RECONNAISSANCE INVESTIGATION OF WATER QUALITY, BOTTOM SEDIMENT, AND BIOTA ASSOCIATED WITH IRRIGATION DRAINAGE IN THE BELLE FOURCHE RECLAMATION PROJECT, WESTERN SOUTH DAKOTA, 1988-89

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CONVERSION FACTORS

For readers who may prefer to use metric (International System) units rather than inch-pound units, the conversion factors for the terms in this report are listed below:

Multiply inch-pound unit	By	To obtain metric unit
acre	4,047	square meter
acre-foot (acre-ft)	1,233	cubic meter
cubic foot per second (ft^3/s)	0.028317	cubic meter per second
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
inch	25.4	millimeter
square mile (mi^2)	2.590	square kilometer

Temperatures may be converted to degrees Fahrenheit (°F) or degrees Celsius (°C) according to the following formulas:

$$°F = 9/5(°C) + 32$$
$$°C = 5/9(°F - 32)$$

Chemical concentrations in water are given in metric units. Milligrams per liter (mg/L) are approximately equal to parts per million (ppm), and micrograms per liter (μg/L) are approximately equal to parts per billion (ppb).

Chemical concentrations in bottom sediment and biota are reported as weight per unit of weight. Abundant elements in bottom sediment, such as iron, are reported in weight percent. Trace elements such as selenium are reported in micrograms per gram (μg/g), which is equivalent in inch-pound units to parts per million.

Sea level: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)--a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called "Mean Sea Level."

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ABSTRACT

The U.S. Department of the Interior initiated nine reconnaissance investigations during 1986-87 in response to nationwide concern about harmful effects of irrigation drainage on human health, fish, and wildlife. The investigation of the Belle Fourche Reclamation Project in western South Dakota is one of ten additional reconnaissance investigations conducted during 1988-89.

For this investigation, the U.S. Geological Survey collected a total of thirty surface-water-quality samples during April, June, August, and October 1988. Six to ten sites were sampled during each sampling period. An additional 40 surface-water-quality samples were collected at three of the sites during October 1987 through April 1989, and these results are included in the discussion. Bottom sediment was collected at eight of the ten water-sampling sites. The U.S. Fish and Wildlife Service collected fish samples at three sites during the spring and fall; samples of bird livers and bird eggs were collected at five sites during the summer; and samples of benthic invertebrates and aquatic plants were collected at six sites during the summer.

Maximum concentrations of major ions in water samples were measured during the non-irrigation season at Horse Creek above Vale and at the Belle Fourche River near Sturgis, two sites receiving irrigation drainage. Maximum concentrations of selected major ions at these two sites, in milligrams per liter, were: calcium, 440; magnesium, 410; sodium, 890; sulfate, 4,000; and chloride, 750.

Concentrations of some dissolved constituents approached or exceeded relevant water-quality criteria at the downstream irrigation drainage sites. Maximum concentrations of selected constituents were: nitrite plus nitrate (as nitrogen), 11 mg/L; boron, 1,500 μg/L (micrograms per liter); molybdenum, 12 μg/L, selenium, 34 μg/L; and uranium, 30 μg/L.

Twenty surface-water samples were collected at six sites and analyzed for 22 pesticides. Atrazine was detected at three of the six sites, with a maximum concentration of 0.3 μg/L; alachlor was detected at a concentration of 0.3 μg/L at two sites; cyanazine was detected in one sample at a concentration of 0.5 μg/L; and prometone was detected in two samples at a concentration of 0.1 μg/L.

Concentrations of some trace elements (arsenic, barium, molybdenum, selenium, and uranium) in bottom sediment at the downstream irrigation drainage sites were near or exceeded the upper range of concentrations measured in western United States soils. The maximum concentration of arsenic was measured at the Belle Fourche River near Sturgis which has received arsenic-contaminated sediment from mining activities in the Black Hills. The pesticides atrazine and carbofuran were not detected in bottom sediment samples.

Samples of four different groups of biota, including fish, birds, invertebrates, and plants, were collected throughout the investigation area. With few exceptions, trace-element concentrations in fish, invertebrates, and plants were less than values known to produce harmful effects on growth or reproduction.

Aluminum concentrations in fish generally were larger than other samples from western South Dakota, but the significance of this result is not known. Arsenic in the majority of samples of fish at the Belle Fourche River near Sturgis exceeded baseline values; the maximum concentration was 7.6 μg/g (micrograms per gram). The largest arsenic concentration in plants, 115 μg/g, was in Sago pondweed also from this site.

Concentrations of arsenic and mercury at the Belle Fourche River near Sturgis greater than at the other sampling sites probably were the result of the mobilization of these elements from flood-plain sediments which have been contaminated by the past release of gold-mine tailings. Cadmium, copper, and mercury concentrations in whole-body fish tissue generally were less than baseline values.

The median concentrations of selenium in fish tissue at Horse Creek (3.0 μg/g) and the Belle Fourche River near Sturgis (2.9 μg/g) exceeded baseline values. The largest concentration of selenium in duck livers was 27.5 μg/g; three of eight samples had concentrations in the range observed in livers from the Kesterson Wildlife Refuge in California, where selenium toxicity is known to be a problem.

A limited number of fish and bird-egg samples were analyzed for organochlorine pesticides or polychlorinated biphenyls (PCB's). No significant elevated concentrations of pesticides or PCB's were measured in the samples.

INTRODUCTION

During the last several years, there has been increasing concern about the quality of irrigation drainage and its potentially harmful effects on humans, fish, and wildlife. Concentrations of selenium greater than the water-quality criterion for the protection of aquatic life (U.S. Environmental Protection Agency, 1986a) 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 developed a management strategy in late 1985 to identify the nature and extent of irrigation-induced water-quality problems that might exist in the Western States. In October 1985, an interbureau group known as the "Task Group on Irrigation Drainage" was formed within the Department of the Interior. The Task Group subsequently prepared a comprehensive plan for reviewing irrigation-drainage concerns in areas for which the Department of the Interior has responsibility.

Initially, the Task Group identified 19 locations in 13 states that warranted reconnaissance-level field investigations. These locations related to three specific areas of Department of the Interior responsibilities: (1) Irrigation or drainage facilities constructed or managed by the Department,

(2) national wildlife refuges managed by the Department, and (3) other migratory-bird or endangered-species management areas that receive water from the Department-funded projects.

Nine of the 19 locations were selected for reconnaissance investigations during 1986-87. The nine areas are:

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

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

California:	Klamath Basin Refuge Complex
California-Oregon:	Sacramento Refuge Complex
Colorado:	Gunnison and Uncompahgre River Basins and Sweitzer Lake
Colorado:	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
South Dakota:	Belle Fourche Reclamation Project
Wyoming:	Riverton Reclamation Project

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

Purpose and Scope

This report describes concentrations of selected major constituents, trace elements, and pesticides in water, bottom sediment, and biota within the Belle Fourche Reclamation Project, South Dakota, and compares the analytical results to available baseline information and to various guidelines for protection of environmental quality. The data from this report are intended to help the Department of the Interior determine whether irrigation drainage from the Belle Fourche Reclamation Project has caused or has the potential to cause harmful effects on humans, fish, and wildlife, or has impaired the suitability of the water for beneficial uses.

For surface-water and bottom-sediment sampling, ten sites were selected upstream, within, and downstream from the investigation area. Biota sampling was conducted at ten sites, three of which corresponded to the surface-water and bottom-sediment sampling sites. Most of the field work for the reconnaissance investigation was conducted during the spring, summer, and fall of 1988. Samples of surface water and bottom sediment were collected by personnel of the U.S. Geological Survey; biota samples were collected by personnel of the U.S. Fish and Wildlife Service. Sample analyses were performed by laboratories of the respective agencies or laboratories contracted by the agencies.

Acknowledgments

The authors thank Bruce Laymon of the U.S. Bureau of Reclamation for gathering statistical data describing the history, hydrology, and economy of the project area. This manuscript was reviewed by members of the Department of the Interior Task Group on Irrigation Drainage, and their assistance is greatly appreciated.

DESCRIPTION OF THE INVESTIGATION AREA

The Belle Fourche Reclamation Project investigation area is located in the Belle Fourche River basin in the undulating plains of western South Dakota, north and northeast of the Black Hills (fig. 1). The cities of Spearfish, Belle Fourche, Whitewood, Newell, Nisland, Vale, St. Onge, and Fruitdale are in the investigation area; the rural areas are sparsely populated.

In downstream order, principal features of the project are the Belle Fourche Diversion Dam on the Belle Fourche River, the Inlet Canal, the Belle Fourche Reservoir and Dam on Owl Creek, and an irrigation system which delivers water from the Inlet Canal and the reservoir to the project lands. The project lands extend downstream from the Inlet Canal and from the dam over an area approximately 25 mi long and 12 mi wide. About 57,100 acres can be irrigated within the project area (U.S. Bureau of Reclamation, 1976).

Construction of the project, the second oldest Bureau of Reclamation project in the Nation, began in 1905 and was completed in 1914 (U.S. Bureau of Reclamation, 1976). Irrigation began in 1908 with the delivery of water to 12,000 acres.

The major upstream feature on the Belle Fourche River is Keyhole Dam and Reservoir in Wyoming, located 146 mi upstream from the Belle Fourche Diversion Dam. Keyhole Dam was completed in 1952, and the reservoir has a capacity of 193,750 acre-ft at a conservation elevation of 4,099 ft above sea level. Keyhole Reservoir is used for flood control and storage of water for riverside irrigation in Wyoming and South Dakota, and for the Belle Fourche Reclamation Project.

Downstream of the project, the Belle Fourche River flows into the Cheyenne River, which in turn flows into the Oahe Reservoir, a major downstream feature. The Oahe Reservoir is located on the Missouri River about 200 mi downstream of the project and has a capacity of 22.24 million acre-ft at a normal maximum elevation of 1,617 ft above sea level.

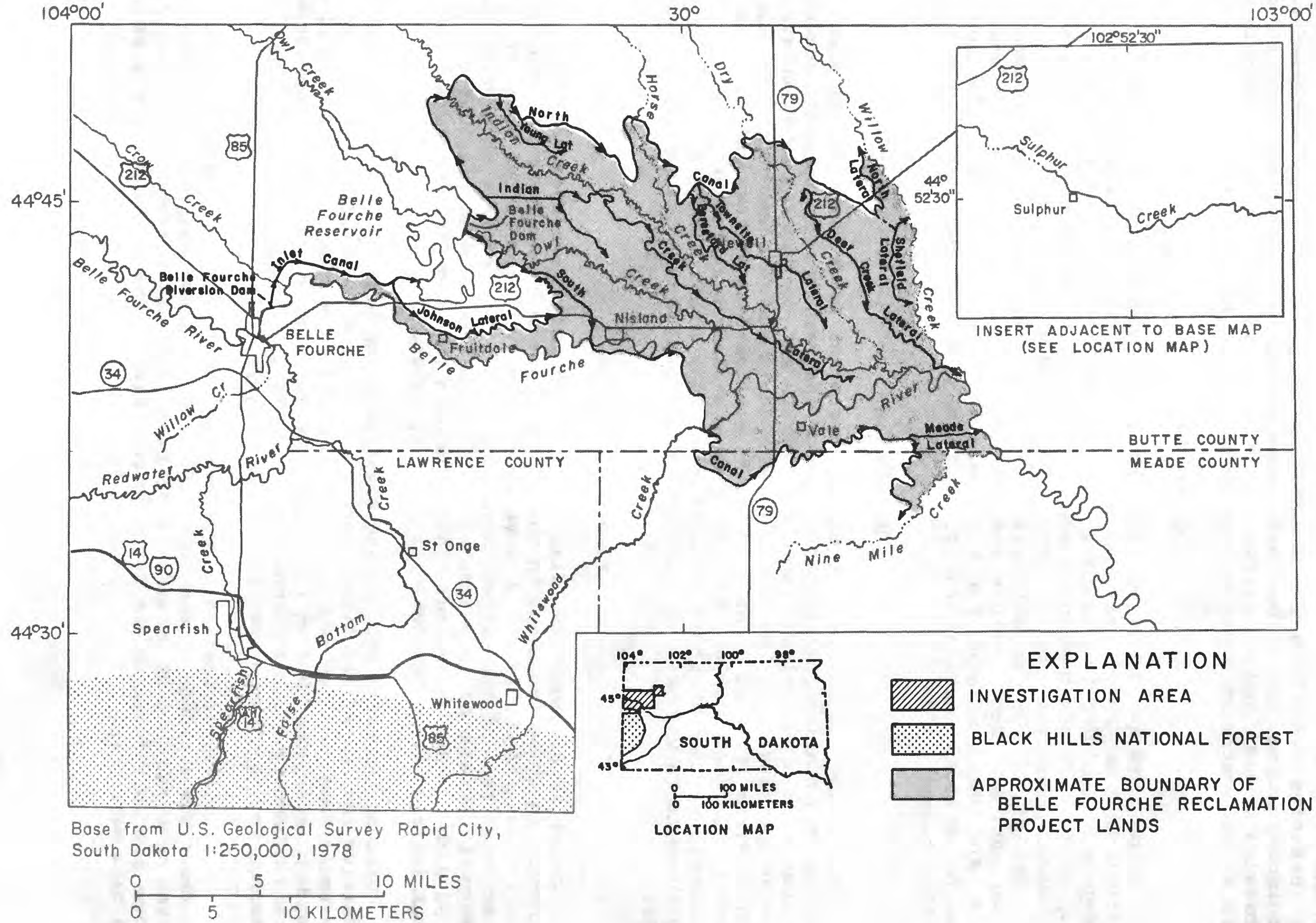


Figure 1.--Location of the Belle Fourche Reclamation Project investigation area.

Land Use

Principal land uses in the investigation area, which consists mostly of undulating plains, are agriculture (rangeland and farmland), recreation, and habitat for fish and wildlife. The Black Hills National Forest occupies a part of the southwest corner of the investigation area.

Agriculture

Agriculture is the major land use in the investigation area. Agriculture in the project area is an integrated type of farming operation (rangeland adjoining the irrigation lands), which generates an annual cash-crop production worth about 12 million dollars (Bruce Laymon, U.S. Bureau of Reclamation, written commun., 1989). Irrigated alfalfa and hay account for 48 percent of the project area; irrigated corn and silage account for 24 percent; irrigated pasture accounts for 12 percent; irrigated barley, oats, and wheat account for 5 percent; and about 11 percent of the land is used for dryland agriculture (Bruce Laymon, U.S. Bureau of Reclamation, written commun., 1989).

Recreation

Recreation associated with the Belle Fourche Reservoir includes fishing, boating, and camping. Recreational use of the reservoir is limited, however, because of the relatively isolated location and the limited services available at the reservoir. During 1988, the South Dakota Department of Game, Fish & Parks reported a total of 50,586 visitor days at the reservoir, which is much less than the 240,667 visitor days at Angostura Reservoir, a smaller reservoir on the southern edge of the Black Hills that has better nearby developments (Bruce Laymon, U.S. Bureau of Reclamation, written commun., 1989).

Fish and Wildlife

There is an important fishery in the Belle Fourche Reservoir and small fisheries in Horse Creek and in the Belle Fourche River near the Wyoming-South Dakota State line. A developing fishery exists in the Belle Fourche River downstream of the project area where the river reach is recovering from the past release of an estimated 110 million tons of mine tailings contaminated with arsenic and mercury that have been carried into it by Whitewood Creek (Marron, 1988; Fox Consultants Inc., 1984).

Fish of the Belle Fourche and Cheyenne River basins include 35 species of native and introduced fishes (table 1). Intensive sampling of the fish in the Belle Fourche River probably would reveal more than the recognized 35 resident species. During the investigation, a diversified fish population, including numerous large channel catfish, carp, goldeye, and redhorse, was observed in the river downstream of the project area.

No wildlife refuges are in the project area, although the Belle Fourche Reservoir was a refuge at one time. The refuge status was removed subsequent to the construction of thousands of farm ponds in western South Dakota. There are no refuges on the Belle Fourche River between the project area and the Oahe Reservoir.

Table 1.--Fish species identified in the Belle Fourche and Cheyenne River drainage basins

[Source: Bailey and Allum, 1962; personal observation of plains topminnow by Sowards during the investigation]

Common name (native species)	Common name (introduced species)
Goldeye	Brown trout
Creek chub	Rainbow trout
Finescale dace	Brook trout
Lake chub	Carp
Flathead chub	Goldfish
Sturgeon chub	Golden shiner
Longnose dace	Plains killifish
Sand shiner	Plains topminnow
Northern plains minnow	Largemouth bass
Silvery minnow	Green sunfish
Fathead minnow	Bluegill
River carpsucker	Orangespotted sunfish
Northern redhorse	Rock bass
White sucker	Walleye
Longnose sucker	Yellow perch
Mountain sucker	
Black bullhead	
Channel catfish	
Stonecat	
Burbut	

Although their populations are small, about 150 to 200 species of birds, including migratory and wintering waterfowl, use irrigated and downstream areas. Resident game birds within the irrigated or downstream areas include ring-necked pheasant, turkey, sharptail grouse, and Hungarian partridge. No epizootic or large-scale die-offs have been recorded in the investigation area.

Resident game and fur-bearing mammals that use the irrigated or downstream areas include whitetail deer, mule deer, muskrat, mink, weasel, racoon, beaver, coyote, bobcat, fox, skunk, and badger. Several species of rodents and shrews also occur in the area, as do a variety of snakes, turtles, and amphibians.

Several Federally listed endangered and threatened species are present within the irrigated or downstream areas. The bald eagle (*Haliaetus leucocephalus*) winters in the general area, and the peregrine falcon (*Aquila chrysaetos*) probably visits the area. Whooping cranes (*Grus americana*) regularly migrate over the downstream areas and may use the sandbar areas of the Belle Fourche and Cheyenne Rivers. The interior least tern (*Sterna antillarum*) and piping plover (*Charadrius melodus*) regularly use the irrigated or downstream areas. Black-footed ferrets (*Mustela nigripes*) have not been observed in the area for many years but isolated populations still may be present in the downstream areas.

Several species of plants and animals listed by the State of South Dakota as endangered or threatened are present in irrigated or downstream areas: Fendler's spurge (Euphorbia fenderi) near Belle Fourche, regal fritillary butterfly (Speyeria idalia) near Milesville, western spiny soft shell turtle (Trionyx spiniferus) near the confluence of Timber Draw and the Cheyenne River, sturgeon chub (Hybopsis gelida) east of Wasta, and the finescale dace (Phoxinus neogaeus, listed as genus Chrosomus in South Dakota Fishes) at several locations. The eastern bluebird (Sialia sialis) is listed as rare by the State of South Dakota.

Physical Setting

The physical setting of the area, including the geology, soils, climate, and hydrology, was a major factor in the selection of the Belle Fourche Reclamation Project for investigation. Large amounts of selenium in parent geologic material is an indication that concentrations of selenium in soils may be naturally large. Given the small amount of precipitation and large amount of evaporation in the area, selenium may not be leached from soils naturally, but might be leached by irrigation. Leached selenium then may move in surface drainage or through the shallow ground water and enter surface water in amounts that might be harmful to humans, fish, or wildlife.

Geology

The investigation area is located in the Great Plains Region of the northeastern flank of the Black Hills uplift. The topography is characterized by broad, shallow valleys and gently sloping hills. Escarpments up to 200 ft in height exist along the Belle Fourche River.

The Black Hills uplift, with a core composed of hard and erosion-resistant Precambrian crystalline rocks, lies to the southwest of the investigation area. Surrounding this core are outcrops of rocks ranging in age from Cambrian to Tertiary. The uplift has had a dramatic effect on the predominantly marine bedrock units causing the older sedimentary units to be uplifted and exposed in roughly parallel bands in the western part of the investigation area (fig. 2).

The bedrock in most of the investigation area is composed of Cretaceous sandstones, limestones, and marine shale (fig. 2). These include the Hell Creek Formation; Fox Hills Sandstone; Pierre Shale; Niobrara Formation; Carlile Shale; Greenhorn Limestone; Belle Fourche and Mowry Shales, undivided; and Skull Creek Shale and Inyan Kara Group, undivided (Darton, 1951).

The pre-Cretaceous rocks (fig. 2) located in the southwest part of the investigation area, but outside of the project area, consist predominantly of limestone and dolomite with a few layers of sandstone and shale. Included with the pre-Cretaceous rocks are several Tertiary intrusive units located on the southwest edge of the investigation area (DeWitt and others, 1989).

Areas of Quaternary alluvial and terrace deposits consisting of sand and gravel overlie the bedrock along many of the larger streams. For example, the extent of alluvium along the Belle Fourche River is quite variable but averages 25 ft in thickness and 0.5 to 4 mi in width. A conceptual schematic diagram of the relation between the alluvial deposits, terrace deposits, and underlying impermeable shale is shown in figure 3.

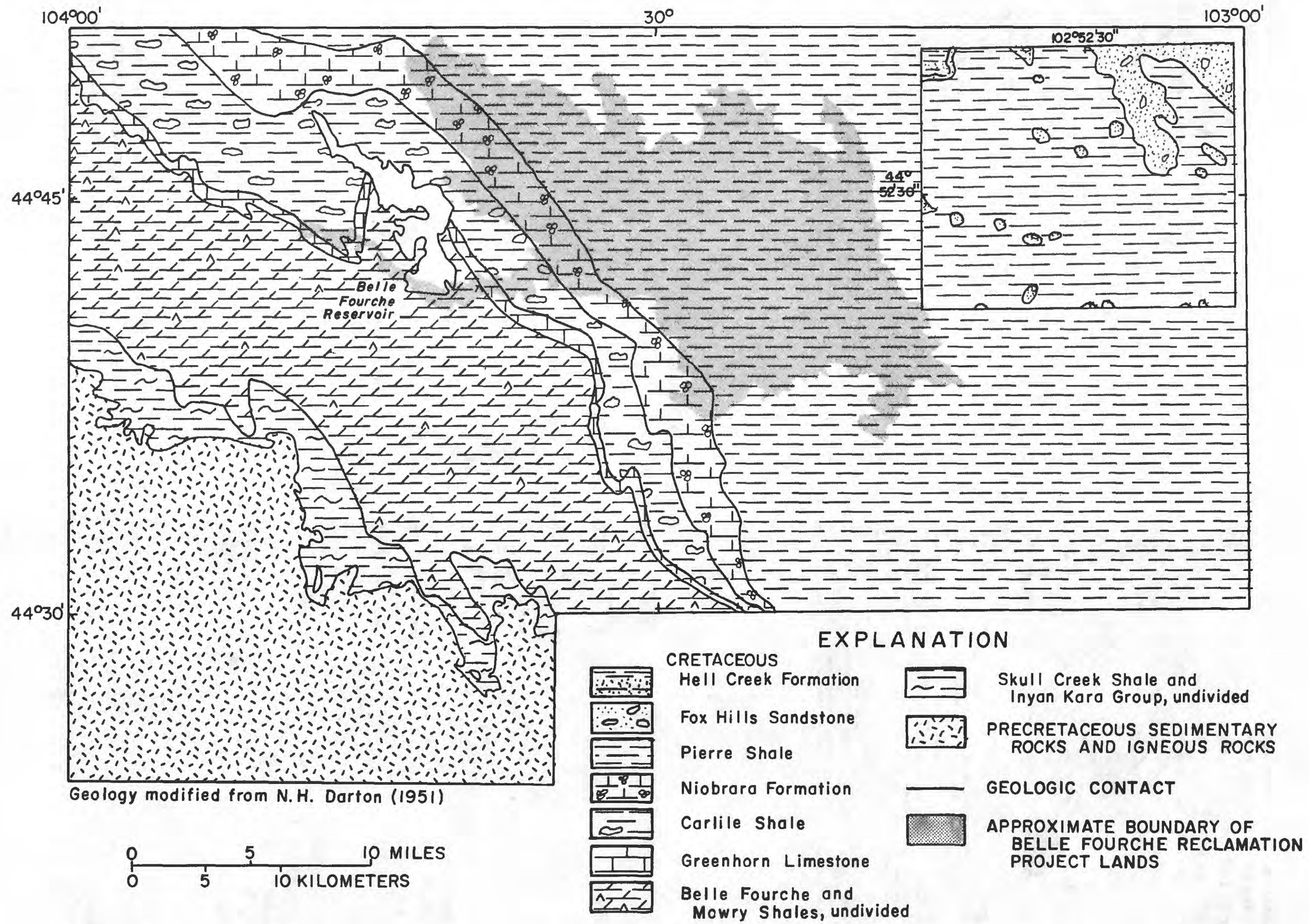
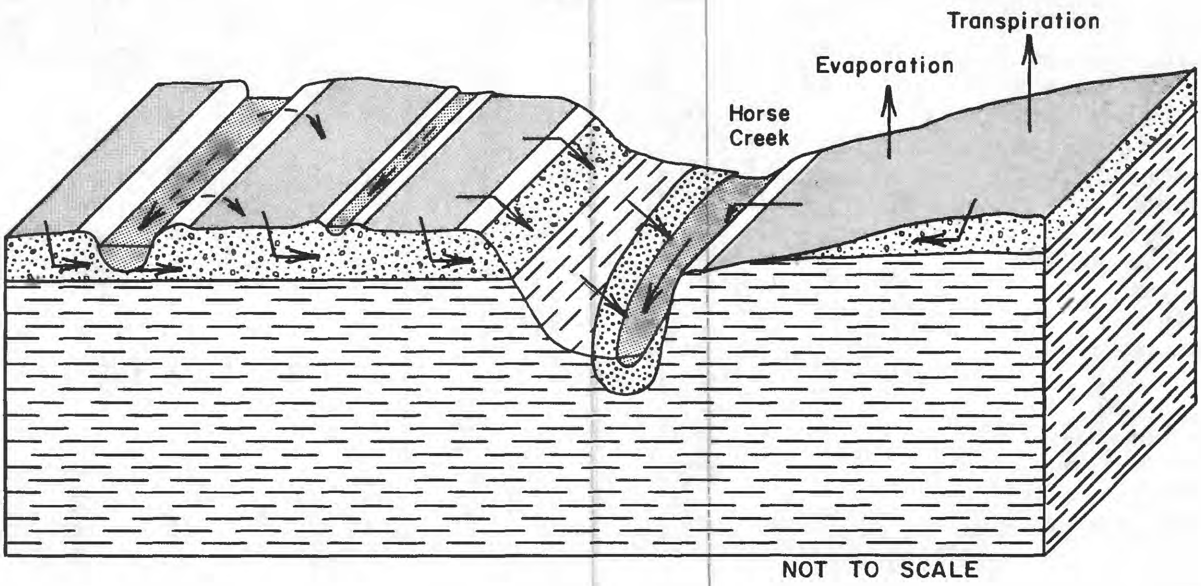


Figure 2.--Geology of the Belle Fourche Reclamation Project investigation area.



EXPLANATION

- IRRIGATED CROPLAND
- TERRACE DEPOSITS
- ONFARM SUPPLY CANAL, DRAIN, AND CREEK
- CRETACEOUS SHALE (PIERRE SHALE AND EQUIVALENT ROCKS)
- ALLUVIUM

<- - - DIRECTION OF FLOW -- Irrigation water

<—— DIRECTION OF IRRIGATION RETURN FLOW AND CANAL LEAKAGE

Figure 3.--A conceptual schematic diagram showing representative hydrogeologic cross section of Horse Creek.

Soils

Soils of the investigation area are described in four reports by the U.S. Soil Conservation Service (Johnson, 1976; Ollila, 1978; and Meland, 1979 and 1986). About one-third of the Belle Fourche Reclamation Project area is composed of flood-plain soils, which are well drained, nearly level to sloping soils formed in alluvium on terraces and bottom lands. About another one-third of the project area is composed of shallow, gently sloping to moderately steep, silty soils over shale and limestone. The remainder of the project area and most of the land surrounding the project area is composed of the Pierre-Kyle association, which are moderately deep to deep, nearly level to moderately steep, clayey soils over clay shale. Most of the land in the Sulphur Creek drainage, a background area for the investigation (insert area, figs. 1 and 2), is composed of deep, well drained, nearly level to moderately sloping loamy and silty soils on uplands and terraces.

In general, the soils of most of the area are slowly drained, with good water-holding capacities, that tend to shrink and crack when dry. The soils of the outer perimeter of the project area, which are derived from shale, usually are very slowly drained, moderately deep, firm clays on undulating to rolling uplands. Saline alkali soils exist locally in the project area.

Climate

The climate of the area is characterized by extreme temperatures, low relative humidity, frequent high winds, and relatively small amounts of precipitation. Winters normally are harsh, but infrequent "chinook winds" can warm temperatures and melt area snows. Lowland snowmelt normally occurs before April, but spring temperatures typically are cool. Summers are hot, and temperatures occasionally will exceed 100 °F. Falls are cool, with first snowfalls usually occurring in November.

During 1988, temperatures at Newell ranged from -21 to 104 °F and were 3 degrees warmer than normal (U.S. Department of Commerce, 1989). Temperatures equaled or exceeded 90 °F for 50 days during 1988, and exceeded 100 °F several times during June, July, and August. June was especially hot, with the average temperature being 11 °F above normal.

Precipitation recorded at Newell during 1988 was 10.85 inches, which is about 75 percent of the 1951-80 average of 14.39 inches (U.S. Department of Commerce, 1989). Normally, about two-thirds of the annual precipitation occurs during the spring and summer; however, this period was drier than usual during 1988 when the precipitation deficit was 3.75 inches (fig. 4).

Average May through October class-A pan evaporation recorded at Newell was 46.25 inches through 1970 (Farnsworth and Thompson, 1982). This value converts to an annual free-water-surface evaporation of about 40 inches (Farnsworth and others, 1982). Site-specific evaporation amounts during 1988 are not available; however, evaporation would be expected to have been greater than average, especially during June, because of the high temperatures and dry conditions.

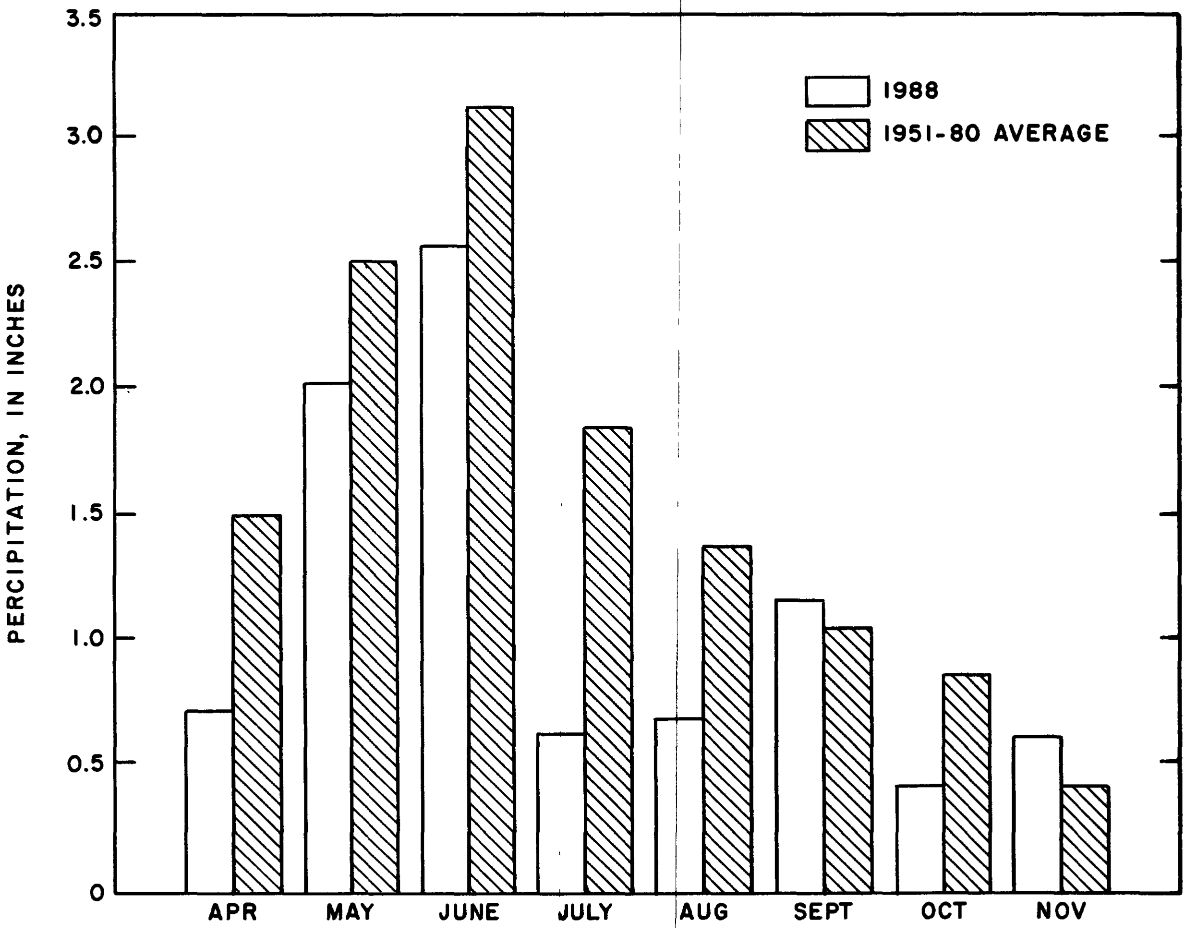


Figure 4.--Monthly precipitation during 1988 and monthly normal precipitation during 1951-80 (April through November) at Newell.

Hydrology

Nearly all of the irrigation water for the Belle Fourche Reclamation Project is obtained from the Belle Fourche River at the Belle Fourche Diversion Dam (fig. 5). Upstream of the diversion dam, the drainage basin of the Belle Fourche River is 4,310 mi^2. Of this total, about 2,000 mi^2 are upstream of Keyhole Dam and Reservoir in Wyoming.

Just upstream of the diversion dam, the average annual flow of the Belle Fourche River is about 170,000 acre-ft; 98,000 acre-ft of this flow is contributed by the Redwater River. Seasonal baseflows of both rivers are affected by irrigation drainage and treated sewage discharges from upstream sources.

At the diversion dam, about 120,000 acre-ft/yr is diverted from the Belle Fourche River through the 6.5-mile-long Inlet Canal. About 4,460 acre-ft of the flow in the canal is diverted into Johnson Lateral to irrigate about 2,600 project acres; the rest of the water flows into the Belle Fourche Reservoir (Bruce Laymon, U.S. Bureau of Reclamation, written commun., 1989).

The Belle Fourche Reservoir has an active conservation capacity of 186,900 acre-ft (Bruce Laymon, U.S. Bureau of Reclamation, written commun., 1989). At a conservation elevation of 2,975 ft above sea level, the reservoir surface area is 8,000 acres, and the average depth is 23.4 ft. The reservoir is located within the Owl Creek basin, which contributes an average 9,700 acre-ft/yr to the reservoir.

Water flows from the reservoir in two canals (North Canal and South Canal), with capacities of 1,190 and 793 acre-ft/d respectively, onto about 54,500 acres of project lands (fig. 5). Within the project lands, the irrigation and drainage systems consist of 94 mi of canals, 450 mi of laterals, 223 mi of unlined drains, and 7 mi of closed-pipe drains (U.S. Bureau of Reclamation, 1976).

Historically, about 120,000 acre-ft of water is used during the irrigation season, which normally begins in May and ends in September. About half this amount of irrigation water, or 1 acre-ft/acre, is actually delivered to the fields. In response to the dry conditions during 1988, however, the amount of water used for irrigation was larger than the average for 1952-87 (fig. 6). Irrigation releases from the reservoir during 1988 exceeded the long-term average by about 36,000 acre-ft.

During the irrigation season, most of the irrigation drainage water enters the Belle Fourche River or its tributaries and is not reused by the project. Throughout this period, irrigation drainage comprises most of the streamflow of the Belle Fourche River downstream of the project. In 1988, streamflow was 200 to 300 ft^3/s.

The soil profile beneath the irrigated areas transmits a small amount of excess water from flood irrigation and leakage from the network of unlined canals and drains. Water infiltrates through the soil layer to the top of the almost impermeable marine shales and then moves laterally downgradient into and through the alluvium along major streams (fig. 3). A portion of this shallow ground water seeps into drains and streams, accounting for a large percentage of the base streamflow during the rest of the year.

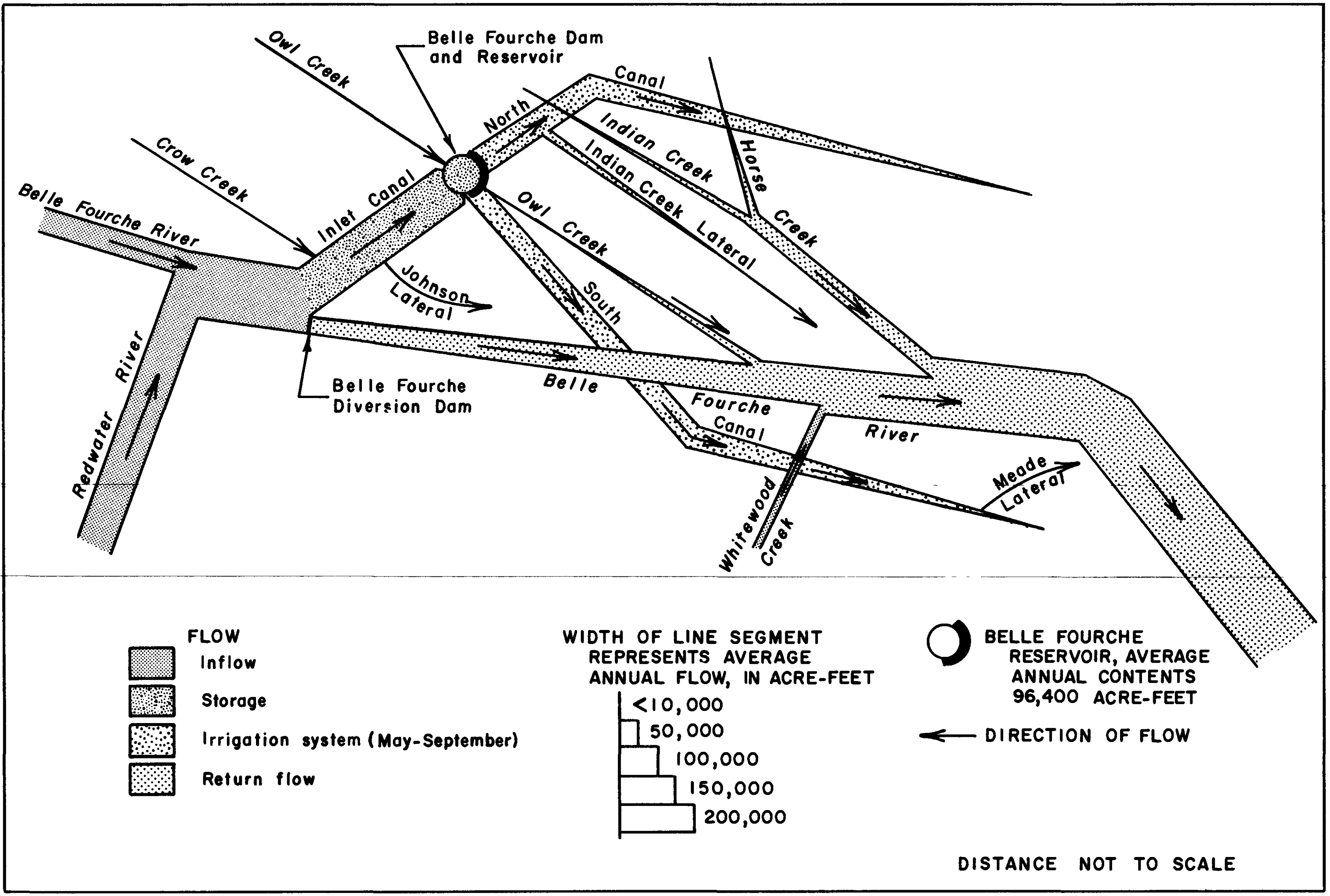


Figure 5.--Schematic diagram showing diversions, storage, and movement of surface water in the investigation area.

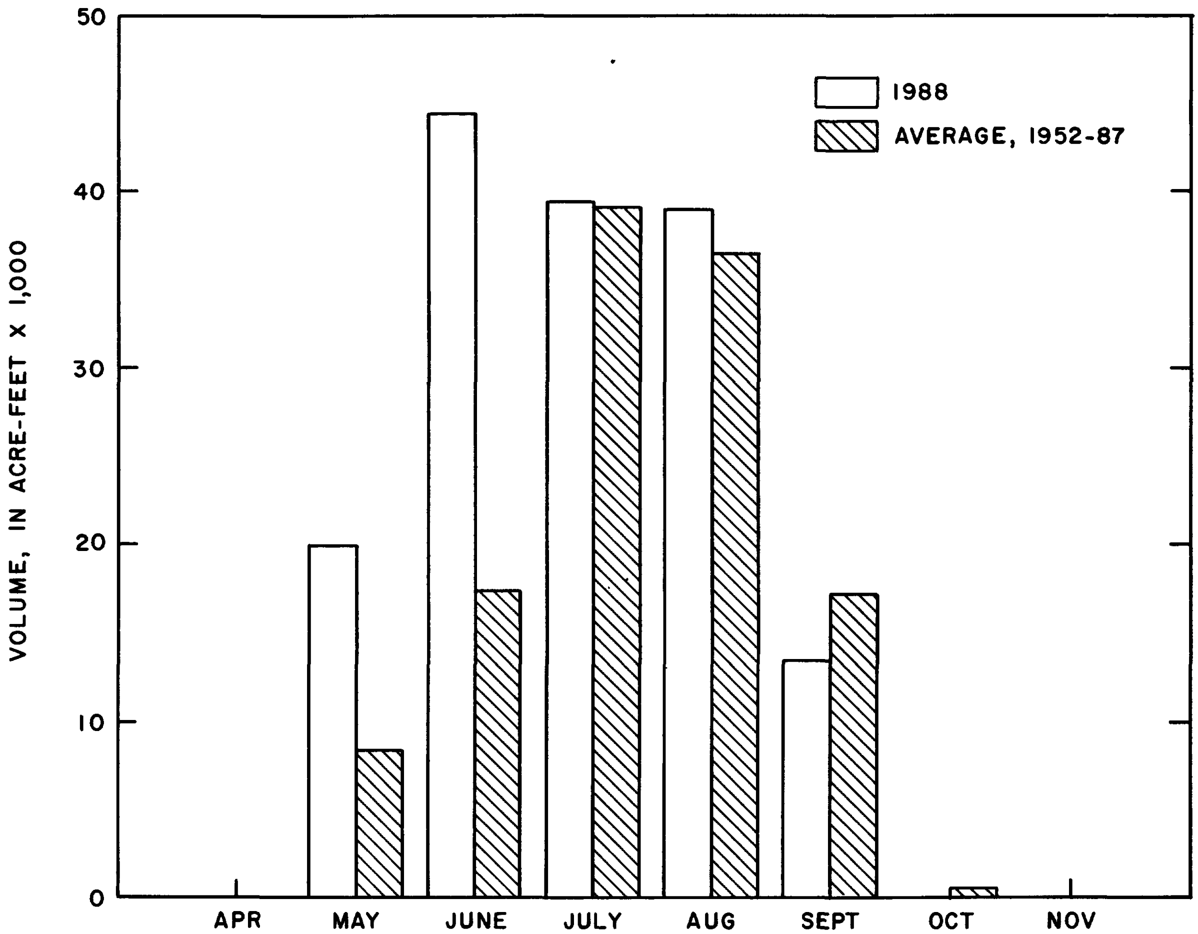


Figure 6.--Monthly releases during 1988 and average monthly releases during 1952-87 (April through November) from Belle Fourche Reservoir.

The use of surface or shallow well water for domestic supply is severely limited by large concentrations of dissolved constituents, particularly sulfate. The cities of Newell and Nisland and most of the farms and ranches in the area use ground water obtained from deeper formations (2,000 to 2,700 ft below land surface). Owing to the poor quality of water from shallow wells, stock water is predominantly provided by surface water, either from project irrigation delivery and surface drainage, or from storm runoff stored in stock ponds throughout the area.

PREVIOUS INVESTIGATIONS

Although there have been several water-quality, geochemical, and bottom-sediment investigations within and near the project area, the effects of the Belle Fourche Reclamation Project have not been previously investigated. Several investigators have assessed the impact of contaminated sediment from mining activities on Whitewood Creek and the Belle Fourche River downstream of Whitewood Creek (U.S. Environmental Protection Agency, 1971, 1973; Stach and others, 1978; Fox Consultants, Inc., 1984; Cherry and others, 1986; Goddard, 1989; Marron, 1988; Roddy and McKallip, 1988). Surface-water, ground-water, bottom-sediment, and suspended-sediment samples were collected during some or all of these investigations. During 1979, the South Dakota School of Mines and Technology collected ground-water and bottom-sediment samples in and near the investigation area as part of a Uranium Resources Evaluation Project for the U.S. Department of Energy (1980).

In addition to these investigations, other water and fish samples have been collected within the investigation area; the U.S. Geological Survey has collected about 1,100 surface-water-quality samples, and the U.S. Fish and Wildlife Service collected 12 fish samples during 1985-87 that were analyzed for trace elements.

Surface Water

The release of approximately 110 million tons of gold-mine tailings to Whitewood Creek from about 1876 to 1977 resulted in large concentrations of cyanide, arsenic, copper, and mercury in Whitewood Creek and elevated concentrations of these constituents in the Belle Fourche River downstream from the confluence with Whitewood Creek (Marron, 1988; U.S. Environmental Protection Agency, 1973). Although no tailings have been released since 1977, millions of tons of contaminated sediment still remain in the flood plain of the Belle Fourche River downstream from the confluence with Whitewood Creek (Marron, 1988; Goddard, 1989). Since the release of contaminated sediment to Whitewood Creek was discontinued, concentrations of these contaminants have decreased. From samples collected at two sites near the confluence of Whitewood Creek and the Belle Fourche River, Goddard (1989) reported median concentrations of cyanide, copper, and mercury during 1983-84 were near or less than reporting limits (table 2). Median arsenic concentrations in samples from these two sites were 30 $\mu g/L$ in Whitewood Creek and 15 $\mu g/L$ in the Belle Fourche River, which are still elevated compared to concentrations from uncontaminated sites.

Table 2.--Statistical summary of selected constituent concentrations measured near the mouth and downstream of Whitewood Creek, water years 1983-84

[Cyanide concentrations in milligrams per liter; others in micrograms per liter. <, less than. Source of data: Modified from Goddard (1989) table 9, pages 40-41]

Constituent	USGS station identification number[1]	Number of samples		Minimum	Median	Maximum
		Total	Detected[2]			
Cyanide	06436198	30	22	<0.01	0.02	1.8
	06436250	17	6	<.01	<.01	1.6
Arsenic	06436198	30	29	17	30	80
	06436250	17	14	<10	15	43
Copper	06436198	30	7	<2	<50	100
	06436250	17	2	<2	<50	100
Mercury	06436198	28	1	<.1	<.2	.3
	06436250	16	1	<.2	<.2	.3
Selenium	06436198	29	3	<1	<2	6
	06436250	16	9	<1	<2.5	40

[1]Station 06436198, Whitewood Creek above Vale, is within one-half mile of the mouth of Whitewood Creek. Station 06436250, Belle Fourche River at Vale, is about 1 mile downstream of the mouth of Whitewood Creek.

[2]Number of samples in which constituent was detected. Analytical reporting limits varied among sample sets.

Previous to this investigation, a large amount of USGS surface-water-quality data was collected at or very near two reconnaissance investigation sampling sites located within the project area. During the 1968-87 water years, 182 samples were collected from the Inlet Canal, upstream from the Belle Fourche Reservoir and the irrigated area. During the 1964-84 water years, 201 samples were collected from Horse Creek, near its confluence with the Belle Fourche River, in the downstream portion of the irrigation area (table 3). Values of pH in water from Horse Creek were slightly lower than water from the Inlet Canal. Median concentrations of dissolved solids, magnesium, sodium, sulfate, chloride, nitrite plus nitrate (as nitrogen), boron, and selenium were much larger in Horse Creek than the Inlet Canal (table 3). Concentrations of sulfate, nitrite plus nitrate (as nitrogen), boron, and selenium in samples from Horse Creek (table 3) exceeded relevant water-quality criteria, standards, or recommended limits for drinking water, protection of freshwater aquatic life, irrigation, or livestock watering (table 4).

Table 3.--Statistical summary of selected surface-water-quality data measured in the Inlet Canal and Horse Creek, water years 1963-87

[All constituent concentrations are dissolved. Units in milligrams per liter unless otherwise noted. µg/L, micrograms per liter; <, less than. Source of data: USGS WATSTORE computer database]

Parameter	Surface water[1]	Number of samples	Minimum	Median	Maximum
pH (standard units)	Inlet Canal	171	7.3	8.1	9.6
	Horse Creek	195	7.0	7.9	8.8
Solids, sum of constituents	Inlet Canal	182	354	965	1,560
	Horse Creek	201	78	2,920	8,380
Magnesium	Inlet Canal	182	13	49	79
	Horse Creek	201	4.7	180	550
Sodium	Inlet Canal	182	11	30	140
	Horse Creek	201	11	390	1,400
Sulfate	Inlet Canal	182	190	560	1,000
	Horse Creek	201	43	1,800	5,300
Chloride	Inlet Canal	182	1.8	4.8	25
	Horse Creek	201	1.9	56	230
Nitrite plus nitrate (as nitrogen)	Inlet Canal	155	<0.01	0.2	1.5
	Horse Creek	112	<.01	1.6	37
Arsenic (µg/L)	Inlet Canal	1	8	8	8
	Horse Creek	4	<1	1.5	2
Boron (µg/L)	Inlet Canal	182	50	100	770
	Horse Creek	198	100	515	2,300
Selenium (µg/L)	Inlet Canal	1	11	11	11
	Horse Creek	3	10	32	33

[1]Inlet Canal includes samples from one site, Inlet Canal near Belle Fourche (USGS station identification number 06434500), sampled during 1968-87 water years. Horse Creek includes samples from two discontinued stations within one-half mile of the mouth: Horse Creek near Vale (06436800), sampled during 1964-82 water years, and Horse Creek at mouth near Vale (443900103193001), sampled during the 1984 water year.

Table 4.--Water-quality criteria, standards, or recommended limits of selected constituents for drinking water, protection of freshwater aquatic life, irrigation, and livestock watering

[All concentrations are from U.S. Environmental Protection Agency (1986a, 1986b, 1986c). Concentrations are in micrograms per liter unless specified. MCL, Maximum Contaminant Level; SMCL, Secondary Maximum Contaminant Level; mg/L, milligrams per liter; --, no criteria or standard available]

	Drinking water				
Constituent	MCL	SMCL	Aquatic life[1]	Irrigation[2]	Livestock watering[2]
pH (pH units)	--	6.5-8.5	--	--	--
Dissolved solids (mg/L)	--	500	--	--	--
Sulfate (mg/L)	--	250	--	--	--
Chloride (mg/L)	--	250	--	--	--
Nitrite plus nitrate (mg/L as nitrogen)	[3]10	--	--	--	100
Arsenic	50	--	[4]850	100	200
Boron	--	--	--	750	5,000
Cadmium	10	--	3.9	10	50
Chromium	50	--	[5]16	100	1,000
Copper	--	1,000	18	200	500
Lead	50	--	82	5,000	100
Mercury	2	--	2.4	--	10
Molybdenum	--	--	--	10	--
Selenium	10	--	20	20	50
Uranium	[6]35	--	--	--	--
Zinc	--	5,000	120	2,000	25,000

[1]Specific criteria for the protection of freshwater aquatic life are based on acute criteria and a water hardness of 100 mg/L.
[2]Recommended limits (National Academy of Sciences-National Academy of Engineering, 1973).
[3]Proposed Maximum Contaminant Level (PMCL).
[4]As^{+5}.
[5]Cr^{+6}.
[6]Suggested No Adverse Response Level (SNARL), National Academy of Sciences (1983).

Also previous to this reconnaissance investigation, a large amount of USGS surface-water-quality data was collected at two sampling sites located on the Belle Fourche River (table 5). During the 1960-85 water years, 158 samples were collected from the Belle Fourche River at the Wyoming-South Dakota State line, which is at the upstream end of the investigation area. During the 1955-87 water years, 255 samples were collected at the Belle Fourche River near Sturgis, which is at the downstream end of the investigation area. Differences in constituent concentrations between these two sites were not as great as the differences in water quality between the Inlet Canal and Horse Creek (table 3), probably because of the effects of inflow from the Redwater River, Whitewood Creek, and other surface water. Maximum concentrations of dissolved solids, sulfate, and selenium (table 5) exceeded relevant water-quality criteria, standards, or recommended limits (table 4) at both sites. The maximum concentration of dissolved boron (2,000 μg/L) at the downstream site exceeded the irrigation criterion (table 4). Except for dissolved arsenic, maximum concentrations of dissolved constituents were smaller in water from the Belle Fourche River than from Horse Creek. The maximum dissolved selenium concentration of 70 μg/L at the upstream Belle Fourche River site probably was not a normal concentration, because the next largest concentration in the 14 samples from this site was 12 μg/L.

Ground Water

Concentrations of dissolved solids exceeded 1,000 mg/L in wells sampled by Stach and others (1978) in shallow alluvial aquifers along Whitewood Creek, and the Belle Fourche and Cheyenne Rivers. Arsenic concentrations ranged from 25 to 1,530 μg/L in wells in areas where alluvial sediment has been contaminated with gold-mill tailings. Selenium concentrations exceeded 10 μg/L in 12 of 64 well samples, probably a result of dissolution of selenium from Pierre Shale.

The U.S. Department of Energy (1980) analyzed 417 ground-water samples from wells completed in alluvium, Cretaceous shales, and deeper ground-water sources in and near the investigation area and found large maximum concentrations of calcium, 514 mg/L; magnesium, 973 mg/L; sulfate, 7,365 mg/L; boron, 3,489 μg/L; manganese, 2,699 μg/L; strontium, 13,463 μg/L; and uranium, 87 μg/L. The maximum concentration of selenium was 6.8 μg/L and the median concentration was 0.4 μg/L. Of the 417 samples, 165 from wells in the Pierre Shale had median concentrations of selected constituents as follows: calcium, 108 mg/L; magnesium, 41.9 mg/L; total alkalinity, 301 mg/L; sulfate, 684 mg/L; boron, 390 μg/L; and uranium, 10.6 μg/L.

During 1973-84, the U.S. Geological Survey collected seven samples from six seeps, mainly along Whitewood Creek, and 21 samples from wells less than 300 ft deep in the investigation area. Median and maximum concentrations of dissolved solids, in milligrams per liter, were as follows: 1,088 and 4,840 from the seeps; 581 and 4,530 from 13 wells developed in the alluvium; and 1,535 and 6,340 from 8 wells developed in the Pierre Shale. Only the 6 seeps were sampled for arsenic and selenium. The maximum observed arsenic concentration was 500 μg/L; the maximum observed selenium concentration was 6 μg/L.

Table 5.--Statistical summary of selected surface-water-quality data measured in the Belle Fourche River upstream and downstream from the Belle Fourche Reclamation Project area, water years 1955-87

[All constituent concentrations are dissolved. Units in milligrams per liter except as otherwise noted. μg/L, micrograms per liter; <, less than. Source of data: USGS WATSTORE computer database]

Parameter	USGS station identification number[1]	Number of samples	Minimum	Median	Maximum
pH (standard units)	06428500	104	6.6	7.9	8.5
	06437000	226	6.9	8.0	8.8
Oxygen	06428500	63	6.4	9.5	13.6
	06437000	35	3.2	9.8	13.2
Solids, sum of constituents	06428500	157	410	1,270	2,680
	06437000	254	443	1,550	4,900
Magnesium	06428500	157	17	57	130
	06437000	255	21	95	300
Sodium	06428500	157	17	100	200
	06437000	255	26	150	840
Sulfate	06428500	157	130	790	1,700
	06437000	254	240	990	3,200
Chloride	06428500	158	<1.0	7.7	36
	06437000	254	3.0	22	140
Nitrite plus nitrate (as nitrogen)	06428500	39	<0.01	0.01	0.85
	06437000	174	.1	1.4	12
Arsenic (μg/L)	06428500	9	<1	1	10
	06437000	72	<2	12	100
Boron (μg/L)	06428500	49	60	140	310
	06437000	229	80	300	2,000
Molybdenum (μg/L)	06428500	10	<1	2	4
	06437000	22	<1	3.5	9
Selenium (μg/L)	06428500	14	<1	2.5	70
	06437000	54	1	5	22

[1]The station at the upstream end of the investigation area, Belle Fourche River at Wyoming-South Dakota State line (06428500), was sampled during water years 1960-85 (site 1, fig. 7). The station at the downstream end of the investigation area, Belle Fourche River near Sturgis (06437000), was sampled during water years 1955-87 (site 18, fig. 7).

Soils and Bottom Sediment

Schultz and others (1980) analyzed the chemical composition of 202 samples of soil developed from the Pierre Shale and collected throughout the northern Great Plains Region. The maximum selenium concentration, 160 μg/g (micrograms per gram), was collected in Charles Mix County in south-central South Dakota. Selenium concentrations in six samples from the counties in the investigation area ranged from less than 1 to 10 μg/g.

The U.S. Department of Energy (1980) collected 514 stream-sediment samples derived from the various lithologic units in and near the investigation area. Maximum concentrations in bottom sediment for streams draining from the Pierre Shale were as follows: arsenic, 11.4 μg/g; chromium, 64.1 μg/g; copper, 31.1 μg/g; manganese, 4,902 μg/g; selenium, 4.5 μg/g; uranium, 3.9 μg/g; and vanadium, 172 μg/g. The largest molybdenum concentration, 14 μg/g, and the largest manganese concentration, 5,811 μg/g, were in samples collected from stream sediment in Graneros Shale (Belle Fourche and Mowry Shale) in the western part of the area.

Goddard and others (1988) collected bottom sediment in Whitewood Creek and the Belle Fourche and Cheyenne Rivers. At a Belle Fourche River site downstream from the project, the arsenic concentration was 260 μg/g, and the selenium concentration was less than 1 μg/g. The very large arsenic concentrations in the Belle Fourche River were attributed to the presence of contaminated sediment originating from gold mining activities, because arsenopyrite commonly is found with the gold ore in deposits throughout the northern Black Hills (Noble, 1950).

Fish

During 1985, 10 fish were collected from the Belle Fourche River and analyzed for selected elements (table 6). Five of these fish were collected from a site near the Wyoming-South Dakota State line, upstream from Belle Fourche and the project area; and the other five were collected from a site near Enning, downstream from the investigation area. The shorthead redhorse was collected at both sites and arsenic concentrations were larger in the fish from the downstream site than in the fish from the upstream site. Mercury and selenium concentrations were about two times larger in shorthead redhorse from the downstream site.

During 1986, two fish were collected from Horse Creek, which is within the project area. Arsenic and mercury concentrations were less than analytical reporting limits; selenium concentrations in white sucker were about twice the concentrations in fish from the upstream site on the Belle Fourche River (table 6).

During 1987, three fish were collected from Whitewood Creek within the investigation area. Selenium concentrations in fish were comparable to concentrations in fish from other sites in the investigation area (table 6).

Table 6.--Concentrations of selected elements in whole-body, dry-weight samples of several fish species, 1985-87

[Analyses performed by U.S. Fish and Wildlife Service. Concentrations in micrograms/gram; mm, millimeters; <, less than; --, no data. Elements were scanned using Atomic Absorption techniques]

Site name	Species	Year of collection	Weight (grams)	Length (mm)	Percent moisture	Aluminum[1]	Arsenic	Mercury	Selenium
Belle Fourche River above Belle Fourche	Shorthead redhorse	1985	125	243	75.3	--	<0.1	0.486	2.71
	Shorthead redhorse	1985	250	297	67.2	--	<.08	.204	2.47
	Stonecat	1985	60.0	184	74.0	--	<.1	.173	1.77
	White sucker	1985	325	321	70.3	--	.337	.219	2.39
	White sucker	1985	350	311	68.5	--	.698	.168	1.46
Whitewood Creek above Vale	Carp	1987	655	357	70.4	--	1.3	<.05	4.9
	Carp	1987	1,080	443	76.0	--	8.4	.18	3.0
	Channel catfish	1987	680	624	70.3	--	.8	.23	1.9
Horse Creek above Vale	Northern redhorse	1986	200	272	69.0	1,060	<.4	<.05	2.1
	White sucker	1986	300	298	77.9	262	<.4	<.05	5.5
Belle Fourche River near Enning	Goldeye	1985	360	348	73.1	--	.260	1.004	3.72
	Shorthead redhorse	1985	210	266	67.3	--	1.865	.765	3.98
	Shorthead redhorse	1985	220	270	68.4	--	1.076	.696	5.06
	Shorthead redhorse	1985	255	305	63.8	--	1.851	.442	3.04
	Shorthead redhorse	1985	260	308	63.7	--	2.562	.606	4.13

[1]Results from inductively coupled plasma-emission spectroscopy with no preconcentration.

DESCRIPTION OF SAMPLING

Samples for the current study were collected and analyzed for potentially harmful chemicals in surface water, bottom sediment, and biota. For consistency among all irrigation drainage investigations, surface-water samples were analyzed for a standard suite of major ions and trace elements designated by the Task Group on Irrigation Drainage (table 7). Bottom-sediment and biota samples were analyzed for a standard suite of elements. Pesticides were analyzed in selected samples. The pesticides analyzed in water and bottom sediment varied between investigation areas and were selected based upon the common types of agricultural chemicals used on the irrigated lands. Organochlorine pesticides and polychlorinated biphenyls (PCB's) were analyzed in samples of biota.

As part of the investigation, the USGS collected surface-water samples once before, twice during, and once after the May through September irrigation season of 1988. In addition to the samples collected for the reconnaissance investigation, the USGS collected 40 additional samples within the investigation area as part of other investigations.

The USGS collected bottom-sediment samples during October and November 1988, after irrigation diversion had ended and near the time of maximum ground-water seepage. Due to laboratory error, additional samples were collected in April 1989 at two sites.

The U.S. Fish and Wildlife Service collected samples from several different trophic levels. Fish were collected in the spring prior to the irrigation season and in the fall after the irrigation season. Aquatic invertebrates, aquatic plants, birds (for element analysis of livers), and bird eggs were collected during the summer months after the period of rapid biological growth and exposure to irrigation water. Pesticides were analyzed only in bird eggs and fish.

Sampling Sites

Ten sites were sampled for water and bottom sediment to provide information for a range of hydrologic conditions within the investigation area (fig. 7 and table 8). Two "inflow" sites were located above the diversion dam to determine the quality of inflow water. Site 1 was on the Belle Fourche River at the Wyoming-South Dakota border, and site 3 was on the Redwater River near the city of Belle Fourche. Two "storage" sites were located between the Belle Fourche Diversion Dam and the Belle Fourche Dam. Site 5 was on the Inlet Canal, and site 6 was in the Belle Fourche Reservoir. Two "irrigation" sites were located on a canal or lateral. Site 7 was on the North Canal about 300 ft downstream from the Belle Fourche Dam, and site 17 was located on the Meade Lateral near the end of the southern delivery system. Two "drainage" sites were located on streams receiving irrigation drainage from the project area. Site 12 was on Horse Creek within the project area, and site 18 was on the Belle Fourche River about 12 mi downstream of the project area. Two "background" sites were located on streams in basins outside of the project area where shales are geologically predominant. Site 4 was on Crow Creek upstream of the confluence with the Inlet Canal, and site 19 was on Sulphur Creek northeast of the project area.

Table 7.--Major ions, properties, trace elements, and pesticides analyzed in surface water, bottom sediment, and biota sampling of the Belle Fourche Reclamation Project investigation area

Water			Bottom sediment			Biota[1]	
Major ions or properties (dissolved)	Trace elements (dissolved)	Pesticides (total)	Major elements (total)	Trace elements (total)	Pesticides (total)	Elements (total)	Pesticides (total)
Alkalinity	Arsenic	1-Napthol	Aluminum	Arsenic	Atrazine	Aluminum	Oxychlordane
Calcium	Boron	3-Hydroxy-carbofuran	Calcium	Barium	Carbofuran	Antimony	C-nonachlor
Chloride	Cadmium	Alachlor	Iron	Beryllium		Arsenic	T-nonachlor
Magnesium	Chromium	Aldicarb	Potassium	Bismuth		Barium	Heptachlor-epoxide
Nitrogen, as NO_2+NO_3	Copper	Aldicarb sulfone	Magnesium	Boron		Beryllium	Lindane
Potassium	Lead	Aldicarb sulfoxide	Sodium	Cadmium		Boron	Heptachlor
Sodium	Mercury	Ametryne	Phosphorus	Cesium		Cadmium	Other chlordanes
Solids, (residue)	Molybdenum	Atrazine	Titanium	Cobalt		Cobalt	O,P'-DDE
Sulfate	Selenium	Carbaryl (Sevin)		Chromium		Chromium	P,P'-DDE
	Uranium	Carbofuran		Copper		Copper	O,P'-DDD
	Vanadium	Cyanazine		Europium		Iron	P,P'-DDD
	Zinc	Methomyl		Gallium		Lead	O,P'-DDT
		Metribuzin		Germanium		Manganese	P,P'-DDT
		Metolachlor		Gold		Mercury	Endrin
		Oxamyl		Holmium		Molybdenum	Dieldrin
		Prometone		Lanthanum		Nickel	Aldrin
		Prometryne		Lead		Selenium	Hexachloro-benzene
		Propazine		Lithium		Silver	Mirex
		Propham		Mercury		Strontium	Toxaphene
		Simazine		Molybdenum		Thallium	Polychlorinated biphenyls
		Simetryne		Neodymium		Tin	
		Trifluralin		Nickel		Vanadium	
				Scandium			
				Silver			
				Strontium			
				Tantalum			
				Thorium			
				Tin			
				Tungsten			
				Uranium			
				Vanadium			
				Ytterbium			
				Yttrium			
				Zinc			

[1]Only bird eggs and fish were analyzed for pesticide concentrations.

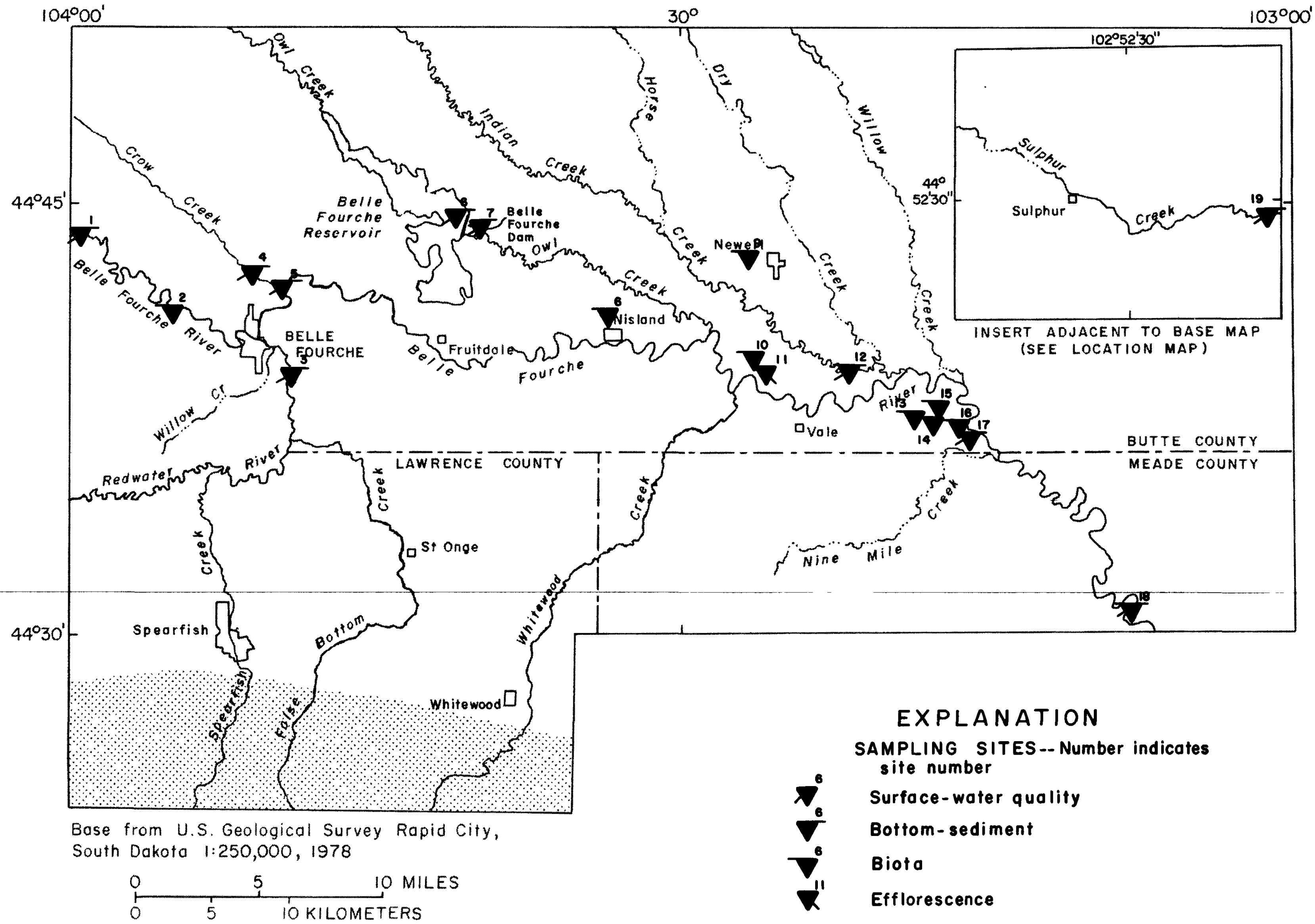


Figure 7.--Location and type of sampling sites.

Table 8.--Location, site name, site type, description of sampling sites, and media sampled for the Belle Fourche Reclamation Project investigation area

Site number (fig. 7)	Station identification number	Latitude and longitude	Site name	Site type	Description	Media sampled
1	06428500	44°44'59" 104°02'49"	Belle Fourche River at Wyoming-South Dakota State line	Inflow	Inflow site upstream from the confluence of the Belle Fourche and Redwater Rivers	Surface water Bottom sediment
2	--	44°41'26" 103°55'03"	Belle Fourche River above Belle Fourche	Inflow	Inflow site between site 1 and the confluence of the Belle Fourche and Redwater Rivers	Biota
3	06432900	44°38'28" 103°49'19"	Redwater River above Willow Creek at Belle Fourche	Inflow	Inflow site on major tributary to the Belle Fourche River, upstream of project area	Surface water Bottom sediment
4	06434496	44°42'29" 103°51"01'	Crow Creek near Belle Fourche	Background	Background site on tributary of Inlet Canal	Surface water Bottom sediment
5	06434500	44°42'14" 103°49'23"	Inlet Canal near Belle Fourche	Storage	Storage site downstream of canal and Crow Creek, upstream from Belle Fourche Reservoir	Surface water Bottom sediment
6	06435000	44°44'06" 103°41'21"	Belle Fourche Reservoir near Belle Fourche	Storage	Storage site on the submerged channel of Owl Creek in the Belle Fourche Reservoir, which stores water to irrigate project lands	Surface water Bottom sediment
7	06436850	44°44'12" 103°40'19"	North Canal near Fruitdale	Irrigation	Irrigation site on one of two canals from the Belle Fourche Reservoir to project lands	Surface water Bottom sediment
8	--	44°41'09" 103°35'30"	Nisland Pond	Miscellaneous	Pond within project area	Biota
9	--	44°42'58" 103°26'57"	Golf Course Pond near Newell	Miscellaneous	Pond within project area	Biota

Table 8.--Location, site name, site type, description of sampling sites, and media sampled for the Belle Fourche Reclamation Project investigation area--Continued

Site number (fig. 7)	Station identification number	Latitude and longitude	Site name	Site type	Description	Media sampled
10	--	44°39'45" 103°27'15"	Section 18 Pond near Newell	Miscellaneous	Pond within project area	Biota
11	--	44°38'21" 103°25'42"	--	Miscellaneous	Irrigated evaporation area	Efflorescence
12	06436760	44°39'08" 103°21'59"	Horse Creek above Vale	Drainage	Drainage site in the project area that receives irrigation drainage	Surface water Bottom sediment Biota
13	--	44°37'42" 103°16'22"	Drainage ditch #1 near Vale	Miscellaneous	Drainage ditch within project area	Biota
14	--	44°37'40" 103°16'20"	Drainage ditch #2 near Vale	Miscellaneous	Drainage ditch within project area	Biota
15	--	44°38'20" 103°17'00"	Pintail Pond near Vale	Miscellaneous	Pond within project area	Biota
16	--	44°37'24" 103°16'04"	Homestake Pond near Vale	Miscellaneous	Pond within project area	Biota
17	06436950	44°36'20" 103°16'00'	Meade Lateral near Vale	Irrigation	Irrigation site on downstream end of distribution system	Surface water Bottom sediment
18	06437000	44°30'47" 103°08'11"	Belle Fourche River near Sturgis	Drainage	Drainage site downstream from the project area	Surface water Bottom sediment Biota
19	06438700	44°52'30" 102°47'20"	Sulphur Creek near Newell	Background	Background site in drainage basin about 15 miles northeast of project area	Surface water Bottom sediment

Samples of fish were collected at the Belle Fourche River above Belle Fourche (site 2), Horse Creek above Vale (site 12), and Belle Fourche River near Sturgis (site 18). Sites 12 and 18 also were water- and bottom-sediment-sampling sites. Site 2 was on the Belle Fourche River northwest of the city of Belle Fourche, downstream of the corresponding water- and bottom-sediment-sampling site 1 (fig. 7 and tables 8 and 9). Fish were not collected at the ditch or pond sites (table 9) because no fish were available.

Table 9.--Sampling sites, types of constituents analyzed, number of samples collected, and schedule of sampling during 1988 for the various types of biota

[E, elements; P, pesticides; --, no sample]

Site number	Site name	Schedule	Birds E	Birds P	Fish E	Fish P	Aquatic invertebrates E	Aquatic plants E
2	Belle Fourche River above Belle Fourche	April	--	--	9	--	--	--
		August	--	--	--	--	1	1
		September	--	--	21	1	--	--
8	Nisland Pond	August	--	--	--	--	1	2
9	Golf Course Pond near Newell	June	4	1	--	--	--	--
10	Section 18 Pond near Newell	June	3	1	--	--	--	--
12	Horse Creek above Vale	April	--	--	21	--	--	--
		August	--	--	--	--	1	2
		September	--	--	26	1	--	--
13,14	Drain ditches near Vale	May	3	--	--	--	--	--
15	Pintail Pond near Vale	May	2	--	--	--	--	--
		August	--	--	--	--	2	1
16	Homestake Pond near Vale	May	6	--	--	--	--	--
		August	--	--	--	--	2	3
18	Belle Fourche River near Sturgis	April	--	--	24	2	--	--
		August	--	--	--	--	1	2
		September	--	--	27	1	--	--
		Totals	18	2	128	5	8	11

Grand total - 172 samples

Aquatic invertebrates and aquatic plants were collected at the Belle Fourche River above Belle Fourche (site 2), Horse Creek above Vale (site 12), the Belle Fourche River near Sturgis (site 18), Nisland Pond (site 8), Pintail Pond near Vale (site 15), and Homestake Pond near Vale (site 16) (fig. 7 and tables 8 and 9).

Bird livers and eggs were collected within the project area from two unlined drains and four small ponds that receive irrigation drainage (fig. 7 and tables 8 and 9). A total of 18 bird samples (8 liver and 10 egg samples) were obtained from the project area. No birds were available for collection at sites 2, 8, 12, and 18 (fig. 7 and tables 8 and 9).

One sample of efflorescence, a whitish evaporite, was collected from site 11, a dried depression in a field northwest of Vale and west of Highway 79. The efflorescence was analyzed for mineral content.

Sampling Techniques and Analytical Methods

Surface Water

Surface-water samples for chemical quality were collected according to techniques recommended by the U.S. Geological Survey (Guidelines for the collection of water-quality samples in the South Dakota District, D.S. Hanson, written commun., 1988); Edwards and Glysson, 1988; Buchanan and Somers, 1969; U.S. Geological Survey, 1977). With the exception of the samples collected at the Belle Fourche Reservoir (site 6), North Canal (site 7), and background sites (4 and 19), samples were a composite of depth-integrated subsamples collected at about 15 to 20 vertical sections across the stream. Samples collected from site 6 were a composite sample obtained by subsampling each of the stratified layers, or by sampling near the top, middle, and bottom of the reservoir if there was no stratification. The site 7 sample was a grab sample collected just upstream of a weir, where the water was well mixed. The depth of the water as it poured over the crest of the weir was about 1 ft. The discharges at sites 4 and 19 were very small, and grab subsamples were collected and composited at these sites. For quality-assurance purposes, one triplicate sample was collected at site 6, and 3 "blank" samples of deionized water also were analyzed. Air temperature, water temperature, pH, specific conductance, dissolved oxygen, and discharge were measured at all surface-water-sampling sites.

Samples for analysis of dissolved major ions and trace elements were filtered through a 0.45-μm (micrometer) filter to remove suspended materials and isolate the dissolved fraction. Pesticide samples were unfiltered. Sample treatment and preservation were conducted by field personnel according to the requirements of the U.S. Geological Survey (1986). Analysis of major ions, trace elements, and pesticides were performed by the U.S. Geological Survey Water Quality Laboratory in Denver, Colorado (Fishman and Friedman, 1985; Friedman and Erdmann, 1982; Wershaw and others, 1987).

Bottom Sediment

Samples of bottom sediment were collected at ten sites within the investigation area after the 1988 irrigation season. Samples were collected from streams and canals using a stainless-steel, Teflon-coated scoop. At least nine evenly spaced subsamples from the upper 2 to 4 inches of sediment were collected along each cross section. Bottom sediment from the reservoir was sampled by obtaining five equal-volume subsamples (Edwards and Glysson, 1988).

Subsamples were composited and mixed in a stainless steel tray. A 300-g (gram) split of the sample was submitted to the U.S. Geological Survey Geologic Division laboratory in Denver, Colorado, and analyzed for trace elements and organic carbon. For quality-assurance purposes, a triplicate split of the sample from the Belle Fourche Reservoir (site 6) also was submitted for analysis. At the laboratory, samples were air dried and sieved through 2-mm (millimeter) opening screens. The samples were then split, and one split was passed through a 0.062-mm sieve. The less than 2-mm split and the less than 0.062-mm split were both analyzed, using methods described in Severson and others (1987).

A 200-g split of the field sample, with large rocks removed, was submitted to the Hygienic Laboratory of the University of Iowa, Iowa City, Iowa, in organic-free glass bottles and analyzed for organic pesticides using standard analytical methods (U.S. Environmental Protection Agency, 1986d).

Biota

All fish were collected with electrofishing equipment. Aquatic invertebrates were collected with Surber samplers or kick nets. Contents of the samplers were placed in shallow pans flooded with distilled water; invertebrates were hand picked and quickly frozen. Aquatic plants were collected by hand, washed in native water at the site or with distilled water at the laboratory, and frozen. Bird eggs were collected, frozen, thawed enough to facilitate removal of the shell, and refrozen. Birds were shot with steel shot, and their livers were removed and put on ice while at the site. Bird livers were then kept frozen until shipment for analysis.

Samples to be analyzed for inorganic constituents were double wrapped in plastic wrap or plastic bags, placed in insulated boxes with dry ice, and shipped for analysis to the University of Missouri Environmental Trace Substances Research Center in Columbia, Missouri, or to Hazleton Laboratories of America, Inc. in Madison, Wisconsin. Samples to be analyzed for organochlorine pesticides and PCB's were double wrapped in aluminum foil and then wrapped in plastic bags, placed in insulated containers with dry ice, and shipped for analysis to the Mississippi State Chemical Laboratory, Starkville, Mississippi. Fish and invertebrates were analyzed on a whole-body basis; plants were analyzed as pulled, including roots; total egg contents were analyzed for elements and pesticides; and bird livers were analyzed for elements. Analyses were performed in accordance with analytical methods approved by the U.S. Fish and Wildlife Service's Patuxent Analytical Control Facility in Laurel, Maryland (U.S. Fish and Wildlife Service, 1985).

The quality control/quality assurance for all analyses was maintained by the Patuxent Analytical Control Facility, U.S. Fish and Wildlife Service, in Laurel, Maryland. The quality control during analysis was carried out by use of spiked samples, duplicate samples, blanks, and by comparison with paired samples analyzed by the Patuxent laboratory.

RESULTS OF ANALYSES

Surface Water

The severe drought conditions during 1988 did not seem to appreciably affect streamflow at the surface-water-quality sampling sites. The inflow into the Inlet Canal, which is a mixture of water from the Belle Fourche River and from the Redwater River, was nearly normal because the inflow is regulated by releases from Keyhole Reservoir, sewage discharges, and flow from springs. The amount of water stored in the Belle Fourche Reservoir decreased from 168,340 acre-ft between the April sampling to 32,550 acre-ft during the October sampling, and this decrease may have affected the results for samples collected from the reservoir (site 6). Surface-water flow at the irrigation sites (7 and 17) during the June sampling was larger than normal because of the increased irrigation. Streamflow at the drainage sites (12 and 18) during the irrigation season was less than maintained by irrigation drainage and hence near the seasonal average. Streamflow at the drainage sites during the non-irrigation season were less than normal, although the largest discharges at these sites occurred during the non-irrigation season as a result of ice break up or isolated storm runoff. Streamflow discharges measured at the two background sites (4 and 19) during the first sampling, in April, were very small. No other samples were collected at these two sites, because the streams did not flow during the other sampling periods.

The results of analysis of the surface-water samples are presented in the Supplemental Data section at the end of this report. Data for the reconnaissance samples are included in table 13 and the data for additional samples available from other investigations in the area are included in table 14.

Concentrations of selected water-quality constituents in water are presented in figures 8, 10, 11, 12, 13, 14, and 15. For ease of comparison, sampling sites in these figures are grouped by site type (table 8), and are not in downstream order.

Maximum concentrations of dissolved solids (sum of constituents), sulfate, chloride, nitrite plus nitrate (as nitrogen), boron, selenium, and uranium (table 10) approached or exceeded relevant water-quality criteria, standards, or recommended limits for various uses of water (table 4). Dissolved-oxygen concentrations were determined at each site and were greater than 6 mg/L at all sites (table 10). Values of pH ranged from 7.6 to 8.7 (table 10) and generally were within secondary maximum contaminant level (SMCL) values established for drinking water (table 4). The reported concentrations of mercury were near the laboratory reporting limit and are probably in error, because mercury was detected in quality-assurance samples composed of deionized water. The other constituents, which had maximum concentrations well above the reporting limit and were not detected in the quality-assurance samples, are discussed in following sections. Four herbicides--alachlor, atrazine, prometone, and cyanazine--were detected at small concentrations and are summarized in following sections.

Dissolved Solids and Major Ions

Dissolved solids are the residue after evaporation of a water sample that has been passed through a 0.45-μm filter. The most common major ions in oxygenated water are calcium, magnesium, sodium, potassium, bicarbonate (calculated from measured alkalinity), sulfate, and chloride. Excessive dissolved-solids concentrations (principally sodium sulfate and magnesium sulfate) can have laxative effects on humans. In addition, excessive concentrations of dissolved sodium in drinking water can have adverse physiological effects on certain people with heart disease and on women with toxemia associated with pregnancy (U.S. Environmental Protection Agency, 1986a). To protect against these health effects, the U.S. Public Health Service (1962) recommended a criterion for drinking water of 500 mg/L for dissolved solids, and the U.S. Environmental Protection Agency (1986a) recommended that neither dissolved sulfate nor dissolved chloride concentrations should exceed 250 mg/L (table 4). Excessive concentrations of dissolved solids (concentrations greater than about 1,000 mg/L) in irrigation water can adversely affect many crops (National Technical Advisory Committee to the Secretary of the Interior, 1968).

Table 10.--Statistical summary of selected surface-water-quality data, Belle Fourche Reclamation Project investigation area, October 1987 through April 1989

[mg/L, milligrams per liter; µg/L, micrograms per liter; <, less than reporting limit; --, not detected at any site]

Property	Number of samples	Minimum	Median	Maximum	Site (fig. 7) where maximum occurred	Date of maximum
pH, field (standard units)	69	7.6	8.3	8.7	5	11-09-87
Oxygen, dissolved (mg/L)	34	6.4	9.4	14.6	5	10-25-88
Oxygen (percent saturation)	22	67	100	131	3	06-20-88
Alkalinity, lab (mg/L)	70	72	166	513	12	01-20-89
Major dissolved inorganic constituents (mg/L)						
Solids, sum of constituents	69	451	1,490	5,970	12	02-03-88
Calcium	69	87	210	440	12	02-03-88
Magnesium	69	22	88	410	12	02-03-88
Sodium	69	7.3	130	890	12	02-03-88
Sulfate	69	240	990	4,000	12	02-03-88
Chloride	69	2.8	19	750	12	03-18-88
Nitrite plus nitrate (as nitrogen)	68	<0.1	0.25	11	18	05-10-88
Trace dissolved inorganic constituents (ug/L)						
Arsenic	48	<1	<1	16	18	08-29-88
Boron	67	50	250	1,500	12	02-03-88
Cadmium	43	<1	<1	1	3 sites	([1])
Chromium	41	<1	2	4	12	10-16-87
Copper	43	<1	<1	4	4 sites	([1])
Lead	39	<5	<5	<5	--	([1])
Mercury	37	<0.1	<0.1	0.3	19	04-28-88
Molybdenum	38	<1	5.5	12	3	10-27-88
Selenium	41	<1	2	34	18	03-26-88
Uranium	30	5.3	8.1	30	12	04-28-88
Vanadium	39	<1	<1	3	3	04-25-88
Zinc	48	<10	<10	150	5	06-13-88

[1]Multiple dates not given.

Concentrations of dissolved solids (sum of constituents) exceeded 1,000 mg/L at all of the sites and in most of the samples collected from 1987 through 1989 (fig. 8); exceptions were two samples collected at the Redwater River (site 3) and six samples at the Inlet Canal (site 5). Comparing the results of the samples collected at sites 5, 12, and 18 shows that dissolved-solids concentration tends to increase as water passes through the irrigation project (fig. 8). The maximum dissolved-solids concentration was 5,970 mg/L at Horse Creek (site 12) in a February 3, 1988, sample; this concentration was less than the maximum of 8,380 mg/L measured at the site during previous sampling (table 3).

Concentrations of dissolved solids in surface water at Horse Creek (site 12) were much smaller during the irrigation season than during the rest of the year. The median dissolved-solids concentration from 5 samples collected during the irrigation season (May through September) was 1,560 mg/L, and the median concentration from 12 samples collected during the non-irrigation season was 4,540 mg/L. Largest concentrations of major ions at site 12 were measured in February 1988, during the winter low-flow period (fig. 9). During this period, the streamflow in Horse Creek was maintained by seepage from shallow ground water probably derived from irrigation water. Dissolved solids were concentrated in stream water as winter ice built up on the stream surface. Major ion concentrations in Horse Creek during spring were similar to concentrations during spring in Sulphur Creek, but less than concentrations during winter in Horse Creek. During the spring, before the start of irrigation, dilute snowmelt water mixes with the shallow ground-water seepage to sustain surface-water flows. Finally, major-ion concentrations in Horse Creek during the summer were nearly identical to concentrations in Belle Fourche Reservoir during the summer, indicating that the streamflow in Horse Creek is sustained by irrigation surface drainage during the irrigation season. These seasonal differences indicate that project irrigation results in larger streamflow in Horse Creek during the irrigation season. Seepage from the shallow ground water to Horse Creek probably is the result of percolating irrigation water. Based on winter samples, ground-water seepage probably contains large concentrations of sulfates and other constituents dissolved from shales. Thus, irrigation probably results in an increase of the annual loads of dissolved constituents in Horse Creek and the Belle Fourche River.

Concentrations of dissolved sulfate exceeded the drinking water SMCL of 250 mg/L (table 4) at all sites and in nearly every sample (tables 10, 13, and 14). The maximum sulfate concentration of 4,000 mg/L was measured at Horse Creek from sampling conducted in February as part of additional sampling. The maximum concentration of chloride (750 mg/L) at drainage site 12 exceeded the drinking-water SMCL (table 4) of 250 mg/L in a March 1988 sample (table 14). Concentrations of chloride at this and other reconnaissance sampling sites did not exceed 250 mg/L in any other samples. Compared to nationwide surface-water-quality sampling results reported by Smith and others (1987), measured concentrations of calcium, magnesium, sodium, and sulfate were larger than the national baselines for surface water.

Dissolved Nitrogen

Nitrogen is a chemical element that is necessary for plant and animal nutrition and is a major ingredient in agricultural fertilizers (Hem, 1985). Nitrogen can be present in water in several chemical forms or "species," which are oxidized by bacteria in the following order: organic nitrogen, ammonia, nitrite, and nitrate. Excessive concentrations of nitrate in drinking water may cause methemoglobinemia in infants. The proposed drinking-water MCL is 10 mg/L of nitrogen in the nitrate form (U.S. Environmental Protection Agency, 1986a).

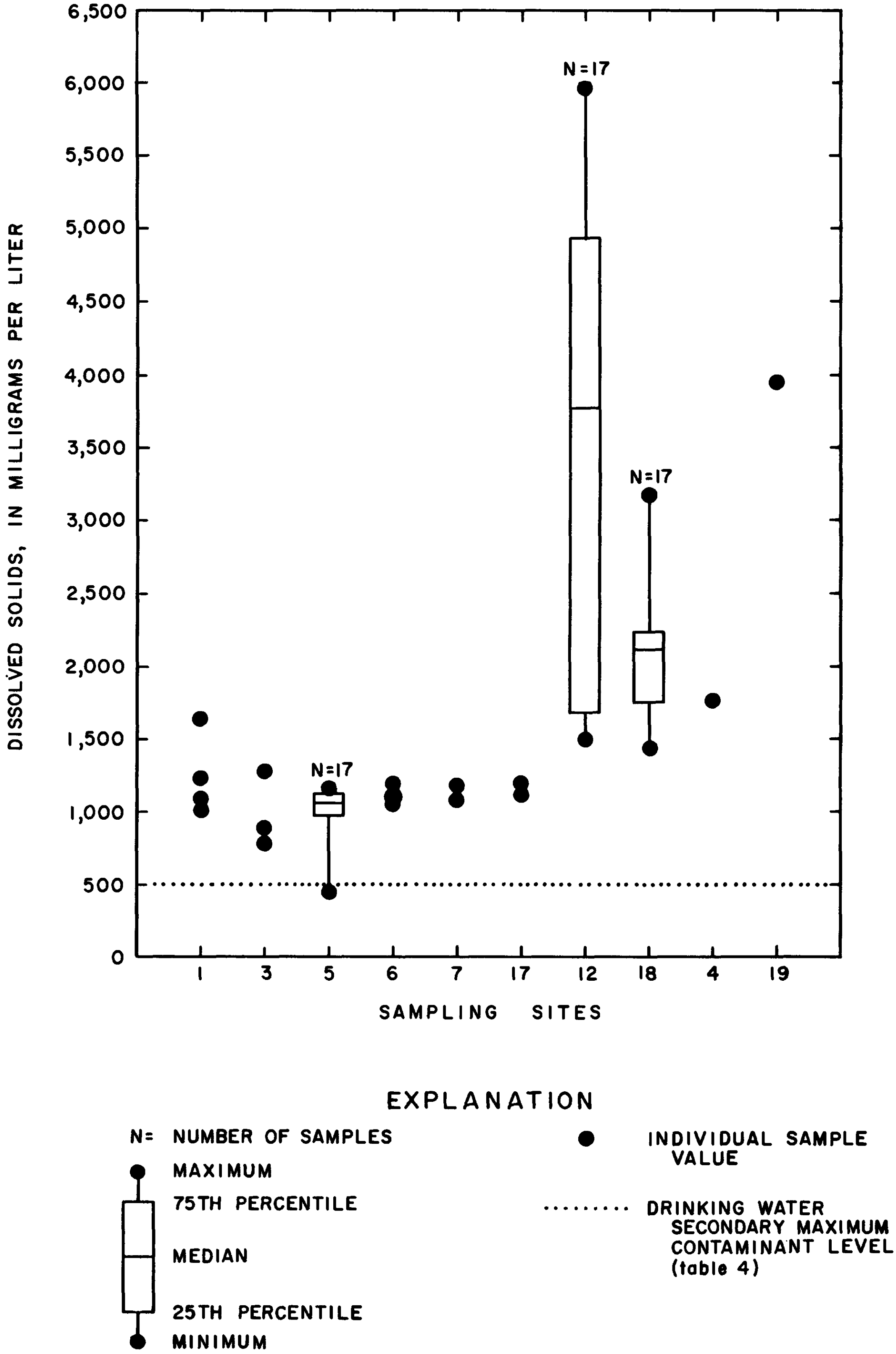


Figure 8.--Distribution of dissolved solids (sum of constituents) at each surface-water-quality sampling site, 1987-89.

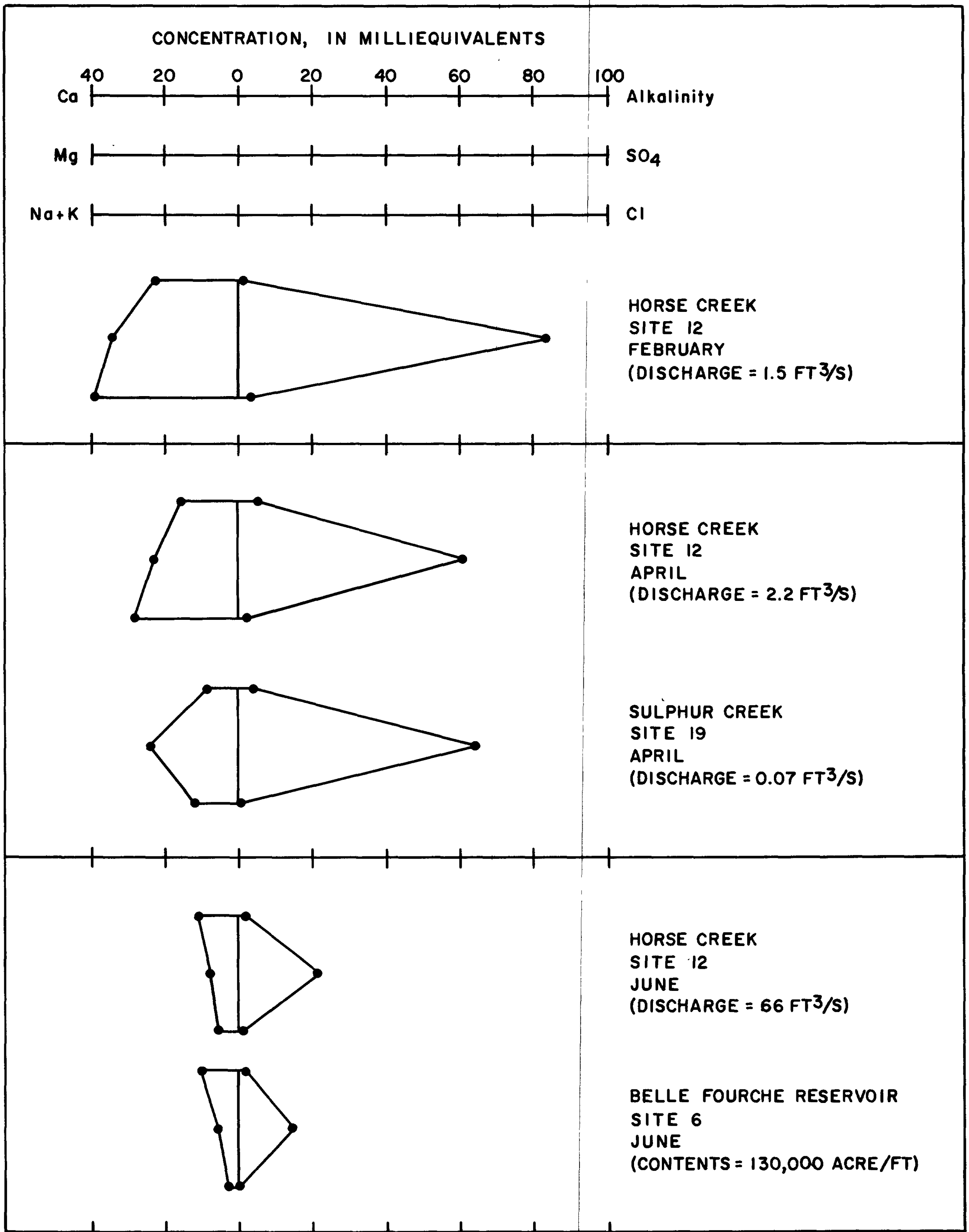


Figure 9.--Seasonal variation of dissolved solids (sum of constituents) for Horse Creek and for two other sites, 1988.

In this investigation, samples were analyzed for nitrite-plus-nitrate nitrogen. In oxygenated surface water, nitrite concentrations are normally less than 0.1 mg/L, which is the analytical reporting limit for nitrate, and the concentration of nitrite plus nitrate is virtually equivalent to nitrate.

Concentrations of nitrite plus nitrate measured in samples collected during the reconnaissance study (table 13) generally were similar to measured values from other studies (table 14) and previous sampling at the same sites (table 3). The largest concentrations of nitrite plus nitrate from the reconnaissance samples were observed at drainage sites 12 and 18 (fig. 10). The maximum concentration (11 mg/L) was observed during additional sampling (table 14) at the Belle Fourche River drainage site 18. This concentration is smaller than the maximum observed in previous sampling, which was 37 mg/L from Horse Creek site 12 (table 3).

A seasonal difference in nitrite-plus-nitrate concentrations was evident at Horse Creek (site 12). The median concentration of four samples collected at site 12 during the irrigation season was less than 0.1 mg/L, and the range was less than 0.1 to 0.15 mg/L. The median of 12 samples collected during the non-irrigation season was 0.845 mg/L, and the range was 0.11 to 1.8 mg/L. A similar difference was evident at the Belle Fourche River near Sturgis (site 18). The median of five samples collected during the irrigation season was 0.44 mg/L, compared to the median of 2.7 mg/L from 12 samples collected during the non-irrigation season. These larger nitrite-plus-nitrate concentrations at the drainage sites during the non-irrigation, low-flow season indicate that crop fertilizers may be percolating through the soil into the shallow ground water or that irrigation may be leaching nitrogen from the soils.

Trace-Inorganic Elements

Trace-inorganic elements usually are measured in microgram-per-liter concentrations in surface water. Arsenic, boron, molybdenum, selenium, and uranium are trace elements that are of interest in the investigation area or were measured in concentrations that could be potentially harmful to human health, crops, or aquatic life.

Dissolved arsenic

Arsenic is a shiny, gray, brittle element normally found in trace concentrations in surface water (Hem, 1985). The drinking-water MCL for arsenic is based on its toxicity and is 50 μg/L (table 4).

Concentrations of arsenic were small at all sites, except at the Belle Fourche River near Sturgis (site 18), downstream of irrigation return flow (fig. 11). Even though the release of the gold-mill tailings has ceased, arsenic is being mobilized upstream of this site from the arsenic-contaminated sediment remaining in the flood plains of Whitewood Creek and the Belle Fourche River (Marron, 1988; Goddard, 1989). The maximum concentration of arsenic (16 μg/L) measured during the investigation was observed at this site. This was less than the maximum arsenic concentration (100 μg/L) measured in previous sampling at site 18 during the release of mine tailings (table 5). All values from this study were below both freshwater aquatic life criteria and the MCL for drinking water.

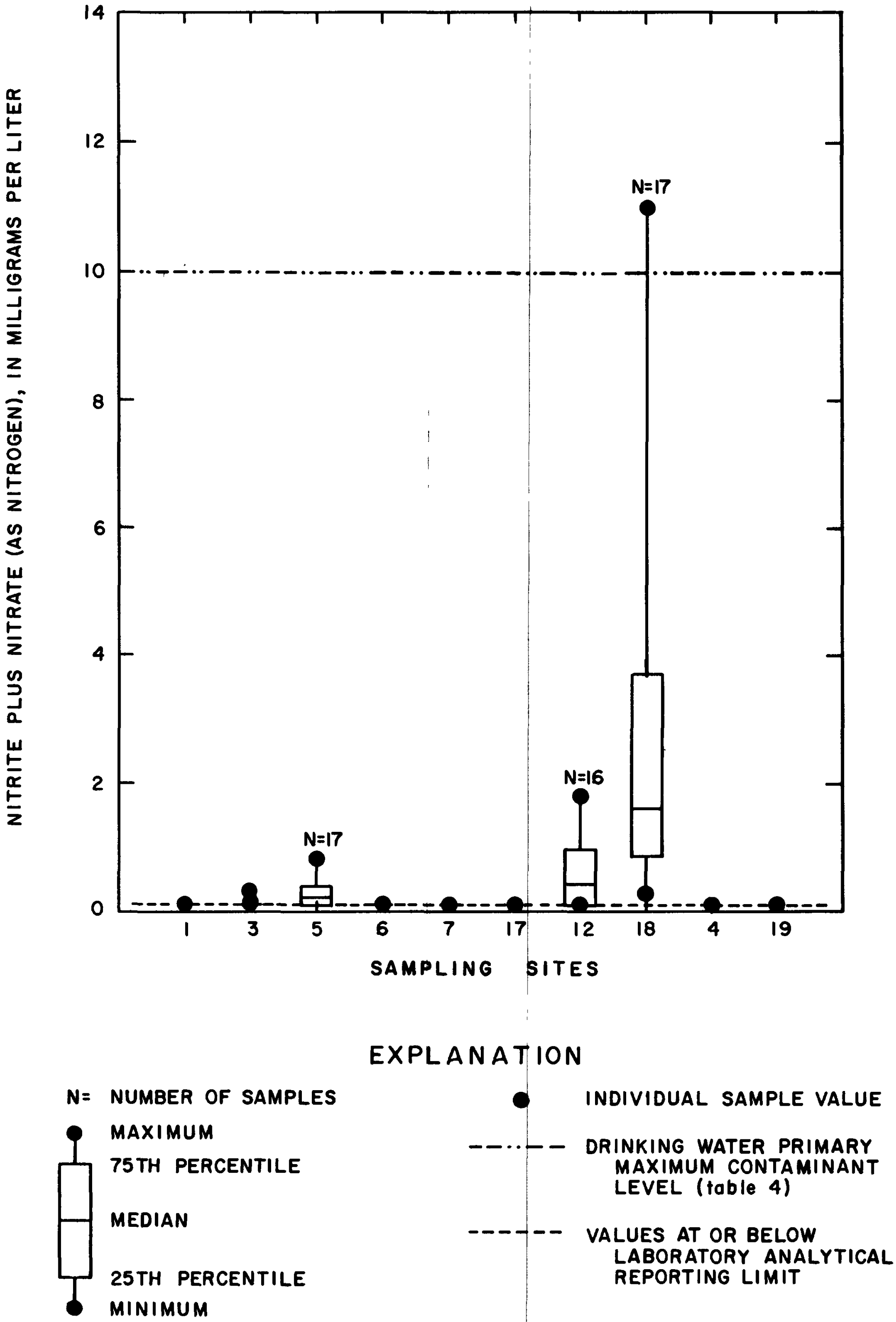


Figure 10.--Distribution of nitrite plus nitrate at each surface-water-quality sampling site, 1987-89.

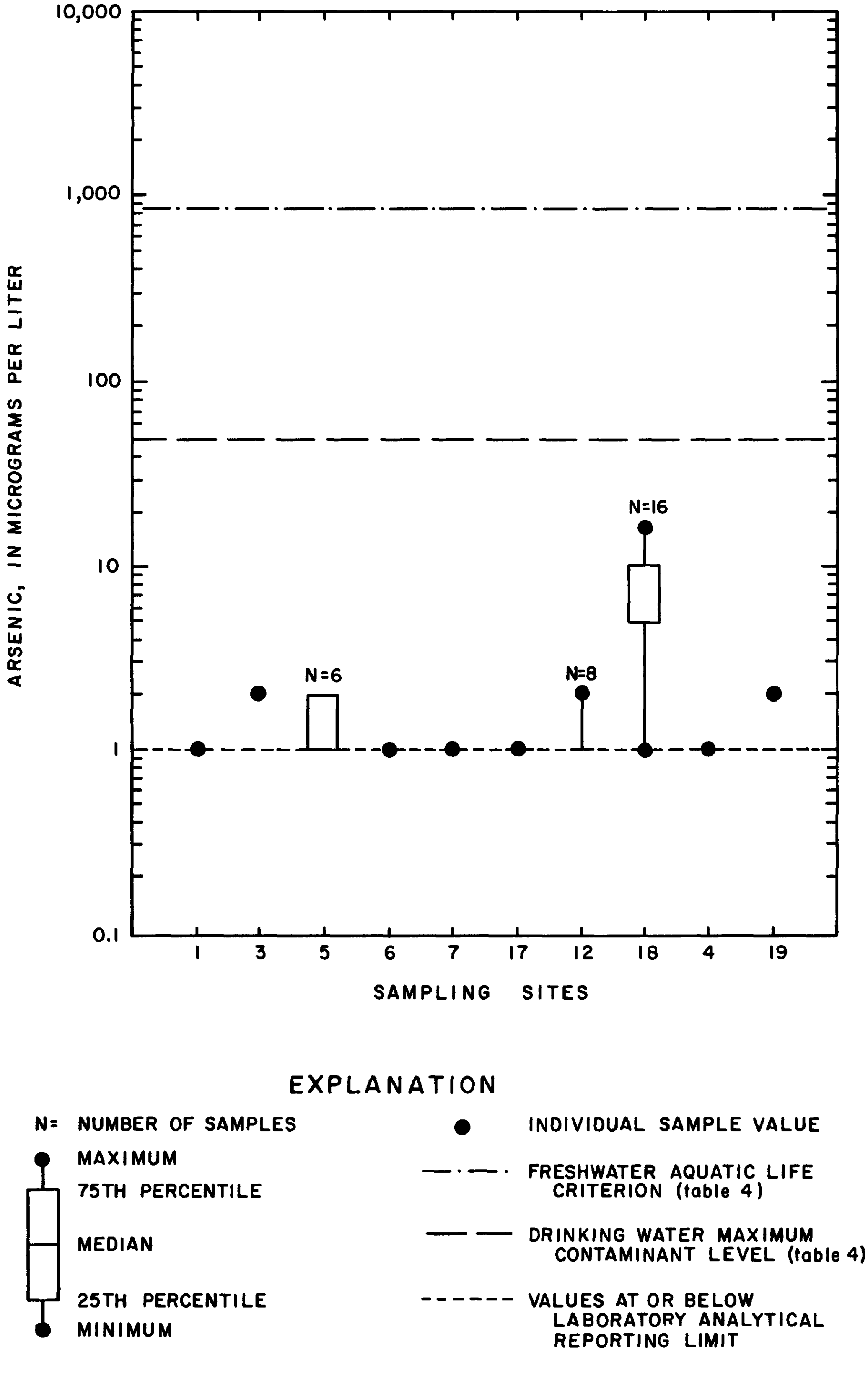


Figure 11.--Distribution of arsenic at each surface-water-quality sampling site, 1987-89.

Dissolved boron

Boron is an element that is essential to plant growth in small concentrations but is toxic to plants in excessive concentrations. The recommended limit for irrigation of sensitive plants is 750 μg/L (table 4).

Concentrations of boron were smaller than 500 μg/L at all of the sites, except for Horse Creek (site 12), where the maximum concentration measured during the investigation was 1,500 μg/L (fig. 12). The observation of large boron concentrations in water from Horse Creek is consistent with previous data, where the largest concentration of boron in previous sampling was 2,300 μg/L at Horse Creek (table 3). Concentrations at the background sites and at site 18 were smaller than at site 12 but slightly larger than at the rest of the sites (fig. 12).

The median boron concentration of five samples collected at site 12 during the irrigation season, 290 μg/L, was much smaller than the median concentration of 970 μg/L from 12 samples collected during the non-irrigation season. This seasonal difference in concentrations is similar to the seasonal difference noted in major ion concentrations. During the non-irrigation season, the generally low streamflow is maintained by ground-water seepage which probably is derived from percolated irrigation water and may contain large concentrations of boron.

Dissolved molybdenum

Molybdenum is an essential element in animal and plant nutrition. Molybdenum from soils or irrigation water can accumulate in vegetation, causing problems for grazing animals (Dye and O'Hara, 1959; Hem, 1985). The irrigation-water criterion is 10 μg/L (table 4). Concentrations equaled or exceeded 10 μg/L at four sites, with a maximum of 12 μg/L measured in a sample from the Redwater River (site 3), an inflow site. This maximum concentration at an inflow site was larger than the maximum of 9 μg/L observed in 22 previous samples from the Belle Fourche River near Sturgis, a drainage site (table 5).

Concentrations of molybdenum generally were slightly smaller at the drainage and background sites than at the other sites (fig. 13). Molybdenum concentrations may be smaller at the drainage sites (concentrations did not exceed 7 μg/L) because of uptake by plants or because of chemical precipitation with calcium.

Dissolved selenium

Selenium is a nonmetallic element necessary for plant and animal nutrition, but it is toxic or teratogenic (causing birth defects) in excessive concentrations (Hem, 1985). The drinking-water standard of 10 μg/L (table 4) is proposed to be revised to 50 μg/L (Marc Parrotta, U.S. Environmental Protection Agency, oral commun., 1989). The U.S. Environmental Protection Agency (1986a) freshwater criterion for the protection of aquatic life is 20 μg/L.

Selenium concentrations were less than 4 μg/L, except at the two drainage sites (sites 12 and 18), where some concentrations were equal to or greater than 10 μg/L (fig. 14). The largest concentration of selenium measured during the investigation period was 34 μg/L. This concentration was measured in a March 1988 sample (table 10) from the Belle Fourche River near Sturgis (site 18) and exceeded the freshwater criterion for the protection of aquatic life (table 4). This value is comparable to the largest concentration observed previously in Horse Creek (33 μg/L, table 3), and in the Belle Fourche River at Vale (40 μg/L, table 2).

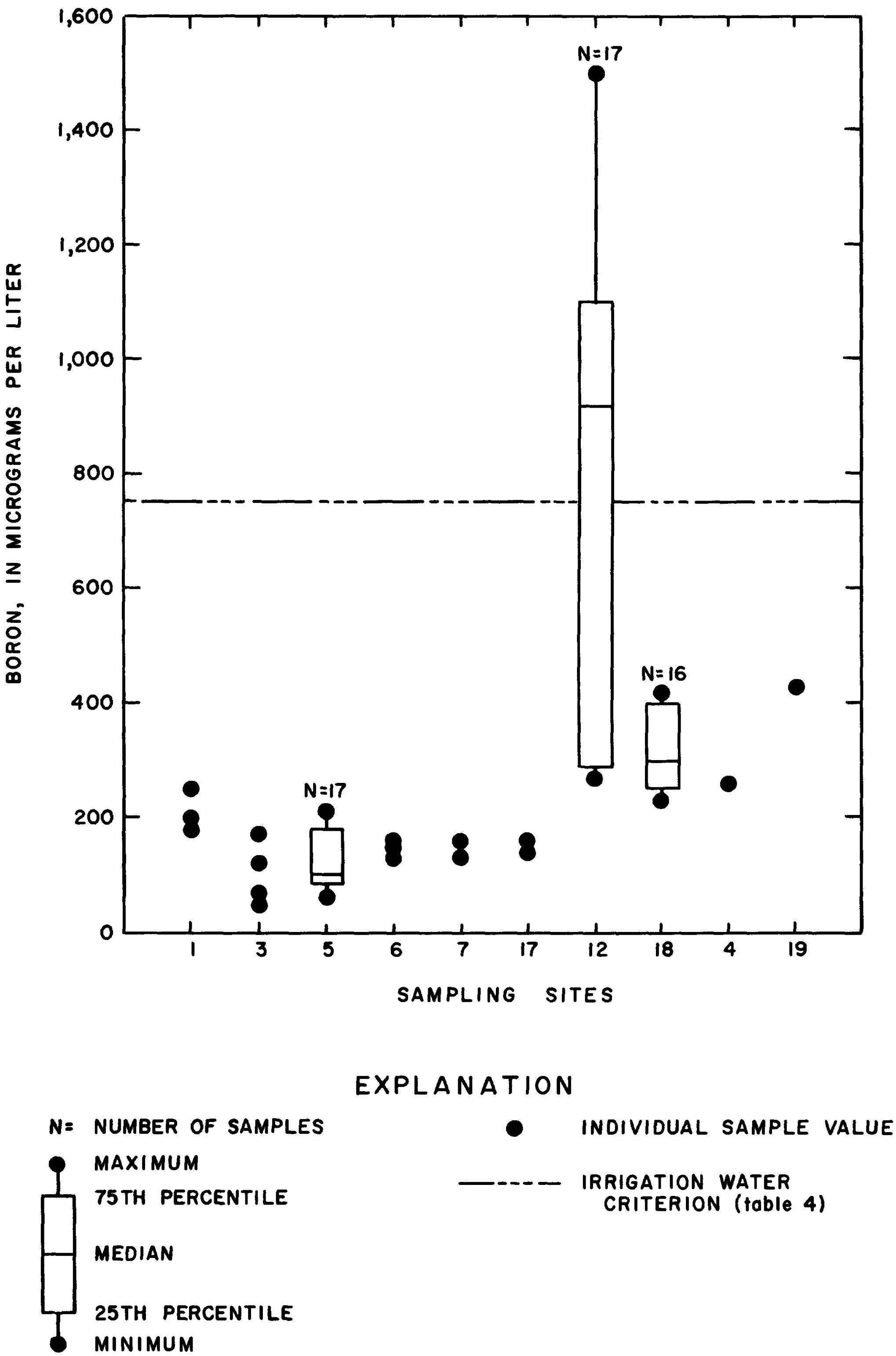


Figure 12.--Distribution of boron at each surface-water-quality sampling site, 1987-89.

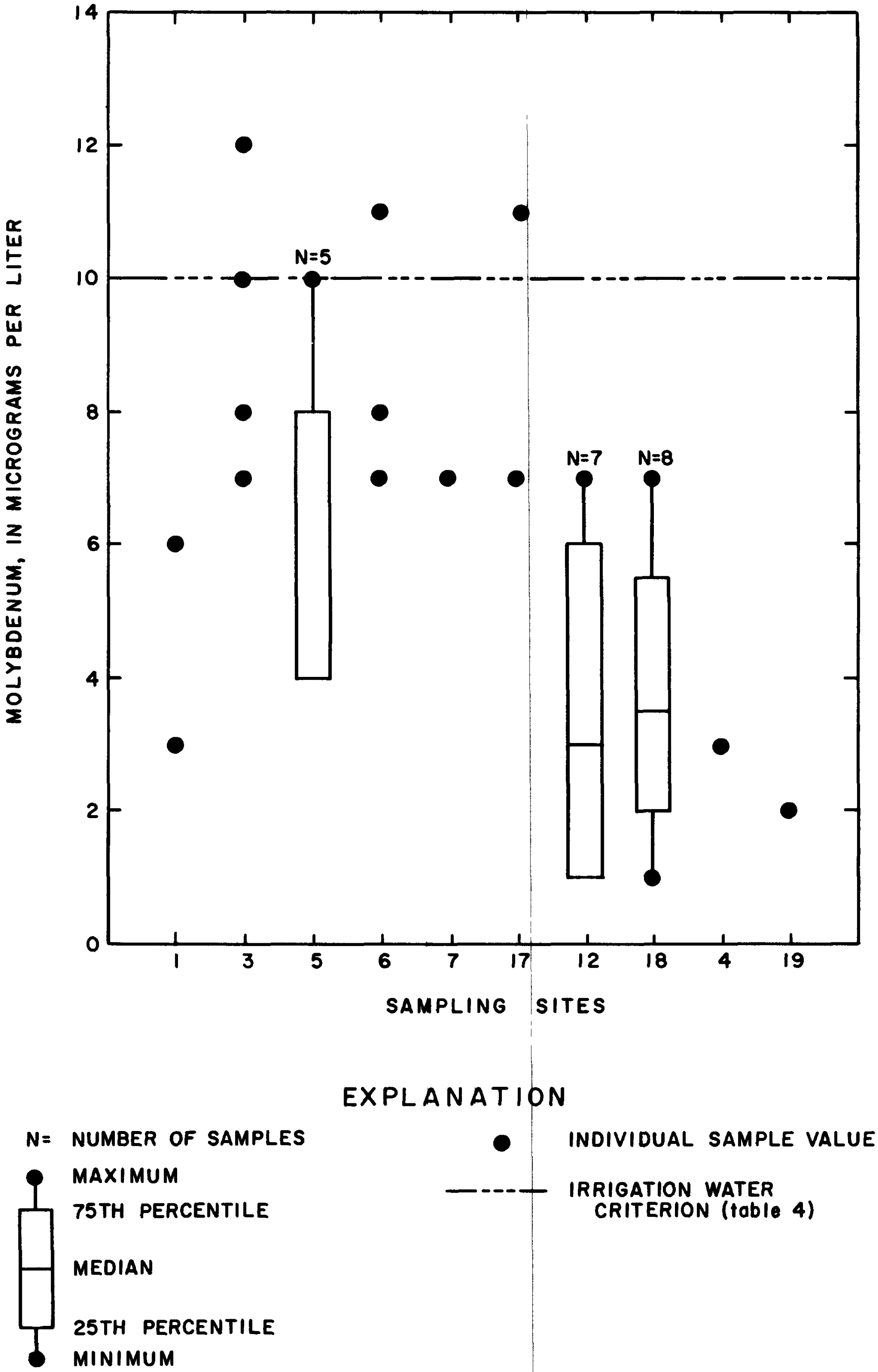


Figure 13.--Distribution of molybdenum at each surface-water-quality sampling site, 1987-89.

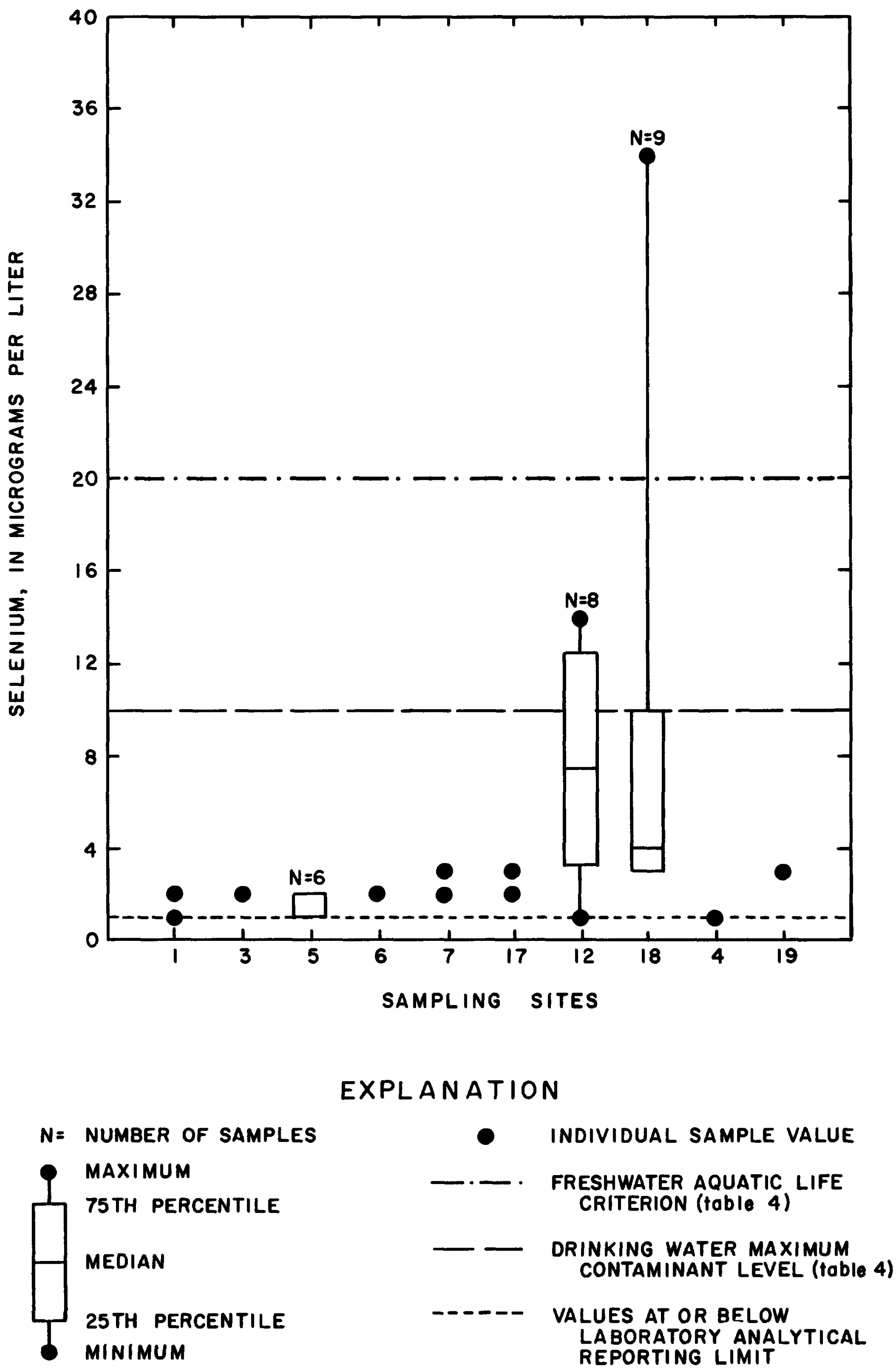


Figure 14.--Distribution of selenium at each surface-water-quality sampling site, 1987-89.

Although only three selenium samples were collected from Horse Creek during the irrigation season, a comparison of these samples with the five samples collected during the non-irrigation season indicates that there is a significant difference in selenium concentrations at Horse Creek. The concentrations of samples collected during the irrigation season were 1, 3, and 4 μg/L, while the concentrations of samples collected during the non-irrigation season were 6, 9, 11, 13, and 14 μg/L. These larger selenium concentrations during the non-irrigation season would indicate that ground-water seepage, probably derived from irrigation water, sustains the streams baseflow during the non-irrigation season.

The largest selenium concentration of the investigation period (34 μg/L) was measured in a sample collected in March 1988 at the Belle Fourche River near Sturgis during ice breakup. During this breakup, the stage of the river rose several feet because of ice jams, allowing the river water to dissolve crustal deposits of salts that had accumulated along the banks at small seeps. These deposits, called efflorescences, commonly are seen in the project area; a sample was collected in April 1989 at site 11 (fig. 7). Predominant minerals in the sample were bloedite and konyaite, which are hydrated magnesium sodium sulfate; and the concentration of selenium in the salts was 4.4 μg/g (Theresa Presser, U.S. Geological Survey, oral commun., 1989). The concentration of selenium is very large in these salts, probably because it accumulates in the sulfate lattice of the efflorescence (Marc Sylvester, U.S. Geological Survey, oral commun., 1989). These efflorescences can then be washed into streams during storms or ice-breakups, resulting in short-term increases in selenium concentrations.

Selenium concentrations measured during this investigation are much smaller than reported concentrations from some of the other reconnaissance investigations, which may be the result of three factors. The first is that concentrations of selenium in shales within the investigation area probably are much smaller than the observed maximum in Pierre Shale of 160 μg/g reported by Schultz and others (1980). Of the eight samples collected near the project area by Schultz and others (1980), concentrations ranged from less than 1 to 10 μg/g. A second factor is the possibility that readily soluble selenium in the top layers of project lands was leached away during the early years of irrigation. Selenium concentrations in drainage water would have thus decreased during the 80 years of project operation. A third factor is the difference in hydrologic setting between the Belle Fourche Reclamation Project and other irrigation drainage reconnaissance-investigation areas in which much larger selenium concentrations were measured. Typically in these other areas, drainage water is ponded in a lake or wetland area where selenium is concentrated biologically or by evaporation. In the Belle Fourche Reclamation Project, no comparable concentration occurs because drainage water flows down the Belle Fourche and Cheyenne Rivers into the Oahe Reservoir. In other words, the Belle Fourche investigation area is a flow-through drainage system, rather than an internal drainage system. Given these differences, although some selenium concentrations do exceed water-quality criteria or standards, it is unlikely that selenium concentrations in streams in the Belle Fourche Reclamation Project area will approach those found in some of the other investigations.

Dissolved uranium

Uranium is an element that occurs as several isotopes, of which uranium-238 is predominant. The drinking-water Suggested No-Adverse-Response Level (SNARL) criterion of 35 μg/L (table 4) is based on the fact that uranium-238 is radioactive. Uranium concentrations in most natural water ranges between 0.1 and 10 μg/L (Hem, 1985).

Uranium concentrations were less than 12 µg/L, except in 4 samples collected during the non-irrigation season. Three of the 4 samples were from the drainage sites (12 and 18) and one was from the background site Crow Creek (site 4) (fig. 15). The maximum concentration of 30 µg/L was measured in the April 1988 sample at Horse Creek (site 12).

Pesticides

Pesticides can be toxic or carcinogenic in extremely small concentrations, and some persistent pesticides such as DDT can become concentrated in biological tissues. Whole-water samples from six of the surface-water sampling sites were analyzed for 22 pesticides known to be used in the project area, including Sevin, carbofuran, and aldicarb herbicides (table 7). Of the 20 samples analyzed, only four pesticides--alachlor, atrazine, cyanazine, and prometone--were detected (table 13), and all of these detections were in small concentrations.

The only detected concentrations of alachlor, 0.3 µg/L, were in samples collected from drainage sites Horse Creek (site 12) and the Belle Fourche River near Sturgis (site 18). Atrazine was detected in concentrations greater than the analytical reporting limit at 3 of the 6 sites, most frequently in June (fig. 16). The maximum concentration (0.3 µg/L) was measured at the Redwater River (site 3), an inflow site, and at site 18. The only measured concentrations of cyanazine, 0.5 µg/L, was in a sample collected from site 18. The only detected concentrations of prometone, 0.1 µg/L, were in two samples collected from site 3.

All but one of the pesticide detections were measured in samples collected during the irrigation season (table 13). Most likely, pesticide residues were transported by irrigation drainage, although they could also seep or be blown into surface water. Ground-water and soil sampling would be needed to determine if these pesticides persisted in the area during the rest of the year.

Bottom Sediment

Because of geochemical processes, including precipitation and sorption, bottom sediment may contain appreciable amounts of contaminants even when overlying water does not. These contaminants may then enter the food chain through uptake by benthic invertebrates or other bottom feeders, or contaminants may be dissolved back into the water column by a change in ambient water-quality conditions.

Bottom sediment samples from eight sites were analyzed for trace-inorganic elements, such as arsenic, mercury, and selenium, and from seven sites for pesticides atrazine and carbofuran. These results are presented in the Supplemental Data section (table 15). A statistical summary of the trace-inorganic sampling (table 11) contains results which are similar to those of the U.S. Department of Energy (1980). No pesticides were detected in bottom sediment.

Concentrations of aluminum were largest at Sulphur Creek (site 19), a background site, and concentrations of molybdenum were largest at Crow Creek (site 4), also a background site. Concentrations of calcium, magnesium, and strontium were largest at Redwater River (site 3), an inflow site. These concentrations probably relate closely to the geology and soils in the respective basins.

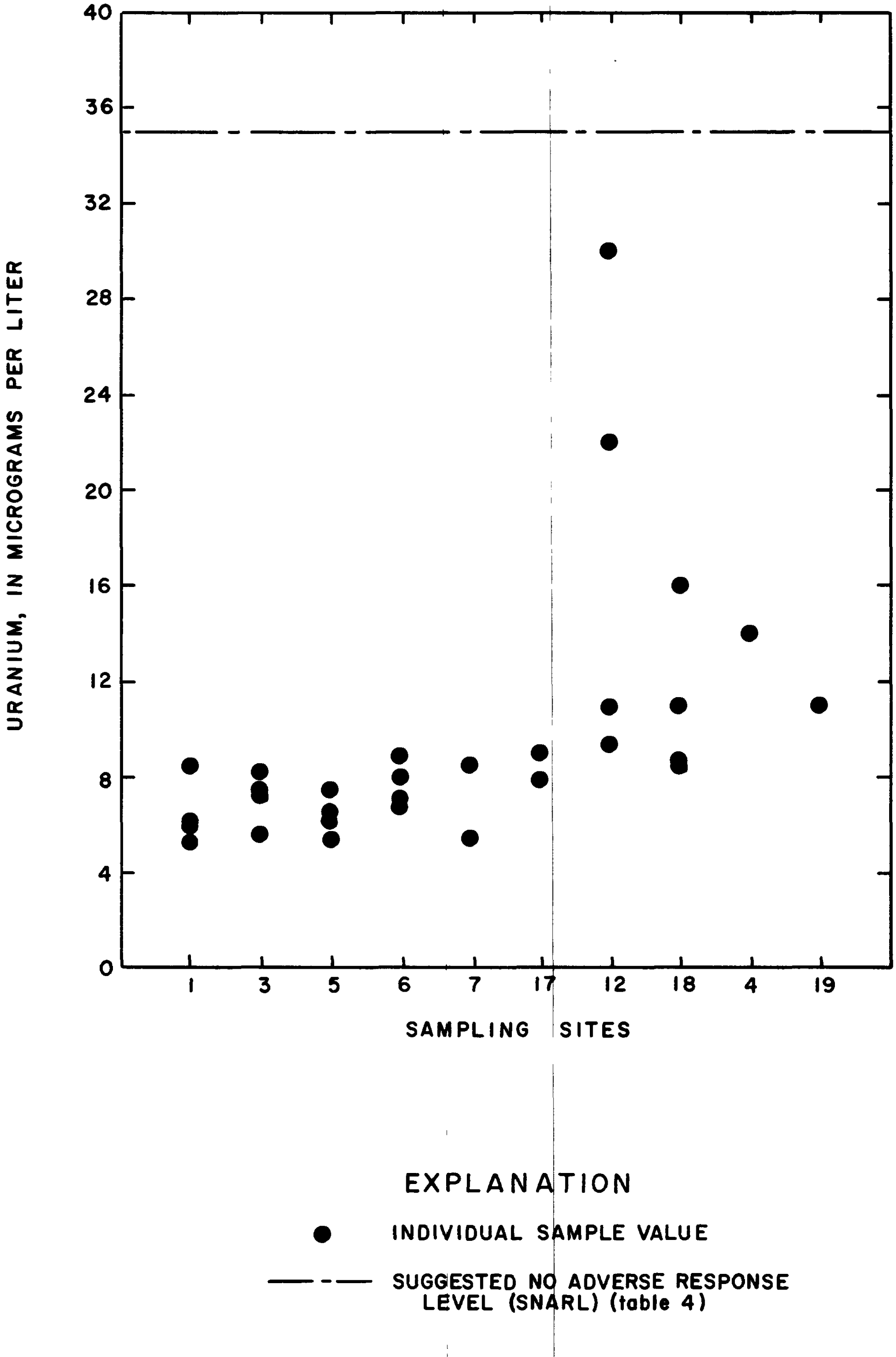


Figure 15.--Distribution of uranium at each surface-water-quality sampling site, 1988.

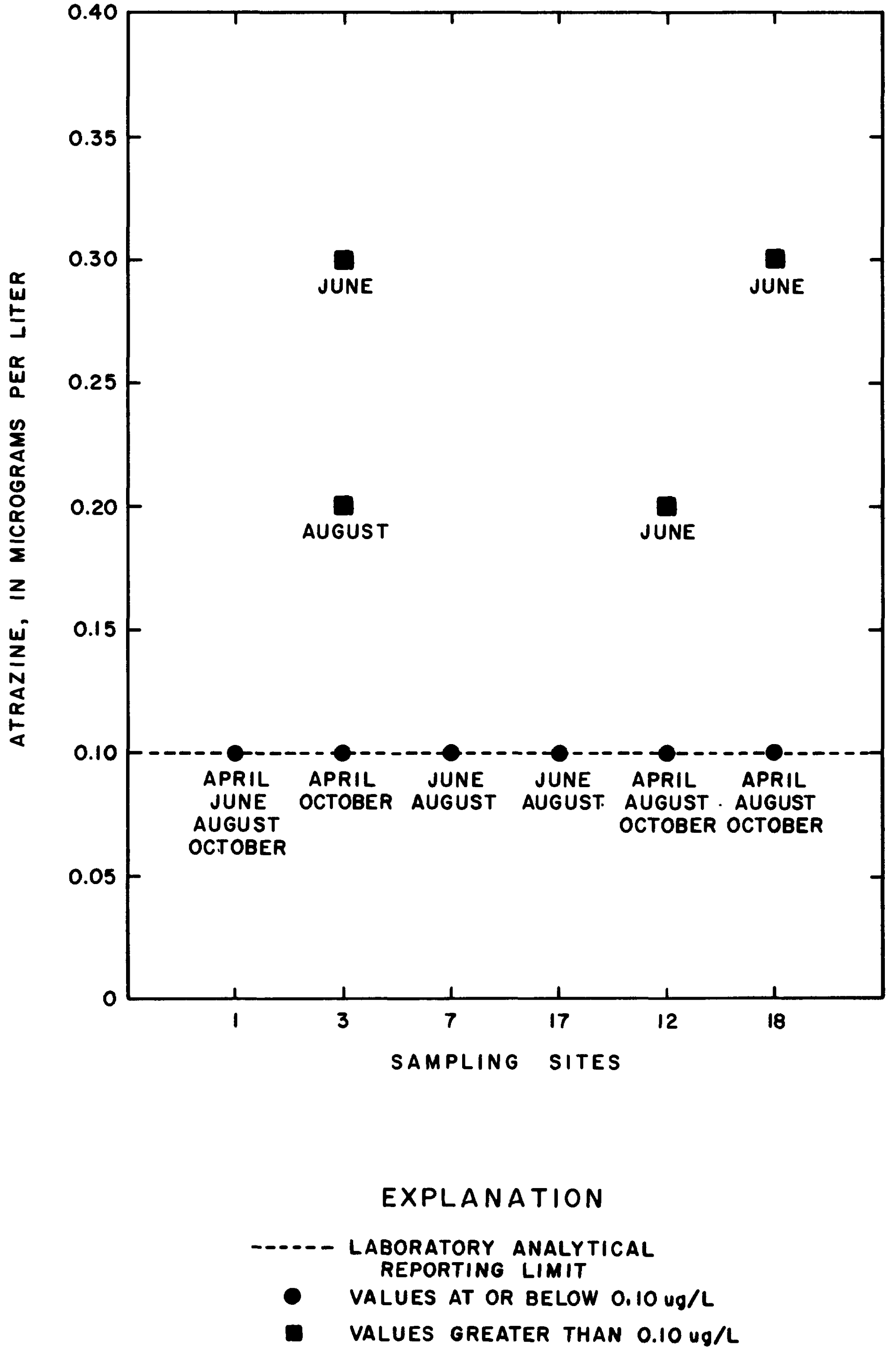


Figure 16.--Concentrations of atrazine in whole-water samples collected at surface-water-quality sampling sites, 1988.

Table 11.--Statistical summary of selected elements in bottom-sediment samples, Belle Fourche Reclamation Project investigation area, 1988-89[1]

[Concentrations of aluminum through sodium in weight percent; concentrations of arsenic through zinc in micrograms per gram; mm, millimeter; <, less than analytical reporting limits]

Element	Particle size (mm)	Minimum	Median	Maximum
Aluminum	<2	2.7	4.1	5.9
	<.062	3.6	5	6.3
Calcium	<2	2.4	3	13
	<.062	1.9	4.2	12
Carbon	<2	1.1	1.9	6
	<.062	1.2	2.1	4.4
Iron	<2	1.4	4.2	8.7
	<.062	1.5	2.9	6.8
Magnesium	<2	0.3	0.8	1.3
	<.062	.6	1.1	1.7
Phosphorus	<2	0.07	0.1	0.5
	<.062	.08	.09	.2
Potassium	<2	1.3	1.6	1.8
	<.062	1.4	1.6	1.8
Sodium	<2	0.4	0.5	1.2
	<.062	.4	.5	1.2
Arsenic	<2	7.5	22	180
	<.062	5.9	12	370
Barium	<2	110	595	1,670
	<.062	91	560	1,140
Boron	<2	0.6	1.9	3.6
	<.062	.7	1.6	5.6
Chromium	<2	21	40	54
	<.062	32	55	62
Cobalt	<2	7	16	20
	<.062	7	14	19
Copper	<2	10	18	22
	<.062	11	19	31
Lead	<2	10	17	47
	<.062	11	16	19
Manganese	<2	320	1,150	1,800
	<.062	220	708	1,770

Table 11.--Statistical summary of selected elements in bottom-sediment samples, Belle Fourche Reclamation Project investigation area, 1988-89[1]--Continued

Element	Particle size (mm)	Minimum	Median	Maximum
Mercury	<2	<0.02	0.015	0.10
	<.062	<.02	<.02	.20
Molybdenum	<2	<2	2	9
	<.062	<2	<2	5
Selenium	<2	0.7	0.9	3.5
	<.062	.6	.9	2.8
Strontium	<2	206	220	460
	<.062	180	246	460
Uranium	<2	1.1	2.3	5.6
	<.062	1.2	2	5.3
Vanadium	<2	33	80	133
	<.062	40	100	140
Zinc	<2	33	91	150
	<.062	35	87	112

[1]Eight samples were collected throughout the investigation area. Three splits of the sample from the Belle Fourche Resevoir were analyzed, and the average of the results was used in the summary.

Some concentrations of arsenic exceeded the baseline range, and concentrations were largest at the drainage site Belle Fourche River near Sturgis. Large concentrations of arsenic, as well as the presence of mercury, in bottom sediment at this site probably were a result of bank sloughing of contaminated flood-plain sediment originating from gold-mining activities in the Black Hills, particularly in the Whitewood Creek drainage.

The maximum concentrations of arsenic (370 μg/g), barium (1,670 μg/g), molybdenum (9 μg/g), selenium (3.5 μg/g), and uranium (5.6 μg/g) measured in samples from Crow Creek, Horse Creek, and the Belle Fourche River near Sturgis were near or exceeded the upper limit of the baseline ranges measured in western United States soils (R.C. Severson, U.S. Geological Survey, written commun., 1987; based on information in Shacklette and Boerngen, 1984). Irrigation drainage from the Belle Fourche Reclamation Project area may have been a factor contributing to these maximum concentrations.

Biota

Samples of four different groups of biota, including fish, birds, invertebrates, and plants, were collected throughout the investigation area. The results of the sampling are presented in the Supplemental Data section (tables 16 and 17). Where possible, results of the fish sampling were compared to results of the National Contaminant Biomonitoring Program (Lowe and others, 1985). Analysis of bird livers and eggs were compared to data from the San Joaquin Valley, where appropriate. Selected results of analysis of invertebrates and plants were noted as an indication of possible biomagnification or bioconcentration.

In the process of biomagnification, a constituent concentration increases with each step up the food chain, resulting in concentrations in predator fish or birds that can be many times larger than surface-water concentrations. A constituent may be accumulated by an organism by means other than food. Thus, a fish can accumulate a contaminant through the gill membranes in concentrations that can be hundreds of times greater than the ambient water concentrations. Because of biomagnification, analyses of biological samples can detect toxic levels of constituents, such as DDT, even when these constituents were undetectable in surface water.

One major disadvantage to biological sampling of mobile organisms is that the source and areal extent of contamination is uncertain. In this respect, organisms that are less mobile, such as plants and invertebrates may be more indicative of local contamination than are mobile organisms.

Populations of fish, invertebrates, and plants in the project area did not appear to be seriously affected by the drought of 1988. Likewise, the drought had little effect on the waterfowl populations in the vicinity of the Belle Fourche Reclamation Project because drainwater or irrigation water, both habitat controls, were not significantly affected by the drought. The small number of waterfowl collected and the lack of eggs from nests within the irrigated areas were a function of a limited habitat resulting in small waterfowl populations throughout the investigation area.

Inorganic Elements

Discussions of chemical elements and pesticides sampled in biota are limited to what is considered to be associated with irrigation drainage. The following discussions of elements are limited to aluminum, arsenic, cadmium, copper, mercury, selenium, and zinc because of their toxicity to fish and wildlife, the potential for these elements to occur at elevated concentrations compared to the National Contaminant Biomonitoring Program (NCBP) 85th-percentile baseline value, or large concentrations of elements at the sample sites. Under each of these elements, residues found in specific taxa (fish, aquatic invertebrates, aquatic plants, and bird livers or eggs) are discussed. When available, literature is cited to help explain the potential effects of element concentrations to the biological organism or the potential relationship to other organisms in the aquatic system.

Aluminum

Aluminum concentrations in fish were larger than in most samples previously collected in western South Dakota by the U.S. Fish and Wildlife Service. The concentration of aluminum in fish samples from sites 2, 12, and 18 ranged from less than 3 to 4,100 μg/g dry weight, and the median concentration was 131 μg/g (table 12). The maximum sample concentration of 4,100 μg/g was measured from a river carpsucker from Horse Creek drainage site 12 (table 16). Median concentrations decreased downstream and generally were smaller in samples collected during the fall sampling period. (fig. 17). Aluminum concentrations generally were greater in aquatic invertebrates and aquatic plants. The reasons for this difference is not known.

Table 12.--Median and range of aluminum, arsenic, cadmium, copper, mercury, selenium, and zinc concentrations for all biota sampled in the Belle Fourche Reclamation Project investigation area, 1988

[Concentrations in micrograms per gram (dry weight); --, no data; N = number of samples]

Element		Fish	Invertebrates	Plants	Bird livers	Bird eggs
		N = 128	N = 8	N = 11	N = 8	N = 10
Aluminum	Median:	131	229	725	<21.5	[1]<30.5
	Range:	<3 - 4,100	<37.0 - 2,980	94.0 - 2,020	<21.5	<30.5
Arsenic	Median:	0.3	1.11	5.03	0.239	[2]0.067
	Range:	<0.2 - 7.6	0.479 - 33.3	1.94 - 115	0.094 - 0.485	0.35 - 0.323
Cadmium	Median:	<0.5	<2.53	<2.75	<1.02	[1]<1.52
	Range:	<0.5 - 1.5	<2.53 - 6.20	<2.75	<0.80 - 1.61	<1.52
Copper	Median:	2.23	21.3	<13.2	43.6	[1]<7.62
	Range:	0.66 - 6.12	6.74 - 29.5	<13.2 - 22.9	9.90 - 155	<7.62
Mercury	Median:	0.32	<0.253	<0.275	0.654	[2]0.210
	Range:	0.038 - 1.1	<0.253	<0.275	0.348 - 2.77	<0.045 - 0.789
Selenium	Median:	2.8	3.2	0.90	14.4	3.0
	Range:	1.4 - 5.7	<2.2 - 5.4	<0.51 - 2.0	6.5 - 27.5	<0.18 - 10.0
Zinc	Median	75.7	121	36.5	133	[1]75
	Range:	42 - 601	37.3 - 189	20.6 - 50.5	92.6 - 214	60 - 85.9

[1]N = 8.
[2]N = 9.

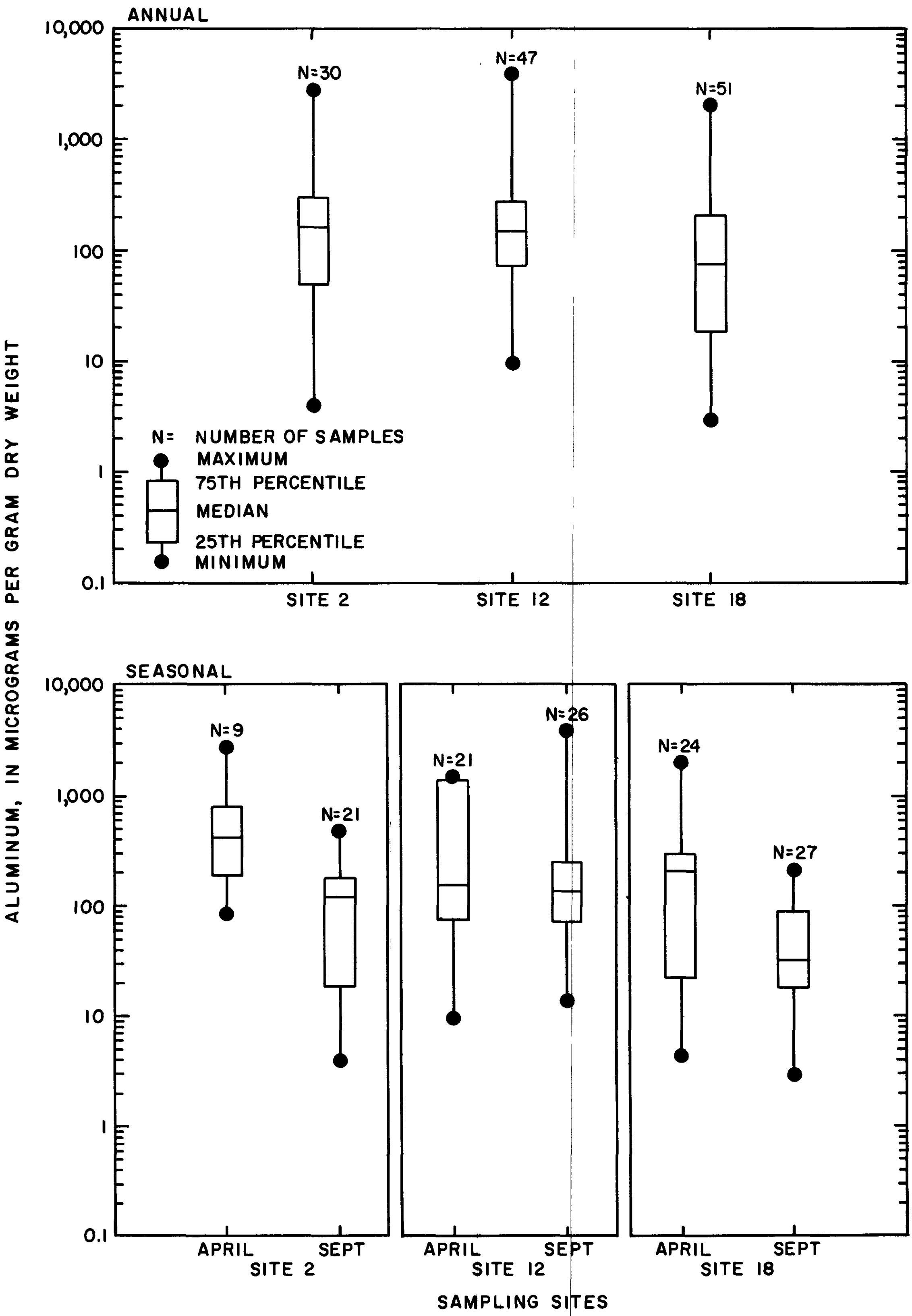


Figure 17.--Distribution of aluminum concentrations in fish tissue from sample sites, 1988.

The largest aluminum concentration for invertebrates (2,980 μg/g) and plants (2,020 μg/g) were from samples from Horse Creek (site 12). The second largest concentration of aluminum sampled in plants (1,640 μg/g) was at Nisland Pond (site 8). The large aluminum concentration in invertebrates at site 12 was substantially larger than aluminum concentrations in invertebrates at the other biological sampling sites.

Arsenic

Arsenic concentrations in fish at sampling sites ranged from less than 0.2 to 7.6 μg/g (table 12). The distribution of arsenic concentrations in fish tissue (fig. 18) showed the majority of samples from the Belle Fourche River near Sturgis (site 18) were greater than the 85th-percentile concentration of 0.81 μg/g dry weight reported by the National Contaminant Biomonitoring Program (Lowe and others, 1985).

There is no criterion for acceptable whole-body arsenic concentrations in fish for human consumption, but the U.S. Department of Agriculture (1988) recommends that arsenic in edible portions of swine and poultry not exceed 0.50 μg/g wet weight. Using this limit, 54 percent of the fish collected from the Belle Fourche River near Sturgis (site 18) in the spring would not be recommended for human consumption. Several of the fish had whole-body concentrations that were three times as great as the recommended limit. Although arsenic concentrations were smaller in fish from site 18 during the fall, several of these fish also had arsenic concentrations greater than the recommended limit and the median value was greater than the NCBP 85th-percentile concentration of 0.81 μg/g dry weight (fig. 18).

Arsenic concentrations in invertebrates tended to be larger than in fish (table 16), especially during the fall. The concentration in the invertebrate sample collected at site 18 in the fall was 33.3 μg/g, while the median concentration in the fish at this site that had presumably fed on invertebrates was only 1.22 μg/g. Arsenic concentrations in aquatic plants collected at sites on the Belle Fourche River (sites 2 and 18) generally were larger than concentrations observed in invertebrates that supposedly fed on the plants. The arsenic concentration in Sago pondweed collected at the Horse Creek site (site 12) was similar to the concentration in invertebrates collected from this site.

Arsenic concentration in bird livers ranged from 0.094 to 0.485 μg/g dry weight. All of these values are less than the concern level of 7.2 to 36.0 μg/g dry weight of arsenic residue in bird livers (Geode, 1985).

Large concentrations of arsenic in fish, invertebrates, and plants at site 18 indicate that there is a large amount of biologically available arsenic in that reach of the river, presumably from contaminated flood-plain sediment originating from mining activities in the Black Hills. The general decrease of arsenic concentrations with higher trophic levels, supports Eisler's (1988) assertion that bioconcentration by organisms rather than biomagnification in the food chain is more important in arsenic cycling.

Cadmium

Cadmium concentrations in fish, invertebrates, plants, and bird livers and eggs generally were less than the analytical reporting limits. The median concentration and majority of sample concentrations were below the NCBP 85th-percentile value of 0.24 μg/g dry weight in fish (Lowe and others, 1985). The maximum value of cadmium concentration was 1.5 μg/g dry weight, sampled at site 2, upstream of irrigation return flow.

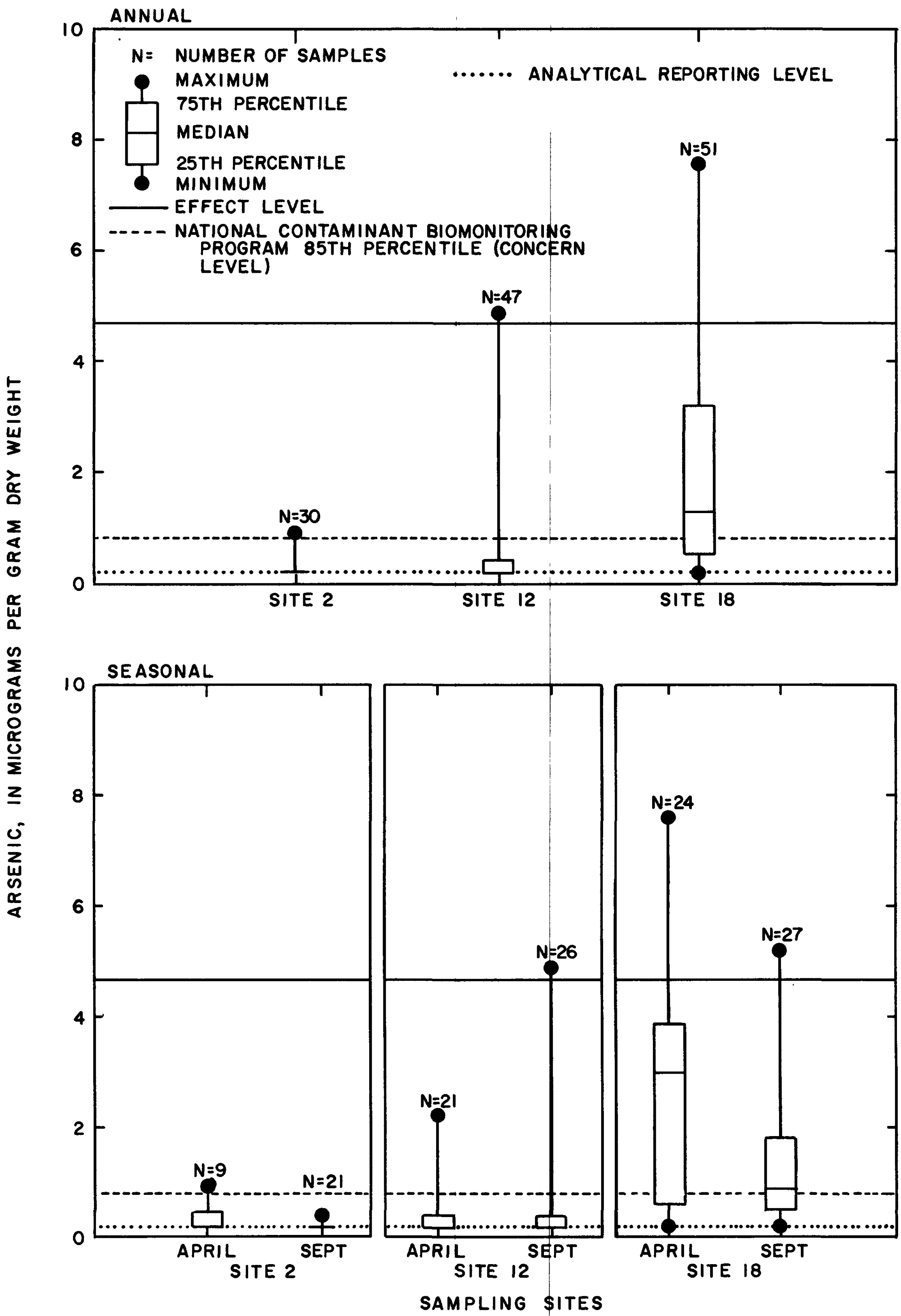


Figure 18.--Distribution of arsenic concentrations in fish tissue from sample sites, 1988.

Copper

Lowe and others (1985) show that the National Contaminant Biomonitoring Program 85th-percentile baseline value for copper in fish is 3.67 μg/g dry weight. Median concentrations of copper in fish tissue at sample sites 2, 12, and 18 were less than this baseline value (fig. 19). Even though 75 percent of the samples from each sampling site had concentrations below the NCBP 85th-percentile value, all three sites had sample concentrations greater than the baseline value (fig. 19).

Mercury

Mercury concentrations in fish ranged from 0.038 to 1.1 μg/g at sampling sites 2, 12, and 18 (table 12). The median concentration of mercury at the Belle Fourche River near Sturgis (site 18) was much greater than the median concentrations at sites 2 and 12 and was only slightly less than the 85th-percentile of 0.65 μg/g dry weight for the National Contaminant Biomonitoring Program (Lowe and others, 1985) (fig. 20). The median concentration (0.637 μg/g dry weight) from site 18 converts to 0.16 μg/g wet weight and is far less than the U.S. Food and Drug Administration (1988) action level of 1.0 μg/g wet weight.

Based on the seasonal values of mercury concentrations in fish at all three sampling sites and the fact that mercury concentrations were similar at the inflow site 2 and the drainage site 12, it appears that irrigation water makes only a slight contribution to the increased mercury concentrations in the fish at site 18. It is probable that the majority of the increased mercury concentration in the fish noted at site 18 is a result of the mobilization of mercury from contaminated sediment in the flood plains of the Belle Fourche River.

Although the reporting limits of some of the analyses for mercury in invertebrates and plants were relatively large, the mercury concentrations in invertebrates and plants collected at sites 2, 12, and 18 were all less than 0.275 μg/g (table 12). No samples of mercury in bird livers collected within the investigation area exceeded 4.3 μg/g, which is the mean liver residue level of mercury in female mallard ducks associated with reduced reproduction (Heinz, 1979).

Selenium

The median concentration of selenium in fish tissue sampled at sites 2, 12, and 18 (table 12) was equal to the National Contaminant Biomonitoring Program 85th-percentile value of 2.8 μg/g dry weight (Lowe and others, 1985). The median values of selenium concentrations in fish were above the NCBP 85th-percentile value at Horse Creek (site 12) and the Belle Fourche River near Sturgis (site 18) (fig. 21); both of these sites receive irrigation return flow. Baumann and May (1984) evaluated cases of obvious selenium fish toxicity problems and suggested that residue levels of 7.1 μg/g dry weight or more might cause toxic effects, whereas Lillebo and others (1988) suggest that the effect level of selenium residue in whole fish tissue is 10.0 μg/g dry weight. The greatest value of selenium in whole-body fish tissue was 5.7 μg/g sampled at site 18, downstream of all irrigation return flow. This value of 5.7 μg/g is below the suggested values of selenium toxicity in fish tissue.

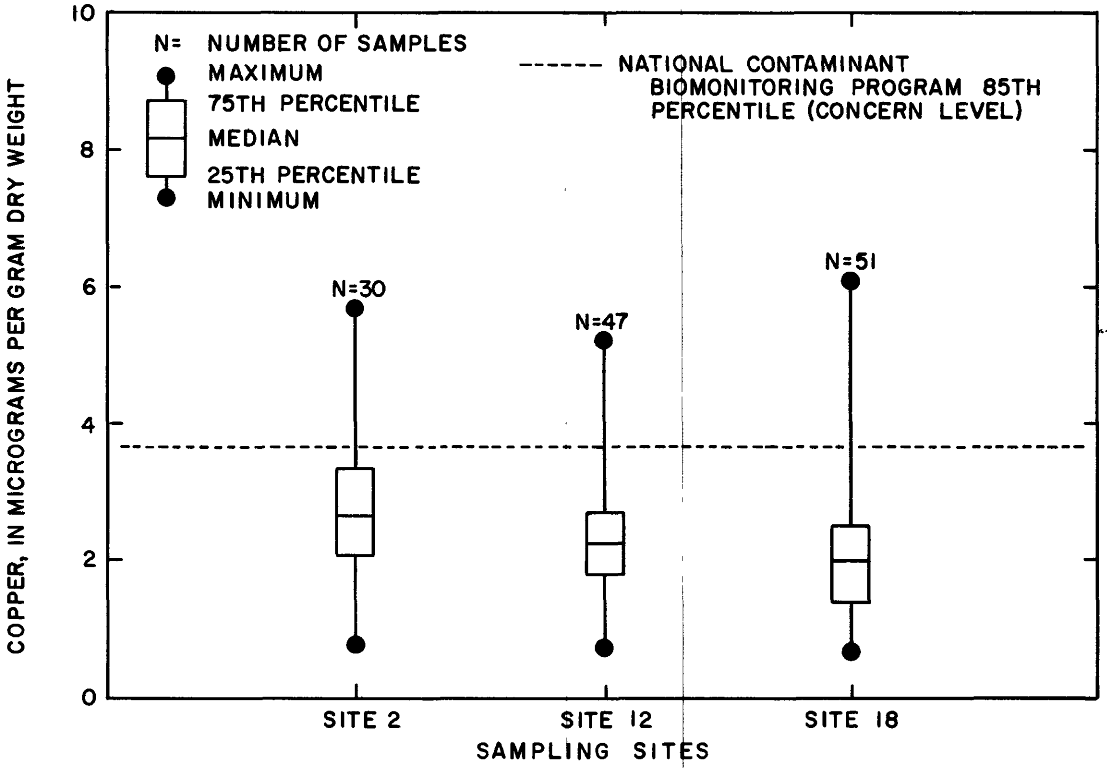


Figure 19.--Distribution of copper concentrations in fish tissue from sample sites, 1988.

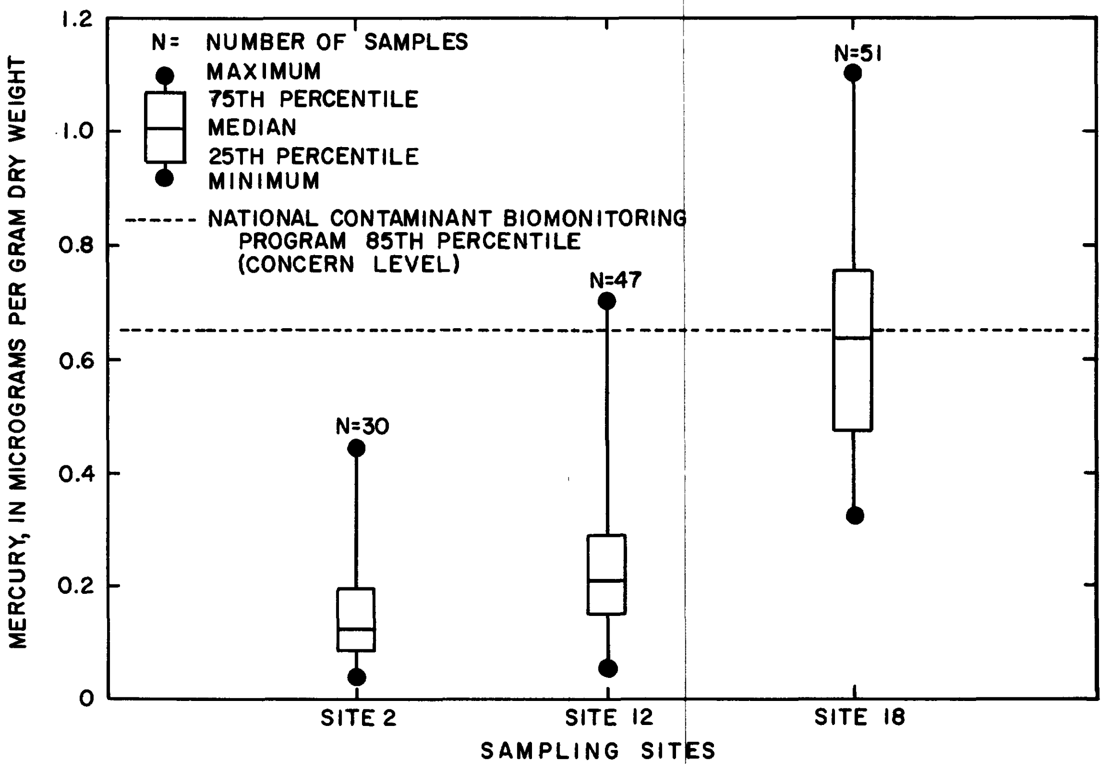


Figure 20.--Distribution of mercury concentrations in fish tissue from sample sites, 1988.

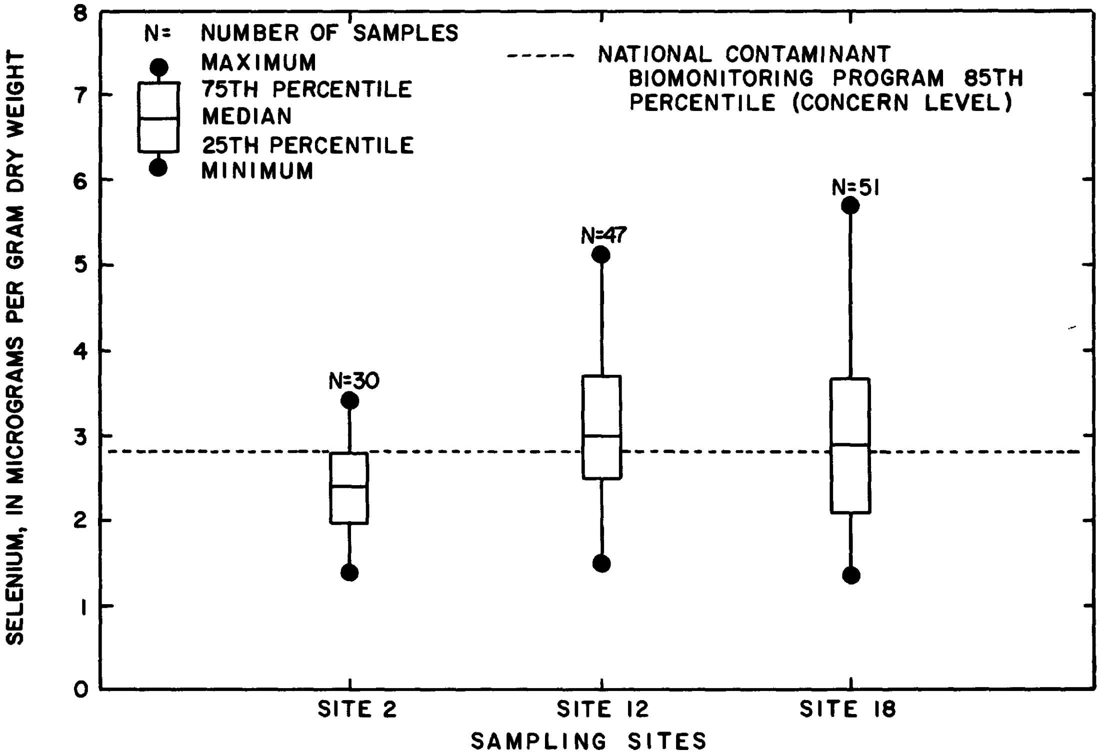


Figure 21.--Distribution of selenium concentrations in fish tissue from sample sites, 1988.

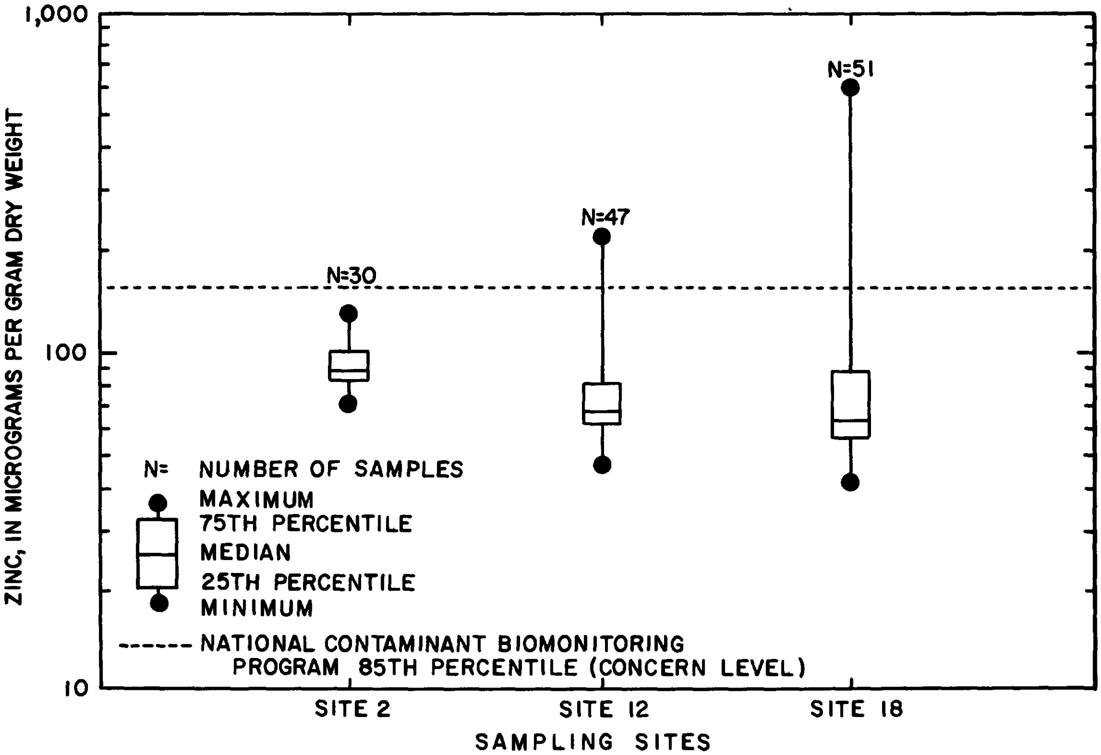


Figure 22.--Distribution of zinc concentrations in fish tissue from sample sites, 1988.

The selenium concentrations in the aquatic invertebrates ranged from less than 2.2 to 5.4 μg/g dry weight and in plants ranged from less than 0.51 to 2.0 μg/g dry weight. These concentrations generally are similar to concentrations of selenium in fish from sites 2, 12, and 18. These concentrations are less than the 7.0 μg/g dry weight dietary effect level for the protection of birds (Hoffman and others, 1990).

The maximum selenium concentration in four blackbird egg samples at the Golf Course Pond near Newell (site 9) was 3.8 μg/g; their diet is unknown, but it is assumed to be primarily terrestrial organisms. The maximum selenium concentration in three samples of pied-billed grebe eggs at Section 18 Pond near Newell (site 10) was 10 μg/g. This level would approach the concentration which might cause embryo toxicity in coot eggs (Ohlendorf, Hothem, Bunck, Aldrich, and Moore, 1986). The maximum selenium concentration in duck eggs, all recovered from the abdominal cavities of female ducks, was 8.0 μg/g. These concentrations may not represent concentrations that would be found in completely matured eggs.

The selenium concentrations in the livers of eight ducks from four sites ranged from 6.5 to 27.5 μg/g (table 12). Three of these samples were in the range of selenium concentrations in duck livers found in the Kesterson Wildlife Refuge, California, in 1983 (Ohlendorf, Hoffman, Saiki, and Aldrich, 1986), where embryo toxicity was suggested to be attributed to selenium concentrations in the liver. While these birds may have accumulated large selenium burdens from wintering grounds or areas outside the project area, their large selenium burdens also could be accumulating from the Belle Fourche Reclamation Project area, given that this area contains soils and geologic formations that are enriched in selenium.

Zinc

The National Contaminant Biomonitoring Program 85th-percentile baseline value of zinc concentrations in whole-body fish tissue is 155 μg/g dry weight (Lowe and others, 1985). The majority of samples collected at the biological sample sites had zinc concentrations less than this baseline value (fig. 22). The largest median concentration (89.2 μg/g dry weight) was from site 2, an inflow site.

Pesticides and Polychlorinated Biphenyls

Two fish collected at site 18 during the spring and one fish each collected at sites 2, 12, and 18 during the fall were analyzed for organochlorine pesticides and PCB's (table 17 in the Supplemental Data section). The concentrations of the pesticides and PCB's were less than the laboratory analytical reporting limits in all but four fish. Detected concentrations of a DDT metabolite, P,P'-DDE, were 0.01 μg/g dry weight in one carp from Horse Creek (site 12) and one carp from the Belle Fourche River near Sturgis (site 18) and 0.02 and 0.03 μg/g dry weight in two goldeyes from site 18. In addition, detected concentrations of P,P'-DDD were 0.01 μg/g dry weight from the two goldeyes at site 18 and one detection of dieldrin at a concentration of 0.01 μg/g from one goldeye at site 18. All concentrations of pesticides and PCB's in blackbird and grebe egg samples were less than the analytical reporting limits.

SUMMARY AND CONCLUSIONS

In 1986, the Department of the Interior initiated nine reconnaissance investigations in response to concerns about potentially adverse effects of irrigation drainage on humans, fish, and wildlife; four of these areas were selected for more detailed investigations in 1988-90. Eleven new areas, including the Belle Fourche Reclamation Project in western South Dakota, were selected for reconnaissance investigation during 1988-89. The Belle Fourche Reclamation Project was selected for investigation because of concerns that large amounts of selenium, which are present naturally in the area's Cretaceous-age shales, might be leaching into the environment by irrigation drainage.

During the investigation, samples of surface water, bottom sediment, and biota were collected and analyzed for major inorganic constituents, trace-inorganic elements, and organic pesticides. Samples were collected upstream, within, and downstream of the project area. Ten surface-water sites were sampled by the U.S. Geological Survey before, during, and after the irrigation season in 1988. Additional water samples were collected at three of these sites during October 1987 through April 1989, and data from these samples were included in the analysis. Bottom sediment was sampled at ten sites after the 1988 irrigation season. Fish-tissue samples were collected at three sites before and after the 1988 irrigation season. Samples of aquatic invertebrates, aquatic plants, bird livers, and bird eggs were collected during the summer of 1988 at several locations throughout the investigation area.

Dissolved-solids concentrations in water samples exceeded 1,000 mg/L at all ten surface-water sites and in most of the samples. The largest concentrations were measured most frequently at Horse Creek above Vale and at the Belle Fourche River near Sturgis, two sites that receive irrigation drainage. The maximum concentration (5,970 mg/L) was measured in a sample collected from Horse Creek during the non-irrigation season. Dissolved-solids concentrations at Horse Creek and the Belle Fourche River near Sturgis were much smaller during the irrigation season than during the non-irrigation season.

The distribution and seasonal variation of major-ion concentrations were similar to dissolved-solids concentrations. Large maximum concentrations of major ions, including calcium (440 mg/L), magnesium (410 mg/L), sodium (890 mg/L), sulfate (4,000 mg/L), and chloride (750 mg/L), were measured at Horse Creek during the non-irrigation season.

Small concentrations, less than 1 mg/L, of dissolved nitrite plus nitrate (as nitrogen) were measured in samples from most surface-water sites. Larger concentrations, including the maximum of 11 mg/L, were measured in non-irrigation-season samples from the Belle Fourche River near Sturgis. Larger concentrations also were measured in samples from Horse Creek. The maximum concentration measured previously was 37 mg/L in a sample obtained at Horse Creek.

Concentrations of arsenic ranged from less than 1 μg/L to a maximum of 16 μg/L in samples from the Belle Fourche River near Sturgis. Concentrations of arsenic generally were larger at this site than at the other sampling sites because of the presence of extensive arsenic-contaminated sediments from gold mining activities in the Whitewood Creek watershed.

Concentrations of trace elements measured in water generally were small in comparison to water-quality criteria, standards, or recommended limits. The few instances in which water-quality guidelines for human consumption were exceeded occurred in water that is not used for domestic water supplies. The few instances in which water-quality guidelines for aquatic life were exceeded are minor and indicate that there probably are no adverse water-quality effects on aquatic life in the study area.

The largest concentrations of boron were measured in samples from Horse Creek (maximum of 1,500 µg/L) and from the Belle Fourche River near Sturgis. The maximum concentration of molybdenum was 12 µg/L in one sample from the Redwater River site upstream of the project area; concentrations decreased slightly within the project area, possibly because of plant uptake or chemical precipitation with calcium. The maximum concentration of selenium (34 µg/L) was measured in a sample collected during the non-irrigation season from the Belle Fourche River near Sturgis. Uranium concentrations were less than 12 µg/L for most samples; the maximum concentration (30 µg/L) was measured at Horse Creek during the non-irrigation season.

Twenty surface-water samples collected at six sites were analyzed for 22 pesticides and only four--alachlor, atrazine, cyanazine, and prometone--were detected. All but one of the detections were from samples collected during the irrigation season. Atrazine was measured in concentrations greater than the analytical reporting limit at three of the six sampled sites; the maximum concentration was 0.3 µg/L at the Redwater River and at the Belle Fourche River near Sturgis. Alachlor was detected at a concentration of 0.3 µg/L at Horse Creek and at the Belle Fourche River near Sturgis. Cyanazine was detected at a concentration of 0.5 µg/L in one sample from the Belle Fourche River near Sturgis. Prometone was detected at a concentration of 0.1 µg/L in two samples from the Redwater River.

Bottom-sediment samples from eight sites were analyzed for trace elements and samples from seven sites were analyzed for two pesticides. No pesticides were detected in any samples. The maximum concentrations of arsenic, barium, molybdenum, selenium, and uranium measured in samples from Crow Creek (a background site), Horse Creek, and the Belle Fourche River near Sturgis were near or exceeded the upper limit of the baseline ranges measured in western United States soils. The relatively large concentrations of arsenic and mercury in bottom sediment at the Belle Fourche River near Sturgis probably are a result of the mobilization of arsenic from flood-plain sediment contaminated with gold-mine tailings.

Samples of four different groups of biota, including fish, birds, invertebrates, and plants, were collected throughout the investigation area. Fish were collected at three sites, birds at five sites, and invertebrates and plants at six sites. With few exceptions, element concentrations in fish, invertebrates, and plants were less than values known to affect growth or reproduction.

Aluminum concentrations in fish ranged from less than 3 to 4,100 µg/g and generally were larger than concentrations in fish samples collected in western South Dakota in connection with other studies. Aluminum concentrations were greater in aquatic invertebrates and plants.

Arsenic concentrations in whole fish ranged from less than 0.2 to 7.6 µg/g; large concentrations of arsenic in fish from the Belle Fourche River near Sturgis probably were a result of mobilization of arsenic from contaminated flood-plain sediment originating from the past release of gold mine tailings. Arsenic concentrations in invertebrates and plants generally were larger than concentrations in fish.

Cadmium and copper concentrations in whole-body fish tissue generally were less than baseline values. The maximum value of cadmium (1.5 µg/g) measured in fish was at the Belle Fourche River upstream of irrigation return flow. Even though median values of copper concentrations in fish were less than the baseline value, all three sampling sites had individual fish sample concentrations greater than the baseline value.

Mercury concentrations in fish ranged from 0.38 to 1.1 μg/g. Median concentrations of mercury in fish were greater at the Belle Fourche River near Sturgis (0.67 μg/g) as compared to Horse Creek (0.21 μg/g) and the Belle Fourche River above Belle Fourche (0.13 μg/g). Elevated concentrations of mercury at the Belle Fourche River near Sturgis probably were also a result of mobilization of mercury from contaminated sediment from past gold mining activities.

The median concentrations of selenium in fish at Horse Creek (3.0 μg/g) and the Belle Fourche River near Sturgis (2.9 μg/g) exceeded baseline values. Measured concentrations of selenium in duck livers ranged from 6.5 to 27.5 μg/g. Three of these samples had selenium concentrations that were in the range of concentrations measured in duck livers from areas in the Kesterson Wildlife Refuge, California, where embryo toxicity was suggested to be attributed to selenium.

Zinc concentrations in whole-body fish tissue generally were less than baseline values. The largest median concentration (89.2 μg/g) was measured at site 2, an inflow site for biota data.

Five fish samples and two bird-egg samples were analyzed for organochlorine pesticides and polychlorinated biphenyls (PCB's). Most concentrations in fish and all concentrations in bird eggs were less than the analytical reporting limits. No significant elevated concentrations of pesticides or PCB's were measured in the fish samples. Data from the limited number of samples indicate that pesticides are not a problem in biota in the study area.

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SUPPLEMENTAL DATA

Table 13.--Water-quality data for reconnaissance investigation sampling of the Belle Fourche Reclamation Project investigation area, 1988

[Number in parentheses in column heading is parameter code identification. DEG C, degrees Celsius; MM, millimeters; MG/L, milligrams per liter; US/CM, microsiemens per centimeter at 25 °C; UG/L, micrograms per liter; --, no data; <, less than]

MISCELLANEOUS STATION ANALYSES

DATE	TIME	TEMPERATURE WATER (DEG C) (00010)	TEMPERATURE AIR (DEG C) (00020)	BAROMETRIC PRESSURE (MM OF HG) (00025)	DISCHARGE, INST. CUBIC FEET PER SECOND (00061)	OXYGEN, DISSOLVED (MG/L) (00300)	OXYGEN, DISSOLVED (PERCENT SATURATION) (00301)	SPECIFIC CONDUCTANCE (US/CM) (00095)	SPECIFIC CONDUCTANCE LAB (US/CM) (90095)	PH (STANDARD UNITS) (00400)
STATION 06428500, BELLE FOURCHE R AT WY-SD STATE LINE (LAT 44 44 59N LONG 104 02 49W)										
APR 1988										
27...	0930	6.5	6.5	680	49	10.9	100	1570	1600	8.48
JUN										
22...	0815	22.5	24.0	681	83	7.0	91	1490	1470	8.26
AUG										
31...	1025	16.0	24.0	--	83	8.6	--	1520	1470	8.49
OCT										
27...	1100	3.0	-2.0	--	14	11.7	--	1470	2060	8.07
STATION 06432900, REDWATER RIVER AB WILLOW CK AT BELLE FOURCHE (LAT 44 38 28N LONG 103 49 19W)										
APR 1988										
25...	1600	6.0	1.0	681	188	12.1	109	1080	1100	8.45
JUN										
20...	1515	27.5	31.5	678	4.7	9.1	131	1500	1610	8.20
AUG										
29...	1440	20.0	28.5	--	5.4	11.0	--	1600	1550	8.26
OCT										
27...	0845	6.5	0.0	--	147	10.4	--	1150	1170	8.39
STATION 06434496, CROW CREEK NR BELLE FOURCHE, SD (LAT 44 42 29N LONG 103 51 01W)										
APR 1988										
26...	1000	8.5	7.0	685	0.15	9.5	91	1810	2210	8.53
STATION 06434500, INLET CANAL NEAR BELLE FOURCHE (LAT 44 42 14N LONG 103 49 23W)										
APR 1988										
26...	1800	--	--	--	186	--	--	1280	1270	8.67
JUN										
22...	1045	25.0	29.0	682	41	6.4	87	1590	1560	8.14
AUG										
29...	1640	21.0	--	--	72	8.9	--	1600	1550	8.40
OCT										
25...	1630	10.0	12.0	--	143	14.6	--	1360	1310	8.54

Table 13.--Water-quality data for reconnaissance investigation sampling of the Belle Fourche Reclamation Project investigation area, 1988--Continued

MISCELLANEOUS STATION ANALYSES

DATE	PH LAB (STAND-ARD UNITS) (00403)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N) (00631)	CALCIUM DIS-SOLVED (MG/L AS CA) (00915)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG) (00925)	SODIUM, DIS-SOLVED (MG/L AS NA) (00930)	SODIUM AD-SORP-TION RATIO (00931)	SODIUM PERCENT (00932)	ALKA-LINITY LAB (MG/L AS CACO3) (90410)	POTAS-SIUM, DIS-SOLVED (MG/L AS K) (00935)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL) (00940)
STATION 06428500, BELLE FOURCHE R AT WY-SD STATE LINE (LAT 44 44 59N LONG 104 02 49W)										
APR 1988										
27...	8.20	<0.100	210	61	69	1	16	165	7.1	4.7
JUN										
22...	8.20	<0.100	120	46	140	3	38	115	10	27
AUG										
31...	8.30	<0.100	100	50	170	4	44	156	10	34
OCT										
27...	8.10	<0.100	210	78	150	2	28	133	12	18
STATION 06432900, REDWATER RIVER AB WILLOW CK AT BELLE FOURCHE (LAT 44 38 28N LONG 103 49 19W)										
APR 1988										
25...	8.30	0.170	180	42	7.3	0.1	2	184	1.9	2.8
JUN										
20...	8.20	<0.100	250	75	27	0.4	6	216	5.6	4.3
AUG										
29...	8.30	<0.100	270	66	17	0.2	4	188	3.6	4.9
OCT										
27...	8.10	0.320	200	48	7.7	0.1	2	206	6.8	3.4
STATION 06434496, CROW CREEK NR BELLE FOURCHE, SD (LAT 44 42 29N LONG 103 51 01W)										
APR 1988										
26...	8.10	<0.100	190	69	240	4	41	226	7.0	19
STATION 06434500, INLET CANAL NEAR BELLE FOURCHE (LAT 44 42 14N LONG 103 49 23W)										
APR 1988										
26...	8.20	0.120	190	50	31	0.5	9	177	3.8	4.0
JUN										
22...	8.30	<0.100	130	49	140	3	36	135	9.9	26
AUG										
29...	8.50	<0.100	130	53	140	3	35	162	10	31
OCT										
25...	8.10	0.210	210	54	32	0.5	8	190	5.0	14

Table 13.--Water-quality data for reconnaissance investigation sampling of the Belle Fourche Reclamation Project investigation area, 1988--Continued

MISCELLANEOUS STATION ANALYSES

DATE	SULFATE DIS-SOLVED (MG/L AS SO4) (00945)	ARSENIC DIS-SOLVED (UG/L AS AS) (01000)	BORON, DIS-SOLVED (UG/L AS B) (01020)	CADMIUM DIS-SOLVED (UG/L AS CD) (01025)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR) (01030)	COPPER, DIS-SOLVED (UG/L AS CU) (01040)	LEAD, DIS-SOLVED (UG/L AS PB) (01049)	MOLYB-DENUM, DIS-SOLVED (UG/L AS MO) (01060)	VANA-DIUM, DIS-SOLVED (UG/L AS V) (01085)	ZINC, DIS-SOLVED (UG/L AS ZN) (01090)
STATION 06428500, BELLE FOURCHE R AT WY-SD STATE LINE (LAT 44 44 59N LONG 104 02 49W)										
APR 1988										
27...	790	<1	180	<1	<1	1	<5	3	<1	<3
JUN										
22...	620	1	200	<1	2	1	<5	6	<1	<3
AUG										
31...	640	1	180	<1	<1	1	<5	3	<1	<10
OCT										
27...	1100	<1	250	<1	2	2	<5	3	<1	<10
STATION 06432900, REDWATER RIVER AB WILLOW CK AT BELLE FOURCHE (LAT 44 38 28N LONG 103 49 19W)										
APR 1988										
25...	440	2	50	<1	<1	1	<5	10	3	8
JUN										
20...	790	2	170	<1	2	<1	<5	8	2	5
AUG										
29...	790	2	120	<1	1	1	<5	7	2	52
OCT										
27...	500	2	70	<1	2	2	<5	12	2	13
STATION 06434496, CROW CREEK NR BELLE FOURCHE, SD (LAT 44 42 29N LONG 103 51 01W)										
APR 1988										
26...	1100	1	260	<1	<1	4	<5	3	<1	<10
STATION 06434500, INLET CANAL NEAR BELLE FOURCHE (LAT 44 42 14N LONG 103 49 23W)										
APR 1988										
26...	590	1	100	<1	<1	1	<5	--	2	9
JUN										
22...	690	2	210	1	2	1	<5	4	<1	36
AUG										
29...	690	1	180	<1	1	1	<5	4	<1	34
OCT										
25...	580	2	100	<1	1	1	<5	10	2	10

Table 13.--Water-quality data for reconnaissance investigation sampling of the Belle Fourche Reclamation Project investigation area, 1988--Continued

MISCELLANEOUS STATION ANALYSES

DATE	SELE-NIUM, DIS-SOLVED (UG/L AS SE) (01145)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L) (70300)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L) (70301)	MERCURY DIS-SOLVED (UG/L AS HG) (71890)	URANIUM NATURAL DIS-SOLVED (UG/L AS U) (22703)	PRO-PAZINE TOTAL (UG/L) (39024)	TRI-FLURA-LIN TOTAL RECOVER (UG/L) (39030)	METHO-MYL TOTAL (UG/L) (39051)	PROPHAM TOTAL (UG/L) (39052)	SIME-TRYNE TOTAL (UG/L) (39054)
STATION 06428500, BELLE FOURCHE R AT WY-SD STATE LINE (LAT 44 44 59N LONG 104 02 49W)										
APR 1988										
27...	2	1260	1240	<0.1	6.2	<0.10	<0.10	<2.0	<2.0	<0.1
JUN										
22...	2	1100	1030	<0.1	5.3	<0.10	<0.10	<0.5	<0.5	<0.1
AUG										
31...	1	1100	1100	<0.1	6.1	<0.10	<0.10	<0.5	<0.5	<0.1
OCT										
27...	1	1800	1650	<0.1	8.5	<0.10	<0.10	<0.5	<0.5	<0.1
STATION 06432900, REDWATER RIVER AB WILLOW CK AT BELLE FOURCHE (LAT 44 38 28N LONG 103 49 19W)										
APR 1988										
25...	2	858	785	<0.1	5.6	<0.10	<0.10	<2.0	<2.0	<0.1
JUN										
20...	2	1400	1280	<0.1	7.5	<0.10	<0.10	<0.5	<0.5	<0.1
AUG										
29...	2	1340	1260	--	8.2	<0.10	<0.10	--	--	<0.1
OCT										
27...	2	925	891	<0.1	7.3	<0.10	<0.10	<0.5	<0.5	<0.1
STATION 06434496, CROW CREEK NR BELLE FOURCHE, SD (LAT 44 42 29N LONG 103 51 01W)										
APR 1988										
26...	<1	1760	1760	<0.1	14	--	--	--	--	--
STATION 06434500, INLET CANAL NEAR BELLE FOURCHE (LAT 44 42 14N LONG 103 49 23W)										
APR 1988										
26...	2	1000	976	<0.1	5.4	--	--	--	--	--
JUN										
22...	2	1190	1130	<0.1	6.2	--	--	--	--	--
AUG										
29...	1	1260	1160	<0.1	6.6	--	--	--	--	--
OCT										
25...	2	1060	1010	<0.1	7.5	--	--	--	--	--

Table 13.--Water-quality data for reconnaissance investigation sampling of the Belle Fourche Reclamation Project investigation area, 1988--Continued

MISCELLANEOUS STATION ANALYSES

DATE	SIMA-ZINE TOTAL (UG/L) (39055)	PROME-TONE TOTAL (UG/L) (39056)	PROME-TRYNE TOTAL (UG/L) (39057)	ATRA-ZINE, TOTAL (UG/L) (39630)	SEVIN, TOTAL (UG/L) (39750)	ALA-CHLOR TOTAL RECOVER (UG/L) (77825)	CYAN-AZINE TOTAL (UG/L) (81757)	AME-TRYNE TOTAL (82184)	METRI-BUZIN WATER WHOLE TOT.REC (UG/L) (82611)	METOLA-CHLOR WATER WHOLE TOT.REC (UG/L) (82612)
STATION 06428500, BELLE FOURCHE R AT WY-SD STATE LINE (LAT 44 44 59N LONG 104 02 49W)										
APR 1988										
27...	<0.10	<0.1	<0.1	<0.10	<2.0	<0.10	<0.10	<0.10	<0.1	<0.1
JUN										
22...	<0.10	<0.1	<0.1	<0.10	<0.50	<0.10	<0.10	<0.10	<0.1	<0.1
AUG										
31...	<0.10	<0.1	<0.1	<0.10	<0.50	<0.10	<0.10	<0.10	<0.1	<0.1
OCT										
27...	<0.10	<0.1	<0.1	<0.10	<0.50	<0.10	<0.10	<0.10	<0.1	<0.1
STATION 06432900, REDWATER RIVER AB WILLOW CK AT BELLE FOURCHE (LAT 44 38 28N LONG 103 49 19W)										
APR 1988										
25...	<0.10	<0.1	<0.1	<0.10	<2.0	<0.10	<0.10	<0.10	<0.1	<0.1
JUN										
20...	<0.10	0.1	<0.1	0.30	<0.50	<0.10	<0.10	<0.10	<0.1	<0.1
AUG										
29...	<0.10	0.1	<0.1	0.20	--	<0.10	<0.10	<0.10	<0.1	<0.1
OCT										
27...	<0.10	<0.1	<0.1	0.10	<0.50	<0.10	<0.10	<0.10	<0.1	<0.1
STATION 06434496, CROW CREEK NR BELLE FOURCHE, SD (LAT 44 42 29N LONG 103 51 01W)										
APR 1988										
26...	--	--	--	--	--	--	--	--	--	--
STATION 06434500, INLET CANAL NEAR BELLE FOURCHE (LAT 44 42 14N LONG 103 49 23W)										
APR 1988										
26...	--	--	--	--	--	--	--	--	--	--
JUN										
22...	--	--	--	--	--	--	--	--	--	--
AUG										
29...	--	--	--	--	--	--	--	--	--	--
OCT										
25...	--	--	--	--	--	--	--	--	--	--

Table 13.--Water-quality data for reconnaissance investigation sampling of the Belle Fourche Reclamation Project investigation area, 1988--Continued

MISCELLANEOUS STATION ANALYSES

DATE	TIME	TEMPER-ATURE WATER (DEG C) (00010)	TEMPER-ATURE AIR (DEG C) (00020)	BARO-METRIC PRES-SURE (MM OF HG) (00025)	DIS-CHARGE, INST. CUBIC FEET PER SECOND (00061)	OXYGEN, DIS-SOLVED (MG/L) (00300)	OXYGEN, DIS-SOLVED (PER-CENT SATUR-ATION) (00301)	SPE-CIFIC CON-DUCT-ANCE (US/CM) (00095)	SPE-CIFIC CON-DUCT-ANCE LAB (US/CM) (90095)	PH (STAND-ARD UNITS) (00400)
STATION 06435000, BELLE FOURCHE RESERVOIR NEAR BELLE FOURCHE SD (LAT 44 44 10N LONG 103 40 10W)										
APR 1988										
26...	1335	9.0	--	--	--	--	--	1400	1410	8.53
JUN										
23...	0830	--	--	--	--	--	--	1430	1420	7.58
AUG										
31...	0800	18.0	--	--	--	8.0	--	1550	1470	8.39
OCT										
25...	0915	8.0	6.0	--	--	11.6	--	1480	1500	8.08
STATION 06436760, HORSE CR ABOVE VALE SD (LAT 44 39 08N LONG 103 21 59W)										
APR 1988										
28...	0850	9.0	8.5	692	2.2	10.4	101	4790	4930	8.24
JUN										
21...	0900	24.0	30.0	687	66	6.8	90	1720	1940	8.18
AUG										
30...	1050	15.5	21.0	--	51	9.5	--	2200	2030	8.35
OCT										
26...	1600	9.0	20.0	--	2.5	10.3	--	4980	4520	8.11
STATION 06436850, NORTH CANAL NR FRUITDALE, SD (LAT 44 44 12N LONG 103 40 19W)										
JUN 1988										
23...	1000	--	--	--	535	--	--	1420	1420	7.83
AUG										
30...	0825	18.0	13.0	--	370	8.6	--	1520	1480	8.30

Table 13.--Water-quality data for reconnaissance investigation sampling of the Belle Fourche Reclamation Project investigation area, 1988--Continued

MISCELLANEOUS STATION ANALYSES

DATE	PH LAB (STAND-ARD UNITS) (00403)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N) (00631)	CALCIUM DIS-SOLVED (MG/L AS CA) (00915)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG) (00925)	SODIUM, DIS-SOLVED (MG/L AS NA) (00930)	SODIUM AD-SORP-TION RATIO (00931)	SODIUM PERCENT (00932)	ALKA-LINITY LAB (MG/L AS CACO3) (90410)	POTAS-SIUM, DIS-SOLVED (MG/L AS K) (00935)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL) (00940)
STATION 06435000, BELLE FOURCHE RESERVOIR NEAR BELLE FOURCHE SD (LAT 44 44 10N LONG 103 40 10W)										
APR 1988										
26...	8.10	<0.100	190	55	49	0.8	13	139	5.0	5.4
JUN										
23...	8.20	<0.100	200	57	52	0.9	13	72	4.8	5.6
AUG										
31...	8.30	<0.100	190	62	67	1	17	103	6.3	8.9
OCT										
25...	8.00	<0.100	200	62	63	1	15	127	7.0	16
STATION 06436760, HORSE CR ABOVE VALE SD (LAT 44 39 08N LONG 103 21 59W)										
APR 1988										
28...	8.10	0.110	290	270	630	7	43	286	10	100
JUN										
21...	8.30	0.150	210	90	120	2	22	107	9.0	15
AUG										
30...	8.30	<0.100	240	97	130	2	22	155	8.6	17
OCT										
26...	8.00	0.410	360	300	490	5	33	321	17	66
STATION 06436850, NORTH CANAL NR FRUITDALE, SD (LAT 44 44 12N LONG 103 40 19W)										
JUN 1988										
23...	8.20	<0.100	200	57	52	0.9	13	74	5.3	5.6
AUG										
30...	8.00	<0.100	190	59	63	1	16	102	6.3	8.9

Table 13.--Water-quality data for reconnaissance investigation sampling of the Belle Fourche Reclamation Project investigation area, 1988--Continued

MISCELLANEOUS STATION ANALYSES

DATE	SULFATE DIS- SOLVED (MG/L AS SO4) (00945)	ARSENIC DIS- SOLVED (UG/L AS AS) (01000)	BORON, DIS- SOLVED (UG/L AS B) (01020)	CADMIUM DIS- SOLVED (UG/L AS CD) (01025)	CHRO- MIUM, DIS- SOLVED (UG/L AS CR) (01030)	COPPER, DIS- SOLVED (UG/L AS CU) (01040)	LEAD, DIS- SOLVED (UG/L AS PB) (01049)	MOLYB- DENUM, DIS- SOLVED (UG/L AS MO) (01060)	VANA- DIUM, DIS- SOLVED (UG/L AS V) (01085)	ZINC, DIS- SOLVED (UG/L AS ZN) (01090)
STATION 06435000, BELLE FOURCHE RESERVOIR NEAR BELLE FOURCHE SD (LAT 44 44 10N LONG 103 40 10W)										
APR 1988										
26...	710	1	130	<1	<1	2	<5	11	<1	<3
JUN										
23...	710	<1	130	1	2	1	<5	7	<1	12
AUG										
31...	800	1	150	<1	2	2	<5	8	<1	<10
OCT										
25...	770	1	160	<1	2	4	<5	11	<1	21
STATION 06436760, HORSE CR ABOVE VALE SD (LAT 44 39 08N LONG 103 21 59W)										
APR 1988										
28...	2900	1	940	<1	<1	<1	<5	1	1	<10
JUN										
21...	990	1	290	<1	2	3	<5	7	2	40
AUG										
30...	1100	1	280	1	2	1	<5	5	<1	10
OCT										
26...	2700	1	1000	1	2	3	<5	3	1	30
STATION 06436850, NORTH CANAL NR FRUITDALE, SD (LAT 44 44 12N LONG 103 40 19W)										
JUN 1988										
23...	720	<1	130	<1	2	1	<5	7	<1	8
AUG										
30...	790	1	160	<1	<1	1	<5	7	<1	<3

Table 13.--Water-quality data for reconnaissance investigation sampling of the Belle Fourche Reclamation Project investigation area, 1988--Continued

MISCELLANEOUS STATION ANALYSES

DATE	SELE-NIUM, DIS-SOLVED (UG/L AS SE) (01145)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L) (70300)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L) (70301)	MERCURY DIS-SOLVED (UG/L AS HG) (71890)	URANIUM NATURAL DIS-SOLVED (UG/L AS U) (22703)	PRO-PAZINE TOTAL (UG/L) (39024)	TRI-FLURA-LIN TOTAL RECOVER (UG/L) (39030)	METHO-MYL TOTAL (UG/L) (39051)	PROPHAM TOTAL (UG/L) (39052)	SIME-TRYNE TOTAL (UG/L) (39054)
STATION 06435000, BELLE FOURCHE RESERVOIR NEAR BELLE FOURCHE SD (LAT 44 44 10N LONG 103 40 10W)										
APR 1988										
26...	2	1150	1100	<0.1	6.8	--	--	--	--	--
JUN										
23...	2	1160	1070	<0.1	7.1	--	--	--	--	--
AUG										
31...	2	1250	1200	0.2	8.0	--	--	--	--	--
OCT										
25...	2	1250	1190	<0.1	8.9	--	--	--	--	--
STATION 06436760, HORSE CR ABOVE VALE SD (LAT 44 39 08N LONG 103 21 59W)										
APR 1988										
28...	9	4800	4370	<0.1	30	<0.10	<0.10	--	--	<0.1
JUN										
21...	3	1690	1510	<0.1	9.4	<0.10	<0.10	<0.5	<0.5	<0.1
AUG										
30...	4	1830	1690	<0.1	11	<0.10	<0.10	<0.5	<0.5	<0.1
OCT										
26...	11	4400	4130	<0.1	22	<0.10	<0.10	<0.5	<0.5	<0.1
STATION 06436850, NORTH CANAL NR FRUITDALE, SD (LAT 44 44 12N LONG 103 40 19W)										
JUN 1988										
23...	3	1160	1080	<0.1	5.4	<0.10	<0.10	<0.5	<0.5	<0.1
AUG										
30...	2	1270	1180	<0.1	8.5	<0.10	<0.10	<0.5	<0.5	<0.1

Table 13.--Water-quality data for reconnaissance investigation sampling of the Belle Fourche Reclamation Project investigation area, 1988--Continued

MISCELLANEOUS STATION ANALYSES

DATE	SIMA-ZINE TOTAL (UG/L) (39055)	PROME-TONE TOTAL (UG/L) (39056)	PROME-TRYNE TOTAL (UG/L) (39057)	ATRA-ZINE, TOTAL (UG/L) (39630)	SEVIN, TOTAL (UG/L) (39750)	ALA-CHLOR TOTAL RECOVER (UG/L) (77625)	CYAN-AZINE TOTAL (UG/L) (81757)	AME-TRYNE TOTAL (82184)	METRI-BUZIN WATER WHOLE TOT.REC (UG/L) (82611)	METOLA-CHLOR WATER WHOLE TOT.REC (UG/L) (82612)
STATION 06435000, BELLE FOURCHE RESERVOIR NEAR BELLE FOURCHE SD (LAT 44 44 10N LONG 103 40 10W)										
APR 1988										
26...	--	--	--	--	--	--	--	--	--	--
JUN										
23...	--	--	--	--	--	--	--	--	--	--
AUG										
31...	--	--	--	--	--	--	--	--	--	--
OCT										
25...	--	--	--	--	--	--	--	--	--	--
STATION 06436760, HORSE CR ABOVE VALE SD (LAT 44 39 08N LONG 103 21 59W)										
APR 1988										
28...	<0.10	<0.1	<0.1	<0.10	--	<0.10	<0.10	<0.10	<0.1	<0.1
JUN										
21...	<0.10	<0.1	<0.1	0.20	<0.50	0.30	<0.10	<0.10	<0.1	<0.1
AUG										
30...	<0.10	<0.1	<0.1	0.10	<0.50	<0.10	<0.10	<0.10	<0.1	<0.1
OCT										
26...	<0.10	<0.1	<0.1	<0.10	<0.50	<0.10	<0.10	<0.10	<0.1	<0.1
STATION 06436850, NORTH CANAL NR FRUITDALE, SD (LAT 44 44 12N LONG 103 40 19W)										
JUN 1988										
23...	<0.10	<0.1	<0.1	0.10	<0.50	<0.10	<0.10	<0.10	<0.1	<0.1
AUG										
30...	<0.10	<0.1	<0.1	0.10	<0.50	<0.10	<0.10	<0.10	<0.1	<0.1

Table 13.--Water-quality data for reconnaissance investigation sampling of the Belle Fourche Reclamation Project investigation area, 1988--Continued

MISCELLANEOUS STATION ANALYSES

DATE	TIME	TEMPER-ATURE WATER (DEG C) (00010)	TEMPER-ATURE AIR (DEG C) (00020)	BARO-METRIC PRES-SURE (MM OF HG) (00025)	DIS-CHARGE, INST. CUBIC FEET PER SECOND (00061)	OXYGEN, DIS-SOLVED (MG/L) (00300)	OXYGEN, DIS-SOLVED (PER-CENT SATUR-ATION) (00301)	SPE-CIFIC CON-DUCT-ANCE (US/CM) (00095)	SPE-CIFIC CON-DUCT-ANCE LAB (US/CM) (90095)	PH (STAND-ARD UNITS) (00400)
STATION 06436950, MEADE LATERAL NR VALE, SD (LAT 44 36 20N LONG 103 16 00W)										
JUN 1988										
21...	1200	24.5	34.5	687	6.0	7.4	99	1300	1440	8.05
AUG										
30...	1240	19.0	27.5	--	0.03	10.3	--	1580	1510	8.44
STATION 06437000, BELLE FOURCHE R NEAR STURGIS SD (LAT 44 30 47N LONG 103 08 11W)										
APR 1988										
27...	1430	13.5	--	693	61	10.9	116	1870	1880	8.45
JUN										
22...	1345	26.5	37.0	694	225	7.4	103	1910	1940	8.23
AUG										
29...	1000	15.0	21.5	700	250	9.6	104	2050	1970	8.38
OCT										
26...	1200	6.0	7.0	--	42	12.9	--	2490	2460	8.10
STATION 06438700, SULPHUR CREEK NEAR NEWELL, SD (LAT 44 52 30N LONG 102 47 30W)										
APR 1988										
28...	1110	9.0	19.5	693	0.07	9.2	89	4310	5090	8.58

Table 13.--Water-quality data for reconnaissance investigation sampling of the Belle Fourche Reclamation Project investigation area, 1988--Continued

MISCELLANEOUS STATION ANALYSES

DATE	PH LAB (STANDARD UNITS) (00403)	NITROGEN, NO2+NO3 DISSOLVED (MG/L AS N) (00631)	CALCIUM DISSOLVED (MG/L AS CA) (00915)	MAGNESIUM, DISSOLVED (MG/L AS MG) (00925)	SODIUM, DISSOLVED (MG/L AS NA) (00930)	SODIUM ADSORPTION RATIO (00931)	SODIUM PERCENT (00932)	ALKALINITY LAB (MG/L AS CACO3) (90410)	POTASSIUM, DISSOLVED (MG/L AS K) (00935)	CHLORIDE, DISSOLVED (MG/L AS CL) (00940)
STATION 06436950, MEADE LATERAL NR VALE, SD (LAT 44 36 20N LONG 103 16 00W)										
JUN 1988										
21...	8.10	0.120	190	57	54	0.9	14	123	6.4	5.9
AUG										
30...	8.10	<0.100	190	62	71	1	17	103	6.8	13
STATION 06437000, BELLE FOURCHE R NEAR STURGIS SD (LAT 44 30 47N LONG 103 08 11W)										
APR 1988										
27...	8.30	1.00	160	96	130	2	26	166	7.9	24
JUN										
22...	8.30	0.440	210	93	120	2	22	109	8.2	15
AUG										
29...	8.30	0.380	230	96	120	2	21	148	9.1	17
OCT										
26...	8.10	1.00	250	130	170	2	24	199	11	29
STATION 06438700, SULPHUR CREEK NEAR NEWELL, SD (LAT 44 52 30N LONG 102 47 30W)										
APR 1988										
28...	8.30	<0.100	160	280	240	3	25	221	11	25

Table 13.--Water-quality data for reconnaissance investigation sampling of the Belle Fourche Reclamation Project investigation area, 1988--Continued

MISCELLANEOUS STATION ANALYSES

DATE	SULFATE DIS-SOLVED (MG/L AS SO4) (00945)	ARSENIC DIS-SOLVED (UG/L AS AS) (01000)	BORON, DIS-SOLVED (UG/L AS B) (01020)	CADMIUM DIS-SOLVED (UG/L AS CD) (01025)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR) (01030)	COPPER, DIS-SOLVED (UG/L AS CU) (01040)	LEAD, DIS-SOLVED (UG/L AS PB) (01049)	MOLYB-DENUM, DIS-SOLVED (UG/L AS MO) (01060)	VANA-DIUM, DIS-SOLVED (UG/L AS V) (01085)	ZINC, DIS-SOLVED (UG/L AS ZN) (01090)
STATION 06436950, MEADE LATERAL NR VALE, SD (LAT 44 36 20N LONG 103 16 00W)										
JUN 1988										
21...	730	1	140	<1	2	<1	<5	11	1	6
AUG										
30...	800	1	160	<1	<1	1	<5	7	<1	16
STATION 06437000, BELLE FOURCHE R NEAR STURGIS SD (LAT 44 30 47N LONG 103 08 11W)										
APR 1988										
27...	920	7	250	<1	<1	3	<5	3	<1	5
JUN										
22...	1100	1	290	<1	2	1	<5	7	2	5
AUG										
29...	1100	16	270	<1	2	1	<5	6	<1	23
OCT										
26...	1400	9	400	<1	2	4	<5	4	<1	20
STATION 06438700, SULPHUR CREEK NEAR NEWELL, SD (LAT 44 52 30N LONG 102 47 30W)										
APR 1988										
28...	3100	2	430	<1	<1	1	<5	2	<1	<10

Table 13.--Water-quality data for reconnaissance investigation sampling of the Belle Fourche Reclamation Project investigation area, 1988--Continued

MISCELLANEOUS STATION ANALYSES

DATE	SELENIUM, DISSOLVED (UG/L AS SE) (01145)	SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED (MG/L) (70300)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L) (70301)	MERCURY DISSOLVED (UG/L AS HG) (71890)	URANIUM NATURAL DISSOLVED (UG/L AS U) (22703)	PROPAZINE TOTAL (UG/L) (39024)	TRIFLURALIN TOTAL RECOVER (UG/L) (39030)	METHOMYL TOTAL (UG/L) (39051)	PROPHAM TOTAL (UG/L) (39052)	SIMETRYNE TOTAL (UG/L) (39054)
STATION 06436950, MEADE LATERAL NR VALE, SD (LAT 44 36 20N LONG 103 16 00W)										
JUN 1988										
21...	3	1190	1120	<0.1	7.9	<0.10	<0.10	<0.5	<0.5	<0.1
AUG										
30...	2	1310	1200	<0.1	9.0	<0.10	<0.10	<0.5	<0.5	<0.1
STATION 06437000, BELLE FOURCHE R NEAR STURGIS SD (LAT 44 30 47N LONG 103 08 11W)										
APR 1988										
27...	3	1560	1440	<0.1	8.5	<0.10	<0.10	<2.0	<2.0	<0.1
JUN										
22...	4	1680	1610	<0.1	8.7	<0.10	<0.10	<0.5	<0.5	<0.1
AUG										
29...	5	1740	1670	<0.1	11	<0.10	<0.10	<0.5	<0.5	<0.1
OCT										
26...	3	2210	2110	<0.1	16	<0.10	<0.10	<0.5	<0.5	<0.1
STATION 06438700, SULPHUR CREEK NEAR NEWELL, SD (LAT 44 52 30N LONG 102 47 30W)										
APR 1988										
28...	3	4640	3950	0.3	11	--	--	--	--	--

Table 13.--Water-quality data for reconnaissance investigation sampling of the Belle Fourche Reclamation Project investigation area, 1988--Continued

MISCELLANEOUS STATION ANALYSES

DATE	SIMA-ZINE TOTAL (UG/L) (39055)	PROME-TONE TOTAL (UG/L) (39056)	PROME-TRYNE TOTAL (UG/L) (39057)	ATRA-ZINE, TOTAL (UG/L) (39630)	SEVIN, TOTAL (UG/L) (39750)	ALA-CHLOR TOTAL RECOVER (UG/L) (77825)	CYAN-AZINE TOTAL (UG/L) (81757)	AME-TRYNE TOTAL (82184)	METRI-BUZIN WATER WHOLE TOT.REC (UG/L) (82611)	METOLA-CHLOR WATER WHOLE TOT.REC (UG/L) (82612)
STATION 06436950, MEADE LATERAL NR VALE, SD (LAT 44 36 20N LONG 103 16 00W)										
JUN 1988										
21...	<0.10	<0.1	<0.1	0.10	<0.50	<0.10	<0.10	<0.10	<0.1	<0.1
AUG										
30...	<0.10	<0.1	<0.1	0.10	<0.50	<0.10	<0.10	<0.10	<0.1	<0.1
STATION 06437000, BELLE FOURCHE R NEAR STURGIS SD (LAT 44 30 47N LONG 103 08 11W)										
APR 1988										
27...	<0.10	<0.1	<0.1	<0.10	<2.0	<0.10	<0.10	<0.10	<0.1	<0.1
JUN										
22...	<0.10	<0.1	<0.1	0.30	<0.50	0.30	0.50	<0.10	<0.1	<0.1
AUG										
29...	<0.10	<0.1	<0.1	0.10	<0.50	<0.10	<0.10	<0.10	<0.1	<0.1
OCT										
26...	<0.10	<0.1	<0.1	<0.10	<0.50	<0.10	<0.10	<0.10	<0.1	<0.1
STATION 06438700, SULPHUR CREEK NEAR NEWELL, SD (LAT 44 52 30N LONG 102 47 30W)										
APR 1988										
28...	--	--	--	--	--	--	--	--	--	--

Table 14.--Water-quality data for additional sampling of the Belle Fourche Reclamation Project investigation area, October 1987 through April 1989

[Number in parentheses in column heading is parameter code identification. DEG C, degrees Celsius; MM, millimeters; MG/L, milligrams per liter; US/CM, microsiemens per centimeter at 25 °C; UG/L, micrograms per liter; --, no data; <, less than]

MISCELLANEOUS STATION ANALYSES

DATE	TIME	TEMPERATURE WATER (DEG C) (00010)	TEMPERATURE AIR (DEG C) (00020)	BAROMETRIC PRESSURE (MM OF HG) (00025)	DISCHARGE, INST. CUBIC FEET PER SECOND (00061)	OXYGEN, DISSOLVED (MG/L) (00300)	OXYGEN, DISSOLVED (PERCENT SATURATION) (00301)	SPECIFIC CONDUCTANCE (US/CM) (00095)	SPECIFIC CONDUCTANCE LAB (US/CM) (90095)	PH (STANDARD UNITS) (00400)
STATION 06434500, INLET CANAL NEAR BELLE FOURCHE (LAT 44 42 14N LONG 103 49 23W)										
OCT 1987										
05...	1345	12.0	16.0	--	139	--	--	1400	1380	8.40
NOV										
09...	1630	4.0	11.0	--	153	--	--	1340	1310	8.69
DEC										
17...	1415	0.0	6.5	--	193	--	--	1390	1430	8.30
FEB 1988										
02...	1515	0.0	-7.0	--	69	--	--	1380	1390	8.40
MAR										
21...	1630	6.0	15.5	--	281	--	--	1350	1370	8.40
JUN										
13...	1230	23.5	21.5	--	76	--	--	1600	1550	8.30
AUG										
09...	1530	26.5	35.5	--	73	--	--	1520	1500	8.40
SEP										
06...	1145	17.0	22.5	--	49	--	--	1480	1550	8.50
OCT										
19...	1430	11.5	14.5	--	161	--	--	1300	1260	8.50
NOV										
29...	1345	2.5	2.5	--	142	--	--	1260	1270	8.40
JAN 1989										
19...	1315	0.0	5.0	--	133	--	--	1190	1200	8.40
MAR										
13...	1530	1.0	4.0	--	704	--	--	670	664	8.20
APR										
25...	1200	11.0	8.0	--	143	--	--	1380	1370	8.40

Table 14.--Water-quality data for additional sampling of the Belle Fourche Reclamation Project investigation area, October 1987 through April 1989--Continued

MISCELLANEOUS STATION ANALYSES

DATE	PH LAB (STAND-ARD UNITS) (00403)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N) (00631)	CALCIUM DIS-SOLVED (MG/L AS CA) (00915)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG) (00925)	SODIUM, DIS-SOLVED (MG/L AS NA) (00930)	SODIUM AD-SORP-TION RATIO (00931)	SODIUM PERCENT (00932)	ALKA-LINITY LAB (MG/L AS CACO3) (90410)	POTAS-SIUM, DIS-SOLVED (MG/L AS K) (00935)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL) (00940)
STATION 06434500, INLET CANAL NEAR BELLE FOURCHE (LAT 44 42 14N LONG 103 49 23W)										
OCT 1987										
05...	8.20	0.210	240	53	27	0.4	7	178	7.3	6.1
NOV										
09...	8.30	0.230	220	54	26	0.4	7	126	3.1	5.8
DEC										
17...	8.10	0.430	220	51	29	0.5	8	154	3.3	6.7
FEB 1988										
02...	8.10	0.540	270	53	11	0.2	3	243	2.9	3.7
MAR										
21...	8.10	0.290	200	50	47	0.8	13	182	5.5	5.9
JUN										
13...	8.30	<0.100	150	53	130	2	32	161	9.6	26
AUG										
09...	8.40	<0.100	120	51	140	3	37	159	11	29
SEP										
06...	8.20	<0.100	120	55	150	3	38	164	10	31
OCT										
19...	8.10	0.160	200	53	31	0.5	9	192	3.6	9.9
NOV										
29...	8.20	0.480	200	50	21	0.4	6	214	2.9	4.8
JAN 1989										
19...	8.10	0.820	190	45	15	0.3	5	217	2.6	3.8
MAR										
13...	7.60	0.350	87	22	20	0.5	12	107	5.2	3.8
APR										
25...	8.10	0.170	220	52	30	0.5	8	191	3.9	4.6

Table 14.--Water-quality data for additional sampling of the Belle Fourche Reclamation Project investigation area, October 1987 through April 1989--Continued

MISCELLANEOUS STATION ANALYSES

DATE	SULFATE DIS- SOLVED (MG/L AS SO4) (00945)	ARSENIC DIS- SOLVED (UG/L AS AS) (01000)	BORON, DIS- SOLVED (UG/L AS B) (01020)	CADMIUM DIS- SOLVED (UG/L AS CD) (01025)	CHRO- MIUM, DIS- SOLVED (UG/L AS CR) (01030)	COPPER, DIS- SOLVED (UG/L AS CU) (01040)	LEAD, DIS- SOLVED (UG/L AS PB) (01049)	MOLYB- DENUM, DIS- SOLVED (UG/L AS MO) (01060)	VANA- DIUM, DIS- SOLVED (UG/L AS V) (01085)	ZINC, DIS- SOLVED (UG/L AS ZN) (01090)
STATION 06434500, INLET CANAL NEAR BELLE FOURCHE (LAT 44 42 14N LONG 103 49 23W)										
OCT 1987										
05...	640	--	90	--	--	--	--	--	--	--
NOV										
09...	570	--	90	--	--	--	--	--	--	--
DEC										
17...	610	--	100	--	--	--	--	--	--	--
FEB 1988										
02...	620	--	60	--	--	--	--	--	--	--
MAR										
21...	640	--	110	--	--	--	--	--	--	--
JUN										
13...	690	1	210	<1	2	2	<5	6	<1	150
AUG										
09...	660	--	180	--	--	--	--	--	--	--
SEP										
06...	680	--	190	--	--	--	--	--	--	--
OCT										
19...	550	--	100	--	--	--	--	--	--	--
NOV										
29...	570	--	80	--	--	--	--	--	--	--
JAN 1989										
19...	500	--	70	--	--	--	--	--	--	--
MAR										
13...	240	<1	70	<1	2	4	<5	4	2	35
APR										
25...	630	--	110	--	--	--	--	--	--	--

Table 14.--Water-quality data for additional sampling of the Belle Fourche Reclamation Project investigation area, October 1987 through April 1989--Continued

MISCELLANEOUS STATION ANALYSES

STATION 06434500, INLET CANAL NEAR BELLE FOURCHE (LAT 44 42 14N LONG 103 49 23W)

DATE	SELENIUM, DISSOLVED (UG/L AS SE) (01145)	SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED (MG/L) (70300)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L) (70301)	MERCURY DISSOLVED (UG/L AS HG) (71890)	URANIUM NATURAL DISSOLVED (UG/L AS U) (22703)
OCT 1987					
05...	--	--	1090	--	--
NOV					
09...	--	--	966	--	--
DEC					
17...	--	--	1030	--	--
FEB 1988					
02...	--	--	1120	--	--
MAR					
21...	--	--	1070	--	--
JUN					
13...	2	--	1160	--	--
AUG					
09...	--	--	1110	--	--
SEP					
06...	--	--	1150	--	--
OCT					
19...	--	--	974	--	--
NOV					
29...	--	--	989	--	--
JAN 1989					
19...	--	--	901	--	--
MAR					
13...	<1	--	451	--	--
APR					
25...	--	--	1060	--	--

Table 14.--Water-quality data for additional sampling of the Belle Fourche Reclamation Project investigation area, October 1987 through April 1989--Continued

MISCELLANEOUS STATION ANALYSES

STATION 06436760, HORSE CR ABOVE VALE SD (LAT 44 39 08N LONG 103 21 59W)

DATE	TIME	TEMPER-ATURE WATER (DEG C) (00010)	TEMPER-ATURE AIR (DEG C) (00020)	BARO-METRIC PRES-SURE (MM OF HG) (00025)	DIS-CHARGE, INST. CUBIC FEET PER SECOND (00061)	OXYGEN, DIS-SOLVED (MG/L) (00300)	OXYGEN, DIS-SOLVED (PER-CENT SATUR-ATION) (00301)	SPE-CIFIC CON-DUCT-ANCE (US/CM) (00095)	SPE-CIFIC CON-DUCT-ANCE LAB (US/CM) (90095)	PH (STAND-ARD UNITS) (00400)
OCT 1987										
16...	1030	6.5	5.0	--	4.2	--	--	3800	3750	8.40
NOV										
09...	1100	4.0	11.5	--	3.4	--	--	4500	4600	8.30
DEC										
18...	1115	0.0	0.0	--	2.4	--	--	5500	5660	8.10
FEB 1988										
03...	1745	0.0	-9.0	--	1.5	--	--	--	6660	7.80
MAR										
18...	1130	0.5	4.0	--	2.4	--	--	5430	4980	8.00
JUN										
14...	0900	18.0	16.0	--	78	--	--	1880	1870	8.21
AUG										
15...	1030	22.5	31.5	--	66	--	--	1920	1970	8.20
SEP										
06...	0830	16.0	14.5	--	52	--	--	1950	1990	8.30
NOV										
30...	1030	0.0	5.5	--	2.4	--	--	4980	5250	8.10
JAN 1989										
20...	1045	1.0	12.5	--	2.4	--	--	5600	6000	7.98
FEB										
28...	1630	0.5	-8.5	--	2.1	--	--	5350	5310	8.20
MAR										
31...	1030	5.0	12.0	--	132	--	--	2290	2290	8.10
APR										
28...	1400	4.0	1.5	--	16	--	--	3860	3900	8.40

Table 14.--Water-quality data for additional sampling of the Belle Fourche Reclamation Project investigation area, October 1987 through April 1989--Continued

MISCELLANEOUS STATION ANALYSES

DATE	PH LAB (STAND- ARD UNITS) (00403)	NITRO- GEN, NO2+NO3 DIS- SOLVED (MG/L AS N) (00631)	CALCIUM DIS- SOLVED (MG/L AS CA) (00915)	MAGNE- SIUM, DIS- SOLVED (MG/L AS MG) (00925)	SODIUM, DIS- SOLVED (MG/L AS NA) (00930)	SODIUM AD- SORP- TION RATIO (00931)	SODIUM PERCENT (00932)	ALKA- LINITY LAB (MG/L AS CACO3) (90410)	POTAS- SIUM, DIS- SOLVED (MG/L AS K) (00935)	CHLO- RIDE, DIS- SOLVED (MG/L AS CL) (00940)
STATION 06436760, HORSE CR ABOVE VALE SD (LAT 44 39 08N LONG 103 21 59W)										
OCT 1987										
16...	8.10	0.300	280	210	370	4	34	183	8.0	52
NOV										
09...	8.20	0.420	300	250	480	5	37	245	7.3	78
DEC										
18...	7.90	1.10	350	300	610	6	39	303	9.3	110
FEB 1988										
03...	7.70	1.80	440	410	890	7	41	117	8.0	130
MAR										
18...	7.80	0.870	320	270	550	6	38	391	8.7	750
JUN										
14...	8.00	--	210	88	110	2	21	161	7.9	14
AUG										
15...	8.20	<0.100	220	92	120	2	22	159	9.4	16
SEP										
06...	8.20	<0.100	220	100	130	2	23	150	8.6	17
NOV										
30...	7.90	0.860	360	310	590	6	37	408	10	85
JAN 1989										
20...	7.80	1.20	400	360	850	8	43	513	11	100
FEB										
28...	7.90	0.990	350	330	630	6	38	435	11	89
MAR										
31...	7.50	0.830	160	96	230	4	38	133	8.2	54
APR										
28...	7.70	0.180	240	230	450	5	39	247	11	63

Table 14.--Water-quality data for additional sampling of the Belle Fourche Reclamation Project investigation area, October 1987 through April 1989--Continued

MISCELLANEOUS STATION ANALYSES

STATION 06436760, HORSE CR ABOVE VALE SD (LAT 44 39 08N LONG 103 21 59W)

DATE	SULFATE DIS-SOLVED (MG/L AS SO4) (00945)	ARSENIC DIS-SOLVED (UG/L AS AS) (01000)	BORON, DIS-SOLVED (UG/L AS B) (01020)	CADMIUM DIS-SOLVED (UG/L AS CD) (01025)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR) (01030)	COPPER, DIS-SOLVED (UG/L AS CU) (01040)	LEAD, DIS-SOLVED (UG/L AS PB) (01049)	MOLYB-DENUM, DIS-SOLVED (UG/L AS MO) (01060)	VANA-DIUM, DIS-SOLVED (UG/L AS V) (01085)	ZINC, DIS-SOLVED (UG/L AS ZN) (01090)
OCT 1987										
16...	2100	2	720	<1	4	2	<5	2	<1	40
NOV										
09...	2500	--	920	--	--	--	--	--	--	--
DEC										
18...	3400	--	1200	--	--	--	--	--	--	--
FEB 1988										
03...	4000	--	1500	--	--	--	--	--	--	--
MAR										
18...	2900	--	930	--	--	--	--	--	--	--
JUN										
14...	950	1	270	<1	2	2	<5	6	1	70
AUG										
15...	1000	--	290	--	--	--	--	--	--	--
SEP										
06...	1100	--	290	--	--	--	--	--	--	--
NOV										
30...	3100	<1	1100	<1	2	1	<5	1	2	<10
JAN 1989										
20...	3700	--	1300	--	--	--	--	--	--	--
FEB										
28...	3200	<1	1100	--	2	--	--	--	--	10
MAR										
31...	1200	--	290	--	--	--	--	--	--	--
APR										
28...	2200	--	700	--	--	--	--	--	--	--

Table 14.--Water-quality data for additional sampling of the Belle Fourche Reclamation Project investigation area, October 1987 through April 1989--Continued

MISCELLANEOUS STATION ANALYSES

DATE	SELENIUM, DISSOLVED (UG/L AS SE) (01145)	SOLIDS, RESIDUE AT 180 DEG. C DISSOLVED (MG/L) (70300)	SOLIDS, SUM OF CONSTITUENTS, DISSOLVED (MG/L) (70301)	MERCURY DISSOLVED (UG/L AS HG) (71890)	URANIUM NATURAL DISSOLVED (UG/L AS U) (22703)
STATION 06436760, HORSE CR ABOVE VALE SD (LAT 44 39 08N LONG 103 21 59W)					
OCT 1987					
16...	6	--	3140	--	--
NOV					
09...	--	--	3770	--	--
DEC					
18...	--	--	4970	--	--
FEB 1988					
03...	--	--	5970	--	--
MAR					
18...	--	--	5040	--	--
JUN					
14...	1	--	1490	--	--
AUG					
15...	--	--	1560	--	--
SEP					
06...	--	--	1670	--	--
NOV					
30...	13	--	4710	--	--
JAN 1989					
20...	--	--	5740	--	--
FEB					
28...	14	--	4880	<0.1	--
MAR					
31...	--	--	1840	--	--
APR					
28...	--	--	3350	--	--

Table 14.--Water-quality data for additional sampling of the Belle Fourche Reclamation Project investigation area, October 1987 through April 1989--Continued

MISCELLANEOUS STATION ANALYSES

DATE	TIME	TEMPER-ATURE WATER (DEG C) (00010)	TEMPER-ATURE AIR (DEG C) (00020)	BARO-METRIC PRES-SURE (MM OF HG) (00025)	DIS-CHARGE, INST. CUBIC FEET PER SECOND (00061)	OXYGEN, DIS-SOLVED (MG/L) (00300)	OXYGEN, DIS-SOLVED (PER-CENT SATUR-ATION) (00301)	SPE-CIFIC CON-DUCT-ANCE (US/CM) (00095)	SPE-CIFIC CON-DUCT-ANCE LAB (US/CM) (90095)	PH (STAND-ARD UNITS) (00400)
STATION 06437000, BELLE FOURCHE R NEAR STURGIS SD (LAT 44 30 47N LONG 103 08 11W)										
OCT 1987										
23...	1345	8.0	9.5	698	--	11.9	111	2320	2440	8.40
NOV										
17...	1035	0.0	0.0	696	--	12.1	92	2560	2670	8.38
JAN 1988										
29...	1420	0.0	11.0	687	--	8.8	67	2820	2840	7.71
MAR										
26...	1550	0.5	13.0	695	--	10.6	81	--	4010	8.34
APR										
27...	1440	13.5	14.5	693	--	10.9	116	1870	1870	8.45
MAY										
10...	1715	20.0	22.5	701	--	9.0	108	2750	2790	8.31
JUN										
30...	1625	20.5	19.5	699	--	8.9	109	1790	1120	8.48
JUL										
21...	1310	25.0	32.0	702	--	9.4	125	1930	1940	8.40
SEP										
22...	1435	17.0	21.5	696	--	9.2	105	2240	2230	8.34
OCT										
20...	1200	13.5	18.5	--	3.15	--	--	2480	2460	8.40
NOV										
28...	1115	0.0	0.0	--	3.09	--	--	2870	2950	8.40
JAN 1989										
20...	1535	0.0	10.0	--	3.92	--	--	3000	2900	8.07
MAR										
01...	1545	0.0	-10.0	--	3.94	--	--	2350	2330	8.10
30...	1240	8.0	11.0	--	3.68	--	--	2350	2380	8.30

Table 14.--Water-quality data for additional sampling of the Belle Fourche Reclamation Project investigation area, October 1987 through April 1989--Continued

MISCELLANEOUS STATION ANALYSES

DATE	PH LAB (STAND-ARD UNITS) (00403)	NITRO-GEN, NO2+NO3 DIS-SOLVED (MG/L AS N) (00631)	CALCIUM DIS-SOLVED (MG/L AS CA) (00915)	MAGNE-SIUM, DIS-SOLVED (MG/L AS MG) (00925)	SODIUM, DIS-SOLVED (MG/L AS NA) (00930)	SODIUM AD-SORP-TION RATIO (00931)	SODIUM PERCENT (00932)	ALKA-LINITY LAB (MG/L AS CACO3) (90410)	POTAS-SIUM, DIS-SOLVED (MG/L AS K) (00935)	CHLO-RIDE, DIS-SOLVED (MG/L AS CL) (00940)
STATION 06437000, BELLE FOURCHE R NEAR STURGIS SD (LAT 44 30 47N LONG 103 08 11W)										
OCT 1987										
23...	8.10	1.60	230	120	180	2	27	110	7.7	23
NOV										
17...	8.20	2.90	230	130	210	3	29	116	7.7	30
JAN 1988										
29...	7.70	3.00	280	135	190	2	25	235	10	34
MAR										
26...	7.90	5.40	180	150	550	7	53	176	10	55
APR										
27...	8.20	1.00	160	91	130	2	27	166	7.0	17
MAY										
10...	7.90	11.0	150	120	350	5	46	136	9.6	40
JUN										
30...	8.30	--	--	--	--	--	--	148	--	--
JUL										
21...	8.00	0.270	180	89	110	2	22	132	8.7	16
SEP										
22...	8.30	0.790	230	110	150	2	24	166	11	21
OCT										
20...	8.20	0.920	270	140	170	2	22	182	22	25
NOV										
28...	8.00	4.40	290	160	240	3	27	274	10	36
JAN 1989										
20...	7.90	2.60	320	150	200	2	23	322	11	29
MAR										
01...	7.90	2.80	240	120	170	2	25	250	9.4	30
30...	8.00	6.20	160	100	270	4	42	140	9.7	34

Table 14.--Water-quality data for additional sampling of the Belle Fourche Reclamation Project investigation area, October 1987 through April 1989--Continued

MISCELLANEOUS STATION ANALYSES

STATION 06437000, BELLE FOURCHE R NEAR STURGIS SD (LAT 44 30 47N LONG 103 06 11W)

DATE	SULFATE DIS-SOLVED (MG/L AS SO4) (00945)	ARSENIC DIS-SOLVED (UG/L AS AS) (01000)	BORON, DIS-SOLVED (UG/L AS B) (01020)	CADMIUM DIS-SOLVED (UG/L AS CD) (01025)	CHRO-MIUM, DIS-SOLVED (UG/L AS CR) (01030)	COPPER, DIS-SOLVED (UG/L AS CU) (01040)	LEAD, DIS-SOLVED (UG/L AS PB) (01049)	MOLYB-DENUM, DIS-SOLVED (UG/L AS MO) (01060)	VANA-DIUM, DIS-SOLVED (UG/L AS V) (01085)	ZINC, DIS-SOLVED (UG/L AS ZN) (01090)
OCT 1987										
23...	1200	8	390	<1	3	2	<5	2	<1	<10
NOV										
17...	1500	6	400	<1	--	<1	--	--	--	<10
JAN 1988										
29...	1400	5	400	<1	--	2	--	--	--	10
MAR										
26...	2100	5	230	<1	2	4	<5	2	<1	10
APR										
27...	920	8	250	--	--	--	--	--	--	6
MAY										
10...	1400	11	250	<1	--	3	--	--	--	<10
JUN										
30...	--	1	--	--	--	--	--	--	--	<10
JUL										
21...	1000	12	270	--	--	--	--	--	--	17
SEP										
22...	1200	10	--	--	--	--	--	--	--	20
OCT										
20...	1400	10	420	<1	1	1	<5	4	<1	<10
NOV										
28...	1600	--	400	--	--	--	--	--	--	--
JAN 1989										
20...	1500	--	420	--	--	--	--	--	--	--
MAR										
01...	1200	5	310	--	2	--	--	--	--	10
30...	1200	<1	260	<1	<1	2	<5	1	<1	<10

Table 14.--Water-quality data for additional sampling of the Belle Fourche Reclamation Project investigation area, October 1987 through April 1989--Continued

MISCELLANEOUS STATION ANALYSES

STATION 06437000, BELLE FOURCHE R NEAR STURGIS SD (LAT 44 30 47N LONG 103 08 11W)

DATE	SELE-NIUM, DIS-SOLVED (UG/L AS SE) (01145)	SOLIDS, RESIDUE AT 180 DEG. C DIS-SOLVED (MG/L) (70300)	SOLIDS, SUM OF CONSTI-TUENTS, DIS-SOLVED (MG/L) (70301)	MERCURY DIS-SOLVED (UG/L AS HG) (71890)	URANIUM NATURAL DIS-SOLVED (UG/L AS U) (22703)
OCT 1987					
23...	3	2160	1840	--	--
NOV					
17...	--	2440	2190	<0.1	--
JAN 1988					
29...	--	2600	2220	<0.1	--
MAR					
26...	34	3470	3180	<0.1	--
APR					
27...	--	--	1430	--	--
MAY					
10...	--	2290	2200	<0.1	--
JUN					
30...	--	--	--	--	--
JUL					
21...	--	--	1490	--	--
SEP					
22...	--	--	1830	--	--
OCT					
20...	4	--	2150	--	--
NOV					
28...	--	--	2530	--	--
JAN 1989					
20...	--	--	2420	--	--
MAR					
01...	6	--	1940	<0.1	--
30...	14	--	1900	--	--

Table 15.--Analytical results of bottom-sediment sampling of the Belle Fourche Reclamation Project investigation area, 1988-89

[Samples collected by the U.S. Geological Survey. Analyses of atrazine and carbofuran by the University of Iowa Hygienic Laboratory; all other analyses by the U.S. Geological Survey. Total, total in bottom material; percent, percent of sample by weight; μg/g, micrograms per gram; mm, millimeter; mg/kg, milligrams per kilogram; --, no data; <, less than;]

Site number (fig. 7)	Date	Particle size of sample split (mm)	Aluminum (percent)	Calcium (percent)	Iron (percent)	Magnesium (percent)	Phosphorus (percent)	Potassium (percent)	Sodium (percent)	Titanium (percent)	Arsenic (μg/g)	Barium (μg/g)	Beryllium (μg/g)	Bismuth (μg/g)	Boron (μg/g)	Cadmium (μg/g)
1	10-27-86	<2	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3	11-04-88	<2	2.7	13	1.4	1.3	0.07	1.3	0.47	0.09	7.5	440	<2	<10	1.6	<2
3	11-04-88	<.062	3.6	12	1.5	1.7	.06	1.6	.63	.16	6.1	380	1	<10	1.1	<2
4	11-04-88	<2	3.5	11	6.3	.54	.19	1.3	.71	.11	25	110	2	<10	3.6	<2
4	11-04-88	<.062	5	9.8	3.5	.74	.13	1.4	.76	.16	16	91	2	<10	5.6	<2
5	11-10-88	<2	3.6	2.8	3.9	.34	.1	1.8	.49	.07	16	720	2	<10	.6	<2
5	11-10-88	<.062	5.0	4.2	2.6	.84	.08	1.5	.42	.16	6.8	610	2	<10	1.1	<2
6	10-25-88	<2	4.6	3.4	2.4	.61	.07	1.5	.37	.14	8.6	480	2	<10	1.7	<2
6	10-25-88	<2	4.7	3.2	2.6	.78	.08	1.5	.35	.15	9.2	460	2	<10	1.7	<2
6	10-25-88	<2	4.6	3.4	2.4	.8	.07	1.5	.36	.14	7.8	480	2	<10	1.7	<2
6	10-25-88	<.062	4.2	4.4	2	.95	.08	1.6	.52	.18	6	530	1	<10	1.1	<2
6	10-25-88	<.062	4.3	4.5	2	.94	.08	1.6	.51	.16	5.9	530	1	<10	.9	<2
6	10-25-88	<.062	4.3	4.4	2	.95	.08	1.6	.52	.17	5.9	530	1	<10	.9	<2
7	10-25-88	<2	4.2	2.4	2.9	.56	.12	1.7	.37	.15	59	820	2	<10	1.4	<2
7	10-25-88	<.062	4.9	1.9	2.1	.61	.09	1.8	.39	.19	30	590	2	<10	.7	<2
12	04-07-89	<2	4.1	6.4	8.7	1.1	.47	1.6	.46	.17	39	1,670	2	<10	3.1	<2
12	04-07-89	<.062	5.2	4.2	3.9	1.4	.16	1.8	.51	.2	12	1,140	2	<10	2.9	<2
17	10-26-88	<2	--	--	--	--	--	--	--	--	--	--	--	--	--	--
18	04-07-89	<2	4.4	2.4	5.8	.76	.16	1.7	.5	.16	180	800	1	<10	2.4	<2
18	04-07-89	<.062	5.7	3.2	6.8	1.2	.15	1.7	.55	.25	370	927	2	<10	2.9	<2
19	11-04-88	<2	5.9	2.7	4.5	1.1	.11	1.8	1.2	.23	19	220	2	<10	2.2	<2
19	11-04-88	<.062	6.3	2.1	3.2	1.3	.09	1.8	1.2	.3	11	160	2	<10	2.1	<2

Table 15.--Analytical results of bottom-sediment sampling of the Belle Fourche Reclamation Project investigation area, 1988-89--Continued

Site number (fig. 7)	Cerium (µg/g)	Chromium (µg/g)	Cobalt (µg/g)	Copper (µg/g)	Europium (µg/g)	Gallium (µg/g)	Gold (µg/g)	Holmium (µg/g)	Lan-thanum (µg/g)	Lead (µg/g)	Lithium (µg/g)	Man-ganese (µg/g)	Mercury (µg/g)	Molyb-denum (µg/g)	Niobium (µg/g)	Neo-dymium (µg/g)	Nickel (µg/g)
1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
3	33	21	7	10	<2	6	<8	<4	21	10	17	360	<0.02	<2	<4	19	8
3	45	32	7	11	<2	8	<8	<4	26	11	23	390	<.02	<2	<4	25	13
4	48	35	16	21	<2	9	<8	<4	28	14	26	1,200	<.02	9	<4	29	43
4	47	55	13	25	<2	14	<8	<4	27	12	40	770	.02	5	<4	29	36
5	44	22	20	12	<2	10	<8	<4	25	21	17	1,800	<.02	2	<4	21	35
5	53	43	19	18	<2	12	<8	<4	29	18	29	1,700	<.02	<2	<4	26	36
6	51	39	11	15	<2	12	<8	<4	28	16	30	590	.02	<2	5	26	26
6	47	40	11	16	<2	12	<8	<4	27	15	31	610	<.02	<2	5	24	27
6	49	39	10	17	<2	12	<8	<4	28	14	30	570	<.02	<2	5	25	26
6	53	36	9	14	<2	10	<8	<4	30	13	27	580	<.02	<2	5	28	19
6	48	38	10	13	<2	11	<8	<4	27	14	27	620	<.02	<2	5	23	26
6	51	36	9	13	<2	11	<8	<4	28	13	27	580	<.02	<2	4	26	21
7	55	41	10	15	<2	11	<8	<4	30	47	33	320	.02	2	5	30	28
7	49	54	10	16	<2	12	<8	<4	28	13	38	220	<.02	<2	7	25	27
12	48	46	20	21	<2	12	<8	<4	31	18	31	1,490	.06	5	5	26	48
12	47	62	14	19	<2	13	<8	<4	27	18	41	686	.12	<2	6	23	37
17	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
18	39	40	15	19	<2	11	<8	<4	24	15	23	1,310	.10	3	6	20	33
18	48	61	19	31	<2	16	<8	<4	29	19	34	1,770	.20	<2	8	24	41
19	49	54	16	22	<2	14	<8	<4	28	19	35	1,100	.02	2	<4	26	36
19	54	62	14	21	<2	15	<8	<4	30	19	37	730	.02	<2	<4	27	33

Table 15.--Analytical results of bottom-sediment sampling of the Belle Fourche Reclamation Project investigation area, 1988-89--Continued

Site number (fig. 7)	Scandium (µg/g)	Selenium (µg/g)	Silver (µg/g)	Strontium (µg/g)	Tantalum (µg/g)	Thorium (µg/g)	Tin (µg/g)	Uranium, natural (µg/g)	Vanadium (µg/g)	Yttrium (µg/g)	Ytterbium (µg/g)	Zinc (µg/g)	Carbon (percent)	Carbon, organic (percent)	Carbon, inorganic (percent)	Atrazine (mg/kg)	Carbofuran (mg/kg)
1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	<0.01	<0.01
3	3	0.9	<2	460	<40	5	<10	1.6	33	10	1	33	6.03	2.03	4	<.01	<.01
3	5	1	<2	460	<40	6	<10	1.7	40	14	2	35	4.44	.83	3.61	--	--
4	6	1.3	<2	380	<40	7	<10	3.7	77	28	2	150	3.76	.89	2.87	--	--
4	8	1.2	<2	360	<40	10	<10	5.3	110	24	2	110	3.84	1.34	2.5	--	--
5	4	.9	<2	210	<40	7	<10	1.9	45	18	1	93	1.29	.54	.75	--	--
5	7	.8	<2	270	<40	9	<10	1.7	67	20	2	91	2.2	1.01	1.19	--	--
6	7	.7	<2	220	<40	11	<10	1.1	65	18	2	74	1.87	.94	.93	<.01	<.01
6	7	.8	<2	210	<40	9	<10	.95	66	19	2	75	1.84	.96	.88	<.01	<.01
6	7	.7	<2	220	<40	9	<10	1.2	64	18	2	72	1.86	.9	.96	<.01	<.01
6	6	.6	<2	250	<40	10	<10	1.1	57	20	2	59	1.91	.58	1.33	--	--
6	6	.6	<2	250	<40	10	<10	1.2	58	19	2	62	2.00	.64	1.36	--	--
6	6	.6	<2	250	<40	10	<10	1.2	57	19	2	60	1.92	.59	1.33	--	--
7	7	1	<2	210	<40	10	<10	2.4	83	26	2	78	1.26	.66	.6	<.01	<.01
7	8	.9	<2	180	<40	13	<10	1.9	100	20	2	72	1.22	.76	.46	--	--
12	8	3.5	<2	319	<40	8	<10	5.6	133	26	2	124	2.65	.82	1.83	<.01	<.01
12	9	2.8	<2	222	<40	8	<10	4.1	140	19	2	104	2.43	.97	1.46	--	--
17	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	<.01	<.01
18	7	1.7	<2	206	<40	7	<10	3.1	93	16	2	89	1.14	.48	.66	<.01	<.01
18	11	2.2	<2	242	<40	9	<10	3.5	126	19	2	112	1.73	.76	.97	--	--
19	8	.9	<2	220	<40	10	<10	2.3	100	21	2	95	1.86	1.22	.64	--	--
19	9	.7	<2	220	<40	11	<10	2.1	100	20	2	82	1.65	1.21	.44	--	--

Table 16.--Field measurements and results of laboratory analyses of biological data from the Belle Fourche Reclamation Project investigation area, April through September 1988

[Collected and analyzed by U.S. Fish and Wildlife Service. Concentrations of trace elements in micrograms per gram, dry weight; mm, millimeters; <, less than; --, no data. Analyses performed by ICP spectroscopy, no preconcentration, unless otherwise noted]

Site number (fig. 7)	Taxa	Collection date	Estimated age class[1]	Sex	Weight (grams)	Length (mm)	Percent moisture	Aluminium[2]	Antimony[3]	Arsenic[3]	Barium	Beryllium[2]	Boron	Cadmium[2]	Chromium[2]
2	Black bullhead[4]	09-20-88	III		94	192	77.0	11	--	<0.1	1.5	<0.1	<2	<0.4	<1
	Black bullhead[4]	09-20-88	III		111	207	75.7	25	--	<.1	3.9	<.1	<2	<.4	<1
	Flathead chub - 3 fish[4]	04-19-88	I		19	129	71.1	1,100	--	.6	7.3	.1	2	.3	2
	Flathead chub[4]	09-20-88	III		37	169	73.2	52	--	<.1	3.5	<.1	<2	<.4	<1
	Flathead chub - 3 fish[4]	04-19-88	II		39	160	68.9	190	--	<.2	4.0	.1	<2	.2	<1
	Flathead chub[4]	09-20-88	III		44	176	71.7	7	--	<.1	2.1	<.1	<2	<.4	<1
	Flathead chub[4]	09-20-88	III		49	168	67.5	4	<0.1	<.2	2.3	<.02	<2	.2	.87
	Flathead chub[4]	09-20-88	III		50	189	75.7	185	<.1	<.2	5.4	<.02	<2	.60	1.7
	Flathead chub - 2 fish[4]	04-19-88	III		54	178	72.8	84	--	<.2	3.7	<.1	<2	.3	2
	Green sunfish[4]	09-20-88	II		25	112	74.1	120	--	<.1	4.1	<.1	<2	<.4	<1
	Green sunfish[4]	09-20-88	II		30	117	72.9	220	--	.2	5.1	<.1	<2	<.4	1
	Green sunfish[4]	09-20-88	II		43	139	74.3	132	<.1	<.2	7.0	<.02	<2	.2	1.2
	Green sunfish[4]	09-20-88	II		44	132	74.1	44	<.1	<.2	1.8	<.02	<2	.1	1.8
	River carpsucker - 2 fish[4]	04-19-88	II		40	151	74.6	2,840	--	.93	26.9	.2	3	<.2	4.4
	Shorthead redhorse - 3 fish[4]	04-19-88	I		17	117	70.4	549	--	<.2	6.9	.1	<2	.4	<1
	Shorthead redhorse - 3 fish[4]	04-19-88	I		17	115	72.6	394	--	<.2	4.7	.1	3	.3	<1
	Shorthead redhorse - 3 fish[4]	04-19-88	II		48	174	71.4	411	--	<.2	5.6	<.1	<2	.5	<1
	Shorthead redhorse[4]	09-20-88	I		50	178	72.2	110	--	.41	6.2	<.1	10	.5	2
	Shorthead redhorse - 3 fish[4]	04-19-88	II		53	178	71.2	190	--	<.2	3.9	<.1	<2	.4	2
	Shorthead redhorse[4]	09-20-88	I		59	183	71.6	250	--	.2	7.1	<.1	12	<.4	2
	Shorthead redhorse[4]	09-20-88	I		62	182	72.4	13	--	.2	4.3	<.1	7.4	<.4	3.6
	Shorthead redhorse[4]	09-20-88	II		96	224	75.2	486	<.1	<.2	7.3	.01	3	.49	1.4
	Shorthead redhorse[4]	09-20-88	II		100	225	74.5	178	<.1	<.2	6.5	<.02	<2	.56	1.4
	Shorthead redhorse[4]	09-20-88	II		110	230	72.0	270	--	.2	4.9	<.1	16	.6	3
	Shorthead redhorse[4]	09-20-88	II		130	233	74.5	166	<.1	<.2	3.8	<.01	<2	.26	1.8
	Shorthead redhorse[4]	09-20-88	II		146	257	75.9	143	<.1	<.2	4.1	<.02	<2	.32	1.5

Table 16.--Field measurements and results of laboratory analyses of biological data from the Belle Fourche Reclamation Project investigation area, April through September 1988--Continued

Site number (fig. 7)	Taxa	Copper[2]	Iron[2]	Lead[2]	Magnesium	Manganese[2]	Mercury[3]	Molybdenum	Nickel[2]	Selenium[3]	Silver[3]	Strontium	Thallium[2]	Tin	Vanadium	Zinc[2]
2	Black bullhead[4]	2.8	105	<4	1,370	35	0.14	<1	<3	1.4	<2	186	<5	--	<0.4	121
	Black bullhead[4]	1.8	123	<4	1,450	24	.089	<1	<3	1.6	<2	255	<5	--	<.3	83.2
	Flathead chub - 3 fish[4]	3.3	649	<4	1,660	56.2	.44	<1	2	2.8	<2	190	<6	--	1.9	92.4
	Flathead chub[4]	2.1	182	<4	1,330	16	.080	<1	<3	2.4	<2	267	<5	--	<.3	99.4
	Flathead chub - 3 fish[4]	4.4	191	<4	1,310	11.0	.038	<1	3	2.0	<2	137	<6	--	.6	88.0
	Flathead chub[4]	1.0	48	<4	1,160	4.6	.049	<1	<3	1.5	<2	205	<5	--	<.4	73.5
	Flathead chub[4]	2.7	44.8	<.9	961	3.2	.054	<.1	<.8	1.5	<.01	157	<.8	--	<.09	71.2
	Flathead chub[4]	2.6	169	<.9	1,550	45.6	.11	.2	2	2.3	<.01	321	<.9	--	.35	121
	Flathead chub - 2 fish[4]	3.8	199	<4	1,460	23.6	.055	<1	1	1.9	<2	229	<6	--	<.4	97.0
	Green sunfish[4]	2.0	107	<4	1,560	21	.090	<1	<3	2.2	<2	243	<5	--	.4	84.1
	Green sunfish[4]	.75	210	<4	1,520	18	.15	<1	<3	3.1	<2	211	<5	--	.6	79.9
	Green sunfish[4]	5.55	132	<.9	1,480	14.4	.12	<.1	<.9	1.8	<.01	227	<.9	--	<.1	76.8
	Green sunfish[4]	3.0	101	<.9	1,560	54.0	.29	.2	1	3.2	<.01	169	<.9	--	.3	88.9
	River carpsucker - 2 fish[4]	4.7	1,480	<4	2,510	134	.056	<1	3	3.0	<2	330	<6	--	4.4	131
	Shorthead redhorse - 3 fish[4]	3.3	468	<4	1,890	56.9	.085	<1	<1	2.6	<2	239	<6	--	1.1	123
	Shorthead redhorse - 3 fish[4]	3.0	228	<4	1,700	51.8	.17	<1	<1	2.5	<2	216	<6	--	.8	101
	Shorthead redhorse - 3 fish[4]	3.8	295	<4	2,130	73.8	.13	<1	1	3.0	<2	286	<6	--	.9	120
	Shorthead redhorse[4]	2.1	239	<4	1,620	44.7	.14	<1	<3	2.7	<2	300	<5	--	.4	101
	Shorthead redhorse - 3 fish[4]	3.2	168	<4	2,190	53.4	.12	<1	2	2.4	<2	330	<6	--	.6	127
	Shorthead redhorse[4]	1.9	300	<4	1,710	73.6	.11	<1	3	2.4	<2	309	<5	--	.6	85.7
	Shorthead redhorse[4]	1.5	58	<4	1,620	32	.16	<1	<3	2.6	<2	276	<5	--	.4	88.5
	Shorthead redhorse[4]	3.51	365	<.6	1,790	85.8	.17	.61	2.8	3.4	<.01	287	<.5	--	.67	105
	Shorthead redhorse[4]	2.5	262	<.9	1,830	61.3	.28	.3	2	2.9	<.01	309	<.8	--	.36	89.4
	Shorthead redhorse[4]	2.3	322	<4	1,660	63.5	.15	<1	<3	2.4	<2	289	<5	--	.8	86.5
	Shorthead redhorse[4]	2.6	165	<.6	1,590	50.6	.40	.2	1.8	2.2	<.01	254	<5	--	.67	92.1
	Shorthead redhorse[4]	2.5	171	<.9	1,680	51.5	.41	<.1	<.8	2.1	<.01	272	<.8	--	.74	86.1

Table 16.--Field measurements and results of laboratory analyses of biological data from the Belle Fourche Reclamation Project investigation area, April through September 1988--Continued

Site number (fig. 7)	Taxa	Col-lection date	Estimated age class[1]	Sex	Weight (grams)	Length (mm)	Percent moisture	Alu-minium[2]	Anti-mony[3]	Ar-senic[3]	Barium	Beryl-lium[2]	Boron	Cad-mium[2]	Chro-mium[2]
2	Shorthead redhorse[4]	09-20-88	II		181	274	73.3	98	<0.1	<0.2	4.5	<0.03	<2	0.39	0.7
(Cont)	Shorthead redhorse[4]	09-20-88	III		230	295	74.5	160	--	.2	4.2	<.1	4	1.5	<1
	Stonecat[4]	09-20-88	IV		71	197	77.6	4.2	<.1	<.2	1.7	<.02	<2	.30	1.3
	White sucker[4]	04-19-88	II		97	196	71.1	423	--	.3	4.2	<.1	<2	.2	1
	Composite invertebrate[4]	08-03-88			19	--	87.1	585	<.194	1.82	<19.4	<1.94	<19.4	6.20	<3.88
	Three square bulrush[4]	08-03-88			220	--	85.1	94	<.168	5.03	22.5	<1.68	17.8	<1.68	<3.36
8	Composite invertebrate[4]	08-03-68			20	--	90.1	490	<.253	1.09	<25.3	<2.53	<25.3	<2.53	<5.05
	River bulrush[4]	08-03-88			185.5	--	84.4	801	.186	3.04	<16.0	<1.60	128	<1.60	4.49
	Sago Pondweed[4]	08-03-88			161.5		89.3	1,640	.654	6.45	31.8	<2.34	459	<2.34	7.01
9	Red-winged blackbird eggs - 4 eggs[4]	06-21-88			13.5	--	81.9	<27.6	<.138	.044	<13.8	<1.38	<13.8	<1.38	<2.76
	Red-winged blackbird eggs - 4 eggs[4]	06-21-88			16.5	--	73.8	<19.1	<.095	.061	<9.54	<.95	<9.54	<.95	<1.91
	Red-winged blackbird eggs - 4 eggs[4]	06-21-88			17.5	--	83.6	<30.5	<.152	.067	<15.2	<1.52	<15.2	<1.52	<3.05
	Red-winged blackbird eggs - 4 eggs[4]	06-21-88			17.5	--	81.4	<26.9	<.134	.156	<13.4	<1.34	<13.4	<1.34	<2.69
10	Pied-billed grebe egg[4]	06-22-88			20	--	74.0	<19.2	<.096	.035	<9.62	<.96	<9.62	<.96	<1.92
	Pied-billed grebe egg[4]	06-22-88			20	--	74.9	<19.9	<.100	.064	<9.96	<1.0	<9.96	<1.0	<1.99
	Pied-billed grebe egg[4]	06-22-88			20	--	74.4	<19.5	<.098	.078	<9.77	<.98	<9.77	<.98	<1.95

Table 16.--Field measurements and results of laboratory analyses of biological data from the Belle Fourche Reclamation Project investigation area, April through September 1988--Continued

Site number (fig. 7)	Taxa	Copper[2]	Iron[2]	Lead[2]	Magnesium	Manganese[2]	Mercury[3]	Molybdenum	Nickel[2]	Selenium[3]	Silver[3]	Strontium	Thallium[2]	Tin	Vanadium	Zinc[2]
2	Shorthead redhorse[4]	2.1	145	<1	1,580	69.9	0.36	0.2	<1	2.6	0.01	267	<1	--	0.3	83.5
(Cont)	Shorthead redhorse[4]	2.7	330	<4	1,880	48.0	.26	<1	<3	2.8	<2	341	<5	--	.7	96.4
	Stonecat[4]	1.8	68.8	<.9	1,410	24.8	.092	.2	.9	1.6	<.01	167	<.9	--	.75	72.6
	White sucker[4]	5.7	398	<4	1,620	56.2	.099	<1	<1	2.3	<2	164	<6	--	.9	73.0
	Composite invertebrate[4]	29.5	1,390	<38.8	1,510	170	<.194	<19.4	<15.5	5.4	<19.4	30.6	<.78	<19.4	<19.4	189
	Three square bulrush[4]	<8.39	4,380	<33.6	2,280	2,520	<.168	<16.8	<13.4	.67	<16.8	114	<.67	<16.8	<16.8	20.8
8	Composite invertebrate[4]	25.8	657	<50.5	2,580	83.3	<.253	<25.3	<20.2	1.0	<25.3	109	<1.1	<25.3	<25.3	158
	River bulrush[4]	10.3	1,710	<32.0	9,360	378	<.161	<16.0	<12.8	<.51	<16.0	136	<.65	<16.0	<16.0	38.5
	Sago Pondweed[4]	15.0	2,320	<46.7	23,300	564	<.234	<23.4	<18.7	<.47	<23.4	405	<.94	39.3	<23.4	46.3
9	Red-winged blackbird eggs - 4 eggs[4]	<6.91	191	<27.6	442	<4.14	<.139	<13.8	<11.0	2.2	<13.8	19.3	<.56	<13.8	<13.8	76
	Red-winged blackbird eggs - 4 eggs[4]	<4.77	153	<19.1	363	5.73	<.096	<9.54	<7.63	1.9	<9.54	14.1	<.39	<9.54	<9.54	85
	Red-winged blackbird eggs - 4 eggs[4]	<7.62	131	<30.5	396	<4.57	.220	<15.2	<12.2	1.8	<15.2	13.4	<.61	<15.2	<15.2	63
	Red-winged blackbird eggs - 4 eggs[4]	<6.72	204	<26.9	376	<4.03	.210	<13.4	<10.4	3.8	<13.4	12.1	<.54	<13.4	<13.4	79
10	Pied-billed grebe egg[4]	5.58	142	<19.2	500	2.88	.750	<9.62	<7.69	9.6	<9.62	12.3	<.39	<9.62	<9.62	73
	Pied-billed grebe egg[4]	6.57	135	<19.9	578	2.99	.789	<9.96	<7.97	10.0	<9.96	12.2	<.40	<9.96	<9.96	68
	Pied-billed grebe egg[4]	5.47	109	<19.5	488	<2.93	.734	<9.77	<7.81	9.0	<9.77	11.1	<.40	<9.77	<9.77	60

Table 16.--Field measurements and results of laboratory analyses of biological data from the Belle Fourche Reclamation Project investigation area, April through September 1988--Continued

Site number (fig. 7)	Taxa	Col-lection date	Estimated age class[1]	Sex	Weight (grams)	Length (mm)	Percent moisture	Alu-minium[2]	Anti-mony[3]	Ar-senic[3]	Barium	Beryl-lium[2]	Boron	Cad-mium[2]	Chro-mium[2]
12	Carp - 3 fish	04-18-88	II		205	243	79.4	548	--	0.4	7.9	<0.01	<2	0.06	1.8
	Channel catfish	09-20-88	I		45	181	76.5	31	<0.1	<.1	1.3	<.02	<2	.1	1.8
	Flathead chub - 3 fish	04-18-88	II		24	135	69.0	335	--	.3	16.0	.045	<2	<.02	1.8
	Flathead chub[4]	09-20-88	II		40	162	72.9	73	--	<.1	4.4	<.1	<2	<.4	<1
	Flathead chub	09-20-88	II		42	174	76.0	384	<.1	<.2	5.9	<.02	<2	.1	1.8
	Flathead chub[4]	09-20-88	II		42	165	74.3	290	--	.2	6.5	<.1	<2	<.4	<1
	Flathead chub	09-20-88	II		43	170	75.2	20	<.1	<.2	2.4	<.02	<2	.2	1.6
	Flathead chub - 3 fish	04-18-88	III		47	171	71.3	93.5	--	<.2	3.6	<.01	<2	.02	.33
	Flathead chub	04-18-88	III		50	175	67.8	210	--	.3	3.8	<.01	<2	<.02	.60
	Flathead chub	04-18-88	III		52	173	68.7	78.1	--	<.2	2.1	<.01	<2	.04	.20
	Flathead chub[4]	09-20-88	III		62	186	72.1	321	--	.1	4.7	<.1	<2	<.4	2
	Flathead chub	04-18-88	III		74	193	69.5	154	--	<.2	3.5	<.01	<2	.03	.56
	Green sunfish[4]	09-20-88	I		19	100	73.9	120	--	.2	4.1	<.1	<2	<.4	<1
	Green sunfish[4]	09-20-88	I		21	103	74.9	64	--	.2	2.3	<.1	<2	<.4	2
	Green sunfish[4]	09-20-88	I		23	110	73.1	150	--	.3	5.3	<.1	<2	<.4	2
	Green sunfish	09-20-88	II		33	116	75.1	106	<.1	.3	4.3	<.02	<2	.1	1.7
	Green sunfish	09-20-88	II		44	130	73.7	71.6	<.1	.2	2.7	<.02	<2	<.08	1.8
	River carpsucker	04-18-88	III		290	283	72.6	11	--	.61	4.1	.01	<2	.04	1.1
	River carpsucker	04-18-88	III		291	291	71.1	1,520	--	1.3	21.9	.061	2	.06	3.0
	River carpsucker	04-18-88	III		295	291	70.5	351	--	.93	7.8	.02	<2	<.02	.95
	River carpsucker	09-20-88	III		382	325	69.0	4,100	<.1	1.1	45.9	.092	8.3	.1	8.4
	Shorthead redhorse	04-18-88	II		55	186	71.6	299	--	<.2	7.2	<.01	6	<.02	1.9
	Shorthead redhorse	04-18-88	II		59	179	67.8	156	--	.2	4.5	<.01	3	<.02	.41
	Shorthead redhorse	04-18-88	II		60	180	66.6	123	--	<.2	5.5	<.01	3	<.02	.30
	Shorthead redhorse[4]	09-20-88	I		84	216	71.4	69	--	.3	4.8	<.1	15	<.4	2
	Shorthead redhorse[4]	09-20-88	II		169	257	73.7	280	--	.37	6.8	<.1	16	<.4	2
	Shorthead redhorse[4]	09-20-88	II		190	274	70.5	14	--	.2	4.3	<.1	17	<.4	2
	Shorthead redhorse	04-18-88	III		260	301	69.7	221	--	<.2	6.7	<.01	3	<.02	.74
	Shorthead redhorse	04-18-88	III		279	308	69.3	358	--	<.2	7.7	<.01	3	.05	1.4

Table 16.--Field measurements and results of laboratory analyses of biological data from the Belle Fourche Reclamation Project investigation area, April through September 1988--Continued

Site number (fig. 7)	Taxa	Copper[2]	Iron[2]	Lead[2]	Magnesium	Manganese[2]	Mercury[3]	Molybdenum	Nickel[2]	Selenium[3]	Silver[3]	Strontium	Thallium[2]	Tin	Vanadium	Zinc[2]
12	Carp - 3 fish	5.21	493	<0.4	1,770	33.4	0.11	<1	0.88	3.9	<0.01	198	<0.7	--	2.0	223
	Channel catfish	1.9	85.8	<.9	1,420	15.4	.19	.1	<.9	3.5	<.01	153	<.9	--	.43	82.2
	Flathead chub - 3 fish	2.96	1,940	.5	1,290	55.4	.088	<1	1.3	3.6	<.01	138	<.7	--	1.5	72.3
	Flathead chub[4]	2.0	89	<4	1,330	8.8	.12	<1	<3	3.6	<2	180	<5	--	.4	86.8
	Flathead chub	2.5	382	<.9	1,580	15.7	.15	<.1	.9	4.1	<.01	188	<.8	--	.80	92.5
	Flathead chub[4]	2.1	208	<4	1,600	16	.28	<1	<3	4.3	<2	233	<5	--	1.2	104
	Flathead chub	2.4	64.4	<.9	1,350	9.68	.16	.71	3.7	4.6	<.01	173	1	--	<.1	85.1
	Flathead chub - 3 fish	2.25	102	<.4	1,290	11.7	.081	<1	.2	3.0	<.01	167	<.7	--	.4	78.1
	Flathead chub	2.0	166	<.4	1,210	17.5	.061	<1	.35	3.8	<.01	124	<.7	--	.9	64.5
	Flathead chub	2.49	91.7	<.4	1,190	10.5	.24	<1	.1	5.1	<.01	125	<.7	--	.4	72.9
	Flathead chub[4]	2.2	232	<4	1,430	15	.20	<1	<3	4.1	<2	199	<5	--	1	90.2
	Flathead chub	2.45	145	<.4	1,190	27.3	.093	<1	.48	3.3	<.01	132	<.7	--	.7	78.7
	Green sunfish[4]	1.4	125	<4	1,650	20	.18	<1	<3	3.2	<2	224	<5	--	.6	81.2
	Green sunfish[4]	1.1	102	<4	1,700	26	.37	<1	<3	2.8	<2	204	<5	--	<.4	119
	Green sunfish[4]	.71	124	<4	1,550	22	.23	<1	<3	3.2	<2	218	<5	--	.7	75.7
	Green sunfish	1.6	134	<.9	1,710	19.8	.23	.2	.9	3.0	<.01	215	<.9	--	<.1	100
	Green sunfish	1.5	99.0	<.9	1,510	19.2	.22	.2	<.8	2.6	<.01	180	<.8	--	.3	81.4
	River carpsucker	2.1	135	<.4	1,770	19.6	.21	<1	.5	3.4	<.01	282	<.7	--	.4	67.3
	River carpsucker	2.79	1,140	<.5	2,220	40.4	.22	<1	1.9	4.0	<.01	253	<.8	--	5.1	66.8
	River carpsucker	1.8	354	<.5	1,520	20.4	.14	<1	.48	3.1	<.01	188	<.7	--	1.6	47.1
	River carpsucker	4.5	2,680	1	2,430	71.8	.22	.2	4.5	4.7	<.01	221	<1	--	15	64.4
	Shorthead redhorse	2.25	208	<.4	1,760	65.0	.10	<1	.96	2.7	<.01	238	<.7	--	1.2	82.6
	Shorthead redhorse	2.28	135	<.4	1,310	42.2	.096	<1	.3	1.8	<.01	151	<.7	--	.6	64.3
	Shorthead redhorse	2.1	92.3	<.4	1,380	35.0	.052	<1	.2	2.9	<.01	185	<.7	--	.7	58.3
	Shorthead redhorse[4]	1.5	93	<4	1,510	38.1	.16	<1	<3	2.8	<2	210	<5	--	.4	79.0
	Shorthead redhorse[4]	1.8	251	<4	1,560	34	.21	<1	<3	2.5	<2	194	<4	--	1.2	67.0
	Shorthead redhorse[4]	1.4	47	<4	1,450	48.8	.16	<1	<3	2.5	<2	211	<5	--	<.4	67.1
	Shorthead redhorse	2.32	193	<.4	1,470	33.6	.17	<1	.3	2.4	>.01	166	<.7	--	.91	56.8
	Shorthead redhorse	2.71	270	<.4	1,630	62.4	.19	<1	.98	3.0	<.01	192	<.7	--	1.4	56.6

Table 16.--Field measurements and results of laboratory analyses of biological data from the Belle Fourche Reclamation Project investigation area, April through September 1988--Continued

Site number (fig. 7)	Taxa	Collection date	Estimated age class[1]	Sex	Weight (grams)	Length (mm)	Percent moisture	Aluminium[2]	Antimony[3]	Arsenic[3]	Barium	Beryllium[2]	Boron	Cadmium[2]	Chromium[2]
12	Shorthead redhorse	09-20-88	III		285	309	72.3	112	<0.1	<0.2	9.4	<0.02	<2	0.1	2.6
(Cont)	Shorthead redhorse[4]	09-20-88	III		293	318	69.5	130	--	.3	5.4	<.1	16	<.4	3
	Shorthead redhorse	04-18-88	III		317	319	69.6	73.8	--	<.2	3.3	<.01	3	<.02	.35
	Shorthead redhorse	09-20-88	III		319	316	71.1	143	<.1	.60	9.4	<.02	<2	.1	3.9
	Shorthead redhorse	09-20-88	III		319	327	72.4	179	<.1	<.2	5.3	<.02	<2	.2	1.3
	Shorthead redhorse	04-18-88	III		326	319	68.4	51.7	--	.2	4.6	<.01	<2	.13	<.1
	Shorthead redhorse	04-18-88	III		351	343	71.0	159	--	<.2	6.3	<.01	<2	.10	1.4
	Shorthead redhorse	09-20-88	III		364	331	71.1	203	<.1	4.9	84.0	<.02	<2	.2	1.8
	Shorthead redhorse	09-20-88	III		384	302	71.6	208	<.1	.3	9.5	.03	<2	.2	1.8
	Shorthead redhorse[4]	09-20-88	IV		400	351	77.0	240	--	1.2	35.0	<.1	4	<.4	2
	Shorthead redhorse	04-18-88	III		424	349	69.3	244	--	2.2	20.3	.020	<2	.11	1.2
	Shorthead redhorse	04-18-88	IV		539	385	73.2	137	--	.4	5.9	<.01	<2	.15	.83
	Stonecat - 3 fish[4]	09-20-88	I		21	104	70.7	190	--	<.1	3.5	<.1	<2	<.4	2
	Stonecat	09-20-88	II		30	147	79.5	733	<.1	.4	19.3	<.02	3	.2	2.0
	Stonecat	09-20-88	IV		30	150	78.4	104	<.1	<.2	3.0	<.02	<2	.3	2.1
	Walleye	04-18-88	II		200	304	76.8	9.6	--	<.2	.80	<.01	<2	<.02	1.1
	Walleye	04-18-88	II		272	322	77.0	13	--	.2	1.1	<.01	<2	.03	.46
	White sucker[4]	09-20-88	III		384	320	75.7	130	--	.75	7.3	<.1	<2	<.4	<1
	Composite invertebrate[4]	08-02-88			28	--	87.5	2,980	.272	4.70	81.6	<2.00	<20.0	<2.00	6.80
	Sago Pondweed[4]	08-02-88			250	--	89.3	2,020	.346	4.67	63.6	<2.34	308	<2.34	7.48
	Three square bulrush[4]	08-02-88			224	--	88.9	725	<.225	1.94	36.9	<2.25	30.6	<2.25	4.50
13	Mallard liver[4]	05-11-88		F	32	--	68.7	<16.0	<.080	.195	<7.99	<.80	<7.99	<.80	<1.60
14	Mallard liver[4]	05-11-88		F	40	--	72.8	<18.4	<.092	.272	<9.19	<.92	<9.19	<.92	<1.84
	Mallard eggs - 3 eggs	05-11-88			6	--	54.80	--	--	.323	--	--	--	--	--

Table 16.--Field measurements and results of laboratory analyses of biological data from the Belle Fourche Reclamation Project investigation area, April through September 1988--Continued

Site number (fig. 7)	Taxa	Copper[2]	Iron[2]	Lead[2]	Magnesium	Manganese[2]	Mercury[3]	Molybdenum	Nickel[2]	Selenium[3]	Silver[3]	Strontium	Thallium[2]	Tin	Vanadium	Zinc[2]
12	Shorthead redhorse	2.4	267	<1	1,520	44.3	0.41	0.39	2	2.5	<0.01	164	<0.9	--	0.79	68.0
(Cont)	Shorthead redhorse[4]	1.7	134	<4	1,510	35	.23	<1	<3	2.7	<2	197	<5	--	1	60.2
	Shorthead redhorse	2.1	86.5	<.4	1,470	25.8	.18	<1	<.1	2.1	<.01	199	<.7	--	.5	63.0
	Shorthead redhorse	3.3	805	<1	1,540	54.3	.32	.2	2.9	2.9	<.01	176	<.9	--	1.3	69.4
	Shorthead redhorse	2.7	155	<.9	1,660	41.4	.41	.2	.9	2.7	<.01	201	<.8	--	.70	72.8
	Shorthead redhorse	2.0	73.4	<.5	1,430	38.1	.662	<1	<.1	2.5	<.01	203	<.5	--	.6	58.6
	Shorthead redhorse	2.59	172	<.5	1,630	42.9	.30	1.0	5.2	2.0	<.01	215	<.7	--	.9	67.9
	Shorthead redhorse	3.5	2,000	<1	1,350	56.6	.33	.35	2	3.9	<.01	116	<.9	--	1.1	64.9
	Shorthead redhorse	3.1	277	2	1,470	40.0	.39	.35	2	2.4	<.01	174	<.8	--	.83	67.0
	Shorthead redhorse[4]	4.9	1,720	<4	1,510	67.8	.702	<1	<3	3.1	<2	138	<4	--	2.0	75.6
	Shorthead redhorse	3.09	2,040	<.5	1,490	75.4	.21	<1	2.4	2.8	<.01	156	<.7	--	1.6	61.8
	Shorthead redhorse	3.27	195	<.4	1,260	35.6	.44	<1	2.4	2.9	<.01	100	<.7	--	.92	60.5
	Stonecat - 3 fish[4]	1.5	190	<4	1,130	30	.16	<1	<3	1.5	<2	108	<5	--	1.1	53.0
	Stonecat	4.1	1,080	<.9	1,530	47.7	.16	.35	2	2.0	<.01	127	<.8	--	1.7	67.9
	Stonecat	2.3	171	<.9	1,490	38.2	.24	.40	2.5	2.2	<.01	139	<.8	--	1.6	76.9
	Walleye	1.2	48.8	<.4	1,580	4.29	.29	<1	.51	3.7	<.01	114	<.7	--	<.3	49.9
	Walleye	1.1	42.8	<.4	1,640	4.0	.32	<1	.2	3.5	<.01	147	<.7	--	<.3	52.4
	White sucker[4]	2.6	680	<4	1,750	54.0	.15	<1	<3	3.7	<2	265	<5	--	1.6	59.2
	Composite invertebrate[4]	26.4	8,160	<40.0	2,760	354	<.200	<20.0	<16.0	3.2	<20.0	64.4	<.80	<20.0	<20.0	164
	Sago Pondweed[4]	22.9	4,790	<46.7	7,990	932	<.234	<23.4	<18.7	.93	<23.4	335	<.93	<23.4	<23.4	50.5
	Three square bulrush[4]	15.3	2,280	<45.0	4,370	1,020	<.225	<22.5	<18.0	.90	<22.5	126	<.90	<22.5	<22.5	36.5
13	Mallard liver[4]	9.90	2,770	<16.0	703	14.2	.380	<7.99	<6.39	19.5	<7.99	<1.60	<.32	<7.99	<7.99	119
14	Mallard liver[4]	11.0	2,480	<18.4	735	16.7	.636	<9.19	<7.35	8.8	<9.19	<1.84	<.37	9.19	<9.19	92.6
	Mallard eggs - 3 eggs	--	--	--	--	--	.088	--	--	<.18	--	--	--	--	--	--

Table 16.--Field measurements and results of laboratory analyses of biological data from the Belle Fourche Reclamation Project investigation area, April through September 1988--Continued

Site number (fig. 7)	Taxa	Collection date	Estimated age class[1]	Sex	Weight (grams)	Length (mm)	Percent moisture	Aluminium[2]	Antimony[3]	Arsenic[3]	Barium	Beryllium[2]	Boron	Cadmium[2]	Chromium[2]
15	Composite invertebrate[4]	08-03-88			20	--	85.6	62.5	<0.174	0.972	<17.4	<1.74	<17.4	<1.74	<3.47
	Odonata[4]	08-03-88			20	--	86.5	<37.0	<.165	.933	<18.5	<1.85	<18.5	<1.85	<3.70
	Sago Pondweed[4]	08-03-88			191.5	--	90.9	104	.286	14.7	69.8	<2.75	46.7	<2.75	<5.49
	Pintail eggs - 2 eggs[4]	05-12-88			19	--	44.0	<8.93	<.045	.084	7.86	<.45	<4.46	<.45	<.89
	Pintail liver[4]	05-12-88		F	20	--	75.4	<20.3	<.102	.293	<10.2	<1.02	<10.2	<1.02	<2.03
16	Composite invertebrate[4]	08-02-88			23.5	--	81.2	71.8	<.132	.479	<13.3	<1.33	<13.3	<1.33	<2.66
	Odonata[4]	08-02-88			31.0	--	83.5	87.9	<.152	1.12	<15.2	<1.52	<15.2	<1.52	<3.03
	Narrow leafed cattail[4]	08-02-88			343.5	--	82.5	409	<.144	1.94	<14.3	<1.43	21.4	<1.43	4.57
	Sago Pondweed[4]	08-02-88			351.5	--	90.5	1,520	.305	6.58	101	<2.63	40.0	<2.63	6.32
	Three square bulrush[4]	08-02-88			197.5	--	82.3	260	<.141	3.53	<14.1	<1.41	19.5	<1.41	3.11
	Blue-wing teal liver[4]	05-11-88		M	10	--	70.9	<17.2	<.086	.485	<8.59	.86	<8.59	1.55	<1.72
	Blue-wing teal liver[4]	05-11-88		F	10	--	72.0	<17.9	<.089	.407	<8.93	.89	<8.93	1.61	<1.79
	Blue-wing teal liver[4]	05-11-88		F	12	--	70.7	<17.1	<.084	.205	<8.53	.85	<8.53	<.85	<1.71
	Blue-wing teal liver[4]	05-11-86		F	14	--	70.9	<17.2	<.086	.155	<8.59	.86	<8.59	<.86	<1.72
	Pintail liver[4]	05-11-88		F	24	--	76.7	<21.5	<.107	.094	<10.7	<1.07	<10.7	1.50	<2.15
	Blue-winged teal egg	05-11-88			2	--	83.7	--	--	--	--	--	--	--	--
18	Carp	04-18-88	II		172	230	79.9	187	--	2.0	3.5	<.01	<2	.11	.56
	Carp	04-18-86	II		205	245	78.6	270	--	3.2	4.9	<.01	<2	.085	.71
	Carp	04-18-88	VI		1,600	511	78.1	270	--	7.6	4.9	<.01	<2	.34	.81
	Carp	04-18-88	VI		1,750	504	76.1	384	--	3.4	3.4	<.01	<2	.14	2.8
	Carp	04-18-88	VI		2,200	549	75.1	211	--	3.8	4.2	<.01	<2	.23	1.5
	Carp	04-18-88	VIII		3,925	626	72.5	208	--	3.5	8.1	<.01	<2	.44	2.8

Table 16.--Field measurements and results of laboratory analyses of biological data from the Belle Fourche Reclamation Project investigation area, April through September 1988--Continued

Site number (fig. 7)	Taxa	Copper[2]	Iron[2]	Lead[2]	Magnesium	Manganese[2]	Mercury[3]	Molybdenum	Nickel[2]	Selenium[3]	Silver[3]	Strontium	Thallium[2]	Tin	Vanadium	Zinc[2]
15	Composite invertebrate[4]	20.8	965	<34.7	1,320	225	<0.174	<17.4	<13.9	3.5	<17.4	14.6	<0.70	64.9	<17.4	98.6
	Odonata[4]	12.6	881	<37.0	1,260	117	<.186	<18.5	<14.8	<2.2	<18.5	11.9	<.75	<18.5	<18.5	86.7
	Sago Pondweed[4]	<13.7	12,400	<54.9	3,900	5,550	<.275	<27.5	<22.0	1.1	<27.5	308	<1.1	<27.5	<27.5	50.5
	Pintail eggs - 2 eggs[4]	<2.23	159	<8.93	232	1.70	<.045	<4.46	1.785	1.3	<4.46	11.8	<.18	7.68	<4.46	85.9
	Pintail liver[4]	12.4	996	<20.3	996	17.1	.382	<10.2	<8.13	8.5	<10.2	<2.03	<.41	<10.2	<10.2	123
16	Composite invertebrate[4]	21.8	239	<26.6	1,060	57.4	.245	<13.3	<10.6	4.8	<13.3	29.8	<.54	<13.3	<13.3	143
	Odonata[4]	19.4	276	<30.3	1,000	76.4	.248	<15.2	<12.1	2.4	<15.2	21.2	<.61	<15.2	<15.2	93.3
	Narrow leafed cattail[4]	8.86	1,490	<28.6	3,460	577	<.143	<14.3	<11.4	<.29	<14.3	155	<.58	<14.3	<14.3	27.4
	Sago Pondweed[4]	<13.2	3,890	<52.6	4,740	5,910	<.263	<26.3	<21.1	1.1	<26.3	769	<1.1	<26.3	<26.3	31.1
	Three square bulrush[4]	<7.06	1,660	<28.2	2,540	972	<.141	<14.1	<11.3	.56	<14.1	97.2	<.56	<14.1	<14.1	20.6
	Blue-wing teal liver[4]	155	9,860	<17.2	859	24.2	2.460	<8.5	<6.87	9.3	<8.59	<1.72	<.35	11.0	<8.59	143
	Blue-wing teal liver[4]	119	5,180	<17.9	929	28.6	2.77	<8.9	<7.14	15.0	<8.93	<1.79	<.36	<8.93	<8.93	143
	Blue-wing teal liver[4]	122	3,620	<17.1	887	19.1	.672	<8.5	<6.83	6.5	<8.53	<1.71	<.35	11.3	<8.53	144
	Blue-wing teal liver[4]	65.3	1,690	<17.2	704	13.9	1.36	<8.5	<6.87	27.5	<8.59	<1.72	<.35	10.1	<8.59	94.2
	Pintail liver[4]	21.9	3,780	<21.5	944	15.7	.348	<10.7	<8.58	21.9	<10.7	<1.07	<.43	10.9	<10.7	214
	Blue-winged teal egg	--	--	--	--	--	--	--	--	8.0	--	--	--	--	--	--
18	Carp	6.12	255	<.4	1,720	24.3	.32	<1	.63	3.9	<.01	263	<.7	--	.7	358
	Carp	6.06	365	<.4	1,680	35.3	.35	<1	.87	3.2	<.01	254	<.7	--	.8	255
	Carp	5.96	530	<.4	1,350	18.7	.69	<1	.75	4.6	<.01	84.0	<.7	--	1.0	601
	Carp	5.21	464	<.4	1,270	11.3	.964	<1	1.4	5.3	<.01	96.9	<.7	--	1.1	355
	Carp	4.85	393	<.4	1,280	15.6	.573	<1	.71	4.8	<.01	98.1	<.7	--	.8	359
	Carp	4.76	759	<.4	1,010	26.1	.894	<1	1.5	4.7	.02	79.2	<.7	--	.9	154

Table 16.--Field measurements and results of laboratory analyses of biological data from the Belle Fourche Reclamation Project investigation area, April through September 1988--Continued

Site number (fig. 7)	Taxa	Col-lection date	Estimated age class[1]	Sex	Weight (grams)	Length (mm)	Percent moisture	Alu-minium[2]	Anti-mony[3]	Ar-senic[3]	Barium	Beryl-lium[2]	Boron	Cad-mium[2]	Chro-mium[2]
18	Channel catfish[4]	09-21-88	II		119	261	72.5	33	--	0.50	1.2	0.1	3	<0.4	1
(Cont)	Channel catfish[4]	09-21-88	II		168	306	79.5	220	--	2.9	4.4	.1	3	<.4	2
	Channel catfish[4]	09-21-88	II		201	303	71.8	19	--	.44	1.0	.1	2	<.4	<1
	Channel catfish	09-21-88	II		215	298	74.1	40	<0.1	5.2	.95	<.02	<2	.1	1.7
	Channel catfish[4]	09-21-88	II		228	257	66.9	54	--	.46	.81	<.1	<2	<.5	<1
	Channel catfish[4]	09-21-88	II		270	329	75.0	19	--	.56	1.9	<.1	3	<.5	2
	Channel catfish[4]	09-21-88	II		281	351	75.3	31	--	.87	1.1	<.1	<2	<.4	<1
	Channel catfish[4]	09-21-88	III		408	390	79.6	83	--	1.3	2.1	<.1	3	<.4	1
	Channel catfish - 3 fish	04-18-88	III		504.3	388.7	73.7	310	--	3.0	3.1	.02	<2	.06	1.2
	Channel catfish	04-18-88	III		533	402	71.8	342	--	3.8	2.8	.02	<2	.04	.3
	Channel catfish	04-18-88	IV		812	445	73.8	2,120	--	1.6	11.3	.068	2	.03	2.6
	Channel catfish	09-21-88	V		961	492	71.8	16	<.1	.66	.87	<.03	<2	.1	1.6
	Channel catfish	04-18-88	VI		1,150	503	73.2	78.2	--	6.8	.98	.01	<2	.03	<.1
	Channel catfish	04-18-88	IV		1,225	499	66.7	58.4	--	.5	2.6	<.01	<2	.04	<.1
	Channel catfish	04-18-88	VII		1,500	539	74.4	675	--	6.3	6.5	.03	<2	.05	.73
	Channel catfish	04-18-88	VII		1,750	605	76.7	193	--	4.5	3.4	<.01	<2	.12	2.9
	Goldeye	09-21-88	II		198	287	72.6	15	<.1	.2	1.5	<.02	<2	.09	2.1
	Goldeye	09-21-88	III		347	346	68.1	22	<.1	<.2	.85	<.03	<2	.1	1.5
	Goldeye	04-18-88	IV		376	354.3	67.0	12	--	.3	.57	<.01	<2	.06	<.1
	Goldeye	04-18-88	IV		379	350	62.0	6.4	--	<.2	.40	<.01	<2	.07	<.1
	Goldeye	09-21-88	III		385	361	70.9	23	<.1	.3	.94	<.02	<2	.1	1.8
	Goldeye	04-18-88	IV		386	360	66.6	4.5	--	<.2	.2	<.01	<2	.06	<.1
	Goldeye[4]	09-21-88	III		429	363	66.7	<3	--	.52	.2	<.1	<2	<.4	<1
	Goldeye[4]	09-21-88	III		456	365	65.1	9	--	.55	.3	<.1	<2	<.4	<1
	Goldeye	04-18-88	IV		488	376	61.3	5.0	--	.3	.3	<.01	<2	.04	<.1
	Goldeye	04-18-88	V		502	398	66.5	6.3	--	.61	.3	<.01	<2	.05	<.1
	Goldeye	04-18-88	IV		572	382	64.8	6.5	--	.64	.3	<.01	<2	.05	<.1
	Green sunfish - 5 fish[4]	09-21-88	O		8.4	78.6	71.6	28	--	.76	1.7	<.1	<2	<.4	1
	Green sunfish[4]	09-21-88	I		18	102	73.1	14	--	.88	1.3	<.1	<2	<.4	3
	Green sunfish[4]	09-21-88	I		20	114	74.2	27	--	.64	1.6	<.1	<2	<.4	2
	Green sunfish	09-21-88	II		34	120	72.7	50	<.1	.95	1.7	<.02	<2	.1	2.7
	Green sunfish	09-21-88	II		38	126	74.0	31	<.1	.97	1.7	<.02	<2	.2	1.9

Table 16.--Field measurements and results of laboratory analyses of biological data from the Belle Fourche Reclamation Project investigation area, April through September 1988--Continued

Site number (fig. 7)	Taxa	Copper[2]	Iron[2]	Lead[2]	Magnesium	Manganese[2]	Mercury[3]	Molybdenum	Nickel[2]	Selenium[3]	Silver[3]	Strontium	Thallium[2]	Tin	Vanadium	Zinc[2]
18	Channel catfish[4]	0.83	113	<4	1,410	15	0.637	<1	<3	3.1	<2	146	<5	--	<0.4	87.6
(Cont)	Channel catfish[4]	1.4	296	<5	1,780	23	.666	<1	<3	2.1	<2	214	<5	--	1.2	98.6
	Channel catfish[4]	.83	76	<4	1,420	9.8	.532	<1	<3	2.2	<2	165	<5	--	<.3	73.8
	Channel catfish	2.0	164	<.9	1,340	20.5	.50	.49	<.8	2.3	<.01	140	<.8	--	.45	79.4
	Channel catfish[4]	.69	121	<5	1,090	7.1	.661	1	4	2.4	<2	111	<5	--	.4	78.2
	Channel catfish[4]	1.5	138	<5	1,220	5.5	.46	1	<3	1.7	<2	132	<5	--	<.4	62.4
	Channel catfish[4]	3.7	103	<4	1,010	4.6	.604	<1	<3	2.0	<2	63.7	<5	--	<.4	58.9
	Channel catfish[4]	1.4	228	<4	1,350	16	.743	<1	<3	1.8	<2	132	<5	--	.6	80.6
	Channel catfish - 3 fish	2.2	562	<.5	1,250	29.8	.38	<1	.90	1.8	<.01	115	<.5	--	1.1	77.2
	Channel catfish	2.0	496	<.5	998	25.4	.35	<1	.3	1.9	<.01	62.9	<.5	--	1.2	62.4
	Channel catfish	3.31	1,690	.8	1,460	49.1	.35	<1	1.7	1.6	<.01	65.5	<.6	--	6.2	56.4
	Channel catfish	2.9	94.9	<1	1,290	9.47	.47	.91	3.0	1.5	<.01	187	<1	--	.3	65.5
	Channel catfish	1.4	238	<.5	813	25.9	.578	<1	.2	1.6	<.01	35.7	<.5	--	.4	42.0
	Channel catfish	1.3	120	<.5	644	7.66	.556	<1	<.1	1.4	<.01	24.0	<.5	--	<.4	43.7
	Channel catfish	2.1	729	<.5	941	40.1	.853	<1	.88	1.7	<.01	47.9	<.5	--	1.8	56.8
	Channel catfish	2.47	353	<.5	1,210	43.2	1.1	<1	1.8	2.2	<.01	57.5	<.5	--	.8	64.2
	Goldeye	1.5	96.5	<.9	1,480	5.1	.47	.1	.8	4.7	<.01	177	<.8	--	<.1	90.7
	Goldeye	2.2	89.3	<1	1,190	7.96	.745	.51	2.8	3.6	<.01	71.9	<1	--	<.1	80.9
	Goldeye	1.9	112	<.4	1,030	5.06	.509	<1	.1	2.4	<.01	59.4	<.5	--	<.4	81.4
	Goldeye	1.9	80.8	<.5	981	4.17	.47	<1	<.1	2.1	<.01	47.2	<.5	--	<.4	62.7
	Goldeye	1.5	97.6	<.9	1,270	4.8	.68	<.1	.9	3.4	<.01	84.3	<.9	--	.1	93.1
	Goldeye	1.8	86.2	<.5	818	2.2	.811	<1	<.1	2.3	<.01	26.5	<.5	--	<.4	53.7
	Goldeye[4]	.66	81	<4	693	1.9	.766	<1	<3	2.9	<2	23.9	<5	--	<.4	47.2
	Goldeye[4]	1.2	82	<4	746	1.8	.770	<1	<3	2.9	<2	33.9	<5	--	<.3	58.6
	Goldeye	1.3	59.3	<.5	776	2.0	.649	<1	<.1	2.0	<.01	36.8	<.5	--	<.4	46.1
	Goldeye	2.19	67.6	<.5	942	2.88	.658	<1	<.1	2.7	<.01	30.5	<.5	--	<.4	61.1
	Goldeye	1.7	60.1	<.5	830	2.4	.73	<1	<.1	2.2	<.01	32.7	<.5	--	<.4	55.9
	Green sunfish - 5 fish[4]	.94	66	<4	1,340	17	.38	<1	<3	5.2	<2	152	<5	--	<.3	92.9
	Green sunfish[4]	.86	59	<4	1,350	13	.39	<1	5	3.8	<2	153	<5	--	<.4	81.8
	Green sunfish[4]	1.3	69	<4	1,560	19	.560	<1	<3	4.0	<2	194	<5	--	<.4	99.4
	Green sunfish	2.5	107	<.9	1,420	15.2	.55	.1	1	2.8	<.01	159	<.8	--	<.1	89.8
	Green sunfish	1.5	112	1	1,410	13.7	.50	.69	4.2	5.7	<.01	146	<.9	--	<.1	85.4

Table 16.--Field measurements and results of laboratory analyses of biological data from the Belle Fourche Reclamation Project investigation area, April through September 1988--Continued

Site number (fig. 7)	Taxa	Collection date	Estimated age class[1]	Sex	Weight (grams)	Length (mm)	Percent moisture	Aluminium[2]	Antimony[3]	Arsenic[3]	Barium	Beryllium[2]	Boron	Cadmium[2]	Chromium[2]
18	Shorthead redhorse	09-21-88	III		246	302	69.2	52	<0.1	1.3	4.9	<0.02	<2	0.2	1.9
(Cont)	Shorthead redhorse	04-18-88	III		312	320	70.3	244	--	3.0	5.1	.02	<2	.12	.49
	Shorthead redhorse	04-18-88	III		319	305	66.6	344	--	4.3	6.0	.02	2	.06	.3
	Shorthead redhorse	04-18-88	III		340	311	70.4	250	--	3.9	4.9	.02	<2	.06	.39
	Shorthead redhorse[4]	09-21-88	III		378	323	71.5	150	--	2.2	3.4	<.1	4	<.4	<1
	Shorthead redhorse	09-21-88	IV		409	336	67.8	130	<.1	2.4	8.0	<.02	<2	.2	2.4
	Shorthead redhorse	09-21-88	IV		426	346	69.7	155	<.1	3.2	6.7	<.02	<2	.2	2.8
	Shorthead redhorse[4]	09-21-88	IV		426	346	69.4	79	--	1.4	9.3	<.1	<2	<.4	<1
	Shorthead redhorse	09-21-88	V		459	353	67.4	91.4	<.1	1.8	4.6	<.02	<2	.2	2.0
	Shorthead redhorse[4]	09-21-88	IV		462	360	70.6	220	--	2.5	4.0	<.1	<2	<.3	2
	Shorthead redhorse	04-18-88	V		568	399	69.1	218	--	2.2	8.4	.02	<2	.12	2.6
	Shorthead redhorse	09-21-88	V		595	381	67.2	103	<.1	1.3	5.2	<.02	<3	.4	2.1
	Shorthead redhorse	04-18-88	VI		1,125	478	67.9	138	--	2.2	3.1	.01	<2	.17	1.1
	Composite invertebrate	08-02-88			48.0	--	80.7	370	<.130	33.3	68.4	<1.30	<13.0	<1.30	<2.59
	~~Sago Pondweed~~	~~08-02-88~~			~~347.5~~	~~--~~	~~83.7~~	~~1,400~~	~~.196~~	~~115~~	~~71.2~~	~~<.307~~	~~261~~	~~<.307~~	~~1.53~~
	Three square bulrush[4]	08-02-88			252.5	--	90.2	383	<.255	34.2	<25.5	<2.55	<25.5	<2.55	<5.10

Table 16.--Field measurements and results of laboratory analyses of biological data from the Belle Fourche Reclamation Project investigation area, April through September 1988--Continued

Site number (fig. 7)	Taxa	Copper[2]	Iron[2]	Lead[2]	Magnesium	Manganese[2]	Mercury[3]	Molybdenum	Nickel[2]	Selenium[3]	Silver[3]	Strontium	Thallium[2]	Tin	Vanadium	Zinc[2]
18	Shorthead redhorse	2.0	315	<1	1,380	79.8	0.39	0.92	4.5	3.4	0.053	196	<0.9	--	0.35	61.1
(Cont)	Shorthead redhorse	2.53	368	<.5	1,430	47.4	.577	<1	.97	3.6	<.01	183	<.5	--	.8	66.4
	Shorthead redhorse	2.45	440	<.5	1,300	70.9	.35	<1	.3	2.9	<.01	158	<.5	--	1.0	56.3
	Shorthead redhorse	2.67	282	<.5	1,400	52.9	.41	<1	.45	3.8	<.01	191	<.5	--	.7	57.6
	Shorthead redhorse[4]	1.7	528	<4	1,060	35	.961	<1	<3	3.7	<2	78.3	<5	--	.7	46.9
	Shorthead redhorse	2.5	489	<.9	1,320	49.4	.778	.55	2.8	2.8	<.01	199	<.8	--	.41	60.3
	Shorthead redhorse	2.3	861	<.8	1,390	73.6	.663	.50	2.7	3.5	<.01	183	<.8	--	.61	58.4
	Shorthead redhorse[4]	1.8	376	<4	1,080	33	.827	<1	<3	3.4	<2	107	<5	--	.6	53.0
	Shorthead redhorse	2.2	177	<.9	1,270	44.0	.668	.89	3.3	2.8	<.01	169	<.9	--	.40	56.9
	Shorthead redhorse[4]	2.0	458	<4	1,160	33	.751	<1	<2	3.8	<2	89.5	<4	--	.95	50.0
	Shorthead redhorse	2.89	387	<.5	1,420	72.8	.91	<1	.75	3.3	<.01	174	<.5	--	.8	64.5
	Shorthead redhorse	3.4	238	<1	1,200	28.1	.711	.97	1	2.9	<.01	147	<.9	--	.63	52.9
	Shorthead redhorse	2.36	228	<.5	943	26.4	.853	<1	.3	3.1	<.01	63.6	<.5	--	.5	50.9
	Composite invertebrate	6.74	1,480	<25.9	492	102	--	<13.0	<10.4	3.1	<13.0	26.9	--	<13.0	3.42	37.3
	Sago Pondweed	10.2	5,760	<6.13	6,440	725	.239	<3.07	11.7	1.8	<3.07	724	--	3.44	5.58	28.8
	Three square bulrush[4]	15.8	1,880	<51.0	2,810	513	<.255	<25.5	<20.4	2.0	<25.5	96.9	<1.0	<25.5	<25.5	50.0

[1] I - 1 year old, second growing season
II - 2 years old, third growing season
III - 3 years old, fourth growing season
IV - 4 years old, fifth growing season
V - 5 years old, sixth growing season

[2] ICP spectroscopy, preconcentration B (pH 6) was performed for this element.

[3] Individual Atomic Absorption was performed for this element.

[4] ICP spectroscopy, no preconcentration, was the only ICP performed for this sample.

Table 17.--Pesticide and PCB concentrations in biological samples of the Belle Fourche Reclamation Project investigation area, April through October 1988

[Collected and analyzed by U.S. Fish and Wildlife Service. Concentrations in micrograms per gram, dry weight; mm, millimeter; <, less than; --, no data]

Site number (fig. 7)	Taxa	Col-lection date	Estimated age class[1]	Weight (grams)	Length (mm)	Percent moisture	Oxy-chlor-dane	C-Non-achlor	T-Non-achlor	Hepta-chlor epoxide	Lindane	Hepta-chlor	Other chlordanes (total)	O,P'-DDE	P,P-'DDE
2	White sucker	09-20-88	III	291	292	77.8	<0.01	<0.01	<0.01	<0.01	--	--	<0.02	<0.01	<0.01
9	Blackbird eggs - 4 eggs	06-21-88	--	17.5	--	84.31	<.05	<.05	<.05	<.05	<0.05	<0.05	<.1	<.05	<.05
10	Pied-billed grebe egg	06-22-88	--	20	--	77.18	<.05	<.05	<.05	<.05	<.05	<.05	<.1	<.05	<.05
12	Carp	09-20-88	V	1,850	520	78.8	<.01	<.01	<.01	<.01	--	--	<.02	<.01	.01
18	Carp	09-21-88	V	1,850	533	72.4	<.01	<.01	<.01	<.01	--	--	<.02	<.01	.01
	Goldeye	04-18-88	V	610	393	61.8	<.01	<.01	<.01	<.01	--	--	--	<.01	.03
	Goldeye	04-18-88	IV	722	394	66.0	<.01	<.01	<.01	<.01	--	--	--	<.01	.02

Table 17.--Pesticide and PCB concentrations in biological samples of the Belle Fourche Reclamation Project investigation area, April through October 1988--Continued

Site number (fig. 7)	Taxa	O,P'-DDD	P,P'-DDD	O,P'-DDT	P,P'-DDT	Endrin	Dieldrin	Aldrin	Alpha BHC	Beta BHC	Gamma BHC	Delta BHC	Hexa-chloro-benzene	Mirex	Toxa-phene	Total PCB's
2	White sucker	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.05	<0.05
9	Blackbird eggs - 4 eggs	<.05	<.05	<.05	<.05	<.05	<.05	<0.05	<.05	<.05	--	<.05	<.05	<.05	<.5	<.5
10	Pied-billed grebe egg	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	<.05	--	<.05	<.05	<.05	<.5	<.5
12	Carp	<.01	<.01	<.01	<.01	<.01	<.01	--	<.01	<.01	<.01	<.01	<.01	<.01	<.05	<.05
18	Carp	<.01	<.01	<.01	<.01	<.01	<.01	--	<.01	<.01	<.01	<.01	<.01	<.01	<.05	<.05
	Goldeye	<.01	.01	<.01	<.01	<.01	.01	--	<.01	<.01	<.01	<.01	<.01	<.01	<.05	--
	Goldeye	<.01	.01	<.01	<.01	<.01	<.01	--	<.01	<.01	<.01	<.01	<.01	<.01	<.05	--

[1]I - 1 year old, second growing season
II - 2 years old, third growing season
III - 3 years old, fourth growing season
IV - 4 years old, fifth growing season
V - 5 years old, sixth growing season

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