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Evaluation of Well-Purging Effects on Water-Quality Results for Samples Collected from the Eastern Snake River Plain Aquifer Underlying the Idaho National Laboratory, Idaho

Scientific Investigations Report 2006–5232

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

Cover: Photograph of U.S. Geological Survey well and equipment used to collect samples and containerize excess purge water at the Idaho National Laboratory, Idaho. View looking north. (Photograph taken by Betty J. Tucker, U.S. Geological Survey, Idaho National Laboratory Project Office.)

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Contents

Figures

Figures—Continued

Figures—Continued

Tables

Conversion Factors, Datums, Abbreviations and Acronyms

Conversion Factors

Multiply	By	To obtain
foot (ft)	0.3048	meter
gallon (gal)	3.785	liter
liter per minute (L/min)	0.2642	gallon per minute
mile (mi)	1.609	kilometer
square mile (mi^2)	2.590	square kilometer

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F=(1.8\times°C)+32$$

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25°C).

Concentrations of chemical constituents in water are given either in milligrams per liter (mg/L), micrograms per liter (µg/L), or picocuries per liter (piC/L).

Datums

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29).

Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27).

Altitude, as used in this report, refers to distance above the vertical datum.

Abbreviations and Acronyms

Abbreviation or acronym	Meaning
DEQ	Idaho Department of Environmental Quality
DOE	U.S. Department of Energy
ESRP	Eastern Snake River Plain
ESRPA	Eastern Snake River Plain aquifer
IBSP	Inorganic Blind Sample Program
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
LRL	laboratory reporting level
LT-MDL	long-term method detection limit
MPV	most probable value
MRL	minimum reporting level
NLCID	no longer contained in decision
NWQL	National Water Quality Laboratory
POC	purgeable organic compond
RCRA	Resource Conservation and Recovery Act
RESL	Radiological and Environmental Sciences Laboratory
SRWS	standard reference water samples
TOC	total organic carbon
USGS	U.S. Geological Survey

Evaluation of Well-Purging Effects on Water-Quality Results for Samples Collected from the Eastern Snake River Plain Aquifer Underlying the Idaho National Laboratory, Idaho

By LeRoy L. Knobel

Abstract

This report presents qualitative and quantitative comparisons of water-quality data from the Idaho National Laboratory, Idaho, to determine if the change from purging three wellbore volumes to one wellbore volume has a discernible effect on the comparability of the data. Historical water-quality data for 30 wells were visually compared to water-quality data collected after purging only 1 wellbore volume from the same wells. Of the 322 qualitatively examined constituent plots, 97.5 percent met 1 or more of the criteria established for determining data comparability. A simple statistical equation to determine if water-quality data collected from 28 wells at the INL with long purge times (after pumping 1 and 3 wellbore volumes of water) were statistically the same at the 95-percent confidence level indicated that 97.9 percent of 379 constituent pairs were equivalent.

Comparability of water-quality data determined from both the qualitative (97.5 percent comparable) and quantitative (97.9 percent comparable) evaluations after purging 1 and 3 wellbore volumes of water indicates that the change from purging 3 to 1 wellbore volumes had no discernible effect on comparability of water-quality data at the INL. However, the qualitative evaluation was limited because only October-November 2003 data were available for comparison to historical data. This report was prepared by the U.S. Geological Survey in cooperation with the U.S. Department of Energy.

Introduction

The Idaho National Laboratory (INL), which occupies about 890 mi^2 of the eastern Snake River Plain (ESRP) in southeastern Idaho (fig. 1), is operated by the U.S. Department of Energy. INL facilities historically were used to develop peacetime atomic-energy applications, nuclear safety research, defense programs, and advanced energy concepts. Liquid-waste disposal resulted in detectable concentrations of several waste constituents in water from the eastern Snake River Plain aquifer (ESRPA) underlying the INL. The U.S. Geological Survey (USGS) INL Project Office provides an independent assessment of the migration and fate of waste constituents in water from the ESRPA. This report was prepared by the USGS in cooperation with the U.S. Department of Energy (DOE).

Ground-water-sampling protocols generally recommend that a well be purged prior to sampling (U.S. Environmental Protection Agency [USEPA], 1986). This recommendation is based on the assumption that the chemistry of stagnant water standing in a well casing or borehole is not the same as the chemistry of water in an aquifer. Three criteria commonly used to determine when a well has been purged sufficiently to yield representative water samples are: (1) removing an arbitrary number (usually three or more) wellbore volumes of water from the well; (2) monitoring field water-quality parameters—temperature, pH, specific conductance, turbidity, and dissolved oxygen—during purging until the values are

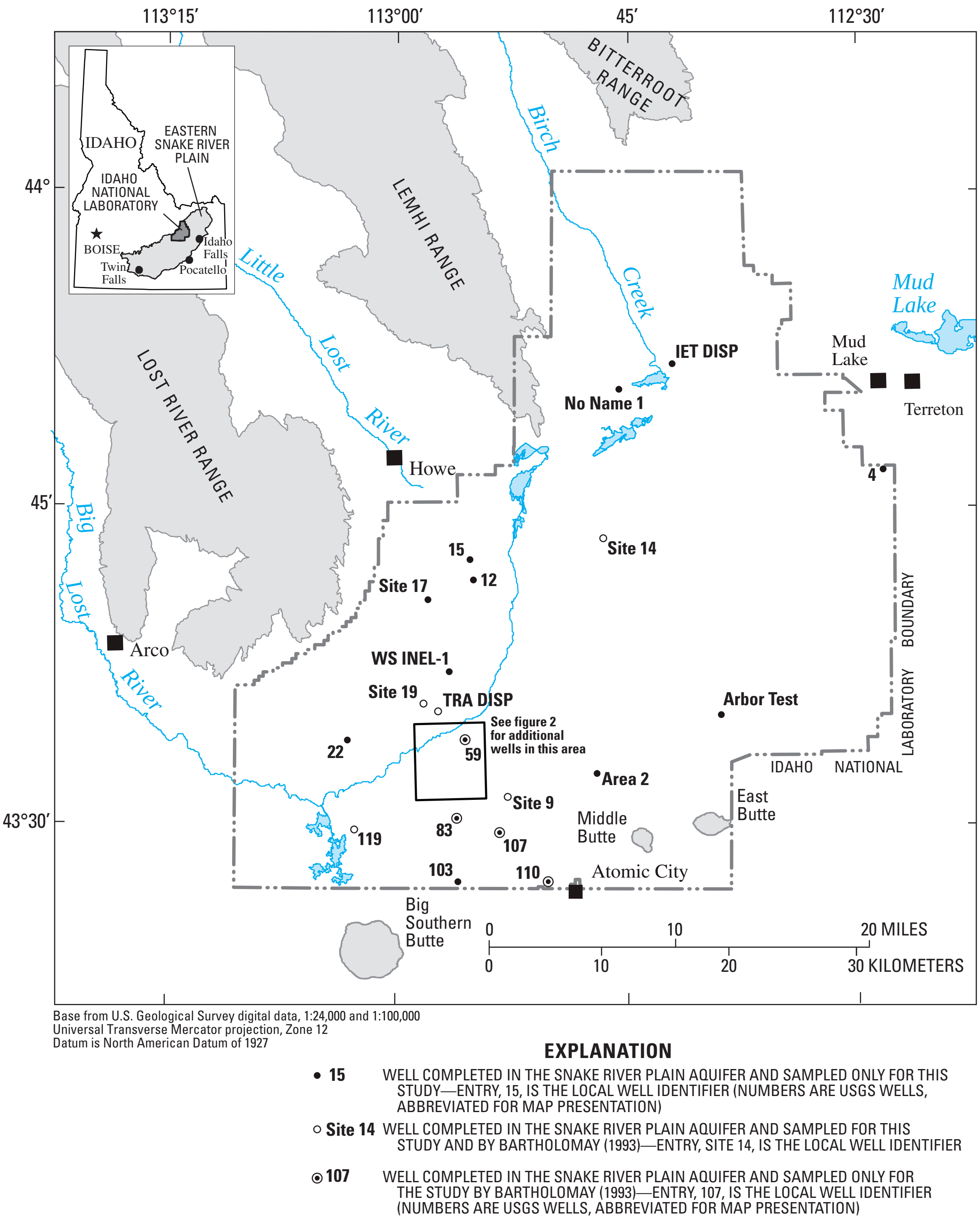

Figure 1. Location of eastern Snake River Plain, Idaho National Laboratory, and selected wells, Idaho.

stable; and (3) purging until hydraulic equilibrium takes place between well water and aquifer water (Gibs and Imbrigiotta, 1990; American Society for Testing and Materials, 1999). USGS policy specifies removing at least 3 wellbore volumes of standing water while measuring field parameters until they are within specified stability criteria for five successive measurements (temperature, ±0.2°C; pH, ±0.1 standard units; specific conductance, ±3 percent if greater than 100 µS/cm or ±5 percent if less than 100 µS/cm; dissolved oxygen (DO) concentration, ±0.3 mg/L; and turbidity, ±10 percent for NTU less than 100). Exceptions to the 3-wellbore-volume rule are allowed if site characteristics or study objectives require modifying the standard procedure by changing the number of borehole volumes removed from the well (Wilde and others, 1999). The American Society for Testing and Materials (1999, 2001, 2002) provide detailed information on additional well-purging criteria and combinations of the criteria described above, different types of equipment that can be used for purging and sampling ground water from monitoring wells, and alternative methods such as low-flow purging and sampling of ground water. Barcelona and others (2005) also described low-flow purging and sampling of ground water under high- and low-permeability conditions.

In 2000, an areal polygon was established downgradient of the Idaho Nuclear Technology and Engineering Center (INTEC) with ground water that contained Resource Conservation and Recovery Act (RCRA) listed waste (fig. 2). In August 2000, the State of Idaho Department of Environmental Quality (DEQ) granted a conditional No Longer Contained In Decision (NLCID) to DOE, which allowed for ground water removed from specific wells in the polygon to be discharged to the ground surface (Brian Monson, State of Idaho Department of Environmental Quality, written commun., August 21, 2000). The conditional NLCID was renewed by the DEQ in June 2002 (Brian Monson, State of Idaho Department of Environmental Quality, written commun., June 19, 2002), but was withdrawn in June 2003 (Brian Monson, State of Idaho Department of Environmental Quality, written commun., May 19, 2003). The USGS INL Project Office routinely collected ground-water samples from 30 wells inside the polygon that required purging 3 wellbore volumes and generated about 25,000 gal of purge water per sampling event. Beginning October 2003, the USGS was no longer allowed to discharge purge water to the ground surface. DEQ required that purge water be treated as a RCRA-listed waste, which necessitated pumping it into containers and transporting it to an approved disposal site.

In October 2003, the USGS began containerization of purge water removed from wells inside the polygon. Removing 3 wellbore volumes of purge water from many of these wells was not possible due to the large volumes of purge water and the size limitations of the containers. The USGS INL Project Office initiated a revised procedure to collect samples after purging 1 wellbore volume if field water-quality parameters stabilized. To evaluate the effects of decreased purging on the comparability of data, two techniques were used (1) a qualitative comparison of historical water-quality data from wells inside the polygon with water-quality data subsequently collected from the same wells after only 1 wellbore volume was purged, and (2) a quantitative comparison of data collected at selected wells (figs. 1, 2) after purging 1 wellbore volume with data collected at the same wells after purging 3 wellbore volumes.

Purpose and Scope

The purpose of this report is to present results of the qualitative and quantitative comparisons of water-quality data to determine if a change from purging 3 wellbore volumes to 1 wellbore volume has a discernible effect on data comparability. Specific objectives of the study were to: (1) plot and visually compare historical water-quality data for 30 wells in the RCRA-listed waste polygon with data collected after the change to purging only 1 wellbore volume; (2) use a simple statistical equation to determine if water-quality data collected from 17 long-pumping wells (after pumping 1 and 3 wellbore volumes) were statistically the same at the 95-percent confidence level; and (3) use the same simple statistical equation to re-evaluate if water-quality data reported by Bartholomay (1993) from 11 long-pumping wells at the INL (after 1, 2, and 3 wellbore volumes were pumped) were statistically the same at the 95-percent confidence level.

Geohydrologic Setting

The ESRP is a northeast-trending structural basin about 200-mi long and 50- to 70-mi wide. The basin is bounded by faults on the northwest and downwarping and faulting on the southeast. The basin is filled with basaltic lava flows interbedded with terrestrial sediments (Whitehead, 1986). Individual basalt flows range from 10- to 50-ft thick, although the average thickness probably ranges from 20 to 25 ft (Mundorff and others, 1964, p. 143). Sedimentary deposits consist mainly of lenticular beds of sand, silt, and clay with

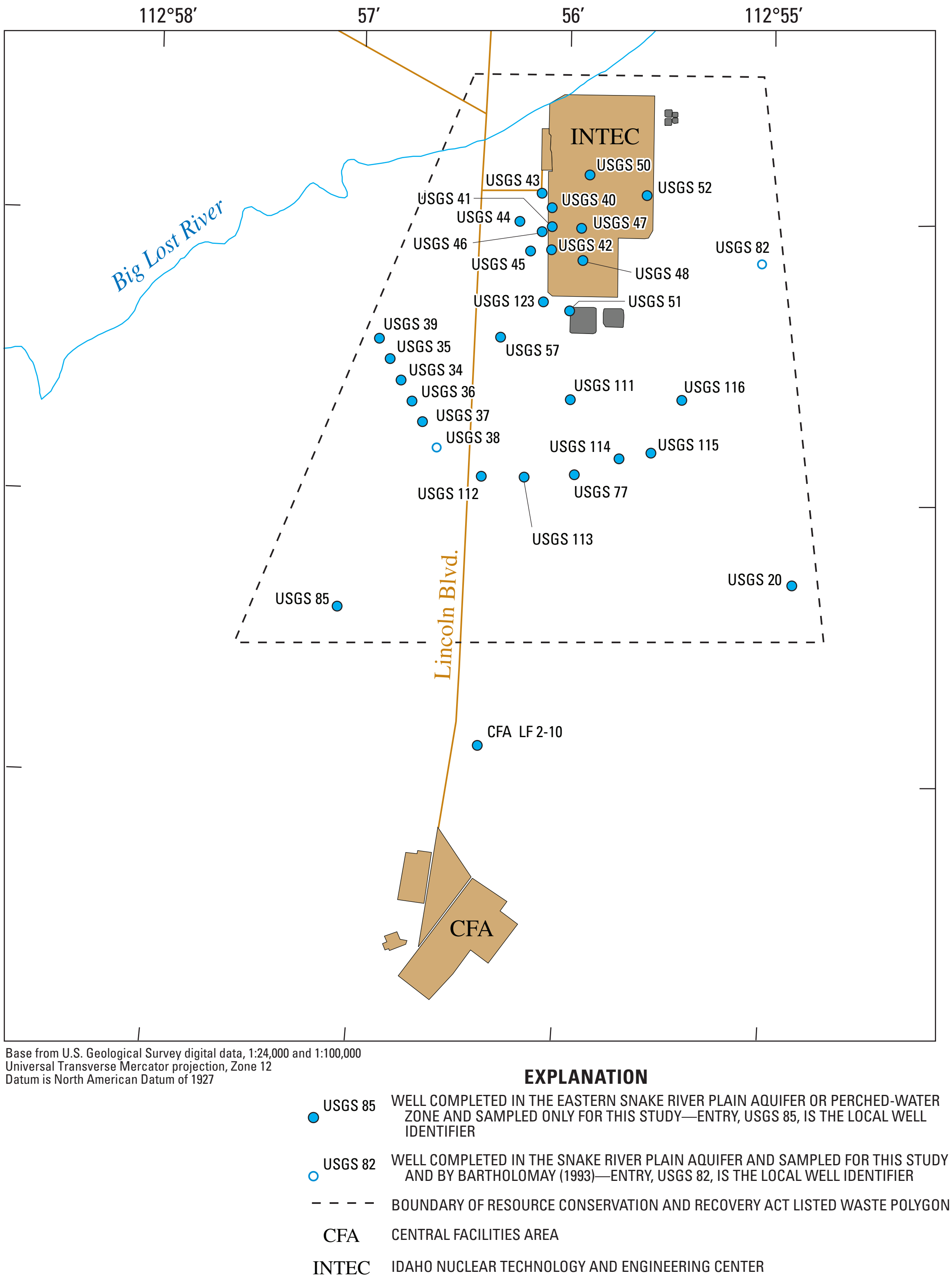

Figure 2. Locations of selected wells near the Idaho Nuclear Technology and Engineering Center and Central Facilities Area, Idaho.

lesser amounts of gravel. Locally, rhyolitic lava flows and tuffs are exposed at the land surface and may exist at depth under most of the ESRP. A 10,365-ft-deep test hole at the INL penetrated 2,160 ft of basalt and sediment and 8,205 ft of rhyolitic volcanic rocks (Mann, 1986).

Basaltic lava flows and interbedded sedimentary deposits combine to form the ESRPA, the main source of ground water on the ESRP. Depth to water in the ESRPA at the INL ranges from about 200 ft in the northern part to more than 900 ft in the southern part. Direction of regional ground-water flow in the ESRPA generally is from the northeast to the southwest. Water moves horizontally through basalt interflow zones and vertically through joints and interfingering edges of the interflow zones. Infiltration of surface water, heavy pumpage, geologic conditions, and seasonal fluxes of recharge and discharge locally affect the movement of ground water (Garabedian, 1986).

Previous Investigations

Many previous studies evaluated well-purging criteria to determine when chemistry of water withdrawn from wells was representative of the chemistry of water in the aquifer. Most studies evaluated how changing well-purging criteria affected organic compound concentrations, especially in shallow sand and gravel aquifers. Dumouchelle and others (1990), Gibs and others (1990), and Herzog and others (1991) provide a comprehensive list of reports presenting results of these studies. Robin and Gilham (1987) used conservative inorganic tracers (sodium bromide and sodium chloride) to evaluate the number of purge volumes required to achieve chemical equilibrium between well water and aquifer water and concluded that less than three wellbore volumes was sufficient under the conditions of their tests. Robin and Gilham (1987) also pointed out that the findings of studies evaluating well-purging criteria are site specific and depend on local hydraulic, hydrologic, and geochemical conditions.

Barcelona and others (2005) presented results of a case study to illustrate low-flow sampling performance under minimal (low permeability) and significant, but stable (high permeability) drawdown conditions. They concluded (for the conditions of their study) that constituent concentrations stabilized after 2 wellbore volumes for a low-permeability well and after one-half wellbore volumes for a high-permeability well. They also concluded that stabilization of field water-quality parameters more effectively indicated when to collect samples than the number of wellbore volumes purged from a well.

The effect on concentrations of inorganic, organic, and radioactive constituents in water from deep aquifers like the ESRPA that result from changing well-purging criteria has not been studied extensively. However, Bartholomay (1993) evaluated changes in concentrations of tritium and strontium-90 after purging 1, 2, and 3 borehole volumes. Samples were collected from 11 ESRPA wells and analyzed by DOE’s Radiological and Environmental Sciences Laboratory (RESL) for tritium and strontium-90. Bartholomay (1993) presents statistical comparisons of analytical data from samples collected at each well. A pair of equations derived from a test method recommended by the American Society for Testing and Materials (1988) was used for the comparisons. Wells included in his study were selected because they required 1 or more hours to purge 1 borehole volume of water. Bartholomay (1993) concluded that tritium and strontium-90 concentrations in water samples from wells with purge times greater than 3 hrs at the INL are not measurably affected by purging either 1, 2, or 3 borehole volumes.

Study Methods

Sample Collection Methods

Methods of collecting water samples for this study generally followed guidelines established by the USGS and documented in the USGS National Field Manual (U.S. Geological Survey, variously dated), in the USGS Idaho Water Science Center Quality-Assurance Plan for water-quality activities (U.S. Geological Survey, Idaho Water Science Center, written commun., 2005), and in Bartholomay and others (2003). Containerization of purge water necessitated some minor adjustments to the guidelines in Bartholomay and others (2003). It was necessary to split the well discharge into three streams to accommodate sample collection, continuous measurement of the field-water-quality indicators (temperature, pH, specific conductance, and DO), and collection of excess purge water. Excess purge water was collected at the discharge point and routed through canvas hoses to trailer-mounted containers. Containerized purge water was then transported to an approved disposal site near INTEC.

Analytical Methods

DOE's Radiological and Environmental Sciences Laboratory (RESL) analyzed water samples for selected radiochemical constituents. A discussion of the procedures used by RESL for the analysis of radionuclides in water samples is provided in reports by Bodner and Percival [eds.] (1982) and U.S. Department of Energy (1995). Analytical methods used by the USGS National Water Quality Laboratory (NWQL) for selected organic and inorganic constituents are described by Goerlitz and Brown (1972), Skougstad and others (1979), Wershaw and others (1987), Fishman and Friedman (1989), Faires (1992), Fishman (1993), and Rose and Schroeder (1995). A list of some analytical methods currently used at the NWQL is available at http://wwwnwql.cr.usgs.gov/Public/ref_list.html. Other analytical methods from the USEPA currently used at the NWQL are available at http://www.epa.gov/epahome/publications.html. Analytical methods from the ASTM that are currently used at the NWQL are available at http://www.astm.org.

Guidelines for Interpretation of Analytical Results

Concentrations of radionuclides are reported with an estimated sample standard deviation, **s**, obtained by propagating sources of analytical uncertainty in measurements. Guidelines for interpreting analytical results for radionuclides are based on an extension of a method by Currie (1984) and are given in a report by Knobel and others (1999). In this report, radionuclide concentrations less than 3**s** are considered to be below a reporting level.

Water samples were analyzed for the following selected non-radioactive chemical constituents: dissolved trace elements, common ions, nutrients, and purgeable organic compounds. Minimum reporting levels (MRL's), long-term method detection limits (LT-MDL's), and laboratory reporting levels (LRL's), are used by the NWQL to determine when a chemical constituent has been detected with sufficient confidence (Childress and others, 1999).

The MRL is the smallest measured constituent concentration that can be reliably reported using a given analytical method (Timme, 1995). In this report, MRL's are used only to report concentrations of purgeable organic compounds. The LT-MDL controls false positive error and is determined by calculating the standard deviation of a large sample population (at least 24 measurements) of spiked-sample measurements over an extended period (often 1 year). At the NWQL, the LT-MDL can change on a yearly basis. The chance of falsely reporting a concentration at or greater than the LT-MDL for a sample that did not contain the analyte is predicted to be less than or equal to 1 percent (Childress and others, 1999, p. 19). A falsely reported detection is known as a false positive and is an error of the first type in hypothesis testing. The LRL controls false negative error and is determined so the probability of falsely reporting a non-detection for a sample containing an analyte at a concentration equal to or greater than the LRL is predicted to be less than or equal to 1 percent (Childress and others, 1999, p. 19). Falsely reporting a non-detection is known as a false negative and is an error of the second type in hypothesis testing. The LRL generally is equal to twice the yearly-determined LT-MDL.

Analytes detected at concentrations between the LT-MDL and the LRL that pass identification criteria are estimated. Estimated concentrations are noted with a remark code "E." These data should be used with the understanding that their uncertainty is greater than data reported without the "E" remark code. For consistency with previous publications, estimated concentrations less than the LRLs are treated as censored data in this report. For censored data used in this report, values are less than the LRL or MRL.

Statistical Equivalency of Sample Pairs

Statistical equivalency of chemical-constituent concentrations in sample pairs was determined following the method outlined by Williams (1996). In this method, statistical equivalence is determined within a specified confidence level. A value for the standard deviate, Z, is calculated, and then the level of significance of the result is evaluated (evaluation of the level of significance assumes that the sample population is distributed normally). For this report, concentrations of individual constituents in sample pairs (constituent pairs) were considered equivalent when the results were within two standard deviations of each other. At this confidence level (95-percent), the level of significance, determined from a standard normal probability curve, was 0.05 for a two-tailed test and corresponded to a Z-value of 1.96.

The equation used to determine Z was adapted from Volk (1969):

$$Z = \frac{|x - y|}{\sqrt{(s_x)^2 + (s_y)^2}}\ , \tag{1}$$

where

x is the concentration of a constituent in the routine sample,

y is the concentration of the same constituent in the sequential replicate sample,

s_x is the standard deviation of x, and

s_y is the standard deviation of y.

When the population is not distributed normally or an approximation of the standard deviation is used, a Z-value less than 1.96 must be considered a guide when testing for equivalence. Constituent concentrations in sample pairs were considered statistically equivalent when the calculated Z-value was less than or equal to 1.96. Constituent concentrations also were considered statistically equivalent, although Z-values were not calculated, when the concentration in both samples was reported as less than the LRL or MRL. In this case, the Z-value was reported as zero.

In this report, three types of sample pairs were evaluated for statistical equivalency: (1) a replicate-sample pair collected from well USGS 22 (fig. 1); (2) sample pairs collected after purging 1 and 3 wellbore water volumes at each of 17 wells (figs. 1, 2); and (3) sample pairs collected in an earlier study (Bartholomay, 1993) after purging 1, 2, and 3 wellbore volumes at each of 11 wells (figs. 1, 2). Each sample pair generates multiple constituent pairs.

Gross Radioactivity and Radionuclides

Using equation 1 is straightforward in determining whether results of radiochemical analyses of a pair of samples were equivalent. RESL reports radionuclide concentrations with an estimated sample standard deviation obtained by propagating sources of analytical uncertainty in measurements. Estimated sample standard deviations can be used directly in equation 1 to calculate a Z-value. Concentrations of radionuclides and measurements of gross radioactivity, estimated sample standard deviations, and calculated Z-values are provided in table 1.

Non-radioactive Inorganic Constituents

Equation 1 cannot be applied directly to results when no standard deviations or uncertainties are reported by the laboratory. The NWQL does not report standard deviations with analytical results for non-radioactive inorganic constituents. As a result, approximations of standard deviations were used. The USGS Branch of Quality Assurance conducts an Inorganic Blind Sample Program (IBSP) in which reference samples disguised as environmental samples are submitted to the NWQL. Maloney and others (1993) describe the program and present evaluations of the analytical results. Samples sent by the IBSP to the NWQL are prepared from standard reference water samples (SRWS's). SRWS's are used by the USGS SRWS project in a round-robin laboratory evaluation program described by Farrar and Long (1997). Until 1988, the SRWS project used means and standard deviations to describe the round-robin data sets. Since 1988, the project used median and *F-pseudosigma* as a summary of location and variability in data sets. Hoaglin and others (1983) showed that *F-pseudosigma* yields an unbiased estimate of standard deviation when the data distribution is Gaussian (http://bqs.usgs.gov/bsp/regress.htm).

Mean and median values in the SRWS data sets traditionally were referred to as Most Probable Values (MPV's). The IBSP uses SRWS data sets to estimate the MPV's of the IBSP sample mixes. MPV estimates are based on the proportion of the SRWS's used in making up the sample mixes. Because SRWS data sets are not always Gaussian, the regression equations were derived from a combination of parametric and nonparametric results. Regression equations were derived for each constituent by regressing the appropriate *F-psuedosigma* or standard deviation against the IBSP MPV using ordinary least squares. Helsel and Hirsch (1992) provided a general model for estimation of ordinary least-squares:

$$F_{\sigma i} = \beta_o + \beta_1 MPV_i + \varepsilon_i \; i = 1, 2, \ldots, n \tag{2}$$

where

$F_{\sigma i}$ is the ith observation of the response variable, F_σ,

MPV_i is the ith observation of the explanatory variable, MPV,

β_o is the intercept,

β_1 is the slope,

ε_i is the random error or residual for the ith observation, and

n is the sample size.

SRWS project summary data for semi-annual round-robin sample studies during 2004-05 were used by the IBSP to derive regression equations for each constituent. Concentration ranges of the SRWS project summary data sets used, the derived F_σ equations, and the correlations are available at http://bqs.usgs.gov/bsp/regress.htm. *F-pseudosigma* values were calculated for each analytical result using the regression equations provided by the IBSP. *F-pseudosigma* values, which correspond to the appropriate time period and concentration range, were then used as an estimate of standard deviations in equation 1 to calculate Z-values. Concentrations of non-radioactive inorganic constituents, *F-pseudosigma* estimated sample standard deviations, and calculated Z-values are provided in table 2.

Table 1. Radionuclide concentrations and gross radioactivity measurements, and associated estimated standard deviations after purging 1 and 3 borehole volumes of water from selected wells during 2004 and 2005, with statistical comparisons of analytical results, Idaho National Laboratory, Idaho.

[See figures 1 and 2 for location of wells. Analytical results and estimated standard deviations are in picocuries per liter. Shading indicates not statistically comparable at the 95-percent confidence level. Z-value, calculated using equation 1 (a Z-value less than or equal to 1.96 indicates statistical equivalence at the 95-percent confidence level). **Abbreviations**: BHV, borehole volume; CFA, Central Facilities Area; NA, not applicable; NS, not sampled; Repl., replicate sample; SD, estimated standard deviation reported as 1 sigma; USGS, U.S. Geological Survey]

Well identifier	Sample date	Radionuclide concentrations									
		Tritium					Strontium-90				
		1-BHV	SD	3-BHV	SD	Z-value	1-BHV	SD	3-BHV	SD	Z-value
Area 2	10-05-04	-110	120	0	130	0.62	0.2	0.6	1.0	0.6	0.94
IET DISP	10-09-04	-80	120	-40	130	.23	-.2	.7	.4	.7	.61
Site 14	10-12-04	-130	120	-120	120	.06	NS	NS	NS	NS	NA
Site 19	10-04-04	-110	120	-100	120	.06	NS	NS	NS	NS	NA
TRA DISP	10-07-04	4,200	300	3,900	300	.71	-.4	.7	4.1	.9	3.95
USGS 4	10-14-04	-80	120	-60	120	.12	NS	NS	NS	NS	NA
USGS 15	10-12-04	-70	120	-30	130	.23	1.2	.6	1.4	.6	.24
WS INEL 1	10-27-04	-60	120	-80	120	.12	NS	NS	NS	NS	NA
Arbor Test	04-25-05	-90	50	-10	60	1.02	NS	NS	NS	NS	NA
CFA LF 2-10	04-12-05	3,060	160	2,880	160	.80	.5	.7	.1	.8	.38
No Name 1	04-11-05	-80	50	-70	50	.14	.1	.7	1.9	.7	1.82
Site 9	04-28-05	0	60	-40	50	.51	-1.2	.6	-1.1	.6	.12
Site 17	04-27-05	-20	50	-40	50	.28	-.8	.6	-4.2	1.5	2.10
USGS 12	04-21-05	30	60	-70	50	1.28	NS	NS	NS	NS	NA
USGS 22	04-25-05	50	60	30	60	.24	NS	NS	NS	NS	NA
USGS 22, 3-BHV, Repl.	04-25-05	NS	NS	0	60	.35	NS	NS	NS	NS	NA
USGS 103	04-18-05	-70	50	20	60	1.15	NS	NS	NS	NS	NA
USGS 119	03-31-05	-80	50	-50	50	.42	.6	.7	.5	.7	.10

Well identifier	Sample date	Radionuclide concentrations									
		Cesium-137					Americium-241				
		1-BHV	SD	3-BHV	SD	Z-value	1-BHV	SD	3-BHV	SD	Z-value
Area 2	10-05-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
IET DISP	10-09-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
Site 14	10-12-04	-20	20	11.9	22.1	1.07	NS	NS	NS	NS	NA
Site 19	10-04-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
TRA DISP	10-07-04	-14.5	37	-30	40	.28	NS	NS	NS	NS	NA
USGS 4	10-14-04	-12.1	33.2	0	20	.31	NS	NS	NS	NS	NA
USGS 15	10-12-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
WS INEL 1	10-27-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
Arbor Test	04-25-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
CFA LF 2-10	04-12-05	0	30	40	30	.94	NS	NS	NS	NS	NA
No Name 1	04-11-05	40	30	50	40	.20	NS	NS	NS	NS	NA
Site 9	04-28-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
Site 17	04-27-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 12	04-21-05	-20	20	20	20	1.41	NS	NS	NS	NS	NA
USGS 22	04-25-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 103	04-18-05	-15.4	22	-20	40	.10	NS	NS	NS	NS	NA
USGS 119	03-31-05	0	40	40	20	.89	0.006	0.009	0.003	0.008	0.25

Table 1. Radionuclide concentrations and gross radioactivity measurements, and associated estimated standard deviations after purging 1 and 3 borehole volumes of water from selected wells during 2004 and 2005, with statistical comparisons of analytical results, Idaho National Laboratory, Idaho.—Continued

[See figures 1 and 2 for location of wells. Analytical results and estimated standard deviations are in picocuries per liter. Shading indicates not statistically comparable at the 95-percent confidence level. Z-value, calculated using equation 1 (a Z-value less than or equal to 1.96 indicates statistical equivalence at the 95-percent confidence level). **Abbreviations**: BHV, borehole volume; CFA, Central Facilities Area; NA, not applicable; NS, not sampled; Repl., replicate sample; SD, estimated standard deviation reported as 1 sigma; USGS, U.S. Geological Survey]

Well identifier	Sample date	Radionuclide concentrations									
		Plutonium-238					Plutonium-239, -240				
		1-BHV	SD	3-BHV	SD	Z-value	1-BHV	SD	3-BHV	SD	Z-value
Area 2	10-05-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
IET DISP	10-09-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
Site 14	10-12-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
Site 19	10-04-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
TRA DISP	10-07-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 4	10-14-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 15	10-12-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
WS INEL 1	10-27-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
Arbor Test	04-25-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
CFA LF 2-10	04-12-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
No Name 1	04-11-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
Site 9	04-28-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
Site 17	04-27-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 12	04-21-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 22	04-25-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 103	04-18-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 119	03-31-05	0.003	0.005	0.003	0.006	0	0.006	0.006	0.003	0.006	0.35

Well identifier	Sample date	Gross radioactivity measurements									
		Alpha					Beta				
		1-BHV	SD	3-BHV	SD	Z-value	1-BHV	SD	3-BHV	SD	Z-value
Area 2	10-05-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
IET DISP	10-09-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
Site 14	10-12-04	0.3	0.6	1.0	0.8	0.70	1.09	2.15	4	2	0.99
Site 19	10-04-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
TRA DISP	10-07-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 4	10-14-04	.7	.7	.7	.7	0	5	2	5	2	0
USGS 15	10-12-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
WS INEL 1	10-27-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
Arbor Test	04-25-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
CFA LF 2-10	04-12-05	.0	.6	.0	.6	0	3	2	3	2	0
No Name 1	04-11-05	.0	.6	.0	.6	0	1	2	5	2	1.41
Site 9	04-28-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
Site 17	04-27-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 12	04-21-05	.3	.6	.3	.6	0	-1	2	1	2	.71
USGS 22	04-25-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 103	04-18-05	.3	.6	.3	.6	0	1.44	2.26	3	2	.52
USGS 119	03-31-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA

Table 2. Non-radioactive inorganic constituent concentrations and *F-pseudosigma* estimated sample standard deviations after purging 1 and 3 borehole volumes of water from selected wells during 2004 and 2005, with statistical comparisons of analytical results, Idaho National Laboratory, Idaho.

[See figures 1 and 2 for location of wells. Analytical results and *F-pseudosigma* estimated standard deviations are in milligrams per liter (mg/L) or micrograms per liter (µg/L). Shading indicates not statistically comparable at the 95-percent confidence level. **Abbreviations**: BHV, borehole volume; *F-pseudos*, *F-pseudosigma* estimated sample standard deviation; NA, not applicable; NC, not calculated; NS, not sampled; Repl., replicate sample; USGS, U.S. Geological Survey; Z-value, calculated using equation 1 (a Z-value less than or equal to 1.96 suggests statistical equivalence at the 95-percent confidence level); E, estimated; <, less than]

Well identifier	Sample date	Inorganic constituent concentrations									
		Sodium (mg/L)					Chloride (mg/L)				
		1-BHV	*F-pseudos*	3-BHV	*F-pseudos*	Z-value	1-BHV	*F-pseudos*	3-BHV	*F-pseudos*	Z-value
Area 2	10-05-04	16.51	0.698	16.60	0.702	0.09	16.83	0.882	16.77	0.881	0.05
IET DISP	10-09-04	16.91	.715	16.25	.687	.67	20.23	.975	19.20	.947	.76
Site 14	10-12-04	14.83	.627	14.80	.626	.03	8.73	.662	8.74	.662	.01
Site 19	10-04-04	8.91	.377	8.88	.376	.06	10.22	.703	10.12	.700	.10
TRA DISP	10-07-04	11.19	.473	10.97	.464	.33	10.55	.711	10.51	.710	.04
USGS 4	10-14-04	47.24	1.998	47.35	2.003	.04	29.91	1.238	29.88	1.237	.02
USGS 15	10-12-04	15.01	.635	15.10	.639	.10	18.82	.936	18.94	.940	.09
WS INEL 1	10-27-04	17.27	.731	17.39	.736	.12	61.29	2.092	60.90	2.081	.13
Arbor Test	04-25-05	NS	NS	NS	NS	NA	14.46	.818	14.49	.819	.03
CFA LF 2-10	04-12-05	12.69	.537	12.98	.549	.38	33.93	1.347	32.13	1.298	.96
No Name 1	04-11-05	11.05	.467	10.49	.444	.87	20.12	.972	19.49	.955	.46
Site 9	04-28-05	12.50	.529	12.33	.522	.23	14.20	.811	14.22	.811	.02
Site 17	04-27-05	10.33	.437	10.38	.439	.08	9.85	.692	9.82	.692	.03
USGS 12	04-21-05	14.15	.599	14.73	.623	.67	25.62	1.121	26.81	1.154	.74
USGS 22	04-25-05	21.62	.915	22.86	.967	.93	62.07	2.113	63.63	2.155	.52
USGS 22, 3-BHV, Repl.	04-25-05	NS	NS	23.87	1.010	.72	NS	NS	64.05	2.167	.14
USGS 103	04-18-05	15.48	.655	15.03	.636	.49	17.10	.890	17.13	.890	.02
USGS 119	03-31-05	10.78	.456	10.63	.450	.23	10.02	.697	9.69	.688	.34

Well identifier	Sample date	Inorganic constituent concentrations									
		Ammonia (mg/L)					Phosphate (mg/L)				
		1-BHV	*F-pseudos*	3-BHV	*F-pseudos*	Z-value	1-BHV	*F-pseudos*	3-BHV	*F-pseudos*	Z-value
Area 2	10-05-04	<0.04	NA	<0.04	NA	0	<0.018	NA	<0.018	NA	0
IET DISP	10-09-04	.529	0.037	.501	0.036	.54	.164	0.008	.157	0.007	.66
Site 14	10-12-04	<.04	NA	<.04	NA	0	.010E	NA	<.018	NA	0
Site 19	10-04-04	<.04	NA	<.04	NA	0	.031	NC	.027	NC	NA
TRA DISP	10-07-04	<.04	NA	<.04	NA	0	.031	NC	.027	NC	NA
USGS 4	10-14-04	<.04	NA	<.04	NA	0	.015E	NA	.015E	NA	0
USGS 15	10-12-04	<.04	NA	<.04	NA	0	.013E	NA	.015E	NA	0
WS INEL 1	10-27-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
Arbor Test	04-25-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
CFA LF 2-10	04-12-05	<.04	NA	<.04	NA	0	.013E	NA	.014E	NA	0
No Name 1	04-11-05	<.04	NA	<.04	NA	0	.013E	NA	.012E	NA	0
Site 9	04-28-05	<.04	NA	<.04	NA	0	<.018	NA	<.018	NA	0
Site 17	04-27-05	<.04	NA	<.04	NA	0	.011E	NA	.010E	NA	0
USGS 12	04-21-05	<.04	NA	<.04	NA	0	.017E	NA	.017E	NA	0
USGS 22	04-25-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 103	04-18-05	<.04	NA	<.04	NA	0	<.018	NA	<.018	NA	0
USGS 119	03-31-05	<.04	NA	<.04	NA	0	<.018	NA	<.018	NA	0

Table 2. Non-radioactive inorganic constituent concentrations and *F-pseudosigma* estimated sample standard deviations after purging 1 and 3 borehole volumes of water from selected wells during 2004 and 2005, with statistical comparisons of analytical results, Idaho National Laboratory, Idaho.—Continued

[See figures 1 and 2 for location of wells. Analytical results and *F-pseudosigma* estimated standard deviations are in milligrams per liter (mg/L) or micrograms per liter (μg/L). Shading indicates not statistically comparable at the 95-percent confidence level. **Abbreviations**: BHV, borehole volume; *F-pseudos*, *F-pseudosigma* estimated sample standard deviation; NA, not applicable; NC, not calculated; NS, not sampled; Repl., replicate sample; USGS, U.S. Geological Survey; Z-value, calculated using equation 1 (a Z-value less than or equal to 1.96 suggests statistical equivalence at the 95-percent confidence level); E, estimated; <, less than]

Well identifier	Sample date	Inorganic constituent concentrations									
		Nitrate (mg/L)					Sulfate (mg/L)				
		1-BHV	*F-pseudos*	3-BHV	*F-pseudos*	Z-value	1-BHV	*F-pseudos*	3-BHV	*F-pseudos*	Z-value
Area 2	10-05-04	1.301	0.072	1.293	0.072	0.08	15.48	0.917	15.36	0.913	0.09
IET DISP	10-09-04	.227	.013	.369	.020	5.95	31.77	1.505	31.77	1.505	0
Site 14	10-12-04	.587	.033	.588	.033	.02	NS	NS	NS	NS	NA
Site 19	10-04-04	1.050	.058	1.043	.058	.09	21.03	1.117	21.04	1.118	.01
TRA DISP	10-07-04	1.050	.058	1.043	.058	.09	33.02	1.550	32.76	1.541	.12
USGS 4	10-14-04	4.498	NC	4.540	NC	NA	NS	NS	NS	NS	NA
USGS 15	10-12-04	1.266	.070	1.289	.071	.23	25.46	1.277	25.56	1.281	.06
WS INEL 1	10-27-04	NS	NS	NS	NS	NA	39.06	1.768	38.94	1.764	.05
Arbor Test	04-25-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
CFA LF 2-10	04-12-05	1.505	.083	1.480	.082	.21	NS	NS	NS	NS	NA
No Name 1	04-11-05	.611	.034	.629	.035	.37	NS	NS	NS	NS	NA
Site 9	04-28-05	.665	.037	.681	.038	.30	24.18	1.231	24.65	1.248	.27
Site 17	04-27-05	.965	.053	.969	.054	.05	19.70	1.069	19.58	1.065	.08
USGS 12	04-21-05	1.659	.092	1.746	.097	.65	29.22	1.413	29.97	1.440	.37
USGS 22	04-25-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 103	04-18-05	.867	.048	.875	.048	.12	NS	NS	NS	NS	NA
USGS 119	03-31-05	1.430	.079	1.490	.083	.52	40.15	1.807	37.22	1.702	1.18

Well identifier	Sample date	Inorganic constituent concentrations									
		Chromium (μg/L)					Antimony (μg/L)				
		1-BHV	*F-pseudos*	3-BHV	*F-pseudos*	Z-value	1-BHV	*F-pseudos*	3-BHV	*F-pseudos*	Z-value
Area 2	10-05-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
IET DISP	10-09-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
Site 14	10-12-04	6.18	NC	6.50	NC	NA	NS	NS	NS	NS	NA
Site 19	10-04-04	5.74	NC	5.51	NC	NA	NS	NS	NS	NS	NA
TRA DISP	10-07-04	13.09	1.121	12.06	1.072	0.66	NS	NS	NS	NS	NA
USGS 4	10-14-04	10.16	.981	10.40	.992	.17	NS	NS	NS	NS	NA
USGS 15	10-12-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
WS INEL 1	10-27-04	8.96	.923	10.00	.973	.78	NS	NS	NS	NS	NA
Arbor Test	04-25-05	3.25	NC	3.55	NC	NA	NS	NS	NS	NS	NA
CFA LF 2-10	04-12-05	11.68	1.054	12.12	1.075	.29	NS	NS	NS	NS	NA
No Name 1	04-11-05	7.72	.864	8.32	.892	.48	0.169E	NA	0.178E	NA	0
Site 9	04-28-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
Site 17	04-27-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 12	04-21-05	10.57	1.000	10.19	.982	.27	NS	NS	NS	NS	NA
USGS 22	04-25-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 103	04-18-05	8.21	.887	8.36	.894	.12	NS	NS	NS	NS	NA
USGS 119	03-31-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA

Table 2. Non-radioactive inorganic constituent concentrations and *F-pseudosigma* estimated sample standard deviations after purging 1 and 3 borehole volumes of water from selected wells during 2004 and 2005, with statistical comparisons of analytical results, Idaho National Laboratory, Idaho.—Continued

[See figures 1 and 2 for location of wells. Analytical results and *F-pseudosigma* estimated standard deviations are in milligrams per liter (mg/L) or micrograms per liter (µg/L). Shading indicates not statistically comparable at the 95-percent confidence level. **Abbreviations**: BHV, borehole volume; *F-pseudos*, *F-pseudosigma* estimated sample standard deviation; NA, not applicable; NC, not calculated; NS, not sampled; Repl., replicate sample; USGS, U.S. Geological Survey; Z-value, calculated using equation 1 (a Z-value less than or equal to 1.96 suggests statistical equivalence at the 95-percent confidence level); E, estimated; <, less than]

Well identifier	Sample date	Inorganic constituent concentrations									
		Arsenic (µg/L)					Lead (µg/L)				
		1-BHV	*F-pseudos*	3-BHV	*F-pseudos*	Z-value	1-BHV	*F-pseudos*	3-BHV	*F-pseudos*	Z-value
Area 2	10-05-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
IET DISP	10-09-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
Site 14	10-12-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
Site 19	10-04-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
TRA DISP	10-07-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 4	10-14-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 15	10-12-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
WS INEL 1	10-27-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
Arbor Test	04-25-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
CFA LF 2-10	04-12-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
No Name 1	04-11-05	2.384	0.552	2.14	0.538	0.32	< 0.08	NA	< 0.08	NA	0
Site 9	04-28-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
Site 17	04-27-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 12	04-21-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 22	04-25-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 103	04-18-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 119	03-31-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA

Well identifier	Sample date	Inorganic constituent concentrations									
		Mercury (µg/L)					Nickel (µg/L)				
		1-BHV	*F-pseudos*	3-BHV	*F-pseudos*	Z-value	1-BHV	*F-pseudos*	3-BHV	*F-pseudos*	Z-value
Area 2	10-05-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
IET DISP	10-09-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
Site 14	10-12-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
Site 19	10-04-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
TRA DISP	10-07-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 4	10-14-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 15	10-12-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
WS INEL 1	10-27-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
Arbor Test	04-25-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
CFA LF 2-10	04-12-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
No Name 1	04-11-05	< 0.010	NA	< 0.010	NA	0	2.60	0.907	2.83	0.918	0.18
Site 9	04-28-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
Site 17	04-27-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 12	04-21-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 22	04-25-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 103	04-18-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 119	03-31-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA

Table 2. Non-radioactive inorganic constituent concentrations and *F-pseudosigma* estimated sample standard deviations after purging 1 and 3 borehole volumes of water from selected wells during 2004 and 2005, with statistical comparisons of analytical results, Idaho National Laboratory, Idaho.—Continued

[See figures 1 and 2 for location of wells. Analytical results and *F-pseudosigma* estimated standard deviations are in milligrams per liter (mg/L) or micrograms per liter (µg/L). Shading indicates not statistically comparable at the 95-percent confidence level. **Abbreviations**: BHV, borehole volume; *F-pseudos*, *F-pseudosigma* estimated sample standard deviation; NA, not applicable; NC, not calculated; NS, not sampled; Repl., replicate sample; USGS, U.S. Geological Survey; Z-value, calculated using equation 1 (a Z-value less than or equal to 1.96 suggests statistical equivalence at the 95-percent confidence level); E, estimated; <, less than]

Well identifier	Sample date	Inorganic constituent concentrations									
		Thallium (µg/L)					Zinc (µg/L)				
		1-BHV	*F-pseudos*	3-BHV	*F-pseudos*	Z-value	1-BHV	*F-pseudos*	3-BHV	*F-pseudos*	Z-value
Area 2	10-05-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
IET DISP	10-09-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
Site 14	10-12-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
Site 19	10-04-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
TRA DISP	10-07-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 4	10-14-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 15	10-12-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
WS INEL 1	10-27-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
Arbor Test	04-25-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
CFA LF 2-10	04-12-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
No Name 1	04-11-05	< 0.04	NA	< 0.04	NA	0	< 0.60	NA	< 0.060	NA	0
Site 9	04-28-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
Site 17	04-27-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 12	04-21-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 22	04-25-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 103	04-18-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 119	03-31-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA

Organic Constituents

The NWQL also does not report standard deviations with analytical results for organic constituents. As a result, approximations of standard deviations were used when appropriate. The Organic Blind Sample Program (OBSP) uses a *F-pseudosigma* method similar to the method described for non-radioactive inorganic constituents to estimate the sample standard deviations for total organic carbon (TOC) measurements in water samples. The *F-pseudosigma* equation is available at http://bqs.usgs.gov/OBSP/WY05Plots/TSbodyLC114TOTAL_ORGANIC_CARBON.html. Concentrations of TOC, *F-pseudosigma* estimated sample standard deviations, and calculated Z-values are provided in table 3. For purgeable organic compounds (POC's), analytical results were less than the respective MRL's for 61 sample pairs in each of 3 water samples. As a result, all 183 Z-values for POC's were set to zero (table 3).

Table 3. Total organic carbon and purgeable organic compound concentrations and *F-pseudosigma* estimated sample standard deviations after purging 1 and 3 borehole volumes of water from selected wells during 2004 and 2005, with statistical comparisons of analytical results, Idaho National Laboratory, Idaho.

[See figures 1 and 2 for location of wells. Analytical results and *F-pseudosigma* uncertainties are in milligrams per liter (mg/L) or micrograms per liter (μg/L). Shading indicates not statistically comparable at the 95-percent confidence level. Z-value, calculated using equation 1 (a Z-value less than or equal to 1.96 suggests statistical equivalence at the 95-percent confidence level). **Abbreviations**: BHV, borehole volume; *F-pseudos*, *F-pseudosigma* (estimated sample standard deviation reported as 1 sigma); MRL, minimum reporting level; NA, not applicable; NS, not sampled; USGS, U.S. Geological Survey; <, less than]

Well identifier	Sample date	Total organic carbon (mg/L)					Purgeable organic compounds (μg/L)				
		1-BHV	*F-pseudos*	3-BHV	*F-pseudos*	Z-value	1-BHV	*F-pseudos*	3-BHV	*F-pseudos*	Z-value
Area 2	10-05-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
IET DISP	10-09-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
Site 14	10-12-04	<0.4	0.000	<0.4	0.000	0	NS	NS	NS	NS	NA
Site 19	10-04-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
TRA DISP	10-07-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 4	10-14-04	2.08	.354	1.358	.231	1.71	NS	NS	NS	NS	NA
USGS 15	10-12-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
WS INEL 1	10-27-04	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
Arbor Test	04-25-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
CFA LF 2-10	04-12-05	2.53	.348	.52	.072	5.66	NS	NS	NS	NS	NA
No Name 1	04-11-05	<.4	.000	4.526	.623	2.82	[1]61<MRL	[2]61 = NA	[1]61<MRL	[2]61 = NA	[3]61 = 0
Site 9	04-28-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
Site 17	04-27-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 12	04-21-05	5.76	.793	5.39	.741	0.34	[1]61<MRL	[2]61 = NA	[1]61<MRL	[2]61 = NA	[3]61 = 0
USGS 22	04-25-05	NS	NS	NS	NS	NA	NS	NS	NS	NS	NA
USGS 103	04-18-05	4.06	.559	1.94	.267	3.42	NS	NS	NS	NS	NA
USGS 119	03-31-05	NS	NS	NS	NS	NA	[1]61<MRL	[2]61 = NA	[1]61<MRL	[2]61 = NA	[3]61 = 0

[1]Sixty-one compounds are less than the minimum reporting levels.

[2]Calculation of *F-pseudosigma* estimated sample standard deviation is not applicable for 61 compounds.

[3]Z-value is set to 0 for 61 compounds.

Qualitative Evaluation of Well-Purging Effects on Water-Quality Results

A qualitative evaluation was initiated to determine if water-quality data collected during October-November 2003 from 30 wells (in the RCRA-listed waste polygon) were consistent with water-quality data collected from the same wells since 1990. October-November 2003 water-quality data were collected at each of the 30 wells for each constituent included in the USGS's routine sample-collection program and plotted on graphs (figs. 3-32, at back of report) along with water-quality data collected since 1990. Water-quality data used to plot the constituent graphs are available at http://water.usgs.gov/nwis/. Graphic water-quality data for the 30 wells (figs. 3-32) were visually inspected to determine if apparent water-quality data trends met one of four criteria: (1) increasing concentrations continued to increase, or (2) decreasing concentrations continued to decrease, or (3) constant concentrations remained constant, or (4) October-November 2003 data were consistent with long-term ranges of water-quality data when no apparent concentration trends existed. If constituents met one of these criteria, the conclusion was that purging either 1 or 3 wellbore volumes from the well did not affect data comparability.

Constituent data examples that met one of the above criteria include:

- Sulfate concentrations for well USGS 34 (fig. 4) and chloride, nitrate, and sodium concentrations for well USGS 40 (fig. 10) exhibited short-term increasing trends since about 2000 and corresponding concentrations for the October-November 2003 samples followed the same pattern;
- Tritium concentrations for well USGS 37 (fig. 7) exhibited a decreasing trend since 1990 and the tritium concentration for the October-November 2003 sample followed the same pattern;
- Fluoride concentrations for well USGS 77 (fig. 23) since 1990 and sulfate concentrations for well USGS 111 (fig. 26) since about 1997 exhibited relatively constant trends and corresponding concentrations for the October-November 2003 samples followed the same pattern; and
- Nitrate, sodium, and strontium-90 concentrations for well USGS 47 (fig. 17) during October-November 2003 increased from previous sample concentrations, but were within the historical range of concentrations for those constituents.

The visual inspection of 322 constituent plots in figs. 3-32 indicated that nearly all plots met one or two of the four criteria identified for data comparability. Six constituent plots and three field-measurement plots did not meet any of the criteria. These included sodium concentrations for wells USGS 57 and 115 (figs. 22, 30), sulfate concentrations for wells USGS 42, 43, and 57 (figs. 12, 13, 22), pH measurements for wells USGS 47 and 112 (figs. 17, 27), temperature measurements for well USGS 111 (fig. 26), and cesium-137 concentrations for well USGS 113 (fig. 28). In each instance, concentrations or measurements for the October-November 2003 samples were 14-year minimums and did not follow any trend. All cesium-137 concentrations at well USGS 113 for the 10-year period of record were less than the radionuclide reporting level of three times the standard deviation and were within two standard deviations of each other (fig. 28). As a result, cesium-137 for the October-November sample is considered comparable to historical data. When cesium-137 is included with the 313 constituent plots or measurements that met one or more of the acceptance criteria for data comparability, 97.5 percent were comparable.

The remaining eight constituent or measurement plots did not follow any trend or fall within the historical range of water-quality data and were not considered comparable; however, concentrations or measurements did plot near the mean values for the period of record. The October-November 2003 pH measurements (7.6 pH units at well USGS 47 and 7.5 pH units at well USGS 112) (figs. 17, 27) were within 0.1 and 0.2 pH units of the previous minimums (7.7 and 7.7 pH units in 2001 and 1994, respectively) and within 0.3 and 0.4 pH units of the respective mean concentrations (7.9 and 7.9 pH units). The October-November 2003 temperature measurement of 12.5°C at well USGS 111 (fig. 26) was within 0.2°C of the previous minimum (12.7°C in 1995) and within 0.8°C of the 13-year mean (13.3°C). The October-November 2003 sodium concentrations (30 mg/L at well USGS 57 and 10 mg/L at well USGS 115) (figs. 22, 30) were within 8 and 3 mg/L of the previous minimums (38 and 13 mg/L in 2001 and 1991, respectively) and within 27 and 4 mg/L of the respective mean concentrations (57 and 14 mg/L). The October-November 2003 sulfate concentrations (22 mg/L at well USGS 42, 22 mg/L at well USGS 43, and 27 mg/L at well USGS 57) (figs. 12, 13, 22) were within 2, 1, and 2 mg/L of the previous minimums (24, 23, and 29 mg/L in 2001, 1998, and 2000, respectively) and within 3, 2, and 4 mg/L of the respective mean concentrations (25, 24, and 31 mg/L).

Because of the good qualitative agreement between the October-November 2003 water-quality data and the corresponding historical water-quality data, there is no indication that the change from purging 3 wellbore volumes of water to purging 1 wellbore volume of water (for the 30 wells in the RCRA listed-waste polygon) has an effect on the comparability of water-quality data.

Quantitative Evaluation of Well-Purging Effects on Water-Quality Results

A quantitative evaluation was initiated to determine if water-quality data from samples collected after purging 1 and 3 wellbore volumes of water were statistically equivalent at a 95-percent confidence level. Water samples were collected from 17 INL wells with long purge times (figs. 1, 2). One quality assurance replicate sample also was collected for evaluation. Equation 1 was used to evaluate the statistical equivalence of 337 constituent pairs using (1) standard deviations reported by the analytical laboratory for radiochemical measurements, and (2) estimated standard deviations for non-radioactive constituents. Regression equations used to calculate the *F-pseudosigma* estimates of standard deviation are available at http://bqs.usgs.gov/bsp/regress.htm. Equation 1 also was used to re-evaluate 63 constituent pairs generated from water samples collected at 11 wells (figs. 1, 2) by Bartholomay (1993). Bartholomay collected samples from 10 wells during spring and autumn and at the TRA DISP well (fig. 1) during autumn after purging 1, 2, and 3 wellbore volumes from the wells. Analytical results for the samples, standard deviations, and calculated Z-values are provided in tables 1-4. If the Z-value was less than 1.96, the sample pair was considered equivalent at the 95-percent confidence level.

Samples collected for this study after purging 1 and 3 wellbore volumes of water from a well were considered a sample pair. Sample pairs from the 17 wells along with the quality assurance replicate sample from USGS 22 (fig. 1, tables 1-3) generated 337 constituent pairs for evaluation using equation 1. Z-values for 331 pairs (98.2 percent) were less than 1.96 and were considered equivalent (tables 1-3).

Samples collected by Bartholomay (1993) after purging 1, 2, and 3 wellbore volumes were analyzed for tritium and strontium-90 and the results were compared using a statistical technique derived from a test method recommended by the American Society for Testing and Materials (1988). To consider the Bartholomay (1993) results in this study, equation 1 was used to re-evaluate his tritium and strontium-90 data. Samples collected by Bartholomay (1993) after purging 1 and 3, 1 and 2, and 2 and 3 wellbore volumes of water from a well were considered sample pairs. The 63 sample pairs from the 11 wells generated 126 constituent pairs for evaluation. Z-values for 120 pairs (95.2 percent) were less than 1.96 and were considered equivalent (table 4). A further breakdown of data from Bartholomay (1993) indicates that statistical equivalence is slightly stronger in autumn (97 percent) than in spring (93.3 percent). Additionally, agreement is slightly better between 1 and 2 wellbore volumes (97.6 percent) than between 1 and 3 wellbore volumes (95.2 percent) or between 2 and 3 wellbore volumes (92.8 percent).

Table 4. Tritium and strontium-90 concentrations, and associated estimated standard deviations after purging 1, 2, and 3 borehole volumes of water from selected wells during 1991, with statistical comparisons of analytical results, Idaho National Laboratory, Idaho.

[See figures 1 and 2 for location of wells. Analytical results and estimated standard deviations are in picocuries per liter. Shading indicates not statistically comparable at the 95-percent confidence level. **Sample pairs** from Bartholomay (1993, table 3); **Abbreviations**: BHV, borehole volume; SD, estimated standard deviation reported as 1-sigma; USGS, U.S. Geological Survey; Z, Z-value calculated using equation 1 (a Z-value less than or equal to 1.96 indicates statistical equivalence at the 95-percent confidence level)]

Well identifier	Sample date	Tritium concentrations								
		1-BHV	SD	2-BHV	SD	3-BHV	SD	Sample pairs		
								Z 1-3 BHV	Z 1-2 BHV	Z 2-3 BHV
Site 9	04-09-91	10	160	-110	160	50	160	0.18	0.53	0.71
	09-27-91	10	170	10	170	-50	170	.25	0	.25
Site 14	04-24-91	50	160	170	170	-20	160	.31	.51	.81
	10-18-91	0	200	100	200	-30	170	.11	.35	.50
Site 19	04-02-91	110	160	-40	160	-50	160	.71	.66	.04
	10-22-91	10	170	0	200	10	170	0	.04	.04
TRA DISP	10-30-91	7,700	400	7,300	400	6,900	300	1.60	.71	.80
USGS 38	04-22-91	28,600	700	28,600	700	27,600	700	1.01	0	1.01
	10-03-91	25,600	700	25,700	700	26,300	700	.71	.10	.61
USGS 59	04-04-91	5,300	300	6,300	300	4,900	300	.94	2.36	3.30
	10-21-91	19,100	600	18,900	600	19,300	600	.24	.24	.47
USGS 82	03-27-91	1,100	200	1,200	200	1100	200	0	.35	.35
	10-23-91	150	170	150	170	100	200	.19	0	.19
USGS 83	03-25-91	-50	160	-50	160	20	160	.31	0	.31
	10-01-91	100	200	-80	170	0	200	.35	.69	.30
USGS 107	04-22-91	110	160	60	160	-70	160	.80	.22	.57
	09-30-91	100	200	-80	170	0	170	.38	.69	.33
USGS 110	03-26-91	210	170	-170	150	20	160	.81	1.68	.87
	10-07-91	-150	160	100	200	-30	170	.51	.98	.50
USGS 119	04-19-91	70	160	150	170	0	160	.31	.34	.64
	10-15-91	150	170	-130	160	-140	160	1.24	1.20	.04

Well identifier	Sample date	Strontium-90 concentrations								
		1-BHV	SD	2-BHV	SD	3-BHV	SD	Sample pairs		
								Z 1-3 BHV	Z 1-2 BHV	Z 2-3 BHV
Site 9	04-09-91	-0.2	1.5	0.7	1.6	-0.8	1.5	0.28	0.41	0.68
	09-27-91	-5.0	2.0	-6.0	2.0	-6.0	2.0	.35	.35	0
Site 14	04-24-91	-1.6	1.8	0	2.0	0	2.0	.59	.59	0
	10-18-91	0	2.0	1.0	2.0	1.3	2.4	.42	.35	.10
Site 19	04-02-91	1.7	2.0	3.0	2.0	1.1	1.9	.22	.46	.69
	10-22-91	0	2.0	4.0	2.0	-1.3	2.3	.43	1.41	1.74
TRA DISP	10-30-91	-.9	1.7	.8	1.6	-0.4	1.5	.22	.73	.55
USGS 38	04-22-91	26.0	3.0	28.0	3.0	29.0	3.0	.71	.47	.24
	10-03-91	23.0	3.0	27.0	5.0	9.0	3.0	3.30	.69	3.09
USGS 59	04-04-91	13.0	3.0	16.0	3.0	13.0	3.0	0	.71	.71
	10-21-91	18.0	3.0	17.0	3.0	14.0	2.0	1.11	.24	.83
USGS 82	03-27-91	-3.1	1.7	0	2.0	8.0	2.0	4.23	1.18	2.83
	10-23-91	-1.0	2.0	-1.2	2.1	-2.0	2.0	.35	.07	.28
USGS 83	03-25-91	-3.7	1.5	-4.4	1.5	-3.8	1.5	.05	.33	.28
	10-01-91	-1.4	1.9	-2.0	2.0	-2.0	2.0	.22	.22	0
USGS 107	04-22-91	-1.0	2.0	-1.0	2.0	-1.0	2.0	0	0	0
	09-30-91	1.0	2.0	1.0	2.0	2.0	2.0	.35	0	.35
USGS 110	03-26-91	-3.6	1.7	-1.2	2.0	-3.0	2.0	.23	.91	.64
	10-07-91	-1.0	2.0	-1.0	2.2	0	2.0	.35	0	.34
USGS 119	04-19-91	.7	1.7	0	1.6	4.0	2.0	1.26	.30	1.56
	10-15-91	-1.0	2.0	-3.0	2.0	1.4	2.1	.83	.71	1.52

When all 1 and 3 wellbore volume constituent pairs were considered together, 371 of 379 pairs (97.9 percent) were statistically equivalent. When the 1 and 2 or the 2 and 3 wellbore volume constituent pairs were included, 451 of 463 (97.4 percent) were statistically equivalent.

Because of the good quantitative agreement between constituent pairs, there is no indication that changing from purging 3 wellbore volumes of water to purging 1 wellbore volume of water effected comparability of water-quality data. On the basis of a smaller data set from Bartholomay (1993), it appears that purging 2 wellbore volumes also is an acceptable practice for data comparability.

Observations

Comparability of water-quality data determined from both the qualitative evaluation (97.5 percent comparable) and the quantitative evaluation (97.9 percent comparable) indicates that the change from purging 3 to 1 wellbore volumes had no discernible effect on comparability of water-quality data at the INL. However, the qualitative evaluation was limited by a small data set. Only October-November 2003 data were available for comparison to historical data.

This comparability of water-quality data is not surprising considering the character of the ESRPA. The ESRPA is mostly an unconfined aquifer and chemical equilibrium with atmospheric gases (such as dissolved oxygen and dissolved carbon dioxide) is maintained in the ground water. Carbon dioxide establishes a buffering process that stabilizes pH in the ESRPA (figs. 3-32). Similarly, the ESRPA is saturated with dissolved oxygen except for areas where organic compounds were introduced by waste disposal. Dissolved oxygen maintains oxidizing conditions in the ground water and stabilizes oxidation-reduction processes in the aquifer, which favors development of the oxidized species such as sulfate and nitrate. The combination of these conditions decreases the tendency of ground water to undergo rapid chemical change because water standing in an open borehole in the unconfined ESRPA is chemically the same as water in the aquifer, and both are in equilibrium with the atmosphere.

Barcelona and others (2005) found that water chemistry from wells in high-permeability materials stabilized after purging only one-half wellbore volume of water from a well. For both the high- and low-permeability wells, stabilization of field water-quality parameters was the principal indicator of chemical stability, one of the ESRPA sample-collection criteria. The ESRPA generally is a high-permeability aquifer, which likely accounts for the comparability of water-quality data. In the Barcelona and others (2005) study, small flow rates (<0.5 L/min) were used for purging and sampling. As a result, their conclusions are not directly comparable to the conclusions of this study.

Summary and Conclusions

This report presents qualitative and quantitative comparisons of water-quality data from the Idaho National Laboratory to determine if the change from purging 3 wellbore volumes to 1 wellbore volume has a discernible effect on the comparability of data. Historical water-quality data for 30 wells were visually compared to water-quality data collected after purging only 1 wellbore volume of water from the same 30 wells. Of the 322 qualitatively examined constituent plots, 97.5 percent met one or more of the criteria established for determining data comparability. A simple statistical equation to determine if water-quality data collected from 17 wells with long purge times (after pumping 1 and 3 wellbore volumes of water) were statistically the same at the 95-percent confidence level indicated that 98.2 percent of 337 constituent pairs were equivalent. The same simple statistical equation to determine if water-quality data collected during a previous study from 11 wells at the Idaho National Laboratory with long purge times (after pumping 1, 2, and 3 wellbore volumes) were statistically the same at the 95-percent confidence level indicated that 95.2 percent of 126 constituent pairs were equivalent. When all 1 and 3 wellbore volume constituent pairs were considered together, 371 of 379 pairs (97.9 percent) were statistically equivalent.

Comparability of water-quality data determined from both the qualitative (97.5 percent comparable) and quantitative evaluations (97.9 percent comparable) indicated that the change from purging 3 to 1 wellbore volumes had no discernible effect on comparability of water-quality data at the Idaho National Laboratory. However, the qualitative evaluation was limited by a small data set. Only October-November 2003 data were available for comparison to historical data.

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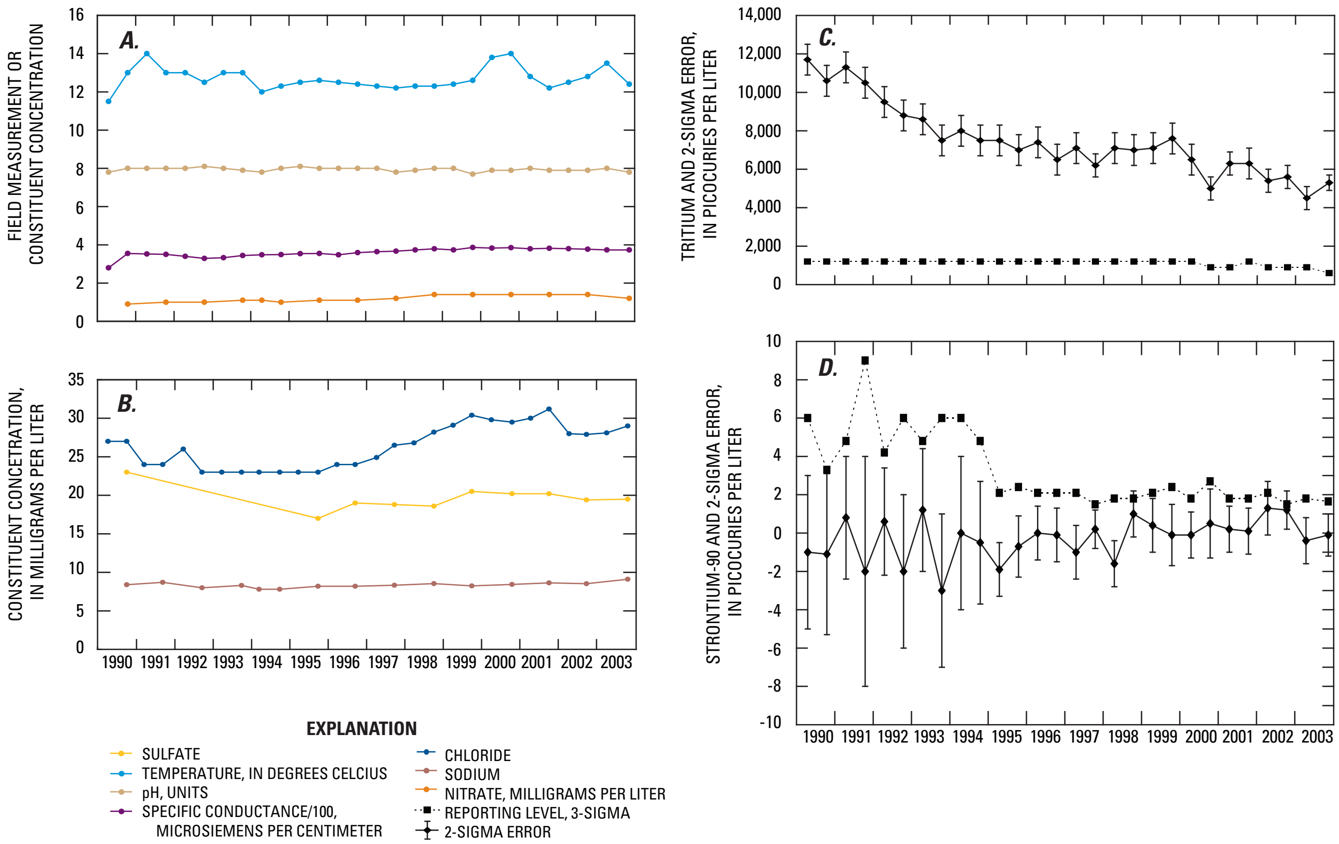


Figure 3. Water-quality data for well USGS 20, 1990-2003, with corresponding data for October-November 2003, Idaho National Laboratory, Idaho.

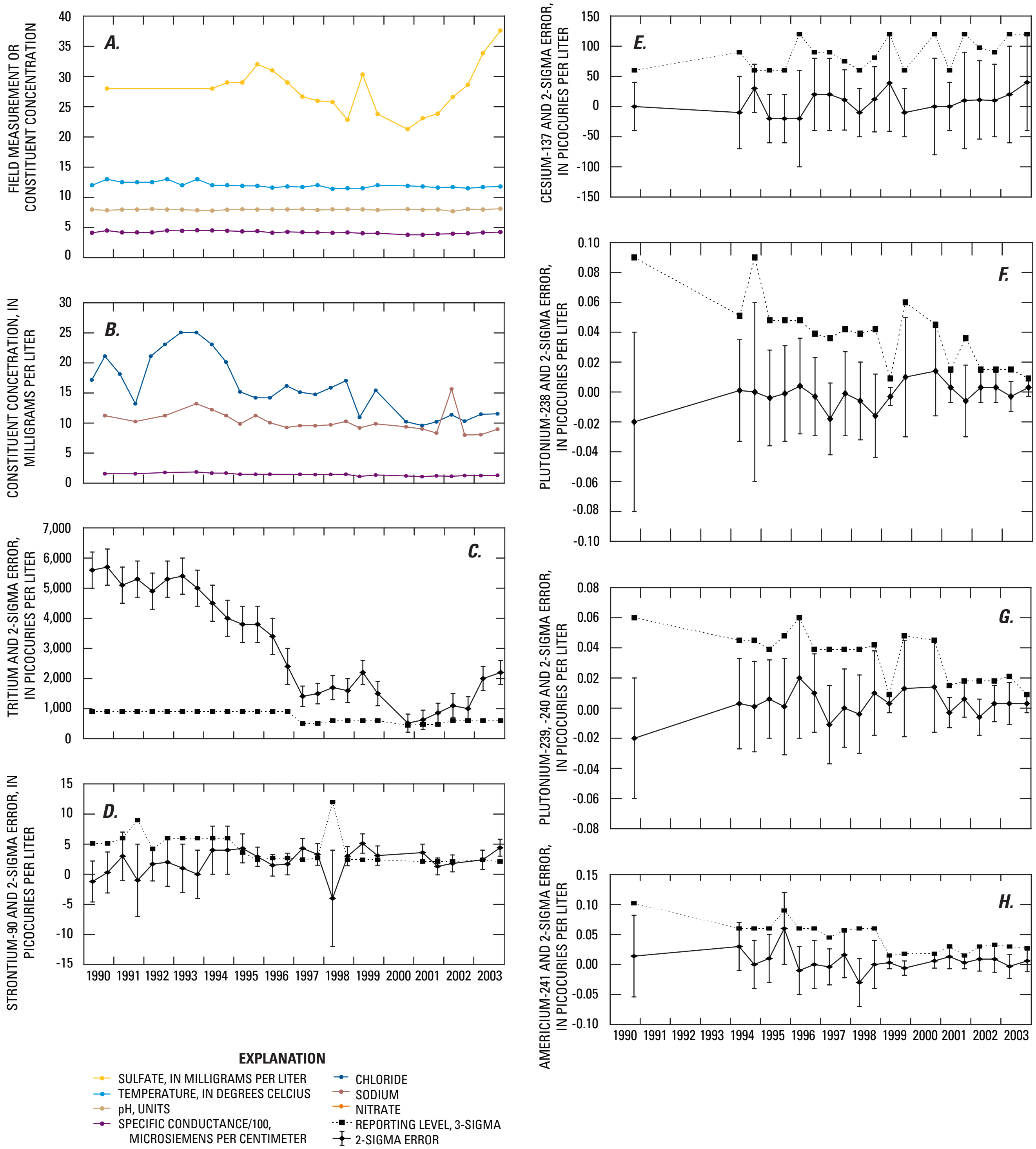


Figure 4. Water-quality data for well USGS 34, 1990-2003, with corresponding data for October-November 2003, Idaho National Laboratory, Idaho.

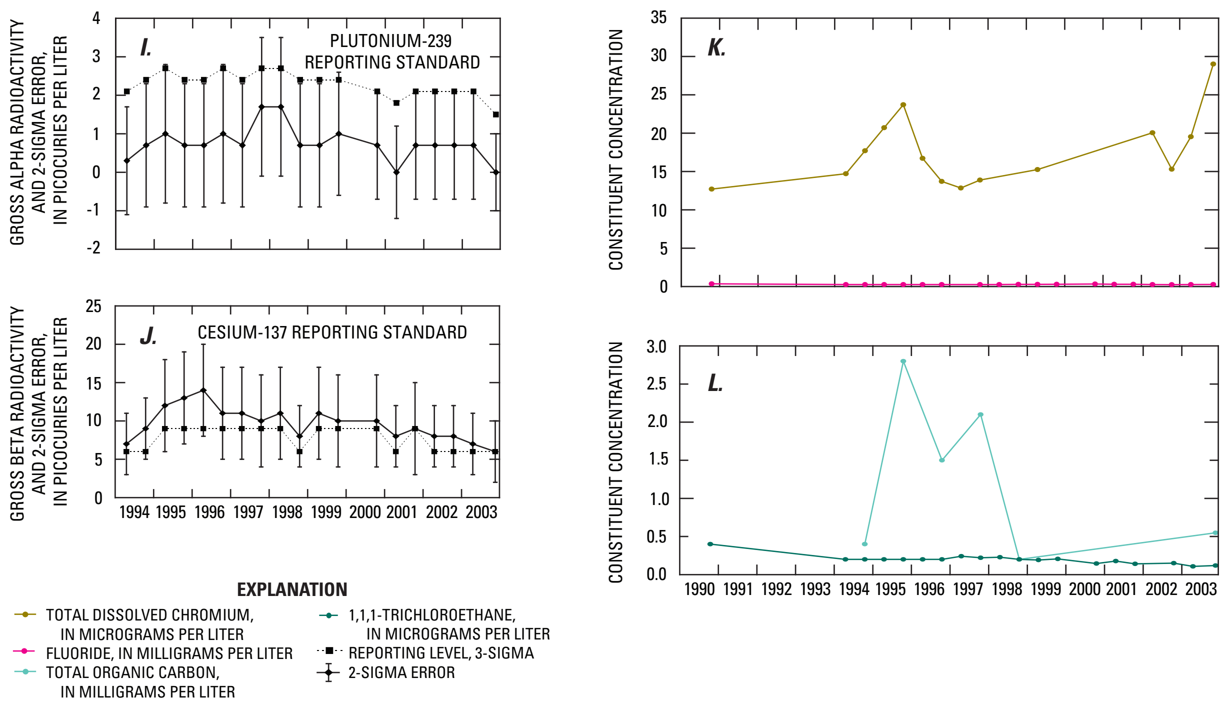


Figure 4. Continued.

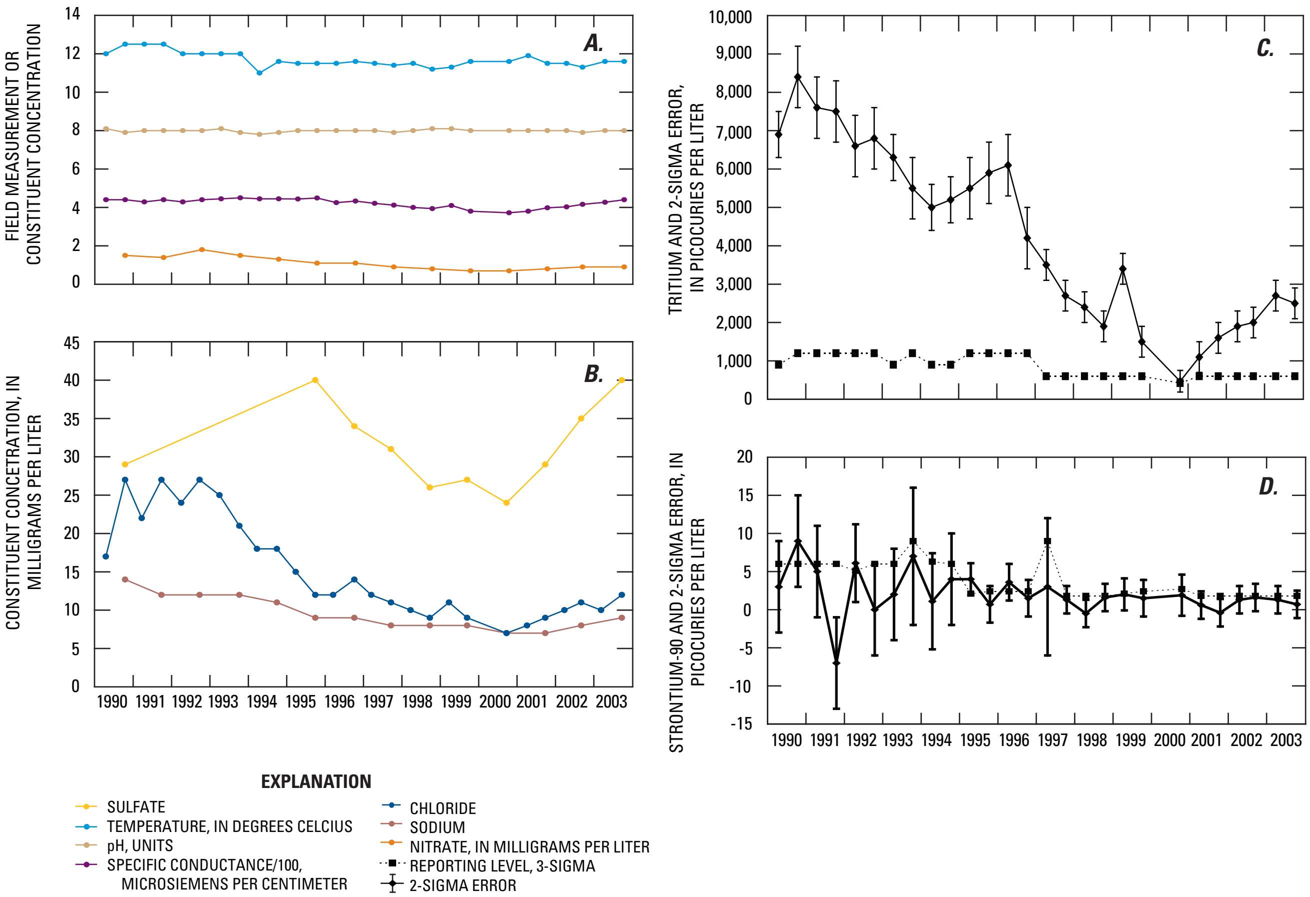


Figure 5. Water-quality data for well USGS 35, 1990-2003, with corresponding data for October-November 2003, Idaho National Laboratory, Idaho.

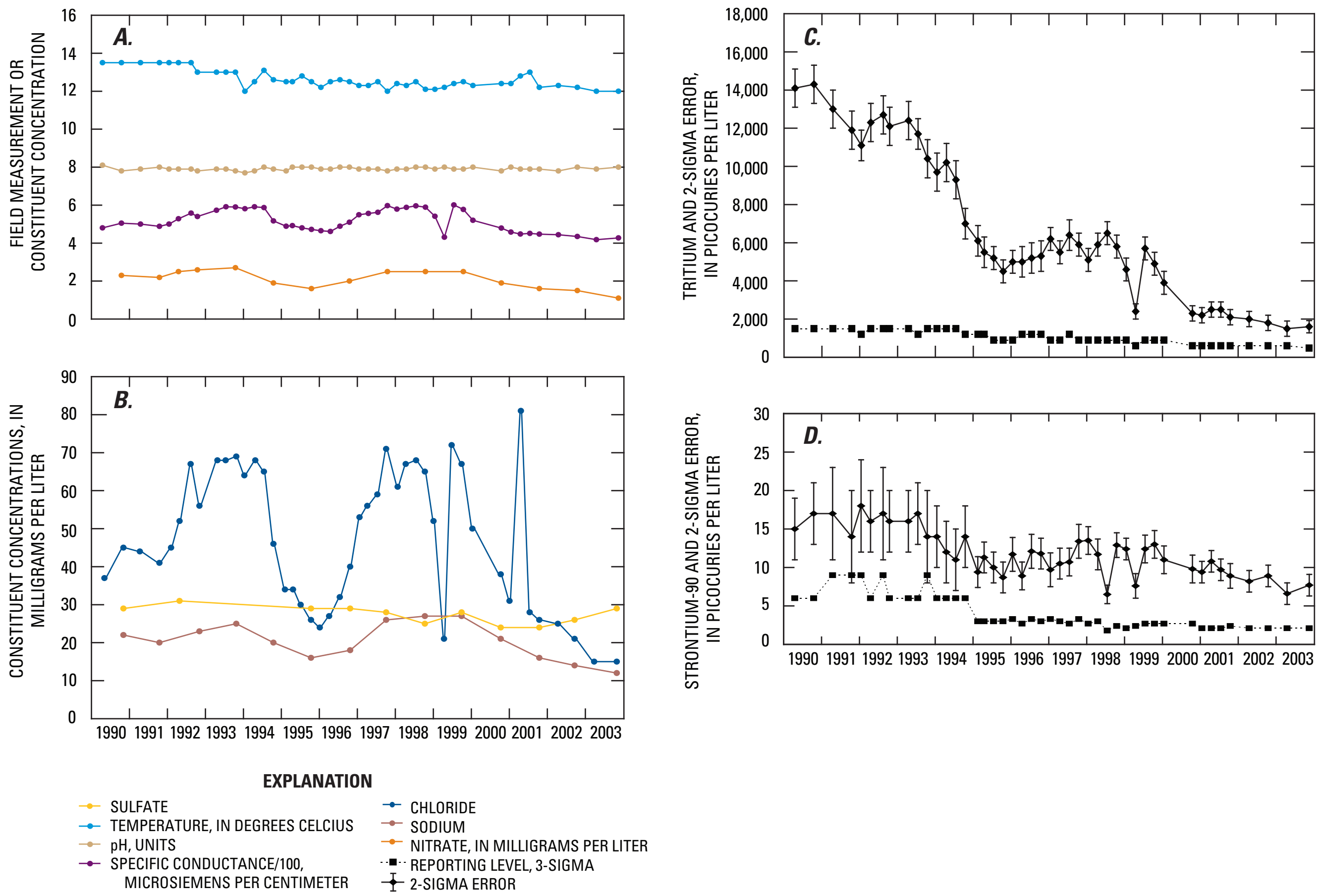


Figure 6. Water-quality data for well USGS 36, 1990-2003, with corresponding data for October-November 2003, Idaho National Laboratory, Idaho.

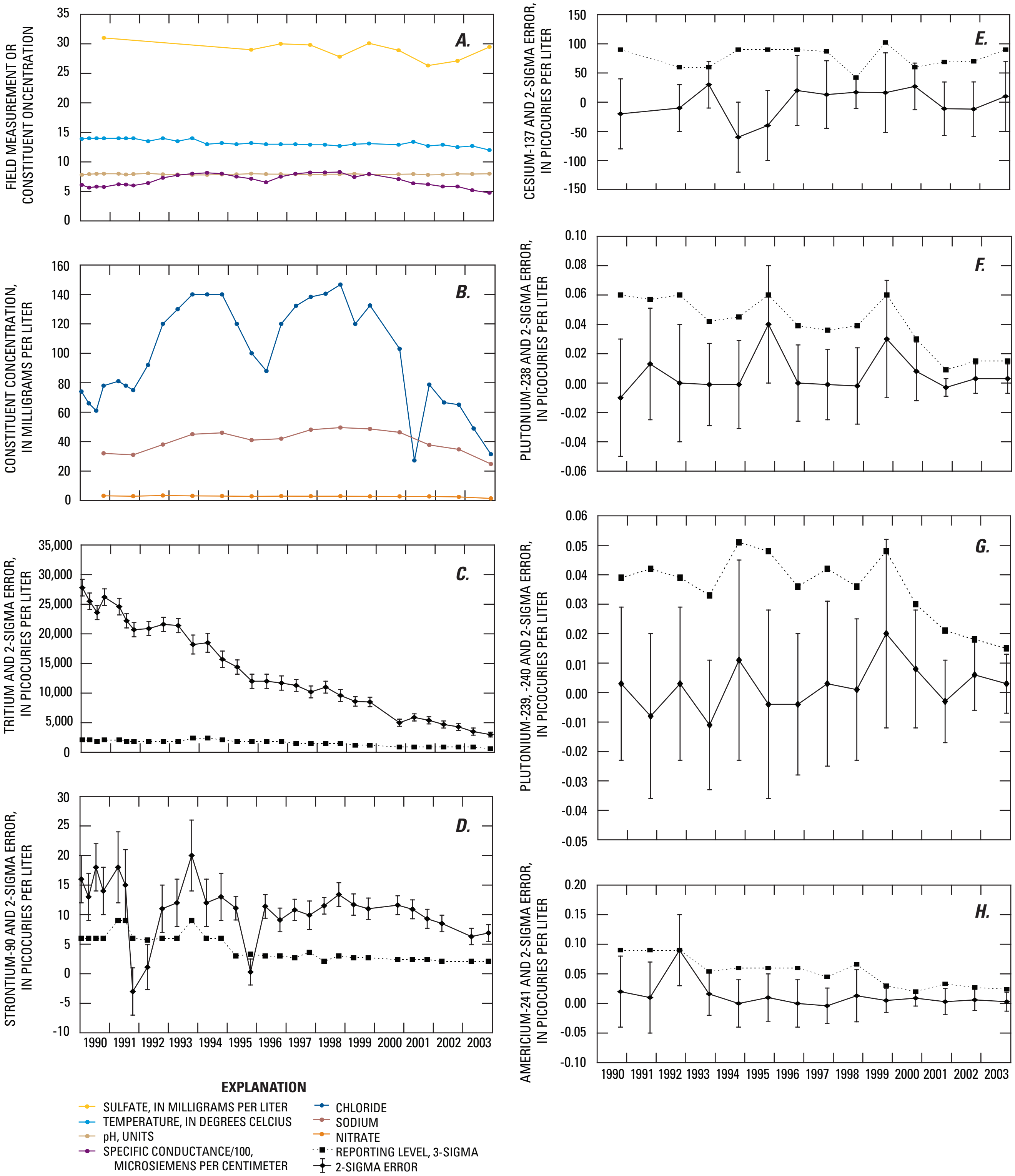


Figure 7. Water-quality data for well USGS 37, 1990-2003, with corresponding data for October-November 2003, Idaho National Laboratory, Idaho.

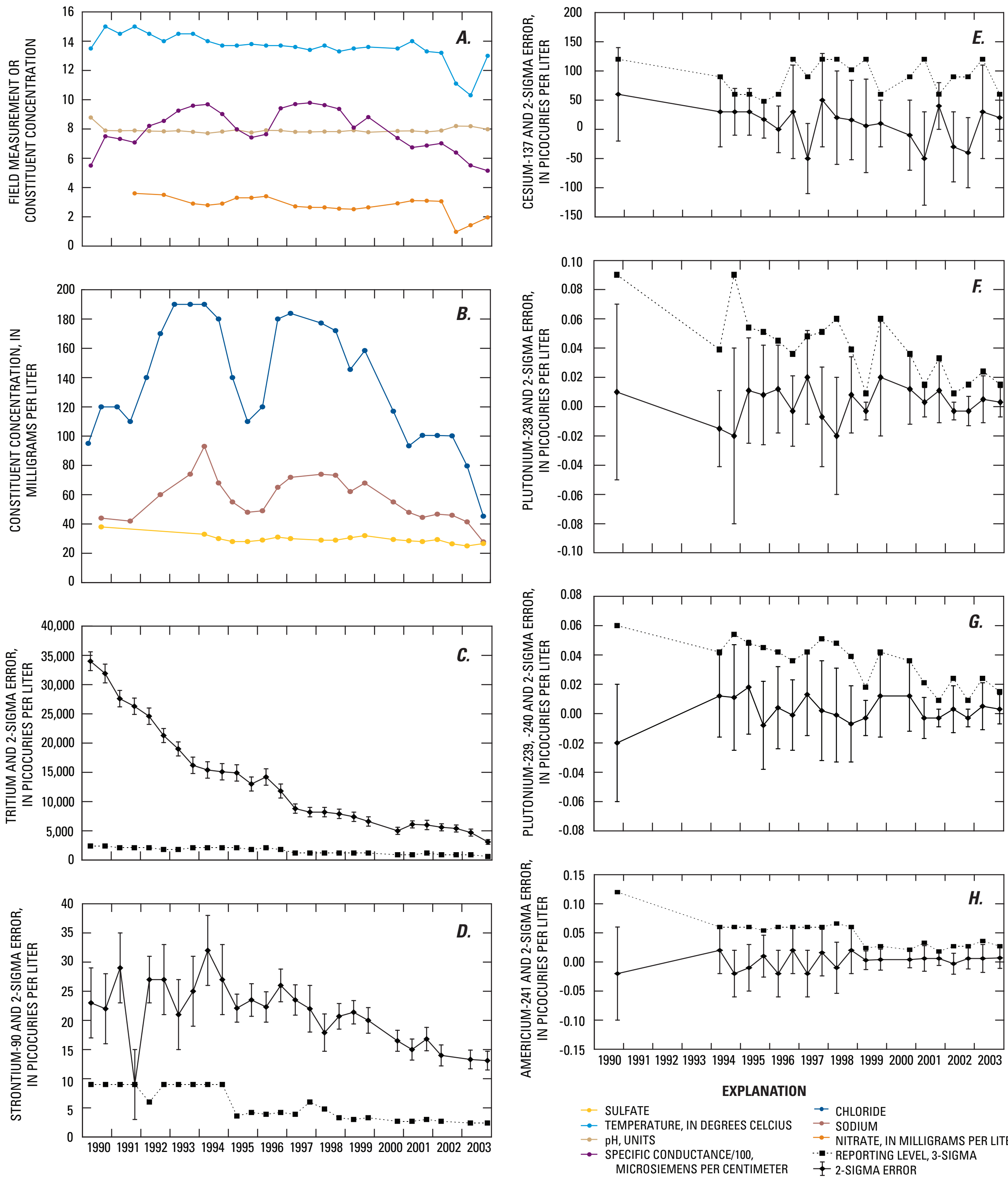
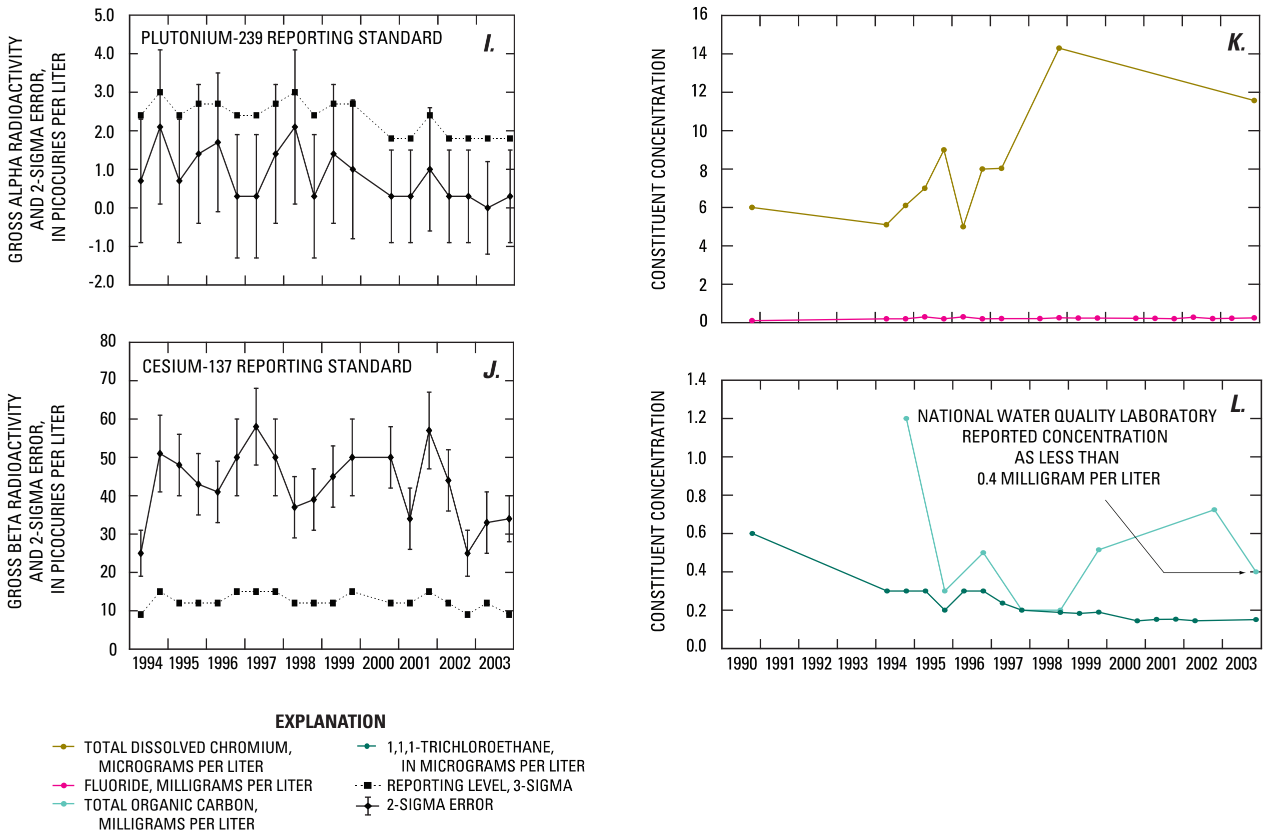


Figure 8. Water-quality data for well USGS 38, 1990-2003, with corresponding data for October-November 2003, Idaho National Laboratory, Idaho.



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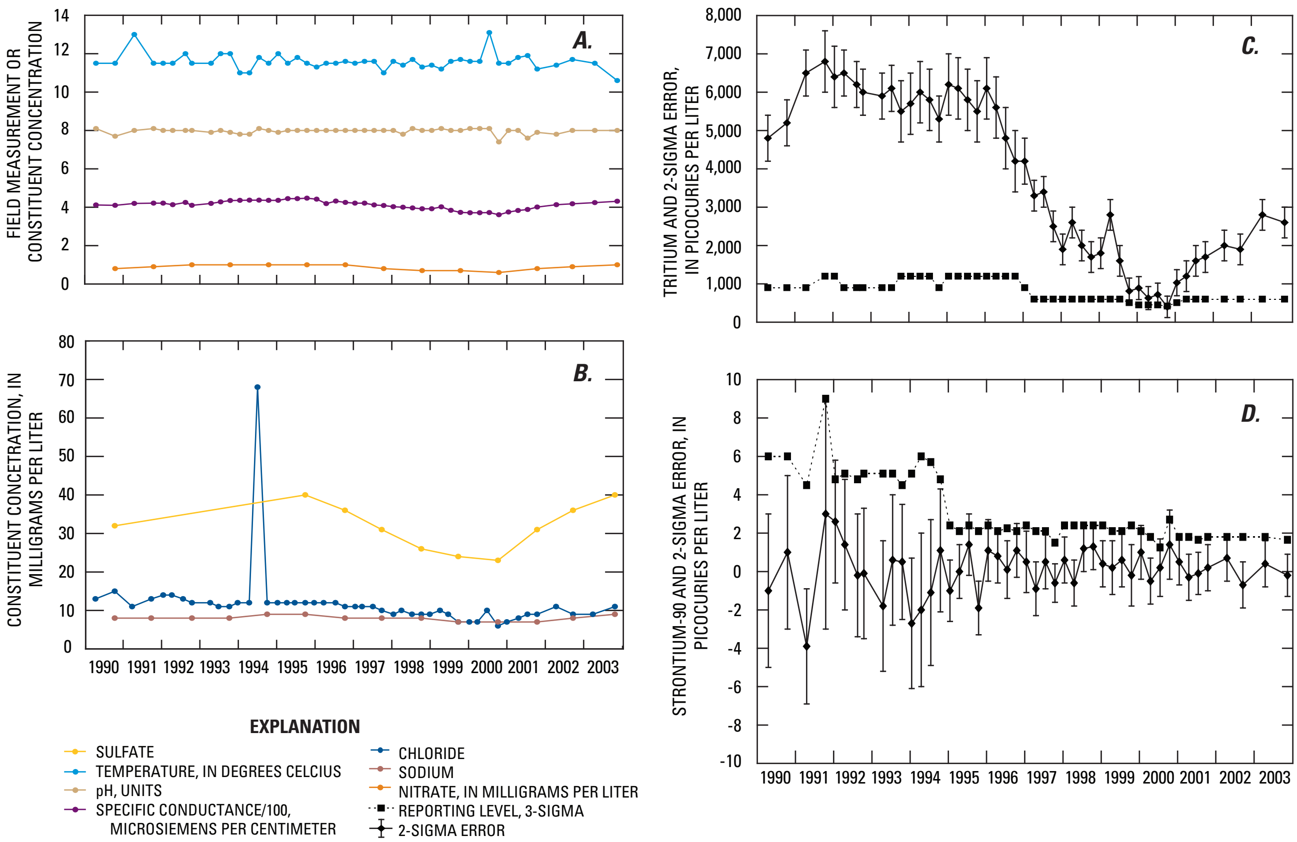


Figure 9. Water-quality data for well USGS 39, 1990-2003, with corresponding data for October-November 2003, Idaho National Laboratory, Idaho.

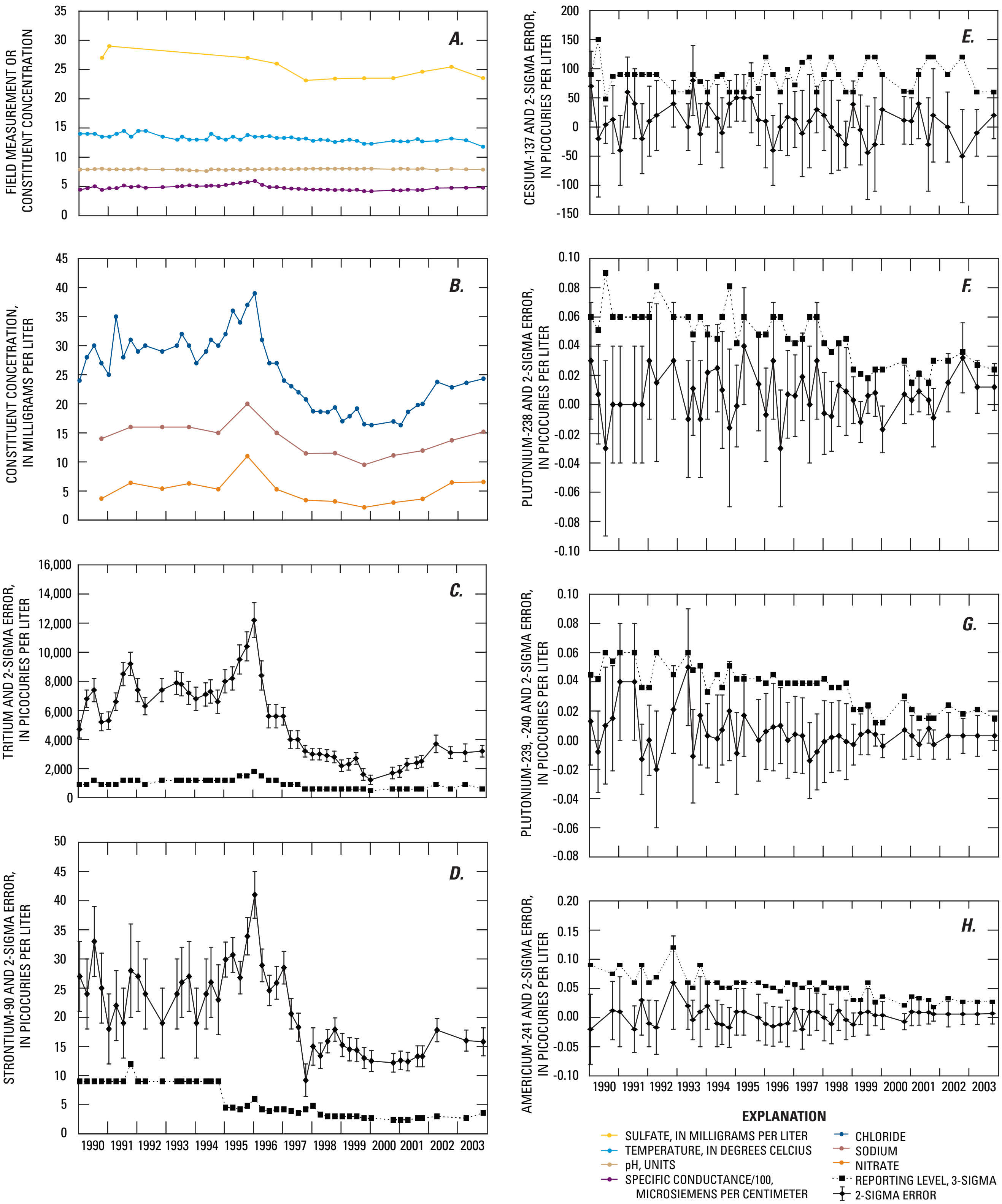


Figure 10. Water-quality data for well USGS 40, 1990-2003, with corresponding data for October-November 2003, Idaho National Laboratory, Idaho.

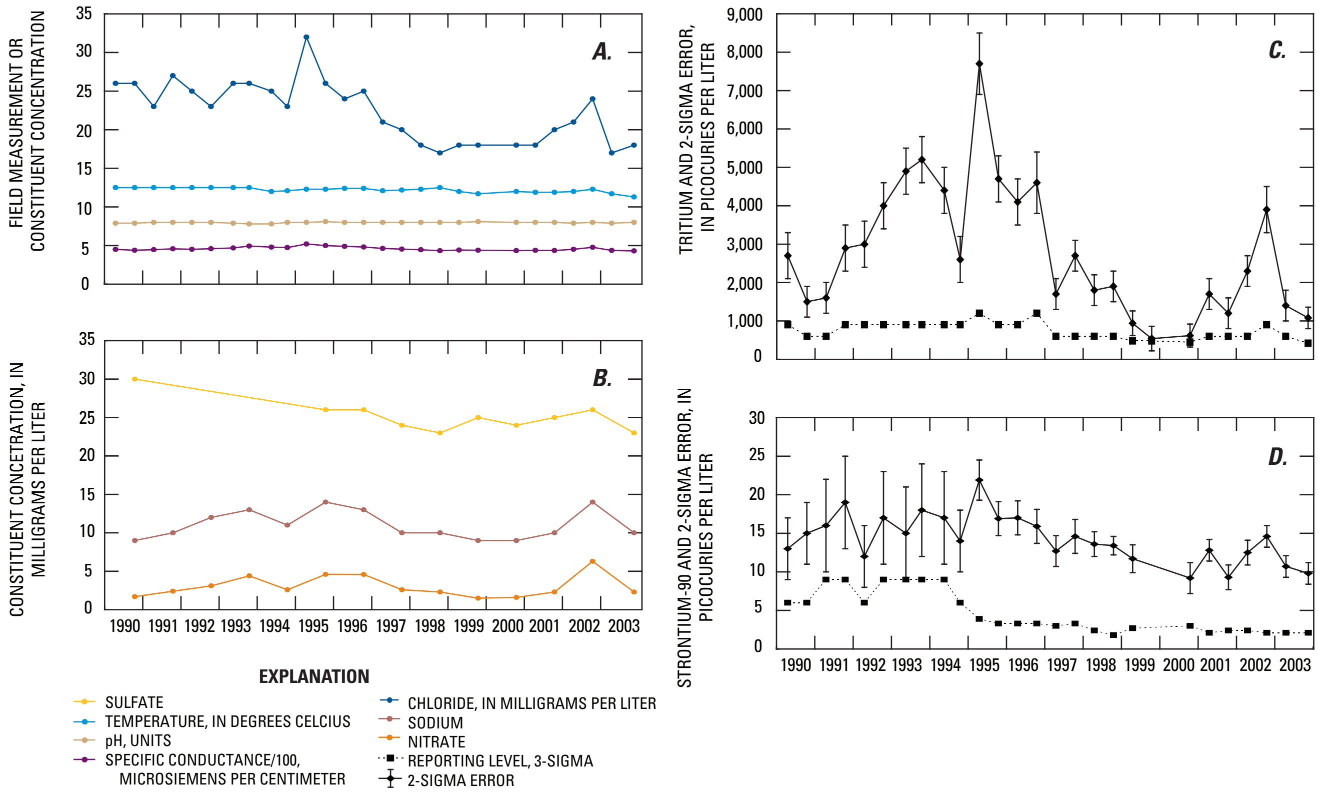


Figure 11. Water-quality data for well USGS 41, 1990-2003, with corresponding data for October-November 2003, Idaho National Laboratory, Idaho.

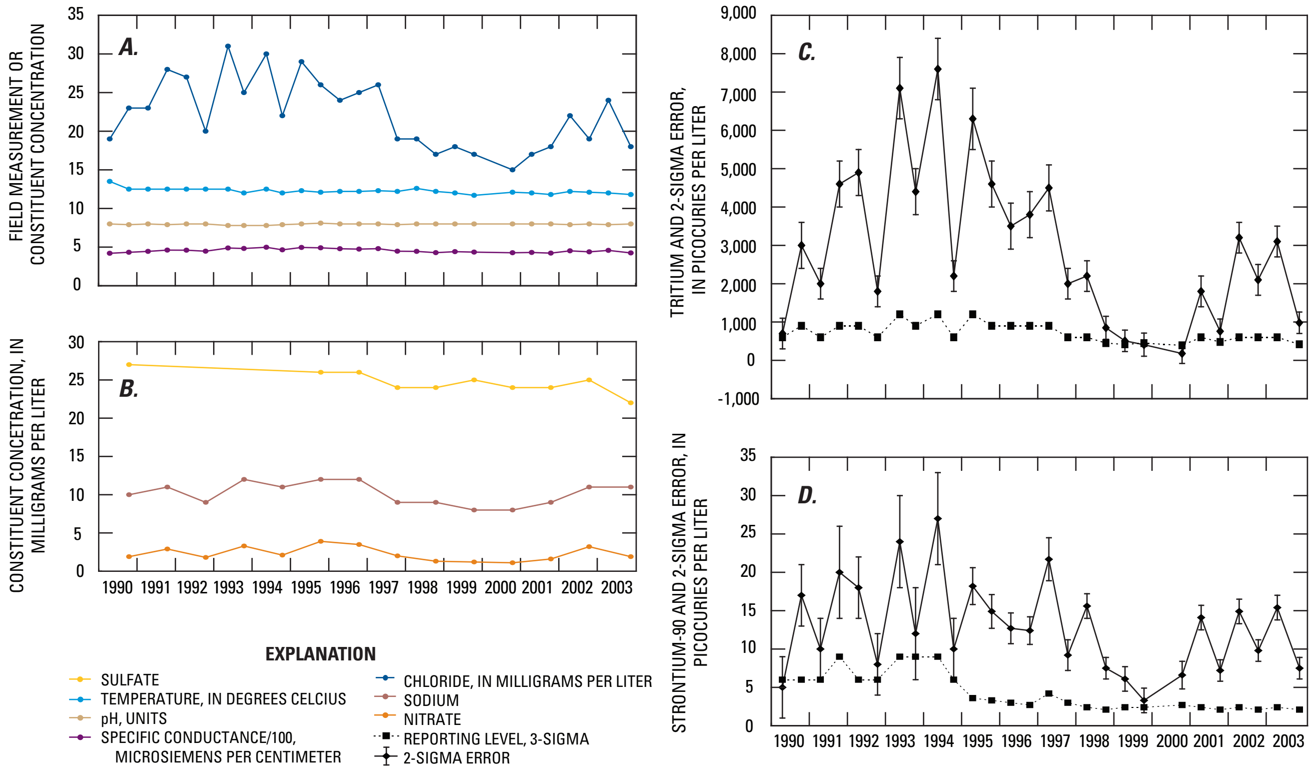


Figure 12. Water-quality data for well USGS 42, 1990-2003, with corresponding data for October-November 2003, Idaho National Laboratory, Idaho.

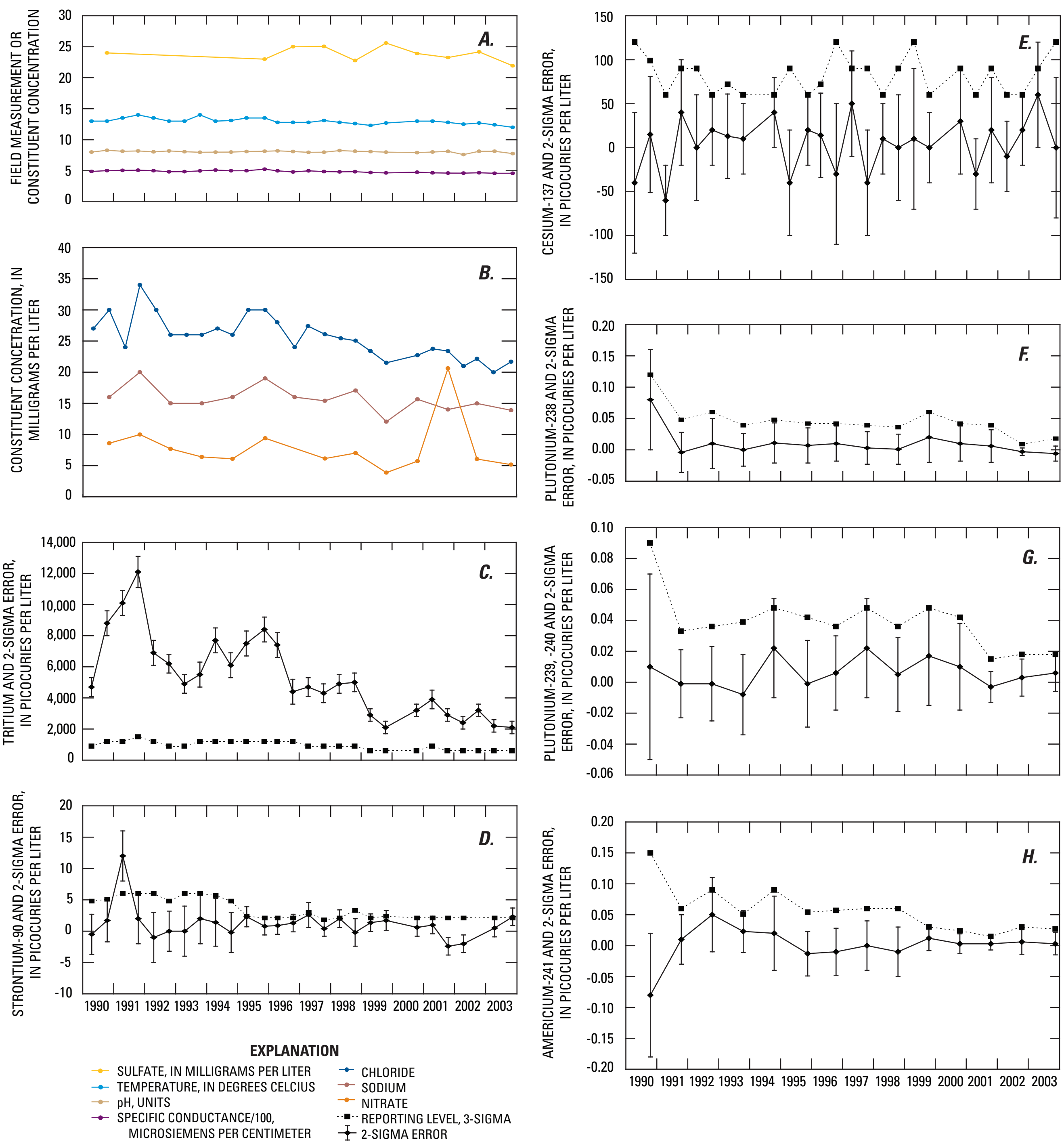


Figure 13. Water-quality data for well USGS 43, 1990-2003, with corresponding data for October-November 2003, Idaho National Laboratory, Idaho.

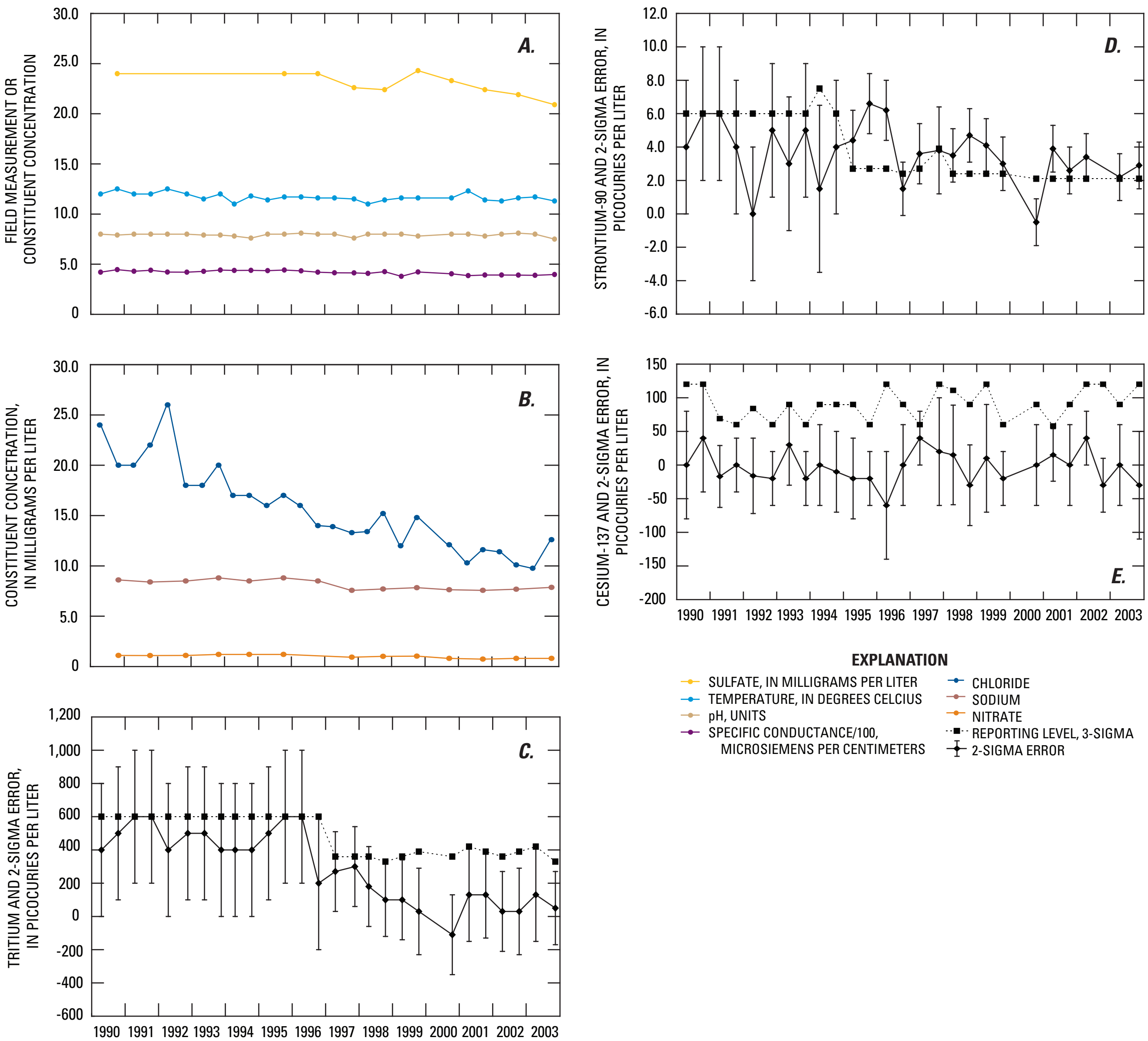


Figure 14. Water-quality data for well USGS 44, 1990-2003, with corresponding data for October-November 2003, Idaho National Laboratory, Idaho.

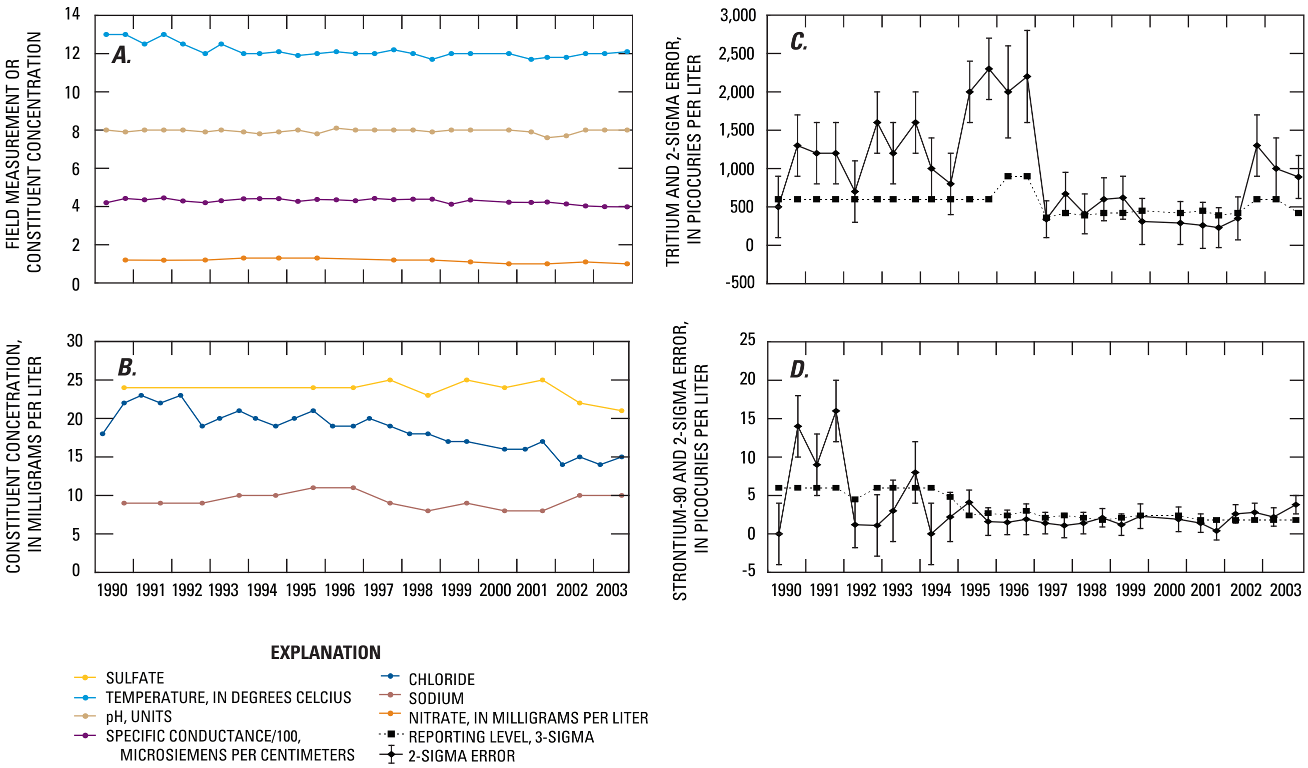


Figure 15. Water-quality data for well USGS 45, 1990-2003, with corresponding data for October-November 2003, Idaho National Laboratory, Idaho.

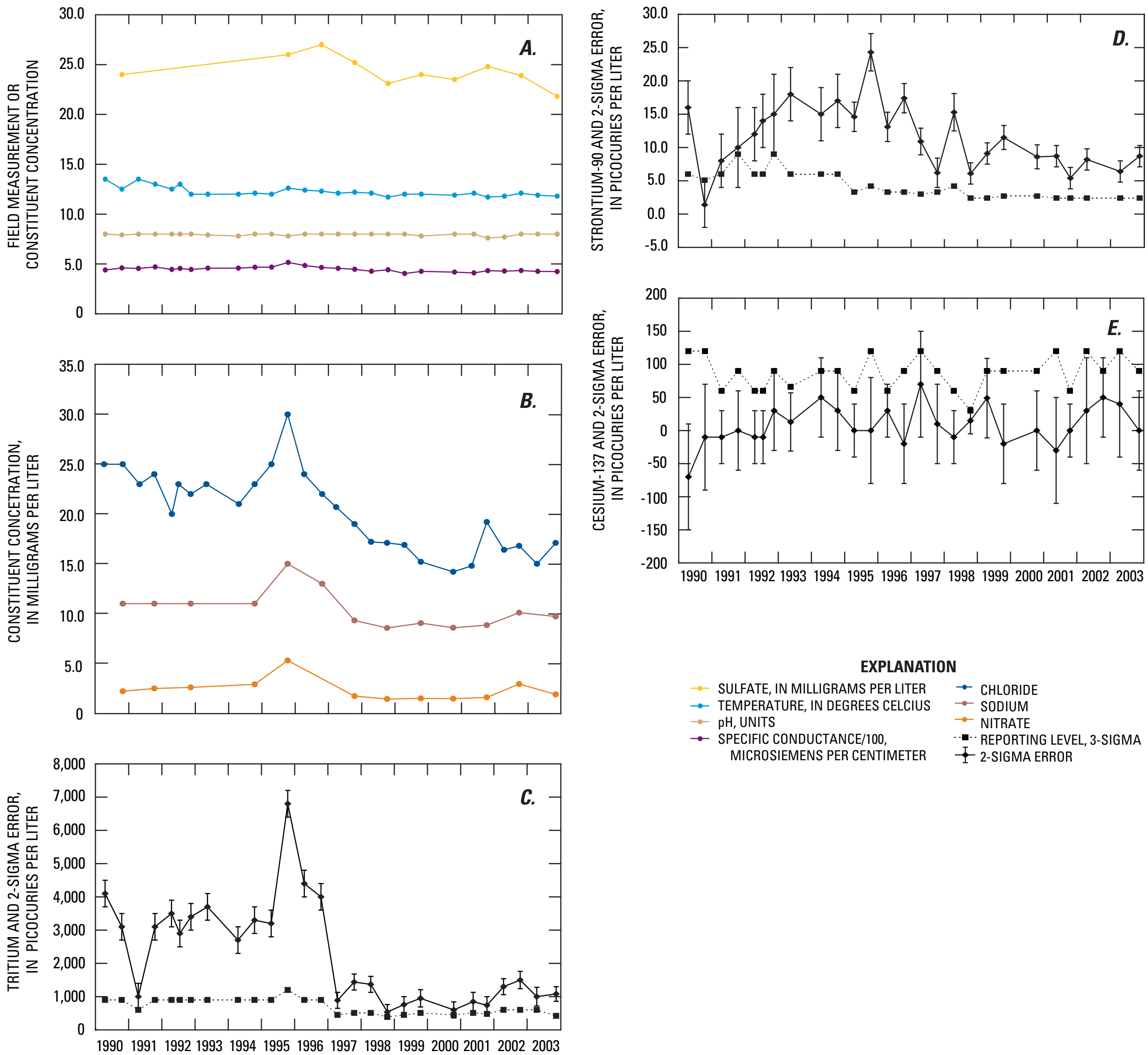


Figure 16. Water-quality data for well USGS 46, 1990-2003, with corresponding data for October-November 2003, Idaho National Laboratory, Idaho.

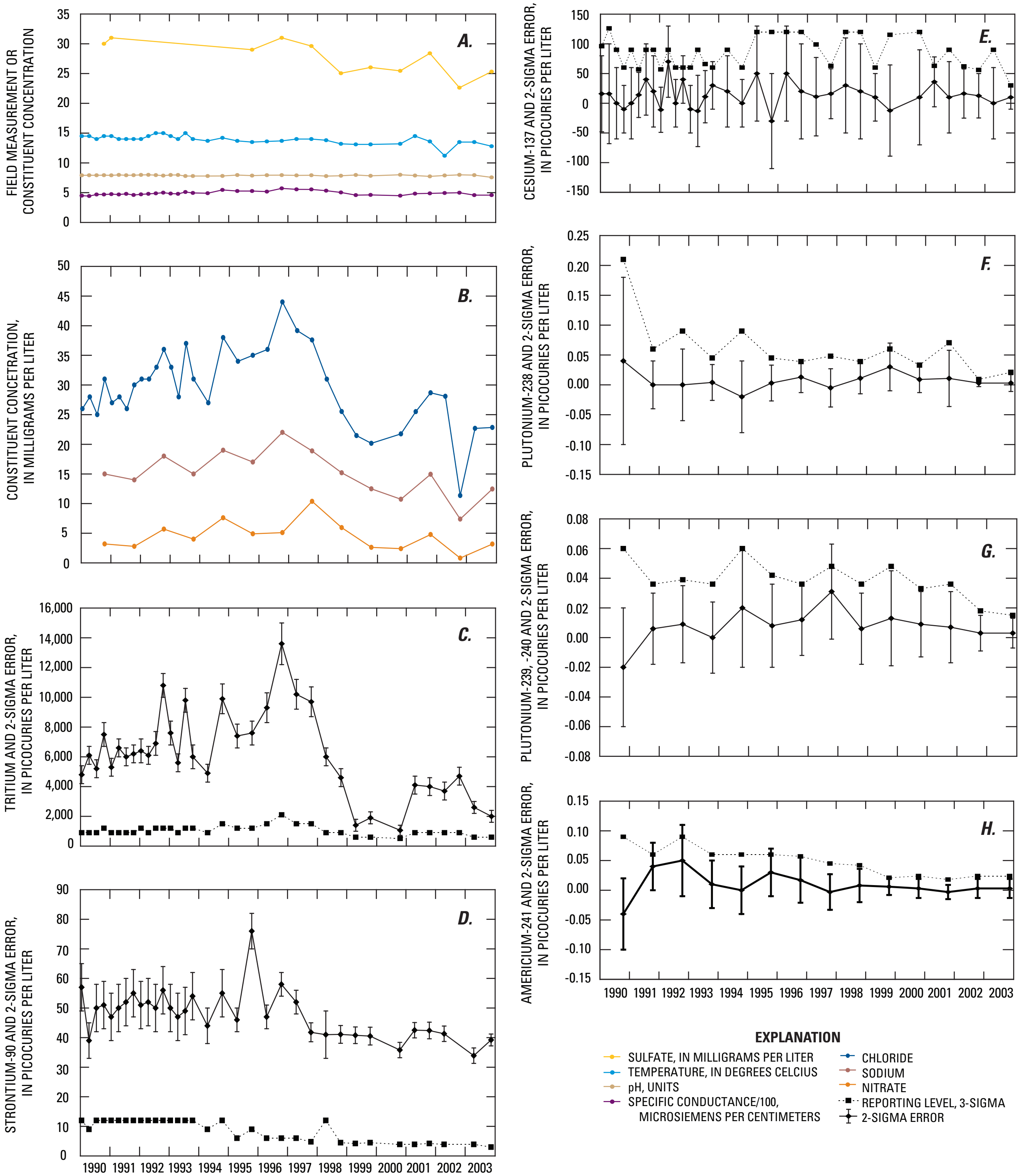


Figure 17. Water-quality data for well USGS 47, 1990-2003, with corresponding data for October-November 2003, Idaho National Laboratory, Idaho.

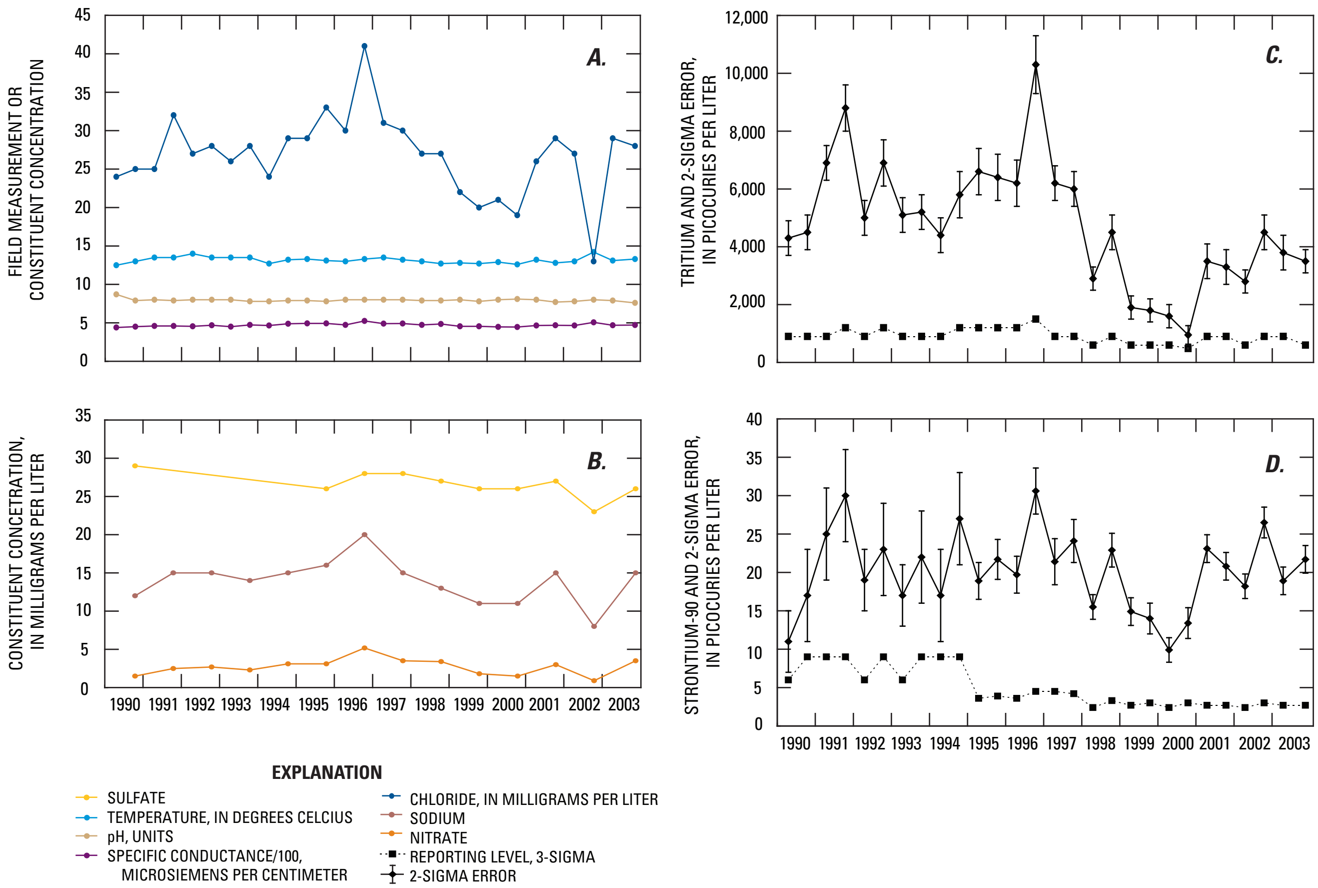


Figure 18. Water-quality data for well USGS 48, 1990-2003, with corresponding data for October-November 2003, Idaho National Laboratory, Idaho.

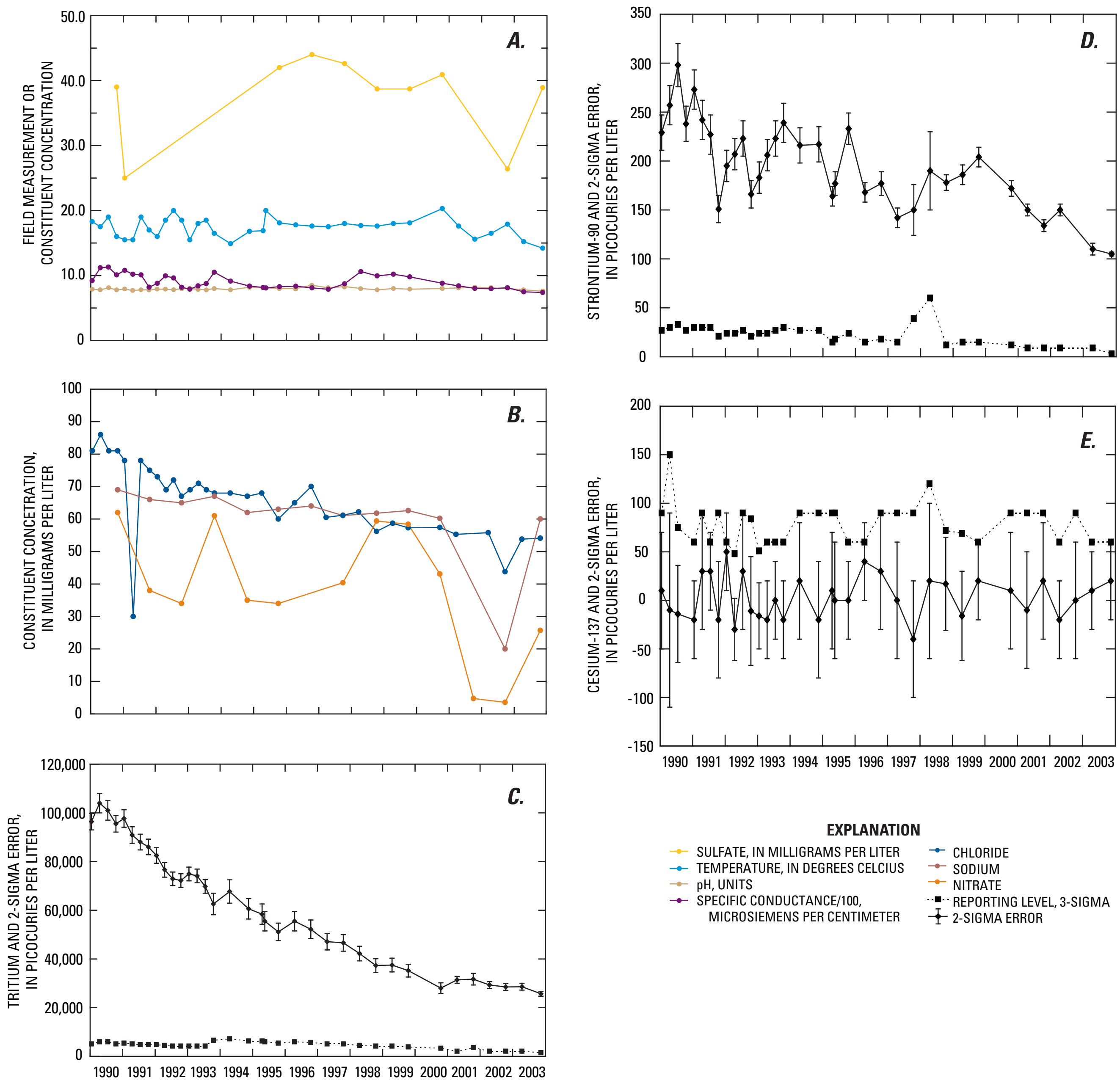


Figure 19. Water-quality data for well USGS 50 (perched well), 1990-2003, with corresponding data for October-November 2003, Idaho National Laboratory, Idaho.

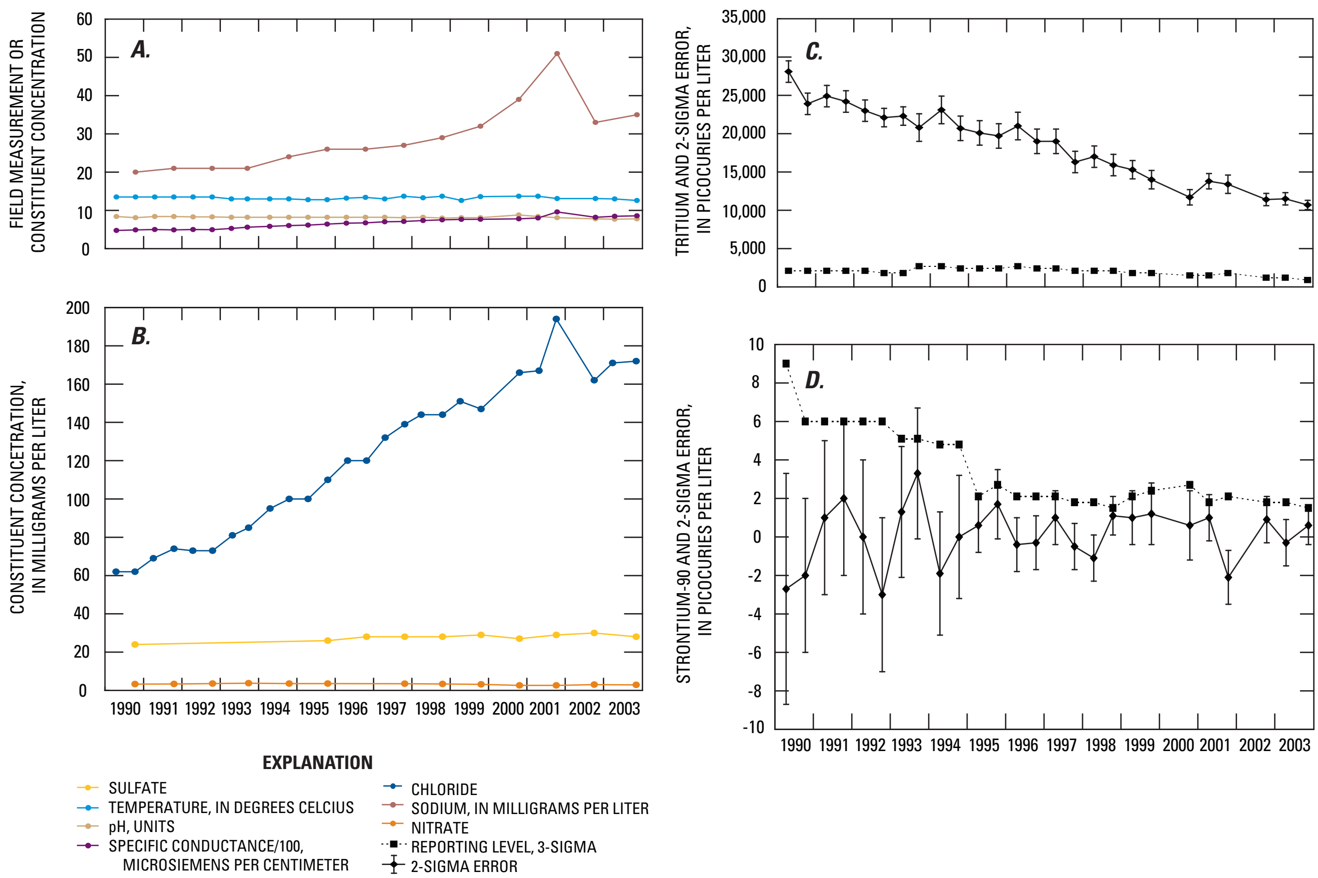


Figure 20. Water-quality data for well USGS 51, 1990-2003, with corresponding data for October-November 2003, Idaho National Laboratory, Idaho.

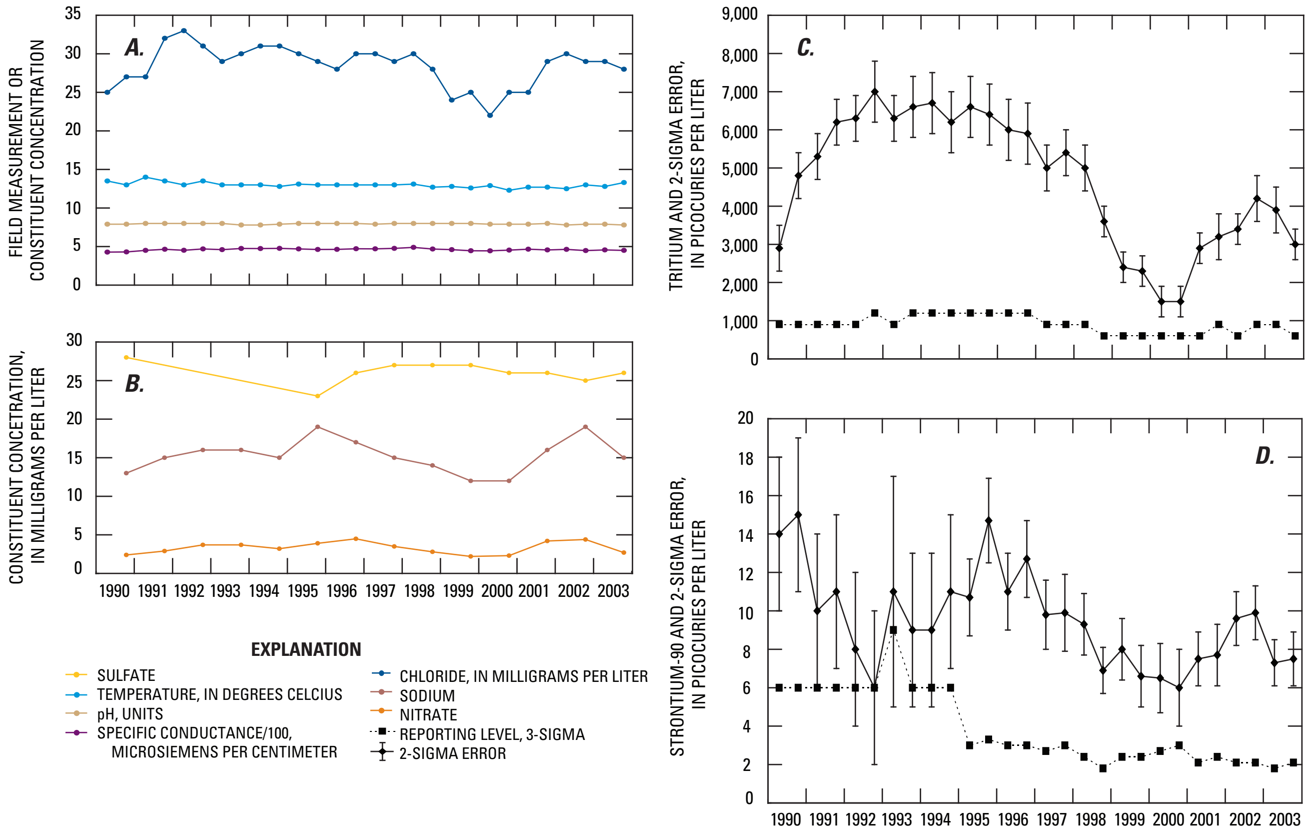


Figure 21. Water-quality data for well USGS 52, 1990-2003, with corresponding data for October-November 2003, Idaho National Laboratory, Idaho.

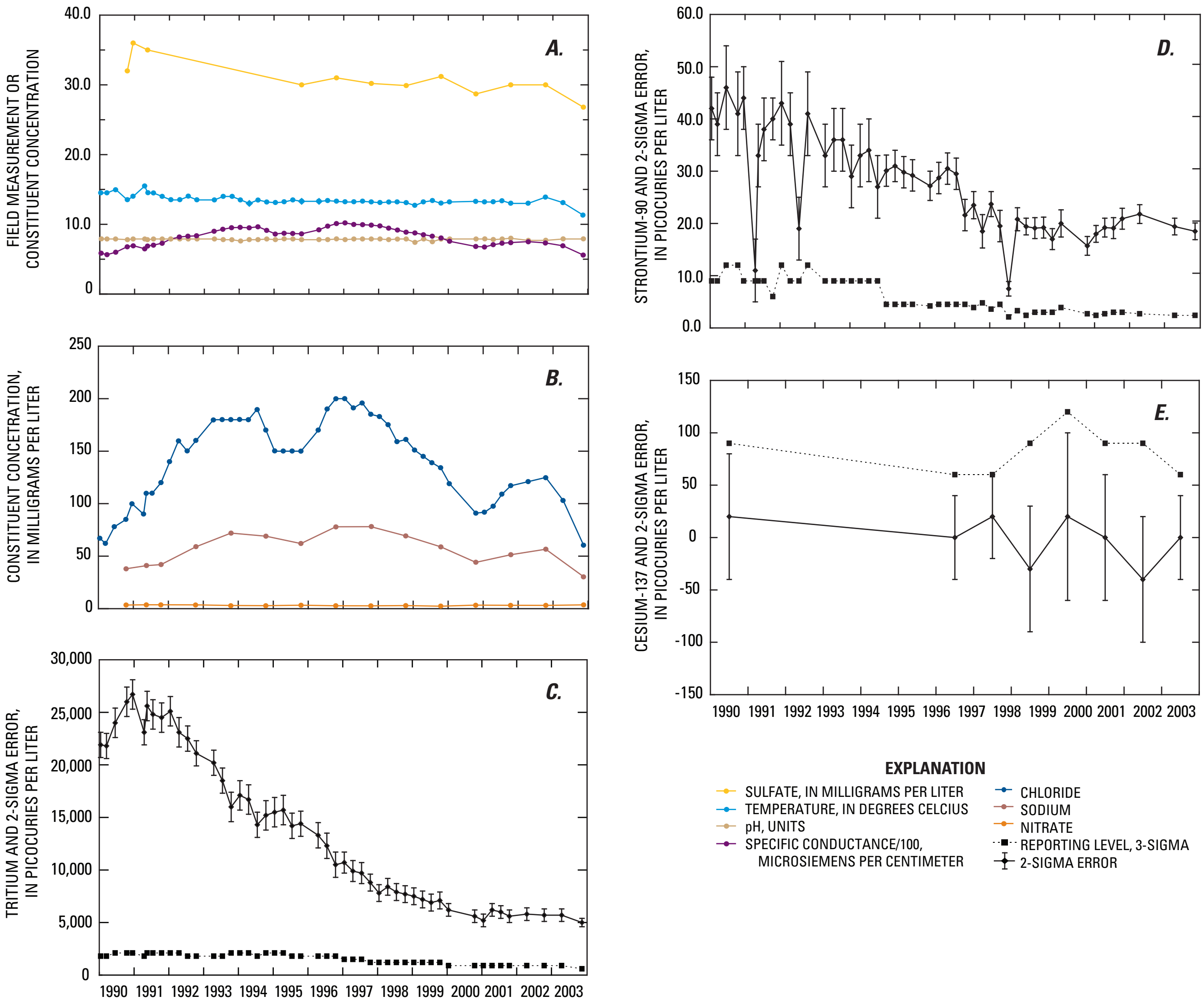


Figure 22. Water-quality data for well USGS 57, 1990-2003, with corresponding data for October-November 2003, Idaho National Laboratory, Idaho.

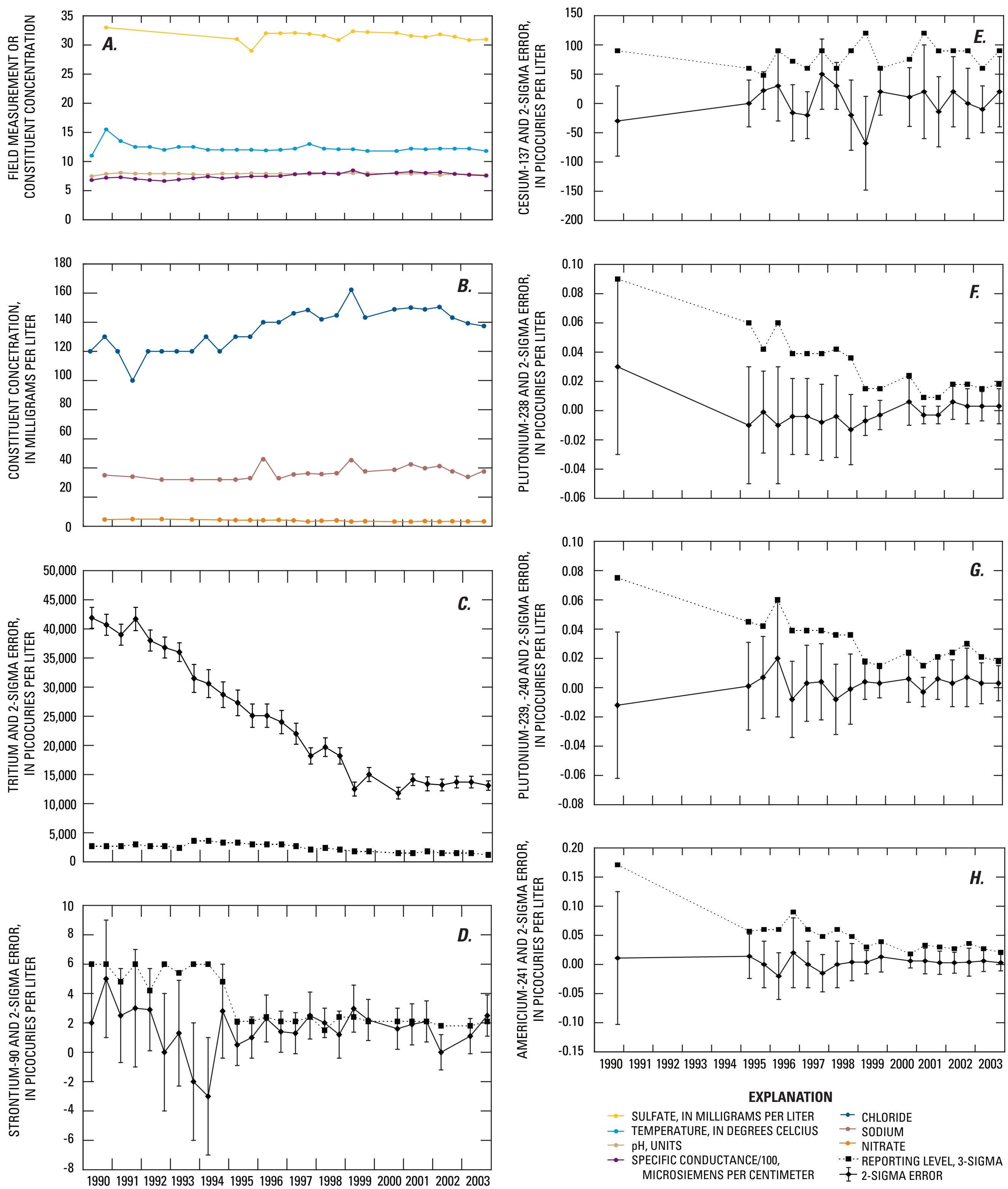
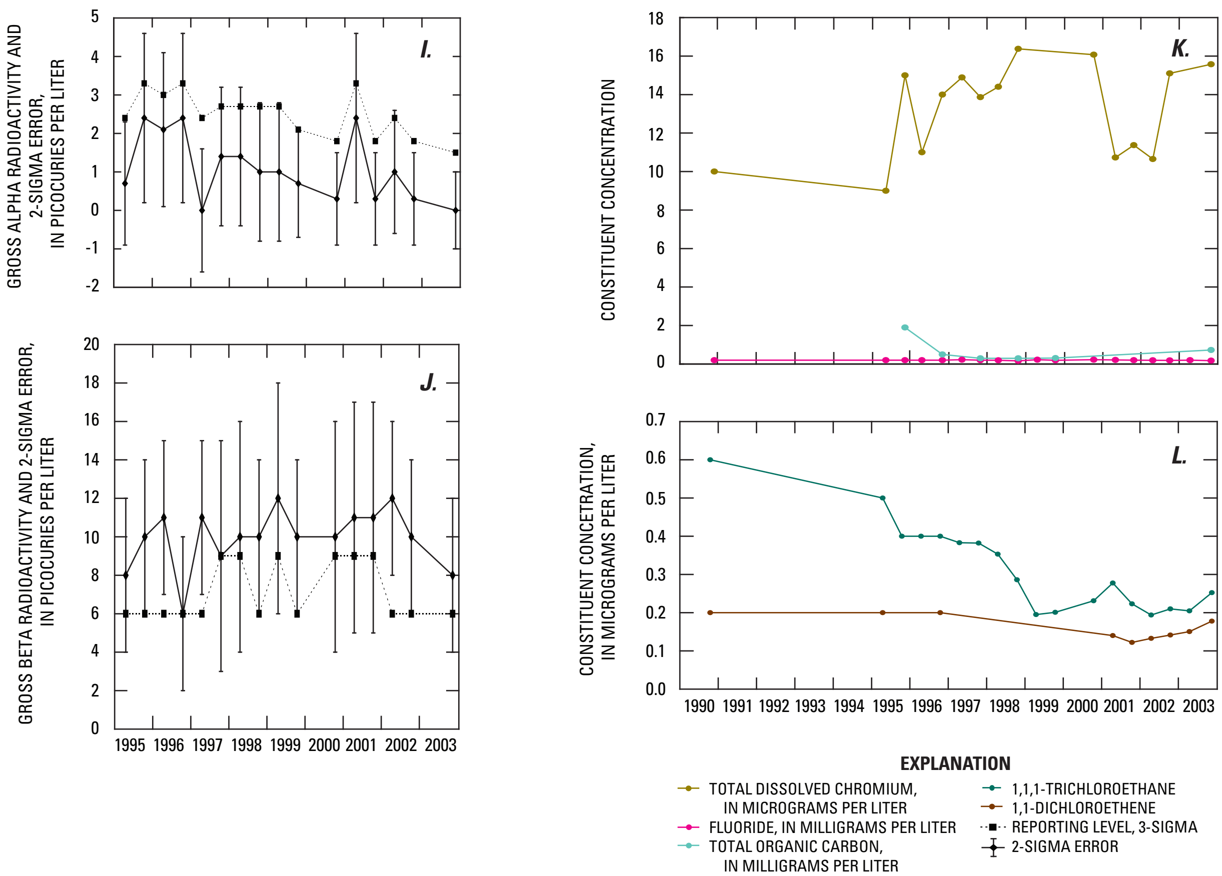


Figure 23. Water-quality data for well USGS 77, 1990-2003, with corresponding data for October-November 2003, Idaho National Laboratory, Idaho.



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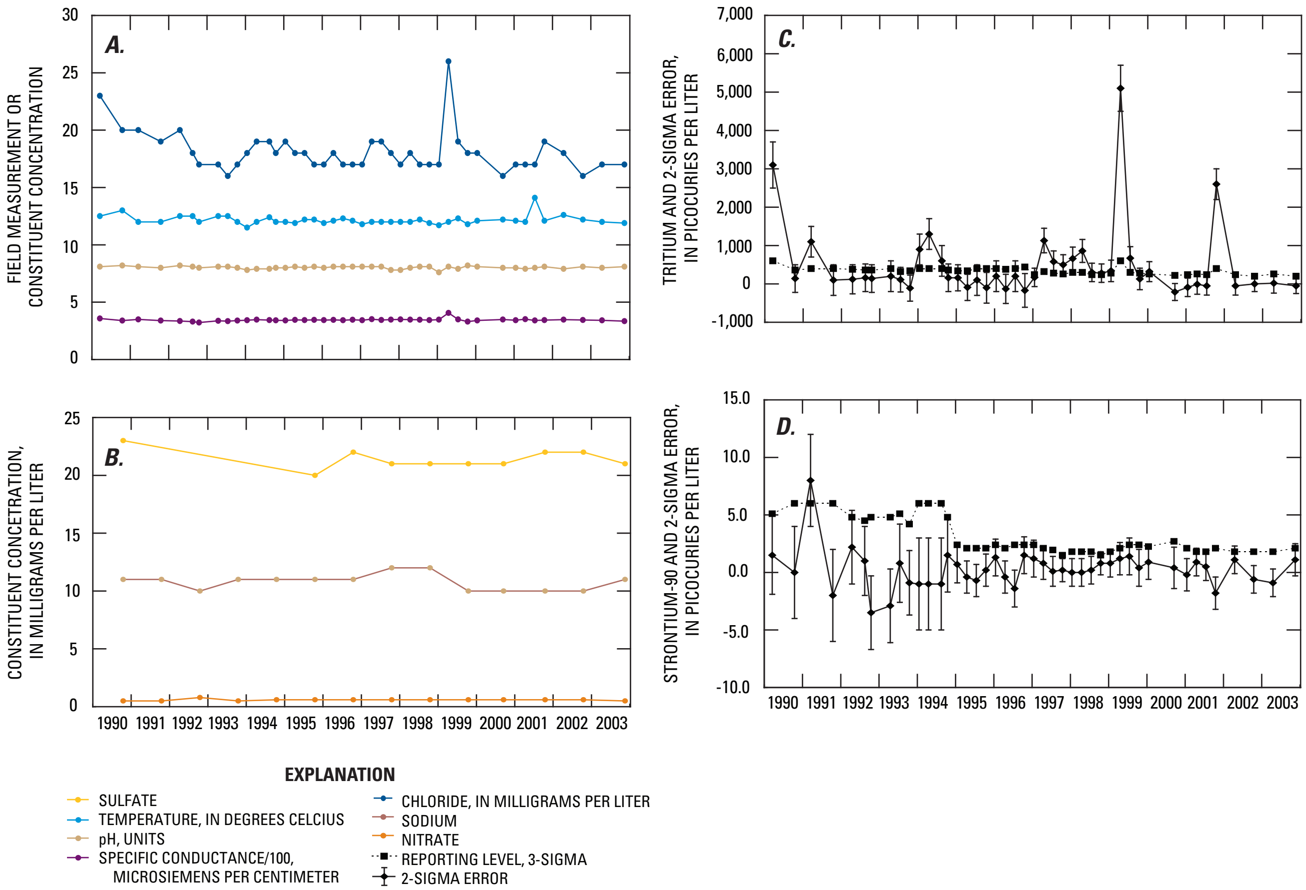

Figure 24. Water-quality data for well USGS 82, 1990-2003, with corresponding data for October-November 2003, Idaho National Laboratory, Idaho.

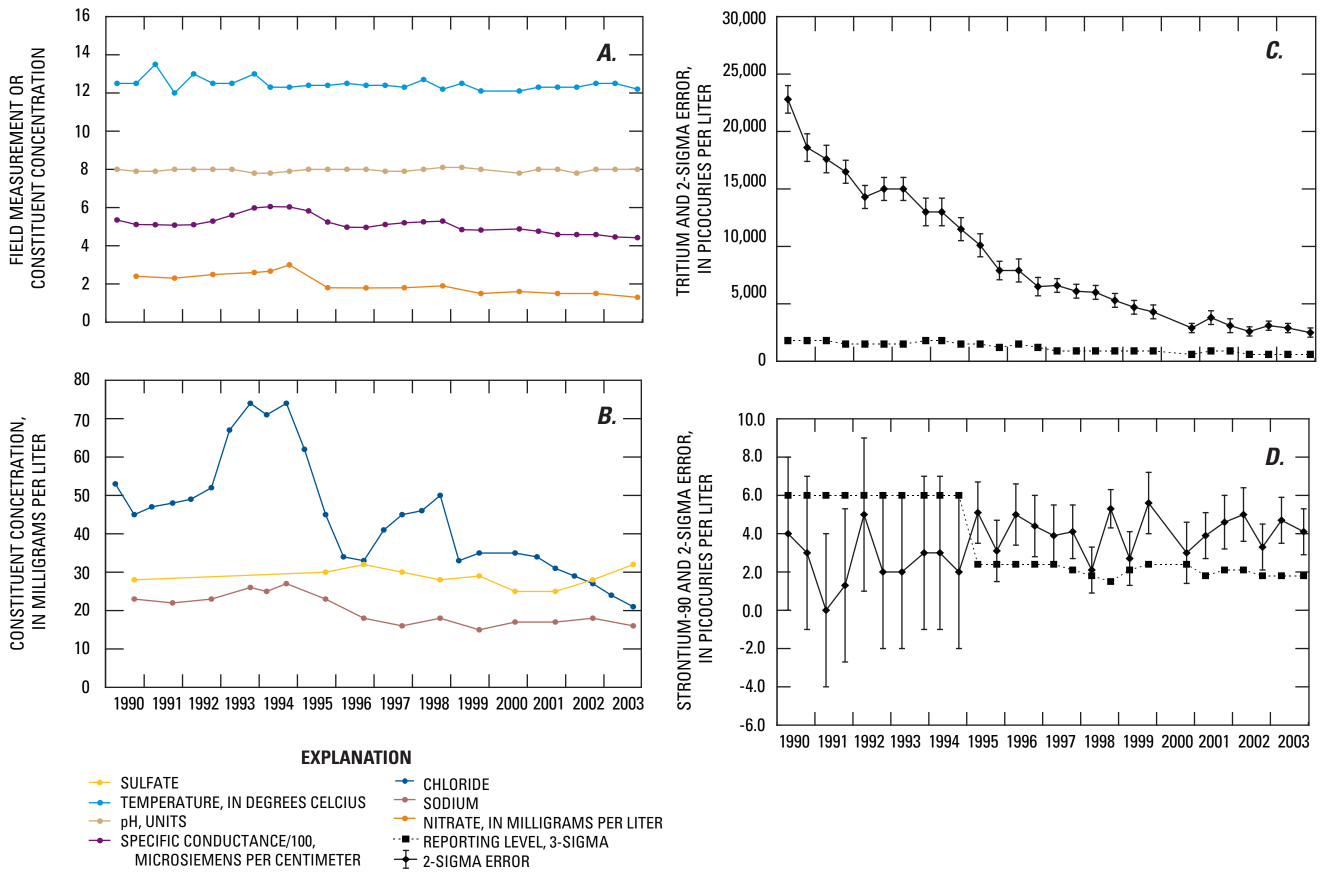

Figure 25. Water-quality data for well USGS 85, 1990-2003, with corresponding data for October-November 2003, Idaho National Laboratory, Idaho.

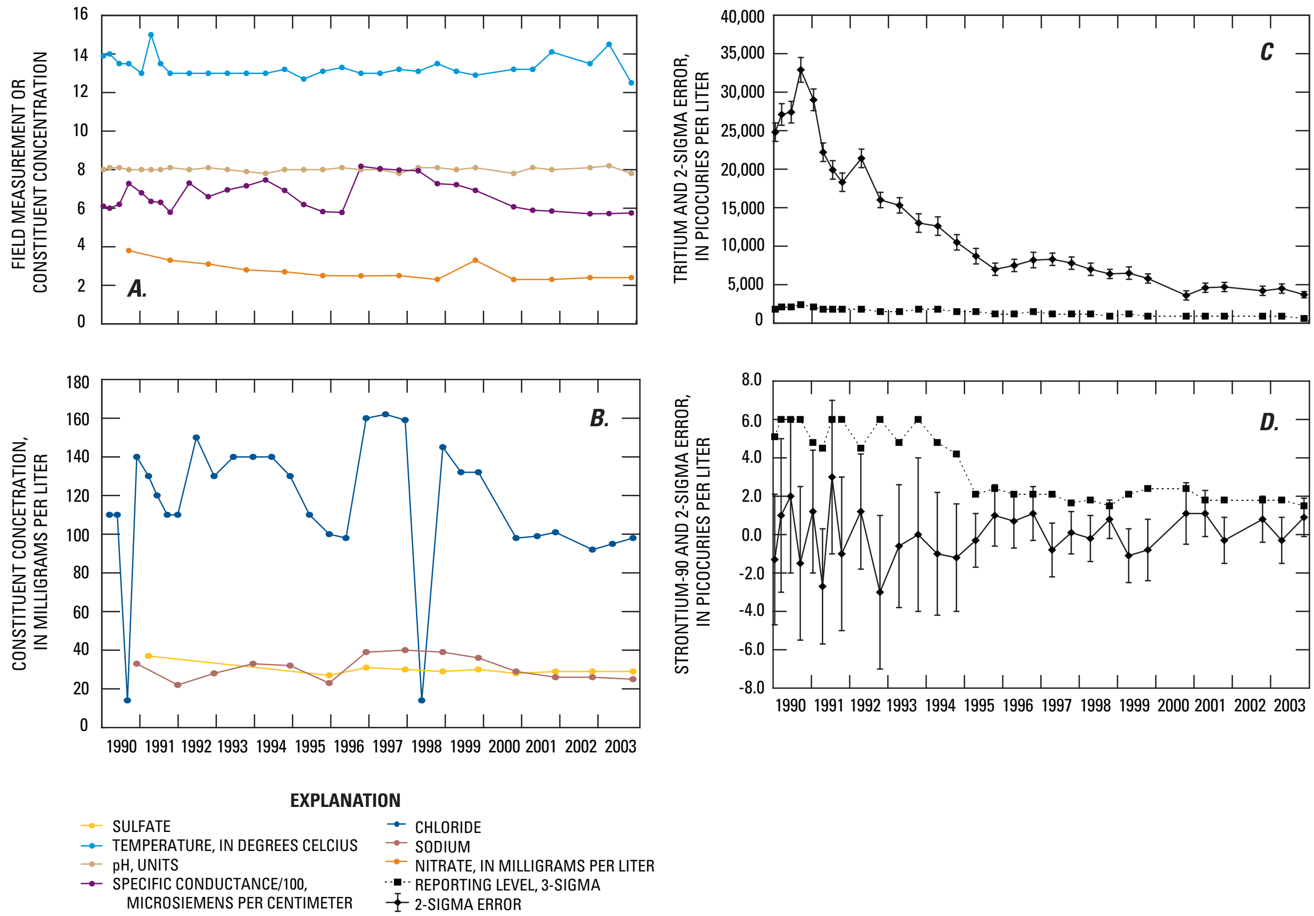

Figure 26. Water-quality data for well USGS 111, 1990-2003, with corresponding data for October-November 2003, Idaho National Laboratory, Idaho.

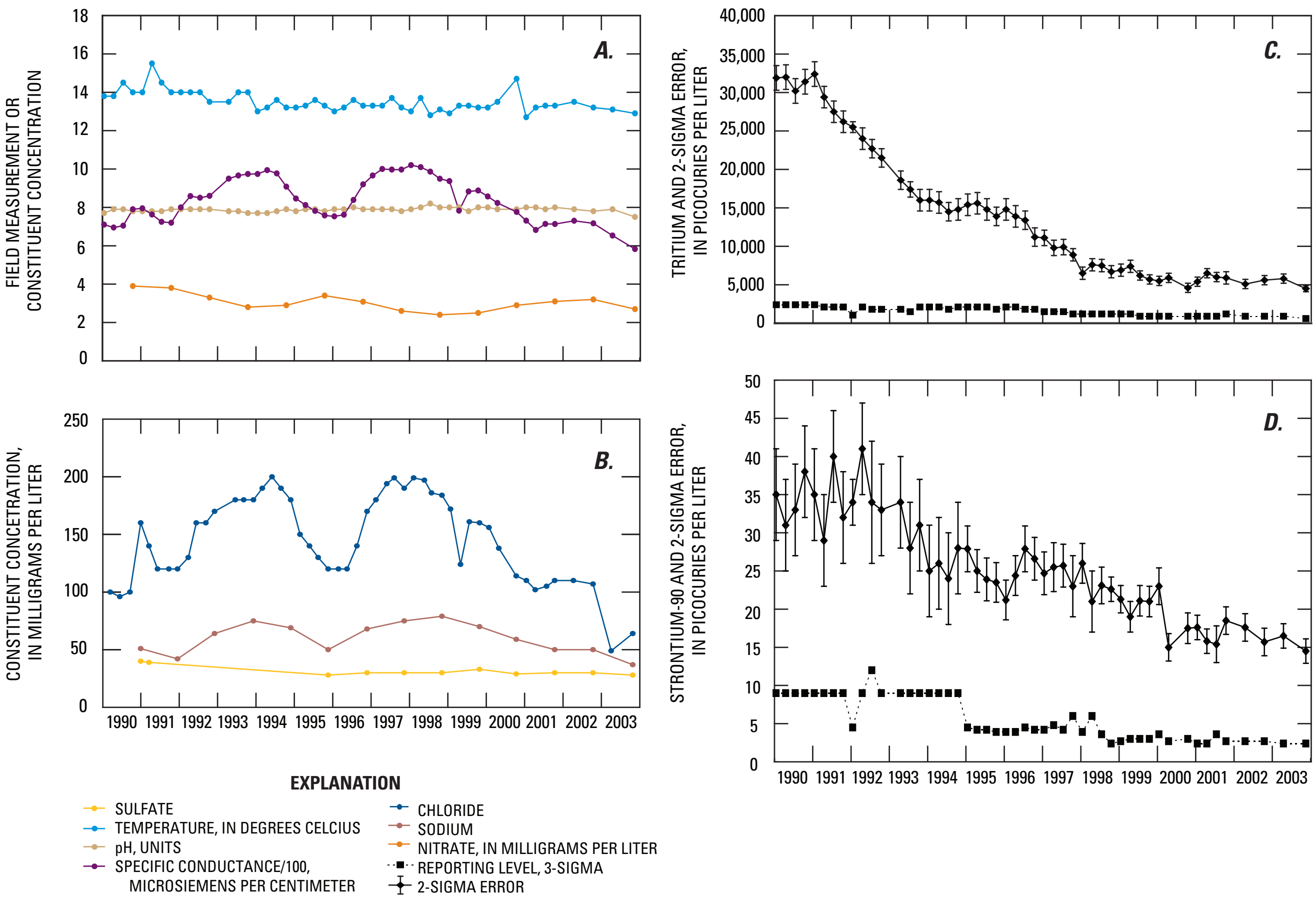

Figure 27. Water-quality data for well USGS 112, 1990-2003, with corresponding data for October-November 2003, Idaho National Laboratory, Idaho.

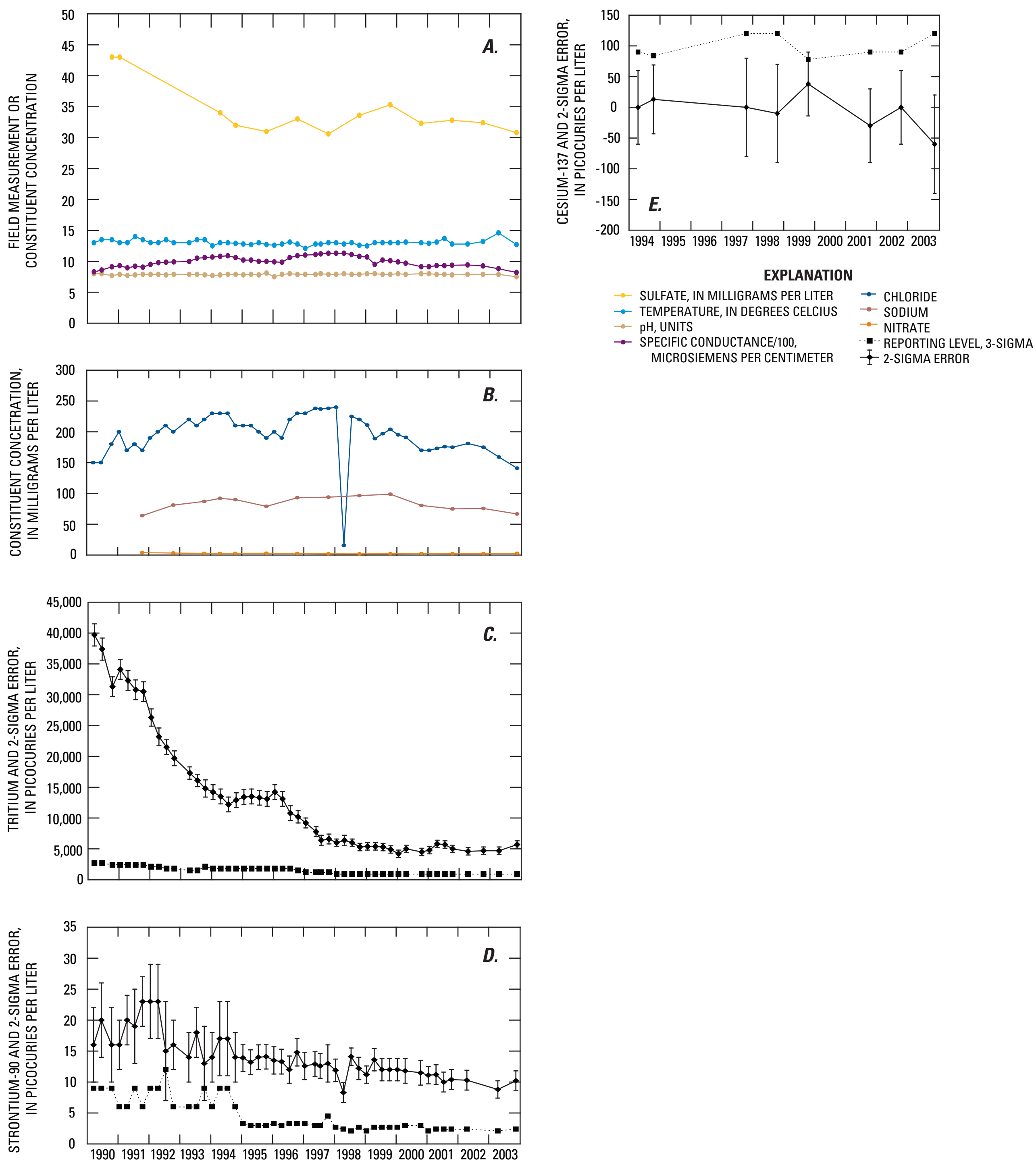

Figure 28. Water-quality data for well USGS 113, 1990-2003, with corresponding data for October-November 2003, Idaho National Laboratory, Idaho.

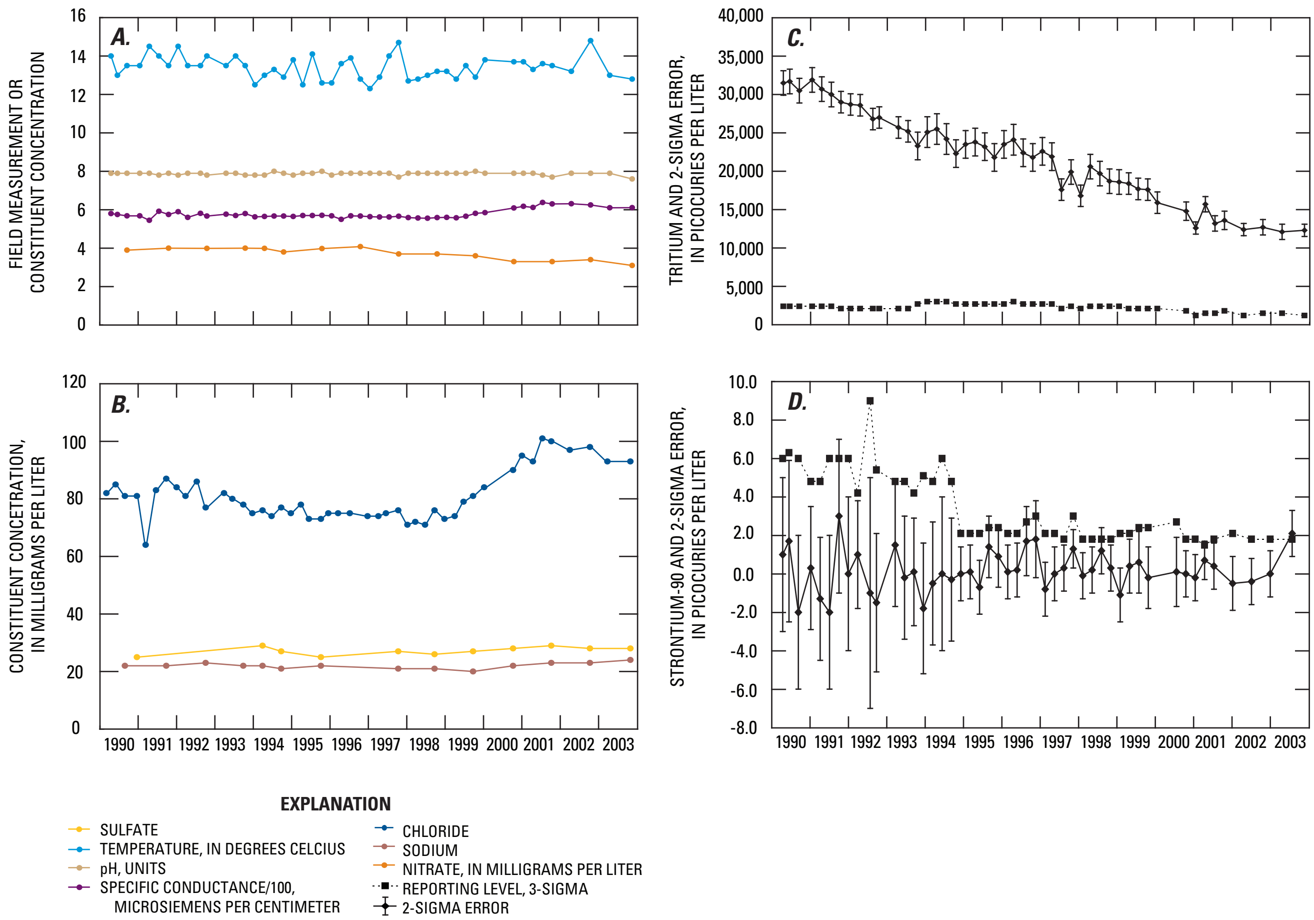

Figure 29. Water-quality data for well USGS 114, 1990-2003, with corresponding data for October-November 2003, Idaho National Laboratory, Idaho.

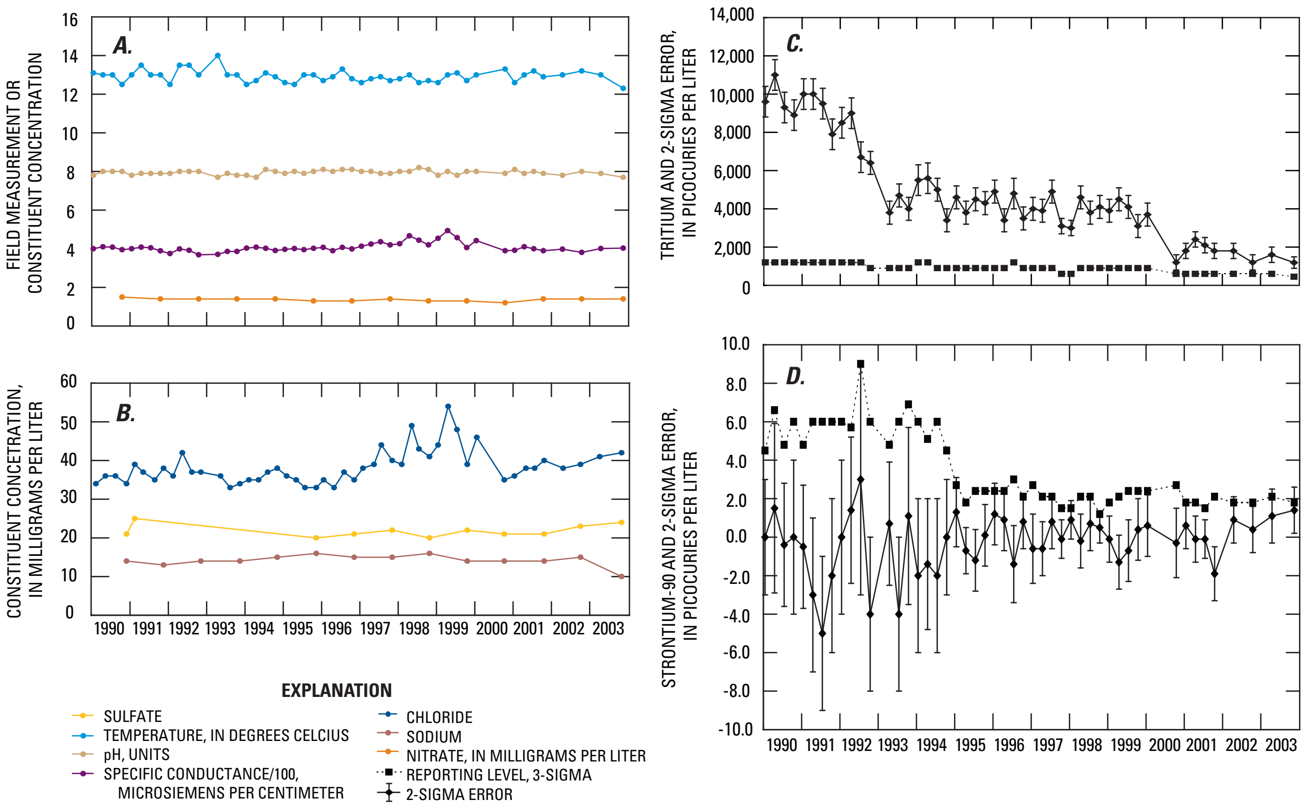

Figure 30. Water-quality data for well USGS 115, 1990-2003, with corresponding data for October-November 2003, Idaho National Laboratory, Idaho.

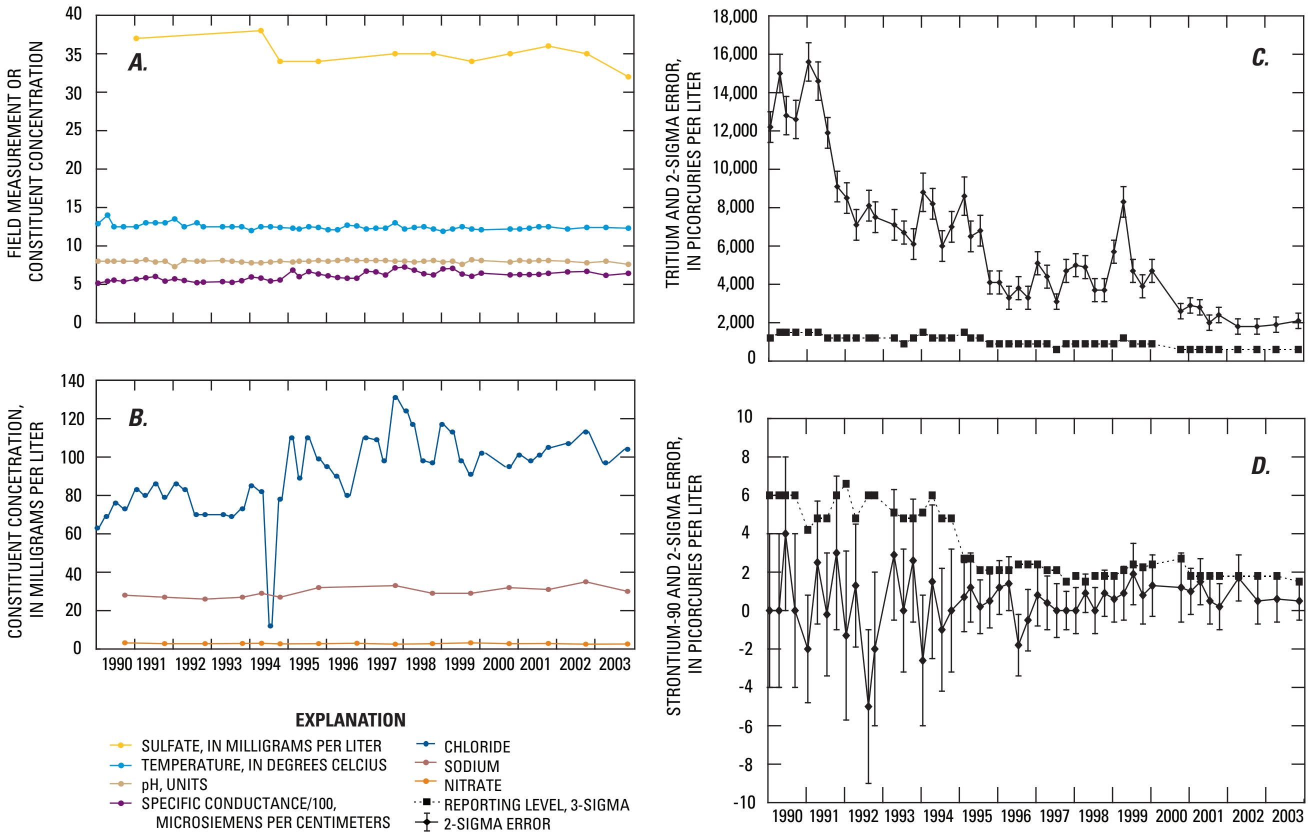

Figure 31. Water-quality data for well USGS 116, 1990-2003, with corresponding data for October-November 2003, Idaho National Laboratory, Idaho.

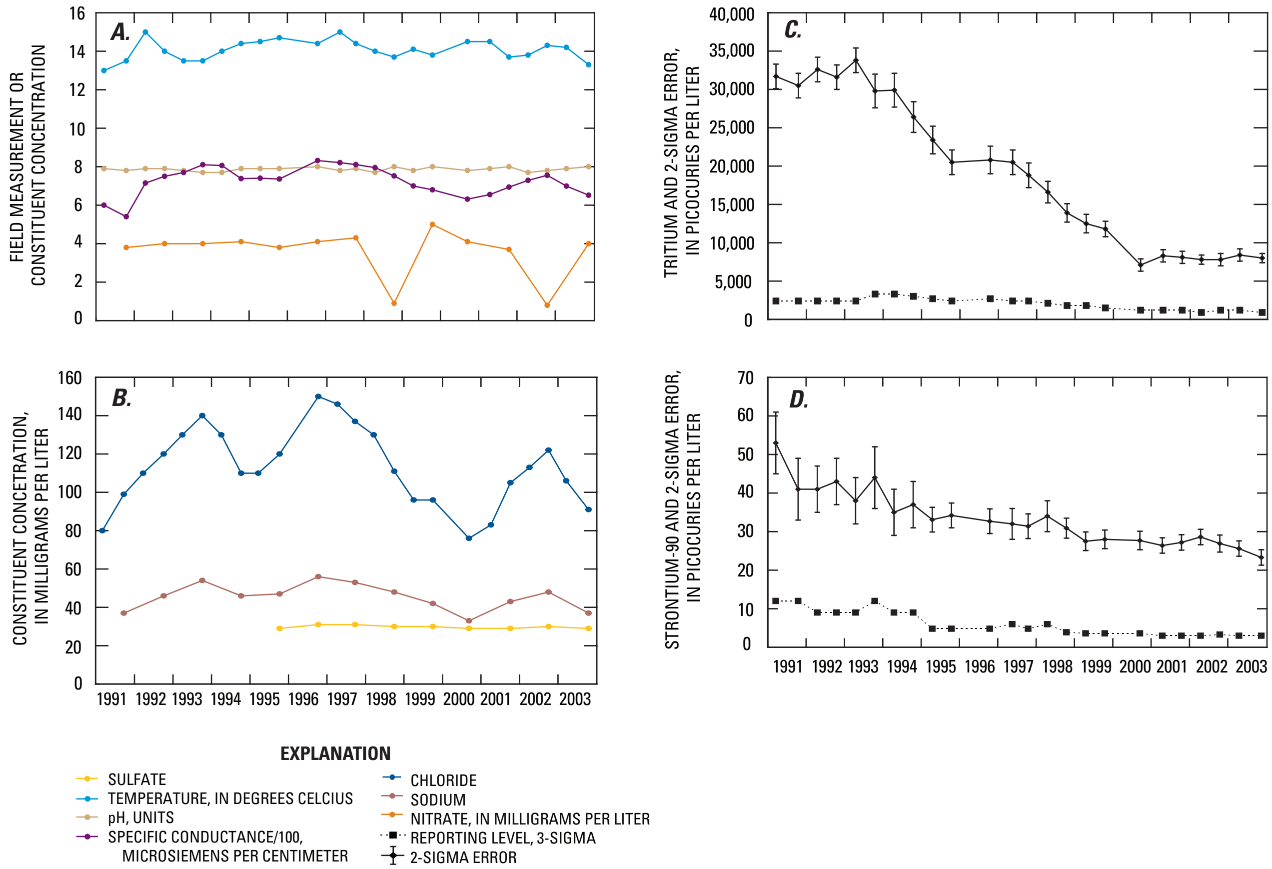

Figure 32. Water-quality data for well USGS 123, 1990-2003, with corresponding data for October-November 2003, Idaho National Laboratory, Idaho.

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Knobel

Evaluation of Well-Purging Effects on Water-Quality Results for Samples Collected from the Eastern Snake River Plain Aquifer Underlying the Idaho National Laboratory, Idaho

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