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Water Quality in the Cook Inlet Basin
Alaska, 1998–2001

U.S. Department of the Interior
U.S. Geological Survey

Circular 1240

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Cook Inlet Basin contact and Web site:

Chief, Water Resources Office
U.S. Geological Survey
Alaska Science Center
4230 University Drive, Suite 201
Anchorage, AK 99508
e-mail: gs-w-ak_dc@usgs.gov
http://ak.water.usgs.gov/projects/nawqa/

National NAWQA Program:

Chief, NAWQA Program
U.S. Geological Survey
Water Resources Division
12201 Sunrise Valley Drive, M.S. 413
Reston, VA 20192
http://water.usgs.gov/nawqa/

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Yellowstone River Basin (Circular 1234

National Assessments

The Quality of Our Nation's Waters—Nutrients and Pesticides (Circular 1225)

Front cover: Mount McKinley overlooking the Chulitna River valley (photograph by Steven A. Frenzel, U.S. Geological Survey).
Back cover: Left, South Fork Campbell Creek near Anchorage (photograph by Robert T. Ourso, U.S. Geologcal Survey); middle, fishing on the Kenai River (photograph by William A. Swenson, U.S. Geological Survey); right, northern lights over the Matanuska River near Sutton (photograph courtesy of Jim Harris).

Water Quality in the Cook Inlet Basin Alaska, 1998–2001

By Roy L. Glass, Timothy P. Brabets, Steven A. Frenzel, Matthew S. Whitman, and Robert T. Ourso

Circular 1240

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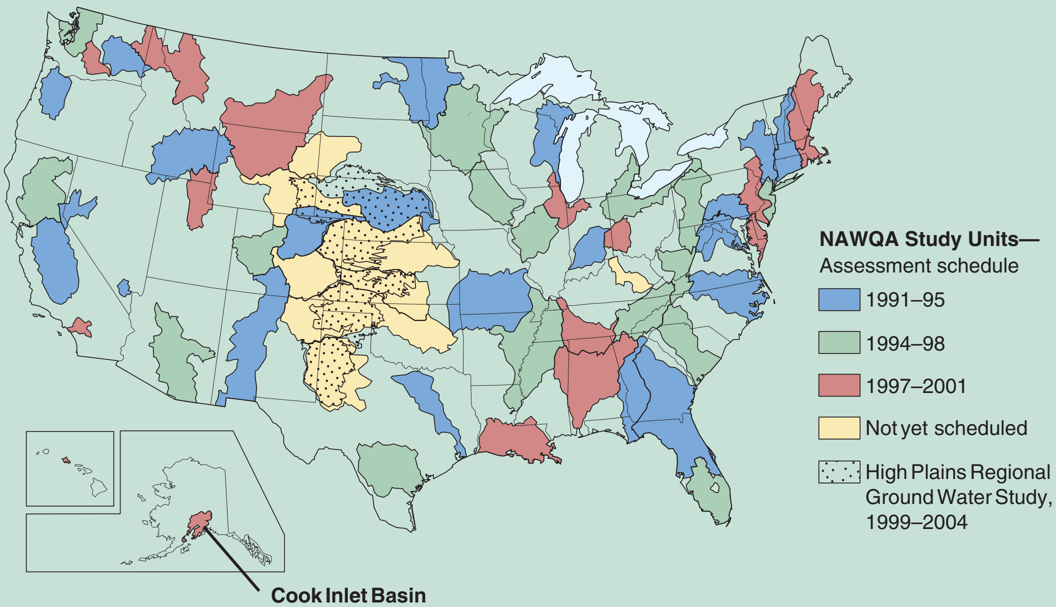
National Water-Quality Assessment Program

The quality of the Nation's water resources is integrally linked to the long-term availability of water that is clean and safe for drinking and recreation and also suitable for industry, irrigation, and habitat for fish and wildlife. Recognizing the need for long-term, nationwide assessments of water resources, the U.S. Congress has appropriated funds since 1991 for the USGS to conduct the **National Water-Quality Assessment (NAWQA) Program**. Scientists in the NAWQA Program work with partners in government, research, and public interest groups to assess the spatial extent of water-quality conditions, how water quality changes with time, and how human activities and natural factors affect water quality. This information is useful for guiding water-management and protection strategies, research, and monitoring in different hydrologic and land-use settings across the Nation.



The Cook Inlet Basin is one of 51 water-quality assessments initiated since 1991. Together, the 51 major river basins and aquifer systems, referred to as "Study Units," include water resources used by more than 60 percent of the population in watersheds that cover about one-half of the land areas of the conterminous United States. Timing of the assessments varies because of the program's rotational design, in which one-third of all Study Units are intensively investigated for 3 to 4 years, with trends assessed every 10 years. As indicated on the map, the Cook Inlet Basin is part of the third set of intensive investigations, which began in 1997.

What kind of water-quality information does the NAWQA Program provide?

Water-quality assessments by a single program cannot possibly address all of the Nation's water-resources needs and issues. Therefore, it is necessary to define the context within which NAWQA information is most useful.

- Total resource assessment—NAWQA assessments are long-term and interdisciplinary, and include information on water chemistry, hydrology, land use, stream habitat, and aquatic life. Assessments are not limited to a specific geographic area or water-resource problem at a specific time. Therefore, the findings describe the general health of the total water resource, as well as emerging water issues, thereby helping managers and decision makers to set priorities.
- Source-water characterization—Assessments focus on the quality of the available, untreated resource and thereby complement (rather than duplicate) Federal, State, and local programs that monitor drinking water. Findings are compared to drinking-water standards and health advisories as a way to characterize the resource.
- Compounds studied—Assessments focus on chemical compounds that have well-established methods of investigation. It is not financially or technically feasible to assess all the contaminants in our Nation's waters. In general, the NAWQA Program investigates those pesticides, nutrients, volatile organic compounds, and metals that have been or are currently used commonly in agricultural and urban areas across the Nation. A complete list of compounds studied is on the NAWQA Web site at water.usgs.gov/nawqa.
- Detection relative to risk—Compounds are measured at very low concentrations, often 10 to 100 times lower than Federal or State standards and health advisories. Detection of compounds, therefore, does not necessarily translate to risks to human health or aquatic life. However, these analyses are useful for identifying and evaluating emerging issues, as well as for tracking contaminant levels over time.
- Multiple scales—Assessments are guided by a nationally consistent study design and uniform methods of sampling and analysis. Findings thereby pertain not only to water quality of a particular stream or aquifer, but also contribute to the larger picture of how and why water quality varies regionally and nationally. This consistent, multiscale approach helps to determine if a water-quality issue is isolated or pervasive. It also allows direct comparisons of how human activities and natural processes affect water quality in the Nation's diverse environmental settings.

Introduction to this Report

This report contains the major findings of a 1998–2001 assessment of water quality in the Cook Inlet Basin. It is one of a series of reports by the National Water-Quality Assessment (NAWQA) Program that present major findings in 51 major river basins and aquifer systems across the Nation.

In these reports, water quality is discussed in terms of local, State, and regional issues. Conditions in a particular basin or aquifer system are compared to conditions found elsewhere and to selected national benchmarks, such as those for drinking-water quality and the protection of aquatic organisms. This report is intended for individuals working with water-resource issues in Federal, State, or local agencies; universities; public interest groups; or in the private sector. The information will be useful in addressing a number of current issues, such as the effects of agricultural and urban land use on water quality, human health, drinking water, source-water protection, hypoxia and excessive growth of algae and plants, pesticide registration, and monitoring and sampling strategies. This report is also for individuals who wish to know more about the quality of streams and ground water in areas near where they live, and how that water quality compares to the quality of water in other areas across the Nation.

The water-quality conditions in the Cook Inlet Basin summarized in this report are discussed in detail in other reports that can be accessed at http://ak.water.usgs.gov. Detailed technical information, data and analyses, collection and analytical methodology, models, graphs, and maps that support the findings presented in this report, in addition to reports in this series from other basins, can be accessed from the national NAWQA Web site (http://water.usgs.gov/nawqa).

Hydrologists taking water-quality samples from the Kenai River below Skilak Lake Outlet near Sterling. (Photograph by Robert T. Ourso, U.S. Geological Survey.)

Hydrologists processing ground-water samples for laboratory analysis. (Photograph by Roy L. Glass, U.S. Geological Survey.)

"Alaska's social and economic fabric are inextricably bound to the health of our salmon habitat and water quality. The NAWQA program has played a critical role helping policy makers, businesses and citizens better understand the complexities of our watersheds, and as a result, we now have better tools to manage our salmon and water resources for future generations."

Bob Shavelson, Executive Director, Cook Inlet Keeper

"The area studied by this program is the most heavily populated and developed area in Alaska. We regard NAWQA as a high quality, scientifically credible assessment effort that has furnished a significant amount of new information on watersheds in this area for which no, or very limited, information previously existed. Of particular value was the program's comprehensive approach which included surface water, land use, conventional pollutants, toxic pollutants, habitat, physical conditions, and biological components."

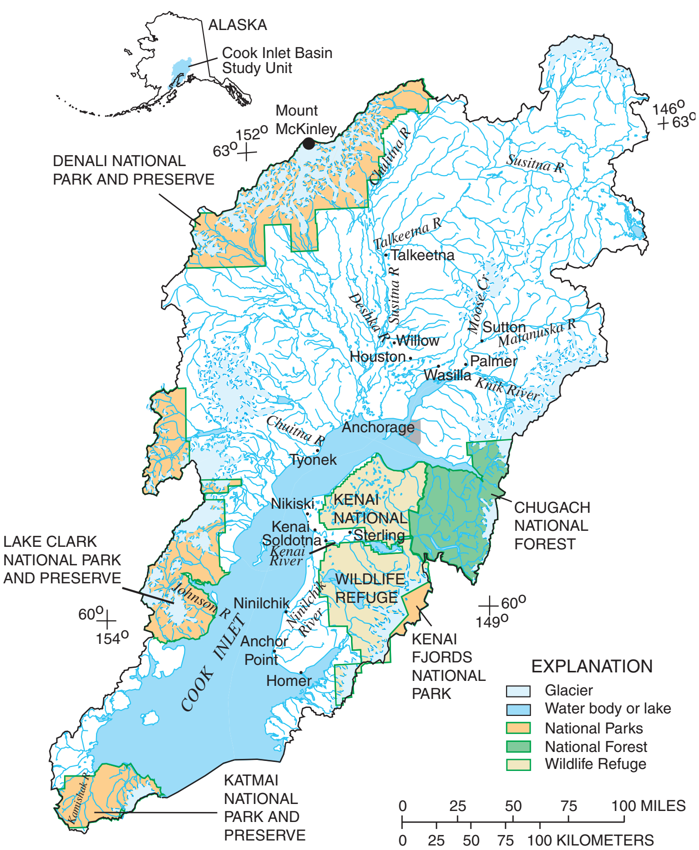
"The information obtained through this program complements our state monitoring efforts to understanding of water quality conditions within the Cook Inlet Basin. The reports produced have been well-written, informative, and contained excellent data evaluations, graphics, and maps. They are frequently consulted for information, and will continue to be consulted as important references for managing the area's water resources."

Ron Klein, Program Manager, Alaska Department of Environmental Conservation, Division of Air and Water Quality, Air & Water Data and Monitoring Program

Summary of Major Findings

Stream and River Highlights

Water quality is generally good in the Cook Inlet Basin, supporting most beneficial uses of water most of the time, including drinking, recreation, and protection of fish, other aquatic life, and wildlife. Much of the water originates in the mountainous headwaters from melting snow and glaciers, and because the snow is relatively pure, much of the water is either free of, or contains only low concentrations of, contaminants. Although water quality generally is good, natural geologic and climatic features, including the presence or absence of glaciers, affect this quality. For example, in the northwestern and southwestern regions of the basin, naturally occurring trace elements, such as arsenic, chromium, nickel, and zinc, frequently are found in streambed sediments at concentrations that exceed guidelines for the protection of sediment-dwelling organisms. Human activities also affect water quality in the basin, particularly in urban areas on lowlands along the northern and eastern shores of Cook Inlet. Runoff from urban areas may contain road deicing salts and gasoline residue from paved surfaces, pesticides, fertilizers, household chemicals, and bacteria. Sediments in some urban streams and lakes contain elevated concentrations of cadmium, lead, zinc, and organic contaminants. In developed and urbanizing watersheds, aquatic communities showed increased degradation, such as decreased diversity and abundance, and increased dominance of organisms tolerant of physical and chemical disturbances.



The Cook Inlet Basin Study Unit encompasses about 39,300 square miles that drain into Cook Inlet in south-central Alaska, but does not include the marine waters of Cook Inlet. About 350,000 people, or 56 percent of Alaska's population, live in the Study Unit, mainly in the city of Anchorage. Streams and rivers provide spawning and rearing habitat for anadromous and nonmigratory fish.

- Pesticides and volatile organic compounds, including components of petroleum products and byproducts of chlorine disinfection, were detected in nearly all water samples from Chester Creek, a stream draining urban areas in Anchorage. Concentrations generally were low and were well below drinking-water standards and guidelines and aquatic-life guidelines, except for carbaryl, an insecticide used to control spruce bark beetles (p. 6–7).

- Nitrate concentrations generally were low in streams throughout the basin. No samples exceeded U.S. Environmental Protection Agency (USEPA) drinking-water standard for nitrate (10 milligrams per liter [mg/L] as nitrogen). However, naturally occurring phosphorus in soils and rocks may contribute to high nutrient levels in some streams (p. 7).

- Concentrations of fecal-indicator bacteria in urban streams varied widely. At times, concentrations of *Escherichia coli* (*E. coli*) and enterococci bacteria exceeded the USEPA guidelines for moderate water-contact recreation, and concentrations of fecal-coliform bacteria exceeded the Alaska standard for contact recreation (p. 9).

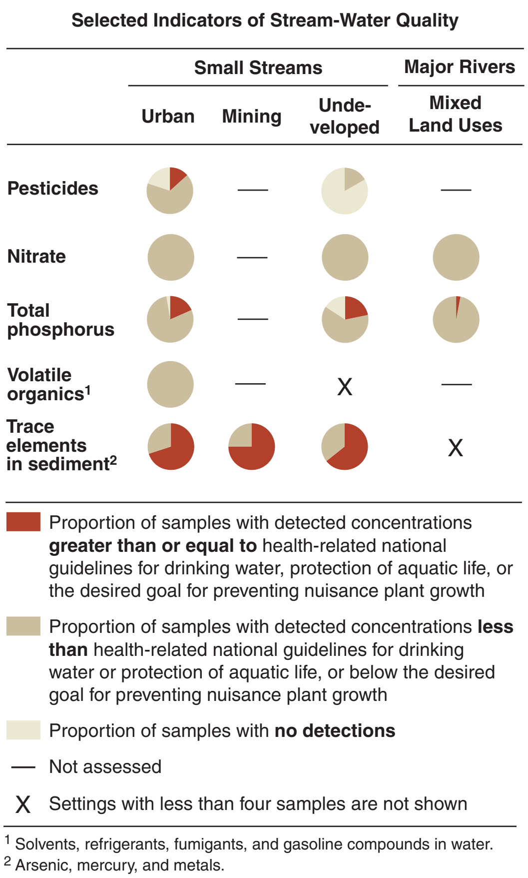
- Concentrations of trace elements in streambed sediments exceeded guidelines for the protection of aquatic life at 23 of 47 sites. Exceedances were most common for arsenic, chromium, cadmium, lead, and zinc, which are naturally abundant in Cook Inlet Basin rocks (p. 11–13).

- Concentrations of chemically persistent organic compounds, such as DDT and polychlorinated biphenyls (PCBs), were low and did not exceed guidelines to protect aquatic life (in recently deposited streambed sediments) or wildlife (in tissues of the resident fish slimy sculpin). However, cores of lakebed sediments from Westchester Lagoon on the main stem of Chester Creek indicate that sediments deposited in the mid-1970s have total PCB concentrations twice as high as aquatic-life guidelines (p. 13–14).

- The presence of pollution-sensitive insects, such as mayflies, stoneflies, and caddisflies, is diminished in streams draining areas with high densities of people compared to areas with low population densities (p. 17–19).

Major Influences on Streams and Aquatic Biology

- Climate and the presence or absence of glaciers
- Natural mineralogy and chemical characteristics of soils and rocks
- Contaminants in runoff from urban land surfaces
- Degraded stream habitat in urban and recreational areas



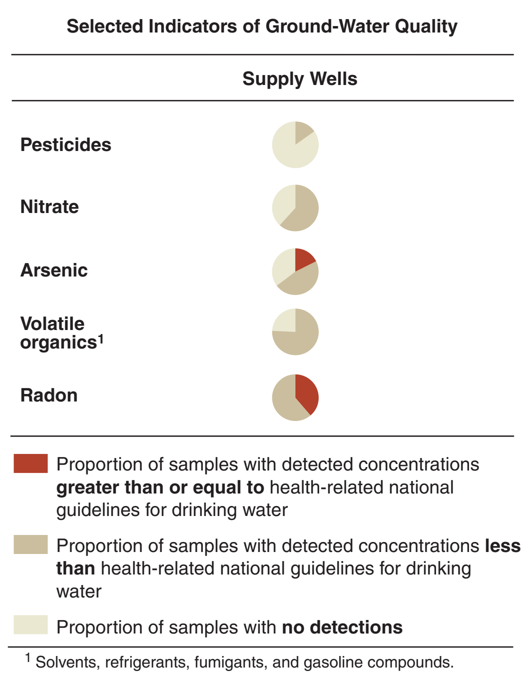
Ground-Water Highlights

Ground water is the primary source of drinking water in rural areas of the Cook Inlet Basin and contributes about one-quarter of the public supply in the metropolitan Anchorage area. On the basis of analyses of water samples collected from 34 water-supply wells, concentrations of most chemical constituents meet State and Federal drinking-water standards and guidelines. Ground-water quality is influenced primarily by natural processes of water-rock interaction and shows minimal evidence of human activities. Most ground water used for domestic, industrial, and public supply is pumped from unconsolidated alluvial and glacial aquifers. Recharge comes from rain, snowmelt, and stream infiltration. Age-dating analyses using tritium and chlorofluorocarbons indicate that water from most wells sampled was recharged within the last 50 years.

- Pesticides and volatile organic compounds were found only in low concentrations, substantially less than drinking-water standards and guidelines (p. 19).
- Concentrations of nitrate were low throughout the basin, never exceeding the USEPA drinking-water standard of 10 mg/L as nitrogen. Nitrate concentrations were highest in water from wells in urban areas (maximum concentration was 4.8 mg/L). Possible sources of nitrate include application of fertilizers, effluent from septic tanks or leaky sewer lines, animal wastes, and nitrogen-fixing plants such as alder and clover (p. 19).
- Arsenic exceeded the USEPA drinking-water standard of 10 micrograms per liter (μg/L) in water from 18 percent of the wells sampled. Arsenic is a naturally occurring element in rocks throughout the basin (p. 20).
- Concentrations of radon exceeded the proposed USEPA drinking-water standard of 300 picocuries per liter in water from 39 percent of the wells sampled. Radon is a naturally occurring radioactive gas that forms during the decay of uranium in rocks (p. 20).

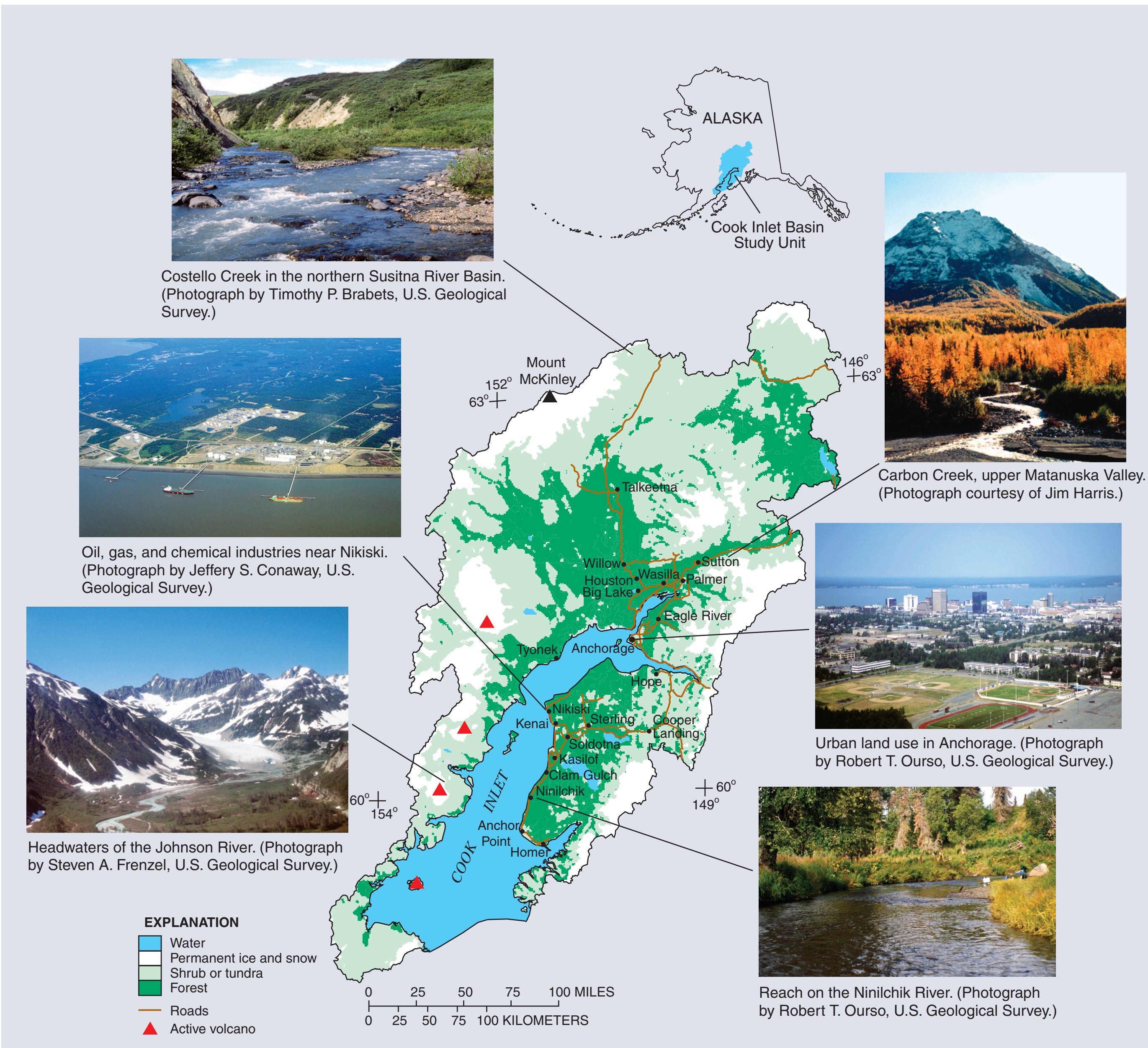
Major Influences on Ground Water

- Mineral composition of soils and rocks
- Urban contaminants (petroleum products, fertilizers, pesticides, wastewater effluent)



Introduction to the Cook Inlet Basin

The Cook Inlet Basin (fig. 1) is unique among the 51 NAWQA Study Units because of its high latitude, abundant glaciers, active volcanoes, and low population density. Snow typically covers the ground for more than 6 months of the year, even in areas near sea level. All of the large lakes are natural and the flows in the major rivers are unregulated. Only a few small dams exist in the 39,300-square-mile basin. State and Federal governments manage about 90 percent of the basin, including parks, wildlife refuges, forests, and areas administered by the Bureau of Land Management that will eventually be conveyed to the State or to Native corporations. There are relatively few roads and communities, especially in the area west of Cook Inlet. Anchorage is the principal urban area in the Study Unit, with a population of about 260,000.



Costello Creek in the northern Susitna River Basin. (Photograph by Timothy P. Brabets, U.S. Geological Survey.)

Oil, gas, and chemical industries near Nikiski. (Photograph by Jeffery S. Conaway, U.S. Geological Survey.)

Headwaters of the Johnson River. (Photograph by Steven A. Frenzel, U.S. Geological Survey.)

Carbon Creek, upper Matanuska Valley. (Photograph courtesy of Jim Harris.)

Urban land use in Anchorage. (Photograph by Robert T. Ourso, U.S. Geological Survey.)

Reach on the Ninilchik River. (Photograph by Robert T. Ourso, U.S. Geological Survey.)

Figure 1. Most of the Cook Inlet Basin is uninhabited, mountainous, and covered by shrubs, tundra, forests, or permanent snow and ice. Population is concentrated on lowlands in three areas adjacent to Cook Inlet: Anchorage, Palmer-Wasilla, and Kenai-Soldotna.

The primary water-resource issues in the Cook Inlet Basin relate to the effects that increasing urbanization and resource development may have on salmon, resident fish, and other aquatic life, and their effects on water quality and supply. Streams draining into Cook Inlet produce world-renowned salmon runs. Five species of Pacific salmon spawn in the fresh waters of the Cook Inlet Basin and are important to the local and State economies. The Kenai River salmon runs alone generate annual revenues of about $70 million to the local economy. High-quality spawning and rearing habitats are crucial to the maintenance of these stocks at sustainable levels. Each year, nearly 1 million visitors from around the world venture to Cook Inlet Basin to experience its magnificent beauty.

Diverse topography results in diverse climate and hydrology

The Cook Inlet Basin has a diverse climate, largely owing to a range in altitude from sea level to 20,320 feet at Mount McKinley, the tallest mountain in North America). Mean annual temperature ranges from about 22 °F in the northeastern region of the basin to about 42 °F in the south. Precipitation varies even more substantially, ranging from about 16 inches per year in Anchorage to more than 200 inches at high elevations along the eastern boundary of the Study Unit. At high elevations, the combination of abundant precipitation and low annual temperatures supports extensive permanent snowfields and glaciers.

Glaciers have a profound influence on runoff characteristics in a watershed because they serve as naturally regulated reservoirs of water. They store water as ice and snow during cool, wet periods and release water to increase streamflows during hot, dry periods. Even small glaciers have large effects on water availability during dry summers. Streams with glaciers that cover as little as 5 percent of their watershed tend to have a prolonged period of high flow during the summer and annual peaks in mid- to late summer resulting from glacial melt or rainfall (fig. 2). Streams lacking headwater glaciers typically have an annual peak resulting from snowmelt in late spring to early summer. If the glaciers in Cook Inlet Basin retreat due to warming of the climate, runoff will decline in dry summer months, when it is needed most. The high flows in the Kenai River during November 1999 and late January 2001 were due to the sudden draining of lakes that form along glaciers. Glacial-lake outbursts in the Kenai River watershed typically occur every 2 to 3 years. Flooding caused by these outbursts can be devastating, especially if they occur during winter when the stream channel is frozen or during open-water periods when streamflows are already high from snowmelt or rainfall runoff.

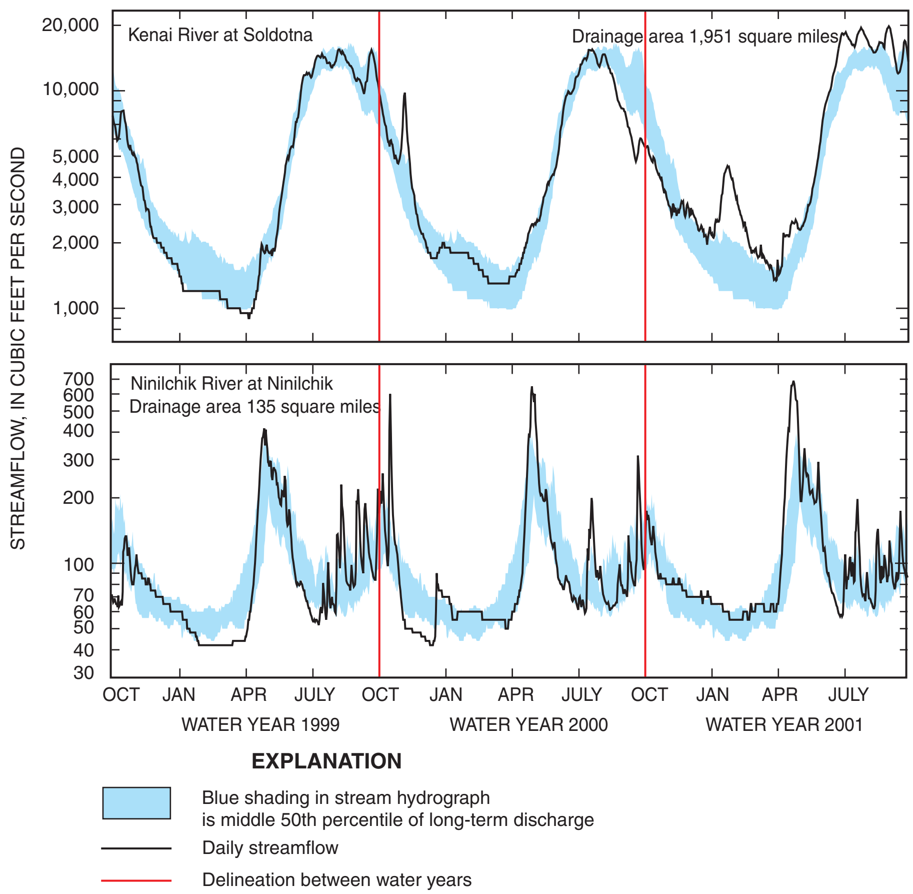


Figure 2. These hydrographs are representative of glacier-fed and nonglacial rivers in the Cook Inlet Basin. About 11 percent of the watershed upstream from the Kenai River at Soldotna is covered by glaciers, whereas there are no glaciers in the Ninilchik River watershed. Streamflows in rivers in the Cook Inlet Basin are low during winter and increase rapidly in response to spring snowmelt and summer rains. During warm, dry periods, streamflows decrease in nonglacial rivers, but the melting of glaciers maintains high flows in glacier-fed rivers. Streams and rivers were sampled between May 1998 and September 2001. The weather was mostly near-normal during the first 2 water years but was drier and warmer than normal during water year 2001. Streamflows generally were about average in nonglacial rivers during the study but were greater than average in glacier-fed rivers during water year 2001 because of the warmer conditions.

The precipitation and temperature were mostly near-normal during water years 1999 and 2000 (October 1, 1998–September 30, 2000) but were slightly drier and warmer than normal during water year 2001 (Brabets and Whitman, 2004). Despite drier conditions, warmer temperatures during 2001 caused higher than average streamflows in glacier-fed streams. For example, annual streamflow at the Kenai River at Soldotna was 18 percent above average during water year 2001.

Most of the basin is undeveloped

Most of the Cook Inlet Basin is undisturbed by humans. Permanent snow and ice (glaciers) are present in the upper reaches of mountains and cover about 17 percent of the land area (fig. 1) (Brabets and others, 1999). Alpine tundra and shrubs grow in the middle regions of mountains below the glaciers and cover about one-half of the basin. Forests, including black-spruce and scrub-shrub wetlands (peat bogs), grow on lowlands and foothills, covering about one-third of the basin. Urban (includes residential, commercial, industrial, and transportation uses) and agricultural lands together account for only about 1 percent of the 39,300-square-mile land area and are located primarily on lowlands near the eastern and northeastern shores of Cook Inlet. Anchorage, Kenai, Soldotna, Palmer, and Wasilla are the main communities.

Hydrologist making discharge measurements in the Johnson River. (Photograph by Steven A. Frenzel, U.S. Geological Survey.)

Human activities affect water quality and aquatic biota

Urban development, agriculture, logging, mining, and recreation have the potential to degrade the quality of water in streams and aquifers. The population within the basin was about 350,000 in 2000 and is increasing. Potential sources of nonpoint-source contaminants to surface and ground water in urban and agricultural areas include automobiles (exhaust emissions, fluid leaks, and tire wear), leaking of petroleum products, application of road deicing chemicals, pesticides and fertilizers, septic-tank effluent, leaking sewer lines, animal wastes, construction activities and materials, and atmospheric deposition. Draining and filling of wetlands, reducing riparian vegetation, and straightening stream channels for urban and agricultural development may degrade stream habitat for invertebrates and fish and affect hydraulic conditions of streams. Logging, which is concentrated in the southern part of the Kenai Peninsula, and construction may increase the amount of sediment in streams, decrease vegetative cover over streams, and increase water temperature. Mining of rock, ores, oil, and gas could affect streams and ground water by point-source mine discharge and nonpoint-source runoff from mined areas. There is a potential for large-scale coal mining near the western shore of Cook Inlet and northeast of Palmer. The extraction of oil and natural gas occurs from offshore platforms in Cook Inlet and from wells in the northwestern part of the Kenai Peninsula, and exploration for new fields continues, including the search for methane gas from coal seams near Wasilla and Homer. Areas of intense recreational use are located within and along most major rivers and streams. Boats may add petroleum products to the water, whereas foot and vehicular traffic within riparian areas may increase the amount of sediment reaching streams and harm fish spawning beds.

Most drinking water comes from rivers and streams

Although surface water provides most of the drinking water for the metropolitan Anchorage area, ground water is used in rural areas, and reliance on ground water as a source of drinking water is increasing with suburban development. In 1995, total water withdrawal for public-supply, domestic, industrial, and irrigation needs was about 49 million gallons per day (Molly Maupin, U.S. Geological Survey, written commun., 2002). About 74 percent of this water was used for public supply in the metropolitan area of Anchorage, of which about 27 percent was from ground water and 73 percent from surface water. Outside of the metropolitan area of Anchorage, almost all water withdrawn for public, domestic, and industrial needs was from wells. As the populations in these outlying areas increase, so does their demand for water.

Results from this study provide a benchmark for measuring changes to come

Because most of the land in the Cook Inlet Basin is undeveloped, results of this study provide a benchmark from which to measure future water-quality changes that may result from human activities associated with population growth and resource development. This opportunity is not possible in most regions of the United States.

Major Findings

Water quality in streams and rivers in the Cook Inlet Basin is affected by natural features and human activities

Natural features and human activities affect water quality of streams and rivers in the Cook Inlet Basin, particularly in urban areas in Anchorage. Runoff from urban areas may contain road deicing salts, pesticides, fertilizers, petroleum products, household chemicals, and bacteria.

Pesticides detected in an urban stream in Anchorage also were detected in urban streams throughout the Nation

One or more pesticides were detected in almost every stream sample in Chester Creek, a stream draining urban areas in Anchorage (Brabets and Whitman, 2004). Some pesticides in streams are a concern because even relatively low concentrations can harm aquatic insects and fish. Concentrations of carbaryl were as great as 0.33 µg/L and exceeded Canadian guidelines (CCME, 2002b) for the protection of aquatic life (0.2 µg/L) in 15 percent of the samples. In contrast, five of seven water samples from an adjacent stream (South Fork Campbell Creek) that drains shrubs, tundra, and forests upstream from urban development had no detectable pesticides. Two samples each had one pesticide detected at concentrations less than reporting levels. Carbaryl, prometon, 2,4-D, and diazinon were the most frequently detected pesticides in Chester Creek. Carbaryl, a broad-spectrum insecticide that is widely used throughout the Cook Inlet Basin area to control spruce bark beetles, was detected in 79 percent of the samples from Chester Creek. Prometon, a nonselective herbicide commonly used to control broadleaf weeds and grasses around homes and along rights-of-way, was detected in about 70 percent of the samples. Diazinon and 2,4-D were detected in 25 and 38 percent of the samples, respectively. Most concentrations were less than 0.05 µg/L, a value often used as the common minimum reporting level for pesticides. Except for carbaryl, no other pesticide exceeded applicable drinking-water standards and guidelines or aquatic-life guidelines. Findings in Chester Creek are consistent with those for other urban streams throughout the Nation, where the insecticides diazinon, carbaryl, chlorpyrifos, and malathion and the herbicides atrazine, simazine, and prometon were frequently detected (U.S. Geological Survey, 1999).

Carbaryl also was detected at five of six stream sites in Anchorage using lipid-containing semipermeable membrane sampling devices (SPMDs), which are passive in-place water samplers that mimic the sorptic uptake of contaminants by biota (J.N. Huckins, U.S. Geological Survey, written commun., 2001). Hexachlorobenzene, used in making other organic chemicals including wood preservatives, and pentachloroanisole, a degradation product of the wood preservative/fungicide pentachlorophenol, which was banned in 1987, were also detected in extremely low concentrations in water from these six sites using SPMDs. Uptake by SPMDs indicates that these pesticides were dissolved in the water column and that organisms at the sites could be exposed.

Chester Creek at Arctic Boulevard at Anchorage, Alaska. (Photograph by Robert T. Ourso, U.S. Geological Survey.)

Many volatile organic compounds were present in an urban stream in Anchorage at low concentrations

All water samples collected from an urbanized reach of Chester Creek contained a mixture of volatile organic compounds (VOCs), including components of petroleum products and byproducts of chlorine disinfection (Brabets and Whitman, 2004). Potential sources of the VOCs detected in the water samples are leaking of gasoline and other fluids from vehicles, disposal of waste oils, solvents, and cleaners onto the ground or into storm drains or septic tanks, emissions from the combustion of fuels, and reaction of chlorinated public drinking-water supplies with organic matter. Eighteen of 55 VOCs for which samples were analyzed were detected at low concentrations. No VOC concentration exceeded applicable drinking-water standards or guidelines or aquatic-life guidelines.

Only methylbenzene (also known as toluene) and methyl *tert*-butyl ether (MTBE) were detected at concentrations exceeding 0.2 µg/L (see Appendix). Both are associated with gasoline. Toluene was present in every water sample from Chester Creek analyzed for VOCs. Concentrations of toluene were as great as 0.23 µg/L in high streamflows after rains, most likely a consequence of surface runoff from roads and parking areas. Concentrations of MTBE, a gasoline additive that was used in Anchorage during the 1992–93 winter, were as great as 0.8 µg/L in Chester Creek during winter low-flow conditions during 1999. MTBE concentrations were diluted and decreased as rain and snowmelt runoff increased.

Trichloromethane (chloroform) was also present in every water sample from Chester Creek analyzed for VOCs. A likely source of chloroform in Chester Creek is surface runoff and ground-water discharge that included water derived from chlorinated public-supply water. Chloroform is formed in drinking water during and after chlorination when naturally occurring organic substances in water react with chlorine.

Nitrate concentrations were low in streams, but phosphorus commonly exceeded criteria for preventing nuisance plant growth

Nitrogen and phosphorus are essential for healthy plant and animal populations; however, elevated concentrations of these nutrients can degrade water quality. Excessive nitrate concentrations in drinking water can result in a condition that causes low oxygen levels in the blood of infants, sometimes causing death. Elevated nitrogen and phosphorus concentrations in lakes and streams can trigger eutrophication, resulting in excessive growth of nuisance aquatic plants, including algae. Subsequent decay of these plants can result in foul odors, bad taste, and low concentrations of dissolved oxygen in water.

Nitrate concentrations at six routinely sampled sites (see basic fixed sites in Study Unit Design) were always low (Brabets and Whitman, 2004), and most samples had concentrations that were less than one-tenth of the U.S. Environmental Protection Agency (USEPA) drinking-water standard of 10 mg/L (fig. 3). Samples from 23 other stream sites in the Cook Inlet Basin (see synoptic sites in Study Unit Design) also were analyzed. All sites outside of Anchorage had median nitrite plus nitrate concentrations that were less than 0.6 mg/L, a national background level (Mueller and Helsel, 1976). Three of 14 sites in Anchorage, including Chester Creek at Arctic Boulevard, had median nitrite plus nitrate concentrations that exceeded the national background level. The highest concentration measured in

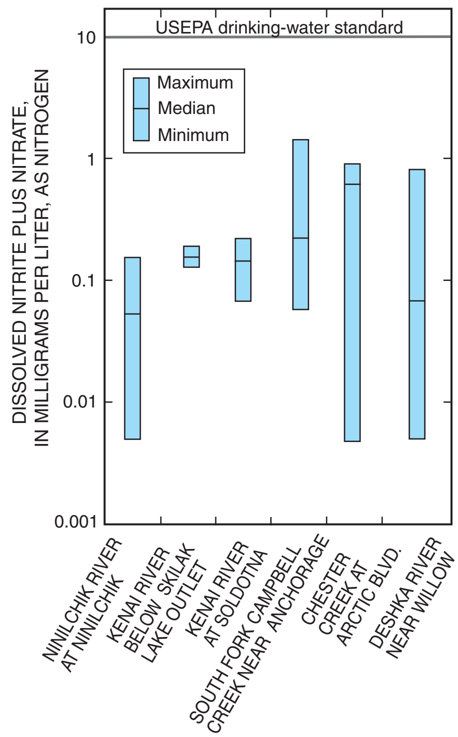


Figure 3. Excessive nitrate levels in surface water are not a serious problem in Cook Inlet Basin streams. Concentrations of dissolved nitrite plus nitrate were highest in streams in Anchorage, such as South Fork Campbell Creek and Chester Creek, but even these are considered low values, about one-tenth of the USEPA drinking-water standard of 10 milligrams per liter (as nitrogen).

a streamwater sample during this study, 2.4 mg/L, was observed in samples collected during snowmelt runoff at the uppermost of three sites on Little Rabbit Creek in the southern part of Anchorage. The 2.6-square-mile watershed upstream from this site has a low population density. Possible sources of nitrogen include animal wastes, fertilizers applied to lawns, effluent from septic systems, and nitrogen-fixing plants such as alder and clover.

Many phosphorus compounds are less soluble than nitrogen compounds and tend to attach to soil particles rather than dissolve in water. Naturally occurring phosphorus in soils and rocks may contribute to high nutrient levels in some Cook Inlet Basin streams, especially during stormflows when soil erosion can carry a considerable amount of particulate phosphate to streams. For example, streams draining lowlands on the Kenai Peninsula, such as Ninilchik River, (fig. 4) had high phosphorus concentrations. Nine of 12 sites in the southern part of the Kenai Peninsula had median concentrations of total phosphorus that exceeded the USEPA desired goal of 0.1 mg/L or less for preventing nuisance plant growth in streams (U.S. Environmental Protection Agency, 1986a). Concentrations of total phosphorus were low in streams draining shrub- and tundra-covered mountains, such as Kenai River below Skilak Lake Outlet, which drains the central region of the Kenai Peninsula or South Fork Campbell Creek near Anchorage. The phosphorus content of Anchorage streams generally was low. Specifically, median concentrations of total phosphorus at all 14 stream sites, including Chester Creek at Arctic Boulevard, were less than 0.03 mg/L. Concentrations of total phosphorus generally increased during stormflows and were as great as 0.59 mg/L in urban Chester Creek and in the undeveloped Johnson River in Lake Clark National Park and Preserve.

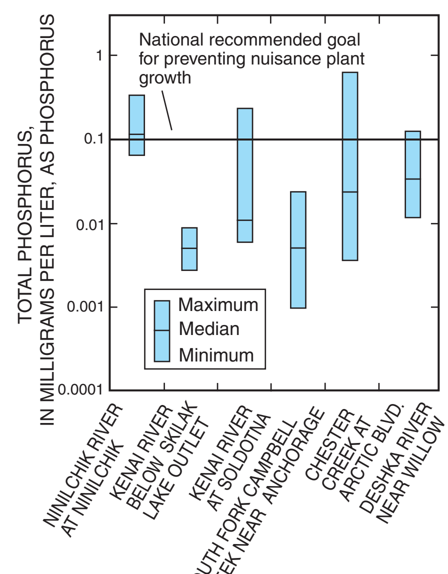


Figure 4. Concentrations of total phosphorus in streamwater at four of the six routinely sampled Cook Inlet Basin sites occasionally exceeded the USEPA recommended goal for preventing nuisance plant growth of 0.1 mg/L or less. Natural geologic conditions may prevent achievement of USEPA's recommended goal for nutrients at many lowland streams on the southern part of the Kenai Peninsula, such as the Ninilchik River.

Standards for Water, Biota, and Sediment Quality

The U.S. Environmental Protection Agency (USEPA) is responsible for setting drinking-water standards and guidelines to protect human health. A Maximum Contaminant Level (MCL) is the maximum allowable concentration of a contaminant in water delivered to any user of public water systems (U.S. Environmental Protection Agency, 2002). MCLs are enforceable standards based on an average concentration taken from four quarterly samples of finished (treated) drinking water. A Lifetime Health Advisory (HAL) is a nonenforceable, risk-based guideline. HALs indicate contaminant exposures below which no short- or long-term human-health effects are expected, based on drinking a specific amount of water for a specific period of time. Risk of illness increases with exposure time and concentration. Standards and guidelines to evaluate the potential adverse effects of volatile organic compounds (VOCs) and pesticides in water have limitations because not all VOCs, pesticides, or their breakdown products have standards or guidelines and drinking-water standards are based on toxicity tests on a single compound and do not evaluate the additive or synergistic effects of multiple compounds.

Nonenforceable guidelines for contaminants in water, sediment, and animal tissue also have been established by various agencies to protect aquatic life and wildlife. For contaminants in water, guidelines have been set by the USEPA (1986a), the Canadian Council of Resource and Environmental Ministers (1997), the Canadian Council of Ministers of the Environment (2002b), and the International Joint Commission of the United States and Canada. For contaminants in sediments, guidelines to protect aquatic life have been set by the Canadian Council of Ministers of the Environment (2002a, 2002b). Probable Effect Levels (PELs) are used to indicate contaminant concentrations in freshwater sediment associated with adverse effects on aquatic life. The PEL is an estimate of the concentration above which adverse biological effects are expected to occur frequently. PELs are established for 8 of the trace elements and 18 of the organochlorine and semivolatile organic compounds analyzed for the Cook Inlet Basin study. These sediment guidelines are based on bulk (whole) sediment samples. For this study, analyses of lakebed sediments were performed on bulk samples, whereas streambed sediments were sieved so that only particles finer than 0.063 millimeter were analyzed for trace elements and only particles finer than 2 millimeters were analyzed for organic contaminants. Some trace elements and organic compounds attach strongly to fine-grained sediment; thus, their concentrations are expected to be higher in sieved streambed samples than in bulk samples, and their toxicity may be overestimated. For contaminants in whole fish, the New York fish-flesh criteria for protection of fish-eating wildlife (Newell and others, 1987) were used. These animal-tissue guidelines are intended to protect wildlife from adverse effects other than cancer, such as mortality, reproductive impairment, and organ damage. Wildlife guidelines from the State of New York were used because no comparable national guidelines are available for a large number of contaminants.

Concentrations of dissolved organic carbon were highest in streams draining wetlands

The watersheds of the Ninilchik and Deshka Rivers include extensive peat-bog and black-spruce wetlands. Concentrations of dissolved organic carbon (DOC) in these rivers (fig. 5) were thereby greater than the national average level of 5.5 mg/L for NAWQA sites draining forested areas. In contrast, concentrations of DOC in the Kenai River below Skilak Lake Outlet, which drains glaciers, shrub, tundra, and forests, were always less than 1 mg/L. Streams in Anchorage, such as Chester Creek, had DOC concentrations that were similar to the national average values for streams draining residential and urban areas, 2.8 and 4.3 mg/L, respectively.

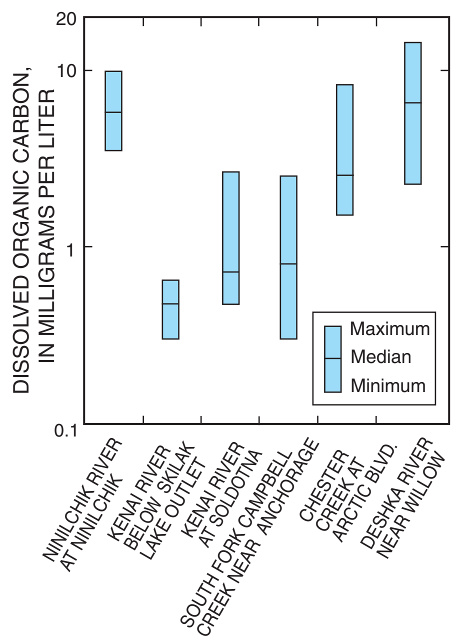


Figure 5. Naturally occurring dissolved organic carbon (DOC) causes the tea-colored water in many of Alaska's rivers that drain wetlands, such as the Ninilchik and Deshka Rivers. Concentrations of dissolved organic carbon in these streams were higher than in Chester Creek and other streams in Anchorage that drain residential and urban areas. Only small amounts of DOC were present in the Kenai River below Skilak Lake Outlet, which drains rugged mountains covered by glaciers, shrubs, tundra, and forests.

Dissolved organic carbon originates from natural sources, such as living and decaying plants, and from anthropogenic (human-related) sources. The amount of DOC in water is important because it can (1) contribute to water color, which absorbs sunlight and reduces the amount of light available for use by submerged aquatic plants and phytoplankton; (2) accelerate bacterial growth; (3) react with chemicals used to disinfect public water supplies and produce undesirable and harmful byproducts, such as chloroform and other trihalomethanes; (4) increase the solubilities of relatively insoluble compounds, such as *p,p'*-DDT and PCBs; and (5) form complexes with mercury and other trace elements and make them more soluble and mobile in water.

Urban streams are contaminated by fecal-indicator bacteria

E. coli, enterococci, and fecal coliform bacteria were present in almost all samples from five streams in Anchorage (Frenzel and Couvillion, 2002). Samples generally contained relatively low concentrations of all three fecal-indicator bacteria, except at sampling sites in subbasins with high population densities (fig. 6). Because of the wide variation, comparisons among streams based on only a few samples can be misleading; a few generalizations, however, can be made. Concentrations of fecal-indicator bacteria at Campbell Creek at C Street, South Fork of South Branch of Chester Creek at Boniface Parkway, and Chester Creek at Arctic Boulevard, three sites that drain subbasins with high population densities (greater than 1,000 people per square mile), were higher than those at six sites that drain subbasins with medium population densities or at five sites that drain subbasins with low population densities (fewer than 100 people per square mile) and occasionally exceeded Federal and State guidelines for water-contact recreation. Concentrations of fecal-indicator bacteria were slightly higher in summer when water-contact recreation occurs than in winter.

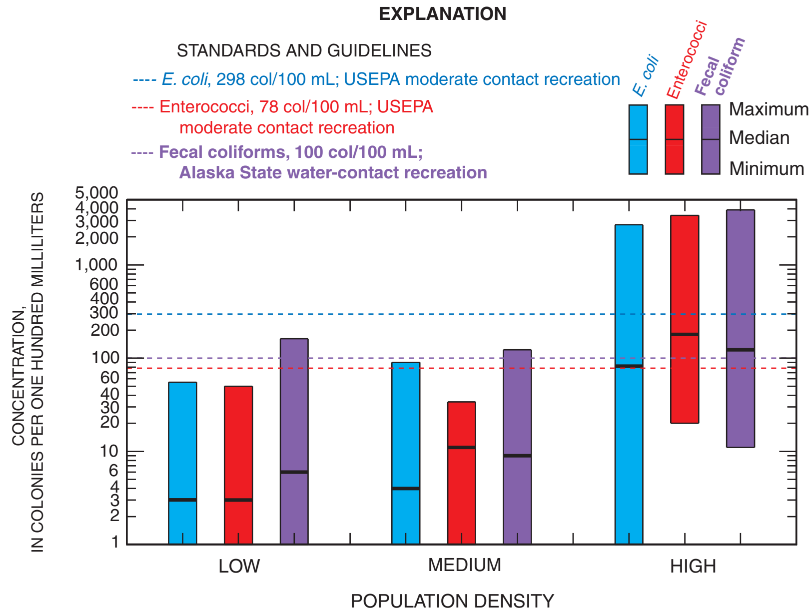


Figure 6. Concentrations of fecal-indicator bacteria were elevated in Anchorage streams draining subbasins with high population densities (greater than 1,000 people per square mile). Concentrations of *E. coli* or enterococci bacteria exceeded U.S. Environmental Protection Agency criteria for moderate full-body contact recreation (U.S. Environmental Protection Agency, 1986b) in about one-fourth to three-fourths of samples collected from two sites on Chester Creek and one site on Campbell Creek. About one-half of the samples collected from these three sites had concentrations of fecal-coliform bacteria that exceeded the Alaska State standard for water-contact recreation (Alaska Department of Environmental Conservation, 2003).

Finally, a large range in fecal-indicator bacteria concentrations over a 2-day period of stable (nonstorm) streamflow indicated that the sources or conditions influencing bacteria concentrations varied widely. Sources of fecal bacteria may include wastes from humans, domestic animals, waterfowl, and other wildlife. Dogs and waterfowl are present in parks and near urban streams throughout the year. During winter, large numbers of waterfowl gather along sections of streams that are free of ice. Most homes outside the major metropolitan areas use septic systems to dispose of their wastewater, whereas wastes within metropolitan areas are piped to wastewater-treatment plants. Effluent from some onsite septic systems or from leaking sewer lines could be reaching local streams.

During winter, ducks congregate near unfrozen reaches of streams, such as this drainage ditch to South Fork Chester Creek in Anchorage. (Photograph by Charles S. Couvillion, U.S. Geological Survey.)

Warning sign on Campbell Creek at C Street in Anchorage. (Photograph by Steven A. Frenzel, U.S. Geological Survey.)

Streams and rivers in the Cook Inlet Basin are colder than other rivers nationally

Stream temperature is an important physical factor for trout, char, and salmon that use the streams and rivers for spawning and rearing. To maximize survival, each species has adapted to specific spawning times and water temperatures in order that incubation of eggs and emergence of alevins and fry occur at the most favorable time of the year. The optimum water temperature for a fish depends on its species, its life stage, and the season. Water that is warmer than optimum may increase the vulnerability of fish to some diseases. The mean annual water temperature for the six routinely sampled sites (see basic fixed sites in Study Unit Design) ranged from 3.3 to 6.2 °C during water years 1999–2001 (fig. 7) (Brabets and Whitman, 2004). In contrast, Mohseni and others (1998) determined the mean annual water temperature of 584 streams and rivers in the contiguous United States to be 12.0 °C.

Water temperatures in Cook Inlet Basin streams are influenced by the physical characteristics of each basin (Kyle and Brabets, 2001). Water temperatures in the six routinely sampled Cook Inlet Basin streams generally were between 0 and 3 °C from November through March. In streams that drain forested lowlands and have no glaciers in their watersheds, such as the Ninilchik and Deshka Rivers, water temperatures warmed rapidly after snowmelt and were at their highest around the beginning of July. Water temperatures in lowland streams were as great as 21.5 °C. In contrast, water temperatures in small streams draining upland areas, such as South Fork Campbell Creek, or rivers draining glaciers, such as the Kenai River, did not exceed 15 °C during this study. The maximum allowable water temperature in Alaskan streams used by fish or other aquatic life is 20 °C (Alaska Department of Environmental Conservation, 2003). The maximum temperature allowed in fish migration routes and rearing areas is 15 °C. The maximum temperature allowed in spawning areas and in areas used for egg and fry incubation is 13 °C.

Spring breakup on the Ninilchik River. (Photograph by Robert T. Ourso, U.S. Geological Survey.)

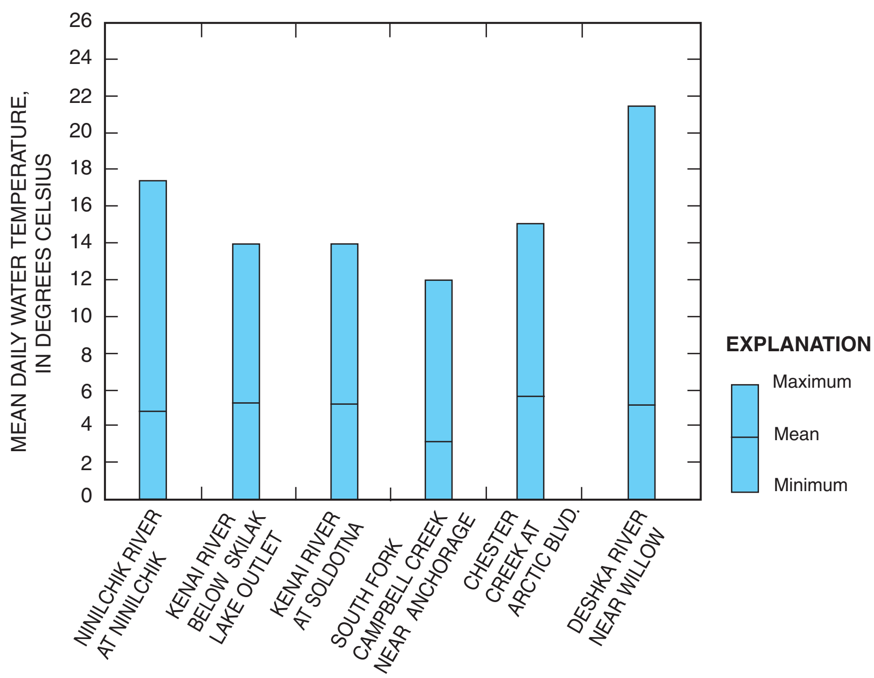


Figure 7. Water temperatures measured in Cook Inlet Basin streams and rivers during water years 1999–2001 were cold. At six of the streams where water temperatures were recorded continuously, water was colder than 6 degrees Celsius more than one-half of the year. Streams draining lowland areas, such as the Ninilchik and Deshka Rivers and Chester Creek, had water temperatures exceeding 16 degrees Celsius during midsummer, when daylight exceeds 19 hours each day. Water temperatures in glacier-fed rivers, such as the Kenai River, and small streams draining upland areas, such as South Fork Campbell Creek, were cooler.

Some streambed and lakebed sediments in the Cook Inlet Basin are contaminated by trace elements and organic compounds

Sediments in some urban streams and lakes contain elevated concentrations of trace elements and persistent organic contaminants. Some trace elements also occur naturally in the sediment and reflect the basin's rocks and minerals.

Trace elements are present at naturally large concentrations in streambed sediments

The trace elements arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc are of particular interest because they are potentially toxic to aquatic organisms and are widespread naturally or are byproducts of human activities. Naturally occurring concentrations of arsenic, chromium, copper, mercury, and nickel are high in streambed sediments throughout the relatively undeveloped Cook Inlet Basin when compared with reference or forested sites in the contiguous United States (Frenzel, 2000 and 2002). Median concentrations for Cook Inlet Basin sites exceeded the national median concentrations for all NAWQA sites (fig. 8), including urban and mining areas. About one-half of the streambed-sediment samples collected at 47 sites in the Cook Inlet Basin exceeded the Canadian aquatic-life guideline for arsenic (fig. 9) (Glass and Frenzel, 2001) or chromium (17 and 90 micrograms per gram [µg/g]), respectively), whereas all copper concentrations were less than the guideline (197 µg/g). At two sites in Anchorage and three sites in Lake Clark National Park and Preserve, mercury concentrations in sediments exceeded the Canadian aquatic-life guideline of 0.486 µg/g. All 15 sites sampled in Anchorage and all 8 sites sampled in a mineral-rich area of Lake Clark National Park and Preserve had concentrations of mercury greater than the national NAWQA median, 0.07 µg/g. In Anchorage, the concentration of mercury in sediments from South Fork Campbell Creek upstream from most urban developments

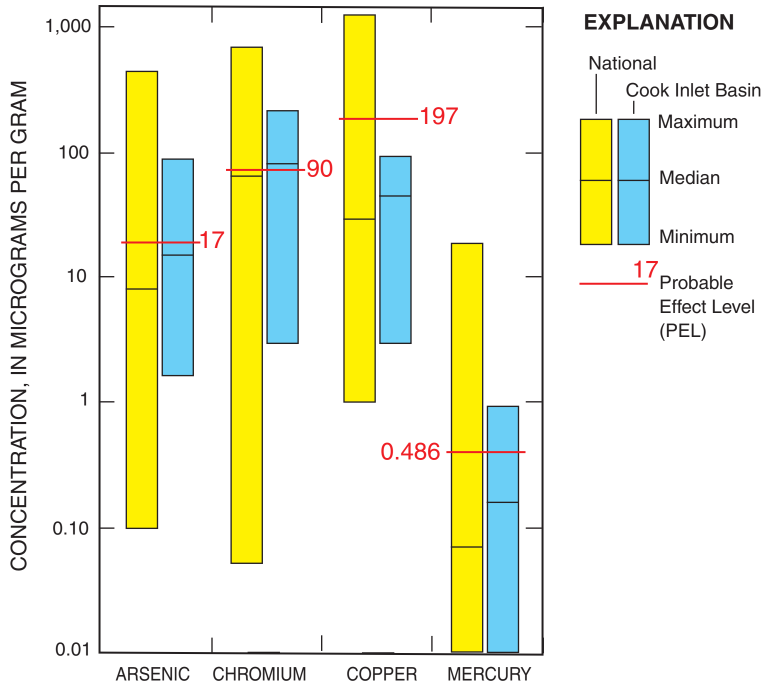


Figure 8. Median concentrations of arsenic, chromium, copper, and mercury in streambed sediments were greater in the Cook Inlet Basin than national medians for NAWQA sites from all types of land use. About one-half of the sediment samples from 47 sites in the Cook Inlet Basin exceeded the probable effect levels (PELs) for arsenic and chromium. PELs are those concentrations at which harmful effects to aquatic life are thought to be likely.

The headwaters of the Crescent River in Lake Clark National Park and Preserve include glaciers in the Aleutian Range (Photograph by Timothy P. Brabets, U.S. Geological Survey.)

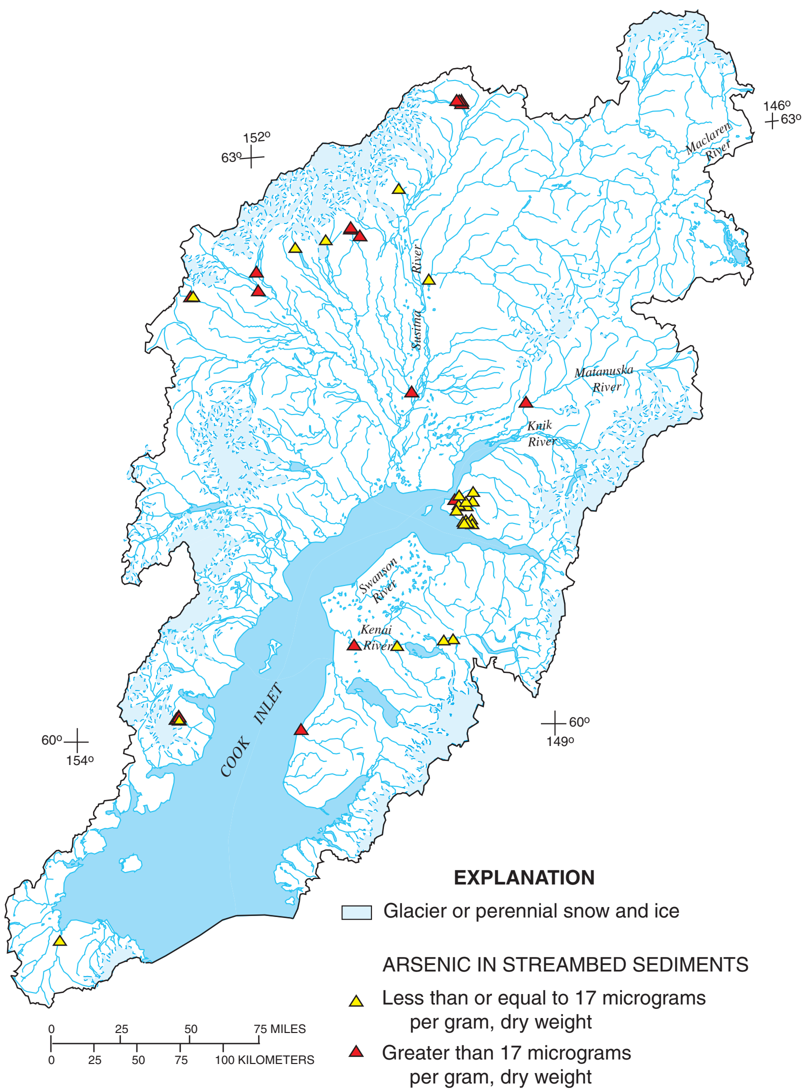


Figure 9. Concentration of arsenic in streambed sediments varied widely, even in nearby streams. About one-half of the samples collected for this study or for studies with the National Park Service using the same collecting and analyzing procedures had arsenic concentrations that exceeded levels at which harmful effects to aquatic life are thought to be likely (17 micrograms per gram).

was as great as 0.81 µg/g. In Lake Clark National Park and Preserve the mercury concentration was as great as 0.93 µg/g in East Fork Ore Creek, which drains the Johnson River prospect. Sources of mercury in the Anchorage area are unknown but may be a combination of natural geologic and atmospheric sources (Frenzel, 2002). However, because streambed samples were sieved and the guidelines are based on unsieved samples, the toxicity for these trace elements in Cook Inlet Basin streambed sediments may be overestimated.

Concentrations of cadmium, lead, and zinc were greatest in streambed sediments from Ore Creek and East Fork Ore Creek (Frenzel, 2002), which are in an undeveloped, mineral-rich area west of Cook Inlet in Lake Clark National Park and Preserve. Concentrations of these three trace elements were approximately 10 times greater in the Ore Creek watershed than the national median concentrations for all NAWQA sites (0.45 µg/g for cadmium, 29 µg/g for lead, and 120 µg/g for zinc). Sediments in a lower urban reach of Chester Creek in Anchorage also had levels of cadmium (1.0–1.2 µg/g), lead (90–110 µg/g), and zinc (590–600 µg/g) that were greater than most other streams in Cook Inlet Basin but were not as great as those at Ore Creek. In contrast, sediments in Chester Creek at a site upstream from urban development had concentrations of cadmium, lead, and zinc of 0.2, 10, and 82 µg/g, respectively. Potential sources of these trace elements in Anchorage's urban streams are the past and present use of motor vehicles and other urban activities.

Concentrations of lead in lakebed sediments have decreased since the 1970s

In its lower, urbanized section, Chester Creek flows through two small impoundments, Hillstrand Pond and Westchester Lagoon. Soil and debris carried by runoff or atmospheric deposition can settle to the bottom of these ponds in successive layers and create a record of water-quality conditions over time. Sediment cores were collected from the deepest parts of the water bodies during April 1998 and the cores were sliced into segments. Each segment was age-dated and individually analyzed to determine concentrations of trace elements and organic contaminants (P.C. Van Metre, U.S. Geological Survey, written commun., 2001). The oldest segments of the samples analyzed from Hillstrand Pond and Westchester Lagoon were deposited around 1971 and 1968, respectively, and historical trends were reconstructed for several persistent, stable contaminants. Lead concentrations in these lakebed sediment cores (fig. 10) followed a trend similar to that shown in other urban lakes sampled throughout the nation, where lead concentrations increased from the 1960s through the early 1970s, peaked in the mid-1970s and then decreased with the introduction of unleaded gasoline (Callender and Van Metre, 1997). Both natural and anthropogenic sources contribute lead to the environment, but lead from anthropogenic sources, mainly from atmospheric emissions, is many times the total contribution from natural sources.

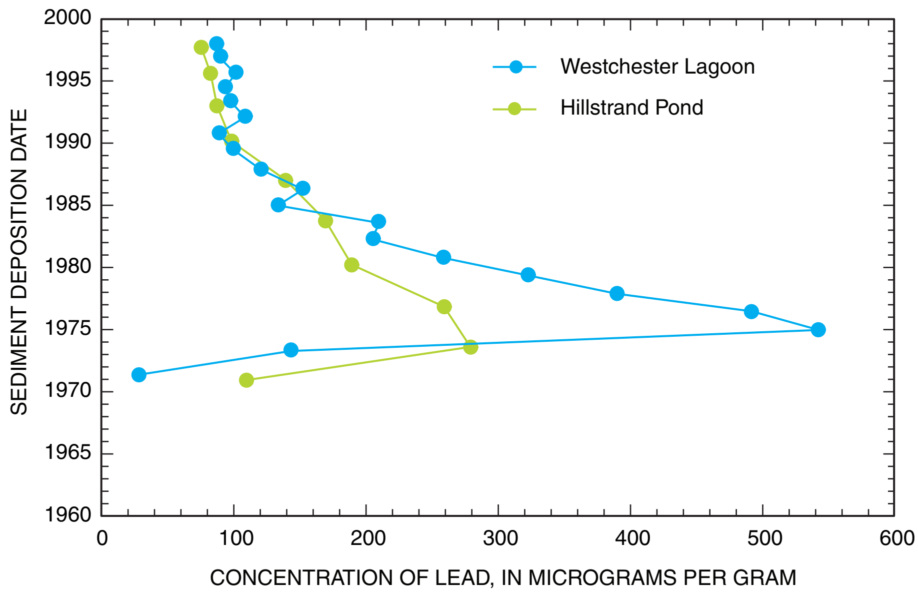


Figure 10. Lead concentrations in sediments from two urban ponds in Anchorage have decreased since the mid-1970s, but recently deposited sediments still have higher concentrations of lead than predevelopment levels (about 10 µg/g). The decrease in lead concentrations in urban lakebed sediments throughout the United States has been attributed primarily to the elimination of lead in gasoline. Concentrations of lead in sediments greater than 91.3 micrograms per gram may adversely affect aquatic life.

The use of lead in other products, such as paints, ceramics, caulk, and pipe solder, also has been reduced greatly in recent years. Concentrations of lead in the sediment cores from Hillstrand Pond and Westchester Lagoon have decreased by 73 and 84 percent, respectively, from their peak levels, indicating improving conditions for this contaminant. However, lead concentrations in these lakebed sediments in 1998 are nearly 10 times greater than predevelopment levels (about 10 µg/g). Large amounts of lead remain in local urban soils and aquatic sediments, and it may take years or even decades to reduce these concentrations to background levels, even if there are no new sources of lead pollution.

In contrast to trends in lead, concentrations of cadmium and zinc in sediments in Westchester Lagoon increased during the 1970s and varied during the 1980s and 1990s, but do not show a definitive downward trend. Cadmium concentrations ranged from 0.23 µg/g in the deepest sample to 1.7 µg/g in the shallowest sample. Zinc concentrations ranged from 129 µg/g in the deepest sample to 690 µg/g in the shallowest sample, with a peak concentration of 921 µg/g in sediments deposited around 1993. Canadian guidelines for the protection of aquatic life for cadmium and zinc are 3.5 and 315 µg/g, respectively (Canadian Council of Ministers of the Environment, 2002b). Cadmium is used as a protective plating on metals; in electrical batteries; in pigments for paint, printing ink, and plastic; as a stabilizer for PVC plastic; and in fluorescent and video tubes. Zinc is used as a protective plating on metals and as an additive to rubber in automobile tires.

Chemically persistent organic contaminants were detected in urban lakebed sediments but were detected only infrequently in streambed sediments or fish tissues

The use of most organochlorine insecticides and polychlorinated biphenyls (PCBs) ended 15 to 30 years ago. However, because they attach strongly to soil particles and degrade very slowly, many of these compounds or their breakdown products are still present in streambed and lakebed sediments and fish throughout the United States at concentrations that may have adverse effects on aquatic organisms and fish-eating wildlife.

In the Cook Inlet Basin, concentrations of organochlorine insecticides, such as chlordane, DDT, and dieldrin, were determined from streambed sediments from 6 sites, from lakebed sediment cores from 2 urban sites, and from whole fish from 12 sites (Frenzel, 2000). The summed concentration of DDT and its metabolites was as great as 51 micrograms per kilogram (µg/kg) in lakebed sediments deposited during the mid-1970s in Westchester Lagoon, whereas the concentration in recently deposited sediments was 10 µg/kg. Concentrations of *p,p'*-DDT, *p,p'*-DDD, and *p,p'*-DDE in recently deposited lakebed sediments did not exceed Canadian guidelines for protection of aquatic life (4.77, 8.51, and 6.75 µg/kg, respectively) (Canadian Council of Ministers of the Environment, 2002b). No organochlorine insecticide was detected in streambed-sediment samples at a concentration above minimum laboratory reporting levels. Only dieldrin was present in low, but unquantifiable, concentrations in streambed sediment from the Talkeetna River.

p,p'-DDT and its breakdown product *p,p'*-DDE were detected in small concentrations (less than 10 µg/kg) in a whole-fish sample from a site on South Fork Campbell Creek in Anchorage, upstream from urban development. No detectable concentrations of organochlorine insecticides were present in fish-tissue samples collected from 11 other sites. The fish species analyzed was slimy sculpin (*Cottus cognatus*), a non-migratory benthic (bottom) feeder present in many Cook Inlet Basin streams. Aquatic insects and salmon eggs make up the bulk of a sculpin's diet. Sculpins are not usually consumed by humans but are eaten by other fish and fish-eating wildlife. The New York guideline for the protection of fish-eating wildlife is 200 µg/kg for total DDT (the summed concentrations of DDT and its breakdown products) (Newell and others, 1987).

Concentrations of total PCBs in urban lakebed sediments that were deposited in the mid-1970s in Westchester Lagoon were as great as 620 µg/kg, whereas recently deposited lakebed sediment had a concentration of 147 µg/kg. The peak total PCB concentration exceeded the Canadian aquatic-life guideline of 277 µg/kg (Canadian Council of Ministers of the Environment, 2002b). No PCBs were detected in samples of streambed sediments at six sites in the Cook Inlet Basin. Of 12 sites sampled for total PCBs in fish tissue, only the urban reach of Chester Creek had fish with a detectable concentration (Frenzel, 2000). The total PCB concentration (79 µg/kg) determined from a composite sample of whole sculpin was below the New York guideline for the protection of fish-eating wildlife (110 µg/kg).

Semivolatile organic compounds were detected infrequently in streambed sediments

At most sites in the Cook Inlet Basin, semivolatile organic compounds (SVOCs) in streambed sediments either were not detected or were detected at low concentrations, far below guidelines for the protection of aquatic life (Frenzel, 2000). SVOCs detected in sediments include phenols, phthalates, and polycyclic aromatic hydrocarbons (PAHs). The highest concentrations in streambed sediments were detected in samples from Chester Creek. Concentrations varied among three samples collected in 1998, 1999, and 2000 from Chester Creek at Arctic Boulevard, but concentrations in the 1999 sample exceeded Canadian aquatic-life guidelines for the PAHs benz[*a*]anthracene, phenanthrene, and pyrene. Coring of lakebed sediments from Hillstrand Pond and Westchester Lagoon on Chester Creek confirmed the presence of elevated concentrations of a variety of SVOCs. Concentrations of phenanthrene and pyrene in lakebed sediments from Westchester Lagoon have been elevated (exceeded aquatic-life guidelines) but variable since the 1970s. Moose Creek, a stream northeast of Palmer with extensive coal deposits in its watershed, also had numerous SVOCs in its streambed sediment. All concentrations were below aquatic-life guidelines.

Lipid-containing semipermeable membrane sampling devices (SPMDs) were used to sample for SVOCs in water at five urban and one undeveloped location on streams in Anchorage during May-July 2000 (J.N. Huckins, written commun., 2001). Total PAH concentrations were highest at a site on Campbell Creek near an area of high vehicular traffic. Three priority-pollutant PAHs—fluoranthene, chrysene, and pyrene—were detected in low concentrations in water from Chester Creek at Arctic Boulevard; all concentrations were less than the Canadian aquatic-life guidelines.

With sufficient exposure, some SVOCs are carcinogenic, causing tumors in fish and other animals, and some are toxic to some organisms (Eisler, 1987). SVOCs are present in many products, such as plastics, dyes, and disinfectants. Some PAHs are byproducts of combustion, such as those associated with forest fires, power generation, and vehicle emissions, and some may occur naturally in areas containing peat, coal, and oil.

Aquatic communities are adversely affected by a variety of natural and human-induced stresses

The diversity (number of taxa and number of individuals of each taxa) of algae, aquatic macroinvertebrates, and fish in a stream reflect its overall condition. Naturally occurring harsh physical conditions in the Cook Inlet Basin, including frozen stream surfaces for several months each year and streambeds that periodically are scoured by ice or high streamflows, can stress aquatic organisms. Productivity and species diversity in these streams are naturally limited because for much of the year the amount of available sunlight is limited and water temperatures are less than 3 °C. Many of the streams have glaciers in their headwaters, which can result in high concentrations of suspended sediment particles that reduce water clarity. Because of the harsh natural conditions of Cook Inlet Basin, the diversity of aquatic organisms is low; consequently, direct comparison of the diversity of aquatic organisms in Alaskan streams with that of streams in the lower 48 contiguous States to indicate water-quality and habitat conditions may not be appropriate.

Anthropogenic factors associated with increased development also can stress aquatic organisms. These include straightening of stream channels; removal of vegetation and woody debris in and near streams; flushing of contaminants (such as road deicing salts, fuels and other automotive fluids, sediments, herbicides, insecticides, and fertilizers) from streets, parking lots, and yards; and changing the natural land surface so that it is less permeable and drains water more quickly. Recreation also can adversely affect aquatic organisms. Pollutants are added directly to the water from two-cycle boat engines. Vehicles crossing stream channels and wakes from motorized boats can increase streambank and streambed erosion. Jet-driven boats in shallow streams may disturb streambeds, including gravels used by salmon and trout for egg and alevin development. Foot traffic can damage vegetation and root systems and can increase streambank erosion.

Algae—Attached algae were collected from 39 streams in the Cook Inlet Basin to help assess stream quality. The forested Ninilchik and Deshka Rivers had the greatest diversities of algae (Brabets and Whitman, 2004), whereas urbanized reaches of Chester and Campbell Creeks had the lowest diversities. In streams where both diatoms and soft algae were sampled, diatoms commonly were the most abundant type of algae present. Blue-green, green, and red algae also were present at most sites.

The algal communities at three sites along Chester Creek in Anchorage were examined during a summer low-flow period in 2000. Land cover upstream from the upper sampling site is mostly undisturbed forests and shrubs that contain little urban development, whereas about 38 percent of the watershed upstream from the lowest site consists of land used for residential, commercial, industrial, or transportation purposes. The chemical makeup of the water (Ourso and Frenzel, 2003) and the composition of algal communities (K.D. Carpenter, U.S. Geological Survey, written commun., 2003) changed as the water flowed downstream and as the land contributing water to the stream became more urbanized. Nutrient concentrations did not change appreciably with increasing urbanization, but concentrations of sodium and chloride (used for road deicing) increased as the percentage of impervious area in a watershed increased. In Chester Creek, the relative abundance of algae that are tolerant of increased salinity, such as *Diatoma moniliformis* and *Diatoma tenuis*, increased from the headwaters to the mouth, as did specific conductance, an indicator of the amount of dissolved minerals in water (fig. 11).

Biologist sampling aquatic invertebrates on the Kenai River below Skilak Lake Outlet near Sterling, Alaska. (Photograph by William A. Swenson, U.S. Geological Survey.)

Aquatic invertebrates—As many as 32 taxa of macroinvertebrates (at the family taxonomic level) were collected in riffles or pools or from woody debris at the six routinely sampled sites in the Cook Inlet Basin (Brabets and Whitman, 2004). Most of the macroinvertebrates were insects and worms. Sites on the less developed Ninilchik River and South Fork Campbell Creek had the highest number of aquatic insects intolerant of physical and chemical disturbances, such as mayflies, stoneflies, and caddisflies (Orders Ephemeroptera, Plecoptera, and Trichoptera, respectively, or EPT taxa), indicating good habitat and water-quality conditions. Midges, mayflies, stoneflies, and caddisflies accounted for 80 percent or more of the macroinvertebrates at five of the six

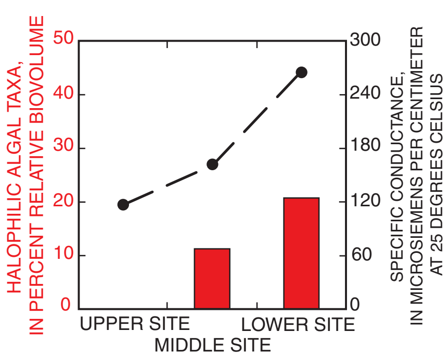


Figure 11. The proportion of algae that prefer water enriched with dissolved minerals (halophilic) increased in Chester Creek during June 2000 from its headwaters to its mouth, corresponding with an increase in the amount of urbanized land contributing water to the stream and consequent increase in specific conductance.

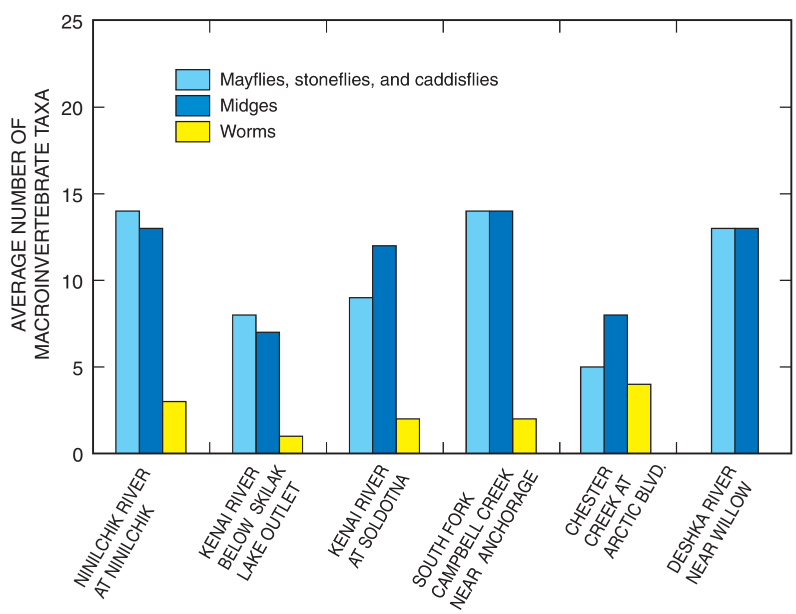


Figure 12. Of the six intensively sampled sites in Cook Inlet Basin, Ninilchik River and South Fork Campbell Creek had the highest diversity of macroinvertebrates, indicating better habitat and water-quality conditions. Chester Creek at Arctic Boulevard, a stream in Anchorage draining urban areas, had the fewest number of mayfly, stonefly, and caddisfly taxa and the greatest number of worm taxa, indicating degraded conditions. As much as 79 percent of the invertebrate individuals in samples from Chester Creek were worms.

routinely sampled sites in the Cook Inlet Basin (fig. 12). Midges were the most dominant of the insect families at most sites. Worms indicative of poor water-quality or stream-habitat conditions made up between 48 and 79 percent of the total number of individual macroinvertebrate organisms at the urban Chester Creek site. In some samples, such worms also made up nearly one-third of the individuals at South Fork Campbell Creek and Kenai River at Soldotna, indicating that conditions are harsh even at these less developed sites. The number of invertebrate taxa present in Anchorage streams generally decreased as the amount of urbanization in the watershed increased (Ourso, 2001; Ourso and Frenzel, 2003). At 12 stream sites in Anchorage, total taxa richness (at the family level) ranged from 17 to 24 in 1999 and from 12 to 22 in 2000.

Aerial view of Anchorage looking north to Knik Arm. (Photograph by Roy L. Glass, U.S. Geological Survey.)

Sport fishing for salmon is an economically important activity in the Cook Inlet Basin. (Photograph courtesy of Kell Frederiksen.)

Coho salmon. (Photograph by William A. Swenson, U.S.Geological Survey.)

Chinook salmon. (Photograph courtesy of Heather Plucinski.)

Fish—Unlike most of the contiguous United States, only a few species of fish are naturally present in streams in the Cook Inlet Basin. Each of the 19 sites in the Cook Inlet Basin where fish were sampled had fewer than 10 species present. Slimy sculpin, three-spine stickleback, and one or more of the five species of Pacific salmon (sockeye, pink, chinook, coho, and chum) were present at most sites. Rainbow trout and Dolly Varden char also were present at many sites, with Dolly Varden often the only salmonid occurring in high-gradient or alpine streams. Even though few species of fish are present in Cook Inlet Basin streams, large numbers of salmon return each summer to spawn. During 1999–2001, the annual commercial harvest of sockeye salmon in Cook Inlet ranged from 1.6 to 3.2 million fish (Alaska Department of Fish and Game, 2003a).

Salmonids are sensitive to changes in water-quality and physical-habitat conditions, and their presence in Cook Inlet Basin streams suggests that habitat and water-quality conditions are generally good. However, chinook and coho salmon and rainbow trout are stocked in several streams and lakes in the basin, including Chester and Campbell Creeks in Anchorage. Thus, the abundance of these sport fish in streams sampled in Anchorage may not accurately reflect actual water-quality and habitat conditions. A few of the rainbow trout and coho salmon collected from Chester and South Fork Campbell Creeks had fin erosion or external anomalies, but these fish may have been stocked. External anomalies were rarely observed on fish at other study sites.

One prominent threat to the health of local fish assemblages in Cook Inlet Basin is urban development. The abundance of native stocks of sensitive fish species, such as coho salmon, has decreased in urban streams such as Chester Creek in Anchorage. Several thousand adult coho salmon used to return to the upper reaches of Chester Creek, but between 1996 and 1999 fewer than a few dozen adult coho returned to the upper reaches (Whitman, 2002).

Possible reasons for the decline in numbers include increased flood intensity, barriers to the movement of adult and juvenile fish, reduced physical-habitat complexity because of the channelization of streambeds, siltation of spawning gravels, stressful water-chemistry conditions, elevated levels of trace elements and organic compounds in streambed sediments, and introduction of nonnative fishes that can prey upon juvenile salmon and compete for food and habitat resources (Whitman, 2002).

The introduction of fish species into streams where they are not native is an issue throughout the United States. Common methods of introduction include intentional and accidental stocking, release of bait fish, release of unwanted aquarium fish, escape from aquaculture facilities, and discharge of ballast water. Potential adverse effects include competition with native species for food and habitat, reduction of natives by predation, transmission of diseases or parasites, and habitat alteration. An example of a nonindigenous fish in the Cook Inlet Basin is the northern pike, which was collected from the Deshka River during this study and has been reported by Alaska Department of Fish and Game (2003b) to be present in several streams and lakes in Anchorage, on the Kenai Peninsula, and in the Matanuska and Susitna River valleys. Northern pike are native to interior and western Alaska but are not native to lakes and streams in the Cook Inlet Basin in south-central Alaska. Pike are voracious eaters and feed on threespine stickleback and juvenile salmon, trout, and char. According to the Alaska Department of Fish and Game, the presence of pike in lakes and streams in the Cook Inlet Basin is jeopardizing local sport fisheries for salmon, trout, and char (Stratton, 2001).

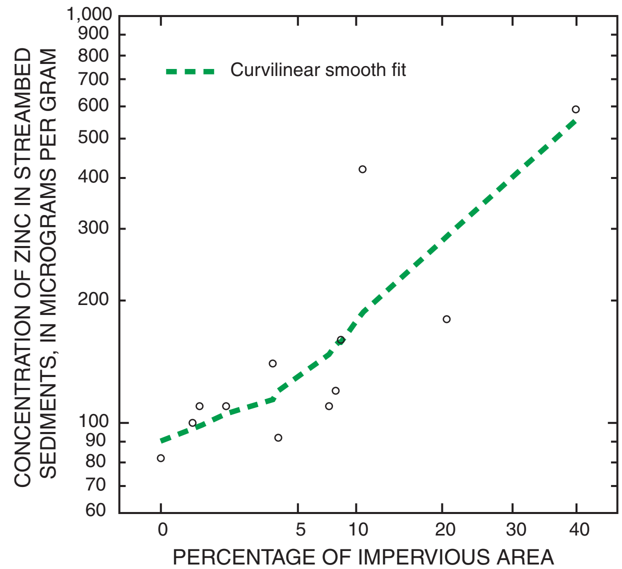


Figure 13. Concentrations of zinc in streambed sediment at 12 sites in Anchorage increase as the percentage of areas developed for homes and businesses and their associated streets and parking lots increases. Concentrations of zinc in streambed sediments greater than 315 micrograms per gram may adversely affect aquatic life. The sediment samples were collected in 2000.

Degradation of water quality and stream ecosystems occurs early in the process of watershed urbanization

An assessment of the chemical, physical, and biological characteristics of 12 subbasins in 4 streams in Anchorage demonstrates the effects of even limited development of watersheds on water quality and stream ecosystems. These characteristics were measured in the subbasins of Chester Creek, Campbell Creek, Rabbit Creek, and Little Rabbit Creek in 1999 (Ourso, 2001; Moran, 2002) and in 2000 (Ourso and Frenzel, 2003). Chemical characteristics may change with increasing watershed development because runoff from roads, parking lots, and yards and emissions from vehicles can add contaminants to the water. Specifically, concentrations of sodium, chloride, iron, and manganese in water in Anchorage streams increased with increasing levels of urbanization, as measured by population density, road density, storm-drain density, or percentage of impervious area within the watershed upstream from a sampling site. Sodium and chloride commonly are associated with the application of deicing salts on roads, sidewalks, and driveways and are present in water softener backwash and domestic wastewater. Concentrations of four trace elements (cadmium, lead, nickel, and zinc) in streambed sediments also increased with increasing impervious area. Zinc (fig. 13), cadmium, and lead were found to increase most notably when more than 5 to 10 percent of the watershed was classified as impervious. Although concentrations of nickel also increased with increasing measures of urbanization, overall, concentrations were not higher than concentrations elsewhere in the Cook Inlet Basin. Potential sources of zinc in the sediments include the wear of automobile tires, vehicle emissions, erosion of galvanized pipes and metals, treatments for controlling moss growth on roofs, and commercial and industrial nonpoint-source activities.

Physical disturbances to streams also are associated with watershed development and urbanization. For example, as forests and wetlands are converted to urban land, some segments of streams are cleared, ditched, and straightened to facilitate drainage and the movement of floodwaters. These modifications to streams cause quicker water runoff, which can transport large amounts of sediment, scour instream habitats, destroy fish spawning beds, and remove woody debris and other stream habitat for invertebrates and fish. Such physical disturbances create stream characteristics that are not tolerated by some aquatic organisms, which require a firm or gravelly substrate, ample food sources, and adequate natural habitat to thrive.

An important indicator of chemical and physical degradation in streams in developed areas is a decrease in populations and communities of aquatic species sensitive to contamination. For example, EPT taxa (mayflies, stoneflies, and caddisflies) decreased with increasing urbanization in a watershed, as measured by human population density, road density, storm-drain density (Ourso, 2001), or percentage of impervious area (Ourso and Frenzel, 2003). Invertebrate communities in riffles in undisturbed reaches in the upper Chester and Campbell Creek watersheds were more diverse and had a greater abundance of EPT taxa than did the more urbanized downstream reaches. At the uppermost Chester Creek site, 8 to 11 families in the EPT taxa were observed during 1999–2000, whereas 4 to 6 EPT taxa were observed at the lower site. At the upper Campbell Creek site, 10 EPT taxa were observed during 1999–2000, whereas 5 to 8 EPT taxa were observed at the lower site. The more developed downstream reaches of these two streams also contained greater numbers of worms that are commonly associated with diminished water quality. Similarly, as urbanization increased (as measured by impervious area), the number and abundance (or "richness") of macroinvertebrates decreased (fig. 14). The decrease or degradation of macroinvertebrate communities in the Cook Inlet Basin occurs early in the process of watershed urbanization. Specifically, macroinvertebrate richness in Anchorage streams may begin to degrade in drainage basins with only about 5 percent impervious area, which in Anchorage correlates with a human population density as low as 125 to 250 people per square mile.

Both chemical contamination and physical-habitat disturbance may be factors in the degradation of biological communities. Relations between

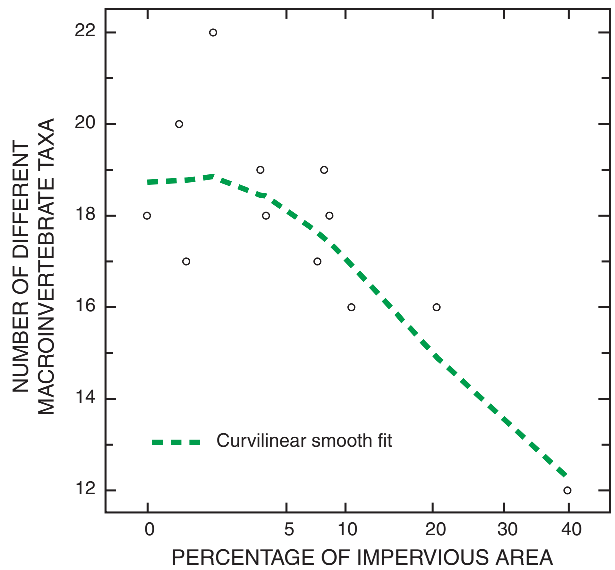


Figure 14. The richness (number and abundance) of macroinvertebrates—mostly aquatic insects and worms—in streams in Anchorage decreased as undisturbed regions of forests and shrubs were converted to less permeable roads, parking lots, and houses. Streams with more than 10 percent of their drainages classified as impervious had fewer types of macroinvertebrates than streams with watersheds with less than 10 percent impervious cover. Macroinvertebrate data were collected during June and July 2000.

Runoff from spring snowmelt in urban areas flows into storm drains and then to local streams. (Photograph by Daniel A. Long, U.S. Geological Survey.)

invertebrate communities and chemical contamination or watershed development (as indicated by population density or impervious land cover, for example) are useful to help understand where water-quality-management actions are likely to have the greatest effects in improving stream conditions for aquatic insects and for the fish that feed on them. The relative role and effects of contaminated water, habitat disturbance, and other factors on the aquatic ecosystem are still uncertain, which demonstrates a need to continue filling the gaps in biological and habitat monitoring. Such information is critical for water-resource managers in prioritizing management strategies that are optimal for a particular system; for example, focusing resources on controlling storm runoff, restoring physical habitat, or tracking chemical use.

Natural and human factors affect ground-water quality

Ground-water quality was investigated in the portion of the unconsolidated alluvial and glacial aquifers used for domestic, public, and industrial supplies. Although ground water is withdrawn from bedrock aquifers in upland areas for domestic supplies, its usage is not as great.

Concentrations of chemical constituents in ground water in the Cook Inlet Basin are influenced by local geologic conditions and indicate minimal adverse effects from human activities. Radon, arsenic, iron, and manganese occur naturally in aquifer materials throughout the Cook Inlet Basin, and their concentrations in ground water commonly exceeded proposed and existing drinking-water standards or guidelines (Glass, 2001). Higher concentrations of sodium and chloride were present in ground water near the mouth of the Kenai River than elsewhere. However, brackish ground water in this coastal area is more likely to be remnant water from the time when a larger ancestral Cook Inlet covered the area than the result of seawater intrusion from the pumping of ground water (Glass, 1999, 2001). Peat and organic-rich soils may contribute color and organic matter to the water. Ground water in coal-bearing or other organic-rich areas, such as the Kenai Peninsula and areas north of Wasilla and Palmer, also may have a hydrogen sulfide or rotten-egg odor. Urban, agricultural, and industrial activities may contribute nutrients, pesticides, and VOCs to underlying aquifers. The effects from these activities appear minimal so far, because concentrations of nitrate, pesticides, and VOCs in ground water were low, all below drinking-water standards and guidelines. Adverse effects may not yet be apparent in water currently pumped from wells because much of the development has occurred within the last 30 years. Analyses of samples for tritium and chlorofluorocarbons indicate that water in most wells was recharged less than 50 years ago (Glass, 2002). Such young ground water indicates that flow paths from areas of water recharge to the water-supply wells are relatively short and that the ground water in the Cook Inlet Basin is vulnerable to contamination.

Low levels of pesticides and volatile organic compounds were detected in ground water

Water from about 25 percent of the wells sampled in the Cook Inlet Basin contained one or more pesticides or pesticide-degradation products at low concentrations (Glass, 2001). Only three pesticides were present at concentrations greater than 0.003 µg/L: methyl azinphos (also known as Guthion or Carfene), tebuthiuron (Spike or Perflan), and fluometuron. The highest concentration was 0.007 µg/L. None of the pesticides detected in ground-water samples exceeded a federally established drinking-water standard or guideline.

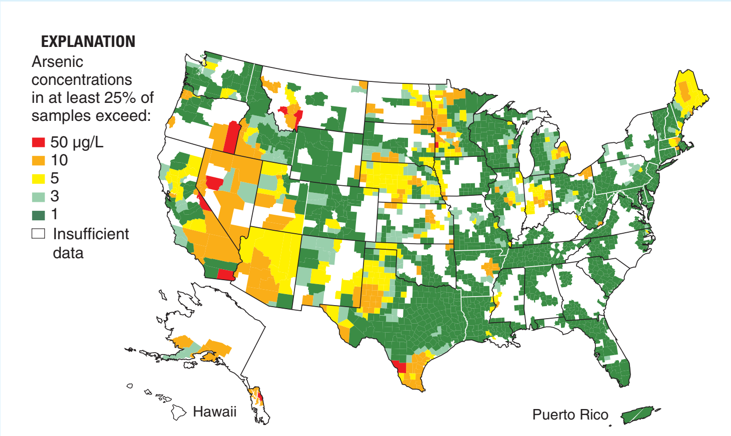
One or more VOCs were detected in most ground-water samples at low concentrations; none exceeded a federally established drinking-water standard or guideline. Only 2 of 55 VOCs for which samples were analyzed were detected at concentrations greater than 0.2 µg/L: methylbenzene (toluene) and trichlorofluoromethane (CFC–11, or freon–11). Water from 18 percent of the wells had concentrations of toluene or CFC–11 greater than 0.2 µg/L. Toluene is present in gasoline and emissions from automobiles. CFCs were used as coolants in refrigeration, as propellants for aerosol cans, and as solvents. The manufacturing of most CFC products ended in 1996 because of concerns that CFCs depleted ozone in the stratosphere. The gasoline additive methyl *tert*-butyl ether (MTBE) was not detected in any ground-water sample, although it was detected in surface-water samples from Chester Creek in Anchorage.

Concentrations of nutrients in ground water were low

Nutrients were prevalent at relatively low concentrations in ground water of the Cook Inlet Basin. All concentrations of nitrite plus nitrate in wells sampled were less than the USEPA drinking-water standard of 10 mg/L (as nitrogen) (see Appendix). Concentrations of nitrate typically were less than 0.2 mg/L in rural areas and highest in Anchorage, as high as 4.8 mg/L. Water from a municipal public-supply well in the eastern part of Anchorage in a relatively undeveloped area had a nitrate concentration of 2.5 mg/L, which may be due to the presence of nitrogen-fixing plants such as alder and clover. Concentrations greater than about 3 mg/L may indicate additional sources of nitrogen, such as from the application of fertilizer, septic-tank effluent, or animal wastes.

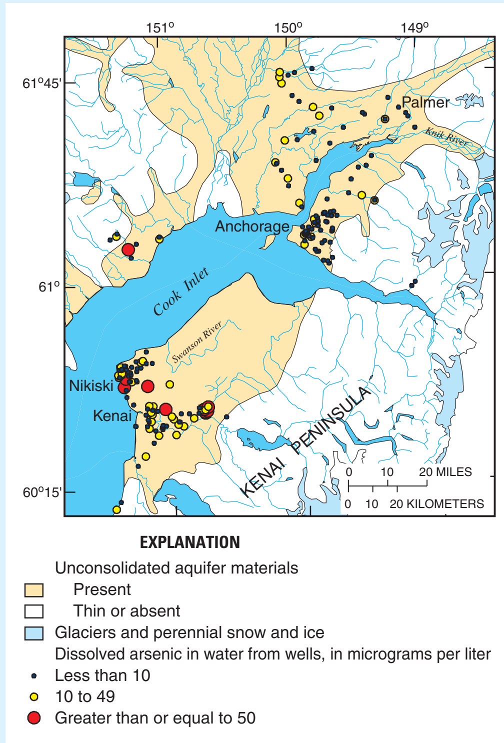
Orthophosphate, which accounts for nearly all the dissolved phosphorus, was less prevalent than nitrate. Forty-seven percent of wells sampled had water containing less than 0.01 mg/L of orthophosphate. The highest concentrations of orthophosphate detected, 0.43 and 0.45 mg/L, were in samples from wells on the Kenai Peninsula and are most likely due to naturally occurring phosphorus in the area’s soils and rocks.

Arsenic in Ground Water is a National Concern



Arsenic is a naturally occurring trace element in natural water. With sufficient exposure, arsenic in drinking water has been associated with skin, lung, bladder, liver, and kidney cancer in humans (National Academy of Sciences, 2001). Arsenic also has been reported to impair development and hearing; to adversely affect the vascular, gastrointestinal, and nervous systems; and to be associated with diabetes. The drinking-water standard (effective 2006) of 10 µg/L established by the U.S Environmental Protection Agency (2001) applies to the sum of all arsenic forms in finished (treated) drinking water.

Areas of the Western United States and upper Midwest have relatively high arsenic concentrations in ground water (Ryker, 2001). Nationally, about 11 percent of 20,000 wells sampled by USGS yielded water that had arsenic concentrations exceeding the 10-µg/L drinking-water standard. Concentrations of arsenic in water sampled from 34 wells in Cook Inlet Basin for this study ranged from less than 1 to 29 µg/L (Glass, 2001) and ranked in the upper three-fourths of the concentrations at NAWQA major-aquifer study sites sampled nationwide during 1991–2001 (see Appendix). Arsenic in water from 18 percent of wells sampled (6 of 34) exceeded the drinking-water standard. In previous ground-water-quality studies in the Cook Inlet Basin, arsenic concentrations as great as 150 µg/L were reported (Glass and Frenzel, 2001). About 40 percent of the 109 wells sampled by USGS through 2001 in the Kenai Peninsula Borough and 29 percent of the 35 wells sampled in the Matanuska-Susitna Borough yielded water exceeding the 10-µg/L standard. Although arsenic resulting from human activities can contaminate water, the high concentrations of arsenic in Cook Inlet Basin are most likely from natural sources.



Concentrations of radon in ground water are a health concern

Radon was detected in all ground-water samples in the Cook Inlet Basin; concentrations ranged from 140 to 610 picocuries per liter (pCi/L) (Glass, 2001). About 39 percent of the wells sampled in the Cook Inlet Basin yielded water in which the concentration of radon exceeded the proposed drinking-water standard of 300 pCi/L; no sample exceeded the proposed alternative standard of 4,000 pCi/L, the higher level applicable when accompanied by a mitigation program to address radon risks in indoor air (U.S. Environmental Protection Agency, 2002). Nationally, water sampled from 62 percent of 2,745 wells in major-aquifer studies by the NAWQA Program had radon concentrations of at least 300 pCi/L.

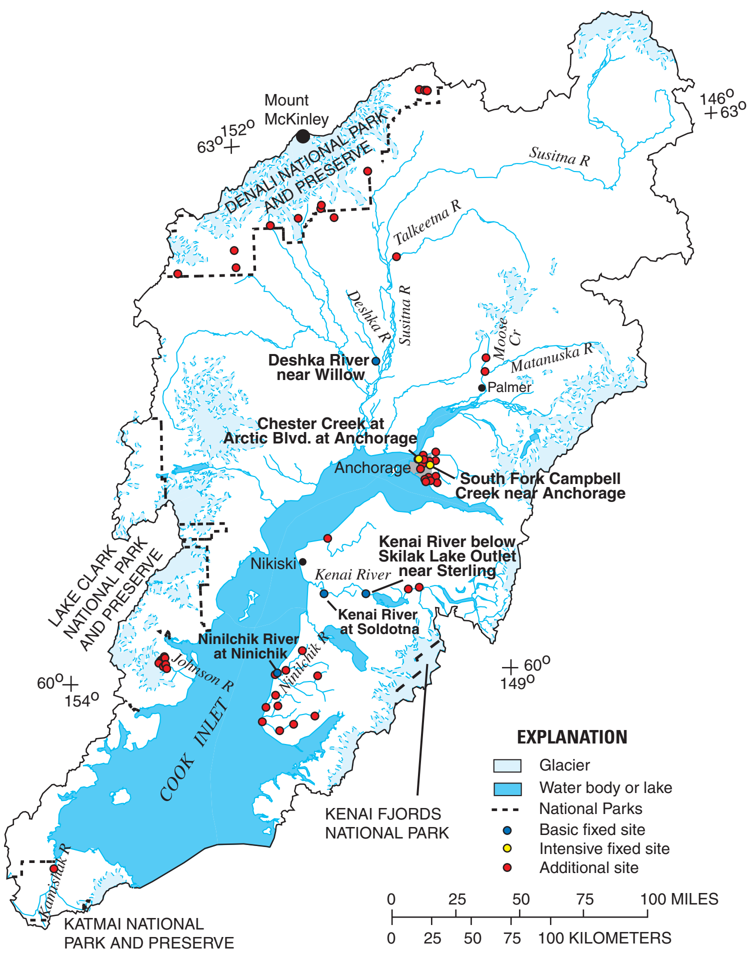
Radon is a colorless, odorless, radioactive gas that forms naturally in rocks and soils as an intermediate product in the radioactive decay of uranium-238. Radon from soil or bedrock can enter homes through cracks in basements or foundations, or radon can be released from water during bathing, cooking, or showering. Breathing radon in indoor air may cause 15,000 to 22,000 lung cancer deaths per year in the United States (National Academy of Sciences, 1999).

Study Unit Design

Studies in the Cook Inlet Basin were designed to describe the general quality of water and the aquatic ecosystem and to relate these conditions to natural and human influences. Nationally consistent protocols and methods were followed so that water-quality findings can be compared with findings in other basins and be placed in regional and national context (Gilliom and others, 1995).

Stream Chemistry and Ecology

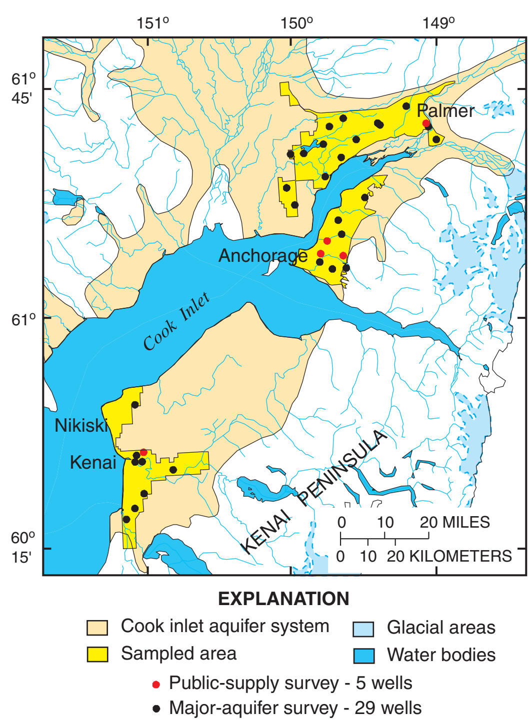
Water, bed-sediment, and fish-tissue chemistry; fish, invertebrate, and algal communities; and physical habitat were used as indicators of stream quality. Six sites on streams and rivers draining into Cook Inlet were sampled monthly from April or May to November and in January and March for water chemistry and at least once for bed-sediment and fish-tissue chemistry and ecological conditions. Twenty-six other sites were sampled one to four times to better describe water-quality variations throughout the basin. Of these 32 sites, 12 sites were sampled to assess conditions in forested settings and 14 sites were used to assess the influence of urban land uses on stream quality. Bed sediments were analyzed from 48 sites to determine the distribution of trace elements or organic contaminants. Many of these sites were in naturally mineralized areas within national parks.



In addition to monthly water-quality sampling at 6 sites, less frequent sampling (1 to 4 times during the study) at 26 other sites across the study area provided data related to specific land uses.

Ground-Water Chemistry

Ground-water assessments focused on quality of water in the alluvial and glacial aquifers from which most water is withdrawn in the basin, including that used for domestic, public, and industrial supplies. The major-aquifer study involved sampling 29 randomly selected wells that produce water from the alluvial and glacial aquifers in developed areas. An additional study of water from 5 municipal-supply wells focused on the quality of water used for public supply.



Ground water was sampled during the summer of 1999 from alluvial and glacial aquifers from which most water is withdrawn.

SUMMARY OF DATA COLLECTION IN THE COOK INLET BASIN, 1998–2001

Study component	What data were collected and why	Types of sites sampled	Number of sites	Sampling frequency and period
Stream Chemistry and Ecology				
Basic fixed sites – General water chemistry	Measured dissolved oxygen, pH, alkalinity, specific conductance, temperature, major ions, nutrients, organic carbon, and suspended sediment to determine concentrations and seasonal variations. Continuously monitored streamflow and water temperature.	Streams draining 27 to 1,951 square miles reflecting shrub/tundra, forest, urban, and mixed land uses.	6	Monthly from April or May to November, and January and March, plus storms; October 1998– September 2001
Intensive fixed sites – Pesticides and VOCs	Analyzed samples for pesticides and volatile organic compounds to describe concentrations and seasonal variability.	Includes two of the basic fixed sites. One reference and one urban site, 29 and 27 square miles.	2	Pesticides: 1998–1999 VOCs: 1999
Synoptic sites – Forest	Determined spatial distribution of major ions, nutrients, organic carbon, and suspended sediment in forested areas.	Streams on the southern Kenai Peninsula: Fixed site. Additional sites.	 1 11	Once in 2001
Synoptic sites – Urban-gradient study	Measured major ions, nutrients, organic carbon, fecal-indicator bacteria, and suspended sediment to assess the effects of urban land uses.	Streams in Anchorage draining areas ranging from 2.6 to 113 square miles: Fixed sites. Additional sites.	 2 12	Three to four times; 1999–2000
Contaminants in streambed sediments	Measured concentrations, as dry weight, of trace elements, organochlorine, and semivolatile organic compounds; percent major elements; and percent organic content in recently deposited streambed sediment to assess occurrence and distribution of contaminants.	Fixed and urban-gradient sites. Additional sites (trace elements and organic carbon only). Several sites are in national parks near mines or in mineral-rich areas	18 30	One or two samples in 1998–2000
Lakebed-sediment core study	Measured trace elements, semivolatile organic compounds, and organochlorine compounds in sediment to determine their historical occurrence in an urban watershed.	Sites in depositional zones of two ponds on Chester Creek in Anchorage.	2	Once in 1998
Contaminants in fish	Determined occurrence and distribution of trace elements, PCBs, SVOCs, and organochlorine pesticides in whole nonmigratory fish (slimy sculpin).	Fixed sites. Selected forest and urban-gradient sites. Selected sites in Denali National Park and Preserve.	6 10 4	Once; 1998–2000
Aquatic biology	Assessed biological communities and stream habitat and quantitatively sampled fish, macroinvertebrates, and algae to determine effects of water quality on aquatic biota.	Fixed, forest, and urban-gradient sites.	29	One to three times; 1998–2001
Ground-Water Chemistry				
Major-aquifer survey	Major ions, nutrients, trace elements, dissolved organic carbon, pesticides, volatile organic compounds, radon, and age-dating chemicals to determine the general water quality of an aquifer that is an important source of drinking water.	Randomly selected water-supply wells completed in unconsolidated alluvial or glacial deposits.	29	Once in 1999
Public-supply survey	Same as for major-aquifer survey.	Municipal water-supply wells completed in unconsolidated alluvial or glacial deposits.	5	Once in 1999

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Glossary

Anadromous fish – Fish that spend most of their adult lives in salt water and migrate to freshwater rivers and lakes to reproduce, such as salmon.

Aquatic-life guidelines – Specific levels of water quality which, if reached, may adversely affect aquatic life. These are nonenforceable guidelines issued by a governmental agency or other institution.

Basic fixed sites – Sites on streams at which streamflow is measured and samples are collected for temperature, salinity, suspended sediment, major ions and metals, nutrients, and organic carbon to assess the broad-scale spatial and temporal character and transport of inorganic constituents of streamwater in relation to hydrologic conditions and environmental settings.

Benthic invertebrates – Insects, mollusks, crustaceans, worms, and other organisms without a backbone that live in, on, or near the bottom of lakes, streams, or oceans.

Concentration – The amount or mass of a substance present in a given volume or mass of sample. Usually expressed as microgram per liter (water sample) or micrograms per kilogram (sediment or tissue sample).

Constituent – A chemical or biological substance in water, sediment, or biota that can be measured by an analytical method.

Detection limit – The minimum concentration of a substance that can be identified, measured, and reported within 99-percent confidence that the analyte concentration is greater than zero; determined from analysis of a sample in a given matrix containing the analyte.

Drainage basin – The portion of the surface of the Earth that contributes water to a stream through overland runoff, including tributaries and impoundments.

Drinking-water standard or guideline – A threshold concentration in a public drinking-water supply, designed to protect human health. As defined here, standards are U.S. Environmental Protection Agency regulations that specify the maximum contamination levels for public water systems required to protect the public welfare; guidelines have no regulatory status and are issued in an advisory capacity.

Ecological studies – Studies of biological communities and habitat characteristics to evaluate the effects of physical and chemical characteristics of water and hydrologic conditions on aquatic biota and to determine how biological and habitat characteristics differ among environmental settings in NAWQA Study Units.

EPT richness index – An index based on the sum of the number of taxa in three insect orders, Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies), that are composed primarily of species considered to be relatively intolerant to environmental alterations.

Fecal-indicator bacteria – Microscopic single-celled organisms (primarily fecal coliforms and fecal streptococci) found in the wastes of warm-blooded animals. Their presence in water is used to assess the sanitary quality of water for body-contact recreation or for consumption. Their presence indicates contamination by the wastes of warm-blooded animals and the possible presence of pathogenic (disease producing) organisms.

Health advisory – Nonregulatory levels of contaminants in drinking water that may be used as guidance in the absence of regulatory limits. Advisories consist of estimates of concentrations that would result in no known or anticipated health effects (for carcinogens, a specified cancer risk) determined for a child or for an adult for various exposure periods.

Intensive fixed sites – Basic fixed sites with increased sampling frequency during selected seasonal periods and analysis of dissolved pesticides for 1 year.

Intolerant organisms – Organisms that are not adaptable to human alterations to the environment and thus decline in numbers where human alterations occur. See also Tolerant species.

Major ions – Constituents commonly present in concentrations exceeding 1.0 milligram per liter. Dissolved cations generally are calcium, magnesium, sodium, and potassium; the major anions are sulfate, chloride, fluoride, nitrate, and those contributing to alkalinity, most generally assumed to be bicarbonate and carbonate.

Maximum contaminant level (MCL) – Maximum permissible level of a contaminant in water that is delivered to any user of a public water system. MCLs are enforceable standards established by the U.S. Environmental Protection Agency.

Median – The middle or central value in a distribution of data ranked in order of magnitude. The median is also known as the 50th percentile.

Micrograms per liter (µg/L) – A unit expressing the concentration of constituents in solution as weight (micrograms) of solute per unit volume (liter) of water; equivalent to one part per billion in most streamwater and ground water. One thousand micrograms per liter equals 1 mg/L.

Milligrams per liter (mg/L) – A unit expressing the concentration of chemical constituents in solution as weight (milligrams) of solute per unit volume (liter) of water; equivalent to one part per million in most streamwater and ground water.

Nitrate – An ion consisting of nitrogen and oxygen (NO_3^-). Nitrate is a plant nutrient and is very mobile in soils.

Nonpoint source – A pollution source that cannot be defined as originating from discrete points such as pipe discharge. Areas of fertilizer and pesticide applications, atmospheric deposition, manure, and natural inputs from plants and trees are types of nonpoint source pollution.

Nutrient – Element or compound essential for animal and plant growth. Common nutrients in fertilizer include nitrogen, phosphorus, and potassium.

Picocurie (pCi) – One trillionth (10^{-12}) of the amount of radioactivity represented by a curie (Ci). A curie is the amount of radioactivity that yields 3.7×10^{10} radioactive disintegrations per second (dps). A picocurie yields 2.22 disintegrations per minute (dpm), or 0.037 dps.

Point-source contaminant – Any substance that degrades water quality and originates from discrete locations such as discharge pipes, drainage ditches, wells, concentrated livestock operations, or floating craft.

Polycyclic aromatic hydrocarbon (PAH) – A class of organic compounds with a fused-ring aromatic structure. PAHs result from incomplete combustion of organic carbon (including wood), municipal solid waste, and fossil fuels, as well as from natural or anthropogenic introduction of uncombusted coal and oil. PAHs include benzo(*a*)pyrene, fluoranthene, and pyrene.

Probable Effect Level (PEL) – A guideline for the protection of aquatic life set by the Canadian Council of Ministers of the Environment. Chronic exposure of aquatic biota to levels above the PEL are expected to result in frequent adverse effects.

Radon – A naturally occurring, colorless, odorless, radioactive gas formed by the disintegration of the element radium; damaging to human lungs when inhaled.

Reference site – A NAWQA sampling site selected for its relatively undisturbed conditions.

Relative abundance – The number of organisms of a particular kind present in a sample relative to the total number of organisms in the sample.

Runoff – Excess rainwater or snowmelt that is transported to streams by overland flow, tile drains, or ground water.

Semipermeable membrane device (SPMD) – A long strip of low-density, polyethylene tubing filled with a thin film of purified lipid such as triolein that simulates the exposure to and passive uptake of highly lipid-soluble organic compounds by biological membranes.

Semivolatile organic compound (SVOC) – Operationally defined as a group of synthetic organic compounds that are solvent-extractable and can be determined by gas chromatography/mass spectrometry. SVOCs include phenols, phthalates, and polycyclic aromatic hydrocarbons (PAHs).

Species diversity – An ecological concept that incorporates both the number of species in a particular sampling area and the evenness with which individuals are distributed among the various species.

Stream reach – A continuous part of a stream between two specified points.

Study Unit – A major hydrologic system of the United States in which NAWQA studies are focused. Study Units are geographically defined by a combination of ground- and surface-water features and generally encompass more than 4,000 square miles of land area.

Synoptic sites – Sites sampled during a short-term investigation of specific water-quality conditions during selected seasonal or hydrologic conditions to provide improved spatial resolution for critical water-quality conditions.

Taxa richness – The number of unique taxa, such as families, genera, or species, present in a defined area or sampling unit.

Tissue study – The assessment of concentrations and distributions of trace elements and certain organic contaminants in tissues of aquatic organisms.

Tolerant species – Those species that are adaptable to (tolerant of) human alterations to the environment and often increase in number when human alterations occur.

Trace element – An element found in only minor amounts (concentrations less than 1.0 milligram per liter) in water or sediment; includes arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc.

Tritium – A radioactive form of hydrogen with atoms of three times the mass of ordinary hydrogen; can be used to determine the age of water.

Volatile organic compounds (VOCs) – Organic chemicals that have a high vapor pressure relative to their water solubility. VOCs include components of gasoline, fuel oils, and lubricants, as well as organic solvents, fumigants, some inert ingredients in pesticides, and some byproducts of chlorine disinfection.

Water-quality criteria –Specific levels of water quality which, if reached, are expected to render a body of water unsuitable for its designated use. Commonly refers to water-quality criteria established by the U.S. Environmental Protection Agency. Water-quality criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes.

Water year – The continuous 12-month period October 1 through September 30 in U.S. Geological Survey reports dealing with the surface-water supply. The water year is designated by the calendar year in which it ends and which includes 9 of the 12 months. Thus, the year ending September 30, 1999, is referred to "water year 1999."

Appendix—Water-Quality Data from the Cook Inlet Basin in a National Context

Concentrations and detection frequencies of the most commonly detected constituents, constituents that exceed a drinking-water standard or aquatic-life guideline, or constituents that are of regulatory or scientific importance, are presented below. Plots of other pesticides, nutrients, VOCs, and trace elements assessed in the Cook Inlet Basin are available at our Web site at:

http://water.usgs.gov/nawqa/graphs

These summaries of chemical concentrations and detection frequencies from the Cook Inlet Basin are compared to findings from 51 NAWQA Study Units investigated from 1991 to 2001 and to water-quality benchmarks for human health, aquatic life, fish-eating wildlife, or prevention of nuisance plant growth. These graphical summaries provide a comparison of chemical concentrations and detection frequencies between (1) surface- and ground-water resources, (2) agricultural, urban, and mixed land uses, and (3) shallow ground water and aquifers commonly used as a source of drinking water.

CHEMICALS IN WATER

Concentrations and detection frequencies, Cook Inlet Basin, 1999–2001

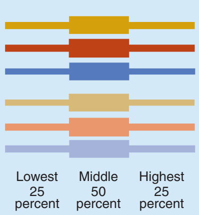
◆ Detected concentration in Study Unit

66 38 Frequencies of detection, in percent. Detection frequencies were not censored at any common reporting limit. The left-hand column is the study-unit frequency and the right-hand column is the national frequency

-- Not measured or sample size less than two

12 Study-unit sample size. For ground water, the number of samples is equal to the number of wells sampled

National ranges of detected concentrations, by land use, in 51 NAWQA Study Units, 1991–2001—Ranges include only samples in which a chemical was detected



Streams in agricultural areas
Streams in urban areas
Streams and rivers draining mixed land uses
Shallow ground water in agricultural areas
Shallow ground water in urban areas
Major aquifers

National water-quality benchmarks

National benchmarks include standards and guidelines related to drinking-water quality, criteria for protecting the health of aquatic life, and the desired goal for preventing nuisance plant growth due to phosphorus. Sources include the U.S. Environmental Protection Agency and the Canadian Council of Ministers of the Environment

| Drinking-water quality (applies to ground water and surface water)

| Protection of aquatic life (applies to surface water only)

| Prevention of nuisance plant growth in streams

* No benchmark for drinking-water quality

** No benchmark for protection of aquatic life

For example, the graph for ammonia shows that in the Cook Inlet Basin (1) detection frequency is lower than the national average for ground water in mixed land-use areas; (2) detection frequency is higher in urban streams than in ground water in areas of mixed land use and; (3) concentrations are lower than the national findings for streams in urban areas, resulting in no violations of the USEPA drinking-water standard in urban streams.

NOTE to users:

- The analytical detection limit varies among the monitored chemicals; thus, frequencies of detections are not comparable among chemicals.
- It is important to consider the frequency of detection along with concentration. For example, Tetrachloroethene was detected more frequently in urban streams in the Cook Inlet Basin than in urban streams nationwide (88 percent compared to 50 percent) but generally was detected at lower concentrations.

Quality-control data for these analytes indicate relatively frequent low-level contamination of samples during sample processing for analysis. Results for these analytes cannot, therefore, be presented using the generalized methods that were applied to other analytes in this Awppendix. Analysis of results for analytes potentially affected by contamination requires special statistical treatment beyond the scope of this report. For more information about these analytes and how to interpret data on their occurrence and concentrations, please contact the appropriate NAWQA Study Unit.

Trace elements in ground water: aluminum, barium, boron, cadmium, chromium, cobalt, copper, lithium, nickel, strontium, zinc
SVOCs in bed sediment: phenol, bis(2-ethylhexyl)phthalate, butylbenzylphthalate, di-*n*-butylphthalate, diethylphthalate
Insecticides in water: *p,p'*-DDE

Pesticides in water—Herbicides

Herbicides detected

Deethylatrazine (Atrazine metabolite, desethylatrazine) * **
Dichlorprop (2,4-DP, Seritox 50, Kildip) * **
Prometon (Pramitol, Princep, Gesagram 50, Ontracic 80) **
Propanil (Stam, Stampede, Wham, Surcopur, Prop-Job) * **
Tebuthiuron (Spike, Tebusan)

Herbicides not detected

Chloramben, methyl ester (Amiben methyl ester) * **
Acetochlor (Harness Plus, Surpass) * **
Acifluorfen (Blazer, Tackle 2S) **
Alachlor (Lasso, Bronco, Lariat, Bullet) **
Atrazine (AAtrex, Atrex, Atred)
Benfluralin (Balan, Benefin, Bonalan, Benefex) * **
Bentazon (Basagran, Bentazone, Bendioxide) **
Bromacil (Hyvar X, Urox B, Bromax)
Bromoxynil (Buctril, Brominal) *
Butylate (Sutan +, Genate Plus, Butilate) **
Clopyralid (Stinger, Lontrel, Reclaim) * **
Cyanazine (Bladex, Fortrol)
2,4-D (Aqua-Kleen, Lawn-Keep, Weed-B-Gone)
2,4-DB (Butyrac, Butoxone, Embutox Plus) *
DCPA (Dacthal, chlorthal-dimethyl) **
Dacthal mono-acid (Dacthal metabolite) * **
Dicamba (Banvel, Dianat, Scotts Proturf)

2,6-Diethylaniline (metabolite of Alachlor) * **
Dinoseb (Dinosebe)
Diuron (Crisuron, Karmex, Direx, Diurex) **
EPTC (Eptam, Farmarox, Alirox) * **
Ethalfluralin (Sonalan, Curbit) * **
Fenuron (Fenulon, Fenidim) * **
Fluometuron (Flo-Met, Cotoran, Cottonex, Meturon) **
Linuron (Lorox, Linex, Sarclex, Linurex, Afalon) *
MCPA (Rhomene, Rhonox, Chiptox)
MCPB (Thistrol) * **
Metolachlor (Dual, Pennant)
Metribuzin (Lexone, Sencor)
Molinate (Ordram) * **
Napropamide (Devrinol) * **
Neburon (Neburea, Neburyl, Noruben) * **
Norflurazon (Evital, Predict, Solicam) * **
Oryzalin (Surflan, Dirimal) * **
Pebulate (Tillam, PEBC) * **
Pendimethalin (Pre-M, Prowl, Weedgrass Control, Stomp, Herbadox) * **
Picloram (Grazon, Tordon)
Pronamide (Kerb, Propyzamid) **
Propachlor (Ramrod, Satecid) **
Propham (Tuberite) **
Simazine (Princep, Caliber 90, Gesatop, Simazat)
2,4,5-T
2,4,5-TP (Silvex, Fenoprop)
Terbacil (Sinbar) **
Thiobencarb (Bolero, Saturn, Benthiocarb, Abolish) * **
Triallate (Far-Go, Avadex BW, Tri-allate) *
Triclopyr (Garlon, Grandstand, Redeem) * **
Trifluralin (Treflan, Gowan, Tri-4, Trific, Trilin)

Pesticides in water—Insecticides

Insecticides detected

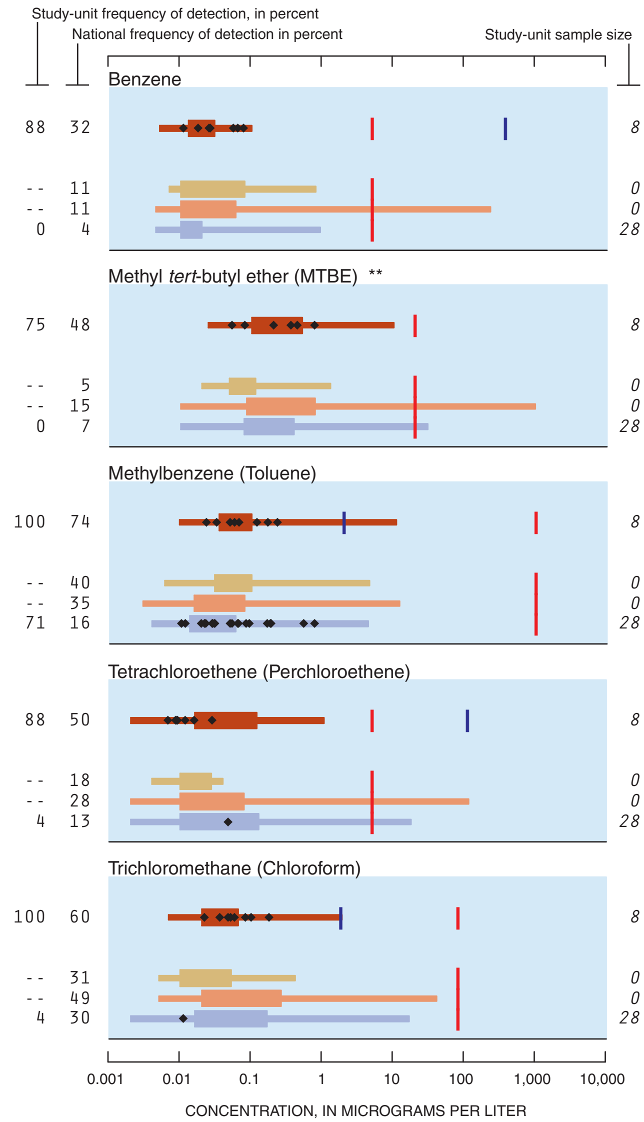
Azinphos-methyl (Guthion, Gusathion M) *
Carbaryl (Carbamine, Denapon, Sevin)
Diazinon (Basudin, Diazatol, Knox Out)

Insecticides not detected

Aldicarb (Temik, Ambush, Pounce)
Aldicarb sulfone (Standak, aldoxycarb)
Aldicarb sulfoxide (Aldicarb metabolite)
Carbofuran (Furadan, Curaterr, Yaltox)
Chlorpyrifos (Brodan, Dursban, Lorsban)
Dieldrin (Panoram D-31, Octalox)
Disulfoton (Disyston, Di-Syston, Frumin AL, Solvirex, Ethylthiodemeton) **
Ethoprop (Mocap, Ethoprophos) * **
Fonofos (Dyfonate, Capfos, Cudgel, Tycap) **
alpha-HCH (alpha-BHC, alpha-lindane) **
gamma-HCH (Lindane, gamma-BHC, Gammexane)
3-Hydroxycarbofuran (Carbofuran metabolite) * **
Malathion (Malathion)
Methiocarb (Slug-Geta, Grandslam, Mesurol) * **
Methomyl (Lanox, Lannate, Acinate) **
Methyl parathion (Penncap-M, Folidol-M, Metacide, Bladan M) **
Oxamyl (Vydate L, Pratt) **
Parathion (Roethyl-P, Alkron, Panthion) *
cis-Permethrin (Ambush, Astro, Pounce) * **
Phorate (Thimet, Granutox, Geomet, Rampart) * **
Propargite (Comite, Omite, Ornamite) * **
Propoxur (Baygon, Blattanex, Unden, Proprotox) * **
Terbufos (Contraven, Counter, Pilarfox) **

Volatile organic compounds (VOCs) in water

These graphs represent data from 32 Study Units, sampled from 1994 to 2001



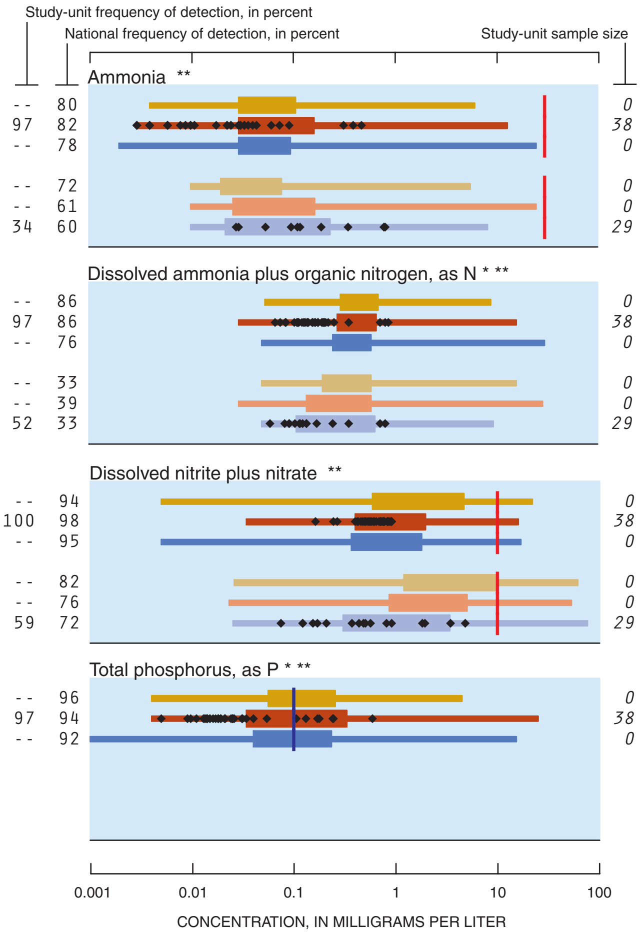
Other VOCs detected

Acetone (Acetone) * **
Bromodichloromethane (Dichlorobromomethane) **
Carbon disulfide * **
Chlorobenzene (Monochlorobenzene)
Chloromethane (Methyl chloride) **
Dichlorodifluoromethane (CFC 12, Freon 12) **
cis-1,2-Dichloroethene ((Z)-1,2-Dichloroethene) **
Dichloromethane (Methylene chloride)
1,2-Dimethylbenzene (*o*-Xylene) **
1,3 & 1,4-Dimethylbenzene (*m*-&*p*-Xylene) **
Ethylbenzene (Phenylethane)
2-Ethyltoluene (*o*-Ethyltoluene) * **
Isopropylbenzene (Cumene) * **
n-Propylbenzene (Isocumene) * **
1,1,1-Trichloroethane (Methylchloroform) **
Trichloroethene (TCE)
Trichlorofluoromethane (CFC 11, Freon 11) **
1,2,3-Trimethylbenzene (Hemimellitene) * **
1,2,4-Trimethylbenzene (Pseudocumene) * **

VOCs not detected

Bromobenzene (Phenyl bromide) * **
Bromochloromethane (Methylene chlorobromide) **
Bromoethene (Vinyl bromide) * **
Bromomethane (Methyl bromide) **
2-Butanone (Methyl ethyl ketone (MEK)) **
n-Butylbenzene (1-Phenylbutane) * **
sec-Butylbenzene ((1-Methylpropyl)benzene) * **
tert-Butylbenzene ((1,1-Dimethylethyl)benzene) * **
3-Chloro-1-propene (3-Chloropropene) * **
1-Chloro-2-methylbenzene (*o*-Chlorotoluene) **
1-Chloro-4-methylbenzene (*p*-Chlorotoluene) **
Chloroethane (Ethyl chloride) * **
Chloroethene (Vinyl chloride) **
1,2-Dibromo-3-chloropropane (DBCP, Nemagon) **
Dibromochloromethane (Chlorodibromomethane) **
1,2-Dibromoethane (Ethylene dibromide, EDB) **
Dibromomethane (Methylene dibromide) * **
trans-1,4-Dichloro-2-butene ((Z)-1,4-Dichloro-2-butene) * **
1,3-Dichlorobenzene (*m*-Dichlorobenzene)
1,4-Dichlorobenzene (*p*-Dichlorobenzene, 1,4-DCB)
1,2-Dichloroethane (Ethylene dichloride)
1,1-Dichloroethane (Ethylidene dichloride) * **
1,1-Dichloroethene (Vinylidene chloride) **
trans-1,2-Dichloroethene ((E)-1,2-Dichlorothene) **
1,2-Dichloropropane (Propylene dichloride) **
2,2-Dichloropropane * **
1,3-Dichloropropane (Trimethylene dichloride) * **
trans-1,3-Dichloropropene ((E)-1,3-Dichloropropene) **
cis-1,3-Dichloropropene ((Z)-1,3-Dichloropropene) **
1,1-Dichloropropene * **
Diethyl ether (Ethyl ether) * **
Diisopropyl ether (Diisopropylether (DIPE)) * **
Ethenylbenzene (Styrene) **
Ethyl methacrylate (Ethyl methacrylate) * **
Ethyl *tert*-butyl ether (Ethyl-t-butyl ether (ETBE)) * **
1,1,2,3,4,4-Hexachloro-1,3-butadiene (Hexachlorobutadiene)
1,1,1,2,2,2-Hexachloroethane (Hexachloroethane) **
2-Hexanone (Methyl butyl ketone (MBK)) * **
Iodomethane (Methyl iodide) * **
p-Isopropyltoluene (*p*-Cymene, 1-Isopropyl-4-methylbenzene) * **
Methyl acrylonitrile (Methacrylonitrile) * **
Methyl methacrylate (Methyl-2-methacrylate) * **
4-Methyl-2-pentanone (Methyl isobutyl ketone (MIBK)) * **
Methyl-2-propenoate (Methyl acrylate) * **
Naphthalene
2-Propenenitrile (Acrylonitrile) **
1,1,2,2-Tetrachloroethane **
1,1,1,2-Tetrachloroethane (1,1,1,2-TeCA) **
Tetrachloromethane (Carbon tetrachloride)
Tetrahydrofuran (Diethylene oxide) * **
1,2,3,4-Tetramethylbenzene (Prehnitene) * **
1,2,3,5-Tetramethylbenzene (Isodurene) * **
Tribromomethane (Bromoform) **
1,1,2-Trichloro-1,2,2-trifluoroethane (Freon 113, CFC 113) * **
1,2,4-Trichlorobenzene
1,2,3-Trichlorobenzene (1,2,3-TCB) *
1,1,2-Trichloroethane (Vinyl trichloride) **
1,2,3-Trichloropropane (Allyl trichloride) **
1,3,5-Trimethylbenzene (Mesitylene) * **
tert-Amyl methyl ether (TAME) * **

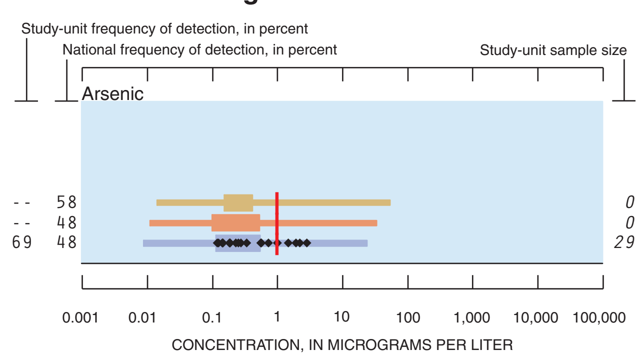
Nutrients in water

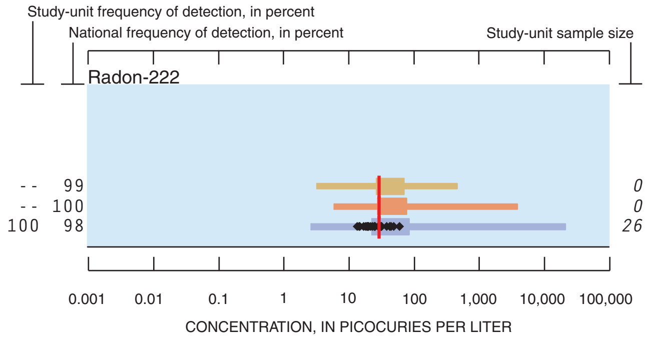


Other nutrients detected

Orthophosphate as P * **

Trace elements in ground water





Other trace elements detected

Lead
Manganese *
Molybdenum
Selenium

Organochlorines in fish tissue (whole body) and bed sediment

Organochlorines not detected

total-Chlordane (sum of 5 chlordanes)
DCPA (Dacthal, chlorthal-dimethyl) * **
o,p'+*p,p'*-DDD (sum of *o,p'*-DDD and *p,p'*-DDD) *
p,p'-DDE * **
o,p'+*p,p'*-DDE (sum of *o,p'*-DDE and *p,p'*-DDE) *
o,p'+*p,p'*-DDT (sum of *o,p'*-DDT and *p,p'*-DDT) *
total-DDT (sum of 6 DDTs) **
Dieldrin (Panoram D-31, Octalox) *
Dieldrin+aldrin (sum of dieldrin and aldrin) **
Endrin (Endrine)
gamma-HCH (Lindane, gamma-BHC, Gammexane) *
Total HCH (sum of alpha, beta, gamma, and delta-HCH) **
Heptachlor epoxide (Heptachlor metabolite) *
Heptachlor+heptachlor epoxide **
Hexachlorobenzene (HCB) **
p,p'-Methoxychlor (Marlate, methoxychlore) * **
o,p'-Methoxychlor * **
Mirex (Dechlorane) **
Pentachloroanisole (PCA, pentachlorophenol metabolite) * **
Toxaphene (Camphechlor, Hercules 3956) * **

Trace elements not detected (water)

Antimony
Beryllium
Silver
Uranium

CHEMICALS IN FISH TISSUE AND BED SEDIMENT

Concentrations and detection frequencies, Cook Inlet Basin, 1999–2001—Study-unit frequencies of detection are based on small sample sizes; the applicable sample size is specified in each graph

◆ Detected concentration in Study Unit

66 38 Frequencies of detection, in percent. Detection frequencies were not censored at any common reporting limit. The left-hand column is the study-unit frequency and the right-hand column is the national frequency

-- Not measured or sample size less than two

12 Study-unit sample size

National ranges of concentrations detected, by land use, in 51 NAWQA Study Units, 1991–2001—Ranges include only samples in which a chemical was detected

Fish tissue from streams in agricultural areas
Fish tissue from streams in urban areas
Fish tissue from streams draining mixed land uses
Sediment from streams in agricultural areas
Sediment from streams in urban areas
Sediment from streams draining mixed land uses

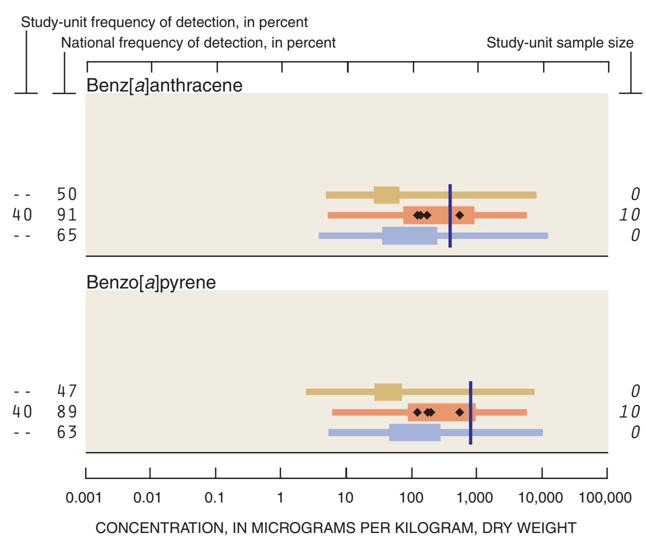
Lowest 25 percent | Middle 50 percent | Highest 25 percent

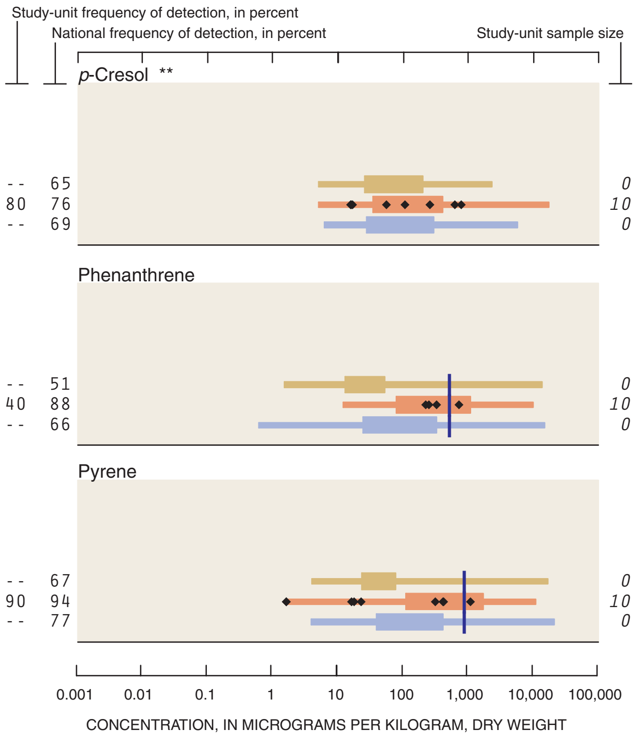
National benchmarks for fish tissue and bed sediment

National benchmarks include standards and guidelines related to criteria for protection of the health of fish-eating wildlife and aquatic organisms. Sources include the U.S. Environmental Protection Agency, other Federal and State agencies, and the Canadian Council of Ministers of the Environment.

| Protection of fish-eating wildlife (applies to fish tissue)
| Protection of aquatic life (applies to bed sediment)
* No benchmark for protection of fish-eating wildlife
** No benchmark for protection of aquatic life

Semivolatile organic compounds (SVOCs) in bed sediment





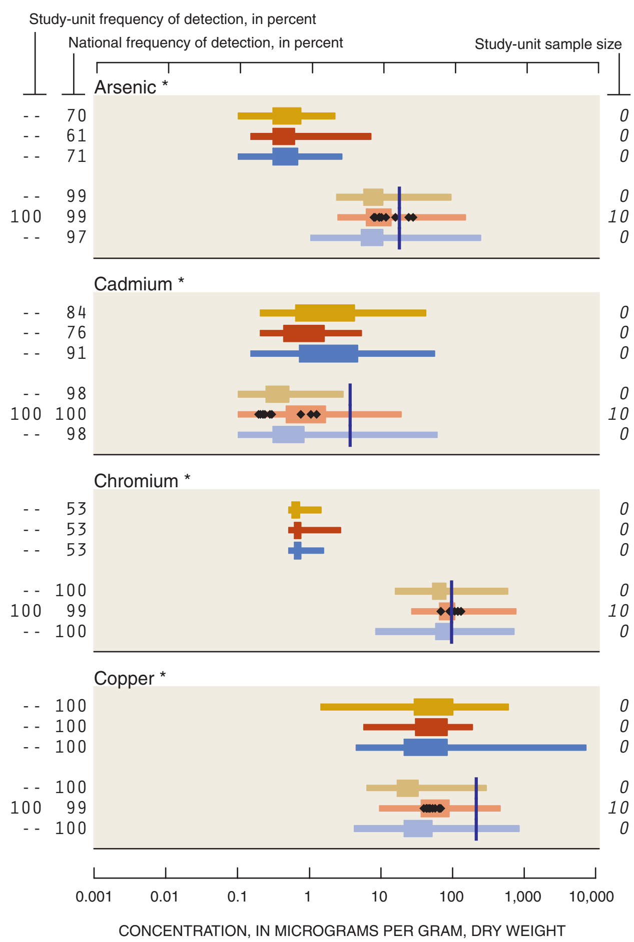
Other SVOCs detected

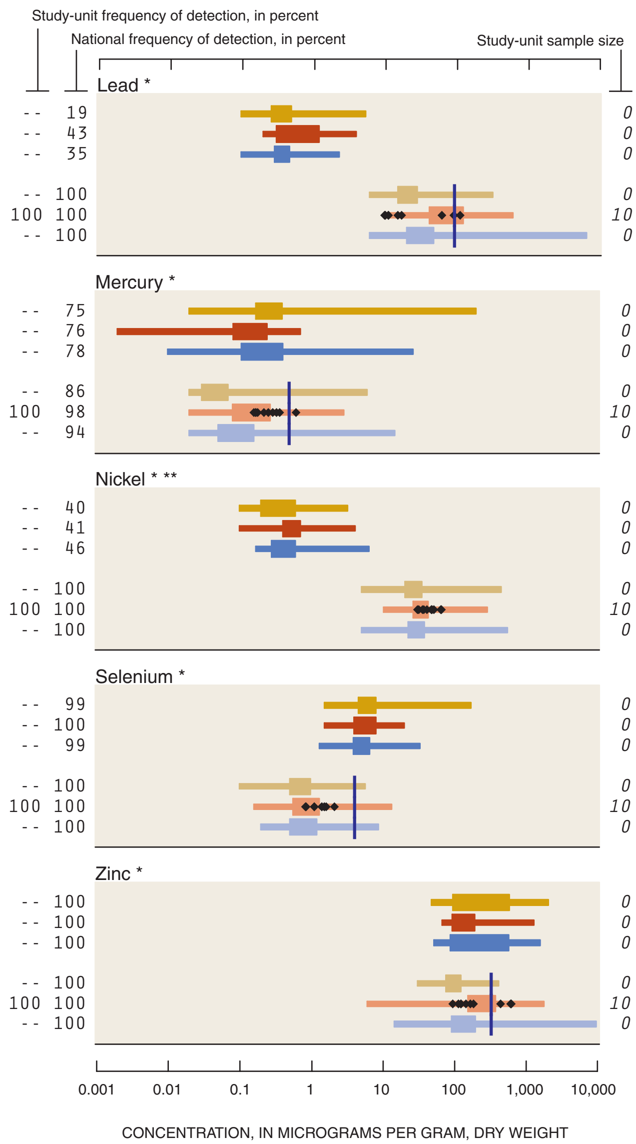
Acenaphthene
Acenaphthylene
Anthracene
Anthraquinone **
Benzo[*b*]fluoranthene **
Benzo[*g,h,i*]perylene **
Benzo[*k*]fluoranthene **
9*H*-Carbazole **
Chrysene
Di-*n*-octylphthalate **
1,6-Dimethylnaphthalene **
2,6-Dimethylnaphthalene **
Fluoranthene
9*H*-Fluorene (Fluorene)
Indeno[1,2,3-*c,d*]pyrene **
Isoquinoline **
2-Methylanthracene **
4,5-Methylenephenanthrene **
1-Methylphenanthrene **
1-Methylpyrene **
Naphthalene

SVOCs not detected

Acridine **
C8-Alkylphenol **
Azobenzene **
Benzo[*c*]cinnoline **
2,2-Biquinoline **
4-Bromophenyl-phenylether **
4-Chloro-3-methylphenol **
bis (2-Chloroethoxy)methane **
bis (2-Chloroethyl)ether **
2-Chloronaphthalene **
2-Chlorophenol **
4-Chlorophenyl-phenylether **
Dibenz[*a,h*]anthracene
Dibenzothiophene **
1,2-Dichlorobenzene (*o*-Dichlorobenzene, 1,2-DCB) **
1,3-Dichlorobenzene (*m*-Dichlorobenzene) **
1,4-Dichlorobenzene (*p*-Dichlorobenzene, 1,4-DCB) **
1,2-Dimethylnaphthalene **
3,5-Dimethylphenol **
Dimethylphthalate **
2,4-Dinitrotoluene **
Isophorone **
1-Methyl-9*H*-fluorene **
Nitrobenzene **
N-Nitrosodi-*n*-propylamine **
N-Nitrosodiphenylamine **
Pentachloronitrobenzene **
Phenanthridine **
Quinoline **
1,2,4-Trichlorobenzene **
2,3,6-Trimethylnaphthalene **

Trace elements in fish tissue (livers) and bed sediment




Study-unit frequency of detection, in percent
National frequency of detection, in percent
Study-unit sample size
Lead *
-- 19 0
-- 43 0
-- 35 0
-- 100 0
100 100 10
-- 100 0
Mercury *
-- 75 0
-- 76 0
-- 78 0
-- 86 0
100 98 10
-- 94 0
Nickel * **
-- 40 0
-- 41 0
-- 46 0
-- 100 0
100 100 10
-- 100 0
Selenium *
-- 99 0
-- 100 0
-- 99 0
-- 100 0
100 100 10
-- 100 0
Zinc *
-- 100 0
-- 100 0
-- 100 0
-- 100 0
100 100 10
-- 100 0
0.001
0.01
0.1
1
10
100
1,000
10,000
CONCENTRATION, IN MICROGRAMS PER GRAM, DRY WEIGHT

Coordination with agencies and organizations in the Cook Inlet Basin Study Unit was integral to the success of this water-quality assessment. We thank those who served as members or our liaison committee and those who contributed in other ways

Federal Agencies
Bureau of Land Management
National Park Service
Natural Resources Conservation Service
U.S. Army Corps of Engineers
U.S. Army Alaska
U.S. Environmental Protection Agency
U.S. Fish and Wildlife Service
U.S. Forest Service

State Agencies
Alaska Department of Environmental Conservation
Alaska Department of Fish and Game
Alaska Department of Natural Resources
Alaska Department of Transportation and Public Facilities

Local Agencies
Municipality of Anchorage

Universities
Alaska Pacific University
University of Alaska, Environment and Natural Resources Institute

Other public and private organizations
Cook Inlet Keeper
Cook Inlet Region Citizens Advisory Council
Cook Inlet Region, Inc.
Kenai Watershed Forum
The Nature Conservancy
Unocal

We thank the following individuals for contributing to this effort.

Charlie Couvillion, Rebecca Kyle, Dan Long, Ted Moran, Gary Solin, and Bill Swenson (USGS Alaska District) played a major role in the collection and compilation of water-quality and streamflow data.

Kurt Carpenter (USGS, Oregon District) provided advice on the analysis of algal data.

Peter VanMetre (USGS, Texas District) collected and compiled lakebed sediment data.

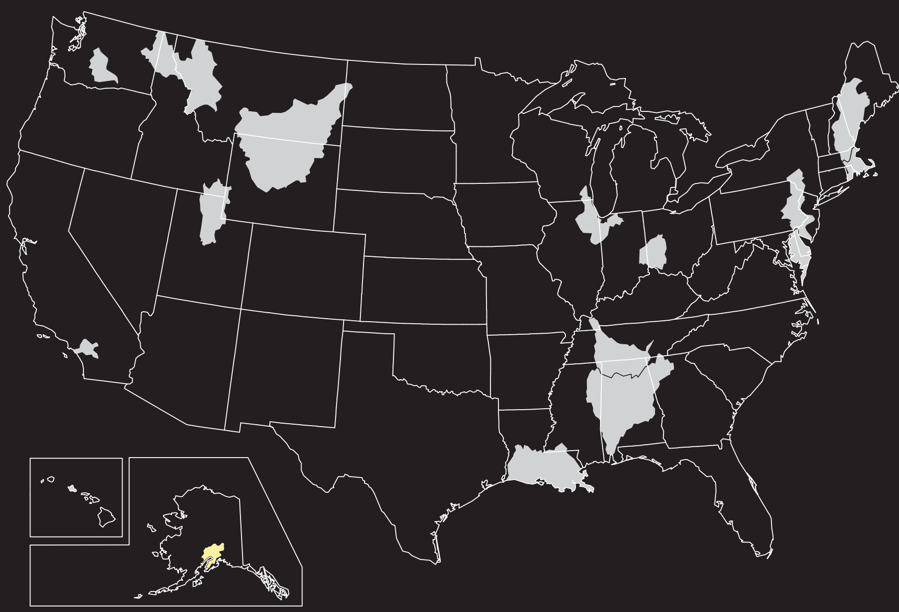
Linda Rogers, Bill Gibbs (USGS, Washington District) and Linda Harris (USGS, Alaska District) for production of the report, including graphics, illustrations, and layout.

Property owners who allowed the USGS to sample wells on their property.

Carol Couch, Jeffrey Deacon, Neil Dubrovsky, Steven Goodbred, Pixie Hamilton, Stephen Kalhkoff, Lisa Nowell, Robert Olmstead, Terry Short, Edward Swibas, Marc Sylvester, Kidd Waddell, John Williams, Chet Zenone, and John Zogorski (USGS) for reviewing the report.

NAWQA

National Water-Quality Assessment (NAWQA) Program
Cook Inlet Basin



Glass and others— Water Quality in the Cook Inlet Basin
U.S. Geological Survey Circular 1240

ISBN 0-607-96401-4
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