Assessment of Fish Habitat, Water Quality, and Selected Contaminants in Streambed Sediments in Noyes Slough, Fairbanks, Alaska, 2001-2002

Water-Resources Investigations Report 03-4328

U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

USGS
science for a changing world

Cover: Large background photograph of beaver dam. View is looking south across Noyes Slough beaver dam upstream of Deere Street, Fairbanks, Alaska, summer 2001. Small foreground photograph of beaver. Beaver delivering brush to Noyes Slough beaver dam upstream of Minnie Street, Fairbanks, Alaska, summer 2001. Photographs taken by Matthew S. Whitman, U.S. Geological Survey, 2001.

Assessment of Fish Habitat, Water Quality, and Selected Contaminants in Streambed Sediments in Noyes Slough, Fairbanks, Alaska, 2001-2002

By Ben W. Kennedy, Matthew S. Whitman, Robert L. Burrows, *and* Sharon A. Richmond

---

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 03-4328

Anchorage, Alaska
2004

U.S. DEPARTMENT OF THE INTERIOR
GALE A. NORTON, *Secretary*

U.S. GEOLOGICAL SURVEY
Charles G. Groat, *Director*

Any use of trade, product, or firm names in this publication is for descriptive purposes only and does not imply endorsement by the U.S. Government.

For additional information write to:

Chief, Water Resources Office
U.S. Geological Survey
Alaska Science Center
4230 University Drive, Suite 201
Anchorage, AK 99508-4664
http://alaska.usgs.gov

Copies of this report can be purchased from:

U.S. Geological Survey
Information Services
Building 810
Box 25286, Federal Center
Denver, CO 80225-0286

Suggested citation:

Kennedy, B.W., Whitman, M.S., Burrows, R.L., and Richmond, S.A., 2004, Assessment of fish habitat, water quality, and selected contaminants in streambed sediments in Noyes Slough, Fairbanks, Alaska, 2001-2002: U.S. Geological Survey Water-Resources Investigations Report 03-4328, 62 p.

Contents

FIGURES

TABLES

CONVERSION FACTORS AND DATUM

CONVERSION FACTORS

Factors for converting inch/pound units to SI metric units

Multiply	By	To obtain
	Length	
inch (in)	2.54	centimeter
inch (in)	25.4	millimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second

Factors for converting SI metric units to inch/pound units

Multiply	By	To obtain
	Length	
centimeter (cm)	0.3937	inch
millimeter (mm)	0.03937	inch
meter (m)	3.281	foot
kilometer (km)	0.6214	mile
	Flow rate	
cubic meter per second (m^3/s)	35.31	cubic foot per second

Temperature in degrees Fahrenheit (^oF) may be converted to degrees Celsius (^oC) as follows:

$$^oC=(^oF-32)/1.8.$$

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

DATUM

Horizontal coordinate information was referenced to the North American Datum of 1927 (NAD 27 Alaska).

Vertical coordinate information is referenced to geodetic heights above the Geodetic Reference System 1980 (GRS80) ellipsoid as determined from survey-grade Global Positioning System (GPS) observations. Separation between the GRS80 ellipsoid and GEOID99 is approximately 37 feet for Fairbanks, Alaska.

Assessment of Fish Habitat, Water Quality, and Selected Contaminants in Streambed Sediments in Noyes Slough, Fairbanks, Alaska, 2001-2002

By Ben W. Kennedy, Matthew S. Whitman, Robert L. Burrows, *and* Sharon A. Richmond

Abstract

During 2001-2002, the U.S. Geological Survey sampled streambed sediment at 23 sites, measured water quality at 26 sites, and assessed fish habitat for the entire length of Noyes Slough, a 5.5-mile slough of the Chena River in Fairbanks, Alaska. These studies were undertaken to document the environmental condition of the slough and to provide information to the public for consideration in plans to improve environmental conditions of the waterway. The availability of physical habitat for fish in the slough does not appear to be limited, although some beaver dams and shallow water may restrict movement, particularly during low flow. Elevated water temperatures in summer and low dissolved-oxygen concentrations are the principle factors adversely affecting water quality in Noyes Slough. Increased flow mitigated poor water-quality conditions and reduced the number of possible fish barriers. Flow appears to be the most prominent mechanism shaping water quality and fish habitat in Noyes Slough.

Streambed sediment samples collected at 23 sites in 2001 were analyzed for 24 trace elements. Arsenic, lead, and zinc were the only trace elements detected in concentrations that exceed probable effect levels for the protection of aquatic life. The background concentration for arsenic in Noyes Slough is naturally elevated because of significant concentrations of arsenic in local bedrock and ground water. Sources of the zinc and lead contamination are uncertain, however both lead and zinc are common urban contaminants.

Streambed-sediment samples from 12 sites in 2002 were analyzed for organochlorine pesticides, polychlorinated biphenyls (PCBs), and semivolatile organic compounds (SVOCs). The concentration of *bis*(2-ethylhexyl)phthalate of 2,600 micrograms per kilogram (µg/kg) for one sample from the site above Aurora Drive approached the aquatic-life criterion of 2,650 µg/kg. Low concentrations of *p*-cresol, chrysene, and fluoranthene were detected in most of the sediment samples. The presence of these compounds in Noyes Slough sediment was expected because cresols are emitted to the atmosphere in the exhaust from motor vehicles and chrysene and fluoranthene are formed during the incomplete burning of coal, oil, gas, wood, garbage, or other organic substances. Low-level concentrations of DDT or its degradation products DDD and DDE were detected in all samples collected during 2002. However, total DDT (DDT+DDD+DDE) concentrations are less than the effects range median aquatic-life criterion of 46.1 µg/kg. In general, total DDT concentrations were less than 10 µg/kg, except for samples from two sites that have estimated concentrations of about 14 and 20 µg/kg.

Introduction

Noyes Slough is a 5.5-mile slough of the Chena River in Fairbanks, Alaska (fig. 1). The slough is located north of the river and meanders through downtown Fairbanks, residential areas, and a park. Several small tributaries flow into the slough from the north, from the Creamers Field Migratory Waterfowl Refuge. Noyes Slough and adjacent wetlands provide habitat for beavers, muskrat, and waterfowl and spawning grounds for grayling and other fish. In addition to providing valuable wildlife habitat, Noyes Slough has been a popular canoeing area and serves as a "living laboratory" where hundreds of local elementary students observe local wildlife and learn about the value of clean waterways and the effects of urban pollution.

Area residents have expressed mounting concern that the slough is deteriorating as a flowing, clean waterway. Some reaches of the slough have become solid-waste dumping grounds and catchments for storm runoff that introduce non-point-source pollution. In many reaches, the slough has become stagnant. Periodically, refuse is removed from the slough, but these efforts alone will not restore Noyes Slough.

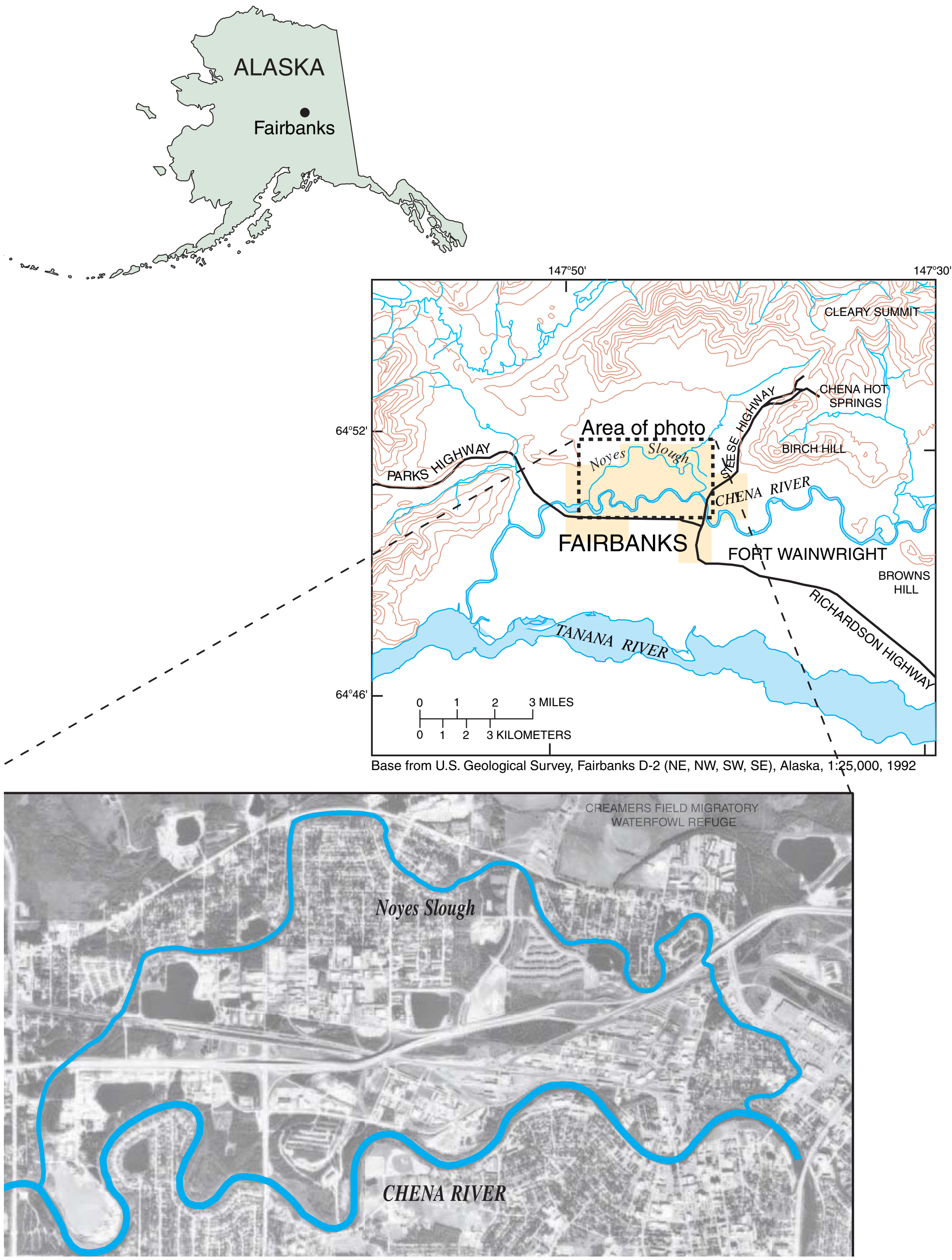


Figure 1. Location of Noyes Slough, Fairbanks, Alaska.
Aerial photograph, from 1996 flight, is from Natural Resources Conservation Service.

Over the past 50 years, flow in the slough channel has declined because of flood-control structures on the Chena and Tanana Rivers. As a result, water flows through Noyes Slough only intermittently during open water season. In 1945, Moose Creek Dike was built across Chena Slough, thereby blocking flow from the Tanana River. After the 1967 flood on the Chena River in Fairbanks, a diversion dam (Moose Creek Dam), a floodway leading to the Tanana River, and a levee along the north bank of the Tanana River were constructed (fig. 2). Although necessary to avoid potentially severe flooding in Fairbanks, these measures have caused down-cutting of the Chena River channel bed at the entrance to Noyes Slough, thereby reducing the magnitude and duration of surface-water flow from the Chena River to the slough. Consequently, Noyes Slough is slowly drying up, and it is likely that flows will continue to decline without some intervention to reverse the process.

The U.S. Geological Survey (USGS) has examined existing and new hydrologic data to better understand hydraulic interactions between the Chena River and Noyes Slough. Increasing flow through the stream channel has been suggested as one means of restoring the slough, and researchers with the USGS have constructed a computer model to evaluate this alternative (Burrows and others, 2000). Results of the computer model imply that conditions within Noyes Slough likely will not improve with the current trend in declining flows. Without some intervention, it is possible that several consecutive years of almost no flow will occur. The most frequently suggested means to increase flow through the slough has been to excavate at the inlet and possibly along other reaches of the slough. However, there are environmental concerns associated with excavation of the slough channel.

Bed sediments within the slough are of particular concern because they may contain trace-element and organic contaminants that, if disturbed, could result in substantial adverse effects on downstream fisheries and water quality. Potential contaminant sources include local geology, which is characterized as highly mineralized with many historic and current placer and lode mining operations in upland areas (Péwé and others, 1976; Metz, 1991). Elevated concentrations of naturally occurring arsenic are common in local ground water (Mueller and others, 2002) and in streambed sediments (Hawkins, 1982). Petroleum hydrocarbon and solvent-based contamination of subsurface waters from industrial and commercial activity has been documented near Noyes Slough (Lilly and others, 1996). Elevated concentrations of selected organic contaminants, particularly DDT, have been reported in streambed sediment from three samples collected along the slough (A.S. Naidu, University of Alaska, written commun., 2000).

Hydrogeologic Framework

Noyes Slough flows through alluvial deposits of the Tanana and Chena Rivers, collectively referred to as the Chena Alluvium (Péwé and others, 1976). The Chena Alluvium consists of layered alluvial silts, sands, and gravels that are more than 400 ft thick in selected localities. Noyes Slough sediments are predominately fine-grain alluvial silts and clays derived from upland bedrock areas, and soils typically are less than 15 ft thick.

The rocks in the Fairbanks area are part of the Yukon-Tanana terrane, a complex assemblage of metasedimentary and metaigneous rocks that are intruded by Mesozoic and Cenozoic granitic rocks and minor amounts of intermediate and mafic rocks (Foster and others, 1994). Fairbanks Schist is the most widespread metasedimentary lithologic unit of the terrane in the Fairbanks area. Granitic rocks are exposed near Cleary Summit and in the area near Chena Hot Springs. Tertiary basalt flows are found at several nearby locations including Browns Hill and Birch Hill. Trace elements associated with the basalts are described by Atkinson and Newberry (1998). Analysis of major and trace elements associated with granitic rocks are reported by Newberry (1996). Common sulfide minerals associated with gold veins that occur in the Fairbanks Schist are documented by McCoy and others (1997). Because of the broad assemblage of rock types found in the Fairbanks area, substantial concentrations of trace elements, including antimony, arsenic, barium, chromium, copper, nickel, vanadium, and zinc, are readily available through physical and chemical weathering.

Chemical weathering of a given element in water is controlled by variations of water temperature, pressure, hydrogen- and hydroxyl-ion concentrations (pH), reduction-oxidation (redox) potential (Eh), and the relative concentrations of other substances in solution (Davis and DeWiest, 1966). The amount of surface area exposed to water also is an important factor in determining the rate of dissolution of minerals. Mueller and others (2002) found that trace-element concentrations in ground water varied widely among sampling sites in the Fairbanks area: calcium, 15-180 mg/L; magnesium, 3.9-82 mg/L; iron, 0.05-17 mg/L; and sulfate, 0.1-130 mg/L. Sites with elevated arsenic concentrations consistently were accompanied by high concentrations of iron (17 mg/L), manganese (5,690 mg/L), phosphorous (1,100 mg/L), and silica (24 mg/L) throughout the year. They found no evidence of seasonal variations in the chemical characteristics of domestic well water, nor did they find systematic seasonal variation in arsenic concentrations in ground water.

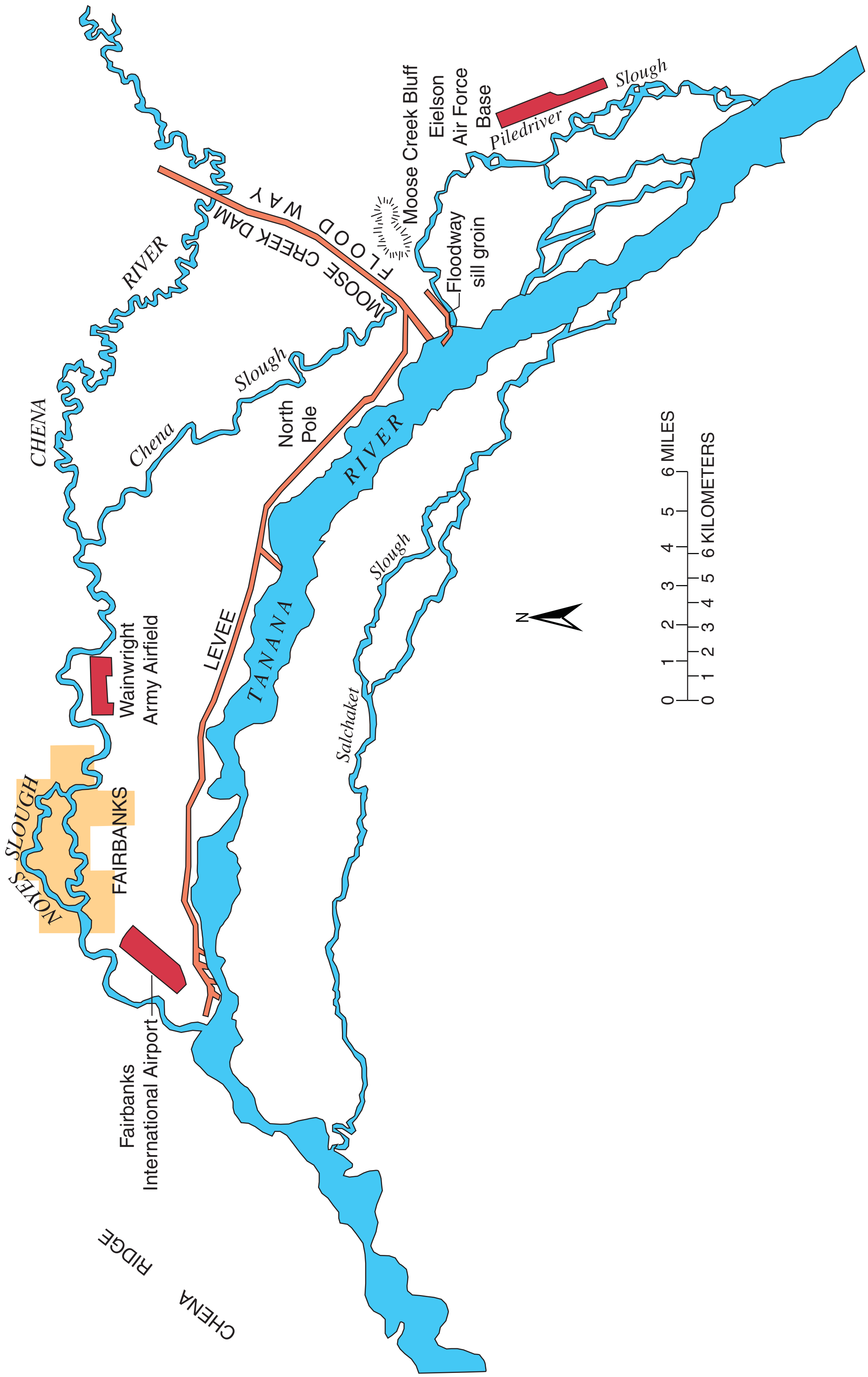


Figure 2. Location of the Chena River Flood Control Project dam, floodway, and levee along the north side of the Tanana River near Fairbanks, Alaska.

The relative magnitude of sediment influx to Noyes Slough varies in response to water-level changes in the Chena River. When water levels are high, suspended sediment and associated trace elements are transported by surface water from the Chena River and deposited in the slough. Bed sediments within the slough typically are reworked during high flows. Urban runoff during storms and spring break-up contribute additional sediment to the slough. At low water levels, the slough acts as a drain for local ground water and any associated trace elements and chemical compounds in solution. In winter, sections of the slough, including the inlet, are completely frozen and filled with ice and snow.

Purpose and Scope

In response to environmental concerns, the USGS completed a baseline assessment of Noyes Slough fish habitat and water quality during 2001 and of selected contaminants in streambed sediment during 2001 and 2002. The fish habitat assessment included habitat characteristics and number and type of fish, the water-quality assessment measured specific conductance, pH, dissolved-oxygen concentration, water temperature, and turbidity, and the assessment of streambed sediments included presence and concentrations of trace elements, semivolatile organic compounds (SVOCs), and pesticides and polychlorinated biphenyls (PCBs).

The purpose of this report is to present the results from these studies, as well as provide general background information about the fish habitat, water quality, and bed sediment of Noyes Slough. The data are intended to provide decision makers with quantitative information that will assist them in making more informed decisions for preserving and enhancing the community value of Noyes Slough. The intended audience for this report includes land- and water-resource managers, regulators, policy makers, and the general public. A limited portion of the Noyes Slough data for the period of record is available on the Internet by linking to the USGS Water Resources of Alaska home page, currently at http://alaska.usgs.gov. (Because of the rapidly evolving nature of the Internet, the Internet references in this report may change. In that event, the reader may alternatively find the information referenced by starting higher in the Internet hierarchy of the USGS, at either the Water Resources Program, at http://water.usgs.gov, or the U.S. Geological Survey, at http://www.usgs.gov.)

Acknowledgments

The authors wish to thank the Noyes Slough Action Committee and local residents for their support of this project and their dedication to restoring Noyes Slough.

Assessment of Fish Habitat

The assessment of fish habitat in Noyes Slough involved identifying and mapping the habitat characteristics, developing midstream depth and substrate profiles along the slough, characterizing channel geometry at selected cross sections, and obtaining a representative sample of the number and types of fish occupying various parts of the slough during low-flow and high-flow periods.

Data Collection

The length of Noyes Slough was divided into 13 study reaches (fig. 3, table 1), numbered 1 to 13 consecutively from the upstream end. To characterize channel geometry, a survey-grade Global Positioning System (GPS) was integrated with a laser range finder to survey cross-section points on the banks and stream bottom. A longitudinal depth profile for low-flow conditions was created using a stadia rod to make midstream depth measurements at increments from surveyed transects determined with a range finder. A substrate profile was generated by classifying the slough bottom at midstream increments of about 330 ft or less. Substrate was classified as silt or a mixture of silt and gravel or cobble; location was determined using a handheld GPS. Midstream profiles and surveyed cross sections were measured for all reaches except reaches 4, 9, and 11. At reaches 4 and 11 cross sections were not surveyed because access was limited, and at reach 9, the electronic data for the cross section were faulty.

A diagrammatic map of habitat characteristics for each study reach in the slough was created using a handheld GPS, a laser range finder, and freehand sketching. Position along the slough was tracked by GPS and coordinates were noted for dams, drainpipes, prominent features, and arbitrary reference locations. Large woody debris, overhanging brush, aquatic vegetation, and riparian continuity were sketched in reference to waypoints on an enlarged template of the slough generated from aerial photography. Habitat characteristics pertinent to fish were mapped for the entire slough. The scale of features on each map was exaggerated to improve the visibility of important features such as bridges, culverts, and beaver dams, but the distribution of features in relation to each other are as observed on site.

The types and numbers of fish present in the reaches were determined by electrofishing, setting minnow traps, seining, and visual observation. The objective was to obtain a representative sample of species utilizing the slough at various locations. Fish were sampled in the vicinity of each water-quality sampling site. Most sites were sampled during both low flow and high flow. Because of biases in sampling methods for size and type of fish and because the entire slough could not be sampled, the list of species may not include all fish that were present.

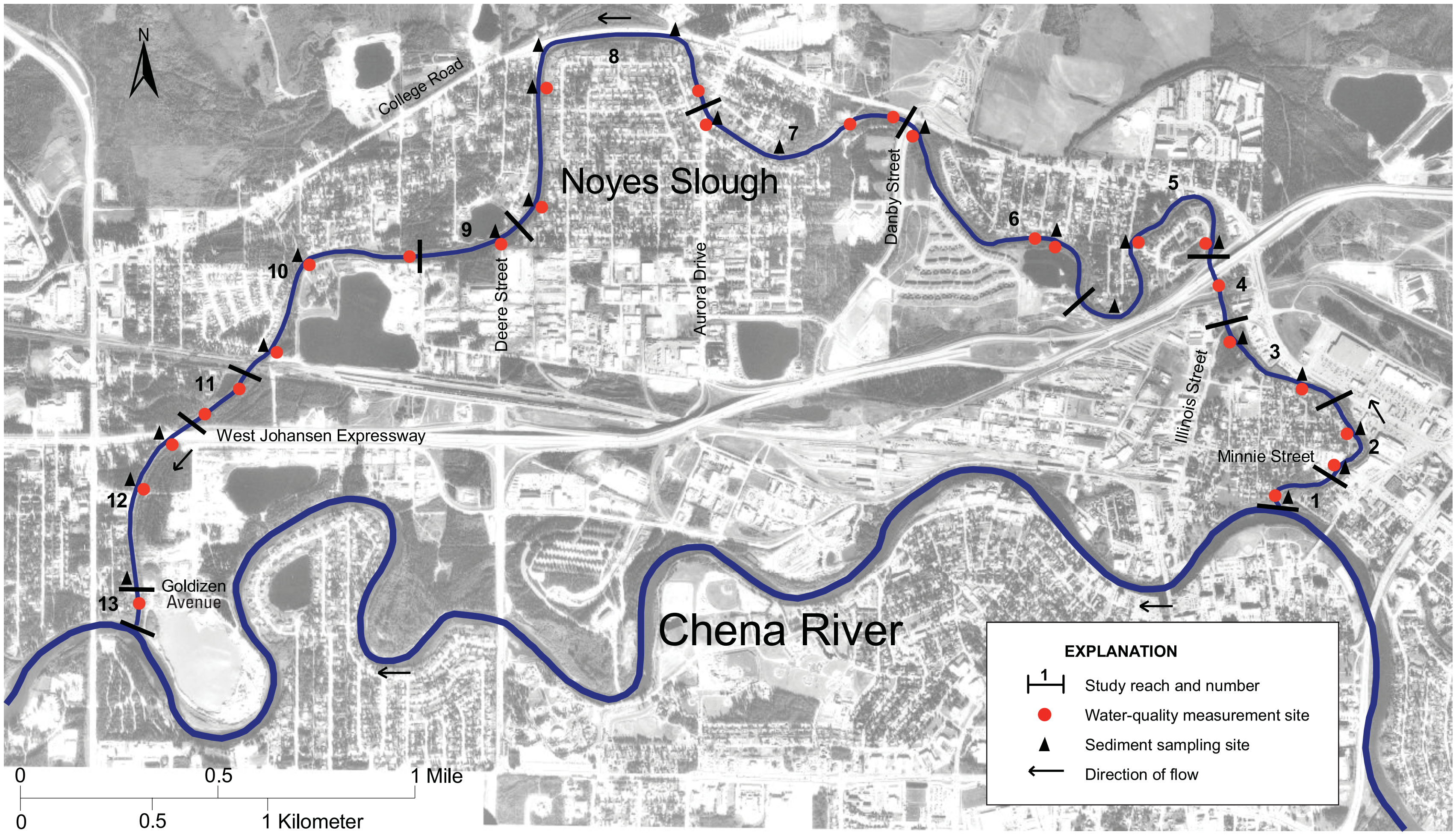


Figure 3. Location of study reach boundaries, water-quality measurement sites, and streambed-sediment sampling sites in Noyes Slough, Fairbanks, Alaska, 2001-2002. Aerial photograph, from 1996 flight, is from Natural Resources Conservation Service.

Table 1. Water-quality and streambed-sediment sampling sites and locations in Noyes Slough, Fairbanks, Alaska, 2001–2002

[**Latitude and Longitude**: North American Datum 1927 (NAD27 Alaska)]

Site identification No.	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	Water-quality measurement site No.	Sediment sampling-site No.	Study reach	Site name
1551400415	645053	1474235	N1	SED01	1	Inlet-Noyes Slough near Wendell Street
1551400425	645057	1474215	N2	SED02	2	Minnie Street bridge
1551400428	645102	1474212	N3	SED03	2	Charles Street
1551400431	645108	1474228	N4	SED04	3	East College Road near Sam's Club
1551400435	645116	1474250	N5	SED05	3	Illinois Street bridge
1551400440	645119	1474253	N6		4	East Alaska Railroad
1551400445	645123	1474257	N7	SED06	5	East Johansen on-ramp
1551400455	645126	1474321	N8	SED07	5	O'Connor Road bridge
1551400460	645117	1474322		SED08	5	Near Antoinette Avenue
1551400465	645126	1474345	N9	SED09	6	Isabella Creek (above)
6451261474349	645126	1474349	N10		6	Isabella Creek (below)
1551400520	645131	1474418		SED10	6	0.25 mile (above) Danby Street bridge
1551400550	645141	1474430	N11	SED11	6	Danby Street bridge (above)
6451421474437	645142	1474437	N12		7	Danby Street bridge (below)
1551400570	645140	1474449	N13		7	Lions Park northwest
1551400600	645136	1474507		SED12	7	Evergreen Street
1551400650	645142	1474532	N14	SED13	7	Aurora Drive bridge (above)
6451441744535	645144	1474535	N15		8	Aurora Drive bridge (below)
1551400700	645152	1474540		SED14	8	College Road near Aurora Motel
1551401510	645150	1474621		SED15	8	College Road/Alaska Way
1551401515	645144	1474624	N16	SED16	8	Smith Street
1551401520	645129	1474624	N17	SED17	8	Central Avenue
1551401525	645125	1474636	N18	SED18	9	Deere Street
1551401527	645123	1474658	N19		10	Commerce Street
1551401530	645122	1474732	N20	SED19	10	Spafford Lane
1551401535	645109	1474747	N21	SED20	10	West Alaska Railroad (above)
6451081474751	645108	1474751	N22		11	West Alaska Railroad (below)
6450591474814	645059	1474814	N23		11	West Johansen bridge (above)
1551401550	645057	1474818	N24	SED21	12	West Johansen bridge (below)
1551401570	645052	1474823	N25	SED22	12	Indiana Avenue
1551401580	645038	1474824	N26	SED23	13	Goldizen Avenue bridge

Characteristics of Fish Habitat

Potential fish cover in Noyes Slough is provided by woody debris, aquatic vegetation, and overhanging brush, and by large man-made debris in a few locations (fig. 4). During the summer of 2001 there were 10 beaver dams along the slough, and most were likely to be barriers to fish at low flow. Some of the dams were probably barriers at higher flows, as well. Beavers were active in the slough, and the number and location of dams may vary on an annual basis.

Twenty locations were noted where one or more drainpipes (culverts) enter the slough (figs. 4 and 5). The highest densities of culverts (six) are in two reaches—reach 3, between Minnie Street and Illinois Street, and reach 8, from the Aurora Drive bridge to about 1 mi (1.6 km) downstream of the bridge. Culverts periodically funnel urban runoff and drainage from low-lying areas into the slough. Urban runoff often includes a variety of organic pollutants, and storm runoff from heavy precipitation may flush stagnant water from low-lying swampy areas into the slough as well. Stagnant waters are usually low in pH and dissolved-oxygen concentration and often contain substantial quantities of dissolved solids. Thus, water quality may occasionally be degraded near culvert areas during storm runoff.

Channel dimensions and substrate composition characterize the basic physical conditions for fish. Channel width and depth define the usable space and influence interactions between fish. Channel depth also influences the limits of water temperature and primary productivity (Wetzel, 1983). This affects the suitability of water for various fish species and for invertebrates that can provide a food base. The composition of substrate materials also affects the suitability for fish and invertebrates (Pedersen and Perkins, 1986).

Mapping of stream features provides an overview of habitat available for fish. Overhanging brush, aquatic vegetation, and woody debris can serve as cover (fig. 6). Beaver dams may be barriers to fish movement (fig. 7), and drainpipes may introduce pollution, which can influence fish distribution. Although riparian vegetation does not directly affect fish, it can moderate water temperatures and provide woody debris and brush to the slough.

Although the maps of habitat characteristics in Noyes Slough did not quantify fish habitat, they show that a large amount of cover was available throughout its course (fig. 4). The variable depths and differing structural features provided conditions that may be suitable for fish species with different preferences, but shallow water at low flow may inhibit passage. Wood from beaver dams and the largely intact riparian zone should continue to provide habitat in the future.

Beavers were a primary factor shaping the physical characteristics of Noyes Slough. Although they helped increase the supply of woody debris, many of their dams probably were a hindrance to fish movement. However, as fish were found throughout most of the slough, the dams do not completely regulate distribution. The slough was effectively divided into disjointed units during low flow, with notable differences in water level and water quality on either side of most dams. Several groups of beavers were observed actively building dams in the summer of 2001 (fig. 8). Beavers likely will continue to influence slough characteristics.

Alaska blackfish (*Dallia pectoralis*) (fig. 9) far outnumbered other species of fish captured or observed in Noyes Slough (table 2). Northern pike (*Esox lucius*) was the second most widely distributed fish, scattered primarily throughout the downstream one-half of the slough. Other fish captured included Arctic grayling (*Thymallus arcticus*), Arctic lamprey (*Lampetra japonica*), burbot (*Lota lota*), humpback whitefish (*Coregonus pidschian*), lake chub (*Couesius plumbeus*), longnose sucker (*Catostomus catostomus*), and slimy sculpin (*Cottus cognatus*). Most of these species were found within a mile of the Chena River.

Differences between the number and type of fish captured at low-flow and high-flow conditions did not provide any conclusive information (table 2). In most cases, fewer fish were captured at high flow. Although it is possible that fish may have migrated from the area, this could not be confirmed because sampling became more difficult in deeper water and the area of wadeable water was reduced.

The fish species inhabiting an area can be an indicator of stream health. Much research has focused on classifying fish species into categories on the basis of their relative tolerance to disturbances (Simon, 1998). A thorough fish-sampling regime is necessary to fully utilize fish communities in an environmental assessment, but the presence of certain tolerant or intolerant species can provide useful information regarding general stream conditions. For Noyes Slough, the relatively high abundance of Alaska blackfish throughout most of the slough was indicative of environmental conditions (table 2). These fish are a member of the mudminnow family, which are highly tolerant of degraded stream conditions (Simon, 1998). They can breathe atmospheric oxygen and can live in water that is uninhabitable to other species (Page and Burr, 1991).

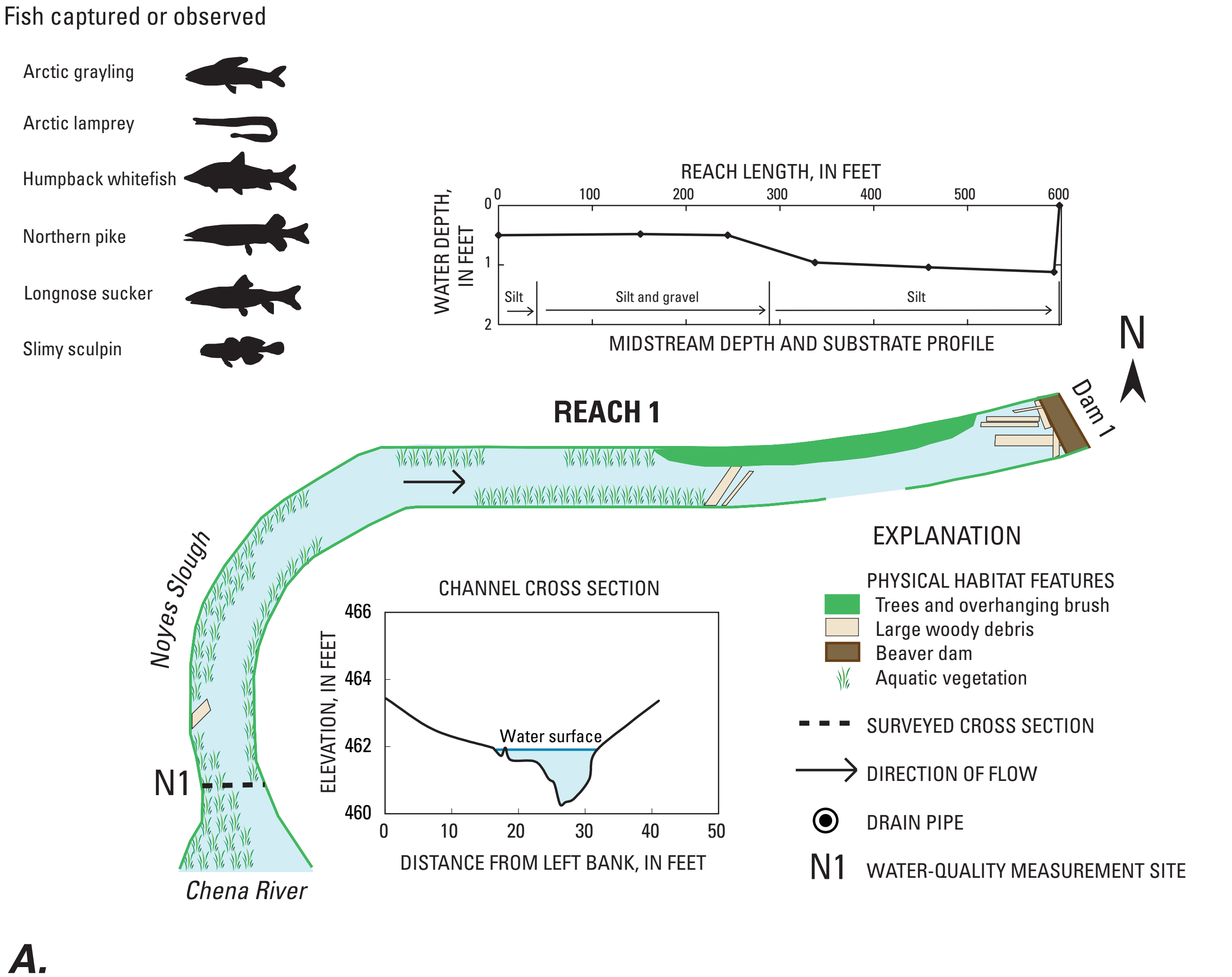
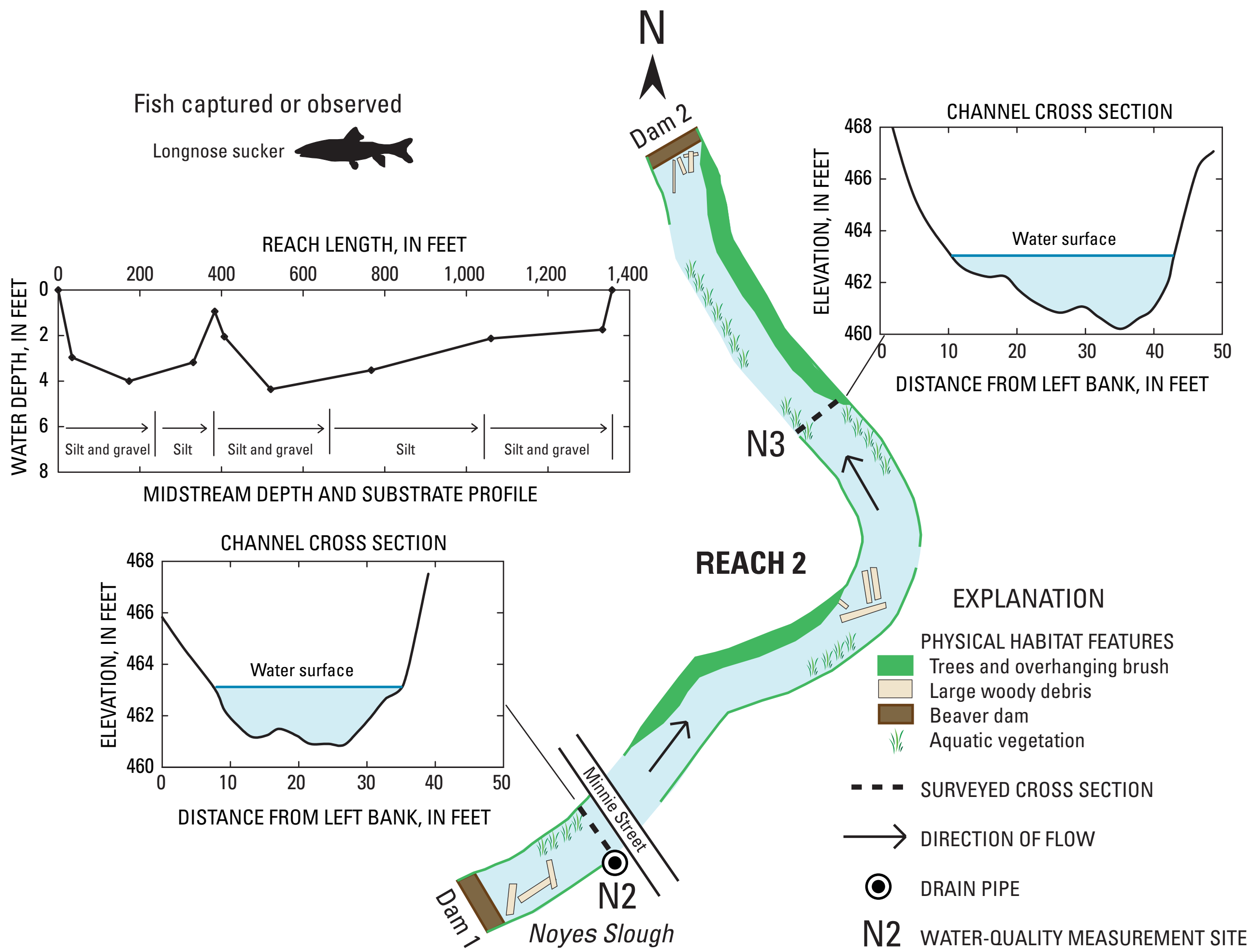


Figure 4. Channel characteristics, fish habitat, and types of fish present during summer 2001 in the 13 study reaches in Noyes Slough, Fairbanks, Alaska.
The scale of features is exaggerated to improve presentation, but their distribution in relation to each other is as observed on site.



B.

Figure 4.—*Continued.*

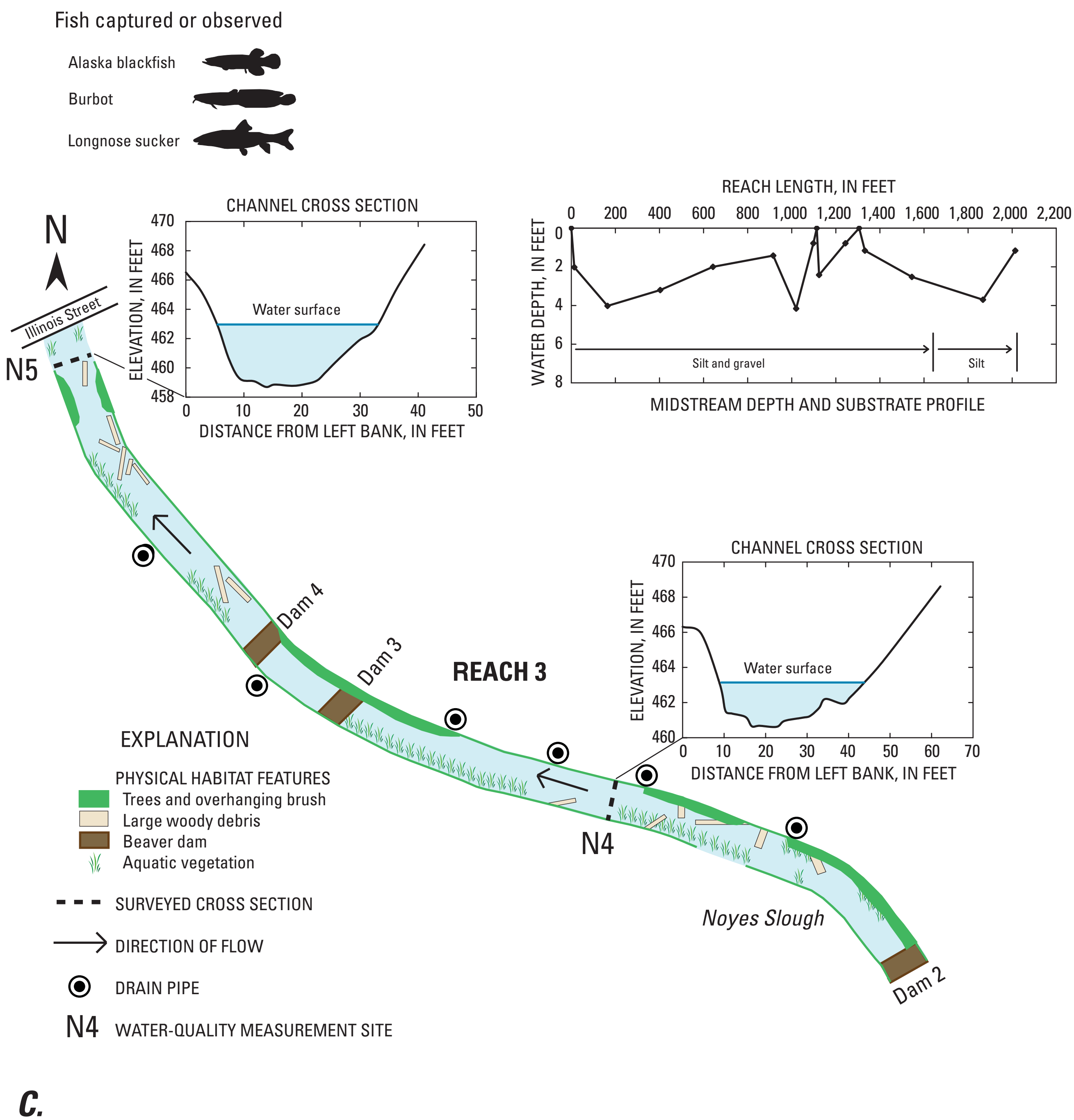
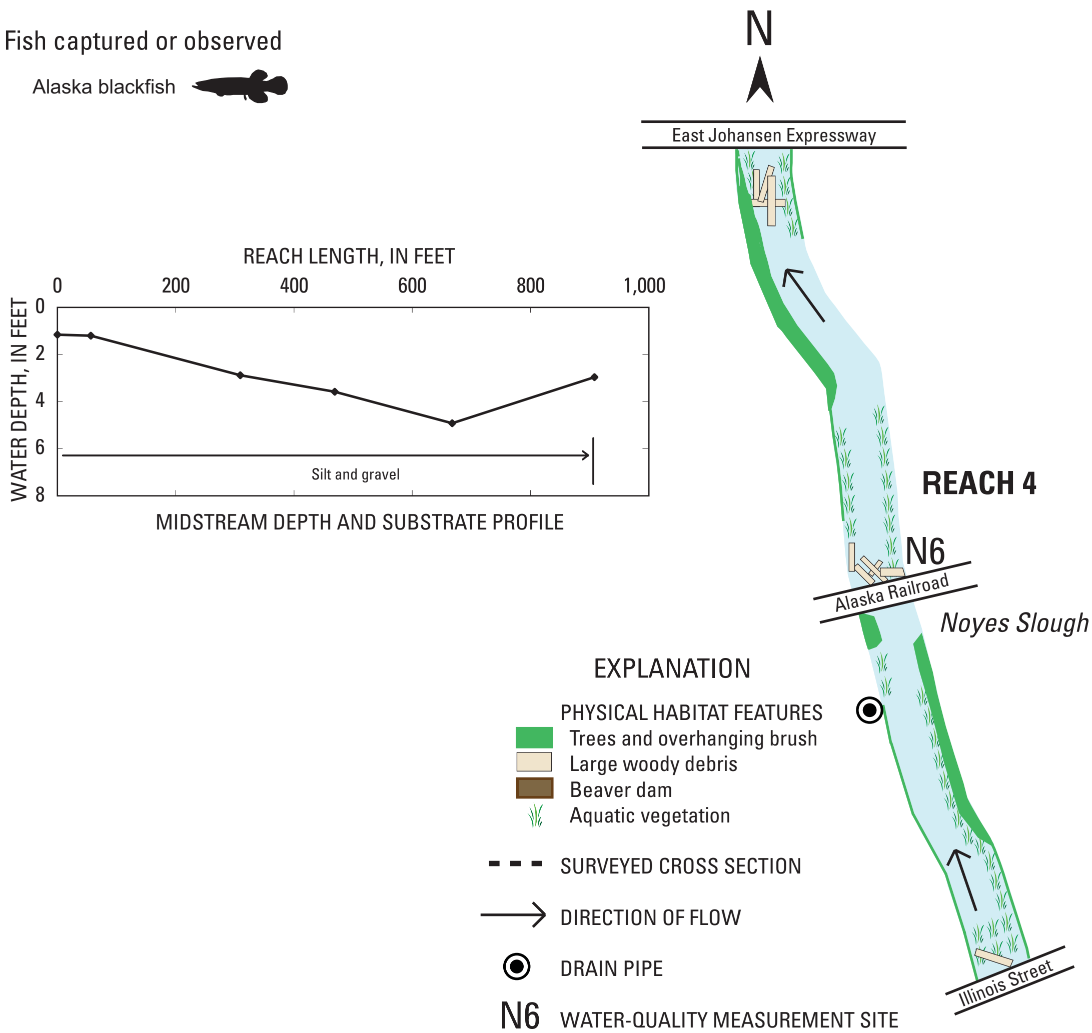
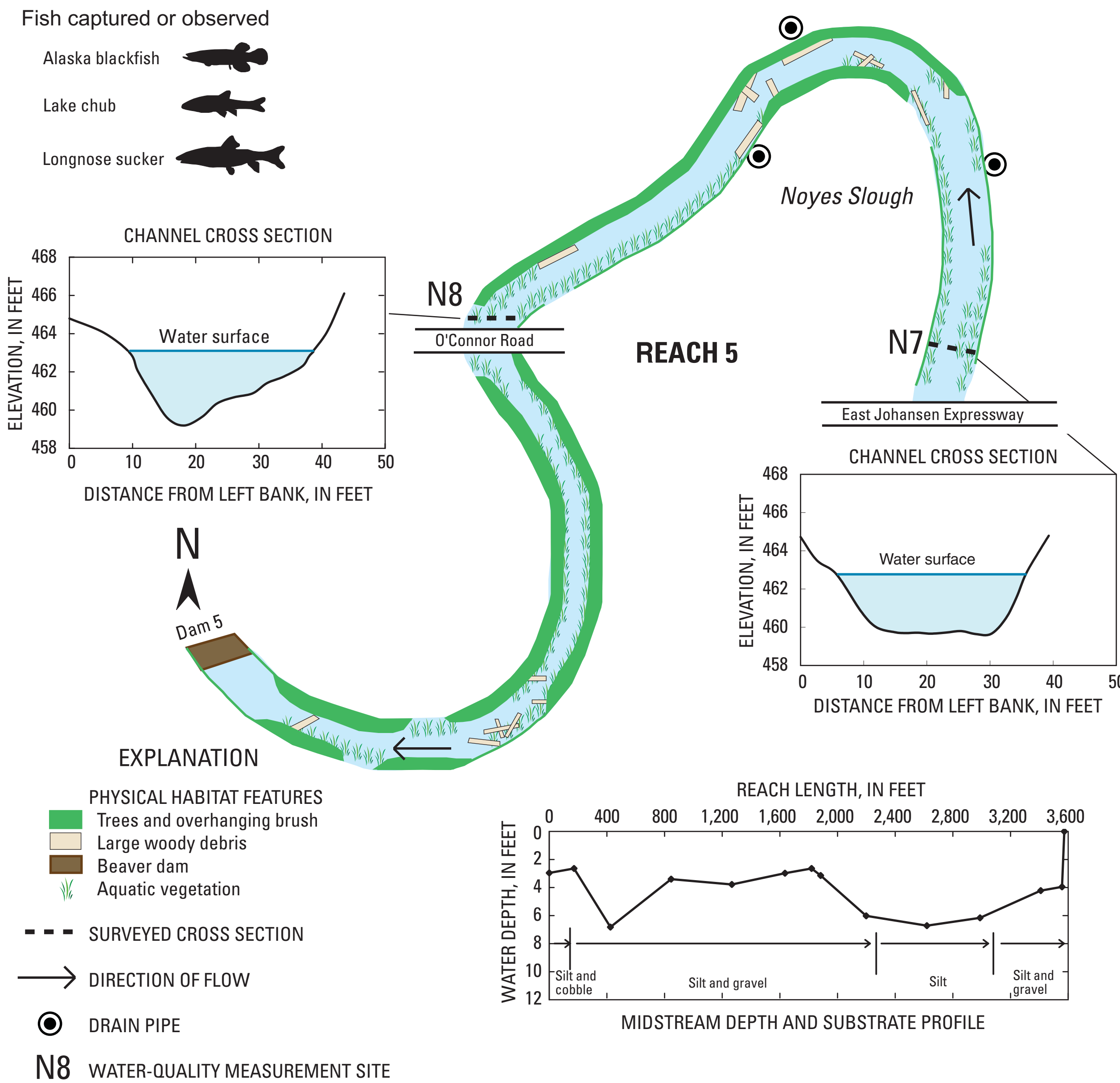


Figure 4.—*Continued.*



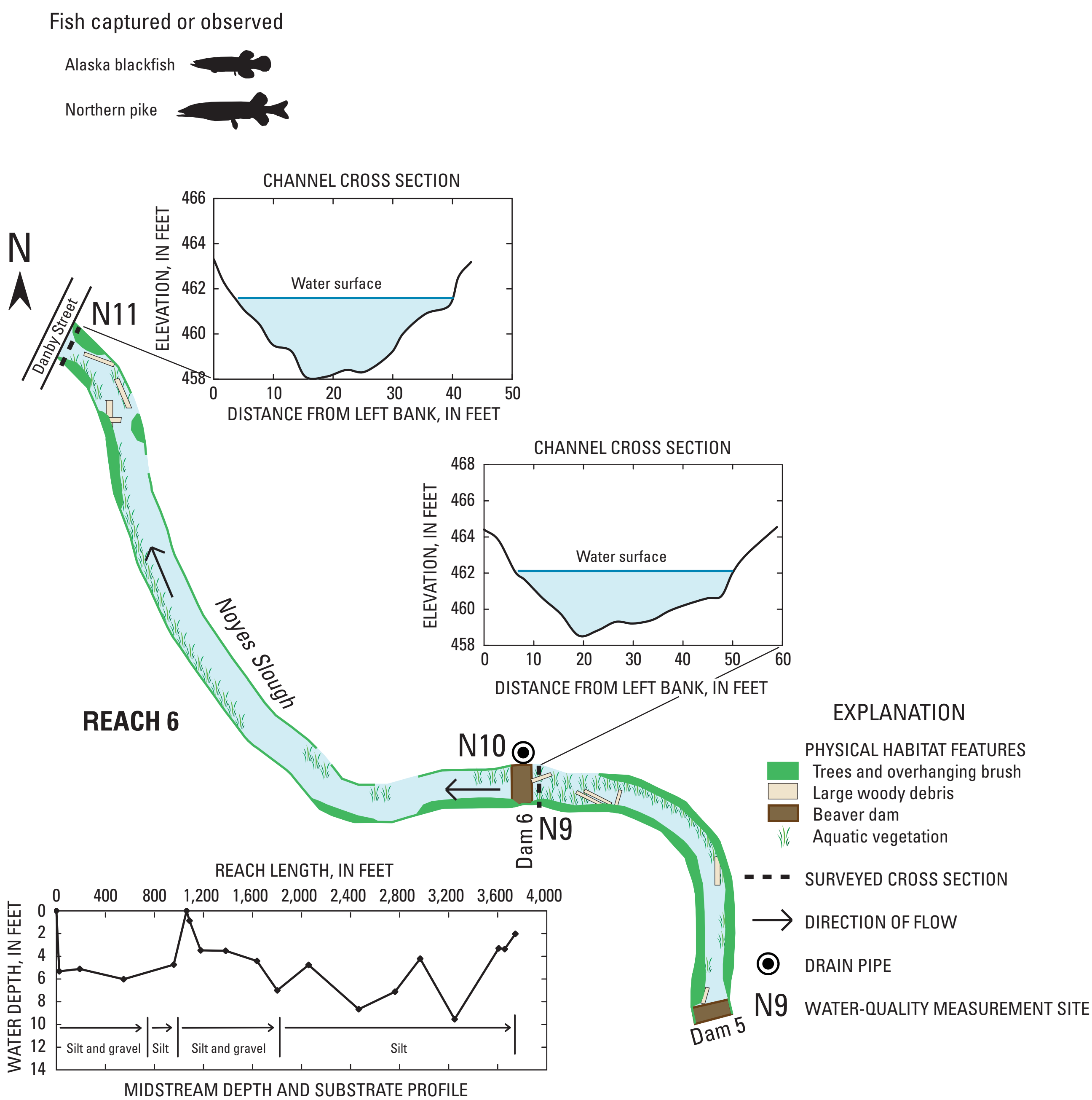
D.

Figure 4.—*Continued*



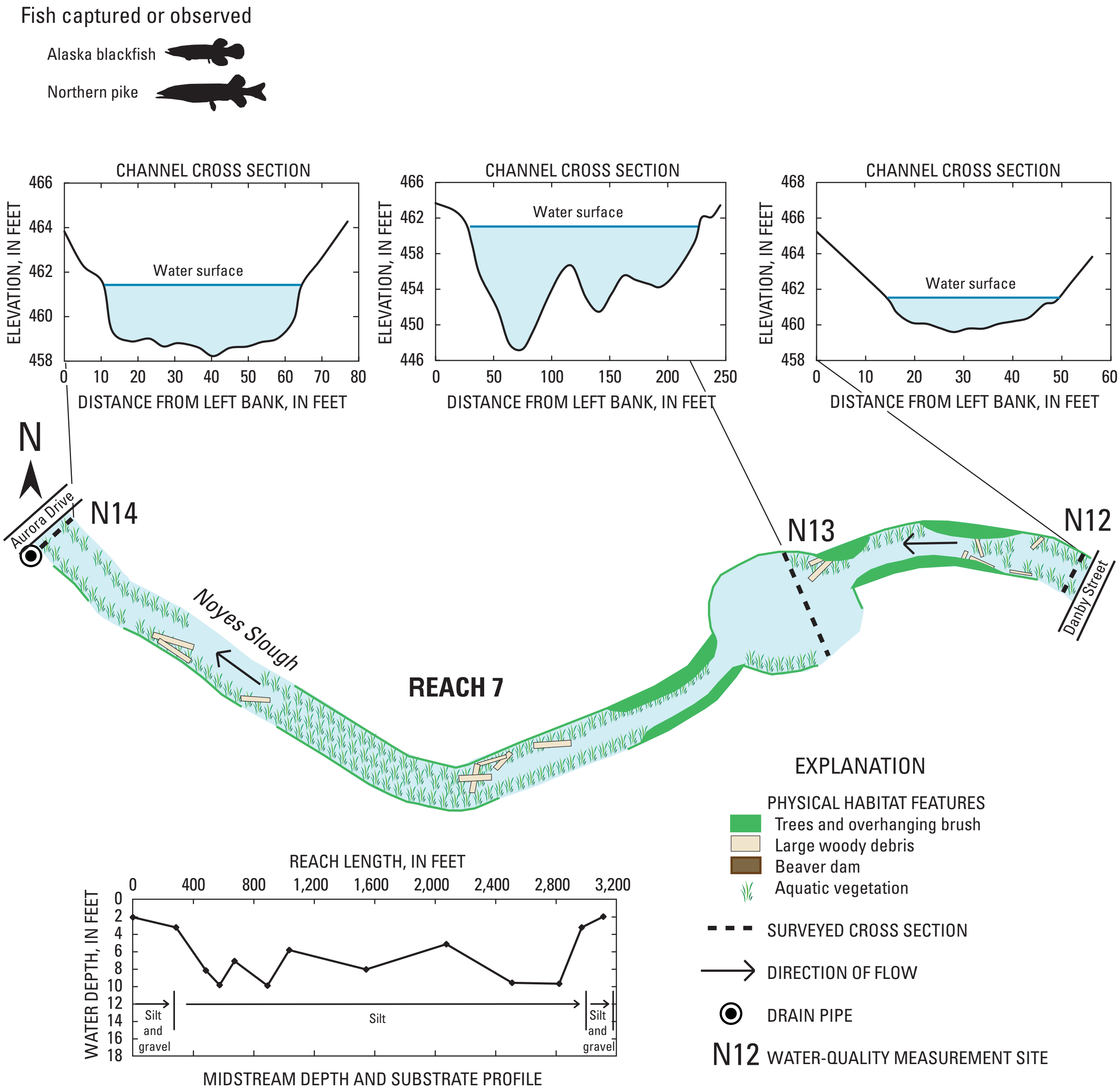
E.

Figure 4.—*Continued.*



F.

Figure 4.—*Continued.*



G.

Figure 4.—*Continued.*

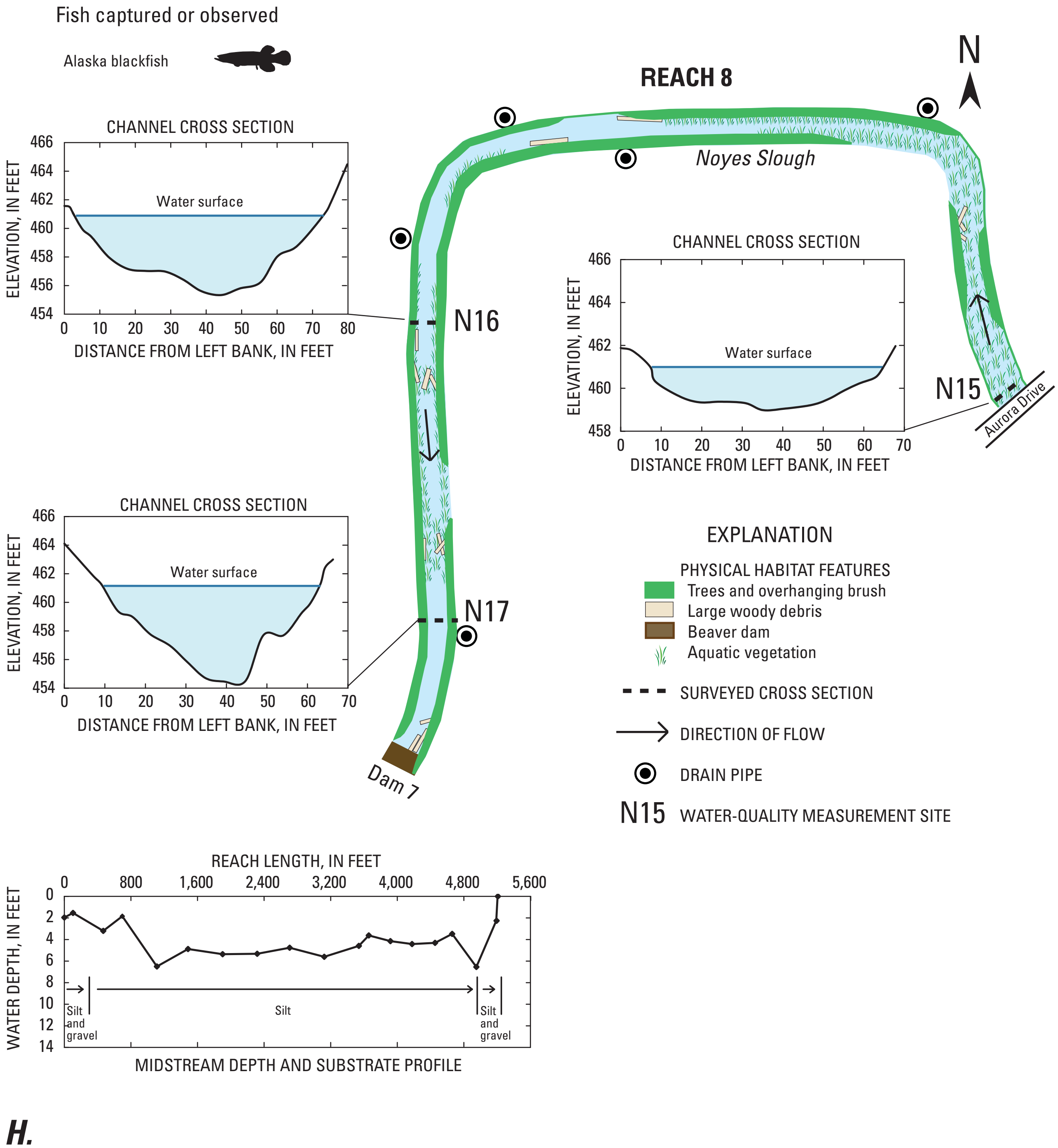
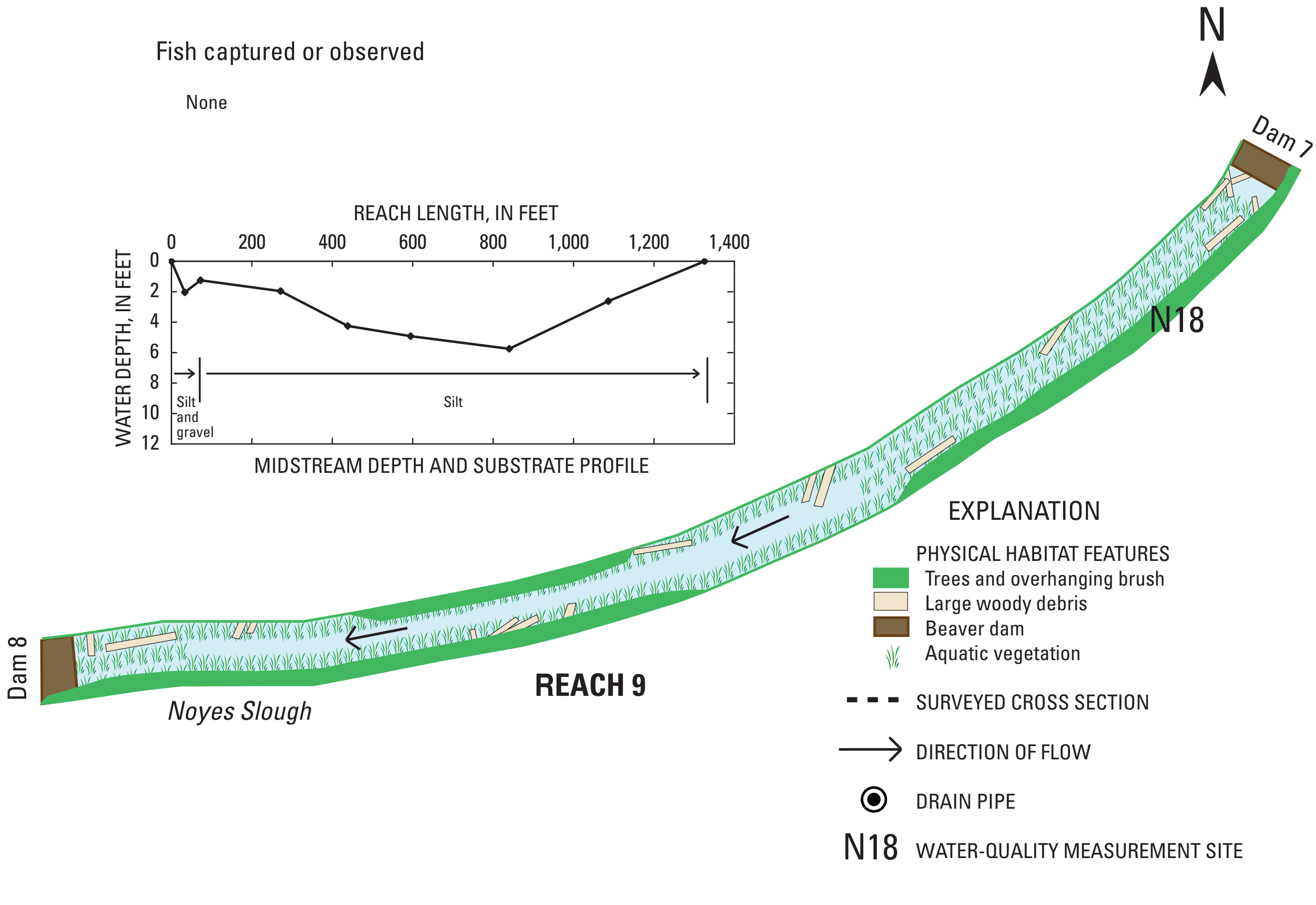


Figure 4.—*Continued.*



I.

Figure 4.—*Continued.*

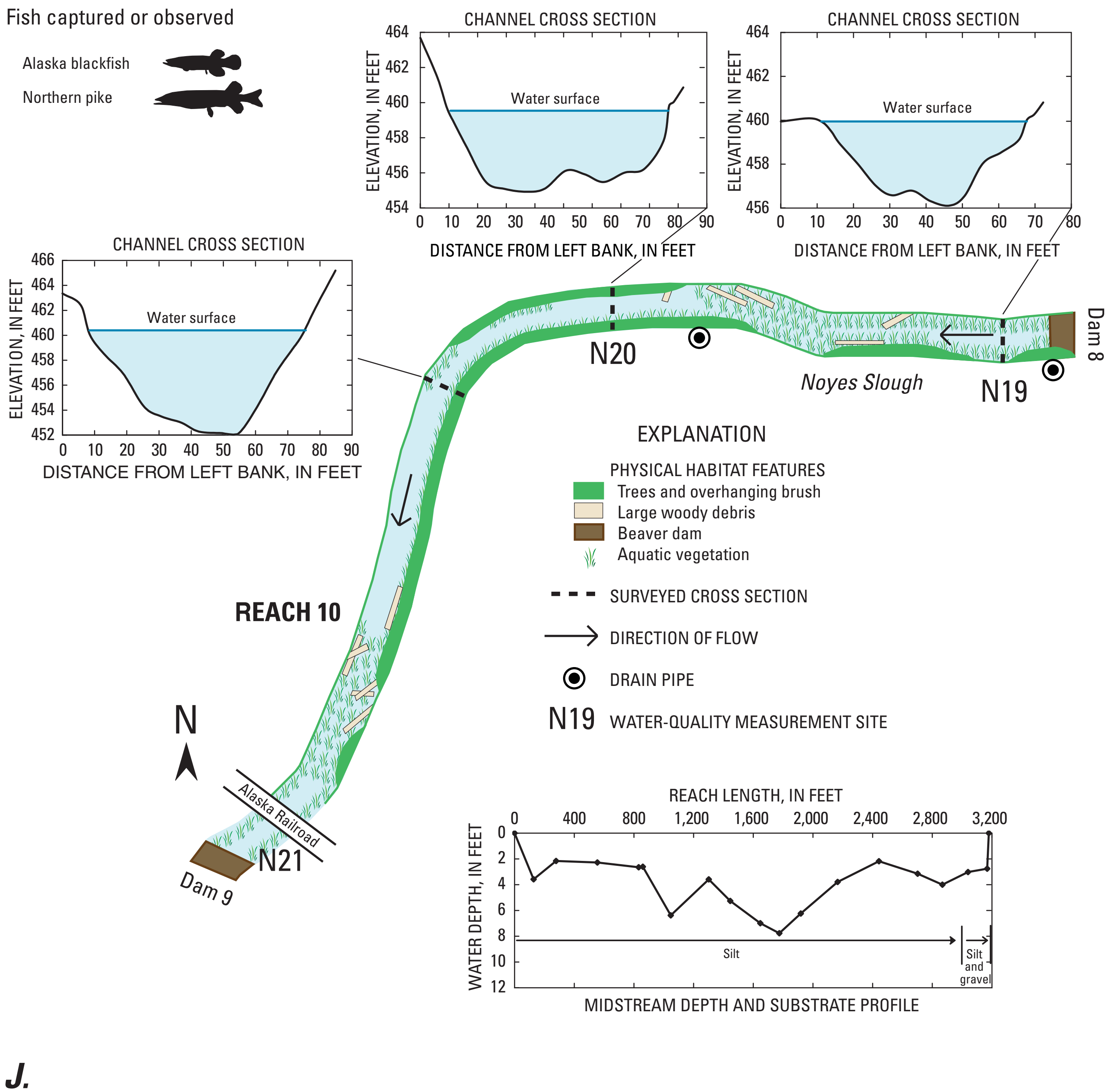
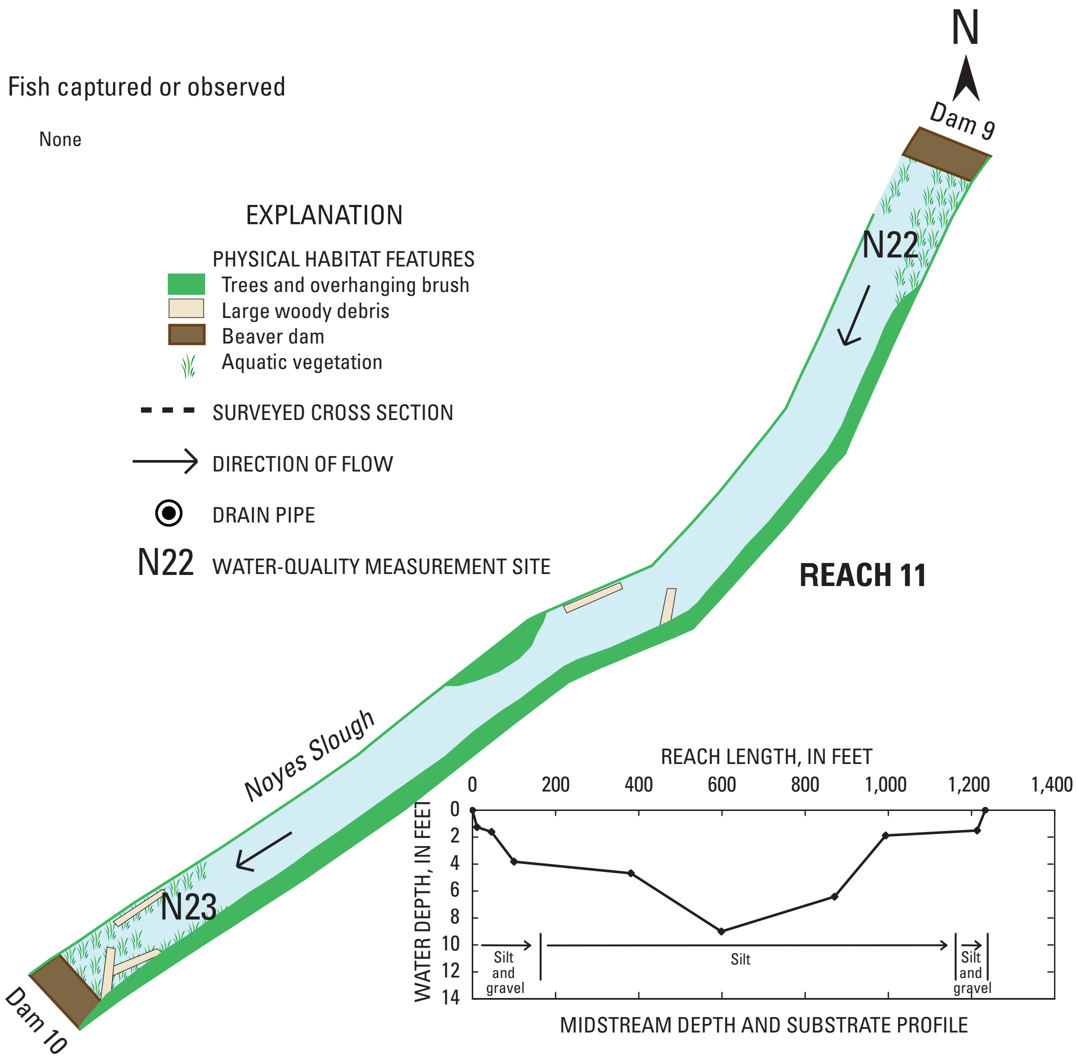


Figure 4.—*Continued.*



K.

Figure 4.—*Continued.*

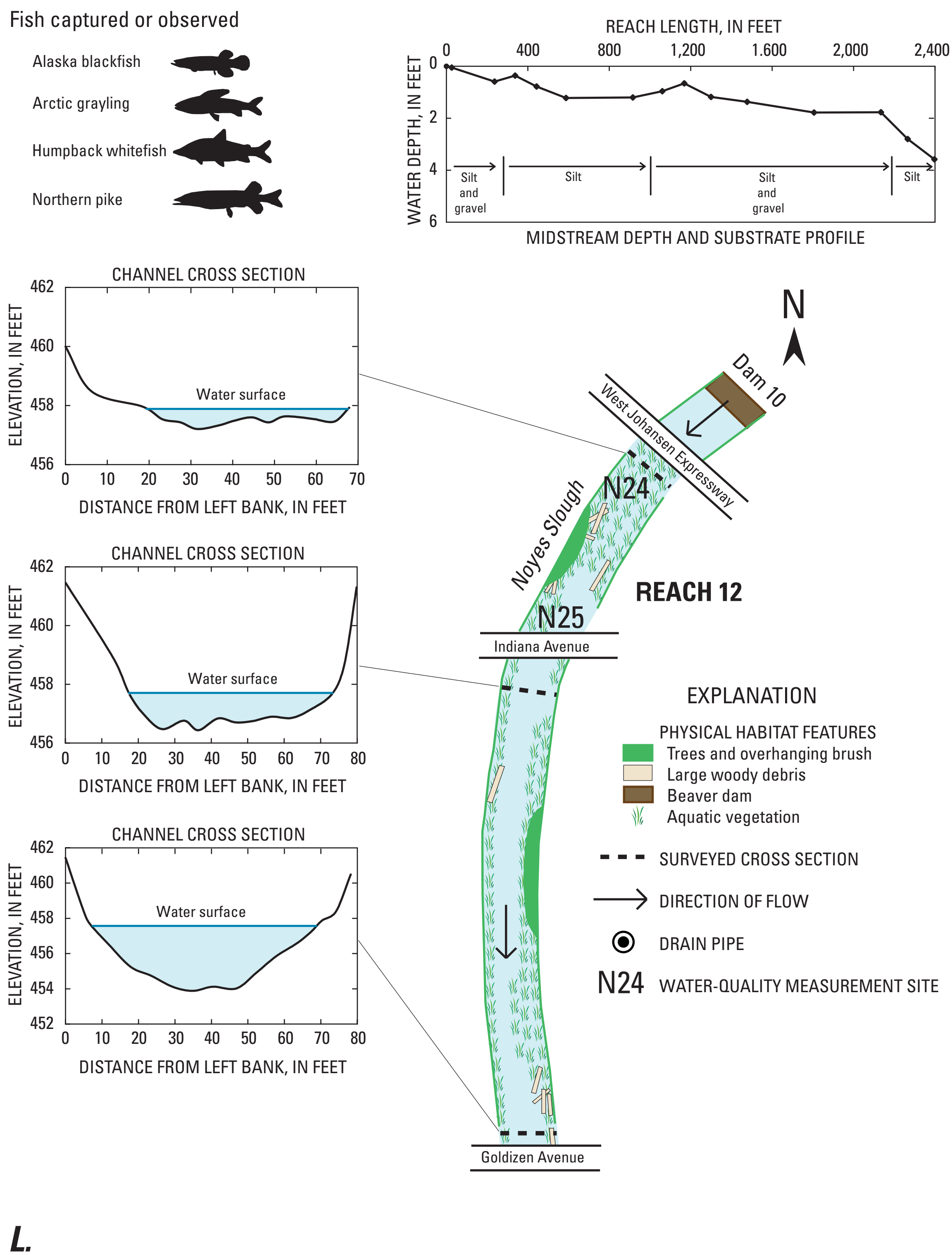
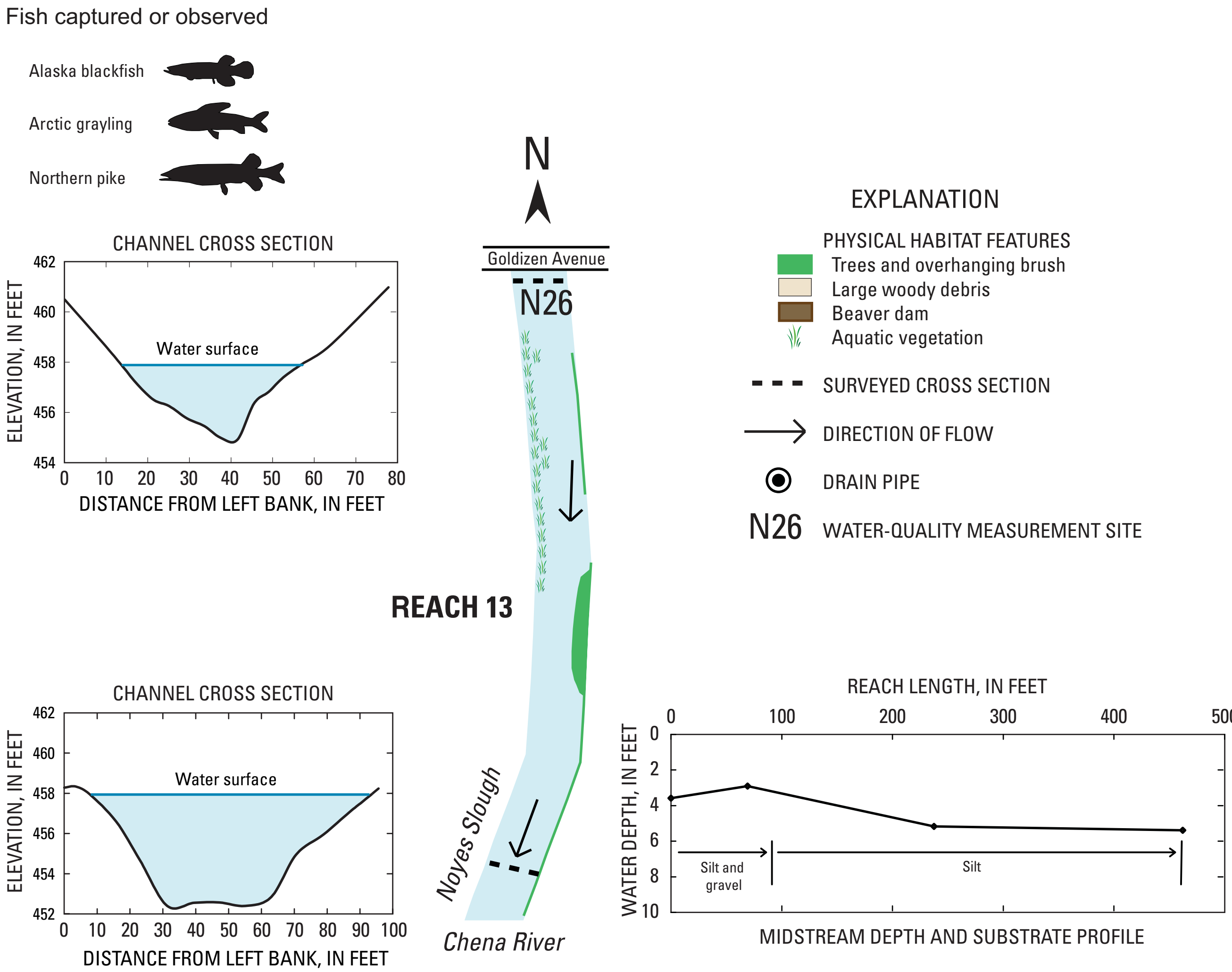


Figure 4.—*Continued.*



M.

Figure 4.—*Continued.*

Figure 5. Culvert discharge into Noyes Slough near East College Road, Fairbanks, Alaska.

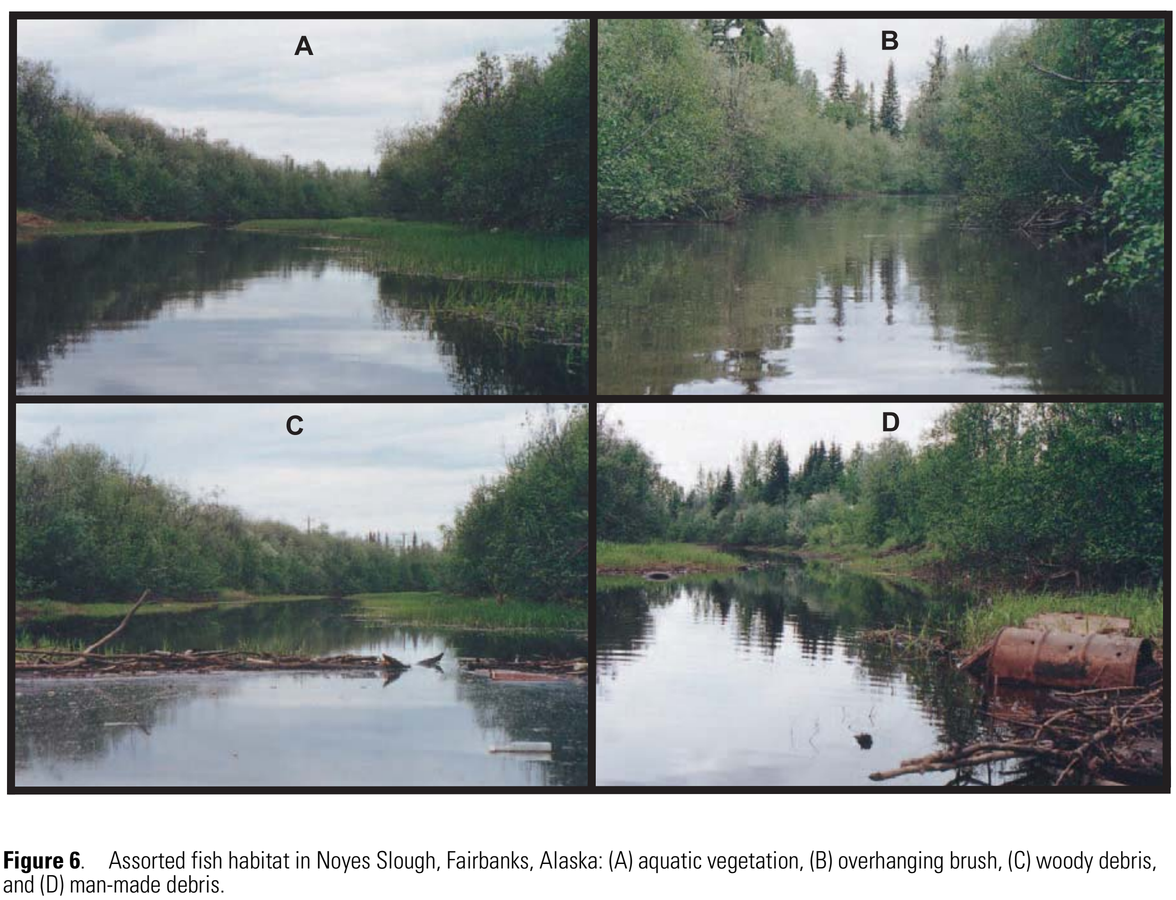


Figure 6. Assorted fish habitat in Noyes Slough, Fairbanks, Alaska: (A) aquatic vegetation, (B) overhanging brush, (C) woody debris, and (D) man-made debris.

Figure 7. Beaver dam on Noyes Slough, Fairbanks, Alaska.
The view is looking across the downstream side of Dam 7 in reach 9, just upstream from Deere Street. This was a likely barrier to fish movement at most streamflow levels during summer 2001.

Figure 8. Beaver delivering brush to Dam 1 on reach 1, upstream of Minnie Street near the source of Noyes Slough, Fairbanks, Alaska.

Figure 9. Alaska blackfish.
Blackfish are found in most reaches of Noyes Slough, Fairbanks, Alaska.

Table 2. Fish captured or observed during low-flow and high-flow conditions in the 13 study reaches in Noyes Slough, Fairbanks, Alaska, July–August 2001

[**Chena River flow:** Less than 2,400 cubic feet per second during low-flow conditions, and greater than 2,400 cubic feet per second during high-flow conditions. **Abbreviations:** ft^3/s, cubic feet per second; mm, millimeters; est, estimated;–, no data]

Date (2001)	Chena River flow (ft^3/s)	Vicinity	Method	Species (common name)	Total	Range of total length (mm)
			REACH 1			
July 10	2,245	N1 (Inlet-Noyes Slough)	Electrofishing	Arctic grayling	2	275-302
				Arctic lamprey	1	–
				Humpback whitefish	2	274-316
				Longnose sucker	2	368-417
				Northern pike	2	59-288
July 11	1,938	N1 (Inlet-Noyes Slough)	Electrofishing	Arctic grayling	1	292
				Northern pike	1	88
				Slimy sculpin	5	40-94
				Unknown whitefish	2	52
August 8	2,396	N1 (Inlet-Noyes Slough)	Electrofishing	Arctic grayling	3	207-266
				Humpback whitefish	1	196
				Northern pike	4	156-582
			REACH 2			
July 11	1,938	N2 (Minnie Street bridge)	Electrofishing	Longnose sucker	1	88
July 19	1,390	N2 (Minnie Street bridge)	Dipnet, observation	Longnose sucker	300+ (est)	5-9
August 1	4,058	N3 (Charles Street)	Minnow traps	Burbot	1	75
				Longnose sucker	2	10 (est)
August 2	3,535	N3 (Charles Street)	Minnow traps	Longnose sucker	1	67
August 8	2,396	N2 (Minnie Street bridge)	Electrofishing	Longnose sucker	1	106
			Observation	Longnose sucker	100+ (est)	15 (est)
			REACH 3			
July 20	1,310	N5 (Illinois Street bridge)	Minnow traps	Alaska blackfish	20	98-119
August 8	2,396	N5 (Illinois Street bridge)	Minnow traps	Alaska blackfish	35	45-121
			REACH 4			
August 1	4,058	N6 (East Alaska Railroad)	Minnow traps	Alaska blackfish	8	89-145
			REACH 5			
July 11	1,938	N7 (East Johansen on-ramp)	Electrofishing	Alaska blackfish	7	15-146
July 22	1,168	N8 (O'Connor Road bridge)	Minnow traps	Alaska blackfish	21	89-137
				Lake chub	21	63-72
				Longnose sucker	8	78-129
August 8	2,396	N8 (O'Connor Road bridge)	Minnow traps	Alaska blackfish	36	44-125
				Longnose sucker	1	120
			REACH 6			
July 10	2,245	N11 and N12 (Danby Street bridge)	Electrofishing	Alaska blackfish	25	14-145
				Northern pike	1	121
July 11	1,938	N9 (Isabella Creek, above)	Electrofishing	Alaska blackfish	3	135-149
August 8	2,396	N11 and N12 (Danby Street bridge)	Electrofishing	Alaska blackfish	6	119-133
				Northern pike	1	119
August 8	2,396	N9 (Isabella Creek, above)	Electrofishing	Alaska blackfish	1	156

Table 2. Fish captured or observed during low-flow and high-flow conditions in the 13 study reaches in Noyes Slough, Fairbanks, Alaska, July–August 2001–*Continued*

[**Chena River flow:** Less than 2,400 cubic feet per second during low-flow conditions, and greater than 2,400 cubic feet per second during high-flow conditions. **Abbreviations:** ft^3/s, cubic feet per second; mm, millimeters; est, estimated;–, no data]

Date (2001)	Chena River flow (ft^3/s)	Vicinity	Method	Species (common name)	Total	Range of total length (mm)
			REACH 7			
July 10	2,245	N11 and N12 (Danby Street bridge)	Electrofishing	Alaska blackfish	25	14-145
		(same sample as reach 6)		Northern pike	1	121
July 10	2,245	N14 and N15 (Aurora Drive bridge)	Electrofishing	Alaska blackfish	15	102-165
				Northern pike	2	90-103
August 8	2,396	N11 and N12 (Danby Street bridge)	Electrofishing	Alaska blackfish	6	119-133
		(same sample as reach 6)		Northern pike	1	119
August 8	2,396	N14 and N15 (Aurora Drive bridge)	Electrofishing	Alaska blackfish	6	91-138
			REACH 8			
July 10	2,245	N14 and N15 (Aurora Drive bridge)	Electrofishing	Alaska blackfish	15	102-165
		(same sample as reach 7)		Northern pike	2	90-103
July 24	1,140	N16 (Smith Street)	Minnow traps	Alaska blackfish	1	119
July 24	1,140	N17 (Central Avenue)	Minnow traps	Alaska blackfish	1	99
August 8	2,396	N14 and N15 (Aurora Drive bridge) (same sample as reach 7)	Electrofishing	Alaska blackfish	7	91-138
August 8	2,396	N16 (Smith Street)	Minnow traps	No fish captured	–	–
August 8	2,396	N17 (Central Avenue)	Minnow traps	No fish captured	–	–
			REACH 9			
July 24	1,140	N18 (Deere Street)	Minnow traps	No fish captured	–	–
August 8	2,396	N18 (Deere Street)	Minnow traps	No fish captured	–	–
			REACH 10			
July 6	1,410	N19 (Commerce Street)	Electrofishing	Alaska blackfish	20	73-145
				Northern pike	1	101
July 27	1,278	N21 (West Alaska Railroad, above)	Minnow traps	No fish captured	–	–
August 8	2,396	N19 (Commerce Street)	Electrofishing	No fish captured	–	–
			REACH 11			
July 27	1,278	N22 (West Alaska Railroad, below)	Minnow traps	No fish captured	–	–
July 27	1,278	N23 (West Johansen, above)	Minnow traps	No fish captured	–	–
			REACH 12			
July 6	1,410	N25 (Indiana Avenue)	Electrofishing	Northern pike	1	93
July 6	1,410	N24 (West Johansen bridge, below)	Electrofishing	Humpback whitefish	1	450
July 6	1,410	N26 (Goldizen Avenue bridge)	Electrofishing	Alaska blackfish	3	65-98
				Northern pike	5	64-651
July 18	1,506	N24 (West Johansen bridge, below)	Observation	Northern pike	1	250 (est)
August 8	2,396	N25 (Indiana Avenue)	Electrofishing	Northern pike	1	98
August 8	2,396	N24 (West Johansen bridge, below)	Electrofishing	No fish captured	–	–
			REACH 13			
June 7	1,460	N26 (Goldizen Avenue bridge)	Observation	Northern pike	1	400 (est)
June 13	1,910	N26 (Goldizen Avenue bridge)	Observation	Arctic grayling	1	200 (est)
				Northern pike	1	400 (est)
July 6	1,410	N26 (Goldizen Avenue bridge)	Electrofishing	Alaska blackfish	3	65-98
		(same sample as reach 12)		Northern pike	5	64-651

Assessment of Water Quality

Specific conductance, water temperature, pH, dissolved-oxygen concentration, and turbidity were measured at 26 sites in Noyes Slough in July and August 2001. These parameters provide quantitative information for assessing water-quality conditions for aquatic life as well as general environmental conditions for fish.

Data Collection

Twenty-six water-quality sampling sites were established on Noyes Slough, with a minimum of one site per reach (fig. 3, table 1). The water-quality sites were labeled N1 through N26 in sequence from the upstream end of the slough (fig. 4). Water-quality was measured at least twice at each sampling site. Water-quality data were recorded in Noyes Slough when discharge in the Chena River was below and above a flow threshold at or above which it contributes water to the slough (fig. 10). A hydraulic model by Burrows and others (2000) determined the flow threshold to be about 2,400 ft^3/s. Conductance, pH, dissolved-oxygen concentration, and water temperature were measured midstream at incremental depths of 0.8 ft, or just subsurface when the depth was less than 0.8 ft, using a Hydrolab. Turbidity was measured with a Hach 2100P at a depth of less than 1.6 ft and at a second depth at sites where water was more than 3.3 ft deep during low flow. Water temperature data loggers were installed in reaches 2, 5, 7, 10, and 12 from June to September, and another logger recorded the ambient air temperature at reach 5.

Water-Quality Characteristics

Conductance, pH, dissolved-oxygen concentration, water temperature, and turbidity data for the 26 water-quality measurement sites are presented in table 3. Mean daily water temperatures for June through August of 2001 are presented in table 4. Water-quality characteristics varied widely at sampling sites along the slough at low flows and relatively large differences in water quality also were observed along depth profiles.

Water-quality data collected from Noyes Slough were evaluated using water-quality standards established by the Alaska Department of Environmental Conservation (ADEC) and the U.S. Environmental Protection Agency (USEPA) (table 5). Dissolved-oxygen concentrations ranged from 0.2 to 10.9 mg/L, and many values fell below criteria established for aquatic life by both the Federal government (5.5 mg/L; U.S. Environmental Protection Agency, 1986b) and the State of Alaska (5 mg/L; Alaska Department of Environmental Conservation, 1997). Only three measured pH values fell slightly below Federal and State standards of 6.5-9.0 standard units. Turbidity was generally at low levels at most sites and was never extreme. Values were typically lower than 25 NTU (nephelometric turbidity units), a limit suggested for salmonids, a sensitive group of fish (Sigler and others, 1984). At times, water temperatures surpassed State criteria for overall maximum limit (20°C) and frequently were above the maximum limit for rearing fish (15°C) during June and July (fig. 11, table 4). Water temperatures were within State criteria during August.

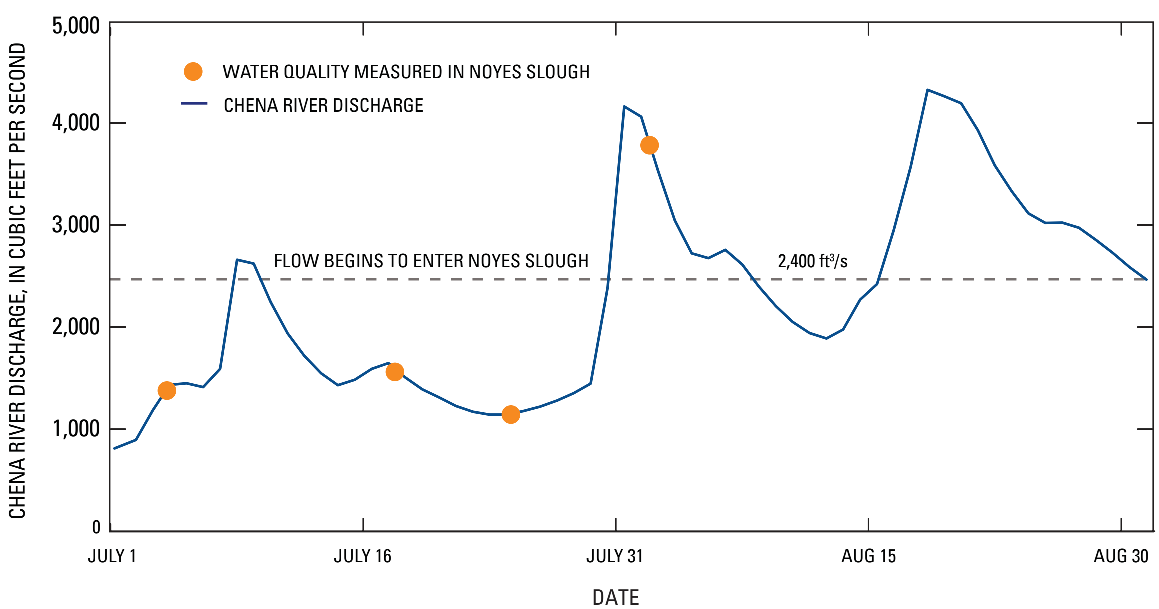


Figure 10. Discharge in the Chena River and dates of water-quality measurements during summer 2001 in Noyes Slough, Fairbanks, Alaska.
At a discharge of about 2,400 cubic feet per second, the Chena River contributes surface water to Noyes Slough.

Table 3. Water quality measured at midstream during low-flow and high-flow conditions at sampling sites in Noyes Slough, Fairbanks, Alaska, July–August 2001

[**Chena River flow:** Less than 2,400 cubic feet per second during low-flow conditions, and greater than 2,400 cubic feet per second during high-flow conditions.**Abbreviations:** ft^3/s, cubic feet per second; ft, feet; µS/cm, microSiemens per centimeter corrected to a standard value of 25ºC; ºC, degrees Celsius; mg/L, milligrams per liter; %, percent; –, no data]

Date (2001)	Chena River flow (ft^3/s)	Sample depth (ft)	Specific conductance (µS/cm)	Temperature (°C)	pH (standard units)	Dissolved-oxygen concentration (mg/L)	Dissolved-oxygen saturation (%)	Turbidity (nephelometric turbidity units)
N1 (Inlet-Noyes Slough near Wendell Street)								
July 5	1,429	0.82	333	14.0	6.9	10.1	98	16.6
July 18	1,530	.82	253	14.0	6.7	4.1	39	12.6
August 2	3,600	.82	133	9.5	7.4	10.7	94	10.1
		1.64	133	9.5	7.4	10.7	93	–
		2.46	134	9.0	7.3	10.7	93	–
		3.28	135	9.0	7.3	10.7	93	–
N2 (Minnie Street bridge)								
July 5	1,429	.82	179	17.0	6.8	2.5	26	6.7
July 18	1,530	.82	160	16.0	6.8	5.0	51	–
		1.64	160	16.0	6.8	5.1	51	3.7
August 2	3,600	.82	137	9.5	7.3	10.9	95	–
		1.64	138	9.0	7.3	10.8	94	9.2
		2.30	138	9.5	7.3	10.7	93	–
N3 (Charles Street)								
July 24	1,140	.82	166	17.0	6.8	3.5	36	–
		1.64	166	17.0	6.7	3.5	36	52.9
		1.97	167	17.0	6.7	3.4	35	–
August 2	3,580	.82	138	9.5	7.2	10.5	92	–
		1.64	138	9.5	7.3	10.8	94	11.2
		2.46	137	9.5	7.3	10.8	95	–
		2.79	138	9.5	7.2	10.5	95	–
N4 (East College Road near Sam's Club)								
July 24	1,130	.82	170	16.5	6.7	1.1	11	–
		1.64	172	16.5	6.6	.8	8	37.8
		1.97	180	16.5	6.6	.7	7	–
August 2	3,590	.82	137	9.5	7.3	10.7	94	–
		1.64	137	9.5	7.3	10.8	94	8.8
		2.30	137	9.5	7.3	10.8	94	–
N5 (Illinois Street bridge)								
July 5	1,429	.82	359	16.5	7.1	3.8	39	–
		1.64	358	16.5	7.0	3.4	35	8.6
		2.46	359	16.0	7.0	2.6	26	–
July 18	1,520	.82	323	14.5	6.7	2.2	21	–
		1.64	327	14.5	6.7	1.7	17	13.3
		2.46	386	13.5	6.7	.9	9	–
		2.95	525	11.5	6.6	.4	4	–
August 2	3,590	.82	136	9.5	7.3	10.4	92	–
		1.64	136	9.5	7.3	10.4	91	5.8
		2.46	136	9.5	7.3	10.4	91	–
		3.28	136	9.5	7.3	10.4	91	–
		4.10	136	9.5	7.3	10.3	90	–

Table 3. Water quality measured at midstream during low-flow and high-flow conditions at sampling sites in Noyes Slough, Fairbanks, Alaska, July–August 2001–*Continued*

[**Chena River flow:** Less than 2,400 cubic feet per second during low-flow conditions, and greater than 2,400 cubic feet per second during high-flow conditions.**Abbreviations:** ft^3/s, cubic feet per second; ft, feet; µS/cm, microSiemens per centimeter corrected to a standard value of 25ºC; ºC, degrees Celsius; mg/L, milligrams per liter; %, percent; –, no data]

Date (2001)	Chena River flow (ft^3/s)	Sample depth (ft)	Specific conductance (µS/cm)	Temperature (°C)	pH (standard units)	Dissolved-oxygen concentration (mg/L)	Dissolved-oxygen saturation (%)	Turbidity (nephelometric turbidity units)
N6 (East Alaska Railroad)								
July 24	1,130	0.82	287	16.5	6.8	3.3	34	–
		1.64	301	16.5	6.8	2.5	25	24.3
		2.46	331	15.0	6.8	.5	5	–
August 2	3,570	.82	132	9.5	7.3	10.5	92	–
		1.64	134	9.5	7.3	10.5	92	6.3
		2.46	134	9.5	7.3	10.4	91	–
		3.28	134	9.5	7.3	10.4	91	–
		3.77	132	9.5	7.3	10.3	91	–
N7 (East Johansen on-ramp)								
July 5	1,429	.82	249	15.0	7.1	7.9	79	–
		1.64	312	14.0	7.0	6.0	59	2.5
July 18	1,510	.82	257	15.5	7.2	7.9	79	–
		1.64	268	15.0	7.1	6.1	60	5.3
		2.30	603	10.5	6.5	1.9	17	–
August 2	3,570	.82	136	10.0	7.3	10.5	93	–
		1.64	136	10.0	7.3	10.4	92	6.2
		2.46	136	10.0	7.3	10.4	92	–
		3.28	136	10.0	7.3	10.4	92	–
		3.61	136	10.0	7.3	10.4	92	–
N8 (O'Connor Road bridge)								
July 5	1,429	.82	164	16.5	7.0	6.0	62	–
		1.64	191	16.0	6.8	4.5	46	2.6
July 18	1,510	.82	243	16.5	7.1	6.2	63	–
		1.64	243	16.5	7.1	6.2	63	5.6
		2.46	297	15.5	6.9	3.1	31	–
August 2	3,550	.82	133	10.0	7.3	10.5	93	–
		1.64	133	10.0	7.3	10.1	90	6.1
		2.46	133	10.0	7.3	10.1	90	–
		3.28	133	10.0	7.3	10.2	91	–
		3.61	133	10.0	7.3	10.1	90	–
N9 (Isabella Creek, above)								
July 5	1,429	.82	231	17.5	7.1	7.0	74	–
		1.64	234	17.5	7.1	6.5	68	3.9
July 18	1,510	.82	245	17.5	7.2	7.9	82	–
		1.64	247	17.0	7.2	7.3	75	5.5
		2.46	270	16.5	6.8	3.3	34	–
August 2	3,550	.82	131	11.0	7.3	10.1	91	–
		1.64	131	10.5	7.3	10.1	91	6.0
		2.46	131	10.5	7.3	10.1	91	–
		2.95	131	10.0	7.3	10.1	90	–

Table 3. Water quality measured at midstream during low-flow and high-flow conditions at sampling sites in Noyes Slough, Fairbanks, Alaska, July–August 2001–*Continued*

[**Chena River flow:** Less than 2,400 cubic feet per second during low-flow conditions, and greater than 2,400 cubic feet per second during high-flow conditions.**Abbreviations:** ft^3/s, cubic feet per second; ft, feet; µS/cm, microSiemens per centimeter corrected to a standard value of 25ºC; ºC, degrees Celsius; mg/L, milligrams per liter; %, percent; –, no data]

Date (2001)	Chena River flow (ft^3/s)	Sample depth (ft)	Specific conductance (µS/cm)	Temperature (°C)	pH (standard units)	Dissolved-oxygen concentration (mg/L)	Dissolved-oxygen saturation (%)	Turbidity (nephelometric turbidity units)
				N10 (Isabella Creek, below)				
July 5	1,429	0.82	430	13.5	6.9	3.3	34	–
July 18	1,510	.82	429	14.5	6.9	3.3	32	11.3
August 2	3,550	.82	134	10.5	7.2	9.6	86	6.3
		1.31	133	10.5	7.2	9.6	85	–
				N11 (Danby Street bridge, above)				
July 24	1,140	.82	479	16.0	6.7	5.5	55	–
		1.64	510	14.5	6.5	2.7	27	2.2
		2.30	526	12.0	6.4	2.6	25	–
August 2	3,550	.82	134	11.0	7.2	9.6	87	–
		1.64	134	10.0	7.2	9.7	88	6.0
		2.46	133	10.0	7.2	9.9	88	–
		2.95	134	10.0	7.2	9.9	88	–
				N12 (Danby Street bridge, below)				
July 5	1,429	.82	483	15.0	7.1	7.0	70	3.1
July 18	1,510	.82	507	15.5	7.1	6.7	66	3.7
		1.48	508	15.0	7.1	6.8	67	–
August 2	3,550	.82	134	10.5	7.2	9.6	86	6.3
		1.64	133	10.5	7.2	9.6	85	–
				N13 (Lions Park northwest)				
July 5	1,440	.82	462	17.0	7.1	6.5	68	–
		1.64	464	16.5	7.1	6.2	65	11.9
		2.46	466	16.0	7.1	6.2	64	–
		3.28	485	14.0	6.9	6.1	60	–
		4.10	479	12.5	6.8	5.6	53	–
		4.92	455	8.5	6.7	4.3	37	–
		5.74	419	4.5	6.5	1.3	10	–
		6.56	423	3.5	6.5	.6	4	–
		7.38	437	3.5	6.5	.5	4	–
July 18	1,510	.82	500	17.0	7.1	6.7	69	–
		1.64	504	16.5	7.0	5.7	59	3.4
		2.46	515	16.0	6.9	4.8	48	–
		3.28	515	15.0	6.8	4.3	42	–
		4.10	525	13.5	6.8	3.8	36	–
		4.92	498	11.0	6.6	3.0	27	–
		5.74	439	5.5	6.6	3.1	25	–
		6.56	430	4.0	6.5	2.3	18	33.8
		7.38	428	3.5	6.5	.5	3	–
		8.20	447	2.5	6.5	.3	2	–
August 2	3,550	.82	133	11.0	7.2	9.6	87	–
		1.64	133	10.5	7.2	9.6	87	7.6
		2.46	133	10.5	7.2	9.6	86	–
		3.28	133	10.5	7.2	9.6	86	–
	3,550	4.10	133	10.5	7.2	9.6	86	–
		4.92	132	10.5	7.2	9.6	86	–

Table 3. Water quality measured at midstream during low-flow and high-flow conditions at sampling sites in Noyes Slough, Fairbanks, Alaska, July–August 2001–*Continued*

[**Chena River flow:** Less than 2,400 cubic feet per second during low-flow conditions, and greater than 2,400 cubic feet per second during high-flow conditions.**Abbreviations:** ft^3/s, cubic feet per second; ft, feet; µS/cm, microSiemens per centimeter corrected to a standard value of 25ºC; ºC, degrees Celsius; mg/L, milligrams per liter; %, percent; –, no data]

Date (2001)	Chena River flow (ft^3/s)	Sample depth (ft)	Specific conductance (µS/cm)	Temperature (°C)	pH (standard units)	Dissolved-oxygen concentration (mg/L)	Dissolved-oxygen saturation (%)	Turbidity (nephelometric turbidity units)
N13 (Lions Park northwest)—*Continued*								
		5.74	133	10.0	7.2	9.5	85	–
		6.56	132	10.0	7.2	9.5	85	5.9
		7.38	132	10.0	7.2	9.5	85	–
		8.20	132	10.0	7.2	9.5	85	–
N14 (Aurora Drive bridge, above)								
July 5	1,440	.82	427	18.5	7.3	8.6	93	–
		1.64	424	18.0	7.3	8.5	91	15.9
		2.46	375	16.0	7.0	5.2	54	–
July 18	1,500	.82	466	19.0	7.5	9.6	104	–
		1.64	462	18.0	7.5	9.8	103	1.9
		2.46	461	18.0	7.5	9.4	98	–
August 2	3,530	.82	128	11.0	7.1	9.2	83	–
		1.64	128	11.0	7.1	9.2	83	9.1
		2.46	128	11.0	7.1	9.1	82	–
		2.95	128	11.0	7.1	9.1	82	–
N15 (Aurora Drive bridge, below)								
July 18	1,500	.82	466	18.0	7.4	8.4	88	15.9
		1.31	466	18.0	7.3	8.1	85	–
August 2	3,530	.82	128	11.0	7.1	9.1	82	7.0
		1.64	128	11.0	7.1	9.0	82	–
		1.97	128	11.0	7.1	9.0	82	–
N16 (Smith Street)								
July 5	1,440	.82	399	16.0	7.2	6.4	65	–
		1.64	402	15.5	7.1	5.7	58	11.4
		2.46	408	15.0	6.8	3.3	33	–
		3.28	443	12.0	6.6	.8	8	–
		4.10	481	9.0	6.6	.5	4	–
		4.92	500	7.5	6.6	.3	2	–
July 18	1,500	.82	438	18.0	7.2	7.0	73	–
		1.64	438	17.0	7.2	6.8	70	3.9
		2.46	438	16.0	6.8	3.9	40	–
		3.28	450	14.5	6.7	2.7	27	–
		4.10	–	-	-	-	-	23.2
		4.76	473	10.0	6.5	.5	5	–
August 2	3,530	.82	134	12.5	7.1	8.5	80	–
		1.64	135	11.5	7.0	8.3	77	7.8
		2.46	132	11.0	7.0	8.4	76	–
		3.28	129	11.0	7.0	8.4	76	–
		4.10	129	11.0	7.0	8.4	76	9.0
		4.92	132	10.5	7.0	8.1	73	–
		5.41	131	10.5	7.0	8.1	73	–

Table 3. Water quality measured at midstream during low-flow and high-flow conditions at sampling sites in Noyes Slough, Fairbanks, Alaska, July–August 2001—*Continued*

[**Chena River flow:** Less than 2,400 cubic feet per second during low-flow conditions, and greater than 2,400 cubic feet per second during high-flow conditions.**Abbreviations:** ft^3/s, cubic feet per second; ft, feet; µS/cm, microSiemens per centimeter corrected to a standard value of 25ºC; ºC, degrees Celsius; mg/L, milligrams per liter; %, percent; –, no data]

Date (2001)	Chena River flow (ft^3/s)	Sample depth (ft)	Specific conductance (µS/cm)	Temperature (°C)	pH (standard units)	Dissolved-oxygen concentration (mg/L)	Dissolved-oxygen saturation (%)	Turbidity (nephelometric turbidity units)
				N17 (Central Avenue)				
July 24	1,140	0.82	402	19.0	7.5	7.9	55	–
		1.64	402	19.0	7.5	7.8	83	2.3
		2.46	402	18.5	7.5	7.5	81	–
		3.28	402	18.5	7.5	7.3	78	–
		3.94	402	18.5	7.4	6.8	72	–
August 2	3,489	.82	146	12.0	7.0	8.2	77	–
		1.64	146	12.0	7.0	8.2	76	7.6
		2.46	146	12.0	7.0	8.1	75	–
		3.28	147	12.0	7.0	8.1	75	–
		4.10	147	12.0	7.0	8.0	74	–
		4.92	148	12.0	7.0	7.9	73	–
		5.58	148	11.5	7.0	7.7	71	–
				N18 (Deere Street)				
July 24	1,140	.82	386	18.5	7.6	7.1	76	–
		1.64	385	18.0	7.5	6.8	72	2.8
		2.46	382	18.0	7.5	5.8	62	–
		3.28	382	17.0	7.1	2.3	24	–
		3.77	386	16.5	7.0	1.3	14	–
August 2	3,489	.82	150	12.0	7.1	8.3	77	–
		1.64	150	12.0	7.1	8.2	76	7.6
		2.46	150	12.0	7.1	8.2	76	–
		3.28	151	12.0	7.1	8.2	76	–
		4.10	153	12.0	7.0	8.1	75	–
		4.59	153	12.0	7.1	7.9	74	–
				N19 (Commerce Street)				
July 5	1,440	.82	362	17.5	7.3	5.9	63	–
		1.64	360	16.0	7.1	3.9	40	6.1
July 18	1,490	.82	383	19.5	7.5	8.1	87	–
		1.64	378	18.0	7.4	7.9	83	4.4
		1.97	377	17.5	7.3	7.9	83	–
August 2	3,489	.82	160	12.5	7.0	7.7	72	–
		1.64	159	12.5	7.0	7.7	72	7.7
		2.46	159	12.5	7.0	7.6	72	–
		3.28	159	12.5	7.0	7.6	71	–
		3.77	159	12.5	7.0	7.6	71	–
				N20 (Spafford Lane)				
July 5	1,450	.82	365	18.5	7.3	5.4	58	–
		1.64	365	18.0	7.3	5.2	56	5.1
		2.46	365	18.0	7.3	5.1	54	–
		3.28	366	18.0	7.3	4.7	50	–
		4.10	361	17.5	7.2	3.9	41	–
		4.92	315	15.5	6.9	.4	4	–
		5.74	325	12.5	7.0	.2	2	–

Table 3. Water quality measured at midstream during low-flow and high-flow conditions at sampling sites in Noyes Slough, Fairbanks, Alaska, July–August 2001—*Continued*

[**Chena River flow:** Less than 2,400 cubic feet per second during low-flow conditions, and greater than 2,400 cubic feet per second during high-flow conditions.**Abbreviations:** ft^3/s, cubic feet per second; ft, feet; µS/cm, microSiemens per centimeter corrected to a standard value of 25ºC; ºC, degrees Celsius; mg/L, milligrams per liter; %, percent; –, no data]

Date (2001)	Chena River flow (ft^3/s)	Sample depth (ft)	Specific conductance (µS/cm)	Temperature (°C)	pH (standard units)	Dissolved-oxygen concentration (mg/L)	Dissolved-oxygen saturation (%)	Turbidity (nephelometric turbidity units)
			N20 (Spafford Lane)—*Continued*					
July 18	1,490	0.82	362	20.0	7.6	7.3	80	–
		1.64	364	18.5	7.5	7.1	76	3.2
		2.46	363	18.0	7.5	6.7	71	–
		3.28	362	18.0	7.5	6.3	66	–
		4.10	362	17.5	7.4	5.0	52	–
		4.92	357	16.0	7.1	1.0	10	38.8
		5.74	358	13.0	6.9	.2	2	–
August 2	3,489	.82	196	14.5	7.1	7.1	69	–
		1.64	187	13.5	7.0	7.1	68	8.1
		2.46	192	13.0	7.0	6.8	65	–
		3.28	195	13.0	7.0	6.5	61	–
		4.10	196	13.0	7.0	6.4	61	–
		4.92	198	12.5	7.0	6.1	57	8.3
		5.74	201	12.5	6.9	6.0	56	–
		6.56	202	12.5	6.9	5.9	55	–
		7.38	203	12.5	6.9	5.7	54	–
			N21 (West Alaska Railroad, above)					
July 24	1,140	.82	334	19.0	7.4	6.0	64	–
		1.64	334	19.0	7.4	5.8	62	2.2
		2.46	333	19.0	7.4	5.6	60	–
		3.28	333	19.0	7.3	5.5	59	–
		3.61	334	19.0	7.3	5.4	59	–
August 2	3,439	.82	247	14.0	7.0	6.6	64	–
		1.64	249	14.0	7.0	6.6	64	9.2
		2.46	249	14.0	7.0	6.5	63	–
		3.28	249	14.0	7.0	6.5	63	–
		3.94	249	14.0	7.0	6.5	63	–
			N22 (West Alaska Railroad, below)					
July 24	1,130	.82	332	19.0	7.5	6.7	72	–
		1.64	332	19.0	7.5	6.6	71	3.8
		2.46	332	19.0	7.5	6.5	71	–
		3.28	332	19.0	7.5	6.5	71	–
		3.94	333	19.0	7.5	5.8	63	–
August 2	3,439	.82	266	14.5	7.0	6.8	66	–
		1.64	260	14.0	7.0	6.7	65	9.0
		2.46	257	14.0	7.0	6.5	63	–
		3.28	258	14.0	7.0	6.4	63	–
		4.10	258	14.0	7.0	6.4	63	–
			N23 (West Johansen bridge, above)					
July 24	1,130	.82	331	19.0	7.3	4.8	51	–
		1.64	332	19.0	7.2	4.3	46	4.5
		2.46	332	19.0	7.2	4.2	45	–
		3.12	333	19.0	7.2	3.6	38	–

Table 3. Water quality measured at midstream during low-flow and high-flow conditions at sampling sites in Noyes Slough, Fairbanks, Alaska, July–August 2001–*Continued*

[**Chena River flow:** Less than 2,400 cubic feet per second during low-flow conditions, and greater than 2,400 cubic feet per second during high-flow conditions.**Abbreviations:** ft^3/s, cubic feet per second; ft, feet; µS/cm, microSiemens per centimeter corrected to a standard value of 25ºC; ºC, degrees Celsius; mg/L, milligrams per liter; %, percent; –, no data]

Date (2001)	Chena River flow (ft^3/s)	Sample depth (ft)	Specific conductance (µS/cm)	Temperature (°C)	pH (standard units)	Dissolved-oxygen concentration (mg/L)	Dissolved-oxygen saturation (%)	Turbidity (nephelometric turbidity units)
N23 (West Johansen bridge, above)—*Continued*								
August 2	3,439	0.82	299	14.5	7.0	6.1	60	–
		1.64	292	14.5	7.0	5.9	58	9.2
		2.46	298	14.0	7.0	5.4	52	–
		3.28	311	14.0	7.0	5.2	50	–
		4.10	315	14.0	7.0	5.0	49	–
		4.76	314	14.0	7.0	4.9	48	–
N24 (West Johansen bridge, below)								
July 5	1,450	< .82	401	14.0	7.3	8.0	78	9.3
July 18	1,490	< .82	347	16.5	7.3	5.8	59	9.3
August 2	3,439	.82	325	15.0	7.0	5.7	57	9.9
		1.64	329	14.5	7.0	5.4	54	–
		2.46	332	14.5	7.0	5.3	52	–
		3.28	328	14.5	7.0	5.2	52	–
N25 (Indiana Avenue)								
July 5	1,450	< .82	213	16.0	7.1	7.6	77	12.4
July 18	1,490	.82	376	18.5	7.3	8.7	93	7.2
August 2	3,469	.82	382	15.0	7.0	5.9	58	9.2
		1.64	382	15.0	7.0	5.8	58	–
		2.46	381	15.0	7.0	5.7	57	–
		3.28	381	15.0	7.0	5.7	57	–
		3.61	381	15.0	7.0	5.7	56	–
N26 (Goldizen Avenue bridge)								
July 5	1,460	.82	202	15.0	7.2	8.5	85	–
		1.64	208	15.0	7.2	8.6	87	6.0
		2.46	208	15.0	7.2	8.7	88	–
July 18	1,490	.82	239	18.0	7.3	8.9	93	–
		1.64	237	17.0	7.3	8.7	90	6.5
		2.46	208	15.5	7.2	8.6	86	–
		3.61	196	15.0	7.2	8.6	85	–
August 2	3,469	.82	409	16.5	7.1	5.8	59	–
		1.64	405	16.0	7.1	5.7	57	8.3
		2.46	384	13.5	7.1	6.1	58	–
		3.28	263	12.0	7.1	7.6	71	–
		4.10	258	12.0	7.1	8.4	78	–
		4.92	193	10.5	7.2	9.8	88	–
		5.74	193	10.5	7.2	9.4	85	–
		6.56	193	10.5	7.2	9.4	85	–
Minimum	1,130	.82	128	2.5	6.4	0.2	2	1.9
Maximum	3,600	8.20	603	20.0	7.6	10.9	104	52.9

Table 4. Mean daily water temperatures measured at selected sites in Noyes Slough, Fairbanks, Alaska, June–August 2001

[**Abbreviations**: °C, degrees Celsius]

Day of month	Water temperature (°C)				
	N2 (Minnie Street bridge)	N8 (O'Connor Road bridge)	N13 (Lions Park northwest)	N20 (Spafford Lane)	N26 (Goldizen Avenue bridge)
June 2001					
1	10.5	11.5	12.0	13.0	11.0
2	11.5	12.0	12.5	15.0	12.5
3	12.5	13.0	13.0	15.5	14.0
4	13.0	13.0	14.0	15.5	14.5
5	13.0	13.5	14.5	16.0	15.5
6	13.5	14.0	14.5	16.0	16.0
7	13.5	14.0	14.5	16.0	15.0
8	12.5	13.5	14.5	15.5	13.5
9	11.0	13.5	14.0	16.0	11.0
10	9.5	11.0	13.5	17.0	10.5
11	10.5	11.0	15.5	17.0	11.5
12	11.5	12.5	16.5	17.5	15.0
13	12.0	13.5	16.5	17.5	16.0
14	13.0	14.5	16.0	17.0	15.0
15	13.0	14.0	15.5	16.5	15.0
16	13.5	14.5	15.5	17.0	15.5
17	14.5	15.0	16.5	18.5	16.5
18	15.5	16.0	18.0	20.0	17.5
19	16.5	17.0	18.5	20.5	18.0
20	17.0	17.5	19.0	21.0	18.0
21	17.5	17.5	18.5	20.5	17.0
22	17.5	18.0	18.0	20.0	17.0
23	18.0	18.0	18.0	20.5	17.0
24	18.5	18.5	18.5	21.0	17.5
25	19.0	18.5	19.0	21.0	18.5
26	18.5	19.0	19.0	21.0	18.5
27	17.5	18.0	18.0	20.0	17.0
28	17.0	17.0	17.0	19.0	17.0
29	18.0	17.5	18.0	19.5	19.5
30	18.0	18.0	17.5	19.5	17.5
July 2001					
1	17.5	17.5	17.0	19.5	16.5
2	18.5	17.5	17.5	19.5	16.5
3	18.5	17.5	18.0	20.0	17.0
4	17.5	17.5	18.0	19.0	16.5
5	16.5	16.5	16.5	18.5	15.0
6	15.5	15.5	15.5	17.5	14.0
7	14.0	14.5	14.0	16.0	12.5
8	11.5	13.5	13.5	15.5	10.5
9	9.5	12.5	13.5	15.0	10.0
10	10.5	13.5	14.0	15.5	11.0
11	12.0	14.5	15.0	16.5	12.0
12	13.0	15.0	15.5	16.5	13.0
13	14.5	15.5	16.0	17.0	14.0
14	15.0	16.0	16.0	17.5	14.5
15	15.5	16.0	16.0	17.5	15.5
16	16.5	16.5	17.5	18.5	16.0
17	17.0	17.5	18.0	19.0	16.0
18	16.5	17.0	17.5	18.5	15.5

Table 4. Mean daily water temperatures measured at selected sites in Noyes Slough, Fairbanks, Alaska, June–August 2001–*Continued*

[**Abbreviations**: °C, degrees Celsius]

Day of month	Water temperature (°C)				
	N2 (Minnie Street bridge)	N8 (O'Connor Road bridge)	N13 (Lions Park northwest)	N20 (Spafford Lane)	N26 (Goldizen Avenue bridge)
July 2001					
19	17.0	17.5	17.5	19.0	16.0
20	18.0	18.0	18.0	20.0	15.5
21	18.0	18.5	18.0	20.0	16.0
22	18.5	19.0	19.0	20.5	16.0
23	18.5	19.0	19.0	20.5	16.0
24	18.0	18.5	18.5	19.5	16.0
25	18.5	18.5	18.5	19.5	16.0
26	18.0	18.0	18.5	19.5	16.0
27	17.0	17.0	18.0	19.0	15.5
28	15.5	16.0	16.5	17.5	14.5
29	14.5	14.5	15.0	16.5	13.5
30	13.5	14.5	15.0	16.0	12.0
31	9.0	10.5	12.5	15.5	10.0
August 2001					
1	9.0	9.5	10.0	13.5	10.5
2	10.0	10.5	10.5	13.0	10.5
3	10.5	11.0	11.5	12.5	11.5
4	11.0	11.5	12.5	13.0	11.0
5	10.5	11.0	12.0	12.5	10.5
6	10.0	11.0	12.0	12.5	9.5
7	10.5	11.5	13.5	13.0	10.0
8	11.5	12.5	13.5	14.0	10.5
9	12.5	13.0	14.5	14.5	12.0
10	13.0	13.5	14.5	15.0	12.5
11	13.0	13.5	14.5	14.5	12.0
12	12.5	13.5	14.0	14.0	11.5
13	12.5	13.5	13.0	14.0	11.0
14	13.5	13.5	13.5	14.5	11.5
15	13.5	13.5	13.0	14.0	10.5
16	12.0	13.5	13.5	14.5	11.0
17	9.5	13.0	12.5	14.0	10.0
18	9.0	10.5	11.5	13.5	10.0
19	9.0	9.0	10.0	12.5	10.5
20	9.0	9.5	10.0	12.0	10.5
21	9.5	10.0	10.5	12.5	10.5
22	9.5	10.0	10.5	12.0	10.5
23	9.5	10.0	10.0	11.5	10.5
24	9.5	10.0	10.5	11.5	9.5
25	10.0	10.5	11.0	12.0	9.5
26	10.0	11.0	11.0	12.0	10.0
27	10.5	11.0	11.0	12.0	10.5
28	10.5	11.0	11.0	12.0	10.0
29	10.5	11.5	11.0	12.5	10.0
Minimum	9.0	9.0	10.0	11.5	9.5
Maximum	19.0	19.0	19.0	21.0	19.5

Table 5. Federal and State of Alaska water-quality standards, criteria, or screening values

[**Standard or Criteria:** Level not to be exceeded except where noted; **ADEC**, Alaska Department of Environmental Conservation, 1977; **USEPA:** U.S. Environmental Protection Agency, 1986b; **Abbreviations**: mg/L, milligrams per liter; NTU, nephelometric turbidity units; ºC, degrees Celsius; >, greater than]

Water-quality constituent (units)	Noyes Slough water-quality constituent range	Standard or criteria	
		State ADEC	Federal USEPA
Dissolved oxygen (mg/L)	0.2 - 10.9	>5.0	>5.5
pH (standard units)	6.4 - 7.6	6.5-8.5	6.5-9.0
Turbidity (NTU)	1.9 - 52.9	[1](25)	[1](25)
Water temperature (ºC)	[2]9.0 - 21.0	15	[3](5-17)

[1]Sigler and others (1984) suggest a limit for salmonids of 25 nephelometric turbidity units.
[2]Mean daily water temperatures, June through August 2001.
[3]Brungs and Jones (1977) suggest water temperature of 5-17ºC for salmonids growth.

Water-quality characteristics provide information on the general environmental conditions for fish. Although conductance does not directly affect fish, it is a good approximation of total dissolved solids, which is often increased by human activities (Lettenmaier and others, 1991). Likewise, pH is a measure of the effective hydrogen-ion concentration, which is controlled by many factors. Changes in these characteristics along a stream or over time can help identify degraded habitat. Dissolved-oxygen concentrations and turbidity directly affect fish. Low concentrations of dissolved oxygen can make water uninhabitable by certain species and cause stress at non-lethal limits (Beschta and others, 1987). Turbidity can impair visibility and feeding (Bisson and Bilby, 1982) or physically harm the respiratory system (Martens and Servizi, 1993).

Depth profiles showed that during low-flow conditions in Noyes Slough oxygen was depleted as a function of depth (fig. 12). The vertical distribution of dissolved-oxygen concentrations resembled that of standing eutrophic waters with a high level of organic production (Wetzel, 1983). This typically is caused by high levels of biochemical oxygen demand, particularly at the sediment-water interface, in waters that are not well mixed.

During high-flow conditions, however, water in the slough was mixed enough to partially offset this layering effect (fig. 12). The mixing brought dissolved-oxygen concentrations above criteria for aquatic life in most reaches. Concentrations of dissolved oxygen varied greatly along the length of Noyes Slough during low flow, but became more uniform during high-flow conditions when the slough was supplied with water from the Chena River (fig. 13). Average dissolved-oxygen concentrations increased at most sites during high flow, with the largest changes occurring in the upper one-half of the slough. The lower three reaches showed an anomalous trend, with concentrations lower at high flow than at low flow (fig. 13).

The mixing action created with increased flow is further demonstrated by the differences in specific conductance between low flow and high flow (fig. 12). During high flow, mean specific conductance decreased at most sites—by 50 percent or greater at 14 of 26 sites, potentially the result of dissolved solids being flushed downstream. The effect of mixing during high flow also was apparent in the distribution of specific conductance throughout the slough (fig. 13). During low flow, when water from the Chena River was not entering Noyes Slough, conductance varied greatly, and values at nearly three-fourths of the sites were greater than 300 µS/cm. During high flow, only the last four downstream reaches had values greater than 300 µS/cm, another indication that dissolved solids were accumulating at the downstream end.

The distribution of water temperature in the slough was moderated by high flow (fig. 13). A typical downstream warming trend was observed during high flow and average temperatures remained below the State criterion of 15^{o}C for rearing fish (Alaska Department of Environmental Conservation, 1997). Mixing resulted in fewer extremes, and a relatively narrow range of temperatures was measured along depth intervals in most locations.

In summary, water sampled in Noyes Slough during the summer of 2001 for this study was generally neutral (pH, 6.4-7.6 standard units), mean daily water temperatures ranged from 9.0 to 21.0^{o}C, measured concentrations of dissolved oxygen ranged from 0.2 to 10.9 mg/L, and specific conductance ranged from 128 to 603 µS/cm. A full understanding of the dynamics that relate to fish use includes the water-quality conditions and streamflow variation in the slough at other times of the year. Examining water-quality attributes during periods of low flow and high flow during summer provides a useful starting point to characterize the slough dynamics.

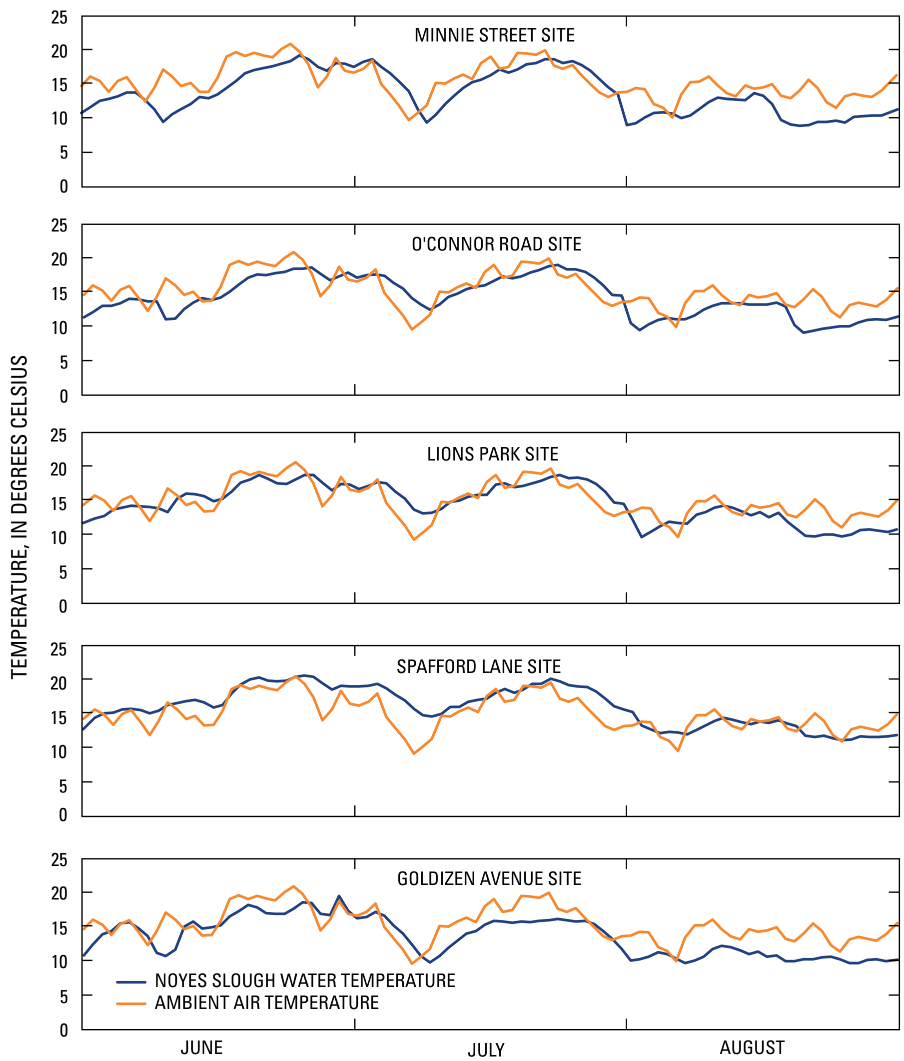


Figure 11. Mean daily water temperature and ambient air temperature for Noyes Slough, Fairbanks, Alaska, June 1-August 30, 2001.
Initial depth of water temperature loggers was 1.6 feet at all sites.

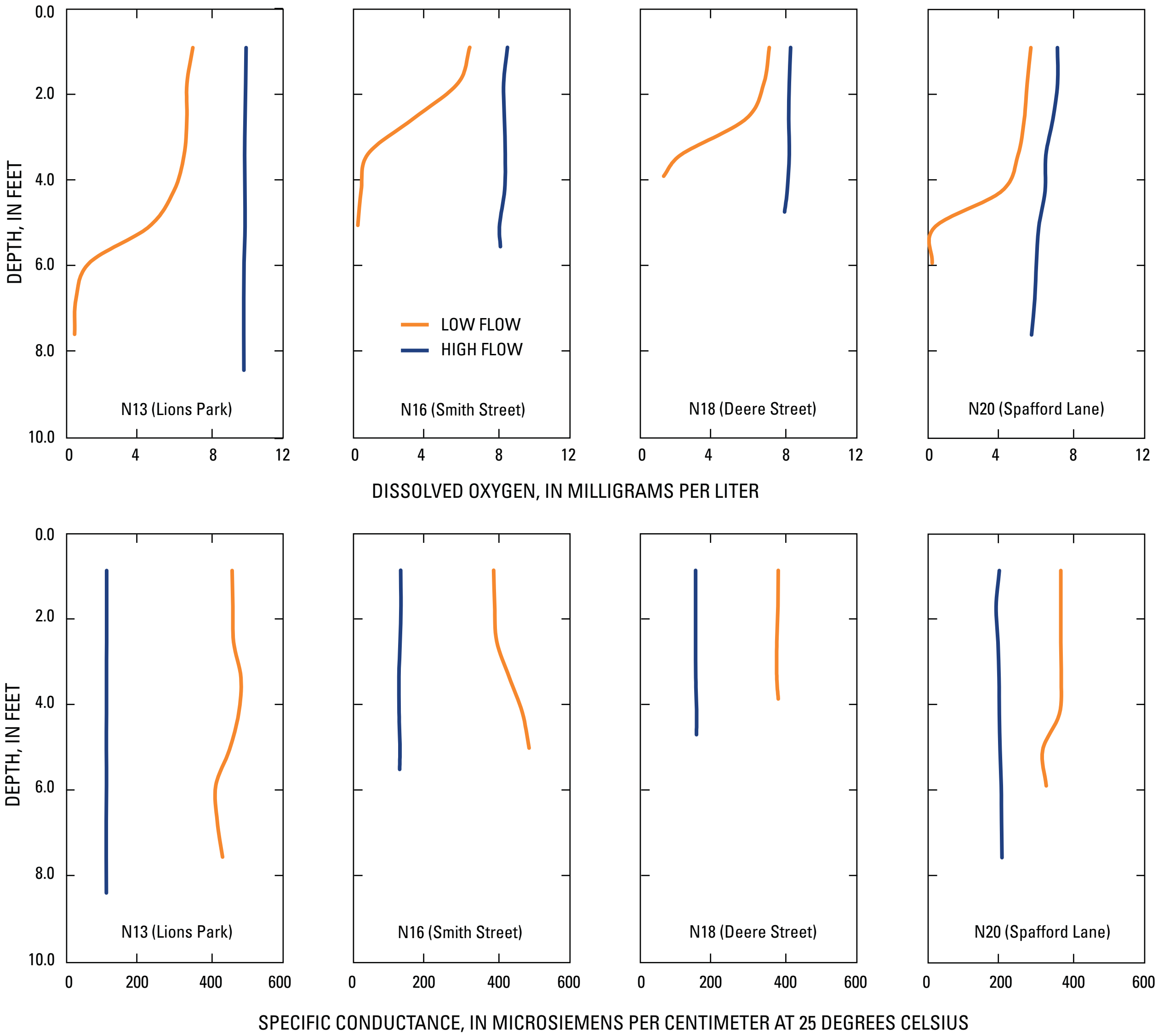


Figure 12. Depth profiles for dissolved-oxygen concentration and specific conductance during high-flow and low-flow conditions at selected sites in Noyes Slough, Fairbanks, Alaska, 2001.

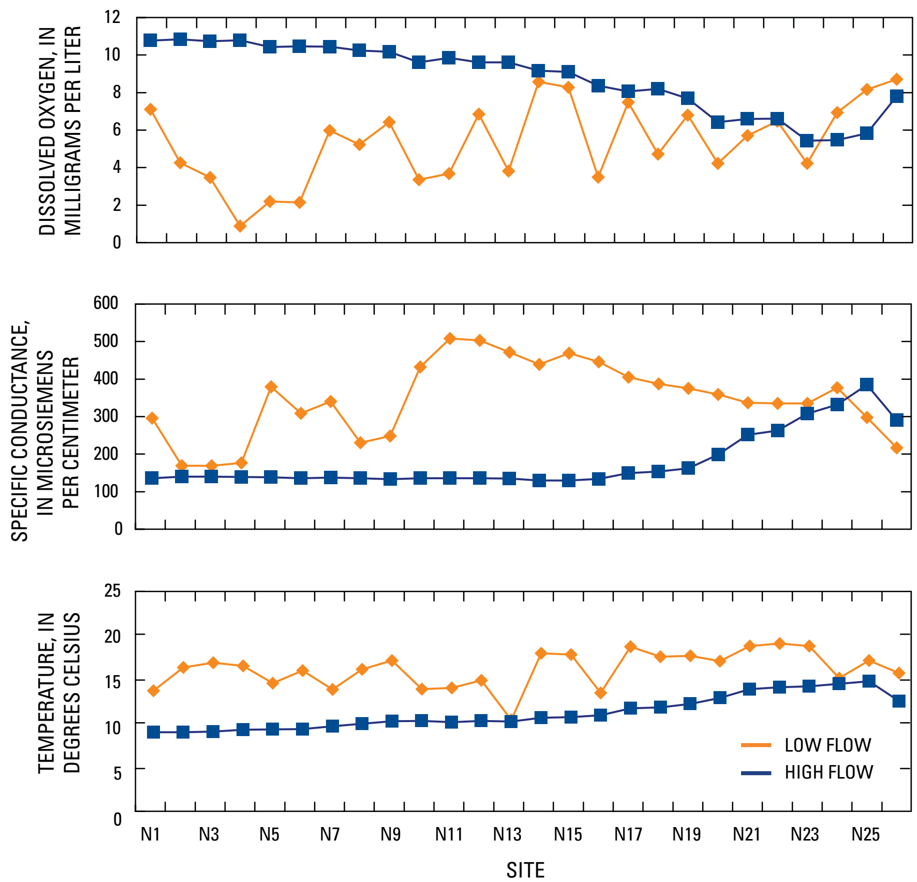


Figure 13. Mean values of dissolved-oxygen concentration, specific conductance, and water temperature during low-flow and high-flow conditions in Noyes Slough, Fairbanks, Alaska, 2001.
Sites are numbered consecutively from the upstream end.

Assessment of Selected Contaminants in Streambed Sediments

Analysis of trace elements and organic compounds in streambed-sediment samples provides a reliable means for assessing the occurrence, concentration, and distribution of contaminants in an aquatic system. Most trace elements and many anthropogenic organic compounds are known to associate with fine-grained sediments (Van Metre and Callender, 1997). Consequently, even though the water may contain only small quantities of these constituents, suspended sediment and bed sediment may contain relatively large concentrations (Shelton and Capel, 1994). Accordingly, sampling and analysis of bed-sediment material increases the likelihood that contaminants will be detected and that spatial distribution of contaminants in the aquatic environment can be evaluated.

Data Collection, Analytical Methods, and Aquatic-Life Criteria

Streambed-sediment samples were collected at selected sites in Noyes Slough during July and September 2001 and June and October 2002. Twenty-three sites were sampled (fig. 3; table 1). The sampling sites were numbered consecutively from the upstream inlet (SED01) to the downstream confluence with the Chena River (SED23). Distance between sampling sites ranged from a minimum of about 800 ft to a maximum of about 2,500 ft. Replicate sediment samples were collected at sites SED02 and SED23 for quality-control purposes. Samples were chilled in the field and shipped overnight to Severn Trent Analytical Services Group Laboratories (STL) in Arvada, Colo., for analyses of trace elements and organic-compound contaminants. One shipment containing five sediment samples (SED19, SED21, SED22, SED23, and SED23R) was misdirected enroute to the laboratory and exceeded holding times. These sites were resampled in late September 2001. Collection and field processing of streambed-sediment samples followed established National Water-Quality Assessment (NAWQA) Program protocols (Shelton and Capel, 1994), except that samples shipped to STL were bulk sediment rather than wet-sieved. Streambed sediments were collected from depositional zones selected to represent various streamflow regimes. Variations in thickness and distribution of sediments in Noyes Slough were dependent on flow regimes and control structures such as beaver dams and inflow from culverts.

Analytical results for organic compounds indicated that non-target interfering compounds (most likely chlorophyll) were present in the sample matrix material of samples collected during 2001 (Severn Trent Laboratories, 2001a; 2001b). In an attempt to reduce the effects of matrix interference, samples were analyzed at relatively large dilutions and many of the target analytes were diluted out or the minimum reporting limits were elevated due to the dilution. Because the analyses for organic compounds in samples collected during 2001 were largely unsuccessful, they are not presented in this report. During early June 2002, five sites were resampled for organic contaminants to determine if chlorophyll-matrix interference problems were reduced in samples collected just after spring break-up of ice cover. However, STL analytical reports indicated that matrix interference effects also were a significant problem for the June 2002 samples (Severn Trent Laboratories, 2002). To minimize chlorophyll levels, resampling of bed sediment for organic contaminants was then delayed until October 2002, when ice covered about 95 percent of the slough. All odd numbered sample sites, SED01 through SED23, were resampled through ice cover for organic contaminants, and one replicate sample was collected at the SED01 site, for a total of 13 samples. The replicate sample, SED01R, was composited from sediment about 10 cm below the bed sediment-water interface. Ice thickness averaged 2-15 cm and was breached with the assistance of an ice chisel or ice auger to gain access to streambed sediments (fig. 14).

Figure 14. Sampling of streambed sediments under ice cover in Noyes Slough, Fairbanks, Alaska, October 2002.

Sampling was confined to the upper 2-10 cm of streambed sediment. At each sampling site, five subsamples were collected, composited, and passed through a 2-millimeter sieve. Samples were shipped overnight to the USGS National Water-Quality Laboratory (NWQL) in Arvada, Colo., for analyses. The container for sample SED21 was broken in transit. Bed sediment at the SED21 site was resampled 4 days later. There were no significant precipitation events between collection of the initial SED21 sample on October 16 and the replacement sample collection on October 21, and ice-cover at the sample site remained at 100 percent.

Composite streambed-sediment samples were analyzed for selected trace-element constituents at STL. Standard USEPA analytical protocols were followed in the analysis of the samples (table 6). Analytical methods are described by the U.S. Environmental Protection Agency (1986a; 1983). Sediment samples were analyzed for selected organic compounds at NWQL. Links to NWQL quality-assurance and analytical procedures are available at the NWQL Web page (http://wwwnwql.cr.usgs.gov/USGS/USGS_srv.html). Laboratory quality-control methods are rigorous for both laboratories and include analysis of blank and spiked samples to quantify analytical accuracy of the reported concentrations.

Table 6. Analytical methods, method detection levels, and laboratory reporting levels for analyzed trace elements in streambed-sediment samples from Noyes Slough, Fairbanks, Alaska, 2001

[**Methods:** U.S. Environmental Protection Agency, 1986a. **Abbreviations: STL-MDL:** Severn Trent Laboratories method detection levels are the levels at which the analyses can detect but not report accurate concentrations for a particular constituent. **STL-RL:** Severn Trent Laboratories reporting levels are the minimum levels at which the analyses can accurately determine constituent concentrations. **MinRL and MaxRL:** Minimum and maximum reporting levels for samples vary with dry weight of the specific sample. **Abbreviations**: mg/kg, milligram per kilogram, dry weight]

Trace element	Method	Concentration (mg/kg)			
		STL-MDL	STL-RL	Sample	
				MinRL	MaxRL
Aluminum	SW846 6010B	3.1	10	13.9	26.2
Antimony	SW846 6010B	.35	1	1.4	2.6
Arsenic	SW846 6010B	.49	1	1.4	2.6
Barium	SW846 6010B	.12	1	1.4	2.6
Beryllium	SW846 6010B	.14	.5	.7	1.3
Cadmium	SW846 6010B	.10	.5	.7	1.3
Calcium	SW846 6010B	3.2	20	27.8	52.3
Chromium	SW846 6010B	.44	1	1.4	2.6
Cobalt	SW846 6010B	.15	1	1.4	2.6
Copper	SW846 6010B	.27	2	2.8	5.2
Iron	SW846 6010B	2.0	10	13.9	26.2
Lead	SW846 6010B	.39	.8	1.1	2.1
Magnesium	SW846 6010B	1.53	20	27.8	52.3
Manganese	SW846 6010B	.14	1	1.4	2.6
Mercury	SW846 7471A	.0037	.033	.046	.086
Molybdenum	SW846 6010B	.24	2	2.8	5.2
Nickel	SW846 6010B	.72	4	5.6	10.5
Potassium	SW846 6010B	31	300	417	785
Selenium	SW846 6010B	.45	1.3	1.8	3.4
Silver	SW846 6010B	.12	1	1.4	2.6
Sodium	SW846 6010B	350	500	695	1,310
Thallium	SW846 6010B	.42	1.2	1.7	3.1
Vanadium	SW846 6010B	.35	1	1.4	2.6
Zinc	SW846 6010B	.73	2	2.8	5.2

STL analytical results for trace elements are expressed as concentrations when they exceeded the Minimum Reporting Level (MRL), as detected (D) when they exceeded the Method Detection Level (MDL) but are less than the MRL, and as not detected (ND) when they were less than the MDL. The Method Detection Level is the minimum concentration of a substance that can be measured and reported with 99-percent confidence that the analyte concentration is greater than zero. It is determined from the analysis of a sample in a given matrix containing the analyte (U.S. Environmental Protection Agency, 1997). The MRL is the smallest measured concentration of a constituent that may be reliably reported by using a given analytical method. NWQL analytical results for organic compounds were expressed as concentrations when they exceeded the MRL, as estimated (E) when values exceeded the MDL but were less than the MRL or the analyte has a high variable recovery, and as less than (<) when concentrations were less than the MDL. Trace element and organic compound concentrations were reported on a dry weight basis.

There are no official Federal or State of Alaska standards for trace-element concentrations in freshwater streambed sediments. However, sediment-quality guidelines for a select number of elements and compounds have been proposed by several agencies and organizations to assess potential effects of sediment contamination on aquatic life. For bulk bed-sediment samples, the Canadian Council of Ministers of the Environment (1999) published probable effect levels (PELs), above which adverse effects to aquatic biota are likely to occur. MacDonald and others (2000) compiled sediment-quality guidelines (SQG) and data from several sources and developed consensus-based probable effect concentration (CB-PECs) guidelines for freshwater ecosystems. Gilliom and others (1998) summarized aquatic-life criteria from various agencies and compiled national median values based on streambed-sediment data collected at 198 nonrandom sites by the USGS NAWQA Program.

Aquatic-life criteria and national data sets are useful for comparison purposes. They provide perspective for evaluation of the streambed-sediment data, but should be used only as indicators of potential sediment-quality problems that may warrant further examination. On the other hand, the absence of criteria for a particular contaminant, or the presence of contaminants that do not exceed one or more criteria, does not necessarily imply that there are no environmental issues of concern at that site. Mixtures of contaminants found at some sites could behave synergistically to cause adverse biological effects that are not indicated by criteria developed for individual contaminants (U.S. Geological Survey, 1999).

Trace Elements

Bed-sediment samples collected during 2001 from 23 sites were analyzed for 24 selected trace elements. Table 6 presents the list of target analytes, methods, reporting units, and sample reporting limits. Analytical trace element data are summarized in table 7.

Agreement between reported trace-element concentrations of replicate bed-sediment samples collected at sites SED02 and SED23 varied. There were significant differences in reported trace-elements concentrations between the SED02 and SED02R samples. Sample SED02 concentrations were 10-30 percent less than concentrations reported for sample SED02R. The sample variance may have been the result of the SED02R sample containing a greater portion of fine-grained material, as suggested by its higher aluminum concentration. Aluminum concentration often can be a broad indicator of aluminosilicate clay content. The aluminum concentration of SED02 (11,300 mg/kg) was about 23 percent less than the aluminum concentration (14,700 mg/kg) of sample SED02R. Wang (1999) reported variances of similar magnitude between trace-element concentrations in replicate sieved and in bulk bed-sediment samples. Generally, there was good agreement between replicate bed-sediment samples SED23 and SED23R. Reported sample concentrations, including aluminum, were within 10 percent. Several trace elements were detected below reporting limits in analyses of laboratory blanks, including beryllium, cadmium, calcium, chromium, copper, iron, manganese, magnesium, selenium, sodium, and zinc. Contaminants detected in the blank analyses were less than 2 percent of reported trace-element concentrations. Reported spike sample recoveries generally were between 88 and 116 percent of the matrix spike amount except for aluminum, barium, chromium, iron, manganese, and vanadium, for which either percent recoveries were not calculated or they exceeded percent-recovery limits. In summary, data from replicate field samples and laboratory quality-control analyses suggested that the reported trace-element concentrations had an estimated uncertainty of about 10-30 percent.

Table 7. Trace-element concentrations and summary statistics for bulk streambed sediments in Noyes Slough, Fairbanks, Alaska, 2001

[**Abbreviations**: Stdev, standard deviation; TRMmean, trimmed mean excludes maximum and minimum data values: TRMstdev, trimmed standard deviation excludes maximum and minimum data values; ND, trace element not detected; B, concentration is below minimum reporting limit; mg/kg, milligram per kilogram, dry weight]

	Concentration (mg/kg)										
Sediment sampling site	Aluminum	Antimony	Arsenic	Barium	Beryllium	Cadmium	Calcium	Chromium	Cobalt	Copper	Iron
SED01	14,400	ND	14.5	150	ND	ND	5,840	26.6	12.4	29.6	28,800
SED02	14,700	1.1 B	13.0	157	ND	ND	5,340	22.6	8.9	25.4	27,800
SED03	15,900	1.4 B	16.6	181	ND	ND	5,310	25.6	11.5	30.5	28,900
SED04	14,500	1.2 B	9.9	169	ND	ND	5,340	30.1	10.6	28.2	24,500
SED05	13,900	ND	9.8	152	ND	ND	5,420	27.5	12.3	29.1	25,900
SED06	15,500	ND	16.3	185	.11 B	ND	5,880	31.1	13.6	32.3	29,300
SED07	16,800	ND	12.6	183	ND	ND	6,300	31.8	14.1	34.4	29,800
SED08	14,900	ND	11.9	165	.10 B	ND	5,360	28.4	12.2	34.4	25,900
SED09	16,600	ND	9.5	165	ND	ND	6,370	24.8	11.2	30.3	27,500
SED10	14,900	ND	13.6	165	ND	ND	6,110	27.3	12.6	31.5	29,600
SED11	13,700	ND	17.3	159	ND	ND	6,380	24.8	11.6	30.0	29,400
SED12	19,600	1.3 B	15.9	237	ND	ND	7,110	36.7	16.2	43.9	36,200
SED13	12,400	ND	11.3	299	ND	ND	6,860	32.1	11.7	34.2	22,400
SED14	10,300	ND	7.4	112	ND	ND	4,750	27.0	8.5	21.3	18,100
SED15	14,700	ND	9.3	159	ND	ND	5,280	27.4	12.6	33.1	25,900
SED16	16,200	ND	16.1	183	ND	ND	6,260	30.8	13.7	37.0	29,300
SED17	17,000	ND	16.0	244	ND	ND	6,010	34.1	15.0	40.4	30,900
SED18	18,200	1.2 B	12.5	239	ND	ND	7,440	34.1	14.9	42.5	31,500
SED19	11,000	ND	12.9	136	.30 B	.53 B	5,820	21.4	9.8	30.4	21,900
SED20	13,200	1.1 B	9.7	164	ND	ND	5,500	21.0	10.2	30.4	24,300
SED21	14,900	ND	18.2	180	.41 B	.83 B	5,130	29.0	12.4	29.4	29,000
SED22	6,830	ND	6.1	66.5	.17 B	.18 B	3,810	14.2	6.2	11.3	12,500
SED23	10,200	1.0 B	10.1	120	.24 B	.45 B	4,810	20.0	8.9	20.0	19,000
Summary Statistics[1]											
Count[2]	23	n<20	23	23	n<20	n<20	23	23	23	23	23
Maximum	19,600		18.2	299			7,440	36.7	16.2	43.9	36,200
Minimum	6,830		6.1	66.5			3,810	14.2	6.2	11.3	12,500
Range	12,770		12.1	232.5			3,630	22.5	10	32.6	23,700
Mean	14,362		12.6	172.6			5,758	27.3	11.8	30.9	26,452
Stdev	2,828		3.3	48.1			815	5.2	2.3	7.1	5,106
TRMmean	14,471		12.7	171.7			5,770	27.5	11.8	31.2	26,652
TRMstdev	2,139		2.9	34.4			632	4.1	1.9	5.3	3,763
Median	**14,700**		**12.6**	**165.0**			**5,820**	**27.4**	**12.2**	**30.4**	**27,800**

Table 7. Trace-element concentrations and summary statistics for bulk streambed sediments in Noyes Slough, Fairbanks, Alaska, 2001—*Continued.*

[**Abbreviations**: Stdev, standard deviation; TRMmean, trimmed mean excludes maximum and minimum data values: TRMstdev, trimmed standard deviation excludes maximum and minimum data values; ND, trace element not detected; B, concentration is below minimum reporting limit; mg/kg, milligram per kilogram, dry weight]

	Concentration (mg/kg)												
Sediment sampling site	**Lead**	**Magne-sium**	**Manga-nese**	**Mercury**	**Molyb-denum**	**Nickel**	**Potassium**	**Selenium**	**Silver**	**Sodium**	**Thallium**	**Vanadium**	**Zinc**
SED01	10.3	6,140	363	0.036 B	0.49 B	25.3	969	3.8	ND	538 B	ND	41.8	82.2
SED02	12.6	5,860	320	.027 B	.78 B	24.2	1,110	1.30 B	0.55 B	ND	ND	39.4	86.4
SED03	12.6	6,110	316	.035 B	.67 B	26.9	1,320	1.50 B	.64 B	ND	ND	44.5	108.0
SED04	20.3	5,780	284	.034 B	.66 B	25.1	1,140	.78 B	.57 B	ND	ND	40.2	200.0
SED05	13.3	6,130	316	.034 B	.77 B	25.7	1,060	3.6	ND	369 B	ND	41.0	104.0
SED06	14.1	6,330	324	.040 B	.77 B	27.7	1,250	4.3	ND	304 B	ND	46.9	118.0
SED07	14.1	7,080	311	.040 B	.56 B	29.5	1,240	3.7	ND	533 B	ND	47.4	115.0
SED08	12.5	6,100	318	.041 B	.55 B	26.1	1,110	3.2	ND	411 B	ND	42.8	89.5
SED09	12.7	6,690	311	.050 B	.63 B	26.9	1,310	1.50 B	.68 B	ND	ND	41.4	128.0
SED10	12	6,370	352	.066 B	ND	27.1	1,060	4.9	ND	633 B	1.2 B	40.5	97.8
SED11	12.4	6,160	398	.033 B	.28 B	25.5	1,140	3.4	.17 B	429 B	ND	39.0	87.6
SED12	17.2	7,620	459	.074 B	.53 B	34.9	1,490	4.5	ND	507 B	ND	54.5	129.0
SED13	59.4	6,000	270	.055 B	.98 B	25.6	941	3.1	.14 B	893 B	ND	34.2	562.0
SED14	56.5	4,910	173	.041 B	.30 B	19.6	761	2.7	.13 B	684 B	ND	30.2	57.4
SED15	14.4	6,560	284	.065	.30 B	26.1	996	3.2	.18 B	902	ND	44.2	78.5
SED16	16	6,850	360	.068	.60 B	29.0	1,290	3.7	.16 B	ND	ND	47.5	92.1
SED17	14.9	6,750	453	.068 B	1.10 B	31.8	1,580	ND	.33 B	911 B	ND	54.2	133.0
SED18	17.7	7,380	338	.062	.57 B	31.9	1,420	4.8	.28 B	574 B	ND	52.6	122.0
SED19	11.3	4,770	301	.080 B	.58 B	22.7	1,030	2.40 B	ND	ND	1.2 B	37.5	87.0
SED20	1,490	5,690	259	.065	.68 B	22.7	971	ND	.69 B	ND	ND	36.8	90.1
SED21	13.7	5,660	344	.060 B	.91 B	28.5	1,330	1.90 B	ND	ND	ND	46.1	142.0
SED22	4.9	3,530	188	.015 B	.22 B	14.3	619	1.20 B	ND	ND	ND	26.3	33.9
SED23	8.3	4,470	292	.046 B	.42 B	19.7	1,010	1.30 B	ND	ND	ND	35.6	57.1
Summary Statistics[1]													
Count[2]	23	23	23	n<20	n<20	23	23	n<20	n<20	n<20	n<20	23	23
Maximum	1,490	7,620	459			34.9	1,580					54.5	562
Minimum	4.9	3,530	173			14.3	619					26.3	33.9
Range	1,485.1	4,090	286			20.6	961					28.2	528.1
Mean	81.4	6,041	319			25.9	1,137					41.9	121.8
Stdev	307.4	941	67			4.4	225					7.0	101.7
TRMmean	17.9	6,085	319			26.1	1,140					42.1	105.0
TRMstdev	13.6	730	53			3.2	180					5.8	31.8
Median	**13.7**	**6,130**	**316**			**26.1**	**1,110**					**41.4**	**97.8**

[1]Summary statistics calculated for trace elements with count (*n*) greater than or equal to 20.

[2]Count does not include values that are below the minimum reporting limit, designated with "B"annotation.

Sixteen of the 24 selected trace elements were detected at all 23 bed-sediment sample sites (table 7). Molybdenum and selenium were detected in all but one and two samples, respectively. Concentrations of eight trace elements—antimony, beryllium, cadmium, mercury, molybdenum, silver, sodium, and thallium—were relatively low and are reported either as not detected or below reporting limits for most sample sites. Concentrations of zinc in sample SED13 (562 mg/kg), lead in sample SED20 (1,490 mg/kg), and arsenic in samples SED11 (17.3 mg/kg) and SED21 (18.2 mg/kg) exceeded PELs published by the Canadian Council of Ministers of the Environment (1999) (table 8).

Discussion of trace element results was focused on zinc, lead, and arsenic, because these elements were detected in concentrations that exceeded PELs prescribed by the Canadian Council of Ministers of the Environment (1999) (table 8). Elevated concentrations of trace elements in sediment may represent contamination from natural or anthropogenic sources. A common approach used for estimating background levels of trace elements is to construct normal probability plots of measured concentrations for a particular element and establish the background level as the breakpoint where the slope of a best-fit line changes abruptly (Velz, 1984; Deacon and Stephens, 1998; Frenzel, 2000). If the trace-element data approximate a statistical normal distribution, the data points will plot roughly along a straight line. By expressing the theoretical distribution as a straight line, departures from the distribution are more easily perceived (Helsel and Hirsch, 1992). Enriched (increased) concentrations (data outliers) will plot above the best-fit line, depleted (decreased) concentrations plot below the best-fit line. Utilizing graphical methods to assess data outliers and distributional assumptions about data are described in detail by Chambers and others (1983).

Zinc concentration at site SED13 (562 mg/kg) was about 78 percent greater than the PEL guideline of 315 mg/kg and was about 22 percent greater than the CB-PEC guideline of 459 mg/kg (tables 7, 8). The calculated zinc background concentration for Noyes Slough was about 150 mg/kg (fig. 15). This background concentration suggests that the reported zinc concentration of 200 mg/kg for SED4 also was elevated, but was less than PEL and CB-PEC guidelines. The source(s) of the elevated zinc concentrations were uncertain.

The concentration of lead in sample SED20 (1,490 mg/kg) exceeded PEL (91.3 mg/kg) and CB-PEC (128 mg/kg) guidelines by an order of magnitude (table 8). A lead concentration of this magnitude at a single site suggests local enrichment. Lead concentrations in samples SED13 (59.4 mg/kg) and SED14 (56.5 mg/kg) were below PEL guidelines but were above the calculated background of about 20 mg/kg (fig. 15). The source(s) of the elevated lead concentrations were uncertain.

Table 8. Comparison of streambed-sediment quality guidelines and trace-element concentrations determined for streambed- sediment samples from Noyes Slough, Fairbanks, Alaska, 2001

[**Noyes Slough Median:** Concentration (*n*>20) excludes values below the reporting limit in the selected data set. **NAWQA National Median**: National median concentrations from NAWQA sampling sites (Gilliom and others, 1998). **Canada PEL:** Probable Effect Level (PEL) (Canadian Council of Ministers of the Environment, 1999). **CB-PEC:** Consensus Based Probable Effect Concentration (CB-PEC) (MacDonald and others, 2000). **Abbreviations:** mg/kg, milligram per kilogram, dry weight; B, below reporting limit; NG, no guideline; >, greater than]

Constituent	Concentration (mg/kg)					
	Noyes Slough median	NAWQA National Median	Canada PEL	CB-PEC	Noyes Slough sample greater than PELs	Noyes Slough sample greater than CB-PEC
Arsenic	12.6	6.35	17	33	SED11; 17.3 SED21; 18.2	None
Cadmium	B	.4	3.53	4.98	None	None
Chromium	27.4	62	90	111	None	None
Copper	30.4	26	197	149	None	None
Lead	13.7	24.3	91.3	128	SED20; 1,490	SED20; 1,490
Mercury	B	.06	.486	1.06	None	None
Nickel	26.1	25	36	48.6	None	None
Selenium	B	.7	NG	NG	NG	NG
Zinc	97.8	110	315	459	SED13; 562	SED13; 562

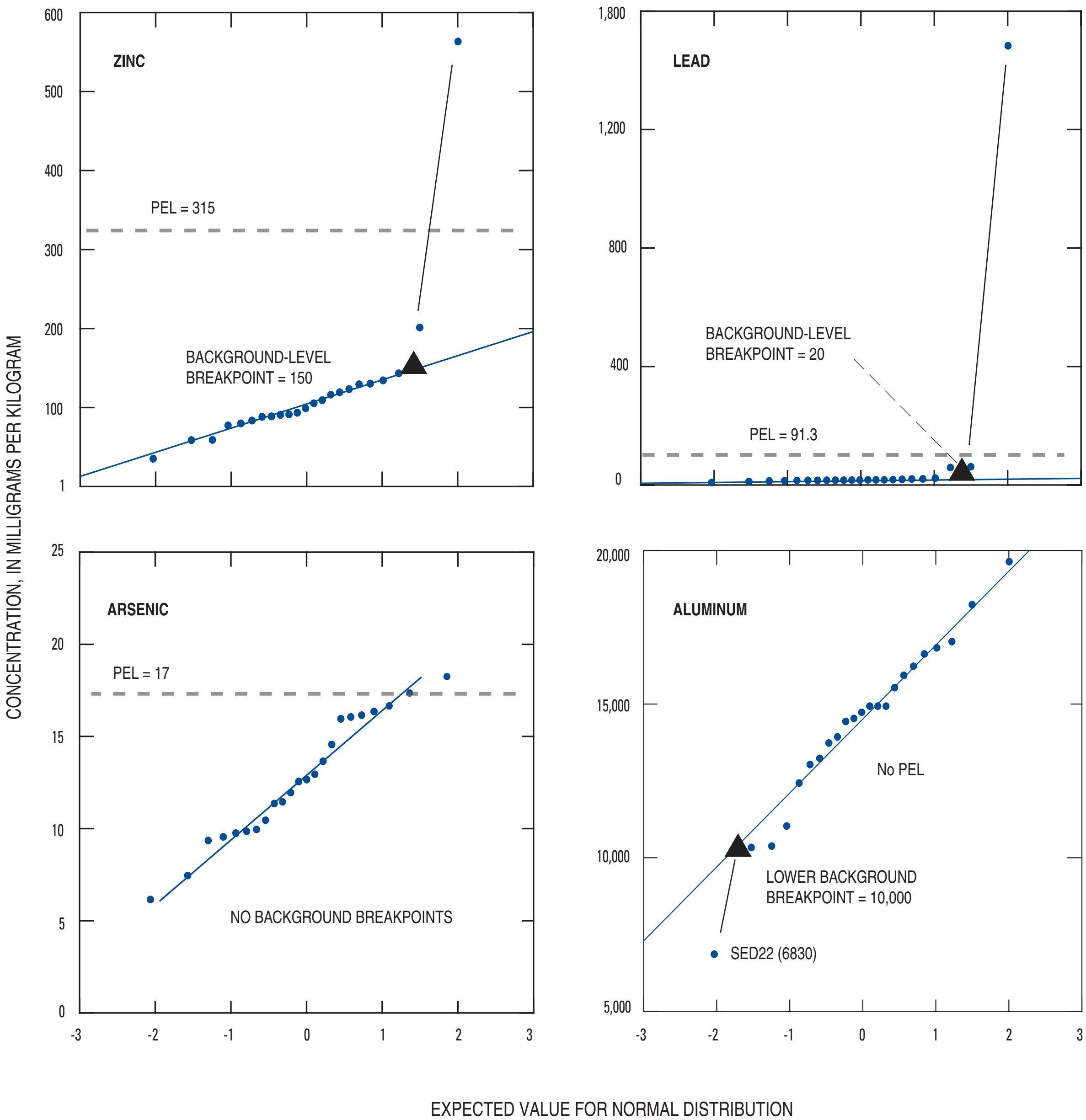


Figure 15. Comparison of normal probability plots of zinc, lead, arsenic, and aluminum concentrations in streambed sediments from Noyes Slough, with estimated background levels and probable effect levels (PELs).
PELs were compiled by Canadian Council of Ministers of the Environment (1999).

Concentrations of arsenic in samples SED11 (17.3 mg/kg) and SED21 (18.2 mg/kg) were greater than the PEL (17 mg/kg) guideline but less than the CB-PEC (33 mg/kg) guideline recommended by MacDonald and others (2000). The background concentration of arsenic in Noyes Slough appeared to be naturally elevated, based on the normal probability plot of arsenic data. There were no significant data departures from the best-fit line (fig. 15). Elevated arsenic concentrations in Noyes Slough bed sediment were expected because significant concentrations of arsenic are present in local bedrock (Newberry, 1996), in local bed-sediments (Hawkins, 1982), and in local ground-water wells (Mueller and others, 2002).

In Noyes Slough, the spatial distributions of trace-element occurrence and concentration were varied. Sixteen of the 24 selected trace elements were detected in bed-sediment from all 23 sites (table 7). There was a broad increase in trace-element concentrations from about the SED04 to SED21 sample locations. Urban runoff from suburban and high-traffic areas likely contributed to elevated trace-element concentrations in much of the center section of the slough.

Trace-element concentrations for the SED22 sample were, for most elements, the lowest reported concentrations for collected samples. The relatively low trace-element concentrations in SED22 were likely the result of low clay content in the sampled material. Clays are the most common of the sedimentary aluminum-enriched minerals (Hem, 1985). Because of their high cation-exchange capacity, aluminosilicate clays tend to sorb more trace elements than do bed sediments that are composed of coarse-grained material. Based on the theory that sediment aluminum concentration is a general indicator of aluminosilicate clay content, the low aluminum concentration of 6,830 mg/kg, about 50 percent less than the mean concentration of aluminum in sediment samples from Noyes Slough of 14,362 mg/kg, suggests a low clay content for the SED22 sample. The normal probability plot for aluminum (fig. 15) corroborates that the aluminum concentration for SED22 was a low-value data outlier because the data point plotted significantly below the best-fit line.

Organic Compounds

Only analytical results for organic compounds in bed-sediment samples collected through ice cover at 12 sites during October 2002 are presented in this report. Previous sampling efforts for organic contaminants during July 2001, September 2001, and June 2002 were not successful, apparently because of sample-matrix interference problems associated with elevated chlorophyll levels. Although organic compound data are presented and discussed herein, no formal interpretation of the data are provided because there are no official Federal or State of Alaska guidelines for acceptable levels of organic contaminants in bed sediment.

Bed-sediment samples collected from 12 sites in Noyes Slough during 2002 were analyzed for 78 semivolatile organic compounds (SVOCs) and 32 organochlorine pesticides and polychlorinated biphenyls (PCBs). There were no extreme variations between concentrations of organic compounds in the SED01 and replicate SED01R samples. When moderate differences existed, the SED01 concentrations were about 40 percent less than the SED01R concentrations and the analyte levels were low, typically between the MRL and the MDL. For example, the MRL for *p*-cresol is 100 µg/kg and the MDL is 50 µg/kg. *p*-cresol concentrations for SED01R (E62 µg/kg) and SED01 (E36 µg/kg) differ by about 42 percent. Most of the variation probably was due to actual differences in sample composition. Sample extraction procedures and subsequent chemical analysis introduced additional variation. Many of the reported organic-compound concentrations were near or below method reporting levels. The resulting increase in analytical uncertainty contributed to variation in the data.

Most of the laboratory spike recoveries were between 60 and 130 percent. However, there were several compounds with relatively low recoveries (less than 50 percent), including heptachlor, phenol, and *p*-cresol. The NWQL deleted analyses of 12 SVOCs, primarily phenol isomers. These compounds are noted in table 9 as method-deleted (M-D).

Reported analytical results for five SVOC analytes—*bis*(2-ethylhexyl)phthalate, di-*n*-butylphthalate, butylbenzyl phthalate, phenol, and diethylphthalate—include laboratory contamination at measurable concentrations (less than 34.1 µg/kg) in laboratory blanks. These data are underlined and footnoted in table 9.

Table 9. Concentrations of semivolatile organic compounds and carbon in samples of streambed sediments from Noyes Slough, Fairbanks, Alaska, October 2002

[**NWIS,** U.S. Geological Survey National Water Information System. **Abbreviations**: µg/kg, micrograms per kilogram, dry weight; <, less than; E, estimated; M-D, method deleted]

Semivolatile organic compound	NWIS code	Method detection level (µg/kg)	Concentration (µg/kg)					
			SED01	SED01R	SED03	SED05	SED07	SED09
Hexachlorobenzene	49343	50	<70	E4	<70	<70	<80	<70
Dibutylphthalate[1]	49381	50	E30	E43	E27	E26	E33	E28
Dioctylphthalate[1]	49382	50	E36	E42	130	95	E59	E44
Diethylphthalate[1]	49383	50	E11	E13	E8	E8	E9	E9
Dimethylphthalate	49384	50	<70	<100	<70	<70	<80	<70
Pyrene	49387	50	E15	E21	E25	E26	E38	E21
1-Methylpyrene	49388	50	<70	<100	E16	<70	<80	E15
Benzo[*a*]pyrene	49389	50	<70	<100	<70	<70	<80	E19
1-Methyl-indeno[*1,2,3-cd*]pyrene	49390	50	<70	<100	<70	<70	<80	<70
2,2'-Biquinoline	49391	50	<70	<100	<70	<70	<80	<70
Quinoline	49392	50	<70	<100	<70	<70	<80	<70
Phenanthridine	49393	50	<70	<100	<70	<70	<80	<70
Isoquinoline	49394	50	<70	<100	<70	<70	<80	<70
2,4-Dinitrotoluene	49395	50	<70	<100	<70	<70	<80	<70
2,6-Dinitrotoluene	49396	50	<70	<100	<70	<70	<80	<70
Benzo[*k*]fluoranthene	49397	50	<70	<100	<70	<70	<80	<70
1-Methyl 9H-fluorene	49398	50	<70	<100	<70	<70	<80	<70
9H-Fluorene	49399	50	<70	<100	<70	<70	<80	<70
Isophorone	49400	50	<70	<100	<70	<70	<80	<70
bis(2-chloroethoxy)methane	49401	50	<70	<100	<70	<70	<80	<70
Naphthalene	49402	50	<70	<100	E10	E10	<80	E10
1,2-Dimethylnaphthalene	49403	50	<70	<100	<70	<70	<80	<70
1,6-Dimethylnaphthalene	49404	50	<70	E15	E22	E12	E13	E11
2,3,6-Trimethylnaphthalene	49405	50	<70	<100	E10	E7	<80	<70
2,6-Dimethylnaphthalene	49406	50	E12	E34	E29	E29	E37	E34
2-Chloronaphthalene	49407	50	<70	<100	<70	<70	<80	<70
Benzo[*g,h,i*]perylene	49408	50	<70	<100	<70	<70	<80	<70
Phenanthrene	49409	50	E8	E12	E13	E18	E22	E13
1-Methylphenanthrene	49410	50	<70	<100	E9	E10	E10	E8
4H-Cyclopenta[*def*]phenanthrene	49411	50	<70	<100	<70	<70	<80	<70
Phenol[1]	49413	50	<70	<100	<70	E42	<80	E38
2,4,6-Trichlorophenol	49415	50	M-D	M-D	M-D	M-D	M-D	M-D
Mesitol	49416	50	M-D	M-D	M-D	M-D	M-D	M-D
2,4-Dichlorophenol	49417	50	M-D	M-D	M-D	M-D	M-D	M-D
2,4-Dinitrophenol	49418	50	M-D	M-D	M-D	M-D	M-D	M-D
2-Methyl-4,6-phenol	49419	50	M-D	M-D	M-D	M-D	M-D	M-D
o-Nitrophenol	49420	50	M-D	M-D	M-D	M-D	M-D	M-D
3,5-Xylenol	49421	50	<70	<100	<70	<70	<80	<70
4-Chloro-*m*-cresol	49422	50	<70	<100	<70	<70	<80	<70
m-Nitrophenol	49423	50	M-D	M-D	M-D	M-D	M-D	M-D
C8-Alkylphenol	49424	50	<70	<100	<70	<70	<80	<70
Pentachlorophenol	49425	50	M-D	M-D	M-D	M-D	M-D	M-D
bis(2-ethylhexyl)phthalate[1]	49426	50	110	E95	610	560	480	200
Butylbenzylphthalate[1]	49427	50	79	110	76	E65	91	79
Acenaphthylene	49428	50	<70	<100	<70	<70	<80	<70
Acenaphthene	49429	50	<70	<100	<70	<70	<80	<70
Acridine	49430	50	<70	<100	<70	<70	<80	<70

Table 9. Concentrations of semivolatile organic compounds and carbon in samples of streambed sediments from Noyes Slough, Fairbanks, Alaska, October 2002–*Continued*

[**NWIS,** U.S. Geological Survey National Water Information System. **Abbreviations**: µg/kg, micrograms per kilogram, dry weight; <, less than; E, estimated; M-D, method deleted]

Semivolatile organic compound	NWIS code	Method detection level (µg/kg)	Concentration (µg/kg)					
			SED01	SED01R	SED03	SED05	SED07	SED09
n-Nitrosodipropylamine	49431	50	<70	<100	<70	<70	<80	<70
n-Nitrosodiphenylamine	49433	50	<70	<100	<70	<70	<80	<70
Anthracene	49434	50	<70	<100	<70	E15	E20	E15
2-Methylanthracene	49435	50	<70	<100	<70	<70	<80	<70
Benzo[*a*]anthracene	49436	50	<70	<100	E12	E13	E15	E13
9,10-Anthraquinone	49437	50	<70	<100	<70	<70	E41	<70
1,2,4-Trichlorobenzene	49438	50	<70	<100	<70	<70	<80	<70
o-Dichlorobenzene	49439	50	<70	<100	<70	<70	<80	E13
m-Dichlorobenzene	49441	50	<70	<100	<70	<70	<80	E23
p-Dichlorobenzene	49442	50	<70	<100	<70	<70	<80	E19
Azobenzene	49443	50	<70	<100	<70	<70	<80	<70
Nitrobenzene	49444	50	<70	<100	<70	<70	<80	<70
Pentachlorobenzene	49446	50	<70	<100	<70	<70	<80	<70
Hexachlorobutadiene	49448	50	M-D	M-D	M-D	M-D	M-D	M-D
Carbazole	49449	50	<70	<100	<70	<70	<80	<70
Chrysene	49450	50	<70	<100	E19	E19	E26	E13
p-Cresol	49451	50	E36	E62	E40	E53	170	E66
Thiophene	49452	50	<70	<100	E12	E12	E15	E12
Hexachloroethane	49453	50	M-D	M-D	M-D	M-D	M-D	M-D
4-Bromophenylphenylether	49454	50	<70	<100	<70	<70	<80	<70
4-Chlorophenylphenylether	49455	50	<70	<100	<70	<70	<80	<70
bis(2-chloroethyl)ether	49456	50	<70	<100	<70	<70	<80	<70
bis(2-chloro-1-methylethyl)ether	49457	50	M-D	M-D	M-D	M-D	M-D	M-D
Benzo[*b*]fluoranthene	49458	50	<70	<100	<70	<70	<80	<70
Pentachloroanisole	49460	50	<70	<100	<70	<70	<80	<70
Dibenz[*a,h*]anthracene	49461	50	<70	<100	<70	<70	<80	<70
Fluoranthene	49466	50	E13	E19	E18	E23	E34	E19
o-Chlorophenol	49467	50	<70	<100	<70	<70	<80	<70
Benzo[*c*]cinnoline	49468	50	<70	<100	<70	<70	<80	<70
Hexachlorocyclopentadiene	49489	50	M-D	M-D	M-D	M-D	M-D	M-D
2-Ethylnaphthalene	49948	50	<70	<100	E11	<70	<80	<70
Inorganic carbon	49270		.22	.29	.26	.33	.25	.3
Organic carbon	49271		25	24	21	20	31	24

Table 9. Concentrations of semivolatile organic compounds and carbon in samples of streambed sediments from Noyes Slough, Fairbanks, Alaska, October 2002—*Continued*

[**NWIS,** U.S. Geological Survey National Water Information System. **Abbreviations**: µg/kg, micrograms per kilogram, dry weight; <, less than; E, estimated; M-D, method deleted]

Semivolatile organic compound	NWIS code	Concentration (µg/kg)						
		SED11	SED13	SED15	SED17	SED19	SED21	SED23
Hexachlorobenzene	49343	<70	E46	<80	<70	<80	<100	<50
Dibutylphthalate[1]	49381	E29	E79	E38	E31	E37	E37	E32
Dioctylphthalate[1]	49382	E42	530	<80	E37	<80	<100	<50
Diethylphthalate[1]	49383	E14	E29	E2	E2	E2	E12	<50
Dimethylphthalate	49384	<70	E10	<80	<70	<80	<100	<50
Pyrene	49387	E19	300	E21	E16	E15	E47	220
1-Methylpyrene	49388	<70	E64	<80	E9	<80	<100	E17
Benzo[*a*]pyrene	49389	<70	E120	<80	<70	<80	E27	E35
1-Methyl-indeno[*1,2,3-cd*]pyrene	49390	<70	E140	<80	<70	<80	<100	<50
2,2'-Biquinoline	49391	<70	<150	<80	<70	<80	<100	<50
Quinoline	49392	<70	<150	<80	<70	<80	<100	<50
Phenanthridine	49393	<70	<150	<80	<70	<80	<100	<50
Isoquinoline	49394	<70	<150	<80	<70	<80	<100	<50
2,4-Dinitrotoluene	49395	<70	<150	<80	<70	<80	<100	<50
2,6-Dinitrotoluene	49396	<70	<150	<80	<70	<80	<100	<50
Benzo[*k*]fluoranthene	49397	<70	E89	E12	<70	<80	E5	E29
1-Methyl 9H-fluorene	49398	<70	E46	<80	<70	<80	<100	<50
9H-Fluorene	49399	<70	E40	<80	E6	<80	<100	E69
Isophorone	49400	<70	<150	<80	<70	<80	<100	<50
bis(2-chloroethoxy)methane	49401	<70	<150	<80	<70	<80	<100	<50
Naphthalene	49402	E10	E30	E10	<70	E10	E20	E60
1,2-Dimethylnaphthalene	49403	<70	<150	<80	<70	<80	<100	E9
1,6-Dimethylnaphthalene	49404	E11	E24	E15	E12	E12	E19	E29
2,3,6-Trimethylnaphthalene	49405	<70	E16	<80	<70	<80	E7	E9
2,6-Dimethylnaphthalene	49406	E43	E57	E35	E42	E27	E80	96
2-Chloronaphthalene	49407	<70	<150	<80	<70	<80	<100	<50
Benzo[*g,h,i*]perylene	49408	<70	E110	<80	<70	<80	<100	<50
Phenanthrene	49409	E12	160	E22	E17	E15	E34	200
1-Methylphenanthrene	49410	<70	E46	<80	E14	E14	E12	E27
4H-Cyclopenta[*def*]phenanthrene	49411	<70	E36	<80	<70	<80	E10	E29
Phenol[1]	49413	E38	E110	<80	<70	<80	<100	<50
2,4,6-Trichlorophenol	49415	M-D	M-D	M-D	M-D	M-D	M-D	M-D
Mesitol	49416	M-D	M-D	M-D	M-D	M-D	M-D	M-D
2,4-Dichlorophenol	49417	M-D	M-D	M-D	M-D	M-D	M-D	M-D
2,4-Dinitrophenol	49418	M-D	M-D	M-D	M-D	M-D	M-D	M-D
2-Methyl-4,6-phenol	49419	M-D	M-D	M-D	M-D	M-D	M-D	M-D
o-Nitrophenol	49420	M-D	M-D	M-D	M-D	M-D	M-D	M-D
3,5-Xylenol	49421	<70	<150	<80	<70	<80	<100	<50
4-Chloro-*m*-cresol	49422	<70	<150	<80	<70	<80	<100	<50
m-Nitrophenol	49423	M-D	M-D	M-D	M-D	M-D	M-D	M-D
C8-Alkylphenol	49424	<70	<150	<80	<70	E37	<100	<50
Pentachlorophenol	49425	M-D	M-D	M-D	M-D	M-D	M-D	M-D
bis(2-ethylhexyl)phthalate[1]	49426	210	2,600	210	130	190	130	130
Butylbenzylphthalate[1]	49427	79	170	E73	81	86	E81	E57
Acenaphthylene	49428	<70	E31	<80	<70	<80	<100	<50
Acenaphthene	49429	<70	<150	<80	<70	<80	<100	85
Acridine	49430	<70	<150	<80	<70	<80	<100	<50

Table 9. Concentrations of semivolatile organic compounds and carbon in samples of streambed sediments from Noyes Slough, Fairbanks, Alaska, October 2002—*Continued*

[**NWIS,** U.S. Geological Survey National Water Information System. **Abbreviations**: µg/kg, micrograms per kilogram, dry weight; <, less than; E, estimated; M-D, method deleted]

Semivolatile organic compound	NWIS code	Concentration (µg/kg)						
		SED11	SED13	SED15	SED17	SED19	SED21	SED23
n-Nitrosodipropylamine	49431	<70	<150	<80	<70	<80	<100	<50
n-Nitrosodiphenylamine	49433	<70	E45	<80	<70	<80	<100	<50
Anthracene	49434	<70	E54	E15	E12	E13	E24	E41
2-Methylanthracene	49435	<70	<150	E24	<70	<80	<100	E23
Benzo[*a*]anthracene	49436	<70	E94	E10	E9	<80	E21	E48
9,10-Anthraquinone	49437	<70	E110	<80	<70	<80	<100	E43
1,2,4-Trichlorobenzene	49438	<70	<150	<80	<70	<80	<100	<50
o-Dichlorobenzene	49439	<70	<150	<80	<70	<80	<100	<50
m-Dichlorobenzene	49441	<70	<150	<80	<70	<80	<100	<50
p-Dichlorobenzene	49442	<70	<150	<80	<70	<80	<100	<50
Azobenzene	49443	<70	<150	<80	<70	<80	<100	<50
Nitrobenzene	49444	<70	<150	<80	<70	<80	<100	<50
Pentachlorobenzene	49446	<70	<150	<80	<70	<80	<100	<50
Hexachlorobutadiene	49448	M-D	M-D	M-D	M-D	M-D	M-D	M-D
Carbazole	49449	<70	E39	<80	<70	<80	<100	E30
Chrysene	49450	<70	230	E11	E8	<80	E27	E66
p-Cresol	49451	E51	200	E150	E66	E70	E86	E99
Thiophene	49452	<70	E41	<80	<70	<80	E17	E15
Hexachloroethane	49453	M-D	M-D	M-D	M-D	M-D	M-D	M-D
4-Bromophenylphenylether	49454	<70	<150	<80	<70	<80	<100	<50
4-Chlorophenylphenylether	49455	<70	<150	<80	<70	<80	<100	<50
bis(2-chloroethyl)ether	49456	<70	<150	<80	<70	<80	<100	<50
bis(2-chloro-1-methylethyl)ether	49457	M-D	M-D	M-D	M-D	M-D	M-D	
Benzo[*b*]fluoranthene	49458	<70	200	E15	<70	<80	E19	E44
Pentachloroanisole	49460	<70	<150	<80	<70	<80	<100	<50
Dibenz[*a,h*]anthracene	49461	<70	E100	<80	<70	<80	<100	<50
Fluoranthene	49466	E18	330	E25	E19	E18	E52	240
o-Chlorophenol	49467	<70	<150	<80	<70	<80	<100	<50
Benzo[*c*]cinnoline	49468	<70	<150	<80	<70	<80	<100	<50
Hexachlorocyclopentadiene	49489	M-D	M-D	M-D	M-D	M-D	M-D	M-D
2-Ethylnaphthalene	49948	<70	<150	<80	<70	<80	<100	E14
Inorganic carbon	49270	.42	.44	.68	.43	.51	.69	.82
Organic carbon	49271	28	38	31	31	32	31	22

[1]Reported value for this analyte includes contamination in laboratory blank at measurable concentrations (less than 34.1 µg/kg).

Semivolatile Organic Compounds

Of the 78 semivolatile organic compounds (SVOCs) that were analyzed, 23 were detected at levels that exceeded MDLs of 50 µg/kg (table 9). Chrysene, *p*-cresol, fluoranthene, and the phthalates, *bis*(2-ethylhexyl) and butylbenzyl were present in most of the samples. More than five SVOCs were detected in samples SED13, SED21, and SED23 (table 9). SVOC concentrations generally were higher in the SED13 sample than in other Noyes Slough samples. The SED13 sample also contained the greatest number of detected SVOCs, although many of the values were estimated because the concentrations were less than or near the MDLs. The organic carbon content of SED13 (37.7 g/kg) also was substantially greater (37 percent) than the average organic carbon content (about 27.5 g/kg) of other Noyes Slough samples (table 9).

Aquatic-life criteria values for 18 common SVOCs, compiled by Gilliom and others (1998) and associated SVOC concentrations in Noyes Slough sediment, are presented in table 10. None of the SVOCs measured in the Noyes Slough streambed-sediment samples were at concentrations exceeding aquatic-life criteria, nor were any of the SVOC analytes consistently detected at concentrations greater than the MRL. However, distributional patterns of two phthalates, *bis*(2-ethylhexyl) and butylbenzyl, as well as chrysene and *p*-cresol, warrant further discussion.

The *bis*(2-ethylhexyl)phthalate concentration in sample SED 13 (2,600 µg/kg) approached the aquatic-life criterion of 2,650 µg/kg (tables 9 and 10). Concentrations of *bis*(2-ethylhexyl)phthalate were moderately elevated in samples SED03 (610 µg/kg), SED05 (560 µg/kg), and SED07 (480 µg/kg). A second phthalate, butylbenzyl, was detected at low levels (less than the MRL) at most sites. Contamination of laboratory blanks ranged from 28.5 to 34.1 µg/kg for butylbenzyl, thus laboratory contamination contributed significantly to reported low-level butylbenzyl concentrations (table 9).

Phthalates are a family of chemical compounds that were developed in the past century. Most of the manufactured phthalates are used as "plasticizers"—they make plastics flexible without sacrificing strength or durability. Except for data on the most widely used phthalate, di-2-ethylhexyl phthalate (DEHP), much of the human-exposure and reproductive-toxicity data now available are preliminary (Raloff, 2000). Because of their persistence in the environment, phthalates are commonly found in ground water, rivers, and drinking water (Jobling and others, 1995).

Low levels of *p*-cresol were detected in all sediment samples (table 9). Cresols are widely occurring natural and anthropogenic products. They are natural components of crude oil and coal tar. Low levels of cresols are constantly emitted to the atmosphere in the exhaust from motor vehicle engines using petroleum based-fuels (Hampton and others, 1982). Biodegradation probably is the dominant mechanism responsible for the fast breakdown of cresols in soil and water; nonetheless, cresols may persist in waters with limited microbial communities, or under anaerobic conditions, such as in some sediments and aquifers (ATSDR, 1992).

Chrysene and fluoranthene were detected in relatively low concentrations (less than 100 µg/kg) in most of the Noyes Slough sediment samples, except for moderately elevated concentrations in the SED13 and SED23 samples. Chrysene and fluoranthene are polycyclic aromatic hydrocarbons (PAHs). PAHs are a group of chemicals that are formed during the incomplete burning of coal, oil, gas, wood, garbage, or other organic substances, such as tobacco and charbroiled meat; they generally occur as complex mixtures (for example, as part of combustion products such as soot), not as single compounds (ASTDR, 1995). They also can be found in substances such as crude oil, coal, coal tar pitch, creosote, and roofing tar. They are present throughout the environment and can occur in the air, attached to dust particles, or as solids in soil or sediment. Because of their low solubility and high affinity for organic carbon, PAHs in aquatic systems primarily are found sorbed to particles that either have settled to the bottom or are suspended in the water column (Eisler, 1983).

The greatest number of SVOC detections was in the SED13 sample from just upstream of the bridge at Aurora Drive (table 9). The organic-carbon content for SED13 (37.7 g/kg) also was substantially greater (37 percent) than the average organic-carbon content (about 27.5 g/kg) of other Noyes Slough samples. This highlights a fundamentally important point: hydrophobic organic compounds have an affinity for organic matter, and consequently, bed sediments that are rich in organic-carbon compounds adsorb more SVOCs than do bottom sediments that are mainly composed of inorganic matter (Miller and McPherson, 2001). Therefore, it is likely that the greater numbers of SVOCs detected in the SED13 sample, as well as the elevated concentration of selected compounds, are at least in part directly related to the high organic-carbon content of the sample.

Table 10. Aquatic-life criteria for semivolatile organic compounds in streambed sediment

[Table modified from Gilliom and others (1998). **Abbreviations:** USEPA, U.S. Environmental Protection Agency; SQC, sediment-quality criterion; SQAL, sediment-quality advisory level; ER-M, effects range-median; PEL, probable effect level; µg/kg, micrograms per kilogram, dry weight; <, less than]

Compound	Noyes Slough concentration range (µg/kg)	Criterion (µg/kg, dry weight)	Type of criterion	Criterion reference
Polycyclic aromatic hydrocarbons (PAHs)				
Acenaphthene	<50-E85	1,300	USEPA SQC[1]	USEPA (1996)
Acenaphthylene	<50	640	ER-M	Long and others (1995)
Anthracene	<50-E54	1,100	ER-M	Long and others (1995)
Benzo[*a*]anthracene	<50-E94	693	Florida PEL	MacDonald (1994)
Benzo[*a*]pyrene	<50-E120	782	Canada PEL	Canadian Council of Ministers of the Environment (1999)
Chrysene	<50-230	862	Canada PEL	Canadian Council of Ministers of the Environment (1999)
Dibenzo[*a,h*]anthracene	<50-E100	260	ER-M	Long and others (1995)
Fluoranthene	<50-330	6,200	USEPA SQC[1]	USEPA (1996)
Naphthalene	<50-E60	470	USEPA SQAL[1]	USEPA (1996)
Phenanthrene	<50-200	1,800	USEPA SQC[1]	USEPA (1996)
Pyrene	<50-300	1,398	Florida PEL	MacDonald (1994)
Phthalates				
Butylbenzylphthalate[2]	E57-173	11,000	USEPA SQAL[1]	USEPA (1996)
Diethylphthalate[2]	<50	630	USEPA SQAL	USEPA (1996)
Di-*n*-butylphthalate[2]	<50-E89	11,000	USEPA SQAL[1]	USEPA (1996)
bis(2-ethylhexyl)phthalate[2]	E95-2,600	2,650	Florida PEL	MacDonald (1994)
Other (semivolatile organic compounds)				
1,2-Dichlorobenzene	<50	340	USEPA SQAL[1]	USEPA (1996)
1,4-Dichlorobenzene	<50	350	USEPA SQAL[1]	USEPA (1996)
1,2,4-Trichlorobenzene	<50	9,200	USEPA SQAL[1]	USEPA (1996)

[1]Value in table assumes a 1-percent sediment organic carbon.

[2]Concentrations in field samples are not corrected for contamination measured in laboratory blanks.

Pesticides and Polychlorinated Biphenyls

No pesticides or PCB compounds were detected at concentrations greater than the MDL in sediment samples from two sites: SED03 and SED09 (table 11). One or two compounds were detected in samples from eight sites: SED05, SED07, SED11, SED15, SED17, SED19, SED21, and SED23. Samples from these eight sites all contained low levels (less than 3.0 µg/kg) of the pesticide p,p'- DDD, except that the SED23 sample contained an estimated p,p'- DDD concentration of E12 µg/kg and a reported o,p'-DDD concentration of 2.6 µg/kg. The total DDD concentration in sample SED23 was less than 15 µg/kg—the sum of the p,p'-DDD and o,p'-DDD isomer concentrations. Samples from two sites, SED01 and SED13, contained detectable amounts of many of the 32 organochlorine pesticides and PCBs listed in table 11. However, most of the reported concentrations were at low levels. Only two of the detected compounds, p,p’-DDD and hexachlorobenzene, in samples from the SED01 and SED13 sites respectively, were at concentrations that were greater than twice the MDL. For sample SED01R, the concentration of p,p'- DDD was estimated to be 2.4 µg/kg, and the MDL was 1.0 µg/kg. For sample SED13, the concentration of hexachlorobenzene was reported as 46 µg/kg and the MDL was 1 µg/kg. Hexachlorobenzene concentrations were less than 2.0 µg/kg in all other analyzed samples (table 11).

Aquatic-life criteria values for six common pesticides and PCBs, compiled by Gilliom and others (1998), as well as values for Noyes Slough sediment-sample concentrations, are presented in table 12. Gilliom and others (1998) do not include specific criteria for either DDD or hexachlorobenzene concentrations. However, the spatial distribution and occurrence of these pesticides in Noyes Slough bed sediments warrant further discussion.

Low-level concentrations of isomers of dichlorodiphenyltrichloroethane (DDT) or its degradation products, DDD and DDE, were detected in all 13 bed-sediment samples collected during 2002. Total DDT (DDT+DDD+DDE) concentrations were less than the effects range median (ER-M) aquatic-life criterion of 46.1 µg/kg. Total DDT concentrations generally were less than 10 µg/kg, except for samples from sites SED13 (about 14 µg/kg) and SED23 (about 20 µg/kg). S.A. Naidu (University of Alaska-Fairbanks, written commun., 2000) reported total DDT concentrations for three samples from Noyes Slough: about 8 µg/kg near the inlet and about 4 and 3 µg/kg at selected sites downstream. Background concentrations of DDT of similar magnitude also were found in bed sediments of Chena Slough, upstream of Noyes Slough (unpublished data from 2002 on file with the U.S. Geological Survey, Fairbanks, Alaska).

DDT was, for many years (1939-72), one of the most widely used pesticide chemicals in the United States (ATSDR, 2002). Its popularity was due to its reasonable cost, effectiveness, persistence, and versatility. In 1972, DDT use was banned in the United States and many parts of the world. DDT was released into the environment primarily by spraying onto agricultural crops and forest lands and to control mosquitoes. DDT does not occur naturally in the environment. DDT and its metabolites, DDD and DDE, are essentially immobile in soil, becoming strongly absorbed onto the surface layer of soils. Likewise, as a consequence of their extremely low water solubilities, DDT and its metabolites become adsorbed onto particulates in water and settle into sediments. There is continued dispersion of DDT to streambed sediments through erosion of contaminated soils. DDT also may attach to small particles and be carried by the wind. DDT, DDD, and DDE are persistent, bioaccumulative, and toxic pollutants (U.S. Environmental Protection Agency, 2003b).

Hexachlorobenzene is a white crystalline solid that was commonly used as a pesticide until 1965. It also was used to make fireworks and ammunition and to manufacture synthetic rubber. This compound does not occur naturally. The source of the HCB is unknown, however, the spatial distribution of significant levels of HCB in Noyes Slough appears to be limited to the SED13 site near the Aurora Drive Bridge. Hexachlorobenzene concentration from that sample was 46 µg/kg. Concentrations were less than 2.0 µg/kg for all other samples, suggesting enrichment of hexachlorobenzene at site SED13. Apparent enrichment may have been related, in part, to the relatively high organic-carbon content in sample SED13. To provide some perspective, the concentration of 46 µg/kg is well below screening values in the U.S. National Oceanic and Atmospheric Administration’s (1999) “Screening Quick Reference Table for Organics,” which suggests an Upper Effects Threshold of 100 µg/kg for infaunal community impacts in freshwater sediment. Nevertheless, hexachlorobenzene is a persistent, bioaccumulative, and toxic pollutant (U.S. Environmental Protection Agency, 2003a).

Table 11. Concentrations of organochlorine pesticides and polychlorinated biphenyls in samples of streambed sediments from Noyes Slough, Fairbanks, Alaska, October 2002

[**Abbreviations:** PCB, polychlorinated biphenyl; NWIS, U.S. Geological Survey National Water Information System; µg/kg, micrograms per kilogram, dry weight; E, estimated; <, less than]

Compound category/name organochlorine pesticide and PCB	NWIS code	Method detection level (µg/kg)	Concentration (µg/kg)					
			SED01	SED01R	SED03	SED05	SED07	SED09
cis-Nonachlor	49316	1	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0
trans-Nonachlor	49317	1	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0
Oxychlordane	49318	1	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0
Aldrin	49319	1	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0
cis-Chlordane	49320	1	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0
trans-Chlordane	49321	1	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0
Chloroneb	49322	5	<5.0	<10	<5.0	<5.0	<5.0	<5.0
DCPA	49324	5	<5.0	<10	<5.0	<5.0	<5.0	<5.0
o,p'-DDD	49325	1	E.21	E.64	E.10	E.42	E.24	E.22
p,p'-DDD	49326	1	E1.1	E2.4	E.77	E1.5	E1.1	E.80
o,p'-DDE	49327	1	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0
p,p'-DDE	49328	1	E.33	E.63	E.34	E.41	E.42	E.39
o,p'-DDT	49329	2	<2.0	<4.0	<2.0	<2.0	<2.0	<2.0
p,p'-DDT	49330	2	E1.1	E.73	E.36	E2.6	E.26	E.22
Dieldrin	49331	1	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0
Endosulfan I	49332	1	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0
Endrin	49335	2	<2.0	<4.0	<2.0	<2.0	<2.0	<2.0
alpha-BHC	49338	1	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0
beta-BHC	49339	1	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0
Heptachlor	49341	1	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0
Heptachlor epoxide	49342	1	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0
Hexachlorobenzene	49343	1	<1.0	<2.0	<1.0	<1.0	1.1	<1.0
Isodrin	49344	1	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0
Lindane	49345	1	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0
p,p'-Methoxychlor	49346	5	<5.0	<10	<5.0	<5.0	<5.0	<5.0
o,p'-Methoxychlor	49347	5	<5.0	<10	<5.0	<5.0	<5.0	<5.0
Mirex	49348	1	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0
cis-Permethrin	49349	5	<5.0	<10	<5.0	<5.0	<5.0	<5.0
trans-Permethrin	49350	5	<5.0	<10	<5.0	<5.0	<5.0	<5.0
Toxaphene	49351	200	<200	<400	<200	<200	<200	<200
PCB	49459	50	<50	<100	E1.8	E2.4	E6.4	E6.7
Pentachloroanisole	49460	1	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0

Table 11. Concentrations of organochlorine pesticides and polychlorinated biphenyls in samples of streambed sediments from Noyes Slough, Fairbanks, Alaska, October 2002—*Continued*

[**Abbreviations:** PCB, polychlorinated biphenyl; NWIS, U.S. Geological Survey National Water Information System; µg/kg, micrograms per kilogram, dry weight; E, estimated; <, less than]

Compound category/name organochlorine pesticide and PCB	Concentration (µg/kg)						
	SED11	SED13	SED15	SED17	SED19	SED21	SED23
cis-Nonachlor	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0
trans-Nonachlor	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0
Oxychlordane	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0
Aldrin	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0
cis-Chlordane	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0
trans-Chlordane	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0
Chloroneb	<5.0	<10	<5.0	<5.0	<5.0	<5.0	<5.0
DCPA	<5.0	<10	<5.0	<5.0	<5.0	<5.0	<5.0
o,p′-DDD	E.44	<2.0	E.65	E.62	E.50	E.49	2.6
p,p′-DDD	E1.8	E1.8	E2.7	E2.3	E2.5	E1.9	E12
o,p′-DDE	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0
p,p′-DDE	E.44	E.64	E.48	E.38	E.45	E.56	E.91
o,p′-DDT	<2.0	<4.0	<2.0	<2.0	<2.0	<2.0	<2.0
p,p′-DDT	E.31	<4.0	E.78	<2.0	<2.0	<2.0	E1.8
Dieldrin	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0
Endosulfan I	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0
Endrin	<2.0	<4.0	<2.0	<2.0	<2.0	<2.0	<2.0
alpha-BHC	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0
beta-BHC	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0
Heptachlor	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0
Heptachlor epoxide	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0
Hexachlorobenzene	<1.0	46	<1.0	<1.0	<1.0	<1.0	<1.0
Isodrin	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0
Lindane	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0
p,p′-Methoxychlor	<5.0	<10	<5.0	<5.0	<5.0	<5.0	<5.0
o,p′-Methoxychlor	<5.0	<10	<5.0	<5.0	<5.0	<5.0	<5.0
Mirex	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0
cis-Permethrin	<5.0	<10	<5.0	<5.0	<5.0	<5.0	<5.0
trans-Permethrin	<5.0	<10	<5.0	<5.0	<5.0	<5.0	<5.0
Toxaphene	<200	<400	<200	<200	<200	<200	<200
PCB	E8.8	E27	E7.6	E9.2	E7.7	E8.8	E9.2
Pentachloroanisole	<1.0	<2.0	<1.0	<1.0	<1.0	<1.0	<1.0

Table 12. Aquatic-life criteria for organochlorine pesticides and polychlorinated biphenyl concentrations in streambed sediment

[Table modified from Gilliom and others (1998). **Abbreviations:** ER-M, effects range-median; AET-H, apparent effects threshold-high; USEPA, U.S. Environmental Protection Agency; SQC, sediment-quality criterion; PEL, probable effect level; PCB, polychlorinated biphenyl; µg/kg, micrograms per kilogram, dry weight; <, less than]

Compound	Noyes Slough concentration range (µg/kg)	Aquatic-life criteria		
		Criterion (µg/kg, dry weight)	Type of criterion	Criterion reference
Total chlordane:		6	ER-M	Long and Morgan (1991)
cis-Chlordane	<2.0			
trans-Chlordane	<2.0			
cis-Nonachlor	<2.0			
trans-Nonachlor	<2.0			
Oxychlordane	<2.0			
Total DDT[1]:		46.1	ER-M	Long and others (1995)
o,p'-DDD	<1.0-2.6			
p,p'-DDD	<1.0-E12			
o,p'-DDE	<2.0			
p,p'-DDE	<1.0			
o,p'-DDT	<2.0-<4.0	15	AET-H	Barrick and others (1988)
p,p'-DDT	<1.0-<4.0			
Dieldrin	<2.0	110	USEPA SQC[2]	USEPA (1996)
Endrin	<4.0	42	USEPA SQC[2]	USEPA (1996)
y-HCH (Lindane)	<2.0	1.38	Canada PEL	Canadian Council of Ministers of the Environment (1999)
Total PCBs	<100	189	Florida PEL	MacDonald (1994)

[1]Sum of *o,p'* and *p,p'* isomers for DDD, DDE, and DDT.

[2]Value in table assumes a 1-percent sediment organic carbon.

Summary

The U.S. Geological Survey collected data to assess fish habitat, water-quality, and the presence of trace elements and organic compounds in Noyes Slough, in Fairbanks, Alaska, in 2001 and 2002 to provide quantitative baseline environmental information for the slough. These data increase the understanding of the Noyes Slough ecosystem and provide baseline data to help guide future management decisions regarding this valuable community resource.

The availability of physical habitat for fish in the slough does not appear to be limited, although some beaver dams and shallow water may restrict movement, particularly during low flow. Water quality is a principal factor affecting the suitability of Noyes Slough for fish habitat. At selected locations, during low flow, water temperature and concentrations of dissolved oxygen approached or were of poorer quality than water-quality levels recommended by the Alaska Department of Environmental Conservation and the U.S. Environmental Protection Agency. High specific-conductance values reflect potentially elevated levels of urban pollutants. Increased flow mitigated poor water-quality conditions and reduced the number of possible barriers to fish. Streamflow appears to be the most prominent mechanism shaping fish habitat in Noyes Slough.

Twenty-three bed-sediment sites were sampled during June 2001 and analyzed for trace elements. Five samples exceeded holding times, so the sites were resampled during September 2001. Arsenic, lead, and zinc were detected in bed-sediment samples from a limited number of sites in concentrations that exceed probable effect levels (PELs) for the protection of aquatic life. Arsenic concentrations in two samples exceeded the PEL guideline of 17 mg/kg (milligrams per kilograms) for arsenic by less than 10 percent. Arsenic concentrations in Noyes Slough are elevated because of significant concentrations of naturally occurring arsenic in local bedrock and ground water. The concentration of zinc in one sample is about 80 percent greater than the PEL guideline of 315 mg/kg. The lead concentration in a separate sample exceeds the PEL guideline of 91.3 mg/kg by an order of magnitude. The sources of the elevated zinc lead concentration are uncertain, however, both lead and zinc are common urban contaminants.

Analyses for organic contaminants in bed-sediment samples collected during 2001 were largely unsuccessful, apparently because of interference caused by high concentrations of chlorophyll in the sample matrix. Twelve sites were resampled through ice cover in October 2002 and were analyzed for organochlorine pesticides, polychlorinated biphenyls, and semivolatile organic compounds. None of the selected organic compounds exceeded available guideline values for the protection of aquatic life compiled by Gilliom and others (1998), although the *bis*(2-ethylhexyl)phthalate concentration for one sample approached within 4 percent of the aquatic-life criterion of 2,650 mg/kg (micrograms per kilogram). Low levels of *p*-cresol, chrysene, and fluoranthene were detected at most of the sediment sampling sites. The presence of these compounds in Noyes Slough sediment was expected, because cresols are emitted to the atmosphere in the exhaust from motor vehicles and chrysene and fluoranthene are formed during the incomplete burning of coal, oil, gas, wood, garbage, or other organic substances. The highest concentrations of *p*-cresol, chrysene, and fluoranthene occurred in one sample (SED13) that also contained substantially more organic carbon than other Noyes Slough samples. Organic contaminants have a high affinity for organic carbon. Consequently, the elevated organic contaminant concentrations found in this sample were likely related, in part, to the high organic-carbon content of the sample.

Low-level concentrations of DDT or its degradation products, DDD and DDE, were detected in all 13 bed-sediment samples collected during 2002, however, total DDT (DDT+DDD+DDE) concentrations were less than the effects range median aquatic-life criterion of 46.1 mg/kg. Total DDT concentrations generally were less than 10 mg/kg, except for samples from two sites that have estimated concentrations of about 14 and 20 mg/kg.

Contaminant concentrations in bed-sediment samples varied because of environmental factors such as differences in sediment grain size and differences in organic and inorganic sediment composition, as well as sample-extraction procedures and subsequent chemical analysis. Replicate trace-element sample concentrations typically varied by 10-30 percent; low-level organic-compound concentrations frequently varied by about 40 percent.

References Cited

Alaska Department of Environmental Conservation, 1997, Alaska water quality standards, 18 AAC 70: Juneau, Alaska, Title 18 Administrative Code chap. 70, 62 p.

Atkinson, P.K., and Newberry, R.J., 1998, Geochemistry of the Fairbanks Basalts, Interior Alaska: Department of Geology and Geophysics, University of Alaska Fairbanks, accessed August 28, 2002, at URL http://www.gi.alaska.edu/~atkinson/FBXBasalts/FBXBasalt1.html.

ATSDR, 1992, Agency for Toxic Substances and Disease Registry (ATSDR), Toxicological Profile for Cresols: Public Health Service, U.S. Department of Health and Human Services, accessed April 16, 2003, at URL http://www.atsdr.cdc.gov/toxprofiles/tp34-c5.pdf.

ATSDR, 1995, Agency for Toxic Substances and Disease Registry (ATSDR), Toxicological Profile for Polycyclic Aromatic Hydrocarbons (PAHs): Public Health Service, U.S. Department of Health and Human Services, accessed April 16, 2003, at URL http://www.atsdr.cdc.gov/toxprofiles/tp69.html.

ATSDR, 2002, Agency for Toxic Substances and Disease Registry (ATSDR), DDT, DDE, and DDD toxicological profile: Public Health Service, U.S. Department of Health and Human Services, accessed April 14, 2003 at URL http://www.atsdr.cdc.gov/toxprofiles/tp35-c1.pdf.

Barrick, R.S., Becker, S., Brown, L., Beller, H., and Pastorok, R., 1988, Sediment quality values refinement: Volume I—Data appendices: 1988 update and evaluation of Puget Sound AET: Seattle, Wash., U.S. Environmental Protection Agency, variously paged.

Beschta, R.L., Bilby, R.E., Brown, G.W., Holtby, L.B., and Hofstra, T.D., 1987, Stream temperature and aquatic habitat: fishery and forestry interactions, in Salo, E.O, and Cundy, T.W., *eds*., Streamside management: forestry and fishery interactions: Seattle, University of Washington, Institute of Forest Resources Contribution 57, p. 191-232.

Bisson, P.A., and Bilby, R.E., 1982, Avoidance of suspended sediment by juvenile coho salmon: North American Journal of Fisheries Management, v. 4, p. 371-374.

Brungs, W.A., and Jones, B.R., 1977, Temperature criteria for freshwater fish: protocol and procedures: Environmental Research Laboratory-Duluth, Office of Research and Development, U.S. Environmental Protection Agency EPA-600-3-77-061, 136 p.

Burrows, R.L, Langley, D.E., and Evetts, D.M., 2000, Preliminary hydraulic analysis and implications for restoration of Noyes Slough, Fairbanks, Alaska: U.S. Geological Survey Water-Resources Investigations Report 00-4227, 32 p.

Canadian Council of Ministers of the Environment, 1999, Canadian sediment quality guidelines for the protection of aquatic life—Summary tables, in Canadian environmental quality guidelines, 1999: Winnipeg, Canadian Council of Ministers of the Environment, variously paged.

Chambers, J.M., Cleveland, W.S., Kleiner, B., and Tukey, P.A., 1983, Graphical methods for data analysis: Belmont, California, Wadsworth International Group, Publishers, 395 p.

Davis, S.N., and DeWiest, R.J.M., 1966, Hydrogeology: New York, John Wiley and Sons, Inc., 463 p.

Deacon, J.R., and Stephens, V.C., 1998, Trace elements in streambed sediment and fish liver at selected sites in the Upper Colorado River Basin, Colorado,1995-96: U.S. Geological Survey Water-Resources Investigations Report 98-4124, 19 p.

Eisler, R., 1987, Polycyclic aromatic hydrocarbon hazards to fish, wildlife, and invertebrates: a synoptic review: U.S. Fish and Wildlife Service, U.S. Department of the Interior, Biological Report 85(1.11), 81 p.

Foster, H.L., Keith, T.E.C., and Menzie, W.D., 1994, Geology of the Yukon-Tanana area of east-central Alaska, in Plafker, G., Berg, H.C., *eds*., The geology of Alaska, v. G-1: Geological Society of America, p. 205-240.

Frenzel, S.A., 2000, Selected organic compounds and trace elements in streambed sediments and fish tissues, Cook Inlet Basin, Alaska: U.S. Geological Survey Water-Resources Investigations Report 00-4004, 39 p.

Gilliom, R.J., Mueller, D.K., and Nowell, L.H., 1998, Methods for comparing water-quality conditions among National Water-Quality Assessment study units, 1992-1995: U.S. Geological Survey Open-File Report 97-589, 54 p.

Hampton, C.V., Pierson, W.R., and Hanrey, T.M., 1982, Hydrocarbon gases emitted from vehicles on the road: A qualitative gas chromatography/mass spectrometry survey: Environmental Science and Technology v. 16, p. 287-298.

Hawkins, D.R., 1982, Hierarchical analysis of variance of stream-sediment samples for geochemical reconnaissance, Ester Dome, Fairbanks Mining District, Alaska: Alaska Division of Geology and Geophysics Open-File Report 167, 86 p.

Helsel, D.R., and Hirsch, R.M., 1992, Statistical methods in water resources: Amsterdam, Elsevier Science Publishers, 522 p.

Hem, J.D., 1985, Study and interpretation of the chemical characteristics of natural water: U.S. Geological Survey Water-Supply Paper 2254, 263 p., 3 plates.

Jobling, S., Reynolds, T., White, R., Parker, M.G., and Sumpter, J.P., 1995, A variety of environmentally persistent chemicals, including some phthalate plasticizers, are weakly estrogenic: Environmental Health Perspective, v. 103, suppl. 7, p. 582-587.

Lettenmaier, D.P., Hooper, E.R., Wagoner, C., and Faris, K.B., 1991, Trends in stream quality in the continental United States, 1978-1987: Water Resources Research, v. 27, p. 327-339.

Lilly, M.R., McCarthy, K.A., Kriegler, A.T., Vohden, J., and Burno, G.E., 1996, Compilation and preliminary interpretation of hydrologic and water-quality data from the Railroad Industrial Area, Fairbanks, Alaska, 1993-94: U.S. Geological Survey Water-Resources Investigations Report 96-4049, 45 p., 1 pl.

Long, E.R., MacDonald, D.D., Smith, S.L., and Calder, F.D., 1995, Incidence of adverse biological effects within ranges of chemical concentrations in marine and estuarine sediments: Environmental Management, v. 19, no.1, p. 81-97.

Long, E.R., and Morgan, L.G., 1991, The potential for biological effects of sediment-sorbed contaminants tested in the National Status and Trends Program: U.S. Department of Commerce, National Oceanic and Atmospheric Administration technical memorandum NOS OMA series, no. 52, variously paged.

MacDonald, D.D., 1994, Florida Sediment Quality Assessment Guidelines (SQAGs): Volume 1: Development and evaluation of Sediment Quality Assessment Guidelines (106 p.) and Volume 2: Application of the Sediment Quality Assessment Guidelines (59 p.). Also online at http://www.dep.state.fl.us/water/monitoring/seds.htm [1999].

MacDonald, D.D., Ingersoll, C.G., and Berger, T., 2000, Development and evaluation of consensus-based sediment quality guidelines for freshwater ecosystems: Archives of Environmental Contamination and Toxicology, v. 39, p. 20-31.

Martens, D.W., and Servizi, J.A., 1993, Suspended sediment particles inside gills and spleens of juvenile Pacific salmon (Oncorhynchus spp.): Canadian Journal of Fisheries and Aquatic Sciences, v. 50, p. 586-590.

McCoy, D., Newberry, R.J., Layer, P., DiMarchi, J.J., Bakke, A., Masterman, J.S., and Minehane, D.L., 1997, Plutonic-related gold deposits of interior Alaska, in Goldfarb, R.J., and Miller, L.D., *eds*., Mineral Deposits of Alaska: Economic Geology Monograph 9, p. 191-124.

Metz, P.A., 1991, Metallogeny of the Fairbanks Mining District, Alaska and Adjacent Areas, University of Alaska, School of Mineral Engineering, Minerals Research Industry Laboratory Report 90, 370 p.

Miller, R.L., and McPherson, B.F., 2001, Occurrence and distribution of contaminants in bottom sediment and water of the Barron River Canal, Big Cypress National Preserve, Florida, October 1998: Florida Scientist, v. 64, winter 2001, no. 1, p. 1-19.

Mueller, S.H., Goldfarb, R.J., Farmer, G.L., Sanzolone, R., Adams, M., Theodorakos, P.M., Richmond, S.A., and McCleskey, R.B., 2002, Trace, minor, and major element data for ground water near Fairbanks, Alaska, 1999-2000: U.S. Geological Survey Open-File Report 02-90, 9 p. plus tables.

Newberry, R.J., 1996, Major and trace element analyses of Cretaceous plutonic rocks in the Fairbanks Mining District, Alaska: Alaska Division of Geology and Geophysics Public-Data File Report 96-18, 18 p.

Page, L.M., and Burr, B.M., 1991, A field guide to freshwater fishes of North America north of Mexico: New York, The Peterson Field Guide Series, Houghton Mifflin, 353 p.

Pedersen, E.R., and Perkins, M.A., 1986, The use of benthic invertebrate data for evaluating impacts of urban runoff: Hydrobiologia, v. 139, p. 13-22.

Péwé, T.L., Bell, J.W., Forbes, R.B., and Weber, F.R., 1976, Geologic map of the Fairbanks, D-2 SW Quadrangle, Alaska: U.S. Geological Survey Miscellaneous Investigations Series Map I-829-A, scale 1:24000.

Raloff, J., 2000, New concerns about phthalates: Science News, v. 158, no. 10, Sept. 2, 2000, p. 152.

Severn Trent Laboratories, Inc., 2001a, Analytical report, Noyes Slough, Fairbanks, Alaska; Lot # D1H010361: 20 samples, August 2001, 235 p.

Severn Trent Laboratories, Inc., 2001b, Analytical report, Noyes Slough, Fairbanks, Alaska; Lot # D1I260321: 6 samples, October 2001, 90 p.

Severn Trent Laboratories, Inc., 2002, Analytical Report, Noyes Slough, Fairbanks, Alaska; Lot # D2F060317: 5 samples, July 2002, 65 p.

Shelton, L.R., and Capel, P.D., 1994, Guidelines for collecting and processing samples of stream bed sediment for analysis of trace elements and organic contaminants for the National Water-Quality Assessment program: U.S. Geological Survey Open-File Report 94-458, 20 p.

Sigler, J.W., Bjornn, T.C., and Everest, F.H., 1984, Effects of chronic turbidity on density and growth of steelheads and coho salmon: Transactions of the American Fisheries Society, v. 113, p. 142-150.

Simon, T.P., *ed*., 1998, Assessing the sustainability and biological integrity of water resources using fish communities: Boca Raton, Fla., CRC Press, 671 p.

U.S. Environmental Protection Agency, 1983, Methods for chemical analysis of water and wastes: EPA-600/4-79-020, variously paged.

U.S. Environmental Protection Agency, 1986a (revised December 1996), Test methods for evaluating of solid waste, physical/chemical methods (3rd edition): EPA-SW-846, variously paged.

U.S. Environmental Protection Agency, 1986b, Quality criteria for water: EPA- 440/5-86-001, 475 p.

U.S. Environmental Protection Agency, 1996, Integrated Risk Information System (IRIS) [CD-ROM]: Enterprise, Fla., Solutions Software Corporation.

U.S. Environmental Protection Agency, 1997, Guidelines establishing test procedures for the analysis of pollutants: App. B, Part 136, Definition and procedures for the determination of the method detection limit: U.S. Code of Federal Regulations, Title 40, revised July 1, 1997, p. 265–267.

U.S. Environmental Protection Agency, 2003a, Persistent Bioaccumulative and Toxic (PBT) Chemical Program-Hexachlorobenzene: accessed April 14, 2003, at URL http://www.epa.gov/pbt/hexa.htm.

U.S. Environmental Protection Agency, 2003b, Persistent Bioaccumulative and Toxic (PBT) Chemical Program-DDT: accessed April 14, 2003, at URL http://www.epa.gov/pbt/ddt.htm.

U.S. Geological Survey, 1999, The quality of our nation's waters: Nutrients and pesticides: U.S. Geological Survey Circular 1225, 82 p.

U.S. National Oceanic and Atmospheric Administration, 1999, Screening quick reference table for organics—Hexachlorobenzene in freshwater sediment: accessed April 14, 2003, at URL http://response.restoration.noaa.gov/cpr/sediment/squirt/squirt.pdf.

Van Metre, P.C., and Callender, E., 1997, Occurrence and trends in hydrophobic contaminants identified using streambed sediments and reservoir sediment cores—the National Water-Quality Assessment Program approach: U.S. Geological Survey Sediment Workshop, Proceedings, February 4-7, 1997: accessed September 23, 2002, at URL http://water.usgs.gov/osw/techniques/workshop/vanmetre.html.

Velz, C.L., 1984, Applied stream sanitation (2nd edition): New York, John Wiley and Sons, Inc., 800 p.

Wang, B., 1999, Spatial distribution of chemical constituents in the Kuskokwim River, Alaska: U.S. Geological Survey Water-Resources Investigations Report 99-4177, 33 p.

Wetzel, R.G., 1983, Limnology: Orlando, Fla., Harcourt Brace Jovanovich, 767 p.

USGS

Kennedy and others

Assessment of Fish Habitat, Water Quality, and Selected Contaminants in Streambed Sediments in Noyes Slough, Fairbanks, Alaska, 2001-2002

WRIR 03 4328

125 years of science for America

1879–2004

Printed on rec cled paper