WYOMING GROUND-WATER QUALITY

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FOREWORD

This report contains summary information on ground-water quality in one of the 50 States, Puerto Rico, the Virgin Islands, or the Trust Territories of the Pacific Islands, Saipan, Guam, and American Samoa. The material is extracted from the manuscript of the *1986 National Water Summary*, and with the exception of the illustrations, which will be reproduced in multi-color in the *1986 National Water Summary*, the format and content of this report is identical to the State ground-water-quality descriptions to be published in the *1986 National Water Summary*. Release of this information before formal publication in the *1986 National Water Summary* permits the earliest access by the public.

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WYOMING
Ground-Water Quality

Ground water that is suitable for most uses has contributed to the development of Wyoming. Wells and springs provide drinking water for 65 percent of the population (fig. 1) and are the principal source of water for livestock (Wyoming Department of Environmental Quality, 1986a, p. 296). In many parts of the State, ground water is the only source of water because surface water is absent, unreliable, or already appropriated. Most ground-water withdrawals in Wyoming are used for irrigation (69 percent) and industry (24 percent), which include power generation, secondary and tertiary oil recovery, and uranium mining and processing.

Ground-water quality (fig. 2) differs greatly between and within aquifers throughout Wyoming. Dissolved-solids concentrations commonly are large. Where dissolved-solids concentrations are large, usually the concentrations of sulfate or chloride generally are large also. Naturally occurring, but large concentrations of fluoride, selenium, iron, manganese, radionuclides, and hardness are also common (fig. 3).

Despite the small population density (fig. 1), ground water has been contaminated in localized areas of Wyoming. The most common contaminants are gasoline and diesel fuel leaking from underground storage tanks, and nitrate from septic-tank leach fields, from applied fertilizers, and from corrals and feedlots. The potential for ground-water contamination exists from the 17,000 tons of hazardous wastes reported to be produced annually in Wyoming (Wyoming Department of Environmental Quality, 1987). These wastes include only the hazardous wastes that are regulated by the U.S. Environmental Protection Agency (EPA) under provisions of the Resource Conservation and Recovery Act (RCRA) of 1976. In addition, the U.S. Department of Defense has recommended 17 sites at 1 facility for a comprehensive survey to determine whether contamination exists.

In general, the water-quality data do not indicate widespread contamination. The data generally reflect only samples collected from wells that are not in areas of contamination and analyses that were limited to major inorganic constituents commonly found in ground water. Data for potential organic contaminants in ground water, including pesticides, are not available for most areas in the State.

WATER QUALITY IN PRINCIPAL AQUIFERS

More than 100 different aquifers are used for ground-water supplies in Wyoming (Larson, 1984, p. 12), some of which have been grouped into four principal aquifers (U.S. Geological Survey, 1985, p. 453). From youngest to oldest, these aquifers are the alluvial aquifer, the High Plains and equivalent aquifers, the structural basin aquifer, and the carbonate and sandstone aquifer (figs. 2A, 2B).

Ground-water quality in Wyoming is affected by both natural conditions and human activities. About 60 percent of ground-water samples collected from principal aquifers in Wyoming contain large dissolved-solids concentrations. Much of the ground water in Wyoming is naturally hard. Large nitrate concentrations are not common but are a concern locally because large concentrations are potentially lethal to infants. Large nitrate concentrations, which are mostly associated with human activities (Larson, 1984, p. 62), are most common in water from the alluvial aquifer and where the other aquifers occur at shallow depths. Large concentrations of fluoride generally are found in water from the structural basin aquifer. Large concentrations of selenium have been measured in about 2 percent of the 225 ground-water analyses in the U.S. Geological Survey's water-quality file, as of 1983 (Larson, 1984, p. 67). In addition to data in the file, Crist (1974) documented concentrations as large as 1,300 μg/L (micrograms per liter) in water samples from wells in a 725-mi^2 (square mile) area near Casper. However, statewide data are too sparse to define the location and extent of all large concentrations of selenium.

Concentrations of other toxic metals elements, such as dissolved arsenic, barium, cadmium, chromium, lead, and mercury, in ground water from the principal aquifers generally do not limit water use in Wyoming. Large iron and manganese concentrations, which are objectionable for esthetic and economic reasons, are fairly common in water that is used for domestic purposes (Larson, 1984, p. 68).

BACKGROUND WATER QUALITY

The concentrations of dissolved solids, hardness, nitrate, fluoride, and selenium in water from the four principal aquifers are graphically summarized in figure 2C from data stored in the U.S. Geological Survey's National Water Data Storage and Retrieval System (WATSTORE). The summary is based on analyses of water samples collected from 1960 to 1985 from the principal aquifers in Wyoming. The data reflect the general water quality of the aquifers being used for livestock or domestic supplies.

The percentiles used in figure 2C are compared to national standards that specify the maximum concentration or level of a contaminant in drinking-water supply as established by the U.S. Environmental Protection Agency (1986a,b). The primary maximum contaminant standards are health related and are legally enforceable. The secondary maximum contaminant standards apply to esthetic qualities and are recommended guidelines. The maximum concentrations permitted by primary drinking-water standards are as follows: nitrate (as nitrogen), 10 mg/L (milligrams per liter); fluoride, 4 mg/L; and selenium, 10 μg/L. The maximum concentrations recommended by secondary drinking-water standards are as follows: dissolved solids, 500 mg/L; fluoride, 2 mg/L.

In applying these water-quality standards, the assumed use of the aquifers is for drinking. However, an evaluation of water quality for other uses would require that other criteria be applied. Generally, if the water is well suited for drinking, it also is well suited for most other uses.

Areas of naturally impaired water quality have been delineated by the Wyoming Department of Environmental Quality (WDEQ) (fig. 3B) using data in their files, files of the Wyoming State Engineer, and a report (Wyoming Water Resources Research Institute, 1981) prepared for the EPA. Naturally occurring constituents that cause the water to be impaired include fluoride, selenium, and radionuclides. Most areas (fig. 3B) were delineated on the basis of fluoride concentrations exceeding the secondary drinking-water standard of 2 mg/L. Concentrations of selenium larger than 10 μg/L were measured in two areas. Three areas were delineated on the basis of levels of radionuclides larger than 5 pCi/L (picocuries per liter) for radium 226 plus radium 228, larger than 15 pCi/L for gross alpha activity, larger than 8 pCi/L for strontium 90, or larger than 20,000 pCi/L for tritium. Two areas were delineated on the basis of selenium concentrations or radionuclide levels in addition to fluoride concentrations.

Water may be available from more than a single aquifer in some areas, and the data used for figure 3B do not represent any one aquifer. Therefore, water that is suitable for domestic use may be available within an area shown as naturally impaired. The areas of naturally impaired water quality (fig. 3B) generally are based on a few scattered wells and also represent several different aquifers.

Alluvial Aquifer

The alluvial aquifer, comprised of gravel, sand, silt, and clay, is located in the valleys and terraces adjacent to most large streams in Wyoming (fig. 2*A*). The alluvial aquifer generally is less than 50 feet thick; however, thicknesses may exceed 200 feet in the Bear River and Snake River drainage basins. Only extensive areas of the alluvial aquifer with potential yields of more than 100 gal/min (gallons per minute) are mapped in figure 2*A*. Many small areas of the alluvial aquifer with lesser potential yields are important locally.

Concentrations of dissolved solids and other variables in water samples from the alluvial aquifer (aquifer 1) are graphically summarized in figure 2*C*. Ten percent of the analyses of water samples collected from the alluvial aquifer had dissolved-solids concentrations of 192 mg/L or less; 25 percent were 330 mg/L or less. The median concentration was 480 mg/L. Seventy-five percent of the concentrations were 760 mg/L or less, and 90 percent were 1,580 mg/L or less. Slightly more than 50 percent of the dissolved-solids concentrations did not exceed the secondary drinking-water standard of 500 mg/L.

Most water from the alluvial aquifer was very hard. The median hardness concentration was 280 mg/L (as calcium carbonate)—the largest median concentration of the four principal aquifers.

Nitrate concentrations in 90 percent of the samples did not exceed the drinking-water standard of 10 mg/L (as nitrogen); most of the remaining samples greatly exceeded the limit. The maximum concentration was 70 mg/L (as nitrogen).

Although concentrations of fluoride in about 90 percent of the water samples from the alluvial aquifer did not exceed the secondary drinking-water standard of 2 mg/L (fig. 2*C*), concentrations in 9 percent of the samples exceeded the primary drinking-water standard of 4 mg/L. Nearly all large fluoride concentrations were measured in water samples collected from alluvial aquifers in Yellowstone National Park. (Large fluoride concentrations commonly are associated with volcanism.) Concentrations of fluoride ranged from 0.1 to 9.1 mg/L, and the median concentration was 0.7 mg/L.

Selenium concentrations exceeded the 10-μg/L standard in 36 of 83 samples collected from the alluvial aquifer in a 725-mi² irrigation project near Casper (Crist, 1974); the largest concentration was 1,300 μg/L. These samples were collected from an area where selenium is known to be a problem. They are not representative of selenium concentrations found in ground-water samples collected from the alluvial aquifer in the remainder of the State.

Other than in the area near Casper, only three ground-water samples collected from the alluvial aquifer and analyzed for selenium are contained in the data base; therefore, selenium data for the alluvial aquifer are not included in figure 2*C*. All three concentrations were at or below the 1-μg/L detection limit.

High Plains and Equivalent Aquifers

Large yields of water from wells and excellent water quality make this aquifer a valuable water resource. Wells in the unconsolidated to consolidated gravel, sand, and silt of the High Plains and equivalent aquifers provide water that is well suited and most commonly used for irrigation, public, livestock, and domestic supplies.

Water samples from the High Plains and equivalent aquifers had the smallest median dissolved-solids concentration (260 mg/L) of the four principal aquifers (fig. 2*C*). Concentrations of dissolved solids in about 80 percent of the water samples from the High Plains aquifer in southeastern Wyoming and equivalent aquifers in southern Carbon County were smaller than the recommended drinking-water standard of 500 mg/L. However, dissolved-solids concentrations were smaller than the recommended drinking-water standard in 60 percent of the water samples from an equivalent aquifer in southern Carbon County (Larson, 1984, p. 23).

Most water samples from the High Plains and equivalent aquifers were moderately hard to hard. The median hardness concentration was 160 mg/L (as calcium carbonate).

Nitrate concentrations in 2 of 87 samples of water from the High Plains and equivalent aquifers exceeded the drinking-water standard of 10 mg/L (as nitrogen). The maximum concentration of nitrate was 176 mg/L (as nitrogen)—the largest in water samples from the four principal aquifers. Although nitrate concentrations generally are small in the water samples from the High Plains and equivalent aquifers, concentrations are locally large around communities.

Fluoride concentrations in water samples from the High Plains and equivalent aquifers generally were less than the secondary drinking-water standard of 2 mg/L. One of the 103 samples, with a concentration of 5 mg/L, exceeded the primary drinking-water standard of 4 mg/L.

Three samples from the High Plains and equivalent aquifers were measured for selenium. The concentrations (1, 2, and 5 μg/L) did not exceed the primary drinking-water standard (10 μg/L).

Structural Basin Aquifer

The structural basin aquifer, found in most structural basins in Wyoming, is the most widespread and most extensively used aquifer in terms of number of wells. This aquifer is the only available source of water in many localities and generally is used by municipalities and rural areas for domestic and livestock supplies. Thickness of the lenticular beds of sandstone, coal, and shale of this aquifer may exceed 5,000 feet. Yields of water to wells generally are less than 50 gal/min. Much of the aquifer is confined, and flowing wells are common.

Although the water quality in the structural basin aquifer generally is well suited for livestock watering, the water commonly is less than desirable for a domestic drinking-water supply. Dissolved-solids concentrations commonly exceed the recommended limit of 500 mg/L. The median dissolved-solids concentration for water samples from the structural basin aquifer was 1,100 mg/L—the largest median of the four principal aquifers. Seventeen percent of the 529 samples did not exceed the recommended limit of 500 mg/L. Ninety-five percent of the samples contained 5,000 mg/L or less, which is suitable for watering livestock.

A median hardness concentration of 160 mg/L (as calcium carbonate) for water samples from the structural basin aquifer is the same as the median concentration for water samples from the High Plains and equivalent aquifers. The structural basin aquifer generally yields water that has been naturally softened by the exchange of calcium and magnesium ions for sodium ions; therefore, water in about 30 percent of the water samples was soft.

Nitrate concentrations in most of the water samples from the structural basin aquifer were at or less than the detection limit (0.1 mg/L, nitrate as nitrogen). Nitrate concentrations exceeded the drinking-water standard in 10 of 335 samples; the maximum concentration was 86 mg/L (as nitrogen).

The median concentration of fluoride in 533 water samples from the structural basin aquifer was 0.6 mg/L—the second largest of the four aquifers. The concentration for the 90th percentile (3.6 mg/L) was the largest of the four principal aquifers. Seventeen percent of the samples had concentrations that exceeded the secondary drinking-water standard of 2 mg/L, and 8 percent exceeded the primary drinking-water standard of 4 mg/L. The maximum fluoride concentration was 13 mg/L.

Selenium concentrations in 93 of 103 water samples collected from the structural basin aquifer were at or below the detection limit of 1 μg/L. Concentrations in 5 percent of the samples exceeded the primary drinking-water standard of 10 μg/L; the maximum concentration was 80 μg/L.

Carbonate and Sandstone Aquifer

The carbonate and sandstone aquifer is recharged where exposed at the edges of the basins in largely uninhabited, mountainous terrain. This aquifer becomes progressively more deeply buried toward the center of the basins. The thickness of limestone, dolomite, and sandstone that compose this aquifer may be several thousands of feet. Large secondary permeability (solution cavities, joints, and fractures) characterizes this aquifer; therefore, large yields of water to wells are possible. Yields of 100 to 700 gal/min are common, but one well near Worland (Washakie County) has reportedly flowed at 14,000 gal/min.

Although the water quality is excellent at or near the edges of the basins, fewer wells are completed in this aquifer than in any of the other three aquifers. Because of the great depth to the aquifer except near the edges of the basins, the drilling and completion of a well are too expensive for many potential users. Abundant streamflow and springs in the largely uninhabited recharge areas provide water for livestock and wildlife. Although the dissolved-solids concentrations were small in samples from wells and springs near the recharge areas, concentrations were larger in samples from wells toward the center of the basins. Therefore, location is an important factor in describing the water quality of this aquifer.

The median dissolved-solids concentration in samples collected from wells and springs in the carbonate and sandstone aquifer was 280 mg/L, only slightly larger than the median concentration for water samples from the High Plains and equivalent aquifers. The maximum dissolved-solids concentration in any sample was 9,400 mg/L.

Water from this aquifer tends to be very hard. The median hardness concentration was 260 mg/L (as calcium carbonate).

None of the 117 samples from the carbonate and sandstone aquifer analyzed for nitrate exceeded the drinking-water standard of 10 mg/L (as nitrogen). The maximum concentration was 7.5 mg/L (as nitrogen). Common sources of nitrate contamination generally are absent in the mountainous outcrop area.

The median fluoride concentration (0.3 mg/L) in water from the carbonate and sandstone aquifer is the smallest of the four principal aquifers. Of the 187 water samples from the carbonate and sandstone aquifer, 15 percent exceeded the secondary drinking-water standard (2 mg/L), and 4 percent exceeded the primary drinking-water standard (4 mg/L). The maximum concentration was 6.1 mg/L. All samples that exceeded the primary drinking-water standard for fluoride also had dissolved-solids concentrations that exceeded 2,600 mg/L, which generally is unsuitable for domestic use.

None of the 27 water samples from the carbonate and sandstone aquifer analyzed for selenium had concentrations that exceeded the primary drinking-water standard of 10 μg/L. The median concentration was the detection limit (1 μg/L).

EFFECTS OF LAND USE ON WATER QUALITY

Ground-water quality has changed in some areas of Wyoming because of the effects of waste disposal, agriculture, mineral extraction and processing, and urbanization. Water-quality contaminants at eight sites have been documented under the RCRA of 1980 and one site is on the National Priorities List (NPL) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) of 1980 (fig. 3*A*). Most severe water-quality problems have been local, and the usefulness of principal aquifers has not been impaired (Wyoming Department of Environmental Quality, 1986a). Statewide contamination of aquifers in Wyoming is not a significant problem because of distribution of the industrial development and the sparse population of about 5 persons per mi^2 in 1980 (Wyoming Department of Administration and Fiscal Control, 1983).

Areas of human-induced contamination have been delineated by the WDEQ (fig. 3*B*); contamination sources include waste disposal and leakage from petroleum refineries and industrial facilities, leakage from underground storage tanks, leakage from septic disposal systems, and percolation of fertilizers in irrigated areas. Wells that yield contaminated water shown by county in figure 3*B* may represent one or more wells in a particular area and generally do not represent wells that are used for drinking water.

Waste Disposal

Hazardous wastes currently (1986) are being disposed at sites near Kemmerer in Lincoln County, Casper, Evansville east of Casper, and Sinclair in Carbon County (Wyoming Department of Environmental Quality, 1986b); these are some of the RCRA sites. Six of the RCRA sites are at oil refineries; the soils, water, or both at these sites have been contaminated by chemicals such as benzene, ethylbenzene, toluene, xylene, chloride, sulfate, and phenol. Another RCRA site is a phosphorus-processing plant south of Kemmerer, where large dissolved-solids concentrations are being contributed to the ground water. A railroad tie-treatment facility at Laramie (Albany County) is classified as both a CERCLA or Superfund site and a RCRA site (fig. 3*A*). The site at Laramie is contaminated by the toxic pollutants, creosote and pentachlorophenol.

The WDEQ has applied to the EPA for the classification of the Brookhurst subdivision, which is near the North Platte River east of Casper, as a CERCLA site (identified as "other" in fig. 3*A*). Several domestic wells completed in the alluvial aquifer near an oil refinery and an adjoining industrial area were discovered recently to be contaminated with the suspected carcinogens, benzene and trichloroethylene. Although the extent and source of the contamination have not been defined at this time (1986), the community has been instructed by the WDEQ to obtain an alternative water supply.

Fourteen hazardous-waste sites at Francis E. Warren Air Force Base in Laramie County, Wyoming were identified (September 1985) by the U.S. Department of Defense (DOD) as part of their Installation Restoration Program (IRP) as having potential for contamination (U.S. Department of Defense, 1986). The IRP, established in 1976, parallels the EPA Superfund program under the CERCLA of 1980. The EPA presently ranks these sites under a hazard-ranking system and may include them in the NPL. After an initial assessment completed under the program, 17 sites (fig. 3*A*) were recommended for a comprehensive survey to determine through environmental sampling and analysis whether problems exist (William Metz, U.S. Department of Defense, oral commun., 1987). Remedial action at 1 of these 17 sites is underway.

Although no hazardous wastes are injected into underground wells in Wyoming, eight Class-I Underground Injection Control (UIC) wells (U.S. Environmental Protection Agency, 1984) are permitted by the WDEQ for industrial or municipal wastes (fig. 3*A*). Other injection wells (not shown in fig. 3*A*) in Wyoming include about 4,000 petroleum-related wells, 350 in-situ uranium-related wells, and 400 underground coal-gasification-related wells (Wyoming Department of Environmental Quality, 1987.

Sites identified as "other" in figure 3*A* include 140 industrial landfills and 5 construction and demolition landfills. Each site represents one permit or one proposed permit; each permit may authorize one or more landfills. The number of county and municipal landfills is indicated by county in figure 3*C*. Ground-water quality is not monitored routinely at landfills in Wyoming; therefore, no ground-water-quality data are available for these sites.

Some septic-tank pumpers are contaminating ground water and surface water by improperly disposing of septic-tank wastes (Richards, 1986, p. A-3). The WDEQ reported three such violations and several more suspected incidents that have occurred in the last few years (John Wagner, Wyoming Department of Environmental Quality, oral commun., 1986). The alluvial aquifer and possibly the High Plains and equivalent aquifers would be the most vulnerable to this type of contamination.

Agriculture

Irrigation can increase the concentration of dissolved solids in shallow aquifers. Salts accumulate in the soil after evapotranspiration has consumed the water. Some of the applied irrigation water transports these salts down to the water table. The alluvial aquifer along the Shoshone, Bighorn, and Big Sandy Rivers has been affected by this process (Wyoming Department of Environmental Quality, 1986a). Where soil has small porosity and slow drainage or where the water table locally is high, infiltration from irrigation can cause waterlogging. The fluctuation of the water table combined with evapotranspiration can result in the concentration of salts in the soil and in the ground water, causing an increase in dissolved-solids concentrations. The Wyoming Department of Agriculture (WDA) began a monitoring program in 1986 to determine the possible degradation of ground-water quality resulting from irrigation.

Contamination by nitrate is fairly common in agricultural areas of Wyoming. Nitrates are leached from corrals and feedlots into the ground water. Nitrate fertilizers used on crops also may increase nitrate concentrations in ground water. Large nitrate concentrations have been detected in ground-water samples from wells in agricultural areas in Laramie, Goshen, Fremont, Washakie, Bighorn, and Park Counties (fig. 3*B*).

The WDA has monitored surface water for the presence of pesticides for several years. Although contamination of ground water by pesticides has not been well documented in Wyoming, extensive usage presents a potential problem.

Mineral Extraction and Processing

Large dissolved-solids concentrations in ground water have been associated with spoil material at coal mines and tailings-disposal sites at trona mines. Concentrations of dissolved solids in spoil water at the mine sites generally are larger than concentrations in water from nearby stock and domestic wells, but some of the spoil water is acceptable for use by livestock. Few people are affected by these large dissolved-solids concentrations because of the sparse population near the mines and the slow rate of ground-water movement from mine spoils.

The WDEQ lists 10 sites where seepage from uranium tailings ponds has escaped past the pumpback systems to increase concentrations of dissolved solids, sulfates, chlorides, and radionuclides in the structural basin aquifer (Michael Carnevale, Wyoming Department of Environmental Quality, written commun., 1986). Leachates from five uranium mines have extended beyond the recovery wells. Seepage from a tailings pond at a uranium processing mill in Fremont County is locally contaminating ground and surface water with cyanide, trace metals, and arsenic; the site is being investigated by the WDEQ.

Experimental underground coal-gasification burns have contaminated ground water at three facilities—in Campbell, Carbon, and Converse Counties. These areas have been contaminated locally by suspected carcinogens and constituents included on the EPA's priority list (U.S. Environmental Protection Agency, 1986c).

Urbanization

Sources of ground-water contamination within urbanized areas include leaking underground petroleum-product storage tanks and septic-tank leach fields. Leaking gasoline- and diesel-fuel storage tanks in or near various communities have contaminated local ground water. The WDEQ lists 55 such sites that have been or are being investigated pending additional ground-water-monitoring data (Tom Williams, Wyoming Department of Environmental Quality, written commun., 1987). Eight additional sites where diesel refueling, solvent spills, and illegal waste pits may have contributed hazardous toxic contaminants to the local ground water also are being investigated by WDEQ. This local contamination has occurred most commonly in aquifers underlying Wyoming's communities.

Wells serving several Wyoming communities have concentrations of nitrate exceeding the drinking-water standard. These wells are contaminated generally as the result of too many septic-tank-disposal systems in too small an area. Nitrate is the primary ground-water contaminant in Laramie County (fig. 3*B*).

POTENTIAL FOR WATER-QUALITY CHANGES

Changes in water quality may be expected in the future. These changes include increased nitrate concentrations in agricultural and urban areas, increased dissolved-solids concentrations in irrigated and mined areas, and contamination by petroleum products. Pesticides in ground water have been documented in many agricultural areas outside Wyoming; however, studies in Wyoming are just beginning.

Future contamination by nitrate in areas associated with the application of fertilizers and the use of septic tanks, such as in agricultural and urban areas, may be expected. The aquifers that most commonly occur in agricultural and urbanized areas are the alluvial aquifer and the High Plains and equivalent aquifers. Of these, the alluvial aquifer is very susceptible to nitrate contamination. The water table usually is very shallow, and the sand and gravel typical of this aquifer are very permeable. Nitrate concentrations may be expected to remain relatively small in water from the structural basin aquifer primarily because the areas of occurrence are not significantly agricultural or urbanized. The structural basin aquifer also is much less susceptible to nitrate contamination because the depth to the water table generally is large, and the material between the land surface and the producing saturated zone is relatively impermeable.

Dissolved-solids concentrations generally may be expected to increase in irrigated and mined areas. Irrigation with ground water generally is practiced where either the alluvial aquifer or the High Plains and equivalent aquifers are present. Large dissolved-solids concentrations also are associated with mine spoils and may be expected to increase in mined areas. Mining generally occurs in the structural basin aquifer areas. Most water-quality changes in the structural basin aquifer are considered to be long term because of the slow movement of ground water in these units.

Contamination of ground water by petroleum products is fairly common in Wyoming, and contamination occurrences can be expected to increase as storage tanks and pipelines age, increased leakage occurs. Increased development of petroleum resources also increases the likelihood of accidental spills.

Incomplete data, along with complex geology, hinder any quantitative assessment of future contamination of ground-water supplies in Wyoming. Data are too sparse to permit spatial and vertical assessment of ground-water quality in many aquifers. The U.S. Geological Survey currently (1986) is studying the quality of water in and near several coal-spoil sites and the occurrence of selenium in surface water and ground water. These studies will improve the water-quality data base. Nevertheless, ground-water contamination can be expected to increase, based on the increasing number of sites where contamination or the potential for contamination, already has been identified.

The distribution of the industrial development and the relatively sparse urbanization in Wyoming currently (1986) decreases the potential for any statewide threat of contamination of the principal aquifers. However, continued regulation of activities that may contaminate ground water, as well as the development of a comprehensive statewide ground-water-quality network, would protect the future ground-water quality in Wyoming.

GROUND-WATER-QUALITY MANAGEMENT

The WDEQ—the principal State agency responsible for protecting the quality of ground water in Wyoming—shares and coordinates this responsibility with the EPA. The WDEQ was created in 1973 in response to the Federal Water Pollution Control Act of 1972.

Other State agencies also have regulatory responsibility for activities that potentially affect ground-water quality. The WDA regulates the use of pesticides and has monitored surface water for the presence of pesticides for several years. The Oil and Gas Commission regulates injection wells related to the production of oil and gas. The Wyoming State Engineer is charged by the Wyoming constitution with the administration of all waters within the State. Well permits are issued and water rights are administered by the Wyoming State Engineer's Office.

Three divisions in the WDEQ deal with ground-water quality—the Water Quality Division, the Land Quality Division, and the Solid Waste Management Program. The Water and Land Quality Divisions require monitoring of ground-water pollution through statutory requirements for commercial and research licenses. The Ground Water Operations Section of the Water Quality Division has the responsibility to protect both present and potential uses of ground water in Wyoming; the Section reviews construction plans and issues permits for surface facilities and underground injection control facilities. The Solid Waste Management Program regulates the operation of existing landfills and the design, location, and operation of new sites.

The Water Quality Division is also responsible for administering and enforcing the Wyoming Oil and Hazardous Substance Pollution Contingency Plan (Wyoming Department of Environmental Quality, 1986b). Although all spills must be reported to the Water Quality Division within 24 hours, the degree of Water Quality Division involvement in such situations is dependent upon the severity and complexity of the spill. Any necessary notification of downstream users and other agencies is conducted by the Water Quality Division. The State of Wyoming may recover not only State response expenses and penalties, but also costs for replacement of natural resources and wildlife. The Wyoming Game and Fish Department has a major role in these later efforts.

The EPA has primary responsibility for administering the RCRA and CERCLA sites. The EPA also enforces the national primary drinking-water regulations. Although the State does not have primary responsibility, a State permit is required for any disposal of hazardous waste in Wyoming. During 1985, the Solid Waste Management Program began requiring applications for hazardous-waste disposal.

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FOR ADDITIONAL INFORMATION: District Chief, U.S. Geological Survey, P.O. Box 1125, Cheyenne, WY 82003

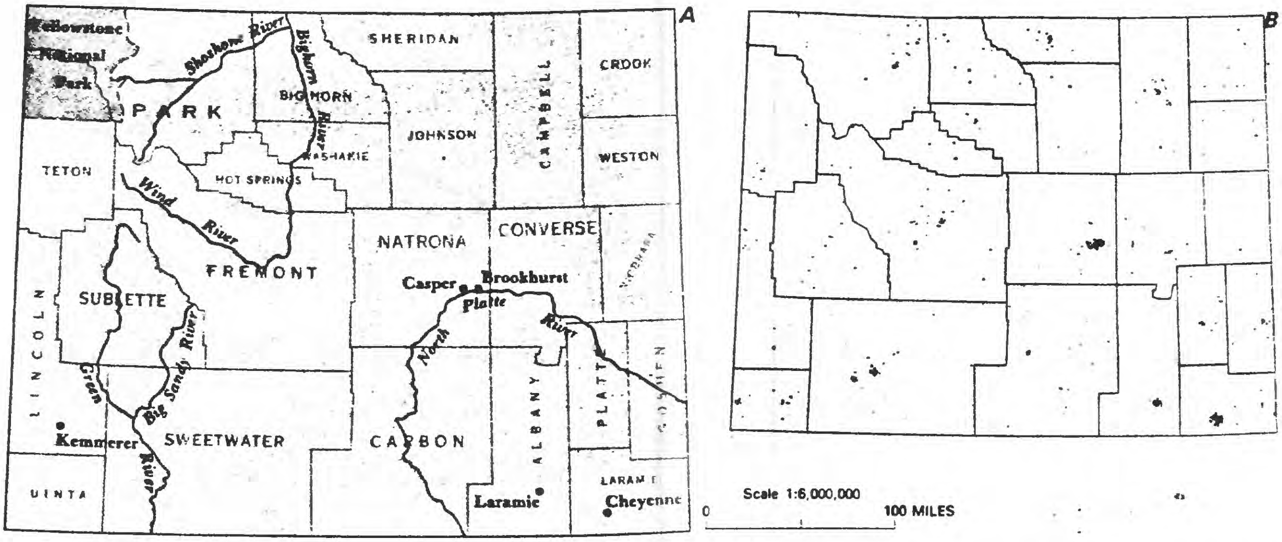

Figure 1. Selected geographic features and 1985 population distribution in Wyoming. *A*, Counties, selected cities, and major drainages. *B*, Population distribution, 1985; each dot on the map represents 1,000 people. (Source: *B*, Data from U.S. Bureau of the Census 1980 decennial census files, adjusted to the 1985 U.S. Bureau of the Census data for county populations.)

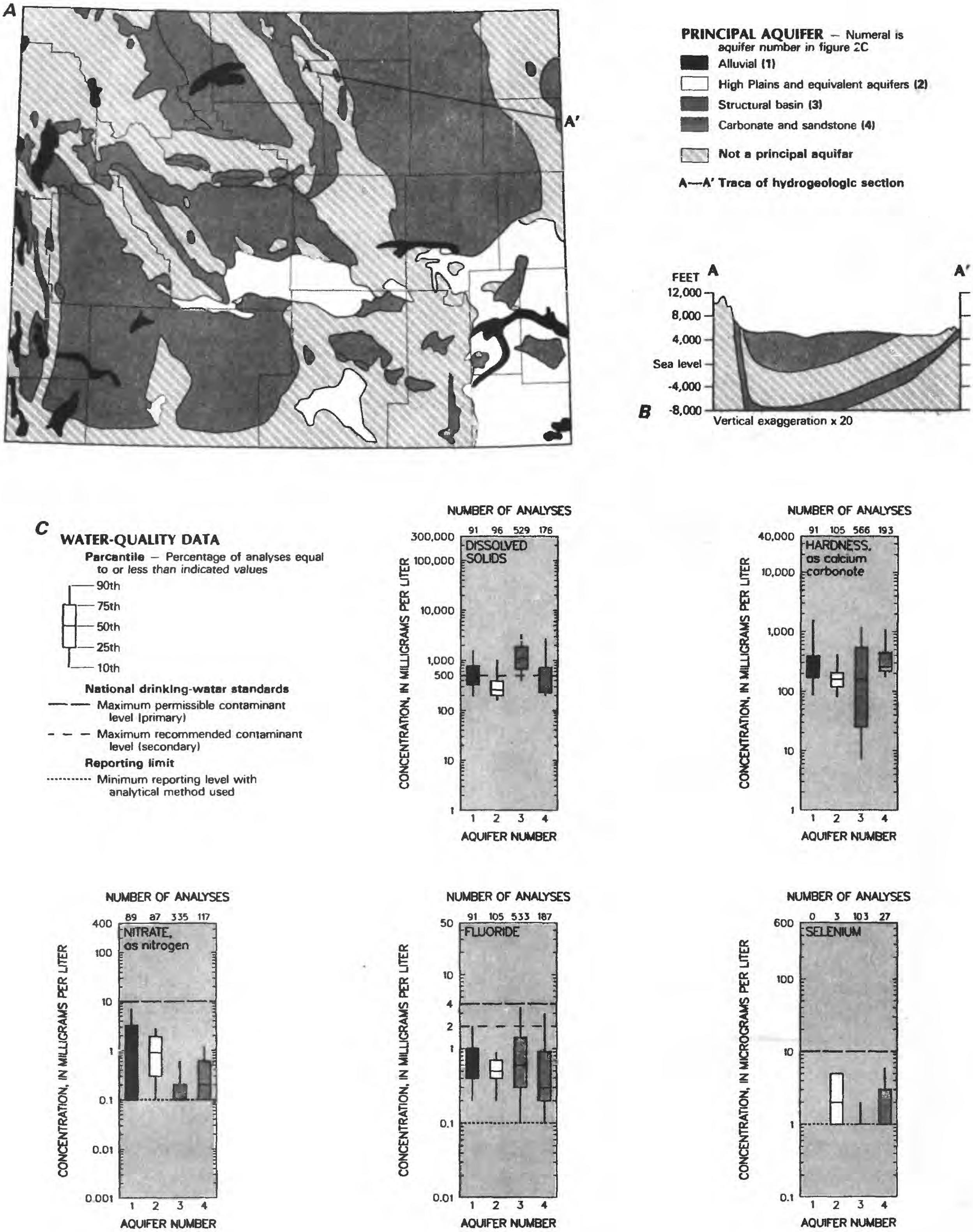

Figure 2. **Principal aquifers and related water-quality data in Wyoming.** *A*, Principal aquifers. *B*, Generalized hydrogeologic section. *C*, Selected water-quality constituents and properties, as of 1960–85 (Sources: *A*, *B*, U.S. Geological Survey, 1985. *C*, Analyses compiled from U.S. Geological Survey files; national drinking-water standards from U.S. Environmental Protection Agency, 1986 a,b.)

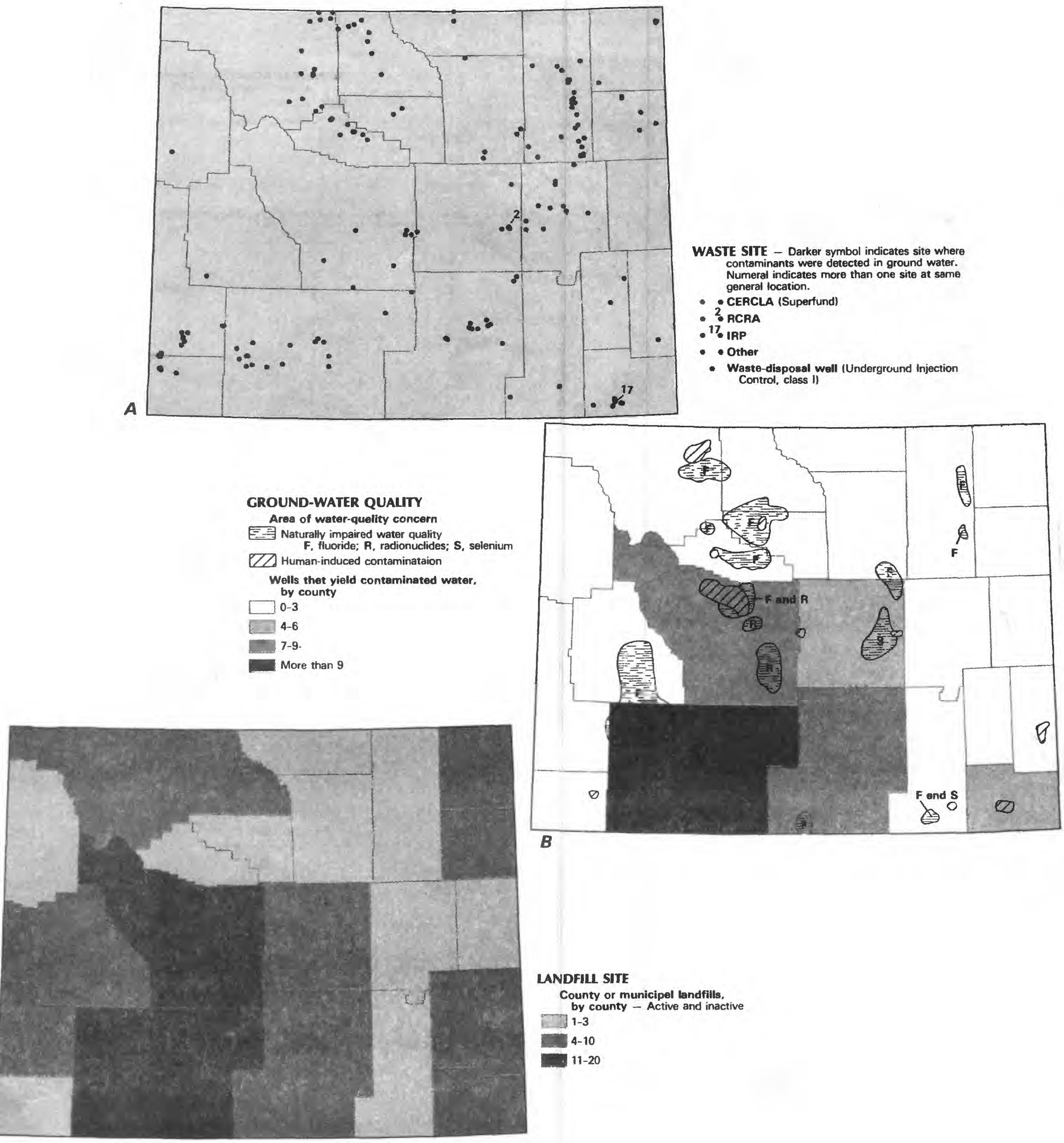

Figure 3. Selected waste sites and ground-water-quality information in Wyoming. *A*, Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) sites, as of 1986; Resource Conservation and Recovery Act (RCRA) sites, as of 1986; Department of Defense Installation Restoration Program (IRP) sites, as of 1985; and other selected waste sites, as of 1986. *B*, Areas of naturally impaired water quality, areas of human-induced contamination, and distribution of well sites that yield contaminated water, as of 1986. *C*, County and municipal landfills, as of 1986. (Sources: *A*, U.S. Environmental Protection Agency, 1986c; U.S. Department of Defense, 1986; Michael Carnevale, Wyoming Department of Environmental Quality, written commun., 1986. *B*, Association of State and Interstate Pollution Control Administrators, 1985; Michael Carnevale, Wyoming Department of Environmental Quality, written commun., 1986. *C*, Michael Carnevale, Wyoming Department of Environmental Quality, written commun., 1986.)