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ESTIMATED AGE AND SOURCE OF THE YOUNG FRACTION OF GROUND WATER AT THE IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY

U.S. GEOLOGICAL SURVEY
Water-resources Investigations Report 01-4265

Prepared in cooperation with the U.S. DEPARTMENT OF ENERGY

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Cover: View of Big Lost River looking towards Middle and East Butte at the Idaho National Engineering and Environmental Laboratory (photo courtesy of INEEL photographic services).

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

For additional information write to:

U.S. Geological Survey
INEEL, MS 1160
P.O. Box 2230
Idaho Falls, ID 83403

Copies of this report can be purchased from:

U.S. Geological Survey
Information Services
Box 25286, Federal Center
Denver, CO 80225
e-mail: *infoservices@usgs.gov*

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CONVERSION FACTORS AND ABREVIATED UNITS

Multiply	By	To obtain
becquerel per liter (Bq/L)	27	picocurie per liter
tera becquerel (TBq)	27	curie
cubic centimeters (cm^3)	0.06102	cubic inch
gram (g)	0.03527	ounce
kilogram (kg)	2.205	pound
kilometer (km)	0.6214	mile
square kilometer (km^2)	0.3861	square mile
meter (m)	3.281	foot
centimeter (cm)	0.3937	inch
millimeter (mm)	0.03937	inch
meter per kilometer (m/km)	5.28	foot per mile
kilopascal (kPa)	0.009869	atmosphere, standard
tritium unit (TU)	3.2	picocurie

For temperature, degrees Celsius (°C) can be converted to degrees Fahrenheit (°F) by using the formula $°F = (1.8)(°C) + 32$.

Isotopic enrichment or impoverishment factors are reported as ±δ values computed from the formula

$$\delta_x = \frac{R_x - R_{STD}}{R_{STD}} \times 1,000$$

where R_x was the ratio of isotopes measured in the sample and R_{STD} was the same isotopes in the reference standard. The δ_x value was in parts per thousand (permil).

Other abbreviated units used in the report: cc, (cubic centimeter), L (liter), mL (milliliter), pg/kg (picogram per kilogram), ppt (parts per trillion), mol (mole), mmol/L (millimole per liter), ppm (parts per million), ppb (parts per billion), m^2/d (meter squared per day), mg/L (milligram per liter), µg/L (microgram per liter), STP (standard temperature and pressure, 0 degrees Celsius and 1 atmosphere pressure).

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Abstract

The U.S. Geological Survey, in cooperation with the U.S. Department of Energy, used concentrations of chlorofluorocarbons (CFCs), sulfur hexafluoride, helium (He), and tritium (^3H) to determine the estimated age of the young fraction of ground water at and near the Idaho National Engineering and Environmental Laboratory (INEEL). These environmental tracers were introduced into the Snake River Plain aquifer by natural recharge, return flow of irrigation water, and wastewater disposal at facilities at the INEEL. The source of the water and the fraction of young water in the samples also were used to date the ground water. The data indicate that most ground-water samples are mixtures containing young fractions of water recharged after 1950 and older regional ground water.

Data indicate that water in samples from wells in the southeastern part of the INEEL are a binary mixture of local recharge and very old regional ground water, and samples from most of the wells are about 20 to 50 percent young water that is about 14 to 21 years old. Two main mechanisms of recharge of the young fraction of ground water were recognized in samples from the northern part of the INEEL: (1) water recharged by rapid focused recharge through the thick unsaturated zone and (2) water recharged by slow infiltration through the thick unsaturated zone. Some of the wells in the northern part of the INEEL contained all old regional water. Three wells in the northeastern part of the INEEL contained water that was strongly affected by agricultural practices and likely was recharged in the Terreton-Mud Lake area. This water was present in wells 4, 27, and 29 and had estimated ages of 5, 10–13, and 24–28 years, respectively.

Water samples from wells that contained a young fraction of water that recharged in the central, western, and southwestern parts of the INEEL are complex mixtures of regional ground water, agricultural return flow, natural recharge, and artificial recharge from infiltration ponds and injection wells at the various facilities at the INEEL. The chemistry and age of the young fraction of the samples varied greatly and could be correlated with distance from the source of recharge, depth of the open interval below the water table, length of the interval sampled, and location of the well with respect to the different sources of recharge. Age increased with distance from the source of recharge and increased with depth below the water table. The young recharge water composes a very small fraction of the total volume of water in the Snake River Plain aquifer, and this young water was sampled because most of the wells at and near the INEEL are completed in the upper 15 m of the aquifer.

Concentrations of fluoride (F), boron, lithium (Li), strontium, oxygen isotope ratios ($\delta^{18}O$), dissolved atmospheric gases, He, and ^3H, were used to determine the sources of water in the Snake River Plain aquifer at and near the INEEL. Three natural ground-water types were identified from their He, Li, and F concentrations: (1) northeastern regional water with very high He, Li, and F concentrations; (2) recharge from the southeast with moderate He and high Li and F concentrations; (3) recharge from mountain valleys in the western part of the INEEL with low concentrations of He and Li and high concentrations of Ca, Mg, and alkalinity. The water was modified locally by mixing with agricultural runoff and wastewater from INEEL facilities. $\delta^{18}O$ ratios were used to calculate the fraction of young water in the samples from the western part of the

INEEL. Terrigenic He and ^3H concentrations were used to calculate the fraction of infiltration recharge at the INEEL.

A preferential ground-water flowpath that extends from the Little Lost River and Big Lost River Sinks southward through central INEEL past Big Southern Butte was identified. Flow velocities were estimated from tritium/helium ages and were about 3 m per day through the preferential flowpath. Flow velocities decreased to 1 m or less per day outside this preferential flowpath.

In areas where fractured basalts are exposed at the surface, both tritium and CFCs were present in the ground water. The presence of these constituents indicates that focused recharge of post-1950s infiltration water occurred along preferential flowpaths through the unsaturated zone. This type of recharge was recognized in many areas at and near the INEEL.

Recharge temperatures were calculated from nitrogen and argon concentrations for many of the ground-water samples and are useful indicators of the source of water in the Snake River Plain aquifer at the INEEL. Recharge temperatures of about 6 degrees Celsius (°C) characterize underflow from Birch and Camas Creeks and Little Lost and Big Lost Rivers. Recharge temperatures of 9 to 13 °C were calculated for the regional ground water of the Snake River Plain aquifer at the INEEL.

Ground water near the Radioactive Waste Management Complex, the Test Reactor Area, and the Idaho Nuclear Technology and Engineering Center (INTEC) contains concentrations of CFCs that are indicative of contamination. A large CFC-12 waste plume originating near the INTEC extends beyond the southern boundary of the INEEL.

Water in wells that are cased a few tens of meters below the water table contained no halocarbons, except for water in wells downgradient from injection wells. Greater-than-atmospheric concentrations of CFCs and other halocarbons were found in soil gases obtained from a depth of 1 m as far as 20 km south of the southwest corner of the INEEL. High concentrations of halocarbons also were found in unsaturated-zone air blowing from the annulus of some wells in the southwestern part of the INEEL. The advective transport of CFCs and other halocarbons throughout the unsaturated zone probably occurs preferentially both vertically and horizontally along fractures associated with volcanic vent corridors. Barometric pumping appears to be the primary mechanism controlling the distribution of gases in the unsaturated zone in the southwestern part of the INEEL. Diffusion is the primary mechanism of gas transport in the northern and northeastern part of the INEEL in the areas that are covered by thick lacustrine and sedimentary playa deposits.

INTRODUCTION

In 1949, the U.S. Atomic Energy Commission, later to become the U.S. Department of Energy (DOE), requested that the U.S. Geological Survey (USGS) investigate the water resources of the area now known as the Idaho National Engineering and Environmental Laboratory (INEEL) (fig. 1). Since that time, the USGS has maintained a monitoring network at the INEEL to determine hydrologic and geochemical trends and to delineate the movement of facility-related radiochemical and chemical wastes in the Snake River Plain aquifer.

As part of continuing investigations at the INEEL, during 1994–97, a detailed study of the ground water at and near the INEEL was done by the USGS in cooperation with DOE to estimate the age of the ground water, sources of water, flow velocities, and mixing fractions of the water from various sources. The geologic and hydrologic framework of the study area is complex, and determination of the ages, sources, and mixing fractions of the ground water has been complicated by agricultural practices at the northern and northeastern boundary of the study area and disposal of wastewater to infiltration ponds and disposal wells at numerous sites at the INEEL. In addition, most environmental tracers are atmospheric gases, and many processes can alter concentrations of these gases in the atmosphere, the unsaturated zone, and the ground water. Consideration of any process that can alter concentrations of the environmental tracers is important when attempting to date the ground water.

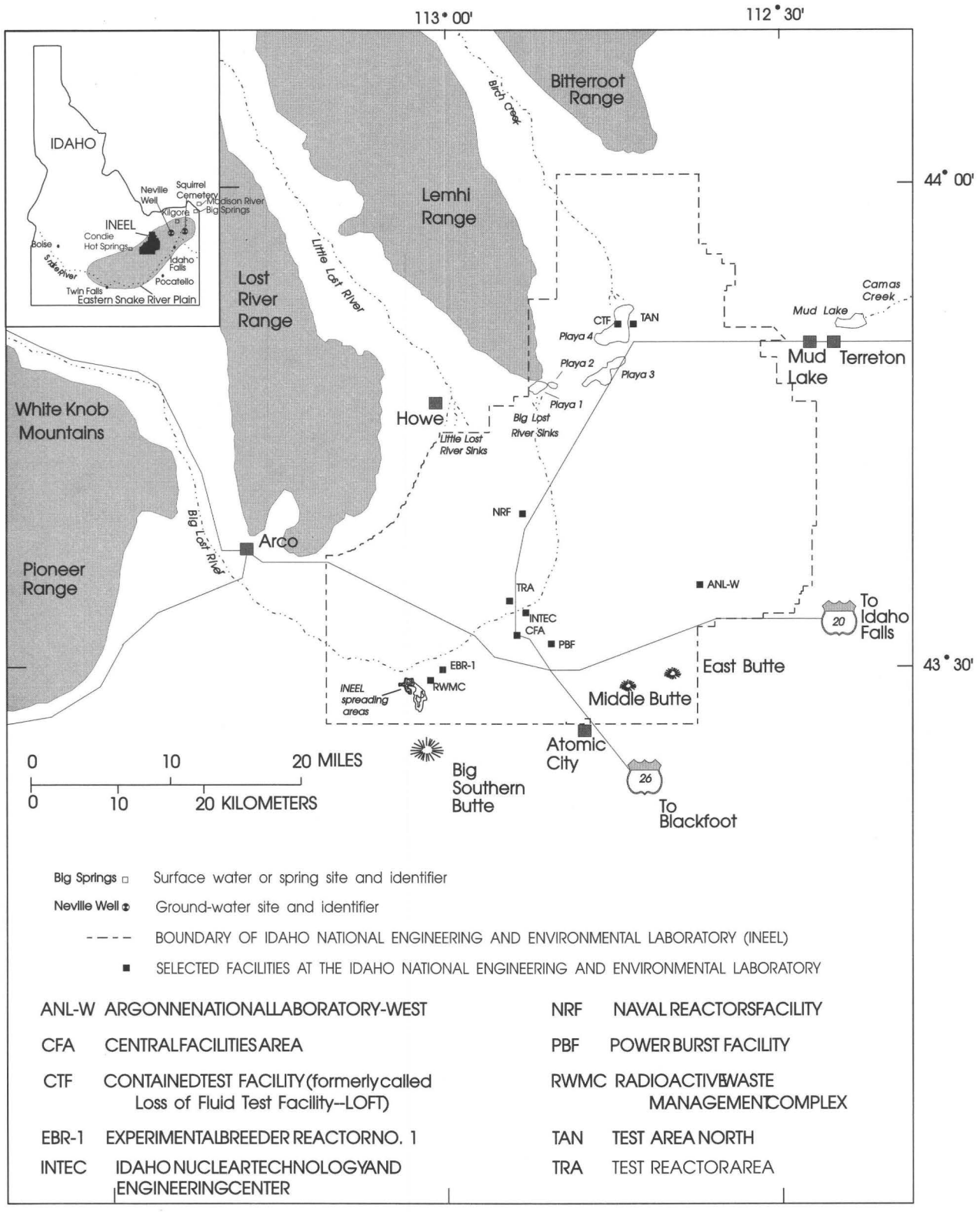


Figure 1. Location of the Idaho National Engineering and Environmental Laboratory, selected sampling sites, and selected facilities.

Because of the complex geochemistry of the ground water at the INEEL, a multi-component approach using environmental tracers, trace and major dissolved gases, trace elements, and isotopes was used to estimate the age and interpret the hydrologic history of the ground water. Properties of the hydrologic system at the INEEL that were considered in estimating the age of the ground water were the physical complexity of the Snake River Plain aquifer, thickness of the unsaturated zone, number of sources of recharge, well construction, recharge mechanisms, and wastewater-disposal practices at the site. Because of the complex nature of the INEEL, the site was divided into six smaller areas (northeastern, northern, southeastern, central, western, and southwestern) (fig. 2) where the sources and mechanisms of recharge were thought to be similar. Each of the six areas was evaluated separately. Understanding the age and recharge mechanisms of ground water at the INEEL is important for determining how waste discharged at facilities will move within the Snake River Plain aquifer system in the future.

Purpose and Scope

The purpose of this report is to use selected environmental tracer data collected at and near the INEEL during 1994–97 to estimate ages and sources of the young fraction of ground water in the Snake River Plain aquifer at the INEEL. The young fraction of ground water is defined as all water that has recharged since the 1940s. The young recharge water composes a very small fraction of the total volume of water in the Snake River Plain aquifer, and this young water was sampled because most of the wells at and near the INEEL are completed in the upper 15 m of the aquifer. Concentrations of chlorofluorocarbons (CFCs), sulfur hexafluoride (SF_6), and hydrogen (H_2) and helium (He) isotopes in water samples from 86 wells at and near the INEEL (Busenberg and others, 1998, 2000) were measured and used to calculate the fraction and age of young water in the samples. Concentrations of nitrogen (N_2), oxygen (O_2), argon (Ar), methane, and carbon dioxide (CO_2) dissolved in ground water were measured (Busenberg and others, 2000) and used to evaluate the temperature and mechanisms of recharge of ground water at the INEEL. Concentrations of gases, isotopic ratios, and other chemical constituents (Busenberg and others, 2000) were measured to determine the source of the water and to calculate the fraction of water from different sources and the fraction of young water in the samples.

Previous Investigations

CFCs and tritium/helium-3 ($^3H/^3He$) were used extensively in this study because they record the last contact of the water with the atmosphere and have been successfully used to date young ground water in numerous other studies (Poreda and others, 1988; Schlosser and others, 1988, 1989; Busenberg and Plummer, 1992; Solomon and others, 1992; Busenberg and others, 1993; Dunkle and others, 1993; Plummer and others, 1993; Ekwurzel and others, 1994; Cook and others, 1995; Oster and others, 1996; Plummer and others, 1998a, 1998b, 2000, 2001; Plummer and Busenberg, 1999). In most of these studies, the water was obtained from sand aquifers with narrow, well-defined, open well intervals of 1 m or less. The relatively uncomplicated nature of the aquifers permitted comparisons between tracer ages and numerical simulations (Reilly and others, 1994; Cook and others, 1995; Szabo and others, 1996; Johnston and others, 1998).

Recently, CFC and $^3H/^3He$ dating methods were applied to complex fractured or karstic-rock aquifers. In the study of karstic parts of the Floridan aquifer system near Valdosta, Ga., wells were completed in long open intervals. The ground-water samples were shown to be three-component mixtures of very old regional ground water, 30-year-old infiltration water, and river water introduced into the aquifer through sinkholes in the riverbed (Plummer and others, 1998a; 1998b). A variety of tracers and isotopes were used to identify the fractions of the three components in the mixtures, and the young fraction was successfully dated by using the CFC and $^3H/^3He$ dating methods.

Plummer and others (2000) recognized two types of water in the Snake River Plain aquifer south and southwest of the INEEL: (1) regional

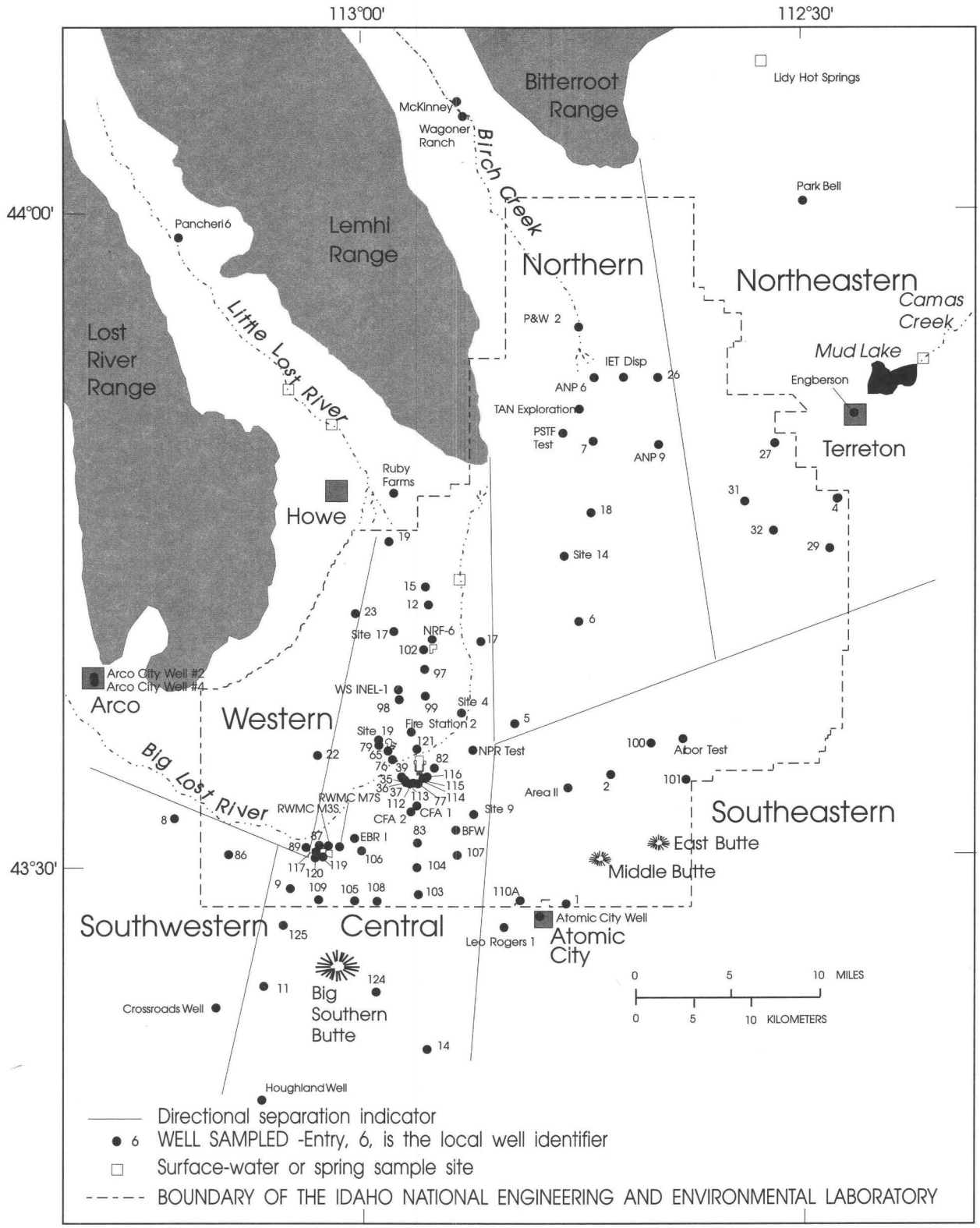


Figure 2. Location of sampling sites at and near the Idaho National Engineering and Environmental Laboratory.

background water, and (2) mixtures of irrigation water and regional background water. The ages of the young fraction were calculated by using ratios of CFC-11/CFC-12, CFC-113/CFC-12, and CFC-113/CFC-11 from individual concentrations after correction for dilution with CFC-free ground water and by $^3H/^3He$ dating. The CFC data indicated that the regional background water contained from 5 to 30 percent young infiltration water. The age of the infiltration water was from less than 2 to about 11.5 years. The irrigation water contained high ^3H concentrations (10 to about 30 TU), and the young fraction, dated by using the $^3H/^3He$ method, ranged in age from 0 to about 8 years. The CFC-based ages of the irrigation water either were in agreement with the $^3H/^3He$ ages or were older by as much as 8 to 10 years. The difference in ages between the two dating methods was attributed to equilibration of the recharge with unsaturated-zone air during recharge.

Geohydrologic Setting

The INEEL is located in the eastern Snake River Plain, which is a northeast-trending structural basin about 320 km long and 80 to 110 km wide in southeastern Idaho (fig. 1). The plain is underlain by a layered sequence of basaltic lava flows and cinder beds interbedded with eolian, fluvial, and lacustrine sedimentary deposits. The thickness of individual flows generally ranges from 3 to 15 m and the average thickness may be from 6 to 7.5 m (Mundorff and others, 1964, p. 143). The sedimentary deposits consist mainly of beds of sand, silt, clay, and lesser amounts of gravel. Locally, andesitic and rhyolitic lava flows and tuffs are exposed at land surface or occur at depth. The basaltic lava flows and interbedded sedimentary deposits combine to form the Snake River Plain aquifer, which is a main source of water on the eastern Snake River Plain.

Surficial unconsolidated deposits are also widespread at the INEEL and include lakebed deposits of the ancestral Lake Terreton and deposits in undrained depressions called playas that contain ephemeral lakes or ponds. Both ancestral Lake Terreton and the playas were or are fed by four streams. The Big Lost River, Little Lost River, Birch Creek, and Camas Creek drain mountain valleys of the Pioneer, Lost River, Lemhi, and Bitterroot Ranges to the west and north of the INEEL and flow intermittently at the INEEL. Losses during occasional floods from the channels, associated sinks, and terminal playas of these streams provide the principal source of local, intermittent recharge to the Snake River Plain aquifer near the INEEL (Bennett, 1990; Bartholomay and others, 2000). The Big Lost River, which drains more than 3,600 km^2 of mountainous area, including parts of the Lost River Range and the Pioneer Range west of the INEEL (fig. 1), is the most important of these streams. Since 1965, excess runoff from the Big Lost River has been diverted to spreading areas in the southwestern part of the INEEL, where much of the water rapidly infiltrates to the aquifer.

Water in the Snake River Plain aquifer moves principally through fractures and interflow zones in the basalt. A large part of the ground water moves through the upper 240 m of saturated rocks (Mann, 1986, p. 21). The hydraulic conductivity of basalt in the upper 240 m of the Snake River Plain aquifer generally is 0.3 to 30 m/day and, in the deeper parts of the aquifer, is several orders of magnitude smaller. The effective base of the Snake River Plain aquifer at the INEEL probably ranges from about 250 to 520 m below land surface (Anderson and others, 1996, table 3).

Recharge to the Snake River Plain aquifer is principally from infiltration of streamflow, infiltration of applied irrigation water, and ground-water inflow from the alluvium of adjoining mountain drainage basins (Garabedian, 1992; Goodell, 1988; Lindholm, 1996). Northeast of the INEEL, significant recharge occurs to the Snake River Plain aquifer from applied irrigation water near Mud Lake and Terreton (fig. 1). Some continuous diffuse recharge occurs from infiltrated precipitation that percolates beneath the root zone of the sagebrush and grasses prevalent in the area. However, because annual precipitation on the plain is small (20 cm at the INEEL), evapotranspiration is significant, and depth to water is large (about 60 m in the northern part to more than 275 m in the southeastern part), such recharge is believed to be small (Rightmire and Lewis, 1987; Bartholomay and others, 2000). Recently, Plummer and others

(2000) found CFCs and tritium in water from rangeland wells south of the INEEL and confirmed the occurrence of areal infiltration on the plain.

Ground-water movement in the Snake River Plain aquifer is from the northeast to the southwest. At the INEEL, the direction of flow within the aquifer is mainly southward and southwestward at an average hydraulic gradient of about 0.8 m/km. Ground water moves southwestward from the INEEL and eventually discharges to springs along the Snake River downstream from Twin Falls, about 150 km southwest of the INEEL (Bartholomay and others, 2000).

Methods of Sample Collection and Analysis

The procedures used to collect ground-water samples and the methods used to analyze for CFCs and other volatile halocarbons, SF_6, dissolved major atmospheric gases, major- and trace-chemical constituents, isotopic ratios of oxygen and hydrogen in the water, helium isotopes in the gases dissolved in the ground water, and carbon isotopes in the dissolved inorganic carbon were described in detail in previous publications (Busenberg and others, 1998, 2000). A brief summary of sample locations and procedures is described here.

Samples were collected from 94 locations (figs. 1 and 2): 73 monitoring wells; 7 domestic or stock wells; 6 INEEL production wells; 3 public supply wells; 2 irrigation wells; and 3 springs. The production wells, irrigation wells, and the Arco City Well #4 were equipped with dedicated turbine pumps. The monitoring wells, domestic wells, stock wells, and the Atomic City Well were equipped with dedicated submersible pumps. Data on the pumping rate, hole diameter, well depth, depth of intake, intake diameter, material of intake, perforation or open-hole intervals, and the water level at the date of sampling were given by Busenberg and others (1998, table 1).

Samples were collected from a portable sampling apparatus attached to the monitoring wells and from sampling ports or spigots on other wells. All portable equipment was decontaminated after collection of each sample. Samples were collected at each site after three well-bore volumes of water were purged and measurements of pH, specific conductance, and water temperature were stable. Conditions at the sampling site during sample collection were recorded in a fieldbook.

Acknowledgments

The authors are grateful to Steven R. Anderson, LeRoy L. Knobel, and David W. Clark of the U.S. Geological Survey for providing valuable technical assistance; to L. DeWayne Cecil and Brennon R. Orr of the U.S. Geological Survey for technically reviewing the manuscript; to Barbara N. Kemp of the U.S. Geological Survey for extensive editorial advice; and to Julian E. Wayland, Gerolamo C. Casile, Betty J. Tucker, and Deborah J. Parliman of the U.S. Geological Survey for helping with sample collection.

RECHARGE MECHANISMS AND SOURCES OF GROUND WATER

In arid and semiarid regions, the mechanisms of ground-water recharge can significantly affect the apparent CFC ages. Gee and Hillel (1988) recognized two mechanisms of recharge in arid regions: (1) continuous spatially distributed diffuse recharge resulting from widespread percolation through the entire unsaturated zone, and (2) occasional concentrated recharge resulting from the short-term penetration of water along distinct pathways through the unsaturated zone that bypass the greater part of its volume. These two mechanisms of recharge can be identified by using data on the concentrations of N_2, Ar, CFCs, and other gases in the ground water. Plummer and others (2000) presented CFC and $^3H/^3He$ data that indicate that both mechanisms of recharge occur on the eastern Snake River Plain. Fractured volcanic rocks exposed at the surface in the southwestern part of the INEEL present avenues for rapid focused recharge. At some of these locations, rapid infiltration of water is known to occur (Nimmo and others, 2001). Rapid recharge occurs along the channel of the Big Lost River at the INEEL (Bennett, 1990), at the INEEL spreading areas, and at the Big and Little Lost River Sinks (fig. 1).

The surface-to-aquifer recharge mechanisms mentioned above along with ground-water movement through the system as underflow from tributary valleys and as regional underflow define the predominant mechanisms for recharge of water that is sampled from the aquifer at the INEEL. In addition to understanding the recharge mechanisms that are occurring, it is also important to understand the source of the ground water in attempting to estimate the age of the young fraction. One factor that can be used to determine the source of water in samples is the chemical composition of the water.

Chemical Composition of the Ground Water

Olmsted (1962, p. 18–19, and fig. 2) classified ground water at the INEEL into four chemical types. The classification was based on equivalent fractions of the various cations and anions in the water. This classification is useful because it can be used to identify the different sources of water at the INEEL. In Olmsted's type A water, calcium (Ca) and magnesium (Mg) together constituted at least 85 percent of cations; bicarbonate (HCO_3) constituted at least 70 percent of the anions. In the type B water, sodium (Na) and potassium (K) together exceeded 15 percent of the cations, and the sum of the Ca and Mg was less than 85 percent of the cations. HCO_3 constituted more than 70 percent of the anions. In type C water, HCO_3 (and carbonate) constituted less than 70 percent of the anions and no limits were placed on the cations. In type D water, sulfate (SO_4) constituted at least 30 percent of the anions, and no limits were placed on the proportion of cations.

The chemistry of the regional ground water is controlled dominantly by the mineralogy of the rocks (Robertson and others, 1974). The tributary valleys to the north and northwest of the INEEL contain alluvium derived from Paleozoic carbonate rocks from the surrounding mountains. The ground water in these valleys is characterized by high concentrations of Ca, Mg, and HCO_3. Type A water is dominant in the Big Lost River Valley, Little Lost River Valley, and Birch Creek Valley, and this water underlies much of the central and western parts of the INEEL (Olmsted, 1962; Robertson and others, 1974). In the tributary valleys, there is a progressive eastward increase in the mole fraction of SO_4 in the surface water; this increase indicates an increase in the amount of gypsum and anhydrite present in the carbonate rocks of the Lemhi and Bitterroot Ranges (Robertson and others, 1974).

Type B water, which is characterized by higher equivalent fractions of Na, K, fluoride (F), and silica and a slightly higher equivalent fraction of chloride (Cl), underlies much of the eastern part of the INEEL. The water originates from the area northeast of the INEEL; this area contains a much higher fraction of rhyolitic and andesitic volcanic rocks, which contribute the higher concentrations of these ions to the water. The silicic volcanics are present on the northeastern edge of the plain and extend from Lidy Hot Springs (fig. 2), eastward to Big Springs (fig. 1) in the Island Park area. Type B water has been altered locally as a result of agricultural runoff or waste discharge from facilities at the INEEL (Olmsted, 1962).

Recharge to the regional aquifer from irrigation water and from water produced by waste-disposal practices at INEEL facilities, classified as type C water, is characterized by higher mole fractions of nitrate (NO_3) and Cl and lower fractions of HCO_3 than type B water (Olmsted, 1962). Type D water was obtained from the perched water table at Test Reactor Area (TRA) (Olmsted, 1962).

Thermal springs occur along faults bounding the Snake River Plain. Discharge of hot water from these springs is likely to occur into the Snake River Plain aquifer along buried faults. The presence of a large fraction of thermal water may be indicated by higher concentrations of F and ammonia (Robertson and others, 1974). Thermal water also may be identified on the basis of He concentrations that exceed the air-water equilibrium concentration by 25 times and by relatively high concentrations of some trace elements, including lithium (Li), rubidium, boron (B), and arsenic (Busenberg and others, 2000).

The Olmsted (1962) classification provides significant insight into the sources and evolution of different ground-water types at and near the

INEEL; however, the classification is based solely on differences in major-element chemistry of water. Classified types can be altered by small additions of wastewater or agricultural return flow and, in some cases, by differences in the depth and production interval. Also, this classification often cannot differentiate between old and recent recharge or sources of recharge. The classification that is developed in this report is not based solely on the major-element chemistry but instead on dissolved He and trace elements that are not significantly affected by additions of wastewater or agricultural return flows. This classification provides a good indication of the sources of water, the fraction of young water, and the age of recharge and is presented in the next section and in Appendix 1.

Areal Distribution of Selected Chemical Constituents

The areal distribution of selected chemical constituents and dissolved gases in the Snake River Plain aquifer provides an insight into the source of the ground water. Concentrations of Li and B (figs. 3 and 4) illustrate the major separation of the two principal types of water (Olmstead, 1962, types A and B). Concentrations of both B and Li in the eastern part of the INEEL are larger than concentrations in other parts of the INEEL. Concentrations of B at the mouth of the Little Lost River are larger than upstream concentrations, which may indicate an addition of B from agricultural practices. The concentration of B at the gaging station on the Little Lost River was 12 µg/L, whereas the concentration 4 km downstream was 37 µg/L. The increase in B below the gaging station was accompanied by large increases in Cl, SO_4, HCO_3, and Na concentrations (Busenberg and others, 2000). The B anomaly in the western part of the INEEL (fig. 4) suggests that surface water recharges the Snake River Plain aquifer at the Little Lost River Sinks east of Howe. The chemistry of the Little Lost River drainage was significantly different between that of the underflow that was sampled at the Pancheri 6 well (Busenberg and others, 2000) and from the mixture of underflow and agricultural runoff sampled at the Ruby Farms well (Schramke and others, 1996; Knobel and others, 1999).

Strontium (Sr) concentrations shown in figure 5 can be used to distinguish the different sources of water that are recharging the Snake River Plain aquifer at the INEEL. Concentrations of Sr were larger in the northeastern part of the INEEL than in the southeastern part. The areas of higher Sr concentrations correspond to the areas of high HCO_3^- concentrations (Robertson and others, 1974, fig. 26), and areas of lower Sr concentrations correspond to areas of low HCO_3^- concentrations. These relations suggest that the Sr and HCO_3^- are of similar origin.

Tritium (^3H) concentrations are present in most ground water at the INEEL except in an area of very low to no ^3H in the northern and northeastern part (fig. 6). This area has received virtually no post-1950 water and has not been contaminated by ^3H released or discharged from facilities at the INEEL. This area also has low concentrations of CFC-12, CFC-11, and CFC-113 (figs. 7, 8, and 9). Normally, the ^3H in precipitation can be calculated from the geographic location from historical areal distribution of ^3H (Michel, 1992). This was not possible at the INEEL because the site has been a significant local environmental source of ^3H. Thousands of curies of tritium were disposed of or discharged, mainly at the Idaho Nuclear Technology and Engineering Center (INTEC) and TRA, but also at other facilities in evaporation ponds, infiltration ponds, and disposal wells (Robertson, 1974; Mann and Cecil, 1990; Bartholomay and others, 2000). Tritium concentrations in the aquifer are larger in the disposal areas (fig. 6). Concentrations of CFCs are also larger in the disposal areas. Figure 7 shows the area of contamination with CFC-12 extending south from TRA and INTEC to beyond the southern boundary of the INEEL. Figure 8 shows that the area of contamination with CFC-11 is less extensive than that with CFC-12. A CFC-11 contaminant plume originates at NRF and combines with other contaminant plumes originating at TRA and INTEC and extends past the CFA. Another contaminant plume originates at the RWMC. Greater-than-air-saturation concentrations in ground water of CFC-113 are present south of NRF, TRA, INTEC, and RWMC (fig. 9).

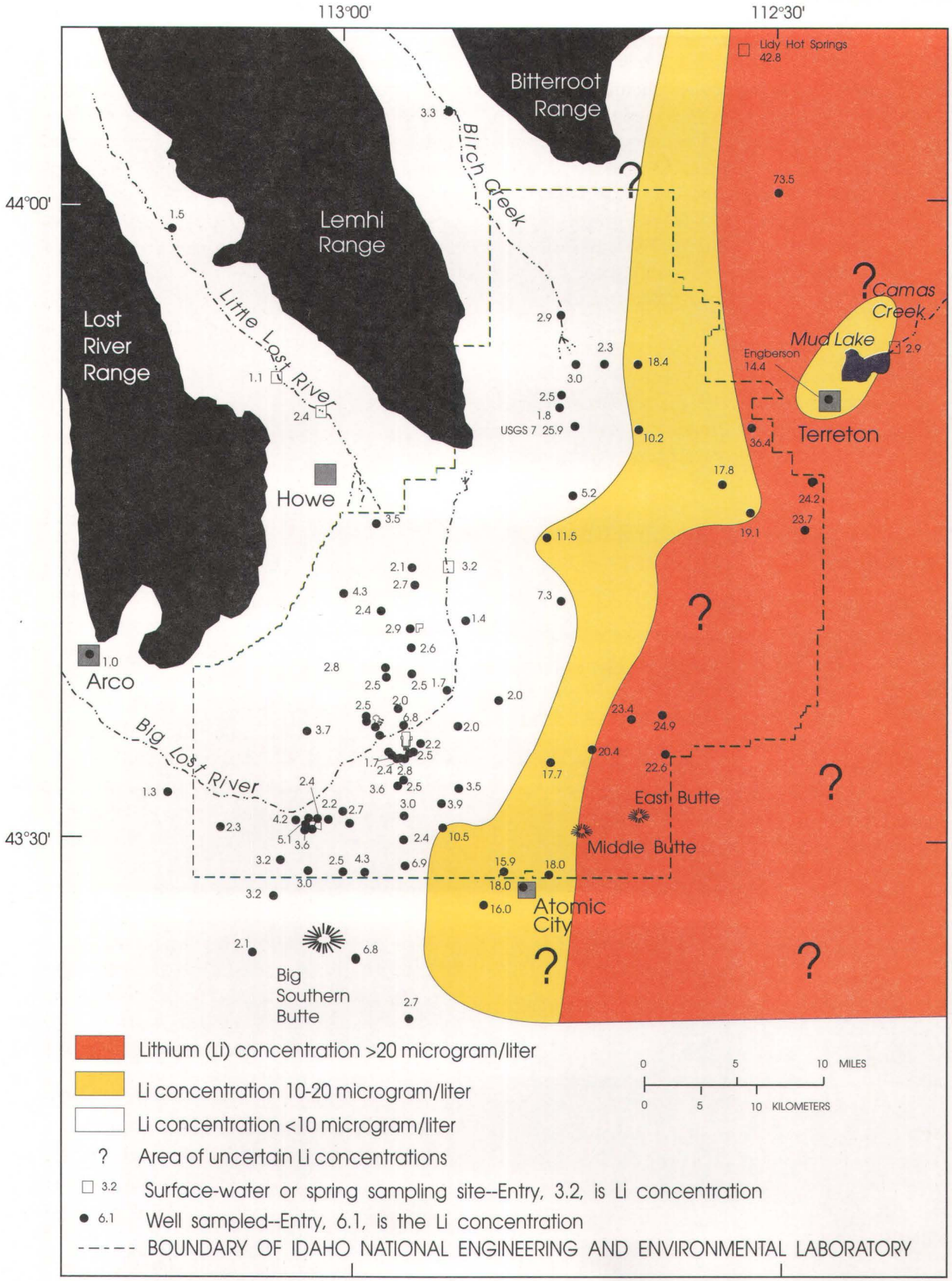


Figure 3. Concentration of lithium in water from selected sites at and near the Idaho National Engineering and Environmental Laboratory, 1994-97.

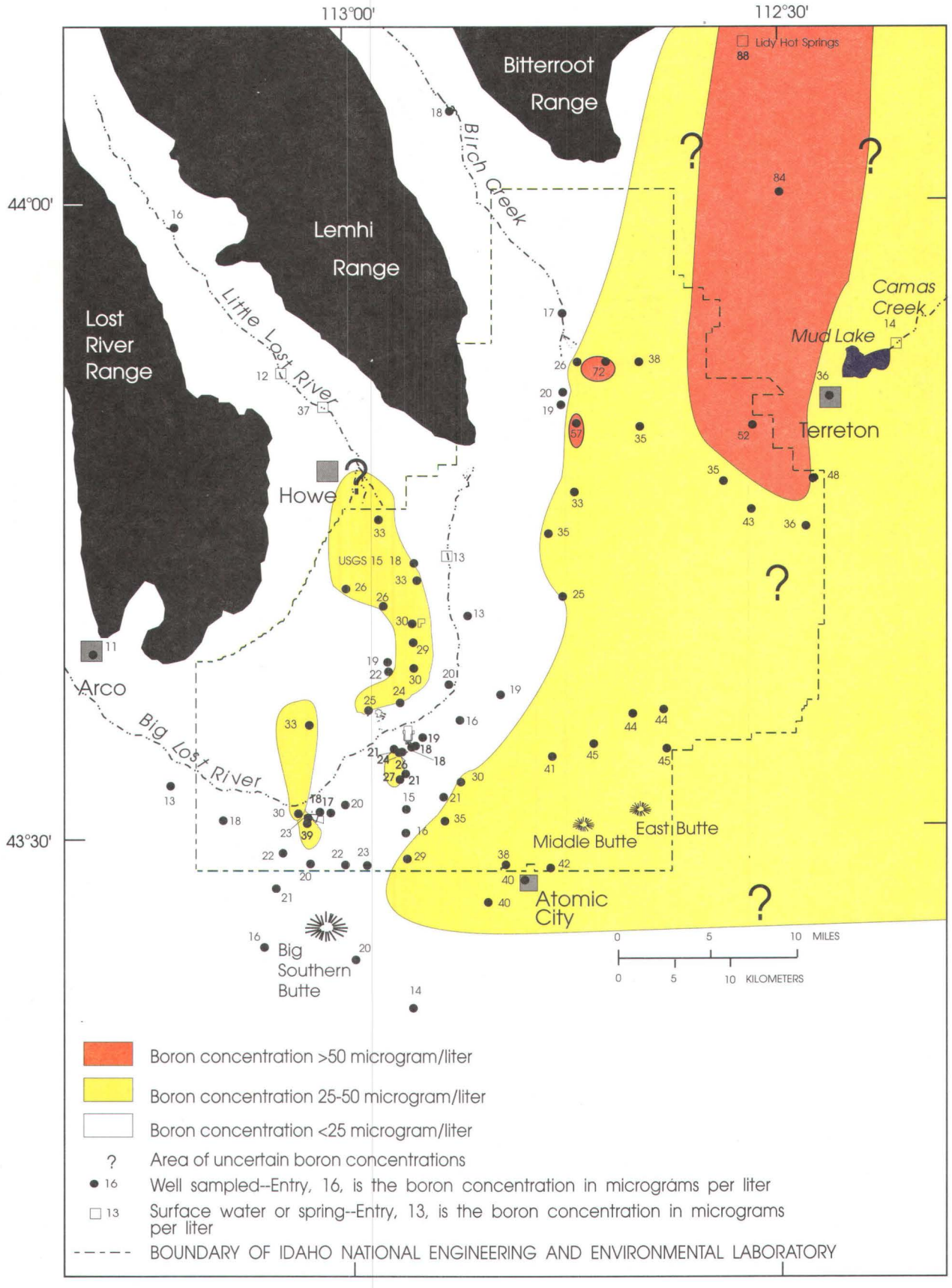


Figure 4. Concentration of boron in water from selected sites at and near the Idaho National Engineering and Environmental Laboratory, 1994-97

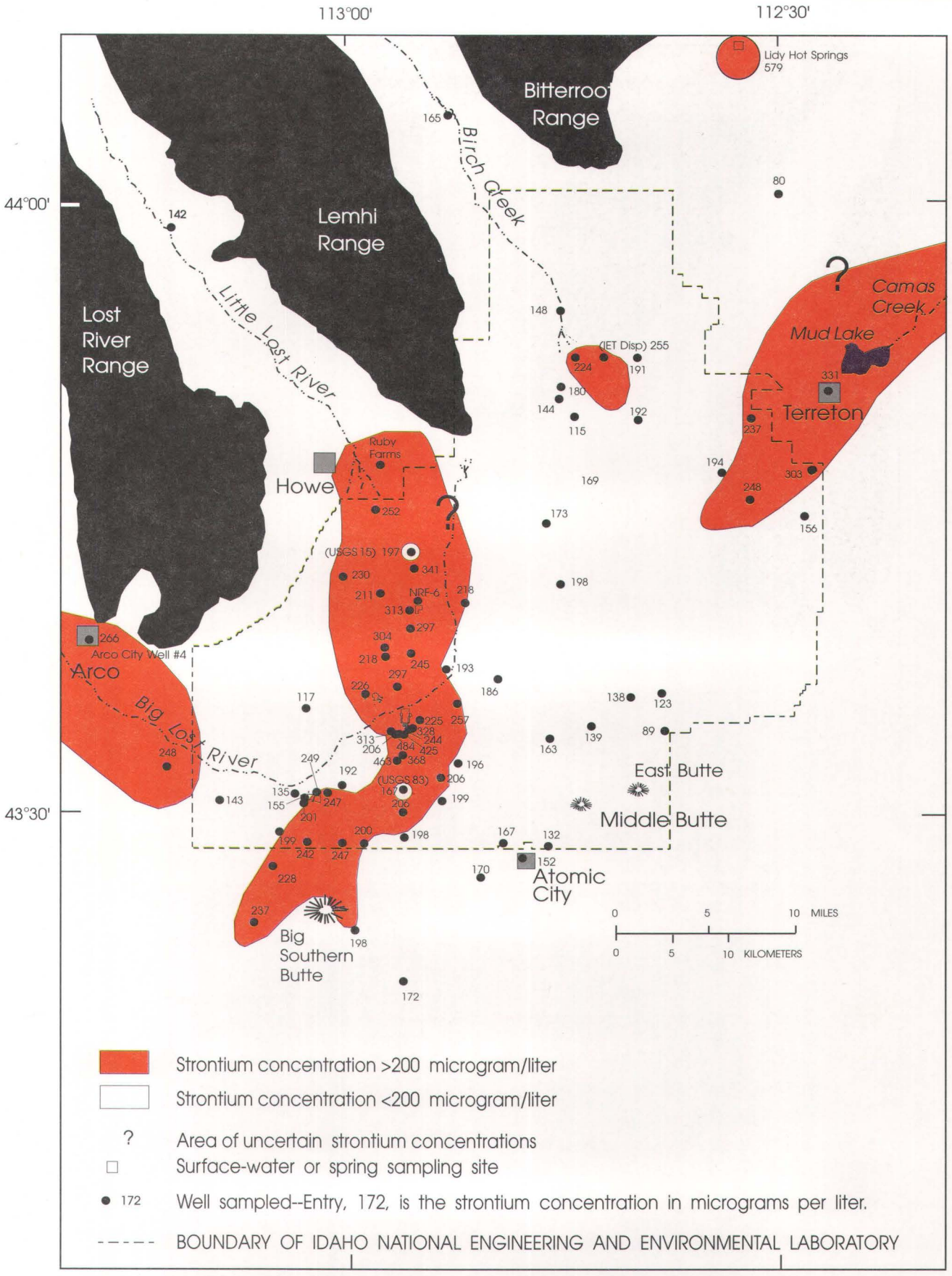


Figure 5. Concentration of natural strontium in water from selected sites at and near the Idaho National Engineering and Environmental Laboratory, 1994-97.

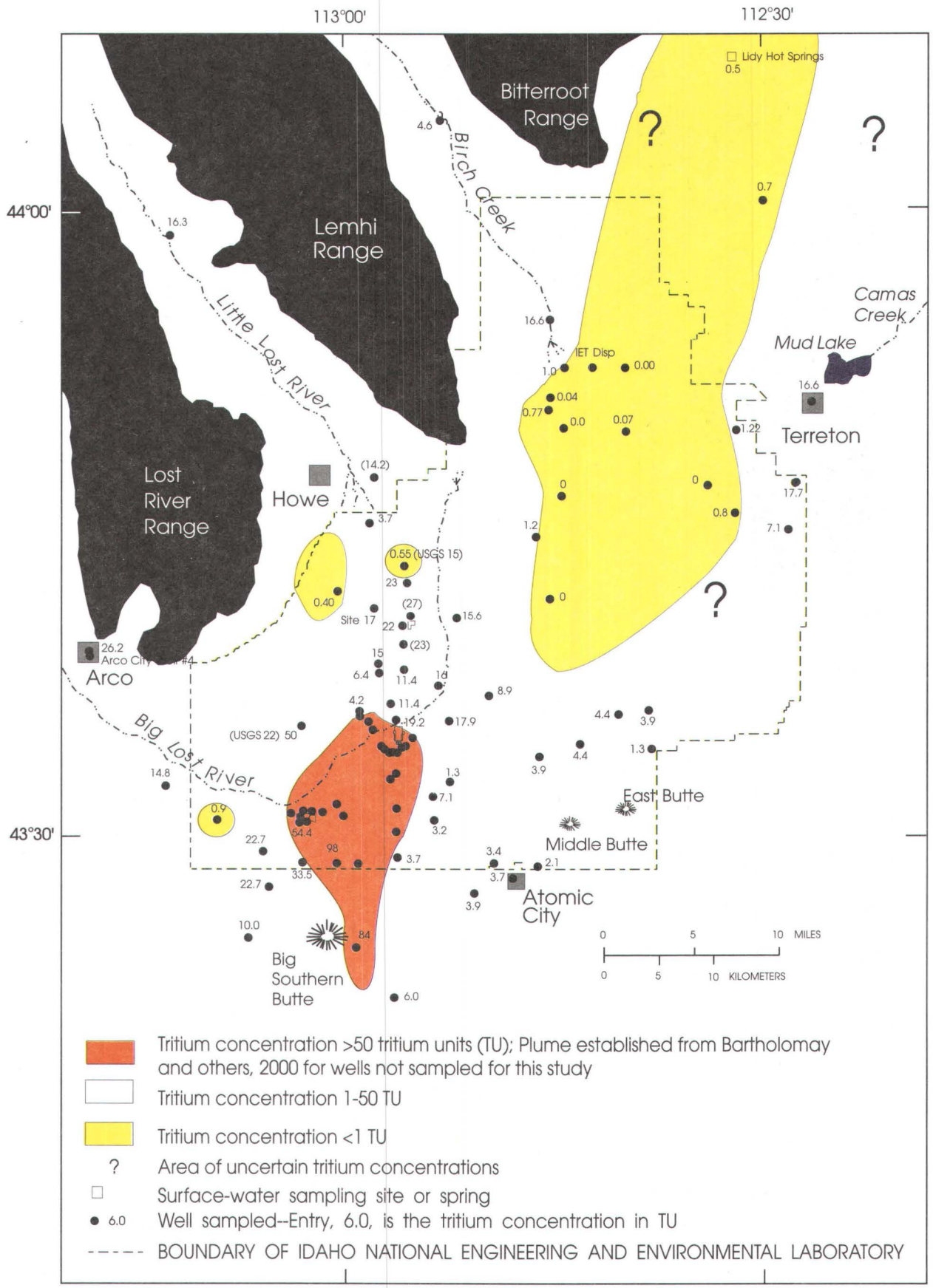


Figure 6. Concentration of tritium in water from selected sites at and near the Idaho National Engineering and Environmental Laboratory, 1994-97.

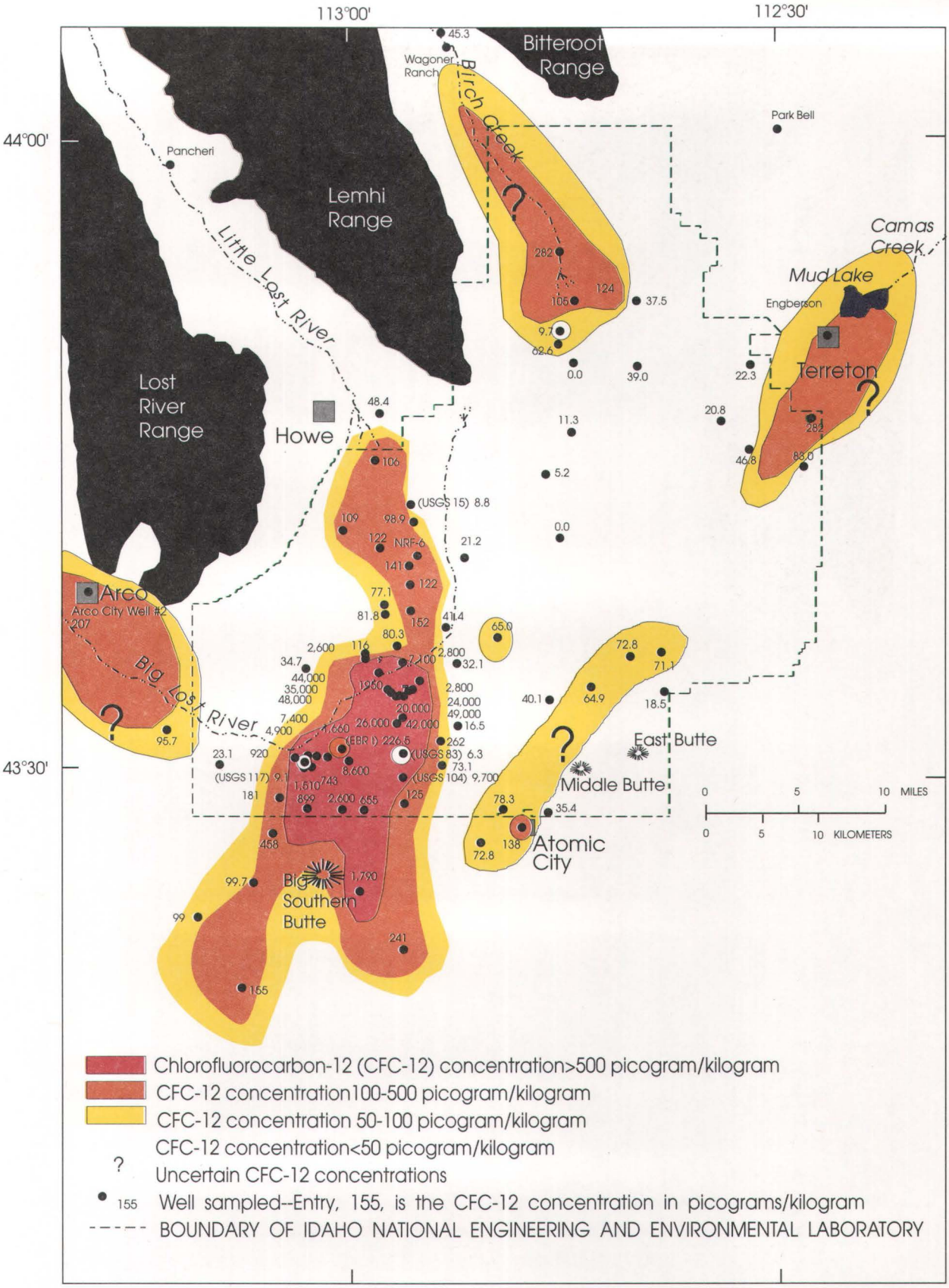


Figure 7. Concentration of chlorofluorocarbon-12 in water from selected sites at and near the Idaho National Engineering and Environmental Laboratory, 1994-97.

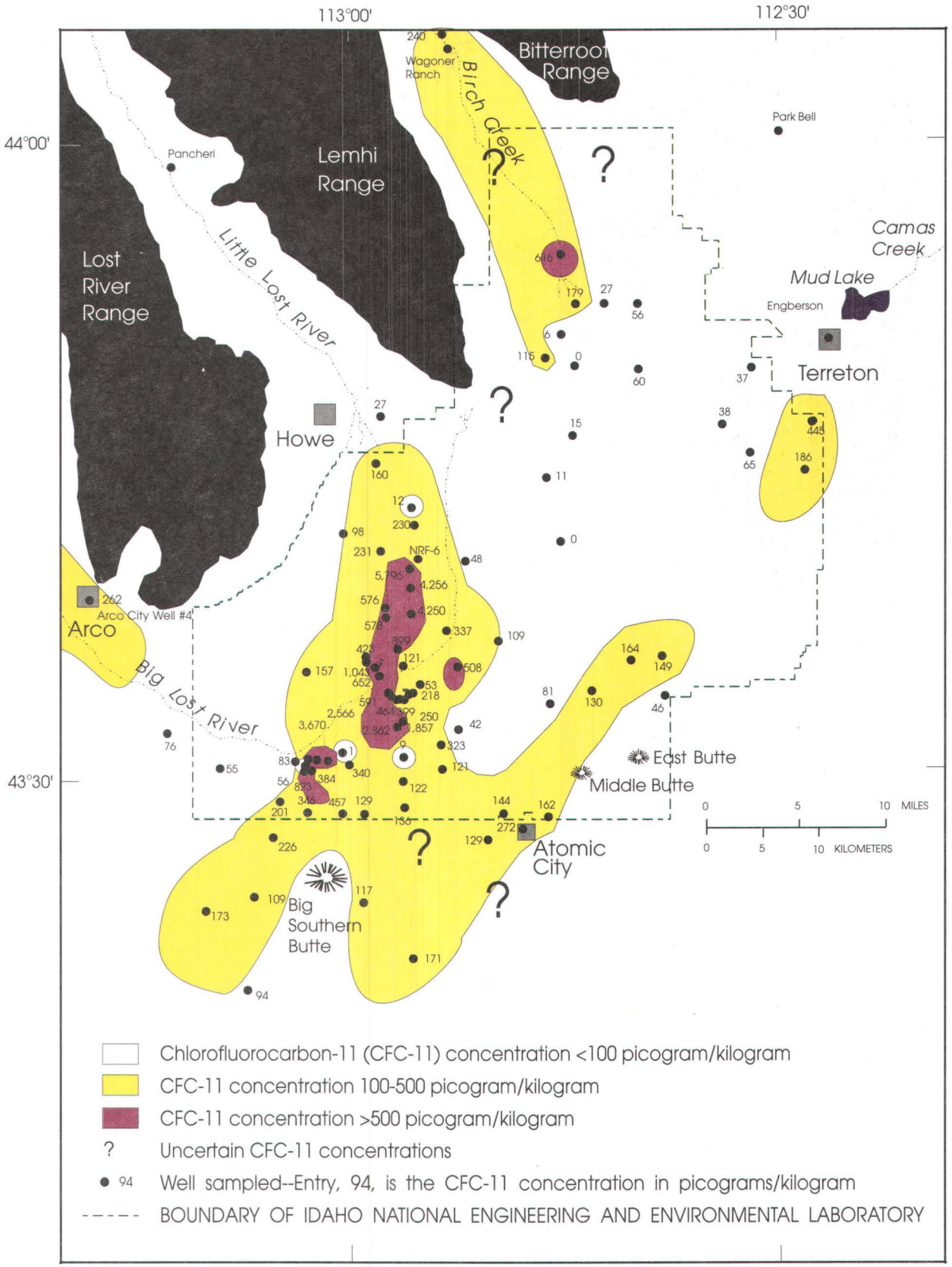


Figure 8. Concentration of chlorofluorocarbon-11 in water from selected sites at and near the Idaho National Engineering and Environmental Laboratory, 1994-97.

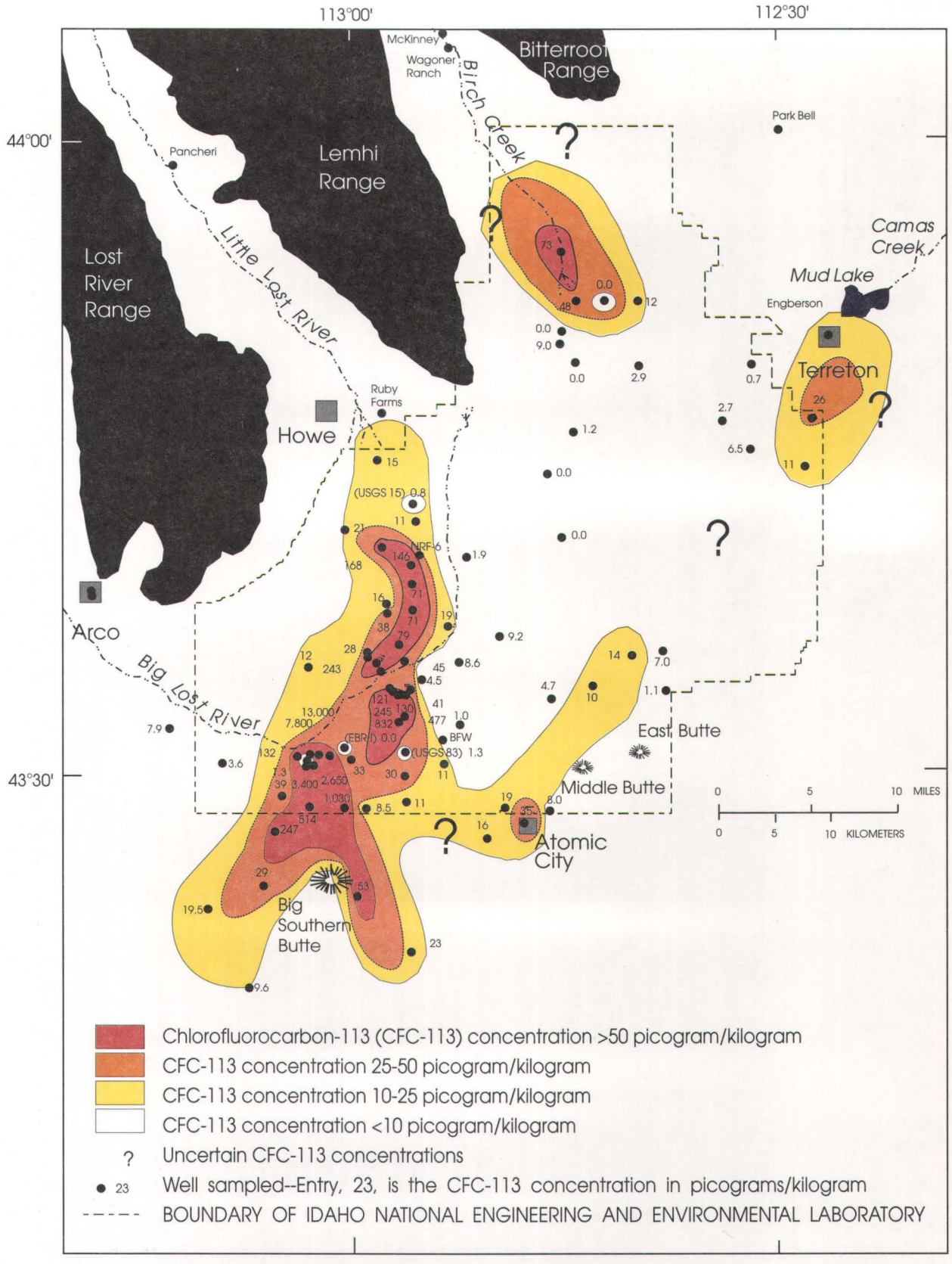


Figure 9. Concentration of chlorofluorocarbon-113 in water from seleceted sites at and near the Idaho National Engineering and Environmental Laboratory, 1994-97.

Sources of the Young Fraction of Ground Water, Determined by Dissolved Gases and Isotopes

Gases dissolve in water in contact with the atmosphere or unsaturated-zone air. Dissolved gases can provide important clues to the source of ground water and the temperature, elevation, and mechanism of recharge. Dissolved gases also can be used to identify the processes that alter the concentrations of environmental tracers in the aquifer and to provide important clues to the geochemical evolution of the ground water. Many factors control the solubility of gases in ground water and are discussed in detail in Appendix 1. Isotopes of carbon-14 (^{14}C), deuterium (^{2}H), oxygen-18 (^{18}O), and carbon-13 (^{13}C) also can be used to determine sources of ground water; concentrations of these isotopes in wells at the INEEL are discussed in Appendix 1.

METHODS OF DATING YOUNG GROUND WATER BY USING ENVIRONMENTAL TRACERS

Ground water was dated by using CFCs, the $^{3}H/^{3}He$ method, and SF_6. The three dating methods were discussed in detail by Plummer and Busenberg (1999), Solomon and Cook (1999), and Busenberg and Plummer (2000) and are described below as they pertain to dating ground water in the Snake River Plain aquifer.

Dating Ground Water with Chlorofluorocarbons

Normally, ground water is dated with CFCs and SF_6 by measuring the concentrations and calculating the partial pressures of the tracers in the ground water and then comparing the partial pressures to the atmospheric growth curves of the tracers (fig. 10A). However, many processes can modify CFC concentrations in ground water in Idaho. Dating ground water can be complicated by a thick unsaturated zone, anaerobic degradation of CFCs (mainly CFC-11) under reducing conditions, sorption of CFCs onto organic matter (particularly of CFC-113), contamination by wastewater and atmospheric discharge of CFCs, mixing of water of different ages during sampling, and hydrodynamic dispersion. Effects of these processes were discussed in detail by Busenberg and Plummer (1992), Plummer and others (1993), Cook and others (1995), and Plummer and Busenberg (1999).

Sampling of ground water from fractured rock aquifers often results in mixing of water of different ages in both the aquifer and the borehole. In wells with short, open intervals, mixing may not be very important, and water often can be dated by comparing the calculated partial pressure of the tracer in the water to the atmospheric growth curve of the environmental tracer (Busenberg and Plummer, 1992; Plummer and Busenberg, 1999). This CFC dating method is best suited for environments where the unsaturated zone is thin or where recharge is rapid and focused and there is little contact between the water and the unsaturated-zone atmosphere. Recharge by slow infiltration through the thick unsaturated zone probably is not the predominant recharge mechanism at the INEEL because of the great depth of the water table (60 to more than 275 m), the large evapotranspiration rates, and small amount of precipitation (about 20 cm/year) (Rightmire and Lewis, 1987; Bartholomay and others, 2000). However, this mechanism of recharge occurs locally at the INEEL and in areas of rangeland south of the INEEL (Plummer and others, 2000).

In wells with large, open intervals and in fractured rock aquifers with multiple fractures or productive zones, mixing of water of different ages occurs during sampling and is important. Theoretically, the age of each fraction in the mixture of n fractions with n ages can be determined if $2n$-1 independent tracers are measured (Plummer and Busenberg, 1999). Solving this equation is difficult when the mixture is of more than two fractions of less than 50 years old, because usually there are not enough independent variables or tracers that can be measured. Many samples from the INEEL appear to be predominantly two-component mixtures of very old CFC- and ^{3}H-free water and young ground water.

For CFC-model dating in this report, young water is defined as water that has come in contact with the atmosphere during the last 60 years as a result of natural recharge or waste-disposal practices at the INEEL. Contamination with respect to

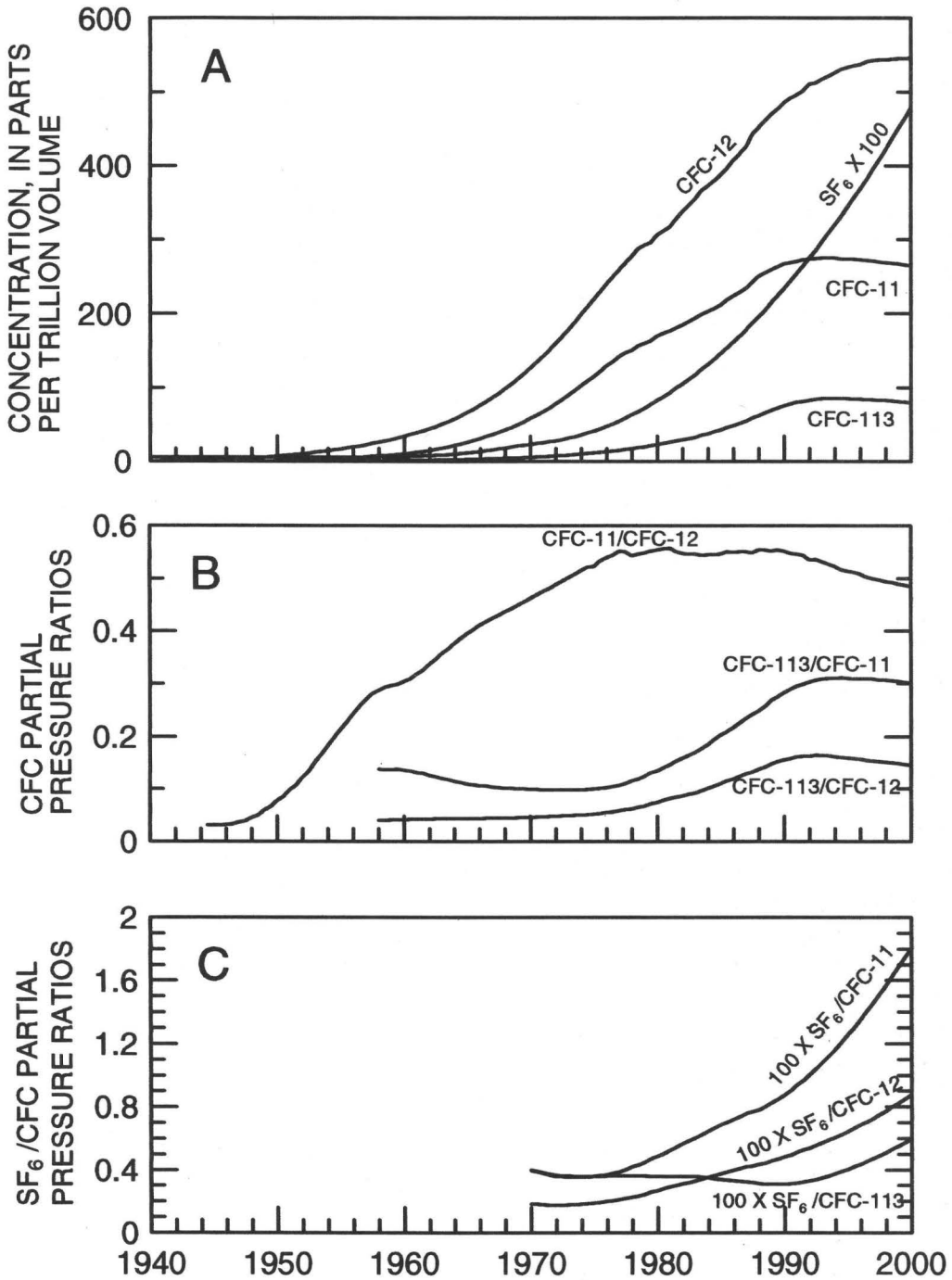


Figure 10. A. Historical concentrations of chlorofluorocarbons (CFCs) and sulfur hexafluoride (SF_6) in the North American atmosphere. B. Historical ratios of CFCs in the North American atmosphere. C. Historical ratios of SF_6 to CFCs in the North American atmosphere.

an environmental tracer is defined as a concentration of the tracer in water that was larger than the concentration for air-water saturation with North American air. Binary mixtures of young and old water often can be recognized by comparing apparent piston-flow ages of two or more tracers. The piston-flow model assumes that all flow lines have the same velocity and that the hydrodynamic dispersion and the molecular diffusion of the tracer are negligible (Maloszewski and Zuber, 1982). Figure 11 shows apparent CFC and SF_6 ages of a mixture of 1995 and pre-1940s water as a function of the percent of old, tracer-free ground water. The apparent ages of CFC-113 and SF_6 are younger than the apparent ages of CFC-11 and CFC-12 in binary mixtures of young and old water (fig. 11). The differences in apparent ages can be used to recognize mixtures of CFC-free water and young ground water.

In simple binary mixtures of young and old water, the young fraction cannot be dated simply by comparing the calculated partial pressure of the tracer in the water to the atmospheric growth curve (fig. 10A). In this case, the apparent ground-water age would be too old because the concentration of the tracer in the ground water was reduced by the dilution with CFC-free water. However, the young fraction can be dated by two different methods. If the percentage of young water can be estimated independently from other chemical characteristics such as ^{14}C activities, $\delta^{13}C$ or $\delta^{18}O$ ratios, or Cl concentrations, then the concentration of the tracer can be corrected for dilution (Plummer and others, 1998a,1998b, 2000). The partial pressure of the CFC and SF_6 is calculated from the recharge temperature, recharge elevation, and the dilution-corrected concentration with Henry's law. The partial pressure of the tracer then is compared to the atmospheric growth curve of the tracer and the young fraction can be dated. Alternatively, the young fraction sometimes can be dated by using the ratio of two environmental tracers with different atmospheric growth rates and comparing the ratio with the atmospheric ratio (Plummer and Busenberg, 1999; Plummer and others, 2000). Figures 10B and 10C show the North American atmospheric CFC and SF_6/CFC ratios during 1940–2000. As a result of the contamination of the Snake River Plain aquifer from wastewater-disposal practices at the various facilities at the INEEL, the ratio method cannot be used to date many of the ground-water samples at the INEEL.

Dating Ground Water with Tritium/Helium-3

The concentrations of ^3H, ^3He, total He, and neon (Ne) in ground water at the INEEL were presented by Busenberg and others (2000). ^3H is a radioactive isotope of hydrogen with a half-life of 12.43 years (Unterweger and others, 1980) and occurs naturally in small concentrations in precipitation. Large concentrations of ^3H were injected into the atmosphere during the period of atmospheric nuclear testing; the largest concentrations in precipitation occurred during 1963–64. About 32,000 Ci of ^3H in wastewater was discharged into evaporation ponds, infiltration ponds, and disposal wells at the INEEL from 1952 through 1998 (Bartholomay and others, 2000). $^3He_{tritiogenic}$ is the radioactive decay product of ^3H. The age of a ground water can be calculated from the radioactive decay equation and the concentrations of ^3H and $^3He_{tritiogenic}$. $^3He_{tritiogenic}$ cannot be distinguished from all other ^3He present in ground water but can be calculated by subtracting all the other sources of ^3He (Jenkins, 1987; Schlosser and others, 1989).

$$^3He_{tritiogenic} = {}^3He_{total} - {}^3He_{eq} - {}^3He_{air} - {}^3He_{rad} - {}^3He_{mantle}, \quad (1)$$

where $^3He_{total}$ is the measured ^3He concentration; $^3He_{eq}$ is the concentration of ^3He from air saturation; $^3He_{air}$ is the ^3He contribution from the excess air dissolved in the water and can be calculated from the excess Ne concentration in the ground water; $^3He_{rad}$ is the concentration of ^3He produced in the rocks and the aquifer and can be calculated from the thorium (Th), uranium (U), and Li concentrations; and $^3He_{mantle}$ is the ^3He contribution from a mantle source (Torgersen and others, 1994).

The ratio of $^3He/^4He$ in air is 1.384×10^{-6} (Clarke and others, 1976), $1–5\times10^{-8}$ in radiogenic He (Lupton, 1983), and $1.1–1.4\times10^{-5}$ in mantle He (Lupton, 1983). Several percent of mantle He can be present in deep ground water in areas of active volcanism or areas undergoing extension tectonics (Oxburgh and others, 1986; Greisshaber and

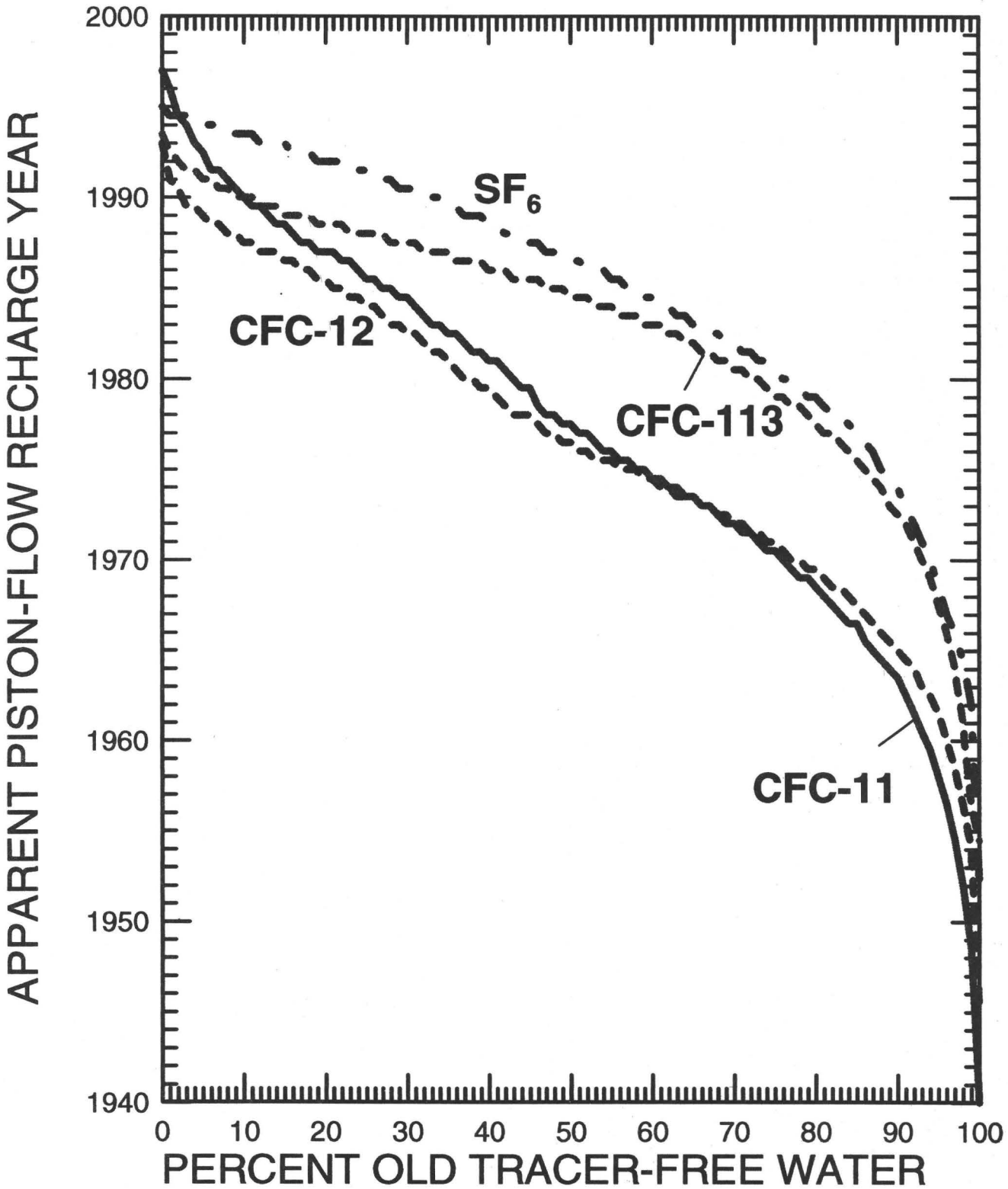


Figure 11. Relation between the percent tracer-free water and the apparent piston-flow recharge year of mixtures of 1995 and tracer-free water.

others, 1992). He concentrations in regional background water in rangeland areas south of the INEEL are about 100 to 200 percent larger than solubility equilibrium values with $^3He/^4He$ ratios of $7–11\times10^{-6}$ and could not be dated by using the $^3H/^3He$ method (Plummer and others, 2000).

Some ground water in the northeastern part of the INEEL could not be dated because of the large percentage of mantle He with large $^3He/^4He$ ratios and large concentrations of radiogenic ^4He (fig. 12). The $^3H/^3He$ age of the ground water within the ^3H contaminant plume (fig. 6) does not represent the age of natural recharge but the age of the contamination of the aquifer by ^3H. In this case, the ^3H concentration in wastewater discharged at INEEL facilities was much larger than the background ^3H concentration (Robertson and others, 1974; Bartholomay and others, 2000). These ages are useful because they represent the traveltime of the water from the site of discharge to the sampling point.

The $He_{crustal}$ is defined as the $^3He/^4He$ ratio from He_{rad} and He_{mantle}. The crustal helium ratio can be calculated from equation 1 for selected water samples of pre-bomb age containing ^3H concentrations of less than 1 TU that were not contaminated by ^3H in wastewater. Equation 1 simplifies to

$$^3He_{crustal} = {}^3He_{total} - {}^3He_{eq} - {}^3He_{air} - {}^3He_{tritiogenic}. \quad (2)$$

The $^3He_{eq}$ is calculated from the recharge temperature, elevation, and solubility of He in water and the fractionation of the isotope in solution; the $^3He_{air}$ is calculated from excess air (Ne_{air}) and the $^3He/^4He$ ratio of air (R_a).

The natural pre-bomb ^3H concentrations in central Europe were from 2 to 5 TU (Roether, 1967; Schlosser and others, 1988; Stute and others, 1992), and the pre-bomb ^3H concentration in southeastern Idaho was about 6 to 8 TU (Thatcher, 1962). The crustal $^3He/^4He$ ratio in seven ground-water samples from the eastern part of the INEEL with no ^3H or very low ^3H concentrations (fig. 13B) is $1.48\times10^{-6}\pm0.26\times10^{-6}$ (R/Ra = 1.07). A pre-bomb ^3H concentration of 7±1 TU was used to calculate the crustal $^3He/^4He$ ratio. The He isotopic ratios in the samples are given in figure 13A. The He isotopic ratios in samples from wells southwest of the INEEL (Plummer and others, 2000) are significantly larger (R/Ra = 5–8) than those in samples from the INEEL (<2); large ratios typically are associated with rift areas and volcanic activity (Oxburgh and others, 1986; Greisshaber and others, 1992). The mantle ^3He was introduced by the migration of the Yellowstone plume through the Snake River Plain (Blackwell and others, 1992; Dodson and others, 1997). He in rocks with R/Ra ratios larger than 8 is believed to be associated with mantle plumes (Craig and Lupton, 1976). R/Ra ratios of 11 were measured in the Imnaha basalts in Idaho (Dodson and others, 1997), and ratios as large as 16 were measured in springs at Yellowstone Park (Craig and others, 1978; Kennedy and others, 1985).

Dating Ground Water with Sulfur Hexafluoride

Sulfur hexafluoride has been used to date ground water recharged in some sedimentary rock aquifers and shallow springs since about 1970 (Busenberg and Plummer, 1997, 2000; Plummer and others, 2000). Busenberg and Plummer (2000) also have shown that less than 2 percent of the total atmospheric concentration of the tracer is from natural sources and appears to be produced by igneous and volcanic processes. Other fluorinated gases, including carbon tetrafluoride (CF_4) and boron trifluoride (BF_3), also were shown to be produced by igneous activity (Hem, 1985; Maiss and others, 1996). The sources of SF_6 are given by the equation

$$SF_{6\,total} = SF_{6\,eq} + SF_{6\,air} + SF_{6\,ign} + SF_{6\,cont}, \quad (3)$$

where $SF_{6\,total}$ is the concentration of SF_6 in the ground water, $SF_{6\,eq}$ is the air saturation concentration, $SF_{6\,air}$ is the SF_6 contributed by the excess air, $SF_{6\,ign}$ is the SF_6 of igneous origin, and $SF_{6\,cont}$ is the SF_6 introduced into the aquifer by wastewater disposal.

The air-saturation concentration can be calculated easily from Henry's law and from the atmospheric growth curve of SF_6 (fig. 10A). The SF_6 contribution from excess air can be evaluated from concentrations of other atmospheric gases in ground water such as N_2, Ar, and Ne. At present, there is no known procedure to quantify the igne-

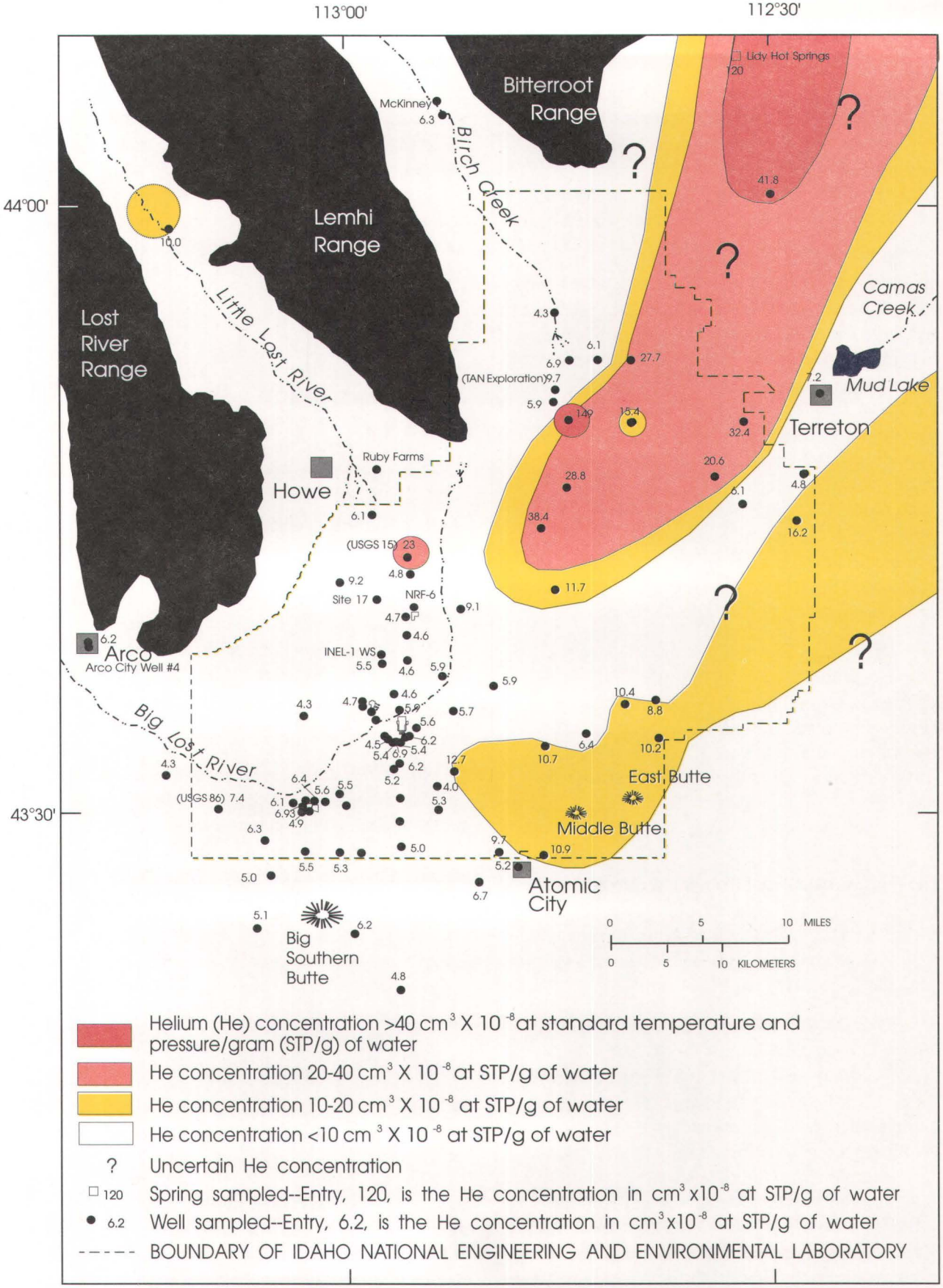


Figure 12. Concentration of dissolved helium per gram of water in water from selected sites at and near the Idaho National Engineering and Environmental Laboratory, 1994-97.

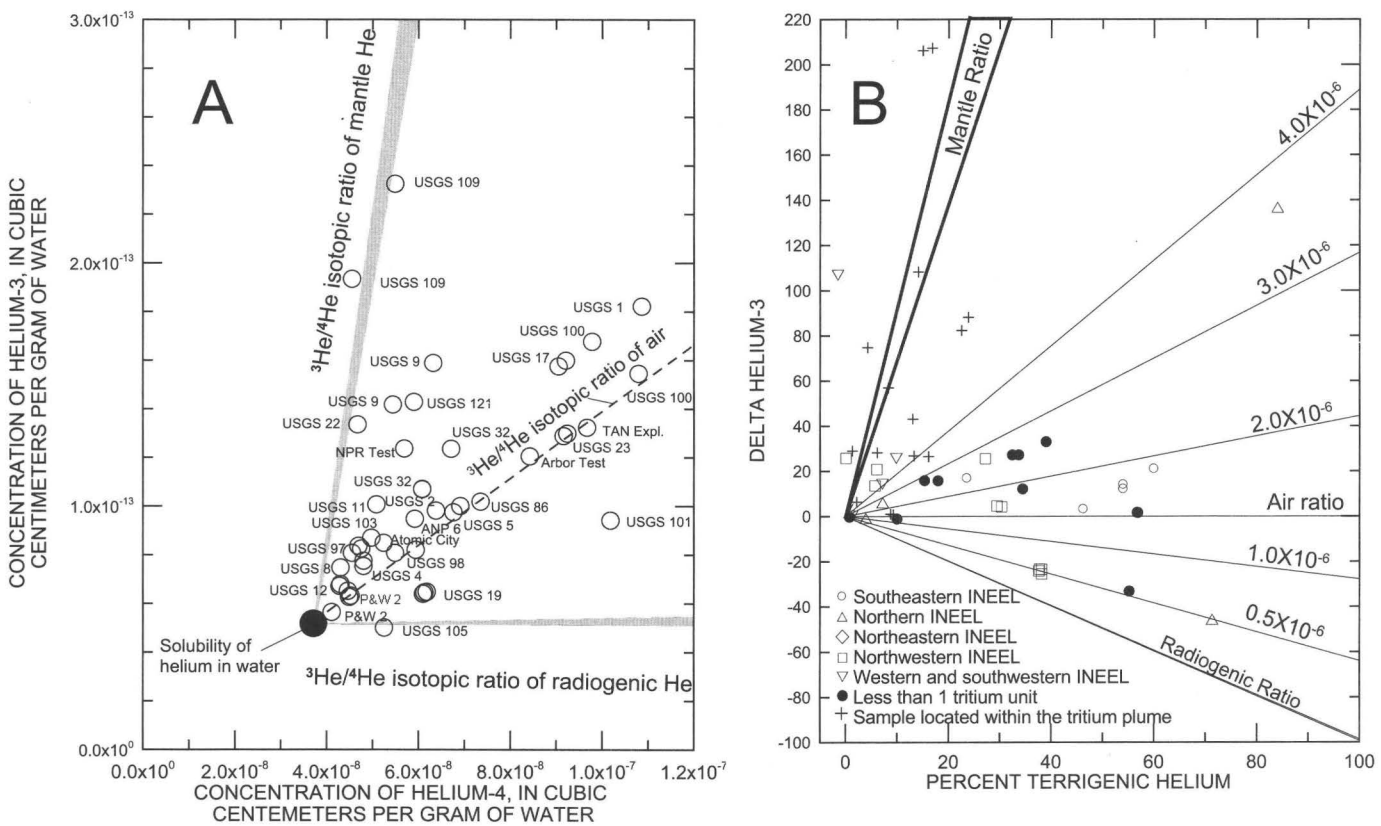


Figure 13. A. Relation between helium-4 and helium-3 concentrations in water from selected wells at and near the Idaho National Engineering and Environmental Laboratory. B. Relation between delta helium-3 and percent terrigenic helium in water from selected wells at and near the INEEL. (The lines that diverge from the solubility of helium in water represent the addition of helium containing the indicated 3He/4He ratios.)

ous fraction of SF_6 in the ground water. Water can be dated when $SF_{6\,ign}$ is much smaller than the sum of $SF_{6\,eq}$ and $SF_{6\,air}$. Much of the deep ground water at the INEEL cannot be dated by using SF_6 because the igneous SF_6 component greatly exceeds all other sources of the tracer. Two areas with very high igneous SF_6 flux have been identified at the INEEL and closely correspond to areas with a high heat flow or the areas with higher ground-water temperatures (Busenberg and Plummer, 2000).

METHODS OF DATING GROUND WATER WITH MULTIPLE ENVIRONMENTAL TRACERS

Several models have been proposed to describe the distribution in an aquifer of ages of water from wells with large, open intervals (see Cook and Böhlke, 1999). The apparent age of a mixture of water of different ages and the mean age of the ground water cannot be determined from the apparent age of any single environmental tracer. The input functions of environmental tracers usually do not vary linearly with time, and the input functions of different environmental tracers are very dissimilar. Multiple tracers with different input histories and input functions can be used to calculate mean transit times in aquifers with constant hydraulic properties. These models have been used successfully for sandstone aquifers but cannot be used for fractured rock aquifers because of the heterogeneity in their hydraulic properties.

At the INEEL, most wells intercept the uppermost part of the Snake River Plain aquifer and the ground-water samples consist of mixtures of recent recharge (<60 years) and regional ground water that may be several thousand years old. These samples can be modeled using a binary mixing model. The methodology for determining mixing fractions and age of the young fractions in simple binary mixtures of young and old water was presented above. Mixing processes can be understood more readily by examining plots of tracer concentrations in the ground water and the variation of the input functions of the tracers with time (see for example, Plummer and others, 2000).

Dating with Multiple Transient Tracers—Ratios of Two Tracers

Figures 10B–C show the ratios of partial pressures of different tracer combinations that can be used to date binary mixtures of young and old water. The CFC-11 to CFC-12 ratio can be used to date 1950 to 1975 water. The ratio method based on the ratio of CFC-11 to CFC-12 gives dual ages for water recharged from 1972 to 1975 and post-1992 water. Water recharged from 1975 to 1992 could not be dated using the CFC-11/CFC-12 ratio because the ratio of these two tracers remained nearly constant in the atmosphere during this time period. The trace atmospheric gases CFC-113 and SF_6 were introduced much later than CFC-11 and CFC-12 and are released into the atmosphere at different rates. The ratios of CFC-12 or CFC-11 with CFC-113 or SF_6 (fig. 10C) can be used to date more recent mixtures than those dated by using CFC-11 or CFC-12. The CFC-113 to CFC-12 ratio can be used to date 1977 to 1992 water, and the CFC-113 to CFC-11 ratio can be used to date 1978 to 1993 water (Plummer and others, 1998a, 1998b; Plummer and Busenberg, 1999; Plummer and others, 2000). The CFC ratio method is used extensively in oceanographic studies but has had little application in ground-water studies because CFC concentrations often were modified by contamination or other physical/chemical processes. Recently, the ratio method has been used to date ground water and binary mixtures of young and of pre-1940 water (Plummer and Busenberg, 1999; Plummer and others, 2000). The SF_6-to-CFC partial-pressure ratio method can be used to date very young ground water. The SF_6-to-CFC-11 partial-pressure ratio is rapidly increasing and, in the year 2000, could be used to date water as old as 23 years. The rate of change of the partial pressure ratio is expected to increase as SF_6 concentrations increase and CFC-11 concentrations decline. The SF_6-to-CFC-12 dating range is from 1975 to 2000; the SF_6-to-CFC-113 dating range is from 1990 to 2000. The young fraction in ground-water samples can be dated by using SF_6-to-CFCs partial pressure ratios in the mixtures of post-1970s water and older water when the samples do not contain a terrigenic component of SF_6 or larger-than-background concentrations of CFCs.

Plots of partial-pressure ratios of pairs of environmental tracers are shown in figures 14A–L. In these figures, the age of the sample corresponds to the intersection of the piston-flow line and tracer-free water. The fraction of young and old water can be determined from the position on the mixing lines. If the partial pressures fall within the curves, then the ground water may be a mixture of water of different ages, if there are no other sources of tracers. If ground-water concentrations fall outside the boundaries of figure 14, then the concentrations of one or both tracers have been modified by contamination or some other process.

Dating with Tritium

Concentrations of tritium in rain vary seasonally, and many other factors affect the natural variability of tritium concentrations in precipitation. Streams that recharge the Snake River Plain aquifer at and near the INEEL are mixtures of rainwater, snowmelt, and ground water, and the tritium concentration in streams is a composite from all these sources. The tritium concentration in streams can be modeled from the tritium concentration in the ground water discharged into the streams, the residence time of this water, historical concentration of tritium in precipitation, the concentration of tritium in runoff, and the fraction of these components in the surface water (Michel, 1992).

Figure 15 is a plot showing the ^{3}H concentration (non-decayed) of precipitation, and the modeled ^{3}H concentration in a stream fed by ground water with average residence times of 1, 2, 5, 10, 20, and 40 years, assuming an exponential distribution of ground-water ages discharging to the stream as a function of year; the figure was constructed using the model given by Cook and Böhlke (1999). It is evident from this figure that ground-water residence time significantly affected tritium concentrations in stream samples collected at or just after the tritium bomb peak.

Residence Time of Tritium in Streams near the Idaho National Engineering and Environmental Laboratory

The residence time of tritium in stream water is needed to date recharge to an aquifer with surface water. An attempt was made to determine the residence times of streams recharging the Snake River Plain aquifer from historical ^{3}H measurements. The historical ^{3}H concentrations of the Big Lost River are shown in figure 15. Also shown are the tritium concentrations in precipitation as well as the calculated concentrations of ^{3}H in the rivers assuming discharge from ground-water reservoirs with residence times of 1, 2, 5, 10, 20, and 40 years. Most of the measured historical ^{3}H concentrations that are available for the surface-water sites are uncertain and difficult to interpret. The residence time of tritium can best be determined for the years of atmospheric nuclear testing during the 1960s. The available historical ^{3}H concentrations do not fit any of the models because of the lack of sufficient surface-water ^{3}H data around the bomb peak.

Even though the average residence time of stream water recharging the aquifer cannot be evaluated from available ^{3}H surface-water data, the average residence times can be estimated from ^{3}H concentrations in the ground water. Figure 16 represents ^{3}H concentrations in a stream assuming recharge from ground water with average residence times of 1 year (fig. 16A) and 5 years (fig. 16B). Water in wells contaminated by ^{3}H is not represented in figure 16. Figure 16B indicates that all the ground-water samples collected at the INEEL were recharged during 1957–59 or that the young fraction was less than 10 years old. These results are inconsistent with $^{3}H/^{3}He$ and CFC ages, which indicate that the age of the young fraction is not greater than 40 years or less than 5 years.

Tritium data for water in the Snake River south of the INEEL are consistent with ground-water residence times of 2 to 5 years (Plummer and others, 2000); water in smaller streams generally has shorter residence times (Michel, 1992). Figure 16A shows modeled tritium concentrations in a stream recharged by ground water with an average residence time of 1 year. The tritium ages obtained for the water are consistent with the $^{3}H/^{3}He$ and CFC ages of the young water fraction and indicate that the streams that recharge the aquifer at or near the INEEL have an average residence time of 1 to 2 years.

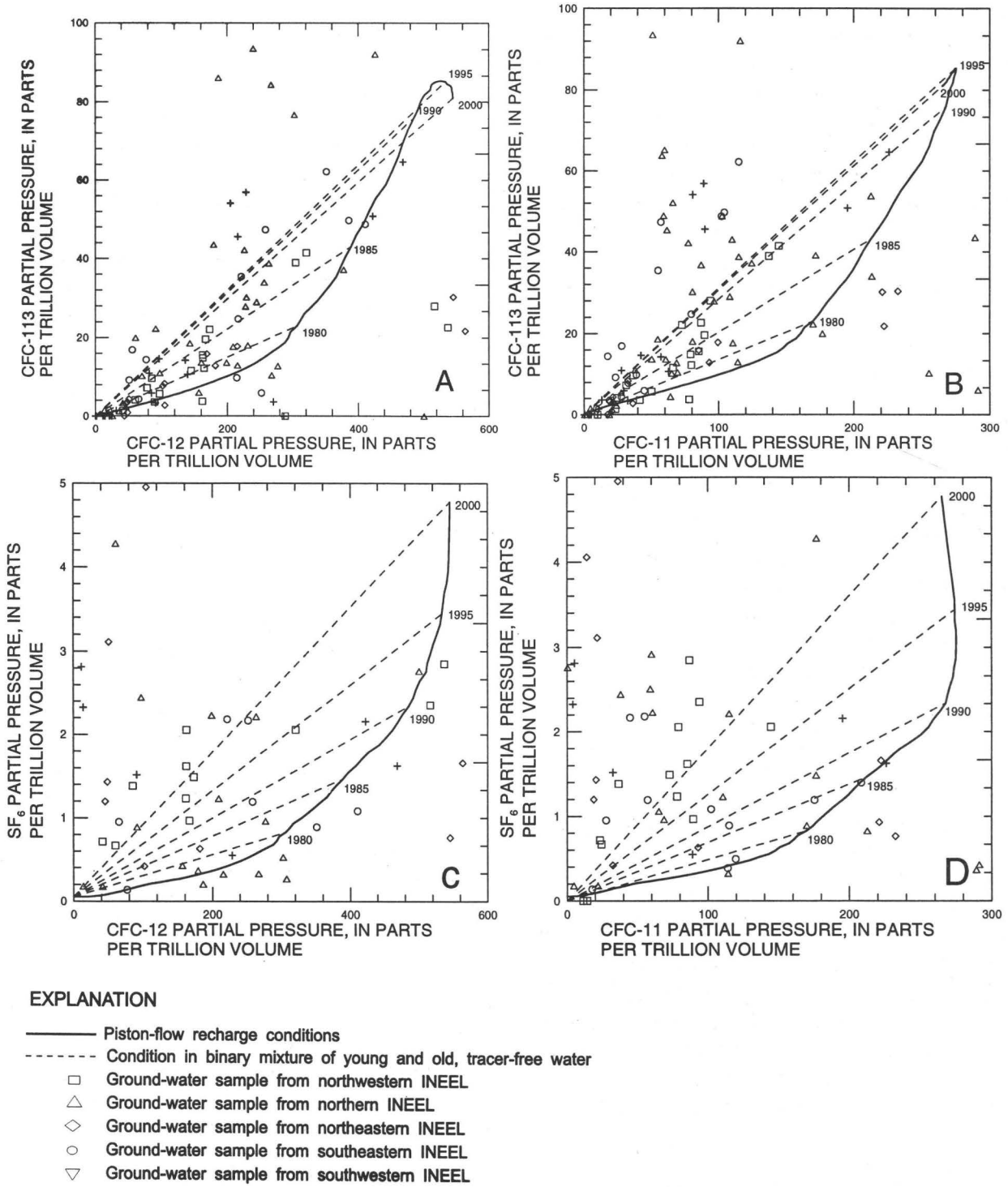
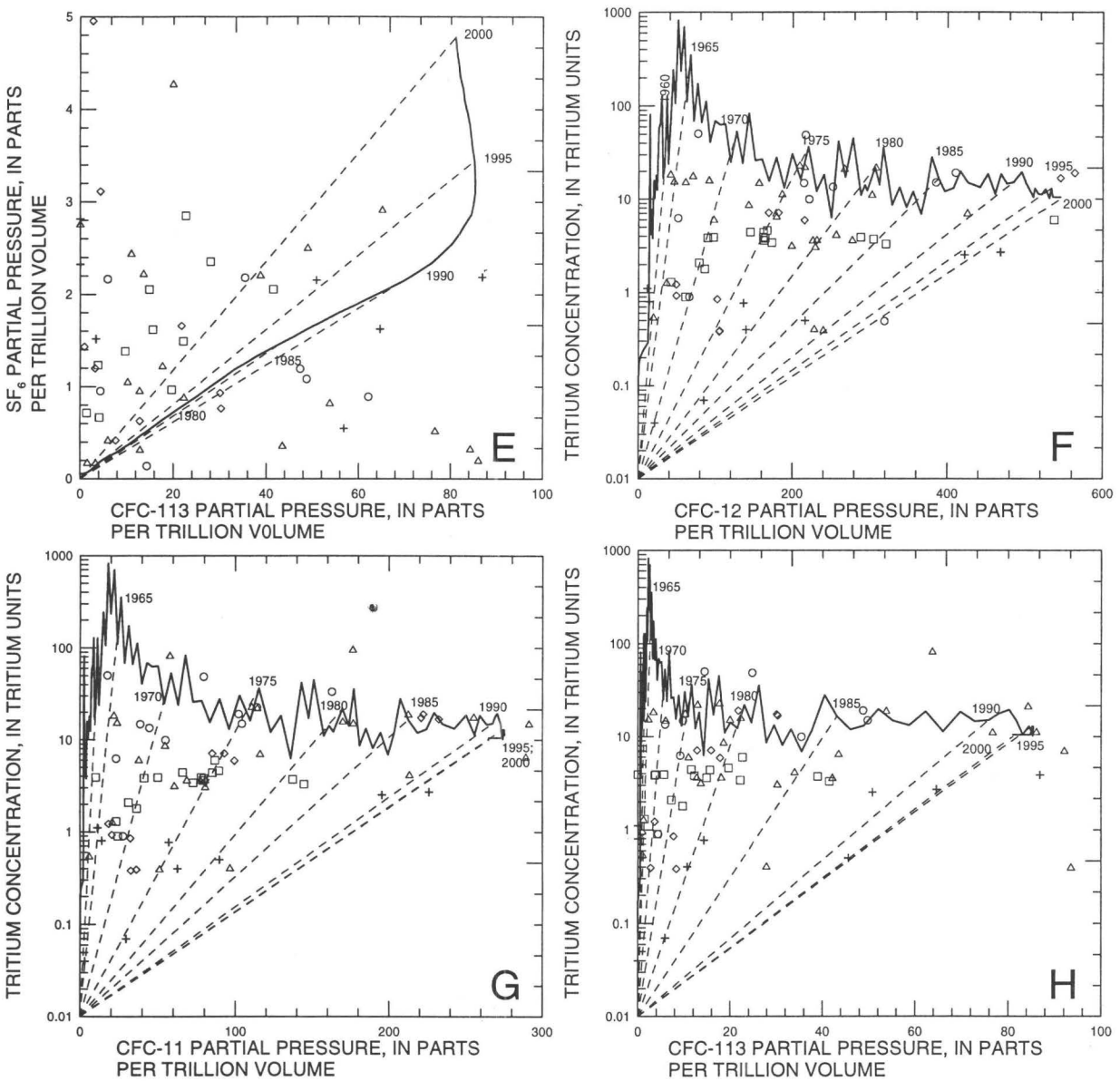


Figure 14A–D. Partial pressure ratios of two tracers in ground-water samples at or near the Idaho National Engineering and Environmental Laboratory. [1980, calendar year of the young water fraction in the binary mixture].



EXPLANATION

- Piston-flow recharge conditions
- Condition in binary mixture of young and old, tracer-free water
- Ground-water sample from northwestern INEEL
- Ground-water sample from northern INEEL
- Ground-water sample from northeastern INEEL
- Ground-water sample from southeastern INEEL
- Ground-water sample from southwestern INEEL

Figure 14E–H. Partial pressure ratios of two tracers in ground-water samples at or near the Idaho National Engineering and Environmental Laboratory—Continued.

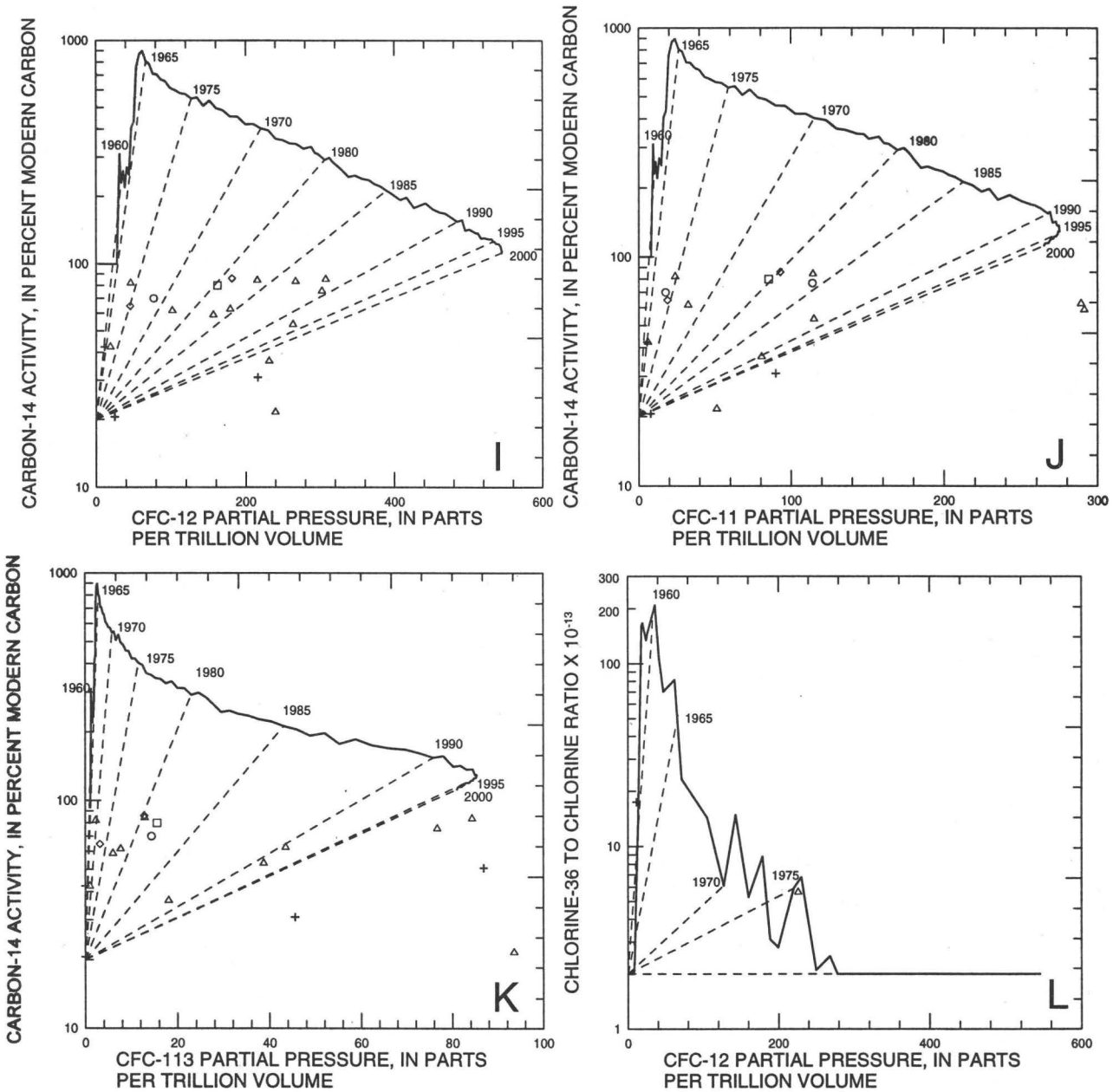


Figure 14I–L. Partial pressure ratios of two tracers in ground-water samples at or near the Idaho National Engineering and Environmental Laboratory—Continued.

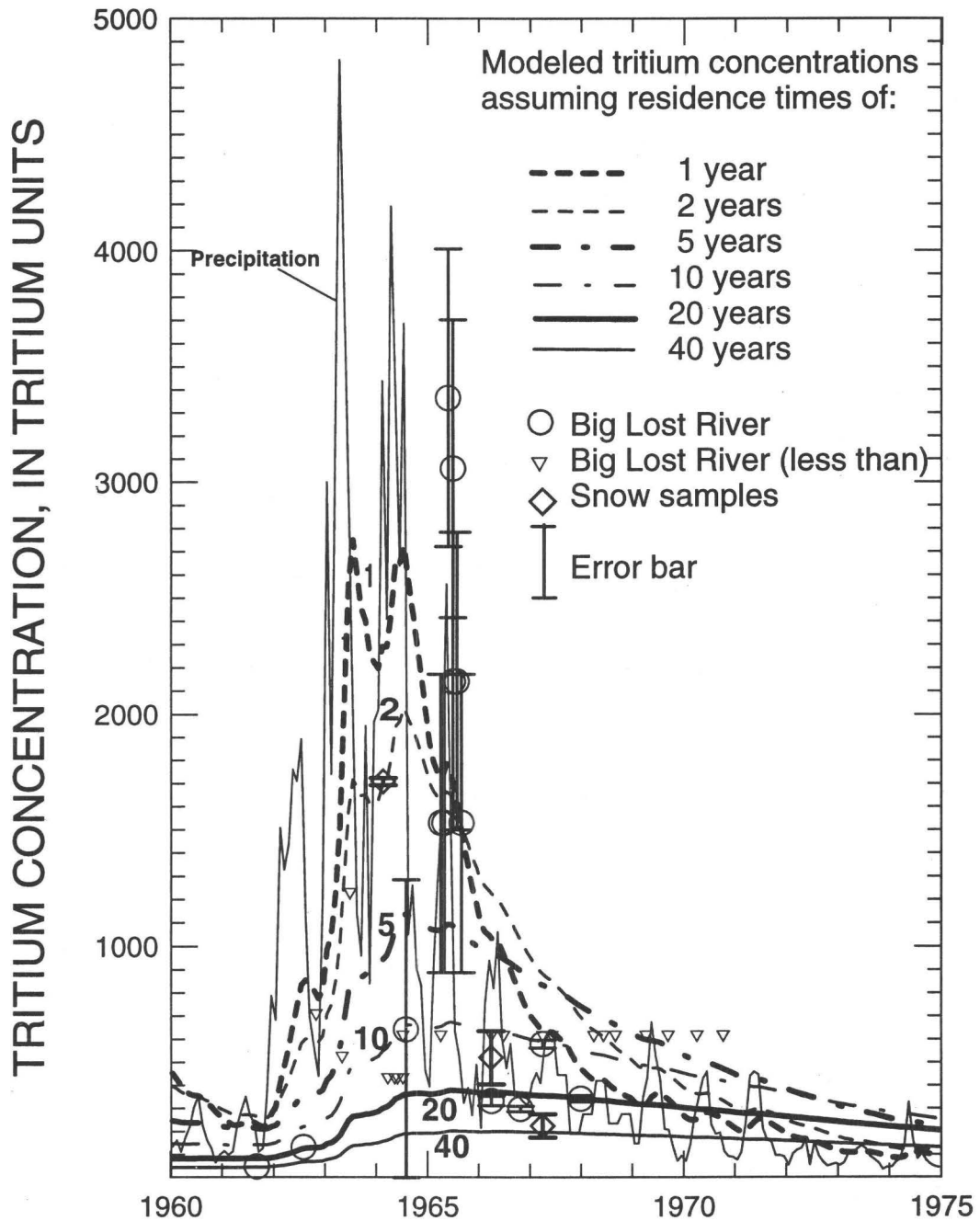


Figure 15. Historical concentrations of tritium in the Big Lost River and modeled concentrations of tritium in the Big Lost River, calculated by assuming recharge by ground water with average residence times of 1, 2, 5, 10, 20, and 40 years. (Triangles represent Big Lost River concentrations of tritium less than the amount indicated by the position of the symbol on the figure.)

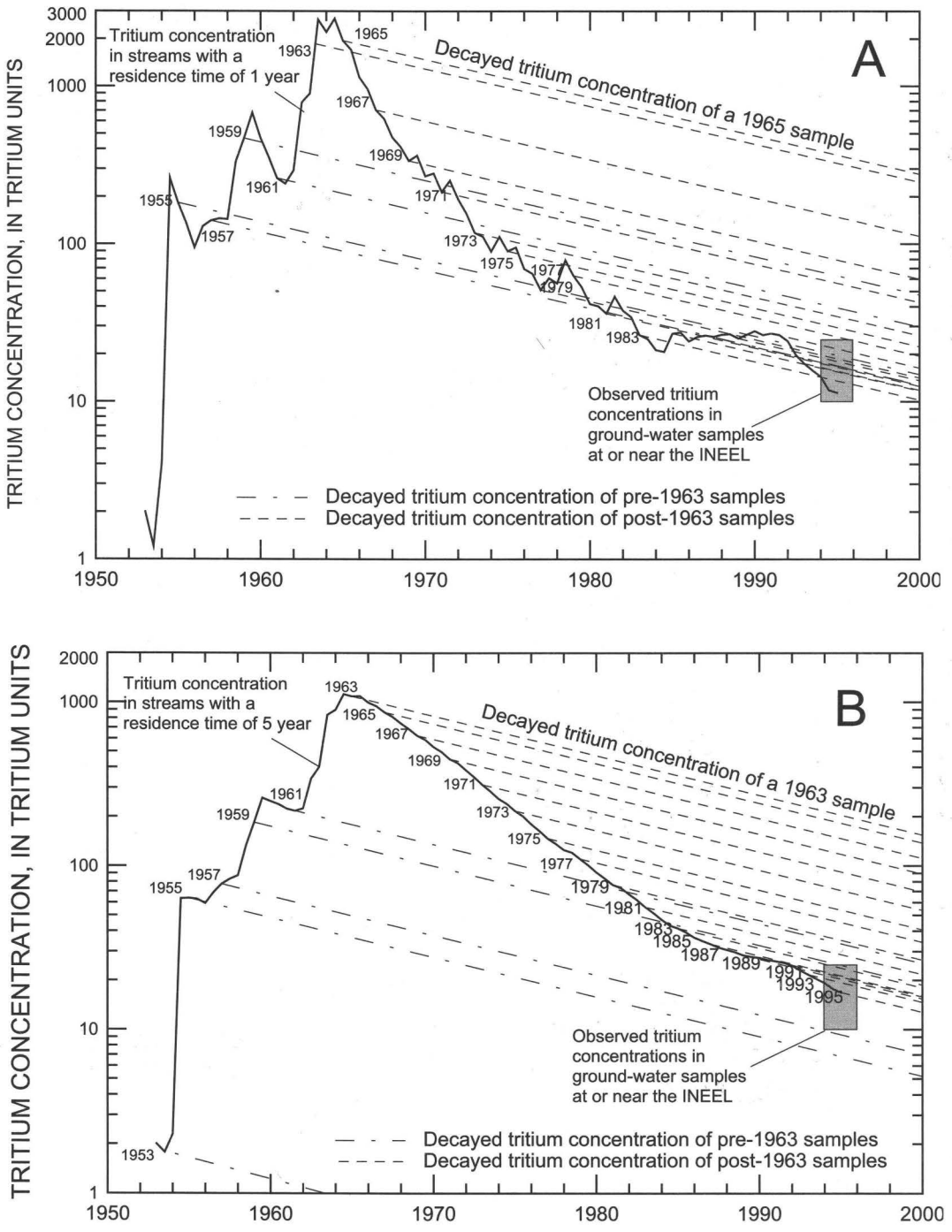


Figure 16. A. Modeled tritium concentrations in a stream recharged by ground water with an average residence time of 1 year. B. Modeled tritium concentrations in a stream recharged by ground water with an average residence time of 5 years.

Figure 15 shows a ^{3}H peak in mid-1965; the ^{3}H peak was present in all surface-water samples collected near the INEEL. This ^{3}H peak may be a result of ^{3}H disposal practices at INEEL facilities.

Dating with the Ratio of Carbon-14 and Another Environmental Tracer

Binary Mixing of Old Ground Water and a Young Component

Figure 17 shows the historical ^{14}C activity to CFC-12 concentrations in Northern Hemisphere air. The ^{14}C activity and CFC-12 concentrations of USGS 1 and USGS 100 also are plotted in this figure. The model assumes a binary mixture of regional ground water with 30 percent modern carbon (pmc) ^{14}C and water in equilibrium with air. The apparent date of the last recharge of USGS 100 was 1987. The fraction of young water in the sample was about 30 percent, and the ^{14}C activity was about the average ^{14}C concentration in the regional ground water. The apparent date of the last recharge of USGS 1 was 1982, and the fraction of young water was about 13 percent. The age and fraction of young water determined from figure 17 for the two wells assume that the ^{14}C activity of soil CO_2 was primarily from root respiration and was similar to the ^{14}C activity of air.

Gas Production of Carbon Dioxide in the Unsaturated Zone

The production of CO_2 in soils occurs predominantly in the upper meter of soil and is mainly produced by plant respiration (Reardon and others, 1979). Seasonal production of soil CO_2 results in variations in CO_2 concentrations in the upper 7 to 8 m of the unsaturated zone; below this depth, CO_2 concentrations show no seasonal variations (Thorstenson and others, 1998). Assuming 30 percent porosity, 8 percent water saturation, 2 mmol/L inorganic carbon in the pore water, and 0.1 percent CO_2 concentration in the unsaturated-zone atmosphere, then more than 95 percent of the inorganic carbon reservoir is in the pore water of the unsaturated zone. Because the diffusive flux of CO_2 was from the soil into the atmosphere, pre-bomb ^{14}C should be present in the unsaturated zone below a few tens of meters. The model can be applied to areas covered with thick sedimentary deposits and where the fractured basalts are not exposed at the Earth's surface, such as at the Test Area North (TAN) and other areas in the northern part of the INEEL. Concentrations of CFCs (Busenberg and others, 1993) and SF_6 in these areas can be modeled simply as diffusive transport through the thick unsaturated zone. If the ^{14}C in the dissolved inorganic carbon were predominantly from soil CO_2, and the CO_2 were added to the water at some depth, and the ^{14}C concentration in soil CO_2 were known, it could be possible to determine the fraction of young water using equation 11 (Appendix 1).

Figure 18 shows a linear relationship between the $\delta^{18}O$ ratio and ^{14}C activity in the ground-water samples at and near the INEEL, which indicates that the samples are mixtures of very old water with small $\delta^{18}O$ concentrations and young water with $\delta^{18}O$ concentrations that are 1.1 to 1.2 permil heavier. As the fraction of young water in the sample increased, the ^{13}C isotopic composition of the dissolved inorganic carbon became lighter (fig. 19). This implies that young water with a slightly heavier $\delta^{18}O$ isotopic ratio recharged the aquifer at and near the INEEL, and that the young water dissolved soil CO_2 and then reacted with the aquifer minerals and rocks.

Dating with the Ratio of Two Environmental Tracers other than Carbon-14, Tritium, and Chlorine-36

Tritium (fig. 14F–H), ^{36}Cl (fig. 14L), and large quantities of ^{14}C (fig. 17) were produced by the atmospheric nuclear testing and their atmospheric input functions are complex. Because of this complexity, ages and mixing fractions in binary mixtures have to be determined graphically when one of the above tracers is used to date the young fraction. On the other hand, atmospheric input functions of CFCs and SF_6 (fig. 10A) are smooth curves, and the ages and the fraction of young water from any combination of CFCs or CFCs and SF_6 (fig. 14A–E) can be calculated. Ages and fractions of young water calculated from these combinations are presented in the next section of this report.

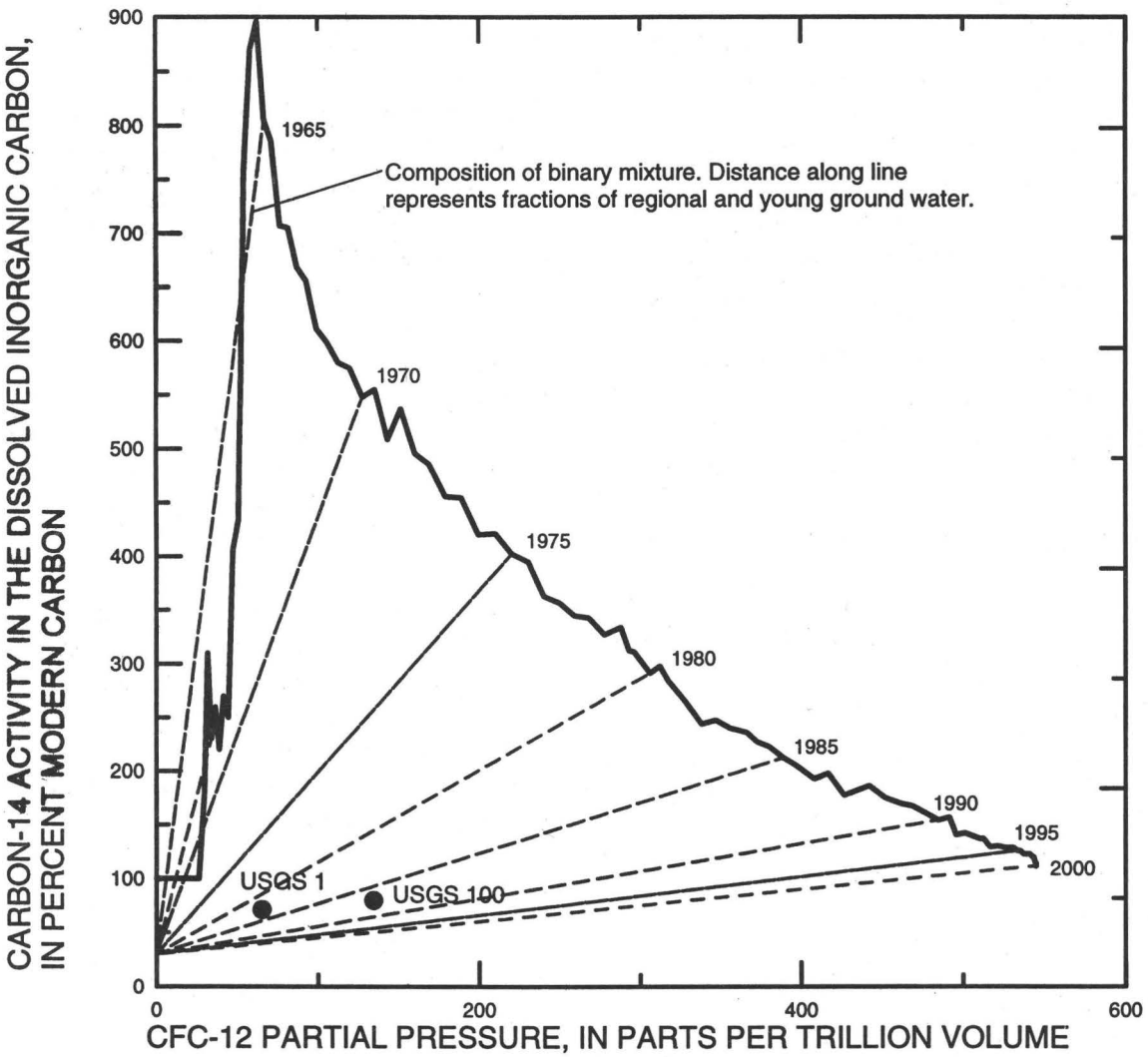


Figure 17. Binary mixtures of regional and young ground water, determined using ratios of carbon-14 activity to partial pressures of chlorofluorocarbon-12 in Northern Hemisphere air, 1965–2000. Model assumes that the soil atmosphere tracks the carbon-14 activity of air.

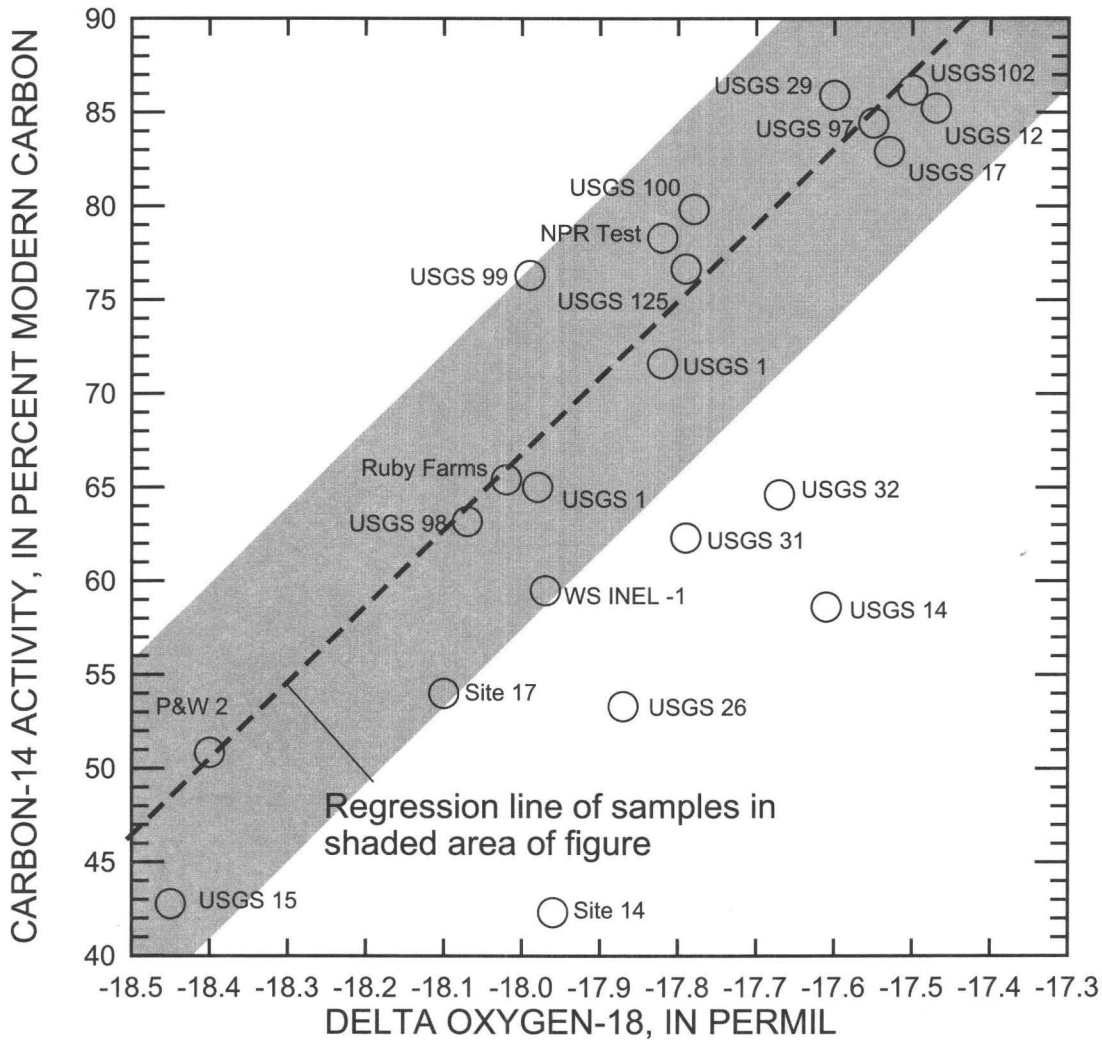


Figure 18. Relation between delta oxygen-18 ratio and carbon-14 activity in the dissolved inorganic carbon in water from selected wells at and near the Idaho National Engineering and Environmental Laboratory.

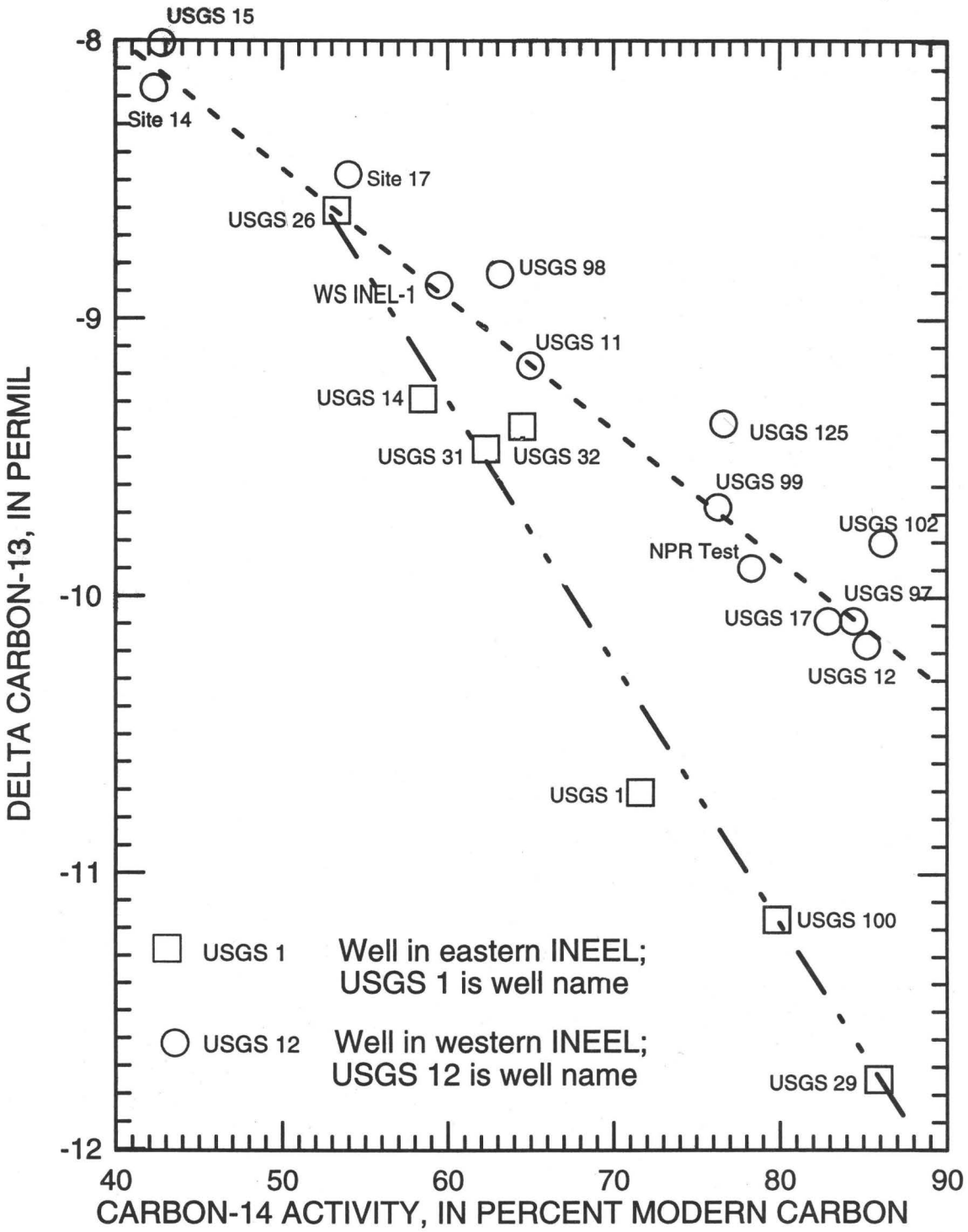


Figure 19. Relation between carbon-14 activity and delta carbon-13 concentration in the dissolved inorganic carbon in water from selected wells at and near the Idaho National Engineering and Environmental Laboratory.

MODELS FOR CALCULATING THE AGE OF THE YOUNG FRACTION OF GROUND WATER USING CHLOROFLUORCARBONS AND SULFER HEXAFLUORIDE

Estimating the age of the young fraction of ground water in the Snake River Plain aquifer at the INEEL is very difficult because of the physical complexity of the fractured rock, the thickness of the unsaturated zone, the number of sources of recharge, and the well construction. Dating the young fraction is further complicated by wastewater disposal at several locations at the INEEL. Some wells at the INEEL have very large, open intervals and contain ground water of different ages; well-bore mixing of ground water is important. Some of the contaminated water could not be dated; in other cases, the date of contamination could be obtained. The date of contamination can be used to estimate traveltimes of ground water from the source of contamination to the well.

Several models were used to date the young fraction of ground water at and near the INEEL. Model 1 assumes that the ground water is not a mixture. Recharge is by infiltration through thin, unsaturated zones (less than 10 m thick) or by rapid movement of water along distinct pathways through thick, unsaturated zones. The age of the young fraction was calculated by comparing the calculated partial pressure of the tracer in water with the historical concentration of the tracer in North American atmosphere. One tracer was sufficient to date the water. The model-1 calculated partial pressures, and apparent ages for the three CFCs and SF_6 are given in table 1 (at back of report). If the ground water is a mixture, then the model-1 age of the sample is greater than the actual age of the young fraction in the sample. For uncontaminated samples, the model-1 age is the maximum age of the young fraction.

Model 2 assumes that the sample is a binary mixture of young, uncontaminated water (<60 years) and old, tracer-free water. This model also assumes that the recharge of the young fraction was by infiltration through a thin, unsaturated zone (less than 10 m thick) or by rapid movement along distinct pathways through the thick, unsaturated zone with negligible if any exchange of gases between the recharge water and the unsaturated-zone atmosphere. The age of the young fraction was calculated by comparing the ratio of partial pressures of two tracers in the sample with the historical ratio of the concentration of the tracers in the North American atmosphere. The apparent ages calculated by using this ratio method are given in table 2. The ratio age will equal the piston-flow age when the sample consists of 100 percent young water. Because the mixing of young water and old, tracer-free water reduces the concentration of tracers in the ground water, the ratio age must be less than the model-1 piston-flow age of the sample. If the ratio age is greater than the piston-flow age, then the concentration of one or both tracers must have been modified during or after recharge, so that the tracers were not in equilibrium with the uncontaminated North American atmosphere during recharge. Invalid results also are indicated in table 2. The fraction of young ground water present in the sample can be calculated by dividing the concentration of the tracer in the North American air at the date of recharge of the young fraction of water by the calculated partial pressure of the same tracer in the ground-water sample.

Model 3 is, in many respects, similar to model 2. Model 3 also assumes that the sample is a binary mixture of young and tracer-free water. The young fraction was calculated independently from chemical, isotopic concentrations in the sample, or by geochemical modeling. The measured partial pressure of the tracer in the sample was normalized by dividing the partial pressure by the percentage of young water in the sample. The age of the young fraction was determined by comparing the normalized partial pressure of the tracer with the concentration of the tracer in the historical North American atmosphere. The $\delta^{18}O$ composition of the regional ground water and the young recharge in the western part of the INEEL differed by 1.2±0.2 permil (fig. 20B). Despite this large uncertainty, the $\delta^{18}O$ ratios provided some indication of the percentage of young water in the samples. The fraction of young water calculated with model 2 and with $\delta^{18}O$ ratios and the ages and uncertainties ($\pm 1\sigma$) are given in table 3.

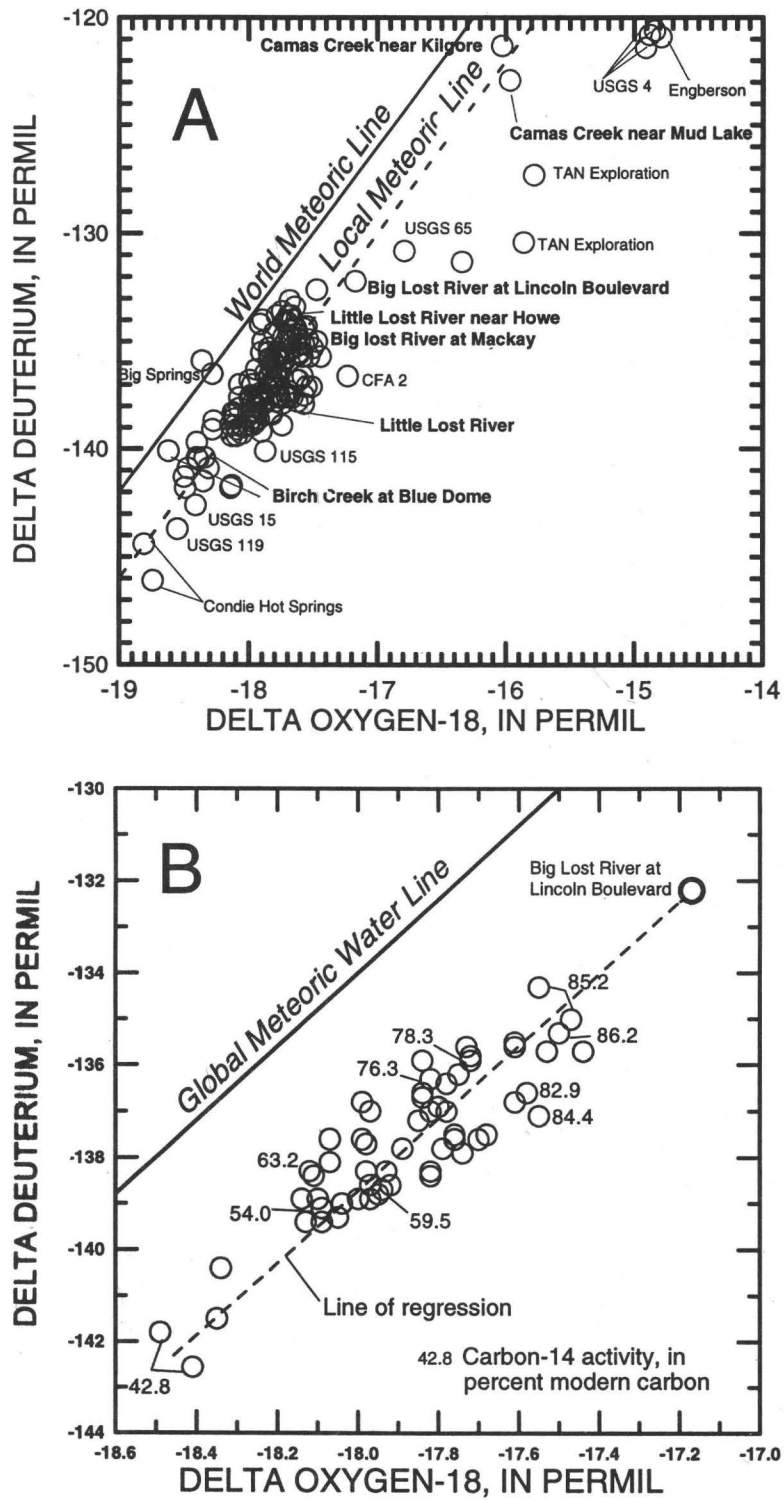


Figure 20. A. Ratios of delta deuterium and delta oxygen-18 concentrations in water from selected sites at or near the Idaho National Engineering and Environmental Laboratory. B. Detail of figure 20A also showing carbon-14 activities in water from the western part of the Idaho National Engineering and Environmental Laboratory.

Several additional models (4–6) were required to calculate the age of infiltration water recharging the Snake River Plain aquifer through the thick, unsaturated zone. The simplest of these models assumes that the infiltration recharge was in equilibrium with the unsaturated-zone atmosphere at the water table during recharge and that diffusion controlled the concentration of the tracer at the water table. The diffusive transport of air through the unsaturated zone occurs beneath playas and sedimentary deposits of ancestral Lake Terreton. The diffusive transport of gases through thick, unsaturated zones results in apparent piston-flow ages that are older than the age of recharge of the infiltration water. Also, the diffusive transport results in apparent piston-flow ages of SF_6 that are less than those from CFC-12, apparent ages of CFC-12 that are less than that of CFC-113, and apparent ages of CFC-113 that are less than those from CFC-11. The theoretical concentration of a tracer at the water table can be calculated by using the model of Cook and Solomon (1995) if the porosity, tortuosity, water saturation, vapor and liquid self-diffusion coefficients, liquid- and gas-partition coefficients, and solubility of the tracer in water are known. This model was used to calculate the concentration profiles of CFC-11 and CFC-12 in the unsaturated zone at the TAN (Busenberg and others, 1993). Figure 21 shows the significant differences between the ages of ground water calculated using tracer concentrations in North American air and in the unsaturated-zone atmosphere just above the water table located at a depth of 70 m. The concentrations of the three CFCs and SF_6 in the unsaturated zone were calculated for the years 1950 to 2000. The calculated partial pressures of all four tracers at the water table are in good agreement with 1991 (Busenberg and others, 1993) and 1994 measured unsaturated-zone concentrations of the four tracers at TAN.

Model 4 assumes that the infiltration recharge at the water table and the unsaturated-zone atmosphere are at equilibrium and also that the ground-water sample is not a mixture of water of different recharge ages. The age of the infiltration water, defined as beginning at the time of isolation of the water from the unsaturated-zone atmosphere, can be significantly different from the age of the precipitation. A characteristic of infiltration recharge and precipitation is the absence or near absence of tritium. The absence or near absence of tritium in ground-water samples indicates that (1) no significant focused recharge has taken place, and (2) water containing ^3H from the 1963 bomb peak has not reached the water table. Model-4 ages of the young fraction of ground-water samples from the northern and northeastern parts of the INEEL are given in table 4.

Model 5 assumes that some ground-water samples may be mixtures of infiltration water passing through deep, unsaturated zones and tracer-free, regional ground water. At the present time, it is nearly impossible to precisely date ground water that is best described by model 5 at the INEEL; however, the criteria used to date model-2 and model-3 water could be applied to date the young fraction of model-5 ground-water samples.

Several lines of evidence suggest that there is an intermediate mechanism of recharge to the Snake River Plain that is neither rapid, focused recharge nor slow infiltration recharge (Gee and Hillel, 1988) (model 6). Large concentrations of ^3H in some ground-water samples far from wastewater-disposal areas indicate that post-1960 precipitation reaches the Snake River Plain aquifer through as much as 300 m thickness of unsaturated zone. However, model-2 and model-3 CFC-12 ages of samples from south and southwest of the INEEL were approximately 8 to 10 years older than the ages calculated by the $^3H/^3He$ method (Plummer and others, 2000) and were inconsistent with rapid, focused recharge. Small CFC-12 concentrations and no ^3H would have been present if the recharge had been by spatially distributed diffuse recharge through the thick, unsaturated zone (model 4, infiltration recharge). Also, recent tracer studies have shown that surface water can reach the water table near the RWMC in weeks or months (Nimmo and others, 2001). If water can move rapidly down to the water table, then gases must move even more rapidly by advection along natural openings and fractures in the basalts throughout the unsaturated zone. There is further evidence of gas movement into the unsaturated zone; significant quantities of air were observed to move in and out of the annulus of several wells in the southern part of the

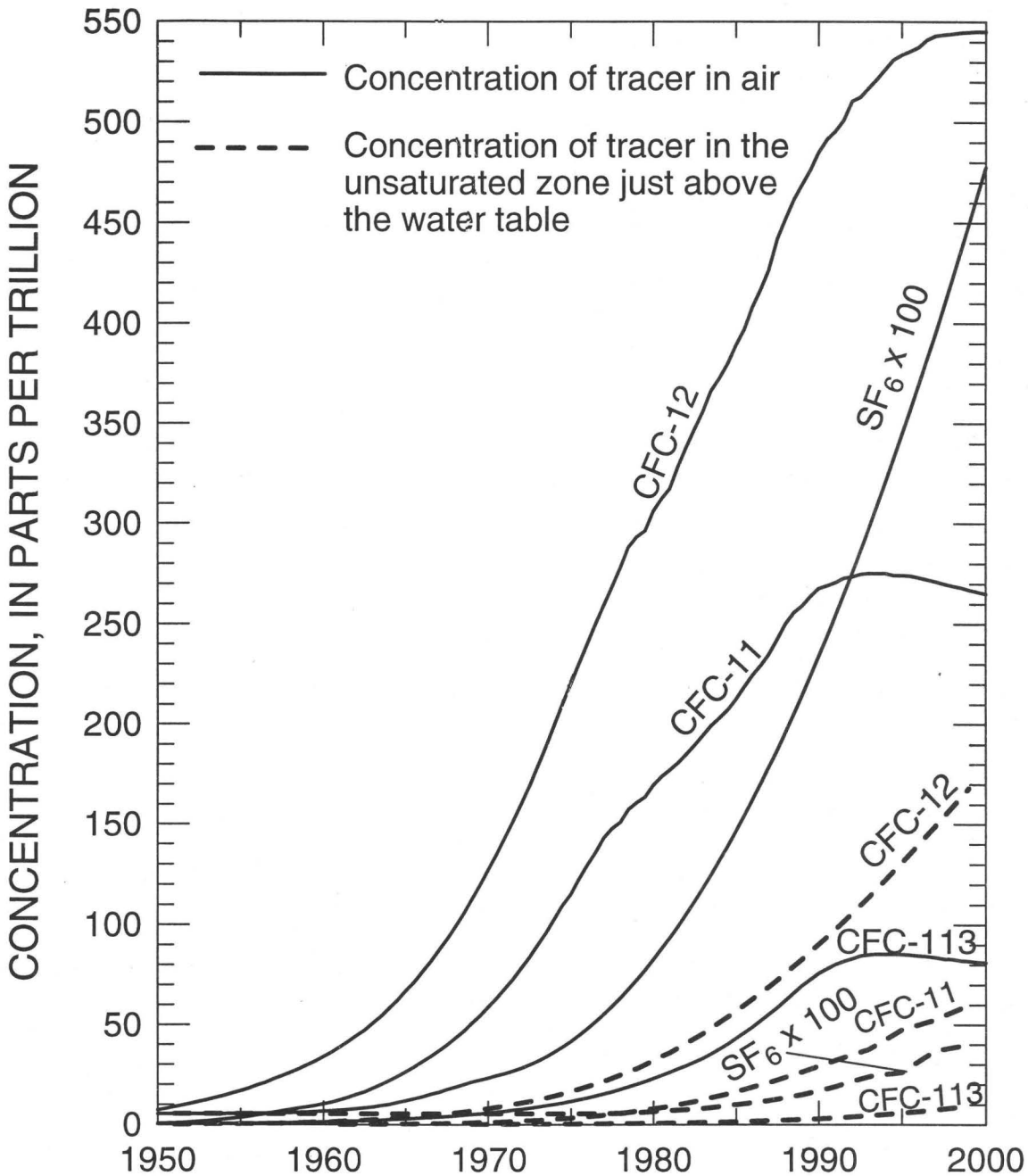


Figure 21. Concentration of chlorofluorocarbons and sulfur hexafluoride in air and in the unsaturated zone just above the water table located at a depth of 70 meters, 1950–2000.

INEEL in response to changes in barometric pressure (fig. 22). Similar movement of air into the deep, unsaturated zone probably takes place down the northwestern trending fractures associated with vent corridors (Anderson and others, 1999). The presence of anthropogenic halocarbons in excess of air concentrations and the areal distribution of the halocarbons at a depth of 1 m suggest that the fractures associated with the vent corridors may be effective pathways for both vertical and lateral movement of gases in and out of the unsaturated zone (fig. 22). The distribution of CFC-113 in soil at a depth of 1 m as far as 20 km south of the southwest corner of the INEEL (E. Busenberg, unpub. data, 1999) suggests that significant vertical and lateral movement of gases occurs in the unsaturated zone in the southwestern part of the INEEL and that the fractures associated with vent corridors may act as important vertical pathways. This exchange of gases between air and the unsaturated-zone atmosphere implies that post-bomb air may be present in some of the deep, unsaturated zone.

Plummer and others (2000) observed the same phenomenon in rangeland wells south and southwest of the INEEL. The average concentrations of CFC-12, CFC-11, and CFC-113 in air blowing out of the unsaturated zone from the annulus of seven wells were 83.4, 254, and 59.7 percent, respectively, of the concentration in air. Excluded from these averages were concentrations from the Apollo well, which contained 19.6, 273, and 5.9 percent of the concentration in air of CFC-12, CFC-11, and CFC-113 (Plummer and others, 2000). Unsaturated-zone air was sampled from the annulus of five wells at the INEEL. The unsaturated-zone air blowing from three wells south of the INTEC (USGS 39, USGS 36, and USGS 35) contained larger-than-background concentrations of CFCs. The concentrations of CFC-12, CFC-11 and CFC-113, in percent of the concentration in atmospheric air, ranged from 890 to 4,900, 110 to 380, and 140 to 430, respectively. The concentrations of CFC-12, CFC-11, and CFC-113 in air from P&W 2 were 88, 79, and 81 percent of the concentration in air, respectively. The concentrations of CFC-12, CFC-11, and CFC-113 in USGS 109 were 93, 87, and 96 percent of the concentration in air, respectively. These CFC concentrations indicate that advection and diffusion are important processes in determining the composition of CFCs in the unsaturated zone throughout the INEEL. Recharge water that takes weeks to a few years to reach the water table exchanges gases with the unsaturated-zone atmosphere, which results in an apparent age that is older than the $^3H/^3He$ age.

MODEL FOR CALCULATING THE AGE OF THE YOUNG FRACTION OF GROUND WATER USING TRITIUM/HELIUM-3

A difficulty in dating the young fraction by using the $^3H/^3He$ method arises from the fact that there are several other sources of ^3He that must be subtracted from the measured ^3He to obtain the $^3He_{tritiogenic}$ (equation 1). Plummer and others (2000) showed that the uncertainty in the terrigenic $^3He/^4He$ ratio ($R_{terr} = [^3He_{rad} + ^3He_{mantle}]/[^4He_{rad} + ^4He_{mantle}]$) was the major difficulty in dating ground water with the $^3H/^3He$ method from the Snake River Plain aquifer south and southwest of the INEEL. If the ground-water sample has a small concentration of ^3H and a large concentration of terrigenic helium (He_{terr}), then the terrigenic ratio (R_{terr}) must be known precisely to date the ground water. The R_{terr} in the eastern part of the INEEL is significantly different from and about 100 times greater than the radiogenic $^3He/^4He$ ratio in the western part of the INEEL. Several ground-water samples from the northeastern part of the INEEL could not be dated because of the uncertainty of the R_{terr}. These samples were obtained near the boundary of the basin south and southeast of Lidy Hot Springs (fig. 2).

The young fraction in many samples from the eastern part of the INEEL was dated by using the $^3H/^3He$ method and an R_{terr} of $1.48\times10^{-6}\pm0.26$. This ratio was calculated by using equation 9 (Appendix 1) for ground-water samples containing ^3H concentrations of 1 TU or less (fig. 13B). The samples contained between 10 and 72 percent He_{terr}. The natural ^3H concentration of 7±1 TU was used for the concentration in precipitation before atmospheric nuclear testing. The $^3H/^3He$ ages of the young fraction in ground-water samples and ages with $\pm1\sigma$ are given in table 8.

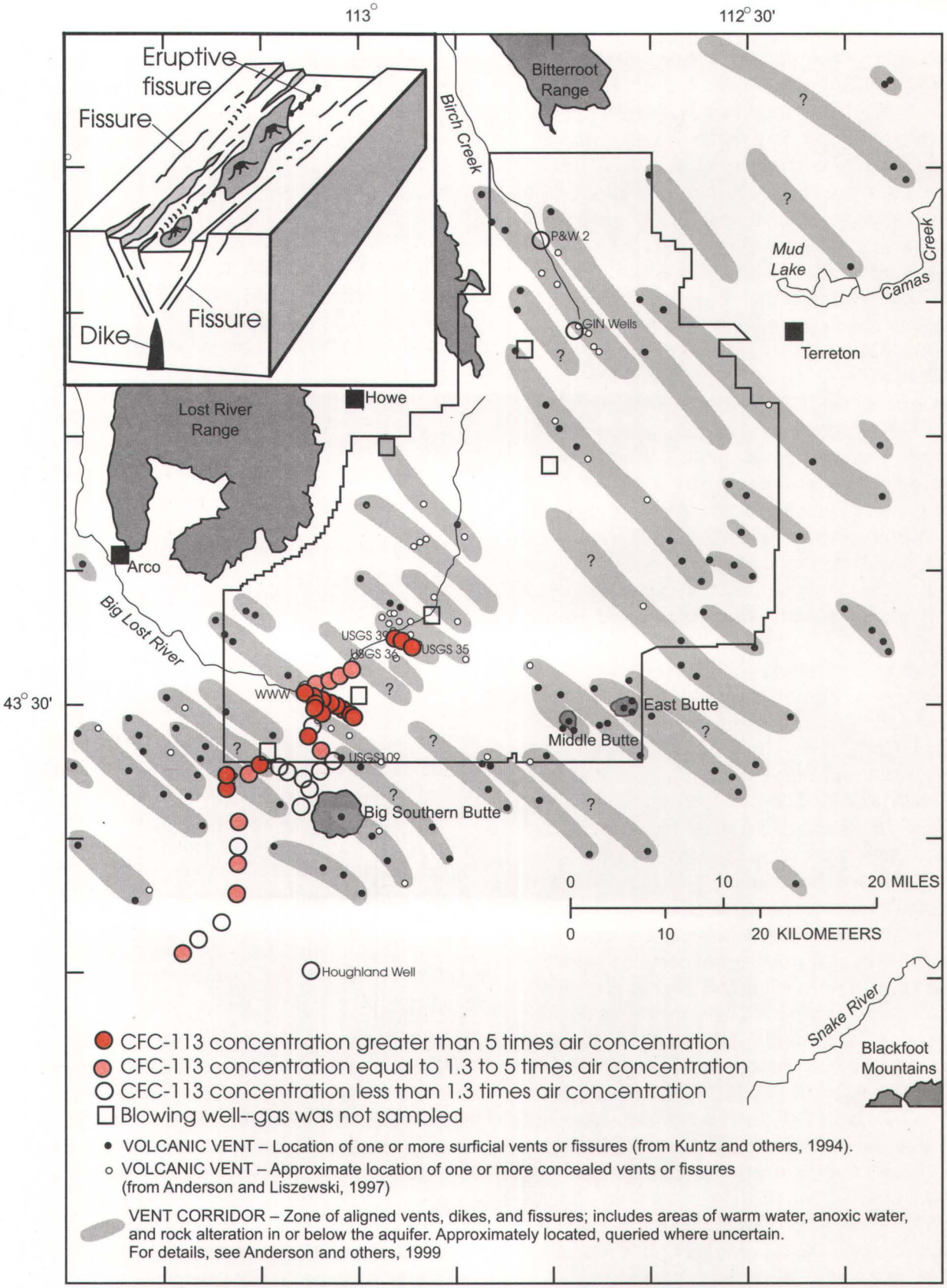


Figure 22. Distribution of chlorofluorocarbon-113 in the unsaturated zone at the Idaho National Engineering and Environmental Laboratory. Insert is a conceptual model of a vent corridor and associated fractures (Anderson and others, 1999).

The ground-water ages were calculated with the $^3H/^3He$ method for several samples from the western part of the INEEL. The ground-water samples have lower concentrations of He_{terr} than the water samples from the eastern part of the INEEL (fig. 23). For most cases, the $^3H/^3He$ age of the water was insensitive to the range of R_{terr} (2×10^{-8} to 1.48×10^{-6}) that was used in the calculation of the age (see table 8). The $^3H/^3He$ age calculated for many samples from the western part of the INEEL did not represent the age of natural recharge but rather the age of injection or the addition of contaminants into the Snake River Plain aquifer (fig. 6). Even though the $^3H/^3He$ ages are not of natural recharge, the ages can be used to determine flow velocities of ground water in the Snake River Plain aquifer. Figure 24 shows the probable location of natural and artificial recharge of the Snake River Plain aquifer and figure 25 shows the flow velocity of water in the upper part of the Snake River Plain aquifer calculated from the $^3H/^3He$ age and the probable location of recharge. The $^3H/^3He$ ages of the young fraction and the calculated flow velocities are presented in table 8.

CALCULATION OF THE FRACTION OF YOUNG WATER WITH A GEOCHEMICAL MODEL

As mentioned earlier, wells at the INEEL commonly have very large, open intervals (fig. 26) and sample ground water of different origin and ages. Because water of different origin has different chemical and isotopic compositions, the fraction of water of different origin can, in theory, be determined by geochemical modeling. NETPATH is a mass-balance geochemical model that is suitable for this purpose (Plummer and others, 1983; 1992; 1994). NETPATH can determine geochemical reactions occurring along a flowpath, the extent of the reactions, the composition of reacting phases, the isotopic evolution of C, S, hydrogen (H), O, and nitrogen (N) along the flowpath, and the ^{14}C age of the ground water. The net geochemical reactions, mass transfer, isotopic evolution, and mixing fractions were determined for water samples from the INEEL; further details of this inverse modeling approach are given by Plummer and others (1983; 1992; 1994).

The presence of CFCs, SF_6, and ^3H in ground water from the southeastern part of the INEEL indicates the presence of at least some recent recharge by surface water. All the ground water from this area conceivably could be modeled by NETPATH (Plummer and others, 1994) as mixtures of the regional background water with surface water. The model can estimate the fractions of young water in the mixtures, which are needed to calculate the age of the young water.

The ground water at USGS 101 was chosen to represent the regional background water. This ground water has virtually no ^3H and extremely low CFC concentrations (Busenberg and others, 2000). Figure 27 shows the relation between F and Sr concentrations in ground-water samples from the southeastern part of the INEEL. The figure suggests that the ground-water samples are binary mixtures of background water with high F and low Sr concentrations (USGS 101) and water with high Sr and low F concentrations. Similar figures can be constructed by plotting the concentrations of F, Li or B versus those of Mg, Ca, K, U, HCO_3^-, SO_4^{2-}. As mentioned previously, Cl, F, Li, and B concentrations are high in the regional background water that recharged northeast of the INEEL.

The chemical composition of surface water was assumed to be that of precipitation, which was considered to be the same as the 10-year average composition (1988–99) of precipitation sampled at Craters of the Moon National Monument (National Atmospheric Deposition Program/NTN, Web site) and is shown in table 5. The precipitation samples were collected in Butte County (43°27'41"N 113° 33' 17"W) at an elevation of 1,807 m at a site that is located approximately 25 km west of the INEEL. The composition of the precipitation was modified by reactions with the rocks, surficial sediments, and sedimentary interbeds. The mineralogy of the sediments and sedimentary interbeds was described by Bartholomay and others (1989), and the composition of the volcanic rocks was given by Wood and Low (1986). Constraints used to model the geochemical reactions included Ca, Mg, Na, K, Sr, aluminum (Al), silica (Si), S, F, C, and ^{13}C. The

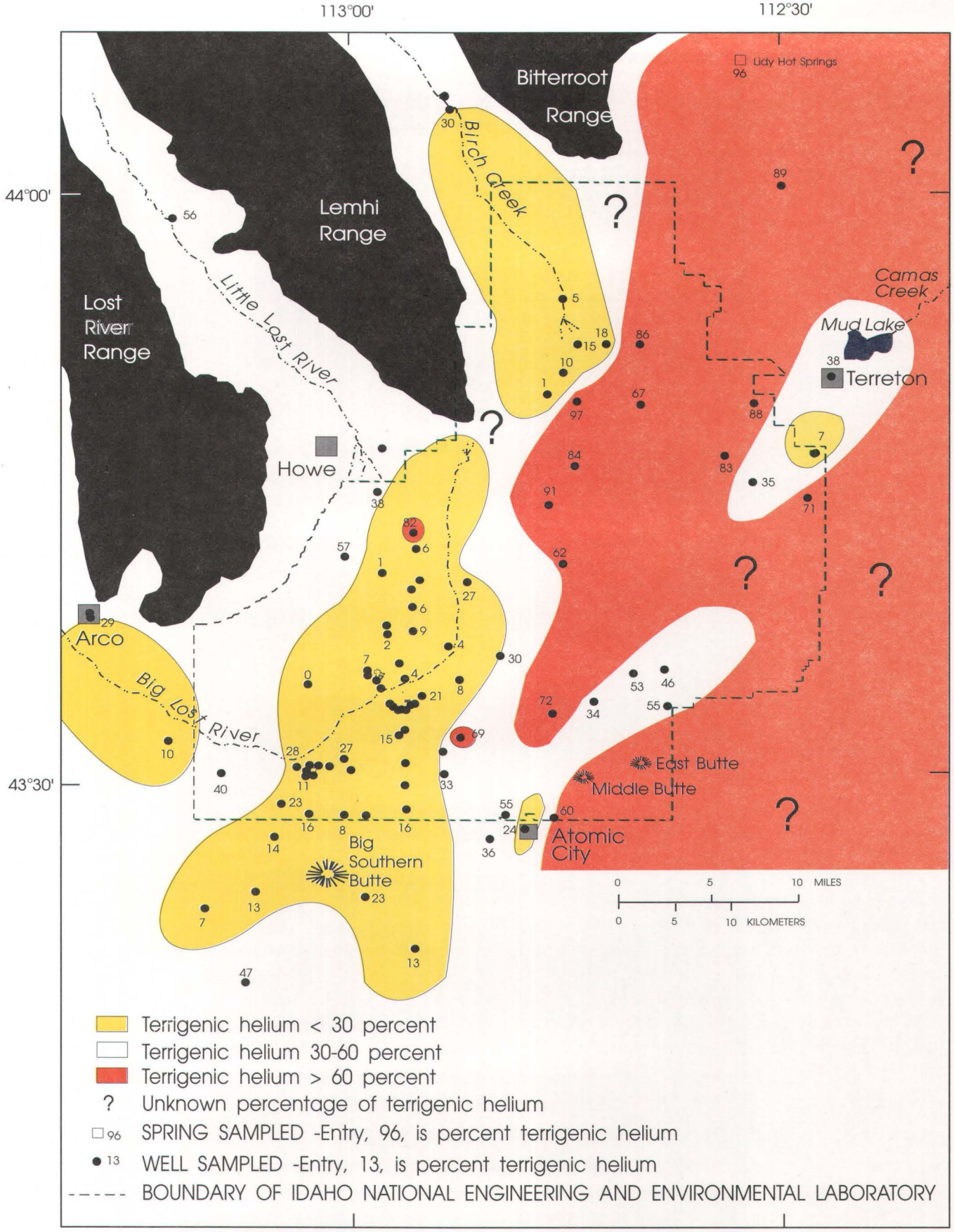


Figure 23. Percent of terrigenic helium in water from selected sites at and near the Idaho National Engineering and Environmental Laboratory, 1994-97.

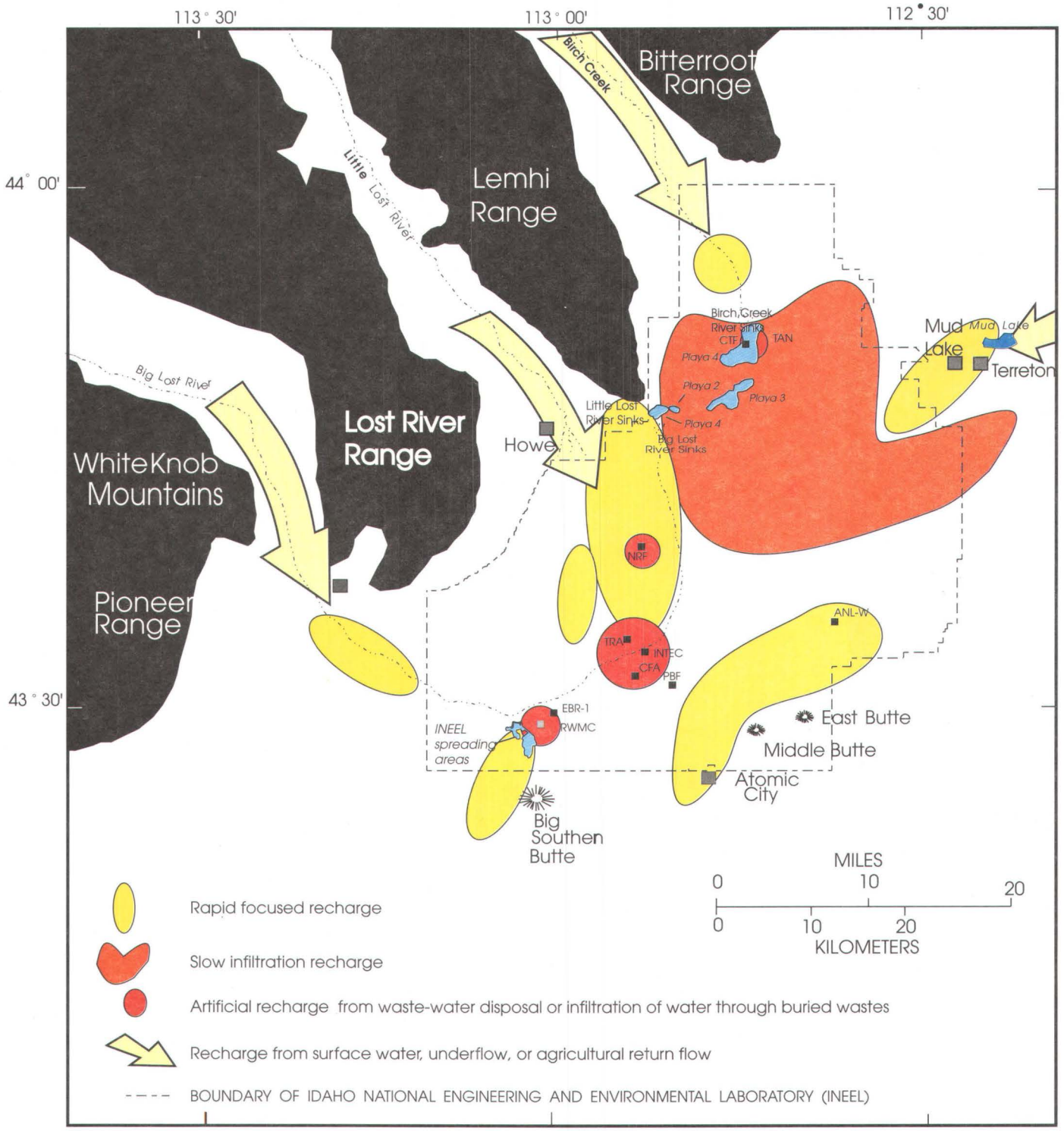


Figure 24. Location of natural and artificial recharge to the eastern Snake River Plain aquifer at and near the Idaho National Engineering and Environmental Laboratory.

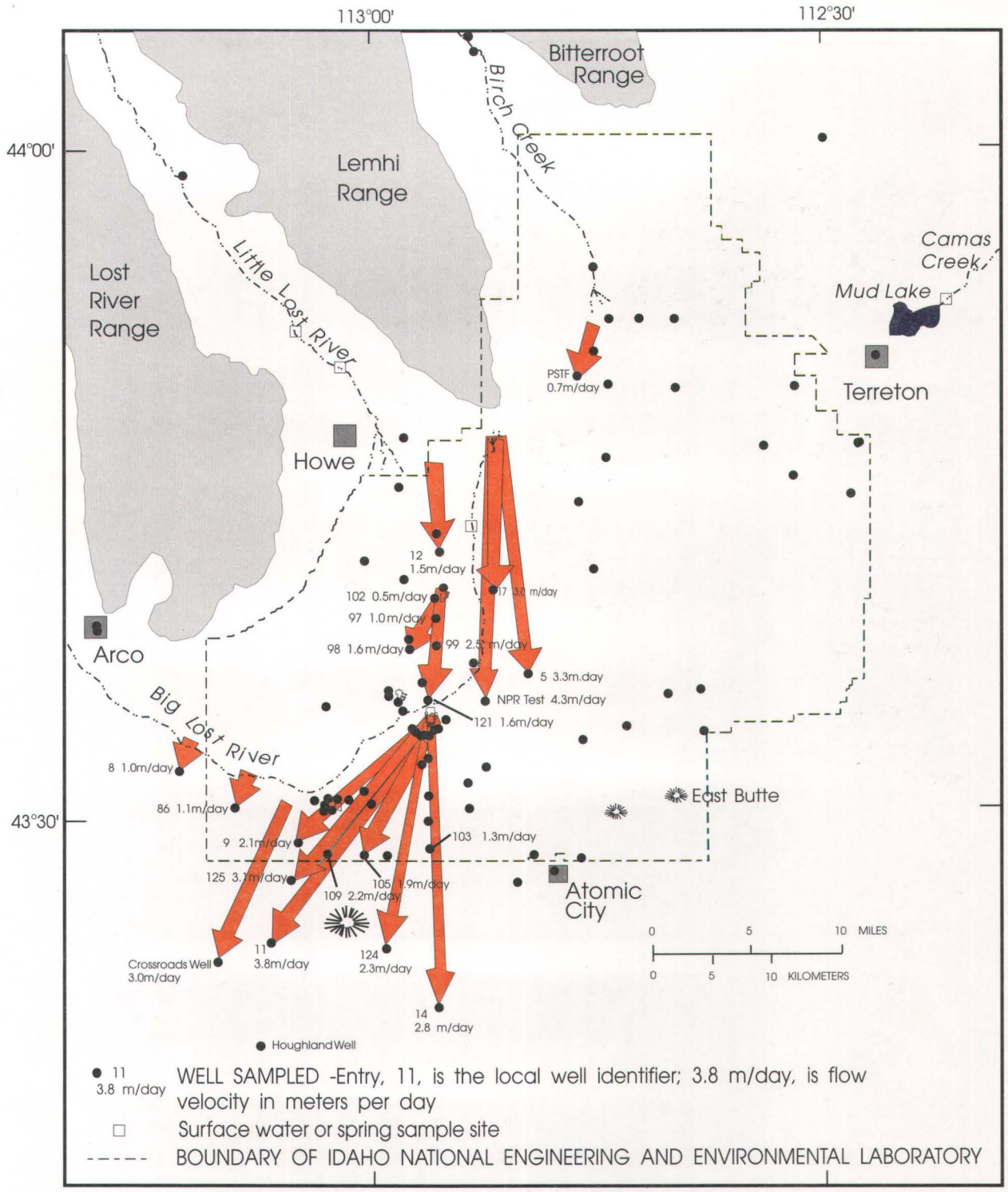


Figure 25. Flow velocity vector of ground water calculated from tritium/helium-3 ages of water from selected wells at and near the Idaho National Engineering and Environmental Laboratory.

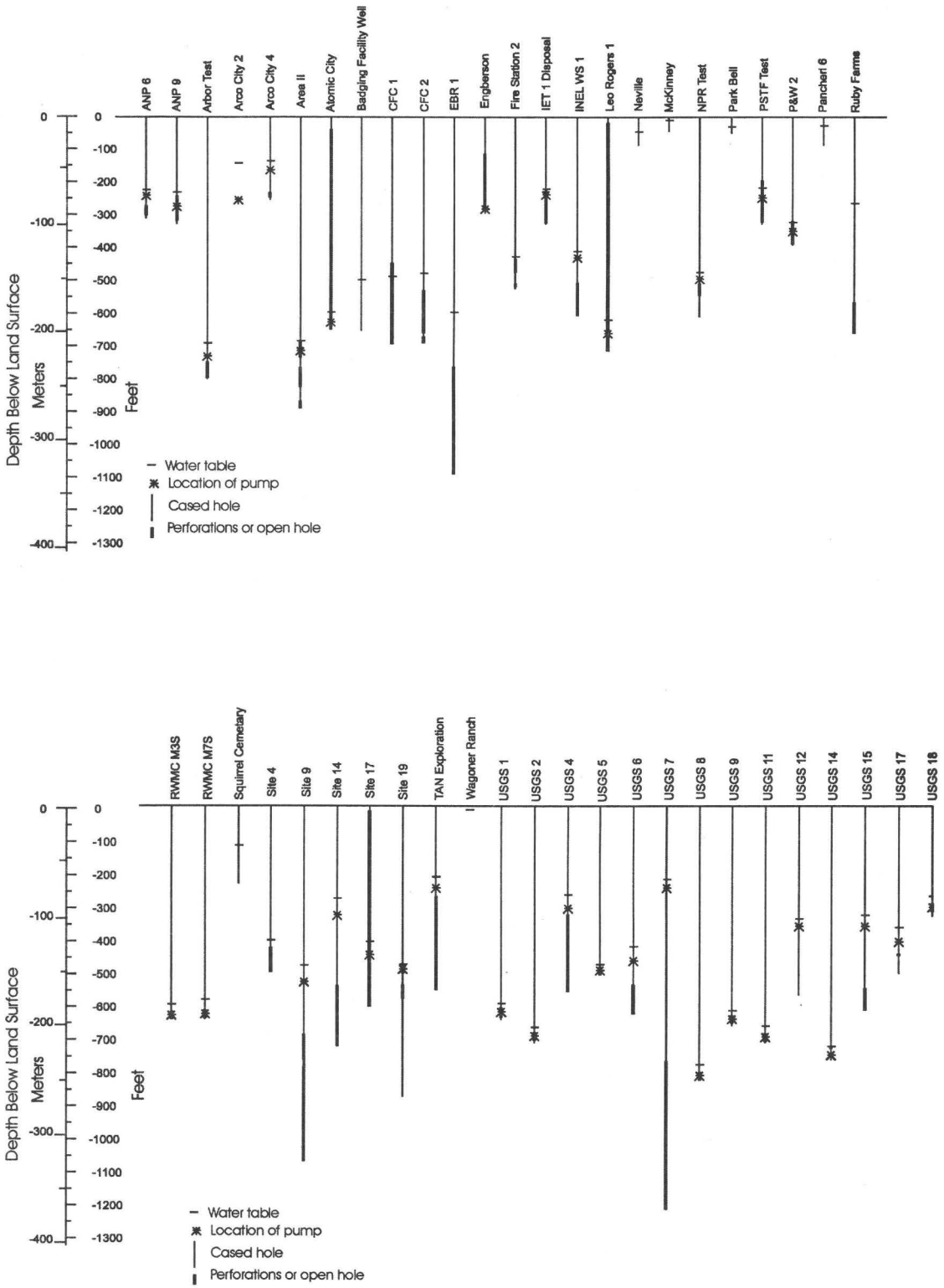


Figure 26. Well-construction data for selected wells at and near the Idaho National Engineering and Environmental Laboratory.

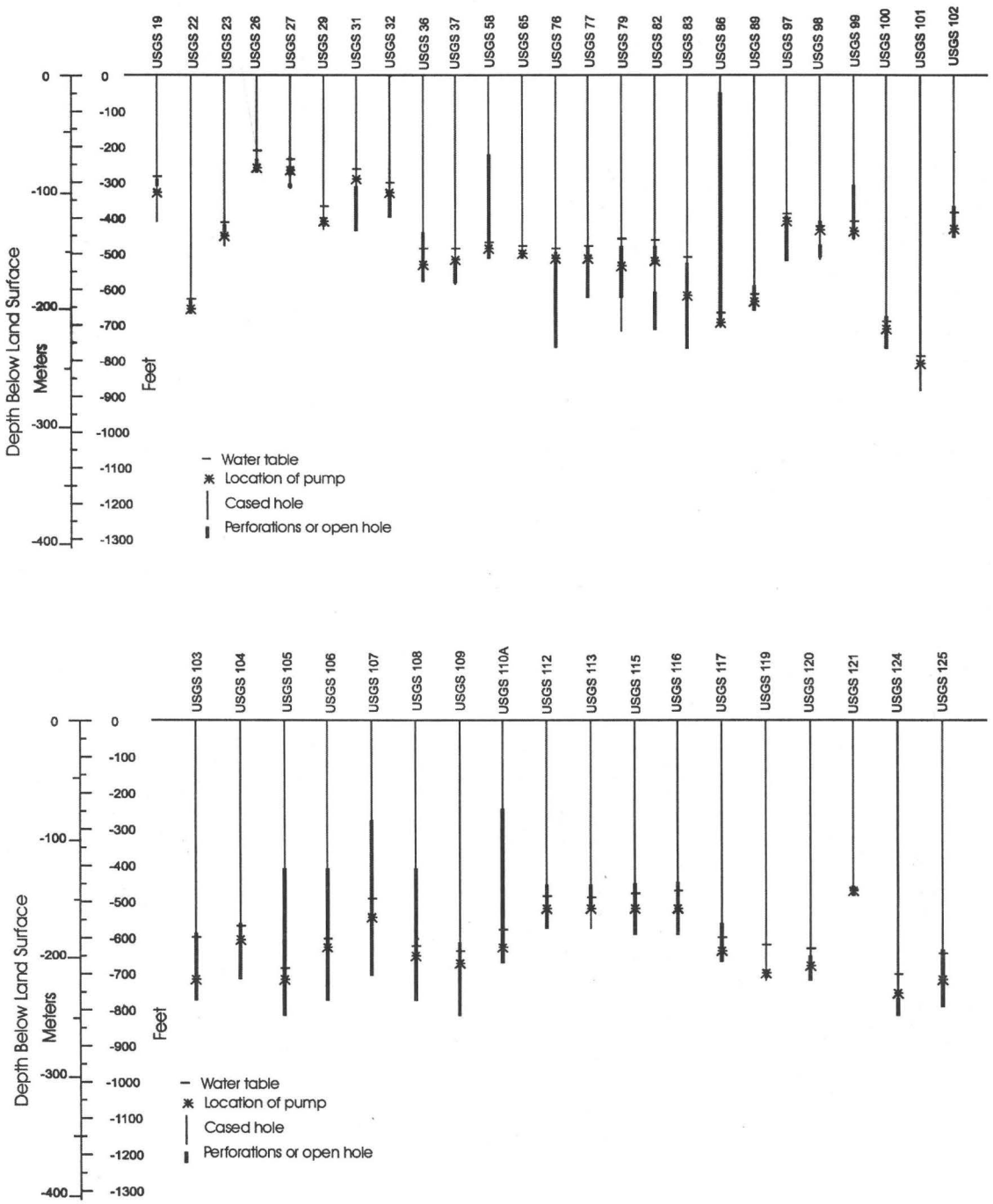


Figure 26. Well-construction data for selected wells at and near the Idaho National Engineering and Environmental Laboratory—Continued

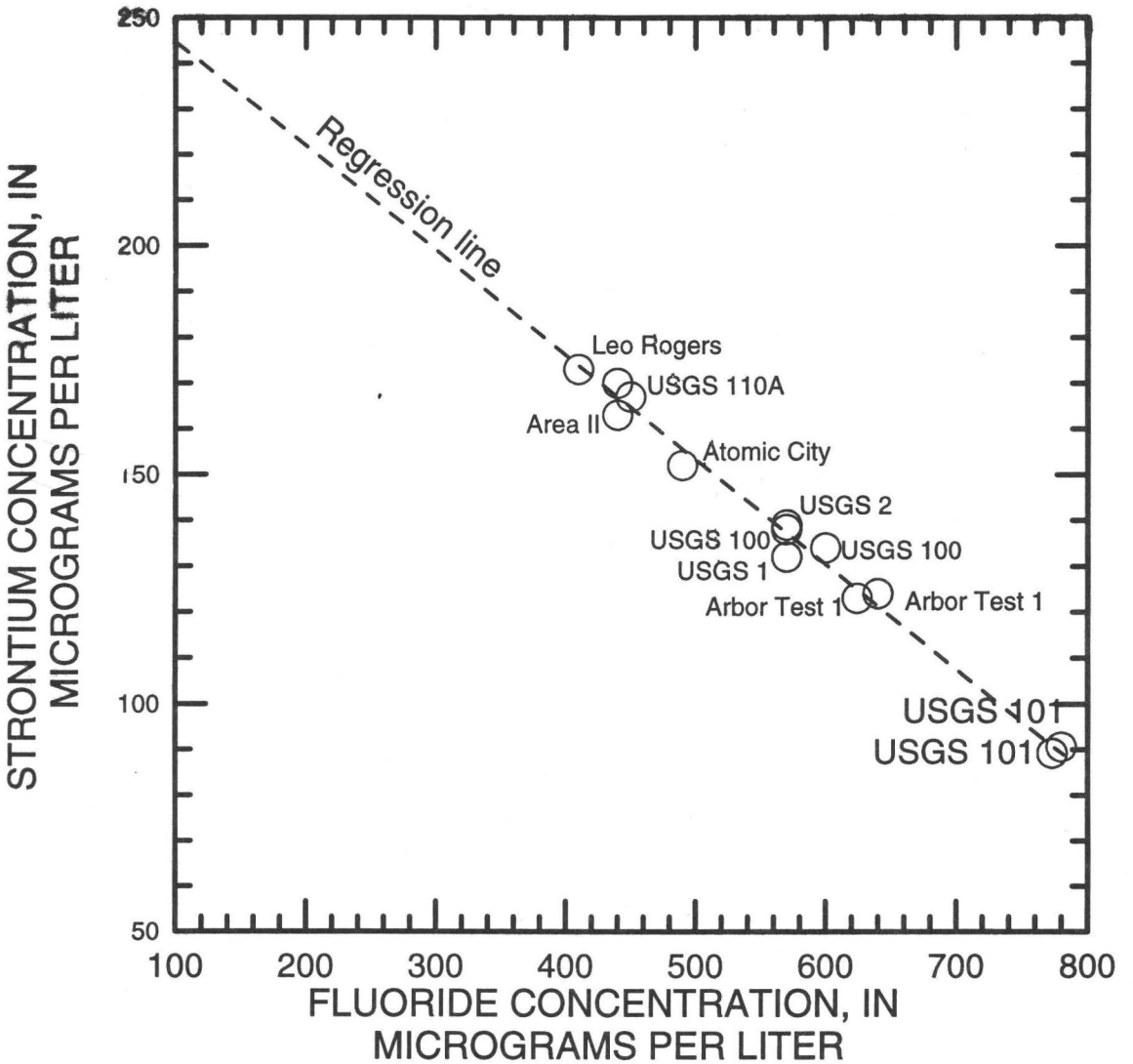


Figure 27. Relation between fluoride and strontium concentrations in water from selected wells in the southeastern part of the Idaho National Engineering and Environmental Laboratory.

reacting mineral phases required to produce the ground water included soil CO_2, olivine, K-feldspar, plagioclase, calcite, fluorite, NaCl, an amorphous phase with the composition of basalt, Fe(OH)3, gibbsite, $SiO_{2(solid)}$, and Na- and Ca-montmorillonite. All these mineral phases are present in the sedimentary and volcanic rocks. The amorphous basalt-phase was not necessary to produce the ground water of the southeastern part of the INEEL. Other crystalline silicate phases present in the basaltic rocks can be used to model the ground-water samples. The plagioclase used in the model had the same composition as the feldspars found in the basalts of the Snake River Group (Wood and Low, 1988). Wood and Low (1988) did not measure the concentrations of Sr in the feldspars; these concentrations were assumed to be similar to the Sr concentrations of other plagioclases of volcanic origin of the same composition (Deer and others, 1971). Inclusion of the Sr in the composition of the feldspar was needed to model the Sr composition in the ground water. When the mineral fluorite was not included in the reacting phases, the F concentrations defined the mixing ratio. The mixing fractions calculated with and without the inclusion of the mineral fluorite were, in all cases, nearly identical because the calculated fluorite mass transfer was very small. The geochemical model closely reproduced the ^{14}C concentrations observed in ground water from the southeastern part of the INEEL (table 6). Similar results were obtained by Schramke and others (1996) with the same isotopic ^{13}C and ^{14}C concentrations. Figure 28 is a schematic representation of the ground water in the southeastern part of the INEEL.

Even though the results appear to be very reasonable, the concentration of CO_2, the isotopic composition of the carbon ($\delta^{13}C$), and the ^{14}C concentrations of the unsaturated-zone CO_2 are uncertain. The composition of the unsaturated-zone CO_2 is extremely important because it determines the extent of reaction and ultimately the isotopic composition of the dissolved inorganic carbon of the ground water. The Area II well composition was recalculated using a range of $\delta^{13}C$ ratios of -24 to -18 permil for the soil CO_2 and ^{14}C activities of 85 to 120 pmc (table 7). In the three first sets of models the young fraction of water did not vary because the F concentrations in the water determined the fraction of mixing; however, the extent of reaction and the calculated ^{14}C concentration in the water varied considerably. In the last set of models, the F concentrations did not determine the mixing fractions; thus, the fraction of young water varied considerably. The extent of reaction and the calculated ^{14}C concentration were also highly variable. Even though many of the results were unrealistic, this sensitivity analysis shows the importance of the isotopic composition of carbon in the unsaturated zone. Data on the concentration, $\delta^{13}C$ isotopic ratio, and ^{14}C concentrations of the CO_2 in the unsaturated zone are needed to refine the geochemical modeling at the INEEL.

ESTIMATED AGES OF THE YOUNG FRACTION OF GROUND WATER SAMPLED AT AND NEAR THE IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY

The criteria used to date the young fraction in ground water from wells completed in the Snake River Plain aquifer are discussed in the above section and in Appendix 2. The results from the various models are presented in tables 1– 4, 8, and 9. Significantly different ages for the same ground-water sample were obtained with the various models presented in the tables. The estimated age of recharge can be obtained only when the model used to date the ground water is consistent with the mechanism of recharge and mixing of the ground-water sample. Different intervals and depths of the aquifer were sampled. The age determined applies to young fraction in the sample at the given depth; thus, it is often impossible to compare ages on maps. Well construction and the depth of the pump significantly influenced the age of the young fraction in the mixture and the model that was used to date the young fraction.

The results should be used with caution because most wells sample long, open or perforated intervals or several open intervals, and the water samples were often mixtures of very old regional ground water with young water that recharged in or near the INEEL. The age given in the various tables is not the average age of the sample but, in most cases, represents the age of a

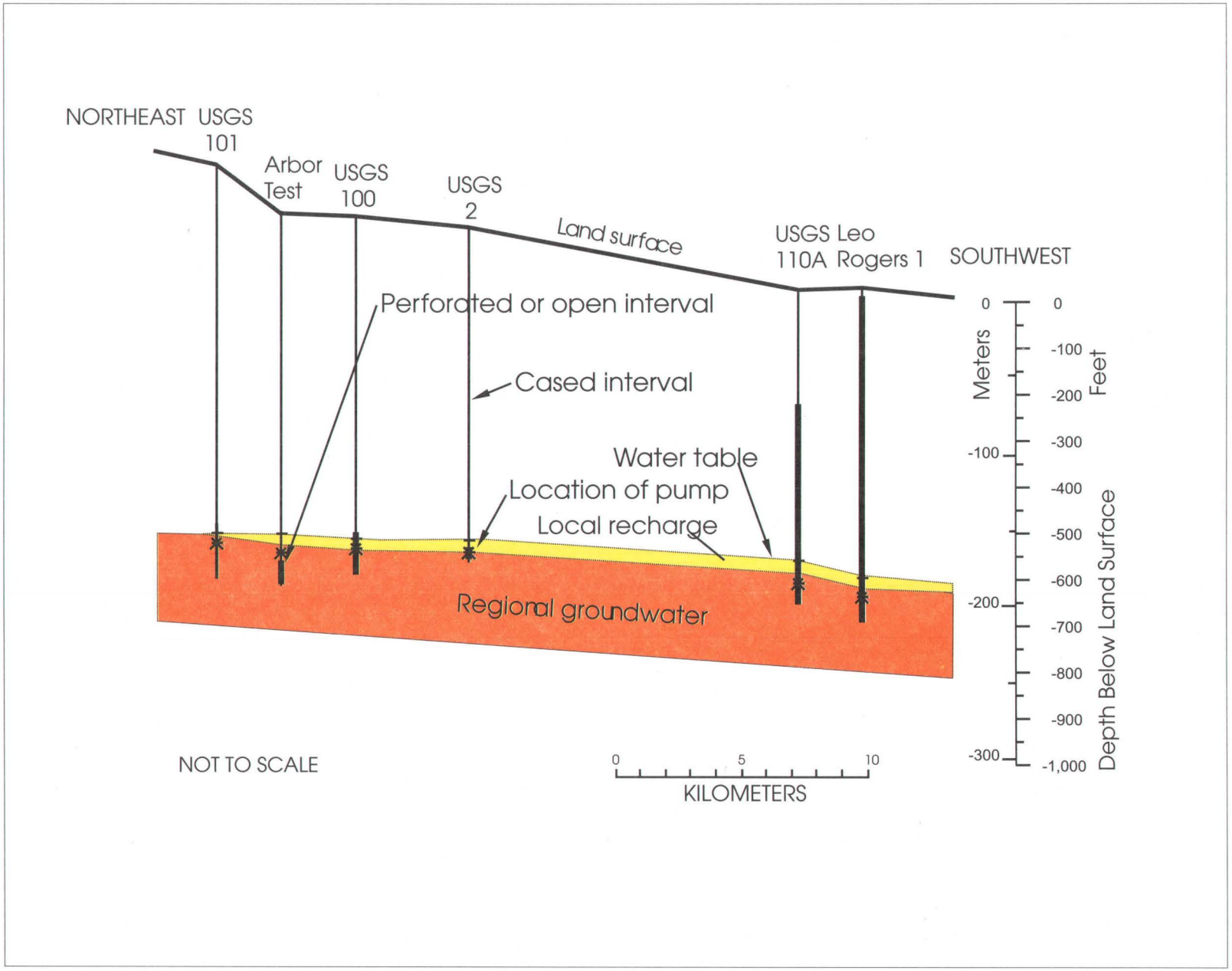


Figure 28. Ground water in selected wells in the southeastern part of the Idaho National Engineering and Environmental Laboratory and vicinity.

very small fraction of the ground-water sample (table 4). The age of the young fraction for the wells sampled is summarized in table 9. Table 9 gives the estimated age of the young fraction in the wells sampled in this and a previous study (Busenberg and others, 1993). The model-1 ages from Busenberg and others (1993) were recalculated from the concentrations of CFC-11 and CFC-12 using models 1 and 2 along with more accurate recharge temperatures (table 9).

Results of this study are summarized in table 9 and figure 24. The terrigenic He concentrations (fig. 23), combined with the CFC concentrations (fig. 7, 8, and 9), ^3H concentrations (fig. 6), Li concentrations (fig. 3), and isotope data were used to identify the mechanism of recharge, the fraction of young water, and the age of the young fraction in many of the ground-water samples. Episodic focused recharge is characterized by small He_{terr} and the presence of natural ^3H and CFCs. Focused recharge occurs in the northeastern part of the INEEL in the Terreton-Mud Lake area, in the southeastern part of the INEEL, in the northern part of the INEEL in the vicinity of P&W 2, in the central part of the INEEL, in the western part of the INEEL in the vicinity of USGS 22, southeast of Arco, and south of the INEEL spreading areas. Diffuse recharge was recognized and is characterized by moderate to large He_{terr}, the presence of CFCs, and absence of ^3H. Diffuse recharge occurs in an extensive area covered by thick sediments in the northern and northeastern part of the INEEL. He_{terr} is very small in the ground water in the central part of the INEEL and is smaller than concentrations of He_{terr} in the underflow of the Big Lost and Little Lost Rivers, indicating significant surface-water recharge. The following is a general description of the estimated ages of the young fraction of ground water based on recharge mechanisms in general parts of the INEEL. Because of the complexity of the INEEL, the site was divided into the general parts where the sources of recharge and modes of recharge were thought to be similar (fig. 2 and 24); each of the six areas was evaluated separately. Well-construction data for all the wells can be found in Busenberg and others (1998) and are shown in figure 26.

Age of the Young Fraction of Ground Water Recharged in the Southeastern Part of the Idaho National Engineering and Environmental Laboratory

Water from nine wells (Arbor Test 1, Area II, Atomic City, Leo Rogers 1, USGS 1, 2, 100, 101, 110A) from the southeastern part of the INEEL was considered together because of similar isotopic, chemical, and dissolved-gas composition. The water in samples from these wells appeared to be a binary mixture of local recharge and very old regional ground water (fig. 27). These samples were discussed in some detail in previous sections of this report. The concentrations of ^4He were moderately large (5.2×10^{-8} to 1.55×10^{-7} cm^3 STP per g of water), and the $^3He/^4He$ ratio (1.385×10^{-6} to 1.391×10^{-6}) was significantly larger than the terrigenic ratio of 1 to 2×10^{-8}. The age of the young fraction was determined by using the $^3H/^3He$ method, ratios of environmental tracers, and CFC concentrations that were corrected for dilution of the young fraction with old, tracer-free water. A detailed discussion of procedures used to date ground-water samples from the nine wells is in Appendix 2. The estimated age of the young fraction of water in the samples is given in table 9. Samples from most of the wells appeared to contain about 20 to 50 percent young water that was about 14 to 21 years old.

Age of the Young Fraction of Ground Water Recharged in the Northern Part of the Idaho National Engineering and Environmental Laboratory

Two main mechanisms of recharge of the young fraction of ground water were recognized in samples from 12 wells (ANP 6, ANP 9, IET Disp., PSTF Test, P&W 2, Site 14, TAN Exploration, USGS 5, 6, 7, 18, 26) in the northern part of the INEEL (fig. 2 and 24). Water recharged by rapid, focused recharge through the thick, unsaturated zone and water recharged by slow infiltration through the thick, unsaturated zone. The first type of water contained small He concentrations and could be dated by using the $^3H/^3He$ method. The second type of water contained He_{terr} concentrations of larger than 60 percent (fig. 23), virtually no ^3H, and detectable concentrations of CFCs that

indicated old regional water that recharged in the past few years. IET Disp. water has been contaminated and could not be dated. Some of the wells consisted of all old regional water. A more detailed discussion of the water samples from wells in the northern part of the INEEL is presented in Appendix 2 and a summary of the estimated ages of the young fraction is given in table 9.

Age of the Young Fraction of Ground Water Recharged in the Northeastern Part of the Idaho National Engineering and Environmental Laboratory

The two main mechanisms of recharge of the young fraction of ground-water samples from five wells (USGS 4, 27, 29, 31, 32) in the northeastern part of the INEEL (fig. 24) were (1) rapid, focused recharge from water that was strongly affected by agricultural practices, contained small concentrations of He, and likely was recharged in the Terreton-Mud Lake area; and (2) water recharged by slow infiltration through the thick, unsaturated zone. The first water type was present in wells 4, 27, and 29 and had estimated ages of 5, 10 to 13, and 24 to 28 years, respectively. The second type of water was a mixture of regional ground water with infiltration water and contained large He concentrations, virtually no ^{3}H, and detectable concentrations of CFCs. This water type was present in wells 31 and 32 and the age of the recharge was estimated to be 11 to 13 years and 5 years, respectively. A more detailed discussion of the water samples from wells of the northeastern part of the INEEL is presented in Appendix 2 and a summary of the estimated ages of the young fraction is given in table 9.

Age of the Young Fraction of Ground Water Recharged in the Central Part of the Idaho National Engineering and Environmental Laboratory

Water samples from 48 wells (Appendix 2) that contained a young fraction of water that recharged in the central part of the INEEL were complex mixtures of regional ground water, agricultural return flow, natural recharge, and artificial recharge from infiltration ponds and injection wells at INEEL facilities (fig. 24). The chemistry and age of the samples varied greatly and could be correlated with distance from the source of recharge, depth of the open interval below the water table, length of the interval sampled, and location of the well with respect to the different sources of recharge. Age increased with distance from the source of recharge and with depth below the water table. Total He concentrations in samples were, with a few exceptions, small and characteristic of recent recharge. The principal exception was water from USGS 15, which is located near the northern boundary of this area (fig. 2). Small total He concentrations were present in the samples from the southern boundary of this area (fig. 12), even at a significant depth below the water table. The He data and the He_{terr} concentrations (fig. 23) indicated that a significant thickness of the aquifer was recharged within the past hundred years and the ground water was not thousands of years old. Many of the samples from this area contained much larger than background concentrations of ^{3}H, which had been discharged into infiltration ponds or injection wells upgradient from these wells. The $^{3}H/^{3}He$ ages of these samples were used to calculate flow velocities of the ground water in the aquifer. A more detailed discussion of the water samples from wells of the central part of the INEEL is presented in Appendix 2 and a summary of the estimated ages of the young fraction is given in table 9.

Age of the Young Fraction of Ground Water Recharged in the Western Part of the Idaho National Engineering and Environmental Laboratory

Two significantly different ground-water compositions were recognized in three wells (USGS 22, 23, 89) in the western part of the INEEL (fig. 2 and 24). USGS 23, located in the northern part of the area (fig. 2), is completed near the water table but contained the smallest ^{14}C concentration (22 pmc) of any of the samples from the INEEL. The sample from USGS 23 also contained a large concentration of terrigenic He (57 percent), heavy $\delta^{13}C$ ratios, and light $\delta^{18}O$ isotopic ratios, and in many respects was similar to the regional ground-water samples from the northern and the northeastern part of the INEEL. The CFC concentrations indicated contact and significant exchange

of gases between old, regional water and the unsaturated-zone atmosphere. The chemistry and the isotopic composition of the water suggested that the recharge water may have been derived from the Lost River Range and was not surface water from the Little Lost River.

The water samples from the other two wells (USGS 22 and 89) contained a large percentage of water from precipitation that had been greatly modified by evapotranspiration (large Cl and small NO_3- concentrations). The alkalinity of the samples was lower than that of the Big Lost River or the other ground-water samples from the western and central parts of the INEEL. The $\delta^{13}C$ ratio of the dissolved inorganic carbon was light, which indicated that the water was not derived from the dissolution of marine carbonate rocks but, rather, from the reaction of isotopically light soil CO_2 with silicate volcanic rocks (fig. 29). A more detailed discussion of water samples from the wells in the western part of the INEEL is presented in Appendix 2 and a summary of the estimated ages of the young fraction is given in table 9.

Age of the Young Fraction of Ground Water Recharged in the Southwestern Part of the Idaho National Engineering and Environmental Laboratory

The water sample from USGS 8 contained large concentrations of alkalinity, Sr (fig. 5), and ^3H, small concentrations of He_{terr} (10 percent), and a chemical composition similar to that of water from the Big Lost River. This sample probably was local recharge from the Big Lost River. Water from USGS 8 was similar in chemical composition to water from the Arco City Well 4 (He_{terr} of 29 percent), which was probably a mixture of Big Lost River underflow and local recharge from the Big Lost River. The estimated age of the young fraction was about 9 years (table 9). The He_{terr} concentration in water from USGS 86 was larger (40 percent) and the ^3H concentration was smaller (0.9 TU) than water from USGS 8, which indicated that the water sample contained a very small percentage of Big Lost River water but probably a large fraction of underflow. The age of the young fraction was uncertain (table 9). A more detailed discussion of the water samples from the wells in the southwestern part of the INEEL is presented in Appendix 2, and a summary of the estimated ages of the young fraction is given in table 9.

COMPARISON OF RESULTS OF THIS STUDY WITH OTHER PUBLISHED STUDIES

The results from a study of in situ transport and ground-water flows at the INEEL derived from U and Th decay-series disequilibrium (Luo and others, 2000) are in general agreement with the results of this study for the INEEL; however, the residence times calculated by Luo and others (2000) for some of their wells at the INEEL are inconsistent with the results obtained in this study. The ground-water residence time of 0.6 years calculated by Luo and others (2000) for the ANP-6 well is inconsistent with the ^3H concentration of 1.0 and 0.5 TU for the 1994 and 1996 samples, the ^{14}C activity of 30.9 pmc, and the CFC concentrations in this well. This well does not contain a significant fraction of young water; our study indicates that some recharge occurred in the past 20 to 30 years with pre-nuclear atmospheric testing infiltration water. The residence time of 9.4 years for USGS 18 calculated by Luo and others (2000) is inconsistent with the very small ^3H concentrations of 0.17±0.15 and 0.09±0.26 for the 1994 and 1995 samples, small ^{14}C activity of 20.6 pmc, but a large excess of radiogenic ^4He of 29×10^{-8} cc STP/g of water, which is more than 6 times the He air-water equilibrium concentration, and a He_{terr} concentration of 86 percent. These data suggest that the ground water is old but may contain a small fraction of local infiltration recharge (<5 percent), which also is indicated by the low concentrations of CFCs. Other inconsistencies are USGS 19 and USGS 22; both of these wells were dated with $^3H/^3He$. The calculated ground-water ages in this study are 15 and 8 years for USGS 19 and USGS 22, respectively. Residence times of 0.4 (USGS 19) and 67 (USGS 22) years were reported for the samples from U and Th decay-series disequilibrium (Luo and others, 2000). The 67-year residence time for the ground-water sample from USGS 22 is highly unlikely because this water was recharged within the INEEL (He_{terr} of 0 percent) and contains large concentrations of both ^3H and CFCs (Busenberg and others, 2000).

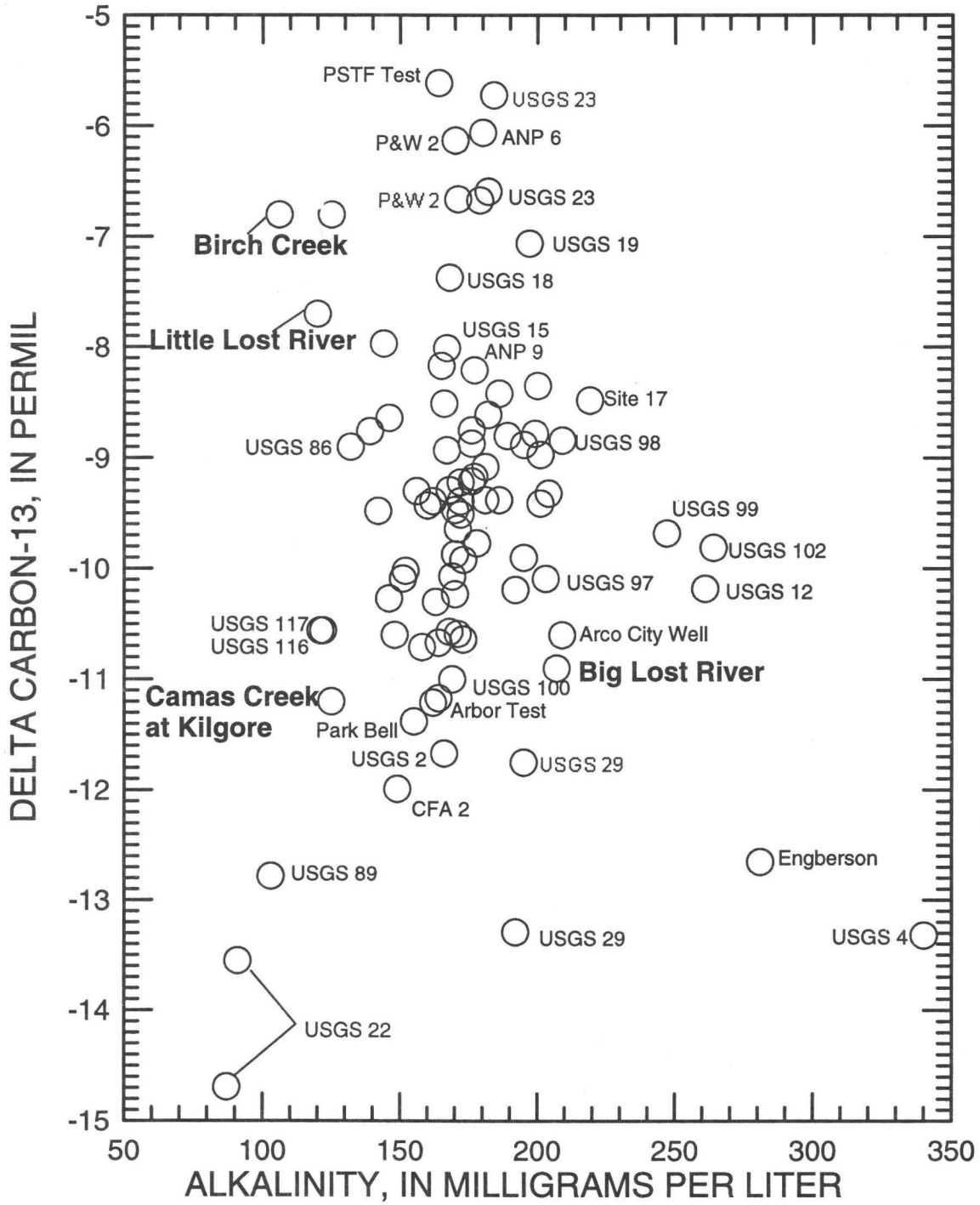


Figure 29. Relation between alkalinity and delta carbon-13 in the dissolved inorganic carbon of water from selected samples at and near the Idaho National Engineering and Environmental Laboratory.

The preferential flowpath through the central part of the INEEL, as defined by Luo and others (2000) from the U and Th decay-series disequilibrium and by Johnson and others (2000) with $^{87}Sr/^{86}Sr$ isotopes, is consistent with the results of this study using transient environmental tracers and the He_{terr} concentrations. Recently, Cecil and others (2000), confirmed the presence of the preferential flowpath using ^{36}Cl, and their 1-D data suggest a small dispersivity of 5 m instead of 90 m that was used by Robertson and others (1974).

SUMMARY AND CONCLUSIONS

Ground water from the Snake River Plain aquifer at and near the INEEL was dated with CFCs, SF_6, and with $^3H/^3He$. These environmental transient tracers were introduced into the Snake River Plain aquifer by natural recharge, return flow of irrigation water, and the disposal of wastewater at INEEL facilities. The young fraction of ground water recharged the Snake River Plain aquifer at various locations within and outside the INEEL boundaries.

Data indicate that the water in samples from wells in the southeastern part of the INEEL appears to be a binary mixture of local recharge and very old, regional ground water, and samples from most of the wells are about 20 to 50 percent young water that is about 14 to 21 years old. Two main mechanisms of recharge of the young fraction of ground water were recognized in samples from the northern part of the INEEL. Water recharged by rapid, focused recharge through the thick, unsaturated zone, and water recharged by slow infiltration through the thick, unsaturated zone. Some of the wells in the northern part of the INEEL consisted of only old, regional water. Three wells in the northeastern part of the INEEL contained water that was strongly affected by agricultural practices and was likely recharged in the Terreton-Mud Lake area. This water was present in wells 4, 27, and 29 and had estimated ages of 5, 10 to 13, and 24 to 28 years, respectively.

Water samples from wells that contained a young fraction of water that recharged in the central, western, and southwestern parts of the INEEL are complex mixtures of regional ground water, agricultural return flow, natural recharge, and artificial recharge from infiltration ponds and injection wells at the various facilities at the INEEL. The chemistry and age of the young fraction of the ground-water samples varied greatly and could be correlated with distance from the source of recharge, depth of the open interval below the water table, length of the interval sampled, and location of the well with respect to the different sources of recharge. Age increased with distance from the source of recharge and increased with depth below the water table.

Concentrations of F, B, Li, Sr, N_2, Ar, O_2, He, $\delta^{18}O$, and ^3H were used to determine the sources of water in the Snake River Plain aquifer at and near the INEEL. Three natural ground-water types were identified from their He, Li, and F concentrations: (1) northeastern regional water with very high He, Li, and F concentrations; (2) recharge from the southeast with moderate He and high Li and F concentrations; (3) recharge from mountain valleys in the western part of the INEEL with low concentrations of He and Li and high concentrations of Ca, Mg, and alkalinity. The water was modified locally by mixing with agricultural runoff and wastewater from INEEL facilities. $\delta^{18}O$ ratios were used to calculate the fraction of young water in the samples from the western part of the INEEL. He_{terr} together with ^3H concentrations were used to calculate the fraction of infiltration recharge in the eastern part of the INEEL.

Recharge temperatures were calculated from N_2 and Ar concentrations for many of the ground-water samples and are useful indicators of the source of water in the Snake River Plain aquifer at the INEEL. Recharge temperatures of about 6°C characterize underflow from Birch and Camas Creeks and Little Lost and Big Lost Rivers. Recharge temperatures of 9 to 13 °C were calculated for the regional ground water of the Snake River Plain aquifer at the INEEL.

The young recharge water composes a very small fraction of the total volume of water in the Snake River Plain aquifer, and this young water was sampled because most of the wells at and near the INEEL are completed in the upper 15 m of the aquifer. Recharge by dispersed infiltration, rapid, focused recharge along flowpaths, and an intermediate mechanism of recharge were

recognized at the INEEL. Significant amounts of infiltration water were recognized in some wells in the northern and northeastern parts of the INEEL. These wells are located in areas covered by extensive playa deposits and sedimentary deposits from ancestral Lake Terreton. The infiltration recharge contained large concentrations of CFCs and SF_6 but virtually no ^3H. The absence of ^3H indicates that the atmospheric thermonuclear ^3H peak probably did not reach the water table. Diffusion is the primary mechanism of transport of trace gases through the unsaturated zone. Rapid, focused recharge along preferential flowpaths was recognized in the northern, northeastern, and the southeastern parts of the INEEL. Water samples from these areas contained both CFCs and ^3H, and many were binary mixtures of very old, regional ground water and young recharge. There appears to be little or no exchange of gases between the recharge and the unsaturated-zone atmosphere in the northern, northeastern, and southeastern parts of the INEEL. In the intermediate type of recharge, the transport of water through the unsaturated zone takes from months to a few years, and some exchange of gases occurs between the recharge water and the unsaturated-zone atmosphere. This type of recharge is less common at the INEEL.

Ground water of the Snake River Plain aquifer at the INEEL is stratified, and the ground-water age increases with depth, as indicated by decreasing ^{14}C concentrations and increasing ^4He concentrations with depth. Environmental transient tracers were present only at or near the water table, except where they were directly introduced into the aquifer through injection wells.

A preferential ground-water flowpath was identified that extends from the Little Lost River and Big Lost River Sinks southward through central INEEL past Big Southern Butte. Flow velocities of about 3 m/day were typical in the preferential flowpath but decreased to about 1 m/day for the rest of the INEEL.

Extensive contamination of the unsaturated zone with volatile organic halocarbons in the southwestern part of the INEEL was recognized. Larger-than atmospheric concentrations of CFC-113 were detected up to 20 km south of the INEEL boundary. The distribution of contamination in the unsaturated zone is highly anisotropic, and fissures associated with eruptive vent corridors may have facilitated the advective transport of volatile organic halocarbons both laterally and vertically. Although the fractures strike perpendicular to the direction of ground-water flow, these fissures are not barriers to water flow.

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Appendix 1. Dissolved gas and isotopic methods used to determine the source of the young fraction of ground water at the INEEL

Introduction

Gases dissolve in water in contact with the atmosphere or unsaturated-zone air. Dissolved gases can provide important clues to the source of ground water and the temperature, elevation, and mechanism of recharge. Dissolved gases also can be used to identify the processes that alter the concentrations of environmental tracers in the aquifer and to provide important clues to the geochemical evolution of the ground water. Many factors control the solubility of gases in ground water and are discussed in detail in this appendix. Isotopes of ^{14}C, ^{2}H, ^{18}O, and ^{13}C, which also can be used to determine sources of ground water and their concentrations in wells at the INEEL, are discussed in this appendix.

Effect of Elevation on Dissolved-Gas Concentrations

Dissolved-gas concentrations depend on barometric pressure. Barometric pressure decreases as elevation increases. Because the sum of the partial pressure of all gases in air is equal to the barometric pressure, the partial pressure of gases also decreases as elevation increases. The effect of elevation on barometric pressure was described by the equation of List (1949)

$$\ln P = \frac{-H}{8300}, \qquad (4)$$

where P is the barometric pressure in atmospheres, and H is the elevation in meters.

Effect of Elevation on Recharge Temperatures Calculated from Gas Concentrations

Air temperature decreases as elevation increases. For the Standard Atmosphere, the rate of cooling was assumed to be 0.0065 °C for every meter of elevation (Committee on Extension to the Standard Atmosphere, 1976); however, local climatic factors can affect the rate of change of air temperature with elevation.

The difference between the barometric and elevation-temperature effects of Ne and He can be used to estimate the recharge elevation and the recharge temperature by using the N_2, Ar, and Ne concentrations (Aeschbach-Hertig and others, 1999; Ballentine and Hall, 1999). Theoretically, it is advantageous to use N_2, Ar, and He in combination because of the smaller change in solubility of He with changes in temperature. However, the He in ground water at the INEEL is derived from air-water equilibrium, excess air, and radiogenic sources, the latter of which cannot be quantified.

Recharge Temperature

In principle, the recharge temperature can be calculated from the concentration of N_2, Ar, or other noble gases on the basis of Henry's law and the assumption that these gases were equilibrated with the atmosphere at the temperature at which recharge water became isolated from the atmosphere. Concentrations of dissolved N_2 and Ar are useful in determining recharge temperatures because their solubilities vary significantly as a function of temperature (Weiss, 1970). He and Ne are less useful because of their small variations in solubility with temperature (Wilhelm and others, 1977).

Henry's law describes the concentration of gases in water in equilibrium with air:

$$\log K_{i,T} = \frac{C_i}{p_i}, \qquad (5)$$

where the subscripts i and T represent the gas i at temperature T, respectively. K is Henry's law constant in moles per atmospheres, C_i is the concentration of the gas in solution in moles per kilogram of water, and P_i is the partial pressure of the gas in air in atmospheres.

Where the unsaturated zone is more than a few meters thick, the recharge temperature is usually within about 1 °C of the mean annual surface-soil temperature (Mazor, 1972; Andrews and Lee, 1979; Herzberg and Mazor, 1979; Heaton and Vogel, 1981; Stute and Schlosser, 1999). In the

contiguous U.S., the mean annual surface-soil temperature is within 1±1 °C of the mean annual air temperature (Smith and others, 1964; Toy and others, 1978); however, larger temperature differences in deserts and snow-covered areas have been reported (Stute and Schlosser, 1999). Where the unsaturated zone is less than 1 to 2 m thick, the unsaturated-zone temperature responds to seasonal variations in soil temperature (Matthess, 1982). In such instances, the episodic recharge to the ground water may reflect the temperature of the unsaturated zone at the water table rather than the mean annual surface-soil temperature (Sugisaki, 1961; Stute and Schlosser, 1999). Gas concentrations in water recharging aquifers through sinkholes or from losing streams often reflect the water temperature during recharge rather than the mean annual surface-soil temperature (Sugisaki, 1961; Plummer and others, 1998a; 1998b). Many other factors, including vegetation cover, can significantly affect the recharge temperatures calculated from gas concentrations (Stute and Sonntag, 1992).

Recharge temperatures calculated from N_2/Ar concentrations in ground water at and near the INEEL are shown in figure 30. The average recharge temperature from 108 analyses of ground-water samples from the Snake River Plain aquifer at and near the INEEL was 9.9±2.5 °C. In 1987, the temperature of undisturbed soil near the Radioactive Waste Management Complex (RWMC) was measured at a depth of 5 m; the monthly average range was 7.6 to 10.5 °C, and the mean annual soil temperature was 9.0 °C (Davis and Pittman, 1990; Pittman, 1995). Recharge temperatures calculated from N_2 and Ar concentrations for many of the ground-water samples are useful indicators of the source of water in the Snake River Plain aquifer at the INEEL. Recharge temperatures of about 6 °C characterize underflow from Birch and Camas Creeks and Little Lost and Big Lost Rivers. Recharge temperatures of 9 to 13 °C were calculated for the regional ground water of the Snake River Plain aquifer at the INEEL.

Excess Air

Detailed studies of N_2 and noble gas solubilities have shown that air bubbles can be transported into the saturated zone and that the bubbles eventually dissolve because of the hydrostatic pressure, resulting in excess air (Heaton, 1981; Heaton and Vogel, 1981; Andrews and others, 1985; Stute and Schlosser, 1993; Wilson and McNeill, 1997; Aeschbach-Hertig and others, 1999; Ballentine and Hall, 1999; Stute and Schlosser, 1999). The amount of excess air introduced into ground water was determined by the physical nature of the capillary fringe just above the saturated zone. The formation of bubbles and their entrapment is favored in fine-grained sediments and by some flow conditions in fractured rocks, but bubbles are less likely to form in coarse sediments or in rocks with wide joints (Heaton, 1981; Heaton and Vogel, 1981; Andrews and others, 1989). Heaton and Vogel (1981) have shown that climate also can affect the amount of excess air introduced into ground water. Occasional significant rainstorms in semiarid areas cause a rapid rise in the water table and the entrapment of air bubbles, resulting in large amounts of excess air (Heaton and Vogel, 1981). The presence of excess air in samples was easily identified because the N_2/Ar ratios in air and the N_2/Ar concentration ratios in solution that were in equilibrium with air were about 80 and 30, respectively. Busenberg and others (1993) evaluated recharge temperatures and excess air in samples collected at nine wells at and near the INEEL and concluded that excess air did not exceed 5 cm^3/kg in any of the samples and that the recharge temperature was adequately represented by the mean annual temperature of 10 °C.

The gas concentration in water can be modified by gas exchange between the water at the water table and the unsaturated-zone atmosphere; however, although the exchange can affect the concentration in the top few centimeters of water, below a meter or so, the gases are confined and do not exchange with the unsaturated-zone atmosphere. Some processes in the saturated zone are known to change the dissolved-gas concentrations, including upward or downward concentration gradients that are present within the aquifer. The changes that take place through diffusive movement are small compared with total concentrations of major gas constituents present (Heaton and others, 1986). N_2 concentrations in ground water can be modified by the microbial reduction of NO_3- to

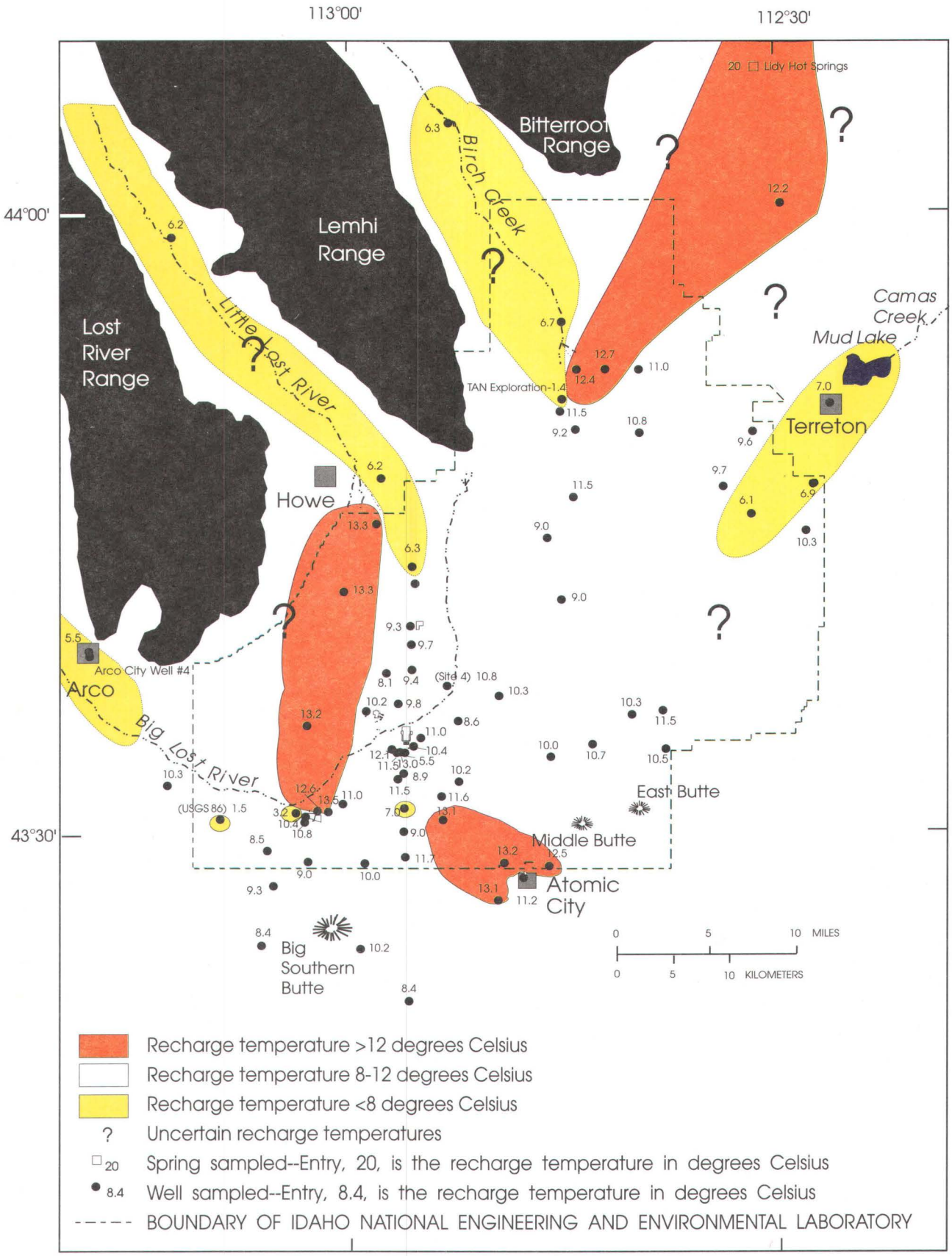

Figure 30. Recharge temperature calculated from nitrogen/argon concentrations from selected sites at and near the Idaho National Engineering and Environmental Laboratory, 1994-97.

N_2 in anoxic ground water (Heaton and others, 1981; 1983). The dissolved N_2 in water can be derived from different sources:

$$N_{2,Total} = N_{2,WEA} + N_{2,Air} + N_{2,DN}, \quad (6)$$

where $N_{2,Total}$ is the total concentration of N_2 in the ground water, $N_{2,WEA}$ is the N_2 introduced as a result of the water in equilibrium with air, $N_{2,Air}$ is the N_2 derived from dissolution of excess air; and $N_{2,DN}$ is the N_2 produced by the bacterial denitrification of nitrate in anoxic ground water. Nitrate reduction in the samples from the INEEL was not significant because all water contained some dissolved O_2 (Busenberg and others, 1998). Nitrate reduction begins after all dissolved O_2 is consumed by bacterial activity in the ground water.

Although Ar is chemically inert, its concentration can be modified by the presence of excess air and radiogenic Ar. Radiogenic Ar is produced by the radioactive decay of ^{40}K. Radiogenic Ar is of little importance even in old water because rates of production are small and most of the radiogenic Ar is retained in the rocks (Podosek and others, 1980; Heaton and others, 1983). The half-life of ^{40}K is 1.28 million years and only 0.01 percent of the ^{40}K decays to ^{40}Ar. The total dissolved Ar in ground water is given by the equation:

$$Ar_{Total} = Ar_{WEA} + Ar_{Air} + Ar_{RA}, \quad (7)$$

where Ar_{Total} is the total dissolved Ar in the ground water, Ar_{WEA} is the Ar introduced as a result of the equilibrium of water with air in the unsaturated zone, Ar_{Air} is the Ar derived from the dissolution of excess air, and Ar_{RA} is the Ar produced by radioactive decay of ^{40}K and released into the ground water. The Ar_{RA} has been found to be proportional to the radiogenic concentrations of He_{RA} in some ground water:

$$Ar_{RA} = k(He_{Total} - He_{WEA}), \quad (8)$$

where k is a constant, He_{Total} is the concentration of He in the ground water, and He_{WEA} is the air-water saturation. Heaton and others (1983) used a k value of 0.14 for South African sedimentary rocks. The value of k can be smaller (Podosek and others, 1980) or in some cases larger than 0.14 (Mazor, 1977) and will vary according to the concentrations of K, U, and Th in the rocks and rates of release of radiogenic gases from the rocks into ground water.

The calculated average excess air from more than 100 N_2/Ar and over 100 Ne analyses of ground-water samples from the Snake River Plain aquifer at and near the INEEL was 1.4±1.2 and 1.6±2.3 cm^3/L of air in water at standard temperature and pressure (STP), respectively.

Mechanism of Recharge as Indicated by Concentrations of Dissolved Gases

The recharge temperatures calculated from N_2/Ar concentrations in ground-water samples are shown in figure 30. Three areas have apparent recharge temperatures greater than 12 °C. One area begins near Lidy Hot Springs and extends southwestward into the northern part of the INEEL. Some of the largest He concentrations were in ground water from this area. Another area of high apparent recharge temperature is in the southeastern part of the INEEL where concentrations of F and He in ground-water samples were large and moderate, respectively. Another area of high apparent recharge temperature is in the western part of the INEEL and extends southward from USGS 19. The ground water of this area contains background He and small F concentrations.

At the INEEL, the temperature of the deep, unsaturated zone is often higher than the mean annual soil temperature, as is indicated by the ground-water temperatures near the top of the water table (fig. 31; Busenberg and Plummer, 2000). This is often the case at the INEEL because the unsaturated zone is very thick and the geothermal gradient is large, especially in the eastern Snake River Plain (Blackwell and others, 1992).

The recharge temperature calculated from N_2 and Ar can be used to evaluate the depth of equilibration of water recharging the INEEL. It was reasonable to assume that the regional gas-recharge temperature was the mean annual soil temperature, because most of the recharge to the Snake River Plain aquifer occurs in mountain valleys, where the unsaturated zone is relatively thin. Some additional recharge occurs near the northern margin through

sinks. The fraction of young water recharging the aquifer through a thick, unsaturated zone can be calculated from the temperature of the unsaturated zone at the water table or from the ground-water temperature, the gas-recharge temperature, and the mean annual temperature. There are several areas at the INEEL where the recharge temperature calculated from gas concentrations was significantly higher than the mean annual soil temperature (fig. 30). This temperature difference indicates that recharge could have occurred by slow infiltration through a thick, unsaturated zone. This possibility was considered when the CFC-model age of the young fraction of the ground water was calculated. Mixing of the regional ground water and this infiltration water would decrease the concentration of gases in the mixture and result in an apparent higher gas recharge temperature. The geothermal gradient is reflected in the ground-water temperature, and the temperatures of water in deep wells are shown in figure 31 but were not considered in the contouring of this figure because temperature increases with depth. Two areas with significantly higher ground-water temperatures correspond to two of the areas with significantly higher recharge temperatures calculated from gas concentrations. This correspondence indicates that the water in these two areas may be a mixture of regional ground water and infiltration water that re-equilibrated with unsaturated-zone atmosphere at the water table. The gas concentrations of two thermal springs, Lidy Hot Springs (fig. 2) and Condie Hot Springs (fig. 1), were determined. He concentrations were very high and recharge temperatures calculated from gas concentrations were high in samples from both springs. The He concentrations were tens of times greater than air saturation, and the chemistry of the water was significantly different from that of ground water at the INEEL. It is highly likely that some of the dissolved gases were lost during sampling of these two hot springs. Mixtures of the regional ground water and thermal water have higher-than-background He concentrations.

In four areas, recharge temperatures were less than 8° C. Ground water in these areas may represent mostly underflow from mountain valleys. The gas-recharge temperature of the underflow from the Big Lost and Little Lost Rivers and from Birch and Camas Creeks was about 3 to 4 °C lower than the gas-recharge temperature of the regional ground water (fig. 30). The underflow possibly could represent recharge through a thin, unsaturated zone in early spring or recharge from an area 1,000 m or higher in elevation.

Partial Pressure of Environmental Tracers in the Unsaturated Zone

Concentrations and ratios of environmental tracers in thick, unsaturated-zone air can be significantly different from those in the atmosphere. Concentrations of CFCs decrease with depth. Many processes affect the transport of gases through the unsaturated zone. The physical processes include displacement of gases as a result of barometric pressure changes (Thorstenson and Pollock, 1989a, 1989b; Massmann and Ferrier, 1992); barometric pumping affects the top of the unsaturated zone. In areas of high relief, horizontal pressure gradients can result in the horizontal transport of gases from several to tens of meters (Massmann and Ferrier, 1992). However, diffusion is the dominant mechanism of transport of gases in the unsaturated zone, as was shown by Weeks and others (1982). Important factors controlling the concentrations of CFCs are diffusion, porosity, tortuosity, water saturation, gas-liquid partitioning, and sorption (Weeks and others, 1982). Near Test Area North (TAN), CFC concentrations in the unsaturated-zone air decreased dramatically with depth (Busenberg and others, 1993) as predicted by the model of Weeks and others (1982). Concentrations of SF_6, CFC-12, CFC-113, and CFC-11 at a depth of 57.5 m were 20, 12, 10, and 7 percent that of the air concentrations, respectively, and were proportional to the value of Henry's law constant at 10 °C. The results show the importance of gas-water partitioning in the transport of gases through the unsaturated zone and the importance of knowing the depth where unsaturated air-water equilibrium is achieved. Both the concentration and the ratios of two tracers vary with the depth of the unsaturated zone. The lag time between the apparent and actual age of ground water resulting from gas diffusion through a thick, unsaturated zone can be calculated by the theoretical model of Cook and Solomon (1995). Figure 32 shows the calculated lag time for SF_6 and the three CFC's at

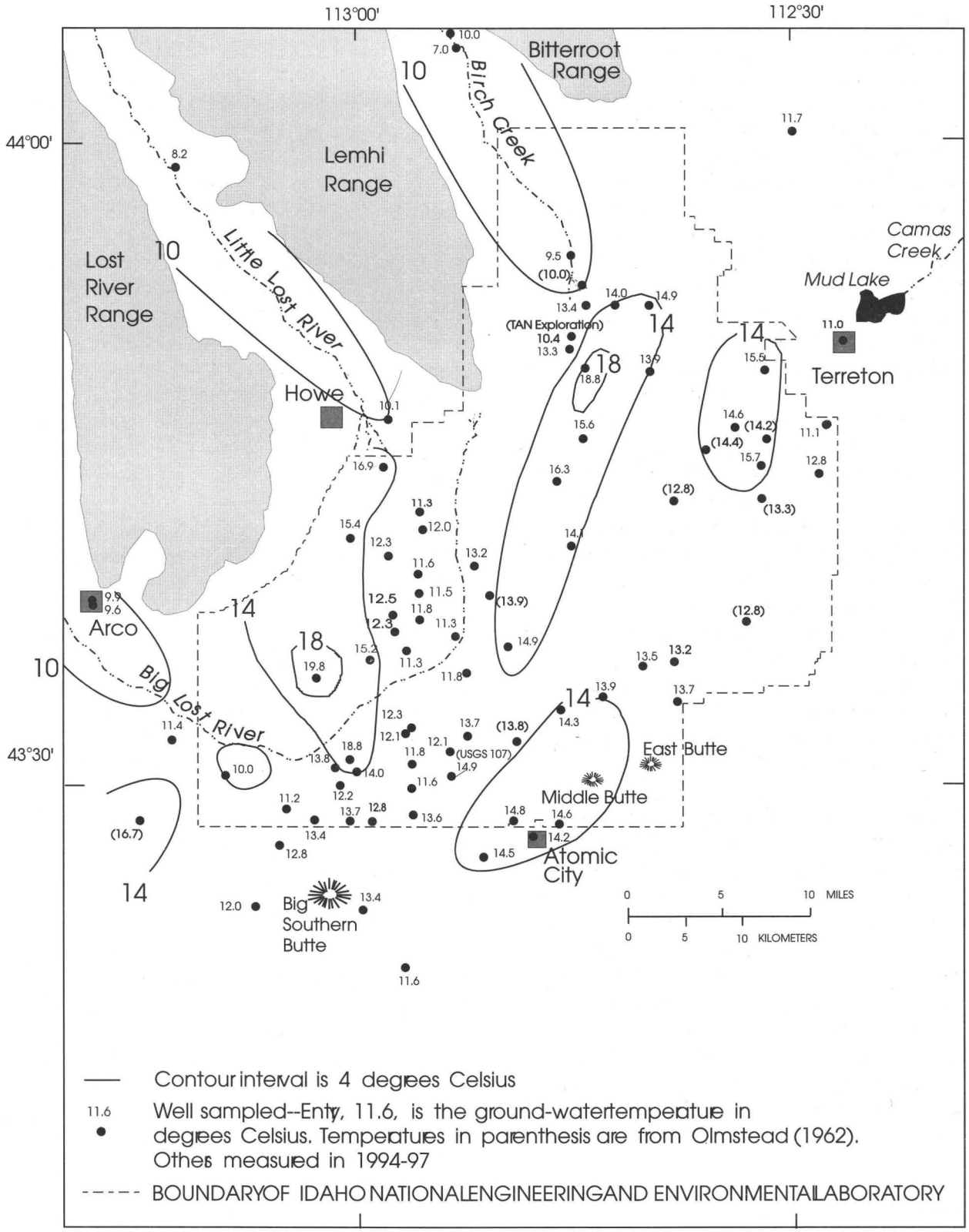

Figure 31. Temperature of ground water in samples from wells at and near the Idaho National Engineering and Environmental Laboratory.

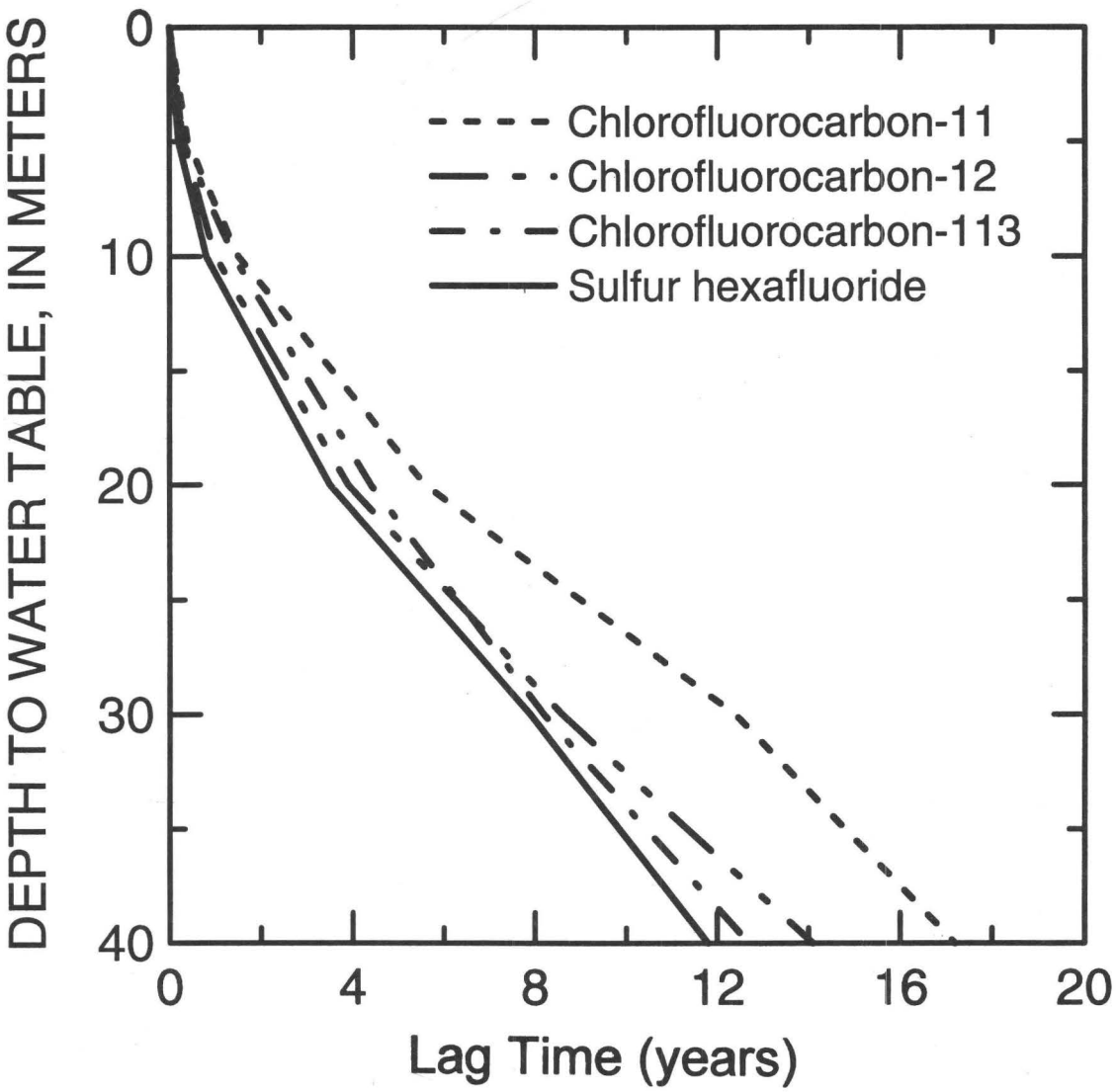

Figure 32. Lag time between the piston-flow age (apparent) and actual age of ground water as a function of the thickness of the unsaturated zone.

the INEEL. The lag time was the smallest for SF_6 mainly because the solubility of SF_6 in water is smallest (smallest K_{Henry}). Figure 21 shows the concentration of the four tracers in air and in the unsaturated zone just above the water table at a depth of 70 m from 1950–2000.

Hydrogen and Methane in Ground Water

Concentrations of H_2 and methane (CH_4) indicate anaerobic degradation of organic material in ground water. Trace concentrations of CH_4 were found in a few ground-water samples at the INEEL. Water from two wells, USGS 6 and 15, contained larger than air-saturation concentrations of H_2. Large H_2 concentrations were found in samples from Lidy Hot Springs, Condie Hot Springs, Big Springs, and from some wells, including Arco City Well #4, Engberson, Neville, and Wagoner Ranch (Busenberg and others, 2000) (figs. 1 and 2). The large concentrations of H_2 were present in anoxic water (Chapelle and others, 1995) or in water from the deeper parts of the Snake River Plain aquifer.

Helium and Neon in Ground Water

He and Ne concentrations were given by Busenberg and others (2000). The concentrations of He in water are shown in figure 12. Saturation with air with small amounts of excess air at the elevation and mean annual air temperature of the INEEL was between 4.5×10^{-8} and 6.5×10^{-8} cm^3 at STP/g of water. Concentrations were greater than 20×10^{-8} cm^3 at STP/g in a southwest trending area extending from Lidy Hot Springs to Site 14. Within this area, many ground-water temperatures were higher than the mean annual temperature (fig. 31) and He concentrations were greater than background. Outside this area, the He concentration was greater than 20×10^{-8} cm^3 at STP/g only in water from USGS 15, which is perforated between 60 and 70 m below the water table. He concentrations in water from Site 9 and USGS 17, which are perforated at 62 m and at 24 m below the water table, respectively, were higher than those at saturation with air. Higher-than-air-saturation concentrations of He were found in the southeastern part of the INEEL. The water in this area contained high ^3He concentrations of presumably mantle origin and was difficult to date by using the $^3H/^3He$ method. Water in USGS 23, located in the western part of the site, contained high He concentrations, unusual chemistry, unusual isotopic composition, and will be discussed in detail in Appendix 2. Because the water intake pipes at USGS 86 and 104 have holes, the ground water was in contact with air prior to sampling. The composition of the dissolved permanent gases also was modified by contamination of the samples with air (Busenberg and others, 2000); therefore, the ground water cannot be dated by using the CFC or $^3H/^3He$ methods.

Plots of the concentrations of He and Li can be used to identify three natural ground-water types at the INEEL (fig. 33). Type I is characterized by Li concentrations of less than 10 µg/L and He concentrations that are near the air-water saturation, and is predominantly the Ca-Mg-HCO_3 water. Type I water is present mainly in the western part of the INEEL and theoretically can be dated by using the $^3H/^3He$ method. All other ground water at the INEEL can be subdivided into two types. Type II is characterized by Li concentrations that are greater than 10 µg/L and moderate concentrations of He of as much as three times the air-water saturation. Type II water is found in the southeastern part of the INEEL. $^3He/^4He$ ratios in many Type II samples were significantly greater than the radiogenic ratio of $1–5\times10^{-8}$ normally found in ground water. Type III water is in the northeastern part of the INEEL and is characterized by He concentrations that are greater than three times air-water saturation and cannot be dated by the $^3H/^3He$ method. An exception is water from USGS 4, which contained background He concentrations. Because this water was mainly irrigation water, it was dated by using the $^3H/^3He$ method. Water from the Park Bell and USGS 7 wells and Lidy and Condie Hot Springs contained even higher concentrations of He or Li or both. Plots of these concentrations were outside the boundaries of figure 33. USGS 15 is in the central part of the INEEL, is completed in the deeper part of the Snake River Plain aquifer, and contained a Li concentration of 2.1 µg/L but a He concentration of more than five times that of air-water saturation. He concentrations increase with depth in the north-

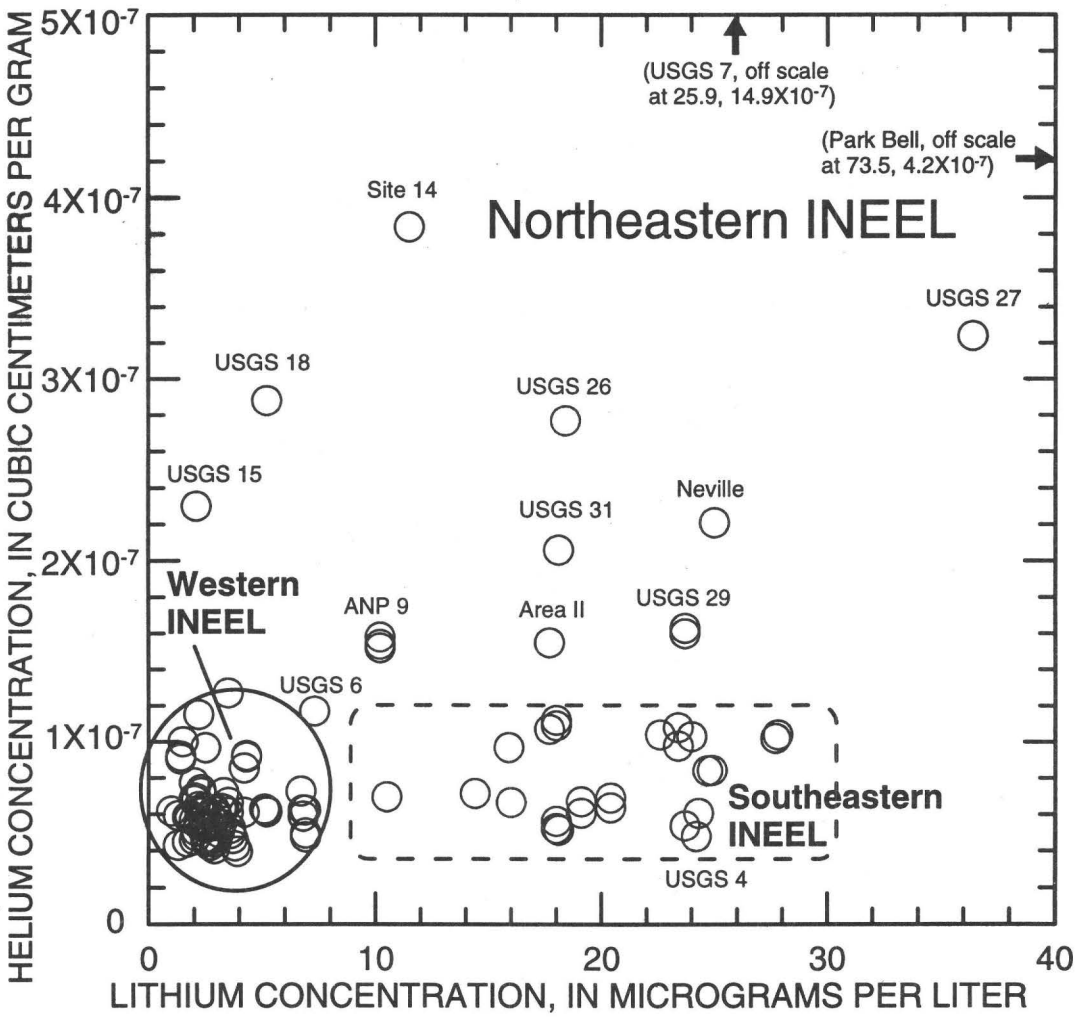

Figure 33. Relation of lithium and helium concentrations in water from selected wells at or near the Idaho National Engineering and Environmental Laboratory.

eastern and northwestern parts of the INEEL. This increase with depth indicates that the age of the ground water increases with depth. However, deep wells in the southwestern part of the INEEL contained small He concentrations, which indicates that a significant amount of water containing low He concentrations has recharged the aquifer.

Plots of the concentration of He and F in figure 34 also show the three natural ground-water types described above. Type I is characterized by small F concentrations and He concentrations that are near the air-water saturation and is present mainly in the western part of the INEEL. Type II water is present in the southeastern part of the INEEL and has moderate He and high F concentrations. Type III water is present in the northeastern part of the INEEL and is characterized by high F and He concentrations.

Terrigenic Helium Concentrations in the Ground Water

The concentration of He in ground water is useful in identifying areas where recharge to the Snake River Plain aquifer has occurred during the past several hundred years. He dissolved in ground water is derived from various sources; He_{terr} is of crustal and mantle origin and can be calculated from the He mass balance equation:

$$He_{terr} = He_{total} - He_{eq} - He_{air} - He_{tritiogenic}, \quad (9)$$

where He_{total} is the measured He concentration in the ground water, He_{eq} is the He concentration in equilibrium with air, and He_{air} is the He concentration introduced into the ground water by some air in excess to the air-water equilibrium. $^3He_{tritiogenic}$, produced by the radioactive decay of ^3H, is exceedingly small and can be ignored. The He_{terr} is given as percent of the total He present.

Water that has been in contact with the air or the unsaturated-zone atmosphere in the past several hundred years contains from 0 to about 10 percent He_{terr}. He_{terr} concentrations are affected by the mechanism of recharge, whether through thin or thick unsaturated zones or by slow infiltration or rapid recharge along distinct pathways. The fraction of recent recharge by infiltration or focused recharge can be estimated from the equation:

$$xHe_{background} + (1-x)He_{recharge} = He_{terr}, \quad (10)$$

where x is the fraction of regional background water, 1-x is the fraction of recent recharge. $He_{background}$, $He_{recharge}$, and He_{terr} are the He_{terr} concentrations in the regional background water, the recent recharge, and the ground-water sample. He_{terr} concentrations average about 7 percent in the recent recharge and 85 percent in the regional background water.

Thermal springs are present along the northern boundary of the Snake Plain Plain aquifer. Lidy Hot Springs and Condie Hot Springs were sampled and the concentrations of He_{terr} were 96 and 99.5 percent, respectively. The He_{terr} concentration in Lidy Hot Springs is probably larger than 96 percent; the N_2/Ar concentrations in the water indicate that about half of the dissolved gases were lost before sampling. Very large He_{terr} concentrations are characteristic of thermal springs.

Underflow from the mountain valleys that recharges the Snake River Plain aquifer at the northern boundary of the study area contains He_{terr} concentrations of about 30 percent. This underflow is a mixture of recent recharge and older ground water containing larger He concentrations discharging into the valleys. He_{terr} concentrations may be about 56 percent in the underflow from the Little Lost River Valley; for example, the He_{terr} concentrations in water from Pancheri 6 and USGS 23 wells were 56 and 57 percent, respectively.

The He_{terr} concentrations in ground water at and near the INEEL are shown in figure 23. The areal distribution of the He_{terr} indicates that regional ground water containing 80 to 90 percent He_{terr} is moving through the study area from the northeast and the He_{terr} concentration is modified by recent recharge within and at the boundaries of the study area. The areal distribution of the He_{terr} and ^3H concentrations (fig. 23 and fig. 6) can be used together to determine not only the amount of recharge but also the mechanism of recharge at and near the INEEL. For example, recharge through a thin, unsaturated zone or focused rapid recharge results in small He_{terr} concentrations (<10 percent) but measurable ^3H concentrations; however, spatially distributed diffuse recharge through a thick, unsaturated zone also results in small He_{terr}

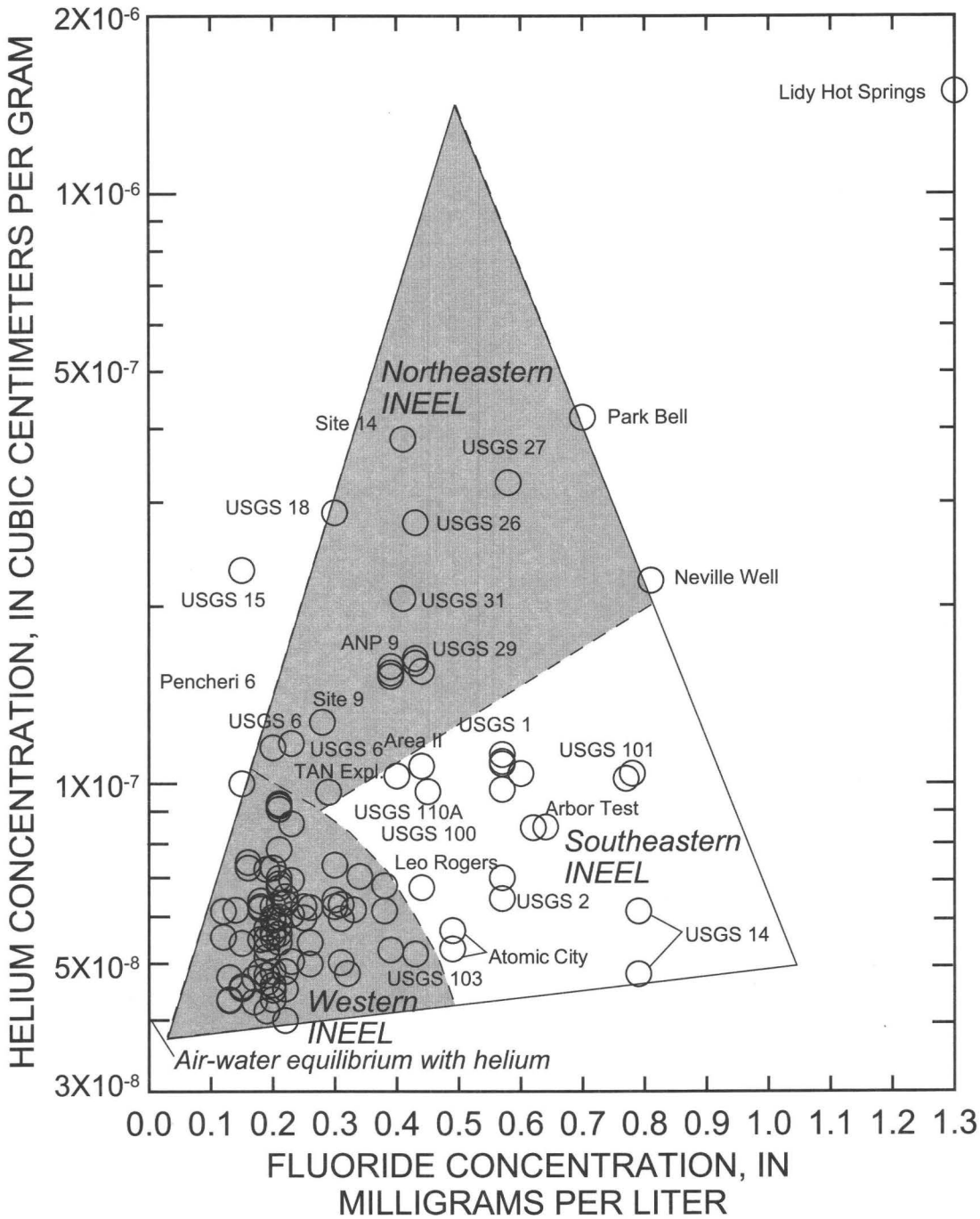

Figure 34. Relation of fluoride and helium concentrations in water from selected wells from northeastern, southeastern and western parts of the Idaho National Engineering and Environmental Laboratory.

concentrations (<10 percent) but little or no ^{3}H. The ground water in the alluvial sediments of the mountain valleys that recharge the northern boundary of the study area also contains characteristic He_{terr} concentrations that can be used to identify this recharge.

In the eastern part of the INEEL, several areas of the Snake River Plain aquifer are being recharged. In the northeastern Terreton-Mud Lake area, significant focused recharge is taking place: the water sample from USGS 4 was entirely local recharge and that from USGS 32 consisted of approximately 60 percent local recharge and 40 percent regional ground water. The small ^{3}H concentration in water from USGS 32 indicates that a large part of the local recharge occurred by infiltration through the thick, unsaturated zone. The sample from USGS 29 contained a smaller percentage of local recharge (about 20) but a large ^{3}H concentration (7.1 TU); these data indicate that the aquifer was recharged rapidly along distinct pathways. In the southeastern part of the INEEL, small He_{terr} concentrations and the presence of ^{3}H in ground-water samples indicate that significant focused recharge has occurred. In the northern part of the INEEL, several different mechanisms of recharge can be identified from the He_{terr} and ^{3}H concentrations. P&W 2 water consisted predominantly of local recharge; this young ground water contained large concentrations of ^{3}H and CFCs. Water in nearby wells (ANP 6, TAN Exploration, PSTF Test, and IET Disp.) contained small He_{terr} concentrations and virtually no ^{3}H. This indicates recharge by infiltration through a thick, unsaturated zone. There is other evidence of infiltration recharge: He_{terr} concentrations in water from USGS 6 and ANP 9 indicate that about 23 and 29 percent of the water, respectively, was recharged within the INEEL.

The He_{terr} concentrations in the band running north to south in the central part of the INEEL (fig. 23) indicate that the water samples consist almost entirely of local recharge. The presence of ^{3}H in water samples outside the ^{3}H contaminant plume (fig. 6) indicates that rapid, focused recharge is the predominant recharge mechanism. The small He_{terr} concentrations in these samples indicate that significant amounts of Little Lost River underflow are not present in the water samples from most wells.

The western part of the INEEL contains He_{terr} concentrations that are similar to those of Little Lost River underflow. The absence of ^{3}H in water from USGS 23 indicates that no focused recharge is occurring in this area. In the area south and southeast of Arco, the small He_{terr} concentrations and the presence of ^{3}H in water from USGS 8 indicate significant focused recharge of the Snake River Plain aquifer.

Carbon-14, Carbon-13, Deuterium, and Oxygen-18 Concentrations in the Ground Water

The differences in ^{14}C concentrations in the samples are primarily the result of mixing of regional ground water and local recharge at and near the INEEL. The $\delta^{18}O$ of the surface water was generally about 1.2 permil heavier than that of the regional ground water. Figure 20A shows the ratios of $\delta^{2}H$ and $\delta^{18}O$ concentrations in all the samples collected at or near the INEEL. Also shown are the global and local meteoric lines. Figure 20B shows ^{14}C activities in selected ground-water samples.

A covariance was found between the ^{14}C and $\delta^{18}O$: as the fraction of young water in the sample increased, both the ^{14}C activity and $\delta^{18}O$ ratio increased (fig. 18). All the outliers in figure 18 are from the northern or northeastern part of the INEEL, except USGS 14, which is probably a mixture of water from the southeastern and central parts of the INEEL. A similar covariance was found between the $\delta^{13}C$ and ^{14}C in ground-water samples from the western part of the INEEL for which the r^{2} value was 0.87 (fig. 19). The differences between $\delta^{13}C$ in samples from the eastern and western parts of the INEEL reflect differences in the extent of carbonate and silicate weathering. The eastern, more depleted, water probably evolved from reactions with rhyolites and other volcanic rocks; the more enriched water of the western part of the INEEL reflects reactions with carbonate rocks. If the water is indeed a simple binary mixture of young and old water, the fraction of young ground water could be calculated from either of the following equations:

$$^{14}C_{mixture} = x^{14}C_{young} + (1-x)^{14}C_{old}, \text{ or} \quad (11)$$

$$\delta^{18}O_{mixture} = x\delta^{18}O_{young} + (1-x)\delta^{18}O_{old}, \quad (12)$$

where x is the fraction of the young recharge water, (1-x) is the fraction of the old regional ground water, ^{14}C is the activity in pmc for the young and old ground water, and $\delta^{18}O$ is the isotopic composition of the young and old fraction, in permil. Unfortunately, it was very difficult to solve equation 11 because the atmospheric ^{14}C activity has varied from about 100 to 200 pmc over the past 60 years as a result of atmospheric testing of nuclear weapons. To complicate matters further, the young ground-water fraction dissolved a large amount of soil CO_2 that was derived from the oxidation of soil organic matter and plant respiration. The ^{14}C concentration and $\delta^{13}C$ of the soil CO_2 may be significantly different from that of the atmosphere at the time of recharge. Similar results can be obtained with plots of the $\delta^{13}C$ ratios. Despite all these difficulties, the linear relations among $\delta^{18}O$ and $\delta^{13}C$ ratios and ^{14}C activities indicate that the ^{14}C activities have not varied significantly in the unsaturated zone.

Most of the $\delta^{2}H$ and $\delta^{18}O$ ratios for surface- and ground-water samples collected at and near the INEEL fall below and parallel to the Global Meteoric Line (fig. 20A). Similar results were obtained for surface- and ground-water samples from the south-central part of the Snake River Plain aquifer (Plummer and others, 2000). Groundwater samples from the Terreton-Mud Lake area were significantly enriched as a result of evaporation in this agricultural area (Engberson and USGS 4 wells). Water from TAN Exploration was significantly enriched from evaporation; however, this water contained small NO_3^- and He_{terr} concentrations, and virtually no ^{3}H. The well probably was recharged by spatially dispersed infiltration within the INEEL. The $\delta^{18}O$ ratio in the sample from the Big Lost River was 1.2 permil heavier than that in the regional ground water. The smaller $\delta^{18}O$ ratio of the regional ground water probably indicates that the water was recharged at higher elevations near Yellowstone Park, northeast of the INEEL. In this report, the difference in $\delta^{18}O$ ratios of the Big Lost River and the regional ground water was used to calculate the fraction of young water in the samples by using equation 11. A similar procedure was used to calculate the amount of Snake River water in the Snake River Plain aquifer in irrigated areas southwest of the INEEL (Plummer and others, 2000). The areal distributions of $\delta^{18}O$ and $\delta^{13}C$ ratios and ^{14}C activities are shown in figures 35, 36, and 37.

SUMMARY

Recharge temperatures were calculated from N_2 and Ar concentrations for many of the ground-water samples and are useful indicators of the source of water in the Snake River Plain aquifer at the INEEL. Recharge temperatures of about 6 °C characterize underflow from Birch and Camas Creeks and Little Lost and Big Lost Rivers. Recharge temperatures of 9 to 13 °C were calculated for the regional ground water of the Snake River Plain aquifer at the INEEL.

Three natural ground-water types were identified from their He, Li, and F concentrations: (1) northeastern regional water with very high He, Li, and F concentrations; (2) recharge from the southeast with moderate He and high Li and F concentrations; (3) recharge from mountain valleys in the western part of the INEEL with low He and Li, and high concentrations of Ca, Mg, and alkalinity. The water was modified locally by mixing with agricultural runoff and wastewater from INEEL facilities.

The areal distribution of the He_{terr} indicates that regional ground water containing 80 to 90 percent He_{terr} is moving through the study area from the northeast and the He_{terr} concentration is modified by recent recharge within and at the boundaries of the study area. The areal distribution of the He_{terr} and ^{3}H concentrations can be used together to determine not only the amount of recharge but also the mechanism of recharge at and near the INEEL. The ground water in the alluvial sediments of the mountain valleys that recharge the northern boundary of the study area also contains characteristic He_{terr} concentrations that can be used to identify recharge.

The differences in ^{14}C concentrations in the samples are primarily the result of mixing of regional ground water and local recharge at and near the INEEL. The $\delta^{18}O$ of the surface water was

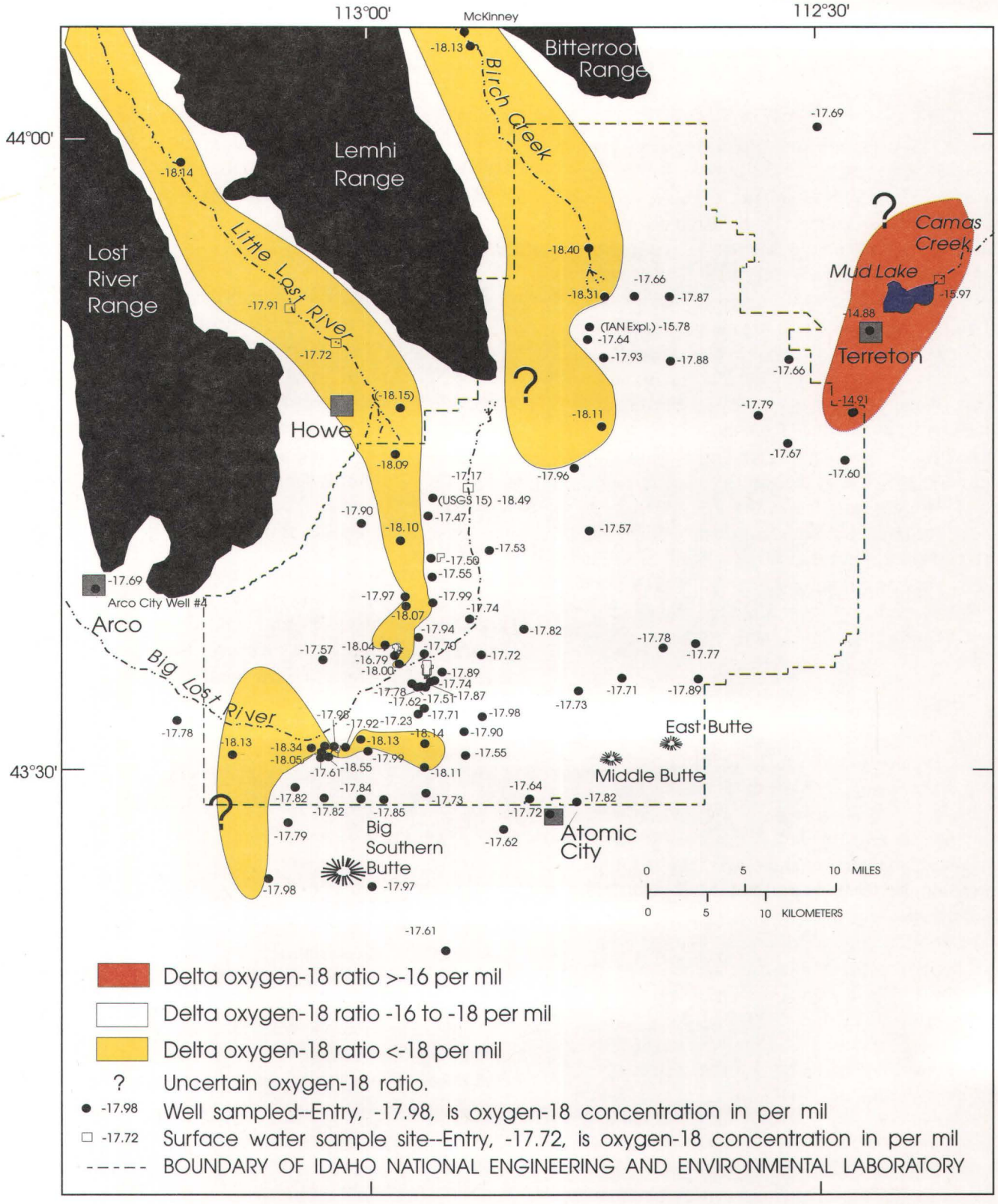

Figure 35. Delta oxygen-18 ratio in water from selected sites at and near the Idaho National Engineering and Environmental Laboratory, 1994-97.

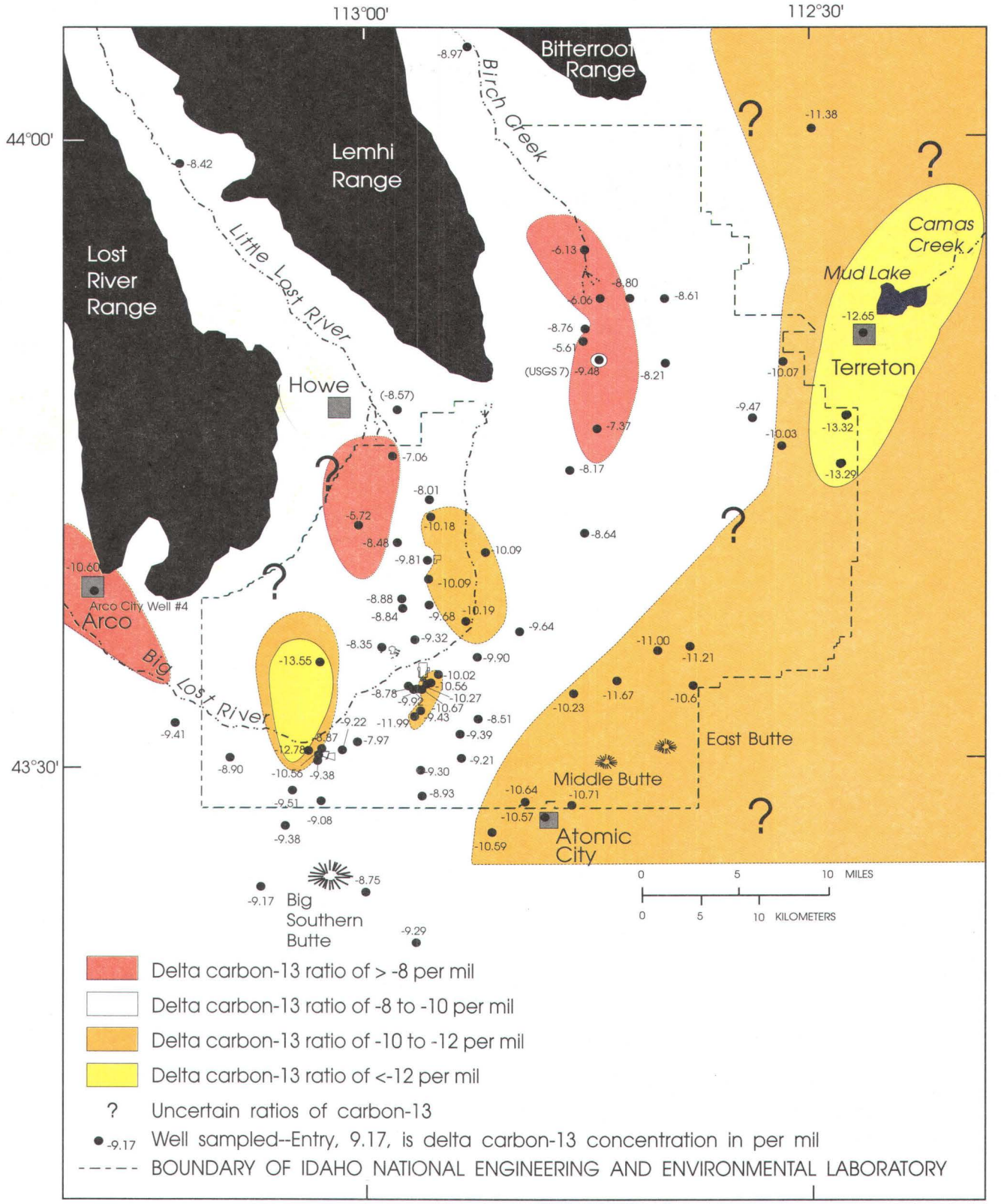

Figure 36. Delta carbon-13 ratio of the inorganic dissolved carbon in water from selected wells at and near the Idaho National Engineering and Environmental Laboratory, 1994-97.

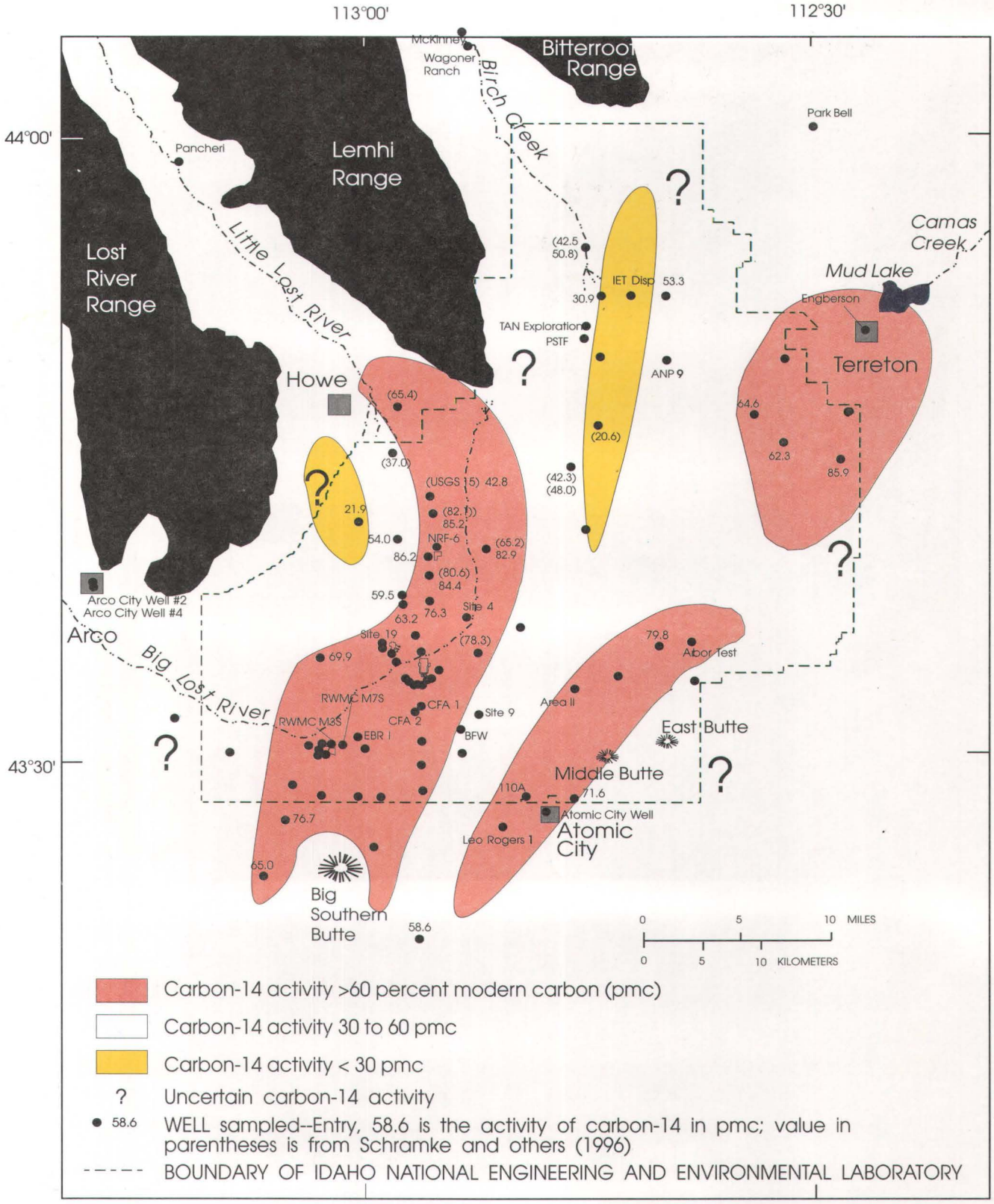

Figure 37. Activity of carbon-14 of the dissolved inorganic carbon in water from selected wells at and near the Idaho National Engineering and Environmental Laboratory, 1994-97.

generally about 1.2 permil heavier than that of the regional ground water. A covariance was found between the ^{14}C and $\delta^{18}O$: as the fraction of young water in the sample increased, both the ^{14}C activity and $\delta^{18}O$ ratio increased. A similar covariance was found between the $\delta^{13}C$ and ^{14}C in ground-water samples from the western part of the INEEL. The $\delta^{18}O$ ratio in the sample from the Big Lost River was 1.2 permil heavier than that in the regional ground water. In this report, the difference in $\delta^{18}O$ ratios of the Big Lost River and the regional ground water was used to calculate the fraction of young water.

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APPENDIX 2. Summary of age-dating methods for water from selected wells

Southeastern

Arbor Test —This well contains two open intervals of 15-m lengths. The first open interval begins 0.5 m above the water table and the second interval at 2 m below the first. The pump is about 11.7 m below the water table (fig. 26). The age of the young fraction of the water sample, calculated by using the $^3H/^3He$ method and the eastern INEEL average R_{terr} ratio of 1.48×10^{-6}, was 1.1 years; however, the 1σ in the uncertainty in the R_{terr} ($\pm0.26\times10^{-6}$) introduced an uncertainty of ±12.3 years (table 8). The model-3 CFC-11, CFC-12, and CFC-113 ages were 18, 16, and 19 years, respectively (table 9). Model-2 ages ranged from 13 to 26 years (table 9). The concentration of ^3H, 3.9 TU, and the calculated fraction of young water of about 45 percent or less (table 3) were consistent with an age of between 13 and 18 years.

Area II—This well contains three perforated intervals of 14-, 19-, and 6.7-m lengths located 1.2, 24, and 56 m below the water table, respectively. The pump is about 9.5 m below the water table (fig. 26). ^3H concentrations were relatively large, 3.8 and 3.9 TU for the October 1994 and July 1996 samples, respectively. The age of the young fraction of water from this well was not calculated by the $^3H/^3He$ method because the sample was lost during the analysis. The presence of ^3H suggested that the sample contained post-1950 focused recharge. Model-2 ages of the young fraction ranged from 18 to 22 years. The model-3 CFC-11, CFC-12, and CFC-113 ages were 21, 21, and 20 years, respectively (table 9). The fraction of young water in this sample was between 35 and 49 percent.

Atomic City Well—This well has only 10.7 m of casing and was sampled in October 1994 and in October 1996. The pump is about 8.5 m below the water table (fig. 26). The age of the young fraction of the water sample calculated by using the $^3H/^3He$ method and the average eastern INEEL He_{terr} isotope ratio was 14±3 years (table 9). The model-1 age was the most appropriate for this water because the young fraction consisted of predominantly local recharge, as indicated by the small concentration of He_{terr} (24 percent). The model-1 ages were 21, 19, and 13 years, respectively (table 9). The most probable age of the water in the sample was between 14 and 19 years.

Leo Rogers 1—This stock well is near the southern boundary of the INEEL (fig. 2). Except for 4.6 m of casing, the well is an open hole containing about 29 m of water. The depth of the pump is not known. The ^3H concentration was 3.9 TU in 1996, which indicated that focused recharge with post-1950s water had occurred. Model-2 ages suggested that there was slight contamination of the water at this location with CFC-11 and more extensive contamination with CFC-113. Model-3 CFC-11 and CFC-12 ages of the young fraction were 22 and 19 years, respectively (table 3). The concentration of He_{terr} in the samples was relatively small (36 percent); the fraction of young water was about 50 percent.

USGS 1—This well is cased to a depth of about 3 m below the water table and contains about 9.1 m of water (fig. 26). The calculated fraction of young water was about 40 percent in the 1994 sample and was dated by using the $^3H/^3He$ method. The age of the water was 32±32 years (table 9) when using the eastern INEEL He_{terr} isotope ratio and 57.4 years when using the radiogenic isotopic ratio. Model-3 CFC-11, CFC-12, and CFC-113 ages of the young fraction were 24, 23, and 18 years, respectively.

USGS 2—This well contains about 6.1 m of water and perforations are about 4 m below the water table. The pump is 6.7 m below the water table (fig. 26). The age of the young fraction of water in the July 1994 sample calculated by using the $^3H/^3He$ method and the eastern INEEL He_{terr} isotope ratio was 11±10 years. The model-3 CFC-11, CFC-12, and CFC-113 ages were 20, 18, and 17 years, respectively. The fractions of young water were between 40 and 50 percent.

USGS 100—This well is open to about 22 m of water. The pump is located about 5 m below the water table (fig. 26). The age of the young fraction of water in the 1994 sample, calculated by using

the $^3H/^3He$ method and the eastern INEEL He_{terr} isotope ratio, was 15±15 years. Model-2 CFC-11/CFC-12 ratio ages of the young fraction in the 1995 and 1996 samples were 21 years. Model-3 CFC-11 and CFC-12 ages were both 17 years (table 9). The estimated fraction of young water in the samples was between 40 and 50 percent.

USGS 101—This well is open to about 28 m of water. The pump is about 5 m below the water table (fig. 26). An attempt was made to date the 1995 sample by using the $^3H/^3He$ method; however, this was not possible because of the very small ^3H concentration and a large He_{terr} concentration. This well contained a very small fraction of young water and was difficult to date. Model-1 CFC ages of the young fraction of ground water ranged from 30 to 34 years. Model-2 CFC-11/CFC-12 ratio ages for the 1995 and 1996 samples were 31 years. Model-3 CFC-11 and CFC-12 ages were 27 years. The water contained large concentrations of He_{terr} (55 percent), and the sample consisted of about 20 to 40 percent recent recharge.

USGS 110A—This well is open to about 28 m of water. The pump is about 14 m below the water table (fig. 26). The model-2 CFC-113/CFC-12 ratio age of the young fraction of the ground water was 15 years. Model-3 CFC-12 and CFC-113 ages were 16 and 13 years, respectively (table 9). About half of the sample was young water.

Northern

ANP 6—This well contains two perforated intervals: an 11-m interval starting at the water table and a 9.2 m-interval starting at 15 m below the water table. The pump is about 6 m below the water table (fig. 26). The CFC concentrations remained nearly constant during the three sampling periods (1994, 1995, and 1996). Water in this well contained a ^3H concentration of about 1 TU in 1994 and 0.5 TU in 1996, indicating that some post-1950s water was present in the samples. The $^3He/^4He$ isotope ratio (R_{terr}) was significantly greater than the radiogenic ratio of $2.0x10^{-8}$, and the eastern INEEL terrigenic ratio was used to calculate the $^3H/^3He$ age of the young fraction. The $^3H/^3He$ ages were 31 and 33 years for the 1994 and 1995 samples, respectively (table 9). Even though the $^3H/^3He$ ages appeared to be reasonable, they were unreliable because of the small ^3H concentration in the samples and uncertainty in the $^3He/^4He$ terrigenic isotope ratio. Model-1 CFC-11, CFC-12, and SF_6 ages were between 20 and 25 years (table 1). The 15- percent He_{terr} concentration in the samples suggested that the water was predominantly infiltration water that recharged between 20 and 30 years ago.

ANP 9—This well has 23.5 m of open interval beginning at 3 m below the water table. The pump is about 13 m below the water table (fig. 26). The water had virtually no detectable ^3H (0.07±0.01 TU), suggesting that no focused recharge of post-1950s water had occurred. The ^3H bomb peak was apparently still in the unsaturated zone at the time of sampling. The concentration of 67 percent He_{terr} and the presence of CFCs in the water suggested significant recent recharge of infiltration water. An amount of 23 percent infiltration recharge in the sample was calculated from concentrations of 85 and 7 percent He_{terr} in the regional ground water and in the infiltration water, respectively. The age of the infiltration water was significantly greater than 55 years, as suggested by the absence of ^3H; however, the recharge by infiltration occurred 6 to 7 years before sampling (table 4).

IET Disposal—This well contains a perforated interval from the water table to about 30 m below the water table (fig. 26). The model-3 CFC-11 and CFC-12 ages of the young fraction of water were 32 and 8 years, respectively (table 3). The model-4 CFC-12 age could not be determined because of contamination, but the CFC-11 age was between 12 and 15 years, and the CFC-113 age was greater than 12 years (table 9). The He_{terr} concentration of 18 percent suggested that about 85 percent of the sample was recharged by infiltration and focused recharge and that the aquifer was contaminated by waste disposal at this site. The age of recharge of infiltration water was probably greater than 12 years.

PSTF Test—This well contains a perforated interval from the water table to about 31 m below the water table. The pump is about 8.6 m below the water table (fig. 26). Water from this well is significantly different both isotopically and chemically

from water in Birch Creek and water from the nearby P&W 2 well. The He_{terr} of 1 percent and the low ^3H concentrations of the 0.77 and 0.44 TU measured in the October 1994 and October 1996 samples, respectively, indicated that local recharge was predominantly by slow infiltration. The 1995 sample dated by using the $^3H/^3He$ method and the radiogenic He isotope ratio of 2×10^{-8} was 9±2 years (table 9). The model-4 CFC-12 age was 1 year for both samples. Even though this infiltration water was very difficult to date by using either CFCs or $^3H/^3He$, both methods suggested that recharge had occurred recently.

P&W 2—This well is located near the northern boundary of the INEEL near the Birch Creek recharge area. This well contains a perforated interval from the water table to about 21.4 m below the water table. The pump is about 8 m below the water table (fig. 26). The ages of the young fraction of water in the 1994 and 1995 samples, calculated by using the $^3H/^3He$ method and the radiogenic He isotope ratio of 2×10^{-8}, were 16.1 and 4.4 years, respectively (table 9). Nearly identical CFC ages were obtained using the piston-flow model (model 1) for the 1994 and 1995 samples (table 1). The CFC model-1 age for the 1996 sample was about 10 to 15 years. Even though the well has a long open interval, the ground-water samples did not appear to be mixtures and could not be dated by any of the mixing models.

Site 14—Perforations for this well are about 79 to 134 m below the water table, so water sampled from this well was from deep in the aquifer. The pump is about 15 m below the water table (fig. 26). The He isotope sample was lost during the analysis because of the high He concentration. The He_{terr} concentration of the sample was 91 percent, which suggested that the young fraction did not exceed 5 percent of the sample. The young fraction of water in the sample calculated using model 3 was 35 to 40 percent; however, the calculated fraction was too high because the $\delta^{18}O$ of the shallow regional ground water rather than the deep regional ground water was used to calculate the young fraction in table 3. The October 1994 and October 1996 ^3H concentrations were 1.2 and 0.8 TU, respectively. The ^3H concentrations required the presence of some post-1963 water, which suggested that a very small fraction of young water was present in this very old water. The young water may have been introduced through a hole in the casing of this 44-year old well.

TAN Exploration—This well is cased to about 17 m below the water table and has an open interval of 86.3 m. The pump is about 9 m below the water table (fig. 26). The samples from this well were enriched in $\delta^{18}O$ and were chemically and isotopically different from other water from the INEEL and vicinity. Figure 20A shows the $\delta^{18}O$ and δ^2H ratio in the ground-water samples and the world and local meteoric lines. The water samples had low bicarbonate and nitrate concentrations but high chloride and sulfate concentrations. The ^3H concentration of the 1994 sample was measured by ^3He ingrowth-mass spectroscopy and was 0.04±0.01 TU. The samples had high excess air (Busenberg and others, 1998), very low CFC concentrations, and apparently were recharged by slow infiltration through a thick, unsaturated zone. The presence of only 10 percent He_{terr} suggested that the ground-water sample was predominantly infiltration water. The model-4 CFC-11 and CFC-12 ages of the ground-water sample were 19 to 21 years, respectively.

USGS 5—This well has a 6.7-m perforated interval starting about 1.3 m below the water table. The pump is about 5.2 m below the water table (fig. 26). The $^3H/^3He$ age of the 1994 sample was 16.4 years. The ^3H concentrations of the 1994 and 1996 samples were 8.8 and 6.1 TU, respectively. The He_{terr} was about 30 percent and suggested that the sample was a mixture of 27 percent regional ground water and recent recharge. The model-3 CFC-11, CFC-12, and CFC-113 ages for the 1994 samples were 21, 18, and 12 years, respectively; however, the ages for the 1996 samples were about 5 years older. The CFC-113/CFC-12 ratio ages for the 1994 and 1996 samples were 10 and 12 years, respectively.

USGS 6—This well is cased to about 35 m below the water table and is open to 26 m of water. The water had no ^3H and virtually no CFCs; thus,

the water was older than the dating range of $^3H/^3He$ (greater than about 40 years) and CFCs (greater than about 55 years).

USGS 7—This well contains two perforated intervals: a 6.1-m interval starting about 6.5 m below the water table and a 134-m interval beginning at about 165 m below the water table. The pump is about 7.5 m below the water table (fig. 26). The water had no ^3H and virtually no CFCs and was very old, suggesting that the upper interval produced an insignificant amount of young water. The recharge water was older than the dating range of $^3H/^3He$ (greater than about 40 years) and CFCs (greater than about 55 years).

USGS 18—This well is cased to about 7 m below the water table and is open to about 7.3 m of water. The pump is about 8 m below the water table (fig. 26). The water contained little if any ^3H; the measured concentrations were 0.17±0.15 and 0.09±0.29 TU in the July 1994 and July 1996 samples. Small amounts of CFCs that were present in the sample were probably the result of the equilibration of the infiltration water with the unsaturated zone atmosphere. The gas recharge temperature of 11.5 °C calculated for this sample from N_2/Ar concentrations was significantly higher than the mean annual temperature of 9.0 °C (fig. 30). The high recharge temperature indicated recharge by infiltration and warming in the deep, unsaturated zone. The calculated model-4 ages were 15, 17, and >13 years for CFC-11, CFC-12, and CFC-113. The He_{terr} concentration in the ground water was 84 percent and suggested that the sample contained a less-than-5 percent fraction of infiltration recharge water.

USGS 26—This well is cased to about 5.4 m below the water table and is open to about 10.5 m of water. The pump is about 12.4 m below the water table (fig. 26). The water samples contained 0.00±0.02 TU of ^3H, which indicated the absence of post-1950 focused recharge and the presence of water from the ^3H-bomb peak still in the unsaturated zone. This conclusion is reasonable because the well is located in an area with extensive playa deposits. Small but significant concentrations of CFCs were present in the water, suggesting that some recharge with infiltration water had occurred in the past 5 to 6 years (model-4 age). The calculated N_2/Ar recharge temperature of 10.8 °C was higher than the mean annual temperature; however, the 86 percent He_{terr} concentration in the ground water suggested that less than 5 percent of the sample was infiltration recharge.

Northeastern

USGS 4—This well contains two perforated intervals: a 9.1-m interval starting about 6 m below the water table and a 70.4-m interval beginning at about 18 m below the water table. The pump is about 10.5 m below the water table (fig. 26). The well is located near the Mud Lake-Terreton area next to an irrigated field, and received significant recharge from agricultural runoff (Olmsted, 1962). The 1994 and 1995 samples were dated by using the $^3H/^3He$ method and were 5.4 and 4.7 years, respectively. The model-1 CFC-12 ages of the water were 5.8±0.4, 2.8±0.4, and 7.8±3.2 years for the 1994, 1995, and 1996 samples, respectively. Even though the well sampled a long perforated interval of the aquifer, the water in the samples came predominantly from near the top of the water table. The young age of the samples indicated that significant recharge of the aquifer was taking place at this site.

USGS 27—This well contains two perforated intervals: a 3.1-m interval starting about 6.3 m below the water table and a 3.1-m interval beginning at about 21 m below the water table. The pump is about 10 m below the water table (fig. 26). The October 1994 and October 1996 samples had ^3H concentrations of 1.22±0.02 and 0.93±0.23 TU, respectively. The model-4 age of the ground water was about 10 to 13 years, which indicated that most of the sample was produced from the shallow, perforated interval.

USGS 29—This well is cased to about 1.4 m below the water table and is open to about 19.0 m of water. The samples did not contain significant mantle ^3He and probably originated from the agricultural Terreton-Mud Lake area. The chemical (Olmsted, 1962) and isotopic composition (Busenberg and others, 1998) of the samples indicated a significant agricultural influence. The $^3H/^3He$ ages of the young fraction were 27.5 and 27.6 for the 1994 and 1995 samples, respectively.

The CFC-11/CFC-12 ratio ages of the young fraction in the samples were 21.8±0.7, 21.8±1.2, and about 21 years for the October 1994, June 1995, and July 1996 samples, respectively.

USGS 31—This well is cased to about 8 m below the water table and is open to about 43 m of water. The pump is about 7.7 m below the water table. The 1994 sample contained virtually no ^3H which indicated no significant recharge of post-1950 precipitation. The presence of CFCs in the samples indicated that some infiltration water had recharged the aquifer in the past 30 years. The area of recharge is covered with extensive playa deposits, and recharge was apparently by slow infiltration through the thick, unsaturated zone. The amount of infiltration recharge calculated from the He_{terr} concentration of 83 percent was probably less than 5 percent. The calculated CFC-11 and CFC-12 model-4 ages of the ground water were 11 and 13 years, respectively.

USGS 32—This well is cased to about 4 m below the water table and is open to about 27.2 m of water. The pump is about 9 m below the water table (fig. 26). The $^3H/^3He$ age of the young fraction of the water sample could not be calculated because of the uncertainty in the R_{terr}. All the samples contained less than 1 TU of ^3H, which indicated no significant recharge of post-1950s precipitation. The chemistry of the water also indicated a small agricultural influence (Olmsted, 1962; Busenberg and others, 1998; 2000). The He_{terr} concentration of 37 percent suggested that about 60 percent of the sample represented slow infiltration recharge through a thick, unsaturated zone. The model-4 age of 5 years indicated recent recharge with infiltration water.

Central

BFW—The Badging Facility Well is cased to about 13 m below the water table and is open to about 34 m of water. The concentration of ^3H was 7.1 TU in July 1996. The well appears to be located at the outer boundary of the TRA-INTEC ^3H plume (fig. 6). The ^3H concentration was consistent with post-1950 focused recharge. The CFC concentrations appeared to be slightly modified by waste disposal practices at the INEEL (fig. 7, 8, and 9). A precise age could not be assigned; however, the CFCs and ^3H concentrations suggested an age of 20 to 30 years for the young fraction of the water. This age was consistent with the estimated flow velocity of 3 m per day calculated for the central part of the INEEL (fig. 25).

CFA-1—This well is a large production well open to 62.8 m of water. The well is located within the TRA-INTEC ^3H contaminant plume and the water was contaminated with CFCs and ^3H. The $\delta^{18}O$ indicated that about half of the sample was young water recharged at or near the INEEL. The well could not be dated by using environmental tracers because of the CFC and ^3H contamination.

CFA-2—This well is also a large production well and is cased to about 15 m below the water table. The well is located within the TRA-INTEC ^3H contaminant plume and the water was contaminated with CFCs and ^3H. The $\delta^{18}O$ indicated that about three quarters of the sample was young water that recharged at or near the INEEL. The well could not be dated by using environmental tracers because of the CFC and ^3H contamination.

EBR I—This well is a deep production well with a 122-m perforated interval. The well is cased to a depth of 27 m below the water table. The water samples contained virtually no CFC-11 and CFC-113; however, the samples contained significant concentrations of CFC-12 (fig. 7). The water contained an excess of SF_6. The absence of CFC-11 and CFC-113 in ground water indicated ages greater than 45 years.

Fire Station 2—This well produces water from a 12.2-m perforated interval near the water table and a 3.1-m interval about 25 m below the water table. The well was contaminated with CFC-11, and the model-1 CFC-12, CFC-113, and SF_6 ages were 26, 8, and 29 years, respectively. Model-2 ages could not be obtained because of some contamination with environmental tracers. The model-3 CFC-12 age was 11.4±0.5 years. The ^3H concentration of 11.4 TU was consistent with the younger age for the young fraction of water.

WS INEL-1—This well produces water from the water table to a depth of 59 m below the water table. The pump is about 7 m below the water table (fig. 26). The young fraction of water contained a slight excess of CFC-11 and the model-1 CFC-11, CFC-12, CFC-113, and SF_6 ages were 8, 25, 22, and 21 years, respectively. The preferred model-2 ages using CFC-113/CFC-12 and SF_6/CFC-12 ratios were 21 years for both ratios. The model-3 ages were 10±10 for CFC-12 and 20±3 for CFC-113. The ^3H concentration of 15.1 TU was consistent with a young age for the young fraction in the ground-water sample.

NPR Test—This well is perforated for about 10.7 m starting about 10.2 m below the water table. The pump is about 6 m below the water table (fig. 26). The water was slightly contaminated with CFC-11, and the concentrations were higher in the 1995 samples. The ages of the young fraction for the April 1995 sample calculated by using eastern INEEL terrigenic and the radiogenic He isotope ratios were 13.9 and 12.1 years, respectively. The measured ^3H concentrations were 19.9 and 15.4 TU for the 1995 and 1996 samples, respectively. The CFC-113 model-3 ages of the water were 17.8±1.0 and 14.4±3.0 years for the 1995 and 1996 samples, respectively; however, the CFC-12 model-3 ages were significantly higher, 26±1 and 28±0 years, respectively. This sample may have been contaminated with ^3H and the 13.9-year age for the 1995 sample may have been younger than the actual age of the water. The age of the young fraction was probably about 25 years.

RWMC M3S—This well was highly contaminated with CFCs, ^3H, and many other volatile halocarbons and could not be dated by using CFCs or the $^3H/^3He$ method.

RWMC M7S—This well was highly contaminated with CFCs, ^3H, and many other volatile halocarbons and could not be dated by using CFCs or the $^3H/^3He$ method.

Site 4—This well is perforated from about 6 to 29 m below the water table. The model-3 ages of the young fraction calculated from the reconstructed partial pressures of CFC-12 and CFC-113 were 24.5±0.3 and 12.5±2.3, respectively. The measured ^3H concentration was 16.1 TU. The age of the young fraction at this depth was about 25 years; however, the age of the water at the water table may have been about 10 years younger as suggested by the $^3H/^3He$ ages of nearby wells.

Site 9—This well is perforated from about 63 to 177 m below the water table. The pump is about 15 m below the water table (fig. 26). Even though this well produces water from a very long interval, the vast majority of the water appeared to come from one zone and the model-1 age best fit the CFC and measured ^3H (1.3±0.3 TU) concentrations. The absence of CFC-113 and very low concentrations of CFC-11 and CFC-12 suggested that the age of the water was between 35 and 40 years. The age of the young fraction at the water table was probably significantly younger at this location.

Site 17— Except for 5 m of casing, this well is an open hole containing about 60 m of water. The pump is about 12 m below the water table (fig. 26). The model-2 age for the young fraction from the CFC-113/CFC-12 ratio was 6.5 years; the water could not be dated with model 3. Even though the well was open to 60 m of aquifer, the water sampled probably was obtained from one zone. Model-1 CFC-11, CFC-12, and CFC-113 ages were 22, 21, and 13 years, respectively.

Site 19—This well has four perforated intervals: the first is at the water table and the others are at 19, 38, and 91 m below the water table. The pump is about 4.6 m below the water table (fig. 26). The model-1 ages of the young fraction of the ground-water samples were from 15 to 22 years. The model-2 CFC-113/CFC-12 and CFC-113/CFC-11 ratio ages were 10 and 15 years, respectively. The ^3H concentration of the 1996 sample was 4.2 TU. The He_{terr} concentration of 7 percent indicated that the water sample contained virtually no regional background water.

USGS 9—This well is located at the outer edge of both the ^3H and CFC plumes (figs. 6–9). This well contains two perforated intervals: a 9.1-m interval starting about 2.7 m below the water table and a 0.5-m interval beginning at about 13 m below the water table. The pump is about 8 m below the water table (fig. 26). The 1994 and 1996 samples were dated by using the $^3H/^3He$ method. The ages obtained represented the traveltime of the

^3H from the waste-disposal well at INTEC to USGS 9. The $^3H/^3He$ traveltimes were 21.3 and 22.7 years for the 1994 and 1995 samples, respectively. The velocity of the water calculated along a straight-line path from the injection point to USGS 9 was 2.1 and 1.9 m/day for the 1994 and 1995 samples. This velocity was comparable to other ground-water flow velocities reported in the literature for the INEEL (Bartholomay and others, 2000). Because of excess CFC concentrations in the samples, the CFC ages were unreliable. The He_{terr} concentration of 23 percent indicated that the samples could contain up to 20 percent regional background water.

USGS 11—This well produces water from a 9.6-m zone starting about 5.5 m below the water table. The pump is about 10 m below the water table, and the well is located at the outer fringe of the tritium plume (fig. 6). The $^3H/^3He$ traveltime was calculated to be 17.3 years from the INTEC waste-disposal well. Because of the presence of some excess CFC concentrations in the samples, the CFC ages were considered unreliable. The He_{terr} concentration of 13 percent indicated that the samples could contain only a small fraction of regional background water.

USGS 12—The location and length of the open interval sampled are not known for this well. The pump is about 7 m below the water table (fig. 26). The chemistry of the water (high nitrate and other agricultural chemicals) and the young age of the samples indicated that the water in this well was from the top of the aquifer. The $^3H/^3He$ ages of the 1994 and 1995 samples were only 2.9 and 4.5 years, respectively. The model-3 CFC-11, CFC-12, and CFC-113 ages were 17, 17, and 15, respectively; significantly older for the young fraction of the ground water. The reason for the large discrepancy between CFC the $^3H/^3He$ ages is not clear. The He_{terr} concentration of 6 percent indicated that the samples were local recharge with little, if any, regional background water.

USGS 14—This well has 9 m of perforated interval starting about 0.9 m below the water table. The $^3H/^3He$ age of the 1994 sample was 27.3 years. If the age of 27.3 years represented the traveltime of ground water from the INTEC waste-disposal well, then the flow velocity was about 2.8 m/day. This was similar to the flow velocity of 3 m/day calculated by Cecil and others (2000) using ^{36}Cl. The well is located at the eastern edge of the CFC contamination plume and could not be accurately dated by using CFCs. Model-1 ages obtained by using CFCs ranged from 6 to 25 years. The young age of the water indicated the presence of a preferential flowpath through central INEEL to USGS 14, passing east of Big Southern Butte (fig. 23). The low concentration of He_{terr} of 13 percent suggested that the ground-water sample consisted of more than 90 percent local recharge.

USGS 15—This well has a 21.3-m perforated interval starting at about 66 m below the water table. The low concentrations of CFCs and ^3H (0.55 TU) and high He concentration (fig.12) indicated the presence of a very small fraction of young water in the sample. The He_{terr} concentration indicated a local recharge concentration in the sample of less than 5 percent; $\delta^{18}O$ ratios indicated a 7-percent concentration of local recharge. The model-3 CFC-11 and CFC-12 ages of the small fraction of young water were 26 and 22 years, respectively. CFC-113 was not present.

USGS 17— This well contains two perforated intervals: a 2.1-m interval starting about 24 m below the water table and a 0.7-m interval beginning at about 41.5 m below the water table. The pump is about 13 m below the water table (fig. 26). The $^3H/^3He$ age for the 1994 sample was 16.1. The water contained low concentrations of CFCs but relatively high concentrations of ^3H. The ^3H concentrations were 18.7 and 15.6 TU in the 1994 and 1995 samples, respectively. The model-3 CFC-11, CFC-12, and CFC-113 ages were 29, 30, and 28 years, respectively. The model-2 ages were from 7 to 27 years. The ground-water ages for this well were calculated from very low partial pressures of CFCs, which resulted in relatively large uncertainties in CFC model ages. The fractions of local recharge calculated from the He_{terr} concentration and $\delta^{18}O$ ratios were about 57 and 74 percent, respectively.

USGS 19—This well has a 6.4-m perforated interval starting about 2 m below the water table and the pump is about 13 m below the water table (fig. 26). The calculated $^3H/^3He$ ages for the young fraction of water for the 1994 and 1995 samples

were 15.6 and 14.9 years, respectively. The model-1 CFC-11, CFC-12, and CFC-113 ages were 25, 22, and 18 years, respectively. The model-2 CFC-113/CFC-12 age was 9 years.

USGS 36—This well could not be dated with CFCs because of contamination with volatile organic compounds. A large fraction of young water was present in this well. The well is located in the TRA-INTEC ^{3}H and CFC contaminant plumes.

USGS 37—This well could not be dated with CFCs because of contamination with volatile organic compounds. A large fraction of young water was present in this well. The well is located in the TRA-INTEC ^{3}H and CFC contaminant plumes.

USGS 65—This well could not be dated with CFCs because of contamination with volatile organic compounds. A large fraction of young water was present in this sample. The well is located in the TRA-INTEC ^{3}H and CFC contaminant plumes.

USGS 76—This well could not be dated with CFCs because of contamination with volatile organic compounds. A large fraction of young water was present in this well. The well is located in the TRA-INTEC ^{3}H and CFC contaminant plumes.

USGS 77—This well could not be dated with CFCs because of contamination with volatile organic compounds. A large fraction of young water was present in this well. The well is located in the TRA-INTEC ^{3}H and CFC contaminant plumes.

USGS 82—This well contains two perforated intervals: a 15.2-m interval starting about 5.5 m below the water table and a 32.6-m interval beginning at about 43 m below the water table. The pump is about 17 m below the water table (fig. 26). The well is located near the eastern edge of the TRA-ICPP ^{3}H contaminant plume. The well was contaminated with CFC-12 but did not appear to be contaminated with the other two CFCs. The ages of the young fraction of water calculated from the reconstructed CFC-11 and CFC-113 partial pressures were 27 and 22 years, respectively.

USGS 83—This well is cased to about 4.6 m below the water table and is open to 71.9 m of water. The pump is about 32 m below the water table (fig. 26). Even though this well is located within the CFC contaminant plume area, the water samples were not contaminated with CFCs because the water sampled was not from the top of the water table. The model-2 CFC-11/CFC-12 age of the sample was 34 years, but was unreliable. Model-3 ages were calculated from the reconstructed partial pressures of CFC-11 and CFC-12 and were 34 and 35 years, respectively. The concentration of CFC-113 in the ground water was very small and ages calculated by using this tracer were unreliable. A concentration of about 25 percent recent recharge was calculated from $\delta^{18}O$ ratios.

USGS 97—This well is cased to about 1 m below the water table and is open to 37.2 m of water. The pump is about 5 m below the water table (fig. 26). The sample was contaminated with CFC-11. The piston flow CFC-12 and SF_6 ages of the water (model 1) were 21 and 24, respectively. A model-3 age of 10 years was calculated with CFC-12. The sample had 21.6 TU of ^{3}H. The age of the young fraction calculated by using the $^{3}H/^{3}He$ method was 6.3 years. This age probably represented the traveltime of the water from disposal at NRF to the well, which indicated an average flow velocity of about 1 m/day.

USGS 98—This well contains two open intervals; a 1.6-m perforated interval starting at the water table and a 30.8-m open interval beginning at about 15 m below the water table. The pump is about 2.5 m below the water table (fig. 26). A model-3 age of 7 years was calculated from the CFC-12 concentration. The CFC concentrations in the water from this well may have been modified by wastewater-disposal practices at NRF and, therefore, the calculated CFC ages were younger than the age of the young fraction of water. The $^{3}H/^{3}He$ age of the young fraction was 6.7 years, and may have represented the traveltime of ground water from NRF to the well. The calculated average flow velocity of the ground water was approximately 2.0 m/day.

USGS 99—This well has about 15 m of perforated interval starting at the water table. The pump is about 8.3 m below the water table (fig. 26). Model-2 ages could not be calculated because of some CFC contamination of the sample. A model-3 age of 11 years was calculated from the SF_6 data. The calculated $^3H/^3He$ age of the young fraction of water was 4.0 years. The well is located just south of NRF (fig. 2). The extremely young age and ^3H concentration were consistent with nearby wastewater-disposal practices at NRF. The $^3H/^3He$ age probably represented the traveltime of the water from NRF to the well. The calculated average flow velocity of the ground water was approximately 2.5 m/day.

USGS 102—This well is open to water from the water table to about 20 m below the water table. The pump is about 13 m below the water table (fig. 26). The calculated model-3 age of the young fraction of water from the reconstructed CFC-12 partial pressures in the sample was 9 years. The sample contained greater than background concentrations of CFC-11 and CFC-113 and a ^3H concentration of 20.4 TU. The calculated $^3H/^3He$ age of the young fraction of water in the sample was 5.7 years. The $^3H/^3He$ age may have represented the traveltime of the water from NRF to the well, which indicated an average ground-water flow velocity of about 0.5 m/day.

USGS 103—This well is open to water from the water table to about 53 m below the water table. The pump is about 35 m below the water table (fig. 26). The 1995 young fraction of the sample was dated by using the $^3H/^3He$ method. The model-3 ages calculated for the young fraction of water with the reconstructed CFC-11 partial pressures were 23 and 8 years for the 1994 and 1996 samples, respectively. The well contained significantly higher concentrations of CFCs in the 1996 sample, and the younger age was the result of contamination of the sample with CFC-11. The calculated $^3H/^3He$ age of the young fraction of water in the 1995 sample was 26 years and was similar to the CFC-11 age from 1994. The $^3H/^3He$ age probably represented the traveltime of ground water from INTEC disposal well to USGS 103, which indicated an average ground-water flow velocity of 1.3 m/day.

USGS 104—This well is open to water from the water table to about 44 m below the water table. The pump is about 10 m below the water table (fig. 26). This well is located in the CFC contaminant plume. Also, there is a hole in the intake pipe that allows air to mix with the ground water. For these reasons, the age of ground water could not be calculated.

USGS 105—This well is open to water from the water table to about 40 m below the water table. The pump is about 8.5 m below the water table. Water from this well contained greater than background concentrations of CFCs and ^3H and could not be dated.

USGS 106—This well is open to water from the water table to about 52 m below the water table. The pump is about 7 m below the water table. Water from this well contained greater than background concentrations of CFCs and ^3H and could not be dated.

USGS 107—This well is open to water from the water table to about 64 m below the water table. The pump is about 15 m below the water table. The well is located at the eastern edge of the CFC-11, CFC-12, and CFC-113 contaminant plumes (fig. 7, 8, and 9) and the ground water could not be dated by the ratio method. The reconstructed partial pressures of CFC-11, for the young fraction of water in the samples indicated a model-1 age of 15 years; however, because of some contamination of the aquifer with CFC-11, the water was probably older than 15 years.

USGS 108—This well is open to water from the water table to about 45 m below the water table. The pump is about 8 m below the water table. The sample was contaminated with CFC-12. The model-3 CFC-11 age was about 20 years; however, the actual age was likely older because of slight contamination with CFC-11.

USGS 109—This well is open to water from the water table to about 54 m below the water table. The pump is about 10 m below the water table. The samples could not be dated with the CFC method because of contamination with CFCs, particularly CFC-12 and CFC-113. The age of the young fraction of ground water calculated by using the $^3H/^3He$ method for the 1994 sample was 18 to

20 years. The $^{3}H/^{3}He$ age may have represented the traveltime of the water from INTEC disposal well to USGS 109, which indicated an average ground-water flow velocity of 2.2 m/day.

USGS 112—This well is open to water from the water table to about 27 m below the water table. The pump is about 10 m below the water table. The sample could not be dated with CFCs because of contamination, particularly with respect to CFC-12 and CFC-113.

USGS 113—This well samples the aquifer from the water table to a depth of about 8 m below the water table. The sample could not be dated because of contamination.

USGS 115—This well is open to water from the water table to about 35 m below the water table. The pump is about 12 m below the water table. The model-3 age calculated from reconstructed partial pressure of CFC-11 was 17 years for the young water fraction in the sample. The ground water probably was older than 17 years because of slight contamination with CFC-11.

USGS 116—This well is open to water from the water table to about 36 m below the water table. The pump is about 14 m below the water table. The model-3 age of the young water fraction in the sample calculated from the reconstructed partial pressure of CFC-11 was 11 years. The ground water probably was older than 11 years because of slight contamination with CFC-11.

USGS 117—This well is open to water from the water table to about 20 m below the water table. The pump is about 14.5 m below the water table. Even though the well is located near the RWMC, the water did not appear to be significantly contaminated with CFCs. The model-2 CFC-11/CFC-12 ratio age for the young fraction of water was 25 years. The model-3 ages calculated from reconstructed partial pressures of CFC-11 and CFC-12 for the young fraction of water were 23 to 31, and 23 to 33 years, respectively. Because the ground-water sample may have been slightly contaminated with all the CFCs, the actual age of the young fraction may have been older than 33 years.

USGS 119—This well has a 20.1-m perforated interval starting about 10 m below the water table. The pump is about 24 m below the water table. The well is located near the RWMC and the sample could not be dated with CFCs because of contamination, particularly with respect to CFC-12 and CFC-113.

USGS 120—This well has a 20.4-m perforated interval starting about 6.5 m below the water table. The pump is about 15 m below the water table. The well is located near the RWMC and the sample could not be dated with CFCs because of contamination, particularly with respect to CFC-12 and CFC-113.

USGS 121—This well is open to water from the water table to about 5.3 m below the water table. The pump is about 0.8 m below the water table. The sample was difficult to date with CFCs because the ground water was contaminated. A model-3 age of 20 years was calculated from the reconstructed partial pressure of CFC-11. An age of 15.5 years was calculated using $^{3}H/^{3}He$. The $^{3}H/^{3}He$ probably represented the traveltime of water from NRF to USGS 121. The average ground-water flow velocity was about 1.6 m/day.

USGS 124—This well has a 15.2-m perforated interval starting about 20 m below the water table. The pump is about 16 m below the water table. The model-3 ground-water age calculated from the reconstructed CFC-11 partial pressure was 19 years. The well is located within the CFC-12, CFC-113, and ^{3}H contaminant plumes. The $^{3}H/^{3}He$ ages of the young fraction of water in the 1994 and 1995 samples were 24 years. The $^{3}H/^{3}He$ age may have represented the traveltime of the water from INTEC disposal well to USGS 124. The estimated average ground-water flow velocity was about 2.3 m/day.

USGS 125—This well is open to water from the water table to about 44 m below the water table. The pump is about 21 m below the water table. The ^{3}H concentration of the ground water was 22.7 TU. The well had greater than background concentrations of CFC-12 and CFC-113. Water from the well was probably contaminated with CFC-11 and thus, the CFC-11 derived age was a minimum age. The model-3 age

of the young fraction calculated from the reconstructed partial pressure of CFC-11 was 11 years. The $^3H/^3He$ age of the young fraction of water was 17 years. The $^3H/^3He$ age may have represented the traveltime of the water from INTEC disposal well to USGS 125. The estimated average ground-water flow velocity was about 3.1 m/day.

Western

USGS 22—This well contains two perforated intervals: a 4.6-m interval starting about 2 m below the water table and a 4-m interval beginning at about 9.5 m below the water table. The pump is about 8.8 m below the water table. This well produces very little water (10 to 12 L per minute). The alkalinity of the water was about half the alkalinity elsewhere in the aquifer. Nitrate concentrations were low and chloride concentrations were high compared with other water in the aquifer (fig. 29). The $\delta^{13}C$ was light, and the ^{14}C activity was high (69.9 pmc) compared with other water in the aquifer. The unusual carbon chemistry and isotopic composition is shown in figures 29, 36, and 38. The fraction of the young water in this well may have been precipitation that recharged in the western part of the INEEL. The absence of He_{terr} in the ground water (0.0 percent) also indicated that the water from this well was local recharge. The light isotopic composition of the $\delta^{13}C$ of the dissolved inorganic carbon suggested that the alkalinity was derived mainly from the reaction of soil carbon dioxide with sediment and basalt and not carbonate rocks of marine origin. Because of the high ^3H concentration, the calculated $^3H/^3He$ age for the 1995 sample was 7.9 years and was independent of the $^3He/^4He$ isotopic ratio of the terrigenic He. The concentrations of CFCs in the water were relatively low and not consistent with the $^3H/^3He$ age of the water. Model-1 CFC ages were 20 to 35 and 18 to 27 years for the 1995 and 1996 samples, respectively. The model-2 ages calculated from the CFC-113/CFC-12 ratio were 6.5 and 11 for the June 1995 and July 1996 samples, respectively. Even though the model-2 age was in closer agreement with the $^3H/^3He$ age, the water was not a mixture of regional ground water and local recharge (fig. 23). The recharge of the ground water possibly occurred over a period of months to a few years and the sample may have represented an intermediate mode of recharge between rapid, focused recharge along distinct pathways and slow, infiltration recharge.

USGS 23—This well has a 6.1-m perforated interval starting about 1.5 m below the water table. The pump is about 11 m below the water table. The chemistry was different from and $\delta^{13}C$ was heavier than that of the Little Lost River water (fig. 29, 36, and 38). The ^{14}C activity was very low (21.9 pmc), but the presence of CFCs and near absence of ^3H (0.4 TU) suggested that the sample contained infiltration water (fig. 36 and 37). The model-1 CFC piston-flow age of about 23 years was inconsistent with the ^3H concentrations and ^{14}C activities of the samples. The model-2 CFC-113/CFC-12 ratio age for the young fraction of water was about 10 years, but this age was unlikely because of the absence of ^3H. The $^3H/^3He$ age could not be calculated because of the high terrigenic concentration of He (57 percent), the low ^3H concentration, and the uncertainty in R_{terr}. The CFC concentrations indicated contact and significant exchange of gases between very old water and the unsaturated-zone atmosphere. Diffusive and advective transport of gases through the unsaturated zone was required to explain the high concentrations of CFCs in this ground water; however, a model-4 age could not be calculated. The chemistry and the isotopic composition of the water suggested that the recharge water may have been derived from the Lost River Range and was not surface water from the Little Lost River.

USGS 89—This well is open to about 13 m of water and the pump is about 5 m below the water table. The well is located near the RWMC and was contaminated with CFC-113 and highly contaminated with CFC-12. The model-1 CFC-11 age was 28 years for the 1994 sample and 27 years for the 1996 sample. The composition of the water of USGS 89 was similar to that of USGS 22 (fig. 29).

Southwestern

USGS 8—This well has a 9.2-m perforated interval starting about 4 m below the water table. The pump is about 9.4 m below the water table. The $^3H/^3He$ age of the 1994 sample was 8.4 years. The CFC-11/CFC-12 and CFC-113/CFC-12 ratios

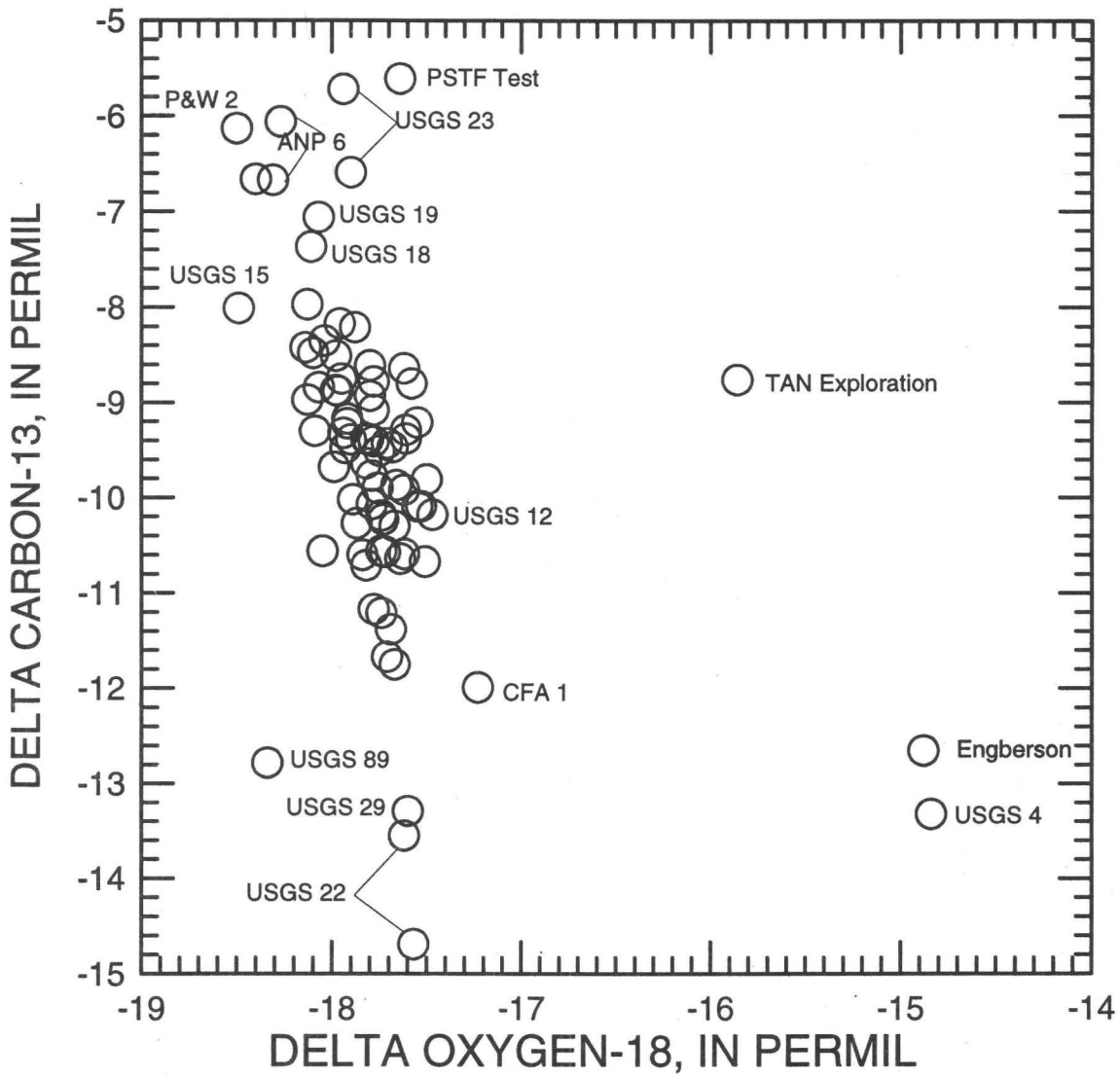

Figure 38. Relation between delta oxygen-18 of the water and the delta carbon-13 of the dissolved inorganic carbon in water from selected wells at and near the Idaho National Engineering and Environmental Laboratory.

suggested that both CFC-11 and CFC-113 concentrations were not consistent with air ratios. The model-3 reconstructed CFC-12 ages were 9.6±0.5 and 8.4±0.2 years for the 1994 and 1996 samples, respectively. The source of young water appeared to be the Big Lost River channel, which is located upgradient of the well. The ground-water flow velocity of the water to the well was about 1.0 m/day.

USGS 86—This well is open to about 12 m of water. The pump is about 8 m below the water table. The 1996 sample contained a significant amount of gas and could not be dated by using CFCs. The CFC-11/CFC-12 ratio age of the 1994 sample was 25.3 years (model 2). The model-3 ages calculated from reconstructed CFC-11 and CFC-12 partial pressures were 24.1 and 23.8 years, respectively. The $^{3}H/^{3}He$ age was 12.1±0.5 years. The large differences in ages between the CFCs and $^{3}H/^{3}He$ were consistent with infiltration water that had partially equilibrated with unsaturated-zone gases that were different in composition from air or model-6 recharge.

Table 1. Recharge temperatures, calculated chlorofluorocarbon partial pressures, and apparent piston-flow ages of ground water from at and near the Idaho National Engineering and Environmental Laboratory

[See figure 2 for location of sites. Blank spaces, no data or not applicable. Abbreviations: temp., temperature; °C, degrees Celsius; elev., elevation above sea level; m, meter; pptv, parts per trillion volume; F11, Chlorofluorocarbon-11; F12, Chlorofluorocarbon-12; F113, Chlorofluorocarbon-113; SF_6, sulfur hexafluoride; C, contaminated or partial pressure exceeds historical atmospheric partial pressures; ERR, interferences, concentration not measured]

		Recharge		Calculated partial pressure, in pptv				Model 1 Apparent piston-flow age, in years			
Well name	Date sampled	temp., °C	Elev., m	F11	F12	F113	SF_6	F11	F12	F113	SF_6
ANP 6	10/14/1994	12.4	1461.4	76.6	196.9	50.3		24.3	22.3	9.8	
ANP 6	10/14/1994	12.4	1461.4	77.7	184.7	55.5		23.8	22.8	9.3	
ANP 6	10/14/1994	12.4	1461.4	77.5	197.5	51.4		24.3	22.3	9.8	
ANP 6	06/15/1995	12.4	1461.4	85.0	210.6	57.4	0.51	24.0	22.5	9.5	19.5
ANP 6	06/15/1995	12.4	1461.4	86.0	227.4	57.4	0.49	24.0	21.5	9.5	19.5
ANP 6	06/15/1995	12.4	1461.4	84.2	208.5	50.2		24.0	22.5	10.5	
ANP 6	07/19/1996	12.4	1461.4	86.5	196.1	43.6	7.47	25.1	24.1	12.6	C
ANP 6	07/19/1996	12.4	1461.4	87.4	200.2	44.7	7.47	25.1	24.1	12.6	C
ANP 6	07/19/1996	12.4	1461.4	83.7	214.9	ERR		25.1	23.1	ERR	
ANP 6	07/19/1996	12.4	1461.4	106.2	233.7	56.8		23.6	22.6	10.6	
ANP 9	10/14/1994	10.7	1461.4	26.6	73.2	5.1		30.3	29.8	26.3	
ANP 9	10/14/1994	10.7	1461.4	24.7	74.4	6.0		30.8	29.3	25.3	
ANP 9	10/14/1994	10.7	1460.0	26.2	73.5	4.4		30.3	29.8	27.3	
ANP 9	10/14/1996	10.7	1460.0	28.4	77.0	0.0	1.30	31.8	31.3	43.8	13.3
ANP 9	10/14/1996	10.7	1460.0	28.4	83.8	4.6		31.8	30.8	29.3	
ANP 9	10/14/1996	10.7	1460.0	28.2	76.3	4.3		31.8	31.3	29.8	
Arbor Test	04/21/1995	11.0	1574.4	72.7	138.0	7.7	0.57	24.3	25.3	23.8	18.3
Arbor Test	04/21/1995	11.0	1574.4	61.7	131.5	19.9	1.54	25.8	25.8	17.3	10.3
Arbor Test	04/21/1995	11.0	1574.4	65.9	142.8	1.2		25.3	24.8	36.8	
Arbor Test	10/10/1996	11.0	1574.4	69.2	140.3	11.5	1.76	26.3	26.8	22.3	10.3
Arbor Test	10/10/1996	11.0	1574.4	71.1	146.1	14.1		26.3	26.3	21.3	
Arbor Test	10/10/1996	11.0	1574.4	67.0	137.5	13.5		26.3	26.8	21.3	
Area II	07/19/1994	16.3	1563.6	49.1	96.5	9.1		28.0	29.0	24.0	
Area II	07/19/1994	16.3	1563.6	48.2	98.3	3.8		28.0	29.0	30.5	
Area II	07/19/1994	16.3	1563.6	45.9	104.3	0.0		28.5	28.5	41.5	
Area II	07/18/1996	16.3	1563.6	58.7	110.5	4.6		29.0	30.0	31.0	
Area II	07/18/1996	16.3	1563.6	59.4	107.9	7.5		29.0	30.5	27.5	
Area II	07/18/1996	16.3	1563.6	55.6	106.0	8.2		29.5	30.5	27.0	
Atomic City	10/03/1994	13.1	1529.2	133.3	296.5	38.1		20.3	18.3	12.3	
Atomic City	10/03/1994	13.1	1529.2	131.6	296.9	36.1		20.3	18.3	12.8	
Atomic City	10/03/1994	13.1	1529.2	140.0	288.7	42.7		19.8	18.8	11.3	
Atomic City	10/09/1996	13.1	1529.2	147.0	312.7	38.0	2.36	21.3	19.3	14.3	6.8
Atomic City	10/09/1996	13.1	1529.2	134.3	305.2	41.0		22.3	19.8	13.8	
Atomic City	10/09/1996	13.1	1529.2	145.5	311.4	45.6		21.3	19.8	12.8	
BFW	07/16/1996	10.7	1524.0	121.1	443.0	ERR		21.5	9.5	ERR	
BFW	07/16/1996	10.7	1524.0	120.6	438.9	ERR		23.0	13.5	ERR	
BFW	07/16/1996	10.7	1524.0	182.0	614.8	96.1		19.0	5.0	6.5	
CFA 1	07/16/1996	8.9	1524.0	746.6	77804.7	415.9		C	C	C	
CFA 1	07/16/1996	8.9	1524.0	809.0	78382.0	406.8		C	C	C	
CFA 1	07/16/1996	8.9	1524.0	643.5	63120.1	509.2		C	C	C	

Table 1. Recharge temperatures, calculated chlorofluorocarbon partial pressures, and apparent piston-flow ages of ground water from at and near the Idaho National Engineering and Environmental Laboratory— Continued

Well name	Date sampled	Recharge temp., °C	Elev., m	Calculated partial pressure, in pptv F11	F12	F113	SF_6	Model 1 Apparent piston-flow age, in years F11	F12	F113	SF_6
CFA 2	07/16/1996	11.7	1524.0	759.3	385.5	372.0		C	14.0	C	
CFA 2	07/16/1996	11.7	1524.0	1715.7	69559.2	932.2		C	C	C	
CFA 2	07/16/1996	11.7	1524.0	1856.8	68700.0	1088.2		C	C	C	
CFA 2	07/16/1996	10.0	1524.0	862.5	66781.7	1156.0		C	C	C	
EBR I	10/16/1996	11.0	1524.0	0.4	452.7	0.0	2.39	47.8	9.8	43.8	6.8
EBR I	10/16/1996	11.0	1524.0	0.4	422.3	0.0		47.8	11.3	43.8	
Fire Station 2	10/16/1996	9.8	1524.0	397.7	156.5	73.8	0.17	C	25.3	7.3	29.8
Fire Station 2	10/16/1996	9.8	1524.0	387.3	150.9	67.8		C	25.3	8.3	
Fire Station 2	10/16/1996	9.8	1524.0	335.7	130.9	92.0		C	26.8		
IET Disp	07/18/1994	11.8	1460.0	9.8	237.9	10.2		35.5	20.0	21.5	
IET Disp	07/18/1994	11.8	1460.0	17.5	259.4	0.0		32.5	19.0	41.5	
IET Disp	07/18/1994	11.8	1460.0	9.6	245.1	0.0		36.0	19.5	41.5	
IET Disp	07/18/1996	11.8	1460.0	8.8	246.1	0.0		38.5	21.5	43.5	
IET Disp	07/18/1996	11.8	1460.0	9.2	243.6	0.0		38.0	21.5	43.5	
IET Disp	07/18/1996	11.8	1460.0	10.0	295.3	0.0		37.5	19.0	43.5	
IET Disp	07/18/1996	11.8	1460.0	9.6	247.4	0.0		38.0	21.5	43.5	
IET Disp	07/18/1996	11.8	1460.0	9.8	249.0	0.0		37.5	21.5	43.5	
INEL 1 WS	06/12/1995	10.0	1486.9	235.4	161.5	38.9	0.41	8.4	23.4	11.4	20.9
INEL 1 WS	06/12/1995	10.0	1486.9	241.9	131.8	6.7	0.35	8.4	25.4	24.4	21.9
INEL 1 WS	06/12/1995	10.0	1486.9	245.2	130.0	3.3		7.9	25.4	29.9	
Leo Rogers 1	07/17/1996	11.2	1524.0	59.4	144.1	22.0		27.0	26.0	17.5	
Leo Rogers 1	07/17/1996	11.2	1524.0	58.6	143.9	15.9		27.0	26.0	20.0	
Leo Rogers 1	07/17/1996	11.2	1524.0	55.6	138.0	12.6		27.5	26.5	21.5	
NPR Test	04/17/1995	8.9	1504.1	200.0	48.0	9.1	6.62	10.3	32.8	21.8	C
NPR Test	04/17/1995	8.9	1504.1	200.2	63.4	6.9		10.3	30.3	23.8	C
NPR Test	10/10/1996	8.9	1504.1	140.3	49.1	11.9	3.45	19.3	33.8	21.3	1.8
NPR Test	10/10/1996	8.9	1504.1	143.3	47.7	10.0		18.8	34.3	22.8	
NPR Test	10/10/1996	8.9	1504.1	132.3	48.0	24.7		20.3	34.3	15.8	
PSTF	10/13/1994	11.5	1459.2	52.2	137.3	12.8		26.3	24.8	19.8	
PSTF	10/13/1994	11.5	1459.2	51.4	114.9	17.7		26.3	26.3	17.8	
PSTF	10/13/1994	11.5	1459.2	52.4	116.6	8.8		26.3	26.3	22.8	
PSTF	10/14/1996	11.5	1459.2	58.0	128.6	7.9		27.8	27.8	25.3	
PSTF	10/14/1996	11.5	1459.2	57.4	124.2	10.7		27.8	27.8	23.3	
PSTF	10/14/1996	11.5	1459.2	55.8	124.6	10.7		27.8	27.8	23.3	
P&W 2	10/25/1994	6.7	1490.9	139.1	312.7	34.8	1.57	15.3	11.3	10.3	9.3
P&W 2	10/25/1994	6.7	1490.9	137.3	294.0	36.9		15.3	12.3	9.8	
P&W 2	10/25/1994	6.7	1490.9	128.6	286.4	31.9		16.8	12.8	10.8	
P&W 2	04/19/1995	6.7	1490.9	226.1	451.1	60.1	1.59		0.3	5.8	9.8
P&W 2	04/19/1995	6.7	1490.9	214.4	414.8	54.6		6.3	4.8	6.8	
P&W 2	04/19/1995	6.7	1490.9	198.6	438.9	62.3		8.3	2.3	5.3	
P&W 2	10/15/1996	6.7	1490.9	161.5	343.0	44.5	1.18	13.8	11.3	10.3	14.3
P&W 2	10/15/1996	6.7	1490.9	158.7	335.0	43.0		14.3	11.3	10.3	
P&W 2	10/15/1996	6.7	1490.9	148.4	312.8	44.2		15.8	13.3	10.3	

Table 1. Recharge temperatures, calculated chlorofluorocarbon partial pressures, and apparent piston-flow ages of ground water from at and near the Idaho National Engineering and Environmental Laboratory— Continued

Well name	Date sampled	Recharge temp., °C	Elev., m	Calculated partial pressure, in pptv				Model 1 Apparent piston-flow age, in years			
				F11	F12	F113	SF_6	F11	F12	F113	SF_6
RWMC M3S	07/22/1996	12.6	1524.0	1571.9	3606.9	9538.5		C	C	C	
RWMC M3S	07/22/1996	12.6	1524.0	1390.3	21436.0	8885.9		C	C	C	
RWMC M3S	07/22/1996	12.6	1524.0	763.4	21363.8	8762.0		C	C	C	
RWMC M7S	07/22/1996	13.5	1524.0	2285.3	3503.5	16218.5		C	C	C	
RWMC M7S	07/22/1996	13.5	1524.0	2332.2	3276.7	16484.2		C	C	C	
RWMC M7S	07/22/1996	13.5	1524.0	969.6	4090.3	15112.2		C	C	C	
Site 4	10/06/1996	10.8	1524.0	152.6	82.2	14.2	0.76	19.8	30.8	20.8	17.8
Site 4	10/06/1996	10.8	1524.0	143.0	76.3	24.7		20.3	31.3	16.8	
Site 9	07/21/1994	14.3	1502.4	20.5	27.0	0.0		32.6	38.1	41.6	
Site 9	07/21/1994	14.3	1502.4	20.2	25.9	0.0		32.6	38.1	41.6	
Site 9	07/21/1994	14.3	1502.4	18.6	26.1	0.0		33.1	38.1	41.6	
Site 9	07/21/1994	14.3	1502.4	18.9	29.2	4.4		32.6	37.6	28.6	
Site 9	07/22/1996	10.2	1502.4	17.1	32.0	0.0		34.1	37.1	43.6	
Site 9	07/22/1996	10.2	1502.4	17.4	29.1	0.0		34.1	38.1	43.6	
Site 9	07/22/1996	10.2	1502.4	18.5	30.8	3.0		33.6	37.6	31.6	
Site 14	10/13/1994	10.5	1461.5	4.8	10.1	0.0		39.3	43.3	41.8	
Site 14	10/13/1994	10.5	1461.5	3.4	9.9	0.0		40.3	43.8	41.8	
Site 14	10/13/1994	10.5	1461.5	5.5	9.4	0.0		38.8	43.8	41.8	
Site 14	10/14/1996	10.5	1461.5	4.2	14.7	0.0	9.42	41.8	43.3	43.8	C
Site 14	10/14/1996	10.5	1461.5	3.0	6.9	0.0		42.8	47.3	43.8	
Site 14	10/14/1996	10.5	1461.5	3.2	14.9	0.0		42.8	43.3	43.8	
Site 17	06/16/1995	10.0	1487.4	97.6	229.3	434.3	1.93	22.0	20.5	ERR	8.0
Site 17	06/16/1995	10.0	1487.4	95.8	219.9	35.3	1.97	22.5	21.0	12.5	7.5
Site 17	06/16/1995	10.0	1487.4	96.6	220.6	29.5	1.99	22.0	20.5	14.0	7.5
Site 19	07/16/1996	14.3	1524.0	227.1	268.4	31.3		15.5	22.0	16.5	
Site 19	07/16/1996	14.3	1524.0	225.2	256.6	42.9		15.5	22.5	13.5	
Site 19	07/16/1996	14.3	1524.0	218.5	261.0	34.9		16.5	22.0	15.5	
TAN Exploration	10/13/1994	10.0	1458.3	2.5	16.8	0.0		41.3	40.3	41.8	
TAN Exploration	10/13/1994	10.0	1458.3	2.7	18.3	0.0		40.8	39.3	41.8	
TAN Exploration	10/13/1994	10.0	1458.3	2.6	18.1	0.0		41.3	39.3	41.8	
TAN Exploration	10/14/1996	10.0	1458.3	2.3	10.1	0.0	-0.09	43.3	45.3	43.8	45.3
TAN Exploration	10/14/1996	10.0	1458.3	3.6	19.8	0.0		41.8	40.8	43.8	
TAN Exploration	10/14/1996	10.0	1458.3	4.5	23.5	0.0		41.3	39.8	43.8	
USGS 1	10/03/1994	12.5	1531.2	30.1	70.8	7.1		30.3	30.3	24.8	
USGS 1	10/03/1994	12.5	1531.2	29.9	75.9	10.6		30.3	29.8	21.8	
USGS 1	10/03/1994	12.5	1531.2	29.3	73.8	3.2		30.3	30.3	30.3	
USGS 1	10/09/1996	12.5	1531.2	34.3	79.3	7.6	1.24	31.3	31.8	26.3	13.8
USGS 1	10/09/1996	12.5	1531.2	34.7	80.1	5.0		31.3	31.8	29.3	
USGS 1	10/09/1996	12.5	1531.2	35.5	81.6	15.3		31.3	31.3	21.3	
USGS 2	07/19/1994	10.5	1562.4	55.4	121.2	6.9		25.5	25.5	23.5	
USGS 2	07/19/1994	10.5	1562.4	56.8	122.9	9.3		25.0	25.0	21.5	
USGS 2	07/19/1994	10.5	1562.4	56.5	124.8	13.4		25.0	25.0	19.0	
USGS 2	07/17/1996	10.5	1562.4	69.4	144.0	10.9		26.0	26.0	22.5	
USGS 2	07/17/1996	10.5	1562.4	68.6	138.4	11.8		26.0	26.0	22.0	
USGS 2	07/17/1996	10.5	1562.4	65.4	136.6	8.5		26.0	26.5	24.0	

Table 1. Recharge temperatures, calculated chlorofluorocarbon partial pressures, and apparent piston-flow ages of ground water from at and near the Idaho National Engineering and Environmental Laboratory— Continued

Well name	Date sampled	Recharge temp., °C	Elev., m	Calculated partial pressure, in pptv				Model 1 Apparent piston-flow age, in years			
				F11	F12	F113	SF_6	F11	F12	F113	SF_6
USGS 4	10/24/1994	6.9	1460.4	153.6	412.7	10.7	1.23	13.3	5.3	19.3	11.8
USGS 4	10/24/1994	6.9	1460.4	162.3	400.7	23.1		12.3	5.8	13.3	
USGS 4	10/24/1994	6.9	1460.4	152.4	396.2	11.4		13.3	6.3	18.8	
USGS 4	04/19/1995	6.9	1460.4	156.1	441.9	19.6	0.69	13.3	2.3	15.3	16.8
USGS 4	04/19/1995	6.9	1460.4	153.9	437.2	17.3		13.8	2.8	16.3	
USGS 4	04/19/1995	6.9	1460.4	155.5	436.0	25.4		13.3	3.3	13.3	
USGS 4	10/15/1996	6.9	1460.4	159.4	355.7	15.6	0.56	14.3	10.3	18.3	19.8
USGS 4	10/15/1996	6.9	1460.4	175.8	446.5	26.1		12.3	3.3	14.3	
USGS 4	10/15/1996	6.9	1460.4	154.4	368.4	21.0		15.3	9.8	16.3	
USGS 5	10/12/1994	10.3	1505.3	47.6	129.0	16.9		26.3	25.3	17.3	
USGS 5	10/12/1994	10.3	1505.3	46.0	111.6	19.7		26.8	26.3	16.3	
USGS 5	10/12/1994	10.3	1505.3	46.0	122.7	10.8		26.8	25.3	20.8	
USGS 5	10/10/1996	10.3	1505.3	31.0	80.9	9.8	2.06	31.3	30.8	23.3	8.3
USGS 5	10/10/1996	10.3	1505.3	30.7	77.0	7.1		31.3	31.3	25.8	
USGS 5	10/10/1996	10.3	1505.3	35.3	90.0	11.1		30.3	29.8	22.3	
USGS 6	07/19/1994	9.0	1493.5	0.0	0.0	0.0		49.5	54.5	41.5	
USGS 6	07/19/1994	9.0	1493.5	0.0	0.0	0.0		49.5	54.5	41.5	
USGS 6	07/19/1994	9.0	1493.5	0.0	0.0	0.0		49.5	54.5	41.5	
USGS 6	07/18/1996	9.0	1493.5	0.0	0.0	0.0		51.5	56.5	43.5	
USGS 6	07/18/1996	9.0	1493.5	0.0	0.0	0.0		51.5	56.5	43.5	
USGS 6	07/18/1996	9.0	1493.5	0.0	0.0	0.0		51.5	56.5	43.5	
USGS 7	10/14/1994	9.2	1460.0	0.0	0.0	3.1		49.8	54.8	29.3	
USGS 7	10/14/1994	9.2	1460.0	0.0	0.0	0.0		49.8	54.8	41.8	
USGS 7	10/14/1996	9.2	1460.0	0.4	3.5	0.0	52.08	47.8	49.8	43.8	C
USGS 7	10/14/1996	9.2	1460.0	0.6	0.0	0.0		46.8	56.8	43.8	
USGS 7	10/14/1996	9.2	1460.0	0.3	0.0	0.0		48.3	56.8	43.8	
USGS 8	10/04/1994	9.6	1583.6	33.1	175.4	9.8		28.8	22.3	21.3	
USGS 8	10/04/1994	9.6	1583.6	30.0	170.5	56.8		29.3	22.3	7.8	
USGS 8	10/04/1994	9.6	1583.6	31.3	175.1	6.0		28.8	22.3	24.8	
USGS 8	10/08/1996	9.6	1583.6	36.3	204.7	4.6	1.63	29.8	22.8	28.8	10.8
USGS 8	10/08/1996	9.6	1583.6	36.2	205.9	4.9	1.90	29.8	22.8	28.3	9.3
USGS 8	10/08/1996	9.6	1583.6	36.0	201.3	13.7		30.3	22.8	20.8	
USGS 9	10/04/1994	8.5	1533.7	111.4	343.3	43.2		19.8	11.3	9.3	
USGS 9	10/04/1994	8.5	1533.7	79.2	284.4	41.3		22.3	14.8	9.8	
USGS 9	10/04/1994	8.5	1533.7	79.2	301.8	36.5		22.3	13.8	10.8	
USGS 9	10/04/1994	8.5	1533.7	80.5	304.8	35.2		22.3	13.3	10.8	
USGS 9	04/20/1995	8.5	1533.7	79.4	337.3	36.5	1.00	22.8	12.3	11.3	13.8
USGS 9	04/20/1995	8.5	1533.7	78.5	320.1	38.9	0.71	22.8	13.3	10.8	16.8
USGS 9	04/20/1995	8.5	1533.7	76.0	282.9	29.5		23.3	15.8	12.8	
USGS 9	04/20/1995	8.5	1533.7	76.3	292.0	35.4		23.3	14.8	11.3	
USGS 9	10/11/1996	8.5	1533.7	211.2	472.4	65.7	0.70	10.3	5.3	7.8	18.3
USGS 9	10/11/1996	8.5	1533.7	89.3	274.3	34.5		23.3	17.8	12.8	
USGS 9	10/11/1996	8.5	1533.7	86.4	266.8	59.7		23.8	18.8	8.8	

Table 1. Recharge temperatures, calculated chlorofluorocarbon partial pressures, and apparent piston-flow ages of ground water from at and near the Idaho National Engineering and Environmental Laboratory— Continued

Well name	Date sampled	Recharge temp., °C	Elev., m	Calculated partial pressure, in pptv				Model 1 Apparent piston-flow age, in years			
				F11	F12	F113	SF_6	F11	F12	F113	SF_6
USGS 11	04/20/1995	10.3	1544.4	46.1	183.3	27.8	1.86	27.3	22.3	14.3	8.3
USGS 11	04/20/1995	10.3	1544.4	47.4	189.7	26.4		27.3	22.3	14.8	
USGS 11	04/20/1995	10.3	1544.4	46.0	186.6	35.6		27.3	22.3	12.3	
USGS 11	10/09/1996	10.3	1544.4	48.8	222.6	40.5	1.01	28.3	22.3	12.8	15.3
USGS 11	10/09/1996	10.3	1544.4	48.5	218.7	37.5		28.3	22.3	13.3	
USGS 11	10/09/1996	10.3	1544.4	47.6	211.5	42.0		28.3	22.8	12.3	
USGS 12	10/27/1994	10.0	1469.3	91.1	174.7	11.5	1.23	21.8	22.3	20.3	11.8
USGS 12	10/27/1994	10.0	1469.3	92.4	182.8	15.3		21.8	21.8	17.8	
USGS 12	10/27/1994	10.0	1469.3	94.7	167.8	17.6		21.8	22.8	16.8	
USGS 12	06/14/1995	10.0	1469.3	95.5	185.4	10.4	0.29	22.5	22.5	21.5	23.5
USGS 12	06/14/1995	10.0	1469.3	96.1	175.8	11.2	0.36	22.5	23.0	21.0	22.0
USGS 14	10/26/1994	14.4	1564.6	90.6	540.1	22.3	3.33	23.8	7.8	17.3	0.3
USGS 14	10/26/1994	14.4	1564.6	91.0	537.1	28.6		23.8	7.8	15.3	
USGS 14	10/26/1994	14.4	1564.6	91.6	570.4	21.9		23.8	6.3	17.3	
USGS 14	10/09/1996	14.4	1564.6	100.9	538.5	31.7	2.23	24.8	9.8	16.8	7.8
USGS 14	10/09/1996	14.4	1564.6	100.4	521.7	23.6		24.8	10.3	18.8	
USGS 14	10/09/1996	14.4	1564.6	93.9	524.6	34.8		25.3	10.3	15.8	
USGS 15	06/14/1995	6.4	1467.1	4.2	12.3	2.0	5.61	39.5	41.5	32.0	C
USGS 15	06/14/1995	6.4	1467.1	4.1	15.5	0.0	4.20	39.5	40.0	42.5	C
USGS 15	06/14/1995	6.4	1467.1	3.9	12.2	0.0	9.33	39.5	41.5	42.5	C
USGS 17	10/27/1994	10.0	1473.6	18.9	34.0	3.5	0.15	31.8	34.8	28.8	C
USGS 17	10/27/1994	10.0	1473.6	18.0	35.7	2.1		32.3	34.8	32.3	
USGS 17	06/13/1995	10.0	1473.6	20.2	45.9	1.2	0.00	31.9	33.4	36.9	35.0
USGS 17	06/13/1995	10.0	1473.6	20.4	38.0	0.0		31.9	34.9	ERR	
USGS 17	06/13/1995	10.0	1473.6	19.8	32.1	4.6		32.4	35.9	27.4	
USGS 18	07/18/1994	11.4	1464.9	7.3	17.4	0.0		37.5	40.0	41.5	
USGS 18	07/18/1994	11.4	1464.9	7.0	28.0	0.0		37.5	36.5	41.5	
USGS 18	07/18/1994	11.4	1464.9	6.4	21.2	0.0		38.0	38.5	41.5	
USGS 18	07/19/1996	11.4	1464.9	8.7	32.0	0.0	12.65	38.6	37.6	43.6	C
USGS 18	07/19/1996	11.4	1464.9	8.5	21.9	3.8	12.65	38.6	40.6	30.6	C
USGS 18	07/19/1996	11.4	1464.9	12.4	31.2	0.0		36.1	38.1	43.6	
USGS 19	10/25/1994	13.0	1463.1	75.3	215.0	56.4	10.73	24.3	21.8	9.3	C
USGS 19	10/25/1994	13.0	1463.1	77.6	223.7	28.1		24.3	21.3	14.8	
USGS 19	10/25/1994	13.0	1463.1	189.6	407.4	51.7		15.8	12.3	9.8	
USGS 19	04/19/1995	13.0	1463.1	76.1	216.9	27.9	13.71	24.8	22.3	15.3	C
USGS 19	04/19/1995	13.0	1463.1	81.8	229.4	10.3		24.3	21.8	22.8	
USGS 19	04/19/1995	13.0	1463.1	75.7	216.6	25.9		24.8	22.3	15.8	
USGS 19	04/19/1995	13.0	1463.1	81.1	227.0	4.5		24.3	21.8	28.8	
USGS 19	10/15/1996	13.0	1463.1	80.6	234.0	26.4	7.82	25.8	22.8	17.3	C
USGS 19	10/15/1996	13.0	1463.1	81.2	235.8	35.0		25.8	22.8	15.3	C
USGS 19	10/15/1996	13.0	1463.1	76.8	197.3	29.4		26.3	24.3	16.3	C
USGS 22	06/13/1995	13.3	1539.0	15.6	77.9	18.9	0.14	34.4	30.9	18.4	29.9
USGS 22	06/13/1995	13.2	1539.0	17.0	73.5	11.0	0.13	33.9	30.9	22.4	30.4
USGS 22	06/13/1995	13.2	1539.0	19.9	73.1	13.6		32.9	30.9	20.9	

Table 1. Recharge temperatures, calculated chlorofluorocarbon partial pressures, and apparent piston-flow ages of ground water from at and near the Idaho National Engineering and Environmental Laboratory— Continued

Well name	Date sampled	Recharge temp., °C	Elev., m	Calculated partial pressure, in pptv				Model 1 Apparent piston-flow age, in years			
				F11	F12	F113	SF_6	F11	F12	F113	SF_6
USGS 22	07/18/1996	13.2	1539.0	80.6	213.1	24.2	6.57	26.0	23.5	18.0	C
USGS 22	07/18/1996	13.2	1539.0	82.0	213.6	25.9	6.57	25.5	23.5	17.5	C
USGS 22	07/18/1996	13.2	1539.0	73.7	203.7	24.5		26.5	24.0	17.5	
USGS 23	10/25/1994	13.3	1488.7	96.8	226.3	28.6	50.82	22.8	21.3	14.8	C
USGS 23	10/25/1994	13.3	1488.7	98.7	225.7	29.1		22.8	21.3	14.8	
USGS 23	10/25/1994	13.3	1488.7	94.3	218.7	27.2		22.8	21.8	15.3	
USGS 23	04/19/1995	13.3	1488.7	99.1	232.1	24.1	29.84	23.3	21.8	16.8	C
USGS 23	04/19/1995	13.3	1488.7	14.6	231.2	26.1		34.8	21.8	16.3	
USGS 23	04/19/1995	13.3	1488.7	32.6	241.4	26.6		30.3	21.3	15.8	
USGS 23	10/15/1996	13.3	1488.7	110.1	245.1	32.7	18.00	23.8	22.8	15.8	C
USGS 23	10/15/1996	13.3	1488.7	109.9	243.7	26.3		23.8	22.8	17.3	
USGS 23	10/15/1996	13.3	1488.7	104.8	230.8	29.5		24.3	23.3	16.8	
USGS 26	10/14/1994	11.6	1459.9	37.7	80.2	9.2		28.3	29.3	22.3	
USGS 26	10/14/1994	11.6	1459.9	0.2	59.1	13.5		47.3	31.3	19.8	
USGS 26	10/14/1994	11.6	1459.9	38.6	82.9	7.6		28.3	28.8	23.8	
USGS 26	10/15/1996	11.6	1459.9	37.2	90.8	9.2	42.64	30.3	30.3	24.3	C
USGS 26	10/15/1996	11.6	1459.9	40.0	86.9	9.3		30.3	30.8	24.3	C
USGS 26	10/15/1996	11.6	1459.9	39.1	84.6	22.0		30.3	30.8	18.3	C
USGS 27	10/11/1994	9.6	1458.3	15.9	39.4	3.6		32.8	33.8	28.3	
USGS 27	10/11/1994	9.6	1458.3	13.5	40.8	5.2		33.3	33.3	25.8	
USGS 27	10/11/1994	9.6	1458.3	16.0	39.5	0.0		32.8	33.8	41.8	
USGS 27	10/15/1996	9.6	1458.3	16.9	44.2	2.2	1.51	34.3	34.8	33.8	11.8
USGS 27	10/15/1996	9.6	1458.3	17.0	42.6	0.0	1.84	34.3	35.3	43.8	9.8
USGS 27	10/15/1996	9.6	1458.3	16.6	33.7	0.0		34.3	36.8	43.8	
USGS 29	10/11/1994	9.7	1486.7	71.1	142.7	13.9		23.8	23.8	18.8	
USGS 29	10/11/1994	9.7	1486.7	69.0	133.9	15.3		23.8	24.3	17.8	
USGS 29	10/11/1994	9.7	1486.7	70.3	140.6	9.9		23.8	24.3	20.8	
USGS 29	06/15/1995	9.7	1486.7	76.4	147.6	8.4	0.61	24.0	24.5	23.0	18.0
USGS 29	06/15/1995	9.7	1486.7	76.4	145.4	11.4	0.48	24.0	24.5	20.5	20.0
USGS 29	06/15/1995	9.7	1486.7	76.6	156.0	11.8		24.0	24.0	20.5	
USGS 29	07/19/1996	9.7	1486.7	82.0	175.3	16.7	7.51	24.6	24.1	19.1	C
USGS 29	07/19/1996	9.7	1486.7	81.7	179.3	12.5	7.51	24.6	23.6	21.1	C
USGS 29	07/19/1996	9.7	1486.7	113.4	222.0	20.8		21.6	21.6	17.6	C
USGS 31	10/11/1994	9.7	1489.3	13.9	35.9	0.0		33.3	34.3	41.8	
USGS 31	10/11/1994	9.7	1489.3	14.2	36.5	0.0		33.3	34.3	41.8	
USGS 31	10/11/1994	9.7	1489.3	15.0	35.8	0.0		32.8	34.3	41.8	
USGS 31	06/15/1995	9.7	1489.3	16.0	40.2	2.2	1.07	33.5	34.5	32.5	13.5
USGS 31	06/15/1995	9.7	1489.3	15.5	37.2	2.5	0.91	33.5	35.0	31.5	15.0
USGS 31	06/15/1995	9.7	1489.3	15.3	35.3	3.2	6.84	33.5	35.5	30.0	C
USGS 31	07/19/1996	9.7	1489.3	17.7	41.8	0.0	7.13	34.1	35.1	43.6	C
USGS 31	07/19/1996	9.7	1489.3	18.7	41.1	10.7	2.86	33.6	35.1	22.1	4.8
USGS 31	07/19/1996	9.7	1489.3	16.7	43.1	0.0	2.28	34.1	35.1	43.6	7.3
USGS 32	10/11/1994	10.4	1466.8	26.2	93.2	9.5		30.3	27.8	21.8	
USGS 32	10/11/1994	10.4	1466.8	28.7	87.6	6.2		29.8	28.3	24.8	
USGS 32	10/11/1994	10.4	1466.8	29.2	87.9	5.6		29.8	28.3	25.3	

Table 1. Recharge temperatures, calculated chlorofluorocarbon partial pressures, and apparent piston-flow ages of ground water from at and near the Idaho National Engineering and Environmental Laboratory— Continued

Well name	Date sampled	Recharge temp., °C	Elev., m	Calculated partial pressure, in pptv				Model 1 Apparent piston-flow age, in years			
				F11	F12	F113	SF_6	F11	F12	F113	SF_6
USGS 32	06/15/1995	10.4	1466.8	28.6	89.2	7.3	0.36	30.5	28.5	24.5	22.0
USGS 32	06/15/1995	10.4	1466.8	27.6	84.0	7.1		30.5	29.0	24.5	
USGS 32	06/15/1995	10.4	1466.8	27.4	88.3	5.3		30.5	29.0	26.5	
USGS 32	07/19/1996	10.4	1466.8	30.0	89.6	0.0	4.22	31.1	29.6	43.6	C
USGS 32	07/19/1996	10.4	1466.8	29.8	84.5	0.0	4.22	31.1	30.1	43.6	C
USGS 32	07/19/1996	10.4	1466.8	33.5	95.4	7.0		30.6	29.1	25.6	
USGS 36	07/16/1996	12.1	1524.0	280.3	78933	157.3		9.0	C	C	
USGS 36	07/16/1996	12.1	1524.0	283.2	72461	143.0		8.5	C	C	
USGS 36	07/16/1996	12.1	1524.0	271.2	65079	108.9		9.5	C	C	
USGS 37	10/07/1994	10.0	1502.6	200.0	105551	203.9		11.3	C	C	
USGS 37	10/07/1994	10.0	1502.6	207.6	91520	242.4		10.3	C	C	
USGS 37	10/07/1994	10.0	1502.6	200.6	107543	205.1		11.3	C	C	
USGS 65	10/12/1994	10.0	1502.6	421.0	83494	225.7		C	C	C	
USGS 65	10/12/1994	10.0	1502.6	421.2	82135	266.8		C	C	C	
USGS 65	10/12/1994	10.0	1502.6	414.0	78331	226.8		C	C	C	
USGS 65	10/12/1994	10.0	1502.6	492.3	76193	248.0		C	C	C	
USGS 76	10/12/1994	10.0	1502.8	279.5	3641	46.3		C	C	9.3	
USGS 76	10/12/1994	10.0	1502.8	263.6	3523	47.3		5.8	C	9.3	
USGS 76	10/12/1994	10.0	1502.8	276.5	3593	40.3		C	C	10.8	
USGS 77	10/07/1994	10.0	1500.4	104.9	96044	ERR		20.8	C	ERR	
USGS 77	10/07/1994	10.0	1500.4	105.3	82181	125.0		20.8	C	C	
USGS 77	10/07/1994	10.0	1500.4	104.1	93131	ERR		20.8	C	ERR	
USGS 82	07/16/1996	9.1	1524.0	21.4	5140	5.6		32.5	C	26.5	
USGS 82	07/16/1996	9.1	1524.0	22.0	4170	3.1		32.5	C	31.0	
USGS 82	07/16/1996	9.1	1524.0	22.3	5609	4.0		32.5	C	29.0	
USGS 83	04/17/1995	7.0	1506.5	2.9	7.2	0.0	2.91	40.8	44.8	42.3	2.8
USGS 83	04/17/1995	7.0	1506.5	3.4	13.1	0.0	0.13	40.3	41.3	42.3	29.8
USGS 83	04/17/1995	7.0	1506.5	3.6	9.4	3.2		39.8	43.3	28.3	
USGS 86	10/04/1994	10.0	1548.7	16.3	33.4	5.7		32.8	35.3	25.3	
USGS 86	10/04/1994	10.0	1548.7	19.2	44.3	11.2		31.8	33.3	20.3	
USGS 86	10/04/1994	10.0	1548.7	22.8	50.1	6.0		30.8	32.3	24.8	
USGS 86	10/11/1996	10.0	1548.7	243.9	558.2	85.3	0.71	9.3	-0.2	43.8	18.3
USGS 86	10/11/1996	10.0	1548.7	51.3	103.2	64.5		27.8	28.8	8.8	
USGS 86	10/11/1996	10.0	1548.7	23.0	54.4	3.6		32.8	33.3	30.3	
USGS 89	10/07/1994	4.3	1532.8	26.1	13248.5	110.8		28.3	C	C	
USGS 89	10/07/1994	4.3	1532.8	26.3	13344.0	114.8		28.3	C	C	
USGS 89	10/07/1994	4.3	1532.8	22.6	12747.7	97.6		28.8	C	C	
USGS 89	07/17/1996	4.3	1532.8	43.6	1195.6	108.5		26.5	C	C	
USGS 89	07/17/1996	4.3	1532.8	38.5	1314.5	83.3		27.5	C	C	
USGS 89	07/17/1996	4.3	1532.8	37.5	16506.7	82.6		27.5	C	C	
USGS 97	06/13/1995	9.7	1481.0	1859.0	225.0	80.8	0.27	C	20.4	C	23.9
USGS 97	06/13/1995	9.7	1481.3	1731.0	218.8	63.0	0.28	C	20.4	7.4	23.9
USGS 97	06/13/1995	9.7	1481.6	1656.8	216.2	64.1		C	20.9	7.4	

Table 1. Recharge temperatures, calculated chlorofluorocarbon partial pressures, and apparent piston-flow ages of ground water from at and near the Idaho National Engineering and Environmental Laboratory— Continued

Well name	Date sampled	Recharge temp., °C	Elev., m	Calculated partial pressure, in pptv				Model 1 Apparent piston-flow age, in years			
				F11	F12	F113	SF_6	F11	F12	F113	SF_6
USGS 98	06/12/1995	8.1	1488.5	203.0	133.2	67.6	0.27	9.4	24.4	5.4	23.9
USGS 98	06/12/1995	8.1	1488.8	222.8	133.1	7.8	0.30	7.9	24.4	22.4	22.9
USGS 98	06/12/1995	8.1	1489.1	225.4	141.6	21.6		7.4	23.9	15.4	
USGS 99	06/12/1995	9.4	1484.4	1681.8	263.7	65.1	0.43	C	17.9	6.9	20.4
USGS 99	06/12/1995	9.4	1484.4	1792.1	264.1	75.1		C	17.9	5.4	
USGS 99	06/12/1995	9.4	1484.4	1679.5	282.2	63.0		C	16.9	7.4	
USGS 99	06/12/1995	9.4	1484.4	1717.6	268.6	67.4		C	17.9	6.4	
USGS 100	04/21/1995	10.3	1569.7	71.5	140.3	12.7	1.36	24.3	24.8	20.3	11.3
USGS 100	04/21/1995	10.3	1569.7	68.1	137.2	17.6		24.8	24.8	17.8	
USGS 100	04/21/1995	10.3	1569.7	72.1	132.3	13.6		24.3	25.3	19.3	
USGS 100	10/10/1996	10.3	1569.7	77.9	141.3	14.2	0.81	25.3	26.3	20.8	17.3
USGS 100	10/10/1996	10.3	1569.7	75.3	143.7	14.0		25.3	26.3	20.8	
USGS 100	10/10/1996	10.3	1569.7	72.8	135.3	21.4		25.8	26.8	17.8	
USGS 101	04/21/1995	10.5	1600.2	19.3	52.6	3.6	0.67	32.3	32.3	29.3	17.3
USGS 101	04/21/1995	10.5	1600.2	20.1	48.5	0.0	0.54	32.3	32.8	42.3	18.8
USGS 101	04/21/1995	10.5	1600.2	20.1	4.6	0.0		32.3	47.3	42.3	
USGS 101	10/10/1996	10.5	1600.2	21.0	50.1	3.2	0.56	33.3	34.3	31.3	19.8
USGS 101	10/10/1996	10.5	1600.2	19.5	50.9	4.2		33.8	34.3	29.8	
USGS 101	10/10/1996	10.5	1600.2	21.7	52.0	3.1		33.3	34.3	31.8	
USGS 102	06/13/1995	9.3	1478.3	2470.6	231.4	141.0	0.24	C	19.9	C	25.4
USGS 102	06/13/1995	9.3	1478.3	2312.5	265.7	138.4	0.21	C	17.9	C	26.9
USGS 102	06/13/1995	9.3	1478.3	2200.2	4339.3	517.3		C		C	
USGS 103	07/20/1994	10.5	1526.7	59.3	225.2	8.6		25.1	20.1	22.1	
USGS 103	07/20/1994	10.5	1526.7	4.7	228.0	13.2		39.1	19.6	19.1	
USGS 103	07/20/1994	10.5	1526.7	59.7	231.0	9.3		25.1	19.6	21.6	
USGS 103	04/18/1995	10.5	1526.7	58.2	236.4	8.0	0.84	25.8	19.8	23.3	15.3
USGS 103	04/18/1995	10.5	1526.7	58.5	234.5	16.1		25.8	20.3	18.3	
USGS 103	04/18/1995	10.5	1526.7	59.9	237.8	8.7		25.8	19.8	22.8	
USGS 103	07/15/1996	10.5	1526.7	111.7	344.1	35.3		22.5	15.0	13.5	
USGS 103	07/15/1996	10.5	1526.7	106.8	311.4	32.5		22.5	17.0	14.0	
USGS 103	07/15/1996	10.5	1526.7	101.2	310.1	27.9		23.0	17.0	15.5	
USGS 104	07/20/1994	9.0	1521.4	52.2	37386.3	42.6		25.1	C	9.6	
USGS 104	07/20/1994	9.0	1521.4	51.8	37532.9	40.5		25.1	C	10.1	
USGS 104	07/20/1994	9.0	1521.4	52.0	38049.0	39.4		25.1	C	10.1	
USGS 104	04/18/1995	9.0	1521.4	41.2	35898.4	36.4	4.88	27.3	C	11.3	C
USGS 104	04/18/1995	9.0	1521.4	162.6	14595.6	49.4		15.3	C	8.8	
USGS 104	04/18/1995	9.0	1526.7	1.6	143.8	0.5		42.8	24.3		
USGS 104	07/15/1996	9.0	1526.7	49.5	5761.3	40.1		27.5	C	12.0	
USGS 104	07/15/1996	9.0	1526.7	48.9	5759.7	40.4		27.5	C	12.0	
USGS 104	07/15/1996	9.0	1526.7	47.2	28944.0	25.9		28.0	C	15.5	
USGS 105	10/03/1994	10.0	1553.0	212.2	4236.3	1041.4		10.3	C	C	
USGS 105	10/03/1994	10.0	1553.0	229.4	4489.6	1050.3		8.8	C	C	
USGS 105	10/03/1994	10.0	1553.0	208.6	4014.9	1004.8		10.3	C	C	

Table 1. Recharge temperatures, calculated chlorofluorocarbon partial pressures, and apparent piston-flow ages of ground water from at and near the Idaho National Engineering and Environmental Laboratory— Continued

Well name	Date sampled	Recharge temp., °C	Elev., m	Calculated partial pressure, in pptv				Model 1 Apparent piston-flow age, in years			
				F11	F12	F113	SF_6	F11	F12	F113	SF_6
USGS 105	04/18/1995	10.0	1553.0	216.0	4562.1	962.1	1.24	10.3	C	C	12.3
USGS 105	04/18/1995	10.0	1553.0	177.0	5099.4	1015.4		14.8	C	C	
USGS 105	04/18/1995	10.0	1553.0	185.4	4874.5	1109.9		13.3	C	C	
USGS 106	10/05/1994	10.0	1530.0	143.9	15782.9	30.0		17.8	C	12.8	
USGS 106	10/05/1994	10.0	1529.1	143.1	15845.3	31.2		17.8	C	12.8	
USGS 106	10/05/1994	10.0	1529.1	141.9	15801.3	36.5		18.3	C	11.3	
USGS 107	10/05/1994	13.1	1499.3	55.5	171.7	16.0		26.3	23.8	19.3	
USGS 107	10/05/1994	13.1	1499.3	53.7	170.7	14.9		26.8	23.8	19.8	
USGS 107	10/05/1994	13.1	1499.3	39.8	124.7	10.3		28.8	26.3	22.3	
USGS 107	10/09/1996	13.1	1499.3	59.7	189.7	14.9	1.41	28.3	24.8	21.8	12.3
USGS 107	10/09/1996	13.1	1499.3	61.1	199.3	15.9	2.31	27.8	24.3	21.3	7.3
USGS 107	10/09/1996	13.1	1499.3	59.2	189.6	10.2		28.3	24.8	24.3	
USGS 108	10/03/1994	10.0	1534.0	53.1	1197.2	0.0		25.8	C	41.8	
USGS 108	10/03/1994	10.0	1534.0	55.1	1235.2	11.1		25.3	C	20.3	
USGS 108	10/03/1994	10.0	1534.0	52.0	1198.1	0.0		25.8	C	41.8	
USGS 108	04/18/1995	10.0	1534.0	53.1	1181.8	8.4	1.00	26.3	C	22.8	13.8
USGS 108	04/18/1995	10.0	1534.0	56.1	1228.5	7.4	0.75	25.8	C	23.8	16.3
USGS 108	04/18/1995	10.0	1534.0	53.3	1205.8	9.7		26.3	C	21.8	
USGS 109	10/04/1994	9.0	1537.7	121.0	1385.2	427.9		19.3	C	C	
USGS 109	10/04/1994	9.0	1537.7	132.5	1415.9	398.8		18.3	C	C	
USGS 109	10/04/1994	9.0	1537.7	130.0	1415.7	422.6		18.3	C	C	
USGS 109	04/20/1995	9.0	1537.7	136.4	1583.1	513.1	1.23	18.3	C	C	12.3
USGS 109	04/20/1995	9.0	1537.7	131.9	1604.1	491.8	0.68	18.8	C	C	17.3
USGS 109	04/20/1995	9.0	1537.7	145.0	1534.3	443.6		17.3	C	C	
USGS 109	10/11/1996	9.0	1537.7	152.3	1763.5	488.3	1.11	17.8	C	C	14.8
USGS 109	10/11/1996	9.0	1537.7	199.3	1792.7	530.7		12.3	C	C	
USGS 109	10/11/1996	9.0	1537.7	139.5	1724.2	539.6		19.8	C	C	
USGS 110A	10/09/1996	13.2	1524.0	71.5	171.3	12.8	1.40	26.8	25.8	22.8	12.3
USGS 110A	10/09/1996	13.2	1524.0	72.5	167.6	18.5		26.8	25.8	19.8	
USGS 110A	10/09/1996	13.2	1524.0	72.0	165.5	35.5		26.8	26.3	15.3	
USGS 112	07/15/1996	11.5	1524.0	213.1	90063.3	302.7		13.5	C	C	
USGS 112	07/15/1996	11.5	1524.0	216.9	92832.4	350.7		13.0	C	C	
USGS 112	07/15/1996	11.5	1524.0	204.3	103631.9	147.8		14.5	C	C	
USGS 113	07/16/1996	13.0	1524.0	202.0	14484.6	ERR		16.5	C	ERR	
USGS 113	07/16/1996	13.0	1524.0	201.8	15077.6	ERR		16.5	C	ERR	
USGS 113	07/16/1996	13.0	1524.0	187.8	94851.3	155.3		18.0	C	C	
USGS 115	07/15/1996	5.5	1524.0	55.7	41816.0	43.2		25.5	C	9.5	
USGS 115	07/15/1996	5.5	1524.0	71.8	35077.8	31.0		23.5	C	12.0	
USGS 115	07/15/1996	5.5	1524.0	69.8	28038.5	17.4		23.5	C	16.5	
USGS 116	07/15/1996	12.0	1524.0	110.6	3957.8	40.8		23.0	C	13.0	
USGS 116	07/15/1996	12.0	1524.0	103.6	5593.5	54.6		23.5	C	11.0	
USGS 116	07/15/1996	12.0	1524.0	92.3	7231.9	25.8		24.5	C	17.0	

Table 1. Recharge temperatures, calculated chlorofluorocarbon partial pressures, and apparent piston-flow ages of ground water from at and near the Idaho National Engineering and Environmental Laboratory— Continued

Well name	Date sampled	Recharge temp., °C	Elev., m	Calculated partial pressure, in pptv				Model 1 Apparent piston-flow age, in years			
				F11	F12	F113	SF_6	F11	F12	F113	SF_6
USGS 117	10/05/1994	10.4	1527.7	24.2	47.0	14.6		30.8	32.8	18.8	
USGS 117	10/05/1994	10.4	1527.7	24.7	51.2	17.2		30.3	32.3	17.3	
USGS 117	10/05/1994	10.4	1527.7	22.8	44.5	11.4		30.8	33.3	20.3	
USGS 117	07/17/1996	10.4	1527.7	9.0	22.8	0.0		38.0	40.0	43.5	
USGS 117	07/17/1996	10.4	1527.7	7.8	17.1	0.0		38.5	42.0	43.5	
USGS 117	07/17/1996	10.4	1527.7	7.0	11.0	3.9		39.0	44.5	30.0	
USGS 119	10/06/1994	10.0	1533.5	160.6	1379.3	2774.6		16.3	C	C	
USGS 119	10/06/1994	10.0	1533.5	162.7	1358.8	2513.2		15.8	C	C	
USGS 120	10/06/1994	10.6	1536.8	347.5	2658.9	1954.8		C	C	C	
USGS 120	10/06/1994	10.6	1536.8	341.8	2613.8	1886.2		C	C	C	
USGS 120	10/06/1994	10.6	1536.8	385.1	2759.4	1853.9		C	C	C	
USGS 120	07/17/1996	10.6	1536.8	562.5	2815.6	3738.3		C	C	C	
USGS 120	07/17/1996	10.6	1536.8	539.2	2888.6	3681.9		C	C	C	
USGS 120	07/17/1996	10.6	1536.8	416.1	2909.1	3155.1		C	C	C	
USGS 121	10/24/1994	10.0	1496.4	159.9	23423.1	17.9	0.63	16.3	C	16.8	17.3
USGS 121	10/24/1994	10.0	1496.4	58.6	5113.3	63.2		25.3	C	6.8	
USGS 121	10/24/1994	10.0	1496.4	314.4	10270.6	53.6			C	8.3	
USGS 124	07/20/1994	10.2	1556.0	49.6	3399.2	51.7		26.1	C	8.6	
USGS 124	07/20/1994	10.2	1556.0	48.0	3352.3	52.1		26.1	C	8.6	
USGS 124	07/20/1994	10.2	1556.0	48.5	3359.0	56.7		26.1	C	7.6	
USGS 124	04/20/1995	10.2	1556.0	50.2	3381.4	ERR	2.50	26.8	C	ERR	4.8
USGS 124	04/20/1995	10.2	1556.0	49.9	3284.8	ERR		26.8	C	ERR	
USGS 124	04/20/1995	10.2	1556.0	50.9	3397.8	54.7		26.8	C	8.8	
USGS 124	10/09/1996	10.2	1556.0	49.1	2838.0	38.4	2.03	28.3	C	12.8	8.8
USGS 124	10/09/1996	10.2	1556.0	50.7	2992.1	41.6		28.3	C	12.3	
USGS 124	10/09/1996	10.2	1556.0	49.1	3046.8	43.1		28.3	C	12.3	
USGS 125	06/06/1995	9.3	1524.0	90.2	751.1	251.6	0.31	22.4	C	C	23.0
USGS 125	06/16/1995	9.3	1524.0	89.7	722.3	210.2	0.26	22.5	C	C	24.5
USGS 125	06/16/1995	9.3	1524.0	93.9	840.7	246.9	0.37	22.0	C	C	21.5
USGS 125	10/11/1996	9.3	1524.0	100.0	835.2	263.5	0.40	22.8	C	C	21.0
USGS 125	10/11/1996	9.3	1524.0	91.1	835.1	251.5	0.88	23.8	C	C	16.3
USGS 125	10/11/1996	9.3	1524.0	96.2	770.7	247.5		23.3	C	C	
Arco City 2	07/09/1991	6.2	1524.0	90.4	174.6			18.5	19.0		
Arco City 2	07/09/1991	6.2	1524.0	91.3	176.7			18.5	19.0		
Arco City 2	07/09/1991	6.2	1524.0	87.4	165.4			19.0	19.5		
Arco City 2	07/09/1991	6.2	1524.0	84.0	164.0			19.0	19.5		
McKinney	07/09/1991	11.8	1524.0	249.0	493.5			4.0	1.0		
McKinney	07/09/1991	11.8	1524.0	207.7	459.3			7.0	3.5		
McKinney	07/09/1991	11.8	1524.0	254.1	502.7			3.5	0.0		
McKinney	07/09/1991	11.8	1524.0	227.5	459.2			5.5	3.5		
McKinney	07/09/1991	11.8	1524.0	254.4	498.5			3.5	0.5		
P&W2	07/11/1991	6.7	1524.0	199.1	354.8			8.5	9.0		
P&W2	07/11/1991	6.7	1524.0	190.1	352.4			9.0	9.0		
P&W2	07/11/1991	6.7	1524.0	212.2	365.5			7.0	8.5		
P&W2	07/11/1991	6.7	1524.0	201.2	347.6			8.0	9.0		
P&W2	07/11/1991	6.7	1524.0	195.8	358.0			8.5	8.5		

Table 1. Recharge temperatures, calculated chlorofluorocarbon partial pressures, and apparent piston-flow ages of ground water from at and near the Idaho National Engineering and Environmental Laboratory— Continued

Well name	Date sampled	Recharge temp., °C	Elev., m	Calculated partial pressure, in pptv F11	F12	F113	SF_6	Model 1 Apparent piston-flow age, in years F11	F12	F113	SF_6
Ruby Farms	07/09/1991	6.2	1524.0	16.4	36.5			29.0	31.0		
Ruby Farms	07/09/1991	6.2	1524.0	22.7	46.9			27.5	29.5		
Ruby Farms	07/09/1991	6.2	1524.0	14.8	28.3			30.0	33.0		
Ruby Farms	07/09/1991	6.2	1524.0	20.8	44.8			28.0	29.5		
Ruby Farms	07/09/1991	6.2	1524.0	22.0	45.8			27.5	29.5		
USGS 1	07/08/1991	12.5	1524.0	30.6	76.5			26.0	25.5		
USGS 1	07/08/1991	12.5	1524.0	31.3	68.0			26.0	26.5		
USGS 1	07/08/1991	12.5	1524.0	30.7	69.4			26.0	26.5		
USGS 1	07/08/1991	12.5	1524.0	28.9	60.7			26.0	27.5		
USGS 1	07/08/1991	12.5	1524.0	29.5	68.0			26.0	26.5		
USGS 8	07/12/1991	8.8	1524.0	22.4	109.7			27.5	23.0		
USGS 8	07/12/1991	8.8	1524.0	24.9	110.3			27.0	23.0		
USGS 8	07/12/1991	8.8	1524.0	25.7	123.7			27.0	22.0		
USGS 9	07/12/1991	8.5	1524.0	125.7	359.3			16.0	8.5		
USGS 9	07/12/1991	8.5	1524.0	127.6	317.2			16.0	11.0		
USGS 9	07/12/1991	8.5	1524.0	126.2	308.0			16.0	11.5		
USGS 9	07/12/1991	8.5	1524.0	122.1	369.1			16.5	8.0		
USGS 9	07/12/1991	8.5	1524.0	124.4	310.3			16.0	11.5		
USGS 18	07/11/1991	11.4	1524.0	3.9	12.3			36.5	39.0		
USGS 18	07/11/1991	11.4	1524.0	4.3	10.3			36.0	40.0		
USGS 18	07/11/1991	11.4	1524.0	4.6	11.7			36.0	39.0		
USGS 18	07/11/1991	11.4	1524.0	4.6	10.8			36.0	39.5		
USGS 18	07/11/1991	11.4	1524.0	4.1	13.9			36.5	38.0		
USGS 23	07/11/1991	13.3	1524.0	109.0	245.4			17.5	15.5		
USGS 23	07/11/1991	13.3	1524.0	103.4	222.1			17.5	16.5		
USGS 23	07/11/1991	13.3	1524.0	109.5	244.9			17.5	15.5		
USGS 23	07/11/1991	13.3	1524.0	101.6	213.2			18.0	17.0		
USGS 23	07/11/1991	13.3	1524.0	111.5	235.0			17.0	16.0		
USGS 23	07/11/1991	13.3	1524.0	128.1	263.0			16.0	14.5		
USGS 23	07/11/1991	13.3	1524.0	117.3	239.1			16.5	16.0		
USGS 23	07/11/1991	13.3	1524.0	111.0	238.0			17.0	16.0		
USGS 26	07/11/1991	12.1	1524.0	27.1	53.9			26.5	28.5		
USGS 26	07/11/1991	12.1	1524.0	27.1	54.5			26.5	28.0		
USGS 26	07/11/1991	12.1	1524.0	25.2	49.7			27.0	29.0		
USGS 26	07/11/1991	12.1	1524.0	25.3	51.0			27.0	28.5		
USGS 27	07/11/1991	9.6	1524.0	11.4	26.8			31.0	33.5		
USGS 27	07/11/1991	9.6	1524.0	9.9	23.2			32.0	34.5		
USGS 27	07/11/1991	9.6	1524.0	9.5	25.8			32.0	34.0		
USGS 27	07/11/1991	9.6	1524.0	9.6	21.2			32.0	35.0		
USGS 27	07/11/1991	9.6	1524.0	9.8	29.7			32.0	33.0		
USGS 58	07/09/1991	10.0	1524.0	244.8	3542.7			4.0	C		
USGS 58	07/09/1991	10.0	1524.0	239.9	3164.3			4.5	C		
USGS 58	07/09/1991	10.0	1524.0	238.7	3505.9			4.5	C		
USGS 58	07/09/1991	10.0	1524.0	237.4	3117.3			4.5	C		
USGS 58	07/09/1991	10.0	1524.0	247.8	3423.0			4.0	C		

Table 1. Recharge temperatures, calculated chlorofluorocarbon partial pressures, and apparent piston-flow ages of ground water from at and near the Idaho National Engineering and Environmental Laboratory— Continued

Well name	Date sampled	Recharge temp., °C	Elev., m	Calculated partial pressure, in pptv				Model 1 Apparent piston-flow age, in years			
				F11	F12	F113	SF_6	F11	F12	F113	SF_6
USGS 65	07/09/1991	10.0	1524.0	566.8	45562.8			C	C		
USGS 65	07/09/1991	10.0	1524.0	641.6	39642.2			C	C		
USGS 65	07/09/1991	10.0	1524.0	566.7	45802.5			C	C		
USGS 65	07/09/1991	10.0	1524.0	641.2	38855.0			C	C		
USGS 65	07/09/1991	10.0	1524.0	583.2	42157.0			C	C		
USGS 79	07/09/1991	10.0	1524.0	181.6	2907.1			10.0	C		
USGS 79	07/09/1991	10.0	1524.0	169.6	2467.7			12.0	C		
USGS 79	07/09/1991	10.0	1524.0	171.1	2761.5			11.5	C		
USGS 79	07/09/1991	10.0	1524.0	165.2	2474.0			12.0	C		
USGS 79	07/09/1991	10.0	1524.0	176.3	2724.4			11.0	C		
USGS 86	07/12/1991	10.0	1524.0	258.8	353.9			3.0	9.0		
USGS 86	07/12/1991	10.0	1524.0	147.0	268.3			14.5	14.0		
USGS 86	07/12/1991	10.0	1524.0	162.0	292.4			12.5	13.0		
USGS 86	07/12/1991	10.0	1524.0	132.4	310.5			15.5	11.5		
USGS 86	07/12/1991	10.0	1524.0	131.8	238.9			15.5	16.0		
USGS 87	05/06/1991	5.7	1524.0	56.4	7233.2			21.8	C		
USGS 87	05/06/1991	5.7	1524.0	24.6	6969.3			26.8	C		
USGS 87	05/06/1991	5.7	1524.0	444.7	107541.			C	C		
USGS 88	05/06/1991	10.0	1524.0	95.8	8743.1			18.3	C		
USGS 88	05/06/1991	10.0	1524.0	138.3	12795.4			14.8	C		
USGS 88	05/06/1991	10.0	1524.0	1035.7	65986.8			C	C		
USGS 88	05/06/1991	10.0	1524.0	1001.2	66778.8			C	C		
USGS 89	05/06/1991	4.3	1524.0	1.4	8586.1			39.3	C		
USGS 89	05/06/1991	4.3	1524.0	1.5	10699.8			39.3	C		
USGS 89	05/06/1991	4.3	1524.0	12.5	46899.7			30.3	C		
USGS 97	07/09/1991	9.7	1524.0	1621.4	126.9			C	22.0		
USGS 97	07/09/1991	9.7	1524.0	1631.2	134.4			C	21.5		
USGS 97	07/09/1991	9.7	1524.0	1622.8	130.5			C	21.5		
USGS 97	07/09/1991	9.7	1524.0	1656.0	145.9			C	20.5		
USGS 100	07/08/1991	10.3	1524.0	51.4	106.9			22.5	23.0		
USGS 100	07/08/1991	10.3	1524.0	50.6	99.8			23.0	23.5		
USGS 100	07/08/1991	10.3	1524.0	50.2	106.6			23.0	23.0		
USGS 100	07/08/1991	10.3	1524.0	46.5	99.5			23.5	23.5		
USGS 100	07/08/1991	10.3	1524.0	52.4	113.6			22.5	22.5		
USGS 104	07/08/1991	7.9	1524.0	69.2	35264.2			20.5	C		
USGS 104	07/08/1991	7.9	1524.0	55.1	35693.4			22.0	C		
USGS 104	07/08/1991	7.9	1524.0	37.3	30048.9			24.5	C		
USGS 104	07/08/1991	7.9	1524.0	27.5	29863.4			26.5	C		
USGS 104	07/08/1991	7.9	1524.0	31.1	34337.8			26.0	C		
USGS 117	05/06/1991	10.4	1524.0	0.0	0.0			46.3	51.3		
USGS 117	05/06/1991	10.4	1524.0	1.4	0.0			39.3	51.3		
USGS 117	05/06/1991	10.4	1524.0	0.0	0.0			46.3	51.3		

Table 1. Recharge temperatures, calculated chlorofluorocarbon partial pressures, and apparent piston-flow ages of ground water from at and near the Idaho National Engineering and Environmental Laboratory— Continued

Well name	Date sampled	Recharge temp., °C	Elev., m	Calculated partial pressure, in pptv				Model 1 Apparent piston-flow age, in years			
				F11	F12	F113	SF_6	F11	F12	F113	SF_6
USGS 117	07/11/1991	10.4	1524.0	29.5	49.8			26.0	29.0		
USGS 117	07/11/1991	10.4	1524.0	24.3	39.8			27.0	30.5		
USGS 117	07/11/1991	10.4	1524.0	15.8	27.4			29.5	33.5		
USGS 117	07/11/1991	10.4	1524.0	12.5	22.5			30.5	35.0		
USGS 117	07/11/1991	10.4	1524.0	10.0	19.5			32.0	36.0		
USGS 117	07/11/1991	10.4	1524.0	8.3	14.3			33.0	38.0		
USGS 117	07/11/1991	10.4	1524.0	7.2	10.6			34.0	39.5		
USGS 117	07/11/1991	10.4	1524.0	6.7	9.8			34.5	40.0		
USGS 117	07/11/1991	10.4	1524.0	5.9	8.0			35.0	41.0		
USGS 117	07/11/1991	10.4	1524.0	5.0	6.9			35.5	42.0		
USGS 117	07/11/1991	10.4	1524.0	5.0	6.7			35.5	42.0		
USGS 117	07/11/1991	10.4	1524.0	4.9	5.8			35.5	42.5		
USGS 117	07/11/1991	10.4	1524.0	4.6	3.3			36.0	44.5		
USGS 117	07/11/1991	10.4	1524.0	4.7	3.2			36.0	44.5		
USGS 117	07/11/1991	10.4	1524.0	4.7	8.1			36.0	41.0		
USGS 117	07/11/1991	10.4	1524.0	3.5	6.2			37.0	42.5		
USGS 117	07/11/1991	10.4	1524.0	3.6	3.9			36.5	44.0		
USGS 117	07/11/1991	10.4	1524.0	4.3	21.0			36.0	35.0		
USGS 117	07/11/1991	10.4	1524.0	4.4	5.0			36.0	43.0		
USGS 117	07/11/1991	10.4	1524.0	4.0	3.4			36.5	44.5		
USGS 119	05/06/1991	10.0	1524.0	15.6	105.0			29.3	23.3		
USGS 119	05/06/1991	10.0	1524.0	51.6	212.3			22.3	16.8		
USGS 119	05/06/1991	10.0	1524.0	44.5	349.0			23.3	8.8		
USGS 119	05/06/1991	10.0	1524.0	122.5	450.0			16.3	3.8		
USGS 120	05/07/1991	10.4	1524.0	45.8	299.4			23.3	11.8		
USGS 120	05/07/1991	10.4	1524.0	91.5	416.6			18.3	4.8		
USGS 120	05/07/1991	10.4	1524.0	206.6	909.3			7.3	C		
USGS 120	05/07/1991	10.4	1524.0	211.6	936.6			6.8	C		
USGS 120	07/12/1991	10.4	1524.0	321.0	2095.1			C	C		
USGS 120	07/12/1991	10.4	1524.0	484.9	1184.1			C	C		
USGS 120	07/12/1991	10.4	1524.0	492.3	1811.7			C	C		
USGS 120	07/12/1991	10.4	1524.0	390.7	2234.7			C	C		
USGS 120	07/12/1991	10.4	1524.0	439.8	1332.2			C	C		
USGS 120	07/12/1991	10.4	1524.0	403.8	2262.5			C	C		
USGS 120	07/12/1991	10.4	1524.0	452.4	1168.6			C	C		
USGS 120	07/12/1991	10.4	1524.0	406.7	2290.5			C	C		
USGS 120	07/12/1991	10.4	1524.0	418.5	2303.7			C	C		
USGS 120	07/12/1991	10.4	1524.0	411.7	4050.8			C	C		
USGS 120	07/12/1991	10.4	1524.0	408.1	2228.4			C	C		
USGS 120	07/12/1991	10.4	1524.0	387.3	1983.1			C	C		
USGS 120	07/12/1991	10.4	1524.0	412.1	2313.1			C	C		
USGS 120	07/12/1991	10.4	1524.0	413.0	2294.3			C	C		
USGS 120	07/12/1991	10.4	1524.0	414.0	2287.4			C	C		
USGS 120	07/12/1991	10.4	1524.0	418.6	2287.1			C	C		
USGS 120	07/12/1991	10.4	1524.0	414.3	2339.8			C	C		
USGS 120	07/12/1991	10.4	1524.0	408.7	2544.1			C	C		

Table 2. Ratio of partial pressures and ratio ages of the young fraction of ground water from at and near the Idaho National Engineering and Environmental Laboratory

[See figure 2 for location of sites. Blank spaces, no data or not applicable. Abbreviations: F11, Chlorofluorocarbon-11; F12, Chlorofluorocarbon-12; F113, Chlorofluorocarbon-113; SF_6, sulfur hexafluoride; C, contaminated or partial pressure exceeds historical atmospheric partial pressures; ERR, interferences, concentration not measured; N, date of recharge younger than the date of sampling; n1, piston-flow age of numerator greater than the ratio age; n2, piston-flow age of denominator greater than the ratio age; n3, piston-flow age of the numerator and the denominator greater than the ratio age]

Well name	Date sampled	Ratio of partial pressures						Estimated age of recharge in years; ratio method						Corrected results					
		F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113	F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113	F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113
ANP 6	10/14/1994	0.389	0.255	0.656				30.3	C	C				n3	C	C			
ANP 6	10/14/1994	0.421	0.300	0.714				28.3	C	C				n3	C	C			
ANP 6	10/14/1994	0.392	0.260	0.663				30.3	C	C				n3	C	C			
ANP 6	06/15/1995	0.404	0.273	0.676	0.59	0.24	0.87	30.0	C	C	13.5	17.0	C	n3	C	C	13.46	n3	C
ANP 6	06/15/1995	0.378	0.252	0.667	0.58	0.22	0.87	31.5	C	C	13.5	18.5	C	n3	C	C	13.46	n3	C
ANP 6	06/15/1995	0.404	0.241	0.597	0.59	0.24	1.00	30.0	C	C	13.0	17.0	C	n3	C	C	n3	n3	C
ANP 6	07/19/1996	0.441	0.222	0.504	8.65	3.81	17.16	28.6	C	C	C	C	C	n3	C	C	C	C	C
ANP 6	07/19/1996	0.436	0.223	0.511	8.55	3.73	16.74	29.1	C	C	C	C	C	n3	C	C	C	C	C
ANP 6	07/19/1996	0.390	ERR	ERR	8.93	3.48	ERR	32.1	ERR	ERR	C	C	ERR	n3	ERR	ERR	C	C	ERR
ANP 6	07/19/1996	0.454	0.243	0.535	7.04	3.20	13.16	27.6	C	C	C	C	C	n3	C	C	C	C	C
ANP 9	10/14/1994	0.363	0.070	0.192				31.8	15.8	10.8				n3	15.79	10.79			
ANP 9	10/14/1994	0.332	0.080	0.242				33.3	14.3	7.8				n3	14.29	7.79			
ANP 9	10/14/1994	0.357	0.059	0.166				32.3	17.8	12.3				n3	17.79	12.29			
ANP 9	10/14/1996	0.369	0.000	0.000	4.57	1.69	ERR	33.3	44.8	22.3	C	C	ERR	n3	n3	22.29	C	C	ERR
ANP 9	10/14/1996	0.339	0.055	0.162	4.56	1.55	28.21	34.8	21.3	14.8	C	C	C	n3	21.29	14.79	C	C	C
ANP 9	10/14/1996	0.370	0.056	0.151	4.60	1.70	30.44	33.3	20.8	15.8	C	C	C	n3	20.79	15.79	C	C	C
Arbor Test	04/21/1995	0.527	0.056	0.106	0.79	0.42	7.45	20.3	19.3	18.8	7.3	8.8	C	20.30	19.30	18.80	7.30	n3	C
Arbor Test	04/21/1995	0.470	0.151	0.322	0.93	0.44	2.89	24.8	6.3	0.8	4.8	7.3	C	24.80	6.30	0.80	4.80	n3	C
Arbor Test	04/21/1995	0.470	0.007	0.016	0.87	0.41	54.73	24.8	43.3	20.8	5.8	9.3	C	24.80	n3	20.80	n3	n3	C
Arbor Test	04/21/1995	0.461	0.009	0.019	0.87	0.40	46.80	25.8	43.3	20.8	5.8	9.3	C	n3	n3	20.80	n3	n3	C
Arbor Test	10/10/1996	0.494	0.082	0.167	2.54	1.26	15.26	24.8	16.3	14.3	C	C	C	24.78	16.28	14.28	C	C	C
Arbor Test	10/10/1996	0.487	0.097	0.198	2.48	1.21	12.49	25.3	13.8	12.3	C	C	C	25.28	13.78	12.28	C	C	C
Arbor Test	10/10/1996	0.487	0.098	0.201	2.63	1.28	13.08	25.3	13.3	12.3	C	C	C	25.28	13.28	12.28	C	C	C
Area II	07/19/1994	0.509	0.094	0.185				21.0	11.5	11.0				21.05	11.55	11.05			
Area II	07/19/1994	0.490	0.039	0.079				22.5	38.5	20.0				22.55	n3	20.05			
Area II	07/19/1994	0.440	0.000	0.000				26.5	42.5	20.0				26.55	n3	20.05			
Area II	07/18/1996	0.531	0.042	0.078				21.5	36.5	22.0				21.55	n3	22.05			
Area II	07/18/1996	0.551	0.069	0.126				20.0	17.5	17.5				20.05	17.55	17.55			
Area II	07/18/1996	0.525	0.077	0.147				21.5	16.5	16.0				21.55	16.55	16.05			
Atomic City	10/03/1994	0.450	0.129	0.286				25.8	8.3	4.8				n3	8.26	4.76			
Atomic City	10/03/1994	0.443	0.122	0.274				26.3	8.8	5.8				n3	8.76	5.76			
Atomic City	10/03/1994	0.485	0.148	0.305				23.3	6.3	2.8				n3	6.26	2.76			
Atomic City	10/09/1996	0.470	0.121	0.258	1.60	0.75	6.21	26.3	10.8	8.8	N	N	C	n3	10.77	8.77	N	N	C
Atomic City	10/09/1996	0.440	0.134	0.305	1.76	0.77	5.76	28.8	9.3	4.8	N	N	C	n3	9.27	4.77	N	N	C
Atomic City	10/09/1996	0.467	0.146	0.313	1.62	0.76	5.18	26.8	8.3	2.3	N	N	C	n3	8.27	2.27	N	N	C
BFW	07/16/1996	0.273	ERR	ERR				39.5	ERR	ERR				n3	ERR	ERR			
BFW	07/16/1996	0.275	ERR	ERR				39.5	ERR	ERR				n3	ERR	ERR			
BFW	07/16/1996	0.296	0.156	0.528				38.0	7.0	C				n3	n3	C			
CFA 1	07/16/1996	0.010	0.005	0.557				59.0	44.5	C				n3	n3	C			
CFA 1	07/16/1996	0.010	0.005	0.503				59.0	44.5	C				n3	n3	C			
CFA 1	07/16/1996	0.010	0.008	0.791				59.0	44.5	C				n3	n3	C			

Table 2. Ratio of partial pressures and ratio ages of the young fraction of ground water from at and near the Idaho National Engineering and Environmental Laboratory—Continued

Well name	Date sampled	Ratio of partial pressures						Estimated age of recharge in years; ratio method						Corrected results					
		F11/F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113	F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113	F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113
CFA 2	07/16/1996	1.970	0.965	0.490				C	C	C				C	C	C			
CFA 2	07/16/1996	0.025	0.013	0.543				58.5	44.5	C				n3	n3	C			
CFA 2	07/16/1996	0.027	0.016	0.586				58.0	44.5	C				n3	n3	C			
CFA 2	07/16/1996	0.013	0.017	1.340				59.0	44.5	C				n3	n3	C			
EBR I	10/16/1996	0.001	0.000	0.000	556.90	0.53	ERR	59.3	44.8	22.3	C	5.3	ERR	n3	n3	22.29	C	n3	ERR
EBR I	10/16/1996	0.001	0.000	0.000	598.32	0.57	ERR	59.3	44.8	22.3	C	4.3	ERR	n3	n3	22.29	C	n3	ERR
Fire Station 2	10/16/1996	2.541	0.472	0.186	0.04	0.11	0.24	C	C	12.8	22.3	25.3	8.3	C	C	n1	22.29	n3	n3
Fire Station 2	10/16/1996	2.567	0.449	0.175	0.04	0.12	0.26	C	C	13.8	22.3	25.3	8.3	C	C	n3	n3	n3	n3
Fire Station 2	10/16/1996	2.564	0.702	0.274	0.05	0.13	0.19	C	C	7.8	22.3	25.3	8.3	C	C	n3	n3	n3	n3
IET Disp	07/18/1994	0.041	0.043	1.045				47.0	31.5	C				n3	n3	C			
IET Disp	07/18/1994	0.068	0.000	0.000				45.0	42.5	20.0				n3	n3	20.05			
IET Disp	07/18/1994	0.039	0.000	0.000				47.5	42.5	20.0				n3	n3	20.05			
IET Disp	07/18/1996	0.036	0.000	0.000				56.5	44.5	22.0				n3	n3	22.05			
IET Disp	07/18/1996	0.038	0.000	0.000				49.5	44.5	22.0				n3	n3	22.05			
IET Disp	07/18/1996	0.034	0.000	0.000				57.5	44.5	22.0				n3	n3	22.05			
IET Disp	07/18/1996	0.039	0.000	0.000				49.5	44.5	22.0				n3	n3	22.05			
IET Disp	07/18/1996	0.040	0.000	0.000				49.0	44.5	22.0				n3	n3	22.05			
INEL 1 WS	06/12/1995	1.457	0.241	0.165	0.16	0.24	0.98	C	C	12.9	20.9	17.4	C	C	C	n1	20.95	n3	C
INEL 1 WS	06/12/1995	1.835	0.051	0.028	0.16	0.29	5.65	C	21.4	20.9	20.9	14.9	C	C	21.45	20.95	20.95	n3	C
INEL 1 WS	06/12/1995	1.887	0.026	0.014	0.15	0.29	11.44	C	43.4	20.9	20.9	14.9	C	C	n3	20.95	n3	n3	C
Leo Rogers 1	07/17/1996	0.412	0.153	0.371				30.5	7.0	C				n3	7.04	C			
Leo Rogers 1	07/17/1996	0.407	0.110	0.271				31.0	12.0	7.5				n3	12.04	7.54			
Leo Rogers 1	07/17/1996	0.403	0.092	0.228				31.5	14.0	10.0				n3	14.04	10.04			
NPR Test	04/17/1995	4.168	0.189	0.045	3.31	13.79	72.89	C	C	20.8	C	C	C	C	C	n2	C	C	C
NPR Test	04/17/1995	3.157	0.108	0.034	3.31	10.44	96.38	C	10.8	20.8	C	C	C	C	10.79	n2	C	C	C
NPR Test	10/10/1996	2.858	0.243	0.085	2.46	7.02	28.87	C	C	22.3	C	C	C	C	C	n3	C	C	C
NPR Test	10/10/1996	3.004	0.210	0.070	2.41	7.23	34.50	C	C	22.3	C	C	C	C	C	22.28	C	C	C
NPR Test	10/10/1996	2.759	0.516	0.187	2.61	7.19	13.94	C	C	12.8	C	C	C	C	C	12.78	C	C	C
PSTF	10/13/1994	0.381	0.093	0.245				30.8	12.3	7.3				n3	12.28	7.28			
PSTF	10/13/1994	0.447	0.154	0.344				26.3	5.3	0.3				26.28	5.28	0.28			
PSTF	10/13/1994	0.449	0.075	0.168				26.3	14.8	12.3				26.28	14.78	12.28			
PSTF	10/14/1996	0.451	0.062	0.137				27.8	19.3	16.8				27.79	19.29	16.79			
PSTF	10/14/1996	0.462	0.086	0.186				27.3	15.3	12.8				27.29	15.29	12.79			
PSTF	10/14/1996	0.447	0.086	0.192				28.3	15.3	12.8				n3	15.29	12.79			
P&W 2	10/25/1994	0.445	0.111	0.250	1.13	0.50	4.51	26.3	9.8	6.8	1.3	4.3	C	n3	9.82	6.82	1.32	n3	C
P&W 2	10/25/1994	0.467	0.125	0.268	1.14	0.53	4.25	24.8	8.3	6.3	1.3	3.3	C	n3	8.32	6.32	n3	n3	C
P&W 2	10/25/1994	0.449	0.111	0.248	1.22	0.55	4.92	26.3	9.8	7.3	0.3	2.8	C	n3	9.82	7.32	n1	n3	C
P&W 2	04/19/1995	0.501	0.133	0.266	0.70	0.35	2.64	22.8	7.8	6.8	10.3	11.8	C	n3	n3	n3	n3	n3	C
P&W 2	04/19/1995	0.517	0.132	0.255	0.74	0.38	2.90	21.3	8.3	7.3	9.3	10.3	C	n3	n3	n3	n3	n3	C
P&W 2	04/19/1995	0.452	0.142	0.314	0.80	0.36	2.55	26.3	7.3	0.8	7.3	11.3	C	n3	n3	0.80	n1	n3	C
P&W 2	10/15/1996	0.471	0.130	0.275	0.73	0.34	2.66	26.3	9.8	7.8	10.8	13.3	C	n3	9.79	7.79	10.79	n3	C
P&W 2	10/15/1996	0.474	0.128	0.271	0.74	0.35	2.75	26.3	10.3	7.8	10.3	13.3	C	n3	10.29	7.79	n1	n3	C
P&W 2	10/15/1996	0.475	0.141	0.298	0.80	0.38	2.68	26.3	8.8	5.8	8.8	11.8	C	n3	8.79	5.79	n1	n1	C

Table 2. Ratio of partial pressures and ratio ages of the young fraction of ground water from at and near the Idaho National Engineering and Environmental Laboratory—Continued

Well name	Date sampled	Ratio of partial pressures						Estimated age of recharge in years; ratio method						Corrected results					
		F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113	F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113	F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113
RWMC M3S	07/22/1996	0.436	2.645	6.068				29.1	C	C				n3	C	C			
RWMC M3S	07/22/1996	0.065	0.415	6.391				47.6	C	C				n3	C	C			
RWMC M3S	07/22/1996	0.036	0.410	11.477				56.6	C	C				n3	C	C			
RWMC M7S	07/22/1996	0.652	4.629	7.097				C	C	C				C	C	C			
RWMC M7S	07/22/1996	0.712	5.031	7.068				C	C	C				C	C	C			
RWMC M7S	07/22/1996	0.237	3.695	15.586				41.1	C	C				n3	C	C			
Site 4	10/06/1996	1.857	0.173	0.093	0.50	0.93	5.37	C	C	22.3	16.8	C	C	C	C	n3	16.77	C	C
Site 4	10/06/1996	1.873	0.323	0.173	0.53	1.00	3.10	C	C	13.8	15.8	C	C	C	C	13.77	n1	C	C
Site 9	07/21/1994	0.759	0.000	0.000				C	42.6	20.1				C	n3	20.05			
Site 9	07/21/1994	0.780	0.000	0.000				C	42.6	20.1				C	n3	20.05			
Site 9	07/21/1994	0.712	0.000	0.000				C	42.6	20.1				C	n3	20.05			
Site 9	07/21/1994	0.646	0.149	0.231				C	5.6	8.1				C	5.55	8.05			
Site 9	07/22/1996	0.534	0.000	0.000				21.1	44.6	22.1				21.06	n3	22.06			
Site 9	07/22/1996	0.600	0.000	0.000				C	44.6	22.1				C	n3	22.06			
Site 9	07/22/1996	0.600	0.099	0.164				C	13.1	14.6				C	13.06	14.56			
Site 14	10/13/1994	0.476	0.000	0.000				23.8	42.8	20.3				23.78	42.78	20.28			
Site 14	10/13/1994	0.348	0.000	0.000				32.3	42.8	20.3				32.28	42.78	20.28			
Site 14	10/13/1994	0.587	0.000	0.000				17.3	42.8	20.3				17.28	42.78	20.28			
Site 14	10/14/1996	0.285	0.000	0.000	225.94	64.29	ERR	39.3	44.8	22.3	C	C	ERR	39.29	n3	n2	C	C	ERR
Site 14	10/14/1996	0.436	0.000	0.000	313.05	136.43	ERR	29.3	44.8	22.3	C	C	ERR	29.29	44.79	n2	C	C	ERR
Site 14	10/14/1996	0.213	0.000	0.000	297.98	63.42	ERR	42.3	44.8	22.3	C	C	ERR	42.29	n3	n2	C	C	ERR
Site 17	06/16/1995	0.426	1.894	4.450	2.01	0.85	0.45	28.5	C	C	C	N	N	n3	C	C	C	N	N
Site 17	06/16/1995	0.436	0.161	0.369	2.05	0.89	5.55	28.0	5.0	C	C	C	C	n3	4.96	C	C	C	C
Site 17	06/16/1995	0.438	0.133	0.305	2.03	0.89	6.65	27.5	8.0	3.5	C	C	C	n3	7.96	3.46	C	C	C
Site 19	07/16/1996	0.846	0.117	0.138				C	11.0	16.5				C	11.04	16.54			
Site 19	07/16/1996	0.878	0.167	0.191				C	4.0	12.5				C	4.04	12.54			
Site 19	07/16/1996	0.837	0.134	0.160				C	9.0	14.5				C	9.04	14.54			
TAN Exploration	10/13/1994	0.151	0.000	0.000				42.3	42.8	20.3				n3	n3	20.28			
TAN Exploration	10/13/1994	0.150	0.000	0.000				42.3	42.8	20.3				n3	n3	20.28			
TAN Exploration	10/13/1994	0.144	0.000	0.000				42.3	42.8	20.3				n3	n3	20.28			
TAN Exploration	10/14/1996	0.228	0.000	0.000	0.00	0.00	ERR	41.3	44.8	22.3			ERR	41.29	44.79	22.29			ERR
TAN Exploration	10/14/1996	0.182	0.000	0.000	0.00	0.00	ERR	43.3	44.8	22.3			ERR	n3	n3	22.29			ERR
TAN Exploration	10/14/1996	0.192	0.000	0.000	0.00	0.00	ERR	42.8	44.8	22.3			ERR	n3	n3	22.29			ERR
USGS 1	10/03/1994	0.425	0.100	0.236				27.8	11.3	7.8				27.76	11.26	7.76			
USGS 1	10/03/1994	0.394	0.140	0.355				30.3	6.8	0.3				30.26	6.76	0.26			
USGS 1	10/03/1994	0.398	0.043	0.107				29.8	32.8	17.8				29.76	n3	17.76			
USGS 1	10/09/1996	0.432	0.095	0.221	3.61	1.56	16.34	29.3	13.8	10.8	C	C	C	29.27	13.77	10.77	C	C	C
USGS 1	10/09/1996	0.433	0.063	0.145	3.57	1.55	24.67	29.3	19.3	16.3	C	C	C	29.27	19.27	16.27	C	C	C
USGS 1	10/09/1996	0.435	0.188	0.431	3.49	1.52	8.09	29.3	C	C	C	C	C	29.27	C	C	C	C	C
USGS 2	07/19/1994	0.458	0.057	0.125				25.0	18.5	16.0				25.05	18.55	16.05			
USGS 2	07/19/1994	0.462	0.076	0.164				25.0	14.5	12.5				25.05	14.55	12.55			
USGS 2	07/19/1994	0.452	0.107	0.237				25.5	10.0	7.5				n3	10.05	7.55			
USGS 2	07/17/1996	0.482	0.076	0.157				25.0	16.5	15.0				25.04	16.54	15.04			
USGS 2	07/17/1996	0.496	0.086	0.172				24.0	15.0	13.5				24.04	15.04	13.54			
USGS 2	07/17/1996	0.479	0.062	0.130				25.5	19.0	17.5				25.54	19.04	17.54			

Table 2. Ratio of partial pressures and ratio ages of the young fraction of ground water from at and near the Idaho National Engineering and Environmental Laboratory—Continued

Well name	Date sampled	Ratio of partial pressures						Estimated age of recharge in years; ratio method						Corrected results					
		F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113	F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113	F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113
USGS 4	10/24/1994	0.372	0.026	0.069	0.80	0.30	11.50	31.3	42.8	20.3	6.8	13.8	C	n3	n3	n3	6.81	n3	C
USGS 4	10/24/1994	0.405	0.058	0.142	0.75	0.31	5.32	29.3	18.3	14.3	8.3	13.3	C	n3	n3	n3	n1	n3	C
USGS 4	10/24/1994	0.385	0.029	0.075	0.80	0.31	10.79	30.8	42.8	20.3	6.3	13.3	C	n3	n3	n3	n1	n3	C
USGS 4	04/19/1995	0.353	0.044	0.125	0.44	0.16	3.50	32.8	28.3	16.3	16.8	23.8	C	n3	n3	n3	16.80	n3	C
USGS 4	04/19/1995	0.352	0.040	0.112	0.45	0.16	3.96	32.8	38.3	17.8	16.8	23.8	C	n3	n3	n3	n3	n3	C
USGS 4	04/19/1995	0.357	0.058	0.163	0.44	0.16	2.70	32.8	18.8	13.3	16.8	23.8	C	n3	n3	13.30	n3	n3	C
USGS 4	10/15/1996	0.448	0.044	0.098	0.35	0.16	3.61	28.3	30.8	22.3	22.3	25.3	C	n3	n3	n3	n3	n3	C
USGS 4	10/15/1996	0.394	0.058	0.149	0.32	0.13	2.16	32.3	20.3	15.8	22.3	25.3	C	n3	n3	n3	n3	n3	C
USGS 4	10/15/1996	0.419	0.057	0.136	0.36	0.15	2.68	30.3	20.8	16.8	21.3	25.3	C	n3	n3	n3	n3	n3	C
USGS 5	10/12/1994	0.369	0.131	0.355				31.3	7.8	0.3				n3	7.78	0.28			
USGS 5	10/12/1994	0.412	0.177	0.429				28.8	C	C				n3	C	C			
USGS 5	10/12/1994	0.375	0.088	0.234				31.3	12.8	8.3				n3	12.78	8.28			
USGS 5	10/10/1996	0.383	0.121	0.317	6.65	2.55	20.98	32.8	10.8	2.3	C	C	C	n3	10.78	2.28	C	C	C
USGS 5	10/10/1996	0.399	0.092	0.231	6.71	2.68	29.09	31.8	14.3	10.3	C	C	C	n3	14.28	10.28	C	C	C
USGS 5	10/10/1996	0.392	0.123	0.315	5.85	2.29	18.59	32.3	10.8	2.3	C	C	C	n3	10.78	2.28	C	C	C
USGS 6	07/19/1994	ERR	ERR	ERR				ERR	ERR	ERR				ERR	ERR	ERR			
USGS 6	07/19/1994	ERR	ERR	ERR				ERR	ERR	ERR				ERR	ERR	ERR			
USGS 6	07/19/1994	ERR	ERR	ERR				ERR	ERR	ERR				ERR	ERR	ERR			
USGS 6	07/18/1996	ERR	ERR	ERR				ERR	ERR	ERR				ERR	ERR	ERR			
USGS 6	07/18/1996	ERR	ERR	ERR				ERR	ERR	ERR				ERR	ERR	ERR			
USGS 6	07/18/1996	ERR	ERR	ERR				ERR	ERR	ERR				ERR	ERR	ERR			
USGS 7	10/14/1994	ERR	ERR	ERR				ERR	ERR	ERR				ERR	ERR	ERR			
USGS 7	10/14/1994	ERR	ERR	ERR				ERR	ERR	ERR				ERR	ERR	ERR			
USGS 7	10/14/1996	0.109	0.000	0.000	13720.37	1491.89	ERR	45.3	44.8	22.3	C	C	ERR	45.29	44.79	n2	C	C	ERR
USGS 7	10/14/1996	ERR	ERR	0.000	8520.55	ERR	ERR	ERR	ERR	22.3	C	ERR	ERR	ERR	ERR	n2	C	ERR	ERR
USGS 7	10/14/1996	ERR	ERR	0.000	16137.87	ERR	ERR	ERR	ERR	22.3	C	ERR	ERR	ERR	ERR	n2	C	ERR	ERR
USGS 8	10/04/1994	0.188	0.056	0.296				40.8	18.8	4.3				n3	18.76	4.26			
USGS 8	10/04/1994	0.176	0.333	1.898				41.3	C	C				n3	C	C			
USGS 8	10/04/1994	0.179	0.034	0.191				41.3	42.8	10.8				n3	n3	10.76			
USGS 8	10/08/1996	0.177	0.023	0.127				43.3	44.8	17.8				n3	n3	17.77			
USGS 8	10/08/1996	0.176	0.024	0.135				43.3	44.8	17.3				n3	n3	17.27			
USGS 8	10/08/1996	0.179	0.068	0.381				43.3	18.3	C				n3	18.27	C			
USGS 9	10/04/1994	0.325	0.126	0.387				33.8	8.3	C				n3	8.26	C			
USGS 9	10/04/1994	0.279	0.145	0.521				37.8	6.3	C				n3	6.26	C			
USGS 9	10/04/1994	0.262	0.121	0.461				38.3	8.8	C				n3	8.76	C			
USGS 9	10/04/1994	0.264	0.115	0.437				38.3	9.8	C				n3	9.76	C			
USGS 9	04/20/1995	0.235	0.108	0.460	1.07	0.25	2.33	39.8	10.8	C	2.8	16.3	C	n3	10.80	C	2.80	n3	C
USGS 9	04/20/1995	0.245	0.122	0.496	1.08	0.27	2.18	39.3	9.3	C	2.3	15.8	C	n3	9.30	C	2.30	n3	C
USGS 9	04/20/1995	0.269	0.104	0.388	1.12	0.30	2.88	38.8	11.3	C	2.3	14.3	C	n3	11.30	C	n1	n1	C
USGS 9	04/20/1995	0.261	0.121	0.464	1.11	0.29	2.40	38.8	9.3	C	2.3	14.8	C	n3	9.30	C	n1	n1	C
USGS 9	10/11/1996	0.447	0.139	0.311	0.33	0.15	1.07	28.3	8.8	2.8	22.3	25.3	C	n3	n3	2.78	n3	n3	C
USGS 9	10/11/1996	0.326	0.126	0.387	0.79	0.26	2.03	35.8	10.3	C	8.8	17.8	C	n3	10.28	C	n1	n1	C
USGS 9	10/11/1996	0.324	0.224	0.690	0.81	0.26	1.18	35.8	C	C	8.3	17.3	C	n3	C	C	n1	n1	C

Table 2. Ratio of partial pressures and ratio ages of the young fraction of ground water from at and near the Idaho National Engineering and Environmental Laboratory—Continued

Well name	Date sampled	Ratio of partial pressures						Corrected results: Estimated age of recharge in years; ratio method											
		F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113	F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113	F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113
USGS 11	04/20/1995	0.252	0.152	0.603	1.52	0.38	2.52	39.3	6.3	C	-2.2	10.3	C	n3	6.30	C	-2.20	n1	C
USGS 11	04/20/1995	0.250	0.139	0.556	1.48	0.37	2.66	39.3	7.3	C	-1.7	10.8	C	n3	7.30	C	-1.70	n1	C
USGS 11	04/20/1995	0.246	0.191	0.774	1.53	0.38	1.97	39.3	C	C	-2.2	10.8	C	n3	C	C	-2.20	n1	C
USGS 11	10/09/1996	0.219	0.182	0.831	2.08	0.46	2.50	41.8	C	C	C	8.3	C	n3	C	C	C	n1	C
USGS 11	10/09/1996	0.222	0.172	0.774	2.09	0.46	2.70	41.8	C	C	C	7.8	C	n3	C	C	C	n1	C
USGS 11	10/09/1996	0.225	0.198	0.883	2.13	0.48	2.41	41.8	C	C	C	7.3	C	n3	C	C	C	n1	C
USGS 12	10/27/1994	0.521	0.066	0.126	1.35	0.70	10.70	20.8	16.3	15.8	N	N	C	20.82	16.32	15.82	N	N	C
USGS 12	10/27/1994	0.505	0.084	0.165	1.33	0.67	8.06	21.8	13.8	12.3	N	N	C	21.82	13.82	12.32	N	N	C
USGS 12	10/27/1994	0.565	0.105	0.186	1.30	0.73	6.98	17.8	10.8	10.8	N	N	C	17.82	10.82	10.82	N	N	C
USGS 12	06/14/1995	0.515	0.056	0.109	0.35	0.18	3.16	22.0	19.5	18.5	21.0	22.5	C	21.95	19.45	18.45	20.95	n1	C
USGS 12	06/14/1995	0.547	0.064	0.117	0.34	0.19	2.94	19.0	17.5	17.5	21.0	21.0	C	18.95	17.45	17.45	20.95	n1	C
USGS 14	10/26/1994	0.168	0.041	0.246	3.68	0.62	14.93	41.3	35.8	7.3	C	0.8	C	n3	n3	7.32	C	n1	C
USGS 14	10/26/1994	0.169	0.053	0.315	3.66	0.62	11.64	41.3	19.8	0.3	C	0.8	C	n3	n3	0.32	C	n1	C
USGS 14	10/26/1994	0.161	0.038	0.240	3.64	0.58	15.19	41.8	39.8	7.8	C	1.8	C	n3	n3	7.82	C	n1	C
USGS 14	10/09/1996	0.187	0.059	0.314	2.21	0.41	7.03	42.8	20.3	2.3	C	10.3	C	n3	n3	2.27	C	n3	C
USGS 14	10/09/1996	0.193	0.045	0.235	2.22	0.43	9.43	42.8	27.8	9.8	C	9.3	C	n3	n3	9.77	C	n1	C
USGS 14	10/09/1996	0.179	0.066	0.370	2.37	0.43	6.41	43.3	18.3	C	C	9.3	C	n3	n3	C	C	n1	C
USGS 15	06/14/1995	0.339	0.160	0.472	152.52	51.68	322.9	33.5	5.0	C	C	C	C	33.45	4.95	C	C	C	C
USGS 15	06/14/1995	0.263	0.000	0.000	156.42	41.10	ERR	39.0	43.5	21.0	C	C	ERR	38.95	n3	n2	C	C	ERR
USGS 15	06/14/1995	0.322	0.000	0.000	162.49	52.35	ERR	34.5	43.5	21.0	C	C	ERR	34.45	n3	n2	C	C	ERR
USGS 17	10/27/1994	0.555	0.104	0.187	0.78	0.43	4.19	17.8	10.8	10.8	7.3	6.8	C	17.82	10.82	n2	n1	n1	C
USGS 17	10/27/1994	0.503	0.058	0.116	0.82	0.41	7.09	21.8	18.3	17.3	6.3	8.3	C	21.82	18.32	n2	n1	n1	C
USGS 17	06/13/1995	0.440	0.026	0.058	0.00	0.00	0.00	27.4	43.4	20.9				27.45	n3	20.95			
USGS 17	06/13/1995	0.537	0.000	0.000	0.00	0.00	ERR	19.9	43.4	20.9			ERR	19.95	n3	ERR			ERR
USGS 17	06/13/1995	0.615	0.143	0.232	0.00	0.00	0.00	C	7.4	8.9				C	7.45	8.95			
USGS 18	07/18/1994	0.422	0.000	0.000				28.0	42.5	20.0				28.05	n3	20.05			
USGS 18	07/18/1994	0.251	0.000	0.000				38.5	42.5	20.0				n3	n3	20.05			
USGS 18	07/18/1994	0.301	0.000	0.000				35.0	42.5	20.0				35.05	n3	20.05			
USGS 18	07/19/1996	0.272	0.000	0.000	0.00	0.00	ERR	39.6	44.6	22.1			ERR	n3	n3	n2			ERR
USGS 18	07/19/1996	0.388	0.175	0.450	0.00	0.00	0.00	32.1	C	C				32.05	C	C			
USGS 18	07/19/1996	0.399	0.000	0.000	0.00	0.00	ERR	31.6	C	22.1			ERR	31.55	C	n2			ERR
USGS 19	10/25/1994	0.350	0.263	0.750	16.81	5.88	22.41	32.3	C	C	C	C	C	n3	C	C	C	C	C
USGS 19	10/25/1994	0.347	0.126	0.362	16.29	5.66	45.02	32.3	8.3	C	C	C	C	n3	8.32	C	C	C	C
USGS 19	10/25/1994	0.465	0.127	0.273	6.67	3.10	24.46	24.8	8.3	5.8	C	C	C	n3	8.32	n2	C	C	C
USGS 19	04/19/1995	0.351	0.129	0.367	18.01	6.32	49.12	32.8	8.8	C	C	C	C	n3	8.80	C	C	C	C
USGS 19	04/19/1995	0.357	0.045	0.125	16.75	5.98	133.5	32.8	27.3	16.3	C	C	C	n3	n3	n2	C	C	C
USGS 19	04/19/1995	0.350	0.120	0.342	18.10	6.33	52.94	32.8	9.8	1.3	C	C	C	n3	9.80	n2	C	C	C
USGS 19	04/19/1995	0.357	0.020	0.056	16.90	6.04	304.1	32.3	43.3	20.8	C	C	C	n3	n3	n2	C	C	C
USGS 19	10/15/1996	0.345	0.113	0.327	9.70	3.34	29.65	34.8	11.8	2.3	C	C	C	n3	11.79	n2	C	C	C
USGS 19	10/15/1996	0.345	0.148	0.430	9.63	3.32	22.38	34.8	8.3	C	C	C	C	n3	8.29	C	C	C	C
USGS 19	10/15/1996	0.389	0.149	0.384	10.19	3.96	26.58	32.3	7.8	C	C	C	C	n3	7.79	C	C	C	C
USGS 22	06/13/1995	0.200	0.242	1.209	0.86	0.17	0.72	40.9	C	C	5.9	23.9	C	n3	C	C	5.95	n1	C
USGS 22	06/13/1995	0.231	0.150	0.649	0.79	0.18	1.22	39.9	6.4	C	7.4	21.4	C	n3	6.45	C	7.45	n1	C
USGS 22	06/13/1995	0.272	0.186	0.682	0.68	0.18	0.99	38.4	C	C	10.9	20.9	C	n3	C	C	n1	n1	C

Table 2. Ratio of partial pressures and ratio ages of the young fraction of ground water from at and near the Idaho National Engineering and Environmental Laboratory—Continued

Well name	Date sampled	Ratio of partial pressures						Estimated age of recharge in years; ratio method						Corrected results					
		F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113	F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113	F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113
USGS 22	07/18/1996	0.378	0.114	0.301	8.15	3.08	27.12	32.5	11.5	5.0	C	C	C	n3	11.55	n2	C	C	C
USGS 22	07/18/1996	0.384	0.121	0.316	8.01	3.07	25.35	32.5	10.5	2.0	C	C	C	n3	10.55	n2	C	C	C
USGS 22	07/18/1996	0.361	0.120	0.332	8.92	3.22	26.84	33.5	10.5	2.0	C	C	C	n3	10.55	n2	C	C	C
USGS 23	10/25/1994	0.428	0.127	0.296	52.49	22.45	177.5	27.8	8.3	4.3	C	C	C	n3	8.32	n2	C	C	C
USGS 23	10/25/1994	0.437	0.129	0.295	51.49	22.52	174.4	26.8	8.3	4.3	C	C	C	n3	8.32	n2	C	C	C
USGS 23	10/25/1994	0.431	0.124	0.288	53.91	23.24	186.9	27.3	8.8	4.8	C	C	C	n3	8.82	n2	C	C	C
USGS 23	04/19/1995	0.427	0.104	0.243	30.11	12.86	124.0	28.3	11.3	7.8	C	C	C	n3	11.30	n2	C	C	C
USGS 23	04/19/1995	0.063	0.113	1.782	203.86	12.91	114.4	46.3	10.3	C	C	C	C	n3	10.30	C	C	C	C
USGS 23	04/19/1995	0.135	0.110	0.818	91.66	12.36	112.1	43.3	10.8	C	C	C	C	n3	10.80	C	C	C	C
USGS 23	10/15/1996	0.449	0.133	0.297	16.35	7.34	55.10	28.3	9.3	5.8	C	C	C	n3	9.29	n2	C	C	C
USGS 23	10/15/1996	0.451	0.108	0.239	16.38	7.39	68.40	27.8	12.3	9.8	C	C	C	n3	12.29	n2	C	C	C
USGS 23	10/15/1996	0.454	0.128	0.282	17.18	7.80	61.02	27.8	10.3	7.3	C	C	C	n3	10.29	n2	C	C	C
USGS 26	10/14/1994	0.470	0.114	0.243	0.00	0.00	0.00	24.3	9.8	7.3				24.29	9.79	7.29			
USGS 26	10/14/1994	0.003	0.228	68.997	0.00	0.00	0.00	57.3	C	C				n3	C	C			
USGS 26	10/14/1994	0.466	0.091	0.196	0.00	0.00	0.00	24.8	12.3	10.3				24.79	12.29	10.29			
USGS 26	10/15/1996	0.410	0.101	0.246	114.51	46.95	465.6	31.3	13.3	9.3	C	C	C	n3	13.29	n2	C	C	C
USGS 26	10/15/1996	0.460	0.107	0.233	106.66	49.08	458.7	27.3	12.3	10.3	C	C	C	27.29	12.29	n2	C	C	C
USGS 26	10/15/1996	0.462	0.260	0.562	109.02	50.38	193.8	27.3	C	C	C	C	C	27.29	C	C	C	C	C
USGS 27	10/11/1994	0.402	0.092	0.230				29.8	12.3	8.3				29.78	12.28	8.28			
USGS 27	10/11/1994	0.331	0.127	0.383				33.3	8.3	C				33.28	8.28	C			
USGS 27	10/11/1994	0.405	0.000	0.000				29.3	42.8	20.3				29.28	n3	20.28			
USGS 27	10/15/1996	0.382	0.049	0.127	9.93	3.80	77.98	32.8	24.8	17.8	C	C	C	32.79	24.79	17.79	C	C	C
USGS 27	10/15/1996	0.401	0.000	0.000	9.85	3.95	ERR	31.8	44.8	22.3	C	C	ERR	31.79	n3	22.29	C	C	ERR
USGS 27	10/15/1996	0.494	0.000	0.000	10.10	4.99	ERR	24.8	44.8	22.3	C	C	ERR	24.79	n3	22.29	C	C	ERR
USGS 29	10/11/1994	0.498	0.097	0.195				22.3	11.3	10.8				22.28	11.28	10.78			
USGS 29	10/11/1994	0.515	0.114	0.221				21.3	9.8	8.8				21.28	9.78	8.78			
USGS 29	10/11/1994	0.500	0.071	0.141				22.3	15.8	14.8				22.28	15.78	14.78			
USGS 29	06/15/1995	0.518	0.057	0.110	0.72	0.37	6.55	21.5	19.5	18.5	10.0	11.0	C	21.46	19.46	18.46	9.96	n1	C
USGS 29	06/15/1995	0.526	0.079	0.150	0.72	0.38	4.81	20.5	15.5	14.5	10.0	10.5	C	20.46	15.46	14.46	9.96	n1	C
USGS 29	06/15/1995	0.491	0.075	0.154	0.72	0.35	4.67	23.5	15.5	14.5	10.0	12.0	C	23.46	15.46	14.46	n1	n1	C
USGS 29	07/19/1996	0.467	0.095	0.203	9.16	4.28	45.02	26.6	13.6	11.6	C	C	C	n3	13.55	n2	C	C	C
USGS 29	07/19/1996	0.456	0.070	0.154	9.19	4.19	59.86	27.1	17.6	15.6	C	C	C	n3	17.55	n2	C	C	C
USGS 29	07/19/1996	0.511	0.094	0.184	6.62	3.38	36.06	23.1	13.6	13.1	C	C	C	n3	13.55	n2	C	C	C
USGS 31	10/11/1994	0.388	0.000	0.000				30.3	42.8	20.3				30.28	n3	20.28			
USGS 31	10/11/1994	0.390	0.000	0.000				30.3	42.8	20.3				30.28	n3	20.28			
USGS 31	10/11/1994	0.418	0.000	0.000				28.8	42.8	20.3				28.78	n3	20.28			
USGS 31	06/15/1995	0.397	0.054	0.135	18.41	7.32	136.0	30.5	20.5	16.0	C	C	C	30.46	20.46	15.96	C	C	C
USGS 31	06/15/1995	0.416	0.067	0.161	19.01	7.91	118.0	29.5	17.0	13.5	C	C	C	29.46	16.96	13.46	C	C	C
USGS 31	06/15/1995	0.434	0.092	0.212	19.19	8.33	90.64	28.0	13.0	10.0	C	C	C	27.96	12.96	n2	C	C	C
USGS 31	07/19/1996	0.422	0.000	0.000	23.16	9.78	ERR	30.1	44.6	22.1	C	C	ERR	30.05	n3	n2	C	C	ERR
USGS 31	07/19/1996	0.455	0.261	0.573	21.88	9.96	38.18	27.6	C	C	C	C	C	27.55	C	C	C	C	C
USGS 31	07/19/1996	0.388	0.000	0.000	24.45	9.49	ERR	32.1	44.6	22.1	C	C	ERR	32.05	n3	22.05	C	C	ERR

Table 2. Ratio of partial pressures and ratio ages of the young fraction of ground water from at and near the Idaho National Engineering and Environmental Laboratory—Continued

Well name	Date sampled	Ratio of partial pressures						Estimated age of recharge in years; ratio method						Corrected results					
		F11 /F12	F113 /F12	F113 /F11	*SF$_6$ /F11	*SF$_6$ /F12	*SF$_6$ /F113	F11 /F12	F113 /F12	F113 /F11	*SF$_6$ /F11	*SF$_6$ /F12	*SF$_6$ /F113	F11 /F12	F113 /F12	F113 /F11	*SF$_6$ /F11	*SF$_6$ /F12	*SF$_6$ /F113
USGS 32	10/11/1994	0.281	0.102	0.362				37.3	10.8	C				n3	10.78	C			
USGS 32	10/11/1994	0.328	0.071	0.217				33.3	15.8	9.3				n3	15.78	n2			
USGS 32	10/11/1994	0.332	0.064	0.193				33.3	16.8	10.8				n3	16.78	n2			
USGS 32	06/15/1995	0.320	0.082	0.255	1.25	0.40	4.91	34.5	15.0	7.5	1.0	9.5	C	n3	14.96	7.46	n2	n1	C
USGS 32	06/15/1995	0.328	0.085	0.259	1.30	0.43	5.01	34.0	14.0	7.0	0.5	8.0	C	n3	13.96	n2	n1	n1	C
USGS 32	06/15/1995	0.311	0.060	0.194	1.31	0.41	6.71	35.0	18.5	11.5	0.0	9.5	C	n3	18.46	11.46	n1	n1	C
USGS 32	07/19/1996	0.335	0.000	0.000	14.06	4.71	ERR	35.1	44.6	22.1	C	C	ERR	n3	n3	n2	C	C	ERR
USGS 32	07/19/1996	0.352	0.000	0.000	14.17	4.99	ERR	34.1	44.6	22.1	C	C	ERR	n3	n3	n2	C	C	ERR
USGS 32	07/19/1996	0.351	0.074	0.210	12.61	4.42	60.12	34.1	17.1	11.6	C	C	C	n3	17.05	n2	C	C	C
USGS 36	07/16/1996	0.004	0.002	0.561				59.0	44.5	C				n3	n3	C			
USGS 36	07/16/1996	0.004	0.002	0.505				59.0	44.5	C				n3	n3	C			
USGS 36	07/16/1996	0.004	0.002	0.402				59.0	44.5	C				n3	n3	C			
USGS 37	10/07/1994	0.002	0.002	1.020				57.3	42.8	C				n3	n3	C			
USGS 37	10/07/1994	0.002	0.003	1.168				57.3	42.8	C				n3	n3	C			
USGS 37	10/07/1994	0.002	0.002	1.022				57.3	42.8	C				n3	n3	C			
USGS 65	10/12/1994	0.005	0.003	0.536				57.3	42.8	C				n3	n3	C			
USGS 65	10/12/1994	0.005	0.003	0.633				57.3	42.8	C				n3	n3	C			
USGS 65	10/12/1994	0.005	0.003	0.548				57.3	42.8	C				n3	n3	C			
USGS 65	10/12/1994	0.006	0.003	0.504				57.3	42.8	C				n3	n3	C			
USGS 76	10/12/1994	0.077	0.013	0.166				45.3	42.8	12.3				n3	n3	n3			
USGS 76	10/12/1994	0.075	0.013	0.180				45.3	42.8	11.3				n3	n3	n3			
USGS 76	10/12/1994	0.077	0.011	0.146				45.3	42.8	14.3				n3	n3	n3			
USGS 77	10/07/1994	0.001	ERR	ERR				57.3	ERR	ERR				n3	ERR	ERR			
USGS 77	10/07/1994	0.001	0.002	1.187				57.3	42.8	C				n3	n3	C			
USGS 77	10/07/1994	0.001	ERR	ERR				57.3	ERR	ERR				n3	ERR	ERR			
USGS 82	07/16/1996	0.004	0.001	0.262				59.0	44.5	8.0				n3	n3	8.04			
USGS 82	07/16/1996	0.005	0.001	0.143				59.0	44.5	16.0				n3	n3	16.04			
USGS 82	07/16/1996	0.004	0.001	0.180				59.0	44.5	13.0				n3	n3	13.04			
USGS 83	04/17/1995	0.395	0.000	0.000	55.99	22.11	ERR	30.8	43.3	20.8	C	C	ERR	30.79	43.29	20.79	C	C	ERR
USGS 83	04/17/1995	0.257	0.000	0.000	47.31	12.17	ERR	39.3	43.3	20.8	C	C	ERR	39.29	n3	20.79	C	C	ERR
USGS 83	04/17/1995	0.386	0.344	0.891	43.96	16.96	49.35	31.3	C	C	C	C	C	31.29	C	C	C	C	C
USGS 86	10/04/1994	0.490	0.170	0.348				22.8	C	0.3				22.76	C	0.26			
USGS 86	10/04/1994	0.433	0.253	0.584				27.3	C	C				27.26	C	C			
USGS 86	10/04/1994	0.455	0.119	0.261				25.8	9.3	6.3				25.76	9.26	6.26			
USGS 86	10/11/1996	0.437	0.153	0.350	0.29	0.13	0.83	29.3	7.8	2.3	22.3	25.3	C	n3	n3	2.28	n3	n3	C
USGS 86	10/11/1996	0.497	0.625	1.258	1.38	0.68	1.09	24.3	C	C	0.8	1.3	C	24.28	C	C	n1	n1	C
USGS 86	10/11/1996	0.423	0.066	0.156	3.07	1.30	19.61	30.3	18.3	15.3	C	C	C	30.28	18.28	15.28	C	C	C
USGS 89	10/07/1994	0.002	0.008	4.241				57.3	42.8	C				n3	n3	C			
USGS 89	10/07/1994	0.002	0.009	4.367				57.3	42.8	C				n3	n3	C			
USGS 89	10/07/1994	0.002	0.008	4.321				57.3	42.8	C				n3	n3	C			
USGS 89	07/17/1996	0.036	0.091	2.487				50.0	14.0	C				n3	n3	C			
USGS 89	07/17/1996	0.029	0.063	2.164				58.0	18.5	C				n3	n3	C			
USGS 89	07/17/1996	0.002	0.005	2.202				59.0	44.5	C				n3	n3	C			

Table 2. Ratio of partial pressures and ratio ages of the young fraction of ground water from at and near the Idaho National Engineering and Environmental Laboratory—Continued

Well name	Date sampled	Ratio of partial pressures						Estimated age of recharge in years; ratio method						Corrected results					
		F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113	F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113	F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113
USGS 97	06/13/1995	8.262	0.359	0.043	0.01	0.12	0.34	C	C	20.9	20.9	23.9	N	C	C	n3	20.95	n3	N
USGS 97	06/13/1995	7.910	0.288	0.036	0.02	0.13	0.44	C	C	20.9	20.9	23.9	N	C	C	n3	20.95	n3	N
USGS 97	06/13/1995	7.665	0.296	0.039	0.02	0.13	0.43	C	C	20.9	20.9	23.9	N	C	C	n3	n3	n3	N
USGS 98	06/12/1995	1.524	0.508	0.333	0.14	0.21	0.42	C	C	0.9	20.9	18.4	N	C	C	0.95	20.95	n1	N
USGS 98	06/12/1995	1.674	0.059	0.035	0.13	0.21	3.64	C	18.9	20.9	20.9	18.4	C	C	18.95	20.95	20.95	n1	C
USGS 98	06/12/1995	1.591	0.152	0.096	0.13	0.20	1.32	C	6.4	20.9	20.9	19.4	C	C	6.45	n3	n3	n1	C
USGS 99	06/12/1995	6.377	0.247	0.039	0.03	0.16	0.67	C	C	20.9	20.9	23.9	C	C	C	n3	n3	n3	C
USGS 99	06/12/1995	6.786	0.284	0.042	0.02	0.16	0.58	C	C	20.9	20.9	23.9	N	C	C	n3	n3	n3	N
USGS 99	06/12/1995	5.951	0.223	0.038	0.03	0.15	0.69	C	C	20.9	20.9	23.9	C	C	C	n3	n3	n3	C
USGS 99	06/12/1995	6.396	0.251	0.039	0.03	0.16	0.64	C	C	20.9	20.9	23.9	C	C	C	n3	n3	n3	C
USGS 100	04/21/1995	0.510	0.090	0.177	1.90	0.97	10.73	21.8	12.8	12.3	C	C	C	21.80	12.80	12.30	C	C	C
USGS 100	04/21/1995	0.497	0.128	0.259	2.00	0.99	7.72	22.8	8.8	6.8	C	C	C	22.80	8.80	6.80	C	C	C
USGS 100	04/21/1995	0.545	0.103	0.189	1.89	1.03	9.99	18.8	11.3	11.3	C	C	C	18.80	11.30	n2	C	C	C
USGS 100	10/10/1996	0.551	0.100	0.182	1.04	0.57	5.72	20.3	13.3	13.3	4.3	4.3	C	20.28	13.28	13.28	n2	n1	C
USGS 100	10/10/1996	0.524	0.098	0.187	1.08	0.56	5.78	21.8	13.3	12.8	4.3	4.3	C	21.78	13.28	12.78	n1	n1	C
USGS 100	10/10/1996	0.538	0.158	0.294	1.11	0.60	3.79	21.3	6.8	6.3	3.8	3.3	C	21.28	6.78	6.28	n1	n1	C
USGS 101	04/21/1995	0.367	0.068	0.185	3.13	1.15	16.96	31.8	16.8	11.8	C	C	C	31.80	16.80	11.80	C	C	C
USGS 101	04/21/1995	0.414	0.000	0.000	3.01	1.25	ERR	29.3	43.3	20.8	C	C	ERR	29.30	n3	20.80	C	C	ERR
USGS 101	04/21/1995	4.391	0.000	0.000	3.01	13.24	ERR	C	43.3	20.8	C	C	ERR	C	43.30	20.80	C	C	ERR
USGS 101	10/10/1996	0.419	0.065	0.154	2.66	1.12	17.26	30.3	18.8	15.3	C	C	C	30.28	18.78	15.28	C	C	C
USGS 101	10/10/1996	0.383	0.083	0.216	2.87	1.10	13.28	32.8	15.8	11.3	C	C	C	32.78	15.78	11.28	C	C	C
USGS 101	10/10/1996	0.417	0.060	0.143	2.58	1.08	18.02	30.8	19.8	16.3	C	C	C	30.78	19.78	16.28	C	C	C
USGS 102	06/13/1995	10.679	0.609	0.057	0.01	0.10	0.16	C	C	20.9	20.9	23.9	6.9	C	C	n3	20.95	n3	n3
USGS 102	06/13/1995	8.702	0.521	0.060	0.01	0.08	0.16	C	C	20.9	20.9	23.9	6.9	C	C	n3	20.95	n3	n3
USGS 102	06/13/1995	0.507	0.119	0.235	0.01	0.01	0.04	22.4	9.9	8.4	20.9	23.9	6.9	n3	n3	n3	n3	n3	n3
USGS 103	07/20/1994	0.263	0.038	0.145				38.1	39.6	14.1				n3	n3	14.05			
USGS 103	07/20/1994	0.021	0.058	2.788				56.6	18.1	C				n3	18.05	C			
USGS 103	07/20/1994	0.259	0.040	0.155				38.1	36.6	13.1				n3	n3	13.05			
USGS 103	04/18/1995	0.246	0.034	0.138	1.45	0.36	10.48	39.3	43.3	15.3	N	11.3	C	n3	n3	15.30	N	n1	C
USGS 103	04/18/1995	0.250	0.069	0.275	1.44	0.36	5.24	39.3	16.3	6.3	N	11.3	C	n3	16.30	n2	N	n1	C
USGS 103	04/18/1995	0.252	0.037	0.145	1.41	0.35	9.67	39.3	42.3	14.8	N	11.3	C	n3	n3	n2	N	n1	C
USGS 103	07/15/1996	0.325	0.103	0.316				35.5	12.5	2.0				n3	12.54	n2			
USGS 103	07/15/1996	0.343	0.104	0.304				34.5	12.5	4.5				n3	12.54	n2			
USGS 103	07/15/1996	0.326	0.090	0.276				35.5	14.5	7.5				n3	14.54	n2			
USGS 104	07/20/1994	0.001	0.001	0.816				57.1	42.6	C				n3	n3	C			
USGS 104	07/20/1994	0.001	0.001	0.782				57.1	42.6	C				n3	n3	C			
USGS 104	07/20/1994	0.001	0.001	0.758				57.1	42.6	C				n3	n3	C			
USGS 104	04/18/1995	0.001	0.001	0.883	11.83	0.01	13.40	57.8	43.3	C	C	23.8	C	n3	n3	C	C	n3	C
USGS 104	04/18/1995	0.011	0.003	0.304	3.00	0.03	9.88	57.8	43.3	3.8	C	23.8	C	n3	n3	n2	C	n3	C
USGS 104	04/18/1995	0.011	0.003	0.304	304.55	3.39	1003	57.8	43.3	3.8	C	C	C	n3	n3	n1	C	C	C
USGS 104	07/15/1996	0.009	0.007	0.810				59.0	44.5	C				n3	n3	C			
USGS 104	07/15/1996	0.008	0.007	0.827				59.0	44.5	C				n3	n3	C			
USGS 104	07/15/1996	0.002	0.001	0.549				59.0	44.5	C				n3	n3	C			

Table 2. Ratio of partial pressures and ratio ages of the young fraction of ground water from at and near the Idaho National Engineering and Environmental Laboratory—Continued

Well name	Date sampled	Ratio of partial pressures						Estimated age of recharge in years; ratio method						Corrected results					
		F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113	F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113	F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113
USGS 105	10/03/1994	0.050	0.246	4.908				46.8	C	C				n3	C	C			
USGS 105	10/03/1994	0.051	0.234	4.579				46.3	C	C				n3	C	C			
USGS 105	10/03/1994	0.052	0.250	4.817				46.3	C	C				n3	C	C			
USGS 105	04/18/1995	0.047	0.211	4.454	0.57	0.03	0.13	47.3	C	C	13.3	23.8	6.8	n3	C	C	n3	n3	n3
USGS 105	04/18/1995	0.035	0.199	5.737	0.70	0.02	0.12	56.3	C	C	10.3	23.8	6.8	n3	C	C	n1	n3	n3
USGS 105	04/18/1995	0.038	0.228	5.986	0.67	0.03	0.11	48.3	C	C	11.3	23.8	6.8	n3	C	C	n1	n3	n3
USGS 106	10/05/1994	0.009	0.002	0.208				57.3	42.8	9.8				n3	n3	9.76			
USGS 106	10/05/1994	0.009	0.002	0.218				57.3	42.8	9.3				n3	n3	9.26			
USGS 106	10/05/1994	0.009	0.002	0.257				57.3	42.8	6.8				n3	n3	6.76			
USGS 107	10/05/1994	0.323	0.093	0.288				33.8	12.3	4.8				n3	12.26	4.76			
USGS 107	10/05/1994	0.315	0.087	0.277				34.3	12.8	5.3				n3	12.76	5.26			
USGS 107	10/05/1994	0.320	0.082	0.258				33.8	14.3	6.8				n3	14.26	6.76			
USGS 107	10/09/1996	0.315	0.078	0.249	3.11	0.98	12.51	36.3	16.8	9.3	C	C	C	n3	16.77	9.27	C	C	C
USGS 107	10/09/1996	0.306	0.080	0.261	3.05	0.93	11.69	36.8	16.3	8.3	C	C	C	n3	16.27	8.27	C	C	C
USGS 107	10/09/1996	0.312	0.054	0.173	3.14	0.98	18.18	36.3	21.8	13.8	C	C	C	n3	21.77	13.77	C	C	C
USGS 108	10/03/1994	0.044	0.000	0.000				47.3	42.8	20.3				n3	n3	20.26			
USGS 108	10/03/1994	0.045	0.009	0.201				47.3	42.8	10.3				n3	n3	10.26			
USGS 108	10/03/1994	0.043	0.000	0.000				47.3	42.8	20.3				n3	n3	20.26			
USGS 108	04/18/1995	0.045	0.007	0.158	1.66	0.07	10.51	47.8	43.3	13.8	N	23.8	C	n3	n3	13.80	N	n3	C
USGS 108	04/18/1995	0.046	0.006	0.131	1.57	0.07	11.95	47.8	43.3	16.3	N	23.8	C	n3	n3	16.30	N	n3	C
USGS 108	04/18/1995	0.044	0.008	0.181	1.65	0.07	9.10	47.8	43.3	11.8	N	23.8	C	n3	n3	11.80	N	n3	C
USGS 109	10/04/1994	0.087	0.309	3.535				44.3	C	C				n3	C	C			
USGS 109	10/04/1994	0.094	0.282	3.011				44.3	C	C				n3	C	C			
USGS 109	10/04/1994	0.092	0.299	3.251				44.3	C	C				n3	C	C			
USGS 109	04/20/1995	0.086	0.324	3.763	0.00	0.00	0.00	44.8	C	C				n3	C	C			
USGS 109	04/20/1995	0.082	0.307	3.729	0.00	0.00	0.00	45.3	C	C				n3	C	C			
USGS 109	04/20/1995	0.095	0.289	3.059	0.00	0.00	0.00	44.8	C	C				n3	C	C			
USGS 109	10/11/1996	0.086	0.277	3.206	0.73	0.06	0.23	46.3	C	C	10.8	25.3	8.3	n3	C	C	10.78	n3	n3
USGS 109	10/11/1996	0.111	0.296	2.662	0.56	0.06	0.21	45.3	C	C	15.3	25.3	8.3	n3	C	C	n3	n3	n3
USGS 109	10/11/1996	0.081	0.313	3.868	0.80	0.06	0.21	46.8	C	C	8.8	25.3	8.3	n3	C	C	n1	n3	n3
USGS 110A	10/09/1996	0.417	0.074	0.178	1.96	0.82	11.00	30.8	17.3	13.3	C	N	C	n3	17.27	13.27	C	N	C
USGS 110A	10/09/1996	0.432	0.110	0.255	1.94	0.84	7.58	29.3	12.3	8.8	C	N	C	n3	12.27	8.77	C	N	C
USGS 110A	10/09/1996	0.435	0.215	0.493	1.95	0.85	3.95	29.3	C	C	C	N	C	n3	C	C	C	N	C
USGS 112	07/15/1996	0.002	0.003	1.421				59.0	44.5	C				n3	n3	C			
USGS 112	07/15/1996	0.002	0.004	1.617				59.0	44.5	C				n3	n3	C			
USGS 112	07/15/1996	0.002	0.001	0.723				59.0	44.5	C				n3	n3	C			
USGS 113	07/16/1996	0.014	ERR	ERR				59.0	ERR	ERR				n3	ERR	ERR			
USGS 113	07/16/1996	0.013	ERR	ERR				59.0	ERR	ERR				n3	ERR	ERR			
USGS 113	07/16/1996	0.002	0.002	0.827				59.0	44.5	C				n3	n3	C			
USGS 115	07/15/1996	0.001	0.001	0.775				59.0	44.5	C				n3	n3	C			
USGS 115	07/15/1996	0.002	0.001	0.432				59.0	44.5	C				n3	n3	C			
USGS 115	07/15/1996	0.002	0.001	0.250				59.0	44.5	8.5				n3	n3	8.54			
USGS 116	07/15/1996	0.028	0.010	0.368				58.0	44.5	C				n3	n3	C			
USGS 116	07/15/1996	0.019	0.010	0.527				58.5	44.5	C				n3	n3	C			
USGS 116	07/15/1996	0.013	0.004	0.279				59.0	44.5	7.0				n3	n3	7.04			

Table 2. Ratio of partial pressures and ratio ages of the young fraction of ground water from at and near the Idaho National Engineering and Environmental Laboratory—Continued

Well name	Date sampled	Ratio of partial pressures						Estimated age of recharge in years; ratio method						Corrected results					
		F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113	F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113	F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113
USGS 117	10/05/1994	0.514	0.311	0.605				21.3	C	C				21.26	C	C			
USGS 117	10/05/1994	0.482	0.337	0.699				23.3	C	C				23.26	C	C			
USGS 117	10/05/1994	0.514	0.257	0.500				21.3	C	C				21.26	C	C			
USGS 117	07/17/1996	0.392	0.000	0.000				32.0	44.5	22.0				32.04	n3	22.04			
USGS 117	07/17/1996	0.455	0.000	0.000				27.5	44.5	22.0				27.54	n3	22.04			
USGS 117	07/17/1996	0.638	0.350	0.550				C	C	C				C	C	C			
USGS 119	10/06/1994	0.116	2.012	17.278				43.3	C	C				n3	C	C			
USGS 119	10/06/1994	0.120	1.850	15.443				43.3	C	C				n3	C	C			
USGS 120	10/06/1994	0.131	0.735	5.625				42.8	C	C				n3	C	C			
USGS 120	10/06/1994	0.131	0.722	5.518				42.8	C	C				n3	C	C			
USGS 120	10/06/1994	0.140	0.672	4.814				42.3	C	C				n3	C	C			
USGS 120	07/17/1996	0.200	1.328	6.646				42.0	C	C				n3	C	C			
USGS 120	07/17/1996	0.187	1.275	6.829				42.5	C	C				n3	C	C			
USGS 120	07/17/1996	0.143	1.085	7.582				44.0	C	C				n3	C	C			
USGS 121	10/24/1994	0.007	0.001	0.112	0.39	0.00	3.49	57.3	42.8	17.3	17.8	23.3	C	n3	n3	n3	n3	n3	C
USGS 121	10/24/1994	0.011	0.012	1.078	1.07	0.01	0.99	57.3	42.8	C	2.3	23.3	C	n3	n3	C	n1	n3	C
USGS 121	10/24/1994	0.031	0.005	0.171	0.20	0.01	1.17	56.3	42.8	11.8	20.3	23.3	C	n3	n3	n3	n3	n3	C
USGS 124	07/20/1994	0.015	0.015	1.041				57.1	42.6	C				n3	n3	C			
USGS 124	07/20/1994	0.014	0.016	1.085				57.1	42.6	C				n3	n3	C			
USGS 124	07/20/1994	0.014	0.017	1.170				57.1	42.6	C				n3	n3	C			
USGS 124	04/20/1995	0.015	ERR	ERR	4.98	0.07	ERR	57.8	ERR	ERR	C	23.8	ERR	n3	ERR	ERR	C	n3	ERR
USGS 124	04/20/1995	0.015	ERR	ERR	5.01	0.08	ERR	57.8	ERR	ERR	C	23.8	ERR	n3	ERR	ERR	C	n3	ERR
USGS 124	04/20/1995	0.015	0.016	1.074	4.92	0.07	4.58	57.8	43.3	C	C	23.8	C	n3	n3	C	C	n3	C
USGS 124	10/09/1996	0.017	0.014	0.783	4.13	0.07	5.27	58.8	44.8	C	C	25.3	C	n3	n3	C	C	n3	C
USGS 124	10/09/1996	0.017	0.014	0.821	3.99	0.07	4.87	58.8	44.8	C	C	25.3	C	n3	n3	C	C	n3	C
USGS 124	10/09/1996	0.016	0.014	0.878	4.13	0.07	4.70	59.3	44.8	C	C	25.3	C	n3	n3	C	C	n3	C
USGS 125	06/06/1995	0.120	0.335	2.789	0.34	0.04	0.12	43.9	C	C	20.9	23.9	6.9	n3	C	C	20.93	n3	n3
USGS 125	06/16/1995	0.124	0.291	2.344	0.35	0.04	0.15	43.5	C	C	21.0	24.0	7.0	n3	C	C	20.96	n3	n3
USGS 125	06/16/1995	0.112	0.294	2.631	0.33	0.04	0.13	44.0	C	C	21.0	24.0	7.0	n3	C	C	20.96	n3	n3
USGS 125	10/11/1996	0.120	0.316	2.635	0.64	0.08	0.24	45.3	C	C	13.3	25.3	8.3	n3	C	C	13.28	n3	n3
USGS 125	10/11/1996	0.109	0.301	2.761	0.70	0.08	0.25	45.3	C	C	11.8	25.3	8.3	n3	C	C	11.78	n3	n3
USGS 125	10/11/1996	0.125	0.321	2.572	0.67	0.08	0.26	44.8	C	C	12.8	25.3	8.3	n3	C	C	n1	n3	n3
Arco City Park 2	07/09/1991	0.518						17.5						17.5					
Arco City Park 2	07/09/1991	0.517						17.5						17.5					
Arco City Park 2	07/09/1991	0.529						16.5						16.5					
Arco City Park 2	07/09/1991	0.512						18.0						18.0					
McKinney	07/09/1991	0.505						18.5						n1					
McKinney	07/09/1991	0.452						22.5						n1					
McKinney	07/09/1991	0.505						18.5						n1					
McKinney	07/09/1991	0.496						19.0						n1					
McKinney	07/09/1991	0.510						18.0						n1					

Table 2. Ratio of partial pressures and ratio ages of the young fraction of ground water from at and near the Idaho National Engineering and Environmental Laboratory—Continued

Well name	Date sampled	Ratio of partial pressures						Estimated age of recharge in years; ratio method						Corrected results					
		F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113	F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113	F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113
P&W2	07/11/1991	0.561						14.5						nl					
P&W2	07/11/1991	0.540						16.0						nl					
P&W2	07/11/1991	0.580						16.0						nl					
P&W2	07/11/1991	0.579						16.0						nl					
P&W2	07/11/1991	0.547						15.0						nl					
Ruby Farms	07/09/1991	0.451						22.5						22.5					
Ruby Farms	07/09/1991	0.483						20.0						20.0					
Ruby Farms	07/09/1991	0.524						16.5						16.5					
Ruby Farms	07/09/1991	0.464						21.5						21.5					
Ruby Farms	07/09/1991	0.481						20.5						20.5					
USGS 1	07/08/1991	0.400						26.5						nl					
USGS 1	07/08/1991	0.460						22.0						22.0					
USGS 1	07/08/1991	0.443						23.0						23.0					
USGS 1	07/08/1991	0.476						20.5						20.5					
USGS 1	07/08/1991	0.434						24.0						24.0					
USGS 8	07/12/1991	0.204						37.0						nl					
USGS 8	07/12/1991	0.225						36.5						nl					
USGS 8	07/12/1991	0.208						37.0						nl					
USGS 9	07/12/1991	0.350						29.0						nl					
USGS 9	07/12/1991	0.402						26.5						nl					
USGS 9	07/12/1991	0.410						26.0						nl					
USGS 9	07/12/1991	0.331						30.0						nl					
USGS 9	07/12/1991	0.401						26.5						nl					
USGS 18	07/11/1991	0.315						31.0						31.0					
USGS 18	07/11/1991	0.417						25.5						25.5					
USGS 18	07/11/1991	0.391						27.0						27.0					
USGS 18	07/11/1991	0.428						24.5						24.5					
USGS 18	07/11/1991	0.292						33.5						33.5					
USGS 23	07/11/1991	0.444						23.0						nl					
USGS 23	07/11/1991	0.466						21.5						nl					
USGS 23	07/11/1991	0.447						23.0						nl					
USGS 23	07/11/1991	0.476						20.5						nl					
USGS 23	07/11/1991	0.474						21.0						nl					
USGS 23	07/11/1991	0.487						20.0						nl					
USGS 23	07/11/1991	0.491						19.5						nl					
USGS 23	07/11/1991	0.466						21.5						nl					
USGS 26	07/11/1991	0.502						19.0						19.0					
USGS 26	07/11/1991	0.498						19.0						19.0					
USGS 26	07/11/1991	0.508						18.5						18.5					
USGS 26	07/11/1991	0.496						19.0						19.0					
USGS 27	07/11/1991	0.423						25.0						25.0					
USGS 27	07/11/1991	0.428						24.5						24.5					
USGS 27	07/11/1991	0.368						28.0						28.0					
USGS 27	07/11/1991	0.450						22.5						22.5					
USGS 27	07/11/1991	0.328						30.0						30.0					

Table 2. Ratio of partial pressures and ratio ages of the young fraction of ground water from at and near the Idaho National Engineering and Environmental Laboratory—Continued

Well name	Date sampled	Ratio of partial pressures						Estimated age of recharge in years; ratio method						Corrected results					
		F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113	F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113	F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113
USGS 58	07/09/1991	0.069						42.0						nl					
USGS 58	07/09/1991	0.076						42.0						nl					
USGS 58	07/09/1991	0.068						42.0						nl					
USGS 58	07/09/1991	0.076						42.0						nl					
USGS 58	07/09/1991	0.072						42.0						nl					
USGS 65	07/09/1991	0.012						54.0						nl					
USGS 65	07/09/1991	0.016						54.0						nl					
USGS 65	07/09/1991	0.012						54.0						nl					
USGS 65	07/09/1991	0.017						53.5						nl					
USGS 65	07/09/1991	0.014						54.0						nl					
USGS 79	07/09/1991	0.062						42.5						nl					
USGS 79	07/09/1991	0.069						42.0						nl					
USGS 79	07/09/1991	0.062						42.5						nl					
USGS 79	07/09/1991	0.067						42.5						nl					
USGS 79	07/09/1991	0.065						42.5						nl					
USGS 86	07/12/1991	0.731						C						C					
USGS 86	07/12/1991	0.548						15.0						nl					
USGS 86	07/12/1991	0.554						14.5						nl					
USGS 86	07/12/1991	0.426						24.5						nl					
USGS 86	07/12/1991	0.552						15.0						15.0					
USGS 87	05/06/1991	0.008						53.8						nl					
USGS 87	05/06/1991	0.004						53.8						nl					
USGS 87	05/06/1991	0.004						53.8						nl					
USGS 88	05/06/1991	0.011						53.8						nl					
USGS 88	05/06/1991	0.011						53.8						nl					
USGS 88	05/06/1991	0.016						53.8						nl					
USGS 88	05/06/1991	0.015						53.8						nl					
USGS 89	05/06/1991	0.000						53.8						nl					
USGS 89	05/06/1991	0.000						53.8						nl					
USGS 89	05/06/1991	0.000						53.8						nl					
USGS 97	07/09/1991	12.777						C						C					
USGS 97	07/09/1991	12.132						C						C					
USGS 97	07/09/1991	12.436						C						C					
USGS 97	07/09/1991	11.354						C						C					
USGS 100	07/08/1991	0.480						20.5						20.5					
USGS 100	07/08/1991	0.507						18.5						18.5					
USGS 100	07/08/1991	0.471						21.0						21.0					
USGS 100	07/08/1991	0.467						21.5						21.5					
USGS 100	07/08/1991	0.461						22.0						22.0					
USGS 104	07/08/1991	0.002						54.0						nl					
USGS 104	07/08/1991	0.002						54.0						nl					
USGS 104	07/08/1991	0.001						54.0						nl					
USGS 104	07/08/1991	0.001						54.0						nl					
USGS 104	07/08/1991	0.001						54.0						nl					

Table 2. Ratio of partial pressures and ratio ages of the young fraction of ground water from at and near the Idaho National Engineering and Environmental Laboratory—Continued

Well name	Date sampled	Ratio of partial pressures						Estimated age of recharge in years, ratio method						Corrected results					
		F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113	F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113	F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113
USGS 117	05/06/1991	ERR						ERR						ERR					
USGS 117	05/06/1991	ERR						ERR						ERR					
USGS 117	05/06/1991	ERR						ERR						ERR					
USGS 117	07/11/1991	0.592						C						C					
USGS 117	07/11/1991	0.612						C						C					
USGS 117	07/11/1991	0.575																	
USGS 117	07/11/1991	0.554						14.5						14.5					
USGS 117	07/11/1991	0.514						18.0						18.0					
USGS 117	07/11/1991	0.582																	
USGS 117	07/11/1991	0.678						C						C					
USGS 117	07/11/1991	0.687						C						C					
USGS 117	07/11/1991	0.741						C						C					
USGS 117	07/11/1991	0.726						C						C					
USGS 117	07/11/1991	0.743						C						C					
USGS 117	07/11/1991	0.837						C						C					
USGS 117	07/11/1991	1.372						C						C					
USGS 117	07/11/1991	1.460						C						C					
USGS 117	07/11/1991	0.583						14.5						14.5					
USGS 117	07/11/1991	0.567						14.5						14.5					
USGS 117	07/11/1991	0.925						C						C					
USGS 117	07/11/1991	0.206						37.0						nl					
USGS 117	07/11/1991	0.892						C						C					
USGS 117	07/11/1991	1.186						C						C					
USGS 119	05/06/1991	0.149						38.8						nl					
USGS 119	05/06/1991	0.243						35.8						nl					
USGS 119	05/06/1991	0.127						39.3						nl					
USGS 119	05/06/1991	0.272						34.3						nl					
USGS 120	05/07/1991	0.153						38.3						nl					
USGS 120	05/07/1991	0.220						36.3						nl					
USGS 120	05/07/1991	0.227						36.3						nl					
USGS 120	05/07/1991	0.226						36.3						nl					
USGS 120	07/12/1991	0.153						38.5						nl					
USGS 120	07/12/1991	0.409						26.0						nl					
USGS 120	07/12/1991	0.272						34.5						nl					
USGS 120	07/12/1991	0.175						38.0						nl					
USGS 120	07/12/1991	0.330						30.0						nl					
USGS 120	07/12/1991	0.178						38.0						nl					
USGS 120	07/12/1991	0.387						27.0						nl					
USGS 120	07/12/1991	0.178						38.0						nl					
USGS 120	07/12/1991	0.182						38.0						nl					
USGS 120	07/12/1991	0.102						40.5						nl					
USGS 120	07/12/1991	0.183						38.0						nl					
USGS 120	07/12/1991	0.195						37.5						nl					
USGS 120	07/12/1991	0.178						38.0						nl					

Table 2. Ratio of partial pressures and ratio ages of the young fraction of ground water from at and near the Idaho National Engineering and Environmental Laboratory—Continued

Well name	Date sampled	Ratio of partial pressures						Estimated age of recharge in years; ratio method						Corrected results					
		F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113	F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113	F11 /F12	F113 /F12	F113 /F11	*SF_6 /F11	*SF_6 /F12	*SF_6 /F113
USGS 120	07/12/1991	0.180						38.0						nl					
USGS 120	07/12/1991	0.181						38.0						nl					
USGS 120	07/12/1991	0.183						38.0						nl					
USGS 120	07/12/1991	0.177						38.0						nl					
USGS 120	07/12/1991	0.161						38.5						nl					

Table 3. Fraction of young water calculated using models 2 and 3, and the model-3 age of the young fraction calculated from chlorofluorocarbons, Idaho National Engineering and Environmental Laboratory and vicinity

[See figure 2 for location of sites. Blank spaces, no data or not applicable. Abbreviations: F11, Chlorofluorocarbon-11; F12, Chlorofluorocarbon-12; F113, Chlorofluorocarbon-113; SF_6, sulfur hexafluoride; yrs, years; C, contaminated or partial pressure exceeds historical atmospheric partial pressures; ERR, interferences, concentration not measured; N, date of recharge younger than the date of sampling; n1, piston-flow age of numerator greater than the ratio age; n2, piston-flow age of denominator greater than the ratio age; n3, piston flow age of the numerator and the denominator greater than the ratio age; -σ, negative sigma, calculated error]

Well name	Date sampled	Model 2 Fraction of young water; ratio method						Model 3 Fraction from ^{18}O		Model-3 age								
										CFC-11 age			CFC-12 age			CFC-113 age		
		F11 /F12	F113 /F12	F113 /F11	SF_6 /F11	SF_6 /F12	SF_6 /F113	Frac-tion	Error	Age yrs	-σ yrs	+σ yrs	Age yrs	-σ yrs	+σ yrs	Age yrs	-σ yrs	+σ yrs
ANP 6	10/14/1994	n3	C	C				0.18	0.03									
ANP 6	10/14/1994	n3	C	C				0.18	0.03									
ANP 6	10/14/1994	n3	C	C				0.18	0.03									
ANP 6	06/15/1995	n3	C	C	0.45	n3	C	0.16	0.03									
ANP 6	06/15/1995	n3	C	C	0.45	n3	C	0.16	0.03									
ANP 6	06/15/1995	n3	C	C	n3	n3	C	0.16	0.03									
ANP 6	07/19/1996	n3	C	C	C	C	C	0.18	0.03									
ANP 6	07/19/1996	n3	C	C	C	C	C	0.18	0.03									
ANP 6	07/19/1996	n3	ERR	ERR	C	C	ERR	0.18	0.03									
ANP 6	07/19/1996	n3	C	C	C	C	C	0.18	0.03									
ANP 9	10/14/1994	n3	0.25	0.13														
ANP 9	10/14/1994	n3	0.23	0.10														
ANP 9	10/14/1994	n3	0.27	0.13														
ANP 9	10/14/1996	n3	n3	0.25	C	C	ERR	0.39	0.06	25.3	2.0	-2.0	23.29	2.0	-4.0			
ANP 9	10/14/1996	n3	0.35	0.15	C	C	C	0.39	0.06	25.3	2.0	-2.0	22.29	2.0	-4.0	21.79	2.0	-2.0
ANP 9	10/14/1996	n3	0.31	0.16	C	C	C	0.39	0.06	25.8	1.5	-2.5	23.29	2.0	-3.5	22.29	2.0	-2.0
Arbor Test	04/21/1995	0.60	0.55	0.51	0.28	n3	C	0.45	0.07	16.3	3.0	-5.0	15.30	3.5	-5.0	17.80	1.0	-2.0
Arbor Test	04/21/1995	0.92	0.28	0.23	0.23	n3	C	0.45	0.07	18.8	2.0	-4.0	16.30	3.0	-5.0	10.30	1.5	-2.0
Arbor Test	04/21/1995	0.98	n3	0.57	n3	n3	C	0.45	0.07	17.8	2.5	-4.5	14.80	3.5	-5.0	31.80	1.5	-1.5
Arbor Test	04/21/1995	n3	n3	0.57	n3	n3	C	0.45	0.07	17.8	2.5	-4.5	14.30	4.0	-4.5	30.80	1.5	-1.5
Arbor Test	10/10/1996	0.83	0.44	0.36	C	C	C	0.46	0.08	19.3	2.0	-4.5	17.28	3.0	-4.5	16.28	1.5	-1.5
Arbor Test	10/10/1996	0.91	0.40	0.33	C	C	C	0.46	0.08	18.8	2.5	-4.5	16.28	3.5	-4.5	14.78	1.5	-2.0
Arbor Test	10/10/1996	0.86	0.37	0.32	C	C	C	0.46	0.08	19.8	2.0	-4.0	17.28	3.5	-4.0	15.28	1.5	-2.0
Area II	07/19/1994	0.48	0.26	0.24				0.49	0.08	21.0	1.0	-1.5	21.05	1.5	-2.5	16.55	1.0	-1.5
Area II	07/19/1994	0.58	n3	0.42				0.49	0.08	21.0	1.0	-1.5	20.55	1.5	-2.0	22.55	1.5	-1.5
Area II	07/19/1994	0.99	n3	0.40				0.49	0.08	21.5	1.0	-1.5	20.05	1.5	-2.5			
Area II	07/18/1996	0.48	n3	0.51				0.47	0.08	21.0	1.5	-2.5	21.05	2.0	-3.0	23.05	1.0	-1.5
Area II	07/18/1996	0.42	0.36	0.36				0.47	0.08	21.0	1.5	-3.0	21.05	2.0	-2.5	19.55	1.0	-1.5
Area II	07/18/1996	0.46	0.34	0.31				0.47	0.08	21.5	1.5	-2.0	21.55	1.5	-3.0	18.55	1.5	-1.5
Atomic City	10/03/1994	n3	0.69	0.50				0.47	0.08							3.76	2.5	-3.8
Atomic City	10/03/1994	n3	0.71	0.50				0.47	0.08							4.76	2.0	-4.8
Atomic City	10/03/1994	n3	0.62	0.51				0.47	0.08									
Atomic City	10/09/1996	n3	0.75	0.57	N	N	C	0.47	0.08							5.77	2.5	-5.8
Atomic City	10/09/1996	n3	0.68	0.49	N	N	C	0.47	0.08							2.77	4.5	-2.8
Atomic City	10/09/1996	n3	0.66	0.53	N	N	C	0.47	0.08									
BFW	07/16/1996	n3	ERR	ERR				0.38	0.06							ERR	ERR	ERR
BFW	07/16/1996	n3	ERR	ERR				0.38	0.06							ERR	ERR	ERR
BFW	07/16/1996	n3	n3	C				0.38	0.06									

Table 3. Fraction of young water calculated using models 2 and 3, and the model-3 age of the young fraction calculated from chlorofluorocarbons, Idaho National Engineering and Environmental Laboratory and vicinity—Continued

Well name	Date sampled	Model 2 Fraction of young water; ratio method						Model 3 Fraction from ^{18}O		Model-3 age								
		F11 /F12	F113 /F12	F113 /F11	SF_6 /F11	SF_6 /F12	SF_6 /F113	Frac-tion	Error	CFC-11 age			CFC-12 age			CFC-113 age		
										Age yrs	-σ yrs	+σ yrs	Age yrs	-σ yrs	+σ yrs	Age yrs	-σ yrs	+σ yrs
CFA 1	07/16/1996	n3	n3	C				0.48	0.08									
CFA 1	07/16/1996	n3	n3	C				0.48	0.08									
CFA 1	07/16/1996	n3	n3	C				0.48	0.08									
CFA 2	07/16/1996	C	C	C				0.73	0.12				2.54	3.0	-2.5			
CFA 2	07/16/1996	n3	n3	C				0.73	0.12									
CFA 2	07/16/1996	n3	n3	C				0.73	0.12									
CFA 2	07/16/1996	n3	n3	C				0.73	0.12									
EBR I	10/16/1996	n3	n3	0.00	C	n3	ERR	0.26	0.04	44.3								
EBR I	10/16/1996	n3	n3	0.00	C	n3	ERR	0.26	0.04	44.3								
Fire Station 2	10/16/1996	C	C	n1	3.45	n3	n3	0.36	0.06				9.79	5.5	-9.8			
Fire Station 2	10/16/1996	C	C	n3	n3	n3	n3	0.36	0.06				10.29	5.5	-10.3			
Fire Station 2	10/16/1996	C	C	n3	n3	n3	n3	0.36	0.06				13.29	5.5	-10.0			
IET Disp	07/18/1994	n3	n3	C				0.50	0.08	31.5	0.5	-1.0	5.55	3.5	-5.5	15.55	1.5	-1.0
IET Disp	07/18/1994	n3	n3	0.15				0.50	0.08	28.0	1.0	-1.0	2.05	5.0	-2.0			
IET Disp	07/18/1994	n3	n3	0.08				0.50	0.08	31.5	1.0	-1.0	4.55	3.5	-4.5			
IET Disp	07/18/1996	n3	n3	0.08				0.54	0.09	34.5	0.5	-1.0	8.55	2.5	-5.5			
IET Disp	07/18/1996	n3	n3	0.08				0.54	0.09	34.0	1.0	-0.5	9.05	2.5	-5.5			
IET Disp	07/18/1996	n3	n3	0.09				0.54	0.09	33.5	1.0	-0.5	0.05	7.5	-0.0			
IET Disp	07/18/1996	n3	n3	0.08				0.54	0.09	34.0	0.5	-1.0	8.55	2.5	-6.0			
IET Disp	07/18/1996	n3	n3	0.09				0.54	0.09	34.0	0.5	-1.0	8.55	2.5	-6.5			
INEL 1 WS	06/12/1995	C	C	n1	2.04	n3	C	0.34	0.06				6.45	6.0	-6.4			
INEL 1 WS	06/12/1995	C	0.63	2.10	2.10	n3	C	0.34	0.06				10.95	6.0	-10.9	16.95	2.0	-3.0
INEL 1 WS	06/12/1995	C	n3	2.13	n3	n3	C	0.34	0.06				10.95	6.0	-10.9	21.95	2.0	-3.0
Leo Rogers 1	07/17/1996	n3	0.30	C				0.52	0.09	22.0	1.0	-1.5	19.04	2.0	-3.5	12.04	1.0	-1.5
Leo Rogers 1	07/17/1996	n3	0.37	0.22				0.52	0.09	22.0	1.0	-1.5	19.04	2.0	-3.5	14.54	1.0	-1.5
Leo Rogers 1	07/17/1996	n3	0.39	0.24				0.52	0.09	22.5	1.0	-1.5	19.54	2.0	-3.0	16.54	1.0	-1.5
NPR Test	04/17/1995	C	C	n2	C	C	C	0.47	0.08				27.29	1.5	-1.5	16.79	1.5	-1.5
NPR Test	04/17/1995	C	0.16	n2	C	C	C	0.47	0.08				25.29	1.0	-2.0	18.79	1.5	-1.5
NPR Test	10/10/1996	C	C	n3	C	C	C	0.45	0.08				28.28	1.5	-2.0	15.78	1.5	-2.0
NPR Test	10/10/1996	C	C	C	C	C	C	0.45	0.08				28.28	1.5	-1.5	17.28	1.5	-2.0
NPR Test	10/10/1996	C	C	0.64	C	C	C	0.45	0.08				28.28	1.5	-1.5	10.28	1.5	-2.0
PSTF Test	10/13/1994	n3	0.39	0.21				0.49	0.08	20.8	1.0	-1.5	16.78	2.5	-3.5	14.28	1.0	-2.0
PSTF Test	10/13/1994	C	0.24	0.19				0.49	0.08	20.8	1.5	-1.5	19.28	2.0	-2.5	11.28	1.5	-1.5
PSTF Test	10/13/1994	C	0.37	0.27				0.49	0.08	20.8	1.0	-1.5	19.28	1.5	-2.5	16.78	1.5	-1.5
PSTF Test	10/14/1996	C	0.46	0.33				0.51	0.09	22.3	1.0	-1.5	20.29	2.0	-3.0	19.79	1.0	-1.0
PSTF Test	10/14/1996	0.98	0.37	0.28				0.51	0.09	22.3	1.0	-1.5	20.79	2.0	-2.0	17.79	1.0	-1.5
PSTF Test	10/14/1996	n3	0.37	0.27				0.51	0.09	22.8	1.0	-1.5	20.79	2.0	-2.5	17.79	1.0	-1.5
P&W 2	10/25/1994	n3	0.79	0.54	0.51	n3	C	0.12	0.02									
P&W 2	10/25/1994	n3	0.69	0.53	n3	n3	C	0.12	0.02									
P&W 2	10/25/1994	n3	0.72	0.51	n1	n3	C	0.12	0.02									

Table 3. Fraction of young water calculated using models 2 and 3, and the model-3 age of the young fraction calculated from chlorofluorocarbons, Idaho National Engineering and Environmental Laboratory and vicinity—Continued

Well name	Date sampled	Model 2 Fraction of young water; ratio method						Model 3 Fraction from ^{18}O		Model-3 age								
										CFC-11 age			CFC-12 age			CFC-113 age		
		F11 /F12	F113 /F12	F113 /F11	SF_6 /F11	SF_6 /F12	SF_6 /F113	Frac-tion	Error	Age yrs	$-\sigma$ yrs	$+\sigma$ yrs	Age yrs	$-\sigma$ yrs	$+\sigma$ yrs	Age yrs	$-\sigma$ yrs	$+\sigma$ yrs
P&W 2	04/19/1995	n3	n3	n3	n3	n3	C	0.12	0.02									
P&W 2	04/19/1995	n3	n3	n3	n3	n3	C	0.12	0.02									
P&W 2	04/19/1995	n3	n3	0.72	n1	n3	C	0.12	0.02									
P&W 2	10/15/1996	n3	0.78	0.61	0.70	n3	C	0.07	0.01									
P&W 2	10/15/1996	n3	0.79	0.60	n1	n3	C	0.07	0.01									
P&W 2	10/15/1996	n3	0.68	0.54	n1	n1	C	0.07	0.01									
RWMC M3S	07/22/1996	n3	C	C				0.34	0.06									
RWMC M3S	07/22/1996	n3	C	C				0.34	0.06									
RWMC M3S	07/22/1996	n3	C	C				0.34	0.06									
RWMC M7S	07/22/1996	C	C	C				0.37	0.06									
RWMC M7S	07/22/1996	C	C	C				0.37	0.06									
RWMC M7S	07/22/1996	n3	C	C				0.37	0.06									
Site 4	10/06/1996	C	C	n3	0.88	C	C	0.46	0.08				24.27	1.5	-2.5	14.77	1.5	-2.0
Site 4	10/06/1996	C	C	0.72	n1	C	C	0.46	0.08				24.77	1.5	-2.0	10.27	1.5	-2.0
Site 9	07/21/1994	C	n3	0.18				0.30	0.05	24.1	2.0	-3.5	27.55	2.5	-3.5			
Site 9	07/21/1994	C	n3	0.17				0.30	0.05	24.1	2.0	-3.5	28.05	2.5	-4.0			
Site 9	07/21/1994	C	n3	0.16				0.30	0.05	24.6	2.0	-3.5	28.05	2.5	-4.0			
Site 9	07/21/1994	C	0.06	0.08				0.30	0.05	24.6	2.0	-3.5	27.05	2.5	-4.0	18.05	2.5	-3.5
Site 9	07/22/1996	0.13	n3	0.15				0.34	0.06	27.6	2.0	-2.5	29.06	2.0	-3.0			
Site 9	07/22/1996	C	n3	0.15				0.34	0.06	27.6	2.0	-2.5	30.06	2.0	-3.0			
Site 9	07/22/1996	C	0.08	0.10				0.34	0.06	27.6	1.5	-3.0	29.56	2.0	-3.0	23.56	2.0	-2.5
Site 14	10/13/1994	0.07	0.88	0.04				0.41	0.07	34.3	1.5	-1.5	37.28	1.5	-2.0			
Site 14	10/13/1994	0.19	0.86	0.03				0.41	0.07	36.3	1.5	-1.5	37.78	1.5	-2.5			
Site 14	10/13/1994	0.03	0.82	0.05				0.41	0.07	33.8	1.0	-1.5	37.78	1.5	-2.0			
Site 14	10/14/1996	0.56	n3	n2	C	C	ERR	0.35	0.06	36.3	1.5	-2.0	35.29	2.0	-2.5			
Site 14	10/14/1996	0.07	0.61	n2	C	C	ERR	0.35	0.06	38.3	1.5	-2.5	40.79	2.0	-2.5			
Site 14	10/14/1996	0.88	n3	n2	C	C	ERR	0.35	0.06	37.8	1.5	-2.0	35.29	2.0	-3.0			
Site 17	06/16/1995	n3	C	C	C	N	N	0.27	0.05									
Site 17	06/16/1995	n3	0.44	C	C	C	C	0.27	0.05									
Site 17	06/16/1995	n3	0.49	0.35	C	C	C	0.27	0.05									
Site 19	07/16/1996	C	0.66	1.31				0.30	0.05									
Site 19	07/16/1996	C	0.50	1.09				0.30	0.05									
Site 19	07/16/1996	C	0.58	1.15				0.30	0.05									
TAN Exploration	10/13/1994	n3	n3	0.02						42.3	0.0	0.0	42.78	0.0	0.0			
TAN Exploration	10/13/1994	n3	n3	0.02						40.8	0.0	0.0	39.28	0.0	0.0			
TAN Exploration	10/13/1994	n3	n3	0.02						41.3	0.0	0.0	39.28	0.0	0.0			
TAN Exploration	10/14/1996	0.52	0.89	0.02			ERR			44.3	0.0	0.0	47.29	0.0	0.0			
TAN Exploration	10/14/1996	n3	n3	0.03			ERR			41.8	0.0	0.0	40.79	0.0	0.0			
TAN Exploration	10/14/1996	n3	n3	0.04			ERR			41.3	0.0	0.0	39.79	0.0	0.0			

Table 3. Fraction of young water calculated using models 2 and 3, and the model-3 age of the young fraction calculated from chlorofluorocarbons, Idaho National Engineering and Environmental Laboratory and vicinity—Continued

Well name	Date sampled	Model 2 Fraction of young water; ratio method						Model 3 Fraction from ^{18}O		Model-3 age								
										CFC-11 age			CFC-12 age			CFC-113 age		
		F11 /F12	F113 /F12	F113 /F11	SF_6 /F11	SF_6 /F12	SF_6 /F113	Fraction	Error	Age yrs	$-\sigma$ yrs	$+\sigma$ yrs	Age yrs	$-\sigma$ yrs	$+\sigma$ yrs	Age yrs	$-\sigma$ yrs	$+\sigma$ yrs
USGS 1	10/03/1994	0.76	0.19	0.12				0.43	0.07	23.8	1.5	-1.5	22.76	2.0	-2.0	17.76	1.0	-2.0
USGS 1	10/03/1994	1.14	0.16	0.11				0.43	0.07	23.8	1.5	-1.5	22.26	1.5	-2.5	14.76	1.5	-2.0
USGS 1	10/03/1994	1.03	n3	0.20				0.43	0.07	24.3	1.0	-2.0	22.26	2.0	-2.0	23.26	1.5	-1.5
USGS 1	10/09/1996	0.80	0.22	0.15	C	C	C	0.42	0.07	24.8	1.5	-2.0	23.27	2.0	-2.5	18.77	1.5	-2.0
USGS 1	10/09/1996	0.81	0.29	0.20	C	C	C	0.42	0.07	24.8	1.5	-2.0	23.27	2.0	-2.5	21.77	1.5	-2.0
USGS 1	10/09/1996	0.82	C	C	C	C	C	0.42	0.07	24.3	1.5	-2.0	23.27	2.0	-3.0	13.27	1.5	-2.0
USGS 2	07/19/1994	0.95	0.48	0.34				0.52	0.09	20.5	1.0	-1.5	19.05	1.5	-2.0	18.55	1.5	-1.0
USGS 2	07/19/1994	0.97	0.39	0.30				0.52	0.09	20.0	1.5	-1.5	19.05	1.5	-2.5	16.55	1.0	-1.0
USGS 2	07/19/1994	n3	0.32	0.23				0.52	0.09	20.5	1.0	-1.5	18.55	2.0	-2.0	14.05	1.0	-1.5
USGS 2	07/17/1996	0.90	0.46	0.38				0.48	0.08	19.5	1.5	-4.0	17.04	3.0	-4.0	17.04	1.0	-2.0
USGS 2	07/17/1996	0.77	0.41	0.34				0.48	0.08	19.5	2.0	-3.5	18.04	2.5	-4.0	16.04	1.5	-1.5
USGS 2	07/17/1996	0.90	0.49	0.40				0.48	0.08	20.0	1.5	-3.0	18.54	2.0	-4.5	18.54	1.5	-1.5
USGS 4	10/24/1994	n3	n3	n3	0.60	n3	C			23.3	0.0	0.0	20.81	0.0	0.0	25.81	0.0	0.0
USGS 4	10/24/1994	n3	n3	n3	n1	n3	C			15.8	0.0	0.0	9.31	0.0	0.0	14.81	0.0	0.0
USGS 4	10/24/1994	n3	n3	n3	n1	n3	C			16.8	0.0	0.0	9.81	0.0	0.0	20.31	0.0	0.0
USGS 4	04/19/1995	n3	n3	n3	0.97	n3	C			23.3	0.0	0.0	20.30	0.0	0.0	21.30	0.0	0.0
USGS 4	04/19/1995	n3	n3	n3	n3	n3	C			17.3	0.0	0.0	8.30	0.0	0.0	17.80	0.0	0.0
USGS 4	04/19/1995	n3	n3	0.82	n3	n3	C			17.3	0.0	0.0	8.30	0.0	0.0	14.80	0.0	0.0
USGS 4	10/15/1996	n3	n3	n3	n3	n3	C			24.8	0.0	0.0	23.79	0.0	0.0	24.79	0.0	0.0
USGS 4	10/15/1996	n3	n3	n3	n3	n3	C			16.3	0.0	0.0	9.29	0.0	0.0	16.29	0.0	0.0
USGS 4	10/15/1996	n3	n3	n3	n3	n3	C			18.8	0.0	0.0	13.29	0.0	0.0	17.79	0.0	0.0
USGS 5	10/12/1994	n3	0.29	0.17				0.47	0.08	21.3	1.0	-2.0	17.28	2.5	-4.0	11.28	1.5	-1.5
USGS 5	10/12/1994	n3	C	C				0.47	0.08	21.3	1.5	-1.5	19.28	2.0	-3.0	10.28	1.5	-1.5
USGS 5	10/12/1994	n3	0.35	0.20				0.47	0.08	21.3	1.5	-1.5	17.78	2.5	-4.0	15.28	1.0	-2.0
USGS 5	10/10/1996	n3	0.19	0.11	C	C	C	0.42	0.07	25.3	1.5	-2.0	23.28	2.0	-3.0	16.78	1.5	-2.0
USGS 5	10/10/1996	n3	0.22	0.13	C	C	C	0.42	0.07	25.3	1.5	-1.5	23.78	2.0	-2.5	19.28	1.5	-2.0
USGS 5	10/10/1996	n3	0.22	0.13	C	C	C	0.42	0.07	24.3	1.5	-1.5	22.28	2.0	-3.5	15.78	2.0	-2.0
USGS 6	07/19/1994	ERR	ERR	ERR				0.55	0.09									
USGS 6	07/19/1994	ERR	ERR	ERR				0.55	0.09									
USGS 6	07/19/1994	ERR	ERR	ERR				0.55	0.09									
USGS 6	07/18/1996	ERR	ERR	ERR				0.52	0.09									
USGS 6	07/18/1996	ERR	ERR	ERR				0.52	0.09									
USGS 6	07/18/1996	ERR	ERR	ERR				0.52	0.09									
USGS 7	10/14/1994	ERR	ERR	ERR				0.52	0.09							24.79	1.0	-1.0
USGS 7	10/14/1994	ERR	ERR	ERR				0.52	0.09									
USGS 7	10/14/1996	0.33	0.31	n2	C	C	ERR	0.36	0.06	45.3	1.0	-0.5	45.29	1.5	-2.0			
USGS 7	10/14/1996	ERR	ERR	n2	C	ERR	ERR	0.36	0.06	44.3	0.5	-1.0						
USGS 7	10/14/1996	ERR	ERR	n2	C	ERR	ERR	0.36	0.06	45.8	0.5	-0.5						
USGS 8	10/04/1994	n3	0.70	0.12				0.44	0.07	23.3	1.5	-1.5	9.26	4.0	-6.0	15.26	1.5	-2.0
USGS 8	10/04/1994	n3	C	C				0.44	0.07	24.3	1.0	-2.0	10.26	3.5	-6.0			
USGS 8	10/04/1994	n3	n3	0.15				0.44	0.07	23.8	1.5	-2.0	9.26	4.5	-6.0	18.76	1.5	-1.5

Table 3. Fraction of young water calculated using models 2 and 3, and the model-3 age of the young fraction calculated from chlorofluorocarbons, Idaho National Engineering and Environmental Laboratory and vicinity—Continued

Well name	Date sampled	Model 2 Fraction of young water; ratio method						Model 3 Fraction from ^{18}O		Model-3 age								
										CFC-11 age			CFC-12 age			CFC-113 age		
		F11 /F12	F113 /F12	F113 /F11	SF_6 /F11	SF_6 /F12	SF_6 /F113	Fraction	Error	Age yrs	$-\sigma$ yrs	$+\sigma$ yrs	Age yrs	$-\sigma$ yrs	$+\sigma$ yrs	Age yrs	$-\sigma$ yrs	$+\sigma$ yrs
USGS 8	10/08/1996	n3	n3	0.22				0.44	0.07	24.8	1.5	-2.0	8.27	4.0	-8.3	22.77	1.5	-1.5
USGS 8	10/08/1996	n3	n3	0.21				0.44	0.07	24.8	1.5	-2.0	8.27	4.0	-8.3	22.27	1.5	-1.5
USGS 8	10/08/1996	n3	0.69	C				0.44	0.07	24.8	1.5	-2.0	8.77	4.0	-8.8	14.77	1.5	-2.0
USGS 9	10/04/1994	n3	0.80	C				0.38	0.06									
USGS 9	10/04/1994	n3	0.61	C				0.38	0.06	10.8	5.0	-10.8						
USGS 9	10/04/1994	n3	0.72	C				0.38	0.06	10.8	5.0	-10.8						
USGS 9	10/04/1994	n3	0.77	C				0.38	0.06	10.3	5.0	-10.3						
USGS 9	04/20/1995	n3	0.87	C	0.29	n3	C	0.42	0.07	13.3	4.0	-5.5				1.30	5.0	-1.3
USGS 9	04/20/1995	n3	0.77	C	0.29	n3	C	0.42	0.07	13.3	4.0	-5.5						
USGS 9	04/20/1995	n3	0.74	C	n1	n1	C	0.42	0.07	13.8	4.5	-5.5				6.30	2.0	-6.3
USGS 9	04/20/1995	n3	0.70	C	n1	n1	C	0.42	0.07	13.8	4.0	-5.5						
USGS 9	10/11/1996	n3	n3	0.77	n3	n3	C	0.46	0.08									
USGS 9	10/11/1996	n3	0.64	C	n1	n1	C	0.46	0.08	13.8	4.0	-4.5				7.28	1.5	-7.3
USGS 9	10/11/1996	n3	C	C	n1	n1	C	0.46	0.08	14.3	4.0	-4.5						
USGS 11	04/20/1995	n3	0.38	C	N	n1	C	0.34	0.06	18.8	2.5	-7.5	-1.70	11.0	1.7			
USGS 11	04/20/1995	n3	0.41	C	N	n1	C	0.34	0.06	18.8	2.5	-8.0				4.80	3.0	-4.8
USGS 11	04/20/1995	n3	C	C	N	n1	C	0.34	0.06	18.8	2.5	-7.5	-1.70	10.5	1.7			
USGS 11	10/09/1996	n3	C	C	C	n1	C	0.37	0.06	20.8	2.0	-6.0						
USGS 11	10/09/1996	n3	C	C	C	n1	C	0.37	0.06	20.8	2.5	-6.0						
USGS 11	10/09/1996	n3	C	C	C	n1	C	0.37	0.06	21.3	2.0	-6.0						
USGS 12	10/27/1994	0.83	0.60	0.56	N	N	C	0.62	0.10	17.8	1.0	-2.5	16.82	1.5	-2.5	16.82	0.5	-1.0
USGS 12	10/27/1994	0.97	0.56	0.47	N	N	C	0.62	0.10	17.3	1.5	-2.0	15.82	1.5	-2.5	14.32	1.0	-0.5
USGS 12	10/27/1994	0.63	0.44	0.46	N	N	C	0.62	0.10	16.8	1.5	-2.0	17.32	1.5	-2.0	13.32	1.0	-1.0
USGS 12	06/14/1995	0.93	0.74	0.65	0.83	n1	C	0.60	0.10	17.0	2.0	-2.5	15.45	2.5	-2.0	17.95	0.5	-1.0
USGS 12	06/14/1995	0.68	0.61	0.61	0.83	n1	C	0.60	0.10	17.0	1.5	-2.5	16.95	1.5	-3.0	17.45	0.5	-1.0
USGS 14	10/26/1994	n3	n3	0.36	C	n1	C	0.60	0.10	17.3	1.5	-2.0				11.32	0.5	-1.0
USGS 14	10/26/1994	n3	n3	0.33	C	n1	C	0.60	0.10	16.8	1.5	-2.0				9.32	1.0	-1.0
USGS 14	10/26/1994	n3	n3	0.38	C	n1	C	0.60	0.10	16.8	1.5	-2.0				11.32	1.0	-1.0
USGS 14	10/09/1996	n3	n3	0.37	C	n3	C	0.53	0.09	14.3	3.0	-3.0				9.27	1.0	-1.5
USGS 14	10/09/1996	n3	n3	0.41	C	n1	C	0.53	0.09	14.3	3.0	-3.0				11.77	1.0	-1.5
USGS 14	10/09/1996	n3	n3	C	C	n1	C	0.53	0.09	15.8	3.0	-3.5				8.77	1.0	-2.0
USGS 15	06/14/1995	0.26	0.02	C	C	C	C	0.07	0.01	25.5	7.0	ERR	22.95	9.0	ERR	13.95	9.0	ERR
USGS 15	06/14/1995	0.68	n3	n2	C	C	ERR	0.07	0.01	26.0	7.0	ERR	20.45	10.0	ERR			
USGS 15	06/14/1995	0.29	n3	n2	C	C	ERR	0.07	0.01	26.0	7.0	ERR	22.95	9.5	ERR			
USGS 17	10/27/1994	0.13	0.09	n2	n1	n1	C	0.54	0.09	28.3	1.0	-1.0	30.32	1.0	-1.0	24.32	1.0	-1.0
USGS 17	10/27/1994	0.19	0.14	n2	n1	n1	C	0.54	0.09	28.8	0.5	-1.0	30.32	1.0	-1.0	28.32	0.5	-1.5
USGS 17	06/13/1995	0.44	n3	0.18				0.57	0.10	28.9	0.5	-1.0	29.45	0.5	-1.0	32.95	1.0	-1.0
USGS 17	06/13/1995	0.16	n3	ERR			ERR	0.57	0.10	28.9	0.5	-1.0	30.95	0.5	-1.0			
USGS 17	06/13/1995	C	0.07	0.08				0.57	0.10	28.9	1.0	-0.5	31.95	1.0	-1.0	23.45	1.0	-1.0
USGS 18	07/18/1994	0.20	n3	0.06						37.0	0.0	0.0	39.55	0.0	0.0			
USGS 18	07/18/1994	n3	n3	0.06						37.0	0.0	0.0	36.05	0.0	0.0			
USGS 18	07/18/1994	0.62	n3	0.06						37.5	0.0	0.0	38.05	0.0	0.0			

Table 3. Fraction of young water calculated using models 2 and 3, and the model-3 age of the young fraction calculated from chlorofluorocarbons, Idaho National Engineering and Environmental Laboratory and vicinity—Continued

Well name	Date sampled	Model 2 Fraction of young water; ratio method						Model 3 Fraction from ^{18}O		Model-3 age								
										CFC-11 age			CFC-12 age			CFC-113 age		
		F11 /F12	F113 /F12	F113 /F11	SF_6 /F11	SF_6 /F12	SF_6 /F113	Frac-tion	Error	Age yrs	-σ yrs	+σ yrs	Age yrs	-σ yrs	+σ yrs	Age yrs	-σ yrs	+σ yrs
USGS 18	07/19/1996	n3	n3	n2			ERR	0.27	0.04	30.6	2.0	-4.0	27.55	2.5	-5.5			
USGS 18	07/19/1996	0.33	C	C				0.27	0.04	30.6	2.5	-3.5	30.05	3.0	-4.5	20.55	2.5	-5.0
USGS 18	07/19/1996	0.44	C	n2			ERR	0.27	0.04	28.6	2.0	-4.5	27.55	3.0	-5.5			
USGS 19	10/25/1994	n3	C	C	C	C	C	0.26	0.04									
USGS 19	10/25/1994	n3	0.52	C	C	C	C	0.26	0.04									
USGS 19	10/25/1994	n3	0.95	n2	C	C	C	0.26	0.04									
USGS 19	04/19/1995	n3	0.51	C	C	C	C	0.28	0.05									
USGS 19	04/19/1995	n3	n3	n2	C	C	C	0.28	0.05							11.80	3.0	-4.5
USGS 19	04/19/1995	n3	0.53	n2	C	C	C	0.28	0.05									
USGS 19	04/19/1995	n3	n3	n2	C	C	C	0.28	0.05							18.30	2.5	-4.5
USGS 19	10/15/1996	n3	0.59	n2	C	C	C	0.29	0.05									
USGS 19	10/15/1996	n3	0.50	C	C	C	C	0.29	0.05									
USGS 19	10/15/1996	n3	0.41	C	C	C	C	0.29	0.05	7.3								
USGS 22	06/13/1995	n3	C	C	0.06	n1	C	0.55	0.09	30.4	0.5	-1.0	24.95	1.0	-1.5	12.45	1.0	-1.0
USGS 22	06/13/1995	n3	0.15	C	0.07	n1	C	0.55	0.09	29.9	0.5	-1.0	25.45	1.0	-1.5	16.95	0.5	-1.5
USGS 22	06/13/1995	n3	C	C	n1	n1	C	0.55	0.09	28.9	0.5	-1.0	25.45	1.0	-1.5	14.95	1.0	-1.0
USGS 22	07/18/1996	n3	0.54	n2	C	C	C	0.52	0.09	18.5	2.0	-3.5	11.05	3.0	-4.0	11.05	1.5	-1.0
USGS 22	07/18/1996	n3	0.51	n2	C	C	C	0.52	0.09	18.5	1.5	-3.5	10.55	3.5	-3.5	10.55	1.5	-1.0
USGS 22	07/18/1996	n3	0.49	n2	C	C	C	0.52	0.09	20.0	1.5	-3.0	11.55	3.5	-3.0	11.05	1.0	-1.0
USGS 23	10/25/1994	n3	0.53	n2	C	C	C	0.36	0.06							3.82	0.0	0.0
USGS 23	10/25/1994	n3	0.53	n2	C	C	C			21.3	0.0	0.0	19.82	0.0	0.0	13.32	0.0	0.0
USGS 23	10/25/1994	n3	0.52	n2	C	C	C			21.8	0.0	0.0	20.32	0.0	0.0	13.82	0.0	0.0
USGS 23	04/19/1995	n3	0.61	n2	C	C	C			6.3	0.0	0.0				7.30	0.0	0.0
USGS 23	04/19/1995	n3	0.58	C	C	C	C			33.8	0.0	0.0	19.80	0.0	0.0	14.80	0.0	0.0
USGS 23	04/19/1995	n3	0.62	C	C	C	C			29.3	0.0	0.0	19.30	0.0	0.0	14.30	0.0	0.0
USGS 23	10/15/1996	n3	0.54	n2	C	C	C											
USGS 23	10/15/1996	n3	0.63	n2	C	C	C			22.3	0.0	0.0	20.79	0.0	0.0	15.79	0.0	0.0
USGS 23	10/15/1996	n3	0.54	n2	C	C	C			22.8	0.0	0.0	21.29	0.0	0.0	14.79	0.0	0.0
USGS 26	10/14/1994	0.56	0.20	0.15						21.8	0.0	0.0	20.79	0.0	0.0	14.79	0.0	0.0
USGS 26	10/14/1994	n3	C	C						47.3	0.0	0.0	30.79	0.0	0.0	18.79	0.0	0.0
USGS 26	10/14/1994	0.61	0.23	0.18						27.8	0.0	0.0	28.29	0.0	0.0	23.29	0.0	0.0
USGS 26	10/15/1996	n3	0.24	n2	C	C	C			24.3	0.0	0.0	22.29	0.0	0.0	17.79	0.0	0.0
USGS 26	10/15/1996	0.68	0.22	n2	C	C	C			29.3	0.0	0.0	30.29	0.0	0.0	23.79	0.0	0.0
USGS 26	10/15/1996	0.67	C	C	C	C	C			29.8	0.0	0.0	30.29	0.0	0.0	17.29	0.0	0.0
USGS 27	10/11/1994	0.55	0.11	0.07						32.8	0.0	0.0	33.78	0.0	0.0	28.28	0.0	0.0
USGS 27	10/11/1994	0.92	0.10	C						33.8	0.0	0.0	33.78	0.0	0.0	25.78	0.0	0.0
USGS 27	10/11/1994	0.52	n3	0.14						32.8	0.0	0.0	33.78	0.0	0.0			
USGS 27	10/15/1996	0.71	0.26	0.10	C	C	C			30.8	0.0	0.0	29.79	0.0	0.0	29.29	0.0	0.0
USGS 27	10/15/1996	0.60	n3	0.15	C	C	ERR			34.3	0.0	0.0	35.29	0.0	0.0			
USGS 27	10/15/1996	0.20	n3	0.14	C	C	ERR			34.3	0.0	0.0	37.29	0.0	0.0			
USGS 29	10/11/1994	0.80	0.38	0.34						17.8	0.0	0.0	16.78	0.0	0.0	13.28	0.0	0.0
USGS 29	10/11/1994	0.67	0.34	0.30						23.8	0.0	0.0	24.78	0.0	0.0	17.78	0.0	0.0
USGS 29	10/11/1994	0.79	0.47	0.40						23.8	0.0	0.0	24.28	0.0	0.0	21.28	0.0	0.0

Table 3. Fraction of young water calculated using models 2 and 3, and the model-3 age of the young fraction calculated from chlorofluorocarbons, Idaho National Engineering and Environmental Laboratory and vicinity—Continued

Well name	Date sampled	Model 2 Fraction of young water; ratio method						Model 3 Fraction from ^{18}O		Model-3 age								
										CFC-11 age			CFC-12 age			CFC-113 age		
		F11 /F12	F113 /F12	F113 /F11	SF_6 /F11	SF_6 /F12	SF_6 /F113	Fraction	Error	Age yrs	-σ yrs	+σ yrs	Age yrs	-σ yrs	+σ yrs	Age yrs	-σ yrs	+σ yrs
USGS 29	06/15/1995	0.70	0.59	0.52	0.34	n1	C			18.5	0.0	0.0	17.96	0.0	0.0	18.46	0.0	0.0
USGS 29	06/15/1995	0.63	0.47	0.42	0.34	n1	C			24.0	0.0	0.0	24.46	0.0	0.0	20.96	0.0	0.0
USGS 29	06/15/1995	0.92	0.50	0.42	n1	n1	C			24.0	0.0	0.0	23.96	0.0	0.0	20.46	0.0	0.0
USGS 29	07/19/1996	n3	0.48	n2	C	C	C			17.1	0.0	0.0	14.05	0.0	0.0	13.55	0.0	0.0
USGS 29	07/19/1996	n3	0.60	n2	C	C	C			24.6	0.0	0.0	23.55	0.0	0.0	21.05	0.0	0.0
USGS 29	07/19/1996	n3	0.61	n2	C	C	C			22.1	0.0	0.0	21.55	0.0	0.0	17.55	0.0	0.0
USGS 31	10/11/1994	0.54	n3	0.12						30.3	0.0	0.0	30.28	0.0	0.0			
USGS 31	10/11/1994	0.55	n3	0.12						33.3	0.0	0.0	34.28	0.0	0.0			
USGS 31	10/11/1994	0.44	n3	0.13						32.8	0.0	0.0	34.78	0.0	0.0			
USGS 31	06/15/1995	0.56	0.17	0.09	C	C	C			29.0	0.0	0.0	28.46	0.0	0.0	26.96	0.0	0.0
USGS 31	06/15/1995	0.46	0.13	0.08	C	C	C			33.5	0.0	0.0	34.96	0.0	0.0	31.96	0.0	0.0
USGS 31	06/15/1995	0.36	0.10	n2	C	C	C			33.5	0.0	0.0	35.46	0.0	0.0	29.96	0.0	0.0
USGS 31	07/19/1996	0.48	n3	n2	C	C	ERR			29.1	0.0	0.0	29.05	0.0	0.0			
USGS 31	07/19/1996	0.34	C	C	C	C	C			29.1	0.0	0.0	29.05	0.0	0.0	16.55	0.0	0.0
USGS 31	07/19/1996	0.65	n3	0.15	C	C	ERR			34.1	0.0	0.0	35.05	0.0	0.0			
USGS 32	10/11/1994	n3	0.25	C						25.3	0.0	0.0	20.78	0.0	0.0	15.78	0.0	0.0
USGS 32	10/11/1994	n3	0.30	n2						29.8	0.0	0.0	27.78	0.0	0.0	24.78	0.0	0.0
USGS 32	10/11/1994	n3	0.31	n2						29.3	0.0	0.0	27.78	0.0	0.0	25.28	0.0	0.0
USGS 32	06/15/1995	n3	0.28	0.11	n2	n1	C			26.0	0.0	0.0	22.46	0.0	0.0	18.96	0.0	0.0
USGS 32	06/15/1995	n3	0.25	n2	n1	n1	C			30.5	0.0	0.0	28.96	0.0	0.0	24.46	0.0	0.0
USGS 32	06/15/1995	n3	0.33	0.13	n1	n1	C			30.5	0.0	0.0	28.46	0.0	0.0	26.46	0.0	0.0
USGS 32	07/19/1996	n3	n3	n2	C	C	ERR			26.6	0.0	0.0	23.55	0.0	0.0			
USGS 32	07/19/1996	n3	n3	n2	C	C	ERR			31.1	0.0	0.0	30.05	0.0	0.0			
USGS 32	07/19/1996	n3	0.31	n2	C	C	C			30.6	0.0	0.0	29.05	0.0	0.0	25.55	0.0	0.0
USGS 36	07/16/1996	n3	n3	C				0.44	0.07									
USGS 36	07/16/1996	n3	n3	C				0.44	0.07									
USGS 36	07/16/1996	n3	n3	C				0.44	0.07									
USGS 37	10/07/1994	n3	n3	C				0.55	0.09									
USGS 37	10/07/1994	n3	n3	C				0.55	0.09									
USGS 37	10/07/1994	n3	n3	C				0.55	0.09									
USGS 65	10/12/1994	n3	n3	C				0.96	0.16									
USGS 65	10/12/1994	n3	n3	C				0.96	0.16									
USGS 65	10/12/1994	n3	n3	C				0.96	0.16									
USGS 65	10/12/1994	n3	n3	C				0.96	0.16									
USGS 76	10/12/1994	n3	n3	n3				0.33	0.05									
USGS 76	10/12/1994	n3	n3	n3				0.33	0.05									
USGS 76	10/12/1994	n3	n3	n3				0.33	0.05									
USGS 77	10/07/1994	n3	ERR	ERR				0.33	0.05							ERR	ERR	ERR
USGS 77	10/07/1994	n3	n3	C				0.33	0.05									
USGS 77	10/07/1994	n3	ERR	ERR				0.33	0.05							ERR	ERR	ERR
USGS 82	07/16/1996	n3	n3	0.08				0.38	0.06	27.0	1.5	-2.0				20.04	2.0	-2.0
USGS 82	07/16/1996	n3	n3	0.12				0.38	0.06	27.0	1.5	-2.5				24.54	1.5	-2.5
USGS 82	07/16/1996	n3	n3	0.11				0.38	0.06	27.0	1.5	-2.5				22.54	1.5	-2.5

Table 3. Fraction of young water calculated using models 2 and 3, and the model-3 age of the young fraction calculated from chlorofluorocarbons, Idaho National Engineering and Environmental Laboratory and vicinity—Continued

Well name	Date sampled	Model 2 Fraction of young water; ratio method						Model 3 Fraction from ^{18}O		Model-3 age								
										CFC-11 age			CFC-12 age			CFC-113 age		
		F11 /F12	F113 /F12	F113 /F11	SF_6 /F11	SF_6 /F12	SF_6 /F113	Fraction	Error	Age yrs	$-\sigma$ yrs	$+\sigma$ yrs	Age yrs	$-\sigma$ yrs	$+\sigma$ yrs	Age yrs	$-\sigma$ yrs	$+\sigma$ yrs
USGS 83	04/17/1995	0.11	0.63	0.02	C	C	ERR	0.25	0.04	34.8	2.5	-3.5	36.79	3.0	-5.0			
USGS 83	04/17/1995	0.63	n3	0.03	C	C	ERR	0.25	0.04	34.3	2.0	-4.0	32.29	3.0	-5.0			
USGS 83	04/17/1995	0.15	C	C	C	C	C	0.25	0.04	33.8	2.0	-3.5	34.79	3.0	-5.0	19.79	3.0	-5.0
USGS 86	10/04/1994	0.20	C	0.06				0.29	0.05	25.3	2.0	-3.5	25.76	2.5	-4.5	16.26	2.5	-4.5
USGS 86	10/04/1994	0.45	C	C				0.29	0.05	24.3	2.0	-4.0	23.26	3.0	-5.5	10.76	3.0	-4.0
USGS 86	10/04/1994	0.42	0.12	0.09				0.29	0.05	22.8	2.5	-4.0	22.26	3.0	-6.5	15.76	2.5	-4.0
USGS 86	10/11/1996	n3	n3	0.89	n3	n3	C	0.26	0.04									
USGS 86	10/11/1996	0.58	C	C	n1	n1	C	0.26	0.04	13.8	7.0	-13.8	11.28	8.0	-11.3			
USGS 86	10/11/1996	0.62	0.19	0.12	C	C	C	0.26	0.04	24.3	2.5	-7.5	22.28	4.0	-11.0	20.78	3.0	-5.0
USGS 89	10/07/1994	n3	n3	C				0.14	0.02	13.3	8.5	-13.3						
USGS 89	10/07/1994	n3	n3	C				0.14	0.02	13.3	8.5	-13.3						
USGS 89	10/07/1994	n3	n3	C				0.14	0.02	16.3	6.5	-16.3						
USGS 89	07/17/1996	n3	n3	C				0.15	0.02									
USGS 89	07/17/1996	n3	n3	C				0.15	0.02	7.5	13.0	-7.5						
USGS 89	07/17/1996	n3	n3	C				0.15	0.02	8.5	12.5	-8.5						
USGS 97	06/13/1995	C	C	n3	16.12	n3	N	0.56	0.09				9.95	3.0	-3.0			
USGS 97	06/13/1995	C	C	n3	15.01	n3	N	0.56	0.09				10.45	3.0	-2.5			
USGS 97	06/13/1995	C	C	n3	n3	n3	N	0.56	0.09				10.95	2.5	-3.0			
USGS 98	06/12/1995	C	C	0.74	1.76	n1	N	0.29	0.05				7.45	7.0	-7.4			
USGS 98	06/12/1995	C	0.51	1.93	1.93	n1	C	0.29	0.05				7.45	7.0	-7.4	14.45	2.5	-4.0
USGS 98	06/12/1995	C	0.30	n3	n3	n1	C	0.29	0.05				5.45	7.5	-5.4	5.95	3.0	-5.9
USGS 99	06/12/1995	C	C	n3	n3	n3	C	0.33	0.06									
USGS 99	06/12/1995	C	C	n3	n3	n3	N	0.33	0.06									
USGS 99	06/12/1995	C	C	n3	n3	n3	C	0.33	0.06									
USGS 99	06/12/1995	C	C	n3	n3	n3	C	0.33	0.06									
USGS 100	04/21/1995	0.70	0.39	0.36	C	C	C	0.44	0.07	16.3	3.0	-5.0	14.30	4.0	-4.5	13.80	1.5	-2.0
USGS 100	04/21/1995	0.77	0.32	0.26	C	C	C	0.44	0.07	17.3	2.5	-5.0	15.30	3.5	-5.0	11.30	1.5	-2.0
USGS 100	04/21/1995	0.51	0.35	n2	C	C	C	0.44	0.07	15.8	3.5	-5.0	15.80	3.5	-5.0	13.30	1.5	-2.0
USGS 100	10/10/1996	0.55	0.38	0.38	n2	n1	C	0.48	0.08	17.8	2.5	-4.0	17.78	3.0	-4.0	15.28	1.0	-2.0
USGS 100	10/10/1996	0.62	0.39	0.36	n1	n1	C	0.48	0.08	18.8	2.0	-4.5	17.28	3.0	-3.5	15.28	1.0	-2.0
USGS 100	10/10/1996	0.56	0.28	0.27	n1	n1	C	0.48	0.08	18.8	2.5	-3.5	18.78	2.5	-4.0	11.78	1.5	-1.5
USGS 101	04/21/1995	0.90	0.18	0.10	C	C	C	0.38	0.06	26.8	1.5	-2.5	24.80	2.0	-2.5	22.30	1.5	-2.5
USGS 101	04/21/1995	0.60	n3	0.17	C	C	ERR	0.38	0.06	26.3	1.5	-2.0	25.80	1.5	-3.0			
USGS 101	04/21/1995	C	0.40	0.17	C	C	ERR	0.38	0.06	26.3	1.5	-2.0	42.80	1.5	-2.0			
USGS 101	10/10/1996	0.58	0.17	0.11	C	C	C	0.41	0.07	27.8	1.5	-1.5	27.28	2.0	-2.5	24.78	1.5	-2.0
USGS 101	10/10/1996	0.82	0.16	0.09	C	C	C	0.41	0.07	28.3	1.5	-1.5	27.28	1.5	-2.5	22.78	1.5	-2.0
USGS 101	10/10/1996	0.64	0.19	0.12	C	C	C	0.41	0.07	27.8	1.5	-2.0	27.28	1.5	-2.5	25.28	1.5	-2.0
USGS 102	06/13/1995	C	C	n3	21.43	n3	n3	0.59	0.10				10.45	2.5	-2.5			
USGS 102	06/13/1995	C	C	n3	20.05	n3	n3	0.59	0.10				7.45	2.5	-4.5			
USGS 102	06/13/1995	n3	n3	n3	n3	n3	n3	0.59	0.10									

Table 3. Fraction of young water calculated using models 2 and 3, and the model-3 age of the young fraction calculated from chlorofluorocarbons, Idaho National Engineering and Environmental Laboratory and vicinity—Continued

Well name	Date sampled	Model 2 Fraction of young water; ratio method						Model 3 Fraction from ^{18}O		Model-3 age								
										CFC-11 age			CFC-12 age			CFC-113 age		
		F11 /F12	F113 /F12	F113 /F11	SF_6 /F11	SF_6 /F12	SF_6 /F113	Frac-tion	Error	Age yrs	$-\sigma$ yrs	$+\sigma$ yrs	Age yrs	$-\sigma$ yrs	$+\sigma$ yrs	Age yrs	$-\sigma$ yrs	$+\sigma$ yrs
USGS 103	07/20/1994	n3	n3	0.33				0.41	0.07	17.6	2.0	-5.5	-2.45	9.5	2.4	15.55	1.5	-2.0
USGS 103	07/20/1994	n3	0.88	C				0.41	0.07	34.1	1.5	-1.5	-2.45	9.5	2.4	12.05	2.0	-2.0
USGS 103	07/20/1994	n3	n3	0.32				0.41	0.07	17.6	2.0	-5.5				15.05	1.5	-2.5
USGS 103	04/18/1995	n3	n3	0.33	N	n1	C	0.47	0.08	19.8	1.5	-2.5	3.80	5.0	-3.8	17.80	1.0	-1.5
USGS 103	04/18/1995	n3	0.79	n2	N	n1	C	0.47	0.08	19.8	1.5	-2.5	3.80	5.0	-3.8	12.30	1.5	-1.5
USGS 103	04/18/1995	n3	n3	n2	N	n1	C	0.47	0.08	19.8	1.5	-3.0	3.80	4.5	-3.8	17.30	1.0	-2.0
USGS 103	07/15/1996	n3	0.91	n2				0.43	0.07	7.5	4.0	-7.5						
USGS 103	07/15/1996	n3	0.82	n2				0.43	0.07	9.0	3.5	-9.0				7.04	2.0	-7.0
USGS 103	07/15/1996	n3	0.89	n2				0.43	0.07	9.5	4.5	-9.5				8.54	1.5	-8.5
USGS 104	07/20/1994	n3	n3	C				0.33	0.05	16.1	3.5	-9.0						
USGS 104	07/20/1994	n3	n3	C				0.33	0.05	16.1	3.5	-9.0						
USGS 104	07/20/1994	n3	n3	C				0.33	0.05	16.1	3.5	-9.0						
USGS 104	04/18/1995	n3	n3	C	C	n3	C	0.27	0.04	17.3	4.0	-17.3						
USGS 104	04/18/1995	n3	n3	n2	C	n3	C	0.27	0.04									
USGS 104	04/18/1995	n3	n3	n1	C	C	C	0.27	0.04	38.8	1.5	-3.5	-0.20	12.0	0.2	33.80	2.5	-4.0
USGS 104	07/15/1996	n3	n3	C				0.28	0.05	15.5	5.5	-15.5						
USGS 104	07/15/1996	n3	n3	C				0.28	0.05	16.0	5.5	-16.0						
USGS 104	07/15/1996	n3	n3	C				0.28	0.05	17.0	4.5	-17.0						
USGS 105	10/03/1994	n3	C	C				0.41	0.07									
USGS 105	10/03/1994	n3	C	C				0.41	0.07									
USGS 105	10/03/1994	n3	C	C				0.41	0.07									
USGS 105	04/18/1995	n3	C	C	n3	n3	n3	0.41	0.07									
USGS 105	04/18/1995	n3	C	C	n1	n3	n3	0.41	0.07									
USGS 105	04/18/1995	n3	C	C	n1	n3	n3	0.41	0.07									
USGS 106	10/05/1994	n3	n3	0.66				0.33	0.06									
USGS 106	10/05/1994	n3	n3	0.64				0.33	0.06									
USGS 106	10/05/1994	n3	n3	0.56				0.33	0.06									
USGS 107	10/05/1994	n3	0.48	0.21				0.53	0.09	20.8	1.0	-1.5	13.76	3.0	-3.5	12.76	1.0	-1.5
USGS 107	10/05/1994	n3	0.49	0.20				0.53	0.09	21.3	1.0	-1.5	13.76	3.0	-3.0	13.26	1.5	-1.0
USGS 107	10/05/1994	n3	0.39	0.16				0.53	0.09	23.3	1.0	-1.0	19.26	1.5	-2.0	16.26	1.0	-1.0
USGS 107	10/09/1996	n3	0.61	0.24	C	C	C	0.56	0.09	22.8	1.0	-1.0	14.77	2.5	-3.0	15.77	1.0	-1.0
USGS 107	10/09/1996	n3	0.63	0.24	C	C	C	0.56	0.09	22.8	0.5	-1.5	13.77	2.5	-3.0	15.27	1.0	-1.0
USGS 107	10/09/1996	n3	0.82	0.30	C	C	C	0.56	0.09	22.8	1.0	-1.0	14.77	2.5	-3.0	18.77	1.0	-1.0
USGS 108	10/03/1994	n3	n3	0.46				0.44	0.07	19.8	1.5	-3.0						
USGS 108	10/03/1994	n3	n3	0.26				0.44	0.07	19.3	1.5	-3.0				14.26	1.5	-2.0
USGS 108	10/03/1994	n3	n3	0.45				0.44	0.07	19.8	1.5	-2.5						
USGS 108	04/18/1995	n3	n3	0.29	N	n3	C	0.40	0.07	19.3	2.0	-4.5				16.30	1.5	-2.0
USGS 108	04/18/1995	n3	n3	0.34	N	n3	C	0.40	0.07	18.8	2.0	-5.0				17.30	1.5	-2.0
USGS 108	04/18/1995	n3	n3	0.26	N	n3	C	0.40	0.07	19.3	2.0	-4.5				15.30	1.5	-2.5
USGS 109	10/04/1994	n3	C	C				0.45	0.08									
USGS 109	10/04/1994	n3	C	C				0.45	0.08									
USGS 109	10/04/1994	n3	C	C				0.45	0.08									

Table 3. Fraction of young water calculated using models 2 and 3, and the model-3 age of the young fraction calculated from chlorofluorocarbons, Idaho National Engineering and Environmental Laboratory and vicinity—Continued

Well name	Date sampled	Model 2: Fraction of young water; ratio method						Model 3: Fraction from ^{18}O		Model-3 age: CFC-11 age			Model-3 age: CFC-12 age			Model-3 age: CFC-113 age		
		F11 /F12	F113 /F12	F113 /F11	SF_6 /F11	SF_6 /F12	SF_6 /F113	Fraction	Error	Age yrs	$-\sigma$ yrs	$+\sigma$ yrs	Age yrs	$-\sigma$ yrs	$+\sigma$ yrs	Age yrs	$-\sigma$ yrs	$+\sigma$ yrs
USGS 109	04/20/1995	n3	C	C				0.42	0.07									
USGS 109	04/20/1995	n3	C	C				0.42	0.07									
USGS 109	04/20/1995	n3	C	C				0.42	0.07									
USGS 109	10/11/1996	n3	C	C	0.66	n3	n3	0.44	0.07									
USGS 109	10/11/1996	n3	C	C	n3	n3	n3	0.44	0.07									
USGS 109	10/11/1996	n3	C	C	n1	n3	n3	0.44	0.07									
USGS 110A	10/09/1996	n3	0.56	0.35	C	N	C	0.51	0.09	20.3	1.5	-3.5	15.27	3.5	-4.5	16.27	1.5	-1.5
USGS 110A	10/09/1996	n3	0.43	0.28	C	N	C	0.51	0.09	20.3	1.5	-3.5	15.77	3.5	-4.5	13.27	1.5	-1.5
USGS 110A	10/09/1996	n3	C	C	C	N	C	0.51	0.09	20.3	1.5	-3.5	15.77	3.5	-4.0	8.27	1.5	-8.3
USGS 112	07/15/1996	n3	n3	C				0.52	0.09									
USGS 112	07/15/1996	n3	n3	C				0.52	0.09									
USGS 112	07/15/1996	n3	n3	C				0.52	0.09									
USGS 113	07/16/1996	n3	ERR	ERR				0.58	0.10							ERR	ERR	ERR
USGS 113	07/16/1996	n3	ERR	ERR				0.58	0.10							ERR	ERR	ERR
USGS 113	07/16/1996	n3	n3	C				0.58	0.10									
USGS 115	07/15/1996	n3	n3	C				0.39	0.07	20.0	2.0	-6.0						
USGS 115	07/15/1996	n3	n3	C				0.39	0.07	15.0	4.5	-6.0				6.04	2.5	-6.0
USGS 115	07/15/1996	n3	n3	0.27				0.39	0.07	15.5	4.5	-6.0				11.54	2.0	-2.5
USGS 116	07/15/1996	n3	n3	C				0.46	0.08	9.5	3.5	-9.5				2.54	4.5	-2.5
USGS 116	07/15/1996	n3	n3	C				0.46	0.08	10.5	4.0	-10.5						
USGS 116	07/15/1996	n3	n3	0.34				0.46	0.08	13.0	4.0	-4.0				9.54	1.5	-1.5
USGS 117	10/05/1994	0.24	C	C				0.30	0.05	22.8	2.5	-4.0	23.26	2.5	-5.0	9.26	2.5	-5.0
USGS 117	10/05/1994	0.32	C	C				0.30	0.05	22.8	2.0	-4.0	22.26	3.0	-5.5	7.76	2.5	-7.8
USGS 117	10/05/1994	0.22	C	C				0.30	0.05	23.3	2.0	-4.0	23.76	2.5	-5.0	10.76	3.0	-4.0
USGS 117	07/17/1996	0.34	n3	0.08				0.30	0.05	31.0	2.0	-3.0	31.04	2.0	-4.0			
USGS 117	07/17/1996	0.14	n3	0.07				0.30	0.05	32.0	1.5	-3.0	33.04	2.5	-4.0			
USGS 117	07/17/1996	C	C	C				0.30	0.05	32.5	1.5	-3.0	36.04	2.5	-3.5	21.04	2.5	-3.5
USGS 119	10/06/1994	n3	C	C				0.04	0.01									
USGS 119	10/06/1994	n3	C	C				0.04	0.01									
USGS 120	10/06/1994	n3	C	C				0.49	0.08									
USGS 120	10/06/1994	n3	C	C				0.49	0.08									
USGS 120	10/06/1994	n3	C	C				0.49	0.08									
USGS 120	07/17/1996	n3	C	C				0.53	0.09									
USGS 120	07/17/1996	n3	C	C				0.53	0.09									
USGS 120	07/17/1996	n3	C	C				0.53	0.09									
USGS 121	10/24/1994	n3	n3	n3	n3	n3	C	0.48	0.08							11.31	1.0	-1.5
USGS 121	10/24/1994	n3	n3	C	n1	n3	C	0.48	0.08	19.8	1.0	-2.5						
USGS 121	10/24/1994	n3	n3	n3	n3	n3	C	0.48	0.08									
USGS 124	07/20/1994	n3	n3	C				0.36	0.06	18.1	2.5	-6.0						
USGS 124	07/20/1994	n3	n3	C				0.36	0.06	18.6	2.5	-6.0						
USGS 124	07/20/1994	n3	n3	C				0.36	0.06	18.6	2.0	-6.5						

Table 3. Fraction of young water calculated using models 2 and 3, and the model-3 age of the young fraction calculated from chlorofluorocarbons, Idaho National Engineering and Environmental Laboratory and vicinity—Continued

Well name	Date sampled	Model 2 Fraction of young water; ratio method						Model 3 Fraction from ^{18}O		Model-3 age								
										CFC-11 age			CFC-12 age			CFC-113 age		
		F11 /F12	F113 /F12	F113 /F11	SF_6 /F11	SF_6 /F12	SF_6 /F113	Fraction	Error	Age yrs	-σ yrs	+σ yrs	Age yrs	-σ yrs	+σ yrs	Age yrs	-σ yrs	+σ yrs
USGS 124	04/20/1995	n3	ERR	ERR	C	n3	ERR	0.34	0.06	18.3	2.5	-8.0				ERR		
USGS 124	04/20/1995	n3	ERR	ERR	C	n3	ERR	0.34	0.06	18.3	2.5	-8.0				ERR		
USGS 124	04/20/1995	n3	n3	C	C	n3	C	0.34	0.06	17.8	3.0	-8.0						
USGS 124	10/09/1996	n3	n3	C	C	n3	C	0.35	0.06	20.3	2.5	-7.0						
USGS 124	10/09/1996	n3	n3	C	C	n3	C	0.35	0.06	19.8	2.5	-7.5						
USGS 124	10/09/1996	n3	n3	C	C	n3	C	0.35	0.06	20.3	2.5	-7.0						
USGS 125	06/06/1995	n3	C	C	0.78	n3	n3	0.43	0.07	10.9	4.5	-5.0						
USGS 125	06/16/1995	n3	C	C	0.78	n3	n3	0.43	0.07	11.5	4.5	-5.0						
USGS 125	06/16/1995	n3	C	C	0.81	n3	n3	0.43	0.07	10.5	4.0	-10.5						
USGS 125	10/11/1996	n3	C	C	0.49	n3	n3	0.42	0.07	9.8	4.5	-9.8						
USGS 125	10/11/1996	n3	C	C	0.42	n3	n3	0.42	0.07	11.8	4.5	-11.8						
USGS 125	10/11/1996	n3	C	C	n1	n3	n3	0.42	0.07	10.3	4.5	-10.3						

Table 4. Average calculated chlorofluorocarbon partial pressures, recharge dates, and apparent age of the infiltration water from the northern part of the Idaho National Engineering and Environmental Laboratory

[See figure 2 for location of wells. CFC-11, Chlorofluorcarbon-11; CFC-12, Chlorofluorocarbon-12; CFC-113, Chlorofluorocarbon-113; <1982, recharged before 1982; >12, the age of the infiltration water is greater than 12 years; -1, the calculated age is negative, water is slightly contaminated; C, contaminated sample, cannot be dated]

Well name	Date sampled	Average partial pressure, in parts per trillion			Model-4 calendar year of recharge			Model-4 recharge age, in years		
		CFC-11	CFC-12	CFC-113	CFC-11	CFC-12	CFC-113	CFC-11	CFC-12	CFC-F113
ANP 9	10/14/1994	25.9	73.7	5.2	1989	1988	1995	6	7	-1
ANP 9	10/14/1996	28.3	79.0	3.0	1990	1989	1990	6	7	6
IET Disp	07/18/1994	9.7	245	0	1982	C	<1982	12	C	>12
IET Disp	07/18/1996	9.4	245	0	1981	C	<1982	15	C	>14
PSTF	10/13/1994	52.0	115.7	13.1	1997	1993	C	-3	1	C
PSTF	10/14/1996	57.1	125.8	9.8	1998	1995	1999	-2	1	-3
Site 14	10/13/1994	4.6	9.8	0	1977	1972	<1982	17	22	>12
Site 14	10/14/1996	3.5	12.2	0	1975	1973	<1982	20	23	>14
TAN Exploration	10/13/1994	2.6	17.7	0	1974	1976	<1982	20	18	>12
TAN Exploration	10/14/1996	3.5	17.8	0	1975	1976	<1982	21	20	>14
USGS 6	07/19/1994	0	0	0	<1965	<1955	<1982	>29	>39	>12
USGS 6	07/18/1996	0	0	0	<1965	<1955	<1982	>31	>41	>14
USGS 7	10/14/1994	0	0	0	<1965	<1955	<1982	>29	>39	>12
USGS 7	10/14/1996	0.5	0	0	1967	<1955	<1982	29	>41	>14
USGS 18	07/18/1994	6.9	22.2	0	1979	1977	<1982	15	17	>12
USGS 18	07/19/1996	9.8	28.4	0	1981	1979	<1982	15	17	>14
USGS 26	10/14/1994	38.2	81.6	8.4	1993	1989	1996	1	5	-2
USGS 26	10/15/1996	38.8	87.4	9.3	1994	1990	1999	2	6	-3
USGS 27	10/11/1994	15.1	39.9	1.8	1984	1982	1986	10	12	8
USGS 27	10/15/1996	16.8	43.4	0.7	1985	1983	1981	11	13	15
USGS 31	10/11/1994	14.4	36.1	0	1983	1981	<1982	11	13	>12
USGS 31	06/15/1995	15.6	37.6	2.3	1984	1982	1989	11	13	6
USGS 31	07/19/1996	17.7	42.0	0	1985	1983	<1982	11	13	>14
USGS 32	10/11/1994	28.0	89.6	5.9	1991	1990	1995	3	4	-1
USGS 32	06/15/1995	27.3	87.2	6.6	1990	1990	1996	5	5	-1
USGS 32	07/19/1996	31.1	89.8	2.3	1991	1990	1988	5	6	8

Table 5. Temperature, pH, and concentration of dissolved species in precipitation and well water at and near the Idaho National Engineering and Environmental Laboratory

[Units concentration are in milligrams per liter except for (1) temperature is in degrees Celsius (°C); pH is the negative base-10 logarithm of the hydrogen-ion activity in moles per liter; 3H is in tritium units (TU); carbon-14 is in percent modern carbon (pmc); and carbon-13, deuterium, and oxygen-18 are in permil. Blank spaces, data not available. *, estimated concentration]

Characteristic or constituent	Precipitation[1]	USGS 101[2]
Temperature	10 °C	14.7 °C
pH	5.61	8.16
DO	9	9
HCO_3	58	168
^3H		5.99 TU
Ca	.379	36.9
Mg	.058	15.3
Na	.315	15.5
K	.055	2.8
Cl	.45	21
SO4	.761	21.5
F	.01	.79
SiO_2		30.4
NO_3	.988	4.8
HN_4	.273	
Sr	.002*	.172
Al		.02
$\delta^{13}C$	-12* permil	-9.29 permil
^{14}C	100* pmc	58.6 pmc
δ_2H	- 140* permil	-135.5 permil
$\delta^{18}O$	-18.2* permil	-17.61 permil

[1] Average concentrations in precipitation from 1988 to 1999 from Craters of the Moon, Idaho.
[2] Busenberg and others, 2000

Table 6. Mineral-phase changes needed to model ground water from selected wells in the southeastern part of the Idaho National Engineering and Environmental Laboratory

[The concentration of fluoride determined the mixing ratio. The $\delta^{13}C$ and ^{14}C of soil CO2 were assumed to be –21 permil and 100 percent modern carbon (pmc), respectively. The CO_2 to HCO_3^- fractionation factor of 9 permil for ^{13}C was used. DIC, dissolved inorganic carbon. Ca/Na Ex., Calcium/sodium exchange. The model constraints were carbon, calcium, potassium, sodium, nitrogen, aluminum, sulfur, magnesium, chloride, fluoride, strontium, iron, and silica, and $\delta^{13}C$. Model units are millimoles per kilogram of water; -, indicates precipitation; others result from dissolution. Blank space indicates no data. *, composition from Wood and Low (1988)]

USGS 100 (Five of the 16 possible models are given.)

Phases	Observed	Model 1	Model 2	Model 3	Model 4	Model 5
HNO^3		0.32	0.32	0.32	0.32	0.32
NaCl		0.28	0.28	0.28	0.28	0.28
CO_2 gas		0.95	0.95	0.95	0.95	0.95
Pyrite		0.04	0.04	0.04	0.04	0.04
Forsterite		0.10	0.10	0.10		
K-feldspar		0.03	0.03	0.03	0.02	
Ca-smectite		-0.23	-0.01	-0.01	-0.29	0.02
Calcite		-0.01	-0.04	-0.04	-0.01	-0.01
$Fe(OH)_3$		-0.04	-0.26	-0.71	-0.20	-0.20
Gibbsite		-0.26	-0.23	-0.75	-0.01	-0.58
SiO_2						-0.95
Anorthite		0.38	0.38	0.34	0.17	0.13
Ca/Na Ex.		-0.04	-0.002	-0.04	-0.07	-0.07
Basalt*					0.96	0.96
$\delta^{13}C$	-11.34	-11.29	-11.29	-11.29	-11.29	-11.29
DIC $\delta^{13}C$	-11.00	-10.95	-10.95	-10.95	-10.95	-10.95
^{14}C	77.89	72.50	72.50	72.50	72.50	72.50
Young fraction		0.23	0.23	0.23	0.23	0.23
Regional fraction		0.77	0.77	0.77	0.77	0.77

USGS 1 (Five of the 8 possible models are given.)

Phases	Observed	Model 1	Model 2	Model 3	Model 4	Model 5
HNO_3		0.21	0.21	0.21	0.21	0.21
NaCl		0.19	0.19	0.19	0.19	0.19
CO_2 gas		0.70	0.70	0.70	0.70	0.70
Pyrite		0.03	0.03	0.03	0.03	0.03
Forsterite		0.11	0.11	0.06	0.08	0.06
K-feldspar		0.03	0.03	0.03	0.03	0.03
Ca-smectite		-0.12				-0.12
Na-smectite				-0.12	-0.13	
Calcite		0.10	0.10	0.10	0.10	0.10
$Fe(OH)_3$		-0.03	-0.03	-0.10	-0.07	-0.10
Gibbsite		-0.06	-0.29			
SiO_2			-0.39	-0.09	-0.09	
Anorthite		0.09	0.07		0.05	
Ca/Na Ex.		-0.02	-0.02	-0.02	-0.01	-0.04
Basalt*				0.41	0.21	0.41
Feldspar*		0.08	0.08	0.08	0.08	0.08
$\delta^{13}C$	-10.80	-10.80	-10.80	-10.80	-10.80	-10.80
DIC $\delta^{13}C$	-10.71	-10.71	-10.71	-10.71	-10.71	-10.71
^{14}C pmc	71.17	67.56	67.56	67.56	67.56	67.56
Young fraction		0.27	0.27	0.27	0.27	0.27
Regional fraction		0.73	0.73	0.73	0.73	0.73

Table 6. Mineral-phase changes needed to model ground water from the southeastern part of the Idaho National Engineering and Environmental Laboratory—Continued

USGS 2 (Five of the 9 of the possible models are given.)

Phases	Observed	Model 1	Model 2	Model 3	Model 4	Model 5
HNO^3		0.01	0.01	0.01	0.01	0.01
NaCl		0.30	0.30	0.30	0.30	0.30
CO_2 gas		1.22	1.22	1.22	1.22	1.22
Pyrite		0.04	0.04	0.04	0.04	0.04
Forsterite		0.06	0.11	0.11	0.11	0.11
K-feldspar		0.03	0.03	0.03	0.03	0.03
Ca-smectite				-0.08		-0.37
Na-smectite		-0.40	-0.37	-0.29	-0.29	0.51
Calcite		-0.20	-0.20	-0.20	-0.20	-0.20
$Fe(OH)_3$		-0.12	-0.04	-0.04	-0.04	-0.04
Gibbsite		-0.18	-0.31	-0.31	-0.47	-0.31
SiO_2					-0.27	
Anorthite		0.40	0.51	0.51	0.49	0.08
Ca/Na Ex.			0.01			
Basalt*		0.51				
Feldspar*		0.08	0.08	0.08	0.08	-0.05
$\delta^{13}C$	-12.16	-11.44	-11.44	-11.44	-11.44	-11.44
DIC $\delta^{13}C$	-11.67	-10.93	-10.93	-10.93	-10.93	-10.93
^{14}C pmc	Undefined	75.79	75.79	75.79	75.79	75.79
Young fraction		0.27	0.27	0.27	0.27	0.27
Regional fraction		0.73	0.73	0.73	0.73	0.73

Arbor Test (Six of the 10 possible models are given.)

Phases	Observed	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
HNO_3		0.13	0.13	0.13	0.13	0.13	0.13
NaCl		0.21	0.21	0.21	0.21	0.21	0.21
CO_2 gas		0.92	0.92	0.92	0.92	0.92	0.92
Pyrite		0.03	0.03	0.03	0.03	0.03	0.03
Forsterite		0.07	0.07	0.07			
K-feldspar		0.02	0.02	0.02	0.01	0.01	0.01
Ca-smectite		-0.21	-0.21				-0.33
Na-smectite		-0.07		-0.29	-0.23		
Calcite		-0.13	-0.13	-0.13	-0.13	-0.13	-0.13
$Fe(OH)^3$		-0.03	-0.03	-0.03	-0.14	-0.14	-0.14
Gibbsite		-0.23	-0.23	-0.23	-0.25	-0.70	-0.05
SiO_2					-0.34	-1.09	
Anorthite		0.39	0.40	0.39	0.23	0.19	0.24
Ca/Na Ex.			-0.01	0.04		-0.04	-0.04
Basalt*					0.70	0.70	0.70
Feldspar*		0.06	0.06	0.06	0.06	0.06	0.04
$\delta^{13}C$	-11.81	-11.33	-11.33	-11.33	-11.33	-11.33	-11.33
DIC $\delta^{13}C$	-11.21	-10.71	-10.71	-10.71	-10.71	-10.71	-10.71
^{14}C pmc	Undefined	72.12	72.12	72.12	72.12	72.12	72.12
Young fraction		0.21	0.21	0.21	0.21	0.21	0.21
Regional fraction		0.79	0.79	0.79	0.79	0.79	0.79

Table 6. Mineral-phase changes needed to model ground water from the southeastern part of the Idaho National Engineering and Environmental Laboratory—Continued

Atomic City Well (Six of the 10 possible models are given.)

Phases	Observed	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
HNO_3		0.01	0.01	0.01	0.01	0.01	0.01
NaCl		0.33	0.33	0.33	0.33	0.33	0.33
CO_2 gas		1.06	1.06	1.06	1.06	1.06	1.06
Pyrite		0.05	0.05	0.05	0.05	0.05	0.05
Forsterite		0.16	0.16	0.16	0.16	0.16	0.16
K-feldspar		0.04	0.04	0.04	0.04	0.04	0.04
Ca-smectite			-0.21			-0.20	-0.23
Na-smectite				-0.21			
Calcite		0.11	0.11	0.11	0.11	0.11	0.11
$Fe(OH)_3$		-0.05	-0.05	-0.05	-0.16	-0.19	-0.12
Gibbsite		-0.52	-0.11	-0.11	-0.42		
SiO_2		-0.69			-0.83	-0.19	
Anorthite		0.16	0.19	0.19			0.10
Ca/Na Ex.		-0.05	-0.05	-0.01	-0.07	-0.08	-0.06
Basalt*					0.69	0.84	0.41
Feldspar*		0.11	0.11	0.11	0.11	0.11	0.11
$\delta^{13}C$	-10.89	-10.89	-10.89	-10.89	-10.89	-10.89	-10.89
DIC $\delta^{13}C$	-10.57	-10.57	-10.57	-10.57	-10.57	-10.57	-10.57
^{14}C pmc	Undefined	72.35	72.35	72.35	72.35	72.35	72.35
Young fraction		0.38	0.38	0.38	0.38	0.38	0.38
Regional fraction		0.62	0.62	0.62	0.62	0.62	0.62

Leo Rogers-1 (Six of the 12 possible models are given.)

Phases	Observed	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
HNO_3		0.09	0.09	0.09	0.09	0.09	0.09
NaCl		0.39	0.39	0.39	0.39	0.39	0.39
CO_2 gas		1.54	1.54	1.54	1.54	1.54	1.54
Pyrite		0.07	0.07	0.07	0.07	0.07	0.07
Forsterite		0.19	0.19	0.19	0.19	0.08	0.03
K-feldspar		0.04	0.04	0.04	0.04	0.03	0.03
Ca-smectite		-0.31				-0.14	
Na-smectite		-0.10	-0.41	-0.10		-0.34	-0.44
Calcite		0.04	0.04	0.04	0.04	0.04	0.04
$Fe(OH)_3$		-0.07	-0.07	-0.07	-0.07	-0.24	-0.31
Gibbsite		-0.28	-0.28	-0.89	-1.10		
SiO_2				-1.02	-1.36		-0.21
Anorthite		0.49	0.49	0.44	0.43	0.26	0.15
Ca/Na Ex.			0.05		-0.02		
Basalt*						1.07	1.53
Feldspar*		0.14	0.14	0.14	0.14	0.14	0.14
$\delta^{13}C$	-11.34	-11.34	-11.34	-11.34	-11.34	-11.34	-11.34
DIC $\delta^{13}C$	-10.59	-10.59	-10.59	-10.59	-10.59	-10.59	-10.59
^{14}C pmc	Undefined	79.39	79.39	79.39	79.39	79.39	79.39
Young fraction		0.44	0.44	0.44	0.44	0.44	0.44
Regional fraction		0.56	0.56	0.56	0.56	0.56	0.56

Table 6. Mineral-phase changes needed to model ground water from the southeastern part of the Idaho National Engineering and Environmental Laboratory—Continued

Area II (Six of the 8 possible models are given.)

Phases	Observed	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
HNO_3		0.37	0.37	0.37	0.37	0.37	0.37
NaCl		0.35	0.35	0.35	0.35	0.35	0.35
CO_2 gas		1.51	1.51	1.51	1.51	1.51	1.51
Pyrite		0.06	0.06	0.06	0.06	0.06	0.06
Forsterite		0.18	0.18	0.18	0.06	0.12	0.18
K-feldspar		0.04	0.04	0.04	0.04	0.04	0.04
Ca-smectite		-0.27			-0.26	-0.30	
Na-smectite			-0.30				
Calcite		0.08	0.08	0.08	0.08	0.08	0.08
$Fe(OH)_3$		-0.06	-0.14	-0.21	-0.25	-0.14	-0.06
Gibbsite		-0.14		-0.54			-0.68
SiO_2				-1.10	-0.29		-0.90
Anorthite		0.26	0.15			0.15333	0.22
Ca/Na Ex.		-0.05	-0.02	-0.09	-0.09	-0.07113	-0.05
Basalt*			0.51	0.97	1.16	0.51419	
Feldspar*		0.13	0.13	0.13	0.13	0.12792	0.13
$\delta^{13}C$	-11.18	-11.18	-11.18	-11.18	-11.18	-11.18	-11.18
DIC $\delta^{13}C$	-10.23	-10.23	-10.23	-10.23	-10.23	-10.23	-10.23
^{14}C pmc	Undefined	78.07	78.07	78.07	78.07	78.07	78.07
Young fraction		0.44	0.44	0.44	0.44	0.44	0.44
Regional fraction		0.56	0.56	0.56	0.56	0.56	0.56

USGS 110A (Six of the 8 possible models are given.)

Phases	Observed	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
HNO_3		0.30	0.30	0.30	0.30	0.30	0.30
NaCl		0.39	0.39	0.39	0.39	0.39	0.39
CO_2 gas		1.38	1.38	1.38	1.38	1.38	1.38
Pyrite		0.07	0.07	0.07	0.07	0.07	0.07
Forsterite		0.20	0.20	0.20	0.20	0.20	0.20
K-feldspar		0.05	0.04	0.04	0.04	0.05	0.05
Ca-smectite		-0.28	-0.28				
Na-smectite					-0.31		-0.27
Calcite		0.11		0.11	0.11	0.11	0.11
$Fe(OH)_3$		-0.06	0.11	-0.23	-0.16	-0.06	-0.06
Gibbsite		-0.16	-0.16	-0.56		-0.71	-0.16
SiO_2				-1.13		-0.92	
Anorthite		0.27	0.15		0.15	0.23	0.27
Ca/Na Ex.		-0.06	-0.08	-0.10	-0.03	-0.06	-0.01
Basalt*			0.59	1.01	0.58		
Feldspar*		0.13	0.13	0.13	0.13	0.13	0.13
$\delta^{13}C$	-11.01	-11.01	-11.01	-11.01	-11.01	-11.01	-11.01
DIC $\delta^{13}C$	-10.64	-10.64	-10.64	-10.64	-10.64	-10.64	-10.64
^{14}C pmc	Undefined	75.95	75.95	75.95	75.95	75.95	75.95
Young fraction		0.43	0.43	0.43	0.43	0.43	0.43
Regional fraction		0.57	0.57	0.57	0.57	0.57	0.57

Table 7. Sensitivity of geochemical models to the carbon-12/carbon-13 ratio and the concentration of carbon-14 in the soil carbon dioxide for a water sample from the Area II well

[$\delta^{13}C$, delta carbon-13; ^{14}C, carbon-14; CO2, carbon dioxide; pmc, percent modern carbon; mmol/kg, millimole per kilogram; H_2O, water. *, there is a ^{13}C fractionation factor of 9 permil between soil CO2 and dissolved inorganic carbon. **, cannot model the ground water by mixing the water with the $\delta^{13}C$ and ^{14}C of the soil CO2]

$\delta^{13}C$ of soil CO_2* (permil)	^{14}C concentration of soil CO_2 (pmc)	Fluoride concentrations determined the mixing ratio of the water	CO_2 Consumed mmol/kg H_2O	Fraction of young water	Fraction of regional water	Model ^{14}C of ground water (pmc)
-24	100	yes	1.21	0.442	0.558	68
-21	100	yes	1.51	0.442	0.558	78
-18	100	yes	2.02	0.442	0.558	84
-24	85	yes	1.21	0.442	0.558	62
-21	85	yes	1.51	0.442	0.558	70
-18	85	yes	2.02	0.442	0.558	75
-24	120	yes	1.21	0.442	0.558	76
-21	120	yes	1.51	0.442	0.558	88
-18	120	yes	2.02	0.442	0.558	97
-24	85	no	1.20 to 2.04	0.38 to 0.90	0.10 to 0.62	62 to 63
-21	85	no	0.52 to 2.55	0.01 to 0.82	0.18 to 0.99	63 to 78
-21	100	no	0.52 to 2.55	0.01 to 0.90	0.09 to 0.99	66 to 90
-21	120	no	0.52 to 2.55	0.01 to 0.83	0.17 to 0.99	69 to 108
-18	120	no	No model**	No model**	No model**	No model**

Table 8. Tritium-helium-3 ages of recharge and flow velocities of ground water from at and near the Idaho National Engineering and Environmental Laboratory

[Blanks, no data or not applicable; yrs, years; σ, sigma; min., minimum; R_{terr}, crustal terrigenic $^3He/^4He$ ratio; BLR, Big Lost River; LLR, Little Lost River; NRF, Naval Reactor Facility; INTEC, Idaho Nuclear Technology and Engineering Center; **bold numbers**, most reliable ages; ERR, cannot be calculated; ±, plus or minus; >, greater than; *, Calculated age using the crustal terrigenic $^3He/^4He$ ratio of $2.0x10^{-8}$; **, Calculated crustal terrigenic $^3He/^4He$ ratio for the eastern INEEL is $1.48±0.26x10^{-6}$; m/day, meters per day. These samples contain some mantle helium with a large $^3He/^4He$ ratio. Comments: Lost He indicates samples were lost because of large concentrations of helium]

Well name	Date sampled	Percent terrigenic He	$^3H/^3He$ age* Age, yrs	1σ ± yrs	R_{terr} $1.48E^{-6}$	$^3H/^3He$ age** Age	Age -σ	Age +σ	Flow velocity, m/day	Location of recharge	Comments
ANP 6	10/14/1994	18.0				31.4	34.4	28.4			Infiltration water; low ^3H
ANP 6	06/15/1995	15.3				33.1	35.7	30.7			Infiltration; low ^3H
ANP 9	10/14/1994	65.2									No $^3He/^4He$ data
ANP 9	10/14/1994	63.8									Low ^3H; old water
Arbor Test	04/21/1995	46.2				**1.1**	13.4	ERR			
Area II	07/19/1994	71.9									No $^3He/^4He$ data
Atomic City	10/03/1994	23.5				**14.4**	17.0	11.4			
Crossroads Well	06/13/1995	7.2	**13.1**	0.4	10.4				3.0	BLR spreading area	(Plummer and others, 2000)
NPR Test	04/17/1995	8.3	**13.9**	0.4	12.1				4.3	BLR sinks	
PSTF	10/13/1994	0.8	**9.3**	2.2	3.9				0.7	Playa	Infiltration water; low ^3H
P&W 2	10/25/1994	7.2	**16.1**	0.6	9.5						
P&W 2	04/19/1995	4.0	**4.4**	2.1	-0.3						
Site 14	10/13/1994										Lost He; high terrigenic He
Site 14	10/13/1994										Lost He; high terrigenic He
TAN Expl.	10/13/1994	10.1									>50 yrs; low ^3H
USGS 1	10/03/1994	59.9				**32.0**	40.0	18.0			
USGS 2	07/19/1994	34.5				**10.8**	4.9	15.3			
USGS 4.	10/24/1994	6.7	**5.4**	0.2	2.6						
USGS 4	04/19/1995	5.5	**4.7**	0.2	2.9						
USGS 5	10/12/1994	30.4	**16.5**	0.5	1.0				3.3	BLR sinks	
USGS 5	10/12/1994	29.5	**16.3**	0.3	1.0				3.3	BLR sinks	
USGS 7	10/14/1994										Lost He; high terrigenic He; old water
USGS 8	10/04/1994	9.9	**8.4**	0.2	5.4				1.0	BLR channel	
USGS 9	10/04/1994	23.9	**21.3**	0.6	19.2				2.1	INTEC Disposal Well	

Table 8. Tritium-helium-3 ages of recharge and flow velocities of ground water from at and near the Idaho National Engineering and Environmental Laboratory—Continued

Well name	Date sampled	$^3H/^3He$ age*				$^3H/^3He$ age**			Flow velocity, m/day	Location of recharge	Comments
		Percent terrigenic He	Age, yrs	1σ ± yrs	R_{terr} $1.48E^{-6}$	Age	Age -σ	Age +σ			
USGS 9	04/20/1995	22.5	**22.7**	0.4	17.8				1.9	INTEC Disposal Well	
USGS 11	04/20/1995	13.1	**17.3**	0.3	14.0				3.8	INTEC Disposal Well	3 m/day with ^{35}Cl; (Cecil and others, 2000)
USGS 12	10/27/1994	6.1	**2.9**	0.4	1.9				1.5	LLR sinks	
USGS 12	06/14/1995	5.7	**4.5**	0.4	3.5				1.2	LLR sinks	
USGS 14	10/26/1994	22.2	**27.3**	0.5	21.6				2.8	INTEC Disposal Well	3 m/day with ^{35}Cl; (Cecil and others, 2000)
USGS 15	06/14/1995										Lost He; high terrigenic He
USGS 17	10/27/1994	27.2	**16.1**	0.3	8.4				3.0	BLR sinks	
USGS 17	06/13/1995	0.1	**11.1**	0.3	10.7				4.4	BLR sinks	Low terrigenic He; problems?
USGS 18	07/18/1994										Lost He; high terrigenic He; old water
USGS 19	10/25/1994	38.2	**15.7**	0.5	ERR						
USGS 19	10/25/1994	37.7	**15.5**	0.4	ERR						
USGS 19	04/19/1995	37.6	**14.9**	0.8	ERR						
USGS 22	06/13/1995	-1.5	**7.9**	0.3	7.6						
USGS 23	10/25/1994	56.7									>50 yrs; R_{terr} unknown; low ^3H
USGS 23	04/19/1995	56.9									>50 yrs; R_{terr} unknown; low ^3H
USGS 26	10/14/1994										Lost He; high terrigenic He
USGS 27	10/11/1994										Lost He; high terrigenic He
USGS 29	10/11/1994	71.3	**27.8**	0.7	ERR						About 25 yrs; 25.5 yrs with R_{terr} = 1.0E-7
USGS 29	06/15/1995	72.2									No $^3He/^4He$ data
USGS 31	10/11/1994	83.2	ERR								R_{terr} unknown; post-1963
USGS 32	10/11/1994	39.0									Pre-bomb; R_{terr} unknown; low ^3H; 1950's
USGS 32	06/15/1995	32.5									Pre-bomb; R_{terr} unknown; low ^3H; 1950's
USGS 86	10/04/1994	1.3	**12.1**	0.5	5.4				1.1	BLR channel	
USGS 97	06/13/1995	6.2	**6.3**	0.5	4.7				1.0	NRF	
USGS 98	06/12/1995	2.2	**6.7**	1.3	4.8				2.0	NRF	

Table 8. Tritium-helium-3 ages of recharge and flow velocities of ground water from at and near the Idaho National Engineering and Environmental Laboratory—Continued

Well name	Date sampled	Percent terrigenic He	$^3H/^3He$ age* Age, yrs	1σ ± yrs	R_{terr} $1.48E^{-6}$	$^3H/^3He$ age** Age	Age -σ	Age +σ	Flow velocity, m/day	Location of recharge	Comments
USGS 99	06/12/1995	9.3	**3.9**	0.2	0.0				2.5	NRF	
USGS 99	06/12/1995	8.8	**4.1**	0.2	-0.1				2.5	NRF	
USGS 100	04/21/1995	53.9				**15.2**	22.9	1.4			
USGS 100	04/21/1995	50.7				**14.4**	22.6	-1.4			
USGS 101	04/21/1995	55.2				ERR	ERR	ERR			Early 1950's
USGS 102	06/13/1995	1.4	**5.7**	0.2	5.0				0.5	NRF ditch	
USGS 103	04/18/1995	16.1	**26.1**	0.4	19.3				1.3	INTEC Disposal Well	
USGS 105	10/03/1994	7.6									No $^3He/^4He$ data
USGS 109	10/04/1994	15.0	**20.0**	0.4	18.6				1.9	INTEC Disposal Well	
USGS 109	04/20/1995	16.8	**17.7**	0.4	16.4				2.2	INTEC Disposal Well	
USGS 121	10/24/1994	4.3	**15.5**	0.6	14.7				1.6	NRF	
USGS 124	07/20/1994	23.0	**23.7**	0.1	23.8				2.3	INTEC Disposal Well	
USGS 124	04/20/1995	25.6	**23.6**	0.5	23.4				2.3	INTEC Disposal Well	
USGS 125	06/06/1995	14.4	**17.0**	0.3	15.3				3.1	INTEC Disposal Well	

Table 9. Estimated model ages of the young fraction of ground water from at and near the Idaho National Engineering and Environmental Laboratory

[Model 1. Recharge through a thin, unsaturated zone or very rapid recharge along distinct pathways without exchange of gases between the unsaturated zone and the recharge water. Model 2. Binary mixture of model-1 water and old, tracer-free regional ground water. Age of the young fraction of water determined from the ratio of two environmental tracers. Model 3. Same as model 2 except the fraction of young water determined from the differences in chemical or isotopic composition of the two end-members. The initial concentration of the tracers is reconstructed from the fraction of young water. Model 4. Recharge through a thick, unsaturated zone where diffusion determines the concentration of gases in the unsaturated zone. The recharge water is in equilibrium with the unsaturated-zone atmosphere at the water table. Model 5. Binary mixture of model-4 water and old, tracer-free regional ground water. Model 6. Recharge through a thick, unsaturated zone. Diffusion and advection determine the concentration of environmental trace gases in the unsaturated zone. There is some gas exchange between the recharge water and the unsaturated-zone atmosphere. The recharge water reaches the water table in months or a few years. All model ages are in years. a, CFC-11; b, CFC-12; c, CFC-113; d, SF6; C, contaminated with the tracer; s, eastern INEEL $^{3}He/^{4}He$ ratio; terr, large concentration of terrigenic He; $L^{3}H$, low tritium; np, not possible; na, not applicable; nd, not determined; ?, uncertain; 96, year sampled–the year 1996; >, greater than; <, less than; ^{3}H, tritium; He, helium; (12), 12-year traveltime determined by $^{3}H/^{3}He$ dating; bold, most reliable age; NRF, Naval Reactor Facility; INTEC, Idaho Nuclear Technology and Engineering Center. Model-2 ages are less reliable than model-3 ages because a slight contamination of one of the tracers can significantly affect the model-2 ages. CFC-12 tracer ages (b) are the most reliable of the CFC ages from samples outside the CFC-12 contaminant plumes]

Well name	Year sampled	Model-1 age	Model-2 age	Model-3 age	Model-4 age	$^{3}H/^{3}He$ age	Terrigenic helium (percent)	Estimated age	Comments
ANP 6	94, 95, & 96	20-30 abcd	np	np	np	31s; 33s	15	20-30	Infiltration water, very small ^{3}H
ANP 9	94 & 96	25-32abc	np	na	6-7	np, terr	67	6-7	Infiltration water, no ^{3}H
Arbor Test 1	95 & 96	21-26abc	13-26 abc	18a, 16b, 19c	na	1±12s	46	13-25	
Arco City 2	91	19a, 19b	17ab	nd	na	nd	nd	17-19	
Arco City 4	97	nd	nd	nd	nd	nd	29	nd	
Area II	94 & 96	28-31abc	18-22 abc	21a, 21b, 20c	na	np, terr	72	20-21	
Atomic City Well	94 & 96	21a, 19b, 13c	na	na	na	14±3s	24	14-19	
BFW	96	21a, 9b, Cc	np	np	na	nd	0	20-30?	Well located at edge of contaminant plumes
CFA 1	96	C-abc	C-abc	C-abc	na	nd	32	C	Well located in contaminant plumes
CFA 2	96	C-abc	C-abc	C-abc	na	nd	15	C	Well located in contaminant plumes
EBR I	96	11b, >45ac	np	np	na	nd	27	>45-50	No CFC-11 or CFC-113; CFC-12 plume
Engberson	97	nd	nd	44a	nd	nd	38	nd	
Fire Station 2	96	C-a, 26b, 8c, 29d	np	11b	np	nd	9	>11.4 but <20	CFC-12 concentration slightly contaminated
IET Disposal	94 & 96	19-44abc	na	32a	12-15a, C-b, >12c	nd	18	>12	Infiltration water
INEL WS 1	95	8a, 25b, 22c, 21d	21, 21 bcd	9b, 19c	na	nd	nd	20-21	CFC-11 concentration modified by contamination

Table 9. Estimated model ages of the young fraction of ground water from at and near the Idaho National Engineering and Environmental Laboratory—Continued

Well name	Year sampled	Model-1 age	Model-2 age	Model-3 age	Model-4 age	$^3H/^3He$ age	Terrigenic helium (percent)	Estimated age	Comments
McKinney	91	5a, 2b	np	np	na	nd	nd	2-5	
NPR Test	95 & 96	19-34	np	26b, 18c; 28b, 14c	na	13.9s, 12.1s	8	25?	Well near 3H plume
Park Bell	97	nd	nd	nd	nd	nd	89	nd	
PSTF Test	94 & 96	24-28abc	na	22a, 20b, 16c	1b; 1b	9±2s	1	<9	Infiltration water
P&W2	91, 94, 95, & 96	variable 4-16 abc	na	np	na	16.1; 4.4	5	Variable 4-16	
Pancheri 6	97	nd	nd	nd	nd	nd	56	nd	
Ruby Farms	91	26a, 27b	20bc	nd	nd	nd	nd	20	
RWMC M3S	96	C abc	C abc	C abc	na	nd	34	C	Well located in contaminate plumes
RWMC M7S	96	C abc	C abc	C abc	na	nd	25	C	Well located in contaminate plumes
Squirrel Cemetery	97	nd	nd	nd	nd	nd	nd	nd	
SITE 04	96	18-31abcd	np	25b, 13c	na	nd	4	25	Water is younger at the water table
SITE 09	94 & 96	35-40 abc	20bc	28a, 30b, 24c	na	nd	69	>35-40	Water is younger at the water table
SITE 14	94 & 96	40-45 abc	37bc	36a, 37b	na	np, terr	91	>40-45	Water is younger at the water table
SITE 17	95	21-22 ab, 13c	6.5, np	np	np	nd	1	21-22	
SITE 19	96	16a, 22b, 15c	10, 15 abc	np	na	nd	7	15	
TAN Exploration	94 & 96	39-44abc	na	42a, 42b	21a, 19b, >12c	nd	10	19-21	Infiltration water; ^3H is still in the unsaturated zone
Wagoner Ranch	97	nd	nd	nd	nd	nd	30	nd	
USGS 1	91, 94, & 96	26-31 abc	12-29 abc	24a, 23b, 18c	na	32±32s	60	18-24	
USGS 2	94 & 96	23-26 abc	25, 15, 14 abc	20a, 18b, 17c	na	11±10s	34	17-20	
USGS 4	94, 95, & 96	13a, 5.5b, 15c	np	na	na	5.4±0.2; 4.7±0.2	7	5	
USGS 5	94 & 96	18-27abc; 24-31 abc	10cb; 12cb	21a, 18b, 12c; 25a, 23b, 17c	na	16.5±0.5	30	17-18	The CFC ages for the 1996 samples are about 5 years older than 1994 samples
USGS 6	94 & 96	No CFCs	No CFCs	No CFCs	No CFCs	np, L3H	62	>55	Significantly older than 55 years
USGS 7	94 & 96	No CFCs	No CFCs	No CFCs	No CFCs	np, terr, L3H	97	>55	Significantly older than 55 years
USGS 8	91, 94, 95, & 96	20-30abc	19b, 13c	24a, 9b, 19c	na	8.4±0.2	10	8-9	
USGS 9	91, 94, 95, & 96	9-23abc	na	na	na	(21; 23)	23	>23	$^3H/^3He$ age—traveltime from INTEC waste-disposal well
USGS 11	95 & 95	12-27abc	na	20a	na	(17.4)	13	>17.3	$^3H/^3He$ age—traveltime from INTEC waste-disposal well

Table 9. Estimated model ages of the young fraction of ground water from at and near the Idaho National Engineering and Environmental Laboratory—Continued

Well name	Year sampled	Model-1 age	Model-2 age	Model-3 age	Model-4 age	$^3H/^3He$ age	Terrigenic helium (percent)	Estimated age	Comments
USGS 12	94 & 95	18-22abc, 12d; 21-23abcd	13-22abcd; 17-22abcd	17a, 17b, 15c	na	2.9; 4.5	6	3-5 or 17	Large difference in recharge age; possible local ^3H contamination
USGS 14	94 & 96	6-25abc	na	16a	na	(27.3)	13	>27.3	$^3H/^3He$ age--travel time from INTEC waste-disposal well
USGS 18	91, 94, & 96	38-44abc	na	na	15a, 17b, >13c	np, terr	84	17	
USGS 19	94, 95, & 96	25a, 22b, 18c	9bc	np	na	15.6; 14.9	38	15-16	
USGS 22	95 & 96	20-35abc; 18-27abc	6.5bc; 11bc	na	np	7.9	0	8	Very large ^3H and relatively small CFCs Intermediate to slow focused recharge with gas exchange
USGS 23	91, 94, 95, & 96	16-35abc	np	na	np	np, L3H	57	Old	Advective and diffusive transport of CFCs through the unsaturated zone
USGS 26	91, 94, & 96	20-30abc	na	na	5-6b	np, terr	86	5-6	Infiltration water, ^3H is still in the unsaturated zone
USGS 27	91, 94, & 96	25-34abc	na	na	10-13abc	np, terr	88	13	Infiltration water, ^3H is still in the unsaturated zone
USGS 29	94, 95, & 96	24-25ab, 21c	22ab, 15cb	22a, 21b, 18c	np	24-28	71	25	
USGS 31	94, 95, & 96	32-35abc	na	na	11-13ab	np, terr	83	13	Infiltration water, ^3H is still in the unsaturated zone
USGS 32	94, 95, & 96	24-31abc	na	na	5ab	np, L3H	35	5	Infiltration water, ^3H is still in the unsaturated zone
USGS 36	96	9a, C bc	C abc	C abc	na	nd	6	C	
USGS 37	94	10a, C bc	C abc	C abc	na	nd	nd	C	
USGS 58	91	4a, C b	C ab	C abc	na	nd	nd	C	
USGS 65	91, 94	C abc	C abc	C abc	na	nd	nd	C	
USGS 76	94	C ab, 10c	C ab	C abc	na	nd	nd	C	
USGS 77	94	21a, C bc	C abc	C abc	na	nd	nd	C	
USGS 79	91	12a, C b	C ab	C abc	na	nd	nd	C	
USGS 82	96	33a, C b, 29c	na	27a, 22c	na	nd	21	27	
USGS 83	95	40-45 abc	34ab	34a, 35b	na	nd	nd	34-35	
USGS 86	91, 94, & 96	32a, 33b, 23c	25ab	24a, 24b, 14c	na	12.1	40	12-19	Very small fraction of young water Uncertainty in age, model-6 recharge
USGS 87	91	24a, C b	C ab	na	na	nd	nd	?	
USGS 88	91	18-C a, C b	C ab	na	na	nd	nd	?	

Table 9. Estimated model ages of the young fraction of ground water from at and near the Idaho National Engineering and Environmental Laboratory—Continued

Well name	Year sampled	Model-1 age	Model-2 age	Model-3 age	Model-4 age	$^3H/^3He$ age	Terrigenic helium (percent)	Estimated age	Comments
USGS 89	91, 94 & 96	28a, C bc	C abc	11a	na	nd	28	?	
USGS 97	91, 95	C a, 21b, 24d	C abc	10b, C ac	na	(6.3)	6	10-20	$^3H/^3He$ age--traveltime from NRF
USGS 98	95	8a, 24b, 23d	C abc	7b	na	(6.7)	2	10-20	$^3H/^3He$ age --traveltime from NRF
USGS 99	95	C a, 18b, 20d	C abc	np	na	(3.9)	9	10-20	$^3H/^3He$ age --traveltime from NRF
USGS 100	91, 95 & 96	25a, 26b, 20c	21ab, 11cb	17a, 17b, 13c	na	15±15	53	17-21	
USGS 101	95 & 96	33a, 34b	31ab, 18cb	27a, 27b 24c	na	np, L3H	55	27-30	Low ^3H—small fraction of young water
USGS 102	95	C a, 19b, C c, 26d	C abc	9b	na	(5.7)	10	26?	$^3H/^3He$ age—traveltime from NRF
USGS 103	94, 95 & 96	14-26 abc	C abc	8-23a, 8-16c	na	(26.1)	16	>26	$^3H/^3He$ age—traveltime from INTEC
USGS 104	91, 94, 95 & 96	25a, C b, 10c, C d	C abc	16-28a	na	nd	na	>28	
USGS 105	94 & 95	10-12a, C bc	C abc	np	na	nd	8	?	
USGS 106	94	17a, C b, 12c	C abc	np	na	nd	20	?	
USGS 107	94 & 96	20-29 abc	16bc	11a,15b, 15c	na	nd	33	>15	
USGS 108	94 & 95	26a, C b, 21-41c	15ac	20a, 15c	na	nd	nd	>20	
USGS 109	94, 95 & 96	19a, C bc	C abc	np	na	(18-20)	16	?	$^3H/^3He$ age—traveltime from INTEC
USGS 110A	96	27a, 26b, 19c	15bc	20a, 16b, 13c	na	nd	55	16-20	
USGS 112	96	14a, C bc	C abc	np	na	nd	22	C	
USGS 113	96	17a, C bc	C abc	np	na	nd	22	C	
USGS 115	96	24a, C b, 13c	C abc	17a	na	nd	42	C	
USGS 116	96	24a, C b, 14c	C abc	11a, 6cc	na	nd	32	C	
USGS 117	91, 91, 94 & 96	30-46, 32-53b, 17-44c	25ab	23-31a, 23-33b, 9-21c	na	nd	33	>33	
USGS 119	91 & 94	16a, C bc	C abc	np	na	nd	nd	?	
USGS 120	91, 91, 94, & 96	C abc	C abc	C abc	na	nd	11	C	
USGS 121	94	21a, C b, 11c, 17d	C abc	20a, 11c	na	(15.5)	4	20	$^3H/^3He$ age—traveltime from NRF
USGS 124	94, 95, & 96	27a, C b.12c	C abc	19a	na	(24)	23	>24	$^3H/^3He$ age—traveltime from INTEC
USGS 125	95 & 96	23a, C bc, 21d	C abc	11a	na	(17)	14	>17	$^3H/^3He$ age--traveltime from INTEC