RECONNAISSANCE INVESTIGATION OF WATER QUALITY, BOTTOM SEDIMENT, AND BIOTA ASSOCIATED WITH IRRIGATION DRAINAGE IN THE RIVERTON RECLAMATION PROJECT, WYOMING, 1988-89

By David A. Peterson and T.F. Harms, U.S. Geological Survey

Pedro Ramirez, Jr. and George T. Allen, U.S. Fish and Wildlife Service

Alfred H. Christenson, U.S. Bureau of Reclamation

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 90-4187

Cheyenne, Wyoming

1991

U.S. DEPARTMENT OF THE INTERIOR

MANUEL LUJAN, JR., Secretary

U.S. GEOLOGICAL SURVEY

Dallas L. Peck, Director

For additional information
write to:

District Chief
U.S. Geological Survey
2617 E. Lincolnway, Suite B
Cheyenne, WY 82001

Copies of this report can be
purchased from:

U.S. Geological Survey
Books and Open-File Reports Section
Federal Center, Building 810
Box 25425
Denver, CO 80225

CONTENTS

CONTENTS--Continued

ILLUSTRATIONS

TABLES

CONVERSION FACTORS AND ABBREVIATIONS

Multiply	By	To obtain
acre	4,047	square meter
acre	0.4047	hectare
acre-foot (acre-ft)	1,233	cubic meter
acre-foot (acre-ft)	0.001233	cubic hectometer
cubic foot per second (ft^3/s)	0.02832	cubic meter per second
foot (ft)	0.3048	meter
foot per mile (ft/mi)	0.1894	meter per kilometer
inch (in.)	25.4	millimeter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer

Temperature can be converted to degrees Fahrenheit (°F) or degrees Celsius (°C) by the following equations:

$$°C = 5/9\ (°F - 32)$$

$$°F = 9/5\ (°C) + 32$$

Abbreviated water-quality units used in report:

cm	centimeter
mg/L	milligram per liter
mm	millimeter
µg/g	microgram per gram
µg/kg	microgram per kilogram
µg/L	microgram per liter
µm	micrometer (3.937×10^{-5} inches)
µS/cm	microsiemens per centimeter at 25 degrees Celsius

Other abbreviations used in report:

BHC	benzene hexachloride
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DOI	U.S. Department of the Interior
EPA	U.S. Environmental Protection Agency
HCB	Hexachlorobenzene
MCL	Maximum Contaminant Level
NCBP	National Contaminant Biomonitoring Program
PCB	Polychlorinated biphenyls
SMCL	Secondary Maximum Contaminant Level

RECONNAISSANCE INVESTIGATION OF WATER QUALITY, BOTTOM SEDIMENT, AND BIOTA ASSOCIATED WITH IRRIGATION DRAINAGE IN THE RIVERTON RECLAMATION PROJECT, WYOMING, 1988-89

By David A. Peterson, T.F. Harms,
Pedro Ramirez, Jr., George T. Allen, and Alfred H. Christenson

ABSTRACT

A reconnaissance investigation of the Riverton Reclamation Project in west-central Wyoming was conducted during 1988 and 1989 to determine if irrigation drainage has caused, or has the potential to cause, harmful effects on human health or biota, or has affected other water uses. The investigation was one of 19 reconnaissance investigations conducted during 1986-89 as part of the U.S. Department of the Interior Irrigation Drainage Program.

Selenium concentrations in water samples collected from 14 sites generally were less than the national drinking-water regulation of 10 µg/L (micrograms per liter), although several concentrations equaled or exceeded the 5 µg/L criterion for protection of aquatic life. Comparison of dissolved selenium to total selenium indicated virtually all of the selenium was present as dissolved selenium. Uranium concentrations in many of the water samples exceeded 35 µg/L, the recommended maximum for human consumption. Concentrations of selenium and uranium in water were correlated significantly (15 samples, coefficient of determination, $r^2 = 0.81$, significant at the 0.01 level).

Pesticides were detected in water samples from irrigation drains, streams, and lakes. One sample contained 0.13 µg/L parathion, which exceeds the freshwater aquatic life criterion of 0.065 µg/L (acute); other pesticide concentrations were less than the applicable criteria or health advisories. Concentrations of dissolved nitrite plus nitrate were less than the drinking-water regulation for nitrate of 10 milligrams per liter as nitrogen.

Samples of bottom sediment from 14 sites were sieved to two size classes, less than 0.062 mm (millimeter) and less than 2 mm. Selenium concentrations in the smaller size fraction ranged from 0.1 to 3.0 µg/g (micrograms per gram); concentrations in the larger size fraction ranged from less than 0.1 to 1.9 µg/g.

Arsenic, boron, mercury, and selenium concentrations in most biological samples were less than concentrations suspected of causing adverse effects. However, selenium concentrations in some samples of aquatic plants, invertebrates, fish, and fish eggs exceeded concentrations associated with adverse effects. A pied-billed grebe (<u>Podilymbus podiceps</u>) egg taken from North Pavillion Pond had a selenium concentration of 16.9 µg/g dry weight, within the 15 to 20 µg/g level of concern identified by other investigators. A liver sample taken from an adult ruddy duck (<u>Oxyura jamaicensis</u>) from North

Pavillion Pond had a selenium concentration of 34.6 μg/g dry weight. Results from other studies of irrigation drainage indicate selenium concentrations greater than 30 μg/g dry weight in aquatic bird livers are likely to cause impaired reproduction.

Concentrations of organochlorine pesticides generally were at or less than the analytical reporting limit. However, small concentrations of DDT and its metabolites and PCBs were found in fish, bird eggs, and bird livers.

INTRODUCTION

Since the mid-1980s, concern has increased about the chemical quality of irrigation drainage and its potential harmful effects on human health, fish, and wildlife. Concentrations of selenium greater than water-quality criteria for the protection of aquatic life (U.S. Environmental Protection Agency, 1986) have been detected in subsurface drainage from irrigated land in the western part of the San Joaquin Valley in California. In 1983, incidences of mortality, birth defects, and reproductive failures in waterfowl were discovered by the U.S. Fish and Wildlife Service at the Kesterson National Wildlife Refuge in the western San Joaquin Valley where irrigation drainage was impounded. In addition, potentially toxic trace elements and pesticide residues have been detected in other areas in western states that receive irrigation drainage.

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

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

Nine of the 20 locations were selected for reconnaissance investigations during 1986 and 1987:

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

Reports for seven of the nine reconnaissance investigations were published during 1988. Reports for the remaining two investigations were published in 1990. On the basis of results of the first nine reconnaissance investigations, detailed studies of four areas were started in 1988: Salton Sea area, Stillwater Wildlife Management area, Middle Green River Basin area, and the Kendrick Reclamation Project area. Reconnaissance investigations of 11 additional areas were begun in 1988:

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

All studies were conducted by interbureau field teams composed of a scientist from the U.S. Geological Survey as team leader, with additional U.S. Geological Survey, U.S. Fish and Wildlife Service, and U.S. Bureau of Reclamation scientists representing different disciplines.

Purpose and Scope

This report describes the results of a reconnaissance investigation of the Riverton Reclamation Project area, Wyoming to determine whether irrigation drainage has caused or has the potential to cause harmful effects on human health, fish and wildlife, or other water users. During 1988, 14 sites were sampled for water and bottom sediment, and 11 sites were sampled for biota.

Acknowledgments

Thanks are extended to Bob Yates, Gary Bodine, Kerry Connell, Dave Dufek, Dave North, and other personnel from the Wyoming Game and Fish Department, who generously donated their time, expertise, and equipment for the biological collections. Bob Grove of the U.S. Fish and Wildlife Service assisted with sample collections. Permission for access to private lands from Bill Brown, manager of the Midvale Irrigation District, and other landowners in the area also is greatly appreciated.

GENERAL DESCRIPTION OF STUDY AREA

The Riverton Reclamation Project is in west-central Wyoming, in Fremont County, between the south flank of the Owl Creek Mountains and the Wind River (fig. 1). The project is on land withdrawn from the Wind River Indian Reservation and is referred to as the Riverton Reclamation Project area. The area includes some State wildlife management areas, not shown in figure 1.

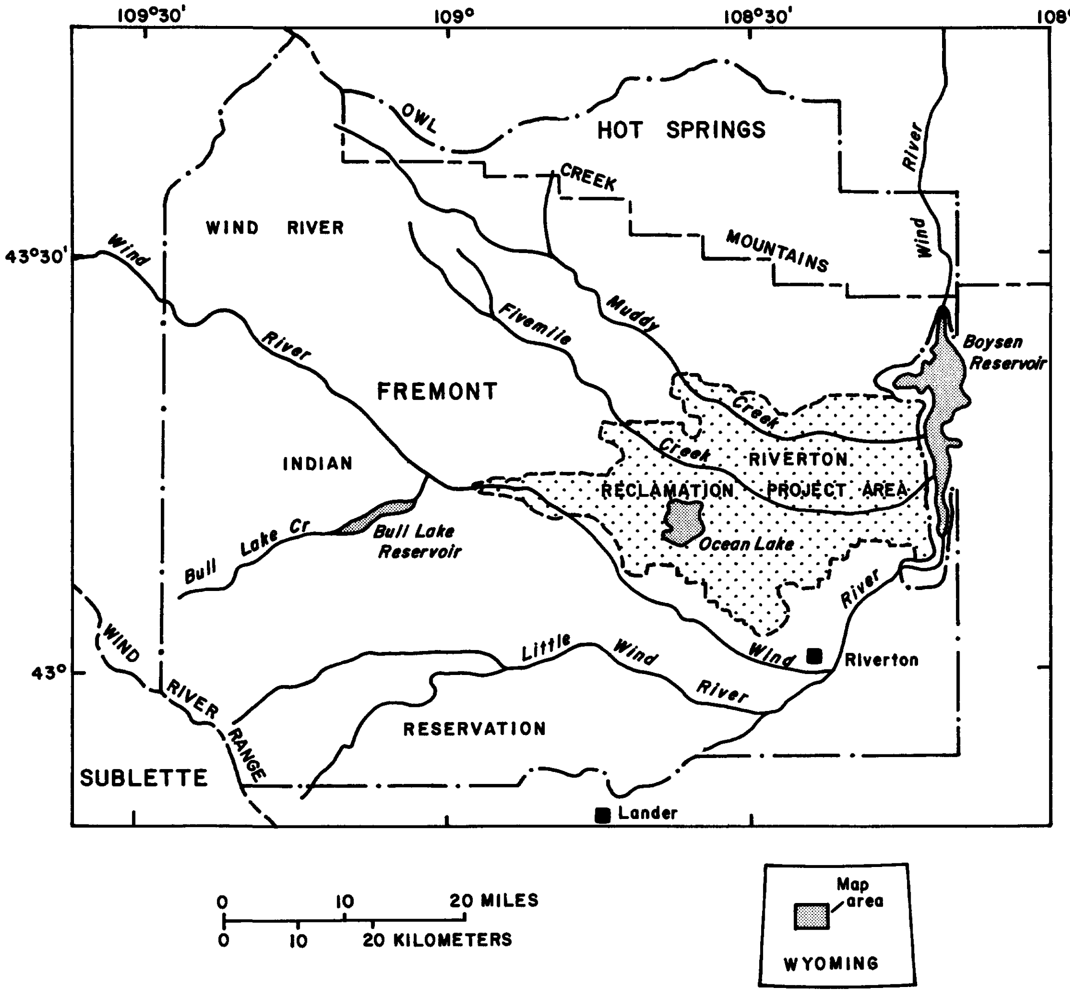
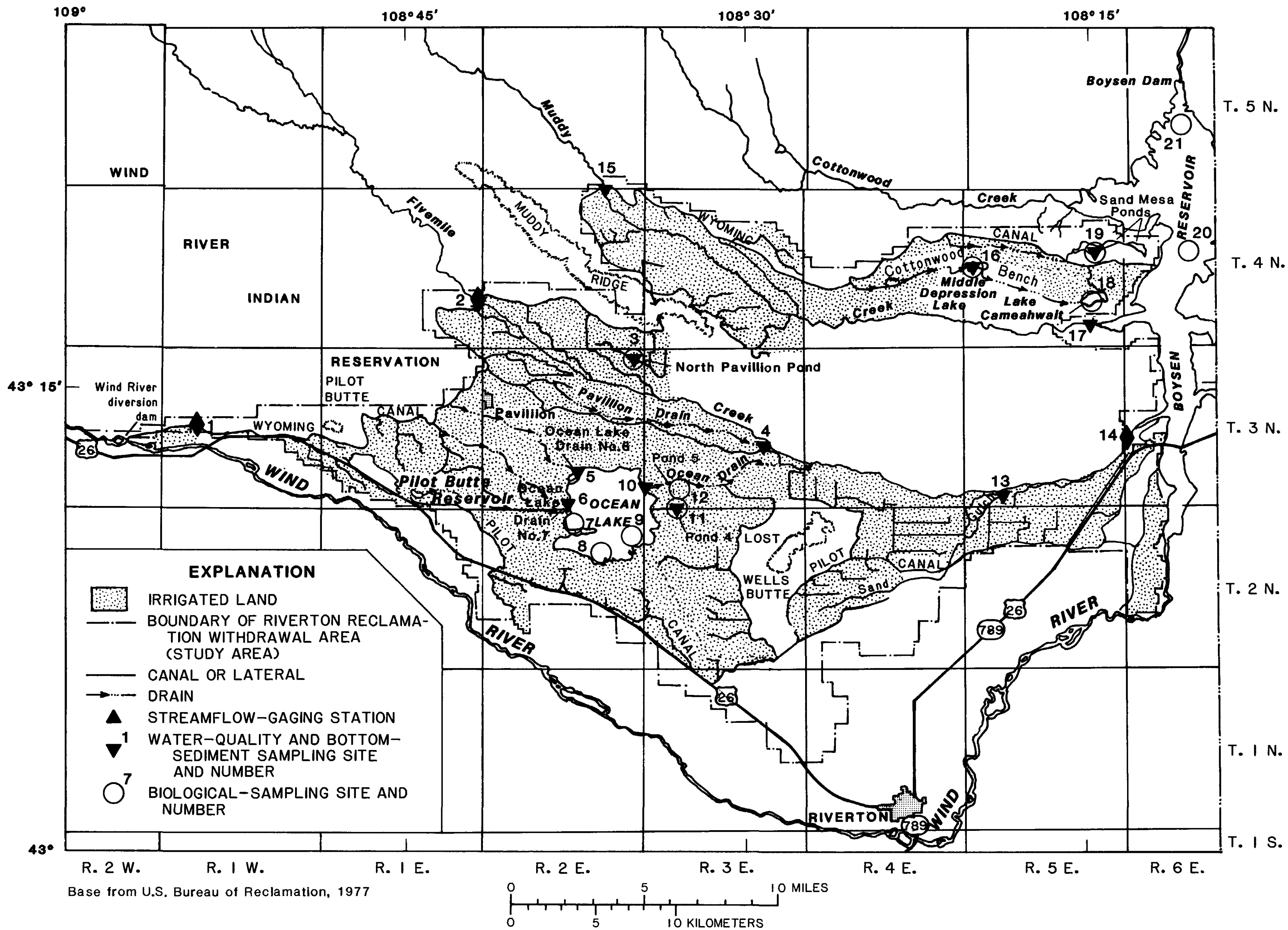


Figure 1.--Location of the Riverton Reclamation Project area.

History and Use

The Riverton Reclamation Project was surveyed by Goyne Drummond of the U.S. Reclamation Service in 1904. Construction of the project and formation of the Midvale Irrigation District began in the 1920s. Additional lands have been added and delivery facilities improved through various acts and legislation throughout the years. Irrigated lands during 1988 totaled approximately 70,000 acres.

Extensive fisheries and waterfowl nesting areas and refuges have been developed in the study area by the Wyoming Game and Fish Department. Notable fisheries are Ocean Lake, Middle Depression Lake (also known as Middle Reservoir), Lake Cameahwait, and Boysen Reservoir (fig. 2). The Wyoming Game and Fish Department, under contract with the Bureau of Reclamation, administers about 28,000 acres of waterfowl habitat along Muddy Creek and Fivemile Creek, and in the Ocean Lake and Cottonwood Bench areas.



Base from U.S. Bureau of Reclamation, 1977

Figure 2.--Location of irrigated lands, canals, drains, and sampling sites. Sites are numbered in downstream order.

Ocean Lake supports carp (Cyprinus carpio), white sucker (Catostomus commersoni), black crappie (Pomoxis Nigromaculatus), yellow perch (Perca flavescens), largemouth bass (Micropterus salmoides), bluegill (Lepomis macrochirus), and walleye (Stizostedion vitreum vitreum). Ocean Lake is lightly to moderately fished. Middle Depression Lake is a lightly fished lake inhabited by white suckers, carp, and rainbow trout (Oncorhynchus mykiss). Lake Cameahwait contains carp, white suckers, largemouth bass, a large population of yellow perch, rainbow trout, and brown trout (Salmo trutta). Lake Cameahwait is moderately to heavily fished. Boysen Reservoir contains carp, white suckers, redhorse suckers (Moxostoma spp.), carpsuckers (Carpiodes spp.), yellow perch, largemouth bass, black crappie, rainbow trout, brown trout, Snake River cutthroat trout (Oncorhynchus clarki), walleye, and sauger (Stizostedion canadense). Boysen Reservoir is moderately to heavily fished.

Waterfowl use of the study area is largest during migration; duck nesting is limited. However, the Wyoming Game and Fish Department manages habitat and artificial nesting structures for Canada geese (Branta canadensis) in the study area. About 325 pairs nest in the study area each year; about 200 in the vicinity of Ocean Lake, about 30 at Sand Mesa ponds, and about 30 pairs on the southern (upstream) end of Boysen Reservoir (Bob Yates, Wyoming Game and Fish Dept., oral commun., February 1989). Other geese nest along the Wind River and on other lakes and ponds. About 1,000 geese are raised in the study area each year.

Several federally listed threatened or endangered species inhabit the study area. Bald eagles (Haliaeetus leucocephalus) migrate through the area and winter primarily along the Wind River. Peregrine falcons (Falco peregrinus) migrate through the area during the spring and fall. Whooping cranes (Grus americanus) are occasional visitors during the spring and summer. Prairie dog (Cynomys spp.) colonies occur in the area and may provide potential habitat for the black-footed ferret (Mustela nigripes), although no ferrets have been sighted in the area.

Climate

Semiarid grasslands and rolling hills characterize the study area. Precipitation at the Riverton weather station during 1988 was about 3.75 in., 4.35 in. less than the average annual precipitation of 8.1 in. for 1951-80 (National Oceanic and Atmospheric Administration, 1989, p. 6-7). In terms of monthly variation, most of the precipitation falls during April, May, and June; less than 10 percent of the precipitation falls during December, January, and February (Martner, 1986, p. 82-85).

Class A pan evaporation at Lander, 15 mi south of the study area, averaged 55 in. during 1956-70; evaporation rates were greatest in July, the warmest month (Martner, 1986, p. 178-179). Temperatures at Riverton were larger than normal during the summer of 1988. The average temperature of 72.2 °F during June was 9.3 °F larger than the long-term average, and temperatures during May, July, and August were all about 2 °F larger than average (National Oceanic and Atmospheric Administration, 1989, p. 10).

Geology and Soils

The Riverton Reclamation Project is in the Wind River Basin, an area of about 8,500 mi^2, in central Wyoming. Cretaceous-age sedimentary rocks including the Thermopolis and Mowry Shales, Frontier Formation, Cody Shale, Mesaverde Formation, Lewis Shale, and Meeteetse and Lance Formations (in ascending order) crop out along the margins of the Wind River Basin and in the headwaters of the two principal streams in the study area (Whitcomb and Lowry, 1968). The presence of these Cretaceous formations is of interest because elsewhere they have been determined to be potential sources of selenium (Erdman and others, 1989; Rosenfeld and Beath, 1964, p. 22-26; Case and Cannia, 1988). The Wind River Formation of early Eocene age is the surface rock in much of the Wind River Basin and crops out in about 50 percent of the study area. The Wind River Formation consists of interbedded claystone, siltstone, sandstone, and conglomerate depending on the depositional environment; extensive uranium deposits occur in the Wind River Formation about 50 mi southeast of the study area.

Quaternary alluvium covers about 50 percent of the study area; it consists of clay, silt, and sand, and, in some places, includes coarse sand and gravel. Alluvium occurs along the two principal streams in the area, Fivemile Creek and Muddy Creek, and also west and north of Ocean Lake. Most of the irrigated lands shown in figure 2 are on alluvium.

Colby and others (1956, p. 18-19) note a variety of soils occur in the area, resulting from differences in climate and in kinds of parent material. The soils of the floodplains are developed from water-deposited clay, silt, sand, and gravel, and all are calcareous. The soils of the terraces are slightly leached and are rich in mineral nutrients for plants but low in organic material. The soils of the older terraces have claypan immediately underlain by a thick accumulation of gypsiferous and calcareous materials. In the uplands, shallow residual soils have developed on bedrock, although unweathered bedrock is exposed in some areas.

HYDROLOGIC SETTING

Water Supply

The principal storage facility for the Riverton Reclamation Project is Bull Lake Reservoir, on Bull Lake Creek, a tributary of the Wind River upstream from the study area (fig. 1). Total storage capacity is 152,500 acre-ft, which includes 722 acre-ft of inactive storage. Irrigation water is released to the Wind River through Bull Lake Creek and is diverted at the Wind River Diversion Dam into the Wyoming Canal (fig. 2). The Wyoming Canal is 62.4 river mi long and is designed for a maximum flow of 2,200 ft^3/s. Annual diversions, in acre-ft, to the Wyoming Canal, 1964-88, were summarized from data on file at the U.S. Bureau of Reclamation as follows:

Minimum (1977)	Median (1979)	Maximum (1987)	Average
226,600	348,300	428,200	346,700

During 1964-88, diversions to the canal averaged 4.53 acre-ft of water per acre of irrigated land; deliveries to the farm turnouts averaged 2.87 acre-ft per acre.

The Wyoming Canal serves distribution laterals in the northern part of the project; water also is diverted from the Wyoming Canal into Pilot Butte Reservoir and Pilot Canal (fig. 3). Pilot Butte Reservoir has a total capacity of 36,910 acre-ft (active capacity of 31,550 acre-ft). The Pilot Canal flows in an easterly direction from Pilot Butte Reservoir, serving lands south of those supplied by the Wyoming Canal. The Pilot Canal is 38.2 river mi long with a discharge capacity of 1,000 ft^3/s. Water from the Wyoming and Pilot Canals is distributed by about 300 mi of laterals.

Diversion from the Wind River to the Wyoming Canal during 1988 totaled 362,500 acre-ft, slightly larger than the 1964-88 average of 346,700 acre-ft. Approximately 50 percent of the amount diverted was from Bull Lake. Snowpack in the mountains during 1988 was less than normal; snowmelt runoff into Bull Lake began about mid-April and ended by early July. Bull Lake contained 86,840 acre-ft when releases for irrigation began on April 27. On July 1, storage peaked at 120,500 acre-ft, about 80 percent of capacity. Total inflow for water year 1988 was 121,600 acre-ft, only 60 percent of normal and the second-smallest on record. Temperatures were above normal during the summer, resulting in increased demand for irrigation water. Reservoir releases were discontinued on September 20, about three weeks earlier than normal. On September 30 the contents of Bull Lake were 25,680 acre-ft.

The diversion provides water for the irrigation of 76,875 acres when fully operational; crops were harvested from about 70,000 acres during 1988. The irrigation deliveries usually start in early April for alfalfa and grass pasture crops and reach a peak during July. For example, the hydrograph of water released from Pilot Butte Reservoir for irrigation during the 1988 season is shown in figure 4. Data from the 1988 crop census indicate principal crops produced, in order of largest number of acres, were alfalfa, barley, corn, grass pasture, oats, and sugar beets. The economic value of crops produced on the project during 1988 was about $12 million.

Irrigation Drainage

Irrigation drainage from the study area flows to Boysen Reservoir through constructed and natural tributaries to Fivemile Creek and Muddy Creek. Nine agricultural drains flow into Ocean Lake; the outlet of Ocean Lake is a constructed tributary to Fivemile Creek. The irrigation drainage originates from two sources: (1) Distribution system losses and waste, and (2) farm application in excess of crop consumption and evaporation. Not all of the drainage reaches the reservoir; a total of about 35 percent is used by noncrop plants in the drainage system, lost at the end of the fields, or lost through deep percolation to ground-water storage.

The rate of return of the irrigation drainage to Boysen Reservoir was estimated for the Wind River Basin Water Supply Study (U.S. Bureau of Reclamation, 1981). Because of hydrologic properties associated with movement of surface and ground water, a lag occurs between the time the water is applied on the farm and the time that the drainage reaches Boysen Reservoir.

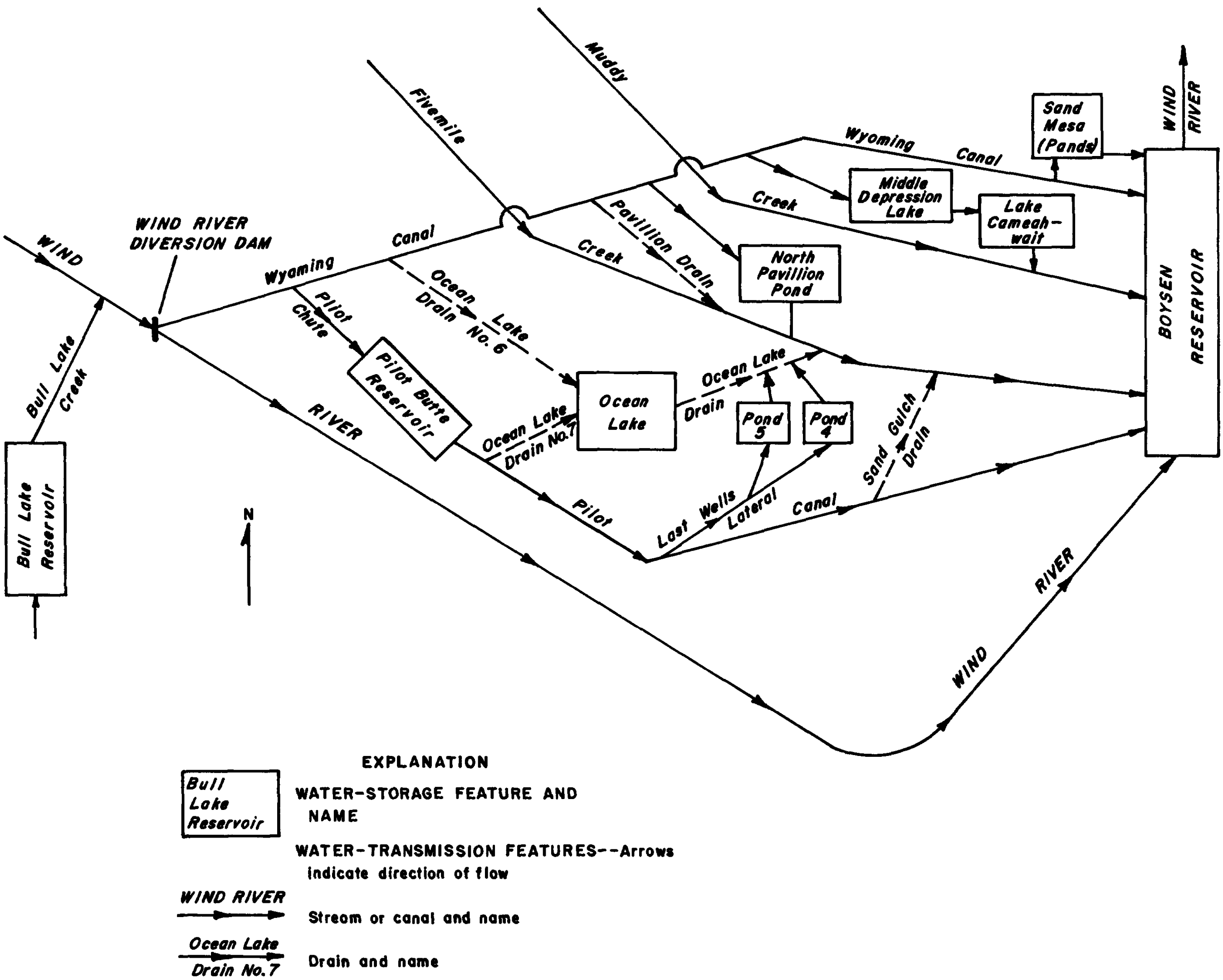


Figure 3.--Riverton Reclamation Project showing principal water-storage and water-transmission features and direction of flow.

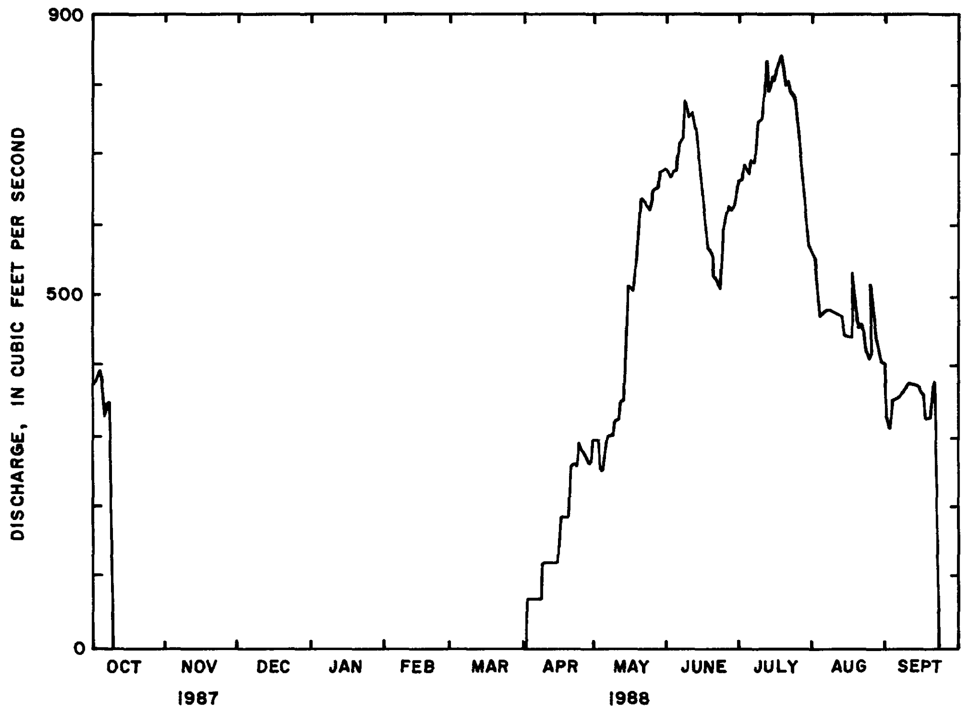


Figure 4.--Daily mean discharge from Pilot Butte Reservoir, water year 1988. (Source: U.S. Bureau of Reclamation)

Of the drainage that reaches Boysen Reservoir, an estimated 50 percent reaches the reservoir during the month in which the water was applied. An additional 15 percent reaches the reservoir during the month following application, and 13 percent reaches the reservoir during the next month. Ninety percent of the drainage reaches the reservoir within 5 months of diversion.

Historical Seepage and Ground Water

Shortly after irrigation started in the 1920s, seepage and salt accumulations resulting from poor drainage became apparent. Mitigation of the problem began with construction of open drains in the early 1930s. As of 1947, about 100 mi of open drains had been constructed on the Riverton Reclamation Project. A drainage survey was authorized in 1947 to examine areas of poor drainage to determine whether soil, subsoil, and alkali conditions would permit reclamation of these areas. In most areas, drainage was a problem because the water table was perched on top of an impermeable substratum.

H.D. Comstock, a consulting engineer, in a 1951 unpublished report on seepage and drainage on the Riverton Reclamation Project, concluded that there was a general rise in ground-water levels because of irrigation. According to the Midvale Irrigation District (boundaries essentially the same as the Riverton Reclamation Project) 1950 water-assessment roll, 4,508 acres had been suspended for lack of drainage.

Poor drainage continued to be a problem through the 1950s and 1960s, leading to the Riverton Reauthorization Act of September 25, 1970. This Act authorized a rehabilitation and betterment program for the First and Second Division on the Project. Under this program, 304 mi of buried field drains were installed, and 47 mi of open drains were closed, which made it possible to reclaim and reclassify some former saline wetland as irrigable. After the 1985 land reclassification, 1,815.6 acres were reclassified by the U.S. Bureau of Reclamation as irrigable.

PREVIOUS STUDIES

A study of sedimentation and chemical quality of surface water in the Wind River Basin by Colby and others (1956) included discussion of chemical quality in relation to irrigation. The Wind River Formation and alluvial deposits in the study area contain appreciable soluble material, principally sulfates of sodium and calcium, which are readily leached by the irrigation water (Colby and others, 1956, p. 127-128). They also note that dissolution of the minerals increases with longer contact times between the soil particles and water, which, using Fivemile Creek for an example, results in an increase in specific conductance in the downstream direction and changes in the proportions of sodium, calcium, and sulfate.

Colby and others (1956, p. 97-107, 111) indicated the discharge of suspended sediment in Fivemile and Muddy Creeks increased due to irrigation. Fivemile Creek contributed 56 percent of the average suspended-sediment discharge but only 7 percent of the average water discharge of the Bighorn River at Thermopolis prior to construction of Boysen Reservoir. On the basis of 1949 and 1950 data, about 87 percent of the suspended-sediment discharge of Fivemile Creek comes from erosion of the streambed and banks within the study area.

The primary source of water to most wells in the area is the lenticular beds of sandstone in the Wind River Formation (Morris and others, 1959, p. 92). The concentrations of dissolved solids in water samples from wells completed in the Wind River Formation ranged from 200 to 5,000 mg/L (McGreevy and others, 1969, p. I14); however, a coarse-grained sequence near the bottom of the formation supplied many wells with water having dissolved-solids concentrations in the range of 200 to 1,000 mg/L (McGreevy and others, 1969, p. I45). The concentrations of dissolved solids in water samples from wells completed in alluvium on floodplains and low terraces ranged from 200 to 2,000 mg/L (McGreevy and others, 1969, p. I13).

Quality of ground water in the study area also was described by W.H. Durum in a report by Morris and others (1959). Durum noted a seasonal variation in water quality corresponding to the seasonal irrigation cycle; concentrations of dissolved solids, sulfate, calcium, and magnesium were smaller during the summer when irrigation water had a dilution effect on the ground water (Morris and others, 1959, p. 83-85). The chemical character of the ground water can be partially derived from deposits of salt on the surface, which are dissolved from shale and fine-grained materials and deposited by capillary action; the predominant ions in the salt are sodium and sulfate (Morris and others, 1959, p. 86). Many samples from domestic wells in the area yield water containing more than 200 mg/L hardness (very hard); concentrations of dissolved solids, sulfate, iron, and fluoride also were large in many samples (Morris and others, 1959, p. 90).

During the 1950s and 1960s, Ocean Lake was nationally renowned as a crappie fishery. In the 1970s a decline in the fishery was observed (Bob Yates, Wyoming Game and Fish Dept., oral commun., 1989). Millis and Pedlar (1985) concluded that silt contributed by irrigation drains is the primary cause of the decline. Trace amounts of Dieldrin, DDE (a DDT metabolite), Tordon, and 2,4-D also were detected in Ocean Lake by Millis and Pedlar (1985). Siltation problems exist in other ponds and lakes in the study area, but no studies of siltation in the ponds in the study area have been conducted.

SAMPLE COLLECTION AND ANALYSIS

In the analysis of samples, trace elements and pesticides were emphasized, because of known potential for these constituents to have negative effects when present at large concentrations. The types of samples collected and constituents to be analyzed for were described in the Department of the Interior protocol for the reconnaissance-level studies. Sampling sites and media sampled are listed in table 1; site locations are shown in figure 2. Constituents included in the analyses are listed in tables 10 through 14 at the back of this report. When using tables 10 through 14, the reader may note that the number of significant figures or the reporting limits for "less than" values may vary between media or between samples for the same media or constituent. Reporting limits vary because of differences in analytical techniques, sample pre-treatment for analysis, and analytical interferences within the various laboratories that analyzed samples for this study.

Sampling Sites

Sampling sites for water and bottom sediment were selected at the upstream and downstream edges of the study area, as well as in the area (fig. 2 and table 1). The Wyoming Canal (site 1), upper Fivemile Creek (site 2), and upper Muddy Creek (site 15) were sampled at the upstream edge of the project, to determine the quality of water flowing into the study area. Lower Fivemile Creek (site 14, fig. 5) and lower Muddy Creek (site 17) were sampled at the downstream edge of the project near their respective mouths at Boysen Reservoir, to determine if water quality changed between the upstream and downstream sites. Five irrigation drains were sampled: Pavillion Drain (site 4), Ocean Lake Drain number 6 (site 5), Ocean Lake Drain number 7 (site 6), Ocean Drain at outlet (site 10), and Sand Gulch (site 13). Water and bottom sediment were sampled in three ponds and one lake, all in State Wildlife Management Areas: North Pavillion Pond (site 3), Pond 4 (site 11), Sand Mesa ponds (site 19), and Middle Depression Lake (site 16). At the pond

Table 1.--Sampling sites and media sampled

[X, sampled; --, not sampled]

Site No. (fig. 2)	Station name	Water		Bottom sediment		Biota	
		Inorganics	Pesticides	Inorganics	Pesticides	Inorganics	Organochlorines
1	Wyoming Canal	X	--	X	--	--	--
2	Upper Fivemile Creek	X	--	X	--	--	--
3	North Pavillion Pond	X	--	X	X	X	X
4	Pavillion Drain	X	X	X	X	--	--
5	Ocean Lake Drain number 6	X	X	X	X	--	--
6	Ocean Lake Drain number 7	X	X	X	X	--	--
7	Ocean Lake, west side	--	--	--	--	X	--
8	Ocean Lake, south side	--	--	--	--	X	X
9	Ocean Lake, east side	--	--	--	--	X	--
10	Ocean Drain at outlet	X	X	X	--	--	--
11	Pond 4	X	--	X	--	X	X
12	Pond 5	--	--	--	--	X	X
13	Sand Gulch	X	X	X	X	--	--
14	Lower Fivemile Creek	X	X	X	X	--	--
15	Upper Muddy Creek	X	--	X	--	--	--
16	Middle Depression Lake	X	X	X	X	X	X
17	Lower Muddy Creek	X	X	X	X	--	--
18	Lake Cameahwait	--	--	--	--	X	--
19	Sand Mesa ponds	X	--	X	--	X	X
20	Boysen Reservoir near Sand Mesa ponds	--	--	--	--	X	--
21	Boysen Reservoir near Boysen Dam	--	--	--	--	X	X

Figure 5.--Fivemile Creek near the mouth, at site 14. View is downstream from the bridge, August 1988.

and lake sites, water and bottom-sediment samples were collected near the inlets to determine the quality of the inflow. Water and bottom sediment were sampled in August, during the irrigation season; water samples also were collected in November, after the irrigation season.

Samples of aquatic vegetation, aquatic invertebrates, fish, bird eggs, or bird livers were collected at 11 sites on ponds, lakes, and a reservoir. Three of the sites (16, 18, and 19) were in the Cottonwood Bench area, in the northeastern corner of the study area (fig. 2). The biological sampling sites and the number of samples of each type of biota collected at each site are listed in table 2.

Sampling Methods

Collection of water samples and measurement of specific conductance, pH, water temperature, and dissolved oxygen were in accordance with methods described by Lester R. Kister and William B. Garrett (U.S. Geological Survey, written commun., 1983) and Knapton (1985). Water samples for dissolved constituents were filtered through a membrane filter with 0.45-µm pore size and acidified onsite. At sites on creeks, canals, and drains, the discharge was measured using techniques described by Rantz and others (1982).

Table 2.--Number of samples of each biota type collected at ponds, lakes, and a reservoir

[--, samples not collected]

Site No. (fig. 2)	Site name	Number of samples: Aquatic vegetation (composite sample)	Aquatic inverte-brates (composite sample)	Fish (indi-vidual sample)	Fish egg masses (indi-vidual sample)	Bird eggs (indi-vidual sample)	Bird livers (indi-vidual sample)
3	North Pavillion Pond	2	2	--	--	3	7
7	Ocean Lake, west side	2	3	14	--	--	--
8	Ocean Lake, south side	--	--	--	--	1	8
9	Ocean Lake, east side	2	4	11	--	--	--
11	Pond 4	4	--	--	--	4	--
12	Pond 5	--	--	--	--	3	--
16	Middle Depression Lake	3	--	10	2	--	7
18	Lake Cameahwait	--	--	18	--	--	--
19	Sand Mesa ponds	3	--	--	--	4	9
20	Boysen Reservoir near Sand Mesa ponds	--	--	11	1	--	--
21	Boysen Reservoir near Boysen Dam	--	--	6	--	--	--

The bottom-sediment samples were collected from the upper 5 to 10 cm of bed material in streams and ponds. Each bottom-sediment sample was a homogenized composite of at least five subsamples representing a cross section of a stream channel or a small area near the inlet of a pond.

Biological samples were collected by personnel of the U.S. Fish and Wildlife Service and the Wyoming Game and Fish Department. Samples of submerged aquatic vegetation were collected by hand and washed of any sediment or detritus. Aquatic invertebrates were collected with light traps similar to those described by Espinosa and Clark (1972). Fish were collected using electroshocking equipment, hoop nets, or gill nets. Eggs were obtained from nests of American coots (Fulica americana) or pied-billed grebes. One bird egg was collected from nests having a clutch of more than one egg. In June 1988, adult American coots and one ruddy duck were collected for liver samples by shooting them with steel shot. All adult birds collected appeared healthy. Livers were removed with acetone-rinsed stainless steel dissection tools and placed in chemically cleaned jars. In 1988, nesting success of birds was poor, and pre-fledgling birds were not available for collection. All biological specimens were kept on ice and then frozen as soon as possible. All biota samples were submitted for trace-element analysis. Bird eggs and livers from North Pavillion Pond, Ocean Lake, Ponds 4 and 5, Middle Depression Lake, and Sand Mesa ponds, as well as fish from Middle Depression Lake and Boysen Reservoir, were submitted for organochlorine analyses.

Analytical Support

Samples of water and of pesticides in bottom sediment were analyzed at the U.S. Geological Survey National Water Quality Laboratory in Denver, Colorado, using methods described by Fishman and Friedman (1985), and Wershaw and others (1987). Quality-assurance practices followed those described by Friedman and Erdmann (1982).

Bottom-sediment samples were air-dried, disaggregated using a mechanical mortar and pestle, and sieved at 2 mm (10 mesh) to remove larger than sand-sized material. Next, the sample was split--one-half of the sample was sieved at 0.062 mm (230 mesh) and the fine-grained material that passed through the sieve was saved for analysis. The second half of the sample less than 2 mm in size was ground in a ceramic plate grinder to size less than 0.15 mm (100 mesh). Both size fractions were analyzed by the U.S. Geological Survey, Branch of Geochemistry analytical laboratories in Denver, Colorado, using procedures described in Baedecker (1987). The sample processing and analysis procedures are also described by Harms and others (1990).

Biological samples were analyzed by laboratories under contract with the U.S. Fish and Wildlife Service Patuxent Analytical Control Facility. Trace elements were analyzed by Hazelton Laboratories America, Inc. in Madison, Wisconsin; Environmental Trace Substances Research Center in Columbia, Missouri; and Research Triangle Institute in Research Triangle Park, North Carolina. Organic compounds were analyzed by the Mississippi State Chemical Laboratory at Mississippi State University, Mississippi. Biological data are reported to two or three significant figures, depending on the level reported by the laboratories. All analyses were reviewed for quality assurance by the Patuxent Analytical Control Facility.

Percentage moisture and dry-weight concentrations in the biological samples were reported by the laboratories. Wet-weight concentrations were calculated by multiplying the dry-weight concentrations by the quantity, 1 minus the percentage of sample moisture (as a decimal); for example, 1 - 0.75. Wet-weight reporting limits were calculated in the same way.

DISCUSSION OF RESULTS

Precipitation during 1988 was about one-half of the average annual precipitation. Given the inverse relation between streamflow and water-quality constituent concentrations that has been shown for other areas of Wyoming, larger-than-average constituent concentrations in water might be expected in 1988, but this cannot be confirmed from the reconnaissance. The less-than-average precipitation adversely affected bird nesting and biological sampling.

Analytical results for all samples collected during this study are listed in tables at the back of the report. The titles and numbers of those tables are as follows: Onsite and laboratory measurements of inorganic constituents in water, table 10; pesticides in water samples and bottom-sediment samples, table 11; inorganic constituents and percentage of carbon in bottom-sediment samples, table 12; trace elements (dry weight) in biological samples, table 13; and organochlorine compounds in biological samples, table 14.

Water Quality

Guidelines used for evaluation of water quality include criteria for aquatic life in ambient waters, the Maximum Contaminant Level (MCL)[1] and Secondary Maximum Contaminant Level (SMCL)[2] as defined in the Primary and Secondary Drinking-Water Regulations established by the U.S. Environmental Protection Agency (1986; 1988a; 1988b). Although most of the water bodies sampled during this project are not being used for long-term human consumption, the contaminant levels are given as a basis for comparison to help readers of this report.

Onsite Measurements

Stream discharge, specific conductance, pH, water temperature, air temperature, barometric pressure, and dissolved oxygen were measured onsite (table 10). Turbidity, the other physical characteristic listed in table 10, was measured in the laboratory.

---

[1] Maximum Contaminant Levels are enforceable, health-based maximum levels (concentrations) for contaminants in public-water supplies.

[2] Secondary Maximum Contaminant Levels are nonenforceable, aesthetically based maximum levels for contaminants in public-water supplies.

The specific conductance of water in the Wyoming Canal (site 1) on the August sampling date was 140 µS/cm, indicating a small concentration of dissolved solids. The specific conductance was about 4,000 µS/cm at the sampling sites on Fivemile Creek (site 2) and Muddy Creek (site 15) upstream from the irrigation project, where flow in both streams is intermittent. The specific conductance was about 1,000 µS/cm at the two downstream sites (14 and 17) on both creeks in August, during the irrigation season. The measurements of specific conductance at the downstream sites indicate an increase in specific conductance of the irrigation water diverted from the Wyoming Canal, because nearly all of the streamflow at the downstream sites was irrigation drainage. Streamflow in Fivemile Creek, for example, was less than 0.25 ft^3/s at the upstream site and 275 ft^3/s at the downstream site in August. In essence, the difference in the conductance of the canal water (140 µS/cm) and the downstream sites on the streams (about 1,000 µS/cm) was a result of the canal-water diversion and return of the associated irrigation drainage to the creek between the upstream and downstream sites.

Specific conductance was larger in November than in August at 10 sites, about the same at one site, and smaller at one site. Streamflow was smaller in November than in August at six sites where specific conductance was larger, and streamflow was larger at one site where specific conductance was smaller. This inverse relation between specific conductance and streamflow may indicate irrigation water is diluting seepage from ground water.

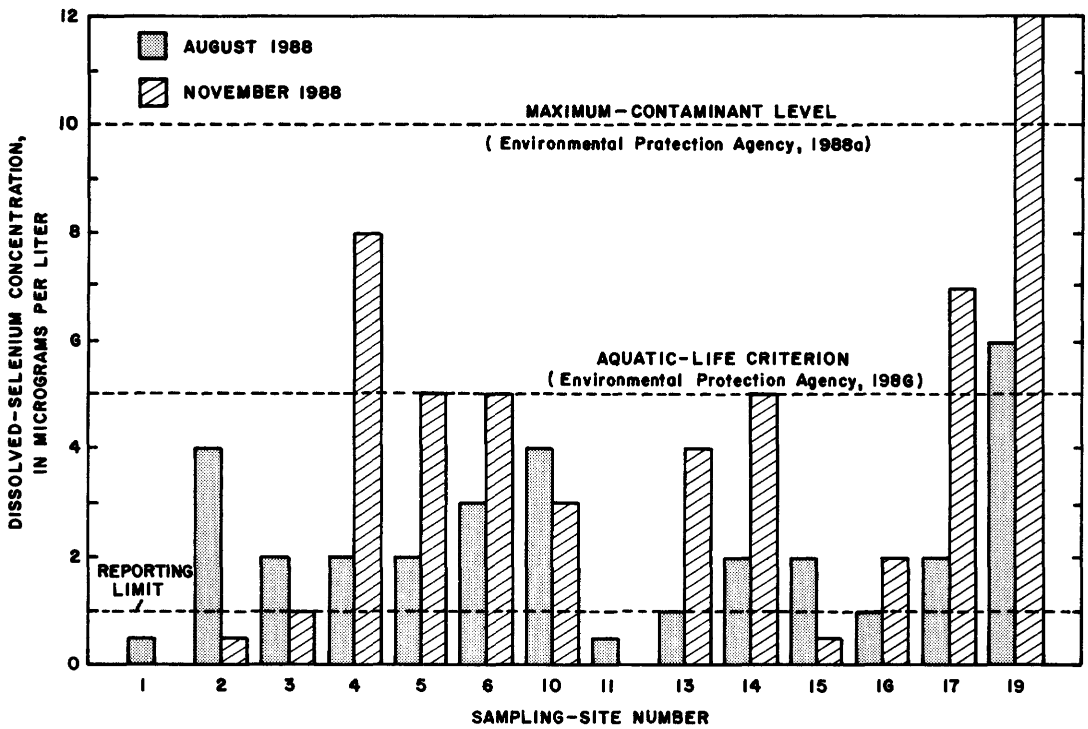
Onsite measurements of pH ranged from 7.8 to 8.8, indicating alkaline conditions. Dissolved-oxygen concentrations generally were near or above saturation at the time of sampling.

Inorganic Constituents

Concentrations of dissolved major ions and trace elements (table 10 at back of report) generally were less than the MCL. Those constituents with concentrations larger than the MCL or aquatic life criteria are discussed in this section.

Concentrations of nitrite plus nitrate, as nitrogen, commonly were less than the reporting limit of 0.1 mg/L. A sample collected in November from Pavillion Drain (site 4) contained 11 mg/L, exceeding the MCL of 10 mg/L. Some of the samples from Ocean Lake Drain numbers 6 and 7 (sites 5 and 6), Sand Gulch (site 13), lower Fivemile Creek (site 14), and the Sand Mesa ponds (site 19) contained concentrations of nitrite plus nitrate in the range of about 1 to 4 mg/L. A common characteristic among these sites is that all are at locations receiving irrigation drainage. A possible source of nitrogen in the irrigation drainage is agricultural fertilizer leached from the soil by surface or ground water.

Concentrations of dissolved selenium ranged from less than the reporting limit of 1 µg/L to 12 µg/L in samples collected in August and November 1988 (fig. 6). Sites where water samples were collected that contained less than 1 µg/L were the Wyoming Canal (site 1) in August, upper Fivemile Creek (site 2) in November, Pond 4 (site 11) in August, and upper Muddy Creek (site 15) in November. Samples from the Sand Mesa ponds (site 19) contained 6 µg/L in August and 12 µg/L in November.



EXPLANATION

SAMPLING-SITE NUMBER AND NAME

No.	Name	No.	Name
1	Wyoming Canal	11	Pond 4
2	Upper Fivemile Creek	13	Sand Gulch
3	North Pavillion Pond	14	Lower Fivemile Creek
4	Pavillion Drain	15	Upper Muddy Creek
5	Ocean Lake Drain No.6	16	Middle Depression Lake
6	Ocean Lake Drain No.7	17	Lower Muddy Creek
10	Ocean Drain at outlet	19	Sand Mesa

Figure 6.--Dissolved-selenium concentrations in water samples, August and November 1988. Concentrations less than the reporting limit, 1 microgram per liter, are shown as 0.5 microgram per liter, an arbitrary value.

Selenium concentrations were larger in the November samples than in the August samples at 8 of the 14 sampling sites (4, 5, 6, 13, 14, 16, 17, and 19). This may indicate irrigation water in August is diluting seepage from ground water, similar to the pattern observed for specific conductance at many of the same sites. At the other sites with data from August and November (sites 2, 3, 10, and 15), selenium concentrations were larger in August than in November, for unknown reasons.

Selenium concentrations in water samples from six sites equaled or exceeded 5 µg/L (fig. 6). The criterion for protection of aquatic life is a 4-day average of 5 µg/L not more than once every 3 years, and the 1-hour average selenium concentration should not exceed 20 µg/L more than once every 3 years (U.S. Environmental Protection Agency, 1988c). Samples containing 5 µg/L or more were collected from Pavillion Drain (site 4), Ocean Lake Drain numbers 6 and 7 (sites 5 and 6), lower Fivemile Creek (site 14), lower Muddy Creek (site 17), and Sand Mesa ponds (site 19), all of which receive irrigation drainage. The selenium concentration in only one sample collected during the study exceeded the EPA MCL of 10 µg/L; that was for a sample collected from Sand Mesa ponds (site 19) in November.

Comparison of dissolved-selenium concentration in relation to total-selenium concentration in the 19 water samples in which both values were greater than the reporting limit (table 10) indicates virtually all of the selenium was present in the dissolved state; that is, the quantity, total minus dissolved concentration, was zero in all but three samples. Linear correlation between dissolved and total selenium is indicated by an r^2 (coefficient of determination) of 0.98, significant at the 0.01 level (fig. 7). Predominance of selenium in the dissolved state indicates that selenium is not being transported in suspension, even though some of the streams, such as Fivemile Creek, were turbid and carried large quantities of suspended sediment (table 10 at back of the report).

Dissolved-uranium concentrations in water samples ranged from less than the reporting limit of 0.40 µg/L at Pond 4 (site 11) in August to 110 µg/L at the Sand Mesa ponds (site 19) in November. Nine of the samples--collected from Pavillion Drain (site 4), Ocean Lake Drain numbers 6 and 7 (sites 5 and 6), Ocean Drain at outlet (site 10), Sand Gulch (site 13), lower Fivemile Creek (site 14), lower Muddy Creek (site 17), and the Sand Mesa ponds (site 19, two samples)--exceeded the 35 µg/L Suggested No-Adverse Response Level recommended by the National Academy of Sciences (1983). This level is the recommended maximum concentration in water for human consumption and is given for reference only. Of the nine samples, eight were collected in November and one in August. This may indicate irrigation water in August is diluting seepage from ground water, similar to the pattern observed for specific conductance and selenium at many of the same sites.

Dissolved-uranium and dissolved-selenium concentrations appear to be associated with each other on the basis of the 15 samples in which both values were greater than the reporting limit (fig. 8 and table 10). Linear correlation between uranium and selenium concentrations is indicated by an r^2 of 0.81, significant at the 0.01 level. The correlation indicates either the concentrations of the two elements are interrelated, or perhaps the concentrations are independent but affected by a common factor. Uranium and selenium

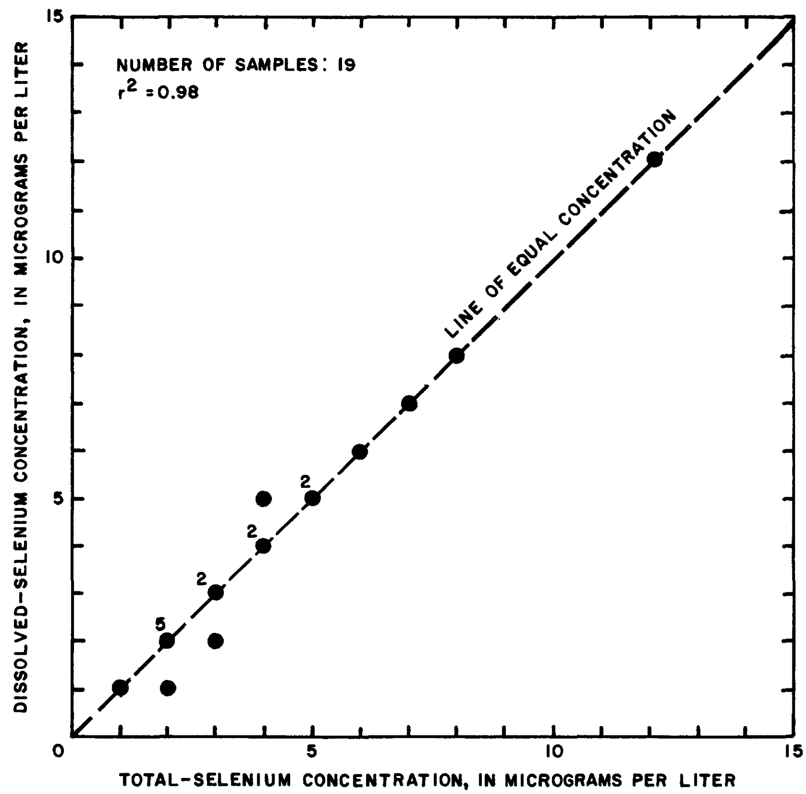


Figure 7.--Correlation between dissolved-selenium and total-selenium concentrations in water samples. Numeral next to symbol indicates number of samples with identical concentrations.

are present naturally in the formations and soils in the study area and probably are mobilized by the irrigation water. In other areas, uranium, arsenic, and molybdenum sometimes are geochemically associated with selenium. Arsenic and molybdenum concentrations in samples collected during this study were small and were not correlated with selenium concentrations.

Pesticides

Pesticide analyses included in the water analyses were for herbicides such as dicamba, picloram, and chlorophenoxy compounds, and for organophosphate insecticides (table 11 at back of report). Pavillion Drain (site 4) contained the widest variety of detectable pesticides of any of the sampling sites. Concentrations detected in a water sample were 0.12 µg/L dicamba, 0.08 µg/L 2,4-D, 0.03 µg/L methyl parathion, and 0.13 µg/L parathion. The concentrations of dicamba and 2,4-D at Pavillion Drain and other sites in this

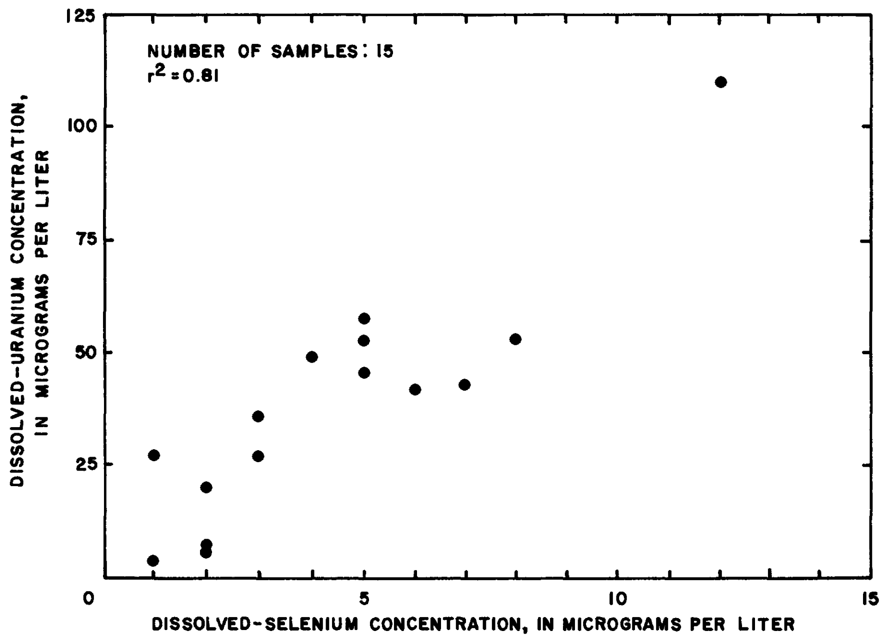


Figure 8.--Correlation between dissolved-uranium and dissolved-selenium concentrations in water samples.

study did not exceed the U.S. Environmental Protection Agency (1989) applicable lifetime human-health advisory levels, which are 200 µg/L for dicamba and 70 µg/L for 2,4-D. However, the concentration of 0.13 µg/L parathion at Pavillion Drain does exceed the 0.065 µg/L acute criterion for freshwater aquatic life (U.S. Environmental Protection Agency, 1987). The acute criterion is the maximum short-term concentration recommended for protection of freshwater and marine aquatic life, based on toxicity studies; the criterion is 0.013 µg/L for chronic or long-term exposure.

Pesticides also were detected at other sites in the study area. In water samples, dicamba was detected at a total of seven sites, 2,4-D was detected at four sites, and parathion was detected at three sites. Samples from Ocean Lake Drain number 6 (site 5) and the outlet of Ocean Lake (site 10) contained dicamba and either 2,4-D or parathion. The presence of pesticides in Ocean Lake is of interest in relation to the decline of the lake's fishery, but the effect of the pesticides at the concentrations detected in water samples is not known.

Bottom Sediment

Samples of bottom sediment were collected from 14 sites for analysis of major ions and trace elements and from 8 sites for analysis of pesticides. The complete analytical results are listed in tables 11 and 12 at back of the report.

Inorganic constituents

A summary of the analytical results for the bottom-sediment samples is listed in table 3. The analytical results for this study are compared to geochemical baseline information for soils in the Wind River Basin and soils in the Western United States in table 4. An explanation of the data in table 4 is necessary before any comparisons are made, because the sampling media for each of the studies in table 4 differ from one study to another. Soils from the Wind River Basin (Severson, 1979) were composited samples collected from the surface to 40 cm deep with a soil auger from a randomly located traverse in each of three geologic units. Soils from the western half of the United States (Shacklette and Boerngen, 1984) consist of soils west of the 96th meridian collected from the B horizon, or below 20 cm, where the B horizon was undefined. The computed baseline values for the soils from the Wind River Basin and soils from the Western United States are referred to as baselines because the natural soils may be affected by humans to an unknown extent. Background values, in contrast, are intended to represent natural concentrations in soils that are not affected by humans and may not be obtainable; baselines may or may not represent true background.

The baseline values are defined by Tidball and Ebens (1976) as the expected 95-percent range in concentration in a set of samples and is computed from the geometric mean and geometric deviation. Values within this range are defined as common, and those values outside the range are uncommon. Baseline data are valid for comparing analyses of the same kind of sample from the area where the baseline was developed. They should be applied with caution to different sample media or to samples collected outside the baseline area. The bottom sediments have been derived from rocks and soils in the basin; the absence of any data on trace-element concentrations in stream sediment makes the Wind River Basin soils data the best available data for comparison. Soils from the Western United States represent a much larger data base and also commonly are used as a guideline. Soils from the Wind River Basin on the average are not greatly different from soils across the Western United States.

Two size fractions (a fine-grained fraction, less than 0.062 mm, and a coarse-grained fraction, less than 2 mm) of bottom sediment were analyzed. For most elements, the concentrations were greater in the fine-grained fraction. Exceptions to this were strontium, barium, and sodium, which had larger concentrations in the coarse-grained fraction. Potassium, and perhaps beryllium, had approximately equal concentration in both size fractions. In the following paragraphs, the values given for various elements are concentrations in the fine-grained fraction.

Table 3.--Statistical summaries of analytical results of bottom-sediment samples

[percent, percent by weight; µg/g, micrograms per gram; <, less than; --, not applicable. Detection ratio, number of samples in which the element was detected in measurable concentrations relative to the number of samples analyzed]

Element (unit)	Minimum	Maximum	Median	Detection ratio
Aluminum (percent)	3.1	7.4	5.8	28:28
Calcium (percent)	1.4	9.3	3.4	28:28
Iron (percent)	.72	4.0	2.0	28:28
Magnesium (percent)	.31	2.3	1.1	28:28
Phosphorus (percent)	.02	.13	.07	28:28
Potassium (percent)	1.0	2.2	1.7	28:28
Sodium (percent)	.51	2.4	1.2	28:28
Titanium (percent)	.08	.43	.19	28:28
Arsenic (µg/g)	.6	7.2	3.0	28:28
Barium (µg/g)	620	2,200	820	28:28
Beryllium (µg/g)	<1	2	1	25:28
Boron (µg/g)	.2	3.2	.5	27:27
Cadmium (µg/g)	All <2	--	--	0:28
Cerium (µg/g)	37	290	67.5	28:28
Chromium (µg/g)	19	190	50	28:28
Cobalt (µg/g)	4	20	8	28:28
Copper (µg/g)	3	23	10	28:28
Gallium (µg/g)	7	19	14	28:28
Lanthanum (µg/g)	24	110	40	28:28
Lead (µg/g)	10	49	14	28:28
Lithium (µg/g)	10	33	18	28:28
Manganese (µg/g)	230	880	430	28:28
Mercury (µg/g)	<.02	.30	<.02	17:28
Molybdenum (µg/g)	All <2	--	--	0:28
Neodymium (µg/g)	16	100	30.5	28:28
Nickel (µg/g)	7	52	17	28:28
Niobium (µg/g)	<4	9	4	14:28
Scandium (µg/g)	3	12	6	28:28
Selenium (µg/g)	<.1	3.0	.3	27:28
Silver (µg/g)	<2	2	--	1:28
Strontium (µg/g)	170	650	290	28:28
Thorium (µg/g)	<4	45	11	26:28
Tin (µg/g)	<10	120	<10	3:28
Uranium (µg/g)	.50	5.7	1.4	28:28
Vanadium (µg/g)	17	130	52	28:28

Table 3.--Statistical summaries of analytical results of bottom-sediment samples--Continued

Element (unit)	Minimum	Maximum	Median	Detection ratio
Ytterbium (μg/g)	<1	3	1.5	25:28
Yttrium (μg/g)	6	26	15	28:28
Zinc (μg/g)	13	510	41	28:28
Total carbon (percent)	.11	3.08	1.02	28:28
Organic carbon (percent)	.02	1.36	.28	28:28
Carbonate carbon (percent)	.07	2.36	.71	28:28

Bottom sediment at site 1 was collected in the Wyoming Canal about 1 mi downstream from the diversion dam on the Wind River. This sample was intended to serve as a reference sample for the irrigation district, because it was collected from a site upstream from any irrigation activities in the study area. However, it contains the largest concentrations detected for a number of metals, including chromium, cobalt, iron, lead, nickel, thorium, vanadium, and several rare-earth elements. The Wyoming Canal sample contains elements such as chromium, cobalt, iron, nickel, and vanadium that normally are detected in larger concentrations in basic rocks such as basalt, and also elements such as thorium and lighter-weight rare-earth elements that are more characteristic of granitic rocks. Both of these rock types are in formations cropping out in the Wind River drainage basin in the volcanics of the Absaroka Range and the gneissic and granitic core of the Wind River Range. These results for bottom sediment in the Wyoming Canal are consistent with the geologic origins of sediments transported by the Wind River. In the spring of 1989, site 1 was re-sampled before irrigation water was diverted into the canal. A modified Frantz magnetometer was used to separate a portion of the sample into magnetic and nonmagnetic fractions. The iron concentration of most basalts is great enough to make them weakly magnetic, making it possible to identify them as basalt. Microscopic examination of the 1- to 2-mm size granules confirmed that the particles were basalt and, therefore, this sample is not representative of the irrigation district.

Selenium concentrations in the fine-grained fraction of bottom-sediment samples collected at several sites equaled or exceeded the upper limit (1.4 μg/g) of the expected 95-percent baseline range for the Wind River Basin. Samples collected in the upstream reaches of both Fivemile Creek (site 2, 0.6 μg/g) and Muddy Creek (site 15, 1.2 μg/g) contained concentrations of selenium that possibly indicate a source in some of the Cretaceous shales in the headwaters of the creeks. Selenium concentrations in the samples collected at the downstream sites on the creeks were not elevated; the slight anomalies upstream appear to have been diluted by additional sediment entering the creeks from within the study area. For example, bottom sediment samples from tributaries to Fivemile Creek contained 0.4 μg/g (site 4) and 0.2 μg/g (site 13).

Table 4.--Comparsion of results of bottom-sediment analyses from the Riverton Reclamation Project with geochemical baselines in soils

[percent, percent by weight; µg/g, micrograms per gram; <, less than; --, no data; baseline, expected 95-percent range calculated from geometric mean and geometric deviation. Data for Wind River Basin from Severson (1979). Data for Western United States from Shacklette and Boerngen (1984)]

Element	Riverton	Wind River Basin		Western United States	
	Measured range	Baseline	Measured range	Baseline	Measured range
Aluminum (percent)	3.1-7.4	3.3-7.2	2.9-7.8	1.45-23	0.5->10
Calcium (percent)	1.4-9.3	0.59-8.2	0.46-8.8	0.19-17	0.06-32
Iron (percent)	0.72-4.0	0.82-2.7	0.77-2.9	0.6-8	0.1->10
Magnesium (percent)	0.31-2.3	0.27-1.5	0.22-1.7	0.15-3.6	0.03->10
Phosphorus (percent)	0.02-0.13	--	--	0.006-0.17	0.004-0.45
Potassium (percent)	1.0-2.2	1.6-2.6	1.5-2.6	0.8-4.3	0.19-6.3
Sodium (percent)	0.51-2.4	0.8-2.1	0.6-2.2	0.26-3.7	0.05-10
Titanium (percent)	0.08-0.43	0.15-0.32	0.12-0.48	0.07-0.7	0.05-2.0
Arsenic (µg/g)	0.6-7.2	1.2-11	0.33-12	1.2-22	<0.1-97
Barium (µg/g)	620-2,200	--	1,000-2,200	200-1,700	70-5,000
Beryllium (µg/g)	<1-2	--	2-5	0.13-3.6	<1-15
Boron (µg/g)	0.2-3.2	16-50	16-66	5.8-91	<20-300
Cadmium (µg/g)	All <2	--	<38	--	<1-10
Cerium (µg/g)	37-290	--	26-940	22-85	<150-300
Chromium (µg/g)	19-190	13-93	11-94	8.5-200	3-2,000
Cobalt (µg/g)	4-20	2.6-12	2-16	2-28	<3-50
Copper (µg/g)	3-23	--	5-97	4.9-90	2-300
Gallium (µg/g)	7-19	9.5-24	7.3-24	6-45	5-70
Lanthanum (µg/g)	24-110	--	22-650	8-107	<30-200
Lead (µg/g)	10-49	--	6-80	5-55	<10-700
Lithium (µg/g)	10-33	6.9-33	5-40	9-55	5-130
Manganese (µg/g)	230-880	130-680	110-680	97-1,500	30-5,000
Mercury (µg/g)	<0.02-0.30	0.011-0.035	<0.01-0.04	0.009-0.25	<0.01-4.6
Molybdenum (µg/g)	All <2	1.5-10	<2-12	0.18-4	<3-7
Neodymium (µg/g)	16-100	--	--	12-110	<70-300
Nickel (µg/g)	7-52	5-38	4-42	3.4-66	<5-700
Niobium (µg/g)	<4-9	--	3-16	3-29	<10-100
Scandium (µg/g)	3-12	--	<3-11	3-25	<5-50
Selenium (µg/g)	<0.1-3.0	--	<0.1-0.4	0.04-1.4	<0.1-4.3
Silver (µg/g)	<2-2	--	<0.22-0.4	--	<0.5-5
Strontium (µg/g)	170-650	180-660	160-690	43-950	10-3,000
Thorium (µg/g)	<4-45	6-24	4-30	4.1-20	2.4-31
Tin (µg/g)	<10-120	--	<0.1-3	0.2-4	<0.1-7.4
Uranium (µg/g)	0.50-5.7	1.8-4.6	1.2-5.8	1.2-5.3	0.68-7.9
Vanadium (µg/g)	17-130	21-86	16-107	18-270	7-500

Table 4.--Comparsion of results of bottom-sediment analyses from the Riverton Reclamation Project with geochemical baselines in soils--Continued

Element	Riverton	Wind River Basin		Western United States	
	Measured range	Baseline	Measured range	Baseline	Measured range
Ytterbium (g/g)	<1-3	--	0.8-12	1-7	<1-20
Yttrium (g/g)	6-26	--	10-120	8-60	<10-150
Zinc (g/g)	13-510	26-72	19-93	17-180	10-2,100
Total carbon (percent)	0.11-3.08	0.34-2.1	0.21-3.2	3-9.5	0.16-10
Organic carbon (percent)	0.02-1.36	--	--	--	--
Carbonate carbon (percent)	0.07-2.36	--	--	--	--

Middle Depression Lake (site 16, 3.0 μg/g) contained the largest concentration of selenium detected at sampling sites in the area. The lake is on a broad bench of terrace and pediment gravels called Cottonwood Bench. The Sand Mesa ponds sample (site 19, 1.3 μg/g) was collected from the north side of this bench; from the limited reconnaissance sampling, Cottonwood Bench appears to contain slightly elevated concentrations of selenium. Two other samples with elevated selenium concentrations in bottom sediment are associated with Ocean Lake. One sample was collected at the mouth of Ocean Lake drain number 6 (site 5, 1.1 μg/g), where it flows into Ocean Lake; and the other was collected at the outlet of Ocean Lake (site 10, 1.1 μg/g).

Bottom-sediment samples from Ocean Lake drain at the outlet (site 10) and Middle Depression Lake (site 16) also contained elevated concentrations of calcium and barium, the probable result of the precipitation of calcium and barium carbonates or sulfates formed as water evaporates. Surface deposits of a white precipitate are common in damp soils along the northeast margin of Ocean Lake and in areas around Middle Depression Lake. Samples from the Ocean Lake area also contained the largest concentrations of uranium detected in bottom-sediment samples from the study area--4.4 μg/g at the drain flowing into the lake (site 5) and 5.7 μg/g at the outlet of the lake (site 10). Both of these concentrations are near the upper limit (4.6 μg/g) of the expected 95-percent baseline range computed for the Wind River Basin. Three other isolated single-element-concentration anomalies are present in the bottom-sediment data. A sample from site 11 contained 510 μg/g zinc in the fine-grained fraction. This sample was collected at Pond 4, a small wildlife pond east of Ocean Lake; the pond is covered with algal growth, and an accumulation of decaying vegetation on the bottom of the pond could be a source of zinc. Sampling site 4 (Pavillion Drain) contained 120 μg/g tin. Local contamination is suspected from old farm equipment and metal debris along the edges of the drain upstream from the sample site. The sample from Ocean Lake Drain number 7 (site 6) contained 0.30 μg/g mercury. No source for the mercury is known; other samples collected in the area had only average concentrations of mercury.

Pesticides

Bottom sediments were analyzed for organochlorine insecticides because of the tendency for these compounds to persist in the sediment. The sample of bottom sediment at Pavillion Drain (site 4) contained 0.6 µg/kg DDT and two metabolites of DDT--0.4 µg/kg DDD and 0.1 µg/kg DDE (table 11 at back of the report). DDE also was detected in bottom-sediment samples from Ocean Lake Drain numbers 6 and 7 (sites 5 and 6), and from Sand Gulch (site 13). The sale of DDT has been outlawed in the United States since the early 1970s, partially because of the persistence of the compound and its metabolites. The origin and timing of application cannot be determined from the available data, and there are no aquatic-life criteria for these compounds in bottom sediment. However, their occurrence is of interest in relation to detection of organochlorine compounds in biota of the study area, as described later in this report.

The sediments also were analyzed for organophosphate insecticides; all concentrations were less than the detection limit. The common factor among sites that contained detectable concentrations of pesticides in bottom sediment was the presence of irrigation drainage.

Biota

Chemical, physical, and biological interactions are dynamic and variable among aquatic habitats. Chemical interactions within the food chain, including synergistic, antagonistic, or other interactions among trace elements, are complex. The effects of these interactions can vary considerably for different trophic concentrations of organisms, among species, as well as from site to site. The degree of contaminant accumulation in aquatic organisms also depends on the type of food chain, the availability and persistence of the contaminant in water, and the physical and chemical properties of the contaminant. Contaminant accumulation in the food chain can occur through bioconcentration, bioaccumulation, or biomagnification. Bioconcentration is the net accumulation of an element or compound directly from the water by an aquatic organism. Bioaccumulation is the accumulation of a chemical by an organism from the water or through the ingestion of food containing the chemical. Biomagnification is the increase in body burden of a chemical in successively greater trophic levels (Biddinger and Gloss, 1984; Hall and Burton, 1982; Macek and others, 1979; Rand and Petrocelli, 1985).

For the study of natural ecosystems, adequate guidelines that are indicative of toxicity have not been established for specific concentrations of most trace elements in fish, birds, or lower aquatic organisms. Additionally, because of the complexity and variability of natural ecosystems, the effects of chemical constituents on biota in one area may not occur in biota in a different area. Hence, the data from controlled-diet studies or from other areas can be used only as guides for determining if concentrations in biota are potentially harmful.

Concentrations of most trace elements and organic compounds in biota of the Riverton Reclamation Project were small. Therefore, the discussion is limited to arsenic, boron, cadmium, copper, mercury, selenium, zinc, PCBs, and DDT metabolites because of their concentrations in biota and their toxicity to fish and wildlife. The concentrations are discussed in terms of either dry weight or wet weight, or both, depending on the method of expression used by the other investigators cited for reference. As an aid to the reader, dry- and wet-weight concentrations for arsenic, mercury, and selenium are listed in tables in the text. Dry-weight concentrations for all of the constituents are given in tables 13 and 14 at the back of the report. Moisture percentages are included in tables 13 and 14 for converting dry-weight concentrations to wet-weight concentrations.

Submerged Aquatic Vegetation

Submerged aquatic vegetation is a common dietary item for some waterfowl species. Arsenic, mercury, and selenium concentrations in pondweed (*Potamogeton vaginatus*) samples that consist of composited stems and leaves are listed in table 5.

Arsenic and boron

Arsenic concentrations in pondweed samples were small and not unusual for plants. The largest arsenic concentrations were detected in samples from site 16, Middle Depression Lake (2.88 to 3.62 μg/g dry weight). Boron concentrations ranged from less than the reporting limit to 848 μg/g dry weight. The largest boron concentration detected, 848 μg/g, was in a plant sample from Pond 4 (site 11, see table 13 at back of the report). Pondweed samples collected from Sand Mesa ponds (site 19) had boron concentrations ranging from 441 to 476 μg/g dry weight. Pondweed collected from Ocean Lake (sites 7 and 9) had boron concentrations ranging from 147 to 226 μg/g dry weight. Two pondweed samples from North Pavillion Pond (site 3) contained boron concentrations of 260 and 783 μg/g dry weight. The effects of the ingestion of boron on waterfowl reproduction are unknown. However, boron concentrations larger than 1,000 μg/g dry weight in the diet have been demonstrated to cause embryotoxicity in ducks in controlled studies (Smith and Anders, 1987), and concentrations between 300 and 1,000 μg/g have caused adverse effects to ducklings (Patuxent Wildlife Research Center, 1986).

Mercury and selenium

Mercury and selenium concentrations in pondweed were small, although two pondweed samples collected from Ocean Lake (sites 7 and 9) had selenium concentrations of 4.00 and 4.75 μg/g dry weight. These concentrations are slightly less than the dietary concentrations known to cause adverse effects in fish (5 μg/g dry weight) but greater than such concentrations for waterfowl (3 μg/g dry weight) (Lemly and Smith, 1987). One sample from North Pavillion Pond (site 3) had a selenium concentration of 7.44 μg/g dry weight. All other concentrations were less than the dietary concentrations known to cause adverse effects in fish and wildlife.

Table 5.--Arsenic, mercury, and selenium concentrations in composite samples of stems and leaves of **Potamogeton vaginatus**

[<, less than]

Site name and No. (fig. 2)	Dry- and wet-weight concentrations, in micrograms per gram					
	Arsenic		Mercury		Selenium	
	Dry	Wet	Dry	Wet	Dry	Wet
North Pavillion Pond						
3	0.499	0.060	<0.020	<0.001	7.44	0.90
	.783	.150	< .020	< .002	2.90	.56
Ocean Lake, west side						
7	.918	.190	< .020	< .002	1.80	.37
	1.36	.320	< .020	< .002	4.75	1.12
Ocean Lake, east side						
9	1.03	.210	.0517	.010	2.48	.50
	.897	.170	< .020	< .002	4.00	.74
Pond 4						
11	.764	.081	1.07	.113	< .94	< .05
	2.00	.154	< .325	< .013	<1.30	< .05
	.730	.084	< .217	< .012	< .87	< .05
	.730	.081	< .225	< .012	< .90	< .05
Middle Depression Lake						
16	2.95	.251	< .294	< .012	1.2	.10
	3.62	.275	.355	.027	1.3	.10
	2.88	.288	< .250	< .012	<1.0	< .05
Sand Mesa ponds						
19	1.29	.110	< .294	< .012	1.2	.10
	.980	.096	.286	.028	1.0	.10
	.800	.056	< .357	.012	<1.4	< .05

Aquatic Invertebrates

Aquatic invertebrates are a common dietary item for some waterfowl and shorebird species and constitute an important food source for juvenile waterfowl. Some fish species also consume aquatic invertebrates. Arsenic, mercury, and selenium concentrations in aquatic invertebrates, primarily waterboatmen (Family Corixidae), are listed in table 6.

Arsenic

Arsenic concentrations in the waterboatmen were small. On the basis of diet studies by Eisler (1988), it is unlikely that arsenic concentrations in aquatic invertebrates found in the study area would have detrimental effects on fish and waterfowl.

Mercury

Mercury concentrations in waterboatmen collected from the west side of Ocean Lake (site 7) ranged from 0.193 to 0.283 µg/g dry weight; however, samples taken from the east side of the lake (site 9) ranged from 0.0596 to 0.0788 µg/g dry weight. Two waterboatmen samples from North Pavillion Pond (site 3) had mercury concentrations of 0.0768 and 0.152 µg/g dry weight.

Selenium

Selenium concentrations in waterboatmen collected from Ocean Lake (sites 7 and 9) ranged from 3.27 to 9.13 µg/g dry weight. Waterboatmen from North Pavillion Pond (site 3) had selenium concentrations of 8.14 and 11.1 µg/g dry weight. Concentrations in seven samples were larger than the dietary concentrations known to cause adverse effects in fish (5 µg/g); concentrations in all nine samples exceeded those known to cause adverse effects in waterfowl (3 µg/g).

Fish

Since 1967, the U.S. Fish and Wildlife Service has participated in the National Contaminant Biomonitoring Program (NCBP), formerly called the National Pesticide Monitoring Program. Selected toxic trace elements and organochlorines have been analyzed in samples of fish and wildlife collected from a nationwide network of stations.

Trace-element concentrations in samples of whole-body fish from the study area were considered not to be elevated relative to the NCBP baseline if the concentrations were less than or equal to the 85th percentile of the NCBP data. Likewise, organochlorine concentrations were considered not to be elevated if they were less than or equal to the geometric means of the NCBP data. Data from the NCBP are not specific to the Riverton Reclamation Project area and include values for several fish species; some of the species in the NCBP may be different from those sampled in the Riverton study. Given the limitations of comparing the two data sets with some difference in species,

Table 6.--Arsenic, mercury, and selenium concentrations in aquatic-invertebrate samples

[<, less than]

Site name and No. (fig. 2)	Common name	Arsenic Dry	Arsenic Wet	Mercury Dry	Mercury Wet	Selenium Dry	Selenium Wet
		Dry- and wet-weight concentrations, in micrograms per gram					
North Pavillion Pond							
3	Water boatmen	<0.20	<0.028	0.0768	0.022	8.14	2.30
	Copepods	1.51	.196	.152	.020	11.1	1.44
Ocean Lake, west side							
7	Water boatmen	.311	.052	.193	.032	3.27	.543
	Water boatmen	1.00	.271	.283	.077	9.13	2.47
	Water boatmen	.561	.070	.254	.031	3.83	.475
Ocean Lake, east side							
9	Water boatmen	.707	.081	.0738	.009	6.43	.733
	Water boatmen	.780	.089	.0621	.007	5.20	.593
	Water boatmen	.711	.090	.0596	.008	5.81	.732
	Water boatmen	.799	.126	.0671	.011	5.02	.793

the NCBP still provides a basis for comparison of the Riverton data to a national data base. Also, although some concentrations may be larger than national-baseline concentrations, this does not mean that these concentrations have caused or will cause adverse biological effects. Trace-element concentrations in the NCBP and from other referenced literature are reported in wet-weight concentrations. All trace-element data were reported in dry-weight concentrations by the laboratories (table 13). To compare these data to wet-weight concentrations reported in the literature, the following formula was used to convert dry weight to wet weight:

$$\text{wet-weight concentration} = \text{dry-weight concentration}\ (1 - \frac{\text{percent moisture}}{100}).$$

Arsenic, mercury, and selenium concentrations (dry and wet weight) in samples of whole-body fish and fish eggs from the study area are listed in table 7. Cadmium, copper, and zinc concentrations (dry weight only) are listed in table 13; organochlorine concentrations (dry weight only) are listed in table 14 (both tables at back of the report).

Table 7.--Arsenic, mercury, and selenium concentrations in whole-body-fish and fish-egg samples

[Concentrations are for whole-body-fish samples unless otherwise specified. <, less than]

Site name and No. (fig. 2)	Common name	Arsenic Dry	Arsenic Wet	Mercury Dry	Mercury Wet	Selenium Dry	Selenium Wet
		Dry- and wet-weight concentrations, in micrograms per gram					
Ocean Lake, west side							
7	Carp	1.10	0.365	0.198	0.066	4.73	1.57
	Carp	.280	.074	.0881	.023	5.21	1.37
	Carp	.412	.127	.108	.033	4.41	1.36
	Carp	.439	.131	.0954	.029	4.24	1.27
	Carp	< .20	< .030	.113	.034	5.16	1.53
	White sucker	< .20	< .030	.0562	.002	4.64	1.37
	White sucker	< .20	< .029	.271	.080	3.30	.970
	Yellow perch	< .20	< .025	.445	.113	7.33	1.85
	Walleye	< .20	< .027	.108	.029	4.79	1.28
	Walleye	< .20	< .024	.159	.038	4.27	1.02
	Walleye	< .20	< .024	.272	.066	6.76	1.64
	Walleye	< .20	< .026	.412	.107	8.35	2.16
	Black crappie	< .20	< .026	1.07	.277	6.32	1.64
	Black crappie	.372	.092	.227	.056	4.20	1.04
Ocean Lake, east side							
9	Carp	.734	.208	.100	.028	6.14	1.74
	Carp	.693	.207	.187	.056	5.92	1.76
	Carp	.456	.138	.237	.072	4.46	1.35
	Carp	.552	.160	.393	.114	7.01	2.03
	Carp	< .20	< .028	.149	.041	7.02	1.94
	Carp	.424	.110	.158	.041	4.51	1.17
	Yellow perch	< .20	< .027	.332	.090	4.72	1.28
	Walleye	< .20	< .020	1.30	.264	7.45	1.51
	Black crappie	< .20	< .026	.327	.083	4.43	1.13
	Black crappie	< .20	< .025	.301	.075	4.38	1.09
	Black crappie	< .20	< .025	.654	.160	7.49	1.84
Middle Depression Lake							
16	Rainbow trout	< .10	.000	.552	.146	14.2	3.76
	Rainbow trout	.20	.050	.490	.122	13.0	3.25
	Rainbow trout	.10	.025	.542	.134	15.2	3.75
	Rainbow trout	< .10	.000	.470	.114	13.0	3.15
	Rainbow trout	.33	.082	.260	.064	9.2	2.28
	White sucker	.34	.086	.370	.093	7.6	1.92
	White sucker	.20	.049	.190	.047	8.6	2.12
	White sucker	.30	.073	.320	.078	5.2	1.27
	White sucker	< .10	.000	.250	.069	8.8	2.41
	White sucker	< .10	.000	.290	.074	7.5	1.92
	Rainbow trout (eggs)	.20	.076	.007	.003	23.0	8.72
	Rainbow trout (eggs)	.10	.042	.031	.013	22.0	9.13

Table 7.--Arsenic, mercury, and selenium concentrations in whole-body-fish and fish-egg samples--Continued

Site name and No. (fig. 2)	Common name	Dry- and wet-weight concentrations, in micrograms per gram					
		Arsenic		Mercury		Selenium	
		Dry	Wet	Dry	Wet	Dry	Wet
Lake Cameahwait							
18	Rainbow trout	0.225	0.045	0.316	0.064	8.14	1.64
	Rainbow trout	< .20	< .025	.576	.143	12.2	3.03
	Rainbow trout	< .20	< .027	.485	.133	11.7	3.21
	Rainbow trout	.361	.082	.297	.067	7.95	1.80
	Rainbow trout	.251	.057	.344	.079	9.65	2.21
	White sucker	< .20	< .026	.414	.108	8.48	2.22
	White sucker	.213	.052	.240	.059	8.60	2.10
	White sucker	.354	.101	.219	.063	8.11	2.32
	White sucker	< .20	< .027	.252	.069	6.68	1.82
	White sucker	< .20	< .026	.278	.071	7.62	1.95
	White sucker	< .20	< .028	.222	.062	6.23	1.74
	White sucker	< .20	< .029	.224	.064	7.42	2.12
	White sucker	.203	.056	.369	.101	8.15	2.24
	White sucker	< .20	< .028	.278	.078	7.40	2.07
	White sucker	< .20	< .030	.266	.069	6.49	1.97
	Yellow perch	< .20	< .027	.570	.154	9.17	2.48
	Yellow perch	< .20	< .028	.796	.223	8.41	2.91
	Yellow perch	< .20	< .029	.891	.254	10.4	2.96
Boysen Reservoir near Sand Mesa ponds							
20	Sauger	.20	.056	1.00	.279	2.6	.725
	Sauger	.30	.080	.844	.224	2.7	.716
	Sauger	.20	.051	.864	.220	2.8	.714
	Walleye	.59	.151	.900	.230	2.7	.691
	Walleye	.46	.120	.781	.204	2.8	.731
	Carp	.69	.181	1.30	.341	3.0	.786
	Carp	.61	.138	1.70	.386	3.7	.840
	Carp	.60	.153	.759	.194	4.4	1.12
	Carp	.48	.114	1.50	.355	3.6	.853
	Carp	.44	.116	1.10	.289	3.4	.894
	Carp	.45	.095	1.50	.316	4.1	.865
	Rainbow trout (eggs)	.10	.037	< .005	< .0003	4.9	1.82
Boysen Reservoir near Boysen Dam							
21	Rainbow trout	.20	.050	.460	.114	3.3	.818
	Rainbow trout	.10	.024	.450	.108	2.8	.675
	Rainbow trout	.20	.062	.320	.099	2.6	.803
	Rainbow trout	.34	.099	.280	.081	2.6	.757
	Rainbow trout	.30	.084	.290	.081	2.6	.731
	Rainbow trout	.30	.099	.240	.079	2.3	.757

Arsenic

Arsenic is accumulated from the water by various organisms; however, evidence of biomagnification along the food chain does not exist (Eisler 1988; Spehar and others, 1980). Spehar and others (1980) reported that the form of arsenic that organisms are exposed to greatly affects arsenic uptake. Spehar and others found that arsenic uptake was much less for fish than for aquatic invertebrates. They also reported that in acute-toxicity tests, fish have great tolerance of arsenic, but that no long-term tests of the effects of subacute exposure to arsenic have been conducted.

Arsenic concentrations in most whole-body-fish samples from the Riverton Project were smaller than the 85-percent baseline of 0.22 µg/g wet weight from the NCBP during 1980 and 1981 (Lowe and others, 1985) and smaller than the whole-body concentrations of 0.5 µg/g dry weight considered harmful to fish and predators by Walsh and others (1977). One carp collected from the west side of Ocean Lake (site 7) had an arsenic concentration of 0.365 µg/g wet weight. Arsenic concentrations in all fish collected were within the background concentrations (1 µg/g wet weight) for fish reported by Eisler (1988, p. 21). Arsenic concentrations in samples of fish do not appear to be elevated in the study area.

Cadmium

Cadmium is toxic to fish and can be bioconcentrated (Eisler, 1987a). Cadmium concentrations in carp sampled from Boysen Reservoir (site 20) and one walleye sampled from the east side of Ocean Lake (site 9) were larger than the NCBP 85-percent baseline of 0.06 µg/g wet weight. These concentrations, however, were smaller than the 0.5 µg/g wet-weight concentration considered adverse to fish by Walsh and others (1977).

Copper

Copper can be toxic to fish (U.S. Environmental Protection Agency, 1986). Where present at concentrations larger than detection limits, copper concentrations in whole-body-fish samples exceeded the NCBP 85-percent baseline of 0.68 µg/g wet weight. One carp from Boysen Reservoir (site 20) had a copper concentration of 130 µg/g wet weight.

Mercury

Of all the trace metals, mercury is the most toxic to fish and is a cumulative poison (Jenkins, 1981; Eisler, 1987b). Mercury concentrations in rainbow trout and white suckers sampled from Middle Depression Lake (site 16) and Boysen Reservoir (site 21) were less than the 85-percent baseline concentration of 0.18 µg/g wet weight from the NCBP during 1978, 1979, 1980, and 1981 (Lowe and others, 1985). However, carp, walleye, and sauger sampled from Boysen Reservoir (site 20), some black crappie and walleye sampled from Ocean Lake (sites 7 and 9), and some yellow perch sampled from Lake Cameahwait (site 18) had mercury concentrations (0.194 to 0.386 µg/g wet weight) larger than the 85-percent baseline.

Selenium

Selenium is physiologically necessary in minute quantities for metabolic processes; however, it is toxic in large concentrations. Aquatic organisms tend to bioaccumulate selenium in concentrations one or more orders of magnitude greater than the concentrations in water or food (Lemly and Smith, 1987). This may result because selenium, being chemically similar to sulfur, replaces sulfur in amino acids (Shamberger, 1981). Selenium concentrations larger than 12 μg/g dry weight in whole-body fish are suspected of causing reproductive failure in fish (Lemly and Smith, 1987).

Selenium concentrations in whole-body fish samples from the study area ranged from 2.30 to 15.2 μg/g dry weight and from 0.675 to 3.76 μg/g wet weight. Selenium concentrations in all samples of rainbow trout and white suckers from Middle Depression Lake (site 16), carp from Boysen Reservoir (site 20), and all fish species sampled from Ocean Lake (sites 7 and 9) and Lake Cameahwait (site 18) exceeded the NCBP 85-percent baseline of 0.71 μg/g wet weight. Selenium concentrations in samples of fish from Ocean Lake (sites 7 and 9) ranged from 0.97 to 2.16 μg/g wet weight. Selenium concentrations in rainbow trout, white suckers, and yellow perch from Lake Cameahwait (site 18) ranged from 1.64 to 3.21 μg/g wet weight. All three sauger and one of two walleye collected from Boysen Reservoir (site 20) also exceeded the NCBP 85-percent baseline for selenium. Four of the five rainbow trout specimens collected at Middle Depression Lake (site 16) exceeded the threshold concentration for adverse effects of 12 μg/g dry weight. Two egg masses from rainbow trout collected at Middle Depression Lake (site 16) had selenium concentrations of 22.0 and 23.0 μg/g, also exceeding the 12 μg/g threshold concentration. One rainbow trout from Lake Cameahwait had a selenium concentration of 12.2 μg/g dry weight. All concentrations in fish collected from the other sites were smaller than the 12 μg/g threshold concentration.

Zinc

Like selenium, zinc is an essential element in the diet of animals. However, it can be toxic at larger concentrations. Zinc concentrations in carp sampled from Boysen Reservoir (site 20) ranged from 120 to 175 μg/g wet weight and were larger than the NCBP 85-percent baseline of 40.1 μg/g wet weight. Concentrations in all carp sampled from Ocean Lake (sites 7 and 9) exceeded the NCBP 85-percent baseline of 40.1 μg/g wet weight for zinc with concentrations ranging from 50.1 to 131 μg/g wet weight. Five rainbow trout from Lake Cameahwait (site 18) had zinc concentrations ranging from 7.97 to 16.4 μg/g, which may be adverse. Lloyd (1960) detected zinc concentrations of 7.4 and 12 μg/g in rainbow trout killed by a 20 μg/g solution of zinc.

Organochlorine compounds

Rainbow trout, rainbow trout eggs, carp, and white suckers sampled from Middle Depression Lake and Boysen Reservoir were analyzed for organochlorine compounds (table 14 at back of the report). All organochlorine compounds were at or below detection limits except for total polychlorinated biphenyls (PCBs) and DDT metabolites (DDE and DDD). One rainbow trout egg sample from Middle Depression Lake (site 16) contained a total PCB concentration of 0.24 μg/g wet weight. This concentration approaches the concentration known to affect fish fry. Hogan and Brauhn (1975) found deformities in 60 to 70 percent of rainbow trout fry, which contained 0.4 μg/g of PCBs, 30 days after hatching. Concentrations of the DDT metabolites were less than concentrations that are considered to be adverse to fish.

Bird Eggs

Bird eggs were collected at five sites. Two coot eggs were collected from North Pavillion Pond (site 3), 7 from Ponds 4 and 5 (sites 11 and 12), and 3 from the Sand Mesa ponds (site 19), for a total of 12 eggs. Pied-billed grebe eggs were collected at the following sites (one egg each): North Pavillion Pond (site 3), Ocean Lake (site 8), and Sand Mesa ponds (site 19). As noted previously, precipitation in 1988 was one-half of average, which may have limited nesting by water birds due to insufficient habitat. The number of samples collected of grebe and waterfowl eggs was less than optimum, due to difficulty in collecting the samples and the reconnaissance nature of the study. Arsenic, mercury, and selenium concentrations in bird eggs are listed in table 8. Organochlorine compound concentrations are listed in table 14. Trace-element and organic-compound concentrations reported for the bird eggs cannot be attributed solely to the collection site, because adult birds are highly mobile.

Arsenic

Arsenic concentrations in 12 American coot eggs ranged from 0.070 to 0.289 μg/g dry weight. An arsenic concentration in a pied-billed grebe egg from Ocean Lake (site 8) was 0.116 μg/g dry weight. All arsenic concentrations in bird eggs collected were less than concentrations associated with adverse effects.

Mercury

Mercury concentrations in 12 American coot eggs ranged from 0.258 to 0.729 μg/g dry weight. Mercury concentrations in three pied-billed grebe eggs were 0.325, 0.810, and 1.43 μg/g dry weight. These concentrations are smaller than the 3.1-μg/g level suspected of causing reproductive effects (Eisler 1987b; Finley and Stendall, 1978).

Selenium

Selenium concentrations in 12 American coot eggs ranged from less than reporting limits to 13.1 μg/g dry weight. The pied-billed grebe eggs had selenium concentrations of 1.3, 7.3, and 16.9 μg/g dry weight. Selenium concentrations of 15 to 20 μg/g dry weight in bird eggs are suspected of causing embryo deformities or mortality (Lemly and Smith, 1987). The maximum concentration of 16.9 μg/g was detected in a pied-billed grebe egg from North Pavillion Pond (site 3).

Table 8.--Arsenic, mercury, and selenium concentrations in bird eggs

[<, less than]

Site name and No. (fig. 2)	Common name	Dry- and wet-weight concentrations, in micrograms per gram					
		Arsenic		Mercury		Selenium	
		Dry	Wet	Dry	Wet	Dry	Wet
North Pavillion Pond							
3	American coot	0.085	0.023	0.258	0.070	10.3	2.79
	American coot	.079	.020	.385	.097	13.1	3.30
	Pied-billed grebe	.112	.027	.810	.196	16.9	4.09
Ocean Lake, south side							
8	Pied-billed grebe	.116	.027	1.43	.333	1.3	.303
Pond 4							
11	American coot	.250	.066	.284	.075	.76	.201
	American coot	.288	.069	.679	.163	.83	.199
	American coot	.289	.070	.558	.135	.83	.201
	American coot	.222	.059	.729	.194	.38	.101
Pond 5							
12	American coot	.148	.034	.517	.119	< .43	< .049
	American coot	.119	.030	.274	.069	.79	.199
	American coot	.121	.031	.284	.073	.78	.200
Sand Mesa ponds							
19	American coot	.106	.025	.297	.070	9.30	2.12
	American coot	.070	.018	.285	.073	10.2	2.61
	American coot	.134	.034	.378	.096	11.0	2.79
	Pied-billed grebe	.073	.018	.325	.080	7.30	1.80

Organochlorine compounds

Seven American coot eggs and one pied-billed grebe egg were submitted for analyses for organochlorine compounds. Two of the five coot eggs collected from Ponds 4 and 5 (sites 11 and 12) contained detectable concentrations of PCBs (0.05 to 0.21 μg/g), and three of the five eggs contained detectable concentrations of DDT and 4,4'-DDE (0.05 to 0.13 μg/g). All organochlorine compounds were less than the reporting limits in the two coot eggs and the pied-billed grebe egg from Sand Mesa ponds (site 19).

Bird Livers

Liver samples were collected from adult birds. Arsenic, mercury, and selenium concentrations in bird livers are listed in table 9. The concentrations reported cannot be attributed solely to the collection site, because the adult birds were highly mobile.

Arsenic and mercury

Arsenic concentrations in samples of American coot livers and a ruddy duck liver were less than the 2 μg/g wet weight concentration considered to be of concern (Eisler, 1988). Mercury concentrations in samples of American coot livers ranged from 0.223 to 9.6 μg/g dry weight. A ruddy duck liver had a mercury concentration of 0.319 μg/g dry weight. These concentrations were smaller than the concentrations determined to cause adverse effects to black ducks in controlled studies (Finley and Stendall, 1978).

Selenium

Selenium concentrations in samples of American coot livers ranged from 1.5 to 16.5 μg/g dry weight. A ruddy duck liver from North Pavillion Pond (site 3) had a selenium concentration of 34.6 μg/g dry weight, the largest concentration in samples of bird livers collected from the study area. Selenium concentrations greater than 30 μg/g dry weight in aquatic-bird livers are likely to cause impaired reproduction (U.S. Fish and Wildlife Service, 1990, p. 30).

Organochlorine compounds

Eighteen American coot livers were submitted for analysis for organochlorine compounds. All organochlorine compounds were less than reporting limits except for PCBs; oxychlordane; 4,4' DDE; total DDT; and HCB.

Comparison among media

All three media--water, bottom sediment, and biota--were sampled in three areas. Those three areas are North Pavillion Pond, the Ocean Lake area, and the Cottonwood Bench area. Time and financial constraints prevented sampling of all media at all sites.

Two water samples from North Pavillion Pond (site 3) contained relatively small selenium concentrations--1 and 2 μg/L. The selenium concentration in a bottom-sediment sample also was relatively small--0.3 μg/g in the fraction smaller than 0.062 mm. However, biological samples from several levels of the food chain at North Pavillion Pond contained elevated concentrations of selenium. Samples of aquatic plants and invertebrates contained selenium concentrations larger than dietary concentrations known to cause adverse effects in fish and waterfowl (Lemly and Smith, 1987). A pied-billed grebe

Table 9.--Arsenic, mercury, and selenium concentrations in bird-liver samples

Site name and No. (fig. 2)	Common name	Arsenic Dry	Arsenic Wet	Mercury Dry	Mercury Wet	Selenium Dry	Selenium Wet
North Pavillion Pond							
3	American coot	0.375	0.090	0.312	0.075	10.4	2.50
	American coot	.390	.090	.589	.136	6.9	1.59
	American coot	.364	.088	.545	.132	13.2	2.19
	American coot	.471	.114	1.05	.254	6.2	1.50
	American coot	.718	.176	.886	.217	9.0	2.20
	American coot	.602	.142	1.05	.248	10.2	2.41
	Ruddy duck	.157	.040	.319	.081	34.6	8.79
Ocean Lake, south side							
8	American coot	.281	.074	.373	.098	1.5	.395
	American coot	.651	.168	.519	.134	5.0	1.29
	American coot	.246	.066	.731	.196	2.2	.590
	American coot	.500	.115	.552	.127	3.0	.690
	American coot	.375	.099	.242	.064	9.8	2.59
	American coot	.715	.125	.523	.171	12.6	3.01
	American coot	.684	.160	.855	.200	3.8	.899
	American coot	.467	.128	.781	.214	6.6	1.81
Middle Depression Lake							
16	American coot	.410	.105	.406	.104	9.8	2.51
	American coot	.403	.114	.428	.121	14.1	3.99
	American coot	.467	.122	.310	.081	11.1	2.90
	American coot	.398	.111	1.32	.365	16.5	4.60
	American coot	.924	.269	.223	.065	10.7	3.11
	American coot	.287	.079	1.08	.297	12.0	3.30
	American coot	.653	.158	.310	.075	7.0	1.69
Sand Mesa ponds							
19	American coot	.540	.156	.253	.073	10.7	3.09
	American coot	.919	.238	.282	.073	10.4	2.69
	American coot	.850	.244	.279	.080	11.8	3.39
	American coot	.722	.182	9.60	2.42	12.3	3.10
	American coot	.615	.158	.463	.119	6.6	1.70
	American coot	.671	.206	.599	.184	5.9	1.81
	American coot	.643	.169	1.26	.331	6.8	1.79
	American coot	.725	.185	.557	.142	11.0	2.80
	American coot	.975	.236	.483	.117	6.2	1.50

(Concentrations: Dry- and wet-weight concentrations, in micrograms per gram) egg contained a selenium concentration in the range suspected of causing embryo deformities or mortality. A liver from an adult ruddy duck collected at North Pavillion Pond contained 34.6 μg/g selenium, which is larger than the 30 μg/g concentration associated with impaired reproduction in other irrigation drainage studies.

In the Ocean Lake area, various samples were collected from drains entering and leaving Ocean Lake, Ocean Lake proper, Pond 4, and Pond 5. Samples from the drains entering and leaving Ocean Lake (sites 5, 6, and 10) contained moderate to slightly elevated concentrations of selenium in water samples and bottom-sediment samples. Selenium concentrations also were elevated in biological samples from Ocean Lake proper (sites 7 and 9). Organochlorine pesticides (DDT and metabolites of DDT) were detected in bottom-sediment samples from Ocean Lake Drain numbers 6 and 7 (sites 5 and 6) and bird-liver samples from Ocean Lake proper (site 8), but the concentrations were less than those known to cause adverse effects. Concentrations in samples of all three media from Pond 4 (site 11) and of biota from Pond 5 (site 12) did not appear to be larger than levels of concern.

Samples of water and bottom sediment from sites in the Cottonwood Bench area contained the largest concentrations of selenium detected in samples collected in the study area. Two water samples from Middle Depression Lake (site 16) contained relatively small concentrations of 1 and 2 μg/L selenium, but the bottom-sediment sample contained 3.0 μg/g selenium, the maximum concentration detected in samples collected in the study area. Water samples from the Sand Mesa ponds (site 19) contained 6 and 12 μg/L (maximum in study area); the bottom-sediment sample contained 1.3 μg/g in the fraction smaller than 0.062 mm, which is a slightly elevated concentration. Four of five rainbow trout and both rainbow trout egg masses collected at Middle Depression Lake exceeded the threshold concentration for adverse effects of 12 μg/g dry weight reported by Lemly and Smith (1987). Samples of bird eggs and livers from Sand Mesa ponds contained selenium concentrations larger than the NCBP 85-percent baseline, but smaller than concentrations known to cause adverse effects.

SUMMARY AND CONCLUSIONS

A reconnaissance investigation of the Riverton Reclamation Project in west-central Wyoming was conducted during 1988 and 1989 to determine if irrigation drainage has caused, or has the potential to cause, harmful effects on human health, fish and wildlife, or other water users. The area was selected by the U.S. Department of the Interior (DOI) for investigation because of the combined presence of a DOI irrigation project and wildlife areas and the known potential for elevated concentrations of selenium in the area. Samples of water, bottom sediment, and (or) biota were collected from Fivemile Creek and Muddy Creek near the upstream and downstream edges of the project, from the Wyoming Canal, from five irrigation drains, and from eight standing-water bodies, including Ocean Lake and Boysen Reservoir. During the study, summer air temperatures generally were above average and precipitation substantially less than average.

Specific conductance of water in the Wyoming Canal, which supplies irrigation water for the project, was 140 µS/cm in August 1988. Irrigation drainage from the project enters constructed drains and natural tributaries to Fivemile Creek and Muddy Creek, which flow into Boysen Reservoir. In August, water in the two creeks at their mouths consisted mostly of irrigation drainage; specific conductance was about 1,000 µS/cm in both creeks in August. The increase in specific conductance, from 140 µS/cm at the upstream edge of the project to 1,000 µS/cm at the downstream edge, is because of return flow of irrigation drainage.

Concentrations of dissolved nitrite plus nitrate were largest at sites receiving irrigation drainage; the concentrations generally were less than the MCL of 10 mg/L (as nitrogen). The concentration of nitrite plus nitrate exceeded 10 mg/L in one sample collected from Pavillion Drain in November.

Dissolved selenium concentrations generally were less than the MCL of 10 µg/L. At the 14 sites sampled, selenium concentrations ranged from less than the analytical reporting limit of 1 µg/L at several sites during the August sampling, to a maximum concentration of 12 µg/L at the Sand Mesa ponds in November. Analyses indicated that nearly all the selenium detected was in the dissolved state. Thus little selenium is transported with suspended material.

Concentrations of dissolved uranium in water samples ranged from less than the reporting limit of 0.40 µg/L at Pond 4 in August, to a maximum of 110 µg/L at the Sand Mesa ponds in November. The uranium concentrations in nine samples exceeded 35 µg/L, the maximum recommended by the National Academy of Science (1983) for human consumption. Uranium concentrations in water samples were positively correlated with selenium concentrations in 15 water samples ($r^2 = 0.81$, significant at the 0.01 level).

Specific conductance, selenium, and uranium concentrations in water samples were larger in November than in August at more than half of the sites. Streamflow at those sites was smaller in November than in August, indicating an inverse relation between concentration and streamflow, and perhaps that irrigation water is diluting seepage from shallow ground water. At the other sites with data for August and November, the concentrations and streamflow did not have a consistent pattern.

Pesticides were detected in water samples from irrigation drains, creeks, and lakes. One sample contained 0.13 μg/L parathion, which exceeds the freshwater aquatic life criterion of 0.065 μg/L (acute); other pesticide concentrations were less than the applicable criteria or health advisories. The common factor among sites that contained detectable concentrations of pesticides was the presence of irrigation drainage.

In samples of bottom sediment, selenium concentrations were largest in the smaller size fraction. Samples from 14 sites were sieved to two size fractions--less than 0.062 mm, and less than 2 mm. Selenium concentrations in the smaller size fraction ranged from 0.1 to 3.0 μg/g; those in the larger size fraction ranged from less than 0.1 to 1.9 μg/g. The maximum concentration of 3.0 μg/g was in a bottom-sediment sample from Middle Depression Lake; concentrations of selenium that were near the upper value for the range of the 95-percent baseline for Western United States soils also were detected in samples from the Sand Mesa ponds (1.3 μg/g), upper Muddy Creek (1.2 μg/g), Ocean Lake Drain number 6 (1.1 μg/g), and Ocean Drain at the outlet (1.1 μg/g).

Except for selenium, concentrations of trace elements in biological samples from 11 sites generally were less than concentrations known to have adverse effects. Concentrations of boron in stem/leaf samples from pondweed ranged from less than the reporting limit of 50 to 848 μg/g dry weight (concentrations between 300 and 1,000 μg/g are reported to have caused adverse effects to ducklings in laboratory tests). Selenium concentrations in three of sixteen samples of pondweed were larger than the dietary concentrations known to cause adverse effects either in fish (5 μg/g, one sample) or in waterfowl (3 μg/g, three samples). Selenium concentrations in samples of pondweed ranged from less than 0.87 to 7.44 μg/g dry weight.

Samples of aquatic invertebrates contained selenium concentrations in the range of 3.27 to 11.1 μg/g dry weight. A total of nine samples was collected from three sites; selenium concentrations in all of the samples exceeded the 3 μg/g dry weight dietary concentration associated with adverse effects in waterfowl. The selenium concentrations in invertebrate samples exceeded the 5 μg/g dry weight dietary concentration associated with adverse effects in fish, as follows: North Pavillion Pond, concentrations in both samples were larger than 5 μg/g; Ocean Lake, west side, the concentration in one of three samples was larger than 5 μg/g; and Ocean Lake, east side, concentrations in all four samples were larger than 5 μg/g.

Arsenic concentrations in whole-body-fish samples generally were smaller than the NCBP (National Contaminant Biomonitoring Program) 85-percent baseline concentration of 0.22 μg/g wet weight. Cadmium concentrations in carp sampled from Boysen Reservoir were greater than the NCBP 85-percent baseline; however, the concentrations were less than the 0.5 μg/g wet-weight concentration considered adverse to fish. Carp, walleye, and sauger sampled from Boysen Reservoir, some black crappie and walleye sampled from Ocean Lake, and some yellow perch sampled from Lake Cameahwait had mercury concentrations larger than the NCBP 85-percent baseline of 0.18 μg/g wet weight. The maximum concentration of mercury in fish was 0.386 μg/g wet weight. Zinc concentrations in carp sampled from Ocean Lake and Boysen Reservoir and in rainbow trout sampled from Lake Cameahwait exceeded the NCBP 85-percent baseline of 40.1 μg/g.

Selenium concentrations in whole-body-fish samples from the study area ranged from 2.30 to 15.2 μg/g dry weight and from 0.675 to 3.76 μg/g wet weight. Selenium concentrations in all samples of rainbow trout and white suckers sampled from Middle Depression Lake, carp from Boysen Reservoir, and all fish species sampled from Ocean Lake and Lake Cameahwait exceeded the NCBP 85-percent baseline of 0.71 μg/g wet weight. All three sauger and one of two walleye sampled from Boysen Reservoir also exceeded the NCBP 85-percent baseline for selenium. Whole-body selenium concentrations larger than 12 μg/g dry weight are suspected of causing reproductive failure in fish (Lemly and Smith, 1987). Four of the five rainbow trout collected at Middle Depression Lake, as well as the rainbow trout egg masses, exceeded the threshold concentration for adverse effects of 12 μg/g. One rainbow trout from Lake Cameahwait had a selenium concentration of 12.2 μg/g dry weight. All concentrations in fish sampled from the other sites were less than the 12 μg/g threshold concentration.

Generally, arsenic, mercury, and selenium concentrations in most bird eggs and bird-liver samples were less than concentrations suspected of causing adverse effects. However, a pied-billed grebe egg from North Pavillion Pond had a selenium concentration of 16.9 μg/g dry weight which is within the 15 to 20 μg/g concentration of concern identified by Lemly and Smith (1987). A liver sample taken from an adult ruddy duck from North Pavillion Pond had a selenium concentration of 34.6 μg/g, which is larger than the 30 μg/g concentration associated with impaired reproduction in other irrigation drainage studies (U.S. Fish and Wildlife Service, 1990, p. 30).

Concentrations of organochlorine pesticides generally were at or less than the detection limit. However, small concentrations of DDT and its metabolites and PCBs were detected in whole-body-fish samples, bird eggs, or bird-liver samples.

Results of this reconnaissance investigation indicate concentrations of selenium in some samples of aquatic plants and invertebrates were larger than dietary levels suspected of causing adverse effects on fish and waterfowl. Elevated concentrations of selenium were detected in rainbow trout and rainbow trout eggs sampled from Middle Depression Lake. All other biota, excluding one pied-billed grebe egg and a ruddy duck liver, had selenium concentrations smaller than levels suspected of causing adverse effects.

Additional sampling would be needed to assess comprehensively the role of selenium and pesticides in irrigation drainage in the the study area. For example, it would be of value to monitor water birds and fish in 1 or 2 years to determine if birds and fish feeding on plants and aquatic invertebrates are accumulating large concentrations of selenium. Temporal sampling also would help to define the effect of the less-than-average precipitation in 1988 on the results of the sampling.

REFERENCES

Baedecker, P.A., editor, 1987, Methods for geochemical analyses: U.S. Geological Survey Bulletin 1770, Chapters A-K.

Biddinger, G.R., and Gloss, S.P., 1984, The importance of trophic transfer in the bioaccumulation of chemical contaminants in aquatic ecosystems: Residue Reviews, v. 91, p. 103-145.

Case, J.C., and Cannia, J.C., 1988, Guide to potentially seleniferous areas in Wyoming: Laramie, Geological Survey of Wyoming Open File Report 88-1, map, scale 1:1,000,000.

Colby, B.R., Hembree, C.H., and Rainwater, F.H., 1956, Sedimentation and chemical quality of surface waters in the Wind River Basin, Wyoming: U.S. Geological Survey Water-Supply Paper 1373, 336 p.

Eisler, Ron, 1987a, Cadmium hazards to fish, wildlife, and invertebrates: A synoptic review: U.S. Fish and Wildlife Service Biological Report, 85 (1.2), 46 p.

_____ 1987b, Mercury hazards to fish, wildlife, and invertebrates: A synoptic review: U.S. Fish and Wildlife Service Biological Report, 85 (1.10), 90 p.

_____ 1988, Arsenic hazards to fish, wildlife, and invertebrates: A synoptic review: U.S. Fish and Wildlife Service Biological Report, 85 (1.12), 92 p.

Erdman, J.A., Severson, R.C., Crock, J.G., Harms, T.F., and Mayland, H.F., 1989, Selenium in soils and plants from native and irrigated lands at the Kendrick Reclamation Project Area, Wyoming: U.S. Geological Survey Open-File Report 89-628, 28 p.

Espinosa, L.R., and Clark, W.E., 1972, A polypropylene light trap for aquatic invertebrates: California Fish and Game Department, v. 58, p. 149-152.

Finley, M.T., and Stendall, R.C., 1978, Survival and reproductive success of black ducks fed methyl mercury: Environmental Pollution, v. 16, p. 51-64.

Fishman, M.J., and Friedman, L.C., editors, 1985, Methods for determination of inorganic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chapter A1, 709 p.

Friedman, L.C., and Erdmann, D.E., 1982, Quality assurance practices for the chemical and biological analyses of water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chapter A6, 181 p.

Hall, L.W., Jr., and Burton, D.T., 1982, Effects of power plant coal pile and coal waste runoff on aquatic biota: An overview with research recommendations: Chemical Rubber Company Critical Reviews in Toxicology, v. 10, p. 287-301.

Harms, T.F., Stewart, K.C., Briggs, P.H., Hageman, P.L., and Papp, C.S.E., 1990, Chemical results for bottom material for Department of the Interior irrigation drainage task group studies 1988-1989: U.S. Geological Survey Open-File Report 90-50, 47 p.

Hogan, J.W., and Brauhn, J.L., 1975, Abnormal rainbow trout fry from eggs containing high residues of a PCB (Aroclor 1242): Progressive Fishery Culturist, v. 37, no. 4, p. 229-230.

Jenkins, Dale W., 1981, Biological monitoring of toxic trace elements: U.S. Environmental Protection Agency Report 600/53-80-090, p. 1-9.

Knapton, J.R., 1985, Field guidelines for collection, treatment, and analysis of water samples: U.S. Geological Survey Open-File Report 85-409, 86 p.

Lemly, A.D., and Smith, G.J., 1987, Aquatic cycling of selenium: Implications for fish and wildlife: Washington D.C., U.S. Fish and Wildlife Service, Fish and Wildlife Leaflet 12, 10 p.

Lloyd, R., 1960, The toxicity of zinc sulphate to rainbow trout: Annals of Applied Biology, v. 48, p. 84-94.

Lowe, T.P., May, T.W., Brumbaugh, W.G., and Kane, D.A., 1985, National contaminant biomonitoring program, concentrations of seven elements in freshwater fish, 1978-1981: Archives of Environmental Contamination and Toxicology, v. 14, p. 363-388.

Macek, K.J., Petrocelli, S.R., and Sleight, B.H., III, 1979, Considerations in assessing the potential for, and significance of, biomagnification of chemical residues in aquatic food chains, in Marking, L.L., and Kimmerle, R.A., eds., Aquatic toxicology: Philadelphia, American Society for Testing and Materials, PA ASTM STP 667, p. 251-268.

Martner, B.E., 1986, Wyoming climate atlas: Lincoln, University of Nebraska Press, 432 p.

McGreevy, L.J., Hodson, W.G., and Rucker, S.J. IV, 1969, Ground-water resources of the Wind River Indian Reservation, Wyoming: U.S. Geological Survey Water-Supply Paper 1576-I, 145 p.

Millis, R.L., and Pedlar, D.E., 1985, Ocean Lake eutrophication and water quality study: Cheyenne, Wyoming Game and Fish Department, Fish Division Completion Report, 61 p.

Morris, D.A., Hackett, O.M., Vanlier, K.E., and Moulder, E.A., 1959, Ground-water resources of the Riverton irrigation project area, Wyoming, with a section on Chemical quality of ground water, by Durum, W.H.: U.S. Geological Survey Water-Supply Paper 1375, 205 p.

National Academy of Sciences, 1983, Drinking water and health, volume V: National Academy of Science Press, 157 p.

National Oceanic and Atmospheric Administration, 1989, Climatological data annual summary, Wyoming, 1988: Asheville, N.C., v. 97, no. 13, 24 p.

Patuxent Wildlife Research Center, 1986, Effects of irrigation drainwater contaminants on wildlife, annual report FY 1986: Laurel, Md., U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center report, 24 p.

Rand, G.M., and Petrocelli, S.R., eds., 1985, Fundamentals of aquatic toxicology: New York, Hemisphere Publishing Corp., 666 p.

Rantz, S.E., and others, 1982, Measurement and computation of streamflow, volume 1: Measurement of stage and discharge: U.S. Geological Survey Water-Supply Paper 2175, 284 p.

Rosenfeld, Irene, and Beath, O.A., 1964, Selenium geobotany, biochemistry, toxicity, and nutrition: New York, Academic Press, 411 p.

Severson, R.C., 1979, Regional soil chemistry in the Bighorn and Wind River Basins, Wyoming and Montana: U.S. Geological Survey Professional Paper 1134-B, 9 p.

Shacklette, H.T., and Boerngen, J.G., 1984, Element concentrations in soils and other surficial materials of the conterminous United States: U.S. Geological Survey Professional Paper 1270, 105 p.

Shamberger, R.J., 1981, Selenium in the environment: The Science of the Total Environment, v. 17, no. 1, p. 59-74.

Smith, G.J., and Anders, V.P., 1987, Toxic effects of boron on mallard reproduction: Implications for agricultural drainwater management: Presentation at meeting of the Society of Environmental Toxicology and Chemistry, Pensacola, Fla., November 1987.

Spehar, R.L., Fiandt, J.T., Anderson, R.L., and DeFoe, D.L., 1980, Comparative toxicity of arsenic compounds and their accumulation in invertebrates and fish: Archives of Environmental Contamination and Toxicology, v. 9, p. 53-63.

Tidball, R.R., and Ebens, R.J., 1976, Regional geochemical baselines in soils of the Powder River Basin, Montana-Wyoming, in Laudon, R.B., ed., Geology and energy resources of the Powder River Basin: Wyoming Geological Association Guidebook, Twenty-eighth Annual Field Conference, Casper, Wyoming, September 1976, p. 299-310.

U.S. Bureau of Reclamation, 1981, Wind River Basin water supply study: Billings, Mont., Field Planning Branch, U.S. Bureau of Reclamation, unnumbered pages.

U.S. Environmental Protection Agency, 1986, Quality criteria for water 1986: Washington, D.C., EPA-440/5-86-001, unnumbered pages.

_____ 1987, Update #2 to quality criteria for water, 1986: Washington, D.C., May 1, 1987, unnumbered pages.

_____ 1988a, National revised primary drinking-water regulations: Maximum contaminant levels (subpart G of part 141, National interim primary drinking-water regulations): U.S. Code of Federal Regulations, Title 40, parts 100 to 149, revised as of July 1, 1988, p. 586-587.

_____ 1988b, Secondary maximum contaminant levels (section 143.3 of part 143, National secondary drinking-water regulations): U.S. Code of Federal Regulations, Title 40, parts 100 to 149, revised as of July 1, 1988, p. 608.

_____ 1988c, Water quality criteria documents: Washington, D.C., Federal Register, v. 53, no. 2, p. 177-179.

_____ 1989, Health advisory summaries: Washington, D.C., variable pagination.

U.S. Fish and Wildlife Service, 1990, Effects of irrigation drainage contaminants on wildlife: Laurel, Md., Patuxent Wildlife Research Center, 38 p.

Walsh, D.F., Berger, B.L., and Bean, J.R., 1977, Mercury, arsenic, lead, cadmium, and selenium residues in fish: 1971-73--National pesticide monitoring program: Pesticides Monitoring Journal, v. 11, p. 5-34. Appendix PRA1: Trace element and organic compound concentrations in biota.

Wershaw, R.L., Fishman, M.J., Grabbe, R.R., and Lowe, L.E., 1987, Methods for the determination of organic substances in water and fluvial sediments: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chapter A3, 80 p.

Whitcomb, H.A., and Lowry, M.E., 1968, Ground-water resources and geology of the Wind River Basin area, central Wyoming: U.S. Geological Survey Hydrologic Investigations Atlas HA-270, scale 1:250,000, 3 sheets.

SUPPLEMENTAL DATA

Table 10.--Onsite and laboratory measurements of inorganic constituents in water

[Identification number: 8-digit, U.S. Geological Survey hydrologic-station number; 15-digit, latitude-longitude and sequence number; ft^3/s, cubic feet per second; µS/cm at 25 °C, microsiemens per centimeter at 25 degrees Celsius; °C, degrees Celsius; NTU, nephelometric turbidity units; mm of Hg, millimeters of mercury; mg/L, milligrams per liter; acre-ft, acre-feet; tons/d, tons per day; µg/L, micrograms per liter; <, less than; >, greater than; --, no data; E, estimate. Analyses by U.S. Geological Survey]

Site No. (fig. 2)	Identification number	Date	Time	Stream-flow, instantaneous (ft^3/s)	Specific conductance (µS/cm at 25 °C)	pH	Temperature, water (°C)	Turbidity (NTU)	Barometric pressure (mm of Hg)	Oxygen, dissolved (mg/L)	Oxygen, dissolved (percent saturation)	Hardness as $CaCO_3$ (mg/L)
1	06226000	08-02-88	0945	1,100	140	8.5	18.0	8.0	620	8.5	111	--
2	06244500	08-02-88	1345	<.25	4,600	8.3	27.5	--	--	--	--	1,800
		11-07-88	1615	5.4	3,600	8.4	4.5	3.8	--	10.2	--	1,600
3	431612108355601	08-16-88	0930	--	1,300	8.5	18.0	2.6	--	--	--	120
		11-08-88	1115	--	1,240	8.4	3.5	1.7	--	10.4	--	190
4	06246000	08-04-88	1900	19	790	8.2	20.0	45	633	6.7	89	250
		11-09-88	0945	1.4	2,900	8.4	3.0	3.6	--	11.1	--	830
5	431240108372201	08-16-88	1635	--	1,100	8.2	22.0	4.5	610	7.4	107	240
		11-08-88	1600	4.7	1,620	8.5	7.0	33	--	9.8	--	340
6	431109108380801	08-18-88	0845	--	1,200	8.1	15.0	17	--	--	--	350
		11-08-88	1445	5.2	2,050	8.4	7.0	26	--	10.3	--	580
10	06246500	08-04-88	1230	62	1,280	8.5	24.0	37	635	7.0	101	260
		11-09-88	1515	1.2	1,340	8.8	5.5	22	--	10.1	--	260
11	431135108331901	08-18-88	1400	--	400	--	31.0	19	--	--	--	47
13	06251500	08-04-88	1430	22	630	8.7	22.0	100	643	8.0	109	170
		11-09-88	1130	8.7	1,500	8.6	4.5	14	--	10.6	--	350
14	06253000	08-03-88	1015	275	1,000	8.4	18.0	200	646	8.5	107	240
		11-10-88	0930	42	2,270	8.6	1.0	3.5	--	12.0	--	570
15	06257500	08-02-88	1530	.10E	3,300	7.8	27.5	--	--	--	--	--
		11-08-88	0930	.05	3,640	8.1	1.0	2.0	--	9.4	--	1,600
16	431907108202501	08-15-88	1900	--	260	8.0	18.0	2.1	631	6.0	77	94
		11-10-88	1530	--	560	8.8	4.0	4.0	--	11.2	--	140
17	06258000	08-03-88	1215	30	1,100	8.4	18.5	95	646	8.3	105	320
		11-10-88	1200	8.4	2,600	8.6	.5	3.2	--	11.4	--	700
19	431938108151901	08-17-88	1550	--	730	8.3	22.0	5.0	636	8.5	117	310
		11-10-88	1400	--	1,660	8.5	6.0	1.7	--	10.6	--	600

Table 10.--Onsite and laboratory measurements of inorganic constituents in water--Continued

Site No. (fig. 2)	Identification number	Date	Calcium, dis-solved (mg/L as Ca)	Magne-sium, dis-solved (mg/L as Mg)	Sodium, dis-solved (mg/L as Na)	Sodium, percent	Sodium-adsorp-tion ratio	Potas-sium, dis-solved (mg/L as K)	Alka-linity, lab (mg/L as $CaCO_3$)	Sulfate, dis-solved (mg/L as SO_4)	Chlo-ride, dis-solved (mg/L as Cl)	Solids, residue at 180 °C, dis-solved (mg/L)
1	06226000	08-02-88	--	--	--	--	--	1.1	58	18	1.3	94
2	06244500	08-02-88	450	170	560	40	6	12	150	2,600	82	--
		11-07-88	420	130	290	28	3	21	182	2,100	61	3,340
3	431612108355601	08-16-88	17	20	240	80	10	3.2	192	410	22	858
		11-08-88	43	21	210	70	7	3.0	258	370	16	838
4	06246000	08-04-88	73	17	70	37	2	3.5	144	240	6.4	520
		11-09-88	240	57	400	51	6	4.1	292	1,400	26	2,410
5	431240108372201	08-16-88	73	14	150	57	4	2.4	251	320	6.3	737
		11-08-88	99	23	250	61	6	2.4	319	570	9.3	1,150
6	431109108380801	08-18-88	100	24	150	48	4	2.8	261	420	7.7	891
		11-08-88	160	43	290	52	5	3.0	299	870	13	1,560
10	06246500	08-04-88	66	22	190	61	5	4.4	196	460	14	903
		11-09-88	66	24	200	62	6	4.1	199	490	14	944
11	431135108331901	08-18-88	14	3.0	66	73	4	4.0	140	56	10	315
13	06251500	08-04-88	50	11	79	50	3	1.9	201	130	4.0	415
		11-09-88	100	24	220	58	5	2.4	327	470	8.2	1,040
14	06253000	08-03-88	67	18	130	54	4	3.1	188	320	8.5	676
		11-10-88	150	47	330	56	6	3.9	274	980	20	1,740
15	06257500	08-02-88	--	--	--	--	--	--	--	--	--	--
		11-08-88	300	200	380	34	4	6.3	389	2,000	38	3,500
16	431907108202501	08-15-88	26	7.1	18	29	.8	1.5	85	40	3.9	155
		11-10-88	37	11	60	48	2	2.8	134	130	12	346
17	06258000	08-03-88	84	26	92	39	2	2.4	154	400	7.8	750
		11-10-88	160	74	360	52	6	4.3	237	1,300	29	2,090
19	431938108151901	08-17-88	91	20	55	28	1	1.4	140	270	6.7	553
		11-10-88	180	37	150	35	3	1.9	206	740	13	1,320

Table 10.--Onsite and laboratory measurements of inorganic constituents in water--Continued

Site No. (fig. 2)	Identification number	Date	Solids, sum of constituents, dissolved (mg/L)	Solids, dissolved (tons/acre-ft)	Solids, dissolved (tons/d)	Nitrogen, NO_2+NO_3 dissolved (mg/L as N)	Arsenic, dissolved (µg/L as As)	Boron, dissolved (µg/L as B)	Cadmium, dissolved (µg/L as Cd)	Chromium, dissolved (µg/L as Cr)	Copper, dissolved (µg/L as Cu)	Lead, dissolved (µg/L as Pb)
1	06226000	08-02-88	--	--	--	<0.1	1	20	--	1	4	<5
2	06244500	08-02-88	3,980	5.40	--	.2	<1	--	1	<5	<10	<10
		11-07-88	3,130	4.54	48.7	< .1	<1	550	1	2	7	<5
3	431612108355601	08-16-88	828	1.17	--	< .1	2	190	1	<1	1	<5
		11-08-88	818	1.14	--	< .1	1	160	1	<1	3	<5
4	06246000	08-04-88	503	.71	26.7	1.4	2	80	<1	<1	9	5
		11-09-88	2,350	3.28	8.98	11	1	260	1	1	1	<5
5	431240108372201	08-16-88	717	1.00	--	.2	2	60	<1	<1	1	<5
		11-08-88	1,150	1.56	14.6	1.0	2	100	3	<1	7	<5
6	431109108380801	08-18-88	864	1.21	--	.6	3	70	<1	<1	3	20
		11-08-88	1,560	2.12	21.8	1.3	2	110	1	<1	5	<5
10	06246500	08-04-88	874	1.23	151	< .1	4	100	<1	<1	7	5
		11-09-88	918	1.28	3.03	.1	3	100	3	<1	1	<5
11	431135108331901	08-18-88	237	.43	--	< .1	4	50	<1	<1	1	<5
13	06251500	08-04-88	407	.56	24.7	2.4	2	60	<1	<1	9	6
		11-09-88	1,030	1.41	24.4	2.9	2	140	4	<1	3	<5
14	06253000	08-03-88	665	.92	502	1.2	2	80	<1	1	14	8
		11-10-88	1,710	2.37	196	3.8	1	250	<1	<1	4	<5
15	06257500	08-02-88	--	--	--	--	--	--	--	--	--	--
		11-08-88	3,160	4.76	.47	< .1	<1	340	<1	1	6	<5
16	431907108202501	08-15-88	147	.21	--	< .1	1	20	<1	<1	2	<5
		11-10-88	333	.47	--	< .1	1	50	3	<1	1	<5
17	06258000	08-03-88	708	1.02	60.7	.7	1	120	<1	1	9	6
		11-10-88	2,070	2.84	47.3	.9	<1	300	2	<1	1	<5
19	431938108151901	08-17-88	533	.75	--	1.1	1	100	<1	<1	1	<5
		11-10-88	1,260	1.80	--	4.0	<1	280	6	2	2	<5

Table 10.--Onsite and laboratory measurements of inorganic constituents in water--Continued

Site No. (fig. 2)	Identification number	Date	Mercury, dis-solved (µg/L as Hg)	Molyb-denum, dis-solved (µg/L as Mo)	Sele-nium, total (µg/L as Se)	Sele-nium, dis-solved (µg/L as Se)	Vana-dium, dis-solved (µg/L as V)	Zinc, dis-solved (µg/L as Zn)	Uranium, natural, dis-solved (µg/L as U)	Sedi-ment, sus-pended (mg/L)	Sedi-ment dis-charge, sus-pended (tons/d)
1	06226000	08-02-88	0.3	1	<1	<1	1	--	--	21	62
2	06244500	08-02-88	.2	20	--	4	<6	29	--	--	--
		11-07-88	< .1	2	<1	<1	1	10	6.6	--	--
3	431612108355601	08-16-88	> .1	<1	2	2	<1	9	5.9	--	--
		11-08-88	< .1	2	1	1	2	4	27	--	--
4	06246000	08-04-88	< .1	<1	2	2	4	10	--	54	2.8
		11-09-88	< .1	3	8	8	2	<10	53	--	--
5	431240108372201	08-16-88	> .1	1	2	2	3	4	20	--	--
		11-08-88	.1	3	5	5	3	5	53	--	--
6	431109108380801	08-18-88	> .1	1	3	3	3	17	27	--	--
		11-08-88	< .1	4	4	5	4	<10	58	--	--
10	06246500	08-04-88	< .1	1	4	4	6	8	--	--	--
		11-09-88	< .1	3	3	3	6	3	36	--	--
11	431135108331901	08-18-88	> .1	<1	<1	<1	4	17	<.4	--	--
13	06251500	08-04-88	< .1	<1	2	1	5	3	--	149	8.9
		11-09-88	< .1	3	4	4	5	4	49	--	--
14	06253000	08-03-88	< .1	1	2	2	4	12	--	290	215
		11-10-88	< .1	4	5	5	2	<10	46	--	--
15	06257500	08-02-88	--	--	--	2	--	--	--	--	--
		11-08-88	< .1	3	<1	<1	1	<10	13	--	--
16	431907108202501	08-15-88	> .1	1	<1	1	2	<3	3.7	--	--
		11-10-88	< .1	2	2	2	2	<3	7.3	--	--
17	06258000	08-03-88	< .1	3	3	2	2	15	--	168	14
		11-10-88	< .1	7	7	7	1	<10	43	--	--
19	431938108151901	08-17-88	> .1	1	6	6	2	30	42	--	--
		11-10-88	< .1	6	12	12	3	6	110	--	--

Table 11.--Pesticides in water samples and bottom-sediment samples

[Identification number: 8-digit, U.S. Geological Survey hydrologic-station number; 15-digit, latitude-longitude and sequence number; µg/L, micrograms per liter; µg/kg, micrograms per kilogram; <, less than; --, no data. Concentrations are for water samples unless indicated otherwise. Analyses by U.S. Geological Survey]

Site No. (fig. 2)	Identification number	Date	Time	Dicamba (Mediben) (Banvel D) total (µg/L)	Picloram (Tordon) (Amdon) total (µg/L)	2,4-D, total (µg/L)	2,4-DP, total (µg/L)	2,4,5-T, total (µg/L)	Silvex, total (µg/L)	Diazinon, total in bottom material (µg/kg)	Ethion, total (µg/L)	Ethion, total in bottom material (µg/kg)
3	431612108355601	08-16-88	0930	--	--	--	--	--	--	<0.1	--	<0.1
4	06246000	08-04-88	1900	0.12	<0.01	0.08	<0.01	<0.01	<0.01	--	<0.01	--
		08-18-88	1245	--	--	--	--	--	--	< .1	--	< .1
5	431240108372201	08-16-88	1635	.05	< .01	< .01	< .01	< .01	< .01	--	< .01	--
		08-16-88	1635	--	--	--	--	--	--	< .1	--	< .1
6	431109108380801	08-18-88	0845	--	--	--	--	--	--	< .1	--	< .1
		08-18-88	0845	--	--	--	--	--	--	--	< .01	--
10	06246500	08-04-88	1230	.07	< .01	.04	< .01	< .01	< .01	--	< .01	--
13	06251500	08-04-88	1430	.02	< .01	.02	< .01	< .01	< .01	--	< .01	--
		08-17-88	1730	--	--	--	--	--	--	< .1	--	< .1
14	06253000	08-05-88	0930	.13	--	.11	< .01	< .01	< .01	--	< .01	--
		08-17-88	1400	--	--	--	--	--	--	< .1	--	< .1
16	431907108202501	08-17-88	1245	.13	< .02	< .01	< .01	< .01	< .01	--	< .01	--
		08-17-88	1245	--	--	--	--	--	--	< .1	--	< .1
17	06258000	08-05-88	1000	.01	<. 01	< .01	< .01	< .01	< .01	--	< .01	--
		08-17-88	1100	--	--	--	--	--	--	< .1	--	< .1

Table 11.--Pesticides in water samples and bottom-sediment samples--Continued

Site No. (fig. 2)	Identification number	Date	Total trithion (µg/L)	Trithion, total in bottom material (µg/kg)	Methyl trithion, total (µg/L)	Methyl trithion, total in bottom material (µg/kg)	Malathion, total (µg/L)	Malathion, total in bottom material (µg/kg)	Methyl parathion, total (µg/L)	Methyl parathion, total in bottom material (µg/kg)	Parathion, total (µg/L)
3	431612108355601	08-16-88	--	<0.1	--	<0.1	--	<0.1	--	<0.1	--
4	06246000	08-04-88	<0.01	--	<0.01	--	<0.01	--	0.03	--	0.13
		08-18-88	--	< .1	--	< .1	--	< .1	--	< .1	--
5	431240108372201	08-16-88	< .01	--	< .01	--	< .01	--	< .01	--	.02
		08-16-88	--	< .1	--	< .1	--	< .1	--	< .1	--
6	431109108380801	08-18-88	--	< .1	--	< .1	--	< .1	--	< .1	--
		08-18-88	< .01	--	< .01	--	< .01	--	< .01	--	< .01
10	06246500	08-04-88	< .01	--	< .01	--	< .01	--	< .01	--	< .01
13	06251500	08-04-88	< .01	--	< .01	--	< .01	--	< .01	--	< .01
		08-17-88	--	< .1	--	< .1	--	< .1	--	< .1	--
14	06253000	08-05-88	< .01	--	< .01	--	< .01	--	< .01	--	.01
		08-17-88	--	< .1	--	< .1	--	< .1	--	< .1	--
16	431907108202501	08-17-88	< .01	--	< .01	--	< .01	--	< .01	--	< .01
		08-17-88	--	< .1	--	< .1	--	< .1	--	< .1	--
17	06258000	08-05-88	< .01	--	< .01	--	< .01	--	< .01	--	< .01
		08-17-88	--	< .1	--	< .1	--	< .1	--	< .1	--

Table 11.--Pesticides in water samples and bottom-sediment samples--Continued

Site No. (fig. 2)	Identification number	Date	Parathion, total in bottom material (µg/kg)	Aldrin, total in bottom material (µg/kg)	Chlordane, total in bottom material (µg/kg)	DDD, total in bottom material (µg/kg)	DDE, total in bottom material (µg/kg)	DDT, total in bottom material (µg/kg)	Dieldrin, total in bottom material (µg/kg)	Endosulfan, total in bottom material (µg/kg)	Endrin, total in bottom material (µg/kg)
3	431612108355601	08-16-88	<0.1	<0.1	<1.0	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
4	06246000	08-18-88	< .1	< .1	<1.0	.4	.1	.6	< .1	< .1	< .1
5	431240108372201	08-16-88	< .1	< .1	<1.0	< .1	.2	< .1	< .1	< .1	< .1
6	431109108380801	08-18-88	< .1	< .1	<1.0	< .1	.1	< .1	< .1	< .1	< .1
10	06246500	08-04-88	--	--	--	--	--	--	--	--	--
13	06251500	08-17-88	< .1	< .1	<1.0	< .1	.1	< .1	< .1	< .1	< .1
14	06253000	08-17-88	< .1	< .1	<1.0	< .1	< .1	< .1	< .1	< .1	< .1
16	431907108202501	08-17-88	< .1	< .1	<1.0	< .1	< .1	< .1	< .1	< .1	< .1
17	06258000	08-17-88	< .1	< .1	<1.0	< .1	< .1	< .1	< .1	< .1	< .1

Table 11.--Pesticides in water samples and bottom-sediment samples--Continued

Site No. (fig. 2)	Identification number	Date	Heptachlor, total in bottom material (µg/kg)	Heptachlor epoxide, total in bottom material (µg/kg)	Lindane, total in bottom material (µg/kg)	Methoxychlor, total in bottom material (µg/kg)	Mirex, total in bottom material (µg/kg)	PCB, total in bottom material (µg/kg)	PCN, total in bottom material (µg/kg)	Perthane, total in bottom material (µg/kg)	Toxaphene, total in bottom material (µg/kg)
3	431612108355601	08-16-88	<0.1	<0.1	<0.1	<0.1	<0.1	<1	<1.0	<1.00	<10
4	06246000	08-18-88	< .1	< .1	< .1	< .1	< .1	<1	<1.0	<1.00	<10
5	431240108372201	08-16-88	< .1	< .1	< .1	< .1	< .1	<1	<1.0	<1.00	<10
6	431109108380801	08-18-88	< .1	< .1	< .1	< .1	< .1	<1	<1.0	<1.00	<10
10	06246500	08-04-88	--	--	--	--	--	--	--	--	--
13	06251500	08-17-88	< .1	< .1	< .1	< .1	< .1	<1	<1.0	<1.00	<10
14	06253000	08-17-88	< .1	< .1	< .1	< .1	< .1	<1	<1.0	<1.00	<10
16	431907108202501	08-17-88	< .1	< .1	< .1	< .1	< .1	<1	<1.0	<1.00	<10
17	06258000	08-17-88	< .1	< .1	< .1	< .1	< .1	<1	<1.0	<1.00	<10

Table 12.--Inorganic constituents and percentage

[percent, percent by weight; µg/g, micrograms per gram; <, less shown) were less than the detection limit of 2

Site No.	Aluminum (percent)	Calcium (percent)	Iron (percent)	Magnesium (percent)	Phosphorus (percent)	Potassium (percent)	Sodium (percent)	Titanium (percent)	Arsenic (µg/g)
				Fine-grained fraction (Size less than 0.062 millimeter)					
1	6.6	5.1	4.0	2.3	0.13	1.7	1.6	0.43	2.0
2	4.5	6.1	1.7	1.2	.07	1.6	.67	.19	4.2
3	6.4	3.6	2.8	1.5	.07	2.1	.88	.26	4.4
4	4.9	3.7	2.2	1.2	.10	1.8	.86	.31	4.2
5	6.2	3.6	2.6	1.4	.08	1.9	1.0	.27	2.8
6	6.1	3.0	2.5	1.2	.09	1.9	1.4	.34	2.2
10	5.2	9.3	2.5	1.4	.08	1.7	1.2	.23	4.4
11	6.5	1.6	2.9	1.5	.08	2.2	.85	.28	3.2
13	5.5	3.1	2.1	1.0	.09	1.9	1.3	.28	3.2
14	4.8	3.6	2.0	1.1	.09	1.8	1.0	.25	3.1
15	5.0	4.0	2.0	1.3	.07	1.7	.51	.20	4.5
16	6.1	6.2	2.7	1.3	.07	2.0	.84	.25	6.3
17	4.0	3.8	1.6	1.1	.09	1.6	.72	.25	2.6
19	7.1	3.6	2.5	1.8	.08	1.5	1.2	.26	2.2
				Coarse-grained fraction (Size less than 2 millimeters)					
1	6.1	3.2	2.1	1.2	.07	1.8	1.9	.22	.6
2	3.7	5.6	1.4	.50	.05	1.4	1.1	.08	7.1
3	5.7	1.8	2.0	1.1	.05	2.0	1.0	.18	2.4
4	4.6	2.7	.99	.40	.04	1.6	1.5	.09	3.1
5	5.6	2.1	1.4	.72	.04	1.8	1.6	.15	1.0
6	6.1	1.9	.72	.31	.02	1.6	2.2	.09	1.0
10	6.0	3.3	1.2	.53	.03	1.7	2.2	.11	1.4
11	5.9	1.4	1.4	.69	.04	1.9	1.6	.15	1.0
13	5.9	2.3	1.3	.56	.04	2.0	1.9	.13	3.3
14	4.7	2.3	1.1	.51	.04	1.5	1.5	.14	2.0
15	3.1	6.0	2.1	1.0	.11	1.0	.62	.10	7.2
16	4.8	3.4	1.7	.76	.04	1.8	1.0	.15	3.2
17	3.2	2.5	1.2	.54	.05	1.1	.87	.15	2.5
19	7.4	2.5	1.7	.91	.05	1.4	2.4	.17	2.0

of carbon in bottom-sediment samples

than. All cadmium and molybdenum concentrations (not
µg/g. Analyses by U.S. Geological Survey]

Site No.	Barium (µg/g)	Beryllium (µg/g)	Boron (µg/g)	Cerium (µg/g)	Chromium (µg/g)	Cobalt (µg/g)	Copper (µg/g)	Gallium (µg/g)	Lanthanum (µg/g)	Lead (µg/g)
					Fine-grained fraction (Size less than 0.062 millimeter)					
1	1,100	1	--	170	190	20	22	16	110	49
2	760	1	3.2	51	43	9	11	11	30	14
3	740	2	1.7	59	73	12	19	17	35	17
4	800	1	.8	120	63	10	16	12	69	17
5	640	2	.7	73	77	11	17	16	43	14
6	760	2	.4	130	82	10	13	16	79	16
10	1,100	2	1.5	69	79	12	20	14	41	15
11	640	2	.6	68	86	12	23	17	40	19
13	690	2	.5	110	63	9	13	14	62	14
14	760	1	.3	100	57	8	9	12	60	14
15	620	1	1.2	53	52	10	12	13	32	15
16	2,200	2	1.0	67	74	14	23	15	39	17
17	810	1	.5	85	46	7	8	10	51	12
19	840	2	.4	120	59	10	13	19	73	18
					Coarse-grained fraction (Size less than 2 millimeters)					
1	1,100	1	.2	87	85	12	7	14	55	19
2	1,300	<1	1.3	38	20	6	6	8	26	14
3	790	2	1.3	52	51	9	14	14	32	14
4	870	1	.3	49	19	5	5	10	32	12
5	680	1	.4	50	39	7	8	14	31	12
6	720	1	.2	37	19	4	3	13	24	11
10	1,000	1	.7	89	34	6	4	14	58	14
11	690	2	.4	53	42	7	8	14	34	13
13	870	1	.3	51	35	6	7	14	33	14
14	850	1	.3	65	24	5	4	11	40	11
15	900	<1	.8	40	34	8	9	7	28	14
16	1,400	1	.8	48	40	8	12	12	29	11
17	950	<1	.4	75	25	5	4	8	47	10
19	1,900	2	.2	290	28	8	5	18	190	13

Table 12.--Inorganic constituents and percentage

Site No.	Lithium (μg/g)	Manganese (μg/g)	Mercury (μg/g)	Neodymium (μg/g)	Nickel (μg/g)	Niobium (μg/g)	Scandium (μg/g)	Selenium (μg/g)	Silver (μg/g)	Strontium (μg/g)
				Fine-grained fraction (Size less than 0.062 millimeter)						
1	17	660	0.14	75	52	7	12	0.1	<2	550
2	23	880	.02	28	17	<4	6	.6	<2	460
3	30	460	.02	30	28	8	9	.3	<2	250
4	22	780	<.02	56	19	6	7	.4	<2	200
5	28	550	.04	36	27	7	8	1.1	<2	260
6	22	790	.30	60	23	8	8	.3	<2	340
10	27	580	.04	30	32	4	7	1.1	<2	470
11	29	360	<.02	33	28	9	9	.2	<2	170
13	21	580	<.02	49	20	5	7	.2	<2	250
14	20	490	.02	49	18	<4	6	.2	<2	210
15	27	720	.02	27	19	4	7	1.2	<2	200
16	33	500	.08	34	29	5	8	3.0	<2	260
17	18	440	<.02	41	13	<4	5	.3	<2	190
19	28	430	.02	52	22	7	8	1.3	<2	400
				Coarse-grained fraction (Size less than 2 millimeters)						
1	10	390	<.02	37	29	<4	7	.1	<2	520
2	12	630	<.02	19	10	<4	3	.5	<2	370
3	22	330	<.02	23	20	5	6	.2	<2	240
4	11	310	<.02	21	10	<4	3	.1	<2	290
5	16	310	<.02	22	15	<4	5	.6	<2	300
6	10	250	<.02	16	8	<4	3	<.1	<2	480
10	14	320	<.02	32	12	<4	4	.2	<2	460
11	15	230	<.02	23	16	4	5	.1	<2	300
13	14	320	<.02	21	15	<4	4	.1	<2	360
14	12	300	<.02	28	11	<4	4	.1	<2	310
15	15	580	<.02	23	17	<4	4	.8	<2	200
16	19	310	.04	23	16	<4	5	1.9	<2	200
17	10	340	<.02	31	7	<4	3	.2	2	210
19	16	320	<.02	100	12	5	5	.4	<2	650

of carbon in bottom-sediment samples--Continued

Site No.	Thorium (μg/g)	Tin (μg/g)	Uranium (μg/g)	Vanadium (μg/g)	Ytterbium (μg/g)	Yttrium (μg/g)	Zinc (μg/g)	Total carbon (percent)	Organic carbon (percent)	Carbonate carbon (percent)
					Fine-grained fraction (Size less than 0.062 millimeter)					
1	45	<10	1.7	130	2	23	66	1.44	0.48	0.96
2	9	<10	2.6	52	2	16	45	2.21	.50	1.71
3	12	20	2.7	74	2	17	63	1.37	.49	.88
4	23	120	1.5	62	3	26	50	1.47	.40	1.07
5	13	<10	4.4	57	2	18	59	1.85	1.12	.73
6	23	<10	1.6	60	3	25	49	.67	.19	.48
10	13	<10	5.7	54	2	16	56	3.08	.72	2.36
11	14	<10	1.6	67	2	19	510	1.53	1.36	.17
13	18	<10	1.3	52	3	22	42	.86	.22	.64
14	17	<10	1.0	54	3	23	40	1.20	.22	.98
15	8	<10	1.5	65	2	17	57	1.91	.59	1.32
16	11	20	2.6	84	2	19	61	2.03	.38	1.65
17	14	<10	.90	51	2	21	36	1.48	.27	1.21
19	19	<10	2.9	55	2	18	55	.94	.25	.69
					Coarse-grained fraction (Size less than 2 millimeters)					
1	20	<10	.65	57	1	11	30	.47	.08	.39
2	5	<10	1.3	25	<1	10	26	1.78	.22	1.56
3	9	<10	1.3	53	1	14	43	1.02	.41	.61
4	6	<10	.80	23	<1	9	20	.64	.09	.55
5	8	<10	1.6	32	1	10	30	.98	.71	.27
6	<4	<10	.50	17	<1	6	13	.11	.02	.09
10	11	<10	1.7	24	1	9	23	.73	.20	.53
11	8	<10	.80	33	1	11	230	.69	.62	.07
13	7	<10	.65	29	1	10	25	.44	.12	.32
14	10	<10	.70	28	1	12	20	.51	.07	.44
15	<4	<10	1.3	40	1	14	41	2.14	.30	1.84
16	7	<10	2.0	50	1	12	33	1.03	.21	.82
17	10	<10	1.0	30	1	13	19	.81	.14	.67
19	24	<10	1.3	33	1	14	34	.22	.06	.16

Table 13.--Trace elements in biological samples

[All concentrations in micrograms per gram, dry weight. Aq. inv., aquatic invertebrates; <, less than; --, no data. Analyses by U.S. Fish and Wildlife Service]

Site No. (fig. 2)	Matrix	Common name	Date	Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium
3	Stems/leaves	Pondweed	08-10-88	203	<30	0.499	64.8	<0.25	260	<0.50	3.10
3	Stems/leaves	Pondweed	08-10-88	87.0	<30	.783	65.6	< .25	783	< .50	2.22
3	Aq. inv.	Water boatmen	08-10-88	32.0	<30	< .20	4.27	< .25	<30	< .50	2.21
3	Aq. inv.	Copepods	08-10-88	304	<30	1.51	16.3	< .25	5.8	< .50	2.33
3	Egg	American coot	07-06-88	< 36.9	< .092	.085	< 18.4	<1.84	<18.4	<1.84	<3.69
3	Egg	American coot	07-06-88	< 39.7	< .100	.079	< 19.8	<1.98	<19.8	<1.98	<3.97
3	Egg	Pied-billed grebe	07-06-88	< 41.3	< .103	.112	< 20.7	<2.07	<20.7	<2.07	<4.13
3	Liver	American coot	06-07-88	< 41.7	< .104	.375	< 20.8	<2.08	<20.8	<2.08	<4.17
3	Liver	American coot	06-07-88	< 43.3	.121	.390	< 21.6	<2.16	<21.6	<2.16	4.33
3	Liver	American coot	06-07-88	< 41.3	< .103	.364	< 20.7	<2.07	<20.7	<2.07	<4.13
3	Liver	American coot	06-07-88	< 41.3	.149	.471	< 20.7	<2.07	<20.7	<2.07	<4.13
3	Liver	American coot	06-07-88	< 40.8	.127	.718	< 20.4	<2.04	<20.4	<2.04	<4.08
3	Liver	American coot	06-07-88	< 42.4	< .106	.602	< 21.2	<2.12	<21.2	<2.12	<4.24
3	Liver	Ruddy duck	06-07-88	< 39.4	< .098	.157	< 19.7	<1.97	<19.7	1.97	<3.94
7	Stems/leaves	Pondweed	08-12-88	775	<30	.918	81.2	< .25	147	< .50	2.62
7	Stems/leaves	Pondweed	08-12-88	861	<30	1.36	107	< .25	194	< .50	<1.5
7	Aq. inv.	Water boatmen	08-12-88	186	<30	.311	80.4	< .25	< 3.0	< .50	<1.5
7	Aq. inv.	Water boatmen	08-12-88	230	<30	1.00	10.6	< .25	< 3.0	< .50	<1.5
7	Aq. inv.	Water boatmen	08-12-88	116	<30	.561	48.2	< .25	< 3.0	< .50	<1.5
7	Fish	Carp	08-11-88	118	<30	1.10	3.94	< .25	< 3.0	< .50	<1.5
7	Fish	Carp	08-11-88	154	<30	.280	4.63	< .25	< 3.0	< .50	<1.5
7	Fish	Carp	08-11-88	244	<30	.412	5.64	< .25	< 3.0	< .50	<1.5
7	Fish	Carp	08-11-88	< 30	<30	.439	4.75	< .25	< 3.0	< .50	<1.5
7	Fish	Carp	08-11-88	< 30	<30	< .20	5.07	< .25	< 3.0	< .50	<1.5
7	Fish	White sucker	08-11-88	< 30	<30	< .20	10.6	< .25	< 3.0	< .50	<1.5
7	Fish	White sucker	08-11-88	< 30	<30	< .20	< 1.0	< .25	< 3.0	< .50	<1.5
7	Fish	Yellow perch	08-11-88	< 30	<30	< .20	3.02	< .25	< 3.0	< .50	<1.5
7	Fish	Walleye	08-11-88	< 30	<30	< .20	2.57	< .25	< 3.0	< .50	<1.5

Table 13.--Trace elements in biological samples--Continued

Site No. (fig. 2)	Matrix	Common name	Date	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Molybdenum	Nickel
3	Stems/leaves	Pondweed	08-10-88	< 3.0	304	< 6.0	4,470	549	<0.020	< 5.0	< 2.0
3	Stems/leaves	Pondweed	08-10-88	< 3.0	193	< 6.0	6,110	1,010	< .020	< 5.0	< 2.0
3	Aq. inv.	Water boatmen	08-10-88	17.7	135	< 6.0	1,170	20.2	.0768	< 5.0	2.09
3	Aq. inv.	Copepods	08-10-88	30.3	1,910	< 6.0	1,900	34.7	.152	< 5.0	< 2.0
3	Egg	American coot	07-06-88	< 19.22	107	< 36.9	517	<5.54	.258	<18.4	<14.8
3	Egg	American coot	07-06-88	< 9.92	139	< 39.7	635	<5.95	.385	<19.8	<15.9
3	Egg	Pied-billed grebe	07-06-88	< 10.3	145	< 41.3	537	<6.20	.810	<20.7	<16.5
3	Liver	American coot	06-07-88	16.7	1,520	< 41.7	792	12.1	.312	<20.8	<16.7
3	Liver	American coot	06-07-88	52.8	7,840	< 43.3	736	11.7	.589	<21.6	<17.3
3	Liver	American coot	06-07-88	31.4	447	< 41.3	868	10.7	.545	<20.7	<16.5
3	Liver	American coot	06-07-88	42.1	557	< 41.3	826	9.50	1.05	<20.7	<16.5
3	Liver	American coot	06-07-88	62.9	3,900	< 40.8	735	8.16	.886	31.4	<16.3
3	Liver	American coot	06-07-88	32.2	729	< 42.4	720	7.20	1.05	<21.2	<16.9
3	Liver	Ruddy duck	06-07-88	220	4,720	< 39.4	669	12.2	.319	<19.7	<15.7
7	Stems/leaves	Pondweed	08-12-88	< 3.0	690	8.83	4,420	230	< .020	< 5.0	< 2.0
7	Stems/leaves	Pondweed	08-12-88	5.70	781	10.6	4,570	356	< .020	< 5.0	< 2.0
7	Aq. inv.	Water boatmen	08-12-88	8.52	316	< 6.0	1,370	35.0	.193	< 5.0	< 2.0
7	Aq. inv.	Water boatmen	08-12-88	9.33	310	< 6.0	1,020	39.5	.283	< 5.0	2.58
7	Aq. inv.	Water boatmen	08-12-88	13.8	346	< 6.0	1,350	39.2	.254	< 5.0	2.75
7	Fish	Carp	08-11-88	< 3.0	188	< 6.0	919	4.81	.198	< 5.0	< 2.0
7	Fish	Carp	08-11-88	< 3.0	282	< 6.0	1,040	10.1	.0881	< 5.0	< 2.0
7	Fish	Carp	08-11-88	< 3.0	322	< 6.0	1,150	8.89	.108	< 5.0	< 2.0
7	Fish	Carp	08-11-88	8.95	112	< 6.0	1,230	6.84	.0954	< 5.0	< 2.0
7	Fish	Carp	08-11-88	7.68	93.2	< 6.0	1,290	6.60	.113	< 5.0	< 2.0
7	Fish	White sucker	08-11-88	8.35	90.3	< 6.0	1,470	8.34	.0562	< 5.0	< 2.0
7	Fish	White sucker	08-11-88	9.77	100	< 6.0	1,750	14.2	.271	< 5.0	< 2.0
7	Fish	Yellow perch	08-11-88	6.46	34.9	< 6.0	1,510	1.54	.445	< 5.0	< 2.0
7	Fish	Walleye	08-11-88	< 3.0	< 25	< 6.0	2,160	3.06	.108	< 5.0	< 2.0

Table 13.--Trace elements in biological samples--Continued

Site No. (fig. 2)	Matrix	Common name	Date	Sele- nium	Silver	Stron- tium	Thal- lium	Tin	Vana- dium	Zinc	Moisture, percent
3	Stems/leaves	Pondweed	08-10-88	7.44	<10	577	--	<20	< 0.80	25.7	87.9
3	Stems/leaves	Pondweed	08-10-88	2.90	<10	383	--	<20	.920	20.9	80.8
3	Aq. inv.	Water boatmen	08-10-88	8.14	<10	24.5	--	<20	< .80	119	71.7
3	Aq. inv.	Copepods	08-10-88	11.1	<10	254	--	<20	1.01	162	87.0
3	Egg	American coot	07-06-88	10.3	<18.4	30.6	<0.37	<18.4	<18.4	70.5	72.9
3	Egg	American coot	07-06-88	13.1	<19.8	52.8	< .40	<19.8	<19.8	77.0	74.8
3	Egg	Pied-billed grebe	07-06-88	16.9	<20.7	25.6	< .41	<20.7	<20.7	73.1	75.8
3	Liver	American coot	06-07-88	10.4	<20.8	< 4.17	< .42	<20.8	<20.8	109	76.0
3	Liver	American coot	06-07-88	6.9	<21.6	< 4.33	< .43	<21.6	<21.6	173	76.9
3	Liver	American coot	06-07-88	13.2	<20.7	< 4.13	< .41	<20.7	<20.7	183	75.8
3	Liver	American coot	06-07-88	6.2	<20.7	< 4.13	< .41	<20.7	<20.7	135	75.8
3	Liver	American coot	06-07-88	9.0	<20.4	< 4.08	< .41	<20.4	<20.4	229	75.5
3	Liver	American coot	06-07-88	10.2	<21.2	< 4.24	< .43	<21.2	<21.2	132	76.4
3	Liver	Ruddy duck	06-07-88	34.6	<19.7	< 3.94	< .39	<19.7	<19.7	111	74.6
7	Stems/leaves	Pondweed	08-12-88	1.80	<10	247	--	<20	2.95	<20	79.7
7	Stems/leaves	Pondweed	08-12-88	4.75	<10	370	--	<20	3.85	21.5	76.5
7	Aq. inv.	Water boatmen	08-12-88	3.27	<10	16.3	--	<20	< .80	152	83.4
7	Aq. inv.	Water boatmen	08-12-88	9.13	<10	11.7	--	<20	< .80	115	72.9
7	Aq. inv.	Water boatmen	08-12-88	3.83	<10	36.9	--	<20	< .80	156	87.6
7	Fish	Carp	08-11-88	4.73	<10	21.5	--	<20	.921	252	66.8
7	Fish	Carp	08-11-88	5.21	<10	35.9	--	<20	1.17	223	73.7
7	Fish	Carp	08-11-88	4.41	<10	55.0	--	<20	1.66	235	69.2
7	Fish	Carp	08-11-88	4.24	<10	63.1	--	<20	< .80	330	70.1
7	Fish	Carp	08-11-88	5.16	<10	101	--	<20	< .80	331	70.3
7	Fish	White sucker	08-11-88	4.64	<10	89.4	--	<20	< .80	83.3	70.6
7	Fish	White sucker	08-11-88	3.30	<10	124	--	<20	2.39	90.3	74.7
7	Fish	Yellow perch	08-11-88	7.33	<10	60.7	--	<20	1.46	96.1	73.3
7	Fish	Walleye	08-11-88	4.79	<10	127	--	<20	1.08	77.8	76.0

Table 13.--Trace elements in biological samples--Continued

Site No. (fig. 2)	Matrix	Common name	Date	Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium
7	Fish	Walleye	08-11-88	< 30	<30	<0.20	1.40	<0.25	< 3.0	<0.50	<1.5
7	Fish	Walleye	08-11-88	< 30	<30	< .20	1.62	< .25	< 3.0	< .50	<1.5
7	Fish	Walleye	08-11-88	< 30	<30	< .20	4.62	< .25	< 3.0	< .50	2.23
7	Fish	Black crappie	08-11-88	< 30	<30	< .20	9.75	< .25	< 3.0	< .50	<1.5
7	Fish	Black crappie	08-11-88	< 30	<30	.372	7.41	< .25	< 3.0	< .50	1.73
8	Egg	Pied-billed grebe	07-06-88	< 42.9	< .108	.116	< 21.5	<2.15	<21.5	<2.15	<4.29
8	Liver	American coot	05-17-88	< 38.0	.144	.281	< 19.0	<1.90	<19.0	<1.90	<3.80
8	Liver	American coot	05-17-88	< 38.8	< .097	.651	< 19.4	<1.94	<19.4	<1.94	<3.88
8	Liver	American coot	05-17-88	< 37.3	< .093	.246	< 18.6	<1.86	<18.6	<1.86	<3.73
8	Liver	American coot	05-17-88	< 43.5	.235	.500	< 21.7	<2.17	<21.7	<2.17	<4.35
8	Liver	American coot	05-17-88	< 37.9	.095	.375	< 18.9	<1.89	<18.9	<1.89	<3.79
8	Liver	American coot	05-17-88	< 41.8	< .105	.715	< 20.9	<2.09	<20.9	<2.09	<4.18
8	Liver	American coot	05-17-88	< 42.7	< .107	.684	< 21.4	<2.14	<21.4	<2.14	<4.27
8	Liver	American coot	05-17-88	< 36.5	< .091	.467	< 18.2	<1.82	<18.2	<1.82	<3.65
9	Stems/leaves	Pondweed	08-12-88	2,640	<30	1.03	107	< .25	201	< .50	3.81
9	Stems/leaves	Pondweed	08-12-88	3,090	<30	.897	105	< .25	226	< .50	4.19
9	Aq. inv.	Water boatmen	08-12-88	228	<30	.707	115	< .25	< 3.0	< .50	<1.5
9	Aq. inv.	Water boatmen	08-12-88	129	<30	.780	139	< .25	< 3.0	< .50	<1.5
9	Aq. inv.	Water boatmen	08-12-88	94.7	<30	.711	130	< .25	< 3.0	< .50	<1.5
9	Aq. inv.	Water boatmen	08-12-88	141	<30	.799	101	< .25	< 3.0	< .50	<1.68
9	Fish	Carp	08-12-88	< 30	<30	.734	1.85	< .25	< 3.0	< .50	<1.5
9	Fish	Carp	08-12-88	< 30	<30	.693	1.91	< .25	< 3.0	< .50	<1.5
9	Fish	Carp	08-12-88	< 30	<30	.456	3.52	< .25	< 3.0	< .50	<1.5
9	Fish	Carp	08-12-88	< 30	<30	.552	1.46	< .25	< 3.0	< .50	<1.5
9	Fish	Carp	08-12-88	< 30	<30	< .20	5.74	< .25	< 3.0	< .50	1.78
9	Fish	Carp	08-12-88	< 30	<30	.424	2.19	< .25	< 3.0	< .50	<1.5
9	Fish	Yellow perch	08-12-88	< 30	<30	< .20	2.47	< .25	< 3.0	< .50	1.53
9	Fish	Walleye	08-12-88	< 30	<30	< .20	2.73	< .25	< 3.0	.584	1.78
9	Fish	Black crappie	08-12-88	< 30	<30	< .20	5.54	< .25	< 3.0	< .50	1.70
9	Fish	Black crappie	08-12-88	< 30	<30	< .20	7.23	< .25	< 3.0	< .50	1.86
9	Fish	Black crappie	08-12-88	< 30	<30	< .20	5.04	< .25	< 3.0	< .50	1.79

Table 13.--Trace elements in biological samples--Continued

Site No. (fig. 2)	Matrix	Common name	Date	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Molybdenum	Nickel
7	Fish	Walleye	08-11-88	< 3.0	31.8	< 6.0	1,860	3.67	0.159	< 5.0	< 2.0
7	Fish	Walleye	08-11-88	< 3.0	32.6	< 6.0	1,470	1.82	.272	< 5.0	< 2.0
7	Fish	Walleye	08-11-88	12.2	35.8	< 6.0	1,470	1.45	.412	< 5.0	< 2.0
7	Fish	Black crappie	08-11-88	14.8	54.7	< 6.0	2,450	13.4	1.07	< 5.0	< 2.0
7	Fish	Black crappie	08-11-88	< 3.0	102	< 6.0	2,200	14.5	.227	< 5.0	< 2.0
8	Egg	Pied-billed grebe	07-06-88	< 10.7	68.7	< 42.9	429	<6.44	1.43	<21.5	<17.2
8	Liver	American coot	05-17-88	24.7	8,020	< 38.0	874	14.8	.373	<19.0	<15.2
8	Liver	American coot	05-17-88	90.3	3,860	< 38.8	775	10.1	.519	<19.4	<15.5
8	Liver	American coot	05-17-88	20.1	7,130	< 37.3	709	11.9	.731	<18.6	<14.9
8	Liver	American coot	05-17-88	33.5	1,070	< 43.5	783	8.70	.552	<21.7	<17.4
8	Liver	American coot	05-17-88	11.7	5,530	< 37.9	644	9.85	.242	<18.9	<15.2
8	Liver	American coot	05-17-88	24.7	3,230	< 41.8	753	10.0	.523	<20.9	<16.7
8	Liver	American coot	05-17-88	20.1	1,540	< 42.7	812	10.3	.855	<21.4	<17.1
8	Liver	American coot	05-17-88	39.4	4,530	< 36.5	730	12.0	.781	<18.2	<14.6
9	Stems/leaves	Pondweed	08-12-88	3.65	2,310	6.88	6,310	107	.0517	< 5.0	5.40
9	Stems/leaves	Pondweed	08-12-88	5.47	2,580	6.76	6,510	129	< .020	< 5.0	4.35
9	Aq. inv.	Water boatmen	08-12-88	12.3	404	< 6.0	1,520	35.3	.0788	< 5.0	2.62
9	Aq. inv.	Water boatmen	08-12-88	11.0	300	< 6.0	1,520	43.2	.0621	< 5.0	3.00
9	Aq. inv.	Water boatmen	08-12-88	11.1	259	< 6.0	1,430	39.0	.0596	< 5.0	< 2.0
9	Aq. inv.	Water boatmen	08-12-88	14.3	277	< 6.0	1,410	35.2	.0671	< 5.0	< 2.0
9	Fish	Carp	08-12-88	< 3.0	80.0	< 6.0	1,060	2.91	.100	< 5.0	< 2.0
9	Fish	Carp	08-12-88	< 3.0	62.6	< 6.0	955	2.68	.187	< 5.0	< 2.0
9	Fish	Carp	08-12-88	< 3.0	90.1	< 6.0	1,160	5.42	.237	< 5.0	< 2.0
9	Fish	Carp	08-12-88	< 3.0	99.5	< 6.0	1,170	4.78	.393	< 5.0	< 2.0
9	Fish	Carp	08-12-88	< 3.0	161	< 6.0	1,710	11.6	.149	< 5.0	< 2.0
9	Fish	Carp	08-12-88	< 3.0	108	< 6.0	1,040	3.47	.158	< 5.0	< 2.0
9	Fish	Yellow perch	08-12-88	< 3.0	41.1	< 6.0	1,550	4.39	.332	< 5.0	< 2.0
9	Fish	Walleye	08-12-88	< 3.0	62.0	< 6.0	1,670	2.54	1.30	< 5.0	< 2.0
9	Fish	Black crappie	08-12-88	8.79	41.3	< 6.0	1,730	8.41	.327	< 5.0	< 2.0
9	Fish	Black crappie	08-12-88	7.40	27.1	< 6.0	2,190	7.72	.301	< 5.0	< 2.0
9	Fish	Black crappie	08-12-88	10.6	33.9	< 6.0	2,050	8.92	.654	< 5.0	< 2.0

Table 13.--Trace elements in biological samples--Continued

Site No. (fig. 2)	Matrix	Common name	Date	Sele-nium	Silver	Stron-tium	Thal-lium	Tin	Vana-dium	Zinc	Moisture, percent
7	Fish	Walleye	08-11-88	4.27	<10	82.7	--	<20	< 0.80	60.4	75.7
7	Fish	Walleye	08-11-88	6.76	<10	36.9	--	<20	< .80	51.6	74.1
7	Fish	Walleye	08-11-88	8.35	<10	37.1	--	<20	1.37	53.9	74.1
7	Fish	Black crappie	08-11-88	6.32	<10	278	--	<20	1.34	81.9	75.2
7	Fish	Black crappie	08-11-88	4.20	<10	294	--	<20	< .80	103	70.4
8	Egg	Pied-billed grebe	07-06-88	1.3	<21.5	6.01	<0.43	<21.5	<21.5	48.1	76.7
8	Liver	American coot	05-17-88	1.5	<19.0	< 3.80	< .38	<19.0	<19.0	246	73.7
8	Liver	American coot	05-17-88	5.0	<19.4	< 3.88	< .39	<19.4	<19.4	171	74.2
8	Liver	American coot	05-17-88	2.2	<18.6	< 3.73	< .37	<18.6	<18.6	271	73.2
8	Liver	American coot	05-17-88	3.0	<21.7	< 4.35	< .43	<21.7	<21.7	160	77.0
8	Liver	American coot	05-17-88	9.8	<18.9	< 3.79	< .38	<18.9	<18.9	142	73.6
8	Liver	American coot	05-17-88	12.6	<20.9	< 4.18	< .42	<20.9	<20.9	156	76.1
8	Liver	American coot	05-17-88	3.8	21.4	< 4.27	< .43	<21.4	<21.4	165	76.6
8	Liver	American coot	05-17-88	6.6	<18.2	< 3.65	< .36	<18.2	<18.2	184	72.6
9	Stems/leaves	Pondweed	08-12-88	2.48	<10	362	--	<20	5.03	29.4	79.7
9	Stems/leaves	Pondweed	08-12-88	4.00	<10	343	--	<20	5.26	24.7	81.4
9	Aq. inv.	Water boatmen	08-12-88	6.43	<10	30.0	--	<20	< .80	196	88.6
9	Aq. inv.	Water boatmen	08-12-88	5.20	<10	25.5	--	<20	< .80	196	88.6
9	Aq. inv.	Water boatmen	08-12-88	5.81	<10	23.8	--	<20	< .8	169	87.4
9	Aq. inv.	Water boatmen	08-12-88	5.02	<10	20.7	--	<20	< .8	176	84.2
9	Fish	Carp	08-12-88	6.14	<10	35.6	--	<20	< .80	351	71.6
9	Fish	Carp	08-12-88	5.92	<10	27.7	--	<20	1.77	168	70.2
9	Fish	Carp	08-12-88	4.46	<10	63.6	--	<20	1.72	433	69.8
9	Fish	Carp	08-12-88	7.01	<10	85.9	--	<20	1.08	379	71.0
9	Fish	Carp	08-12-88	7.02	<10	164	--	<20	2.16	301	72.3
9	Fish	Carp	08-12-88	4.51	<10	34.8	--	<20	.941	352	74.0
9	Fish	Yellow perch	08-12-88	4.72	<10	70.0	--	<20	1.23	92.0	72.8
9	Fish	Walleye	08-12-88	7.45	<10	56.5	--	<20	1.76	65.3	79.7
9	Fish	Black crappie	08-12-88	4.43	<10	200	--	<20	< .80	86.3	74.5
9	Fish	Black crappie	08-12-88	4.38	<10	312	--	<20	< .80	82.2	75.1
9	Fish	Black crappie	08-12-88	7.49	<10	256	--	<20	< .80	82.1	75.5

Table 13.--Trace elements in biological samples--Continued

Site No. (fig. 2)	Matrix	Common name	Date	Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium
11	Stems/leaves	Pondweed	07-06-88	< 94.3	< 0.236	0.764	169	<4.72	220	<4.72	38.7
11	Stems/leaves	Pondweed	07-06-88	143	< .325	2.00	261	<6.49	<64.9	<6.49	50.6
11	Stems/leaves	Pondweed	07-06-88	< 87.0	.296	.730	75.7	<4.35	848	<4.35	37.4
11	Stems/leaves	Pondweed	07-06-88	< 90.1	< .225	.730	180	<4.50	<45.0	<4.50	36.0
11	Egg	American coot	07-06-88	< 37.9	< .095	.250	< 18.9	<1.89	<18.9	<1.89	<3.79
11	Egg	American coot	07-06-88	< 41.7	< .104	.288	< 20.8	<2.08	<20.8	<2.08	<4.17
11	Egg	American coot	07-06-88	< 41.3	< .103	.289	< 20.7	<2.07	<20.7	<2.07	<4.13
11	Egg	American coot	07-06-88	< 37.6	< .094	.222	< 18.8	<1.88	<18.8	<1.88	<3.76
12	Egg	American coot	07-06-88	< 43.5	< .109	.148	< 21.7	<2.17	<21.7	<2.17	<4.35
12	Egg	American coot	07-06-88	< 39.7	< .099	.119	< 19.8	<1.98	<19.8	<1.98	<3.97
12	Egg	American coot	07-06-88	< 38.9	< .097	.121	< 19.4	<1.94	<19.4	<1.94	<3.89
16	Stems/leaves	Pondweed	07-06-88	<118	< .294	2.95	124	<5.88	209	<5.88	45.9
16	Stems/leaves	Pondweed	07-06-88	658	< .329	3.62	124	<6.58	236	<6.58	56.6
16	Stems/leaves	Pondweed	07-06-88	220	< .250	2.88	155	<5	<50	<5	39
16	Fish	Rainbow trout	05-19-88	11	--	< .10	2.8	< .1	< 2	< .3	<1
16	Fish	Rainbow trout	05-19-88	18	--	.20	1.8	< .1	< 2	<9.3	<1
16	Fish	Rainbow trout	05-19-88	9.5	--	.10	3.6	< .1	< 2	< .3	<1
16	Fish	Rainbow trout	05-19-88	48	--	< .10	3.9	< .1	< 2	< .3	<1
16	Fish	Rainbow trout	05-19-88	< 3	--	.33	2.2	< .1	< 2	< .3	<1
16	Fish	White sucker	05-19-88	95	--	.34	3.8	< .1	< 2	< .3	<1
16	Fish	White sucker	05-19-88	69	--	.20	1.9	< .1	< 2	< .3	<1
16	Fish	White sucker	05-19-88	46	--	.30	4.2	< .1	< 2	< .3	<1
16	Fish	White sucker	05-19-88	140	--	< .10	5.2	< .1	< 2	< .4	2
16	Fish	White sucker	05-19-88	110	--	< .10	5.5	< .1	< 2	< .3	1
16	Fish eggs	Rainbow trout	05-19-88	7	--	.20	.81	< .1	< 2	< .3	<1
16	Fish eggs	Rainbow trout	05-19-88	< 4	--	.10	1.1	< .1	< 2	< .3	<1
16	Liver	American coot	05-17-88	< 39.1	.109	.410	< 19.5	<1.95	<19.5	<1.95	<3.91
16	Liver	American coot	05-17-88	< 35.3	< .088	.403	< 17.7	<1.77	<17.7	<1.77	<3.53
16	Liver	American coot	05-17-88	< 38.3	< .096	.467	< 19.2	<1.92	<19.2	<1.92	<3.83
16	Liver	American coot	05-17-88	< 35.8	< .090	.398	< 17.9	<1.79	<17.9	<1.79	<3.58

Table 13.--Trace elements in biological samples--Continued

Site No. (fig. 2)	Matrix	Common name	Date	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Molybdenum	Nickel
11	Stems/leaves	Pondweed	07-06-88	23.6	236	< 94.3	7,830	390	1.07	<47.2	<37.7
11	Stems/leaves	Pondweed	07-06-88	< 32.5	442	130	7,270	1,110	< .325	<64.9	<51.9
11	Stems/leaves	Pondweed	07-06-88	< 21.7	148	< 87.0	10,200	194	< .217	<43.5	<34.8
11	Stems/leaves	Pondweed	07-06-88	< 22.5	153	< 90.1	5,230	274	< .225	<45.0	<36.0
11	Egg	American coot	07-06-88	< 9.47	49.5	< 37.9	492	<5.68	.284	<18.9	<15.2
11	Egg	American coot	07-06-88	< 10.4	62.5	< 41.7	500	<6.25	.679	<20.8	<16.7
11	Egg	American coot	07-06-88	< 10.3	49.6	< 41.3	413	<6.20	.558	<20.7	<16.5
11	Egg	American coot	07-06-88	< 9.40	60.1	< 37.6	413	<5.64	.729	<18.8	<15.0
12	Egg	American coot	07-06-88	< 10.9	43.5	< 43.5	478	<6.52	.517	<21.7	<17.4
12	Egg	American coot	07-06-88	< 9.92	59.5	< 39.7	516	<5.95	.274	<19.8	<15.9
12	Egg	American coot	07-06-88	< 9.73	< 38.9	< 38.9	506	<5.84	.284	<19.4	<15.6
16	Stems/leaves	Pondweed	07-06-88	< 29.4	306	<118	4,940	473	< .294	<58.8	<47.1
16	Stems/leaves	Pondweed	07-06-88	< 32.9	908	<132	4,610	308	.355	<65.8	<52.6
16	Stems/leaves	Pondweed	07-06-88	< 25	390	<100	3,400	271	< .250	<50	<40
16	Fish	Rainbow trout	05-19-88	9.1	76	< 4	1,270	4.5	.552	< 1	< 2
16	Fish	Rainbow trout	05-19-88	5.4	70	< 4	1,280	3.9	.49	< 1	< 2
16	Fish	Rainbow trout	05-19-88	10	64	< 4	1,330	4.6	.542	< 1	< 2
16	Fish	Rainbow trout	05-19-88	10	88	< 5	1,230	5.8	.47	< 1	< 2
16	Fish	Rainbow trout	05-19-88	9.4	65	< 4	1,150	3.0	.26	< 1	< 2
16	Fish	White sucker	05-19-88	6.5	148	< 4	1,080	11	.37	< 1	< 2
16	Fish	White sucker	05-19-88	4.0	115	< 4	942	9.5	.19	< 1	< 2
16	Fish	White sucker	05-19-88	4.0	83	< 4	1,170	11	.32	< 1	< 2
16	Fish	White sucker	05-19-88	8.3	158	< 5	1,160	20.7	.25	2	< 2
16	Fish	White sucker	05-19-88	6.3	129	< 4	1,190	17	.29	< 1	< 2
16	Fish eggs	Rainbow trout	05-19-88	8.0	43	< 4	1,540	1.9	.007	< 1	< 2
16	Fish eggs	Rainbow trout	05-19-88	14	48	< 4	1,360	7.1	.031	< 1	< 2
16	Liver	American coot	05-17-88	15.2	6,950	< 39.1	703	10.5	.406	<19.5	<15.6
16	Liver	American coot	05-17-88	11.3	859	< 35.3	671	13.8	.428	<17.7	<14.1
16	Liver	American coot	05-17-88	< 9.58	533	< 38.3	728	11.1	.310	<19.2	<15.3
16	Liver	American coot	05-17-88	34.8	2,290	< 35.8	717	14.3	1.32	<17.9	<14.3

Table 13.--Trace elements in biological samples--Continued

Site No. (fig. 2)	Matrix	Common name	Date	Sele-nium	Silver	Stron-tium	Thal-lium	Tin	Vana-dium	Zinc	Moisture, percent
11	Stems/leaves	Pondweed	07-06-88	<0.94	<47.2	391	<0.94	<47.2	<47.2	24.5	89.4
11	Stems/leaves	Pondweed	07-06-88	<1.30	<64.9	549	<1.3	<64.9	<64.9	<26.0	92.3
11	Stems/leaves	Pondweed	07-06-88	< .87	<43.5	205	< .87	<43.5	<43.5	<17.4	88.5
11	Stems/leaves	Pondweed	07-06-88	< .90	<45.0	377	< .90	<45.0	<45.0	<18.0	88.9
11	Egg	American coot	07-06-88	.76	<18.9	7.58	< .38	<18.9	<18.9	56.8	73.6
11	Egg	American coot	07-06-88	.83	<20.8	6.25	< .42	<20.8	<20.8	62.9	76.0
11	Egg	American coot	07-06-88	.83	<20.7	6.20	< .41	<20.7	<20.7	62.4	75.8
11	Egg	American coot	07-06-88	.38	<18.8	7.52	< .38	<18.8	<18.8	75.9	73.4
12	Egg	American coot	07-06-88	< .43	<21.7	14.3	< .43	<21.7	<21.7	57.4	77.0
12	Egg	American coot	07-06-88	.79	<19.8	17.1	< .40	<19.8	<19.8	70.6	74.8
12	Egg	American coot	07-06-88	.78	<19.4	12.1	< .39	<19.4	<19.4	55.6	74.3
16	Stems/leaves	Pondweed	07-06-88	1.2	<58.8	242	<1.2	<58.8	<58.8	23.5	91.5
16	Stems/leaves	Pondweed	07-06-88	1.3	<65.8	246	<1.3	<65.8	<65.8	<26.3	92.4
16	Stems/leaves	Pondweed	07-06-88	<1.0	<50	309	<1.0	<50	<50	21	90.0
16	Fish	Rainbow trout	05-19-88	14.2	< 2	23.5	<4	--	< .3	115	73.5
16	Fish	Rainbow trout	05-19-88	13.0	< 2	19.8	<4	--	< .3	141	75.0
16	Fish	Rainbow trout	05-19-88	15.2	< 2	25.1	<4	--	< .3	126	75.3
16	Fish	Rainbow trout	05-19-88	13.0	< 2	30.3	<4	--	< .3	157	75.8
16	Fish	Rainbow trout	05-19-88	9.2	< 2	17.3	<4	--	< .3	75.8	75.2
16	Fish	White sucker	05-19-88	7.6	< 2	26.9	<4	--	< .3	57.2	74.8
16	Fish	White sucker	05-19-88	8.6	< 2	9.6	<4	--	< .3	49.3	75.3
16	Fish	White sucker	05-19-88	5.2	< 2	38.6	<4	--	< .3	56.4	75.5
16	Fish	White sucker	05-19-88	8.8	< 2	51.1	<4	--	< .6	49.3	72.6
16	Fish	White sucker	05-19-88	7.5	< 2	55.5	<4	--	< .3	49.3	74.4
16	Fish eggs	Rainbow trout	05-19-88	23.0	< 2	4.6	<4	--	< .3	70.5	62.1
16	Fish eggs	Rainbow trout	05-19-88	22.0	< 2	5.4	<4	--	< .3	86.2	58.5
16	Liver	American coot	05-17-88	9.8	<19.5	< 3.91	< .39	<19.5	<19.5	125	74.4
16	Liver	American coot	05-17-88	14.1	<17.7	< 3.53	< .35	<17.7	<17.7	91.9	71.7
16	Liver	American coot	05-17-88	11.1	<19.2	< 3.83	< .38	<19.2	<19.2	133	73.9
16	Liver	American coot	05-17-88	16.5	<17.9	< 3.58	< .36	<17.9	<17.9	149	72.1
16	Liver	American coot	05-17-88	10.7	<17.2	< 3.44	< .34	<17.2	<17.2	119	70.9

Table 13.--Trace elements in biological samples--Continued

Site No. (fig. 2)	Matrix	Common name	Date	Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium
16	Liver	American coot	05-17-88	89.3	< 0.086	0.924	< 17.2	<1.72	<17.2	<1.72	<3.44
16	Liver	American coot	05-17-88	< 36.4	< .091	.287	< 18.2	<1.82	<18.2	<1.82	<3.64
16	Liver	American coot	05-17-88	< 41.3	< .103	.653	< 20.7	<2.07	<20.7	<2.07	<4.13
18	Fish	Rainbow trout	08-23-88	< 30	<30	.225	3.69	< .25	< 3.0	< .50	<1.5
18	Fish	Rainbow trout	08-23-88	< 30	<30	< .20	< 1.0	< .25	< 3.0	< .50	1.70
18	Fish	Rainbow trout	08-23-88	< 30	<30	< .20	1.84	< .25	< 3.0	< .50	<1.5
18	Fish	Rainbow trout	08-23-88	< 30	<30	.361	3.90	< .25	< 3.0	< .50	2.34
18	Fish	Rainbow trout	08-23-88	< 30	<30	.251	2.43	< .25	< 3.0	< .50	<1.5
18	Fish	White sucker	08-23-88	45.3	<30	< .20	< 1.0	< .25	< 3.0	< .50	<1.5
18	Fish	White sucker	08-23-88	129	<30	.213	< 1.0	< .25	< 3.0	< .50	<1.5
18	Fish	White sucker	08-23-88	129	<30	.354	10.7	< .25	< 3.0	< .50	<1.5
18	Fish	White sucker	08-23-88	77	<30	< .20	5.96	< .25	< 3.0	< .50	<1.5
18	Fish	White sucker	08-23-88	64.8	<30	< .20	10.5	< .25	< 3.0	< .50	<1.5
18	Fish	White sucker	08-23-88	< 30	<30	< .20	7.24	< .25	< 3.0	< .50	1.62
18	Fish	White sucker	08-23-88	53.1	<30	< .20	5.93	< .25	< 3.0	< .50	<1.5
18	Fish	White sucker	08-23-88	54.7	<30	.203	5.13	< .25	< 3.0	< .50	3.33
18	Fish	White sucker	08-23-88	54.9	<30	< .20	4.85	< .25	< 3.0	< .50	2.68
18	Fish	White sucker	08-23-88	< 30	<30	< .20	3.06	< .25	< 3.0	< .50	2.46
18	Fish	Yellow perch	08-23-88	< 30	<30	< .20	8.12	< .25	< 3.0	< .50	1.75
18	Fish	Yellow perch	08-23-88	< 30	<30	< .20	8.88	< .25	< 3.0	< .50	<1.5
18	Fish	Yellow perch	08-23-88	< 30	<30	< .20	1.64	< .25	< 3.0	< .50	<1.5
19	Stems/leaves	Pondweed	07-06-88	<118	< .294	1.29	< 58.8	<5.88	441	<5.88	48.2
19	Stems/leaves	Pondweed	07-06-88	<102	.296	.980	< 51.0	<5.10	476	<5.10	41.8
19	Stems/leaves	Pondweed	07-06-88	<143	< .357	.800	< 71.4	<4.14	466	<7.14	61.4
19	Egg	American coot	07-06-88	< 42.4	< .106	.106	< 21.2	<2.12	<21.2	<2.12	<4.24
19	Egg	American coot	07-06-88	< 39.1	< .098	.070	< 19.5	<1.95	<19.5	<1.95	<3.91
19	Egg	American coot	07-06-88	< 39.4	< .098	.134	< 19.7	<1.97	<19.7	<1.97	<3.94
19	Egg	Pied-billed grebe	07-06-88	< 40.6	< .102	.073	< 20.3	<2.03	<20.3	<2.03	<4.06
19	Liver	American coot	05-17-88	< 34.6	.100	.540	< 17.3	<1.73	<17.3	<1.73	<3.46
19	Liver	American coot	05-17-88	< 38.6	.124	.919	< 19.3	<1.93	<19.3	<1.93	<3.86

Table 13.--Trace elements in biological samples--Continued

Site No. (fig. 2)	Matrix	Common name	Date	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Molybdenum	Nickel
16	Liver	American coot	05-17-88	< 8.59	33,100	< 34.4	653	11.0	0.223	<17.2	<13.7
16	Liver	American coot	05-17-88	11.6	4,110	< 36.4	727	8.0	1.08	<18.2	<14.5
16	Liver	American coot	05-17-88	< 10.3	5,000	< 41.3	785	13.2	.310	<20.7	<16.5
18	Fish	Rainbow trout	08-23-88	16.4	106	< 6.0	2,010	9.42	.316	< 5.0	< 2.0
18	Fish	Rainbow trout	08-23-88	11.8	75.8	< 6.0	1,060	1.07	.576	< 5.0	< 2.0
18	Fish	Rainbow trout	08-23-88	11.1	63.1	< 6.0	1,240	2.99	.485	< 5.0	< 2.0
18	Fish	Rainbow trout	08-23-88	7.97	68.2	< 6.0	1,930	9.06	.297	< 5.0	< 2.0
18	Fish	Rainbow trout	08-23-88	13.1	64.7	< 6.0	1,370	4.36	.344	< 5.0	< 2.0
18	Fish	White sucker	08-23-88	< 3.0	104	< 6.0	987	3.27	.414	< 5.0	< 2.0
18	Fish	White sucker	08-23-88	< 3.0	232	< 6.0	1,250	11.4	.240	< 5.0	< 2.0
18	Fish	White sucker	08-23-88	< 3.0	261	< 6.0	1,330	123	.219	< 5.0	< 2.0
18	Fish	White sucker	08-23-88	< 3.0	180	< 6.0	1,240	20.3	.252	< 5.0	< 2.0
18	Fish	White sucker	08-23-88	< 3.0	167	< 6.0	1,660	143	.278	< 5.0	< 2.0
18	Fish	White sucker	08-23-88	4.07	86.1	< 6.0	1,310	12.4	.222	< 5.0	< 2.0
18	Fish	White sucker	08-23-88	4.38	110	< 6.0	1,370	51.0	.224	< 5.0	< 2.0
18	Fish	White sucker	08-23-88	3.90	109	7.32	1,360	29.6	.369	< 5.0	< 2.0
18	Fish	White sucker	08-23-88	5.26	106	< 6.0	1,250	9.93	.278	< 5.0	< 2.0
18	Fish	White sucker	08-23-88	3.08	44.4	6.39	1,040	6.78	.266	< 5.0	< 2.0
18	Fish	Yellow perch	08-23-88	< 3.0	83.4	< 6.0	1,840	16.8	.570	< 5.0	< 2.0
18	Fish	Yellow perch	08-23-88	< 3.0	76.9	< 6.0	2,050	15.8	.796	< 5.0	< 2.0
18	Fish	Yellow perch	08-23-88	< 3.0	81.7	< 6.0	1,080	3.88	.891	< 5.0	< 2.0
19	Stems/leaves	Pondweed	07-06-88	< 29.4	235	<118	7,290	392	< .294	<58.8	<47.1
19	Stems/leaves	Pondweed	07-06-88	< 25.5	143	<102	5,710	517	.286	<51.0	<40.8
19	Stems/leaves	Pondweed	07-06-88	< 35.7	414	<143	6,570	486	< .357	<71.4	<57.1
19	Egg	American coot	07-06-88	< 10.6	165	< 42.4	551	<6.36	.297	<21.2	<16.9
19	Egg	American coot	07-06-88	< 9.76	89.8	< 39.1	547	<5.86	.285	<19.5	<15.6
19	Egg	American coot	07-06-88	< 9.84	106	< 39.4	472	<5.90	.378	<19.7	<15.7
19	Egg	Pied-billed grebe	07-06-88	< 10.2	142	< 40.6	406	<6.10	.325	<20.3	<16.3
19	Liver	American coot	05-17-88	< 8.65	1,190	< 34.6	588	10.4	.253	<17.3	<13.8
19	Liver	American coot	05-17-88	34.4	919	< 38.6	772	8.88	.282	<19.3	<15.4

Table 13.--Trace elements in biological samples--Continued

Site No. (fig. 2)	Matrix	Common name	Date	Sele-nium	Silver	Stron-tium	Thal-lium	Tin	Vana-dium	Zinc	Moisture, percent
16	Liver	American coot	05-17-88	12.0	<18.2	< 3.64	<0.36	<18.2	<18.2	139	72.5
16	Liver	American coot	05-17-88	7.0	<20.7	< 4.13	< .41	<20.7	<20.7	183	75.8
16	Liver	American coot	05-17-88	11.1	<19.2	< 3.83	< .38	<19.2	<19.2	133	73.9
18	Fish	Rainbow trout	08-23-88	8.14	<10	133	--	<20	< .80	217	79.9
18	Fish	Rainbow trout	08-23-88	12.2	<10	5.73	--	<20	< .80	139	75.2
18	Fish	Rainbow trout	08-23-88	11.7	<10	41.8	--	<20	< .80	269	72.6
18	Fish	Rainbow trout	08-23-88	7.95	<10	157	--	<20	< .80	175	77.4
18	Fish	Rainbow trout	08-23-88	9.65	<10	40.5	--	<20	< .80	133	77.1
18	Fish	White sucker	08-23-88	8.48	<10	7.36	--	<20	1.04	68.6	72.1
18	Fish	White sucker	08-23-88	8.60	<10	35.2	--	<20	.925	79.4	71.5
18	Fish	White sucker	08-23-88	8.11	<10	82.1	--	<20	< .80	77.8	72.5
18	Fish	White sucker	08-23-88	6.68	<10	51.1	--	<20	1.67	54.2	72.0
18	Fish	White sucker	08-23-88	7.62	<10	145	--	<20	2.32	62.7	69.6
18	Fish	White sucker	08-23-88	6.23	<10	80.8	--	<20	< .80	56.4	73.8
18	Fish	White sucker	08-23-88	7.42	<10	88.0	--	<20	< .80	52.7	75.6
18	Fish	White sucker	08-23-88	8.15	<10	72.8	--	<20	.948	53.6	71.4
18	Fish	White sucker	08-23-88	7.40	<10	58.2	--	<20	< .80	56.8	72.7
18	Fish	White sucker	08-23-88	6.49	<10	35.9	--	<20	< .80	54.7	74.4
18	Fish	Yellow perch	08-23-88	9.17	<10	158	--	<20	1.94	107	73.0
18	Fish	Yellow perch	08-23-88	8.41	<10	198	--	<20	.996	131	72.0
18	Fish	Yellow perch	08-23-88	10.4	<10	29.6	--	<20	< .80	111	71.5
19	Stems/leaves	Pondweed	07-06-88	1.2	<58.8	493	<1.2	<58.8	<58.8	23.5	91.5
19	Stems/leaves	Pondweed	07-06-88	1.0	<51.0	308	<1.0	<51.0	<51.0	<20.4	90.2
19	Stems/leaves	Pondweed	07-06-88	<1.4	<71.4	679	<1.4	<71.4	<71.4	<28.6	93.0
19	Egg	American coot	07-06-88	9.3	<21.2	25.8	< .42	<21.2	<21.2	83.5	76.4
19	Egg	American coot	07-06-88	10.2	<19.5	24.2	< .39	<19.5	<19.5	72.7	74.4
19	Egg	American coot	07-06-88	11.0	<19.7	18.9	< .39	<19.7	<19.7	53.9	74.6
19	Egg	Pied-billed grebe	07-06-88	7.3	<20.3	15.9	< .41	<20.3	<20.3	54.5	75.4
19	Liver	American coot	05-17-88	10.7	<17.3	< 3.46	< .35	<17.3	<17.3	66.4	71.1
19	Liver	American coot	05-17-88	10.4	<19.3	< 3.86	< .39	<19.3	<19.3	134	74.1

Table 13.--Trace elements in biological samples--Continued

Site No. (fig. 2)	Matrix	Common name	Date	Aluminum	Antimony	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium
19	Liver	American coot	05-17-88	< 34.8	0.101	0.850	< 17.4	<1.74	<17.4	<1.74	<3.48
19	Liver	American coot	05-17-88	< 39.7	< .100	.722	< 19.8	<1.98	<19.8	3.57	<3.97
19	Liver	American coot	05-17-88	< 38.9	< .097	.615	< 19.4	<1.94	<19.4	<1.94	<3.89
19	Liver	American coot	05-17-88	< 32.6	.085	.671	< 16.3	<1.63	<16.3	<1.63	<3.26
19	Liver	American coot	05-17-88	< 38.0	< .095	.643	< 19.0	<1.90	<19.0	<1.90	<3.80
19	Liver	American coot	05-17-88	< 39.2	< .098	.725	< 19.6	<1.96	<19.6	<1.96	<3.92
19	Liver	American coot	05-17-88	< 41.3	< .103	.975	< 20.7	<2.07	<20.7	<2.07	<4.13
20	Fish	Sauger	08-23-88	5	--	.20	1.4	< .1	< 2	< .3	<1
20	Fish	Sauger	08-23-88	< 3	--	.30	2.0	< .1	< 2	< .3	<1
20	Fish	Sauger	08-23-88	5	--	.20	1.2	< .1	< 2	< .3	<1
20	Fish	Walleye	08-23-88	4	--	.59	2.6	< .1	< 2	< .3	<1
20	Fish	Walleye	08-23-88	7	--	.46	1.9	< .1	< 2	< .3	<1
20	Fish	Carp	08-23-88	52	--	.69	3.2	< .1	< 2	.6	<1
20	Fish	Carp	08-23-88	64	--	.61	5.1	< .1	< 2	2.1	1
20	Fish	Carp	08-23-88	85	--	.60	5.7	< .1	< 2	.7	<1
20	Fish	Carp	08-23-88	43	--	.48	5.6	< .1	< 2	1.0	<1
20	Fish	Carp	08-23-88	130	--	.44	6.1	< .1	< 2	.85	<1
20	Fish	Carp	08-23-88	130	--	.45	11.6	< .1	< 2	2.0	1
20	Fish eggs	Rainbow trout	08-23-88	< 3	--	.10	.62	< .1	< 2	< .3	<1
21	Fish	Rainbow trout	08-23-88	17	--	.20	1.9	< .1	< 2	< .3	<1
21	Fish	Rainbow trout	08-23-88	16	--	.10	1.7	< .1	< 2	< .3	<1
21	Fish	Rainbow trout	08-23-88	27	--	.20	1.5	< .1	< 2	< .3	<1
21	Fish	Rainbow trout	08-23-88	13	--	.34	1.0	< .1	< 2	< .2	<1
21	Fish	Rainbow trout	08-23-88	16	--	.30	1.1	< .1	< 2	< .3	<1
21	Fish	Rainbow trout	08-23-88	15	--	.30	.81	< .1	< 2	< .3	<1

Table 13.--Trace elements in biological samples--Continued

Site No. (fig. 2)	Matrix	Common name	Date	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Molybdenum	Nickel
19	Liver	American coot	05-17-88	9.41	1,390	< 34.8	557	9.41	0.279	<17.4	<13.9
19	Liver	American coot	05-17-88	33.7	841	< 39.7	675	6.75	9.60	<19.8	<15.9
19	Liver	American coot	05-17-88	31.1	3,690	< 38.9	100	12.8	.463	<19.4	<15.6
19	Liver	American coot	05-17-88	29.0	964	< 32.6	586	8.47	.599	<16.3	<13.0
19	Liver	American coot	05-17-88	< 9.50	859	< 38.0	722	12.2	1.26	<19.0	<15.2
19	Liver	American coot	05-17-88	55.7	4,860	< 39.2	706	11.4	.557	<19.6	<15.7
19	Liver	American coot	05-17-88	49.2	8,840	< 41.3	744	8.68	.483	23.1	<16.5
20	Fish	Sauger	08-23-88	.71	39	< 5	1,300	3.4	1.00	< 1	< 2
20	Fish	Sauger	08-23-88	.81	39	< 4	1,480	2.9	.844	< 1	< 2
20	Fish	Sauger	08-23-88	.85	45	< 5	1,330	3.5	.864	< 1	< 2
20	Fish	Walleye	08-23-88	1.0	57	< 4	1,400	3.2	.90	< 1	< 2
20	Fish	Walleye	08-23-88	.87	59	< 5	1,410	3.5	.781	< 1	< 2
20	Fish	Carp	08-23-88	5.5	136	< 4	995	3.9	1.3	< 1	< 2
20	Fish	Carp	08-23-88	16	227	< 4	1,210	6.6	1.7	< 1	< 2
20	Fish	Carp	08-23-88	5.1	243	< 4	1,110	7.4	.759	< 1	< 2
20	Fish	Carp	08-23-88	6.4	165	< 4	1,200	5.0	1.5	< 1	< 2
20	Fish	Carp	08-23-88	496	262	< 4	1,150	7.6	1.1	< 1	< 2
20	Fish	Carp	08-23-88	19	313	< 4	1,440	10	1.5	< 1	< 2
20	Fish eggs	Rainbow trout	08-23-88	6.7	40	< 4	1,530	3.1	< .005	< 1	< 2
21	Fish	Rainbow trout	08-23-88	4.7	117	< 4	1,300	3.4	.46	< 1	< 2
21	Fish	Rainbow trout	08-23-88	2.3	110	< 4	1,170	2.8	.45	< 1	< 2
21	Fish	Rainbow trout	08-23-88	5.4	82	< 4	992	2.2	.32	< 1	< 2
21	Fish	Rainbow trout	08-23-88	2.5	67	< 4	1,040	2.7	.28	< 1	< 2
21	Fish	Rainbow trout	08-23-88	2.1	68	< 4	1,040	2.4	.29	< 1	< 2
21	Fish	Rainbow trout	08-23-88	2.5	71	< 4	939	2.9	.24	< 1	< 2

Table 13.--Trace elements in biological samples--Continued

Site No. (fig. 2)	Matrix	Common name	Date	Sele-nium	Silver	Stron-tium	Thal-lium	Tin	Vana-dium	Zinc	Moisture, percent
19	Liver	American coot	05-17-88	11.8	<17.4	< 3.48	<0.35	<17.4	<17.4	114	71.3
19	Liver	American coot	05-17-88	12.3	<19.8	< 3.97	< .40	<19.8	<19.8	155	74.8
19	Liver	American coot	05-17-88	6.6	<19.4	< 3.89	< .39	<19.4	<19.4	182	74.3
19	Liver	American coot	05-17-88	5.9	<16.3	< 3.26	< .33	<16.3	<16.3	85.0	69.3
19	Liver	American coot	05-17-88	6.8	<19.0	< 3.80	< .38	<19.0	<19.0	74.5	73.7
19	Liver	American coot	05-17-88	11.0	<19.6	< 3.92	< .39	<19.6	<19.6	314	74.5
19	Liver	American coot	05-17-88	6.2	<20.7	< 4.13	< .41	<20.7	<20.7	190	75.8
20	Fish	Sauger	08-23-88	2.6	< 2	47.1	<4	--	< .3	47.2	72.1
20	Fish	Sauger	08-23-88	2.7	< 2	73.6	<4	--	< .3	57.7	73.5
20	Fish	Sauger	08-23-88	2.8	< 2	51.9	<4	--	< .3	49.9	74.5
20	Fish	Walleye	08-23-88	2.7	< 2	67.8	<4	--	< .3	54.8	74.4
20	Fish	Walleye	08-23-88	2.8	< 2	62.4	<4	--	< .3	50.8	73.9
20	Fish	Carp	08-23-88	3.0	< 2	33.9	<4	--	.6	458	73.8
20	Fish	Carp	08-23-88	3.7	< 2	49.6	<4	--	1.1	770	77.3
20	Fish	Carp	08-23-88	4.4	< 2	50.7	<4	--	.7	522	74.5
20	Fish	Carp	08-23-88	3.6	< 2	52.0	<4	--	.7	659	76.3
20	Fish	Carp	08-23-88	3.4	< 2	56.9	<4	--	.7	647	73.7
20	Fish	Carp	08-23-88	4.1	< 2	96.1	<4	--	1.0	704	78.9
20	Fish eggs	Rainbow trout	08-23-88	4.9	< 2	5.8	<4	--	< .3	80.4	62.9
21	Fish	Rainbow trout	08-23-88	3.3	< 2	29.3	<4	--	< .3	107	75.2
21	Fish	Rainbow trout	08-23-88	2.8	< 2	28.2	<4	--	< .3	103	75.9
21	Fish	Rainbow trout	08-23-88	2.6	< 2	24.9	<4	--	< .3	116	69.1
21	Fish	Rainbow trout	08-23-88	2.6	< 2	26.3	<4	--	< .3	104	70.9
21	Fish	Rainbow trout	08-23-88	2.6	< 2	26.0	<4	--	< .3	85.4	71.9
21	Fish	Rainbow trout	08-23-88	2.3	< 2	23.9	<4	--	< .3	95.3	67.1

Table 14.--Organochlorine compounds in biological samples

[All concentrations in micrograms per gram, wet weight. BHC, benzene hexachloride; Cl, chlorine; <, less than; *, confirmed by gas chromatograph and mass spectrometry; --, not measured; ND, not detected. Analyses by U.S. Fish and Wildlife Service]

Site No. (fig. 2)	Matrix	Common name	Date	Aldrin	Alpha-BHC	Beta-BHC	Delta-BHC	Gamma-BHC	Biphenyl, total Cl2	Biphenyl, total Cl3	Biphenyl, total Cl4	Biphenyl, total Cl5
3	Liver	American coot	06-07-88	<0.05	<0.05	<0.05	<0.05	--	<0.05	<0.05	<0.05	<0.05
3	Liver	American coot	06-07-88	< .05	< .05	< .05	< .05	--	.12	< .05	< .05	< .05
3	Liver	American coot	06-07-88	< .05	< .05	< .05	< .05	--	< .05	< .05	< .05	< .05
3	Liver	American coot	06-07-88	< .05	< .05	< .05	< .05	--	.13	.09	< .05	< .10
8	Liver	American coot	05-17-88	< .05	< .05	< .05	< .05	--	< .05	< .05	< .05	< .05
8	Liver	American coot	05-17-88	< .05	< .05	< .05	< .05	--	< .05	< .05	< .05	< .05
8	Liver	American coot	05-17-88	< .05	< .05	< .05	< .05	--	< .05	< .05	< .05	< .05
8	Liver	American coot	05-17-88	< .05	< .05	< .05	< .05	--	.23	< .05	< .05	.14
8	Liver	American coot	05-17-88	< .05	< .05	< .05	< .05	--	< .05	< .05	< .05	< .05
8	Liver	American coot	05-17-88	< .05	< .05	< .05	< .05	--	.17	< .05	< .05	.30
11	Egg	American coot	07-06-88	< .05	< .05	< .05	< .05	--	< .05	< .05	.14	.12
11	Egg	American coot	07-06-88	< .05	< .05	< .05	< .05	--	< .05	< .05	< .05	< .05
12	Egg	American coot	07-06-88	< .05	< .05	< .05	< .05	--	< .05	< .05	< .05	< .05
12	Egg	American coot	07-06-88	< .05	< .05	< .05	< .05	--	< .05	< .05	< .05	.21
12	Egg	American coot	07-06-88	< .05	< .05	< .05	< .05	--	< .05	< .05	< .05	< .05
16	Liver	American coot	05-17-88	< .05	< .05	< .05	< .05	--	< .05	< .05	< .05	< .05
16	Liver	American coot	05-17-88	< .05	< .05	< .05	< .05	--	< .05	< .05	< .05	< .05
16	Liver	American coot	05-17-88	.06	< .05	< .05	< .05	--	< .05	.08	.05	< .05
16	Liver	American coot	05-17-88	< .05	< .05	< .05	< .05	--	< .05	< .05	< .05	< .05
16	Fish	Rainbow trout	05-17-88	--	ND	ND	ND	ND	--	--	--	--
16	Fish	Rainbow trout	05-17-88	--	ND	ND	ND	ND	--	--	--	--
16	Fish	Rainbow trout	05-17-88	--	ND	ND	ND	ND	--	--	--	--

Table 14.--Organochlorine compounds in biological samples--Continued

Site No. (fig. 2)	Matrix	Common name	Date	Biphenyl, total C16	Biphenyl, total C17	Biphenyl, total C18	Biphenyl, total C19	Biphenyl, total C110	PCB, total	Hepta-Chlor	Alpha-Chlordane	Gamma-Chlordane
3	Liver	American coot	06-07-88	<0.05	<0.05	<0.05	<0.05	<0.05	<0.50	<0.05	<0.05	<0.05
3	Liver	American coot	06-07-88	.08	.18	.18	< .05	< .05	.56	< .05	< .05	< .05
3	Liver	American coot	06-07-88	< .05	< .05	< .05	< .05	< .05	< .50	< .05	< .05	< .05
3	Liver	American coot	06-07-88	.14	.09	.19	< .05	< .05	.74	< .05	< .05	< .05
8	Liver	American coot	05-17-88	.05	< .05	< .05	< .05	< .05	< .50	< .05	< .05	< .05
8	Liver	American coot	05-17-88	< .05	< .05	< .05	< .05	< .05	< .50	< .05	< .05	< .05
8	Liver	American coot	05-17-88	< .05	< .05	< .05	< .05	< .05	< .50	< .05	< .05	< .05
8	Liver	American coot	05-17-88	.14	.13	.09	< .05	< .05	.72	< .05	< .05	< .05
8	Liver	American coot	05-17-88	< .05	< .05	< .05	< .05	< .05	< .50	< .05	< .05	< .05
8	Liver	American coot	05-17-88	.29	.22	.16	.08	.05	*1.27	< .05	< .05	< .05
11	Egg	American coot	07-06-88	.09	.05	< .05	< .05	< .05	< .50	< .05	< .05	< .05
11	Egg	American coot	07-06-88	< .05	< .05	< .05	< .05	< .05	< .50	< .05	< .05	< .05
12	Egg	American coot	07-06-88	< .05	< .05	< .05	< .05	< .05	< .50	< .05	< .05	< .05
12	Egg	American coot	07-06-88	.12	.06	< .05	< .05	< .05	< .50	< .05	< .05	< .05
12	Egg	American coot	07-06-88	< .05	< .05	< .05	< .05	< .05	< .50	< .05	< .05	< .05
16	Liver	American coot	05-17-88	.07	.07	.12	< .05	< .05	< .50	< .05	< .05	< .05
16	Liver	American coot	05-17-88	< .05	< .05	< .05	< .05	< .05	< .50	< .05	< .05	< .05
16	Liver	American coot	05-17-88	< .05	< .05	< .05	< .05	< .05	< .50	< .05	< .05	< .05
16	Liver	American coot	05-17-88	< .05	< .05	< .05	< .05	< .05	< .50	< .05	< .05	< .05
16	Fish	Rainbow trout	05-17-88	--	--	--	--	--	ND	--	ND	ND
16	Fish	Rainbow trout	05-17-88	--	--	--	--	--	ND	--	ND	ND
16	Fish	Rainbow trout	05-17-88	--	--	--	--	--	ND	--	ND	ND

Table 14.--Organochlorine compounds in biological samples--Continued

Site No. (fig. 2)	Matrix	Common name	Date	Oxy-Chlor-dane	Cis-Non-achlor	Trans-Non-achlor	2,4'-DDD (O,P'-DDD)	4,4'-DDD (P,P'-DDD)	2,4'-DDE (O,P'-DDE)	4,4'-DDE (P,P'-DDE)	2,4'-DDT (O,P'-DDT)	4,4'-DDT (P,P'-DDT)
3	Liver	American coot	06-07-88	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	0.08	<0.05	<0.05
3	Liver	American coot	06-07-88	< .05	< .05	< .05	< .05	< .05	< .05	.08	< .05	< .05
3	Liver	American coot	06-07-88	.07	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05
3	Liver	American coot	06-07-88	< .05	< .05	< .05	< .05	< .05	< .05	.05	< .05	< .05
8	Liver	American coot	05-17-88	< .05	< .05	< .05	< .05	< .05	< .05	.08	< .05	< .05
8	Liver	American coot	05-17-88	.10	< .05	< .05	< .05	< .05	< .05	.09	< .05	< .05
8	Liver	American coot	05-17-88	.11	< .05	< .05	< .05	< .05	< .05	* .18	< .05	< .05
8	Liver	American coot	05-17-88	.05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05
8	Liver	American coot	05-17-88	.08	< .05	< .05	< .05	< .05	< .05	.06	< .05	< .05
8	Liver	American coot	05-17-88	< .05	< .05	< .05	< .05	.06	< .05	.05	< .05	< .05
11	Egg	American coot	07-06-88	< .05	< .05	< .05	< .05	< .05	< .05	.05	< .05	< .05
11	Egg	American coot	07-06-88	< .05	< .05	< .05	< .05	< .05	< .05	.06	< .05	< .05
12	Egg	American coot	07-06-88	< .05	< .05	< .05	< .05	< .05	< .05	.13	< .05	< .05
12	Egg	American coot	07-06-88	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05
12	Egg	American coot	07-06-88	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05
16	Liver	American coot	05-17-88	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05
16	Liver	American coot	05-17-88	< .05	< .05	< .05	< .05	< .05	< .05	* .22	< .05	< .05
16	Liver	American coot	05-17-88	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05
16	Liver	American coot	05-17-88	.05	< .05	< .05	< .05	< .05	< .05	.15	< .05	< .05
16	Fish	Rainbow trout	05-17-88	ND	ND	ND	ND	ND	ND	.02	ND	ND
16	Fish	Rainbow trout	05-17-88	ND	ND	ND	ND	ND	ND	.01	ND	ND
16	Fish	Rainbow trout	05-17-88	ND	ND	ND	ND	ND	ND	.02	ND	ND

Table 14.--Organochlorine compounds in biological samples--Continued

Site No. (fig. 2)	Matrix	Common name	Date	DDT, total	Dieldrin	Endrin	Hepta-Epoxide	HCB	Lindane	Mirex	Toxa-phene	Moisture, percent
3	Liver	American coot	06-07-88	0.08	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.50	73.19
3	Liver	American coot	06-07-88	.08	< .05	< .05	< .05	.06	< .05	< .05	< .50	75.31
3	Liver	American coot	06-07-88	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .50	74.13
3	Liver	American coot	06-07-88	.05	< .05	< .05	< .05	.07	< .05	< .05	< .50	75.21
8	Liver	American coot	05-17-88	.08	< .05	< .05	< .05	< .05	< .05	< .05	< .50	72.59
8	Liver	American coot	05-17-88	.09	< .05	< .05	< .05	< .05	< .05	< .05	< .50	73.26
8	Liver	American coot	05-17-88	.18	< .05	< .05	< .05	< .05	< .05	< .05	< .50	76.05
8	Liver	American coot	05-17-88	< .05	< .05	< .05	< .05	.05	< .05	< .05	< .50	71.04
8	Liver	American coot	05-17-88	.06	< .05	< .05	< .05	< .05	< .05	< .05	< .50	74.86
8	Liver	American coot	05-17-88	.12	< .05	< .05	< .05	< .05	< .05	< .05	< .50	72.27
11	Egg	American coot	07-06-88	.05	< .05	< .05	< .05	< .05	< .05	< .05	< .50	77.16
11	Egg	American coot	07-06-88	.06	< .05	< .05	< .05	< .05	< .05	< .05	< .50	75.34
12	Egg	American coot	07-06-88	.13	< .05	< .05	< .05	< .05	< .05	< .05	< .50	79.37
12	Egg	American coot	07-06-88	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .50	74.44
12	Egg	American coot	07-06-88	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .50	76.1
16	Liver	American coot	05-17-88	< .05	< .05	< .05	< .05	.06	< .05	< .05	< .50	73.9
16	Liver	American coot	05-17-88	.22	< .05	< .05	< .05	< .05	< .05	< .05	< .50	72.3
16	Liver	American coot	05-17-88	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .50	74.08
16	Liver	American coot	05-17-88	.15	< .05	< .05	< .05	< .05	< .05	< .05	< .50	72.81
16	Fish	Rainbow trout	05-17-88	--	ND	ND	ND	ND	--	ND	ND	65
16	Fish	Rainbow trout	05-17-88	--	ND	ND	ND	ND	--	ND	ND	73.4
16	Fish	Rainbow trout	05-17-88	--	ND	ND	ND	ND	--	ND	ND	74.6

Table 14.--Organochlorine compounds in biological samples--Continued

Site No. (fig. 2)	Matrix	Common name	Date	Aldrin	Alpha-BHC	Beta-BHC	Delta-BHC	Gamma-BHC	Biphenyl, total C12	Biphenyl, total C13	Biphenyl, total C14	Biphenyl, total C15
16	Fish	White sucker	05-17-88	--	ND	ND	ND	ND	--	--	--	--
16	Fish	White sucker	05-17-88	--	ND	ND	ND	ND	--	--	--	--
16	Fish	White sucker	05-17-88	--	ND	ND	ND	ND	--	--	--	--
16	Fish eggs	Rainbow trout	05-17-88	--	ND	ND	ND	ND	--	--	--	--
16	Fish eggs	Rainbow trout	05-17-88	--	ND	ND	ND	ND	--	--	--	--
19	Liver	American coot	05-17-88	<0.05	<0.05	<0.05	<0.05	--	<0.05	<0.05	0.30	0.22
19	Liver	American coot	05-17-88	< .05	< .05	< .05	< .05	--	< .05	< .05	< .05	< .05
19	Liver	American coot	05-17-88	< .05	< .05	< .05	< .05	--	< .05	< .05	< .05	< .05
19	Liver	American coot	05-17-88	< .05	< .05	< .05	< .05	--	< .05	< .05	.17	.22
19	Egg	American coot	07-06-88	< .05	< .05	< .05	< .05	--	< .05	< .05	< .05	< .05
19	Egg	American coot	07-06-88	< .05	< .05	< .05	< .05	--	< .05	< .05	< .05	< .05
19	Egg	Pied-billed grebe	07-06-88	< .05	< .05	< .05	< .05	--	< .05	< .05	< .05	< .05
21	Fish	Rainbow trout	08-23-88	--	ND	ND	ND	ND	--	--	--	--
21	Fish	Rainbow trout	08-23-88	--	ND	ND	ND	ND	--	--	--	--
21	Fish	Rainbow trout	08-23-88	--	ND	ND	ND	ND	--	--	--	--
21	Fish	Carp	08-23-88	--	ND	ND	ND	ND	--	--	--	--
21	Fish	Carp	08-23-88	--	ND	ND	ND	ND	--	--	--	--
21	Fish	Carp	08-23-88	--	ND	ND	ND	ND	--	--	--	--
21	Fish	Carp	08-23-88	--	ND	ND	ND	ND	--	--	--	--
21	Fish eggs	Rainbow trout	08-23-88	--	ND	ND	ND	ND	--	--	--	--

Table 14.--Organochlorine compounds in biological samples--Continued

Site No. (fig. 2)	Matrix	Common name	Date	Biphenyl, total C16	Biphenyl, total C17	Biphenyl, total C18	Biphenyl, total C19	Biphenyl, total C110	PCB, total	Hepta-Chlor	Alpha-Chlordane	Gamma-Chlordane
16	Fish	White sucker	05-17-88	--	--	--	--	--	ND	--	ND	ND
16	Fish	White sucker	05-17-88	--	--	--	--	--	ND	--	ND	ND
16	Fish	White sucker	05-17-88	--	--	--	--	--	ND	--	ND	ND
16	Fish eggs	Rainbow trout	05-17-88	--	--	--	--	--	0.24	--	ND	ND
16	Fish eggs	Rainbow trout	05-17-88	--	--	--	--	--	ND	--	ND	ND
19	Liver	American coot	05-17-88	0.15	0.09	<0.05	<0.05	<0.05	* .77	<0.05	<0.05	<0.05
19	Liver	American coot	05-17-88	.50	< .05	< .05	< .05	< .05	.50	< .05	< .05	< .05
19	Liver	American coot	05-17-88	< .05	.12	.11	.09	.07	< .50	< .05	< .05	< .05
19	Liver	American coot	05-17-88	.12	.06	< .05	< .05	< .05	.56	< .05	< .05	< .05
19	Egg	American coot	07-06-88	< .05	< .05	< .05	< .05	< .05	< .50	< .05	< .05	< .05
19	Egg	American coot	07-06-88	< .05	< .05	< .05	< .05	< .05	< .50	< .05	< .05	< .05
19	Egg	Pied-billed grebe	07-06-88	< .05	< .05	< .05	< .05	< .05	< .50	< .05	< .05	< .05
21	Fish	Rainbow trout	08-23-88	--	--	--	--	--	ND	--	ND	ND
21	Fish	Rainbow trout	08-23-88	--	--	--	--	--	ND	--	ND	ND
21	Fish	Rainbow trout	08-23-88	--	--	--	--	--	ND	--	ND	ND
21	Fish	Carp	08-23-88	--	--	--	--	--	.15	--	.01	.01
21	Fish	Carp	08-23-88	--	--	--	--	--	.10	--	ND	ND
21	Fish	Carp	08-23-88	--	--	--	--	--	.12	--	.01	.01
21	Fish	Carp	08-23-88	--	--	--	--	--	.10	--	ND	ND
21	Fish eggs	Rainbow trout	08-23-88	--	--	--	--	--	ND	--	ND	ND

Table 14.--Organochlorine compounds in biological samples--Continued

Site No. (fig. 2)	Matrix	Common name	Date	Oxy-Chlor-dane	Cis-Non-achlor	Trans-Non-achlor	2,4'-DDD (O,P'-DDD)	4,4'-DDD (P,P'-DDD)	2,4'-DDE (O,P'-DDE)	4,4'-DDE (P,P'-DDE)	2,4'-DDT (O,P'-DDT)	4,4'-DDT (P,P'-DDT)
16	Fish	White sucker	05-17-88	ND	ND	ND	ND	ND	ND	0.01	ND	ND
16	Fish	White sucker	05-17-88	ND	ND	ND	ND	ND	ND	.02	ND	ND
16	Fish	White sucker	05-17-88	ND	ND	ND	ND	ND	ND	.01	ND	ND
16	Fish eggs	Rainbow trout	05-17-88	ND	ND	ND	ND	ND	ND	.02	ND	ND
16	Fish eggs	Rainbow trout	05-17-88	ND	ND	ND	ND	ND	ND	.02	ND	ND
19	Liver	American coot	05-17-88	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	< .05	<0.05	<0.05
19	Liver	American coot	05-17-88	< .05	< .05	< .05	< .05	< .05	< .05	.06	< .05	< .05
19	Liver	American coot	05-17-88	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05
19	Liver	American coot	05-17-88	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05
19	Egg	American coot	07-06-88	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05
19	Egg	American coot	07-06-88	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05
19	Egg	Pied-billed grebe	07-06-88	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .05
21	Fish	Rainbow trout	08-23-88	ND	ND	ND	ND	ND	ND	.02	ND	ND
21	Fish	Rainbow trout	08-23-88	ND	ND	ND	ND	ND	ND	.02	ND	ND
21	Fish	Rainbow trout	08-23-88	ND	ND	ND	ND	ND	ND	.02	ND	ND
21	Fish	Carp	08-23-88	ND	ND	.01	ND	.03	ND	* .17	ND	ND
21	Fish	Carp	08-23-88	ND	ND	ND	ND	.01	ND	.09	ND	ND
21	Fish	Carp	08-23-88	ND	ND	.01	ND	.02	ND	.08	ND	ND
21	Fish	Carp	08-23-88	ND	ND	.01	ND	.01	ND	.09	ND	ND
21	Fish eggs	Rainbow trout	08-23-88	ND	ND	ND	ND	.01	ND	.01	ND	ND

Table 14.--Organochlorine compounds in biological samples--Continued

Site No. (fig. 2)	Matrix	Common name	Date	DDT, total	Dieldrin	Endrin	Hepta-Epoxide	HCB	Lindane	Mirex	Toxa-phene	Moisture, percent
16	Fish	White sucker	05-17-88	--	ND	ND	ND	ND	--	ND	ND	75.4
16	Fish	White sucker	05-17-88	--	ND	ND	ND	ND	--	ND	ND	76.2
16	Fish	White sucker	05-17-88	--	ND	ND	ND	ND	--	ND	ND	76.8
16	Fish eggs	Rainbow trout	05-17-88	--	ND	ND	ND	ND	--	ND	ND	61.8
16	Fish eggs	Rainbow trout	05-17-88	--	ND	ND	ND	ND	--	ND	ND	59.4
19	Liver	American coot	05-17-88	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.50	71.16
19	Liver	American coot	05-17-88	.06	< .05	< .05	< .05	< .05	< .05	< .05	< .50	74.47
19	Liver	American coot	05-17-88	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .50	71.97
19	Liver	American coot	05-17-88	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .50	74.34
19	Egg	American coot	07-06-88	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .50	75.71
19	Egg	American coot	07-06-88	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .50	76.91
19	Egg	Pied-billed grebe	07-06-88	< .05	< .05	< .05	< .05	< .05	< .05	< .05	< .50	77.18
21	Fish	Rainbow trout	08-23-88	--	ND	ND	ND	ND	--	ND	ND	75.8
21	Fish	Rainbow trout	08-23-88	--	ND	ND	ND	ND	--	ND	ND	75.8
21	Fish	Rainbow trout	08-23-88	--	ND	ND	ND	ND	--	ND	ND	69.6
21	Fish	Carp	08-23-88	--	ND	ND	ND	ND	--	ND	ND	74.4
21	Fish	Carp	08-23-88	--	ND	ND	ND	ND	--	ND	ND	78
21	Fish	Carp	08-23-88	--	ND	ND	ND	ND	--	ND	ND	74.8
21	Fish	Carp	08-23-88	--	ND	ND	ND	ND	--	ND	ND	77.2
21	Fish eggs	Rainbow trout	08-23-88	--	ND	ND	ND	ND	--	ND	ND	62.5

☆U.S. GOVERNMENT PRINTING OFFICE: 1991-574-833/45055