PREPARED IN COOPERATION WITH THE
IDAHO DEPARTMENT OF HEALTH AND WELFARE, DIVISION OF ENVIRONMENTAL QUALITY

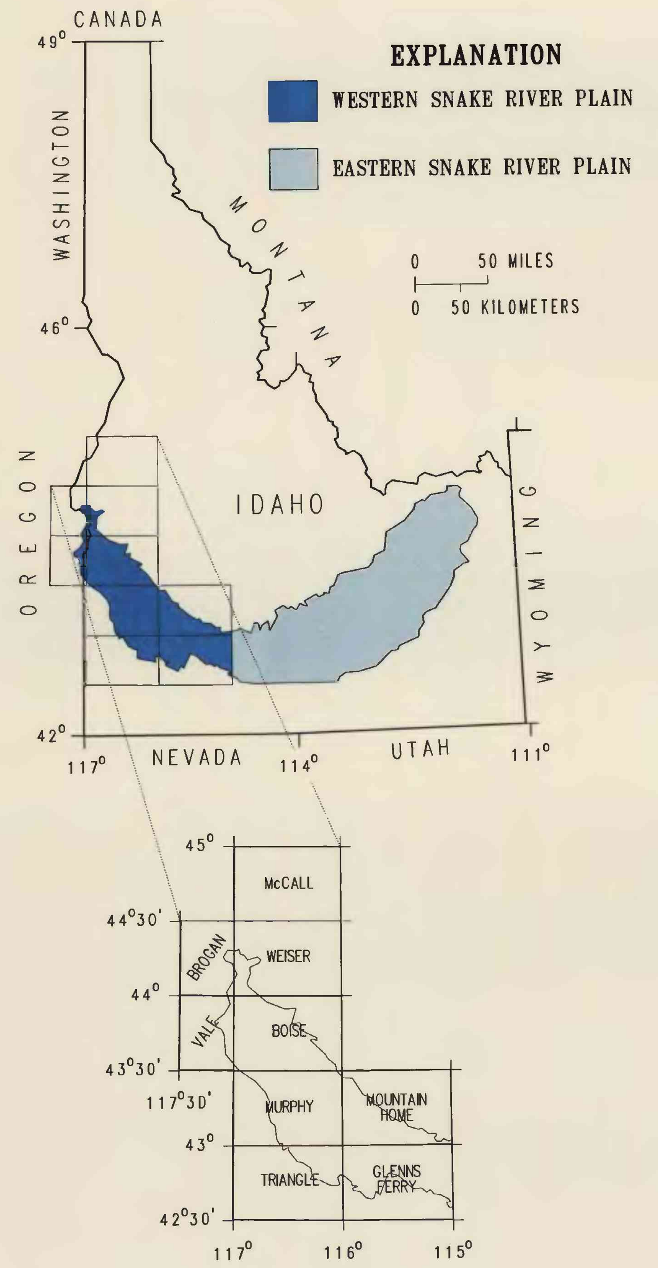

Figure 1.—Location of study area and index to 1:100,000-scale quadrangles.

INTRODUCTION

The vulnerability of ground water to contamination in Idaho is being assessed by the IDHW/DEQ (Idaho Department of Health and Welfare, Division of Environmental Quality), using a modified version of the Environmental Protection Agency DRASTIC methods (Allers and others, 1985). The project was designed as a technique to: (1) Assign priorities for development of ground-water management and monitoring programs; (2) build support for, and public awareness of, vulnerability of ground water to contamination; (3) assist in the development of regulatory programs; and (4) provide access to technical data through the use of a GIS (geographic information system) (C. Grantham, Idaho Department of Health and Welfare, written commun., 1989).

A digital representation of first-encountered water below land surface is an important element in evaluating vulnerability of ground water to contamination. Depth-to-water values were developed using existing data and computer software to construct a GIS data set to be combined with a soils data set developed by the SCS (Soil Conservation Service) and the IDHW/WQB (Idaho Department of Health and Welfare/Water Quality Bureau), and a recharge data set developed by the IDWR/RSF (Idaho Department of Water Resources/Remote Sensing Facility). The USGS (U.S. Geological Survey) has developed digital depth-to-water values for eleven 1:100,000-scale quadrangles on the eastern Snake River Plain and surrounding tributary valleys.

PURPOSE AND SCOPE

This report illustrates the digitally generated depth-to-water zones for nine 1:100,000-scale quadrangles on the western Snake River Plain in southwestern Idaho and eastern Oregon. The values that make up the zones were generated using water-level altitudes, land-surface altitudes, and selected computer software. The nine quadrangles cover about 14,200 mi^2 and extend from near King Hill westward to, and just beyond, the Idaho–Oregon border. Included are the Boise, Glenns Ferry, McCall, Mountain Home, Murphy, Triangle, and Weiser quadrangles (fig. 1). Parts of the eastern half of the Brogan and Vale, Oreg., quadrangles also are shown.

AREA OF STUDY

Encompassing nearly 4,800 mi^2 in southwestern Idaho and eastern Oregon, the western Snake River Plain (fig. 1) is bordered by high-angle faults and is composed mostly of Quaternary and Tertiary sediments of varying thicknesses. The plain is underlain by several aquifers that are major sources of water for agricultural, industrial, municipal, and domestic uses (Lindholm, 1986, p. 102). Ground-water movement in the western Snake River Plain is toward the Snake River (Lindholm and others, 1988).

Tributary valleys in the study area cover almost 1,500 mi^2 and include the upper Weiser and Payette Rivers. Major use of water is for domestic, stock, and irrigation purposes. Ground water in the tributary valleys generally flows from north to south toward the western Snake River Plain. Mountainous areas in the nine quadrangles, for which no depth-to-water data were available, cover nearly 7,900 mi^2.

ACKNOWLEDGMENTS

The IDHW/DEQ coordinated and supported the cooperative efforts between the USGS, the SCS, the IDHW/WQB, and the IDWR/RSF in the development of data sets for assessment of areas where ground water is potentially vulnerable to contamination.

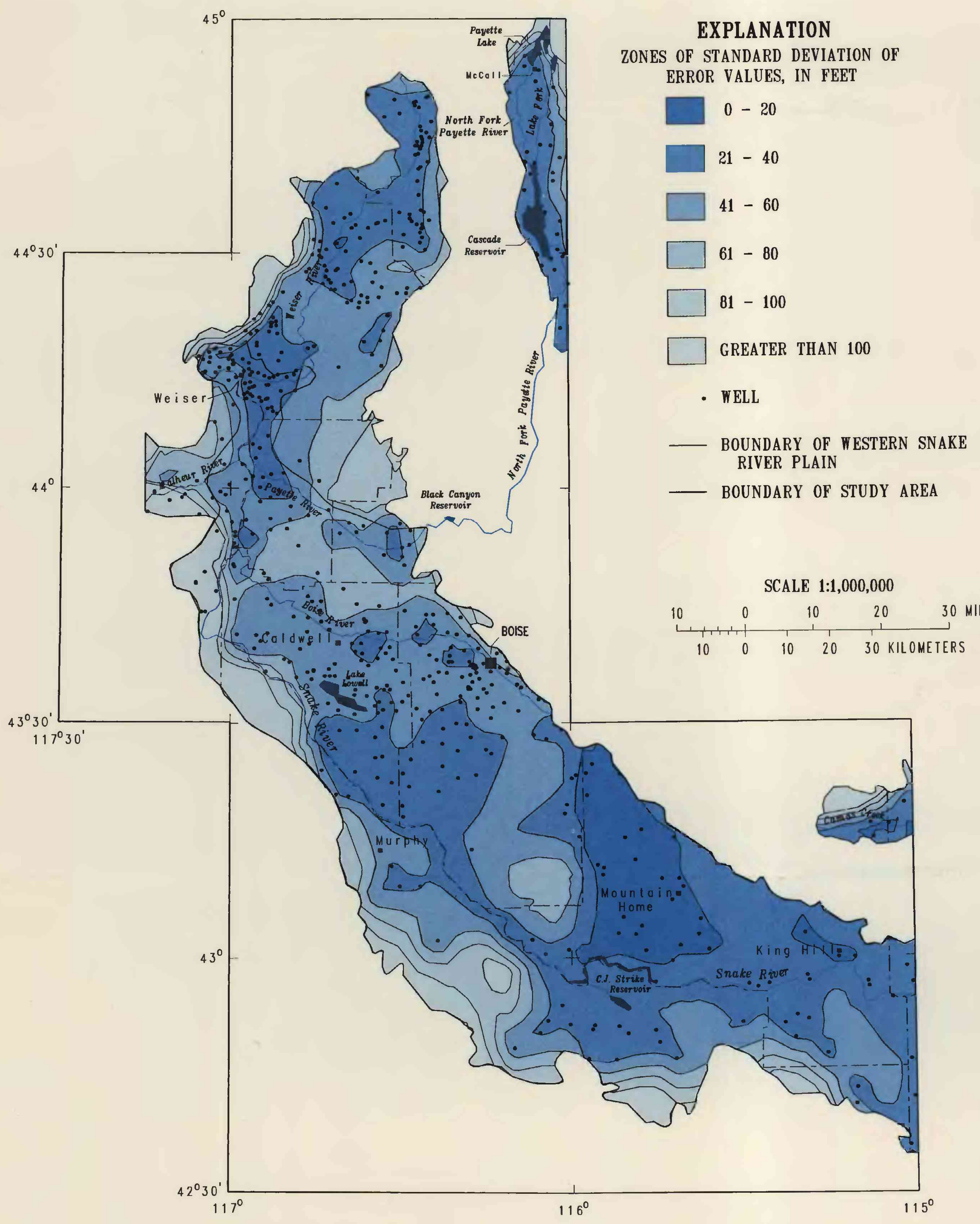

Figure 2.—Zones of standard deviation of error values and locations of wells used for analysis.

DEVELOPMENT OF MAP

Data from 1-degree DEM's (Digital Elevation Models) and the GWSI (Ground-Water Site Inventory) data base maintained by the USGS were used to construct a grid and a data set for each quadrangle. DEM's provided the land-surface-altitude data and GWSI provided well data from which wells were chosen to best represent ground-water conditions from 1980 to 1988. Universal kriging software was used to estimate water-table altitudes for first-encountered water at grid intersections for the western Snake River Plain and tributary valleys. Depth to water was calculated by subtracting water-table altitudes from land-surface altitudes at the grid intersections. All depth-to-water values and corresponding locational attributes then were loaded into ARC/INFO[1] and contoured to depict the depth-to-water zones.

SOURCE AND DEVELOPMENT OF DATA

A DEM is an array of altitude values representing ground positions at regularly spaced intervals. DEM's are created by the Defense Mapping Agency and are reformatted and distributed by the USGS. One-degree DEM's are referenced horizontally on the geographic coordinate system (latitude/longitude) of the World Geodetic System of 1972 Datum (U.S. Geological Survey, 1987, p. 1, 5).

The DEM's were used to construct a grid of land-surface altitudes; water-table altitudes were estimated at grid intersections. Grids were constructed by splitting 1-degree DEM's into nine 1:100,000-scale quadrangles and reducing the number of altitude points to one per square mile.

Well data were acquired from the GWSI data base, which is maintained on the USGS Idaho District Prime computer in Boise, Idaho. Data in GWSI include location, depth, altitude, and water levels of wells. All wells in the study area for which total depth of well, land-surface altitude, and water levels for the period 1980 to 1988 were available were identified from the GWSI data base. Only wells with water-level data for this period were used for analysis.

The data were refined additionally to develop a data set that best represented water-table conditions. Artesian wells were excluded from the data set to avoid false representation of the water table. An artesian well is one that penetrates an artesian, or confined, aquifer, and in which the water level stands above the top of the aquifer it taps. If these wells had not been eliminated from the data set, their high water levels would have erroneously increased the estimated water-table altitudes and created a more shallow depth-to-water value than was actually present. Wells with known total depths were selected so that water levels from wells of unknown depths were not integrated with water levels from wells of known depths. This process was necessary to accurately map first-encountered water. No attempt was made to exclude wells completed in perched-water zones. Therefore, the well-selection process excluded the ability to distinguish a shallow ground-water system from a deep ground-water system.

March water levels were selected because at that time the water table is relatively stable and less affected by water use than at other times of the year. March water levels also represent most of the available data because mass water-level measurements on the Snake River Plain are made in early spring. North of the plain and in tributary valleys, where March water-level measurements were sparse, June and July measurements were selected because they represented the shallowest water levels and the majority of data available. If more than one water-level measurement in the last 8 years was available for a well, the shallowest water-level measurement was selected. Water-level measurements were converted to water-level altitudes in feet above sea level to relate measurements to a standard datum.

To develop a depth-to-water map representing first-encountered water, the shallowest representative wells were selected. Wells 100 ft deep or less were selected first from the data set, and deeper wells within 1 mi or less of a selected well were deleted. If there was more than one well 100 ft deep or less within 1 mi, all wells within that area were retained and water-table altitudes were examined and deleted as necessary. Where there were no wells 100 ft deep or less, wells 101 to 300 ft deep were selected from the data set and deeper wells were deleted. This process was repeated until no wells remained to select from. The total number of wells selected within each depth range is shown in table 1.

Table 1.—*Ranges of well depths and number of wells used for analysis*

Total depth of well, in feet below land surface	Total number of wells used for analysis
0 to 100	268
101 to 300	190
301 to 600	84
601 to 900	29
901 and greater	14

SELECTION AND APPLICATION OF SOFTWARE

Universal kriging was the statistical technique used to estimate water-table altitudes at grid intersections from measured water levels for irregularly spaced selected wells. Kriging is a two-step process in which data measurements are used to determine a mathematical definition for a semi-variogram. The semi-variogram was used to generate estimated water-table altitudes at the supplied grid intersections (Skrivan and Karlinger, 1980, p. 2–3). The semi-variogram is a diagram of the irregularity of the difference of the data measurements compared to the distance between the data points (Dunlap and Spinazola, 1984). Unlike other interpolation methods, kriging provides an SDE (standard deviation of error), or a square root of the variance, for each estimated water-table altitude (fig. 2). Low SDE values signify a greater confidence than high SDE values. If SDE values are low, estimated water-table altitudes are closer to actual water-table altitudes than if SDE values are high.

The ARC/INFO GIS software consists of a spatial data base and a tabular data base. Each data set developed has directories of files that define the data set and associated tabular data. Associated tabular data consist of attributes such as locational information, well depth, water levels, and SDE values. ARC/INFO contains software capable of editing, plotting, estimating, and contouring.

Wells in the western Snake River Plain and tributary valleys for which appropriate data were available were selected for analysis. Kriging estimated the water-table altitudes at supplied grid intersections. Well data from adjoining quadrangles were incorporated into each kriging operation to improve estimates along quadrangle boundaries. Depth-to-water values were calculated as the difference between land-surface altitudes and kriged water-table altitudes. If negative depth-to-water values were calculated at grid intersections that did not intersect with water bodies, the SDE values were used to recalculate the depth-to-water values below land surface. If depth-to-water values still remained negative, the kriging program was rerun and a new semi-variogram was developed.

After depth-to-water values were calculated, they were combined into an ARC/INFO data set and contoured. Corresponding attributes such as SDE values were added to the data set and contoured. Depth-to-water zones were generated from the contours and shaded in figure 3.

DEPTH-TO-WATER ZONES

Depth to first-encountered water in the western Snake River Plain is shallow (less than 100 ft below land surface) along the Boise, Payette, Snake, and Weiser Rivers, as well as in the central part of Camas Prairie and near Mountain Home. Depth to water is mostly less than 50 ft below land surface along the Boise and Payette Rivers and Camas Prairie. Shallow ground-water movement, as indicated by the kriged water-table altitudes, is toward the Boise, Payette, and Weiser Rivers initially, then toward the Snake River. Ground-water movement in Camas Prairie is toward the central part of the valley and then eastward. In the Mountain Home area, ground-water movement is southward toward the Snake River. Water in these areas is used for domestic, industrial, irrigation, municipal, and stock supplies.

SDE values for the shallow depth-to-water zones are lowest (0 to 20 ft) near Mountain Home and in the central part of Camas Prairie. Along the Snake River from King Hill to Murphy and in the valley of the North Fork of the Payette River, SDE values range from 21 to 40 ft. In the Boise River valley near Boise, most SDE values range from 41 to 60 ft. In most shallow depth-to-water zones, SDE values are less than 60 ft, although, in some areas south and west of the Snake River (Owyhee County), values are greater than 100 ft. Depth-to-water values in these areas are the least reliable because few wells were available for analysis.

Depth to water increases from 101 to 300 ft below land surface with increasing distance from the rivers and along the margins of some valleys. Many domestic, stock, and irrigation wells were available for analysis; however, the number of wells decreases with increasing distance from the rivers.

SDE values for the 101-to-300-ft depth-to-water zones are mostly less than 80 ft, except in the central parts of the Weiser and Snake River valleys, where they are less than 40 ft. SDE values are lowest (0 to 20 ft) in the Mountain Home area and highest (greater than 100 ft) south and west of the Snake River (Owyhee County).

Depth to water ranges from 301 to 600 ft below land surface in the central part of the plain (Ada, Canyon, and Elmore Counties), along the margins of the Weiser and North Fork of the Payette River valleys, and along the boundary of the plain. The few wells available for analysis in these depth-to-water zones are located mostly in the central part of the plain (Ada and Elmore Counties); all are greater than 300 ft deep. Water is used mostly for domestic, municipal, and stock supplies.

SDE values for the 301-to-600-ft depth-to-water zones are lowest (0 to 20 ft) in the Mountain Home area and highest (greater than 100 ft) along the boundary of the plain south and west of the Snake River (Owyhee County). Most of the SDE values are less than 60 ft.

Depth to water is greater than 600 ft below land surface in the central part of the plain (Ada County), in a small area in the Weiser River valley, and along the outermost margins of the North Fork of the Payette River valley. Few wells were available for analysis in these areas. SDE values are mostly less than 60 ft.

[1]Use of trade names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

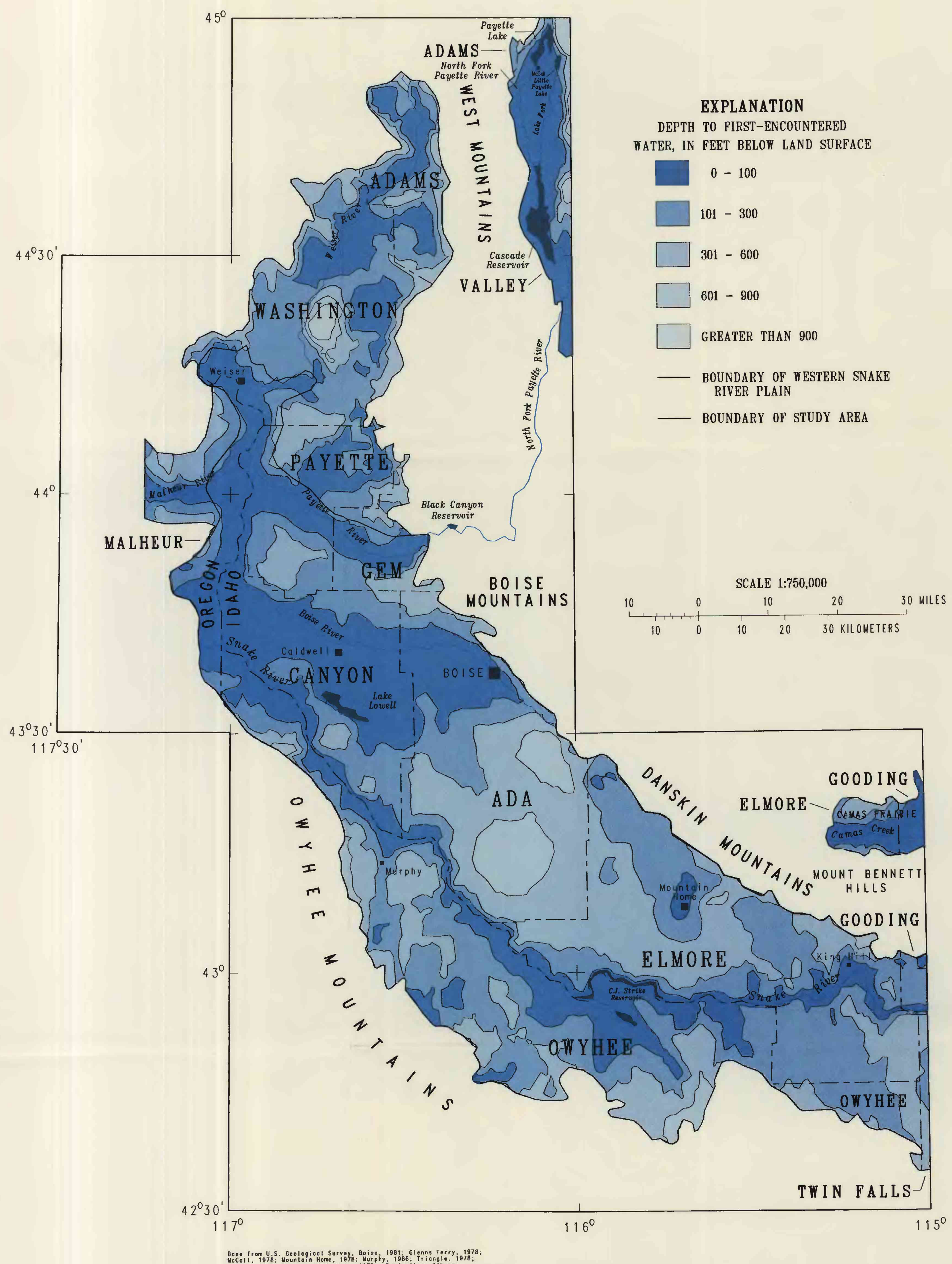

Figure 3.—Depth-to-water zones.

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CONVERSION FACTORS

Multiply	By	To obtain
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer

Sea level: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada and formerly called "Sea Level Datum of 1929."

DEPTH TO WATER IN THE WESTERN SNAKE RIVER PLAIN AND SURROUNDING TRIBUTARY VALLEYS, SOUTHWESTERN IDAHO AND EASTERN OREGON, CALCULATED USING WATER LEVELS FROM 1980 TO 1988

By
Molly A. Maupin
1991

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