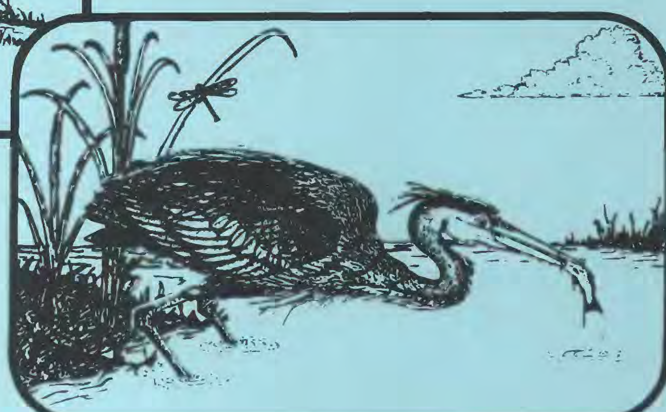
# Field Screening of Water Quality Bottom Sediment, and Biota Associated with Irrigation Drainage in the North Platte Project Area, Nebraska and Wyoming, 1995

U.S. Geological Survey
Water-Resources Investigations Report 98-4210



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

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Brent J. Esmoil, U.S. Fish and Wildlife Service, and
J. Mark Spears, Bureau of Reclamation

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U.S. GEOLOGICAL SURVEY
Water-Resources Investigations Report 98-4210

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

Lincoln, Nebraska
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U.S. DEPARTMENT OF THE INTERIOR
BRUCE BABBITT, Secretary

U.S. GEOLOGICAL SURVEY
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# CONTENTS


| | Page |
|---|---|
| Abstract | 1 |
| Introduction | 2 |
| Purpose and Scope | 2 |
| Description of the Study Area | 2 |
| Climate | 4 |
| Hydrogeology | 4 |
| Land Use | 5 |
| Biota | 5 |
| Endangered Species | 5 |
| Fisheries | 5 |
| Aquatic Birds | 5 |
| Sample Collection, Measurement, and Analysis | 6 |
| Surface-Water Sample Collection | 6 |
| Bottom-Sediment Sample Collection | 9 |
| Biological Sample Collection | 9 |
| Quality Assurance and Quality Control | 10 |
| Analytical Results | 11 |
| Surface-Water Quantity and Quality | 11 |
| Stream Discharge, Specific Conductance, and Dissolved Solids | 11 |
| Major Ions | 11 |
| Trace Elements | 12 |
| Bottom-Sediment Quality | 15 |
| Major Ions and Trace Elements | 15 |
| Carbon and Selected Organochlorine Compounds | 17 |
| Biological Quality | 18 |
| Fish | 18 |
| Aquatic Vegetation | 22 |
| Quality Assurance Results | 22 |
| Summary and Conclusions | 24 |
| References | 25 |


## FIGURES


1. Map showing Bureau of Reclamation North Platte Project lands along the North Platte River showing surface-water, bottom-sediment, and biological sample collection sites, 1995 ... 3

2. Graph showing major-ion composition of water samples from the North Platte River, selected tributaries, and Lake Alice, early spring and mid-summer, 1995 ... 13

# CONTENTS--Continued

Page

## TABLES

1. Fish species potentially found in the North Platte Project area, western Nebraska, 1995 ... 6

2. Aquatic-bird species potentially found in the North Platte National Wildlife Refuge, Nebraska ... 7

3. Sample types and physiographic, geologic, and land-use descriptions for sampling sites in and adjacent to the North Platte River in western Nebraska and eastern Wyoming, 1995 ... 8

4. Surface-water and bottom-sediment quality data for selected sites in the North Platte Project area, early spring and mid-summer 1995 ... 30

5. Statistical summary of concentrations of major ions and trace elements in bottom sediment from selected sites in the North Platte Project area, 1995, in comparison to sediment collected by the National Uranium Resource Evaluation Program for the Scottsbluff Quadrangle, 1979 ... 16

6. Concentrations of trace elements in composite biological samples collected in the North Platte Project area, western Nebraska and eastern Wyoming, 1995 ... 38

7. Concentrations of organochlorine compounds in composite biological samples collected in the North Platte Project area, western Nebraska and eastern Wyoming, 1995 ... 19

8. Results of quality assurance analyses of surface-water samples for concentrations of trace elements and of bottom-sediment samples for concentrations of trace elements, selected major ions, and selected organochlorine compounds, from the North Platte Project area, western Nebraska and eastern Wyoming, 1995 ... 23

## CONVERSION FACTORS AND VERTICAL DATUM

| Multiply | By | To obtain |
|---|---|---|
| foot (ft) | 0.3048 | meter |
| mile (mi) | 1.609 | kilometer |
| acre | 0.004047 | square kilometer |
| square foot ($ft^2$) | 929.0 | square centimeter |
| gallon (gal) | 0.003785 | cubic meter |
| cubic foot ($ft^3$) | 0.02832 | cubic meter |
| cubic foot per second ($ft^3/s$) | 0.02832 | cubic meter per second |
| gallon per minute (gal/min) | 0.06309 | liter per second |
| gallon per day (gal/d) | 0.003785 | cubic meter per day |

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows: °F = (1.8 × °C) + 32

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows: °C = (°F - 32) / 1.8

**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 Sea Level Datum cf 1929.

**Specific conductance** is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

# Field Screening of Water Quality, Bottom Sediment, and Biota Associated with Irrigation Drainage in the North Platte Project Area, Nebraska and Wyoming, 1995

*By* A.D. Druliner, Brent J. Esmoil, and J. Mark Spears

## ABSTRACT

In 1994, the National Irrigation Water Quality Program of the U.S. Department of the Interior identified the North Platte Project area in western Nebraska and eastern Wyoming for a field screening investigation. The purpose of the investigation was to determine if accumulations of selected trace elements and/or organochlorine compounds resulting from projects built or operated by agencies of the Department of Interior might have caused harmful effects on fish and wildlife or the suitability of water for other beneficial uses.

Sites on six creeks or drains and one lake that carried drain water from lands irrigated by the North Platte Project area were selected for the investigation in addition to sites upstream and downstream from the Project area. In the early spring and summer of 1995, samples of surface water, bottom sediment, fish, and vegetation were collected. Water samples were analyzed for field parameters and trace elements; and bottom sediment, fish, and vegetation samples were analyzed for trace elements and selected organochlorine compounds.

Concentrations of selenium in surface water from two sites were slightly larger than the U.S. Environmental Protection Agency's freshwater aquatic criterion of 5 micrograms per liter. Concentrations of selenium in 17 of 19 surface-water samples collected in the North Platte Project area exceeded the 2 micrograms per liter threshold, above which selenium can have adverse effects on biota through bioaccumulation. Concentrations of uranium in surface water ranged from 18 to 61 micrograms per liter and exceeded the maximum contaminant level for drinking water at five sites. Median concentrations of arsenic, cerium, and chromium in bottom sediment from the North Platte Project area were larger than regional median concentrations determined by the National Uranium Resources Evaluation Program. Concentrations of DDD, DDE, or DDT were detected in bottom-sediment samples at five of seven sampling sites.

Concentrations of trace elements in biological samples from the North Platte Project area generally were less than or comparable to concentrations from several U.S. Department of Interior studies in the western United States and concentrations from the National Contaminant Biomonitoring Program. The range of concentrations in fish as wet weight in micrograms per gram was 0.06 to 0.29 for arsenic, 0.27 to 1.4 for chromium, less than 0.08 to 2.5 for copper, and 0.012 to 0.18 for lead. Concentrations of selenium in fish from eight samples in the North Platte Project area exceeded the dry-weight level of concern for selenium of 4.0 micrograms per gram proposed by Lemly in his 1993 guidelines for evaluating selenium data from aquatic monitoring and assessment studies. Maximum concentrations of many of the trace elements were detected in composite fish samples collected at Nine Mile Creek, Owl Creek, and Sheep Creek.

Small concentrations (less than 1 microgram per gram) of DDE, a metabolite of the pesticide DDT, were detected in all of the biological samples. Trace concentrations of dieldrin and polychlorinated

biphenols also were detected in fish samples from one site.

## INTRODUCTION

The quality of irrigation drainage from agricultural land in the western United States has become an environmental concern. Physical abnormalities, reproductive failures, and mortality rates in fish and waterfowl at the Kesterson National Wildlife Refuge in the western San Joaquin Valley, California, were discovered in 1983 during studies conducted by the U.S. Fish and Wildlife Service (USFWS) and later associated with large concentrations of selenium released in drain water from irrigated land in the area (Gilliom, 1989). Additional potentially toxic trace elements and organochlorine compounds also have been detected in other areas in the western states that receive water from irrigation drainage (Sylvester and others, 1990).

In 1985, the U.S. Department of the Interior (DOI) established the National Irrigation Water Quality Program to address water-quality problems related to irrigation drainage for which DOI may have responsibility. The U.S. Geological Survey (USGS), USFWS, Bureau of Reclamation (BOR), and the Bureau of Indian Affairs are the principal participants in the program. Twenty-six areas were identified as having the potential to affect fish and wildlife populations adversely and were scheduled for field screening investigations. Field screening investigations were designed to assess if target areas had been affected by trace element and/or accumulations of organochlorine compounds resulting from irrigation drainage from projects built or operated by agencies of the DOI. In 1994, the BOR North Platte Project area, in western Nebraska and eastern Wyoming, was identified for a field screening investigation. The North Platte Project was initiated in 1903 by the U.S. Reclamation Service (later renamed the Bureau of Reclamation). The purpose of the project, centered near Scottsbluff, was primarily to store water for late-season irrigation supplies in eastern Wyoming and western Nebraska, and secondarily, to generate hydroelectricity. The project consists of 5 storage dams, 4 diversion dams, 333 miles of canals and 1,325 miles of distribution systems. The project irrigates about 335,000 acres in Wyoming and Nebraska, of which 224,000 acres are serviced by BOR canals (Bureau of Reclamation, undated).

An intricate network of private and Federal canals and drains, dating back to the early 1900s, are located throughout the North Platte Project area (fig. 1). Two principal irrigation canals built by the BOR divert water from the North Platte River above Whalen Dam in Wyoming. The Interstate Canal runs about 95 miles along the northern edge of the project area and threads through Lake Alice and Lake Minatare north of the town of Scottsbluff. The Fort Laramie Canal is about 130 miles long and carries water along the southern boundary of the North Platte Project area. The Tristate Canal, constructed with private funds, diverts water from the North Platte River just downstream from the Wyoming-Nebraska state line. The Tristate Canal runs about 80 miles along the north side of the river to the head gate of the Northport Canal, which extends another 31 miles.

### Purpose and Scope

This report describes the results of a field screening study of the physical and chemical conditions of the North Platte Project area conducted jointly by the USFWS, BOR, and the USGS. Researchers investigated the occurrence of selected trace elements in surface water and of selected trace elements and organic compounds in bottom sediment and biological samples at sites in the North Platte Project area. The physical and chemical data collected during this study and a discussion of the results of the analyses are presented in the report.

### Description of the Study Area

The North Platte River flows from its origin in northern Colorado through southeastern Wyoming to west-central Nebraska, where it combines with the South Platte River to become the Platte River. The area of interest for this study, the North Platte Project area, is the part of the North Platte River Valley from Whalen, Wyoming, to Broadwater, Nebraska, about 90 miles southeast of Whalen (fig. 1). This part of the North Platte River lies in the High Plains Section of the Great Plains Province and generally consists

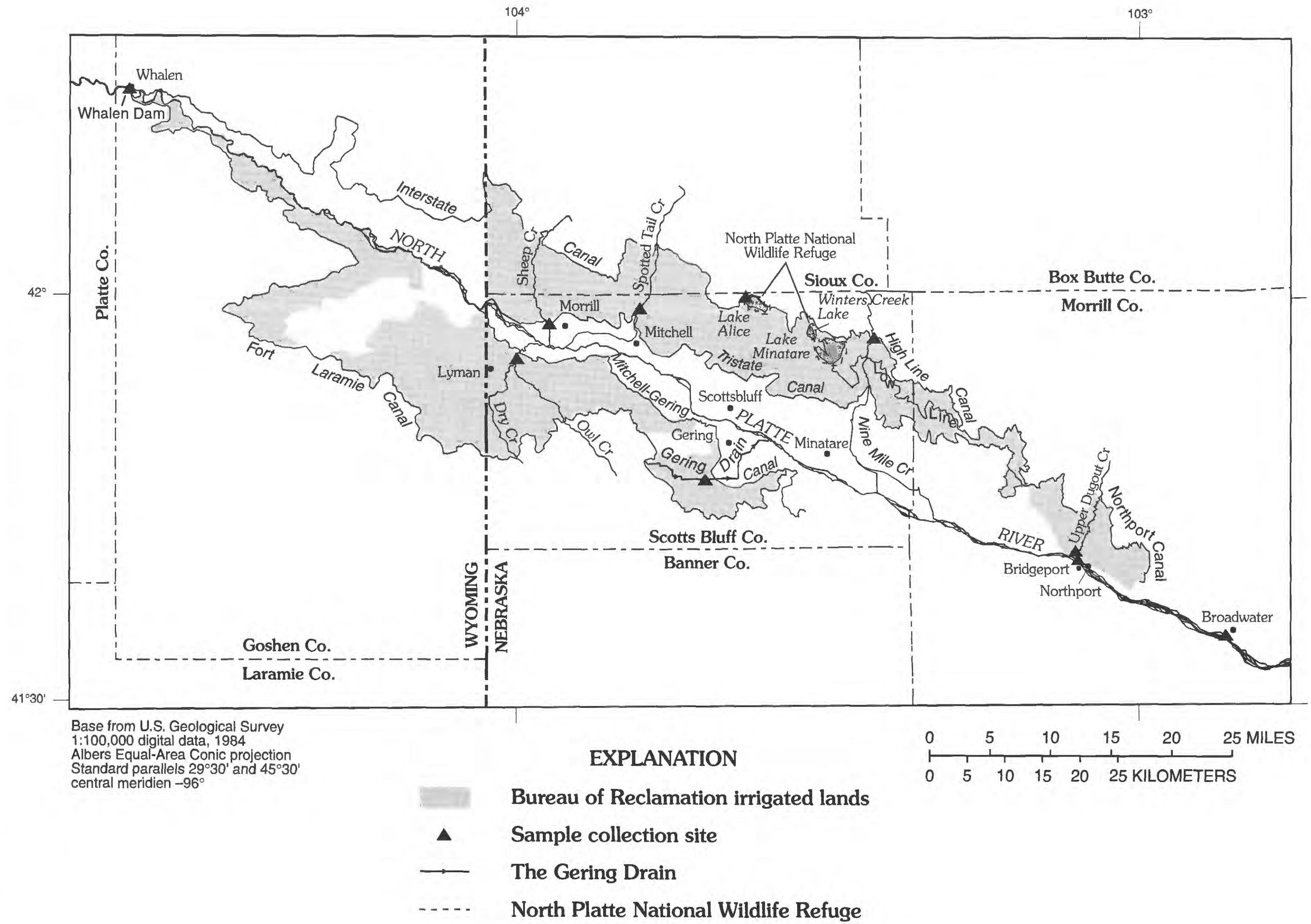


**Figure 1.** Bureau of Reclamation North Platte Project lands along the North Platte River showing surface-water, bottom-sediment, and biological sample collection sites, 1995.

of broad intervalley remnants of smooth fluvial plains (Fenneman and Johnson, 1946). Along this reach, the North Platte River is a braided stream on a 2- to 8-mile-wide, alluvium-filled flood plain.

### Climate

The climate of the North Platte Project area is typical of the upper High Plains in which the summers are hot and the winters, cold. According to climatic data collected at the Scottsbluff weather station from 1951 through 1980, July is the hottest month with a mean maximum monthly temperature of 89.2 °F (degrees Fahrenheit); January is the coldest month with a mean minimum monthly temperature of 11.2 °F (National Oceanic and Atmospheric Administration, 1982). Annual precipitation in the area ranged from 15 to 18 inches per year during the period from 1951 through 1980. Most of the annual precipitation fell as rain during the late spring and early summer. On an annual basis, potential evapotranspiration in the North Platte Project area is larger than precipitation (Lawson and others, 1977).

### Hydrogeology

The North Platte River valley cuts through sandstone and shale of Cretaceous age in the Wyoming part of the study area and through progressively younger siltstones and silty sandstones of Tertiary age eastward throughout the rest of the study area. Cretaceous units underlie the study area and consist of the Pierre Shale, a thick, dark, marine shale with sandy zones near its contact with the overlying Fox Hills Formation. The Pierre Shale is known to be a source of a variety of trace elements such as selenium, boron, chromium, copper, molybdenum, nickel, uranium, and vanadium (Tourtelot, 1956). The Fox Hills Formation is a fine- to medium-grained sandstone interbedded with gray shale of Cretaceous age. The Lance Formation, which is of Cretaceous age, overlies the Fox Hills Formation and consists of argillaceous sand, sandstone, and clay that may be more than 100 feet thick (Wenzel and others, 1946). The rocks of Cretaceous age contain some confined water-bearing units that serve as local sources of water supply for stock and domestic uses in areas where other sources of ground water are not available.

The Chadron Formation, which was deposited during the Oligocene Epoch of Tertiary age, unconformably overlies the Lance Formation and is composed of clay and silt with buried sand and gravel stream channels at its base. The thickness of the Chadron Formation may exceed 260 feet and much of the clay was determined to be reworked volcanic ash deposits (Wenzel and others, 1946). Uranium deposits have been identified in sand and gravel channel deposits near the base of the Chadron Formation in northwestern Nebraska, north of the study area. The source of the deposits may have been volcanic ash and reworked volcanic ash found in the upper parts of the Chadron Formation and the overlying Brule Formation, which also is of Tertiary age (Spalding and others, 1984). The clay and silt in the upper part of the Chadron Formation serve as a confining layer for the more permeable sediment below. The Chadron Formation is not generally considered to be a source of water supply because of its great depth below the land surface and the highly mineralized nature of its water.

The Brule Formation consists of mostly light tan siltstone with interbedded lenses of volcanic ash. The thickness of the Brule Formation varies from a few tens of feet in the western part of the study area to more than 500 feet in the east. The Brule Formation is an unconfined aquifer and provides local water supply with large yields in some areas.

Other geologic units of Tertiary age bordering the study area in the tablelands to the north and south of the North Platte River valley include the Arikaree and Ogallala Formations. These units consist of silty sandstone to fine- and coarse-grained sand and gravel. They also contain ash beds and local lenses of siltstone. Both the Arikaree and Ogallala Formations are unconfined aquifers. In the tablelands, the Ogallala Formation yields large quantities of water for irrigation and domestic uses.

In Nebraska, the North Platte River alluvium rests directly on the Brule or on the Chadron Formations where the channel has cut through the Brule Formation. The alluvium is composed of sand and gravel deposits with isolated lenses of silt and clay and may exceed 150 feet in depth in some locations. The alluvial deposits extend laterally 2 to 8 miles throughout much of the valley. The history of the North Platte River involved many cut-and-fill periods and resulted in the formation of numerous sand- and gravel-filled terraces in the valley (Wenzel and others, 1946). The sand and gravel deposits of the alluvium are the principal source of ground-water supply in the study area.

### Land Use

Agriculture is the dominant land use in Scotts Bluff, Morrill, and Sioux Counties, Nebraska, and Goshen County, Wyoming. The principal crops produced in 1995 included corn, hay, winter wheat, dry beans, and sugar beets (Nebraska Department of Agriculture, 1995; Wyoming Department of Agriculture, 1996). During 1995, nearly 75 percent of the crops grown in Scotts Bluff and Morrill Counties were irrigated. Cattle production also is a dominant land use and rangeland accounts for much of the total farm land in the four-county area. Much of the irrigated agriculture is in the North Platte River valley and land immediately adjacent to the valley. The uplands frequently are used as rangeland.

### Biota

Land in the North Platte Project area provides habitat for a variety of local and migratory species of wildlife. The North Platte National Wildlife Refuge (NWR), which occupies 2,909 acres, is 8 miles northeast of Scottsbluff and lies partly in the North Platte Project area. North Platte NWR has been under USFWS management since 1985. Major water bodies on the refuge include Lake Alice and Lake Minatare. These lakes are supplied by precipitation and by irrigation water from the Interstate and High Line Canals. Chemical usage on the refuge is minimal.

### Endangered Species

Several federally listed threatened and endangered species may be found in the North Platte Project area. Bald eagles (*Haliaeetus leucocephalus*) use mature riparian timber near streams and lakes. Eagles may be present in the North Platte Project area from November 1 to April 1. Whooping crane (*Grus americana*) sightings have been confirmed in Scotts Bluff County in the vicinity of North Platte NWR. Whooping cranes use shallow, sparsely vegetated streams and wetlands for roosting and feeding sites during migration. Migration through the area typically occurs between October 1 and December 1 in the fall, and March 15 and May 15 in the spring. Prairie dog (*Cynomys ludovicianus*) colonies are present in the North Platte Project area. The North Platte Project area also is considered to be potential habitat for the black-footed ferret (*Mustela nigripes*). Peregrine falcons (*Falco peregrinus*) have been observed in the area and generally are associated with wetlands and open areas such as cropland and grassland. Most sightings of peregrine falcons in Nebraska are in late April to early May, September, and October.

#### Fisheries

Lakes, streams, and rivers in the North Platte Project area provide habitat for a number of fish species. Lake Minatare is known as an important walleye (*Stizostedion vitreum*) and wiper-hybrid [white bass (*Morone chrysops*)/striped bass (*Morone saxatilis*)] fishery. Other fish species that inhabit the lakes in the North Platte Project area include the white bass, largemouth bass (*Micropterus salmoides*), smallmouth bass (*Micropterus dolomieui*), green sunfish (*Lepomis cyanellus*), bluegill (*Lepomis macrochirus*), black bullhead (*Ictalurus melas*), stonecat (*Noturus flavus*), and madtom (*Noturus gyrinus*) (J. Peterson, Nebraska Game and Parks Commission, oral commun., 1995). A list of various fish species potentially found in the North Platte River area is shown in table 1.

#### Aquatic Birds

The North Platte NWR includes three BOP reservoirs: Lake Minatare, Winters Creek Lake, and Lake Alice. Lake Minatare is managed under a lease agreement with the Nebraska Game and Parks Commission as a State Recreation Area. As many as 20 bald eagles and over 200,000 waterfowl may concentrate on the refuge during fall migration. Further, a pair of bald eagles has nested on Lake Alice since 1993 (U.S. Fish and Wildlife Service, unpublished data, 1993). While the refuge is used primarily as a resting and feeding area for waterfowl and shorebirds, it also provides habitat for bald eagles and nesting waterbirds. A list of aquatic bird species potentially found in the North Platte NWR is shown in table 2.

**Table 1.** Fish species potentially found in the North Platte Project area, western Nebraska, 1995

[Nebraska Game and Parks Commission, unpublished data]

| Common name | Species |
|---|---|
| Brown trout | *Salmo trutta* |
| Rainbow trout | *Oncorhynchus mykiss* |
| Walleye | *Stizostedion vitreum* |
| Largemouth bass | *Micropterus salmoides* |
| Smallmouth bass | *Micropterus dolomieui* |
| White bass | *Morone chrysops* |
| Wiper hybrid (white bass/striped bass hybrid) | *Morone chrysops x Morone saxatilis* |
| Green sunfish | *Lepomis cyanellus* |
| Bluegill | *Lepomis macrochirus* |
| Black bullhead | *Ictalurus melas* |
| Stonecat | *Noturus flavus* |
| Madtom | *Noturus gyrinus* |
| Bigmouth shiner | *Notropus dorsalis* |
| Brassy minnow | *Hybognathus hankinsoni* |
| Common carp | *Cyprinus carpio* |
| Common shiner | *Luxilus cornutus* |
| Creek chub | *Semoilus atromaculatus* |
| Fathead minnow | *Pimephales promelas* |
| Flathead chub | *Hybopsis gracilis* |
| Longnose dace | *Rhinichthys cataractae* |
| Red shiner | *Cyprinella lutrensis* |
| Sand shiner | *Notropsis stramineus* |
| Central stoneroller | *Campostoma anomalum* |
| Longnose sucker | *Catostomus catostomus* |
| Quillback carpsucker | *Carpiodes cyprinus* |
| Shorthead redhorse | *Moxostoma macrolepidotum* |
| White sucker | *Catostomus commersoni* |
| Channel catfish | *Ictalurus punctatus* |
| Plains killifish | *Fundulus zebrinus* |
| Plains topminnow | *Fundulus sciadicus* |
| Orangethroat darter | *Etheostoma spectabile* |
| Yellow perch | *Perca flavescens* |

## SAMPLE COLLECTION, MEASUREMENT, AND ANALYSIS

Data for the field screening study was collected in 1995. Personnel from the BOR provided information and insights about the part of the North Platte Project area that was constructed with Federal funds. Sample collection sites were selected (fig. 1 and table 3) by a team consisting of a member from each agency. Personnel from the USGS collected and analyzed surface-water samples from 10 sites, and bottom-sediment samples from 7 sites. Personnel from the USFWS collected biological samples at six sites. Biological analyses were performed by contract laboratories for the USFWS.

### Surface-Water Sample Collection

Water samples were collected at eight sites during the early spring (North Platte River near Bridgeport, Upper Dugout Creek, Gering Drain, Nine Mile Creek, Owl Creek, Sheep Creek, Spotted Tail Creek, and the North Platte River above Whalen Dam) and nine sites during the mid-summer of 1995 (North Platte River near Bridgeport, Upper Dugout Creek, Gering Drain, Nine Mile Creek, Owl Creek, Sheep Creek, Spotted Tail Creek, Lake Alice, and the North Platte River above Whalen Dam). Seven sites were in the interior of the North Platte Project area and were on streams and drains below lands irrigated by water from canals built by the BOR. Six of these sites were sampled both during the early spring and during mid-summer. The seventh site, Lake Alice, which contains water only during the canal-irrigation season from late April through September, was sampled near the inlet on the west side only during the mid-summer sampling period. Water samples also were collected from the North Platte River upstream from the North Platte Project area (above Whalen Dam) during the early spring and mid-summer sampling periods and below the Project area near Bridgeport in the early spring and near Broadwater during the mid-summer sampling periods (fig. 1 and table 3). The purpose of the sampling of the upstream and downstream sites was to determine the quality of surface water entering the canals and being returned to the river from the canals.

**Table 2.** Aquatic-bird species potentially found in the North Platte National Wildlife Refuge, Nebraska

[U.S. Fish and Wildlife Service, unpublished data]

| Common name | Species | Common name | Species | Common name | Species |
|---|---|---|---|---|---|
| Common loon | *Gavia immer* | American widgeon | *Anas americana* | Spotted sandpiper | *Actitis macularia* |
| Pied-billed grebe | *Podilymbus podiceps* | Canvasback | *Aythya valisineria* | Long-billed curlew | *Numenius americanus* |
| Horned grebe | *Podiceps auritus* | Redhead | *Aythya americana* | Marbled godwit | *Limosa fedoa* |
| Eared grebe | *Podiceps nigricollis* | Ring-necked duck | *Aythya collaris* | Sanderling | *Calidris alba* |
| Western grebe | *Aechmophorus occidentali* | Lesser scaup | *Aythya affinis* | Semipalmated sandpiper | *Calidris pusilla* |
| American white pelican | *Pelecanus erythrorhyncho* | Common goldeneye | *Bucephala clangula* | Western sandpiper | *Calidris mauri* |
| Double-crested cormorant | *Phalacrocorax auritus* | Barrow's goldeneye | *Bucephala islandica* | Least sandpiper | *Calidris minutilla* |
| American bittern | *Botaurus lentiginosus* | Bufflehead | *Bucephala albeola* | White-rumped sandpiper | *Calidris fuscicollis* |
| Great blue heron | *Ardea herodias* | Hooded merganser | *Lophodytes cucullatus* | Baird's sandpiper | *Calidris bairdii* |
| Green heron | *Butorides virescens* | Common merganser | *Mergus merganser* | Pectoral sandpiper | *Calidris melanotos* |
| Black-crowned night heron | *Nycticorax nycticorax* | Red-breasted merganser | *Mergus serrator* | Stilt sandpiper | *Calidris himantopus* |
| Tundra swan | *Cygnus columbianus* | Ruddy duck | *Oxyura jamaicensis* | Buff-breasted sandpiper | *Tryngites subruficollis* |
| White-fronted goose | *Anser albifrons* | Virginia rail | *Rallus limicola* | Long-billed dowitcher | *Limnodromus scolopaceus* |
| Snow goose | *Chen hyperborea* | Sora | *Porzana carolina* | Common snipe | *Gallinago gallinago* |
| Ross' goose | *Chen rossii* | American coot | *Fulica americana* | Wilson's phalarope | *Phalaropus tricolor* |
| Canada goose | *Branta canadensis* | Sandhill crane | *Grus canadensis* | Rednecked phalarope | *Phalaropus lobatus* |
| Wood duck | *Aix sponsa* | Black-bellied plover | *Pluvialis squatarola* | Franklin's gull | *Larus pipixcan* |
| Green-winged teal | *Anas carolinensis* | Semipalmated plover | *Charadrius semipalmatus* | Bonaparte's gull | *Larus philadelphia* |
| Mallard | *Anas platyrhynchos* | Killdeer | *Charadrius vociferus* | Ring-billed gull | *Larus delawarensis* |
| Northern pintail | *Anas acuta* | American avocet | *Recurvirostra americana* | Herring gull | *Larus argentatus* |
| Blue-winged teal | *Anas discors* | Greater yellowlegs | *Tringa melanoleuca* | Common tern | *Sterna hirundo* |
| Cinnamon teal | *Anas cyanoptera* | Lesser yellowlegs | *Tringa flavipes* | Forster's tern | *Sterna forsteri* |
| Northern shoveler | *Anas clypeata* | Solitary sandpiper | *Tringa solitaria* | Black tern | *Chlidonias niger* |
| Gadwall | *Anas strepera* | Willet | *Catoptrophorus semipalmatus* | | |

**Table 3.** Sample types and physiographic, geologic, and land-use descriptions for sampling sites in and adjacent to the North Platte River in western Nebraska and eastern Wyoming, 1995

[SW, surface water; BS, bottom sediment; BIO, biota]

| Site name | Sample type | Physiographic description | Dominant geologic unit within study area | Land use within study area |
|---|---|---|---|---|
| North Platte River near Broadwater | SW | North Platte River Valley | Platte River alluvium | Woodland adjacent to river rangeland and recreational area near river |
| North Platte River near Bridgeport | SW | North Platte River Valley | Platte River alluvium | Woodland adjacent to river with recreation, rangeland, and agriculture near the river |
| Upper Dugout Creek | SW, BS, BIO | Low terraces | Platte River alluvium | Row-crop agriculture with woodlands adjacent to river |
| Gering Drain | SW, BS, BIO | Bottomland | Brule Formation | Row-crop agriculture |
| Nine Mile Creek | SW, BS, BIO | Terraces, hilly | Brule Formation | Row-crop agriculture with timber and brush adjacent to the creek |
| Owl Creek | SW, BS, BIO | Bottomland | Brule Formation | Row-crop agriculture |
| Sheep Creek | SW, BS, BIO | Bottomland associated with North Platte tributaries | Platte River alluvium | Mixed rangeland and row-crop agriculture |
| Spotted Tail Creek | SW, BS, BIO | High terraces with alkaline soils | Brule Formation | Mixed rangeland and row-crop agriculture |
| Lake Alice | SW, BS | Hilly area between valley terraces and upland area | Brule Formation | Rangeland and woodland |
| North Platte River above Whalen Dam | SW | North Platte River Valley | Platte River alluvium | Rangeland, water diversion structures and some agriculture |

Surface-water samples were collected with a hand sampler using a modified version of the part per billion protocol (U.S. Geological Survey Office of Water Quality, written commun., 1994) and were analyzed for major ions and selected trace elements by the USGS National Water-Quality Laboratory (NWQL) in Arvada, Colorado.

The initial water sample collected from the North Platte River below the areas irrigated by BOR canals was collected near Bridgeport, Nebraska. Second and third water samples were collected near Broadwater during the early and mid-summer, respectively. A water sample from Lake Alice was collected only during the mid-summer sampling period because the lake remains dry during the nonirrigation season (September through late April).

## Bottom-Sediment Sample Collection

Bottom-sediment samples were collected during the early spring sampling period from the six sites draining fields irrigated by canal water and from Lake Alice, which was dry. Bottom-sediment samples were collected with a hand-operated, stainless-steel corer with a stainless-steel core-barrel liner and nose piece for samples to be analyzed for organic compounds, and a cellulose-acetate butyrate core-barrel liner and nose piece for samples to be analyzed for trace elements. A transect was established across each stream or drain and a minimum of five core samples was collected at equally-spaced intervals along each transect. Interval samples were composited, homogenized in either stainless-steel or plastic containers, subsampled, and sent to the Geologic Division Laboratory of the USGS in Denver, Colorado, and the NWQL to be analyzed for selected major ions and trace elements, organic carbon, and selected organochlorine compounds.

## Biological Sample Collection

Fish and aquatic vegetation were collected from five and six sites, respectively, by USFWS (table 3) during spring and mid-summer of 1995. Vegetation samples were collected once in May. Fish samples were collected in May and again in July or August. Samples were collected following methods described by the U.S. Fish and Wildlife Service (1986). All of these sites were on streams or drains below irrigated land. For comparison purposes, attempts were made to collect similar species of fish and aquatic plants from each site. However, consistency among species could not always be achieved because of differences in habitat, substrates, and flows.

Samples of common carp (*Cyprinus carpio*), brown trout (*Salmo trutta*), white sucker (*Catostomus commersoni*), rainbow trout (*Oncorhynchus mykiss*), and creek chubs (*Semotilus atromaculatus*) were collected by electrofishing. Each fish was rinsed in ambient water, evaluated for abnormalities, weighed, and double-wrapped in aluminum foil. For each site, three to five individuals of each species were combined to form a single, whole-body composite sample for residue determinations. Approximately 10 individuals were composited for smaller fish to ensure sufficient sample size for the analyses. Samples were placed on ice in the field, and later frozen, until shipped to the analytical laboratory.

Aquatic vegetation is an important dietary component for many species of waterfowl (Bellrose, 1980). Although attempts were made to collect aquatic vegetation that would be eaten by waterfowl, the effort was only partially successful due to drain configuration. The drains sampled for this study were typically narrow, with swift water and sand substrate. Aquatic vascular plant samples and algae were collected by hand from all six sites. Vascular plant samples were rinsed, placed in plastic bags, weighed, and frozen. Green algae samples (*Spirogyra* and *Chlodophora*) were collected by hand or by scraping from substrates. Algal samples then were placed in chemically cleaned glass jars, weighed, and frozen.

Attempts were made to collect aquatic birds, bird eggs, and aquatic invertebrates. Although some killdeer (*Charadrius vociferus*) were at Lake Alice, efforts to collect samples were unsuccessful. High-water conditions appear to have reduced successful nesting attempts in the study area. Efforts to collect aquatic invertebrates also were unsuccessful because of high flows and scouring of substrates typically populated by invertebrates.

Whole-body composite fish and vegetation samples were analyzed for trace elements by the Environmental Trace Substances Research Center, Rolla, Missouri, using in-house procedures that were independently reviewed and tested by USFWS's Patuxent Analytical Control Facility (PACF), Laurel, Maryland. Samples were homogenized, lyophilized, and re-homogenized prior to acid digestion. Vegetation samples (analyzed for aluminum, arsenic, barium, boron, chromium, copper, iron, magnesium, manganese, molybdenum, nickel, strontium, vanadium, and zinc) and fish-tissue samples (analyzed for aluminum, barium, boron, copper, iron, magnesium, manganese, molybdenum, strontium, vanadium, and zinc) were digested under reflux in perchloric and nitric acids and quantified by simultaneous inductively-coupled plasma spectroscopy. Vegetation samples analyzed for beryllium, cadmium, and lead, and fish-tissue samples analyzed for beryllium, cadmium, chromium, nickel, and lead were digested under reflux in nitric acid and quantified by inductively coupled plasma-mass spectrometry. Vegetation and tissue samples analyzed for selenium, and vegetation samples analyzed for arsenic, were digested under reflux in perchloric and nitric acids. Fish-tissue samples analyzed for arsenic were ashed in magnesium nitrate. All arsenic and selenium determinations were made by hydride generation atomic absorption spectrophotometry. Samples analyzed for mercury were digested under reflux in nitric acid and quantified by cold-vapor atomic absorption spectrophotometry.

Fish samples also were analyzed for organochlorine compounds by the Mississippi State Chemical Laboratory in Mississippi State, Mississippi. Analysis for organochlorine pesticides and polychlorinated biphenyls (PCBs) in fish tissue also were conducted using in-house procedures that have been reviewed independently and tested by PACF. In summary, 10-gram fish-tissue samples were mixed thoroughly with anhydrous sodium sulfate and soxhlet extracted with hexane for 7 hours. The extract was concentrated by rotary evaporation to dryness for lipid determination. Lipids were dissolved in petroleum ether and extracted four times with acetonitrile saturated with petroleum ether. Extracts were partitioned into petroleum ether, concentrated, and cleaned using florisil column chromatography eluting with a mixture of 6 percent diethyl ether and 94 percent petroleum ether (Fraction I) followed by a 200-mL (milliliter) mixture of 15 percent diethyl ether and 85 percent petroleum ether (Fraction II). Fraction I was concentrated and transferred to a silicic acid chromatographic column for separation of PCBs from other organochlorines. Quantification of pesticides and PCBs was done by electron-capture gas chromatography.

For this study, both wet-weight and dry-weight concentrations of organic and inorganic compounds were provided by the contract laboratories. Because many publications provide results only on a wet- or dry-weight basis, the results from this study are compared to wet- and dry-weight results reported in source publications.

## Quality Assurance and Quality Control

A variety of quality control techniques is a part of analyses performed at the NWQL. Bottles used for sample collection, the chemicals used for sample preservation, and the field filters are subject to quality control by the NWQL. The NWQL adheres to standard analytical methodologies and maintains strict protocols in handling both samples and analytical results. The NWQL maintains a series of checks and balances on analytical production such as the systematic inclusion of laboratory blanks and standards of known concentrations in each batch of field samples that are analyzed.

The water-quality assurance program of the NWQL includes a laboratory blind-sample program in which blind quality-assurance samples are intermixed with field samples on a daily schedule to verify the precision and accuracy of analyses for inorganic parameters. The NWQL participates in an external blind-sample program through the USGS Branch of Quality Assurance, which submits blind samples for most inorganic analyses on a daily basis. Additionally, the NWQL participates in the USGS and U.S. Environmental Protection Agency (USEPA) interlaboratory evaluation programs, in which laboratories throughout the Nation receive and analyze blind samples.

In addition to standard sampling and processing protocols, duplicate samples and spiked samples were submitted with regular field samples for laboratory analysis to evaluate further the precision and accuracy of the laboratory analyses.

Laboratory quality control for biological samples was reviewed by the PACF. Precision and accuracy of the laboratory analyses were confirmed with procedural blanks, duplicate analyses, test recoveries of spiked materials, and reference material analyses. Standard reference materials and spiked samples were analyzed to verify the accuracy of analytical techniques.

# ANALYTICAL RESULTS

## Surface-Water Quantity and Quality

Surface-water data collection at each site included measurement of field parameters for stream discharge, specific conductance, pH, and temperature and collection of samples for analysis of major ions and trace elements.

### Stream Discharge, Specific Conductance, and Dissolved Solids

Stream-discharge measurements for most sites were much larger during the mid-summer sampling period than during the early spring period (table 4 at the back of the report). Discharge measured in the North Platte River above Whalen Dam in March was less than 10 $ft^3/s$ (cubic feet per second) and was 700 $ft^3/s$ at Bridgeport. The increase in flow from the upper to lower ends of the study area was caused by ground-water discharge to the North Platte River. During the mid-summer sampling period, discharges were much higher in the North Platte River above Whalen Dam (4,460 $ft^3/s$) and at Broadwater (2,500 $ft^3/s$) than during the early spring. The net loss of flow between the upper and lower reaches of the North Platte River during the mid-summer is likely because of diversions from the river for irrigation. Discharges at Sheep Creek decreased from 57 to 2.7 $ft^3/s$ during the two sampling periods because drain water was diverted from the creek for irrigation about 0.4 miles above the sampling site. Discharge changed minimally between the two sampling periods at Spotted Tail Creek. The lack of increased flow during the second sampling period at Spotted Tail Creek was probably the result of limited canal leakage in the area and the pumpage of ground-water irrigation wells immediately adjacent to the creek about 1.5 miles upstream from the sampling site.

Specific-conductance measurements and dissolved solids concentrations (dissolved residue on evaporation at 180 °C (degrees Celsius)) for water samples collected in the early spring did not vary much from samples collected in the mid-summer at most sites (table 4). The largest concentrations of dissolved solids occurred during low-flow conditions in the early spring at Gering Drain (858 mg/L) (milligrams per liter) and Owl Creek (1,070 mg/L), when heavily mineralized ground-water discharge was the principal source of flow. Water samples from Gering Drain and Owl Creek had specific conductance values of 1,320 and 1,650 µS/cm (microsiemens per centimeter at 25 °C) in the early spring and 835 and 992 µS/cm in the summer, respectively. During the mid-summer sampling period, discharges increased by 5 to 7 times, respectively, at these sites, as water from irrigation drainage and canal leakage flowed into the creeks and drains and diluted the ground-water contribution.

Specific-conductance measurements and dissolved-solids concentrations in water samples from the North Platte River above Whalen Dam were less (670 µS/cm and 467 mg/L, respectively) than water samples from the North Platte River near Bridgeport (1,060 µS/cm and 688 mg/L) during the early spring sampling period (table 4). The same relation of dissolved solids was observed in samples collected during the mid-summer sampling period from the North Platte River above Whalen Dam (438 mg/L) and near Broadwater (647 mg/L) downstream from the North Platte Project area; however, the differences were not large. Thus, the dissolved-solids concentrations in the North Platte River appear to increase from upstream to downstream in the study area as mineralized water from tributaries drains into the river, even when the canals are full of diverted water.

### Major Ions

Surface-water samples collected during the early spring and mid-summer sampling periods were calcium-sodium bicarbonate-sulfate water types (fig. 2). Only water samples from Gering Drain and Owl Creek showed any notable variation in the ratio of major ions between samples collected during the early spring and mid-summer. Water samples collected during the early spring for both sites had about 2.5 times more sodium and slightly less sulfate than the mid-summer samples. The specific conductance and total dissolved-solids concentrations also decreased from early spring to mid-summer only in water samples collected at Gering Drain and Owl Creek. Other sites showed little, if any, change in concentrations and relative ratios of major ions between the two sampling periods, even though the streamflow increased 3 to 90 times at most sites.

Concentrations of chloride ranged from 11 to 35 mg/L for samples collected during both sampling periods. Maximum concentrations of chloride were detected in water from Gering Drain (35 mg/L) and from Owl Creek (32 mg/L) during the early spring sampling period. The largest fluoride concentrations detected also were in samples from Gering Drain (0.6 mg/L) and Owl Creek (0.8 mg/L), during the early spring sampling period.

### Trace Elements

The analyses of surface-water samples for dissolved trace elements revealed only very small or non-detectable concentrations of many potentially toxic trace elements (table 4, at back of report). A few constituents, however, were present in slightly larger concentrations at some sites. Concentrations of arsenic in surface water ranged from 1 to 34 µg/L (micrograms per liter). The largest concentrations of arsenic were detected in water samples from Gering Drain (34 µg/L) and Owl Creek (32 µg/L), during the early spring sampling period. Concentrations of arsenic in water samples collected at these sites during the mid-summer and from other sites during both the early spring and mid-summer were much smaller and ranged from 1 to 8 µg/L. Concentrations of arsenic were less than the acute (360 µg/L for $As^{3+}$ and 850 µg/L for $As^{5+}$) and chronic (190 µg/L for $As^{3+}$ and 48 µg/L for $As^{5+}$) criteria for freshwater aquatic life (U.S. Environmental Protection Agency, 1987) and were less than the Maximum Contaminant Level (MCL) of 50 µg/L for public drinking water (U.S. Environmental Protection Agency, 1994). In general, concentrations of arsenic in water samples collected during the early spring from most sampling sites were larger than those collected in mid-summer.

Ground-water quality data collected from 44 sites in Scotts Bluff, Morrill, and adjacent counties (Verstraeten and others, 1995) detected arsenic concentrations ranging from less than 1 to 59 µg/L. The largest concentrations of arsenic were detected in water samples from the Chadron Formation. Large concentrations of arsenic also were detected in North Platte River alluvium (19 µg/L) and the Ogallala Formation (18 µg/L). Thus, concentrations of arsenic detected during low-flow conditions from Gering Drain and Owl Creek may represent background ground-water concentrations, possibly from the Chadron Formation.

Concentrations of boron in surface-water samples ranged from 70 µg/L in the North Platte River above Whalen Dam, in the mid-summer, to 310 µg/L in Owl Creek and 400 µg/L in Gering Drain, during the early spring (table 4). The peak concentrations from the early spring samples at Owl Creek and Gering Drain were about 2 to 4 times larger than concentrations observed at other sampling locations during the same period. No criteria for freshwater aquatic life has been established for boron, and observed concentrations were less than the 600 µg/L lifetime drinking-water health advisory for adults (U.S. Environmental Protection Agency, 1994). Regionally, the largest concentrations of boron in ground water observed by Verstraeten and others (1995) were in water samples from the Chadron Formation and had a median of 1,050 µg/L for six samples. Again, the relatively large concentrations of boron detected in water samples from Gering Drain and Owl Creek may represent local ground water contributed to the streams during baseflow conditions.

Cadmium, cobalt, lead, and silver were not present in any of the surface-water samples in concentrations larger than the minimum detection limits of the NWQL of 1 µg/L for these elements (table 4). Chromium concentrations ranged from less than 1 to 5 µg/L with the largest concentrations detected in samples collected in the early spring from Gering Drain (3 µg/L) and Owl Creek (5 µg/L). All chromium concentrations were less

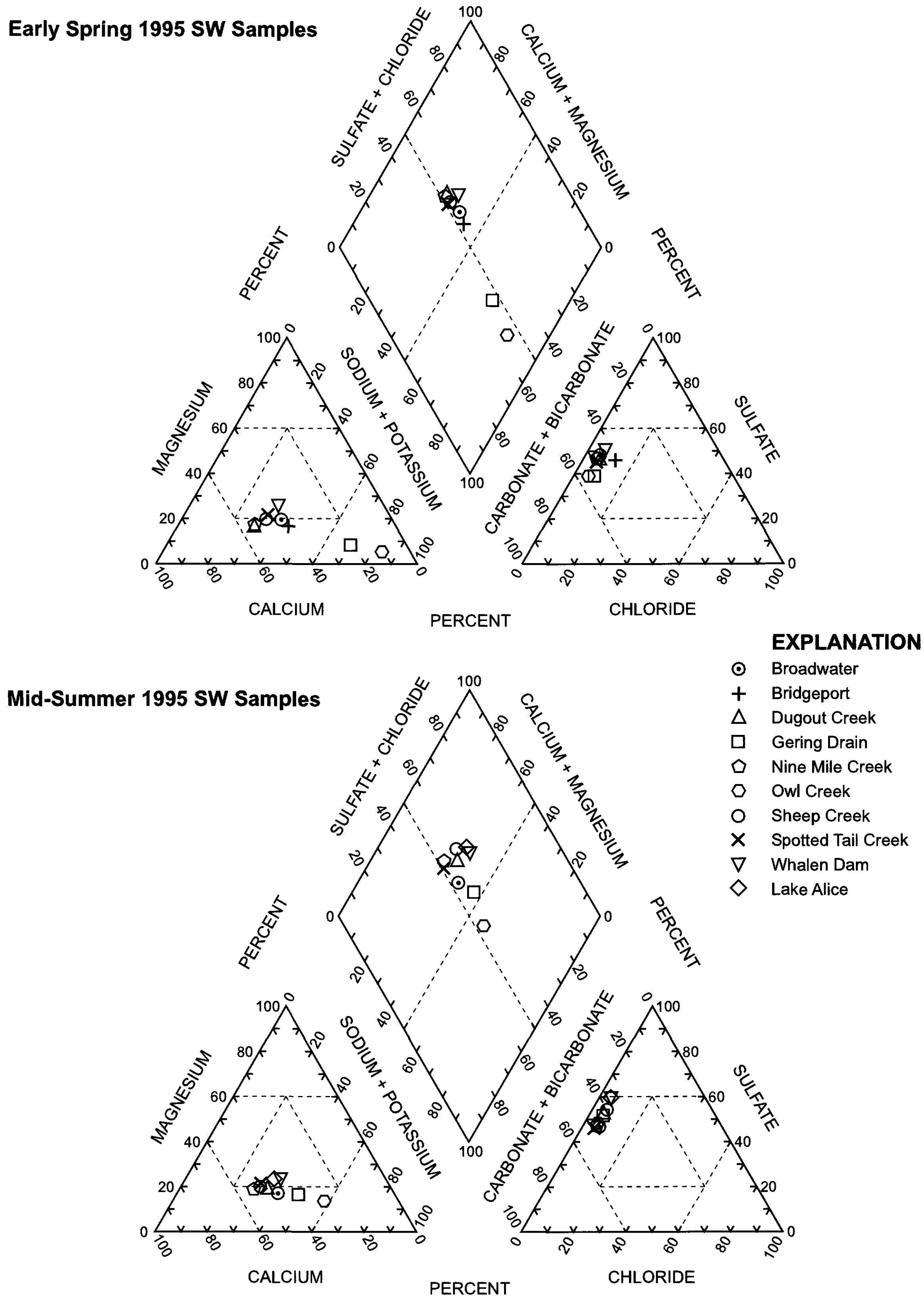


**Figure 2.** Major-ion composition of water samples from the North Platte River, selected tributaries, and Lake Alice, early spring and mid-summer, 1995.

than the USEPA's chronic and acute freshwater aquatic life criteria of 11 and 16 µg/L, respectively.

Concentrations of selenium in surface-water samples ranged from 1 to 8 µg/L (table 4). Water samples from the North Platte River near Bridgeport (early spring), Upper Dugout Creek (early spring), Gering Drain (early spring and mid-summer), Owl Creek (early spring), and Lake Alice (mid-summer) contained concentrations of selenium that equaled or exceeded the freshwater aquatic-life chronic criterion of 5 µg/L (U.S. Environmental Protection Agency, 1987). All but 2 of the 19 water samples exceeded the 2-µg/L threshold for selenium in water, suggested by Lemly (1996), above which selenium may have adverse effects on biota through bioaccumulation. The acute criterion of 20 µg/L (U.S. Environmental Protection Agency, 1987) was not exceeded in any of the water samples. The largest concentrations of selenium were detected in water samples collected in the early spring from both Gering Drain and Owl Creek. Concentrations of selenium decreased in water samples from early spring to mid-summer from Gering Drain, Nine Mile Creek, and Owl Creek. The range of observed concentrations of selenium are similar to those observed regionally by Verstraeten and others (1995) in ground-water samples and do not appear to be anomalous.

Concentrations of uranium in surface-water samples ranged from 13 to 61 µg/L (table 4). Concentrations of uranium exceeded the MCL of 20 µg/L for drinking water established by the U.S. Environmental Protection Agency (1994) in water samples from the North Platte River near Bridgeport (34 µg/L), Gering Drain (61 µg/L), Nine Mile Creek (29 µg/L), Owl Creek (50 µg/L), and Spotted Tail Creek (27 µg/L). No criteria for uranium have been proposed for aquatic life. Most of the water samples were collected for uranium analysis in the early spring; however, concentrations of uranium are assumed to have declined in the mid-summer samples due to dilution from increased flows in the North Platte River as apparently occurred with concentrations of most of the other trace elements.

Concentrations of uranium in ground water larger than 20 µg/L are common in the Nebraska panhandle. A major uranium deposit was found in Dawes County and concentrations of uranium in ground water in excess of 1,000 µg/L were reported (Spalding and others, 1984). Verstraeten and others (1995) reported concentrations of uranium in ground water ranging from less than 1 to 72 µg/L regionally with the largest concentrations detected in the North Platte River alluvial aquifer (median concentration of 16 µg/L and maximum concentration of 72 µg/L) and the Brule Formation (median concentration of 11 µg/L and maximum concentration of 19 µg/L). The ratio of uranium isotopes $^{234}U$ and $^{238}U$ were relatively large (larger than 4) for some of the ground-water samples collected from the Chadron Formation, which suggests the possibility of uranium mineralization in the aquifer substrate under thermodynamically reducing conditions (Cowart and Osmond, 1980). Thus, uranium concentrations observed in surface-water samples during the early spring for the field screening study could be the result of ground-water discharge to the streams.

As discussed in the Hydrogeology section, ash and/or other minerals contained in the Brule Formation and underlying Chadron Formation may be the source of the uranium observed during base streamflow. This theory is supported, in part, by the presence of large concentrations of uranium in streams that are incised into the Brule Formation and are often near the top of the Chadron Formation (Gering Drain, Nine Mile Creek, Owl Creek, and Spotted Tail Creek) relative to concentrations found in streams underlain by thick alluvial deposits (Upper Dugout and Sheep Creeks). Verstraeten and others (1995) attribute the large concentrations of uranium in the alluvial aquifer to the presence of weathered granite and volcanoclastics that were eroded from uplifts farther west, transported by the North Platte River, and deposited as part of the alluvium.

Concentrations of aluminum, antimony, beryllium, copper, lead, mercury, nickel, and silver in surface-water samples collected from all sites for both sampling periods were either less than the minimum detection limits or did not exceed 10 µg/L (table 4). All of these trace elements were detected in concentrations that were less than the acute and chronic criteria for freshwater aquatic life established by U.S. Environmental Protection

Agency (1987) and Nebraska Department of Environmental Quality (1995). Concentrations of most of these trace elements changed only slightly or remained the same at most sampling sites between the early spring and mid-summer samples, except for samples from Gering Drain and Owl Creek. Although the concentrations of zinc were very low in surface-water samples, zinc was the only constituent that increased in concentration between the early spring and mid-summer samples at most sites. The increase suggests that the source of the zinc is upstream from the North Platte Project area and likely is associated with the headwaters of the North Platte River.

In summary, concentrations of some trace elements that were analyzed decreased from the early spring to mid-summer. Concentrations of many trace elements tended to increase between the upstream and downstream parts of the North Platte Project area. It is hypothesized that the early spring samples were composed primarily of ground-water recharge to the streams and drains. During the irrigation season, when the canals were filled, the flow in most streams and drains increased by 3 to 90 times. (Flow in Spotted Tail Creek changed minimally and flow in Sheep Creek decreased by a factor about 20.) This increased flow likely resulted both from drainage of irrigation water into the streams and leakage of canal water to the ground water, which then discharged to the streams. Water from the canals and irrigation drainage appeared to dilute the more mineralized ground water discharging to the streams and generally improved the quality of the water in most cases.

## Bottom-Sediment Quality

Bottom-sediment samples were analyzed for major ions, trace elements, inorganic and organic carbon, and a suite of organochlorine compounds.

### Major Ions and Trace Elements

Median concentrations of most major ions and trace elements in bottom sediment from the North Platte Project area generally were comparable to or less than median concentrations of 315 bottom-sediment samples collected in 1979 in the Scottsbluff Quadrangle for the National Uranium Resource Evaluation (NURE) Program (1981). Results of bottom-sediment analyses collected during the field screening study are presented in table 4. A statistical summary of results for the North Platte Project area in comparison to NURE results for the Scottsbluff Quadrangle is in table 5.

Concentrations of trace elements in bottom-sediment samples collected during both studies generally were small (table 5). Median concentrations of arsenic (3 μg/g (micrograms per gram)), cerium (63 μg/g), and chromium (24 μg/g) in samples from the North Platte Project area were 2 to 10 times larger than median concentrations from the Scottsbluff Quadrangle. The median concentration for arsenic in bottom sediment detected during this study was 3 μg/g compared to 1.4 μg/g for the NURE data. The largest concentration of arsenic in bottom sediment was 6 μg/g from Gering Drain. Concentrations of arsenic were mostly less than concentrations detected in soil samples from uncultivated flood-plain forests (2.4-170 μg/g) and unglaciated prairie (3.4-38 μg/g) in Missouri (Connor and Shacklette, 1975), and were mostly less than the mean concentration of 5.5 μg/g for arsenic detected in soil in the western United States (Shacklette and Boerngen, 1984).

The median concentration of cerium in bottom sediment in the North Platte Project area was 63 μg/g compared to 5 μg/g for the NURE data (table 5). Concentrations of cerium in bottom sediment in the North Platte Project area ranged from 46 to 67 μg/g and were within the range of concentrations observed in soil samples from uncultivated flood-plain forests and unglaciated prairie in Missouri (Connor and Shacklette, 1975). Concentrations of cerium from the North Platte Project area (46-67 μg/g) were toward the lower end of the range of concentrations (less than 150-300 μg/g) detected in soil samples in the western United States compiled by Shacklette and Boerngen (1984).

Concentrations of chromium in bottom sediment from the North Platte Project area ranged from 15 to 37 μg/g (table 4) with a median of 24 μg/g (table 5). The median concentration of chromium in bottom sediment collected during the NURE program was 12 μg/g. The largest concentrations of chromium in bottom sediment from the North Platte Project area were from Lake Alice (37 μg/g) and

**Table 5.** Statistical summary of concentrations of major ions and trace elements in bottom sediment from selected sites in the North Platte Project area, 1995, in comparison to sediment collected by the National Uranium Resource Evaluation Program for the Scottsbluff Quadrangle, 1979

[Source of data is National Uranium Resources Program, 1982; concentrations in micrograms per gram (µg/g) unless stated; <, less than; --, not analyzed; %, percent]

| | North Platte Project area | | | | National Uranium Resource Evaluation Program | | | |
|---|---|---|---|---|---|---|---|---|
| **Element** | **Number** | **Minimum** | **Median** | **Maxi-mum** | **Number** | **Minimum** | **Median** | **Maximum** |
| Aluminum (%) | 7 | 4.7 | 5.3 | 7.1 | 315 | 3 | 5.2 | 7 |
| Arsenic | 7 | 2 | 3 | 6 | 310 | <0.1 | 1.4 | 7.4 |
| Barium | 7 | 8 | 770 | 950 | 315 | 644 | 827 | 1,393 |
| Beryllium | 7 | <1 | 1 | 2 | 315 | 1 | 2 | 6 |
| Cadmium | 7 | <1 | <1 | <1 | -- | -- | -- | -- |
| Calcium | 7 | 1.6 | 2.5 | 4.1 | 315 | .82 | 1.6 | 6.83 |
| Cerium | 7 | 46 | 63 | 67 | 315 | <4 | 5 | 16 |
| Chromium | 7 | 15 | 24 | 37 | 315 | 4 | 12 | 27 |
| Cobalt | 7 | 3 | 6 | 8 | 241 | 6 | 22 | 92 |
| Copper | 7 | 3 | 5 | 12 | 315 | 4 | 12 | 27 |
| Iron (%) | 7 | 1.1 | 1.6 | 2.2 | 315 | .73 | 1.9 | 9.5 |
| Lead | 7 | 10 | 14 | 19 | -- | -- | -- | -- |
| Lithium | 7 | 10 | 20 | 40 | 315 | 10 | 22 | 49 |
| Magnesium (%) | 7 | .31 | .52 | .99 | 315 | .21 | .62 | 1 |
| Manganese | 7 | 280 | 330 | 490 | 315 | 138 | 427 | 1,525 |
| Mercury | 7 | <1 | <1 | <1 | -- | -- | -- | -- |
| Molybdenum | 7 | <2 | <2 | <2 | 315 | <4 | <4 | <4 |
| Nickel | 7 | 5 | 7 | 13 | 311 | <2 | 10 | 44 |
| Phosphorus (%) | 7 | .03 | .04 | 0.12 | 315 | .018 | .046 | 0.11 |
| Potassium (%) | 7 | 1.9 | 2.2 | 2.5 | 315 | .81 | 1.6 | 3.2 |
| Scandium | 7 | 3 | 5 | 8 | 315 | 2 | 6 | 10 |
| Selenium | 7 | <1 | <1 | 1 | 90 | <.1 | <0.1 | 1.3 |
| Sodium (%) | 7 | 1.1 | 1.5 | 2.2 | 315 | .52 | 1.1 | 1.9 |
| Strontium | 7 | 260 | 320 | 350 | 315 | 153 | 252 | 458 |
| Titanium | 7 | .12 | .20 | .28 | 315 | .094 | .23 | 1.4 |
| Uranium | 7 | 2 | 3 | 6 | 315 | 1.3 | 3.4 | 17 |
| Zinc | 7 | 34 | 39 | 68 | 315 | 18 | 57 | 181 |

Gering Drain (28 µg/g) (table 4). Concentrations of chromium from the North Platte Project area were within the ranges of concentrations reported by Conner and Shacklette (1975) for soil from uncultivated flood-plain forests (7-70 µg/g) and unglaciated prairie (30-100 µg/g) in Missouri, and were near the mean of 41 µg/g) for chromium in 778 soil samples collected in the western United States (Shacklette and Boerngen, 1984).

The median concentration of strontium in bottom sediment from the North Platte Project area was 320 µg/g compared to 252 µg/g from the NURE program (table 5). The largest concentrations of strontium in the North Platte Project area were from samples from Owl Creek (350 µg/g), Gering Drain (340 µg/g), and Nine Mile Creek (340 µg/g) (table 4). Concentrations of strontium in all bottom-sediment samples from the North Platte Project area exceeded the maximum concentration in soil samples from uncultivated flood-plain forests (200 µg/g) and unglaciated prairie (200 µg/g) in Missouri (Connor and Shacklette, 1975). The minimum concentration of strontium (260 µg/g) from the North Platte Project area was larger than the mean for 778 soil samples (200 µg/g) collected in the western United States (Shacklette and Boerngen, 1984).

Concentrations of cadmium, mercury, and selenium in bottom sediment from the North Platte Project area were equal to or less than the minimum detection limits of 1 to 2 µg/g of the USGS Geologic Division laboratory and may not be present in sediment in sufficient quantities to constitute a known hazard to fish and wildlife. Concentrations of copper in bottom sediment ranged from 3 to 12 µg/g with the largest concentration in a sample from Gering Drain (table 4). The median concentration of copper in bottom sediment in the North Platte Project area was 5 µg/g compared to 12 µg/g for the NURE program (table 5).

Concentrations of lead in bottom sediment from the North Platte Project area ranged from 10 to 19 µg/g and were near the mean of 17 µg/g for 778 soil samples from the western United States (Shacklette and Boerngen, 1984). The largest concentrations of lead (19 µg/g) in the North Platte Project area were in samples from Gering Drain and from Lake Alice.

Concentrations of uranium in bottom sediment ranged from 2 to 6 µg/g (table 4) and had a median of 3 µg/g (table 5), which was slightly less than the median concentration of 3.4 µg/g for the NURE program and very close to the mean concentration of 2.5 µg/g for 224 soil samples from the western United States (Shacklette and Boerngen, 1984). The maximum concentration of uranium in bottom sediment in the North Platte Project area was from Gering Drain (6 µg/g) (table 4).

### Carbon and Selected Organochlorine Compounds

Concentrations of total carbon (organic plus inorganic carbon) in bottom-sediment samples varied from 0.15 percent at Sheep Creek to 1.1 percent for Gering Drain and Lake Alice (table 4). Concentrations of organic carbon ranged from 0.03 percent at Sheep Creek to 0.68 percent at Gering Drain. The slightly larger concentrations of organic carbon in bottom-sediment samples from Gering Drain (0.68 percent) and Lake Alice (0.56 percent) compared to samples from the other sites could explain, in part, the relatively larger concentrations of some trace elements and selected organochlorine compounds observed at Gering Drain and some trace elements at Lake Alice.

Analysis of bottom sediment for organochlorine compounds, PCBs, and polychlorinated naphthalenes (PCNs) detected trace amounts of DDT and its metabolites, DDD and DDE, in many samples. Trace amounts of DDT and/or its metabolites were detected in samples from Upper Dugout Creek, Gering Drain, Nine Mile Creek, Owl Creek, and Spotted Tail Creek. The sample from Gering Drain contained the largest concentrations of organochlorine compounds detected in this field screening study, with 0.4 µg/kg of DDD, 7.1 µg/kg of DDE, and 0.4 µg/kg of DDT. The concentrations of DDE in bottom sediment from Gering Drain were nearly an order of magnitude larger than concentrations in bottom sediment from major streams in eastern Nebraska in 1994 and 1995 (Druliner and others, 1996).

Trace concentrations of DDT and its metabolites are relatively common in soil and sediment samples, even though DDT was banned from use in 1973. Because organochlorine compounds tend to sorb strongly to soil and sediment, the presence of these compounds in the sediment of the streams and drains of the North Platte Project area is a reflection of past land use and the continuous erosion of soil from land once treated with DDT. Concentrations of other organochlorine compounds, PCBs, and PCNs in bottom sediment were below the minimum detection limits.

## Biological Quality

Concentrations of trace elements in fish and aquatic plants collected in this study are listed in table 6 at the end of the report. Organochlorine compounds detected in fish in the North Platte Project area are listed in table 7. The laboratory analyzing the trace elements had difficulties with the chromium and nickel analysis on the vegetation samples; therefore, results for these analytes should be considered estimates. Further, the laboratory analyzing the organic compounds noted that spike recoveries for dieldrin were less than normal levels. Therefore, dieldrin concentrations presented in this report may be smaller than actual concentrations.

Concentrations of trace elements and organochlorine compounds in composite biological samples collected for this study were compared to concentrations detected in other studies. In general, concentrations of trace elements were less than or comparable to concentrations detected in several DOI studies conducted in the western United States (Stephens and others, 1988; Radtke and others, 1988; and Knapton and others, 1988) and/or to concentrations reported from the National Contaminant Biomonitoring Program (NCBP) (May and McKinney, 1981; Lowe and others, 1985; and Schmitt and Brumbaugh, 1990). In the NCBP, seven trace elements (arsenic, cadmium, copper, lead, mercury, selenium, and zinc) were evaluated from selected sites throughout the United States. In western Nebraska, the NCBP samples were collected from the North Platte River east of the study area near Lake McConaughy and the South Platte River. Data collected from the NCBP at these sites and nationwide were compared to data collected for the North Platte Project area study.

For the NCBP, descriptive statistics (minimum, maximum, geometric mean, and the 85$^{th}$ percentile of the geometric mean) were used to identify nationwide trends in metal concentrations (May and McKinney, 1981; Lowe and others, 1985; Schmitt and Brumbaugh, 1990). The 85$^{th}$ percentile of the geometric mean is an arbitrary concentration identifying sites with large metal concentrations (May and McKinney, 1981; Lowe and others, 1985). Although May and McKinney (1981) and Lowe and others (1985) established that the 85$^{th}$ percentile has no connection to regulatory statutes and may not be biologically meaningful, NCBP sites exceeding it were considered above background and potential candidates for additional investigation. All fish collected for the NCBP were analyzed as whole-body, composite samples, and were reported in µg/g wet weight (May and McKinney, 1981; Lowe and others, 1985; Schmitt and Brumbaugh, 1990).

Results from this study also were compared to literature evaluating toxic effect thresholds to determine potential impacts to fish and wildlife resources. The following discussion focuses on samples and areas with large trace-element and organochlorine compound concentrations.

### Fish

Concentrations of aluminum, arsenic, cadmium, chromium, copper, lead, mercury, selenium, and zinc in composite fish samples were generally small or comparable to results from the NCBP conducted from 1976 to 1984 (Schmitt and Brumbaugh, 1990). Maximum concentrations of many of the trace elements were detected in composite fish samples collected at Nine Mile Creek, Owl Creek, and Sheep Creek. Aluminum concentrations in fish from all sites ranged from 1.70 to 296 µg/g wet weight. Concentrations of aluminum in fish collected from all sites exceeded the mean concentration reported by Brumbaugh and Kane (1985) (13.8 µg/g wet weight) in their national comparison of aluminum concentrations in smallmouth bass. Only one fish sample from Nine Mile Creek (296 µg/g wet weight) exceeded the largest concentration reported by Brumbaugh and Kane (1985) (97.4 µg/g wet weight). Brumbaugh and Kane (1985) discovered high variability in aluminum concentrations in gut contents and gill filaments of fish, which in turn added discrepancies in concentrations for whole-body analyses. Because whole-body fish analyses were used in this study, the

**Table 7.** Concentrations of organochlorine compounds in composite biological samples collected in the North Platte Project area, western Nebraska and eastern Wyoming, 1995

[Concentrations are in micrograms per gram wet weight; <, less than minimum detection limit]

| Site name | Owl Creek | | Nine Mile Creek | | | | Sheep Creek | | | Spotted Tail Creek | | Upper Dugout Creek | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample name/ Common name | HC1-1 (Common carp) | HC2-1 (Common carp) | NM2 (Brown trout) | NM4 (White sucker) | NMC2-2 (Rainbow trout) | NMC2-4 (White sucker) | SC-2 (White sucker) | SC2-2 (White sucker) | SC2-4 (White sucker) | ST-1 (Brown trout) | STC2-1 (Rainbow trout) | UDC2 (White sucker) | UDC2-2 (Common carp) |
| Date | 05-02-95 | 05-02-95 | 05-03-95 | 05-03-95 | 08-08-95 | 08-08-95 | 05-02-95 | 07-07-95 | 07-07-95 | 05-02-95 | 07-07-95 | 05-03-95 | 08-07-95 |
| HCB | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| PCB-total | .05 | <.05 | <.05 | <.05 | <.05 | <.05 | <.05 | <.05 | <.05 | <.05 | <.05 | <.05 | <.05 |
| Alpha BHC | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 |
| Alpha chlordane | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 |
| Beta BHC | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 |
| Cis-nonach | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 |
| Delta BHC | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 |
| Dieldrin[1] | <.01 | 0.03 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 |
| Endrin | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 |
| Gamma BHC | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 |
| Gamma chlordane | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 |
| Heptachlor epoxide | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 |
| Mirex | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 |
| o,p'-DDD | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 |
| o,p'-DDE | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 |
| o,p'-DDT | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 |
| Oxychlordane | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 |
| p,p'-DDD | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 |
| p,p'-DDE | .12 | .20 | .08 | .13 | .07 | .11 | .03 | .03 | .03 | .06 | .06 | .05 | .12 |
| p,p'-DDT | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 |
| Toxaphene | <.05 | <.05 | <.05 | <.05 | <.05 | <.05 | <.05 | <.05 | <.05 | <.05 | <.05 | <.05 | <.05 |
| Trans-nonachlor | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 | <.01 |

[1] Because of low spike recoveries, true concentrations are likely lower than concentrations reported here.

gut contents and gill filaments of the collected fish may have influenced the reported aluminum concentrations. Concentrations of aluminum in white suckers collected from Nine Mile Creek in spring and summer varied from 86.5 µg/g to 296 µg/g wet weight, respectively. Conversely, aluminum concentrations decreased between spring (64.4 µg/g) and summer (18.0 µg/g and 42.0 µg/g wet weight) in fish collected from Sheep Creek and Upper Dugout Creek from spring (62.8 µg/g) to summer (31.0 µg/g wet weight).

Arsenic concentrations in composite fish samples in this study ranged from 0.06 to 0.29 µg/g wet weight. The concentration of arsenic (0.29 µg/g wet weight) in a composite sample of white suckers collected in August from Nine Mile Creek exceeded the NCBP geometric mean concentration of arsenic (0.08 µg/g wet weight) in white suckers from the South Platte River in western Nebraska (Lowe and others, 1985). A concentration of arsenic in white suckers collected in May from Nine Mile Creek was 0.16 µg/g wet weight. Arsenic concentrations in trout from Nine Mile Creek did not differ between sampling dates (0.09 µg/g wet weight), and were less than the NCBP 85$^{th}$ percentile concentrations (0.22 to 0.38 µg/g wet weight) (Lowe and others, 1985; Schmitt and Brumbaugh, 1990). Smaller concentrations of arsenic and other trace elements in trout from Nine Mile Creek may be related to different feeding behavior than white suckers. While fingerling white suckers feed primarily on bottom material, adults have more generalized food habits but subsist primarily on immature aquatic insects (Pflieger, 1975). Background arsenic concentrations typically are less than 1 µg/g wet weight in freshwater aquatic biota (Eisler, 1988).

Cadmium concentrations in composite fish samples ranged from the minimum detection limit (0.03 µg/g) to 0.14 µg/g wet weight. Cadmium concentrations in two composite samples from Owl Creek (0.06 and 0.14 µg/g wet weight) and two of three composite samples from Sheep Creek (0.05 and 0.13 µg/g wet weight) equaled or exceeded the 85$^{th}$ percentile concentration of 0.05 µg/g wet weight reported by Schmitt and Brumbaugh (1990). The maximum cadmium concentration in composite fish samples (0.14 µg/g wet weight) was much lower than the 2.0 µg/g wet weight suggested by Eisler (1985) as evidence of probable cadmium contamination in whole-body fish.

Chromium concentrations in composite fish samples ranged from 0.27 to 1.4 µg/g wet weight (0.95 to 4.8 µg/g dry weight). White suckers collected in early August from Nine Mile Creek contained 4.8 µg/g (dry weight) chromium (1.4 µg/g wet weight). Giesy and Wiener (1977) stated fish in South Carolina typically contain less than 0.4 µg/g dry weight chromium. Eisler (1986) considers concentrations greater than 4.0 µg/g dry weight as indicative of chromium contamination.

Copper concentrations in composite fish samples ranged from less than 0.08 µg/g (the minimum detection limit) to 2.5 µg/g wet weight. Copper concentrations in whole-body fish collected from the North Platte River in western Nebraska for the NCBP ranged from 0.31 to 0.79 µg/g wet weight (Schmitt and Brumbaugh, 1990). Schmitt and Brumbaugh (1990) reported a nationwide 85$^{th}$ percentile copper concentration of 1.0 µg/g wet weight. Copper concentrations for 7 of 13 composite fish samples analyzed for this study exceeded the nationwide 85$^{th}$ percentile wet weight for copper. Peterson and others (1988) reported copper concentrations of 5.3 µg/g wet weight in rainbow trout collected from the North Platte River in Wyoming.

Concentrations of lead in composite fish samples ranged from 0.012 to 0.18 µg/g wet weight. Lead concentrations in white suckers from Nine Mile Creek varied between sampling dates. White suckers collected in early May contained 0.077 µg/g wet weight, whereas those collected in early August contained 0.18 µg/g wet weight. The early August concentration exceeded maximum NCBP concentrations (0.06 and 0.09) for two sites in western Nebraska (Schmitt and Brumbaugh, 1990). The NCBP 85$^{th}$ percentile for lead in whole-body fish was 0.22 µg/g wet weight (Schmitt and Brumbaugh, 1990).

Mercury concentrations in composite fish samples ranged from 0.035 to 0.13 µg/g wet weight. None of the samples exceeded the NCBP 85$^{th}$ percentile concentration (0.17 µg/g wet weight) for mercury in fish (Schmitt and Brumbaugh, 1990). However, 3 of 13 samples equaled or exceeded the maximum NCBP concentration (0.11 µg/g wet weight) in common carp from the North Platte River in western Nebraska (Schmitt and Brumbaugh, 1990). Mercury concentrations in common carp collected from Owl Creek in early May and rainbow trout collected from Spotted Tail Creek in early July exceeded the geometric mean concentration (0.11 µg/g wet weight) for NCBP samples collected from 1976 to 1981 (May and McKinney, 1981; Lowe and others, 1985).

Selenium concentrations in composite fish samples ranged from 0.87 to 1.9 µg/g wet weight (2.7 to 7.0 µg/g dry weight). All selenium concentrations in fish exceeded geometric mean (0.42 µg/g wet weight) and 85th percentile (0.73 µg/g wet weight) concentrations reported by Schmitt and Brumbaugh (1990). Geometric means for wet weight selenium concentrations in whole-body fish for the NCBP ranged from 0.48 µg/g in 1978-79 to 0.42 µg/g in 1984 (May and McKinney, 1981; Lowe and others, 1985; Schmitt and Brumbaugh, 1990). Eight of 13 samples exceeded the 4.0 µg/g dry weight level of concern for whole-body fish that Lemly (1993, 1996) recommended for protection against juvenile mortality and reproductive failure.

Zinc concentrations in whole-body fish samples ranged from less than 0.03 µg/g wet weight (the minimum detection limit) to 60.8 µg/g wet weight. The nationwide NCBP maximum wet-weight zinc concentrations were 168.1 µg/g in 1978-79, 109.2 µg/g in 1980-81, and 118.4 µg/g in 1984 (Schmitt and Brumbaugh, 1990). Further, the respective geometric mean and 85th percentile concentrations for wet-weight zinc were 23.8 and 46.3 µg/g in 1978-79, 21.4 and 40.1 µg/g in 1980-81, and 21.7 and 34.2 µg/g in 1984 (Lowe and others, 1985; Schmitt and Brumbaugh, 1990). Concentrations of zinc in fish collected in western Nebraska for the NCBP ranged from 11.8 µg/g to 69.2 µg/g wet weight (Schmitt and Brumbaugh, 1990). In the NCBP, common carp analyzed from 1976 to 1981 contained the highest mean zinc concentration (63.4 µg/g wet weight) relative to the mean concentration of all other species combined (17.7 µg/g wet weight) (Lowe and other, 1985). The largest concentrations of zinc (51.8 and 60.8 µg/g wet weight) in this study were detected in common carp collected from Owl Creek. All other sites were either below or comparable to the NCBP nationwide 85th percentile values (May and McKinney, 1981; Lowe and others, 1985; Schmitt and Brumbaugh, 1990). Schmitt and Brumbaugh (1990) suggested common carp and other *Cyprinids* (minnow species) contain larger concentrations of zinc than other species of fish. Increased zinc concentrations in fish tissue can lead to growth retardation, inhibition of spawning, as well as mortality (Sorenson, 1991). Zinc concentrations in fish can vary dramatically depending on diet, age, and reproductive state (Eisler, 1993). Further, metabolic rate, previous zinc exposure, and feeding patterns can change zinc uptake or toxicity (Sorenson, 1991).

Three organochlorine compounds were detected in composite fish samples from the North Platte Project area (total PCBs, dieldrin, and p,p'-DDE). Although samples were not analyzed for individual PCB congeners, one composite common carp sample collected in May 1995 from Owl Creek contained 0.05 µg/g wet weight total PCBs. This concentration was less than the geometric mean (0.39 µg/g wet weight) in fish collected in 1984 for the NCBP (Schmitt and others, 1990). Concentrations in fish tissue exceeding 50 µg/g are suspected of adversely affecting growth and reproduction (Niimi, 1996).

A composite sample of common carp collected from Owl Creek contained 0.03 µg/g wet weight dieldrin, which is less than the geometric mean concentration (0.04 µg/g wet weight) for NCBP results of 1984 (Schmitt and others, 1990). Dieldrin is classified as a cyclodiene insecticide and is altered readily from aldrin (Peakall, 1996). The National Academy of Sciences and National Academy of Engineering (1973) recommended, for protection of aquatic life, that combined concentrations of all cyclodiene compounds should not exceed 0.1 µg/g whole-body wet weight.

All composite fish samples from the North Platte Project area contained detectable concentrations of p,p'-DDE. Whole-body, wet weight concentrations ranged from 0.02 µg/g in white suckers from Sheep Creek to 0.20 µg/g in common carp from Owl Creek. Concentrations of p,p'-DDE in fish from the North Platte Project area compare closely to concentrations in fish (0.05 to

0.16 µg/g wet weight) from NCBP sites sampled in western Nebraska (Schmitt and others, 1990). All but one composite sample collected from Owl Creek was less than the 1984 nationwide geo-metric mean concentration (0.19 µg/g wet weight) of p,p'-DDE (Schmitt and others, 1990).

### Aquatic Vegetation

The following taxa were collected at six sites and were analyzed for trace elements: (1) disk water hyssop (*Bacopa rotundifolia*), (2) horsetail (*Equisetumm laevigatum*), (3) river bulrush (*Scirpus fluviatilis*), and (4) green algae (*Cladophora* and *Spirogyra*). Little documentation could be found relating metal concentrations in plants and a resultant impact to fish and wildlife. Therefore, to identify areas with large metal concentrations, the discussion below compares concentrations in plants from this study to concentrations from published literature.

Aluminum concentrations were largest in *Spirogyra* collected in Owl Creek (10,600 and 15,900 µg/g dry weight). Comparatively, concentrations of aluminum in aquatic mosses collected from metal-mine drainage in Wales contained 54,000 µg/g dry weight (Moore, 1990). In less contaminated reaches the concentrations of aluminum in the mosses decreased to 2,000 to 7,000 µg/g dry weight (Moore, 1990). Large concentrations of aluminum in plants can result in decreased root growth, increased mucilage production (Crowder, 1991), and reduction in plant biomass (Parker and others, 1989). Toxic thresholds for aquatic plants are not well documented, although a toxicity threshold of 300 µg/g dry weight for rice has been proposed (Crowder, 1991).

Concentrations of arsenic were largest in algae collected from Owl Creek (5.1 and 7.7 µg/g dry weight) and from Gering Drain (6.8 and 7.1 µg/g dry weight). The corresponding wet-weight arsenic concentrations were 0.19 and 0.39 µg/g from Owl Creek and 0.52 and 0.55 µg/g from Gering Drain.

Barium concentrations were largest in algae collected from Gering Drain (1,500 and 2,660 µg/g dry weight). However, barium is not known to accumulate in plants in sufficient quantities to cause toxicity to wildlife (International Programme on Chemical Safety, 1990).

Boron concentrations in aquatic plants ranged from 11 to 61 µg/g dry weight. The largest concentrations of boron were evident in algae samples collected from Spotted Tail Creek (61µg/g dry weight). Comparatively, filamentous algae collected for an irrigation drain-water study in California contained 280 µg/g dry-weight boron (Saiki and others, 1993), and aquatic macrophytes collected from a boron-contaminated wetland in Florida contained up to 142 µg/g dry weight (Powell and others, 1997). Aquatic macrophytes usually contain less than 20 µg/g dry weight boron and range from 1.2 to 100 µg/g dry weight (Eisler, 1990). All aquatic plants collected for this study contained boron concentrations within this range.

The largest selenium concentration (2.5 µg/g dry weight) was found in algae collected from Gering Drain but was much less than concentrations (20 µg/g dry weight) known to cause inhibition of cell division (Lemly, 1993). Concentrations of selenium in filamentous algae from nonseleniferous habitats usually average less than 5 µg/g dry weight (Saiki and others, 1993). By comparison, selenium concentrations in algae collected from Pond 11 at Kesterson Reservoir in California ranged from 16.0 to 32.0 µg/g dry weight (Saiki and Lowe, 1987).

## Quality Assurance Results

Dissolved concentrations of major ions and trace elements for the original and duplicate samples collected at Sheep Creek were almost identical for all constituents except selenium, for which concentrations were 1 and 4 µg/L for the original and duplicate samples, respectively (table 4).

One surface-water sample was spiked in the field by diluting 10 mL of known concentrations of trace elements with water from Sheep Creek for a total volume of 2,000 mL. The analytical results of the spiked water sample, the most probable concentrations of the spikes, and the range of acceptable concentrations (two standard deviations, as determined by the commercial provider of the spikes) are presented in table 8. Of the 19 trace

**Table 8.** Results of quality assurance analyses of surface-water samples for concentrations of trace elements and of bottom-sediment samples for concentrations of trace elements, selected major ions, and selected organochlorine compounds, from the North Platte Project area, western Nebraska and eastern Wyoming, 1995

[µg/L, micrograms per liter; µg/g, micrograms per gram; µg/kg, micrograms per kilogram; %, percent; *, concentration was affected by constituents in the natural water sample; Acceptable range: 95-percent confidence level determined by the provider of the spike materials]

| Constituent | Observed concentration | Spike concentration | Acceptable range |
|---|---|---|---|
| | **Surface-water samples** | | |
| Aluminum, dissolved, (µg/L as Al) | 120 | 259 | 212-305 |
| Antimony, dissolved (µg/L as Sb) | 62 | 44 | 33-52 |
| Arsenic, dissolved (µg/L as As) | 43 | 54 | 41-64 |
| Barium, dissolved (µg/L as Ba) | 210* | 49 | 65-94 |
| Beryllium, dissolved (µg/L as Be) | 42 | 59 | 48-69 |
| Boron, dissolved (µg/L as B) | 200* | 73 | 60-85 |
| Cadmium, dissolved (µg/L as Cd) | 52 | 52 | 43-62 |
| Chromium, dissolved (µg/L as Cr) | 30 | 96 | 78-113 |
| Cobalt, dissolved (µg/L as Co) | 80 | 77 | 63-91 |
| Copper, dissolved (µg/L as Cu) | 62 | 88 | 72-103 |
| Lead, dissolved (µg/L as Pb) | 15 | 71 | 58-84 |
| Manganese, dissolved (µg/L as Mn) | 59 | 59 | 48-69 |
| Mercury, dissolved (µg/L as Hg) | 1.2 | 1.7 | 1.2-2.2 |
| Molybdenum, dissolved (µg/L as Mo) | 98 | 88 | 72-103 |
| Nickel, dissolved (µg/L as Ni) | 86 | 84 | 69-93 |
| Selenium, dissolved (µg/L as Se) | 65 | 52 | 40-65 |
| Silver, dissolved (µg/L as Ag) | 13 | 64 | 53-76 |
| Vanadium, dissolved (µg/L as V) | 40 | 129 | 106-152 |
| Zinc, dissolved (µg/L as Zn) | 69 | 77 | 63-91 |
| | **Bottom-sediment samples** | | |
| Aluminum in sediment (%) | 5.4 | 4.7 | 2.5-6.5 |
| Antimony in sediment (µg/g) | 240 | 54 | 18-210 |
| Arsenic in sediment (µg/g) | 6 | 65 | 32-97 |
| Barium in sediment (µg/g) | 990 | 319 | 213-415 |
| Beryllium in sediment (µg/g) | 150 | 152 | 97-211 |
| Cadmium in sediment (µg/g) | 91 | 82 | 41-114 |
| Calcium in sediment (%) | .80 | .29 | 0.2-.4 |
| Chromium in sediment (µg/g) | 77 | 57 | 34-80 |
| Cobalt in sediment (µg/g) | 120 | 128 | 81-178 |
| Copper in sediment (µg/g) | 150 | 146 | 89-205 |
| Iron in sediment (%) | 1.8 | 1.0 | .57-1.3 |
| Lead in sediment (µg/g) | 140 | 128 | 70-179 |
| Magnesium in sediment (%) | .42 | .32 | .20-.45 |
| Manganese in sediment (µg/g) | 320 | 162 | 114-219 |
| Mercury in sediment (µg/g) | 18 | 24 | 10-37 |
| Molybdenum in sediment (µg/g) | 180 | 198 | 109-325 |
| Nickel in sediment (µg/g) | 38 | 36 | 21-51 |
| Potassium in sediment (%) | 3.0 | .31 | .19-.41 |
| Selenium in sediment (µg/g) | 54 | 48 | 24-70 |
| Silver in sediment (µg/g) | 99 | 85 | 34-125 |

**Table 8.** Results of quality assurance analyses of surface-water samples for concentrations of trace elements and of bottom-sediment samples for concentrations of trace elements, selected major ions, and selected organochlorine compounds, from the North Platte Project area, western Nebraska and eastern Wyoming, 1995--Continued

| Constituent | Observed concentration | Spike concentration | Acceptable range |
|---|---|---|---|
| **Bottom-sediment samples--Continued** | | | |
| Sodium in sediment (%) | 1.4 | 1.5 | 0.80-2.1 |
| Vanadium in sediment (µg/g) | 77 | 58 | 40-78 |
| Zinc in sediment (µg/g) | 75 | 76 | 44-116 |
| Aldrin, total in sediment (µg/kg) | 78 | 151 | 81-171 |
| Chlordane, total in sediment (µg/kg) | 180 | 50 | 23-54 |
| DDD, total in sediment (µg/kg) | 76 | 108 | 52-130 |
| DDE, total in sediment (µg/kg) | 37 | 55 | 31-65 |
| DDT, total in sediment (µg/kg) | 58 | 118 | 47-136 |
| Dieldrin, total in sediment (µg/kg) | 66 | 124 | 63-153 |
| Endrin, total in sediment (µg/kg) | 19 | 124 | 63-153 |
| Heptachlor, total in sediment (µg/kg) | 31 | 50 | 27-56 |

elements dissolved in the spiked water sample, the observed concentrations of 9 of them were in the acceptable range of concentrations. Seven of the other 10 were less than the minimum acceptable values. This downward bias may be the result of limited accuracy in measuring the volume of the field sample.

One commercially prepared sediment sample containing known concentrations of selected trace elements and a mixture of three commercially prepared sediment samples containing known concentrations of organochlorine compounds and semivolatile organic compounds were submitted to the NWQL and the USGS Geologic Division laboratory for analysis. The mixed sample of target compounds was prepared in the field to accommodate the NWQL analytical schedules and sample-size requirements. Concentrations of 16 of the 23 trace elements in the sediment spike were in the acceptable range determined by the provider of the spikes. Concentrations of five of the eight organic compounds in the spike-sediment sample were in the acceptable range determined by the provider of the spikes. Deviations in observed concentrations and spiked concentrations may be the result of field mixing and incomplete homogenization of the spiked samples.

## SUMMARY AND CONCLUSIONS

In 1994, the National Irrigation Water Quality Program of the U.S. Department of the Interior identified the North Platte Project in western Nebraska and eastern Wyoming for a field screening investigation. The purpose of the investigation was to determine if the accumulation of selected trace elements and/or organic compounds resulting from irrigation drainage from projects built or operated by agencies of the DOI might have caused harmful effects on fish and wildlife or impaired the suitability of water for other beneficial uses.

Ten sites were selected for sample collection. Seven sites were representative of streams and drains that carry irrigation drain water to sites on the North Platte River and the remaining sites were upstream and downstream from the North Platte Project area. Sites sampled in the North Platte Project area included the North Platte River near Broadwater and Bridgeport, Upper Dugout Creek, Gering Drain, Nine Mile Creek, Owl Creek, Sheep Creek, Spotted Tail Creek, Lake Alice, and the North Platte River above Whalen Dam. Surface-water, bottom-sediment, and fish and vegetation samples were collected at most sites. Surface-water samples were collected in the early spring and mid-summer and analyzed for major ions and trace elements. Bottom-sediment samples were collected in the early spring at seven of the sites and were analyzed for both trace elements and selected organochlorine compounds. Fish were collected at five of six sites during the early and late summer and were analyzed for trace elements and selected organochlorine compounds. Samples of vegetation were collected at all six sites during both sampling periods and were analyzed for trace elements.

Generally the surface water was a calcium-sodium bicarbonate-sulfate water type. During the early spring, surface-water samples from Gering Drain and Owl Creek were a sodium carbonate-sulfate water type. Specific conductance and dissolved solids tended to increase from upstream to downstream in the North Platte River. Specific conductance and dissolved solids, in addition to concentrations of specific trace elements, decreased as streamflow increased at Gering Drain and Owl Creek.

Concentrations of many trace elements in surface water were either less than the minimum detection limits or were small. Concentrations of most trace elements were less than the acute and chronic criteria for freshwater aquatic life established by the USEPA. Concentrations of selenium in water samples from five sites equaled or slightly exceeded USEPA's chronic criterion for freshwater aquatic life of 5 µg/L. Concentrations of selenium in 17 of 19 surface-water samples collected in the North Platte Project area also exceeded the 2-µg/L threshold above which selenium can have adverse effects on biota through bioaccumulation.

Concentrations of uranium in surface-water samples collected at five sites exceeded drinking water regulations established by the USEPA. The two largest concentrations of uranium, 61 and 50 µg/L, were in water samples from Gering Drain and Owl Creek, respectively. Larger concentrations of arsenic, boron, selenium, and uranium in surface water from some streams and drains in the North Platte Project area were detected during low-flow conditions, when ground-water discharge was the principal source of water to the streams. The quality of this ground water may be representative of the Brule and Chadron Formations and is not necessarily a product of irrigation drainage.

Concentrations of most trace elements in bottom-sediment samples generally were small. Nonetheless, median concentrations of arsenic, cerium, and chromium in bottom sediment from the North Platte Project area were 2 to 10 times larger than median concentrations determined by the NURE program for the Scottsbluff Quadrangle. Concentrations of cadmium, mercury, and selenium in bottom sediment were equal to or less than the minimum detection limits of 1 to 2 µg/g and most likely are not present in sufficient quantities to constitute a known hazard. The median concentrations for copper, lead, and uranium tended to be equal to or smaller than medians for the Scottsbluff Quadrangle and/or mean concentrations for the western United States.

One or more of three organochlorine compounds (DDD, DDE, and DDT) were detected in bottom sediment from five of the seven streams or drains from which samples were collected in the North Platte Project area. DDE, a metabolite of DDT, was the most frequently detected organochlorine compound and was detected in bottom-sediment samples at four sites. DDD, which also is a metabolite of DDT, was detected in bottom sediment at one site and DDT was detected in bottom sediment at three sites. The largest concentration of organochlorine compounds was detected in bottom sediment from Gering Drain.

In general, concentrations of trace elements in biological samples from the North Platte Project area were less than or comparable to concentrations detected in several DOI studies in the western United States and/or concentrations from the NCBP. Concentrations of aluminum in fish from Nine Mile Creek were large, but the reported concentrations may have been influenced by the inclusion of gut contents and gill filaments in the whole-body analyses. Concentrations of arsenic in composite fish samples from the North Platte Project area ranged from 0.06 to 0.29 µg/g wet weight, and concentrations of arsenic in composite fish (trout) samples were less than the NCBP 85$^{th}$ percentile. Concentrations of cadmium in composite fish samples ranged from less than 0.03 to 0.14 µg/g wet weight with two samples exceeding the NCBP 85$^{th}$ percentile of 0.05 µg/g wet weight. Concentrations of chromium in composite fish samples ranged from 0.27 to 1.4 µg/g wet weight and were less than levels considered indicative of chromium contamination. Although concentrations of copper in composite fish samples were not large (less than 0.08 to 2.5 µg/g wet weight), 7 of 13 samples had concentrations exceeding the NCBP 85th percentile (1.0 µg/g wet weight) for copper in whole-body fish. Concentrations of lead ranged from 0.012 to 0.18 µg/g wet weight in composite fish samples and the maximum lead concentration was less than the NCBP 85th percentile of 0.22 µg/g wet weight. None of the composite fish samples exceeded the NCBP 85th percentile (0.17 µg/g wet weight) for mercury in fish. Eight of 13 composite fish samples collected in the North Platte Project area had concentrations of selenium that exceeded the 4.0 µg/g dry weight level of concern for protection against juvenile mortality and reproductive failure. Maximum concentrations of many of the trace elements were detected in composite fish samples collected at Nine Mile Creek, Owl Creek, and Sheep Creek.

Total PCBs, dieldrin, and p,p'-DDE were the only organochlorine compounds detected in composite fish samples from the North Platte Project area. One composite fish sample collected in Owl Creek contained a detectable concentration of PCBs (0.05 µg/g wet weight). Another composite sample also collected in Owl Creek contained a concentration of dieldrin of 0.03 µg/g wet weight. All composite fish samples contained detectable amounts of p,p'-DDE (0.02 to 0.20 µg/g wet weight). Concentrations of p,p'-DDE in fish from the North Platte Project area compare closely to concentrations in fish (0.05 to 0.16 µg/g wet weight) from NCBP sites sampled in western Nebraska.

Vegetation samples of disk water hyssop, horsetail, river bulrush, and green algae were collected at six sites and analyzed for trace elements. Concentrations of many trace elements ranged between less than 1 and 10 µg/g dry weight. Generally, the largest concentrations of many trace elements in vegetation were detected in samples collected from Gering Drain.

Concentrations of most trace elements in surface water, bottom sediment, and biota were generally similar to or only slightly larger than regional concentrations. Nonetheless, an increase in concentrations of dissolved solids and some trace elements was detected between the upstream and downstream sites in the North Platte Project area. These differences could be the result of naturally occurring minerals in the Brule and/or Chadron Formations that are contained in ground water discharging to streams and drains. Also, it is possible that these differences are caused by the accumulation of major ions and trace elements on fields through the application and evaporation of irrigation water followed by leaching of those materials into the ground water and later discharge to local streams and drains.

Of the constituents examined during this study for which there are established or tentative fish and wildlife health criteria, selenium was the only constituent present in surface water and in composited, whole-body fish samples in concentrations that approached or exceeded those criteria. Concentrations of selenium in 17 of 19 water samples collected during this study exceeded the 2 µg/L threshold above which selenium may have adverse effects on biota through bioaccumulation. Additionally, concentrations of selenium in composited, whole-body fish samples were equal to or slightly larger than the threshold concentrations associated with reproductive impairment of fish. No abnormalities were observed in fish. The impact of elevated selenium concentrations on the reproductive success of fish and wildlife populations was not determined. Also, efforts to collect aquatic invertebrates were not successful; therefore, the uptake of selenium through the food chain could not be addressed. Therefore, selenium concentrations in aquatic invertebrates and bird eggs collected in conjunction with analysis of surface-water, bottom-sediment, and fish samples would be useful to facilitate a more thorough assessment of selenium impacts to fish and wildlife resources in the North Platte Project area.

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**Table 4.** Surface-water and bottom-sediment quality data for selected sites in the North Platte Project area, early spring and mid-summer 1995

[$ft^3/s$, cubic feet per second; μS/cm, microsiemens per centimeter at 25 degress Celsius; $^{o}C$, degrees Celsius; mg/L, milligrams per liter; μg/L, micrograms per Liter; μg/g, micrograms per gram; μg/kg, micrograms per kilogram; SW, surface water; BS, bottom sediment; SWDUPL, surface-water duplicate sample; <, less than mimium detection limit; --, not analyzed; %, percent]

| Station number | Site name | Date | Time | Sample type | Discharge, inst. ($ft^3/s$) | Specific conductance (μS/cm) | Specific conductance, lab (μS/cm) | pH, water, whole, field (standard units) | pH, water, whole, lab (standard units) | Temperature, water ($^{o}C$) | Alkalinity, lab (mg/L as $CaCO_3$) | Calcium, dissolved (mg/L as Ca) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 413458102512401 | N. Platte River Broadwater | 07-05-95 | 1045 | SW | 2,500 | 800 | 790 | 8.3 | 8.0 | 19.0 | 200 | 72 |
| | | 07-31-95 | 1500 | SW | 450 | 938 | 926 | 8.5 | 8.1 | 21.0 | 229 | 86 |
| 414054103055401 | N. Platte River Bridgeport | 03-27-95 | 1600 | SW | 700 | 1,060 | 1,020 | 8.4 | 7.9 | 8.5 | 247 | 90 |
| 414131103054601 | Upper Dugout Creek | 03-30-95 | 1600 | SW | 2.8 | 732 | 702 | 8.8 | 8.1 | 11.0 | 168 | 79 |
| | | 03-30-95 | 1600 | BS | -- | 732 | -- | 8.8 | -- | 11.0 | -- | -- |
| | | 08-03-95 | 1100 | SW | 258 | 586 | 750 | 8.4 | 7.9 | 20.0 | 165 | 72 |
| 414653103403001 | Gering Drain | 03-30-95 | 0900 | SW | 8.9 | 1,320 | 1,280 | 8.0 | 7.4 | 7.0 | 341 | 55 |
| | | 03-30-95 | 0900 | BS | -- | -- | -- | -- | -- | -- | -- | -- |
| | | 08-02-95 | 1330 | SW | 48 | 835 | 819 | 8.2 | 7.8 | 22.0 | 182 | 62 |
| 415336103255601 | Nine Mile Creek | 03-30-95 | 1230 | SW | 6.4 | 842 | 829 | 8.2 | 7.6 | 12.0 | 205 | 92 |
| | | 03-30-95 | 1230 | BS | -- | -- | -- | -- | -- | -- | -- | -- |
| | | 08-02-95 | 1630 | SW | 19 | 817 | 802 | 8.1 | 7.8 | 20.0 | 198 | 91 |
| 415542104001401 | Owl Creek | 03-29-95 | 1400 | SW | 11 | 1,650 | 1,610 | 8.6 | 8.3 | 6.5 | 442 | 36 |
| | | 03-29-95 | 1400 | BS | -- | -- | -- | -- | -- | -- | -- | -- |
| | | 08-02-95 | 1130 | SW | 77 | 992 | 972 | 8.2 | 7.8 | 20.5 | 232 | 58 |
| 415814103571401 | Sheep Creek | 03-28-95 | 1100 | SW | 57 | 885 | 854 | 8.2 | 7.7 | 6.0 | 212 | 85 |
| | | 03-28-95 | 1100 | BS | -- | -- | -- | -- | -- | -- | -- | -- |
| | | 08-01-95 | 0930 | SW | 2.7 | 900 | 891 | 8.1 | 7.8 | 15.0 | 222 | 90 |
| | | 08-01-95 | 0935 | SWDUPL | 2.7 | 900 | 891 | 8.1 | 7.8 | 15.0 | 221 | 93 |
| 415920103475301 | Spotted Tail Creek | 03-28-95 | 1600 | SW | 9.8 | 815 | 798 | 8.4 | 8.0 | 11.0 | 203 | 78 |
| | | 03-28-95 | 1600 | BS | -- | -- | -- | -- | -- | -- | -- | -- |
| | | 08-01-95 | 1200 | SW | 9.7 | 820 | 809 | 8.4 | 7.8 | 16.5 | 211 | 86 |
| 415942103374601 | Lake Alice | 03-29-95 | 1800 | BS | -- | -- | -- | -- | -- | -- | -- | -- |
| | | 08-01-95 | 1400 | SW | 160 | 692 | 674 | 8.3 | 7.9 | 22.0 | 125 | 60 |
| 421500104374001 | N. Platte River Whalen Dam | 03-29-95 | 1130 | SW | 8.7 | 670 | 725 | 8.3 | 7.3 | 2.5 | 160 | 60 |
| | | 08-02-95 | 0915 | SW | 4,460 | 686 | 667 | 8.2 | 7.9 | 18.0 | 126 | 54 |

**Table 4.** Surface-water and bottom-sediment quality data for selected sites in the North Platte Project area, early spring and mid-summer 1995--Continued

| Site name | Date | Magnesium, dissolved (mg/L as Mg) | Sodium, dissolved (mg/L as Na) | Potassium, dissolved (mg/L as K) | Sulfate, dis-solved (mg/L as $SO_4$) | Chloride, dis-solved (mg/L as Cl) | Fluoride, dis-solved (mg/L as F) | Solids, residue at 180 °C, dis-solved (mg/L) | Alumi-num, dis-solved, (µg/L as Al) | Anti-mony, dis-solved (µg/L as Sb) | Arsenic, dis-solved (µg/L as As) | Barium, dis-solved (µg/L as Ba) | Beryl-lium, dis-solved (µg/L as Be) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N. Platte River Broadwater | 07-05-95 | 20 | 70 | 7.2 | 200 | 16 | 0.4 | 550 | 6 | <1 | 4 | 87 | <1 |
| | 07-31-95 | 20 | 80 | 9.5 | 220 | 21 | .5 | 647 | -- | -- | 5 | -- | -- |
| N. Platte River Bridgeport | 03-27-95 | 22 | 100 | 11 | 230 | 24 | .5 | 688 | 5 | <1 | 6 | 100 | <1 |
| Upper Dugout Creek | 03-30-95 | 15 | 44 | 8.4 | 160 | 15 | .5 | 503 | 5 | <1 | 4 | 170 | <1 |
| | 03-30-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 08-03-95 | 18 | 54 | 7.2 | 200 | 13 | .4 | 520 | -- | -- | 3 | -- | -- |
| Gering Drain | 03-30-95 | 13 | 200 | 13 | 240 | 35 | .6 | 858 | 4 | <1 | 34 | 60 | <1 |
| | 03-30-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 08-02-95 | 17 | 85 | 8.5 | 210 | 15 | .4 | 559 | -- | -- | 8 | -- | -- |
| Nine Mile Creek | 03-30-95 | 18 | 52 | 8.6 | 190 | 14 | .5 | 602 | 3 | <1 | 7 | 120 | <1 |
| | 03-30-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 08-02-95 | 20 | 51 | 8.8 | 190 | 14 | .5 | 586 | -- | -- | 5 | -- | -- |
| Owl Creek | 03-29-95 | 11 | 310 | 13 | 300 | 32 | .8 | 1,070 | 3 | <1 | 32 | 74 | <1 |
| | 03-29-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 08-02-95 | 17 | 130 | 8.2 | 230 | 17 | .5 | 659 | -- | -- | 9 | -- | -- |
| Sheep Creek | 03-28-95 | 21 | 59 | 11 | 200 | 16 | .5 | 603 | 3 | <1 | 8 | 110 | <1 |
| | 03-28-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 08-01-95 | 22 | 57 | 10 | 210 | 15 | .5 | 640 | -- | -- | 7 | -- | -- |
| | 08-01-95 | 23 | 59 | 11 | 210 | 15 | .5 | 641 | -- | -- | 7 | -- | -- |
| Spotted Tail Creek | 03-28-95 | 22 | 57 | 8.3 | 180 | 16 | .4 | 570 | 4 | <1 | 5 | 120 | <1 |
| | 03-28-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 08-01-95 | 23 | 56 | 7.1 | 190 | 14 | .4 | 581 | -- | -- | 4 | -- | -- |
| Lake Alice | 03-29-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 08-01-95 | 20 | 53 | 3.5 | 200 | 11 | .3 | 454 | -- | -- | 2 | -- | -- |
| N. Platte Rriver Whalen Dam | 03-29-95 | 23 | 55 | 4.6 | 180 | 16 | .5 | 467 | 3 | <1 | 1 | 58 | <1 |
| | 08-02-95 | 19 | 54 | 3.4 | 200 | 11 | .3 | 438 | -- | -- | 2 | -- | -- |

**Table 4.** Surface-water and bottom-sediment quality data for selected sites in the North Platte Project area, early spring and mid-summer 1995--Continued

| Site name | Date | Boron, dis-solved (µg/L as B) | Cadmium, dis-solved, (µg/L as Cd) | Chromium, dissolved (µg/L as Cr) | Cobalt, dis-solved (µg/L as Co) | Copper, dis-solved (µg/L as Cu) | Lead, dis-solved (µg/L as Pb) | Manga-nese, dissolved (µg/L as Mn) | Mercury, dissolved (µg/L as Hg) | Molyb-denum, dissolved (µg/L as Mo) | Nickel, dis-solved (µg/L as Ni) | Selenium, dissolved (µg/L as Se) | Silver, dis-solved (µg/L as Ag) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N. Platte River Broadwater | 07-05-95 | 90 | <1 | 2 | <1 | 2 | <1 | 4 | <0.1 | 4 | 10 | 4 | <1 |
| | 07-31-95 | 140 | <1 | <1 | -- | 2 | <1 | -- | <.1 | <1 | -- | 3 | -- |
| N. Platte River Bridgeport | 03-27-95 | 170 | <1 | 2 | <1 | 2 | <1 | 2 | .3 | 4 | 4 | 5 | <1 |
| Upper Dugout Creek | 03-30-95 | 120 | <1 | 1 | <1 | 2 | <1 | 1 | <.1 | 3 | 3 | 5 | <1 |
| | 03-30-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 08-03-95 | 100 | <1 | <1 | -- | 6 | <1 | -- | <.1 | 2 | -- | 4 | -- |
| Gering Drain | 03-30-95 | 400 | <1 | 3 | <1 | 2 | <1 | 13 | <.1 | 7 | 2 | 8 | <1 |
| | 03-30-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 08-02-95 | 140 | <1 | 2 | -- | 3 | <1 | -- | <.1 | 4 | -- | 5 | -- |
| Nine Mile Creek | 03-30-95 | 130 | <1 | 1 | <1 | 2 | <1 | 3 | <.1 | 3 | 3 | 4 | <1 |
| | 03-30-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 08-02-95 | 120 | <1 | <1 | -- | 1 | <1 | -- | <.1 | 3 | -- | 2 | -- |
| Owl Creek | 03-29-95 | 310 | <1 | 5 | <1 | 4 | <1 | 4 | <.1 | 8 | 2 | 8 | <1 |
| | 03-29-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 08-02-95 | 150 | <1 | <1 | -- | 3 | <1 | -- | <.1 | 3 | -- | 4 | -- |
| Sheep Creek | 03-28-95 | 100 | <1 | 2 | <1 | 1 | <1 | 3 | <.1 | 2 | 3 | 4 | <1 |
| | 03-28-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 08-01-95 | 100 | <1 | <1 | -- | 1 | <1 | -- | <.1 | 3 | -- | 1 | -- |
| | 08-01-95 | 100 | <1 | <1 | -- | <1 | <1 | -- | <.1 | 3 | -- | 4 | -- |
| Spotted Tail Creek | 03-28-95 | 120 | <1 | 1 | <1 | 2 | <1 | 7 | <.1 | 2 | 3 | 3 | <1 |
| | 03-28-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 08-01-95 | 110 | <1 | 1 | -- | 3 | <1 | -- | <.1 | 3 | -- | 4 | -- |
| Lake Alice | 03-29-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 08-01-95 | 80 | <1 | <1 | -- | 2 | <1 | -- | <.1 | 1 | -- | 5 | -- |
| N. Platte River Whalen Dam | 03-29-95 | 90 | <1 | 1 | <1 | 2 | <1 | 28 | <.1 | 3 | 3 | 3 | <1 |
| | 08-02-95 | 70 | <1 | <1 | -- | 4 | <1 | -- | <.1 | 2 | -- | 4 | -- |

**Table 4.** Surface-water and bottom-sediment quality data for selected sites in the North Platte Project area, early spring and mid-summer 1995--Continued

| Site name | Date | Uranium, natural, dissolved (µg/L as U) | Vanadium, dissolved (µg/L as V) | Zinc, dissolved (µg/L as Zn) | Aluminum (%) | Anti-mony (µg/g) | Arsenic (µg/g) | Barium (µg/g) | Beryl-lium (µg/g) | Bismuth (µg/g) | Cad-mium (µg/g) | Calcium (µg/g) | Cerium (µg/g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N. Platte River Broadwater | 07-05-95 | 18 | 5 | 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 07-31-95 | -- | 8 | <3 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| N. Platte River Bridgeport | 03-27-95 | 34 | 9 | 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Upper Dugout Creek | 03-30-95 | 19 | 14 | 6 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-30-95 | -- | -- | -- | 5.3 | <1 | 3 | 770 | 1 | <10 | <1 | 2.5 | 48 |
| | 08-03-95 | -- | 6 | 8 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Gering Drain | 03-30-95 | 61 | 40 | 3 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-30-95 | -- | -- | -- | 6.9 | 1 | 6 | 770 | 2 | <10 | <1 | 3.0 | 65 |
| | 08-02-95 | -- | 10 | 7 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Nine Mile Creek | 03-30-95 | 29 | 13 | 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-30-95 | -- | -- | -- | 5.6 | <1 | 3 | 760 | 1 | <10 | <1 | 1.9 | 46 |
| | 08-02-95 | -- | 11 | <3 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Owl Creek | 03-29-95 | 50 | 29 | 5 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-29-95 | -- | -- | -- | 7.1 | <1 | 4 | 950 | 1 | <10 | <1 | 4.1 | 67 |
| | 08-02-95 | -- | 10 | 14 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Sheep Creek | 03-28-95 | 16 | 15 | 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-28-95 | -- | -- | -- | 4.7 | <1 | 2 | 720 | <1 | <10 | <1 | 1.6 | 66 |
| | 08-01-95 | -- | 12 | 11 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 08-01-95 | -- | 12 | 12 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Spotted Tail Creek | 03-28-95 | 27 | 11 | 4 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-28-95 | -- | -- | -- | 5.1 | 1 | 3 | 830 | 1 | <10 | <1 | 1.8 | 46 |
| | 08-01-95 | -- | 8 | 32 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Lake Alice | 03-29-95 | -- | -- | -- | 5.2 | 1 | 4 | 8 | 1 | <10 | <1 | 2.8 | 63 |
| | 08-01-95 | -- | 2 | 10 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| N. Platte River Whalen Dam | 03-29-95 | 13 | 1 | 2 | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 08-02-95 | -- | 2 | 10 | -- | -- | -- | -- | -- | -- | -- | -- | -- |

**Table 4.** Surface-water and bottom-sediment quality data for selected sites in the North Platte Project area, early spring and mid-summer 1995--Continued

| Site name | Date | Chromium (µg/g) | Cobalt (µg/g) | Copper (µg/g) | Europium (µg/g) | Gallium (µg/g) | Gold (µg/g) | Holmium (µg/g) | Iron (%) | Lanthanum (µg/g) | Lead (µg/g) | Lithium (µg/g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N. Platte River Broadwater | 07-05-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 07-31-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| N. Platte River Bridgeport | 03-27-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Upper Dugout Creek | 03-30-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-30-95 | 19 | 5 | 5 | <2 | 11 | <8 | <4 | 1.5 | 30 | 14 | 20 |
| | 08-03-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Gering Drain | 03-30-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-30-95 | 28 | 7 | 12 | <2 | 16 | <8 | <4 | 2.2 | 37 | 19 | 40 |
| | 08-02-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Nine Mile Creek | 03-30-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-30-95 | 17 | 6 | 4 | <2 | 10 | <8 | <4 | 1.4 | 31 | 11 | 20 |
| | 08-02-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Owl Creek | 03-29-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-29-95 | 15 | 3 | 3 | <2 | 15 | <8 | <4 | 1.1 | 42 | 14 | 10 |
| | 08-02-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Sheep Creek | 03-28-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-28-95 | 25 | 6 | 3 | <2 | 10 | <8 | <4 | 1.8 | 44 | 15 | 10 |
| | 08-01-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 08-01-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Spotted Tail Creek | 03-28-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-28-95 | 24 | 6 | 6 | <2 | 10 | <8 | <4 | 1.6 | 29 | 10 | 20 |
| | 08-01-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Lake Alice | 03-29-95 | 37 | 8 | 8 | <2 | 12 | <8 | <4 | 2.2 | 39 | 19 | 20 |
| | 08-01-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| N. Platte River Whalen Dam | 03-29-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 08-02-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

**Table 4.** Surface-water and bottom-sediment quality data for selected sites in the North Platte Project area, early spring and mid-summer 1995--Continued

| Site name | Date | Magnesium (%) | Manga-nese (µg/g) | Mercury (µg/g) | Molyb-denum (µg/g) | Neody-mium (µg/g) | Nickel (µg/g) | Nio-bium (µg/g) | Phos-phorus (%) | Potas-sium (%) | Scan-dium (µg/g) | Sele-nium (µg/g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N. Platte River Broadwater | 07-05-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 07-31-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| N. Platte River Bridge-port | 03-27-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Upper Dugouot Creek | 03-30-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-30-95 | 0.54 | 320 | <1 | <2 | 22 | 7 | 6 | 0.04 | 2.3 | 5 | <1 |
| | 08-03-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Gering Drain | 03-30-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-30-95 | .99 | 490 | <1 | <2 | 27 | 11 | 9 | .07 | 2.5 | 8 | 1 |
| | 08-02-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Nine Mile Creek | 03-30-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-30-95 | .52 | 280 | <1 | <2 | 21 | 6 | 5 | .04 | 2.3 | 5 | <1 |
| | 08-02-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Owl Creek | 03-29-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-29-95 | .40 | 350 | <1 | <2 | 32 | 6 | <4 | .12 | 2.2 | 3 | <1 |
| | 08-02-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Sheep Creek | 03-28-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-28-95 | .31 | 330 | <1 | <2 | 27 | 5 | 6 | .03 | 1.9 | 4 | <1 |
| | 08-01-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 08-01-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Spotted Tail Creek | 03-28-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-28-95 | .51 | 310 | <1 | <2 | 22 | 8 | 6 | .04 | 2.1 | 5 | 1 |
| | 08-01-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Lake Alice | 03-29-95 | .73 | 410 | <1 | <2 | 26 | 13 | 8 | .05 | 1.9 | 6 | 1 |
| | 08-01-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| N. Platte River Whalen Dam | 03-29-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 08-02-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

**Table 4.** Surface-water and bottom-sediment quality data for selected sites in the North Platte Project area, early spring and mid-summer 1995--Continued

| Site name | Date | Silver (µg/g) | Sodium (%) | Strontium (µg/g) | Sulfur (µg/g) | Tantalum (µg/g) | Thorium (µg/g) | Tin (µg/g) | Titanium, dry wt (µg/g) | Uranium (%) | Vanadium (µg/g) | Yttrium (µg/g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N. Platte River Broadwater | 07-05-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 07-31-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| N. Platte River Bridgeport | 03-27-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Upper Dugout Creek | 03-30-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-30-95 | <1 | 1.3 | 320 | <1 | <40 | 9 | <10 | 0.200 | 3 | 40 | 14 |
| | 08-03-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Gering Drain | 03-30-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-30-95 | <1 | 1.5 | 340 | <1 | <40 | 14 | <10 | .270 | 6 | 57 | 20 |
| | 08-02-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Nine Mile Creek | 03-30-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-30-95 | <1 | 1.5 | 340 | <1 | <40 | 8 | <10 | .180 | 3 | 37 | 15 |
| | 08-02-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Owl Creek | 03-29-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-29-95 | <1 | 2.2 | 350 | <1 | <40 | 5 | <10 | .120 | 2 | 24 | 27 |
| | 08-02-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Sheep Creek | 03-28-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-28-95 | <1 | 1.5 | 310 | <1 | <40 | 10 | <10 | .240 | 2 | 53 | 13 |
| | 08-01-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 08-01-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Spotted Tail Creek | 03-28-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-28-95 | <1 | 1.4 | 290 | <1 | <40 | 9 | <10 | .200 | 4 | 46 | 15 |
| | 08-01-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Lake Alice | 03-29-95 | <1 | 1.1 | 260 | <1 | <40 | 11 | <10 | .280 | 4 | 73 | 16 |
| | 08-01-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| N. Platte River Whalen Dam | 03-29-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 08-02-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

**Table 4.** Surface-water and bottom-sediment quality data for selected sites in the North Platte Project area, early spring and mid-summer 1995--Continued

| Site name | Date | Ytterbium (µg/g) | Zinc (µg/g) | Carbon, organic + inorg. (%) | Carbon, inorg. (%) | Carbon, organic (%) | Aldrin, total (µg/kg) | Chlordane, total (µg/kg) | DDD, total (µg/kg) | DDE, total (µg/kg) | DDT, total (µg/kg) | Dieldrin, total (µg/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N. Platte River Broadwater | 07-05-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 07-31-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| N. Platte River Bridgeport | 03-27-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Upper Dugout Creek | 03-30-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-30-95 | 1 | 43 | 0.85 | 0.37 | 0.48 | <0.1 | <1 | <0.1 | 0.6 | 0.2 | <0.4 |
| | 08-03-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Gering Drain | 03-30-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-30-95 | 2 | 68 | 1.1 | .43 | .68 | <1 | <1 | .4 | 7.1 | .4 | <.4 |
| | 08-02-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Nine Mile Creek | 03-30-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-30-95 | 1 | 39 | .43 | .16 | .27 | <1 | <1 | <.1 | .3 | <.1 | <.4 |
| | 08-02-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Owl Creek | 03-29-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-29-95 | 2 | 36 | .66 | .56 | .10 | <1 | <1 | <.1 | <.1 | .1 | <.4 |
| | 08-02-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Sheep Creek | 03-28-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-28-95 | 1 | 34 | .15 | .12 | .03 | <1 | <1 | <.1 | <.1 | <.1 | <.4 |
| | 08-01-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 08-01-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Spotted Tail Creek | 03-28-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-28-95 | 1 | 39 | .59 | .18 | .41 | <1 | <1 | <.1 | .4 | <.1 | <.4 |
| | 08-01-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Lake Alice | 03-29-95 | 2 | 55 | 1.1 | .56 | .56 | <1 | <1 | <.1 | <.1 | <.1 | <.4 |
| | 08-01-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| N. Platte River Whalen Dam | 03-29-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 08-02-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

**Table 4.** Surface-water and bottom-sediment quality data for selected sites in the North Platte Project area, early spring and mid-summer 1995--Continued

| Site name | Date | Endo-sulfan, total (μg/kg) | Endrin, total (μg/kg) | Hepta-chlor, total (μg/kg) | Hepta-chlor epoxide, total (μg/kg) | Lindane, total (μg/kg) | Meth-oxy-chlor, total (μg/kg) | Mirex, total (μg/kg) | PCB, total (μg/kg) | PCN, total (μg/kg) | Perthane, total (μg/kg) | Toxa-phene, total (μg/kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N. Platte River Broadwater | 07-05-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 07-31-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| N.Platte River Bridgeport | 03-27-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Upper Dugout Creek | 03-30-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-30-95 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.4 | <0.1 | <1 | <1 | <1 | <10 |
| | 08-03-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Gering Drain | 03-30-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-30-95 | <.1 | <.1 | <.1 | <.1 | <.1 | <.4 | <.1 | <1 | <1 | <1 | <10 |
| | 08-02-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Nine Mile Creek | 03-30-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-30-95 | <.1 | <.1 | <.1 | <.1 | <.1 | <.4 | <.1 | <1 | <1 | <1 | <10 |
| | 08-02-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Owl Creek | 03-29-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-29-95 | <.1 | <.1 | <.1 | <.1 | <.1 | <.4 | <.1 | <1 | <1 | <1 | <10 |
| | 08-02-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Sheep Creek | 03-28-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-28-95 | <.1 | <.1 | <.1 | <.1 | <.1 | <.4 | <.1 | <1 | <1 | <1 | <10 |
| | 08-01-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 08-01-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Spotted Tail Creek | 03-28-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 03-28-95 | <.1 | <.1 | <.1 | <.1 | <.1 | <.4 | <.1 | <1 | <1 | <1 | <10 |
| | 08-01-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| Lake Alice | 03-29-95 | <.1 | <.1 | <.1 | <.1 | <.1 | <.4 | <.1 | <1 | <1 | <1 | <10 |
| | 08-01-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| N. Platte River Whalen Dam | 03-29-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |
| | 08-02-95 | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- | -- |

**Table 6.** Concentrations of trace elements in composite biological samples collected in the North Platte Project area, western Nebraska and eastern Wyoming, 1995

[All concentrations in micrograms per gram; %, percent; <, less than minimum detection limit; --, not analyzed]

| Site and sample name | Collection date | Common name | Moisture (%) | Aluminum | | Arsenic | |
|---|---|---|---|---|---|---|---|
| | | | | Dry weight | Wet weight | Dry weight | Wet weight |
| | | | **Gering Drain** | | | | |
| | | | **Vegetation** | | | | |
| GDP1 | 05-02-95 | Green algae | 92.3 | 6,040 | 464 | 6.8 | 0.52 |
| GDP2 | 05-02-95 | Green algae | 92.3 | 7,430 | 573 | 7.1 | .55 |
| | | | **Owl Creek** | | | | |
| | | | **Vegetation** | | | | |
| HCP1 | 05-02-95 | Green algae | 96.2 | 10,600 | 403 | 5.1 | .19 |
| HCP2 | 05-02-95 | Green algae | 94.9 | 15,900 | 808 | 7.7 | .39 |
| | | | **Fish** | | | | |
| HC1-1 | 05-02-95 | Common carp | 72.5 | 100 | 28.0 | .40 | .10 |
| HC2-1 | 05-02-95 | Common carp | 70.1 | 46 | 14.0 | .20 | .06 |
| | | | **Nine Mile Creek** | | | | |
| | | | **Vegetation** | | | | |
| NMP-1 | 05-03-95 | Green algae | 93.3 | 7,930 | 532 | 3.1 | .21 |
| NMP-2 | 05-03-95 | Water hyssop | 88.9 | 8,860 | 982 | 2.9 | .32 |
| | | | **Fish** | | | | |
| NM1 | 05-03-95 | Brown trout | 70.7 | 160 | 42.0 | .30 | .09 |
| NM3 | 05-03-95 | White sucker | 73.4 | 325 | 86.5 | .59 | .16 |
| NMC2-1 | 08-08-95 | Rainbow trout | 71.0 | 69 | 20.0 | .30 | .09 |
| NMC2-3 | 08-08-95 | White sucker | 71.0 | 1,020 | 296 | 1.0 | .29 |
| | | | **Sheep Creek** | | | | |
| | | | **Vegetation** | | | | |
| SCP1 | 05-02-95 | Horsetail | 88.5 | 6,200 | 712 | 1.2 | .14 |
| SCP2 | 05-02-95 | Horsetail | 75.6 | 6,950 | 1,700 | 2.1 | .51 |
| SCP3 | 05-02-95 | River bulrush | 89.3 | 6,330 | 675 | 1.8 | .19 |
| SCP4 | 05-02-95 | River bulrush | 87.8 | 4,160 | 506 | 1.9 | .23 |
| | | | **Fish** | | | | |
| SC-1 | 05-02-95 | White sucker | 71.0 | 222 | 64.4 | .36 | .10 |
| SC2-1 | 07-07-95 | White sucker | 72.9 | 66 | 18.0 | .43 | .12 |
| SC2-3 | 07-07-95 | Rainbow trout | 73.7 | 160 | 42.0 | .50 | .10 |
| | | | **Spotted Tail Creek** | | | | |
| | | | **Vegetation** | | | | |
| STCP-1 | 05-02-95 | Green algae | 84.3 | 5,930 | 930 | 4.1 | .64 |
| STCP-2 | 05-02-95 | Green algae | 88.5 | 4,310 | 496 | 2.4 | .28 |
| | | | **Fish** | | | | |
| ST-2 | 05-02-95 | Brown trout | 73.0 | 6.4 | 1.70 | .30 | .08 |
| STC2-2 | 07-07-95 | Rainbow trout | 71.4 | 70 | 20.0 | .30 | .09 |
| | | | **Upper Dugout Creek** | | | | |
| | | | **Vegetation** | | | | |
| UDCP1 | 05-03-95 | Green algae | 84.7 | 3,420 | 523 | 2.1 | .51 |
| | | | **Fish** | | | | |
| UDC1 | 05-03-95 | Creek chub | 73.5 | 237 | 62.8 | .50 | .10 |
| UDC2-1 | 08-07-95 | Creek chub | 74.2 | 120 | 31.0 | .30 | .08 |

**Table 6.** Concentrations of trace elements in composite biological samples collected in the North Platte Project area, western Nebraska and eastern Wyoming, 1995--Continued

| Site and sample name | Barium | | Beryllium | | Boron | | Cadmium | | Chromium[1] | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Dry weight | Wet weight | Dry weight | Wet weight | Dry weight | Wet weight | Dry weight | Wet weight | Dry weight | Wet weight |
| **Gering Drain** | | | | | | | | | | |
| **Vegetation** | | | | | | | | | | |
| GDP1 | 1,500 | 115 | 0.27 | 0.021 | 21 | 1.6 | 0.72 | 0.55 | 6.7 | 0.52 |
| GDP2 | 2,660 | 205 | .19 | .015 | 12 | .93 | .86 | .07 | 5.5 | .42 |
| **Owl Creek** | | | | | | | | | | |
| **Vegetation** | | | | | | | | | | |
| HCP1 | -- | -- | .35 | .013 | 21 | .80 | .66 | .03 | -- | -- |
| HCP2 | 370 | 18.8 | .55 | .028 | 29 | 1.5 | .35 | <.03 | 9.5 | .48 |
| **Fish** | | | | | | | | | | |
| HC1-1 | 12.4 | 3.41 | <.01 | <.003 | <.03 | <.08 | .20 | .06 | 1.2 | .33 |
| HC2-1 | 5.20 | 1.60 | <.01 | <.003 | <.03 | <.08 | .46 | .14 | .96 | .29 |
| **Nine Mile Creek** | | | | | | | | | | |
| **Vegetation** | | | | | | | | | | |
| NMP-1 | 597 | 40.1 | .31 | .021 | 11 | .74 | .22 | <.03 | 4.7 | .32 |
| NMP-2 | 104 | 11.5 | .24 | .027 | 13 | 1.4 | .27 | .03 | 20 | 2.2 |
| **Fish** | | | | | | | | | | |
| NM1 | 4.00 | 1.20 | <.01 | <.003 | <.3 | <.09 | <.10 | <.03 | .95 | .28 |
| NM3 | 7.59 | 2.02 | <.01 | <.003 | <.3 | <.09 | <.10 | <.03 | 2.7 | .70 |
| NMC2-1 | 3.20 | .93 | <.01 | <.003 | <.3 | <.09 | <.10 | <.03 | 1.0 | .29 |
| NMC2-3 | 17.9 | 5.19 | .02 | .006 | 2.0 | .58 | <.10 | <.03 | 4.8 | 1.4 |
| **Sheep Creek** | | | | | | | | | | |
| **Vegetation** | | | | | | | | | | |
| SCP1 | 82.4 | 9.46 | .18 | .021 | 15 | 1.7 | .089 | <.03 | 16 | 1.8 |
| SCP2 | 87.7 | 21.4 | .19 | .046 | 17 | 4.2 | .18 | .04 | 12 | 2.9 |
| SCP3 | 92.6 | 9.87 | .19 | .020 | 15 | 1.6 | .28 | .03 | 11 | 1.2 |
| SCP4 | 74.5 | 9.06 | .18 | .022 | 17 | 2.1 | .12 | .02 | 11 | 1.3 |
| **Fish** | | | | | | | | | | |
| SC-1 | 12.7 | 3.68 | <.01 | <.003 | <.3 | <.09 | <.10 | <.03 | 1.6 | .46 |
| SC2-1 | 11.6 | 3.14 | <.01 | <.003 | <.3 | <.08 | .49 | .13 | 1.0 | .27 |
| SC2-3 | 4.90 | 1.30 | <.01 | <.003 | <.3 | <.08 | .20 | .05 | 1.4 | .37 |
| **Spotted Tail Creek** | | | | | | | | | | |
| **Vegetation** | | | | | | | | | | |
| STCP-1 | 100 | 15.7 | .24 | .038 | 61 | 9.6 | .43 | .07 | 56 | 8.8 |
| STCP-2 | 108 | 12.4 | .28 | .032 | 61 | 7.0 | .25 | .03 | 25 | 2.9 |
| **Fish** | | | | | | | | | | |
| ST-2 | .06 | .02 | <.01 | <.003 | <.3 | <.08 | <.10 | <.03 | 1.4 | .38 |
| STC2-2 | 2.80 | .80 | <.01 | <.003 | <.3 | <.09 | <.10 | <.03 | 1.3 | .37 |
| **Upper Dugout Creek** | | | | | | | | | | |
| **Vegetation** | | | | | | | | | | |
| UDCP1 | 346 | 53.0 | .20 | .031 | 45 | 6.9 | .18 | .03 | 5.6 | .86 |
| **Fish** | | | | | | | | | | |
| UDC1 | 9.41 | 2.49 | <.01 | <.003 | <.3 | <.08 | .20 | .05 | 1.8 | .47 |
| UDC2-1 | 7.35 | 1.89 | <.01 | <.003 | <.3 | <.08 | .10 | .03 | 1.3 | .34 |

[1] Because of analytical difficulties, concentrations for vegetation samples are considered estimates.

**Table 6.** Concentrations of trace elements in biological samples collected in the North Platte Project area, western Nebraska and eastern Wyoming, 1995--Continued

| Site and sample name | Copper | | Iron | | Lead | | Magnesium | | Manganese | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Dry weight | Wet weight | Dry weight | Wet weight | Dry weight | Wet weight | Dry weight | Wet weight | Dry weight | Wet weight |
| **Gering Drain** | | | | | | | | | | |
| **Vegetation** | | | | | | | | | | |
| GDP1 | 7.3 | 0.56 | 4,280 | 329 | 3.60 | 0.28 | 4,260 | 327 | 608 | 46.7 |
| GDP2 | 7.3 | .56 | 4,910 | 379 | 3.37 | .26 | 4,030 | 311 | 477 | 36.8 |
| **Owl Creek** | | | | | | | | | | |
| **Vegetation** | | | | | | | | | | |
| HCP1 | -- | -- | -- | -- | 5.04 | .19 | -- | -- | -- | -- |
| HCP2 | 11 | .56 | 9,830 | 499 | 7.80 | .40 | 8,030 | 408 | 374 | 19.0 |
| **Fish** | | | | | | | | | | |
| HC1-1 | 3.6 | .99 | 144 | 39.6 | .032 | .088 | 1,490 | 410 | 11.2 | 3.08 |
| HC2-1 | 3.8 | 1.1 | 109 | 32.6 | .280 | .084 | 1,040 | 311 | 5.40 | 1.60 |
| **Nine Mile Creek** | | | | | | | | | | |
| **Vegetation** | | | | | | | | | | |
| NMP-1 | 4.9 | .33 | 4,950 | 332 | 4.39 | .290 | 4,900 | 329 | 492 | 75.3 |
| NMP-2 | 7.0 | .78 | 6,380 | 707 | 4.29 | .480 | 3,420 | 379 | 284 | 31.5 |
| **Fish** | | | | | | | | | | |
| NM1 | 6.8 | 2.0 | 92.9 | 27.3 | .088 | .026 | 1,160 | 340 | 6.30 | 1.80 |
| NM3 | 3.7 | .98 | 367 | 97.6 | .290 | .077 | 1,500 | 399 | 14.2 | 3.78 |
| NMC2-1 | 8.6 | 2.5 | 105 | 30.4 | .098 | .028 | 1,180 | 342 | 5.70 | 1.70 |
| NMC2-3 | 7.6 | 2.2 | 972 | 282 | .622 | .18 | 1,720 | 499 | 45.1 | 13.1 |
| **Sheep Creek** | | | | | | | | | | |
| **Vegetation** | | | | | | | | | | |
| SCP1 | 4.5 | .52 | 3,760 | 432 | 2.38 | .27 | 3,470 | 398 | 242 | 27.8 |
| SCP2 | 4.7 | 1.1 | 4,410 | 1,080 | 2.42 | .59 | 3,460 | 845 | 165 | 40.3 |
| SCP3 | 5.0 | .53 | 5,110 | 545 | 2.86 | .31 | 4,480 | 478 | 305 | 32.5 |
| SCP4 | 4.6 | .56 | 3,680 | 447 | 2.43 | .30 | 4,280 | 520 | 426 | 51.8 |
| **Fish** | | | | | | | | | | |
| SC-1 | 3.3 | .96 | 348 | 101 | .220 | .064 | 1,710 | 496 | 12.3 | 3.57 |
| SC2-1 | 2.9 | .79 | 99.0 | 26.8 | .170 | .046 | 1,760 | 477 | 13.0 | 3.52 |
| SC2-3 | 2.4 | .63 | 149 | 39.1 | .110 | .029 | 1,310 | 344 | 6.90 | 1.80 |
| **Spotted Tail Creek** | | | | | | | | | | |
| **Vegetation** | | | | | | | | | | |
| STCP-1 | 6.9 | 1.1 | 6,180 | 969 | 4.62 | .72 | 3,320 | 520 | 276 | 43.3 |
| STCP-2 | 5.2 | .60 | 7,640 | 879 | 4.18 | .48 | 3,830 | 441 | 279 | 32.1 |
| **Fish** | | | | | | | | | | |
| ST-2 | <.3 | <.08 | <.3 | <.08 | .045 | .012 | .36 | .097 | <.08 | <.02 |
| STC2-2 | 6.2 | 1.8 | 86.9 | 24.8 | .065 | .019 | 1,270 | 363 | 4.30 | 1.20 |
| **Upper Dugout Creek** | | | | | | | | | | |
| **Vegetation** | | | | | | | | | | |
| UDCP1 | 3.2 | .49 | 2,500 | 383 | 3.24 | .50 | 2,630 | 402 | 492 | 33.0 |
| **Fish** | | | | | | | | | | |
| UDC1 | 5.5 | 1.5 | 214 | 56.7 | .170 | .045 | 1,300 | 345 | 11.0 | 2.92 |
| UDC2-1 | 5.3 | 1.4 | 98.4 | 25.4 | .120 | .031 | 1,360 | 351 | 5.70 | 1.50 |

**Table 6.** Concentrations of trace elements in biological samples collected in the North Platte Project area, western Nebraska and eastern Wyoming, 1995--Continued

| Site and sample name | Mercury | | Molybdenum | | Nickel[1] | | Selenium | | Strontium | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Dry weight | Wet weight | Dry weight | Wet weight | Dry weight | Wet weight | Dry weight | Wet weight | Dry weight | Wet weight |
| **Gering Drain** | | | | | | | | | | |
| **Vegetation** | | | | | | | | | | |
| GDP1 | 0.025 | 0.0019 | 0.6 | 0.05 | 5.1 | 0.39 | 2.0 | 0.15 | 323 | 25.2 |
| GDP2 | .029 | .0022 | .9 | .07 | 3.9 | .30 | 2.5 | .19 | 157 | 12.1 |
| **Owl Creek** | | | | | | | | | | |
| **Vegetation** | | | | | | | | | | |
| HCP1 | .040 | .0015 | -- | -- | -- | -- | 1.9 | .072 | -- | -- |
| HCP2 | .022 | .0011 | <.4 | <.02 | 6.3 | .32 | 2.3 | .12 | 577 | 29.3 |
| **Fish** | | | | | | | | | | |
| HC1-1 | .49 | .13 | <.2 | <.06 | .36 | .09 | 5.2 | .14 | 180 | 21.7 |
| HC2-1 | .32 | .096 | <.2 | .06 | .20 | .06 | 5.4 | 1.6 | 72.7 | 21.8 |
| **Nine Mile Creek** | | | | | | | | | | |
| **Vegetation** | | | | | | | | | | |
| NMP-1 | .029 | .0019 | <.4 | <.08 | 3.6 | .24 | 1.6 | .11 | 562 | 37.7 |
| NMP-2 | .010 | .0010 | .6 | .07 | 9.6 | 1.1 | 1.4 | .16 | 133 | 15.3 |
| **Fish** | | | | | | | | | | |
| NM1 | .21 | .062 | <.2 | <.06 | .10 | .029 | 4.6 | 1.4 | 73.2 | 20.6 |
| NM3 | .29 | .077 | <.2 | <.05 | .54 | .14 | 3.0 | .87 | 103 | 28.7 |
| NMC2-1 | .16 | .046 | <.2 | <.06 | .12 | .03 | 4.5 | 1.3 | 61.6 | 17.8 |
| NMC2-3 | .33 | .096 | <.2 | <.06 | 1.1 | .32 | 2.7 | .78 | 118 | 34.2 |
| **Sheep Creek** | | | | | | | | | | |
| **Vegetation** | | | | | | | | | | |
| SCP1 | .004 | .0005 | .6 | .07 | 7.0 | .080 | 1.3 | .15 | 180 | 20.7 |
| SCP2 | .007 | .0020 | .6 | .10 | 6.4 | 1.6 | 1.6 | .39 | 185 | 45.2 |
| SCP3 | .008 | .0009 | .5 | .05 | 5.3 | .57 | 1.3 | .14 | 193 | 20.6 |
| SCP4 | .010 | .0010 | .7 | .09 | 5.6 | .68 | 1.1 | .13 | 204 | 24.8 |
| **Fish** | | | | | | | | | | |
| SC-1 | .16 | .046 | <.2 | <.06 | .024 | .070 | 3.0 | .87 | 153 | 44.4 |
| SC2-1 | .13 | .035 | <.2 | <.05 | .20 | .060 | 3.4 | .92 | 167 | 45.2 |
| SC2-3 | .20 | .053 | <.2 | <.05 | .18 | .047 | 5.9 | 1.6 | 60.7 | 15.9 |
| **Spotted Tail Creek** | | | | | | | | | | |
| **Vegetation** | | | | | | | | | | |
| STCP-1 | .018 | .0028 | 1.4 | .22 | 27 | 4.2 | 2.0 | .31 | 187 | 29.3 |
| STCP-2 | .017 | .0020 | .7 | .08 | 12 | 1.4 | 1.4 | .16 | 195 | 22.4 |
| **Fish** | | | | | | | | | | |
| ST-2 | .40 | .11 | <.2 | <.05 | .14 | .038 | 7.0 | 1.9 | .007 | .0019 |
| STC2-2 | .45 | .13 | <.2 | <.06 | .11 | .031 | 5.4 | 1.5 | 103 | 29.4 |
| **Upper Dugout Creek** | | | | | | | | | | |
| **Vegetation** | | | | | | | | | | |
| UDCP1 | .005 | .0008 | <.4 | <.06 | 4.0 | .61 | 1.6 | .24 | 494 | 75.6 |
| **Fish** | | | | | | | | | | |
| UDC1 | .19 | .050 | <.2 | <.05 | .33 | .087 | 5.3 | 1.4 | 75.2 | 19.9 |
| UDC2-1 | .22 | .057 | <.2 | <.05 | .17 | .044 | 3.9 | 1.0 | 74.7 | 19.3 |

[1] Because of analytical difficulties, concentrations for vegetation samples are considered estimates.

**Table 6.** Concentrations of trace elements in biological samples collected in the North Platte Project area, western Nebraska and eastern Wyoming, 1995--Continued

| Site and sample name | Vanadium | | Zinc | |
|---|---|---|---|---|
| | Dry weight | Wet weight | Dry weight | Wet weight |
| | | **Gering Drain** | | |
| | | **Vegetation** | | |
| GDP1 | 28 | 2.2 | 57.5 | 4.42 |
| GDP2 | 26 | 2.0 | 67.3 | 5.19 |
| | | **Owl Creek** | | |
| | | **Vegetation** | | |
| HCP1 | -- | -- | -- | -- |
| HCP2 | 21 | 1.1 | 42.4 | 2.15 |
| | | **Fish** | | |
| HC1-1 | .7 | .20 | 221 | 60.8 |
| HC2-1 | .4 | .10 | 173 | 51.8 |
| | | **Nine Mile Creek** | | |
| | | **Vegetation** | | |
| NMP-1 | 14 | .94 | 33.3 | 2.23 |
| NMP-2 | 17 | 1.9 | 36.9 | 4.09 |
| | | **Fish** | | |
| NM1 | .6 | .20 | 108 | 31.7 |
| NM3 | 1.4 | .37 | 67.3 | 17.9 |
| NMC2-1 | .7 | .20 | 112 | 32.4 |
| NMC2-3 | 3.2 | .93 | 69.2 | 20.1 |
| | | **Sheep Creek** | | |
| | | **Vegetation** | | |
| SCP1 | 12 | 1.4 | 24.2 | 2.78 |
| SCP2 | 16 | 3.9 | 27.0 | 6.60 |
| SCP3 | 16 | 1.7 | 26.1 | 2.78 |
| SCP4 | 13 | 1.6 | 25.9 | 3.15 |
| | | **Fish** | | |
| SC-1 | 1.6 | .46 | 67.7 | 19.6 |
| SC2-1 | .7 | .20 | 70.5 | 19.1 |
| SC2-3 | .7 | .20 | 92.1 | 24.2 |
| | | **Spotted Tail Creek** | | |
| | | **Vegetation** | | |
| STCP-1 | 17 | 2.7 | 29.9 | 4.69 |
| STCP-2 | 20 | 2.3 | 31.3 | 3.60 |
| | | **Fish** | | |
| ST-2 | <.3 | .08 | <.01 | <.03 |
| STC2-2 | .6 | .20 | 94.5 | 27.0 |
| | | **Upper Dugout Creek** | | |
| | | **Vegetation** | | |
| UDCP1 | 12 | 1.8 | 18.4 | 2.80 |
| | | **Fish** | | |
| UDC1 | .8 | .20 | 89.1 | 23.6 |
| UDC2-1 | <.3 | <.08 | 75.7 | 19.5 |



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