-90	433	3	66.0	<.01	<.01	<.01	.01	.01	<.01	.05	<.01
AK	Fish	Bluehead sucker	07-10-90	236	7	72.5	<.01	<.01	<.01	.01	.02	.01	.12	.02
AK	Fish	Fm. sucker	04-08-90	453	2	70.0	<.01	<.01	<.01	<.01	<.01	<.01	.16	<.01
AK	Fish	Fm. sucker	11-08-90	468	3	--	<.01	<.01	<.01	<.01	<.01	<.01	.10	<.01
DD	Eggs	Rw. blackbird	05-30-90	--	5	83.0	<.01	<.01	<.01	<.01	<.01	<.01	.08	<.01
AKP	Eggs	Rw. blackbird	05-24-90	--	4	86.0	<.01	<.01	<.01	<.01	<.01	<.01	.17	<.01
MN2	Fish	Carp	04-07-90	425	1	74.0	<.01	<.01	<.01	<.01	<.01	<.01	.01	<.01

Table 28. Concentrations of selected pesticides and polychlorinated biphenyls (PCB's) in fish and bird samples collected in the Dolores Project area in 1990 --Continued

Site number (fig. 1)	Matrix	Species	Date	p, p′ -DDD	o, p′ -DDT	p, p′ -DDT	Dieldrin	Endrin	HCB	Heptachlor epoxide	Mirex	cis-Nonachlor
ME2	Fish	Fm. sucker	04-04-90	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
ME2	Fish	Fm. sucker	07-11-90	.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
ME2	Fish	Fm. sucker	11-07-90	.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
ME4	Fish	Fm. sucker	04-04-90	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
TT	Fish	Northern pike	04-17-90	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
TT	Eggs	Coot	07-12-90	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
TT	Eggs	Yh. blackbird	05-30-90	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
LP	Eggs	Yh. blackbird	05-23-90	<.01	<.01	.03	<.01	<.01	<.01	<.01	<.01	<.01
HD2	Fish	Fm. sucker	04-04-90	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
HD2	Fish	Fm. sucker	07-11-90	.03	<.01	.03	.01	<.01	<.01	.01	<.01	<.01
HD2	Fish	Fm. sucker	11-07-90	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
AK	Fish	Bluehead sucker	07-10-90	.03	<.01	.01	<.01	<.01	<.01	.01	<.01	<.01
AK	Fish	Fm. sucker	04-08-90	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
AK	Fish	Fm. sucker	11-08-90	.01	<.01	.01	<.01	<.01	<.01	<.01	<.01	<.01
DD	Eggs	Rw. blackbird	05-30-90	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
AKP	Eggs	Rw. blackbird	05-24-90	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01
MN2	Fish	Carp	04-07-90	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01	<.01

Table 28. Concentrations of selected pesticides and polychlorinated biphenyls (PCB's) in fish and bird samples collected in the Dolores Project area in 1990--Continued

Site number (fig. 1)	Matrix	Species	Date	trans-Nonachlor	Oxychlordane	Toxaphene	PCB
ME2	Fish	Fm. sucker	04-04-90	<0.01	<0.01	<0.05	<0.05
ME2	Fish	Fm. sucker	07-11-90	.01	<.01	<.05	<.05
ME2	Fish	Fm. sucker	11-07-90	<.01	<.01	<.10	<.10
ME4	Fish	Fm. sucker	04-04-90	<.01	<.01	<.05	<.05
TT	Fish	Northern pike	04-17-90	<.01	<.01	<.05	<.05
TT	Eggs	Coot	07-12-90	<.01	<.01	<.05	.44
TT	Eggs	Yh. blackbird	05-30-90	<.01	<.01	<.05	<.05
LP	Eggs	Yh. blackbird	05-23-90	<.01	<.01	<.05	<.05
HD2	Fish	Fm. sucker	04-04-90	<.01	<.01	<.05	<.05
HD2	Fish	Fm. sucker	07-11-90	.03	.01	<.05	.05
HD2	Fish	Fm. sucker	11-07-90	.01	<.01	<.10	<.10
AK	Fish	Bluehead sucker	07-10-90	.01	.01	<.05	<.05
AK	Fish	Fm. sucker	04-08-90	<.01	<.01	<.05	<.05
AK	Fish	Fm. sucker	11-08-90	<.01	<.01	<.10	<.10
DD	Eggs	Rw. blackbird	05-30-90	<.01	<.01	<.05	<.05
AKP	Eggs	Rw. blackbird	05-24-90	<.01	<.01	<.05	<.05
MN2	Fish	Carp	04-07-90	<.01	<.01	<.05	<.05

Table 29. Polycyclic-aromatic hydrocarbon (PAH) concentrations in fish bile collected in the Dolores Project area, 1990–91

[Concentrations in micrograms per gram wet weight; <, less than]

Site number (figs. 1, 2)	Species	Number in sample	Date	Naphthalene	Phenanthrene	Benzo [a] pyrene
ME2	Flannelmouth sucker	5	11-01-90	44.0	10.0	0.18
ME4	Flannelmouth sucker	5	11-01-90	24.0	4.9	.14
MP	Flannelmouth sucker	1	11-01-90	37.0	19.0	.13
PU	Walleye	3	11-01-90	46.0	6.8	.24
TT	Northern pike	1	11-01-90	27.0	27.0	.12
HD2	Flannelmouth sucker	7	11-01-90	94.0	12.0	.15
AK	Flannelmouth sucker	5	11-01-90	17.0	4.2	<.10
AK	Flannelmouth sucker	1	08-01-91	77.0	21.0	.18
AK	Flannelmouth sucker	1	08-01-91	84.0	20.0	.33
AK	Flannelmouth sucker	1	08-01-91	66.0	12.0	.16
AK	Flannelmouth sucker	1	08-01-91	67.0	13.0	.18
AK	Flannelmouth sucker	1	08-01-91	65.0	12.0	.20
MN2	Flannelmouth sucker	3	11-01-90	46.0	8.6	.22
SJ1	Channel catfish	1	11-01-90	160.0	36.0	.56
SJ1	Flannelmouth sucker	5	11-01-90	59.0	12.0	.21
SJ3	Flannelmouth sucker	1	11-01-90	65.0	11.0	.26

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