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Prepared in cooperation with Idaho Division of Environmental Quality

Ground-Water Quality in Northern Ada County, Lower Boise River Basin, Idaho, 1985–96

INTRODUCTION

In October 1992, the U.S. Geological Survey (USGS), in cooperation with the Idaho Division of Environmental Quality, Boise Regional Office (IDEQ-BRO), began a comprehensive study of ground-water quality in the lower Boise River Basin. The study in northern Ada County has been completed, and this report presents selected results of investigations in that area. Results and discussion presented herein are based on information in publications listed under “References Cited” on the last page of this Fact Sheet.

DESCRIPTION OF THE AREA

Northern Ada County is located in southwestern Idaho (fig. 1). The area is in the lower Boise River Basin and comprises about 560 square miles. Regional slope of the valley floor generally is westward to northwestward; the slope of the Boise River floodplain is about 13 feet per mile. The area receives about 12 inches of precipitation annually.

Northern Ada County includes sparsely populated rangeland and farmland, as well as the city of Boise and some of the most densely populated and rapidly developing urban and suburban areas of Idaho. Prior to

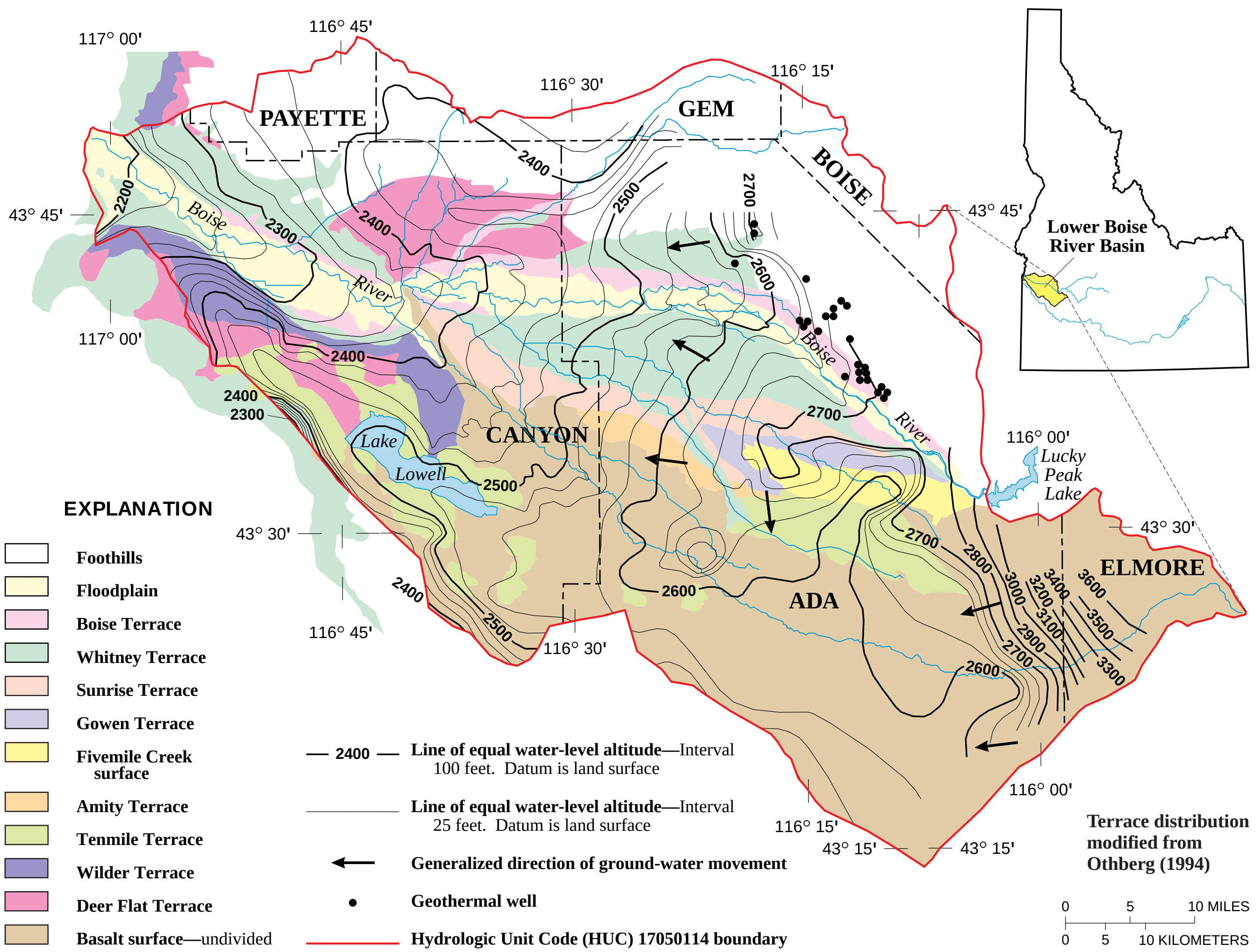

Figure 1. Location of the lower Boise River Basin, northern Ada County, selected geologic features, and hydrologic conditions in March and April 1996.

about 1985, rates of land-use change were highest on the floodplain and adjacent terraces. In recent years, urbanization has accelerated throughout the area. Changes in land and water uses that accompany development (such as irrigation methods or home, well, and septic-tank drainfield densities) have affected ground-water recharge and quality.

Occurrence, movement, and quality of ground water in northern Ada County are determined, in part, by geologic environment. Geologic features in the area include the foothills, floodplain, steplike terraces (ranging in age from the approximately 10,000-year-old Boise Terrace to the 2,000,000-year-old Tenmile Terrace), and faults at the base of the foothills and at depth in terraces. These geologic features are the result of a complex history of valley-floor subsidence, glacial episodes, and volcanism. Foothills are composed of granite, basalt, and consolidated sedimentary rocks. Floodplain and most terrace sediments have been weathered from nearby foothills and mountains. These sediments are composed primarily of varying thicknesses of soil overlying beds and lenses of clay, sand, and gravel. Although types of sediments are similar in all terraces, distribution of beds and lenses of sediments is heterogeneous and erratic within each terrace and probably discontinuous from one terrace to another. Basalt is exposed at land surface or interbedded at depth in older terrace sediments. Older regional sedimentary and volcanic rocks underlie floodplain and terrace sediments.

Ground water is the primary source of private and public drinking water. Large amounts of ground water also are used for irrigation, stock, commercial, industrial, and air-conditioning supplies. Ground water is present at varying depths in floodplain and terrace sediments. Layers of water-bearing zones are less than 30 feet to more than 1,000 feet below land surface, and wells throughout the area are open to one or several water-bearing zones. Water-bearing zones within a local ground-water system (floodplain and terrace sediments—depth to water near land surface to several hundred feet below land surface) overlie a regional ground-water system. Geothermal water (temperature greater than 29 degrees Celsius,°C; 84 degrees Fahrenheit,°F) occurs along faults at the base of the foothills. The extent of local, regional, and geothermal systems currently has not been determined.

Major sources of recharge to water-bearing zones within the first few hundred feet of land surface are seepage from the Boise River, streams, canals, and ditches, and underflow from adjacent areas. In some near-surface zones, water is unconfined (water table); there can be large changes in depth to water during the irrigation season; and there can be seasonal change in direction of ground-water movement. Ground water in most deeper zones of the local ground-water system is confined (artesian); there is some seasonal change in depth to water; and direction of water movement is relatively constant. Information on the regional system is sparse because few wells are completed in deepest water-bearing zones. Most of the deepest wells are used for public supply or irrigation, and in order to increase water production, these wells are open to multiple zones in local and regional systems.

Ground water in most zones generally moves northwestward. Contours of water-level altitude and general directions of ground-water movement are shown in figure 1. Contours are based on static water-level measurements in 335 wells throughout the lower Boise River Basin during March and April 1996. Water-level altitude was calculated by subtracting depth to water (feet below land surface) from land-surface altitude. Total well depths range from about 30 to more than 1,000 feet below land surface. Ground-water movement generally is from areas of recharge to areas of discharge, and arrows showing the direction of movement are drawn perpendicular to contours of the water-level altitude.

GROUND-WATER QUALITY CHARACTERISTICS

Water samples collected from 884 wells representing all major water-bearing zones throughout northern Ada County and analyzed from 1985 through December 1996 are summarized in this report. Wide variations in temperature and chemical concentrations occur naturally in northern Ada County ground water. Water temperatures range from 9° to 79.5°C (about 48° to 175°F), and about 80 percent of ground water is cold, 13° to 16°C (55° to 61°F). More than 19 percent of ground water is warm, 16.5° to 28.5°C (62° to 83°F), the result of increasing rock temperature with depth or, more rarely, mixing of geothermal and nonthermal water near fault zones. At least 25 wells produce geothermal water (fig. 1).

Ground water in northern Ada County generally is characterized by predominantly calcium and bicarbonate, calcium and sulfate, or sodium and bicarbonate ions (fig. 2). Nonthermal water (temperature less than 29°C) generally is enriched in calcium and bicarbonate ions, but relative proportions of cations and anions vary in nonthermal water from predominantly calcium and bicarbonate to calcium and sulfate ions. Highly mineralized water commonly is enriched in calcium and sulfate ions. Geothermal water characteristically is enriched in sodium and bicarbonate ions, and concentrations of fluoride are distinctively large. Warm water is

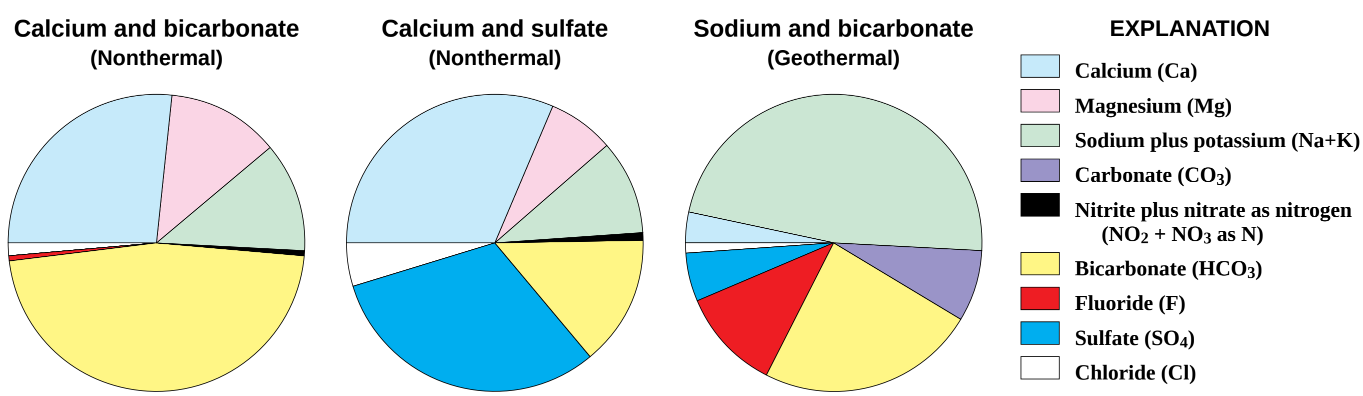

Figure 2. Proportions of major ions in nonthermal and geothermal ground water in northern Ada County. (Proportions based on total milliequivalents per liter)

produced by many wells completed in deep water-bearing zones and generally has a calcium and bicarbonate or calcium and sulfate composition. Small concentrations of fluoride indicate that water temperature in these wells probably is not the result of a mixing of nonthermal and geothermal water.

Radiochemical analyses of water for carbon-14, chlorofluorocarbon, tritium, and isotopes of carbon, hydrogen, oxygen, sulfur, chlorine, nitrogen, or helium can be used to delineate ground-water flowpaths, define sources of recharge and contamination, or characterize water from various water-bearing zones. A few analyses for carbon-14, tritium, and isotopes of carbon, hydrogen, and oxygen are available for ground water in northern Ada County. No carbon-14 analyses are available for nonthermal wells less than 500 feet total depth. Ages of water from four deeper nonthermal wells range from about 2,000 to 11,000 years before present, but these ages might represent a mixture of younger and older water from local and regional systems. Ages of water from five geothermal wells range from about 15,000 to 28,000 years before present. Few isotope data currently are available for nonthermal water. Isotope data are available for water from most geothermal wells, however, and have been used to define at least two geothermal circulation systems along foothills faults in northern Ada County.

On the basis of U.S. Environmental Protection Agency (EPA) standards for public water supplies, ground water in northern Ada County is suitable for most public and private drinking-water uses. Water from some water-bearing zones in a few areas, however, contains contaminants—components that can limit the water's suitability for use or can represent degradation of water quality. Contaminants can be naturally occurring or can be the result of land- and water-use activities (table 1, last page of report).

Naturally Occurring Contaminants

The most common naturally occurring water-quality contaminant in northern Ada County is large concentrations of total dissolved solids (TDS), a measure of the total amount of minerals dissolved in the water. TDS can be calculated from concentrations of major ions or estimated from specific conductance measurements. Water containing TDS concentrations of less than 500 mg/L (milligrams per liter, equivalent to parts per million) is preferred for home use and many industrial processes. Water containing TDS concentrations of more than 500 mg/L might require treatment for taste, color, or hardness, or might contain one or more ions of specific concern.

In northern Ada County, TDS concentrations in water from about 10 percent of wells exceeds the EPA drinking-water standard of 500 mg/L. These wells are distributed throughout the area, and highly mineralized water generally is from wells less than 400 feet total depth. Water hardness and large concentrations of dissolved sulfate, fluoride, iron, or manganese are the most common problems in mineralized water. Hydrogen sulfide odor ('rotten egg' or 'swampy' smell) is present in water from some wells, an esthetically objectionable trait for some domestic water uses.

Radon is a naturally occurring, odorless, tasteless, inert gas formed by the natural radioactive decay of uranium, present to some extent in nearly all rocks and soil. Household activities that heat, aerate, or expose ground water to air release dissolved radon from the water and increase the radon concentration in indoor air. To keep radon concentrations in indoor air to a minimum, the EPA has proposed that radon concentrations in water not exceed 300 picocuries per liter (pCi/L). This proposed limit currently is under review, and other suggested maximum limits are 1,000 pCi/L or a range of 2,500 to 5,000 pCi/L.

In northern Ada County, radon concentrations in water from more than 90 percent of wells exceed 300 pCi/L, and concentrations from about 25 percent of wells exceed 1,000 pCi/L. Radon concentrations in ground-water supplies are determined by mineral content of water-bearing rocks and soil and by well location and construction. For most ranges of concentration, no correlation has been observed between radon concentrations and physical properties of water (temperature, specific conductance, total alkalinity, or pH), major ion concentrations, or well depth. However, all water samples that contain concentrations exceeding 1,800 pCi/L (26 samples from 21 wells) are from wells less than 125 feet deep with water temperatures less than 16.5°C.

Contaminants Related to Land and Water Uses

Potential pathways of contaminant movement to water-bearing zones include seepage, leakage, or dumping of contami-

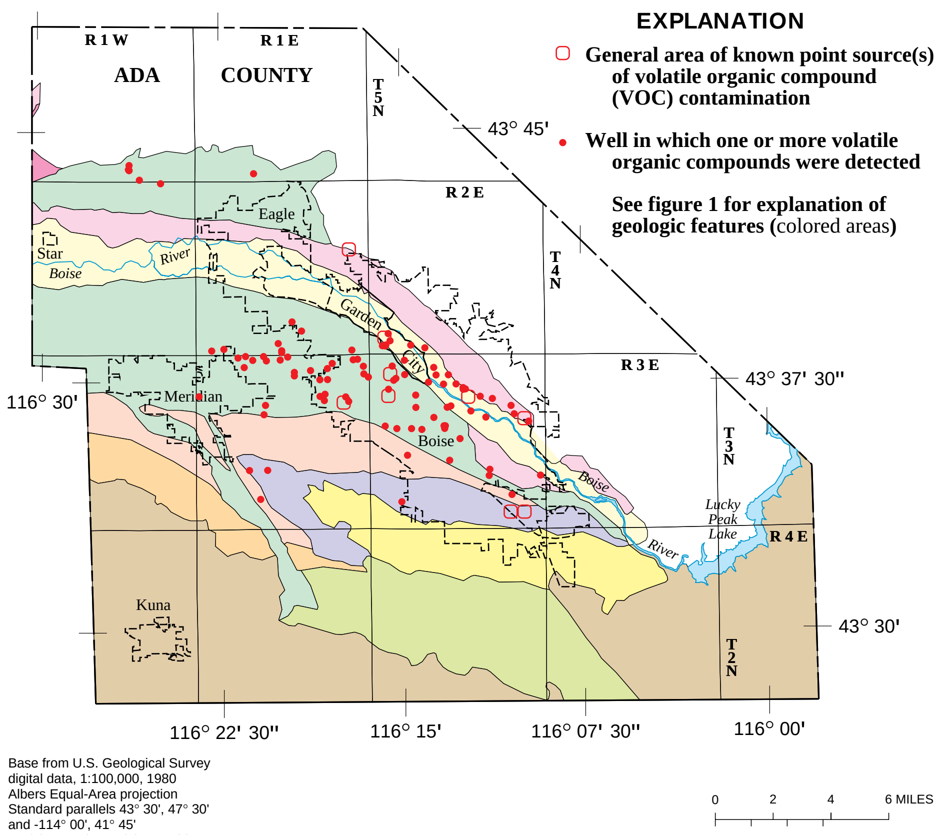

Figure 3. Wells in which one or more volatile organic compounds were detected, and general areas of known point-source contamination, northern Ada County.

nants at or near land surface; downward flushing of contaminants by infiltration of precipitation, floodwater, or applied irrigation water; flushing of contaminants from soil and unsaturated rocks by seasonal variations in ground-water levels; leakage around or into well casings or dumping of contaminants into wells; backflushing contaminants to wells through water-supply systems; and transport from upgradient sources. Contamination from land and water uses can be localized (point source) or widespread (nonpoint source).

Point-source contamination in northern Ada County is mainly the result of leakage, spillage, or dumping of chemicals at land surface; leakage from underground storage tanks; leakage and infiltration of chemicals at dump sites or landfills; and dumping of chemicals around or into wells. In most areas where contaminated soil or unsaturated rocks have been identified, contaminated materials were removed before ground water was affected. In some areas, ground-water contamination from point sources has been identified (fig. 3), and these point-source problems are under investigation by local, State, or Federal regulatory agencies.

Two groups of nonpoint-source contaminants are pesticides and volatile organic compounds (VOCs). Because laboratory analyses for pesticides and VOCs are relatively expensive, nonquantitative methods for determining the presence or absence of these compounds were used as preliminary screening tools. When preliminary screening indicated that compounds were present, duplicate samples were sent for laboratory confirmation of contamination. Quality assurance samples were sent for laboratory analyses without preliminary screening.

Water samples from 148 wells were screened for pesticides, and pesticide compounds were detected in water from 45 wells (fig. 4). In general, very small concentrations of pesticide compounds were detected, and the most commonly detected compounds were triazine herbicides. Distribution of pesticide detections is similar to that of elevated nitrate concentrations. Land-use sources and pathways of contaminant movement probably are similar for both groups of compounds.

Water samples from 847 wells were screened for presence of VOCs, and VOCs were detected in water from 96 wells (fig. 3). Concentrations of VOCs generally were very small except in areas affected by point-source contamination. The most commonly detected compounds were tetrachloroethylene (PERC) and trichloroethylene (TCE), components of many cleaning products used in businesses and homes. Most VOCs were detected in the floodplain in the Boise and Garden City areas and from Boise to Meridian in south Whitney Terrace areas. Nonpoint-source VOC contamination probably is the result of long-term use of chemical products at many locations rather than spillage or leakage of chemicals from a few locations. History of suburban and urban land development, densities of septic-tank drainfield systems, and length of time since conversion from septic tanks to municipal sewer systems probably are important factors in distributions of small concentrations of VOCs in floodplain and terrace areas.

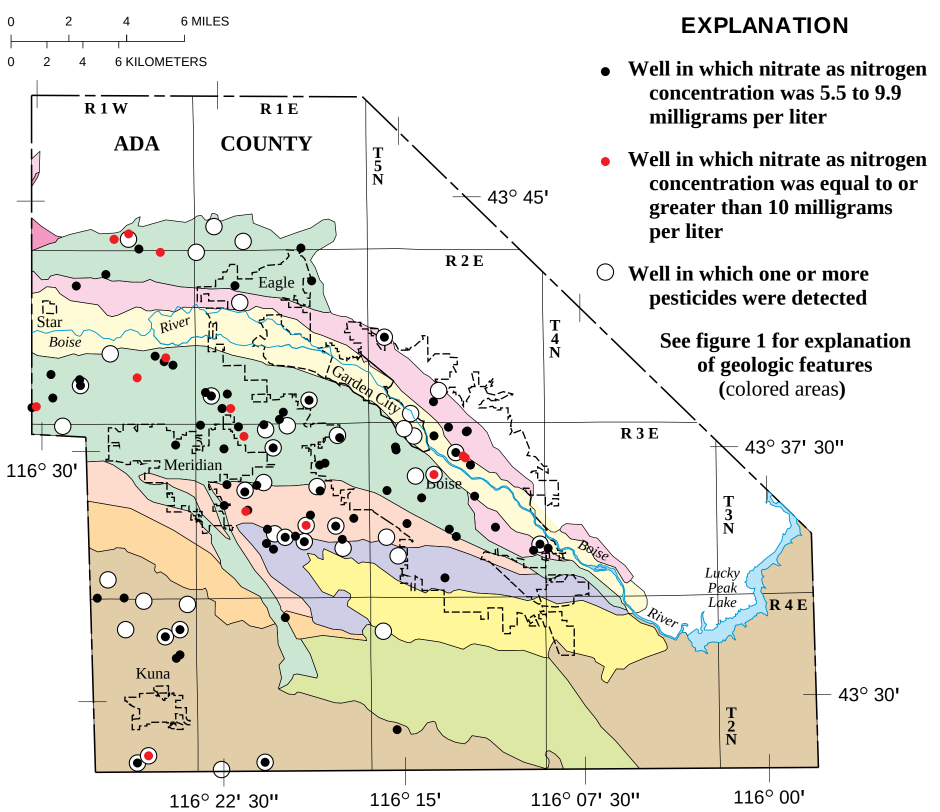

Figure 4. Wells in which nitrate as nitrogen concentrations were greater than or equal to 5.5 milligrams per liter, and wells in which one or more pesticides were detected, northern Ada County.

Another indicator of water-quality degradation resulting from land and water uses is change in nitrate concentration, commonly reported in milligrams per liter as nitrogen(N). During 1985–96, the median concentration (50th percentile) of nitrate in ground water from all areas of Idaho was 1.5 mg/L(N). In northern Ada County, about 63 percent of all concentrations exceeded 1.5 mg/L(N); the median concentration was 2.2 mg/L(N). Concentrations of nitrate in samples from about 10 percent of the wells were greater than or equal to 5.5 mg/L(N) (fig. 4). Anomalous concentrations of nitrate in samples from many wells completed within two or three hundred feet of land surface indicate an active exchange of water from land surface to water-bearing zones. Many samples containing elevated nitrate concentrations are from wells outside city boundaries. Elevated concentrations in these wells possibly are the result of large numbers and densities of homes with septic-tank drainfield systems and primary land uses related to agricultural practices.

Few data currently are available to assess seasonal or long-term trends in nitrate concentrations. Boxplots (fig. 5) show a statistical summary of nitrate data for wells grouped by major geologic feature and geothermal systems. Each boxplot represents the variability of nitrate in ground water from a broad variety of hydrogeologic environments and historical water-quality influences. Smallest median concentrations are from ground water in foothills, geothermal, and floodplain areas. Greatest ranges of concentrations are from ground water in Whitney Terraces north and south of the Boise River. Median concentrations from ground water in all terraces south of the river gener-

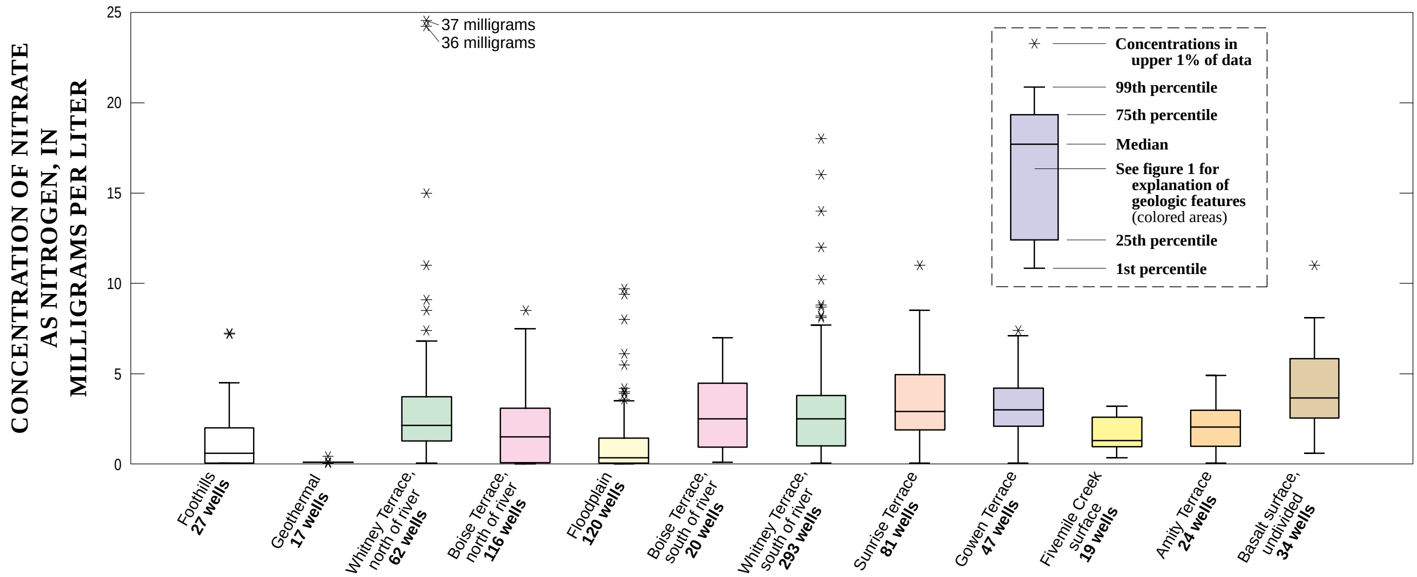

Figure 5. Nitrate as nitrogen data for wells grouped by major geologic feature and geothermal system, northern Ada County.

ally are larger than from ground water in terraces north of the river.

When nitrate data were grouped by selected geologic feature and generalized direction of ground-water movement (fig. 6), nitrate concentrations decrease from east to west and down valley in ground water in the Boise Terrace north of the Boise River (north Boise Terrace) and floodplain. In contrast, ranges and median concentrations increase in ground water in the south Whitney Terrace, confirming trends indicated in figure 4. Distribution of nitrate concentrations shown in figures 4, 5, and 6 reflects effects of a long-term history of changing land uses and development.

ADDITIONAL INFORMATION NEEDED

Effects of several hydrogeologic and environmental factors on ground-water quality are not well understood at this time. For example, little information is available on hydrogeologic relations between surface water and ground water; near-surface water-bearing zones and deeper zones in the local ground-water system; local and regional ground-water systems; or geothermal systems and adjacent or overlying nonthermal water. Areal and vertical extent of local and regional systems currently is not defined. Few data currently are available on seasonal variation in ground-water movement in water-bearing zones or ground-water systems. Few chemical analyses are available for water from wells completed in discrete water-bearing zones. Documentation of historical land use and development, especially progressive changes in uses and development, is fragmentary and sparse. Comprehensive studies of hydrogeologic and environmental factors are needed to better understand historical and current ground-water quality and to estimate future effects of development on water quality. Many data currently are available on general ground-water chemistry in the area, but radiochemical analyses of water from discrete water-bearing zones could help define extent of ground-water systems, sources of recharge, and flowpaths.

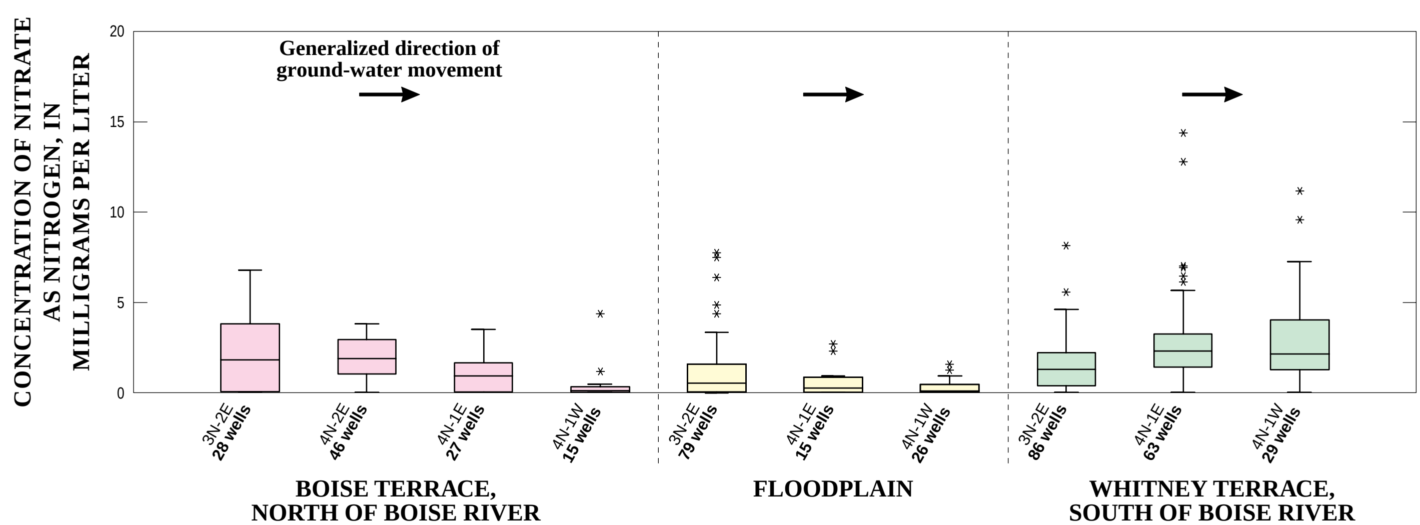

Figure 6. Nitrate as nitrogen data for wells grouped by townships within selected geologic features, northern Ada County. (N, township north; E, range east; W, range west)

Table 1. Contaminants[1] in northern Ada County ground water

Naturally Occurring

pH, hardness, sulfate, fluoride, total dissolved solids, iron, manganese, gross alpha and beta radioactivity, radon

Related to Land and Water Uses

Nutrients (nitrogen and phosphorus compounds)
Total dissolved solids
Bacteria (total coliform, fecal coliform, fecal streptococci, and additional "opportunistic" noncoliform bacteria)
Pesticides
- Herbicides (primarily triazine compounds but including dacthal, dicamba [Banvel], diuron, and metolachlor)
- Insecticides (including chlorpyrifos and p,p'DDE)

Organic compounds, including:

toluene 1,2,3-trimethylbenzene 1,2,4-trimethylbenzene (pseudocumene) 1,3,5-trimethylbenzene (mesitylene) benzene ethylbenzene xylene	trichlorofluoromethane dichlorodifluoromethane	1,3-DCB (1,3-dichlorobenzene) 1,4-DCB (1,4-dichlorobenzene) 1,2-DCP (1,2-dichloropropane) 1,2,3-TCP (1,2,3-trichloropropane) MTBE (methyl tert-butyl ether) vinyl chloride carbon tetrachloride methylene chloride (dichloromethane) carbon disulfide ethyl acetate naphthalene phenanthrene
dichlorobromomethane chlorodibromomethane bromoform chloroform	PERC (tetrachloroethylene, PERK, PCE, perchloroethylene) TCE (trichloroethylene) 1,1,1-TCA (1,1,1-trichloroethane) 1,1,2-TCA (1,1,2-trichloroethane) 1,1-DCA (1,1-dichloroethane) 1,2-DCA (1,2-dichloroethane) 1,1-DCE (1,1-dichloroethylene) 1,2-DCE (1,2 [cis- and trans-] dichloroethene) 1,2-DCB (1,2-dichlorobenzene)	

[1] Water-quality component(s) that can limit the water's suitability for use or can represent degradation of water quality.

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