Field Screening of Water, Soil, Bottom Sediment, and Biota Associated with Irrigation Drainage in the Dolores Project and the Mancos River Basin, Southwestern Colorado, 1994

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CONVERSION FACTORS AND ACRONYMS

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter
inch (in.)	2.54	centimeter
inch (in.)	25.4	millimeter
mile (mi)	1.609	kilometer
	Area	
acre	4,047	square meter
acre	0.4047	hectare
	Volume	
acre-foot (acre-ft)	1,233	cubic meter
acre-foot per year (acre-ft/yr)	1,233	cubic meter per year

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F = (1.8 \times °C) + 32$$

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L) or micrograms per liter (µg/L).

Concentrations of chemical constituents in bottom sediment, soil, and biota are give in micrograms per gram (µg/g).

To convert dry-weight concentrations to wet-weight concentrations for biological samples, the equation is:

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

Acronyms

Bureau of Reclamation (BOR)
Montezuma Valley Irrigation Company (MVIC)
National Irrigation Water Quality Program (NIWQP)
U.S. Fish and Wildlife Service (USFWS)

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Abstract

A reconnaissance investigation for the National Irrigation Water Quality Program in 1990 indicated elevated selenium concentrations in some water and biota samples collected in the Dolores Project in southwestern Colorado. High selenium concentrations also were indicated in bird samples collected in the Mancos Project in 1989. In 1994, field screenings were done in parts of the Dolores Project and Mancos River Basin to collect additional selenium data associated with irrigation in those areas.

Selenium is mobilized from soils in newly irrigated areas of the Dolores Project called the Dove Creek area, which includes newly (since 1987) irrigated land north of Cortez and south of Dove Creek. Selenium was detected in 18 of 20 stream samples, and the maximum concentration was 12 micrograms per liter. The Dove Creek area is unique compared to other study areas of the National Irrigation Water Quality Program because selenium concentrations probably are indicative of initial leaching conditions in a newly irrigated area. Selenium concentrations in nine shallow soil samples from the Dove Creek area ranged from 0.13 to 0.20 microgram per gram. Selenium concentrations in bottom sediment from six ponds were less than the level of concern for fish and wildlife of 4 micrograms per gram.

Many biota samples collected in the Dove Creek area had elevated selenium concentrations when compared to various guidelines and effect levels, although selenium concentrations in water, soil, and bottom sediment were relatively low. Selenium concentrations in 12 of 14 aquatic-invertebrate samples from ponds exceeded 3 micrograms per gram dry weight, a dietary guideline for protection of fish and wildlife. The mean selenium concentration of 10.3 micrograms per gram dry weight in aquatic-bird eggs exceeded the guideline for reduced hatchability of 8 micrograms per gram dry weight. Two ponds in the Dove Creek area had a high selenium-hazard rating based on a new protocol for assessing selenium hazard in the environment; however, waterfowl were reproducing at the two ponds.

Three tributary streams of Mc Elmo Creek that drain irrigated areas of the Montezuma Valley south of the creek were sampled in 1994. Mud Creek probably is the largest source of selenium to Mc Elmo Creek. Most biota samples from Mud Creek had elevated selenium concentrations when compared to guidelines for dietary items and freshwater fish.

Selenium concentrations in water samples collected in the Mancos River Basin upstream from Navajo Wash, which includes the Mancos Project, ranged from less than 1 to 10 micrograms

per liter. Mud Creek contributed about 74 percent of the selenium load to the upper Mancos River in March 1994. Selenium concentrations were much higher in Navajo Wash; a sample collected in March had 97 micrograms per liter of selenium. Bottom-sediment samples from two ponds in the Mancos Project exceeded the concentration of concern of 4 micrograms per gram.

The highest selenium concentrations in biota samples from streams in the Mancos River Basin were for samples from Navajo Wash. Most concentrations in biota in the upper Mancos River Basin were less than guidelines. Mean selenium concentrations in eggs from aquatic birds collected at three ponds in the Mancos Project slightly exceeded the guideline associated with reduced hatchability. Five bird livers had a mean selenium concentration of 32.6 micrograms per gram dry weight, which slightly exceeded the mean concentration of 30 micrograms per gram dry weight that is associated with reproductive impairment. Two of the ponds had a high selenium-hazard rating; however, mallard reproduction was observed in 1994 at one of the ponds that had a high selenium-hazard rating.

INTRODUCTION

During 1990–91, water, bottom-sediment, and biota samples were collected for a reconnaissance investigation of the Dolores Project area in southwestern Colorado (fig. 1). The investigation was part of the National Irrigation Water Quality Program (NIWQP), which was started by the U.S. Department of the Interior in 1985 to identify the nature and extent of irrigation-induced water-quality problems in the Western United States. Results of the reconnaissance investigation were published in Butler and others (1995).

Background

Selenium was elevated in some water, bottom-sediment, and biota samples collected in 1990 in the Dolores Project area (Butler and others, 1995). Many of the water and biota samples collected in the newly irrigated area (since 1987) of the Dolores Project between Cortez and Dove Creek (the Dove Creek area in fig. 1) had elevated selenium concentrations. Samples of irrigation drainage from three washes in the Dove Creek area had selenium concentrations ranging from 3 to 12 µg/L (Butler and others, 1995). Selenium concentrations in 10 of 11 aquatic-invertebrate samples from the Dove Creek area exceeded a guideline for food items consumed by fish and wildlife. Selenium in bird eggs was in the range of uncertainty for biological risk. The highest selenium concentration in a biota sample collected for the study in 1990 was 37.5 µg/g dry weight in a mallard liver collected from a pond in Woods Canyon in the newly irrigated area of the Dolores Project (fig. 1).

The long-term irrigated area of the Dolores Project is the service area of the Montezuma Valley Irrigation Company (MVIC) shown in figure 1. The MVIC area also was sampled in 1990, and generally, selenium concentrations in water, bottom sediment, and biota were not elevated in samples collected from streams and ponds north of Mc Elmo Creek (Butler and others, 1995). However, samples from Navajo Wash, which receives irrigation drainage from areas on Mancos Shale in the southern part of the Montezuma Valley, had high selenium concentrations. The maximum selenium concentration in water samples collected for the reconnaissance investigation was 88 µg/L in a sample from Navajo Wash (Butler and others, 1995).

Selenium concentrations were elevated in some water and biota samples collected from the lower Mancos River in 1990 (Butler and others, 1995). During 1989, the U.S. Fish and Wildlife Service (USFWS) collected biota samples at five sites in the Mancos River Basin, and some samples had selenium concentrations that exceeded guideline concentrations. Bird livers collected from a pond in the irrigated area of the Mancos Project (fig. 1) in 1989 had high selenium concentrations; one liver had a concentration of 69 µg/g dry weight (Butler and others, 1995). No sampling was done in the upper part of the basin in the Mancos Project area for the reconnaissance investigation in 1990.

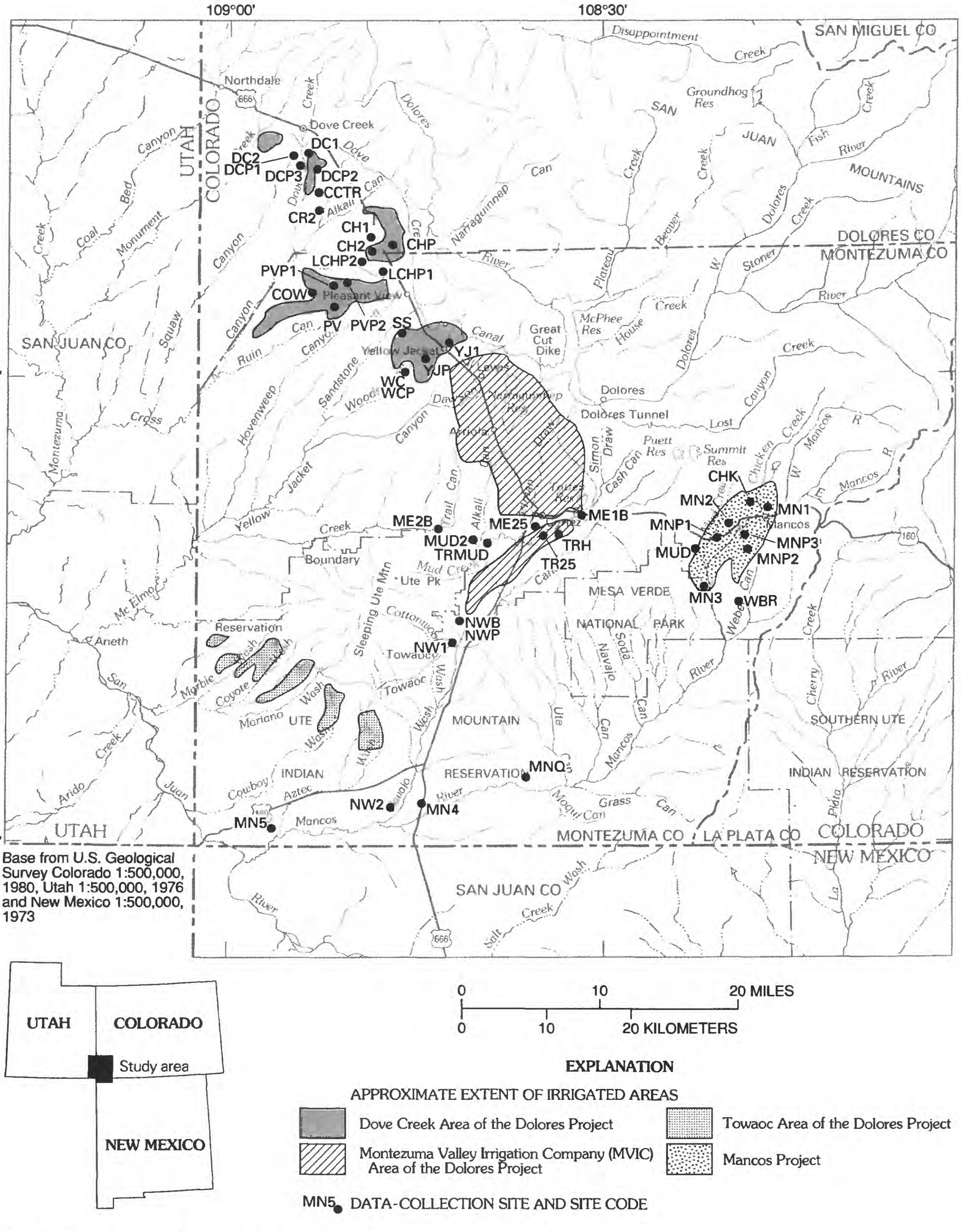

Figure 1. Locations of study area and sampling sites.

The reconnaissance investigation of the Dolores Project in 1990 reported that the only other trace element that might be of concern was mercury in fish (Butler and others, 1995). Two area reservoirs (McPhee and Narraguinnep Reservoirs in fig. 1) were posted by the State of Colorado because mercury concentrations in game fish exceeded guidelines for human consumption. Mercury concentrations in some of the warm-water game fish collected from reservoirs in the Dolores Project area in 1990 exceeded consumption guidelines of the State.

The Dolores Project was only partly completed at the time of the reconnaissance investigation in 1990. About 50 percent of the allocated irrigated acreage in the Dove Creek area (fig. 1) was being irrigated by the end of 1990. Almost all of the irrigation system in the Dove Creek area was operational by late 1993. Sampling in the Dove Creek area for the reconnaissance investigation in 1990 was limited to four streams (one was a reference site not affected by irrigation), three wells, and two ponds. Water and bottom sediment were collected only at one pond in 1990. In the MVIC area of the Dolores Project, all but one of the sampling sites were on Mc Elmo Creek or on tributaries draining irrigated land of the MVIC areas north of Mc Elmo Creek. Only one site was sampled in the southern MVIC area (south of Mc Elmo Creek); that site was on Navajo Wash near Towaoc (fig. 1). Navajo Wash is tributary to the Mancos River and not to Mc Elmo Creek.

The NIWQP decided in 1994 that additional field investigations were needed in parts of the Dolores Project and in the Mancos River Basin. Because of elevated selenium concentrations in some of the water and biota samples from newly irrigated areas and because only part of the irrigation system was in operation in 1990, the Dove Creek area of the Dolores Project was selected for additional sampling. Additional sampling in the Dove Creek area was done to provide better spatial coverage of streams in the irrigated area and to expand the sampling of ponds and wetlands that are used by migratory birds. Data collected in 1990 on Mc Elmo Creek and tributaries draining the northern MVIC area indicated that much of the selenium in Mc Elmo Creek may be discharging from the Mancos Shale areas south of the creek. Therefore, NIWQP decided to expand coverage of the MVIC area of the Dolores Project by sampling tributaries of Mc Elmo Creek that drain the irrigated MVIC area south of the creek. Biota data collected in 1989 by the USFWS in the Mancos River Basin indicated that there was a need to investigate the Mancos River and Mancos Project in greater detail. Therefore, in 1994, a field screening of the Mancos River Basin was included with the additional sampling of the Dolores Project.

Purpose and Scope

This report presents and discusses results of field screenings in parts of the Dolores Project and in the Mancos River Basin in 1994. Analytical results are presented for the following: (1) Water and biota samples collected from streams in the Dove Creek area, three tributaries of Mc Elmo Creek in the southern MVIC area of the Dolores Project, and in the Mancos River Basin; (2) water samples collected from Mc Elmo Creek; (3) water, bottom-sediment, and biota samples collected at ponds and wetlands in the Dove Creek area and in the irrigated area of the Mancos Project; and (4) soil samples collected adjacent to pond sites and selected stream sites in the Dove Creek area. Selenium data are presented for all water, soil, bottom-sediment, and biota samples. Mercury also was analyzed for in bottom-sediment samples and selected biota samples. Also presented are major-ion and dissolved-solids data for all water samples collected for this study and onsite measurements that were made in conjunction with collection of water samples. Selenium concentrations in water, bottom sediment, and biota are compared to various selenium criteria and guidelines for fish and wildlife, and concentrations in soil are compared to background levels for soils in the Western United States. Selenium concentrations in water are compared for sites that were sampled in 1990 for the reconnaissance investigation and in 1994 for this study.

Acknowledgments

The authors thank numerous property owners for allowing collection of samples on their property. The authors also acknowledge Kirk Lashmett of the Bureau of Reclamation (BOR), Durango, Colo., Sue Groves, an employee of the Ute Mountain Ute Tribe, Towaoc, Colo., and Christopher Theel, formerly of the USFWS, for their assistance with the collection of biological samples.

DESCRIPTION OF STUDY AREA

The Dolores Project and Mancos Project are briefly described, including location, irrigated land, water sources, and drainage flow. Issues regarding endangered species, fisheries, and migratory bird usage in the study areas also are described.

Dolores Project

The BOR has done extensive hydrologic, water-supply, irrigation-drainage, geologic, and soils investigations for planning reports for the Dolores Project (Bureau of Reclamation, 1977a, b, 1988, 1989) and water-quality studies for the Mc Elmo Creek Basin (Bureau of Reclamation, 1981). Some of that information was included in Butler and others (1995); therefore, only a brief overview of the Dolores Project is presented in this report.

The Dolores Project is located in southwestern Colorado and was designated by three specific areas (fig. 1) in BOR planning reports. Those designations are used in this report. The area referred to as the Dove Creek area consists of the five irrigated areas (fig. 1) between Yellow Jacket Canyon and Monument Creek. The MVIC area consists of the irrigated area between Yellow Jacket Canyon and Mesa Verde National Park. The third area is named the Towaoc area and consists of the irrigated areas (fig. 1) on the Ute Mountain Indian Reservation, south and southwest of Sleeping Ute Mountain.

Major features of the Dolores Project include McPhee Reservoir (completed in 1984), the Dolores Tunnel, Great Cut Dike, Dove Creek Canal, and Towaoc Canal (fig. 1). Other components include laterals, pumping plants, powerplants, drainage facilities, and salinity-control features. By 1994, all major features of the project were complete. The Dolores Project was planned to deliver an average of 90,900 acre-ft/yr of water from the Dolores River Basin (McPhee Reservoir) for irrigation and 8,700 acre-ft/yr of water for municipal and industrial uses. Project allocations are: 54,300 acre-ft to irrigate 27,920 acres in the Dove Creek area; 13,700 acre-ft of supplemental water to irrigate 26,300 acres in the MVIC area; and 22,900 acre-ft to irrigate 7,500 acres in the Towaoc area. The MVIC continues to receive its historical diversion from the Dolores River, which averaged about 105,000 acre-ft/yr (Bureau of Reclamation, 1977a).

The Dove Creek area is a broad plateau dissected by numerous canyons (fig. 1). All irrigated land is on residual soils (the red soils) that were derived from eolian deposits. Eolian deposits are windblown silt and sand that were reworked by water (Haynes and others, 1972). Red soils are loam to clay loam and are underlain at relatively shallow depths by sandstone and shale of the Dakota Sandstone. Red soils generally have high permeability. Irrigation water from McPhee Reservoir is supplied by the Dove Creek Canal through pressurized pipe laterals to sprinklers. The first water deliveries to the Dove Creek area were in 1987 in the Cahone and Yellow Jacket areas (fig. 1); the distribution system was completed by 1992. The irrigated lands are on ridge lands of rolling terrain dissected by many small streams, gullies, and swales. The natural drainages provide pathways for discharge of most of the subsurface drainage in the Dove Creek area. The small drainages are tributary to the major canyons, such as Yellow Jacket, Hovenweep, and Cross Canyons (fig. 1).

The MVIC area is on gently rolling terrain of the Montezuma Valley, which is dissected by many small streams, washes, and swales. Irrigation began in this area in the 1880's. Considerable irrigated land in the MVIC area is on gray soils, which are alluvial soils derived from the Mancos Shale and Mesaverde Formation of Upper Cretaceous age. Gray soils in some areas present problems for irrigation because of high salinity and poor drainage. All the MVIC area south of Mc Elmo Creek is on gray soils. The irrigation-supply water (historical and supplemental) is transported from McPhee Reservoir through the Dolores Tunnel or the Great Cut Dike into the MVIC area. Most of the MVIC area is irrigated by gravity distribution systems and flood irrigation. As a result of salinity-control work for the Dolores Project, some MVIC canals and laterals have been replaced or lined. Most of the irrigation drainage from the MVIC area discharges into Mc Elmo Creek through diffuse discharge of ground water or by tributary streams, washes, and ditches that intercept irrigation drainage. Irrigation drainage in the extreme southern part of the MVIC area discharges into Navajo Wash, which is tributary to the lower Mancos River.

Irrigated land in the Towaoc area is on long fans extending southwest of Sleeping Ute Mountain that are dissected by many ephemeral washes. The irrigated area in Aztec and Cowboy Washes (fig. 1) is on gray soils and the other areas to the west are on red soils. Initial water delivery to the Towaoc area was in late 1993. Irrigation in the Towaoc area was not completely developed as of 1995. Irrigation water is transported from the Dolores Tunnel by the Towaoc Canal to pressurized pipe laterals and sprinklers. Irrigation drainage is into the natural washes and gullies, but BOR expects that a piped outlet system may be needed in gray-soil areas to prevent accumulation of subsurface water (Bureau of Reclamation, 1977b).

Mancos Project

Irrigated land in the Mancos Project is in the upper Mancos River Basin in the vicinity of the town of Mancos (fig. 1). Irrigation in this area began in the 1880's. The irrigated area is about 13,700 acres. The facilities built by BOR for the Mancos Project were for supplemental irrigation water and for domestic water for the town of Mancos, the rural Mancos area, and for Mesa Verde National Park. The primary feature of the project is Jackson Gulch Reservoir, built in 1950 by BOR to provide water storage. The irrigation-water supply for the project is from the Mancos River. Most of the Mancos Project is irrigated by gravity distribution systems and flood irrigation. The irrigated land primarily is on various alluvial deposits that were partly derived from Mancos Shale. The entire irrigated area is underlain by Mancos Shale. All irrigation drainage from the Mancos Project discharges into the Mancos River or its tributaries, such as Weber Canyon and Mud Creek (fig. 1).

Fish and Wildlife Resources

Federally listed endangered fish are present in the San Juan River downstream from the Dolores Project and the Mancos River Basin. The endangered Colorado squawfish (*Ptychocheilus lucius*) was identified in 1987 and in 1988 in the San Juan River (Meyer and Moretti, 1988; Roberts and Moretti, 1989). Young-of-the-year squawfish were caught from the river, indicating that the fish were reproducing. More recent studies (Ryden and Ahlm, in press) of the San Juan River by the USFWS have indicated that Colorado squawfish use the area at the mouth of the Mancos River as a staging area during the spring. Two adult Colorado squawfish were captured about 10 mi upstream from Lake Powell during the summer of 1996 (Dale Ryden, U.S. Fish and Wildlife Service, oral commun., 1996). Adults of the endangered razorback sucker (*Xyrauchen texanus)* were captured in the San Juan arm of Lake Powell. The San Juan River from Farmington, N. Mex., to Lake Powell has been designated as critical habitat for the Colorado squawfish and razorback sucker (Brookshire and others, 1994).

Two endangered birds are present in the study area, the bald eagle and the peregrine falcon. Bald eagles winter in Colorado and use open-water areas to feed on fish. Fish could be a potential source of selenium contamination to bald eagles. Peregrine falcons nest in the Mesa Verde National Park area, and they probably feed on other birds in the Dolores Project area and in the Mancos River Basin. The threatened Mexican spotted owl is present in Mesa Verde National Park, but the owl feeds on small mammals and probably is not affected by selenium bioaccumulation in the aquatic food chain.

The two major streams draining the irrigated areas, the Mancos River and Mc Elmo Creek, are not considered sport fisheries. The forks of the Mancos River (fig. 1) upstream from the Mancos Project contain cold-water fish, such as trout. In the Mancos Project, the Mancos River and its larger tributaries, such as Chicken Creek (fig. 1), have a mixture of fish species, including suckers, rainbow trout, speckled dace, mottled sculpin, and roundtail chubs. The lower Mancos River primarily has sucker species, fathead minnows, roundtail chubs, and channel catfish. Some reaches of the lower Mancos River become dewatered during late summer and contain no fish, except for fish trapped in pools. Mc Elmo Creek is affected by irrigation return flows and irrigation drainage (Butler and others, 1995), and fish species are dominated by sucker species, fathead minnows, speckled dace, red shiners, and common carp. Most of the streams and drainages in the Dove Creek area of the Dolores Project are intermittent or have very low streamflow and do not have fish.

Reservoirs in the study area have a variety of game fish. Narraguinnep and Totten Reservoirs (fig. 1) in the MVIC area contain warm-water game fish, such as walleye, northern pike, largemouth bass, yellow perch, and black crappie. McPhee Reservoir is a popular fishery containing species, such as trout, kokanee salmon, bass, yellow perch, and black crappie. The numerous small farm ponds in the Dolores and Mancos Projects might be stocked by the owner with warm-water game fish. Ponds that have not been stocked often have fathead minnows or green sunfish.

The reservoirs and the numerous small ponds and wetlands in the study area are used by migratory waterfowl for nesting and resting areas. During the sampling in 1994, the most common bird species collected were mallards, red-winged blackbirds, American coots, and ruddy ducks.

SAMPLE COLLECTION AND ANALYSIS

Water, soil, and bottom-sediment samples were collected by the U.S. Geological Survey (USGS), and biological samples were collected by the USFWS. All samples collected for the field screening of the Dolores Project and the Mancos River Basin were collected during March through July 1994. Sampling sites and the samples collected at each site are listed in table 1. Locations of sampling sites are shown in figure 1.

Water Samples

Sampling of streams in the Dove Creek area in 1994 was designed to provide more areal coverage of the area than was possible during the reconnaissance investigation in 1990. Only four drainages were sampled in 1990, and those four sites were resampled in 1994 (sites CR2, CH1, YJ1, and WC in fig. 1). Six additional drainages were sampled in the Dove Creek area in 1994, primarily in areas that were not irrigated in 1990, but were irrigated in 1994. Streams were sampled twice for this study; in early April prior to the irrigation season and in July during the irrigation season. Water samples were collected at six ponds in the Dove Creek area in June 1994 (table 1). Water samples were collected at three sites on Mc Elmo Creek and from three drainages south of Mc Elmo Creek (sites TRH, TR25, and MUD2) in the MVIC area in 1994. Pre-irrigation samples were collected in March, and irrigation-season samples were collected in July. Water samples in the Mancos River Basin were collected at four sites on the Mancos River, from three tributaries that flow into or drain irrigated areas of the Mancos Project, and from site NW1 on Navajo Wash (table 1; fig. 1). Samples were collected in March and July. In June 1994, water samples were collected at three ponds located within irrigated areas of the Mancos Project (table 1; fig. 1).

Water samples were collected on March 8, 1994, at three sites in the Mud Creek and upper Navajo Wash Basins (sites TRMUD, NWP, and NWB in fig. 1 and table 1). Those samples were not collected for the field-screening study, but the selenium data for those sites are included in this report.

Onsite measurements at water-sampling sites included specific conductance, pH, water temperature, and dissolved oxygen using standard procedures of the USGS (Knapton, 1985). Stream discharge was measured at stream sites using techniques described by Rantz and others (1982). In addition to dissolved selenium, all water samples were analyzed for calcium, magnesium, sodium, potassium, alkalinity, sulfate, chloride, fluoride, silica, dissolved solids, and nitrite plus nitrate as nitrogen. Chemical analyses were done at the USGS National Water Quality Laboratory in Arvada, Colo., using methods described by Fishman and Friedman (1989).

Soil Samples

Soil samples were collected adjacent to nine pond-sampling sites in the Dove Creek area and the Mancos Project and at three stream sites in the Dove Creek area (table 1; fig. 1). Soil samples generally were collected within 0.25 mi upstream from the sampling site. Soil samples were collected to provide information about selenium concentrations in parent soils near pond sites. The three samples from tributary sites were collected to provide additional information on selenium concentrations in red-soil areas.

Soil samples were collected using a 0.75-in.-diameter soil corer. Only shallow soil samples were collected, and most cores were about 6 in. deep. Generally, about 10 to 15 cores were collected at each site at randomly selected locations upstream from the site. Individual cores were composited in a bucket, and a subsample was taken for analysis. Soil samples were analyzed for concentrations of total selenium by the USGS Branch of Geochemistry using the method described by Severson and others (1991).

Table 1. Sampling sites and samples collected for the 1994 field study

[na, not applicable because the U.S. Geological Survey (USGS) did not collect samples at this site; --, sample not collected; X, sample collected]

Site code (fig. 1)	USGS station number	Site location	Samples			
			Water	Soil	Bottom sediment	Biota
		DOLORES PROJECT—DOVE CREEK AREA				
DC1	na	Tributary of Dove Cup upstream from large pond	--	--	--	X
DC2	374238108540301	Dove Creek downstream from large pond	X	--	--	X
DCP1	374246108540901	Large pond on Dove Creek	X	X	X	X
DCP2	na	Pond between Dove Creek and Cross Canyon	--	--	--	X
DCP3	na	Lower pond on Dove Creek tributary	--	--	--	X
CCTR	374109108523201	Unnamed tributary of Cross Canyon upstream from Alkali Canyon	X	--	--	X
CR2	374056108523801	Cross Canyon downstream from unnamed tributary	X	X	--	X
CH1	373857108483001	Cahone Canyon at Highway 666	X	--	--	X
CHP	373821108465201	Pond on Cahone Canyon, west of 15 Road	X	X	X	X
CH2	373803108483601	Tributary of Cahone Canyon at 13 Road	X	--	--	X
LCHP1	373626108465301	Pond on Little Cahone Canyon, near Highway 666	X	X	X	X
LCHP2	na	Lower pond on Little Cahone Canyon	--	--	--	X
PV	373511108510201	Unnamed drainage into west pond at CC Road	X	--	--	X
PVP1	373516108505201	West pond at CC Road	X	X	X	X
PVP2	na	East pond at CC Road	--	--	--	X
COW	373511108541101	Unnamed tributary of Cow Canyon at 8 Road	X	X	--	X
SS	373157108462501	Unnamed tributary of Sandstone Canyon at 15 Road	X	--	--	--
YJ1	373136108423301	Tributary of Yellow Jacket Canyon at Highway 666	X	X	--	X
YJP	373026108441701	Pond on tributary of upper Yellow Jacket Canyon	X	X	X	X
WC	372934108462501	Woods Canyon at 15 Road	X	--	--	X
WCP	372933108462801	Pond on Woods Canyon at 15 Road	X	X	X	X
		DOLORES PROJECT—MVIC AREA				
ME1B	372045108314901	Mc Elmo Creek upstream from Simon Draw	X	--	--	--
TRH	371938108331901	Unnamed drainage, near H and 27 Roads	X	--	--	X
ME25	371934108352101	Mc Elmo Creek at 25 Road	X	--	--	--
TR25	371909108354601	Unnamed drainage downstream from 25 Road	X	--	--	X
TRMUD	371715108381401	Tributary of Mud Creek at E Road	X	--	--	--
MUD2	09371492	Mud Creek at Highway 32, near Cortez	X	--	--	X
ME2B	09371520	Mc Elmo Creek upstream from Trail Canyon	X	--	--	--
		MANCOS RIVER BASIN				
MN1	372113108154001	Mancos River downstream from east and west forks	X	--	--	X
CHK	372042108184501	Chicken Creek at old Highway 160	X	--	--	X
MN2	371938108194401	Mancos River at H Road downstream from Chicken Creek	X	--	--	X
MUD	371747108215801	Mud Creek at mouth, near Mancos	X	--	--	X
MN3	371648108214301	Mancos River 1.2 miles downstream from Mud Creek	X	--	--	X
WBR	371503108183201	Weber Canyon downstream from irrigated area	X	--	--	X

Table 1. Sampling sites and samples collected for the 1994 field study—Continued

[na, not applicable because the U.S. Geological Survey (USGS) did not collect samples at this site; --, sample not collected; X, sample collected]

Site code (fig. 1)	USGS station number	Site location	Samples			
			Water	Soil	Bottom sediment	Biota
		MANCOS RIVER BASIN—Continued				
MNQ	na	Mancos River, near Moqui Canyon	--	--	--	X
MN4	09371000	Mancos River at Highway 666	X	--	--	X
MN5	na	Mancos River at State line	--	--	--	X
MNP1	371840108210901	Pond, near 38 and G Roads, Mancos Valley	X	X	X	X
MNP2	371835108182701	Large pond south of G Road, southern Mancos Valley	X	X	X	X
MNP3	371837108183601	Pond downstream from site MNP2, southern Mancos Valley	X	X	X	X
NWP	371415108410001	Pond, near B Road and Navajo Wash	X	--	--	--
NWB	371414108410301	Navajo Wash upstream from B Road	X	--	--	--
NW1	09371002	Navajo Wash at Towaoc	X	--	--	--
NW2	na	Navajo Wash, near mouth	--	--	--	X

Bottom-Sediment Samples

Bottom-sediment samples were collected at six ponds in the Dove Creek area and at three ponds in the Mancos Project in June 1994 (table 1). Selenium concentrations in bottom-sediment samples from ponds were used to examine selenium bioaccumulation in water, bottom sediment, food-chain items, and bird liver and eggs at sites used by migratory birds. Bottom sediment was not sampled from streams.

Bottom-sediment samples were collected from ponds using a BMH–53 sampler (Edwards and Glysson, 1988). Four to six cores of sediment were collected at each site, and cores were composited in a stainless-steel bucket. Generally, sediment cores were about 3 to 6 in. deep. Bottom-sediment samples were analyzed for total selenium and total mercury by the USGS Branch of Geochemistry in Lakewood, Colo. Analytical methods are described by Severson and others (1991).

Biota Samples

The collection of biota samples from streams in the Dove Creek area of the Dolores Project was scheduled at the same sites where water samples were collected (table 1); however, biota samples were not collected from the Sandstone Canyon tributary (site SS) in the Dove Creek area because of a lack of biota. In the MVIC area, biota samples were collected at three tributaries (sites TRH, TR25, and MUD2 in table 1) of Mc Elmo Creek where water samples were collected. Biota samples were collected at all stream sites in the Mancos River Basin where water samples were collected. In addition, some biota samples also were collected at two sites on the lower Mancos River (sites MNQ and MN5). The biota sampling site on Navajo Wash was at the mouth (site NW2) and not at the water-sampling site (site NW1) (fig. 1). Biota samples were collected at the six ponds in the Dove Creek area and the three ponds in the Mancos Project where water and bottom sediment were collected. Some additional biota sampling also was done at ponds DCP2, DCP3, LCHP2, and PVP2 (table 1) in the Dove Creek area.

The objective of biota sampling at stream sites was to collect aquatic plants, aquatic invertebrates, and whole-body fish concurrent with collection of water samples during the pre-irrigation and irrigation seasons in 1994. In the Dove Creek area, most streams do not support a viable fish population, and fish samples were collected only at site WC. Fish samples were collected at the tributary sites in the MVIC area and at all stream sites in the Mancos River

Basin. At pond sites, sampling was designed to collect food items of migratory birds, such as various aquatic plants and invertebrates, and to collect livers and eggs of birds associated with a particular pond or wetland area. Salamanders were collected at most ponds in the Dove Creek area. A few fish samples also were collected from ponds in the Mancos Project. Availability of nesting birds at some ponds was limited, and bird samples were not collected at all pond sites. Attempts were made to collect livers from pre-fledglings because the pre-fledglings are confined to a given locale until they fledge, and selenium concentrations in their livers would be a function of selenium in the food and water at the specific site. Bird eggs generally were collected soon after they were discovered because of potential loss to predators. Although developmental abnormalities among embryos in bird eggs cannot be detected before the eggs reach one-half term (Ohlendorf and others, 1986), eggs were collected to ensure that representative samples were available for selenium analysis. Pathological information related to abnormalities was collected, if possible. All biota sampling at pond and wetland sites was done in late May and in June 1994.

Biological samples were collected using standard equipment and techniques of the USFWS (U.S. Fish and Wildlife Service, 1986, 1990). Aquatic vegetation was collected by handpicking. Benthic invertebrates were collected by handpicking from rocks or using a kick screen. Benthic invertebrates in ponds were collected using a hand net and sweeping along the bottom of vegetation. Crayfish and salamanders were collected when present. Fish were collected using electroshocking equipment or seine or gill nets. Birds were shot using steel shot, and livers were removed using stainless-steel dissecting equipment. Bird eggs were removed from nests and opened to examine the embryos for developmental abnormalities.

All biological samples were analyzed for selenium, and selected fish samples were analyzed for mercury at the Environmental Trace Substances Research Center in Columbia, Mo. That laboratory is contracted by the USFWS Patuxent Analytical Control Facility in Laurel, Md. Analysis for 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.

FIELD-SCREENING RESULTS

The results of the 1994 field screening in parts of the Dolores Project and in the Mancos River Basin are described by areas. Selenium concentrations in the various sampling media are discussed for the Dove Creek area and the MVIC area of the Dolores Project and for the Mancos River Basin. Water-quality data for stream sites are listed in table 2 and for pond sites in table 3. Selenium and mercury data for bottom-sediment and soil samples are listed in table 4. Biological data for stream sites in the Dolores Project and the Mancos River Basin are listed in table 5, and biological data collected at ponds are listed in table 6. Tables 2–6 are in the "Supplemental Data" section at the back of this report.

Selenium concentrations in water are compared to the chronic aquatic-life criterion of 5 µg/L (U.S. Environmental Protection Agency, 1987). Selenium concentrations in soil are compared to the selenium concentrations in Western United States soils (Shacklette and Boerngen, 1984), and concentrations in bottom sediment are compared to a level of concern of 4 µg/g (Lemly and Smith, 1987).

Selenium concentrations in biota are compared to various proposed guidelines and levels of concern based on recent literature. Selenium in aquatic plants and invertebrates are compared to a dietary guideline of 3 µg/g dry weight for protection of fish and wildlife resources (Lemly and Smith, 1987; Lemly, 1993). Selenium in whole-body fish is compared to a guideline concentration of 4 µg/g dry weight in whole-body fish (Lemly, 1993) for protection of freshwater fisheries. A mean selenium concentration that exceeds 3 µg/g dry weight in aquatic-bird eggs is an indicator of selenium contamination in birds in a nonmarine environment (Skorupa and Ohlendorf, 1991). Skorupa and Ohlendorf (1991) also reported that a mean selenium concentration greater than 8 µg/g dry weight in bird eggs was associated with reduced hatchability and that the threshold for embryo deformities (teratogenesis) occurred with selenium concentrations between 13 and 24 µg/g dry weight. Seiler and Skorupa (1995) classified sets of bird eggs as embryotoxic when the 75th-percentile selenium concentration exceeded 8 µg/g dry weight. The selenium concentrations in bird eggs collected in 1994 are compared to these guidelines.

A new protocol developed by Lemly (1995) was used to evaluate the hazard of selenium to fish and migratory birds at ponds and wetlands that were sampled in the Dove Creek area and in the Mancos Project. The protocol uses a data set of selenium concentrations in five ecosystem components, water, bottom sediment, benthic invertebrates, fish eggs, and bird eggs, to assess selenium hazard. An individual hazard score is assigned to each ecosystem component, and an overall hazard is determined by adding the individual scores. The hazard-assessment method incorporates food-chain bioaccumulation and uses reproductive impairment in fish and aquatic birds (the most sensitive biological endpoints) to determine the potential for ecosystem-level effects of selenium. The hazard assessment was used for some sites that had selenium data for four of the ecosystem components. Lemly (1995) noted that the hazard assessment can be used with incomplete data sets; however, the predictive power is weakened.

Mercury analysis was done on bottom-sediment samples (table 4), on a few fish samples (table 5), and on selected bird-egg samples (table 6). Concentrations of mercury were not at concentrations of concern (Eisler, 1987) in the fish and bird-egg samples; therefore, mercury is not discussed further in this report.

Dove Creek Area of the Dolores Project

Water

Selenium was detected in 18 of 20 water samples collected from 10 streams and washes in the Dove Creek area in 1994 (fig. 2; table 2). Those results indicate that selenium is mobilized from red soils in the newly irrigated areas in the Dove Creek area. The selenium concentrations might be representative of selenium concentrations in irrigation drainwater from red-soil areas under initial leaching conditions. The median selenium concentration for the 20 samples is 4 μg/L, and concentrations ranged from less than 1 to 12 μg/L (fig. 2; table 2). Selenium concentrations in 9 of the 20 samples equaled or exceeded the chronic aquatic-life criterion for selenium of 5 μg/L (U.S. Environmental Protection Agency, 1987). Selenium concentrations were higher in the nonirrigation-season samples (April) than in the irrigation-season samples (July) at all sites, except site DC2 (fig. 2). A small quantity of surface return flow in summer diluted selenium concentrations in surface drainages. The higher selenium concentrations generally were in the Dove Creek and Cahone Canyon drainages.

Four stream sites that were sampled for the reconnaissance investigation in 1990 also were sampled in 1994 (sites CR2, CH1, YJ1, and WC). Selenium concentrations in the pre-irrigation and irrigation-season samples collected in 1990 and 1994 are compared in figure 3. In 1990, sites CH1, YJ1, and WC were downstream from newly irrigated areas, and the data collected in 1994 indicate that selenium concentrations have not markedly changed at these three sites since 1990 (fig. 3). In 1990, site CR2 was a reference site for the Dove Creek area because irrigation had not yet begun upstream from that site. Selenium was not detected in the three samples collected at site CR2 in 1990, but in 1994, the concentration was 7 μg/L in April and 1 μg/L in July. Apparently, most of the selenium in the mainstem of Cross Canyon at site CR2 was from an unnamed tributary upstream from site CCTR (fig. 1), where the selenium concentration was 8 μg/L in April. The introduction of irrigation apparently mobilized some selenium from the red soils, although selenium concentrations in red soils are low. The mobilization of selenium from the red soils by irrigation might gradually decrease over time as the remaining soluble or oxidizable selenium is removed.

Six ponds were sampled in June 1994 in the Dove Creek area, and selenium in water samples ranged from less than 1 to 5 μg/L (table 3). The highest selenium concentration of 5 μg/L was from pond CHP in Cahone Canyon, and samples from Cahone Canyon at site CH1 (table 2) had the highest selenium concentration in stream samples from the Dove Creek area. Selenium concentrations in pondwater were somewhat lower than in samples of irrigation drainwater collected from streams in the same drainage basin.

Selenium concentrations in water in the Dove Creek area are somewhat anomalous when compared to other irrigation projects studied by NIWQP. Seiler (1995) analyzed data from 26 NIWQP study areas to determine if there were common factors among areas that were identified as having potential problems for aquatic wildlife resulting from irrigation-induced

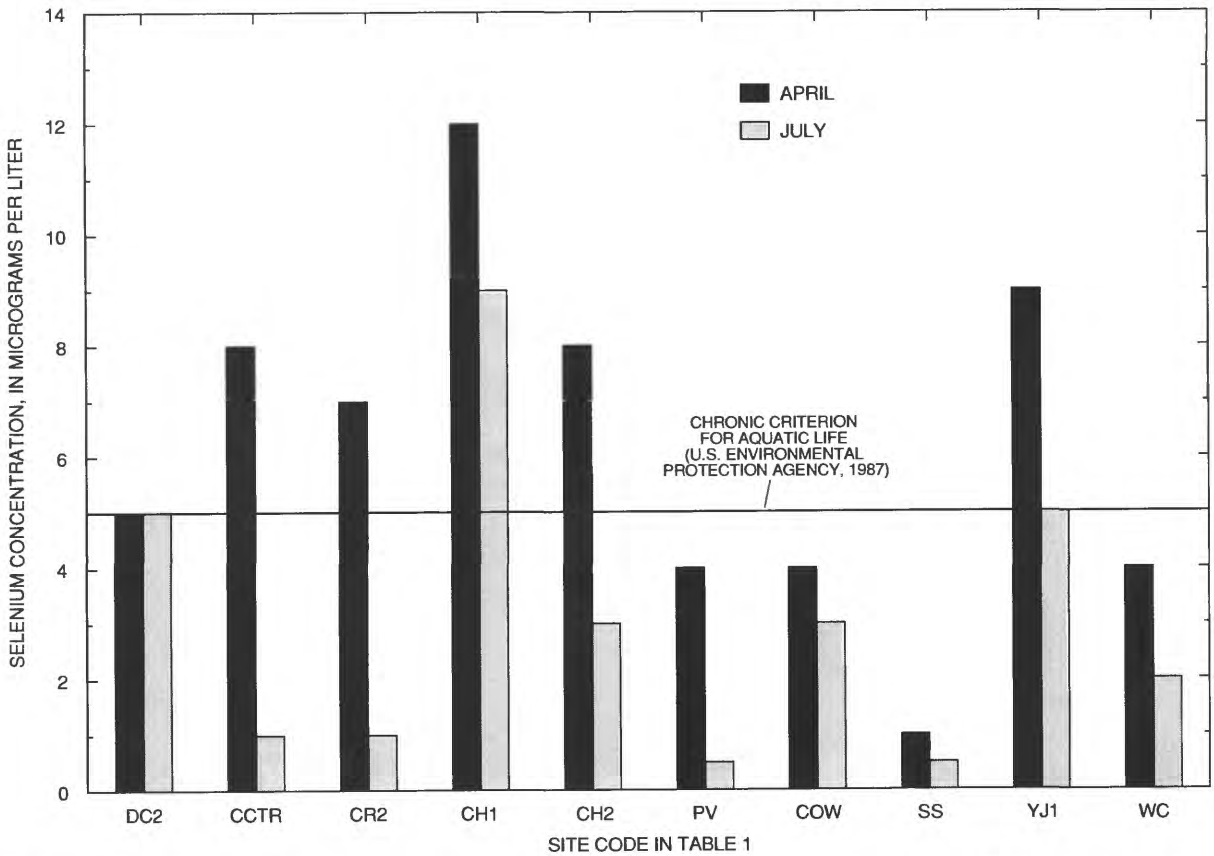

Figure 2. Selenium concentrations in water samples from streams in the Dove Creek area, April and July 1994. Concentrations of less than 1 are plotted as 0.5.

selenium contamination. Factors identified were: the presence of Upper Cretaceous, primarily marine sediments; evaporation exceeding precipitation by a factor of 3.5 or more; and drainage into topographically closed basins. The 75th-percentile selenium concentration in all surface-water samples (streams, ponds, and lakes) collected in or downstream from the irrigated land in each study area was compared to a selenium concentration of 3 µg/L (Seiler, 1995), a concentration in water that could be hazardous to some aquatic birds under certain conditions (Skorupa and Ohlendorf, 1991). Areas that had a 75th-percentile selenium concentration greater than or equal to 3 µg/L were considered susceptible to possible selenium problems. Using the three common factors and the 75th-percentile selenium concentrations for the 26 NIWQP study areas, Seiler (1995) developed a decision tree to predict where irrigation drainage might induce selenium problems. By use of the decision tree to predict the likelihood of selenium contamination, the Dove Creek area would be classified as unlikely to have a selenium problem. In the Dove Creek area, the first two factors do not apply, and the third factor only applies at certain sites. However, the 75th-percentile selenium concentration for the 26 surface-water samples collected in 1994 (tables 2 and 3) is 5 µg/L, which exceeds the criterion of 3 µg/L that was considered indicative of possible selenium problems. It is not realistic to expect the decision tree developed by Seiler (1995) to accurately predict selenium contamination in every situation. One variable not in the decision tree is the length of time the area had been irrigated, and that time might be a critical factor in the Dove Creek area, where irrigation (in 1994) had been ongoing only for 2 to 7 years. In most of the 26 NIWQP study areas used by Seiler (1995), irrigation had been present for much longer

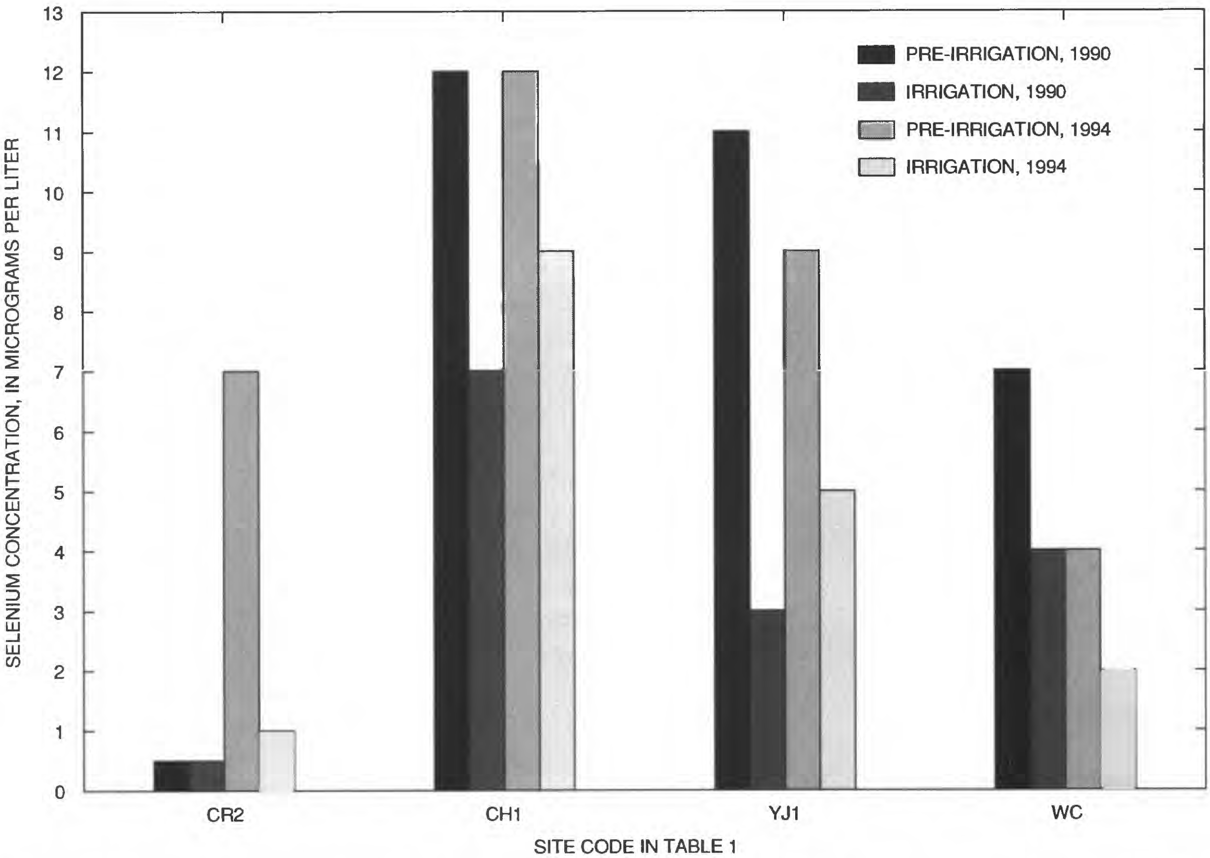

Figure 3. Selenium concentrations in water samples from four streams in the Dove Creek area, 1990 and 1994. Concentrations of less than 1 are plotted as 0.5.

periods. It is possible that selenium concentrations in the Dove Creek area represent concentrations under initial leaching conditions, a factor that generally is unique among NIWQP study areas.

Dissolved-solids and major-constituent concentrations in the Dove Creek area were variable (tables 2 and 3). Generally, the higher dissolved-solids concentrations were in the Dove Creek and Cahone Canyon drainages. The maximum dissolved-solids concentration in a stream in the Dove Creek area was 4,440 mg/L at site CH1 on Cahone Canyon, and in ponds, the maximum was 4,900 mg/L at site LCHP1 in the Little Cahone drainage basin. Selenium and dissolved-solids concentrations are weakly correlated in stream samples collected in April in the Dove Creek area (Pearson correlation coefficient 0.63; significance probability of the correlation is 0.0507).

Soil and Bottom Sediment

The nine shallow soil samples collected in the Dove Creek area had total selenium concentrations of 0.13 to 0.20 μg/g (table 4), which are less than the geometric mean selenium concentration of 0.23 μg/g for soils in the Western United States (Shacklette and Boerngen, 1984). The soluble part of the total selenium in red soils was not determined. Despite low total-selenium concentrations in the soil, there apparently is sufficient soluble selenium in soils in the Dove Creek area to produce detectable selenium in irrigation drainwater in newly irrigated areas.

Bottom-sediment samples from ponds in the Dove Creek area had selenium concentrations that ranged from 0.65 to 3.2 μg/g (table 4). The concentrations are less than the guideline of 4 μg/g suggested by Lemly and Smith (1987) as a level of concern for fish and wildlife. The selenium concentrations in the bottom sediment from ponds was greater than the geometric mean selenium concentration of 0.47 μg/g for bottom sediment from 24 NIWQP study areas in the Western United States (Stewart and others, 1992). Because bottom-sediment samples had about 10 to 20 times greater selenium concentrations than soil samples (table 4), pond sediment is enriched in selenium compared to shallow soils. Apparently, biogeochemical processes transfer selenium from water to bottom sediment in ponds, which results in the enrichment of selenium in pond sediment compared to the parent soils.

Biota

Streams

Almost all aquatic invertebrates and fish collected in 1994 from streams in the Dove Creek area at sites CH1, YJ1 (no fish), and WC had selenium concentrations that exceeded the dietary guideline of 3 μg/g dry weight for protection of fish and wildlife (table 5; fig. 4). Those results are similar to results from 1990 (Butler and others, 1995). Also, the concentrations in fish samples exceeded the guideline of 4 μg/g dry weight in whole-body fish for protection of freshwater fisheries. Aquatic-invertebrate samples collected at stream sites DC1, DC2, CCTR, CR2, CH2, PV, and COW in 1994 (table 5; fig. 4) had selenium concentrations that often exceeded the dietary guideline for protection of fish and wildlife.

Ponds and Wetlands

Although selenium concentrations in water, soil, and bottom sediment at ponds in the Dove Creek area did not seem excessively high, numerous biological samples (especially bird samples) had elevated selenium concentrations (table 6). There also were marked differences in selenium concentrations in biota samples among ponds. Ponds LCHP1 and YJP had the lowest selenium concentrations (fig. 5), and pond CHP had the highest concentrations in biota samples (table 6; fig. 5). Pond CHP also had the highest selenium concentration (5 μg/L) in pondwater samples (table 3).

Selenium concentrations in all aquatic-plant samples were less than the dietary guideline of 3 μg/g dry weight, except for the samples from site CHP (table 6). However, selenium concentrations in 12 of the 14 invertebrate samples collected from Dove Creek area ponds exceeded the dietary guideline of 3 μg/g dry weight. Skorupa and Ohlendorf (1991) stated that aquatic invertebrates began to bioaccumulate selenium to concentrations greater than 4 μg/g dry weight when waterborne selenium concentrations ranged between 2 and 10 μg/L. Water samples from pond sites DCP1, CHP, PVP1, and WCP had selenium concentrations equal to or greater than 2 μg/L (table 3). Most invertebrate samples from these ponds exceeded 4 μg/g dry weight, and the highest concentration was 19 μg/g dry weight in a snail sample from site CHP. Site CHP also had the highest selenium concentration in a water sample from ponds in the Dove Creek area.

Two fathead minnows collected at site WCP in 1994 had selenium concentrations of 10 and 15 μg/g dry weight (table 6), which were similar to the concentrations in fathead minnows from site WCP in 1990 (Butler and others, 1995). These concentrations exceeded the selenium guideline of 4 μg/g dry weight for protection of freshwater fish. In most ponds sampled in the Dove Creek area in 1994, fish were absent. However, salamanders were present and were collected at most ponds. Selenium concentrations in salamander samples ranged from 2 (site LCHP1) to 21 μg/g dry weight (site CHP) (table 6). Few studies have been done concerning the effects of selenium on amphibians. Furr and others (1979) analyzed selenium concentrations in frog tadpoles collected from a fly-ash contaminated pond near a coal-fired powerplant. These frog tadpoles contained about 47 μg/g dry weight selenium and newts about 30 μg/g dry weight selenium. In the study by Furr and others (1979), frog tadpoles and newts from a reference pond had selenium concentrations of about 15 and 12.9 μg/g dry weight. Most of the salamanders collected from Dove Creek area ponds (table 6) had selenium concentrations similar to concentrations in the reference pond, except for site CHP. Selenium concentrations in three salamanders from site CHP (17 to 21 μg/g dry weight; table 6) exceeded the concentrations associated with the reference pond, but were less than the concentrations associated with the contaminated pond. A recent study reported that selenium concentrations at or exceeding 10 times normal (or about 20 μg/g dry weight) probably are associated with toxicity in populations of the more sensitive amphibians (J.P. Skorupa, U.S. Fish and Wildlife Service,

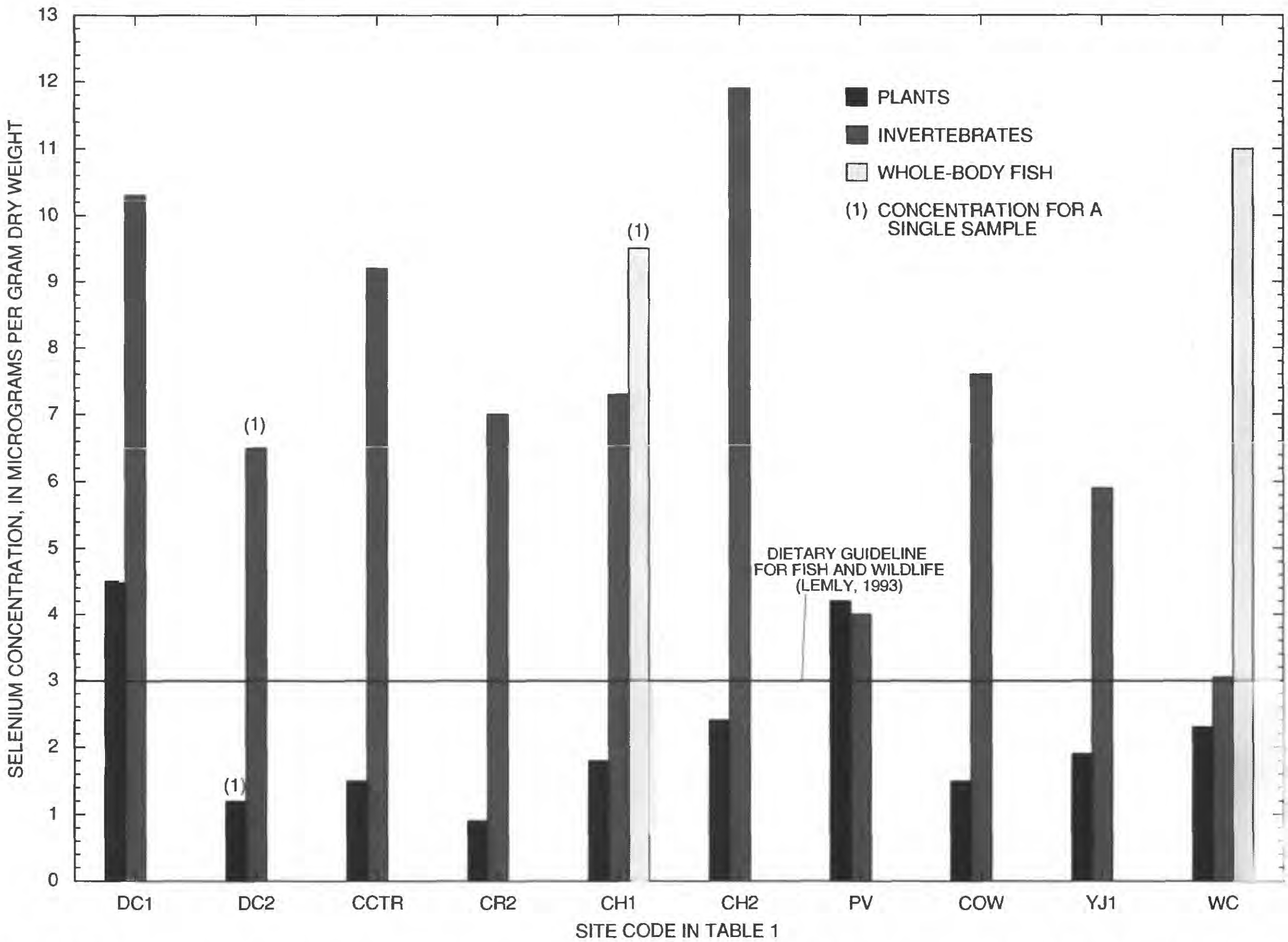

Figure 4. Geometric mean selenium concentrations in biota samples collected from streams in the Dove Creek area, April and July 1994.

written commun., 1996). The three salamander samples from site CHP had selenium concentrations that are similar to the concentration of 20 μg/g dry weight that might be toxic to sensitive amphibians.

Most selenium concentrations in bird-egg samples collected from the Dove Creek area in 1994 (table 6; fig. 5) were elevated when compared to guidelines. The mean selenium concentration in 10 aquatic-bird eggs (excluding blackbirds) collected at Dove Creek area ponds was 10.3 μg/g dry weight, which exceeded the guidelines suggested by Skorupa and Ohlendorf (1991) for avian contamination (3 μg/g dry weight) and for reduced hatchability (8 μg/g dry weight), but was less than the teratogenesis threshold of 13 μg/g dry weight. Blackbird eggs (and livers) were not used to calculate the mean selenium concentrations for bird eggs (and livers) because blackbird diets are not limited to aquatic-food items. According to Skorupa and Ohlendorf (1991), waterborne selenium concentrations often can be an imprecise indicator of selenium in bird eggs. However, Ohlendorf (1989) reported that bird eggs contained selenium concentrations that were one to three times greater than the dietary selenium concentrations; that relation was applicable to the Dove Creek area.

There may be a high risk of adverse biological effects if the mean selenium concentrations for a bird population exceed 30 μg/g dry weight in livers in environments that have normal mercury concentrations; conversely, mean concentrations less than 10 μg/g dry weight in bird livers could be indicative of a background (or no-effect level) selenium exposure (J.P. Skorupa, U.S. Fish and

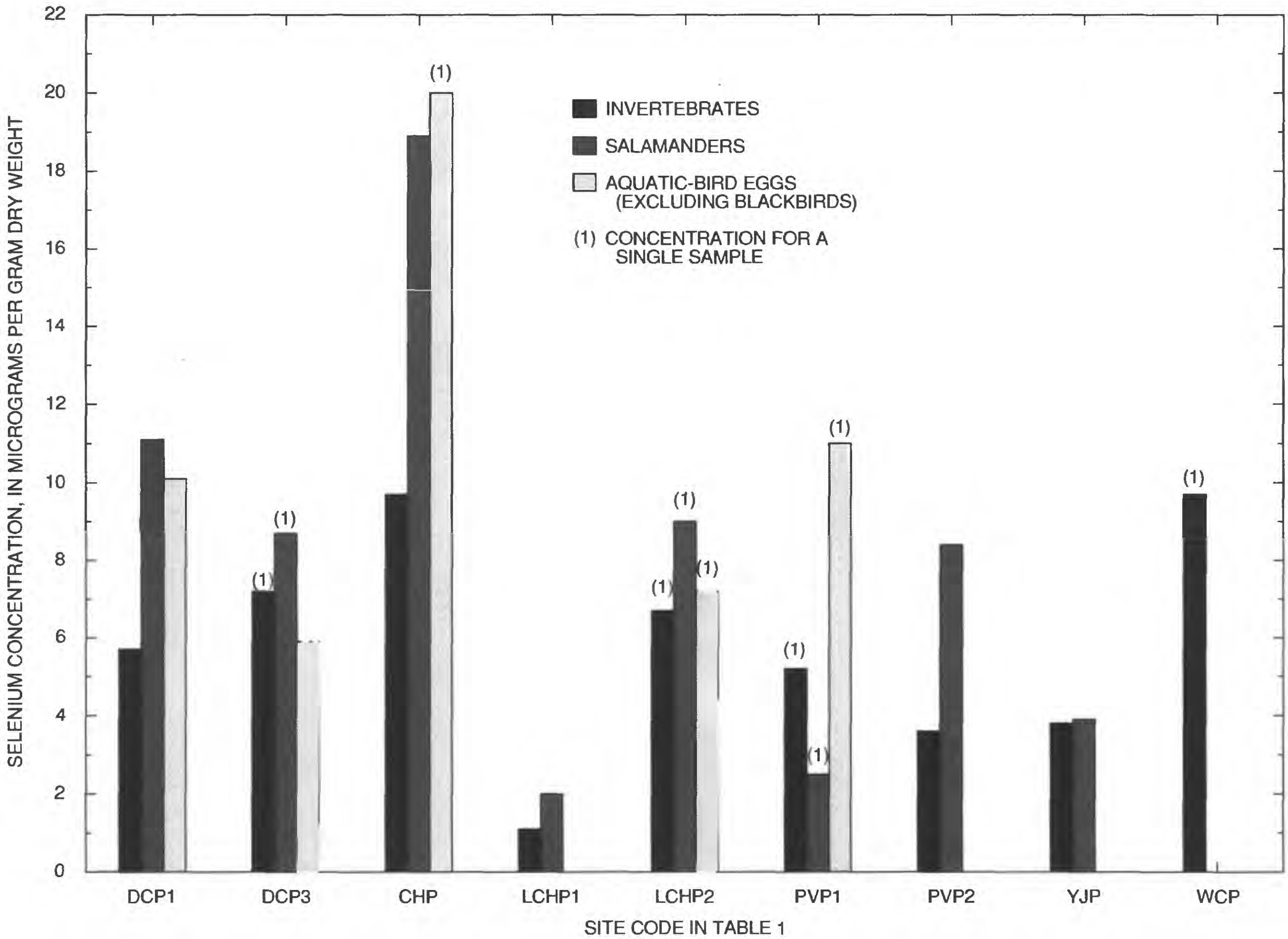

Figure 5. Geometric mean selenium concentrations in selected biota samples collected from ponds in the Dove Creek area, June 1994.

Wildlife Service, written commun., 1996). The mean selenium concentration in all aquatic-bird livers (excluding blackbirds) from the Dove Creek area was about 25 μg/g dry weight, which exceeded the no-effect concentration of 10 μg/g dry weight, but was slightly less than the adverse effect threshold of 30 μg/g dry weight. The mean selenium concentrations in bird livers from sites CHP and PVP2 exceeded 30 μg/g dry weight.

Ponds in the Dove Creek area were evaluated for effects of selenium contamination using the hazard assessment protocol developed by Lemly (1995). Selenium-hazard ratings for Dove Creek area ponds that had selenium data for at least four ecosystem components are listed in table 7 in the "Supplemental Data" section at the back of this report. The ponds at sites LCHP1 and YJP were rated as having a low selenium hazard, and ponds at sites DCP1 and PVP1 had a moderate selenium hazard. High selenium hazard was indicated for the ponds at sites CHP in the Cahone Canyon drainage and WCP in the Woods Canyon drainage. According to Lemly (1995, p. 281), a high hazard signifies an "imminent, persistent toxic threat sufficient to cause complete reproductive failure in most species of fish and aquatic birds." However, there was waterfowl and fish reproduction at sites rated with a high selenium hazard, which does not substantiate the prediction of complete reproductive failure. Mallard ducklings were collected at sites CHP and WCP, and fathead minnows were quite numerous in the pond at site WCP. The ponds at sites CHP and WCP are small and had limited numbers of birds. Perhaps if there had been a greater number of nesting birds at these ponds, reproductive impairment might have been more readily assessed.

Because selenium concentrations in the red soils of the Dove Creek area and in most water and bottom-sediment samples were relatively low, but concentrations in biota exceeded the guidelines, the processes affecting selenium bioaccumulation in the Dove Creek area are unknown. Perhaps much of the selenium is in a soluble, bioavailable chemical form (such as organic selenium forms). Based on laboratory experiments, nitrate can oxidize selenium (Wright and McMahon, 1994); therefore, nitrates in ground water might be mobilizing selenium from red soils. The bottom-sediment samples were composites of core samples collected to depths as great as 6 in. and were not surficial samples. Presser and others (1994) reported that surficial detrital material in ponds at Kesterson National Wildlife Refuge in California has much higher selenium concentrations than sediment samples. The selenium concentrations for the bottom-sediment samples collected from Dove Creek area ponds may underestimate the selenium concentrations in detrital material; selenium in detrital material can have a profound effect on selenium concentrations in aquatic food-chain organisms. In highly productive water bodies, less dissolved selenium remained in the water column, although food-chain exposure of fish and wildlife to selenium may be substantial (J.P. Skorupa, U.S. Fish and Wildlife Service, written commun., 1996). Zhang and Moore (1996) reported that, when drainwater containing selenium primarily in the selenate chemical form was discharged into a wetland system at Benton Lake National Wildlife Refuge in Montana, the dissolved selenium was removed from the water column and transferred to the sediment. Zhang and Moore (1996) reported that selenium concentrations decreased as water flowed through the pond system and that a change to a larger proportion of organic selenium facilitated bioconcentration, although selenium concentrations in the water decreased substantially. High selenium concentrations in biota at Benton Lake indicated that selenium uptake by wetland organisms was important in ponds containing low selenium concentrations in water and bottom sediment. Perhaps such processes are applicable to the ponds and wetlands in the Dove Creek area.

The Dove Creek area has only been irrigated for a short period (irrigation in part of the area began in 1987) and, therefore, provides a unique opportunity to collect baseline data for newly irrigated areas and to track the changes in selenium over time. When selenium concentrations would decrease in irrigation drainage in the Dove Creek area as the soluble selenium is removed, how long such a process would take, and what changes would occur regarding selenium bioaccumulation are unknown. For these reasons, the Dove Creek area of the Dolores Project is a valuable research area for investigating irrigation-induced contamination problems.

Montezuma Valley Irrigation Company Area of the Dolores Project

Water

Based on the two sets of samples collected in 1994, Mud Creek (site MUD2 in fig. 1) is the major source of selenium loading to Mc Elmo Creek. For the sample collected on March 23 (table 2), Mud Creek accounted for 79 percent of the selenium load at the downstream site on Mc Elmo Creek (site ME2B). Samples of irrigation drainage collected at sites TRH and TR25 had unexpectedly low selenium concentrations (table 2), despite draining Mancos Shale areas in the southern MVIC area. In the MVIC area, only water samples from Mud Creek had selenium concentrations exceeding the aquatic-life criterion of 5 μg/L. The maximum selenium concentration was 53 μg/L in a sample collected March 8 on a tributary of Mud Creek (site TRMUD in table 2).

Dissolved-solids concentrations in Mc Elmo Creek and tributaries ranged from 2,810 to 5,940 mg/L in samples collected in March 1994. Selenium concentrations did not correlate with dissolved-solids concentrations, especially for samples from the pre-irrigation season. There was a substantial gain in dissolved-solids discharge in Mc Elmo Creek between sites ME25 and ME2B, but less than one-half of that gain was from drainage basins upstream from sites TRH, TR25, and MUD2. These results imply that there are large sources of dissolved solids discharging into Mc Elmo Creek from irrigated areas north of the creek. In contrast, the field-screening results indicated that the largest source of selenium discharge into Mc Elmo Creek is Mud Creek (site MUD2), which drains part of the MVIC area south of Mc Elmo Creek.

Biota

Similar to selenium concentrations in the water samples collected in the MVIC area, the selenium concentrations in most biota samples from sites TR25 and TRH were lower than the concentrations in biota samples from site MUD2 (table 5). Selenium concentrations in aquatic plants and invertebrates from sites TRH and TR25 were less than the dietary guideline of 3 µg/g dry weight. Two crayfish from site MUD2 had selenium concentrations slightly greater than 3 µg/g dry weight (table 5). Selenium concentrations in all four whole-body fish samples from site TR25 and in seven of eight samples from site MUD2 equaled or exceeded the guideline of 4 µg/g dry weight for protection of freshwater fisheries.

Mancos River Basin

Water

Selenium concentrations in water samples collected in or downstream from irrigated areas of the Mancos Project (fig. 1) ranged from less than 1 to 10 µg/L (sites MN1 through MN4 in fig. 6 and table 2). The aquatic-life criterion of 5 µg/L (U.S. Environmental Protection Agency, 1987) was exceeded in the two samples from Mud Creek (site MUD in fig. 1) and the July sample from the Mancos River at site MN3 (fig. 6) for sites associated with the Mancos Project. Mud Creek accounted for about 74 percent of the selenium load in the Mancos River at site MN3 in March 1994. Because of irrigation diversions, an accurate comparison of selenium loads between Mud Creek and the Mancos River could not be made for the July samples.

Selenium concentrations were much higher in water samples collected in the Navajo Wash Basin (sites NWP, NWB, and NW1 in table 2; site NW1 in fig. 6) in 1994 compared to samples associated with irrigation in the Mancos Project. Navajo Wash drains irrigated areas on Mancos Shale in the extreme southern end of the MVIC area of the Dolores Project, and the wash discharges into the lower Mancos River downstream from site MN4 (fig. 1). At site NW1, the selenium concentration was 97 µg/L in March 1994 (table 2) compared to 88 µg/L in March 1990 (Butler and others, 1995). A sample collected March 8, 1994, in upper Navajo Wash (site NWB) had 170 µg/L of selenium, which is the highest selenium concentration reported in all water samples collected in the Dolores Project area and in the Mancos River Basin during 1990 and 1994.

Water samples from the three ponds in the Mancos Project had less than 1 to 3 µg/L of selenium in June 1994 (table 3). These concentrations were less than the aquatic-life criterion of 5 µg/L.

Dissolved-solids concentrations in stream samples associated with the Mancos Project (upstream from site MN4) ranged from 125 to 1,800 mg/L (table 2). The dissolved-solids concentrations were considerably lower than concentrations in the southern MVIC area, although both areas are irrigated on soils that are at least partly derived from Mancos Shale. Dissolved-solids concentrations were much higher in Navajo Wash than in the Mancos Project; the sample collected in March 1994 from site NW1 had a concentration of 8,490 mg/L. Dissolved-solids concentrations in the three water samples from ponds in the Mancos Project ranged from 544 to 671 mg/L (sites MNP1–MNP3 in table 3) and were considerably less than dissolved-solids concentrations in ponds in the Dove Creek area.

Soil and Bottom Sediment

The three soil samples collected adjacent to the pond-sampling sites (table 4) in the Mancos Project had selenium concentrations that exceeded the geometric mean of 0.23 µg/g for soils in the Western United States, and the sample from site MNP3 exceeded the upper baseline concentration of 1.4 µg/g (Shacklette and Boerngen, 1984). The soils in the irrigated area of the Mancos Project consist partly of gray soils derived from shale and other sedimentary material. The soil samples from the Mancos Project had higher selenium concentrations than the red soils in the Dove Creek area.

The selenium concentrations in bottom-sediment samples from ponds MNP2 and MNP3 exceeded the level of concern of 4 µg/g (Lemly and Smith, 1987) and also were higher than concentrations in bottom sediment from ponds in the Dove Creek area. The lower selenium concentration in bottom sediment from pond MNP1 compared to ponds MNP2 and MNP3 indicated that less selenium accumulation has occurred at this site. There was little vegetation around site MNP1, and the surficial material around the pond is quite rocky.

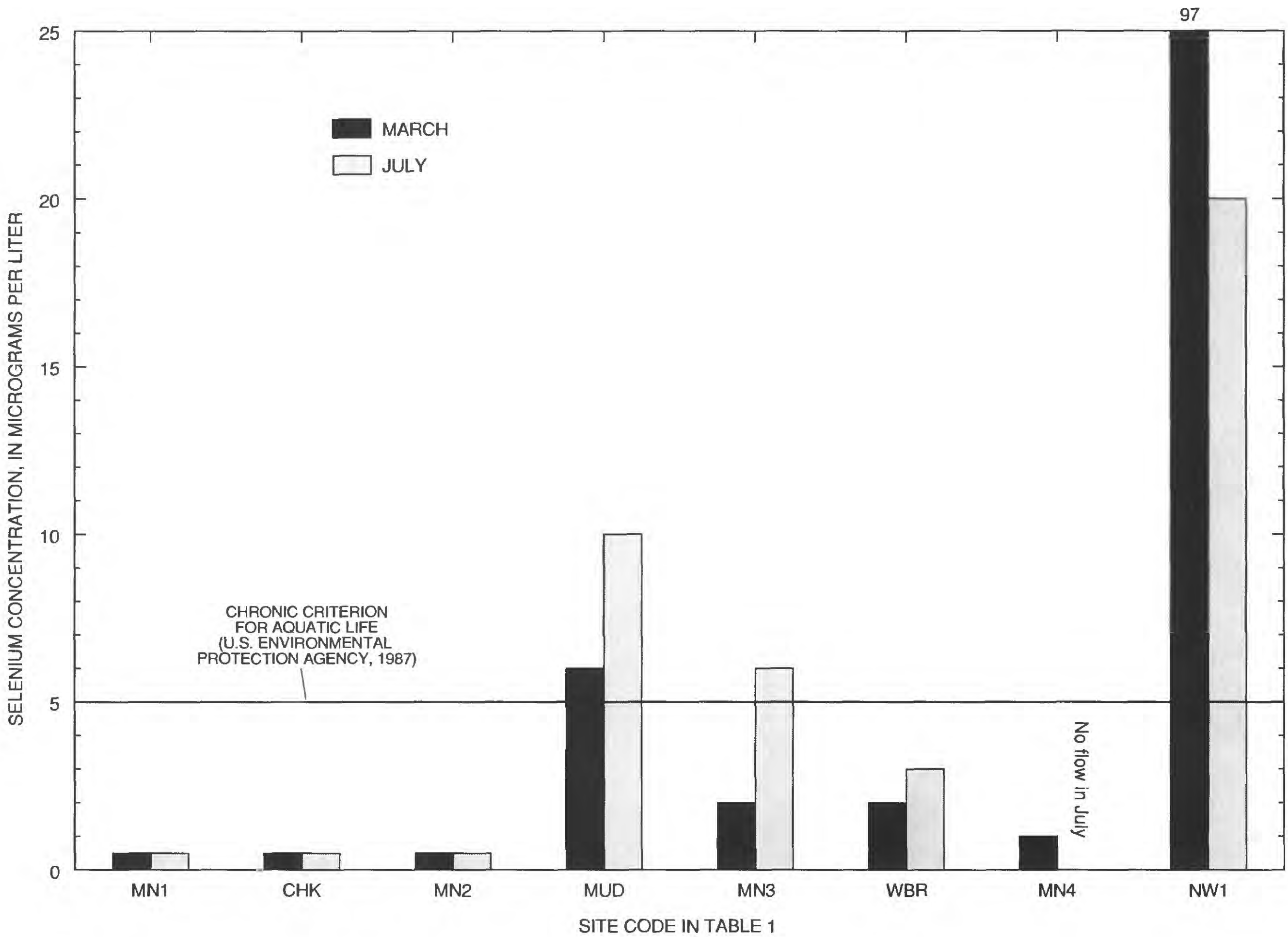

Figure 6. Selenium concentrations in water samples from streams in the Mancos River Basin, March and July 1994. Concentrations of less than 1 are plotted as 0.5.

Biota

Streams

Most selenium concentrations in biota samples from streams in the Mancos River Basin between sites MN1 and MNQ were relatively low when compared to guidelines (table 5; fig. 7). Most of the exceedances of selenium guidelines in biota samples from the upper Mancos River Basin were in samples from sites MUD, MN3, and WBR, which are downstream from irrigated areas on Mancos Shale. Selenium concentrations in aquatic invertebrates and in fish collected from Navajo Wash (site NW2) and from the Mancos River downstream from Navajo Wash (site MN5) exceeded the dietary guideline for fish and wildlife of 3 μg/g dry weight. Selenium concentrations in whole-body fish collected at sites NW2 and MN5 (fig. 7) also exceeded the guideline of 4 μg/g dry weight for protection of freshwater fisheries. The higher selenium concentrations in biota from Navajo Wash coincide with the high selenium concentrations in water samples from site NW1.

Ponds and Wetlands

Bird samples from site MNP2 contained elevated selenium concentrations (table 6) based on proposed guidelines, and those results were similar to data collected in 1989 at this site (Butler and others, 1995). The mean selenium concentration for 11 aquatic-bird-egg samples (excluding blackbirds) of about 8.3 μg/g dry weight exceeded the concentration of 3 μg/g dry weight, indicating possible contamination, and slightly exceeded the 8 μg/g dry weight threshold for reduced hatchability. The mean

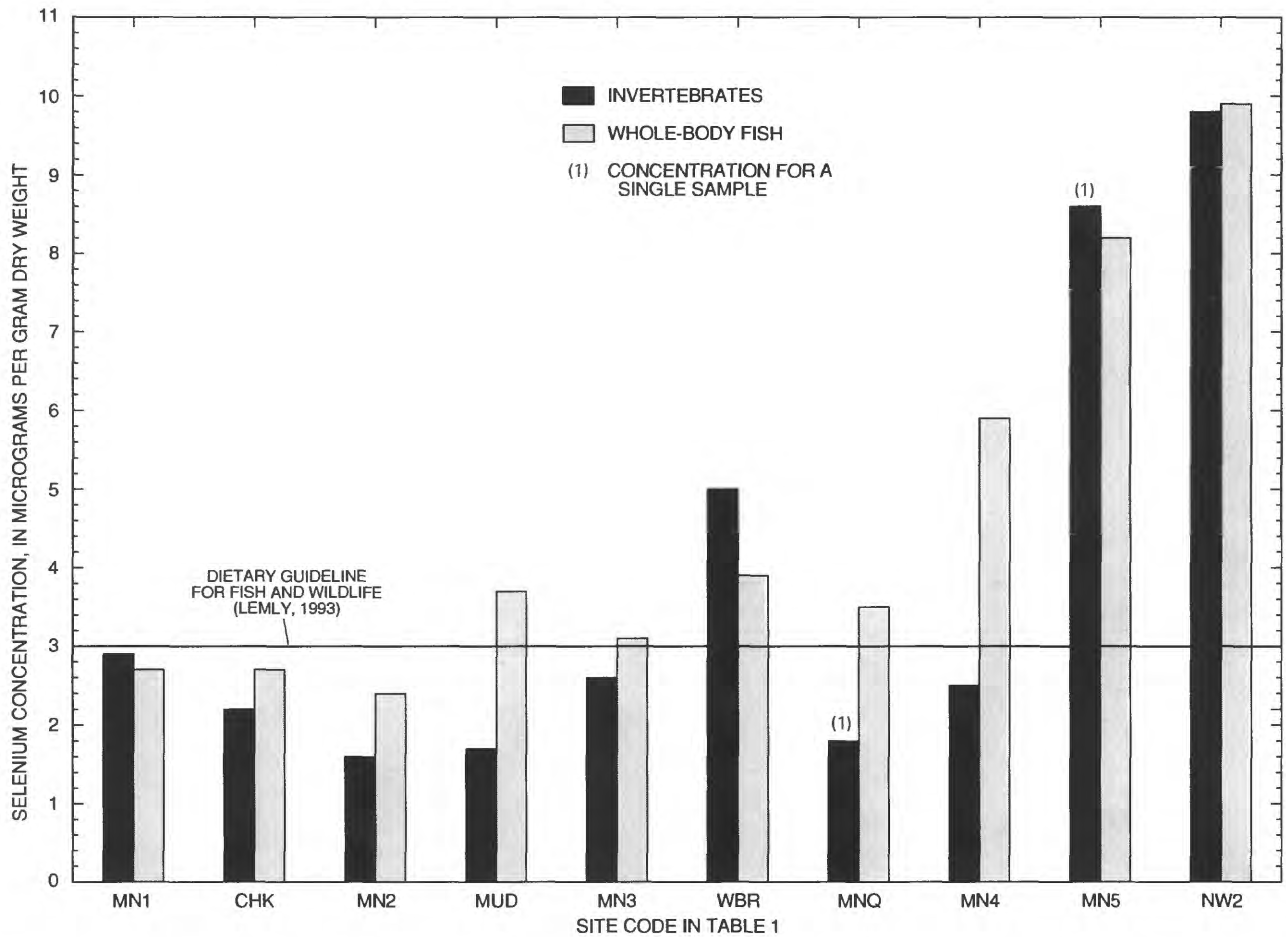

Figure 7. Geometric mean selenium concentrations in selected biota samples collected from streams in the Mancos River Basin, March and July 1994.

selenium concentration in five bird-liver samples (excluding blackbirds) of 32.6 µg/g dry weight exceeded a population mean concentration of 30 µg/g dry weight that is associated with reproductive impairment (Skorupa and Ohlendorf, 1991). Fish samples from sites MNP2 and MNP3 had selenium concentrations of 11 µg/g dry weight or greater, which exceeded the selenium guideline of 4 µg/g dry weight for whole-body fish. The biota samples from site MNP1 had relatively low selenium concentrations, which correlated with low selenium concentrations in water and bottom sediment at this site. Bioaccumulation of selenium at sites MNP2 and MNP3 seems more readily explained than bioaccumulation for the Dove Creek area because the selenium concentrations in the bottom sediment from sites MNP2 and MNP3 were elevated (table 4).

As done for ponds in the Dove Creek area, the protocol developed by Lemly (1995) was used to assess the selenium hazard for the three ponds in the Mancos Project (table 7). Site MNP1 was rated as having a minimal selenium hazard, whereas sites MNP2 and MNP3 were rated as having a high selenium hazard. As was the case for pond sites CHP and WCP in the Dove Creek area, reproduction was observed at pond and wetland areas in the Mancos Project that were rated as having a high selenium hazard. Aquatic-bird eggs and ducklings were collected at site MNP2, indicating that there was some successful bird reproduction at that site. The observed bird reproduction at site MNP2 does not substantiate the prediction of complete reproductive failure as indicated by a high hazard rating using the selenium-hazard assessment protocol. No deformities were found after examination of embryos that were at least one-half the way through incubation. Although hatching success was not determined, at least four separate broods of ducklings were observed in 1994 at the wetland area at site MNP2.

SUMMARY

In 1990, a reconnaissance investigation of the Dolores Project was done for the National Irrigation Water Quality Program. Results of that investigation indicated that some water and biota samples had elevated selenium concentrations, and some of those samples were collected from newly irrigated areas. Also, some bird-liver samples collected in 1989 by the USFWS in the Mancos Project had elevated selenium concentrations. Because results of those sampling efforts indicated potential selenium problems, additional field screenings were done in 1994 in the Dove Creek and MVIC (Montezuma Valley) areas of the Dolores Project and in the Mancos River Basin. Analytical results for samples collected in 1994 are tabulated in this report along with brief interpretative discussions of the data.

Selenium concentrations in water samples collected in 1994 indicated that selenium is mobilized in the newly (since 1987) irrigated Dove Creek area. Selenium was detected in 18 of 20 water samples collected from streams in the Dove Creek area in 1994, and concentrations ranged from less than 1 to 12 μg/L. Selenium concentrations in nine of these samples equaled or exceeded the U.S. Environmental Protection Agency chronic aquatic-life criterion of 5 μg/L. Selenium concentrations in water samples from six ponds ranged from less than 1 to 5 μg/L, and concentrations generally were lower in ponds than in streams in the same drainage basin.

Selenium concentrations in the newly irrigated Dove Creek area of the Dolores Project seem to be unique when compared to high selenium areas studied by NIWQP. Common factors have been identified in other areas that have potential selenium problems, but in general, those factors do not apply to the Dove Creek area. The selenium concentrations in water samples collected in 1994 in the Dove Creek area might be indicative of concentrations under initial leaching conditions, a factor not common to other NIWQP study areas.

Nine shallow samples of red soils from the Dove Creek area had low selenium concentrations that ranged from 0.13 to 0.20 μg/g. Despite low soil concentrations, there apparently is sufficient soluble or oxidizable selenium in the red soils to produce detectable selenium concentrations in irrigation drainage. Selenium concentrations in bottom-sediment samples from six ponds were less than the level of concern for fish and wildlife of 4 μg/g.

Many aquatic-invertebrate samples collected from streams in the Dove Creek area in 1994 had selenium concentrations greater than 3 μg/g dry weight, which is a dietary guideline for protection of fish and wildlife. Also, whole-body fish samples from two streams had selenium concentrations greater than the guideline of 4 μg/g dry weight for protection of freshwater fish.

Biota sampling in 1994 from ponds used by migratory birds in the Dove Creek area indicated elevated selenium concentrations in numerous biota samples. Most aquatic-plant samples from ponds had selenium concentrations less than 3 μg/g dry weight, but 12 of 14 aquatic-invertebrate samples had concentrations greater than the dietary guideline of 3 μg/g dry weight. The maximum selenium concentration in an invertebrate sample from Dove Creek area ponds was 19 μg/g dry weight in a sample from site CHP in Cahone Canyon. Salamanders also were collected at many Dove Creek area ponds, and selenium concentrations in those samples were similar to concentrations in amphibians from a reference site in another study. However, the three salamanders collected at site CHP in the Cahone Canyon Basin had selenium concentrations of 17 to 21 μg/g dry weight, which were similar to a possible toxic concentration of 20 μg/g for the most selenium-sensitive amphibians.

The mean selenium concentration of 10.3 μg/g dry weight for aquatic-bird eggs from Dove Creek area ponds exceeded the guideline for reduced hatchability of 8 μg/g dry weight, but was less than the teratogenesis threshold of 13 μg/g dry weight. The mean selenium concentration of about 25 μg/g dry weight in bird livers exceeded the no-effect concentration of 10 μg/g dry weight, but was less than the adverse effect threshold of 30 μg/g dry weight. Based on a new selenium-hazard assessment protocol, two ponds in the Dove Creek area had a low selenium hazard, two ponds had a moderate selenium hazard, and two ponds (one in the Cahone Canyon drainage and one in the Woods Canyon drainage) had a high selenium hazard. Some waterfowl reproduction was observed in 1994 at the sites assessed as having a high selenium hazard. That result does not substantiate the prediction of complete reproductive failure associated with a high hazard rating using the new selenium-hazard protocol.

The specific processes affecting selenium bioaccumulation in the Dove Creek area are not clearly understood. Selenium concentrations in the red soils and in bottom-sediment samples were low, and concentrations in surface-water samples were slightly elevated in some samples; however, selenium concentrations in numerous biota samples were elevated when compared to guidelines for protection of aquatic wildlife. The Dove Creek area provides an opportunity to measure selenium concentrations in a newly irrigated area and to assess changes in selenium over time.

Water and biota samples were collected in 1994 from three tributaries draining Mancos Shale areas in the southern MVIC area, south of Mc Elmo Creek, and water samples were collected at three sites on Mc Elmo Creek. Based on two sets of water samples, Mud Creek (southwest of Cortez) probably is the largest single selenium source to Mc Elmo Creek. Most biota samples from Mud Creek were elevated when compared to dietary and freshwater-fish guidelines.

Selenium concentrations in water samples collected in the irrigated area of the Mancos Project in 1994 ranged from less than 1 to 10 μg/L, and most concentrations did not exceed the chronic aquatic-life criterion of 5 μg/L. In March 1994, Mud Creek (west of the town of Mancos) accounted for about 74 percent of the selenium load in the upper Mancos River. Selenium concentrations in Navajo Wash, which drains the extreme southern part of the MVIC area and is a tributary to the lower Mancos River, were much higher than concentrations in the Mancos Project. Water samples collected from two sites on Navajo Wash in March 1994 had selenium concentrations of 170 and 97 μg/L. Three pondwater samples collected in irrigated areas of the Mancos Project had selenium concentrations of less than 1 to 3 μg/L.

Selenium concentrations in all soil samples and in most bottom-sediment samples from ponds were higher in the Mancos Project than in the Dove Creek area. Bottom-sediment samples from ponds MNP2 and MNP3, located in the eastern part of the Mancos Project, had selenium concentrations that exceeded the concentration of concern of 4 μg/g.

Most selenium concentrations in biota samples collected from streams in the upper Mancos River Basin were relatively low when compared to guidelines for diet items for fish and wildlife or for whole-body fish. The highest selenium concentrations in biota in the Mancos River Basin were in samples from Navajo Wash and from the Mancos River downstream from Navajo Wash. The high selenium concentrations in biota from Navajo Wash correlated with the high selenium concentrations in water samples from the wash.

The mean selenium concentration of about 8.3 μg/g dry weight in aquatic-bird eggs (excluding blackbirds) from three ponds located in irrigated areas of the Mancos Project exceeded the concentration of 3 μg/g dry weight, which indicates possible selenium contamination, and slightly exceeded the 8 μg/g dry weight concentration that might indicate reduced hatchability. Five bird livers had a mean selenium concentration of 32.6 μg/g dry weight, which exceeded the mean concentration of 30 μg/g dry weight that is associated with reproductive impairment. Using a new selenium-hazard assessment protocol, pond sites MNP2 and MNP3 were rated as having a high selenium hazard, and site MNP1 had a minimal selenium hazard. At least four broods of mallard ducklings were observed at site MNP2 in 1994. The observed bird reproduction at site MNP2 does not substantiate the prediction of complete reproductive failure associated with a high selenium-hazard rating.

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SUPPLEMENTAL DATA

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Table 2. Onsite measurements and chemical analyses of water samples collected at streams in the Dolores Project and the Mancos River Basin, 1994

[ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; MVIC, Montezuma Valley Irrigation Company; all chemical concentrations are for dissolved constituents; --, no data]

Site code (fig. 1)	Date	Time	Stream discharge (ft^3/s)	Specific conductance (µS/cm)	pH (standard units)	Water temperature (°C)	Dissolved oxygen (mg/L)	Dissolved oxygen (percent saturation)
DOLORES PROJECT—DOVE CREEK AREA								
DC2	04–05–94	1200	0.26	3,720	7.8	10.0	8.5	97
DC2	07–12–94	1030	.01	4,250	7.6	21.5	4.0	58
CCTR	04–06–94	0910	.17	4,300	8.1	2.0	10.5	97
CCTR	07–12–94	1235	1.5	784	8.5	18.0	8.1	108
CR2	04–06–94	0945	.40	4,150	8.1	2.0	10.6	98
CR2	07–12–94	1300	1.5	893	8.4	18.5	8.0	108
CH1	04–05–94	1330	.24	4,860	8.2	8.0	14.2	156
CH1	07–12–94	1510	.16	2,380	8.5	21.0	9.6	138
CH2	04–05–94	1500	.04	2,820	8.1	8.5	14.1	158
CH2	07–12–94	1610	.04	881	8.0	21.0	5.7	82
PV	04–06–94	1240	.02	1,780	8.0	4.0	9.4	92
PV	07–13–94	1130	.50	427	8.3	16.0	7.6	98
COW	04–06–94	1340	.09	1,320	8.1	8.5	12.1	132
COW	07–13–94	1015	<.01	1,020	7.9	13.5	5.5	67
SS	04–06–94	1510	.02	3,040	7.7	9.0	9.6	108
SS	07–13–94	0915	<.01	3,550	8.0	13.0	5.4	66
YJ1	04–05–94	1610	.12	2,550	8.0	7.5	12.4	134
YJ1	07–13–94	0720	.06	1,480	7.9	12.0	6.2	74
WC	04–06–94	1540	.18	2,440	8.1	9.5	8.6	97
WC	07–13–94	0825	.31	1,250	8.1	13.0	6.6	80

Site code (fig. 1)	Date	Hardness (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Alkalinity (mg/L)	Sulfate (mg/L)
DOLORES PROJECT—DOVE CREEK AREA—Continued								
DC2	04–05–94	1,900	390	230	230	7.2	302	1,600
DC2	07–12–94	2,100	480	210	270	5.3	416	1,600
CCTR	04–06–94	2,600	500	340	210	2.9	314	2,300
CCTR	07–12–94	340	71	40	26	1.7	118	250
CR2	04–06–94	2,400	520	270	200	2.7	302	2,100
CR2	07–12–94	390	87	43	31	1.6	121	300
CH1	04–05–94	2,800	430	430	330	4.1	314	2,800
CH1	07–12–94	1,100	180	170	140	4.8	231	1,100
CH2	04–05–94	1,500	250	210	200	1.8	425	1,200
CH2	07–12–94	380	80	43	32	7.7	181	240
PV	04–06–94	880	200	93	87	2.1	336	690
PV	07–13–94	180	49	14	13	1.6	130	78
COW	04–06–94	500	110	54	110	3.1	429	200
COW	07–13–94	400	94	40	70	2.3	326	190

Table 2. Onsite measurements and chemical analyses of water samples collected at streams in the Dolores Project and the Mancos River Basin, 1994—Continued

[ft³/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; MVIC, Montezuma Valley Irrigation Company; all chemical concentrations are for dissolved constituents; --, no data]

Site code (fig. 1)	Date	Hardness (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Alkalinity (mg/L)	Sulfate (mg/L)
				DOLORES PROJECT—DOVE CREEK AREA—Continued				
SS	04–06–94	1,700	350	190	160	4.7	538	1,200
SS	07–13–94	1,900	390	220	180	6.7	452	1,400
YJ1	04–05–94	1,500	410	120	99	2.1	276	1,300
YJ1	07–13–94	700	210	43	47	2.3	187	620
WC	04–06–94	1,200	280	130	150	2.8	385	920
WC	07–13–94	520	120	53	74	5.0	344	290

Site code (fig. 1)	Date	Chloride (mg/L)	Fluoride (mg/L)	Silica (mg/L)	Dissolved solids (mg/L)	Dissolved-solids discharge (tons per day)	Nitrite plus nitrate nitrogen (mg/L)	Selenium (µg/L)
				DOLORES PROJECT—DOVE CREEK AREA—Continued				
DC2	04–05–94	350	0.2	8.8	3,000	2.10	0.06	5
DC2	07–12–94	440	.1	22	3,280	.09	<.05	5
CCTR	04–06–94	250	.3	13	3,800	1.75	.07	8
CCTR	07–12–94	24	.2	6.7	490	2.03	<.05	1
CR2	04–06–94	270	.2	14	3,560	3.84	.06	7
CR2	07–12–94	32	.2	6.9	574	2.36	<.05	1
CH1	04–05–94	240	.3	8.7	4,440	2.87	.89	12
CH1	07–12–94	73	.2	13	1,820	.79	.13	9
CH2	04–05–94	86	.3	16	2,240	.24	4.2	8
CH2	07–12–94	21	.2	18	550	.06	<.05	3
PV	04–06–94	31	.3	16	1,350	.07	5.9	4
PV	07–13–94	5.2	.2	7.2	248	.33	.32	<1
COW	04–06–94	71	.5	18	841	.20	3.8	4
COW	07–13–94	30	.5	19	646	<.02	.99	3
SS	04–06–94	190	.2	12	2,430	.13	.14	1
SS	07–13–94	210	<.1	13	2,690	<.07	.13	<1
YJ1	04–05–94	32	.4	15	2,170	.70	6.9	9
YJ1	07–13–94	14	.3	14	1,080	.18	4.6	5
WC	04–06–94	110	.2	16	1,850	.90	2.2	4
WC	07–13–94	48	.2	22	820	.69	.26	2

Site code (fig. 1)	Date	Time	Stream discharge (ft³/s)	Specific conductance (µS/cm)	pH (standard units)	Water temperature (°C)	Dissolved oxygen (mg/L)	Dissolved oxygen (percent saturation)
				DOLORES PROJECT—MVIC AREA				
ME1B	03–22–94	1615	2.2	4,610	8.3	13.5	7.8	97
ME1B	07–06–94	1520	<.01	7,370	8.2	27.0	6.7	108
TRH	03–23–94	1330	.07	6,190	7.9	10.5	10.9	125
TRH	07–06–94	1430	.08	2,110	8.3	22.0	6.4	92
ME25	03–23–94	1435	9.9	3,500	8.1	11.5	8.3	96

Table 2. Onsite measurements and chemical analyses of water samples collected at streams in the Dolores Project and the Mancos River Basin, 1994—Continued

[ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; MVIC, Montezuma Valley Irrigation Company; all chemical concentrations are for dissolved constituents; --, no data]

Site code (fig. 1)	Date	Time	Stream discharge (ft^3/s)	Specific conductance (µS/cm)	pH (standard units)	Water temperature (°C)	Dissolved oxygen (mg/L)	Dissolved oxygen (percent saturation)
				DOLORES PROJECT—MVIC AREA—Continued				
ME25	07–07–94	1040	8.6	1,600	8.5	16.5	8.5	109
TR25	03–23–94	1145	.57	5,920	7.8	8.0	8.8	95
TR25	07–06–94	1320	.70	3,320	8.3	21.5	7.0	100
TRMUD	03–08–94	1130	.50	3,510	7.8	6.5	--	--
MUD2	03–23–94	0950	2.9	5,250	8.2	6.0	10.9	111
MUD2	07–07–94	0740	7.9	1,990	8.4	15.5	7.6	95
ME2B	03–23–94	0830	38	3,210	8.0	6.0	10.2	102
ME2B	07–07–94	0905	45	1,420	8.6	15.5	8.3	102
				MANCOS RIVER BASIN				
MN1	03–21–94	1420	35	433	7.7	8.0	9.0	98
MN1	07–05–94	1320	7.8	219	8.8	17.0	7.5	100
CHK	03–21–94	1530	4.1	1,370	7.8	10.5	8.6	99
CHK	07–05–94	1500	14	425	8.5	18.0	7.5	103
MN2	03–22–94	0820	39	579	7.8	2.0	10.9	102
MN2	07–05–94	1610	1.2	610	8.5	25.5	6.9	108

Site code (fig. 1)	Date	Hardness (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Alkalinity (mg/L)	Sulfate (mg/L)
				DOLORES PROJECT—MVIC AREA—Continued				
ME1B	03–22–94	2,300	360	340	430	5.7	265	2,800
ME1B	07–06–94	1,600	230	250	1,000	6.3	334	4,600
TRH	03–23–94	3,300	380	560	650	13	433	4,000
TRH	07–06–94	890	140	130	190	7.5	232	980
ME25	03–23–94	1,900	330	250	270	6.9	450	2,000
ME25	07–07–94	780	180	80	77	4.8	218	700
TR25	03–23–94	2,900	440	440	670	7.0	377	3,600
TR25	07–06–94	1,600	280	210	260	6.1	233	1,800
TRMUD	03–08–94	--	--	--	--	--	--	--
MUD2	03–23–94	2,600	400	380	530	7.9	356	3,100
MUD2	07–07–94	960	220	100	110	4.1	218	940
ME2B	03–23–94	1,800	340	220	220	6.3	265	1,800
ME2B	07–07–94	710	170	70	57	3.6	222	600
				MANCOS RIVER BASIN—Continued				
MN1	03–21–94	190	53	14	12	2.4	105	110
MN1	07–05–94	97	31	4.8	3.8	1.4	75	30
CHK	03–21–94	670	160	65	66	4.1	193	600
CHK	07–05–94	190	51	14	13	1.5	101	110
MN2	03–22–94	270	72	21	18	2.1	125	180
MN2	07–05–94	300	87	20	15	2.2	155	150

Table 2. Onsite measurements and chemical analyses of water samples collected at streams in the Dolores Project and the Mancos River Basin, 1994—Continued

[ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; MVIC, Montezuma Valley Irrigation Company; all chemical concentrations are for dissolved constituents; --, no data]

Site code (fig. 1)	Date	Chloride (mg/L)	Fluoride (mg/L)	Silica (mg/L)	Dissolved solids (mg/L)	Dissolved-solids discharge (tons per day)	Nitrite plus nitrate nitrogen (mg/L)	Selenium (µg/L)
				DOLORES PROJECT—MVIC AREA—Continued				
ME1B	03–22–94	56	0.4	7.1	4,160	25.0	<0.05	4
ME1B	07–06–94	120	.5	9.9	6,420	<.17	<.05	<1
TRH	03–23–94	68	.4	8.0	5,940	1.12	.68	<1
TRH	07–06–94	7.9	.3	11	1,610	.35	.07	<1
ME25	03–23–94	54	.4	9.0	3,200	85.8	2.3	2
ME25	07–07–94	17	.4	9.5	1,200	28.0	.84	<1
TR25	03–23–94	75	.5	9.7	5,530	8.52	15.0	5
TR25	07–06–94	29	.4	7.6	2,760	5.21	5.7	4
TRMUD	03–08–94	--	--	--	--	--	--	53
MUD2	03–23–94	92	.6	8.2	4,810	37.8	18.0	31
MUD2	07–07–94	19	.4	9.7	1,550	33.0	3.4	6
ME2B	03–23–94	45	.4	9.3	2,810	289	2.4	3
ME2B	07–07–94	13	.3	10	1,060	129	.34	<1
				MANCOS RIVER BASIN—Continued				
MN1	03–21–94	3.0	.1	8.9	266	25.2	<.05	<1
MN1	07–05–94	1.0	.2	8.3	125	2.64	<.05	<1
CHK	03–21–94	13	.2	10	1,030	11.4	<.05	<1
CHK	07–05–94	2.1	.1	7.9	260	9.97	<.05	<1
MN2	03–22–94	4.7	.1	8.6	381	40.6	<.05	<1
MN2	07–05–94	2.1	.2	9.2	379	1.24	<.05	<1

Site code (fig. 1)	Date	Time	Stream discharge (ft^3/s)	Specific conductance (µS/cm)	pH (standard units)	Water temperature (°C)	Dissolved oxygen (mg/L)	Dissolved oxygen (percent saturation)
				MANCOS RIVER BASIN—Continued				
MUD	03–22–94	0930	13	1,680	8.0	5.0	9.8	98
MUD	07–06–94	0735	4.9	1,540	8.4	12.0	7.7	91
MN3	03–22–94	1035	53	1,010	8.0	5.5	10.2	103
MN3	07–06–94	0845	8.9	1,680	8.4	13.0	8.3	100
WBR	03–21–94	1215	3.6	2,140	7.8	8.5	9.2	100
WBR	07–05–94	1120	1.6	2,280	8.2	16.0	8.2	106
MN4	03–22–94	1415	76	1,210	8.4	10.5	8.9	97
MN4	07–06–94	1400	.00	--	--	--	--	--
NWP	03–08–94	1200	--	3,860	8.1	10.5	--	--
NWB	03–08–94	1205	.50	9,920	7.9	9.5	--	--
NW1	03–22–94	1240	1.8	8,670	8.2	12.0	9.6	114
NW1	07–06–94	1040	4.5	1,600	8.4	16.0	8.2	102

Table 2. Onsite measurements and chemical analyses of water samples collected at streams in the Dolores Project and the Mancos River Basin, 1994—*Continued*

[ft^3/s, cubic feet per second; µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than; MVIC, Montezuma Valley Irrigation Company; all chemical concentrations are for dissolved constituents; --, no data]

Site code (fig. 1)	Date	Hardness (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Alkalinity (mg/L)	Sulfate (mg/L)
				MANCOS RIVER BASIN—Continued				
MUD	03–22–94	680	140	80	140	4.1	168	770
MUD	07–06–94	700	160	74	94	3.6	223	650
MN3	03–22–94	430	100	44	52	2.8	150	390
MN3	07–06–94	850	200	84	87	3.8	238	740
WBR	03–21–94	1,100	200	140	120	3.9	306	960
WBR	07–05–94	1,200	220	150	140	2.9	273	1,100
MN4	03–22–94	530	120	57	80	4.5	151	520
MN4	07–06–94	--	--	--	--	--	--	--
NWP	03–08–94	--	--	--	--	--	--	--
NWB	03–08–94	--	--	--	--	--	--	--
NW1	03–22–94	3,800	400	680	1,300	16	444	5,600
NW1	07–06–94	620	110	83	130	3.6	187	680

Site code (fig. 1)	Date	Chloride (mg/L)	Fluoride (mg/L)	Silica (mg/L)	Dissolved solids (mg/L)	Dissolved-solids discharge (tons per day)	Nitrite plus nitrate nitrogen (mg/L)	Selenium (µg/L)
				MANCOS RIVER BASIN—Continued				
MUD	03–22–94	19	0.2	9.0	1,260	44.4	0.26	6
MUD	07–06–94	13	.2	9.5	1,140	15.1	.30	10
MN3	03–22–94	9.0	.2	8.3	696	99.3	<.05	2
MN3	07–06–94	12	.2	9.8	1,280	30.6	.13	6
WBR	03–21–94	12	.3	13	1,640	15.9	.64	2
WBR	07–05–94	11	.2	13	1,800	7.69	.45	3
MN4	03–22–94	10	.2	8.4	891	184	.11	1
MN4	07–06–94	--	--	--	--	--	--	--
NWP	03–08–94	--	--	--	--	--	--	27
NWB	03–08–94	--	--	--	--	--	--	170
NW1	03–22–94	170	.5	7.5	8,490	40.6	11.0	97
NW1	07–06–94	20	.3	7.5	1,160	13.9	2.3	20

Table 3. Onsite measurements and chemical analyses of water samples collected at ponds in the Dolores Project and the Mancos River Basin, 1994

[µS/cm, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; mg/L, milligrams per liter; µg/L, micrograms per liter; all chemical concentrations are for dissolved constituents; --, no data; <, less than]

Site code (fig. 1)	Date	Time	Specific conductance (µS/cm)	pH (standard units)	Water temperature (°C)	Dissolved oxygen (mg/L)	Dissolved oxygen (percent saturation)	Hardness (mg/L)
				DOLORES PROJECT—DOVE CREEK AREA				
DCP1	06–13–94	1300	4,210	8.2	21.0	12.1	175	2,100
CHP	06–13–94	1630	4,030	8.8	22.0	14.0	208	2,100
LCHP1	06–14–94	0800	5,070	8.6	18.0	10.7	148	3,300
PVP1	06–14–94	1000	1,050	8.1	16.0	10.3	134	510
YJP	06–14–94	1330	2,370	8.0	22.0	5.7	85	1,200
WCP	06–14–94	1530	2,400	8.1	19.0	16.1	225	1,200
				MANCOS RIVER BASIN				
MNP1	06–15–94	1245	801	8.4	21.0	8.3	119	390
MNP2	06–15–94	0845	1,010	8.1	19.0	3.9	54	510
MNP3	06–15–94	1030	920	8.9	20.0	8.7	124	450

Site code (fig. 1)	Date	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Alkalinity (mg/L)	Sulfate (mg/L)	Chloride (mg/L)
				DOLORES PROJECT—DOVE CREEK AREA—Continued				
DCP1	06–13–94	360	290	280	7.5	218	1,900	390
CHP	06–13–94	310	330	290	1.6	80	2,200	220
LCHP1	06–14–94	350	600	300	6.4	171	3,400	140
PVP1	06–14–94	110	56	48	1.8	205	350	16
YJP	06–14–94	270	130	150	12	381	900	92
WCP	06–14–94	270	130	160	.80	406	890	93
				MANCOS RIVER BASIN—Continued				
MNP1	06–15–94	100	34	25	6.3	175	250	7.5
MNP2	06–15–94	77	78	44	3.7	369	210	8.1
MNP3	06–15–94	79	61	35	2.0	53	430	5.0

Site code (fig. 1)	Date	Fluoride (mg/L)	Silica (mg/L)	Dissolved solids (mg/L)	Nitrite plus nitrate nitrogen (mg/L)	Selenium (µg/L)
			DOLORES PROJECT—DOVE CREEK AREA—Continued			
DCP1	06–13–94	0.1	3.6	3,360	<0.05	2
CHP	06–13–94	<.1	1.8	3,400	<.05	5
LCHP1	06–14–94	<.1	1.1	4,900	<.05	<2
PVP1	06–14–94	.2	2.1	711	.89	2
YJP	06–14–94	.2	5.4	1,790	.17	<1
WCP	06–14–94	.2	20	1,810	.06	3
			MANCOS RIVER BASIN—Continued			
MNP1	06–15–94	.2	16	544	<.05	<1
MNP2	06–15–94	.6	28	671	<.05	3
MNP3	06–15–94	.2	2.3	646	<.05	1

Table 4. Selenium and mercury concentrations in bottom-sediment samples collected from ponds and selenium concentrations in shallow soil samples in the Dove Creek area of the Dolores Project and in the Mancos River Basin, 1994

[Analyses by U.S. Geological Survey Branch of Geochemistry; all concentrations in micrograms per gram; <, less than; --, not applicable; soil samples represent composites of shallow (less than 1-foot depth) soil cores collected adjacent to the site. Soil samples collected from nearby irrigated fields if available]

Site code (fig. 1)	Date	Bottom sediment from ponds		Soil samples
		Selenium	Mercury	Selenium
		DOVE CREEK AREA PONDS		
DCP1	06–13–94	2.1	<0.02	0.20
CHP	06–13–94	2.1	<.02	.18
LCHP1	06–14–94	1.1	<.02	.14
PVP1	06–14–94	1.4	<.02	.13
YJP	06–14–94	.65	.02	.14
WCP	06–14–94	3.2	<.02	.14
		MANCOS RIVER BASIN PONDS		
MNP1	06–15–94	.54	<.02	.41
MNP2	06–15–94	6.7	<.02	.70
MNP3	06–15–94	5.9	<.02	2.8
		MISCELLANEOUS SOIL SAMPLES, DOVE CREEK AREA		
CR2	07–12–94	--	--	.14
COW	07–13–94	--	--	.18
YJ1	07–13–94	--	--	.14

Table 5. Selenium concentrations in biological samples and mercury concentrations in selected fish samples collected from streams in the Dolores Project and the Mancos River Basin, 1994

[Mean length in millimeters; concentrations in micrograms per gram dry weight; comp., composite; inv., invertebrate; flmouth., flannelmouth; --. no data; MVIC, Montezuma Valley Irrigation Company]

Site code (fig. 1)	Matrix	Species	Date	Mean length	Number in sample	Percent moisture	Selenium	Mercury
			DOLORES PROJECT—DOVE CREEK AREA					
DC1	Aquatic plant	Algae	04–05–94	--	comp.	67.6	2.7	--
DC1	Aquatic plant	Algae	07–14–94	--	comp.	88.5	8.9	--
DC1	Aquatic plant	Watercress	04–05–94	--	comp.	86.9	3.8	--
DC1	Aquatic inv.	Composite	04–05–94	--	comp.	76.2	7.6	--
DC1	Aquatic inv.	Composite	07–14–94	--	comp.	74.7	14	--
DC2	Aquatic plant	Algae	04–05–94	--	comp.	73.1	1.2	--
DC2	Aquatic inv.	Composite	04–05–94	--	comp.	73.8	6.5	--
CCTR	Aquatic plant	Algae	04–06–94	--	comp.	76.7	1.7	--
CCTR	Aquatic plant	Algae	07–14–94	--	comp.	90.5	1.8	--
CCTR	Aquatic plant	Potamogeton	07–14–94	--	comp.	83.2	1.1	--
CCTR	Aquatic plant	Zanichellia	07–14–94	--	comp.	90.2	1.5	--
CCTR	Aquatic inv.	Composite	04–06–94	--	comp.	76.8	10	--
CCTR	Aquatic inv.	Composite	07–14–94	--	comp.	79.4	8.4	--

Table 5. Selenium concentrations in biological samples and mercury concentrations in selected fish samples collected from streams in the Dolores Project and the Mancos River Basin, 1994—Continued

[Mean length in millimeters; concentrations in micrograms per gram dry weight; comp., composite; inv., invertebrate; flmouth., flannelmouth; --. no data; MVIC, Montezuma Valley Irrigation Company]

Site code (fig. 1)	Matrix	Species	Date	Mean length	Number in sample	Percent moisture	Selenium	Mercury
			DOLORES PROJECT—DOVE CREEK AREA—Continued					
CR2	Aquatic plant	Algae	07–14–94	--	comp.	76.6	0.98	--
CR2	Aquatic plant	Potamogeton	07–14–94	--	comp.	82.4	.83	--
CR2	Aquatic inv.	Composite	04–06–94	--	comp.	81.3	11	--
CR2	Aquatic inv.	Composite	07–14–94	--	comp.	76.3	4.4	--
CH1	Aquatic plant	Algae	04–05–94	--	comp.	87.9	1.7	--
CH1	Aquatic plant	Algae	07–13–94	--	comp.	89.2	2.4	--
CH1	Aquatic plant	Potamogeton	07–13–94	--	comp.	93.3	1.5	--
CH1	Aquatic inv.	Composite	04–05–94	--	comp.	84.8	9.1	--
CH1	Aquatic inv.	Composite	07–13–94	--	comp.	73.6	5.9	--
CH1	Amphibian	Salamander	07–13–94	86	1	88.6	10	--
CH1	Fish, whole body	Green sunfish	07–13–94	110	1	71.9	9.5	--
CH2	Aquatic plant	Algae	04–05–94	--	comp.	93.4	1.2	--
CH2	Aquatic plant	Algae	07–13–94	--	comp.	82.3	2.3	--
CH2	Aquatic plant	Watercress	04–05–94	--	comp.	92.1	5.1	--
CH2	Aquatic inv.	Composite	04–05–94	--	comp.	71.7	23	--
CH2	Aquatic inv.	Composite	07–13–94	--	comp.	73.0	6.2	--
PV	Aquatic plant	Algae	04–06–94	--	comp.	89.6	4.2	--
PV	Aquatic plant	Watercress	04–06–94	--	comp.	91.8	2.7	--
PV	Aquatic plant	Buttercup	07–13–94	--	comp.	90.1	6.3	--
PV	Aquatic inv.	Composite	04–06–94	--	comp.	75.1	3.4	--
PV	Aquatic inv.	Composite	07–13–94	--	comp.	79.4	4.7	--
COW	Aquatic plant	Algae	04–06–94	--	comp.	75.1	1.5	--
COW	Aquatic plant	Algae	07–13–94	--	comp.	89.5	1.4	--
COW	Aquatic inv.	Composite	04–06–94	--	comp.	72.0	6.6	--
COW	Aquatic inv.	Composite	07–13–94	--	comp.	66.7	8.7	--
YJ1	Aquatic plant	Algae	07–13–94	--	comp.	79.5	1.6	--
YJ1	Aquatic plant	Algae	07–13–94	--	comp.	77.0	2.1	--
YJ1	Aquatic plant	Watercress	04–05–94	--	comp.	91.6	2.0	--
YJ1	Aquatic plant	Watercress	07–13–94	--	comp.	92.4	1.8	--
YJ1	Aquatic inv.	Composite	04–05–94	--	comp.	74.3	5.0	--
YJ1	Aquatic inv.	Composite	07–13–94	--	comp.	66.1	7.0	--
WC	Aquatic plant	Algae	04–06–94	--	comp.	78.5	2.9	--
WC	Aquatic plant	Watercress	04–06–94	--	comp.	90.5	1.8	--
WC	Aquatic inv.	Composite	04–06–94	--	comp.	71.4	4.5	--
WC	Aquatic inv.	Snail	04–06–94	--	comp.	62.4	1.6	--
WC	Fish, whole body	Fathead minnow	04–06–94	72	5	77.4	11	--
WC	Fish, whole body	Fathead minnow	04–06–94	70	5	76.8	11	--

Table 5. Selenium concentrations in biological samples and mercury concentrations in selected fish samples collected from streams in the Dolores Project and the Mancos River Basin, 1994–Continued

[Mean length in millimeters; concentrations in micrograms per gram dry weight; comp., composite; inv., invertebrate; flmouth., flannelmouth; --, no data; MVIC, Montezuma Valley Irrigation Company]

Site code (fig. 1)	Matrix	Species	Date	Mean length	Number in sample	Percent moisture	Selenium	Mercury
			DOLORES PROJECT—MVIC AREA					
TRH	Aquatic plant	Algae	03–24–94	--	comp.	67.5	1.2	--
TRH	Aquatic plant	Algae	07–13–94	--	comp.	90.1	1.3	--
TRH	Aquatic plant	Watercress	03–24–94	--	comp.	91.1	1.5	--
TRH	Aquatic inv.	Composite	03–24–94	--	comp.	81.3	2.7	--
TRH	Aquatic inv.	Crayfish	07–13–94	89	4	70.9	.98	--
TRH	Aquatic inv.	Crayfish	07–13–94	--	1	80.0	1.6	--
TRH	Fish, whole body	Fathead minnow	03–24–94	61	5	77.9	4.3	--
TRH	Fish, whole body	Fathead minnow	03–24–94	54	5	78.7	4.2	--
TRH	Fish, whole body	Fathead minnow	07–13–94	61	2	74.5	3.0	--
TRH	Fish, whole body	Fathead minnow	07–13–94	25	40	81.3	2.2	--
TRH	Fish, whole body	Green sunfish	07–13–94	80	1	73.4	3.3	--
TR25	Aquatic plant	Algae	03–24–94	--	comp.	69.7	1.4	--
TR25	Aquatic plant	Zanichellia	07–13–94	--	comp.	90.7	1.2	--
TR25	Aquatic plant	Ceratophyllum	07–13–94	--	comp.	85.1	1.0	--
TR25	Aquatic inv.	Composite	07–13–94	--	comp.	75.9	2.0	--
TR25	Aquatic inv.	Crayfish	07–13–94	69	2	74.1	1.6	--
TR25	Fish, whole body	Fathead minnow	03–24–94	59	5	76.2	4.0	--
TR25	Fish, whole body	Fathead minnow	07–13–94	78	5	76.9	5.2	--
TR25	Fish, whole body	Fathead minnow	07–13–94	78	5	77.1	6.0	--
TR25	Fish, whole body	Green sunfish	07–13–94	68	1	77.0	4.4	--
MUD2	Aquatic plant	Algae	03–24–94	--	comp.	72.4	1.4	--
MUD2	Aquatic plant	Algae	07–13–94	--	comp.	61.0	1.2	--
MUD2	Aquatic inv.	Crayfish	03–24–94	80	5	73.7	3.1	--
MUD2	Aquatic inv.	Crayfish	07–13–94	71	5	77.2	3.8	--
MUD2	Fish, whole body	Fathead minnow	03–24–94	66	5	76.3	7.7	--
MUD2	Fish, whole body	Fathead minnow	03–24–94	70	5	75.7	12	--
MUD2	Fish, whole body	Fathead minnow	07–13–94	60	5	73.9	6.5	--
MUD2	Fish, whole body	Bluehead sucker	03–24–94	63	5	77.4	2.5	--
MUD2	Fish, whole body	Bluehead sucker	07–13–94	195	1	75.0	5.6	--
MUD2	Fish, whole body	Bluehead sucker	07–13–94	97	4	73.6	5.2	--
MUD2	Fish, whole body	Green sunfish	03–24–94	--	1	76.5	7.6	--
MUD2	Fish, whole body	Green sunfish	07–13–94	60	1	77.7	7.0	--
			MANCOS RIVER BASIN					
MN1	Aquatic plant	Algae	03–22–94	--	comp.	76.0	.82	--
MN1	Aquatic plant	Algae	07–11–94	--	comp.	76.9	.60	--
MN1	Aquatic plant	Moss	07–11–94	--	comp.	84.4	1.4	--
MN1	Aquatic inv.	Composite	03–22–94	--	comp.	81.3	2.8	--
MN1	Aquatic inv.	Composite	07–11–94	--	comp.	76.3	3.0	--
MN1	Fish, whole body	Mottled sculpin	03–22–94	109	5	78.1	3.4	--
MN1	Fish, whole body	Mottled sculpin	07–11–94	99	5	76.9	3.2	--
MN1	Fish, whole body	Speckled dace	03–22–94	97	2	72.9	3.7	--

Table 5. Selenium concentrations in biological samples and mercury concentrations in selected fish samples collected from streams in the Dolores Project and the Mancos River Basin, 1994—Continued

[Mean length in millimeters; concentrations in micrograms per gram dry weight; comp., composite; inv., invertebrate; flmouth., flannelmouth; --, no data; MVIC, Montezuma Valley Irrigation Company]

Site code (fig. 1)	Matrix	Species	Date	Mean length	Number in sample	Percent moisture	Selenium	Mercury
			MANCOS RIVER BASIN—Continued					
MN1	Fish, whole body	Bluehead sucker	07–11–94	215	2	75.9	1.4	--
MN1	Fish, whole body	Rainbow trout	03–22–94	212	1	76.5	2.6	0.19
MN1	Fish, whole body	Rainbow trout	03–22–94	204	5	77.3	2.5	--
MN1	Fish, whole body	Rainbow trout	07–11–94	229	5	77.0	3.2	--
MN1	Fish, whole body	Brook trout	07–11–94	185	1	73.9	2.2	--
CHK	Aquatic plant	Algae	03–23–94	--	comp.	84.8	1.4	--
CHK	Aquatic plant	Algae	07–12–94	--	comp.	78.2	.98	--
CHK	Aquatic inv.	Composite	03–23–94	--	comp.	78.8	4.8	--
CHK	Aquatic inv.	Composite	07–12–94	--	comp.	72.2	2.4	--
CHK	Aquatic inv.	Crayfish	03–23–94	--	comp.	72.0	.90	--
CHK	Fish, whole body	Mottled sculpin	03–23–94	107	5	77.5	4.4	--
CHK	Fish, whole body	Mottled sculpin	07–12–94	116	5	73.5	3.1	--
CHK	Fish, whole body	Speckled dace	03–23–94	85	1	70.5	5.2	--
CHK	Fish, whole body	Speckled dace	07–12–94	115	1	72.3	3.8	--
CHK	Fish, whole body	Bluehead sucker	03–23–94	290	1	72.7	1.6	--
CHK	Fish, whole body	Bluehead sucker	07–12–94	266	4	70.6	1.2	--
CHK	Fish, whole body	Rainbow trout	03–23–94	390	1	75.3	2.2	.21
CHK	Fish, whole body	Rainbow trout	03–23–94	290	5	73.9	2.5	--
CHK	Fish, whole body	Rainbow trout	07–12–94	187	5	74.7	2.9	--
CHK	Fish, whole body	Rainbow trout	07–12–94	275	1	76.6	2.8	--
CHK	Fish, liver	Rainbow trout	07–12–94	300	1	73.4	20	--
CHK	Fish, fillet	Rainbow trout	07–12–94	300	1	78.0	1.8	.17
MN2	Aquatic plant	Algae	03–23–94	--	comp.	77.8	.64	--
MN2	Aquatic plant	Algae	07–12–94	--	comp.	79.7	.93	--
MN2	Aquatic plant	Watercress	03–23–94	--	comp.	79.5	.78	--
MN2	Aquatic inv.	Composite	03–23–94	--	comp.	77.6	2.2	--
MN2	Aquatic inv.	Composite	07–12–94	--	comp.	84.0	2.3	--
MN2	Aquatic inv.	Crayfish	07–12–94	78	5	77.7	.83	--
MN2	Fish, whole body	Mottled sculpin	07–12–94	78	2	73.7	2.6	--
MN2	Fish, whole body	Speckled dace	03–23–94	97	5	73.9	2.7	--
MN2	Fish, whole body	Speckled dace	07–12–94	87	5	73.6	3.6	--
MN2	Fish, whole body	Bluehead sucker	07–12–94	218	5	74.9	1.2	--
MN2	Fish, whole body	Rainbow trout	03–23–94	435	1	72.9	2.8	.20
MN2	Fish, whole body	Rainbow trout	03–23–94	335	3	70.9	2.1	--
MN2	Fish, liver	Rainbow trout	03–23–94	400	2	75.6	18	--
MUD	Aquatic plant	Algae	07–12–94	--	comp.	63.9	1.5	--
MUD	Aquatic inv.	Composite	07–12–94	--	comp.	71.9	4.3	--
MUD	Aquatic inv.	Crayfish	03–24–94	--	comp.	76.0	1.2	--
MUD	Aquatic inv.	Crayfish	07–12–94	76	5	73.9	2.3	--
MUD	Fish, whole body	Speckled dace	03–24–94	77	5	70.6	7.2	--
MUD	Fish, whole body	Speckled dace	07–12–94	82	5	70.8	6.1	--

Table 5. Selenium concentrations in biological samples and mercury concentrations in selected fish samples collected from streams in the Dolores Project and the Mancos River Basin, 1994—Continued

[Mean length in millimeters; concentrations in micrograms per gram dry weight; comp., composite; inv., invertebrate; flmouth., flannelmouth; --, no data; MVIC, Montezuma Valley Irrigation Company]

Site code (fig. 1)	Matrix	Species	Date	Mean length	Number in sample	Percent moisture	Selenium	Mercury
			MANCOS RIVER BASIN—Continued					
MUD	Fish, whole body	Flmouth. sucker	03–24–94	45	5	76.4	4.1	--
MUD	Fish, whole body	Flmouth. sucker	07–12–94	436	3	71.1	2.7	--
MUD	Fish, whole body	Bluehead sucker	03–24–94	219	1	71.0	2.3	--
MUD	Fish, whole body	Bluehead sucker	07–12–94	146	5	68.4	1.8	--
MUD	Fish, whole body	Roundtail chub	07–12–94	104	3	77.8	4.6	--
MN3	Aquatic plant	Algae	07–12–94	--	comp.	68.1	2.4	--
MN3	Aquatic inv.	Composite	03–23–94	--	comp.	73.7	3.3	--
MN3	Aquatic inv.	Composite	07–12–94	--	comp.	78.2	4.0	--
MN3	Aquatic inv.	Crayfish	03–23–94	--	2	74.1	1.7	--
MN3	Aquatic inv.	Crayfish	07–12–94	59	5	72.7	2.1	--
MN3	Fish, whole body	Speckled dace	03–23–94	89	5	73.2	6.0	--
MN3	Fish, whole body	Speckled dace	07–12–94	88	5	68.7	4.3	--
MN3	Fish, whole body	Flmouth. sucker	03–23–94	470	3	69.9	2.3	--
MN3	Fish, whole body	Flmouth. sucker	07–12–94	453	3	70.7	2.6	--
MN3	Fish, whole body	Bluehead sucker	03–23–94	275	1	73.7	1.5	--
MN3	Fish, whole body	Rainbow trout	07–12–94	200	1	70.1	2.6	--
MN3	Fish, whole body	Rainbow trout	07–12–94	368	1	67.9	4.9	--
MN3	Fish, liver	Rainbow trout	07–12–94	387	1	71.6	79	--
MN3	Fish, fillet	Rainbow trout	07–12–94	387	1	71.5	2.9	0.36
WBR	Aquatic plant	Algae	07–11–94	--	comp.	76.2	.95	--
WBR	Aquatic plant	Potamogeton	07–11–94	--	comp.	85.1	1.0	--
WBR	Aquatic inv.	Composite	03–23–94	--	comp.	73.1	5.7	--
WBR	Aquatic inv.	Composite	07–11–94	--	comp.	80.1	4.4	--
WBR	Fish, whole body	Speckled dace	03–23–94	99	5	73.6	9.7	--
WBR	Fish, whole body	Speckled dace	07–11–94	119	5	71.5	5.5	--
WBR	Fish, whole body	Bluehead sucker	03–23–94	245	1	75.7	2.8	--
WBR	Fish, whole body	Bluehead sucker	07–11–94	154	4	70.9	1.8	--
WBR	Fish, whole body	Rainbow trout	07–11–94	263	2	72.6	5.1	--
MNQ	Aquatic inv.	Crayfish	07–19–94	73	5	72.9	1.8	--
MNQ	Fish, whole body	Speckled dace	07–19–94	76	13	69.9	5.9	--
MNQ	Fish, whole body	Flmouth. sucker	07–19–94	95	2	77.8	3.2	--
MNQ	Fish, whole body	Flmouth. sucker	07–19–94	452	1	65.8	2.1	.46
MNQ	Fish, whole body	Flmouth. sucker	07–19–94	102	4	76.5	3.5	--
MN4	Aquatic inv.	Composite	07–19–94	--	comp.	74.2	3.4	--
MN4	Aquatic inv.	Crayfish	07–19–94	69	5	75.7	1.9	--
MN4	Fish, whole body	Speckled dace	07–19–94	88	5	73.5	7.9	--
MN4	Fish, whole body	Red shiners	07–19–94	68	4	74.2	4.2	--
MN4	Fish, whole body	Flmouth. sucker	07–19–94	191	5	80.2	5.1	--
MN4	Fish, whole body	Flmouth. sucker	07–19–94	366	1	79.9	9.6	.37
MN4	Fish, whole body	Channel catfish	07–19–94	360	1	80.0	4.2	1.1

Table 5. Selenium concentrations in biological samples and mercury concentrations in selected fish samples collected from streams in the Dolores Project and the Mancos River Basin, 1994–Continued

[Mean length in millimeters; concentrations in micrograms per gram dry weight; comp., composite; inv., invertebrate; flmouth., flannelmouth; --. no data; MVIC, Montezuma Valley Irrigation Company]

Site code (fig. 1)	Matrix	Species	Date	Mean length	Number in sample	Percent moisture	Selenium	Mercury
			MANCOS RIVER BASIN—Continued					
MN5	Aquatic inv.	Crayfish	07–20–94	32	9	82.3	8.6	--
MN5	Fish, whole body	Fathead minnow	07–20–94	61	8	81.8	7.3	--
MN5	Fish, whole body	Speckled dace	07–20–94	49	1	79.4	14	--
MN5	Fish, whole body	Red shiner	07–20–94	61	3	77.3	4.4	--
MN5	Fish, whole body	Flmouth. sucker	07–20–94	132	6	78.1	8.4	--
MN5	Fish, whole body	Common carp	07–20–94	102	1	80.8	16	--
MN5	Fish, whole body	Channel catfish	07–20–94	335	1	76.4	5.0	0.40
NW2	Aquatic plant	Algae	07–20–94	--	comp.	52.7	1.8	--
NW2	Aquatic inv.	Composite	07–20–94	--	comp.	80.7	17	--
NW2	Aquatic inv.	Crayfish	07–20–94	62	4	73.7	5.8	--
NW2	Fish, whole body	Speckled dace	07–20–94	72	5	73.3	11	--
NW2	Fish, whole body	Flmouth.sucker	07–20–94	124	5	74.2	11	--
NW2	Fish, whole body	Flmouth.sucker	07–20–94	118	3	73.7	11	--
NW2	Fish, whole body	Roundtail chub	07–20–94	80	1	75.9	6.9	--

Table 6. Selenium concentrations in biological samples and mercury concentrations in selected bird-tissue samples collected at ponds in the Dolores Project and the Mancos River Basin, 1994

[Mean length in millimeters; concentrations in micrograms per gram dry weight; comp., composite; inv., invertebrate; all egg, liver, and muscle samples are from birds; --, no data]

Site code (fig. 1)	Matrix	Species	Date	Mean length	Number in sample	Percent moisture	Selenium	Mercury
			DOLORES PROJECT—DOVE CREEK AREA					
DCP1	Aquatic plant	Algae	06–13–94	--	comp.	94.3	1.0	--
DCP1	Aquatic plant	Potamogeton	06–13–94	--	comp.	88.2	1.9	--
DCP1	Aquatic inv.	Composite	06–13–94	--	comp.	82.6	9.4	--
DCP1	Aquatic inv.	Snail	06–13–94	--	comp.	86.9	3.5	--
DCP1	Amphibian	Salamander	06–13–94	210	1	82.6	9.6	--
DCP1	Amphibian	Salamander	06–13–94	193	2	80.8	12	--
DCP1	Amphibian	Salamander	06–13–94	173	2	80.8	12	--
DCP1	Eggs	Red-winged blackbird	06–02–94	--	4	82.4	4.2	--
DCP1	Eggs	Red-winged blackbird	06–02–94	--	4	82.6	5.3	--
DCP1	Eggs	Red-winged blackbird	06–02–94	--	3	85.0	4.8	--
DCP1	Eggs	American coot	06–02–94	--	2	75.4	8.2	0.31
DCP1	Eggs	American coot	06–02–94	--	2	75.9	18	.36
DCP1	Eggs	American coot	06–02–94	--	1	74.2	8.6	--
DCP1	Eggs	American coot	06–07–94	--	2	74.0	9.7	--

Table 6. Selenium concentrations in biological samples and mercury concentrations in selected bird-tissue samples collected at ponds in the Dolores Project and the Mancos River Basin, 1994—Continued

[Mean length in millimeters; concentrations in micrograms per gram dry weight; comp., composite; inv., invertebrate; all egg, liver, and muscle samples are from birds; --, no data]

Site code (fig. 1)	Matrix	Species	Date	Mean length	Number in sample	Percent moisture	Selenium	Mercury
		DOLORES PROJECT—DOVE CREEK AREA—Continued						
DCP1	Eggs	American coot	06–07–94	--	2	75.4	8.7	--
DCP1	Liver	American coot, adult	06–02–94	--	1	69.9	29	--
DCP1	Liver	American coot, adult	06–02–94	--	1	71.8	25	--
DCP1	Liver	Mallard, young	06–02–94	--	1	71.9	45	--
DCP1	Liver	Mallard, young	06–02–94	--	1	71.3	32	--
DCP1	Liver	Mallard, young	06–02–94	--	1	70.6	27	--
DCP1	Liver	Mallard, young	06–30–94	--	1	72.9	27	--
DCP1	Liver	Mallard, young	06–30–94	--	1	71.3	22	--
DCP1	Muscle	Mallard, young	06–30–94	--	1	79.1	9.2	0.68
DCP1	Muscle	Mallard, young	06–30–94	--	1	79.8	8.9	.62
DCP1	Muscle, leg	Mallard, young	06–30–94	--	1	77.1	9.2	.75
DCP2	Bird, whole body	Red-winged blackbird, young	06–07–94	--	2	74.9	8.6	--
DCP3	Aquatic plant	Potamogeton	06–16–94	--	comp.	91.0	2.1	--
DCP3	Aquatic inv.	Composite	06–16–94	--	comp.	81.6	7.2	--
DCP3	Amphibian	Salamander	06–16–94	--	2	89.5	8.7	--
DCP3	Eggs	Cinnamon teal	06–16–94	--	2	68.4	5.7	.46
DCP3	Eggs	Cinnamon teal	06–16–94	--	1	67.6	6.1	.40
DCP3	Liver	Mallard, young	06–16–94	--	1	72.6	16	--
CHP	Aquatic plant	Algae	06–13–94	--	comp.	86.2	4.0	--
CHP	Aquatic plant	Potamogeton	06–13–94	--	comp.	87.3	3.5	--
CHP	Aquatic inv.	Composite	06–13–94	--	comp.	76.3	5.0	--
CHP	Aquatic inv.	Snail	06–13–94	--	comp.	82.2	19	--
CHP	Amphibian	Salamander	06–13–94	--	1	77.2	19	--
CHP	Amphibian	Salamander	06–13–94	--	1	80.6	21	--
CHP	Amphibian	Salamander	06–13–94	--	3	82.6	17	--
CHP	Eggs	Red-winged blackbird	06–03–94	--	4	83.8	7.7	--
CHP	Eggs	Red-winged blackbird	06–03–94	--	3	82.8	5.8	--
CHP	Eggs	Red-winged blackbird	06–03–94	--	4	84.4	9.9	--
CHP	Eggs	Red-winged blackbird	06–03–94	--	3	81.1	7.1	--
CHP	Eggs	Cinnamon teal	06–09–94	--	2	68.3	20	.16
CHP	Liver	Mallard, young	06–10–94	--	1	72.8	67	--
CHP	Liver	Mallard, young	06–10–94	--	1	74.9	60	--
LCHP1	Aquatic plant	Algae	06–13–94	--	comp.	96.1	.33	--
LCHP1	Aquatic plant	Ceratophyllum	06–13–94	--	comp.	91.8	.54	--
LCHP1	Aquatic inv.	Composite	06–13–94	--	comp.	87.0	3.5	--
LCHP1	Aquatic inv.	Snails	06–13–94	--	comp.	81.3	.32	--

Table 6. Selenium concentrations in biological samples and mercury concentrations in selected bird-tissue samples collected at ponds in the Dolores Project and the Mancos River Basin, 1994—Continued

[Mean length in millimeters; concentrations in micrograms per gram dry weight; comp., composite; inv., invertebrate; all egg, liver, and muscle samples are from birds; --, no data]

Site code (fig. 1)	Matrix	Species	Date	Mean length	Number in sample	Percent moisture	Selenium	Mercury
		DOLORES PROJECT--DOVE CREEK AREA—Continued						
LCHP1	Amphibian	Salamander	06–14–94	--	5	89.2	2.0	--
LCHP1	Amphibian	Salamander	06–14–94	--	5	86.9	2.0	--
LCHP1	Eggs	Red-winged blackbird	06–02–94	--	4	81.1	2.9	--
LCHP1	Eggs	Red-winged blackbird	06–09–94	--	4	82.4	3.0	--
LCHP1	Eggs	Red-winged blackbird	06–09–94	--	4	83.3	3.0	--
LCHP1	Liver	Mallard, young	06–14–94	--	1	70.5	8.3	--
LCHP1	Liver	Mallard, young	06–14–94	--	1	70.2	7.8	--
LCHP1	Liver	Mallard, young	06–30–94	--	1	71.9	8.7	--
LCHP1	Liver	Mallard, young	06–30–94	--	1	71.8	9.8	--
LCHP1	Liver	Mallard, young	06–30–94	--	1	71.3	13	--
LCHP1	Liver	Mallard, young	06–30–94	--	1	71.4	16	--
LCHP1	Muscle	Mallard, young	06–30–94	--	1	79.7	3.2	0.47
LCHP2	Aquatic plant	Algae	06–30–94	--	comp.	81.9	2.5	--
LCHP2	Aquatic plant	Ceratophyllum	06–30–94	--	comp.	86.6	2.6	--
LCHP2	Aquatic plant	Ceratophyllum	06–30–94	--	comp.	89.0	2.7	--
LCHP2	Aquatic inv.	Composite	06–30–94	--	comp.	80.9	6.7	--
LCHP2	Amphibian	Salamander	06–30–94	--	comp.	87.1	9.0	--
LCHP2	Bird, whole body	Red-winged blackbird, young	06–09–94	--	2	78.9	6.3	--
LCHP2	Eggs	Red-winged blackbird	06–09–94	--	2	81.7	7.6	--
LCHP2	Eggs	American coot	06–09–94	--	2	74.5	7.2	.62
LCHP2	Liver	Mallard, young	06–30–94	--	1	71.3	17	--
LCHP2	Liver	Mallard, young	06–30–94	--	1	72.2	14	--
LCHP2	Liver	Mallard, young	06–30–94	--	1	70.6	16	--
LCHP2	Liver	Mallard, young	06–30–94	--	1	70.8	18	--
PVP1	Aquatic plant	Algae	06–14–94	--	comp.	82.8	1.5	--
PVP1	Aquatic plant	Potamogeton	06–14–94	--	comp.	88.4	1.0	--
PVP1	Aquatic inv.	Composite	06–14–94	--	comp.	81.2	5.2	--
PVP1	Amphibian	Salamander	06–14–94	--	10	92.5	2.5	--
PVP1	Eggs	Red-winged blackbird	06–02–94	--	4	81.8	3.7	--
PVP1	Eggs	Red-winged blackbird	06–02–94	--	4	84.2	4.6	--
PVP1	Eggs	Red-winged blackbird	06–02–94	--	4	83.1	3.5	--
PVP1	Eggs	Red-winged blackbird	06–02–94	--	4	83.2	4.2	--
PVP1	Eggs	Red-winged blackbird	06–02–94	--	4	84.7	5.6	--
PVP1	Eggs	American coot	06–02–94	--	2	78.4	11	.04
PVP1	Liver	Red-winged blackbird, young	06–16–94	--	1	68.5	9.1	--

Table 6. Selenium concentrations in biological samples and mercury concentrations in selected bird-tissue samples collected at ponds in the Dolores Project and the Mancos River Basin, 1994—Continued

[Mean length in millimeters; concentrations in micrograms per gram dry weight; comp., composite; inv., invertebrate; all egg, liver, and muscle samples are from birds; --, no data]

Site code (fig. 1)	Matrix	Species	Date	Mean length	Number in sample	Percent moisture	Selenium	Mercury
			DOLORES PROJECT—DOVE CREEK AREA—Continued					
PVP2	Aquatic plant	Algae	06–14–94	--	comp.	83.5	2.1	--
PVP2	Aquatic plant	Zanichellia	06–14–94	--	comp.	91.3	1.5	--
PVP2	Aquatic plant	Ceratophyllum	06–14–94	--	comp.	82.1	1.6	--
PVP2	Aquatic inv.	Composite	06–14–94	--	comp.	77.9	6.6	--
PVP2	Aquatic inv.	Snails	06–14–94	--	comp.	71.2	2.0	--
PVP2	Amphibian	Salamander	06–14–94	--	1	82.7	9.5	--
PVP2	Amphibian	Salamander	06–14–94	--	1	83.3	8.7	--
PVP2	Amphibian	Salamander	06–14–94	--	5	92.0	7.3	--
PVP2	Liver	Mallard, young	06–10–94	--	1	70.8	37	--
PVP2	Liver	Mallard, young	06–10–94	--	1	70.3	40	--
PVP2	Liver	Mallard, young	06–14–94	--	1	73.6	41	--
PVP2	Liver	Mallard, young	06–14–94	--	1	71.1	42	--
YJP	Aquatic plant	Algae	06–09–94	--	comp.	88.3	2.6	--
YJP	Aquatic inv.	Composite	06–09–94	--	comp.	76.2	3.5	--
YJP	Aquatic inv.	Composite	06–09–94	--	comp.	81.5	4.2	--
YJP	Amphibian	Salamander	06–09–94	--	5	85.7	3.9	--
YJP	Amphibian	Salamander	06–09–94	--	5	86.4	3.9	--
YJP	Liver	Killdeer, young	06–14–94	--	2	68.9	21	--
YJP	Liver	Mallard, young	06–14–94	--	2	70.8	25	--
WCP	Aquatic plant	Algae	06–14–94	--	comp.	77.0	2.3	--
WCP	Aquatic plant	Ceratophyllum	06–14–94	--	comp.	79.5	2.3	--
WCP	Aquatic inv.	Composite	06–14–94	--	comp.	80.1	9.7	--
WCP	Fish, whole body	Fathead minnow	06–14–94	71	5	74.1	10	--
WCP	Fish, whole body	Fathead minnow	06–14–94	66	5	76.7	15	--
WCP	Bird, whole body	Red-winged blackbird	06–03–94	--	4	83.4	5.4	--
WCP	Eggs	Red-winged blackbird	06–03–94	--	4	83.8	2.1	--
WCP	Eggs	Red-winged blackbird	06–03–94	--	3	83.7	2.8	--
WCP	Eggs	Red-winged blackbird	06–03–94	--	4	81.3	3.1	--
WCP	Liver	Red-winged blackbird	06–14–94	--	1	70.0	8.4	--
WCP	Liver	Mallard, young	06–30–94	--	1	73.4	13	--
WCP	Liver	Mallard, young	06–30–94	--	1	72.6	16	--
			MANCOS RIVER BASIN					
MNP1	Aquatic plant	Ceratophyllum	06–15–94	--	comp.	84.0	.32	--
MNP1	Aquatic plant	Watercress	06–15–94	--	comp.	95.7	.52	--
MNP1	Aquatic inv.	Crayfish	06–15–94	92	5	72.0	.73	--
MNP1	Aquatic inv.	Crayfish	06–15–94	85	5	69.4	.67	--
MNP1	Fish, whole body	Fathead minnow	06–15–94	59	5	81.8	1.7	--
MNP1	Fish, whole body	Fathead minnow	06–15–94	60	5	77.5	1.8	--
MNP2	Aquatic plant	Algae	06–15–94	--	comp.	91.8	5.4	--
MNP2	Aquatic plant	Hippuris	06–15–94	--	comp.	93.4	2.7	--
MNP2	Aquatic plant	Typha	06–15–94	--	comp.	90.5	5.0	--

Table 6. Selenium concentrations in biological samples and mercury concentrations in selected bird-tissue samples collected at ponds in the Dolores Project and the Mancos River Basin, 1994–Continued

[Mean length in millimeters; concentrations in micrograms per gram dry weight; comp., composite; inv., invertebrate; all egg, liver, and muscle samples are from birds; --, no data]

Site code (fig. 1)	Matrix	Species	Date	Mean length	Number in sample	Percent moisture	Selenium	Mercury
			MANCOS RIVER BASIN—Continued					
MNP2	Aquatic plant	Scirpus	06–15–94	--	comp.	91.3	.68	--
MNP2	Aquatic inv.	Composite	06–15–94	--	comp.	81.5	6.8	--
MNP2	Aquatic inv.	Snails	06–15–94	--	comp.	80.5	2.0	--
MNP2	Amphibian	Salamander	06–15–94	--	5	89.1	8.4	--
MNP2	Amphibian	Salamander	06–15–94	--	10	90.8	9.0	--
MNP2	Amphibian	Chorus frog	06–15–94	--	1	90.6	7.0	--
MNP2	Fish, whole body	Fathead minnow	06–15–94	74	5	78.1	11	--
MNP2	Fish, whole body	Fathead minnow	06–15–94	57	5	78.1	11	--
MNP2	Fish, whole body	Fathead minnow	06–15–94	71	5	77.3	11	--
MNP2	Eggs	Yellow-headed blackbird	05–27–94	--	4	83.8	7.0	--
MNP2	Eggs	Yellow-headed blackbird	05–27–94	--	3	85.5	5.2	--
MNP2	Eggs	Yellow-headed blackbird	05–27–94	--	4	81.5	3.4	--
MNP2	Eggs	Yellow-headed blackbird	05–27–94	--	4	84.2	5.9	--
MNP2	Eggs	American coot	05–27–94	--	2	75.7	8.1	0.02
MNP2	Eggs	American coot	05–27–94	--	2	76.9	3.6	.44
MNP2	Eggs	American coot	06–15–94	--	2	74.3	6.9	--
MNP2	Eggs	American coot	06–29–94	--	2	75.3	8.4	--
MNP2	Eggs	American coot	06–29–94	--	2	73.3	7.5	--
MNP2	Eggs	American coot	06–29–94	--	1	74.2	8.4	--
MNP2	Eggs	Cinnamon teal	05–27–94	--	2	68.7	11	.09
MNP2	Eggs	Ruddy duck	05–27–94	--	2	68.4	9.6	.02
MNP2	Eggs	Ruddy duck	05–27–94	--	2	68.2	9.4	.02
MNP2	Eggs	Ruddy duck	05–27–94	--	4	42.5	7.0	.01
MNP2	Eggs	Ruddy duck	05–27–94	--	1	66.5	11	.07
MNP2	Liver	American coot, adult	06–15–94	--	1	70.4	27	--
MNP2	Liver	Ruddy duck, adult	05–27–94	--	1	70.3	35	--
MNP2	Liver	Ruddy duck, adult	05–27–94	--	1	74.1	52	--
MNP2	Liver	Ruddy duck, young	06–15–94	--	1	61.8	22	--
MNP2	Liver	Mallard, adult	06–29–94	--	1	71.4	27	--
MNP2	Muscle	American coot, adult	06–15–94	--	1	74.1	15	.09
MNP2	Muscle	Mallard, adult	06–29–94	--	1	71.5	5.8	.03
MNP3	Aquatic plant	Algae	06–15–94	--	comp.	90.2	4.5	--
MNP3	Aquatic plant	Ceratophyllum	06–15–94	--	comp.	89.5	2.6	--
MNP3	Aquatic plant	Hippuris	06–15–94	--	comp.	93.8	3.2	--
MNP3	Aquatic inv.	Composite	06–15–94	--	comp.	83.5	7.0	--
MNP3	Aquatic inv.	Crayfish	06–15–95	--	6	75.0	5.3	--
MNP3	Fish, whole body	Smallmouth bass	06–15–94	263	5	75.4	12	.26
MNP3	Fish, fillet	Smallmouth bass	06–15–94	370	1	79.7	12	.83

Table 7. Aquatic hazard assessment of selenium for ponds in the Dove Creek area and the Mancos River Basin

[Hazard assessment protocol from Lemly (1995); selenium concentrations in water in micrograms per liter, and in bottom sediment and biota in micrograms per gram dry weight; mean concentrations used for aquatic invertebrates and bird eggs (excluding blackbirds); <, less than; *, in some cases where sample type was not available, conversion factors were used to estimate selenium concentration for bird eggs and fish eggs using the following factors: bird-egg selenium = bird-liver selenium times 0.33, and fish-egg selenium = fish whole-body selenium times 3.3]

Site (fig. 1)	Environmental component	Selenium concentration	Component evaluation		Site evaluation	
			Score	Hazard	Score	Hazard
		DOVE CREEK AREA				
DCP1	Water	2	2	Minimal	12	Moderate
	Bottom sediment	2.1	2	Minimal		
	Invertebrates	6.5	5	High		
	Bird eggs	10.7	3	Low		
CHP	Water	5	4	Moderate	16	High
	Bottom sediment	2.1	2	Minimal		
	Invertebrates	12	5	High		
	Bird eggs	20	5	High		
LCHP1	Water	<2	2	Minimal	8	Low
	Bottom sediment	1.1	2	Minimal		
	Invertebrates	2.0	2	Minimal		
	Bird eggs*	3.5	2	Minimal		
PVP1	Water	2	2	Minimal	12	Moderate
	Bottom sediment	1.4	2	Minimal		
	Invertebrates	5.2	5	High		
	Bird eggs	11	3	Low		
YJP	Water	<1	1	None	8	Low
	Bottom sediment	.65	1	None		
	Invertebrates	3.9	3	Low		
	Bird eggs*	7.6	3	Low		
WCP	Water	3	3	Low	18	High
	Bottom sediment	3.2	3	Low		
	Invertebrates	9.7	5	High		
	Bird eggs*	4.8	2	Minimal		
	Fish eggs*	41.3	5	High		
		MANCOS RIVER BASIN				
MNP1	Water	<1	1	None	6	Minimal
	Bottom sediment	.54	1	None		
	Invertebrates	.7	1	None		
	Fish eggs	5.9	3	Low		
MNP2	Water	3	3	Low	20	High
	Bottom sediment	6.7	5	High		
	Invertebrates	4.0	4	Moderate		
	Bird eggs	8.3	3	Low		
	Fish eggs*	36.3	5	High		
MNP3	Water	1	1	None	16	High
	Bottom sediment	5.9	5	High		
	Invertebrates	6.2	5	High		
	Fish eggs*	39.6	5	High		

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