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Prepared in cooperation with
Idaho Department of Environmental Quality

Analysis of Nitrate (NO_3–N) Concentration Trends in 25 Ground-Water-Quality Management Areas, Idaho, 1961–2001

Water-Resources Investigations Report 02–4056

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By D.J. Parliman

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CONVERSION FACTORS

Multiply	By	To obtain
foot	0.3048	meter
mile	1.609	kilometer

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

$$°C = (°F - 32)/1.8$$

Analysis of Nitrate (NO_3–N) Concentration Trends in 25 Ground-Water-Quality Management Areas, Idaho, 1961–2001

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Abstract

In Idaho, drinking-water supplies are pumped from relatively shallow ground-water zones where water quality has great potential for degradation by land- and water-use activities. One indicator of water quality, and one of the most widespread contaminants in Idaho ground water related to land and water uses, is dissolved nitrate.

In December 2000, the U.S. Geological Survey, in cooperation with the Idaho Department of Environmental Quality, began a study to compile and assess nitrate data for ground water in 25 ground-water-quality management areas in Idaho. The primary objective of the study was to determine whether statistically significant trends in ground-water concentrations were discernible. Data included ground-water analyses but not analyses of water from springs, drains, or thermal water sources. A total of 8,465 nitrate analyses were compiled from 2,931 wells in the 25 priority areas; analyses dates ranged from June 1961 to February 2001.

A time-period comparison was used to assess general trends in nitrate concentrations within individual priority areas. A time-series comparison was used to assess trends in nitrate concentrations from selected wells in each priority area.

In time-period assessments, general trends in an area were evaluated by compiling nitrate data for selected time intervals to determine whether the population distributions were significantly different between one period and another. Data within each priority area were sorted into decades—1970s, 1980s, and 1990s—for long-term trend assessment. The 1990s data also were divided into sets of selected years corresponding to Statewide Ambient Ground-Water Quality Program sampling cycles—1991 through 1994, 1995 through 1998, and a partial cycle, 1999 through 2000—for short-term trend assessment. Data were analyzed by summary statistics, boxplots, and the Mann-Whitney statistical test.

Long-term increasing trends in nitrate concentrations were evident for 6 of 25 priority areas, and long-term decreasing trends were evident for 4 of 25 areas. Short-term increasing trends were evident for 7 of 25 areas, and a short-term decreasing trend was evident for only 1 area. No long-term nitrate trends were evident for 7 of 25 areas, and no short-term trends were evident for 15 of 25 areas. Data were insufficient for long-term trend assessment in 8 areas and for short-term assessment in 2 areas.

Time-series trend analyses were conducted on data from wells with 7 or more nitrate analyses and longest periods of record, at least 10 years between oldest and most recent analyses. Because long-term records were available for so few wells and well construction data were not available for several of these wells, time-series analyses were not helpful to the nitrate trend assessment study.

Trend results may be strongly affected by well construction, hydrogeologic environments, and changes in density and areal distribution of wells and analyses. The utility of nitrate trend assessments in priority areas would be improved by more consistent and specific well location descriptions between agencies; well construction and major water-yielding zone information to accompany the water-quality data for each well; and addition of historical nitrate data to data bases, particularly analyses prior to about 1990. Investigations of the possible effects of changing priority area boundaries and time periods on both long-term and short-

term trend assessments are needed. Addition of these kinds of information would allow assessment of trends associated with hydrology and geology of each area and would provide a much stronger basis for trend assessment than currently possible.

INTRODUCTION

In Idaho, ground water currently is the principal source of about 95 percent of public water supplies and most rural-domestic and livestock supplies (E. Hagan, Idaho Department of Water Resources, IDWR, oral commun., 2001). Many drinking-water supplies are pumped from relatively shallow zones where ground-water quality has great potential for degradation by land- and water-use activities. One indicator of water quality, and one of the most widespread contaminants[1] in Idaho ground water related to land and water uses, is dissolved nitrate-nitrogen (NO_3–N) concentrations.[2]

The maximum U.S. Environmental Protection Agency (EPA, 2000, p. 9) limit for nitrate concentrations in public water supplies is 10 mg/L. Concentrations of nitrate in Idaho ground water prior to land and water development probably were less than 1 mg/L (Parliman, 2000, p. 1), but elevated nitrate concentrations in ground water have been reported for more than 40 years (see Selected References). The median concentration (50th percentile) of nitrate in Idaho ground water from 1990 through 2000, for example, was about 1.5 mg/L, but the range of concentrations was less than 0.05 to 110 mg/L.

Widespread elevated nitrate concentrations historically have been detected in some areas of Idaho more frequently than in other areas. In 1998, personnel with the Idaho Department of Environmental Quality (IDEQ) conducted a preliminary assessment of statewide nitrate concentrations and delineated 33 ground-water-quality management areas (nitrate priority areas) where more than 25 percent of nitrate concentrations exceeded 5 mg/L (S. Short, IDEQ, written commun., 2000; fig. 1).

In July 2000, IDEQ convened the Ground-Water Monitoring Technical Committee to discuss ground-water-quality management issues in Idaho. One goal of the committee was to prioritize the 33 ground-water-quality management areas where nitrate has significantly degraded ground-water quality; one component of the prioritization process was identification of nitrate concentration trends within each area. In December 2000, the U.S. Geological Survey (USGS), in cooperation with IDEQ, began a study to compile and assess nitrate data for ground water in the 33 priority areas. The primary objective of the study was to determine whether statistically significant trends in nitrate concentrations were discernible. On the basis of statistical trend analysis results, nitrate trends would be defined as increasing, decreasing, or neither increasing nor decreasing (no trend). Areas would be identified where data were insufficient for statistical assessment. The purpose of this report is to present findings of these trend analyses.

DATA COMPILATION

The first task of the nitrate trends study was to identify sources of electronically transferable nitrate data in Idaho and combine these data into one data set. Data were compiled from data bases maintained by the following agencies: (1) Idaho Department of Agriculture (IDAG)—ground-water-monitoring networks and a one-time analysis of water from wells at dairies statewide, (2) IDEQ—individual ground-water-quality investigations statewide and the Drinking Water Information Management System (DWIMS) public water-supply data base, (3) USGS—individual ground-water-quality investigations statewide by Idaho and Utah Districts, and (4) the USGS/IDWR Statewide Ambient Ground-Water Quality Monitoring Program (Statewide GW-QW Program).[3]

Data included ground-water analyses but not analyses of water from springs, drains, or thermal water (greater than 84.5°F) sources. Nitrite plus nitrate as nitrogen (NO_2+NO_3–N) and nitrate-nitrogen (NO_3–N) data[4] were moved into one Microsoft Excel 2000 spreadsheet. Minimum required information for each analysis included sample date and agency source. Minimum required location information for each well

[1] Contaminants are components of ground-water quality that can limit the water's suitability for use or can represent degradation of water quality.

[2] In this report, nitrate is reported as nitrogen, NO_3–N, in milligrams per liter (mg/L), equivalent to parts per million.

[3] A description of this program is available at http://www.idwr.state.id.us/planpol/techserv/gwmon/statewide.htm

[4] USGS laboratory analyses are reported in units of nitrite plus nitrate as nitrogen (NO_2+NO_3–N). Idaho State Laboratory analyses are reported in units of nitrate as nitrogen (NO_3–N). Concentrations of nitrite in ground water generally are negligible. For purposes of this study, USGS and IDEQ analyses are comparable.

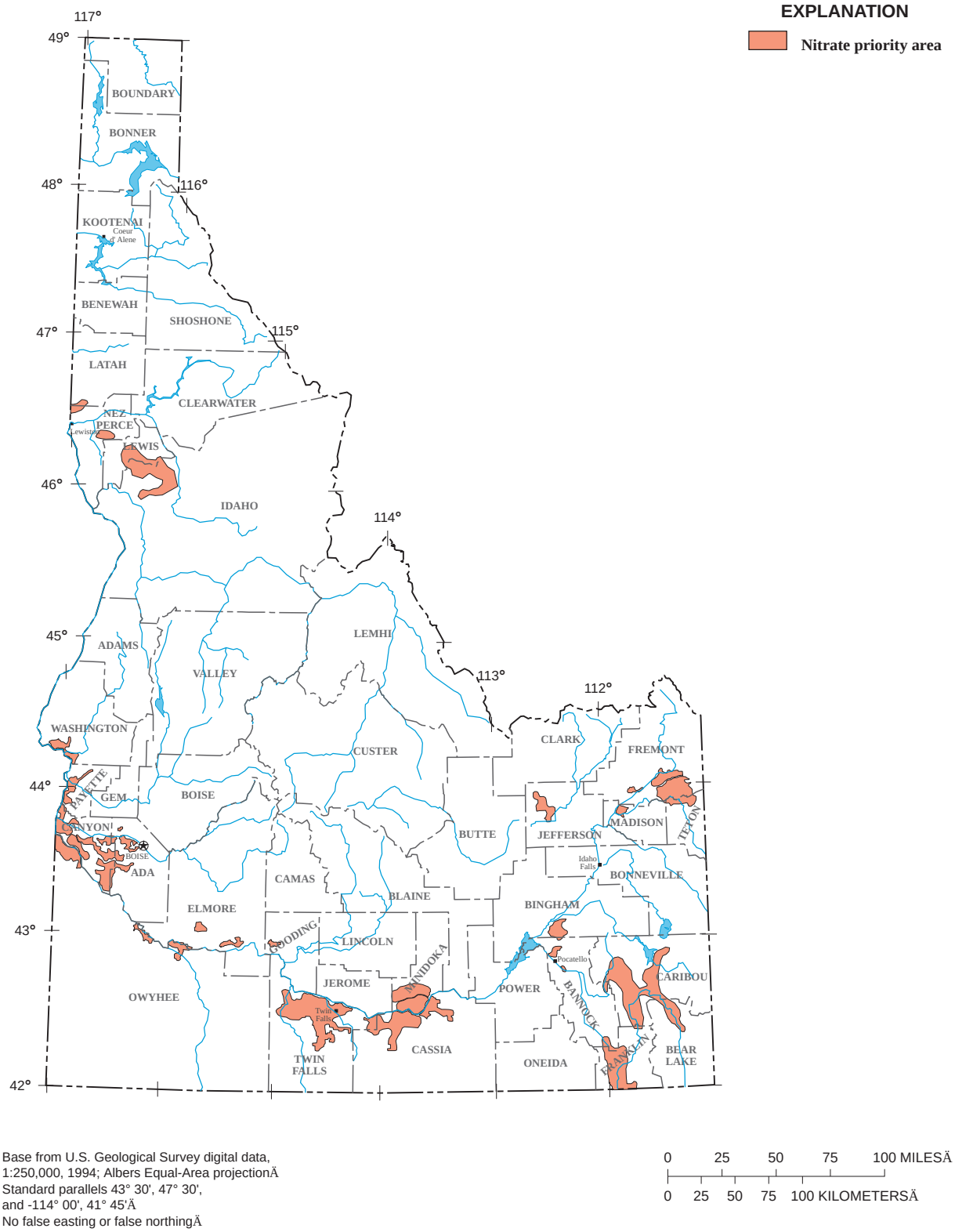

Figure 1. Locations of 33 priority ground-water-quality management areas in Idaho, July 2000. (Nitrate contamination areas from S. Short, Idaho Department of Environmental Quality, written commun., 2000)

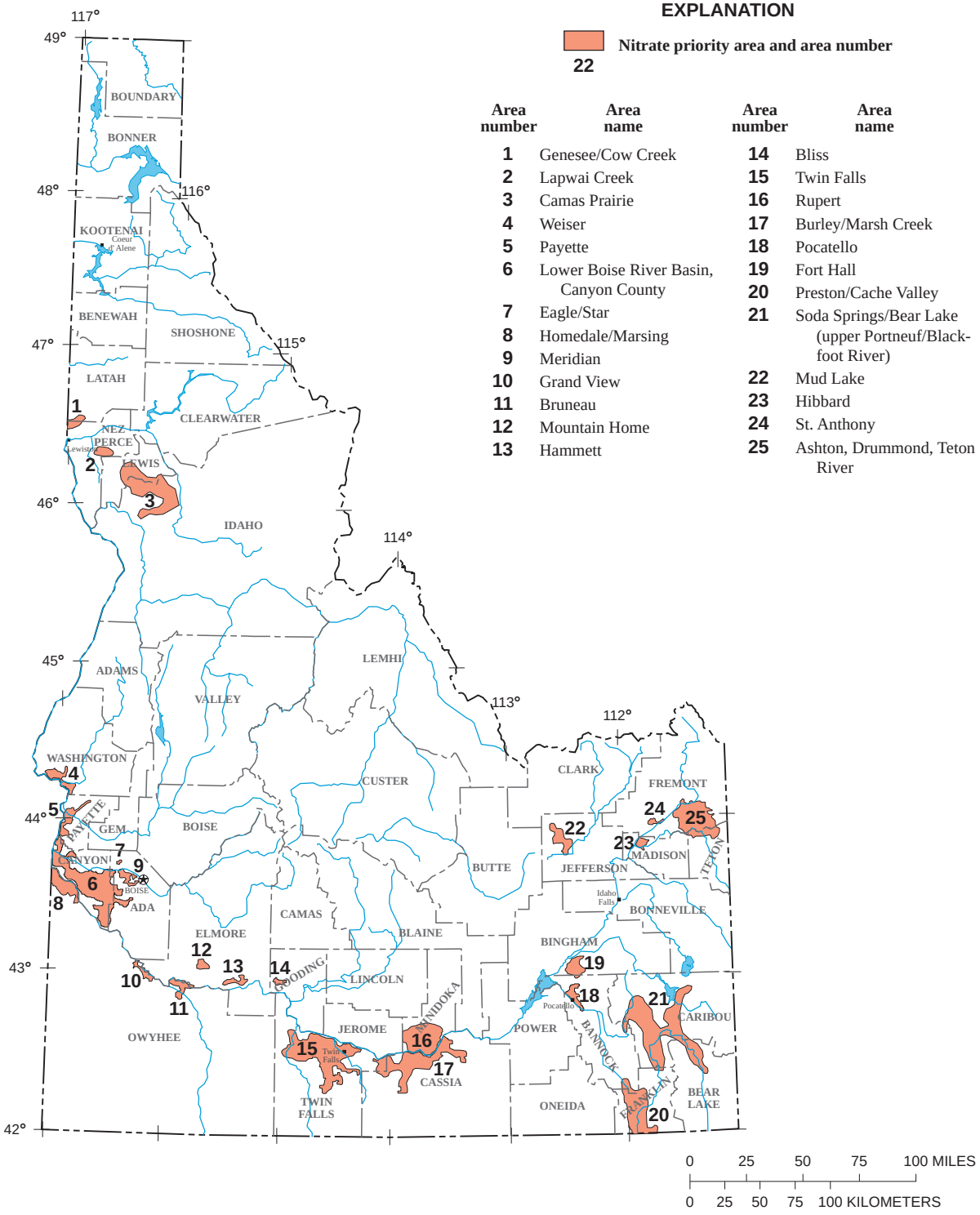

Figure 2. Locations and identification of 25 ground-water-quality management areas in Idaho selected for nitrate trend analyses, February 2001.

included latitude-longitude, township-range-section, and county. Total well depth and identifying name were requested for each well, but this information was not available for most wells.

Because shapes of the 33 priority areas were based on approximate boundaries of areas where nitrate concentrations were relatively large, data for wells in and near (within approximately 1 mile) each priority area were used for trend analyses. Adding approximately 1 mile to some boundaries, however, caused several priority areas to overlap. When priority areas with overlapping boundaries were located in one major drainage basin and hydrogeologic characteristics of the areas were similar, the multiple areas were combined. The original 33 nitrate priority areas thereby were reduced to 25 areas for trend analyses. Locations and names for the final 25 priority areas are shown in figure 2.

Reporting formats for remaining data were standardized—latitude and longitude to North American Datum of 1927 (NAD27) and decimal degrees; township-range-section to uniform columns, spaces, and characters; county names to numbers; and sample dates to yyyymmdd numeric format. Priority area numbers, shown in figure 2, were assigned to each datum, and the data were sorted by priority area. When identified, duplicate data (identical data from two or more agency sources) and replicate data (multiple analyses of water from a single well on one sample date) were removed from the data sets. Zeros and "less-than" concentrations (concentrations reported as less than a minimum laboratory reporting limit) were important components of the data sets, indicating that, although nitrate concentrations were extremely small, laboratory analyses had been completed for those ground-water samples.

A number of approaches are available for use of less-than concentrations in data analyses (Helsel and Hirsch, 1995, p. 359–376). In this study, less-than qualifiers were removed, and 0.001 mg/L was subtracted from the reported nitrate concentration. A concentration of <0.05 mg/L, for example, was replaced in the data set by 0.049 mg/L. For purposes of this study, use of this approach and assignment of very small concentrations to less-than data should have little effect on the overall outcome of the trend analyses.

A total of 8,465 nitrate analyses were compiled from 2,931 wells in the 25 priority areas: dates for nitrate data ranged from June 1961 (USGS data) to February 2001 (DWIMS data). General characteristics of the data for each of the 25 priority areas are presented in table 1 and figures 3–6.

The number of analyses by year and priority area are shown in table 1. Prior to about 1990, numbers of analyses and periods of time when data were collected were not evenly distributed for individual areas or throughout all the areas. Data generally were the result of relatively small-scale ground-water studies by individual agencies. After about 1990 and the beginning of the Statewide GW-QW Program, data were more uniformly collected from all parts of the State each year.

The number of analyses in relation to the number of wells in each priority area is shown in figure 3. Areas 6, 9, 15, 16, and 17 have a relatively large number of wells with analyses, and many of these wells have multiple water analyses. In most other areas, few analyses are available and few multiple analyses are available for individual wells. The ranges of nitrate concentrations are shown in figure 4, and mean (average) versus median (50th percentile) values for each priority area are shown in figure 5. Nitrate concentrations exceed 10 mg/L in nearly all areas. Large differences between mean and median concentrations in an area often indicate the presence of anomalously large nitrate concentrations in the data set. Nitrate concentrations in relation to total well depth for selected wells in all priority areas are shown in figure 6. For wells with total depth information, all nitrate concentrations greater than 10 mg/L were from wells less than about 400 feet total depth.

TREND ANALYSES

Two principal statistical approaches were applied to the compiled data set. A time-period comparison was used to assess general trends in nitrate concentrations within individual priority areas. A time-series comparison was used to assess trends in nitrate concentrations from selected wells in each priority area.

Time-Period Trends by Decades or Selected Years

In time-period assessments, general trends in an area were evaluated by compiling nitrate data for selected time intervals to determine whether the population distributions were significantly different between one period and another. Data within each priority area were sorted into decades—1970s (1/1/70–12/31/79), 1980s (1/1/80–12/31/89), and 1990s (1/1/90–

Table 1. Number of nitrate analyses per year for 25 ground-water-quality management areas in Idaho, 1961–2001

Year	Ground-water-quality management area (locations and names shown in figure 2)																								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1961									1																
1964																									2
1968																				1					
1970						14			7																
1972				1											1	9									
1973				6						4	5					44									
1974				3													2				6				1
1975				1	3	17	1		5							1	4				4				7
1976						7						6						12		2	31		1		
1977						5			6	1					1										
1978					1	18			8							1	5						1		
1979						17		1	10						4		4	1				9		4	8
1980						19			11	7	9	13	12				1	3			1				1
1981						26	1		17			2			10		4								1
1982					8										15		8	1							
1983																	4	16			1				
1984								1								1	3	18				3			
1985																	17	19							
1986																1	12	17	15		2				
1987					1	1			5						2	24	84	21			1		1		1
1988						1									1	14	20	17	22	1					1
1989								1			2	19					1	24	50		2	9			1
1990			4	1		11			9		1	13	1		4	4	2	5	21	1	4	2			2
1991	1		3	3	2	33	2	1	5	1	2	4	2	1	14	7	8	28	5	2	8	4	3	3	5
1992	1	1	4	2	21	40		1	19		2	1	1		20	8	9	9	1	4	9	4		3	5
1993	1	4	14	7	16	105	2	6	150	3	3	23	3		30	63	33	46	1	4	24	5	16		9
1994		2	13	11	6	121	2	8	295	3	4	27	4		57	22	31	40		7	28	5	10		7
1995	1	3	11	18	17	209	12	5	208	4	4	31	6	1	61	26	34	43	4	8	25	8	16	3	14
1996	1	4	10	47	19	291		10	106	3	5	33	4	1	55	40	32	47	4	9	18	7	9	5	11
1997	2	4	12	44	25	236	12	12	116	6	6	35	5		109	104	68	47	1	10	30	7	22	3	64
1998	1	4	68	42	26	146	2	11	102	14	8	43	4		144	104	83	49	2	15	28	21	40	7	98
1999	1	5	13	44	46	154	2	49	104	5	5	33	5	3	192	111	99	50	6	17	27	22	54	26	51
2000	2	4	13	50	28	163	2	62	81	6	5	48	3		175	120	90	50	4	53	24	19	22	8	24
2001				1	11	36		5	5		2		2		6	5	8	1				4	5		
Number of analyses	11	31	165	281	230	1,670	38	173	1,270	57	63	331	52	6	901	709	666	564	136	134	273	129	200	62	313
Number of wells	3	6	88	75	93	613	24	78	328	26	28	98	20	3	345	254	267	78	61	70	90	49	70	33	131
Total number of analyses	8,465																								
Total number of wells	2,931																								

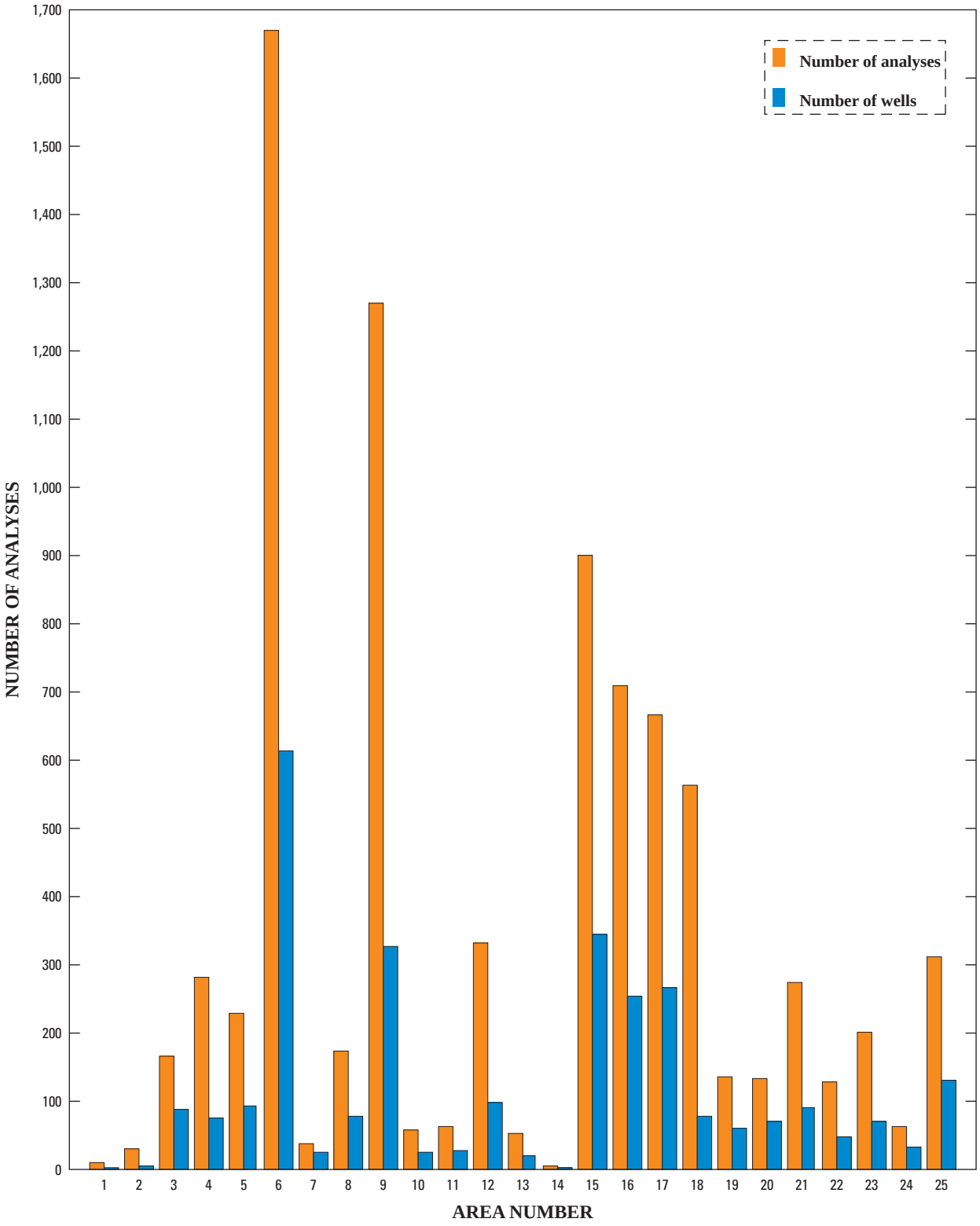

Figure 3. Number of nitrate analyses in relation to number of wells in 25 ground-water-quality management areas in Idaho, 1961–2001.

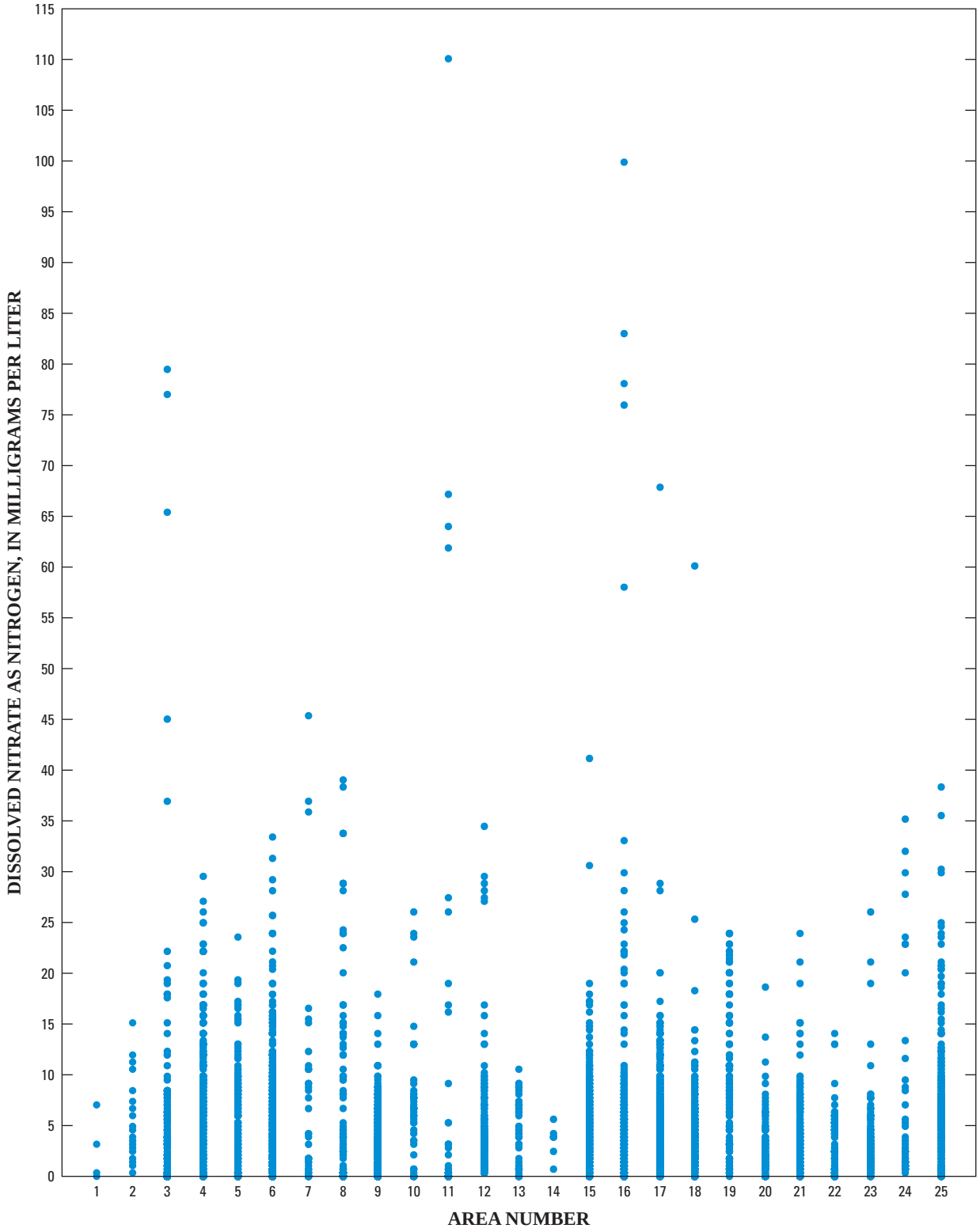

Figure 4. Ranges of nitrate concentrations for 25 ground-water-quality management areas in Idaho, 1961–2001.

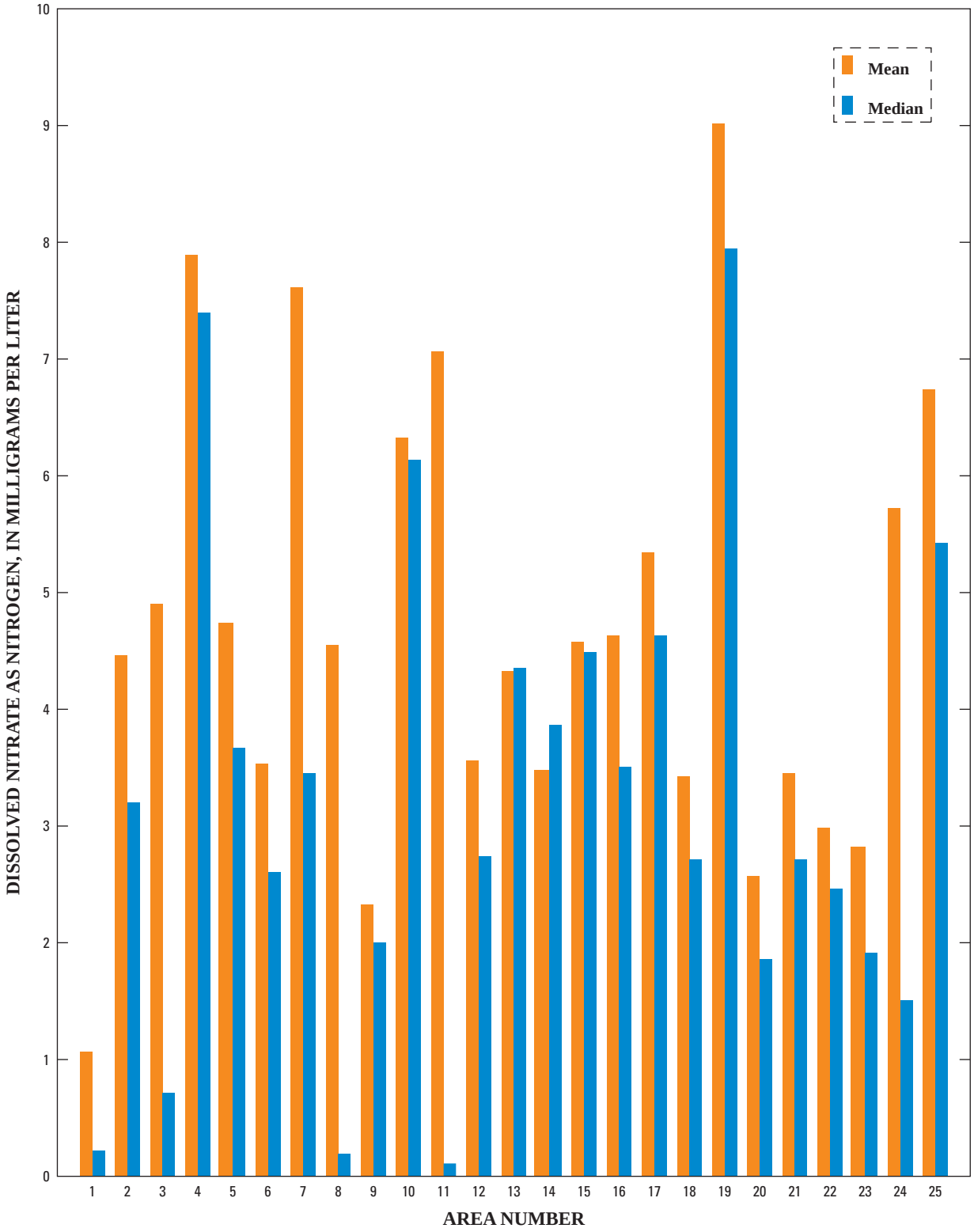

Figure 5. Mean (average) nitrate concentrations in relation to median (50th percentile) concentrations for 25 ground-water-quality management areas in Idaho, 1961–2001.

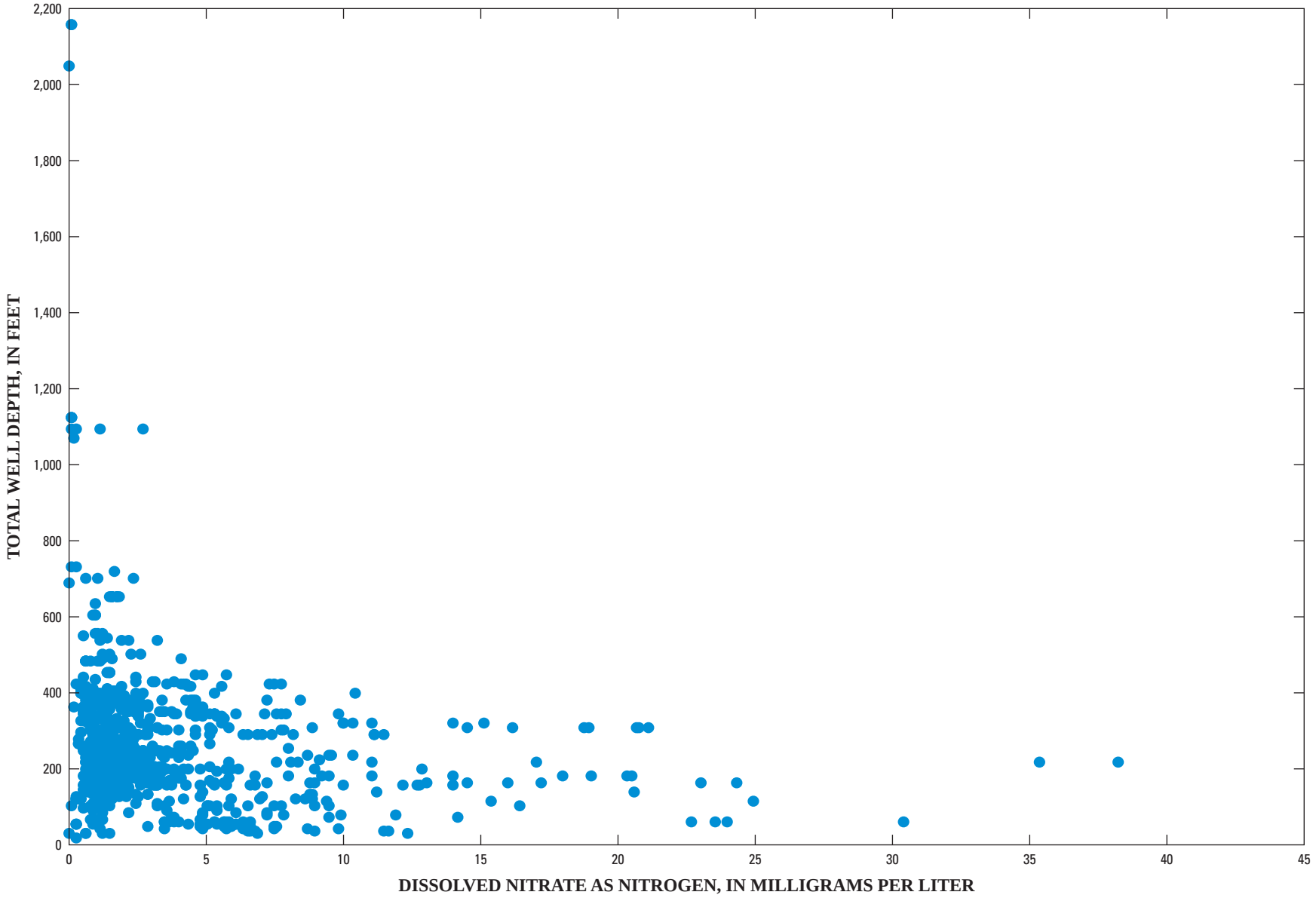

Figure 6. Nitrate concentrations in relation to total well depth, selected wells in ground-water-quality management areas in Idaho, 1961–2001.

12/31/99)—for long-term trend assessment. Data from the 1960s were not used in trend analyses because there were too few data (a total of four analyses) for trend comparisons.

The 1990s data also were divided into sets of selected years corresponding to Statewide GW-QW Program sampling cycles—1991 through 1994, 1995 through 1998, and a partial cycle, 1999 through 2000, for short-term trend assessment. During 1991, the first year of the Statewide Program's initial 4-year sampling cycle, water samples were collected for laboratory analyses from approximately 400 wells throughout Idaho. Each year of the 4-year sampling cycle, samples from 400 additional wells were analyzed and, by the final year of the sampling cycle, 1994, water samples from more than 1,600 wells had been analyzed. Wells originally included in the 1991 sampling were sampled again in 1995, and by December 2000, 2 1/2 sampling cycles had been completed. Data from these sampling cycles were useful for short-term nitrate trend assessment because, although only 2 1/2 sampling cycles had been completed, analyses were from a consistent and large number of wells for each cycle. The sampling cycles also provided a periodic, statewide overview of water-quality conditions in most major water-yielding zones and from wells with various well construction conditions and water uses.

In both decade and selected year (sampling cycle) data assessments, only one nitrate analysis per well per year was used. For wells with multiple analyses per year, selection of one analysis per year primarily was based first on time of year, then on uniformity of sample dates. Samples from June through September, the general period of time when Statewide GW-QW Program samples are collected, were chosen over samples from other times of the year. If June-September samples were not available, samples from the same season of the year or month each year were chosen for individual wells.

Several methods were used to analyze and compare nitrate data by these decades and sampling cycles. Microsoft Excel 2000 was used to calculate summary statistics (number of analyses, median or 50th percentile, mean or average, and range of data) for wells with four or more analyses and to prepare comparative compilations or plots of data (table 1 and figures 3–6) for analyses in the nitrate trend data set. SPSS Inc. SYSTAT Version 9 was used to create boxplot diagrams and perform Mann-Whitney statistical tests for analyses in the nitrate trend data set.

A boxplot diagram (see half-title page for Appendix A) summarizes the distribution of a data set and is useful for comparing several related data sets, such as nitrate data by decades or selected ranges of years. The boxplot "box" shows the upper quartile (75th percentile), median (50th percentile), and lower quartile (25th percentile) of data. One and one-half (1.5) times the height of the box (75th percentile to 25th percentile) is defined as a "step." Lines extending above and below the box ("whiskers") are 1 step away from the box. Blue circles on the diagram represent values between 1 and 2 steps above or below the box, and orange circles represent values more than 2 steps above or below the box.

The Mann-Whitney test is a nonparametric rank-sum test (Helsel and Hirsch, 1995, p. 118) for whether one population set tends to produce larger or smaller observations than another set. This nonparametric test is an alternative to the parametric two-sample t test (Ott, 1988, p. 183) and has less stringent assumptions of normality and equal variances of the two sets being compared.[5] No assumptions are needed in this test concerning the distribution of data in either set. Results of the Mann-Whitney test are expressed as *p*-values, the significance level attained by the data. For groups of nitrate data, *p*-values less than or equal to 0.050 indicate there is a 95-percent-or-greater confidence that data from the two decades or selected years compared are different. When statistical comparison methods indicated that two sets of data were different, summary statistics and boxplot comparisons were used to determine increasing or decreasing trends in the nitrate data.

Boxplots, summary statistics, and Mann-Whitney test values for each priority area are shown in appendix A. A summary of Mann-Whitney *p*-values for comparisons of data by decade and selected years is presented in table 2 and indicates increasing, decreasing, or no trend (*p*-values greater than 0.050) assessments of the data. Data for areas 1 and 14 were insufficient (fewer than four analyses per decade and selected years) for either long- or short-term trend assessments. No data existed from the 1970s and 1980s or were insufficient

[5] Helsel and Hirsch (1995, p. 118) state that if the only interest in the data is to determine whether one group tends to produce higher observations—the objective of this analysis—the two groups do not need to have the same distribution. Application of the Mann-Whitney test for more specific purposes, such as determining whether two groups come from the same population, assumes that the shapes of the distributions are the same. In fact, the shapes of the distributions of data in groups used in this analysis are generally similar (figs. 4 and 5 and boxplots in appendix A), demonstrating nonnormality (distribution skewed to the right) and extreme outliers.

Table 2. Long-term (decades) and short-term (selected years) nitrate trend summaries for 25 ground-water-quality management areas in Idaho, 1970–2000.

[Mann-Whitney test *p*-value for decade (1970, 1980, 1990) or selected years (1991–94, 1995–98, 1999–2000); 2 groups compared, 4 samples or more each group; *p*-values: 0.050 = significant at the 95-percent level: "+" increasing trend; "-" = decreasing trend; **x** = insufficient data]

Area	Name	1970 through 1980	1970 through 1990	1970 through 1991–94	1970 through 1995–98	1970 through 1999–2000	1980 through 1990	1980 through 1991–94	1980 through 1995–98	1980 through 1999–2000	Long-term trend (decades)	1991–94 through 1995–98	1991–94 through 1999–2000	Short-term trend (selected years)
1	Genesee/Cow Creek										x			x
2	Lapwai Creek										x	0.245	0.491	no trend
3	Camas Prairie										x	.005+	.702	increasing
4	Weiser		0.002+	0.619+	0.003+	0.003+					increasing	.006+	.005+	increasing
5	Payette	0.352	.555	.609	.480	.717	0.266	0.493	0.206	0.305	no trend	.548	.661	no trend
6	Lower Boise-Canyon	.162	.757	.267	.839	.702	.161	.512	.071	.219	no trend	.011+	.727	increasing
7	Eagle/Star										x	.717	.670	no trend
8	Homedale/Marsing										x	.289	.131	no trend
9	Meridian	.352	.359	.925	.310	.007-	.119	.415	.086	.001-	decreasing	.032-	.000-	decreasing
10	Grand View	.239	.019+	.803	.010+	.002+	.084	.847	.048+	.016+	increasing	.031+	.021+	increasing
11	Bruneau	.561	.492	.955	.439	.164	.614	.643	.462	.129	no trend	.277	.164	no trend
12	Mountain Home	.211	.686	.762	.627	.769	.005-	.030-	.007-	.012-	decreasing	.629	.828	no trend
13	Hammett						.000+	.029+	.001+	.004+	increasing	.801	.004+	increasing
14	Bliss										x			x
15	Twin Falls	.032+	.000+	.001+	.000+	.000+	.010+	.050+	.032+	.001+	increasing	.769	.015+	increasing
16	Rupert	.004+	.923	.808	.936	.678	.000-	.006-	.000-	.002-	decreasing	.850	.682	no trend
17	Burley/Marsh Creek	.000+	.002+	.008+	.003+	.001+	.000-	.000-	.003-	.017-	decreasing	.850	.050+	increasing
18	Pocatello	.433	.058	.138	.060	.029+	.031+	.174	.067	.029+	increasing	.726	.343	no trend
19	Fort Hall						.398	.480	.214	.762	no trend	.786	.696	no trend
20	Preston/Cache Valley										x	.927	.279	no trend
21	Soda Springs/Bear Lake	.849	.315	.234	.455	.580	.397	.369	.450	.511	no trend	.516	.311	no trend
22	Mud Lake	.522	.403	.877	.446	.456	.514	1.000	.575	.456	no trend	.548	.856	no trend
23	Hibbard										x	.594	.937	no trend
24	St. Anthony	.477	.131	.268	.447						no trend	1.000	.677	no trend
25	Ashton-Teton River	.214	.000+	.045+	.000+	.001+	.270	.707	.195	.468+	increasing	.075	.311	no trend

for long-term trend assessment for areas 2, 3, 7, 8, 20, and 23. In priority areas with a mix of increasing and no trend, decreasing and no trend, or increasing/decreasing and no trend indications, the overall trend was based on assessments from longest periods of time—1970s or 1980s to 1999–2000, for example. Short-term assessments were made for data between only 1991–94 and 1995–98 or 1999–2000. No assessments were made for data between 1995–98 and 1999–2000 because there were relatively few years between the two sample groups and few sites with multiple analyses during this time.

Long-term increasing trends in nitrate concentrations were evident for areas 4, 10, 13, 15, 18, and 25. Short-term increasing trends during either 1991–94 to 1995–98 or during 1991–94 to 1999–2000 were evident for areas 3, 4, 6, 10, 13, 15, and 17, but short-term increasing trends in both sets of selected years were evident only for areas 4 and 10.

Long-term decreasing trends in nitrate concentrations were evident for areas 9, 12, 16, and 17. A short-term decreasing trend was evident only for area 9 and for both sets of selected years.

No long-term nitrate trend was evident for areas 5, 6, 11, 19, 21, 22, and 24. No short-term trends were evident for areas 2, 5, 7, 8, 11, 12, 16, and 18 through 25 for either set of selected years.

Time-Series Trends for Data From Individual Wells

Time-series trend analyses were conducted on data from 24 wells with 7 or more nitrate analyses and longest periods of record, at least 10 years between oldest and most recent analyses. The Mann-Kendall test statistic was used to assess whether nitrate concentrations tended to increase or decrease with time (Helsel and Hirsch, 1995, p. 326) at individual wells. The statistic was calculated for each data set by using an Excel spreadsheet. Results of the Mann-Kendall test are expressed as *p*-values, the significance level attained by the data. A *p*-value less than or equal to 0.050 indicated a 95-percent-or-greater confidence that there was a change in nitrate concentration over time at an individual well.

Plots of nitrate concentration in relation to time were used to determine increasing, decreasing, or no trend for data from a particular well. Plots of nitrate concentration, *p*-values, and trend determination; and well location, priority area, county, source of nitrate data, and total well depth for the 24 wells are shown in appendix B.

Long-term increasing trends were evident for selected wells in priority areas 5, 9, 17, 18, and 25. Decreasing trends were evident for selected wells in area 9, and no trend was evident for selected wells in areas 6, 9, 12, 16, 17, 18, and 21. Time-series trends for water analyses from individual wells reflect hydrogeologic conditions specific to the location and well construction. Data from a well may show increasing, decreasing, or no trend in nitrate concentrations with time, but the trend for that well may or may not be representative of general area water-quality conditions. Because long-term records were available for so few wells (fewer than 1 percent of 2,931 wells) and well construction data were available for fewer than half of these wells, time-series analyses were of interest but not helpful to the current nitrate trend study. As longer periods of record and well construction information become available for increasing numbers of wells in the priority areas, time-series analyses may become a more valuable tool for assessment of nitrate trends in ground-water-quality management areas.

ADDITIONAL INFORMATION NEEDED

To improve the utility of nitrate trend assessments in priority areas, additional well location and construction information is needed. Some duplicate data may have been included in the data set for this study, but site inventory information for wells often was not comparable from agency to agency. For example, wells were located to $^1/_4$-$^1/_4$-$^1/_4$ section in some data bases but only to section in others, and total depth information was available for only a few wells. Without more specific legal descriptions or well depth information, decisions could not be made on whether the wells were the same. Also, methods for determining latitude-longitude locations for wells have changed over time, and reported locations for wells in different data bases were inconsistent from agency to agency.

Well construction information (including total depth, completion date, and screen/perforations/open borehole data) and major water-yielding zone information to accompany the water-quality data are needed. Addition of these kinds of information would allow assessment of trends associated with hydrology and geology of each area and would provide a much stron-

ger basis for trend assessment than analyzing values distributed over a map area.

Addition of historical nitrate data, particularly analyses prior to about 1990, to data bases is needed. Public water-supply analyses from the 1950s, 1960s, 1970s, and 1980s, for example, may be available but have not been entered into data bases. Addition of these types of data would be invaluable to both long-term nitrate trend assessment and time-trend assessments within priority areas.

Investigation of possible effects of increasing or decreasing the size of priority area boundaries on nitrate trend assessment results is needed. Trend results may be strongly affected by changes in numbers of wells, numbers of analyses, density and areal distribution of wells and analyses, well construction, and hydrogeologic environments represented by wells and water samples.

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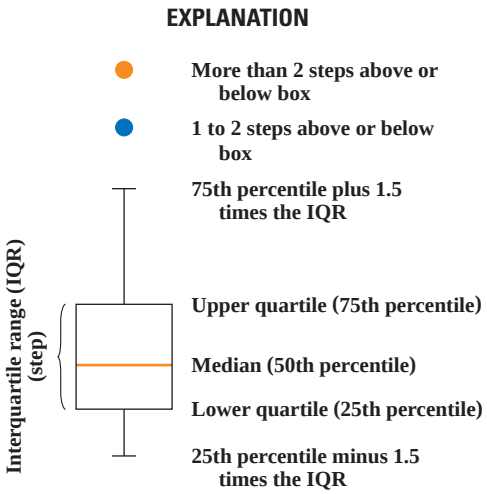
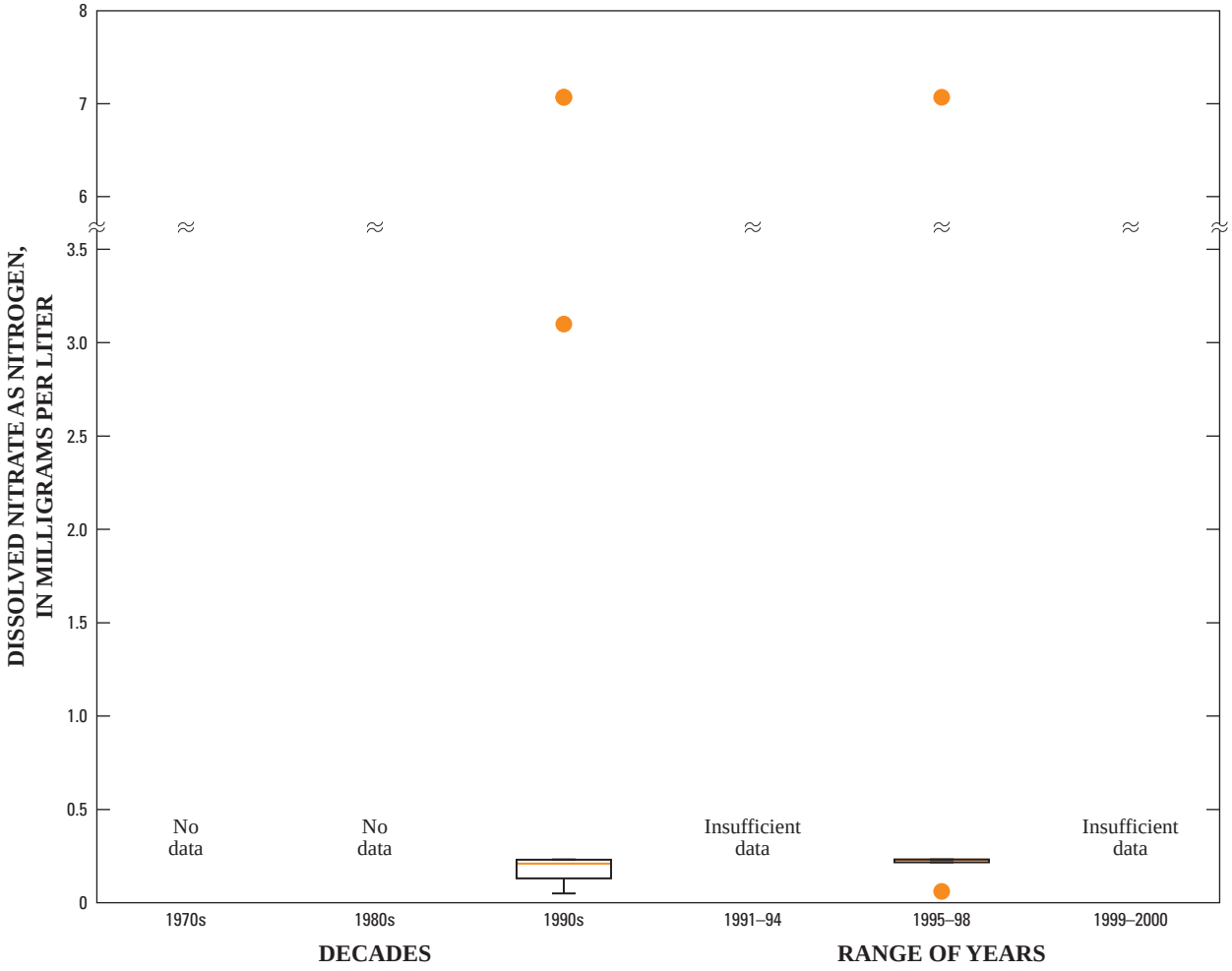
Appendix A. Boxplots, summary statistics, and Mann-Whitney test *p*-values for 25 ground-water-quality management areas in Idaho, 2001



Area 1 Genesee/Cow Creek

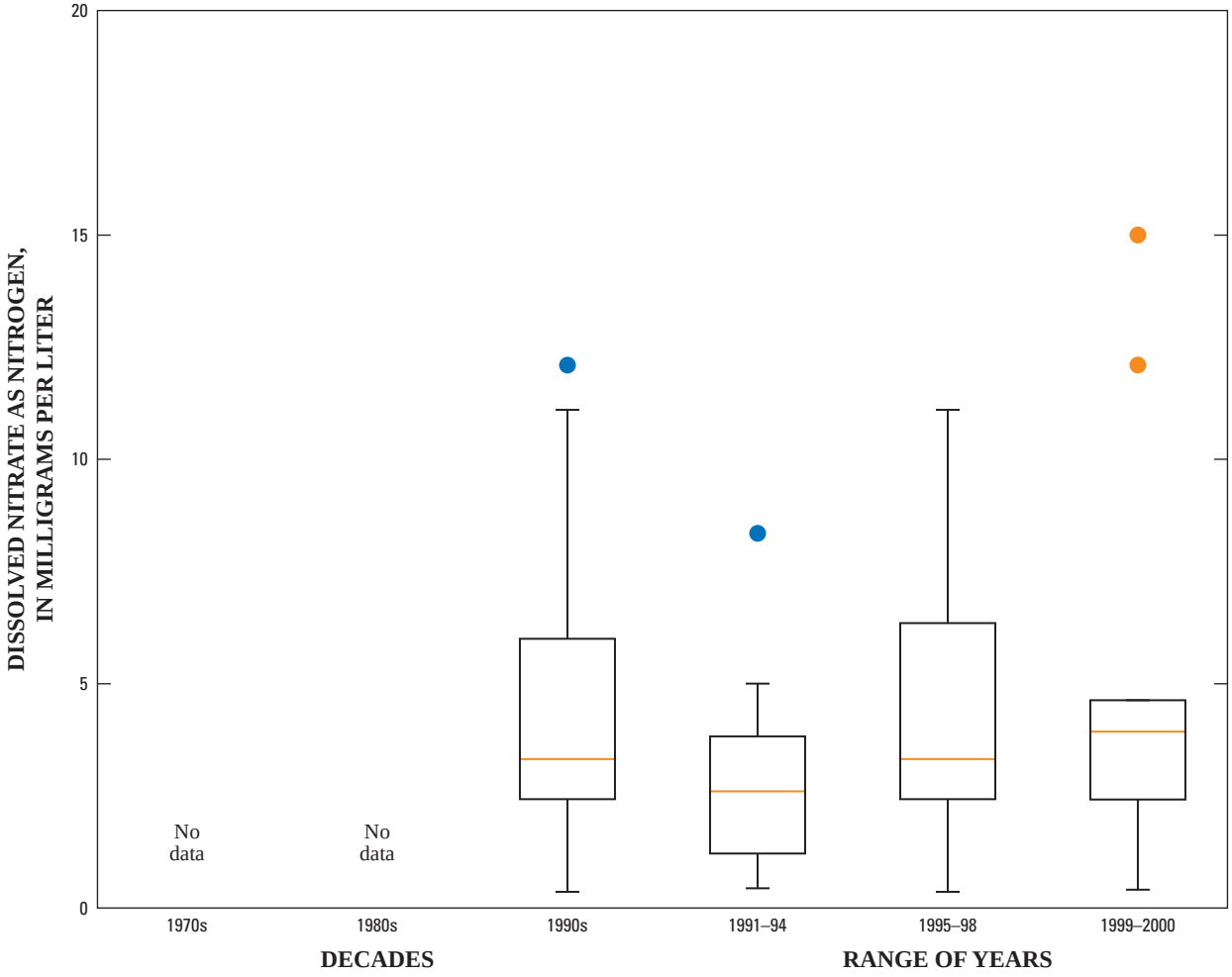


Selected summary statistics		Number of analyses	Nitrate concentrations, milligrams per liter		
			Median	Mean	Maximum
Decade					
1970	(1/1/70 to 12/31/79)				
1980	(1/1/80 to 12/31/89)				
1990	(1/1/90 to 12/31/99)	11	0.21	1.1	7.1
Range of years					
1991–94	(1/1/91 to 12/31/94)	3	.20	1.1	3.1
1995–98	(1/1/95 to 12/31/98)	5	.23	1.6	7.1
1999–2000	(1/1/99 to 12/31/00)	3	.21	.16	.21

Mann-Whitney test

Decade or range of years	*p*-value	Decade or range of years	*p*-value
1970 to 1980		1980 to 1990	
1970 to 1990		1980 to 1991–94	
1970 to 1991–94		1980 to 1995–98	
1970 to 1995–98		1980 to 1999–2000	
1970 to 1999–2000		1991–94 to 1995–98	
		1991–94 to 1999–2000	

Area 2 Lapwai Creek

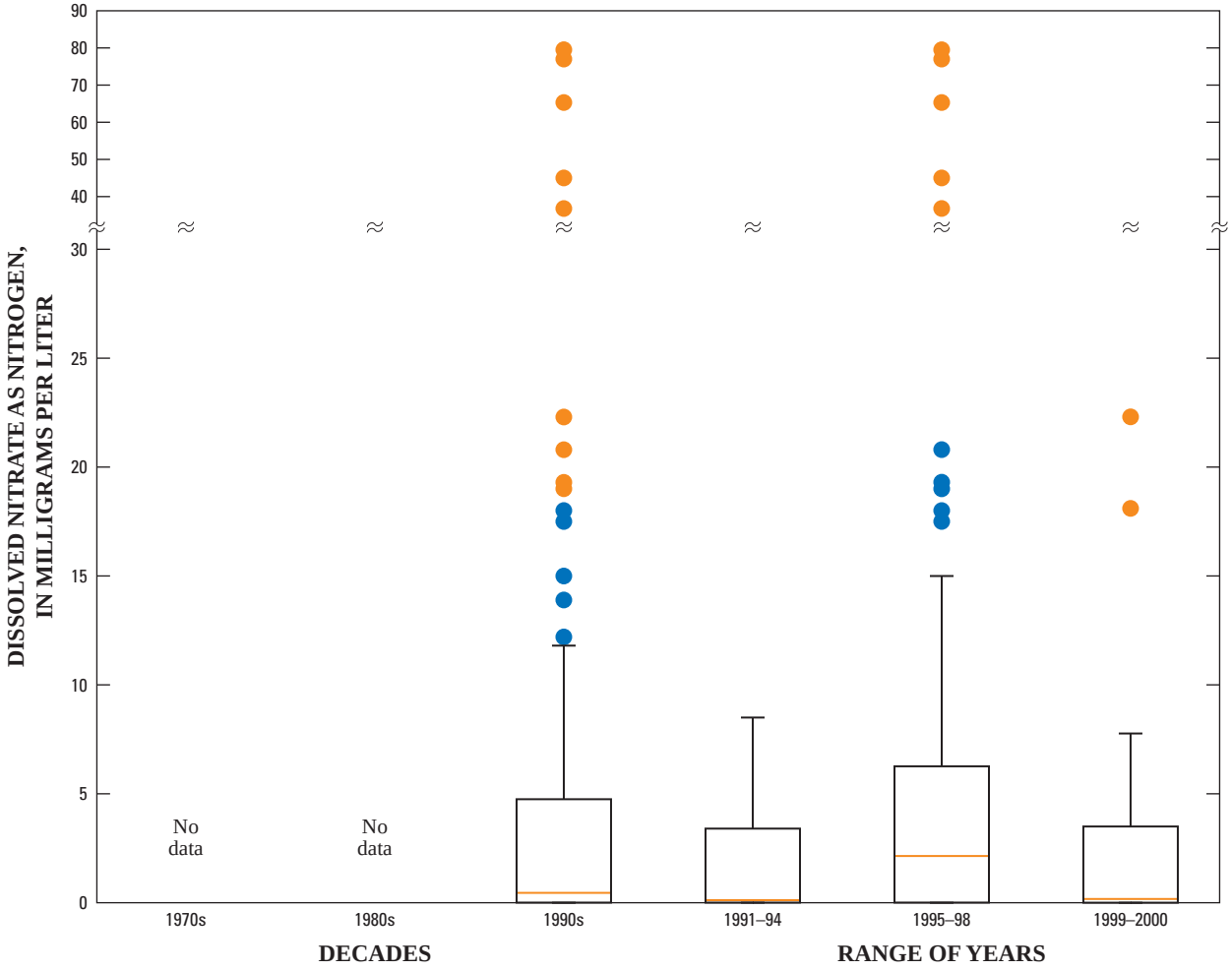


Selected summary statistics		Number of analyses	Nitrate concentrations, milligrams per liter		
			Median	Mean	Maximum
	Decade				
1970	(1/1/70 to 12/31/79)				
1980	(1/1/80 to 12/31/89)				
1990	(1/1/90 to 12/31/99)	27	3.3	4.4	12
	Range of years				
1991–94	(1/1/91 to 12/31/94)	7	2.6	3.1	8.4
1995–98	(1/1/95 to 12/31/98)	15	3.3	4.6	11
1999–2000	(1/1/99 to 12/31/00)	9	3.9	5.3	15

Mann-Whitney test

Decade or range of years	*p*-value	Decade or range of years	*p*-value
1970 to 1980		1980 to 1990	
1970 to 1990		1980 to 1991–94	
1970 to 1991–94		1980 to 1995–98	
1970 to 1995–98		1980 to 1999–2000	
1970 to 1999–2000		1991–94 to 1995–98	0.245
		1991–94 to 1999–2000	.491

Area 3 Camas Prairie

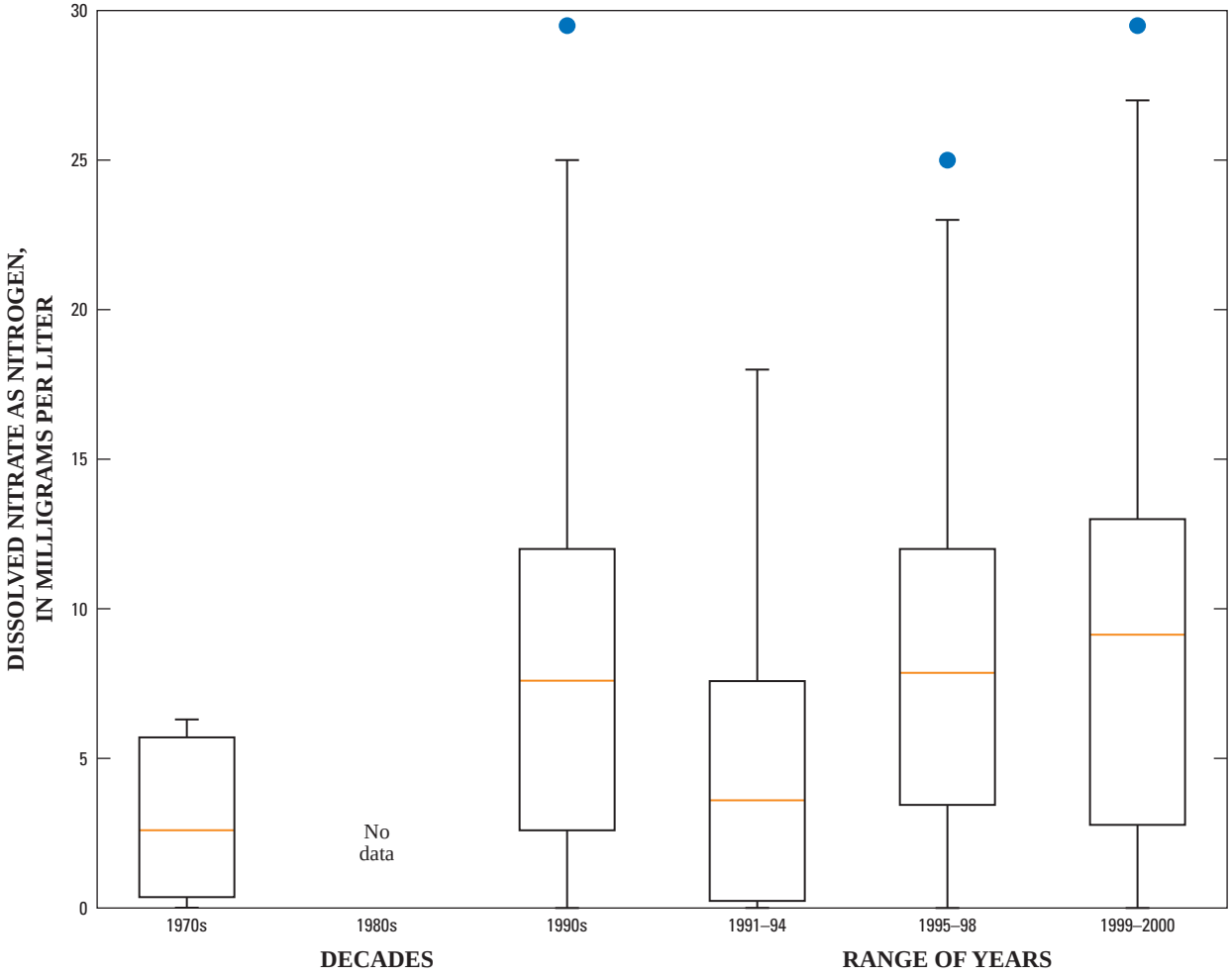


Selected summary statistics		Number of analyses	Nitrate concentrations, milligrams per liter		
			Median	Mean	Maximum
	Decade				
1970	(1/1/70 to 12/31/79)				
1980	(1/1/80 to 12/31/89)				
1990	(1/1/90 to 12/31/99)	152	0.93	5.1	80
	Range of years				
1991–94	(1/1/91 to 12/31/94)	34	.12	1.6	8.5
1995–98	(1/1/95 to 12/31/98)	101	2.8	6.7	80
1999–2000	(1/1/99 to 12/31/00)	26	.17	2.9	22

Mann-Whitney test

Decade or range of years	*p*-value	Decade or range of years	*p*-value
1970 to 1980		1980 to 1990	
1970 to 1990		1980 to 1991–94	
1970 to 1991–94		1980 to 1995–98	
1970 to 1995–98		1980 to 1999–2000	
1970 to 1999–2000		1991–94 to 1995–98	0.005
		1991–94 to 1999–2000	.702

Area 4 Weiser

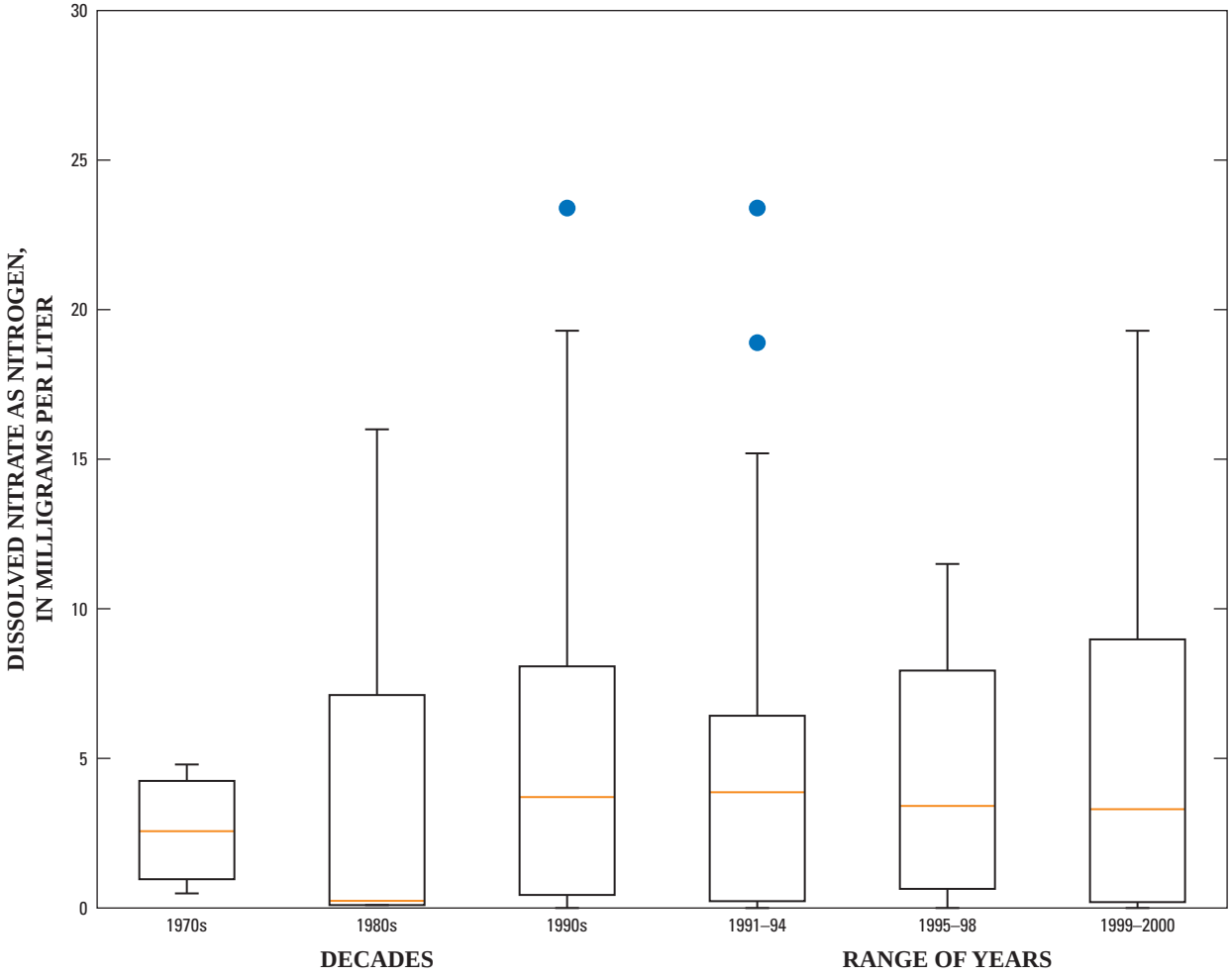


Selected summary statistics		Number of analyses	Nitrate concentrations, milligrams per liter		
			Median	Mean	Maximum
Decade					
1970	(1/1/70 to 12/31/79)	11	2.6	3.0	6.3
1980	(1/1/80 to 12/31/89)				
1990	(1/1/90 to 12/31/99)	219	7.6	7.9	30
Range of years					
1991–94	(1/1/91 to 12/31/94)	23	3.6	4.8	18
1995–98	(1/1/95 to 12/31/98)	151	7.9	8.1	25
1999–2000	(1/1/99 to 12/31/00)	94	9.1	8.9	30

Mann-Whitney test

Decade or range of years	*p*-value	Decade or range of years	*p*-value
1970 to 1980		1980 to 1990	
1970 to 1990	0.002	1980 to 1991–94	
1970 to 1991–94	.619	1980 to 1995–98	
1970 to 1995–98	.003	1980 to 1999–2000	
1970 to 1999–2000	.003	1991–94 to 1995–98	0.006
		1991–94 to 1999–2000	.005

Area 5 Payette

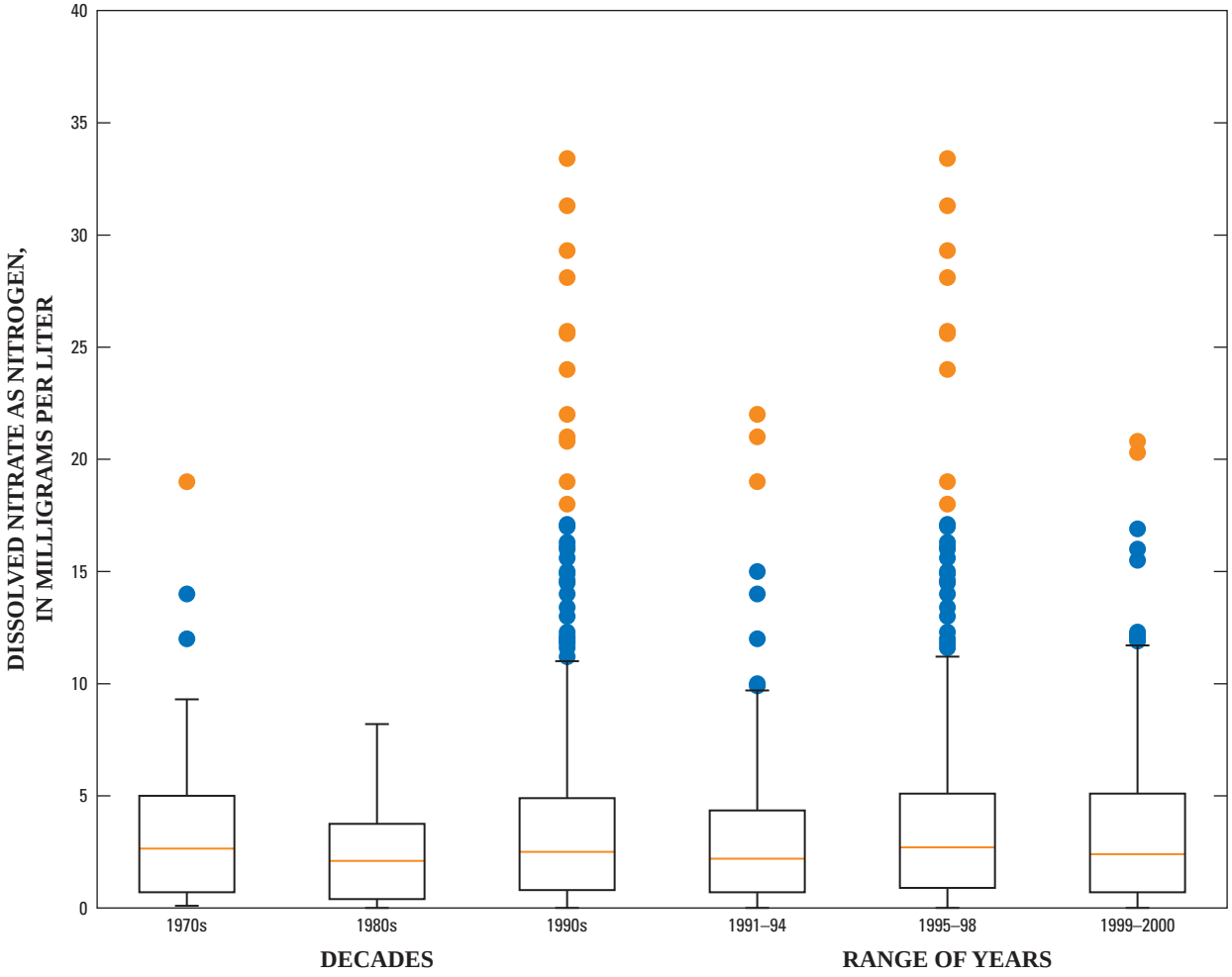


Selected summary statistics		Number of analyses	Nitrate concentrations, milligrams per liter		
			Median	Mean	Maximum
Decade					
1970	(1/1/70 to 12/31/79)	4	2.6	2.6	4.8
1980	(1/1/80 to 12/31/89)	9	.24	3.5	16
1990	(1/1/90 to 12/31/99)	178	3.7	4.7	23
Range of years					
1991–94	(1/1/91 to 12/31/94)	45	3.9	4.6	23
1995–98	(1/1/95 to 12/31/98)	87	3.4	4.4	12
1999–2000	(1/1/99 to 12/31/00)	74	3.3	5.2	19

Mann-Whitney test

Decade or range of years	*p*-value	Decade or range of years	*p*-value
1970 to 1980	0.352	1980 to 1990	0.266
1970 to 1990	.555	1980 to 1991–94	.493
1970 to 1991–94	.609	1980 to 1995–98	.206
1970 to 1995–98	.480	1980 to 1999–2000	.305
1970 to 1999–2000	.717	1991–94 to 1995–98	.548
		1991–94 to 1999–2000	.661

Area 6 Lower Boise River Basin, Canyon County

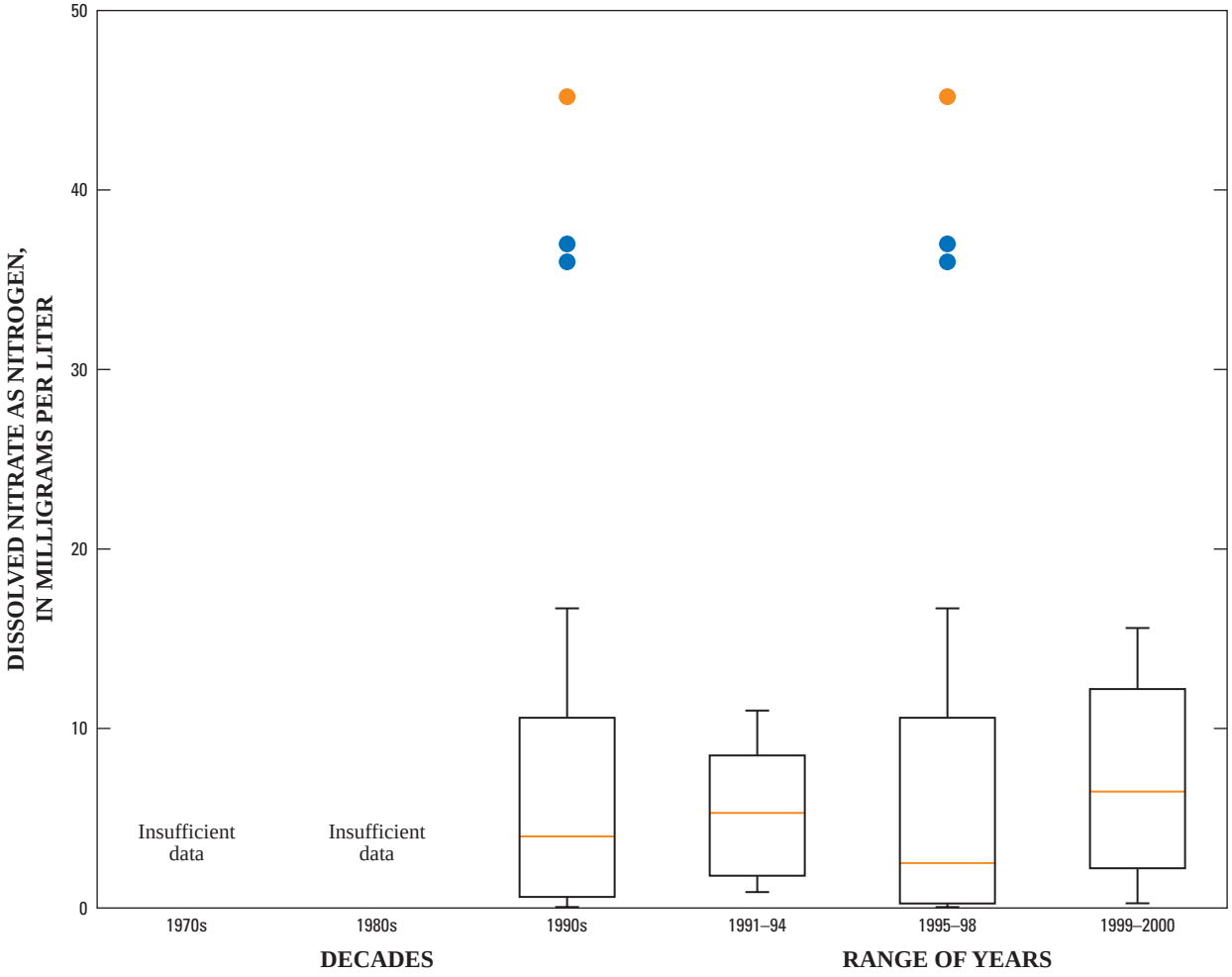


Selected summary statistics		Number of analyses	Nitrate concentrations, milligrams per liter		
			Median	Mean	Maximum
Decade					
1970	(1/1/70 to 12/31/79)	78	2.7	3.6	19
1980	(1/1/80 to 12/31/89)	47	2.1	2.5	8.2
1990	(1/1/90 to 12/31/99)	1,346	2.5	3.5	33
Range of years					
1991–94	(1/1/91 to 12/31/94)	299	2.2	3.0	22
1995–98	(1/1/95 to 12/31/98)	882	2.7	3.8	33
1999–2000	(1/1/99 to 12/31/00)	317	2.4	3.4	21

Mann-Whitney test

Decade or range of years	*p*-value	Decade or range of years	*p*-value
1970 to 1980	0.162	1980 to 1990	0.161
1970 to 1990	.757	1980 to 1991–94	.512
1970 to 1991–94	.267	1980 to 1995–98	.071
1970 to 1995–98	.839	1980 to 1999–2000	.219
1970 to 1999–2000	.702	1991–94 to 1995–98	.011
		1991–94 to 1999–2000	.272

Area 7 Eagle/Star

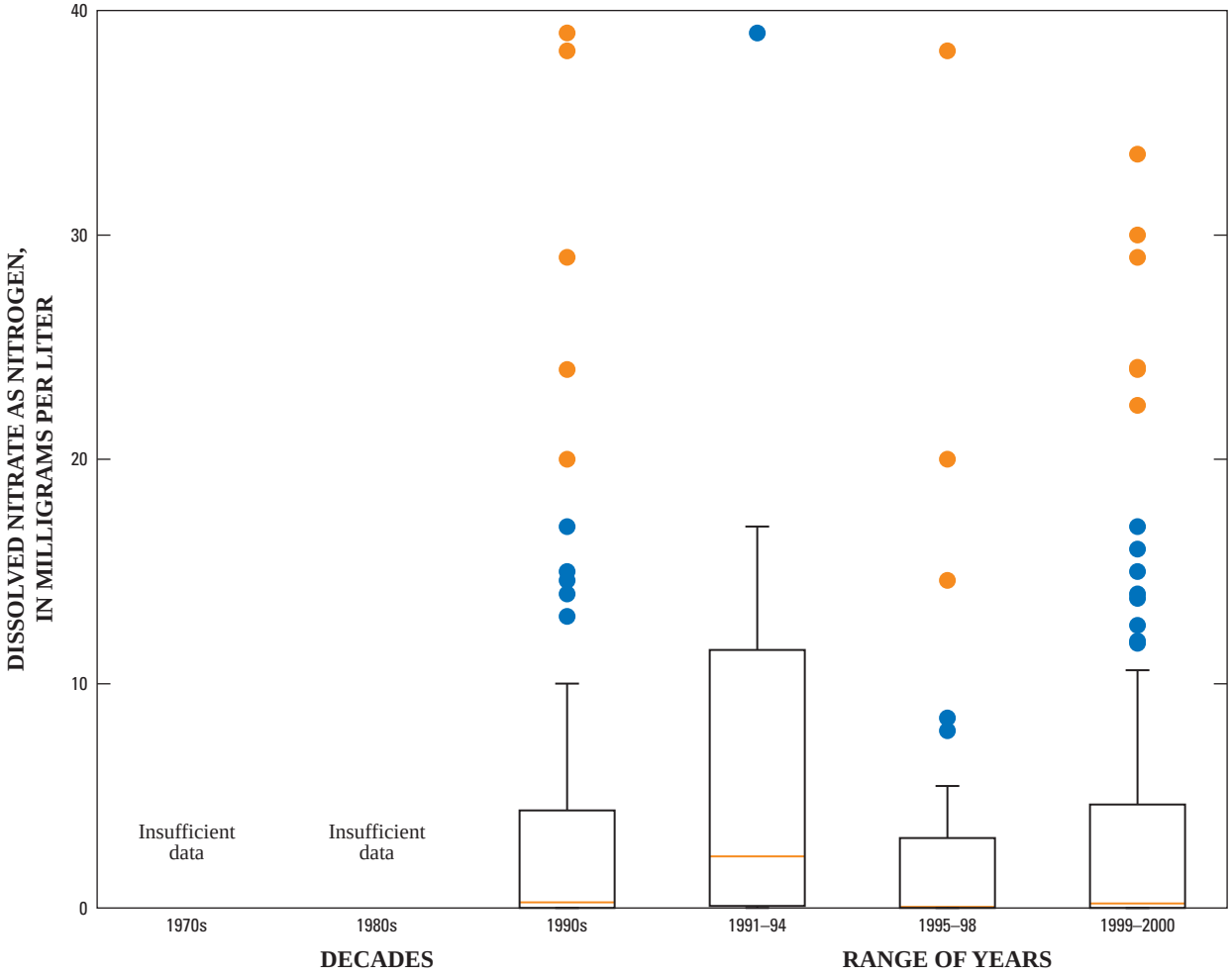


Selected summary statistics		Number of analyses	Nitrate concentrations, milligrams per liter		
			Median	Mean	Maximum
Decade					
1970	(1/1/70 to 12/31/79)	1			
1980	(1/1/80 to 12/31/89)	1			
1990	(1/1/90 to 12/31/99)	34	4.0	8.0	45
Range of years					
1991–94	(1/1/91 to 12/31/94)	6	5.3	5.4	11
1995–98	(1/1/95 to 12/31/98)	26	2.5	8.7	45
1999–2000	(1/1/99 to 12/31/00)	4	6.5	7.2	16

Mann-Whitney test

Decade or range of years	*p*-value	Decade or range of years	*p*-value
1970 to 1980		1980 to 1990	
1970 to 1990		1980 to 1991–94	
1970 to 1991–94		1980 to 1995–98	
1970 to 1995–98		1980 to 1999–2000	
1970 to 1999–2000		1991–94 to 1995–98	0.717
		1991–94 to 1999–2000	.670

Area 8 Homedale/Marsing



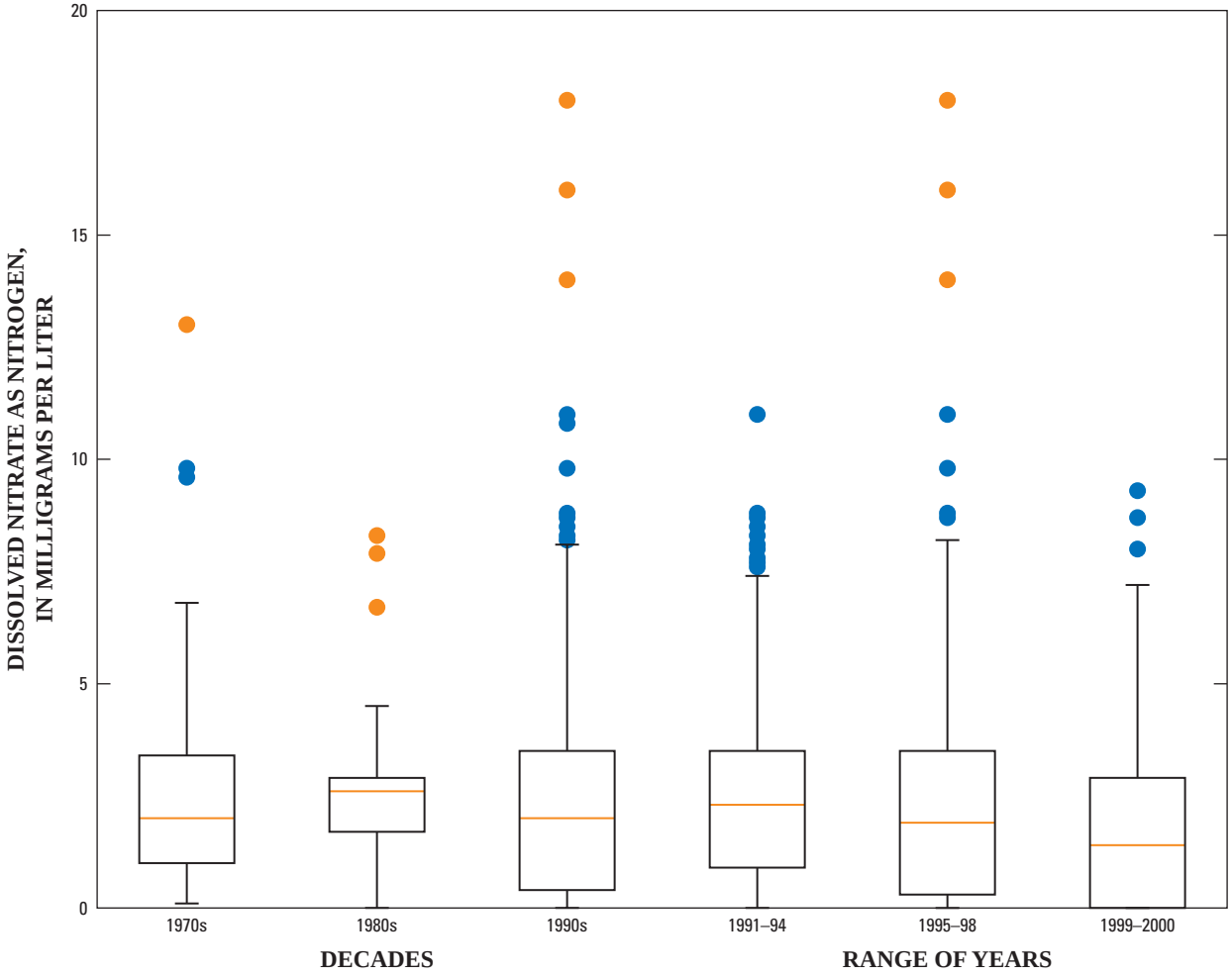
Selected summary statistics		Number of analyses	Nitrate concentrations, milligrams per liter		
			Median	Mean	Maximum
	Decade				
1970	(1/1/70 to 12/31/79)	1			
1980	(1/1/80 to 12/31/89)	2			
1990	(1/1/90 to 12/31/99)	103	0.25	4.4	39
	Range of years				
1991–94	(1/1/91 to 12/31/94)	16	2.3	6.8	39
1995–98	(1/1/95 to 12/31/98)	38	mrl*	3.2	38
1999–2000	(1/1/99 to 12/31/00)	111	.20	4.6	34

Mann-Whitney test

Decade or range of years	*p*-value	Decade or range of years	*p*-value
1970 to 1980		1980 to 1990	
1970 to 1990		1980 to 1991–94	
1970 to 1991–94		1980 to 1995–98	
1970 to 1995–98		1980 to 1999–2000	
1970 to 1999–2000		1991–94 to 1995–98	0.289
		1991–94 to 1999–2000	.131

*mrl, minimum reporting limit

Area 9 Meridian

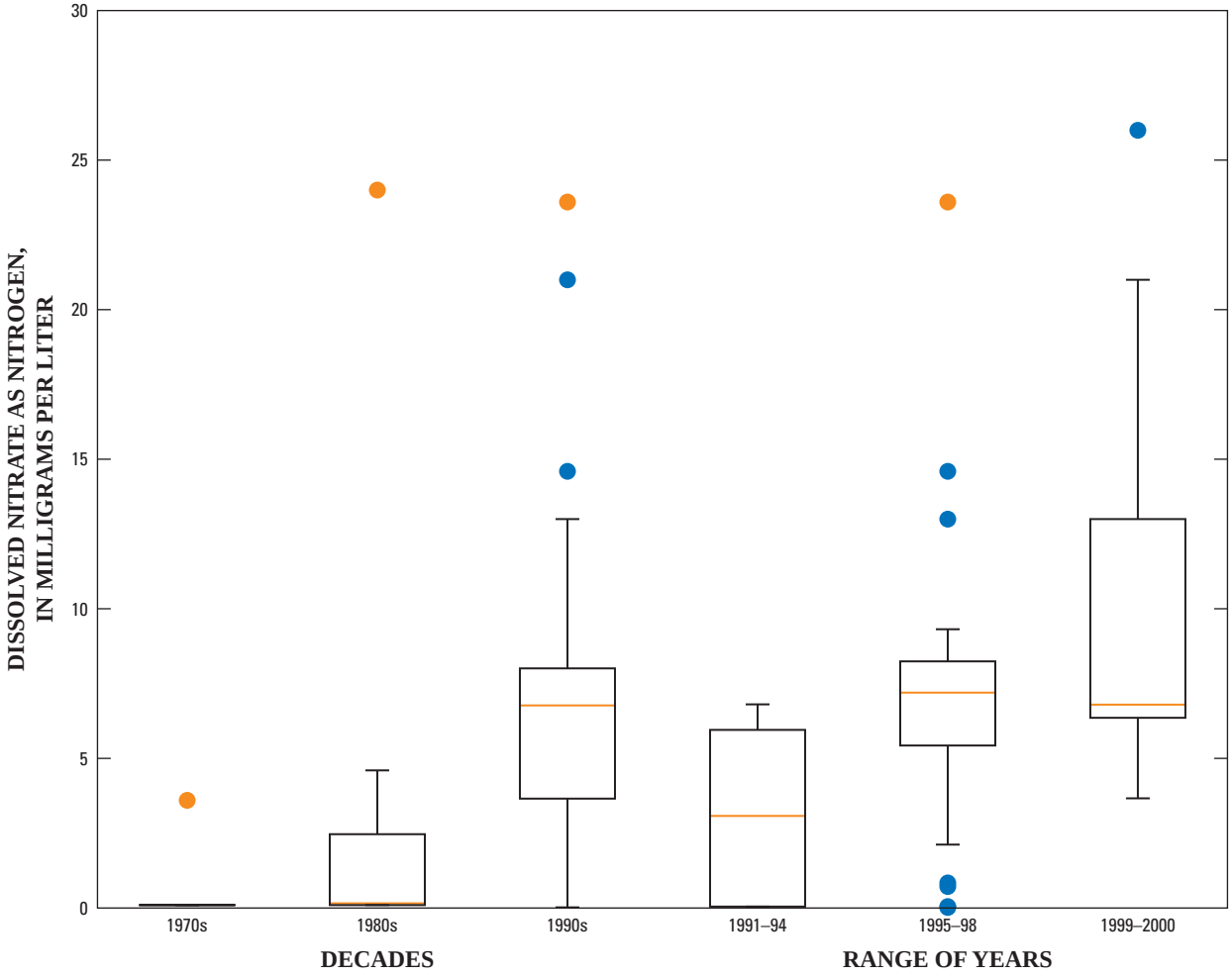


Selected summary statistics		Number of analyses	Nitrate concentrations, milligrams per liter		
			Median	Mean	Maximum
Decade					
1970	(1/1/70 to 12/31/79)	36	2.0	2.8	13
1980	(1/1/80 to 12/31/89)	33	2.6	2.8	8.3
1990	(1/1/90 to 12/31/99)	1,114	2.0	2.3	18
Range of years					
1991–94	(1/1/91 to 12/31/94)	469	2.3	2.5	11
1995–98	(1/1/95 to 12/31/98)	532	1.9	2.3	18
1999–2000	(1/1/99 to 12/31/00)	185	1.4	1.7	9.3

Mann-Whitney test

Decade or range of years	*p*-value	Decade or range of years	*p*-value
1970 to 1980	0.352	1980 to 1990	0.119
1970 to 1990	.359	1980 to 1991–94	.415
1970 to 1991–94	.925	1980 to 1995–98	.086
1970 to 1995–98	.310	1980 to 1999–2000	.001
1970 to 1999–2000	.007	1991–94 to 1995–98	.032
		1991–94 to 1999–2000	.000

Area 10 Grand View



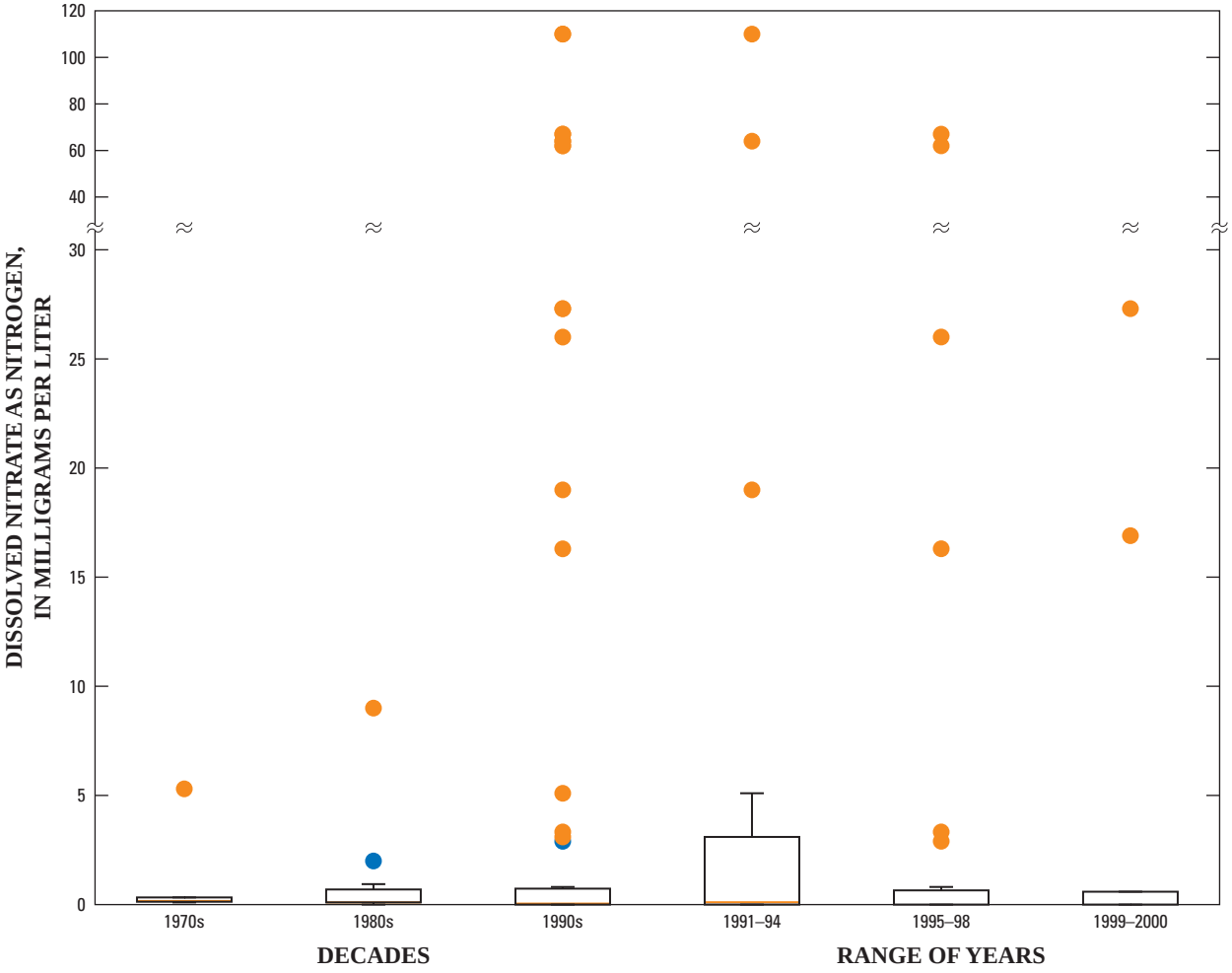
Selected summary statistics		Number of analyses	Nitrate concentrations, milligrams per liter		
			Median	Mean	Maximum
Decade					
1970	(1/1/70 to 12/31/79)	5	mrl*	0.8	3.6
1980	(1/1/80 to 12/31/89)	7	0.16	4.2	24
1990	(1/1/90 to 12/31/99)	39	6.8	6.8	24
Range of years					
1991–94	(1/1/91 to 12/31/94)	7	3.1	3.1	6.8
1995–98	(1/1/95 to 12/31/98)	27	7.2	7.1	24
1999–2000	(1/1/99 to 12/31/00)	11	6.8	10	26

Mann-Whitney test

Decade or range of years	*p*-value	Decade or range of years	*p*-value
1970 to 1980	0.239	1980 to 1990	0.084
1970 to 1990	.019	1980 to 1991–94	.847
1970 to 1991–94	.803	1980 to 1995–98	.048
1970 to 1995–98	.010	1980 to 1999–2000	.016
1970 to 1999–2000	.002	1991–94 to 1995–98	.031
		1991–94 to 1999–2000	.021

*mrl, minimum reporting limit

Area 11 Bruneau



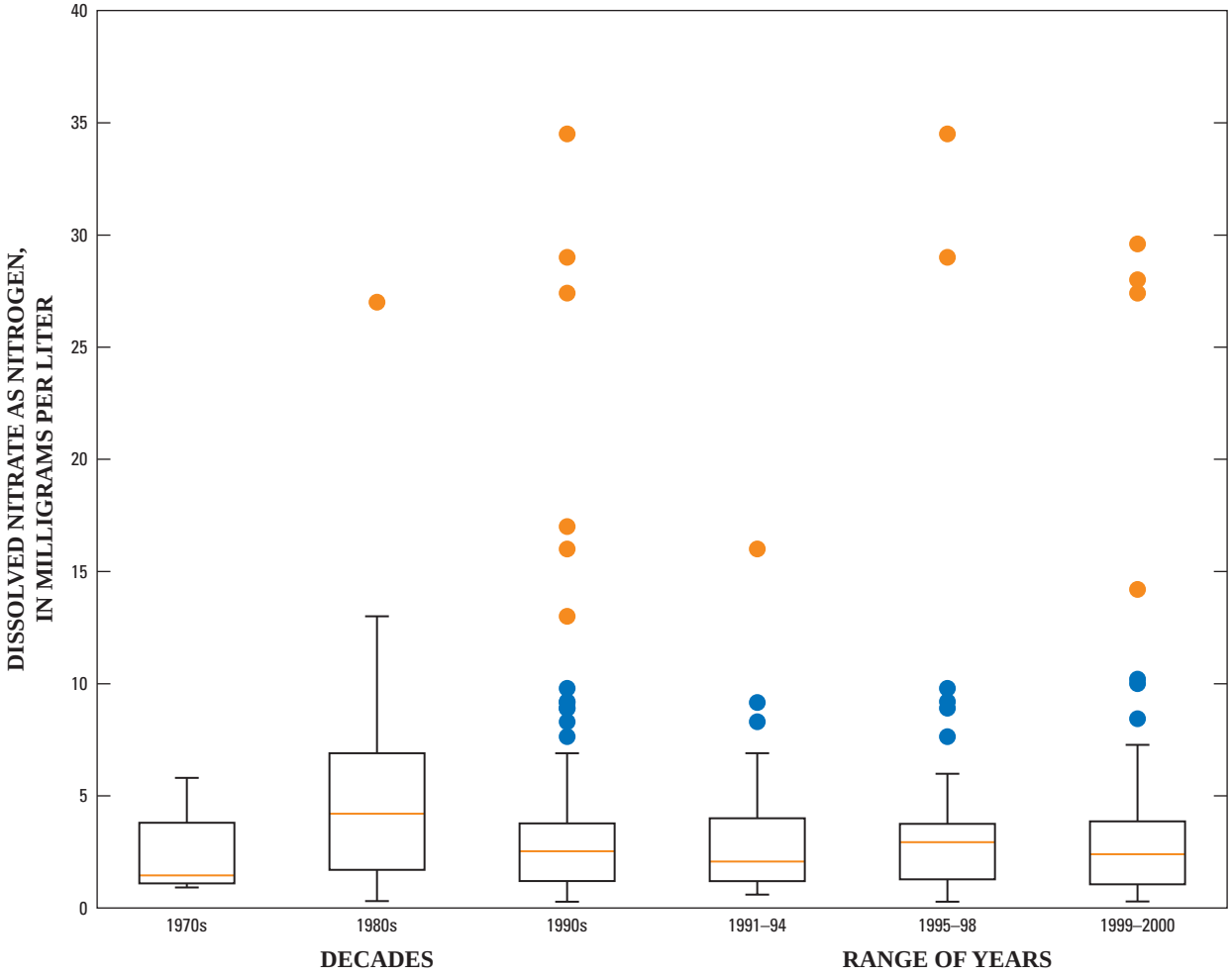
Selected summary statistics		Number of analyses	Nitrate concentrations, milligrams per liter		
			Median	Mean	Maximum
Decade					
1970	(1/1/70 to 12/31/79)	5	0.17	1.2	5.3
1980	(1/1/80 to 12/31/89)	11	mrl*	1.2	9
1990	(1/1/90 to 12/31/99)	40	.10	10	110
Range of years					
1991–94	(1/1/91 to 12/31/94)	11	.20	18	110
1995–98	(1/1/95 to 12/31/98)	23	mrl*	7.8	67
1999–2000	(1/1/99 to 12/31/00)	10	0	4.4	27

Mann-Whitney test

Decade or range of years	*p*-value	Decade or range of years	*p*-value
1970 to 1980	0.561	1980 to 1990	0.614
1970 to 1990	.492	1980 to 1991–94	.643
1970 to 1991–94	.955	1980 to 1995–98	.462
1970 to 1995–98	.439	1980 to 1999–2000	.129
1970 to 1999–2000	.164	1991–94 to 1995–98	.277
		1991–94 to 1999–2000	.164

*mrl, minimum reporting limit

Area 12 Mountain Home

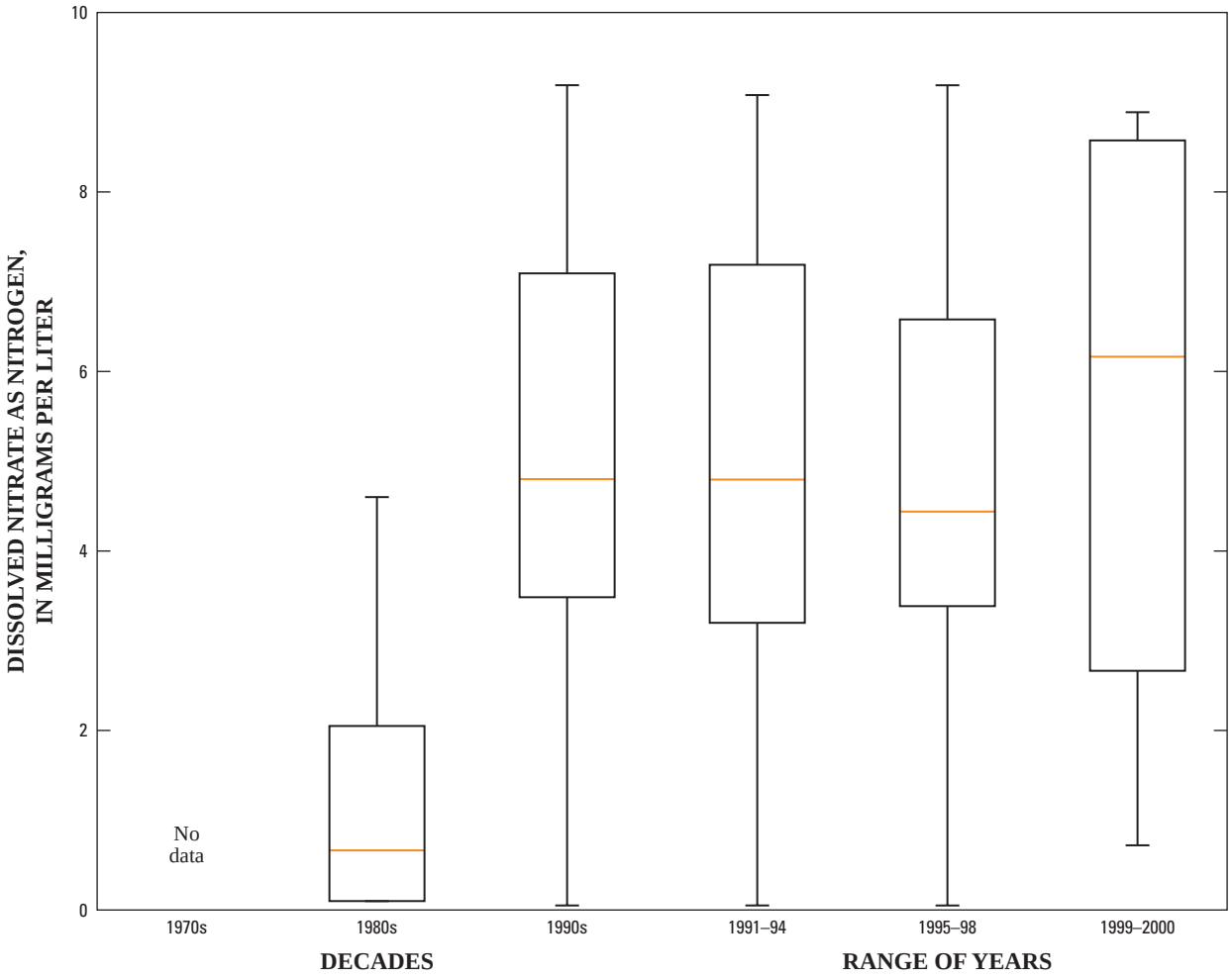


Selected summary statistics		Number of analyses	Nitrate concentrations, milligrams per liter		
			Median	Mean	Maximum
Decade					
1970	(1/1/70 to 12/31/79)	6	1.5	2.4	5.8
1980	(1/1/80 to 12/31/89)	34	4.2	5.2	27
1990	(1/1/90 to 12/31/99)	243	2.5	3.2	35
Range of years					
1991–94	(1/1/91 to 12/31/94)	55	2.1	3.0	16
1995–98	(1/1/95 to 12/31/98)	142	2.9	3.2	35
1999–2000	(1/1/99 to 12/31/00)	81	2.4	3.7	30

Mann-Whitney test

Decade or range of years	*p*-value	Decade or range of years	*p*-value
1970 to 1980	0.211	1980 to 1990	0.005
1970 to 1990	.686	1980 to 1991–94	.030
1970 to 1991–94	.762	1980 to 1995–98	.007
1970 to 1995–98	.627	1980 to 1999–2000	.012
1970 to 1999–2000	.769	1991–94 to 1995–98	.629
		1991–94 to 1999–2000	.828

Area 13 Hammett

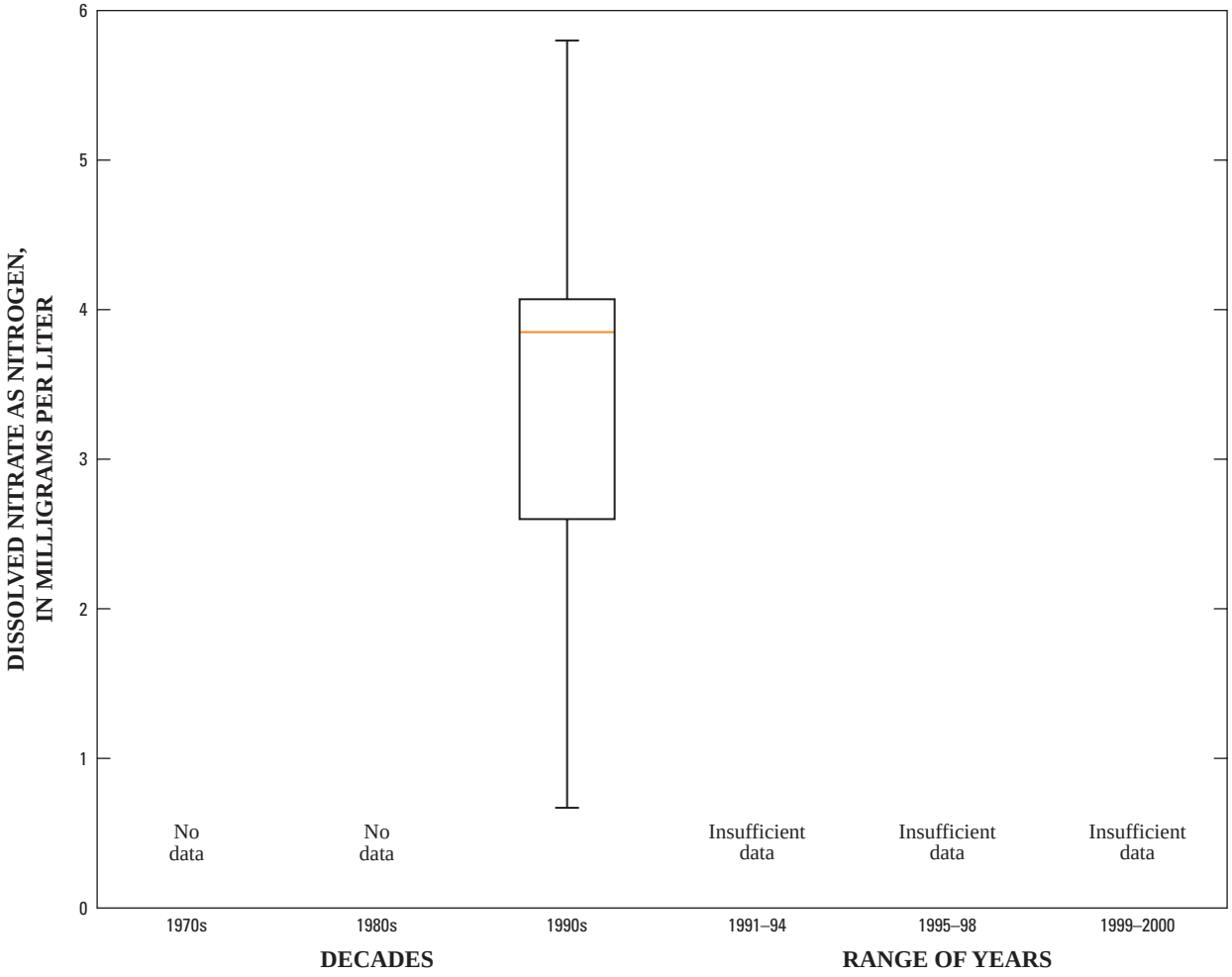


Selected summary statistics		Number of analyses	Nitrate concentrations, milligrams per liter		
			Median	Mean	Maximum
Decade					
1970	(1/1/70 to 12/31/79)				
1980	(1/1/80 to 12/31/89)	12	0.67	1.3	4.6
1990	(1/1/90 to 12/31/99)	35	4.8	5.0	9.2
Range of years					
1991–94	(1/1/91 to 12/31/94)	10	4.8	4.9	9.1
1995–98	(1/1/95 to 12/31/98)	19	4.4	4.9	9.2
1999–2000	(1/1/99 to 12/31/00)	8	6.2	5.6	8.9

Mann-Whitney test

Decade or range of years	*p*-value	Decade or range of years	*p*-value
1970 to 1980		1980 to 1990	0.000
1970 to 1990		1980 to 1991–94	.029
1970 to 1991–94		1980 to 1995–98	.001
1970 to 1995–98		1980 to 1999–2000	.004
1970 to 1999–2000		1991–94 to 1995–98	.801
		1991–94 to 1999–2000	.004

Area 14 Bliss

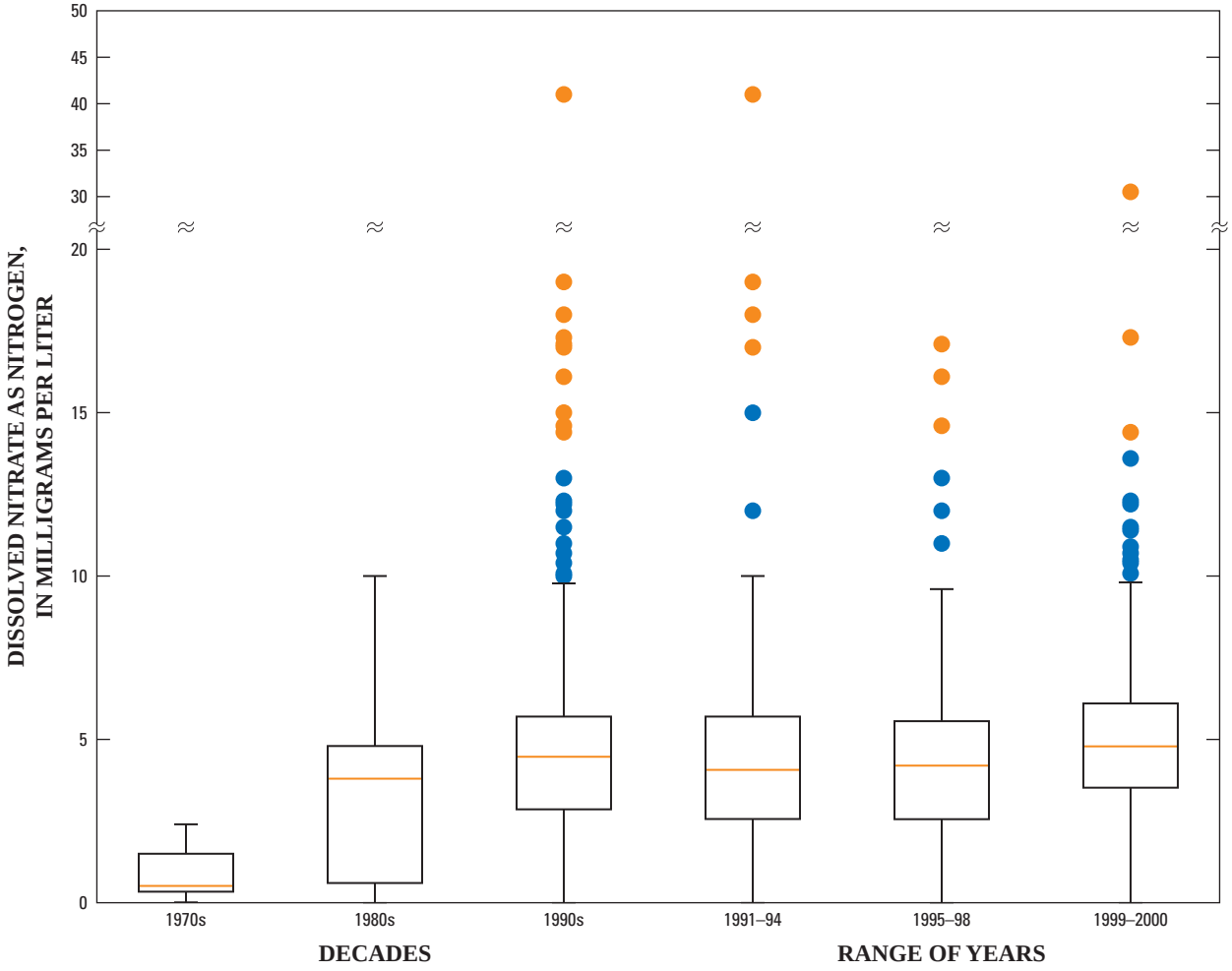


Selected summary statistics		Number of analyses	Nitrate concentrations, milligrams per liter		
			Median	Mean	Maximum
	Decade				
1970	(1/1/70 to 12/31/79).....				
1980	(1/1/80 to 12/31/89).....				
1990	(1/1/90 to 12/31/99).....	6	3.9	3.5	5.8
	Range of years				
1991–94	(1/1/91 to 12/31/94).....	1			
1995–98	(1/1/95 to 12/31/98).....	2			
1999–2000	(1/1/99 to 12/31/00).....	3			

Mann-Whitney test

Decade or range of years	*p*-value	Decade or range of years	*p*-value
1970 to 1980		1980 to 1990.....	
1970 to 1990		1980 to 1991–94.....	
1970 to 1991–94		1980 to 1995–98.....	
1970 to 1995–98		1980 to 1999–2000.....	
1970 to 1999–2000		1991–94 to 1995–98	
		1991–94 to 1999–2000	

Area 15 Twin Falls

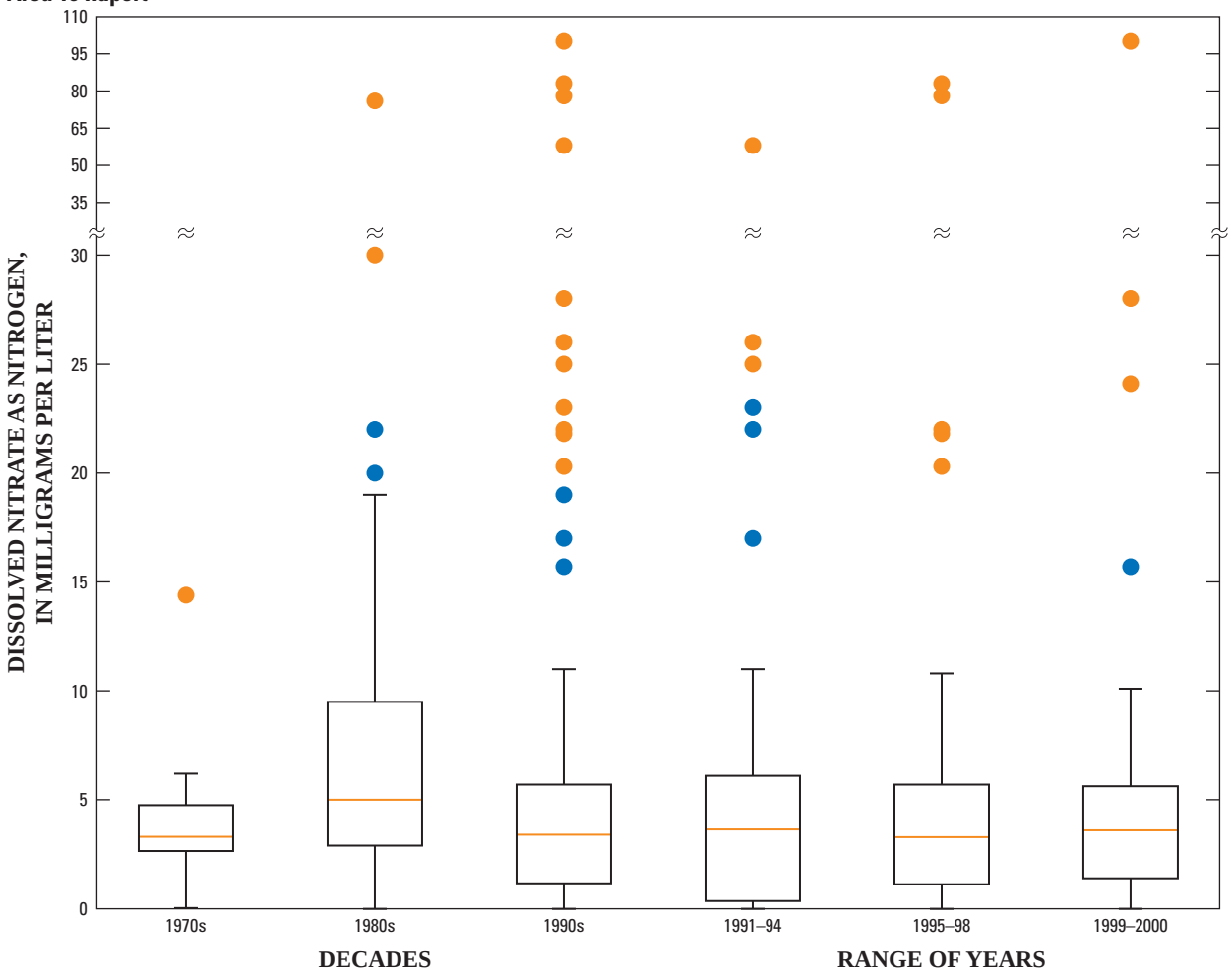


Selected summary statistics		Number of analyses	Nitrate concentrations, milligrams per liter		
			Median	Mean	Maximum
Decade					
1970	(1/1/70 to 12/31/79)	6	0.52	0.88	2.4
1980	(1/1/80 to 12/31/89)	28	3.8	3.2	10
1990	(1/1/90 to 12/31/99)	666	4.5	4.6	41
Range of years					
1991–94	(1/1/91 to 12/31/94)	121	4.1	4.9	41
1995–98	(1/1/95 to 12/31/98)	369	4.2	4.3	17
1999–2000	(1/1/99 to 12/31/00)	367	4.6	5.0	31

Mann-Whitney test

Decade or range of years	*p*-value	Decade or range of years	*p*-value
1970 to 1980	0.032	1980 to 1990	0.010
1970 to 1990	.000	1980 to 1991–94	.050
1970 to 1991–94	.001	1980 to 1995–98	.032
1970 to 1995–98	.000	1980 to 1999–2000	.001
1970 to 1999–2000	.000	1991–94 to 1995–98	.769
		1991–94 to 1999–2000	.015

Area 16 Rupert

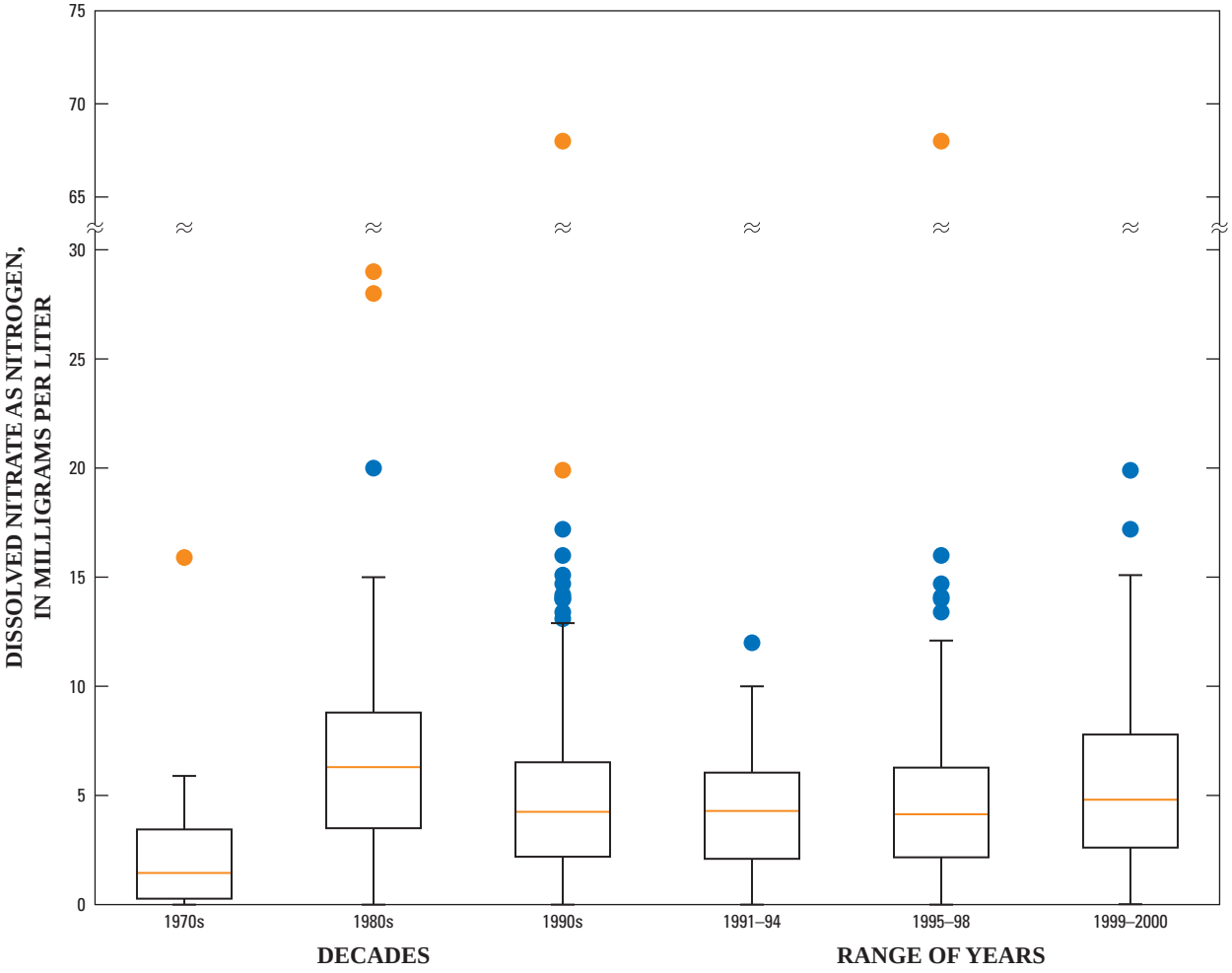


Selected summary statistics		Number of analyses	Nitrate concentrations, milligrams per liter		
			Median	Mean	Maximum
Decade					
1970	(1/1/70 to 12/31/79)	55	3.3	3.5	14
1980	(1/1/80 to 12/31/89)	40	5.0	9.7	76
1990	(1/1/90 to 12/31/99)	489	3.4	4.5	100
Range of years					
1991–94	(1/1/91 to 12/31/94)	100	3.7	5.1	58
1995–98	(1/1/95 to 12/31/98)	274	3.3	4.2	83
1999–2000	(1/1/99 to 12/31/00)	231	3.6	4.4	100

Mann-Whitney test

Decade or range of years	*p*-value	Decade or range of years	*p*-value
1970 to 1980	0.004	1980 to 1990	0.000
1970 to 1990	.923	1980 to 1991–94	.006
1970 to 1991–94	.808	1980 to 1995–98	.000
1970 to 1995–98	.936	1980 to 1999–2000	.002
1970 to 1999–2000	.678	1991–94 to 1995–98	.850
		1991–94 to 1999–2000	.682

Area 17 Burley/Marsh Creek

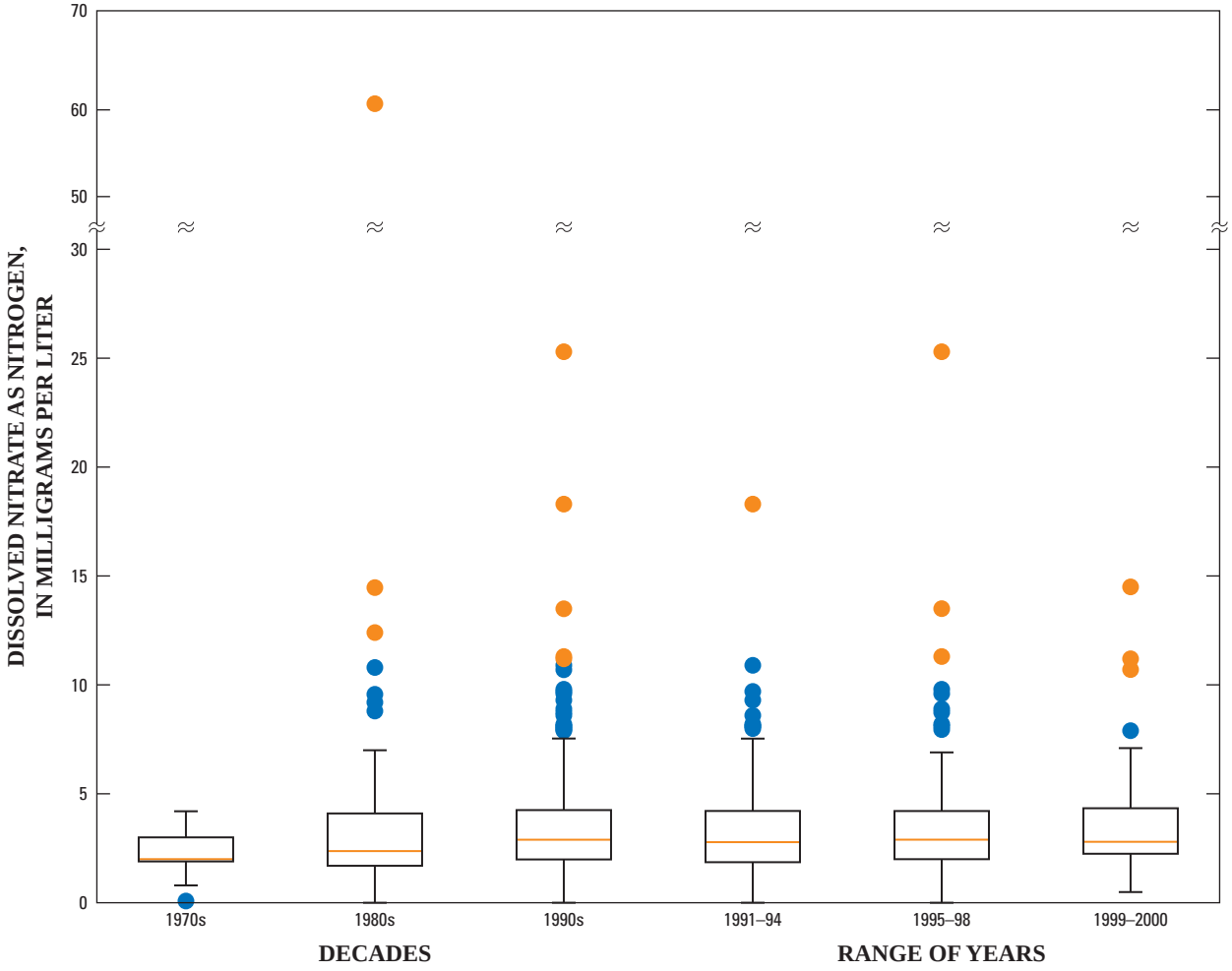


Selected summary statistics		Number of analyses	Nitrate concentrations, milligrams per liter		
			Median	Mean	Maximum
	Decade				
1970	(1/1/70 to 12/31/79)	15	1.5	2.7	16
1980	(1/1/80 to 12/31/89)	154	6.3	6.5	29
1990	(1/1/90 to 12/31/99)	399	4.3	5.0	68
	Range of years				
1991–94	(1/1/91 to 12/31/94)	81	4.3	4.3	12
1995–98	(1/1/95 to 12/31/98)	217	4.2	4.9	68
1999–2000	(1/1/99 to 12/31/00)	189	4.8	5.5	20

Mann-Whitney test

Decade or range of years	*p*-value	Decade or range of years	*p*-value
1970 to 1980	0.000	1980 to 1990	0.000
1970 to 1990	.002	1980 to 1991–94	.000
1970 to 1991–94	.008	1980 to 1995–98	.003
1970 to 1995–98	.003	1980 to 1999–2000	.017
1970 to 1999–2000	.001	1991–94 to 1995–98	.850
		1991–94 to 1999–2000	.050

Area 18 Pocatello

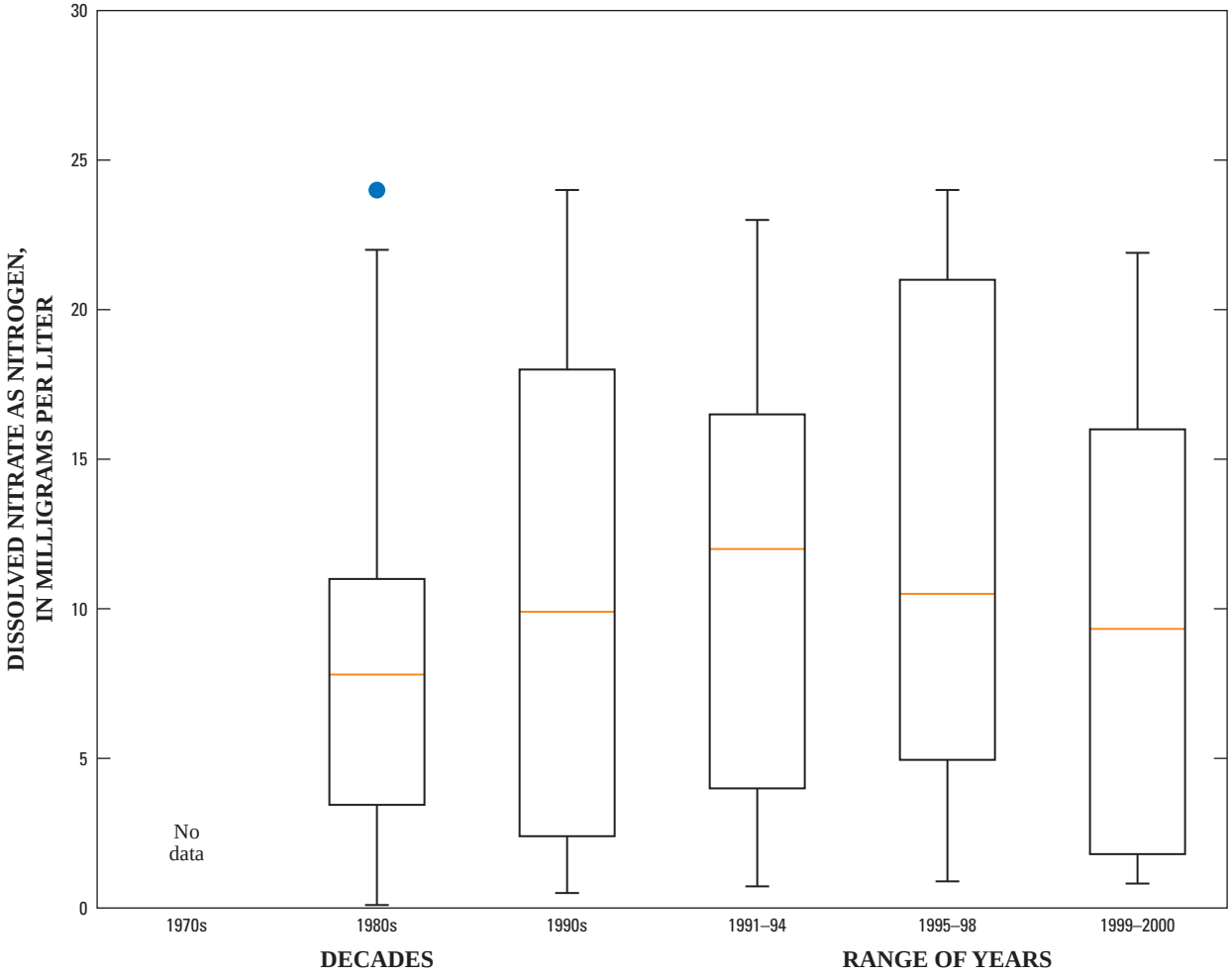


Selected summary statistics		Number of analyses	Nitrate concentrations, milligrams per liter		
			Median	Mean	Maximum
	Decade				
1970	(1/1/70 to 12/31/79)	13	2.0	2.2	4.2
1980	(1/1/80 to 12/31/89)	136	2.4	3.5	60
1990	(1/1/90 to 12/31/99)	364	2.9	3.5	25
	Range of years				
1991–94	(1/1/91 to 12/31/94)	123	2.8	3.5	18
1995–98	(1/1/95 to 12/31/98)	186	2.9	3.4	25
1999–2000	(1/1/99 to 12/31/00)	101	2.8	3.5	15

Mann-Whitney test

Decade or range of years	*p*-value	Decade or range of years	*p*-value
1970 to 1980	0.433	1980 to 1990	0.031
1970 to 1990	.058	1980 to 1991–94	.174
1970 to 1991–94	.138	1980 to 1995–98	.067
1970 to 1995–98	.060	1980 to 1999–2000	.029
1970 to 1999–2000	.029	1991–94 to 1995–98	.726
		1991–94 to 1999–2000	.343

Area 19 Fort Hall

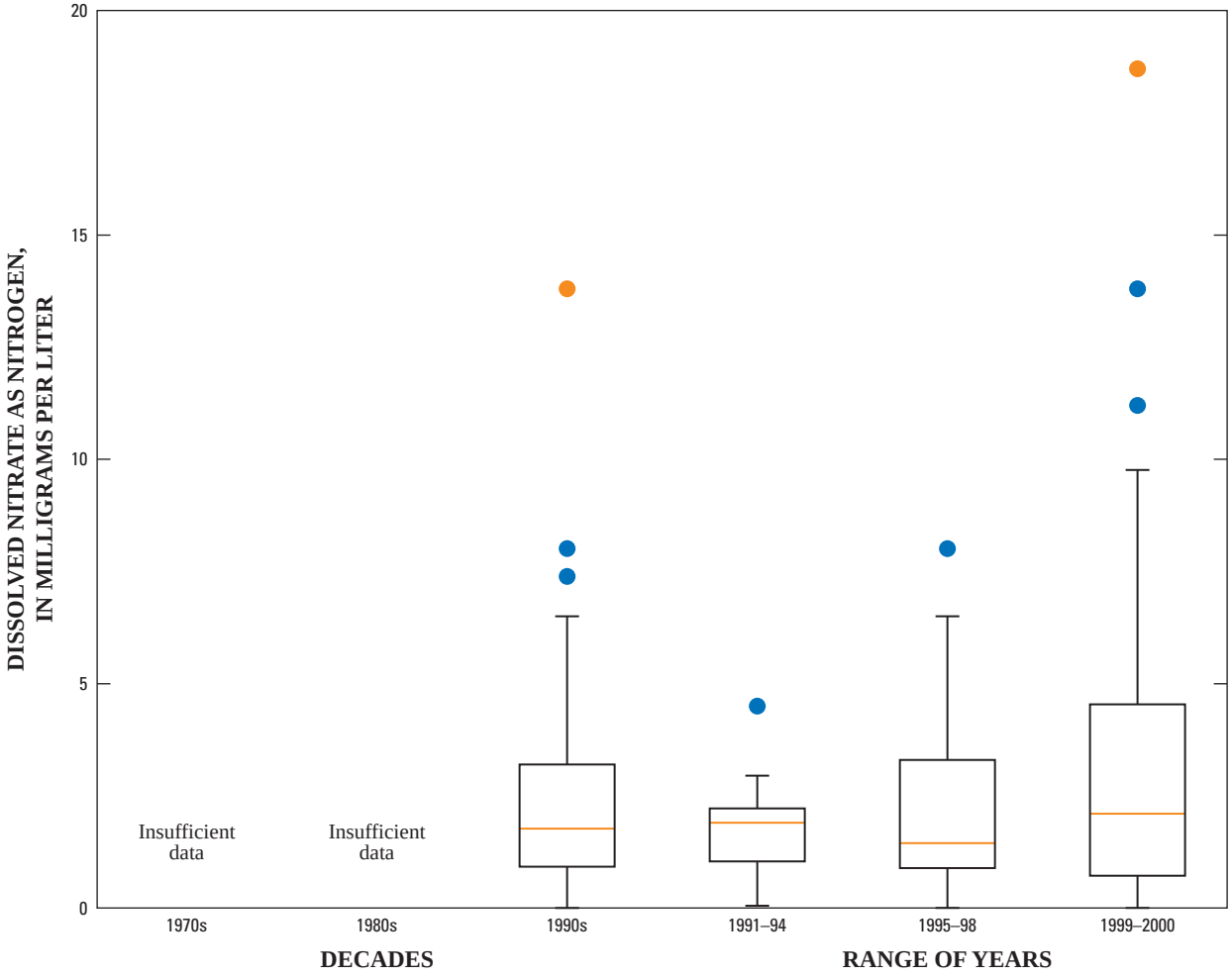


Selected summary statistics		Number of analyses	Nitrate concentrations, milligrams per liter		
			Median	Mean	Maximum
Decade					
1970	(1/1/70 to 12/31/79)				
1980	(1/1/80 to 12/31/89)	87	7.8	8.5	24
1990	(1/1/90 to 12/31/99)	45	9.9	10	24
Range of years					
1991–94	(1/1/91 to 12/31/94)	7	12	11	23
1995–98	(1/1/95 to 12/31/98)	11	11	12	24
1999–2000	(1/1/99 to 12/31/00)	10	9.3	9.6	22

Mann-Whitney test

Decade or range of years	*p*-value	Decade or range of years	*p*-value
1970 to 1980		1980 to 1990	0.398
1970 to 1990		1980 to 1991–94	.480
1970 to 1991–94		1980 to 1995–98	.214
1970 to 1995–98		1980 to 1999–2000	.762
1970 to 1999–2000		1991–94 to 1995–98	.786
		1991–94 to 1999–2000	.696

Area 20 Preston/Cache Valley

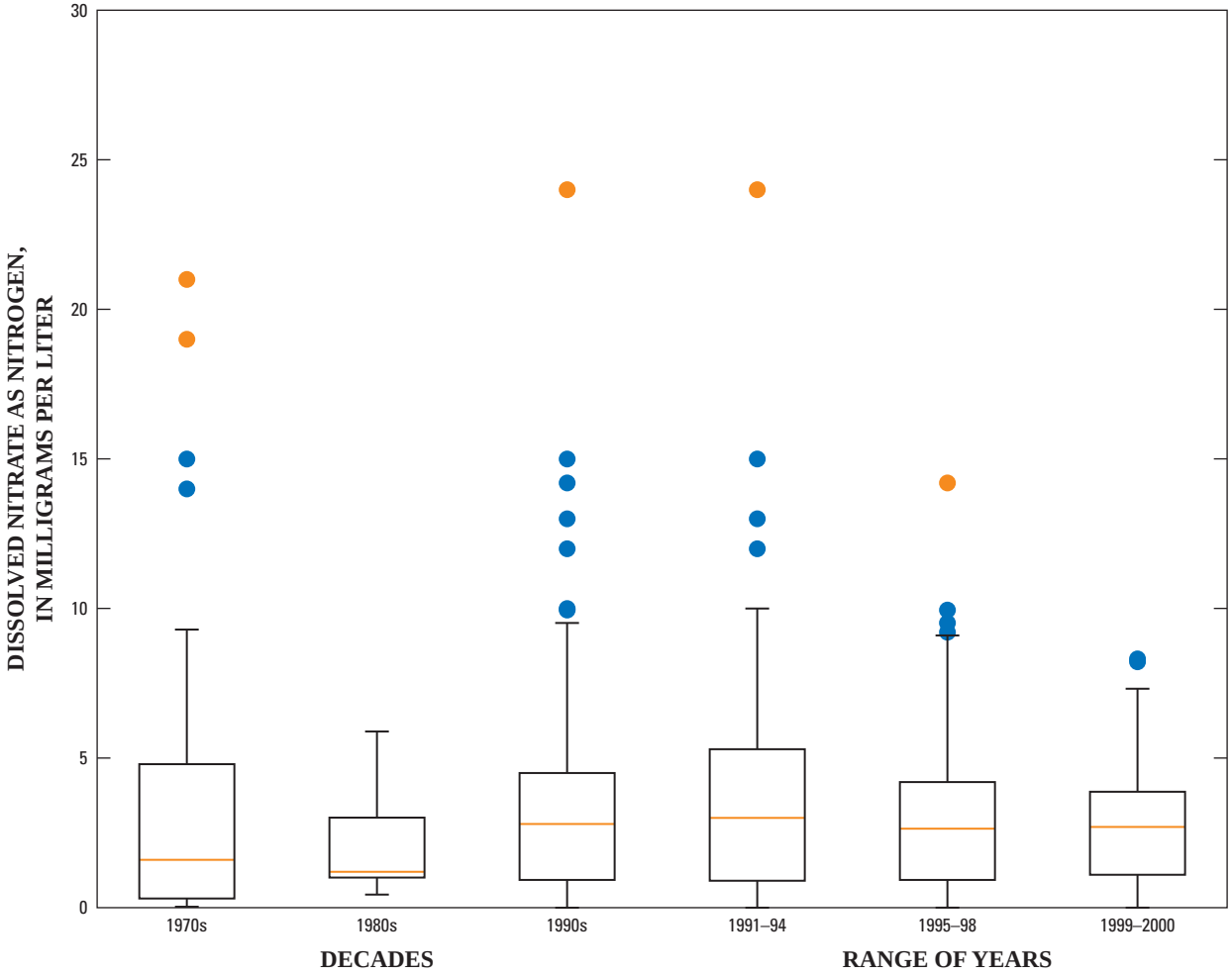


Selected summary statistics		Number of analyses	Nitrate concentrations, milligrams per liter		
			Median	Mean	Maximum
	Decade				
1970	(1/1/70 to 12/31/79)	2			
1980	(1/1/80 to 12/31/89)	1			
1990	(1/1/90 to 12/31/99)	77	1.8	2.3	14
	Range of years				
1991–94	(1/1/91 to 12/31/94)	17	1.9	1.7	4.5
1995–98	(1/1/95 to 12/31/98)	42	1.4	2.2	8.0
1999–2000	(1/1/99 to 12/31/00)	70	2.1	3.1	19

Mann-Whitney test

Decade or range of years	*p*-value	Decade or range of years	*p*-value
1970 to 1980		1980 to 1990	
1970 to 1990		1980 to 1991–94	
1970 to 1991–94		1980 to 1995–98	
1970 to 1995–98		1980 to 1999–2000	
1970 to 1999–2000		1991–94 to 1995–98	0.927
		1991–94 to 1999–2000	.279

Area 21 Soda Springs/Bear Lake (upper Portneuf/Blackfoot River)

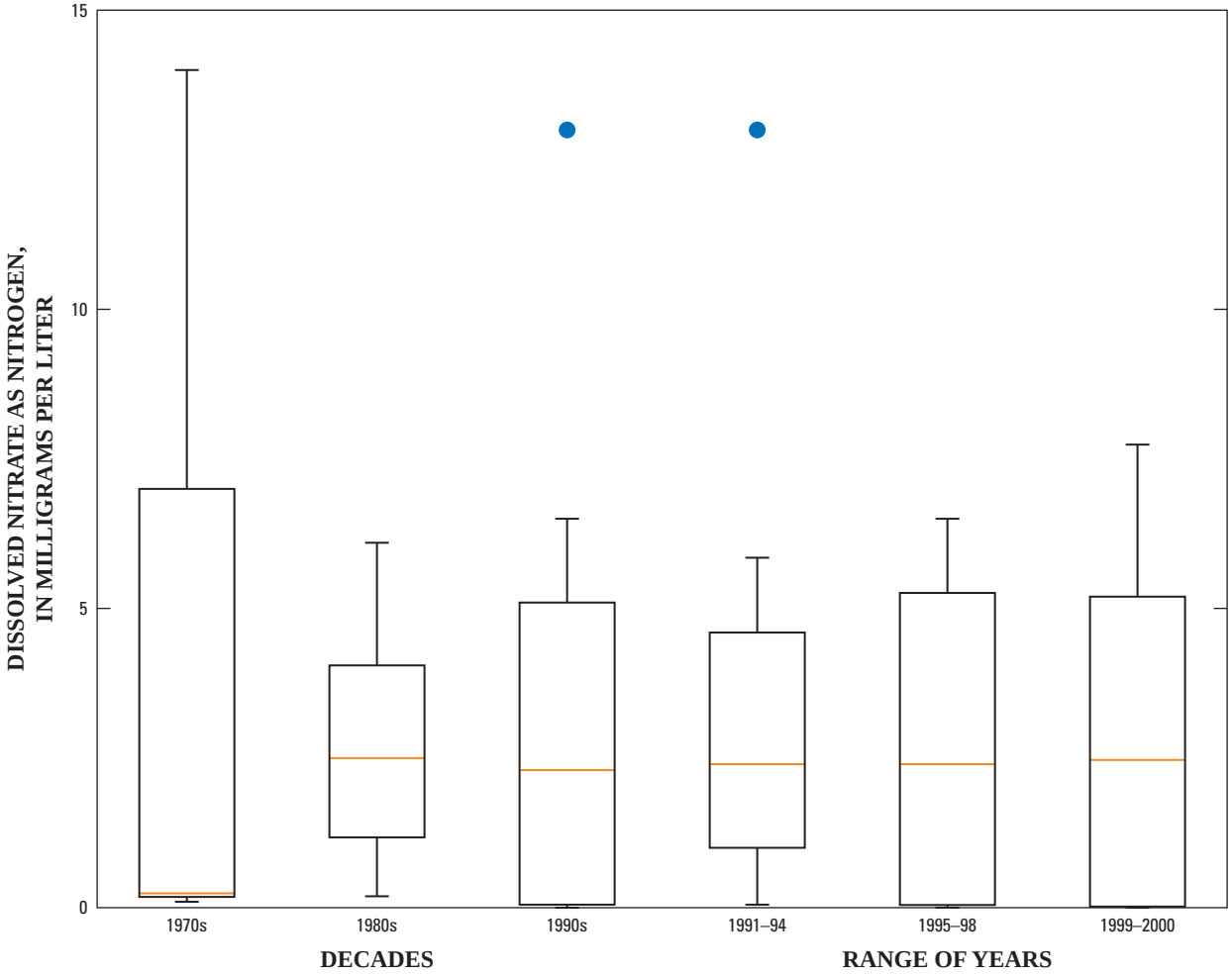


Selected summary statistics		Number of analyses	Nitrate concentrations, milligrams per liter		
			Median	Mean	Maximum
Decade					
1970	(1/1/70 to 12/31/79)	41	1.6	4.0	21
1980	(1/1/80 to 12/31/89)	7	1.2	2.2	5.9
1990	(1/1/90 to 12/31/99)	201	2.8	3.4	24
Range of years					
1991–94	(1/1/91 to 12/31/94)	69	3.0	3.9	24
1995–98	(1/1/95 to 12/31/98)	101	2.6	3.3	14
1999–2000	(1/1/99 to 12/31/00)	51	2.7	2.8	8.3

Mann-Whitney test

Decade or range of years	*p*-value	Decade or range of years	*p*-value
1970 to 1980	0.849	1980 to 1990	0.397
1970 to 1990	.315	1980 to 1991–94	.369
1970 to 1991–94	.234	1980 to 1995–98	.450
1970 to 1995–98	.455	1980 to 1999–2000	.511
1970 to 1999–2000	.580	1991–94 to 1995–98	.516
		1991–94 to 1999–2000	.311

Area 22 Mud Lake

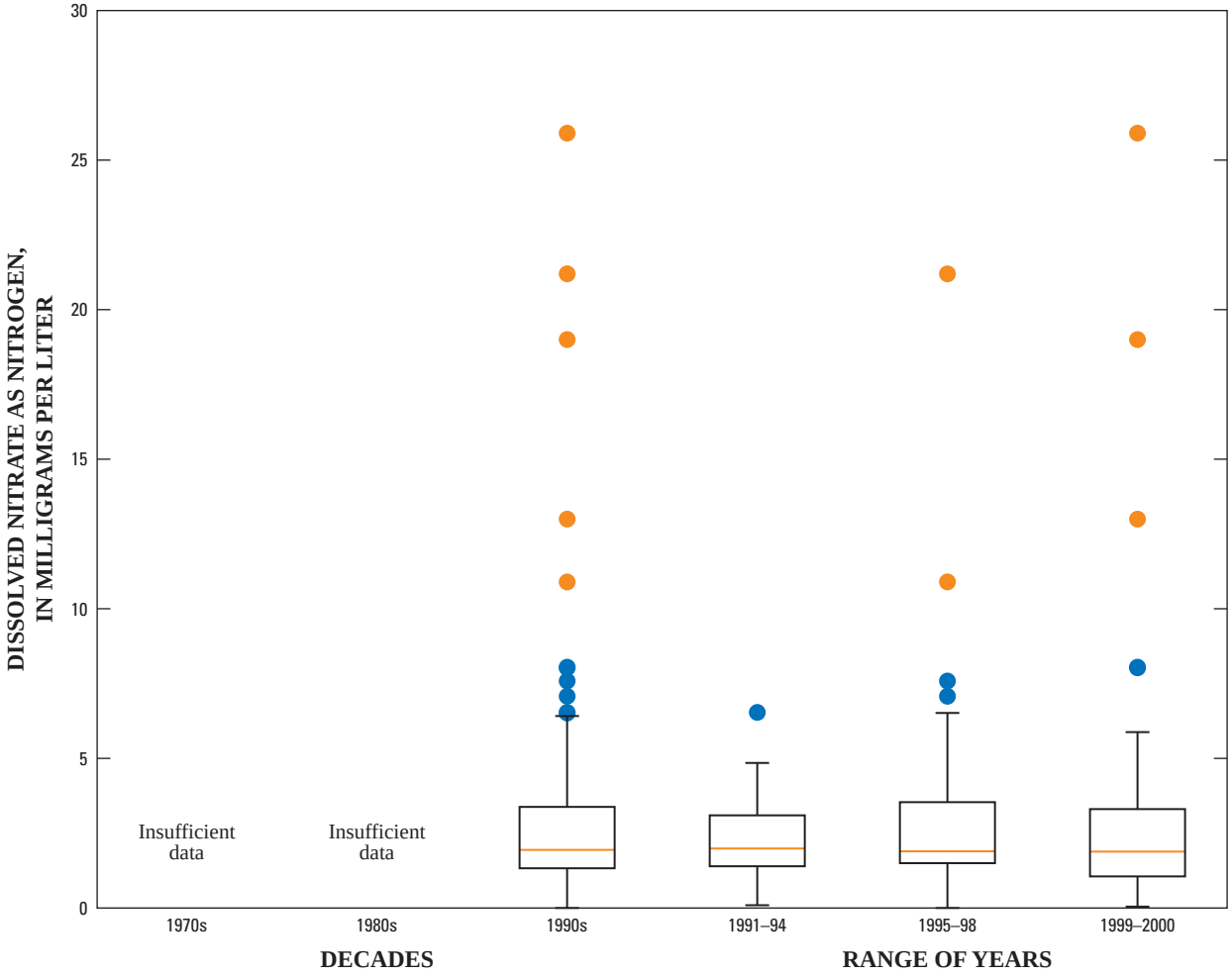


Selected summary statistics		Number of analyses	Nitrate concentrations, milligrams per liter		
			Median	Mean	Maximum
Decade					
1970	(1/1/70 to 12/31/79)	9	0.24	3.8	14
1980	(1/1/80 to 12/31/89)	12	2.5	2.8	6.1
1990	(1/1/90 to 12/31/99)	85	2.3	2.7	13
Range of years					
1991–94	(1/1/91 to 12/31/94)	18	2.4	3.2	13
1995–98	(1/1/95 to 12/31/98)	43	2.4	2.6	6.5
1999–2000	(1/1/99 to 12/31/00)	41	2.5	2.9	7.7

Mann-Whitney test

Decade or range of years	*p*-value	Decade or range of years	*p*-value
1970 to 1980	0.522	1980 to 1990	0.514
1970 to 1990	.403	1980 to 1991–94	1.000
1970 to 1991–94	.877	1980 to 1995–98	.575
1970 to 1995–98	.446	1980 to 1999–2000	.456
1970 to 1999–2000	.456	1991–94 to 1995–98	.548
		1991–94 to 1999–2000	.856

Area 23 Hibbard

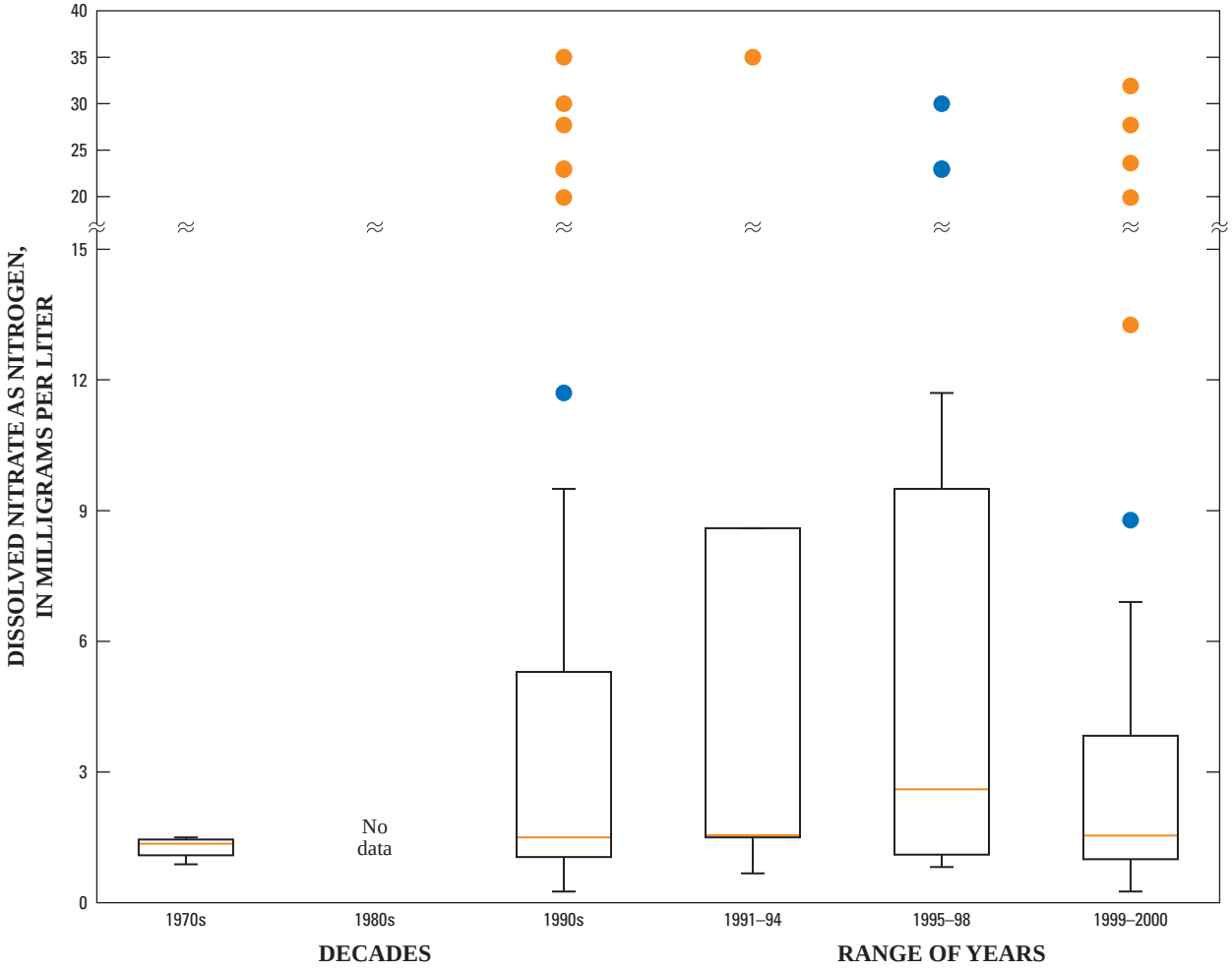


Selected summary statistics		Number of analyses	Nitrate concentrations, milligrams per liter		
			Median	Mean	Maximum
	Decade				
1970	(1/1/70 to 12/31/79)	2			
1980	(1/1/80 to 12/31/89)	1			
1990	(1/1/90 to 12/31/99)	170	1.9	2.9	26
	Range of years				
1991–94	(1/1/91 to 12/31/94)	29	2.0	2.3	6.5
1995–98	(1/1/95 to 12/31/98)	87	1.9	2.8	21
1999–2000	(1/1/99 to 12/31/00)	76	1.9	3.0	26

Mann-Whitney test

Decade or range of years	*p*-value	Decade or range of years	*p*-value
1970 to 1980		1980 to 1990	
1970 to 1990		1980 to 1991–94	
1970 to 1991–94		1980 to 1995–98	
1970 to 1995–98		1980 to 1999–2000	
1970 to 1999–2000		1991–94 to 1995–98	0.594
		1991–94 to 1999–2000	.937

Area 24 St. Anthony

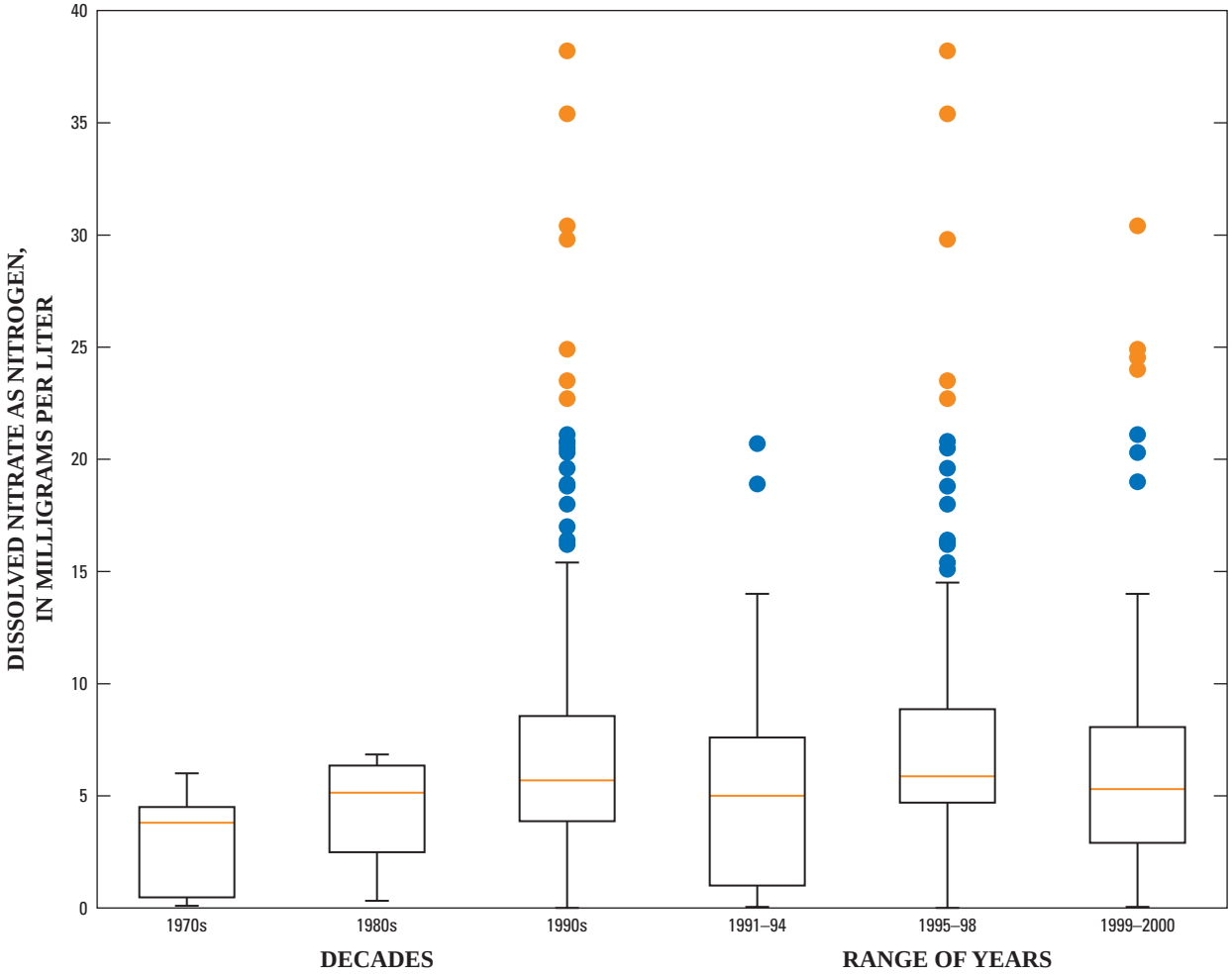


Selected summary statistics		Number of analyses	Nitrate concentrations, milligrams per liter		
			Median	Mean	Maximum
Decade					
1970	(1/1/70 to 12/31/79)	4			
1980	(1/1/80 to 12/31/89)				
1990	(1/1/90 to 12/31/99)	50	1.5	5.4	35
Range of years					
1991–94	(1/1/91 to 12/31/94)	6	1.6	8.1	35
1995–98	(1/1/95 to 12/31/98)	18	2.6	7.0	30
1999–2000	(1/1/99 to 12/31/00)	34	1.5	5.2	32

Mann-Whitney test

Decade or range of years	*p*-value	Decade or range of years	*p*-value
1970 to 1980		1980 to 1990	
1970 to 1990	0.447	1980 to 1991–94	
1970 to 1991–94	.131	1980 to 1995–98	
1970 to 1995–98	.268	1980 to 1999–2000	
1970 to 1999–2000	.447	1991–94 to 1995–98	1.000
		1991–94 to 1999–2000	.677

Area 25 Ashton, Drummond, Teton River

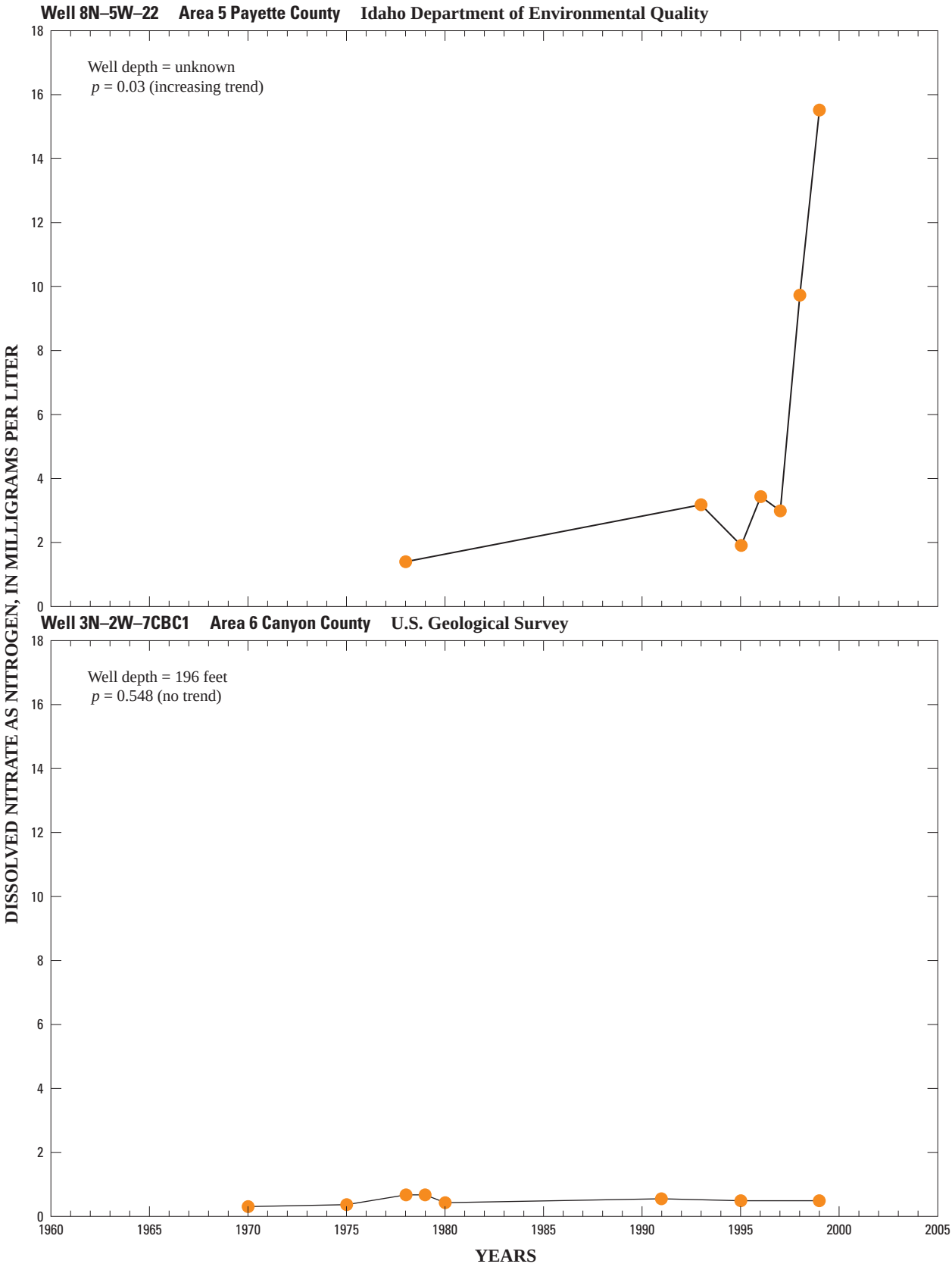


Selected summary statistics		Number of analyses	Nitrate concentrations, milligrams per liter		
			Median	Mean	Maximum
Decade					
1970	(1/1/70 to 12/31/79)	16	3.8	2.9	6.0
1980	(1/1/80 to 12/31/89)	5	5.1	4.2	6.8
1990	(1/1/90 to 12/31/99)	266	5.7	7.0	38
Range of years					
1991–94	(1/1/91 to 12/31/94)	26	5.0	5.8	21
1995–98	(1/1/95 to 12/31/98)	187	5.9	7.3	38
1999–2000	(1/1/99 to 12/31/00)	75	5.3	6.9	30

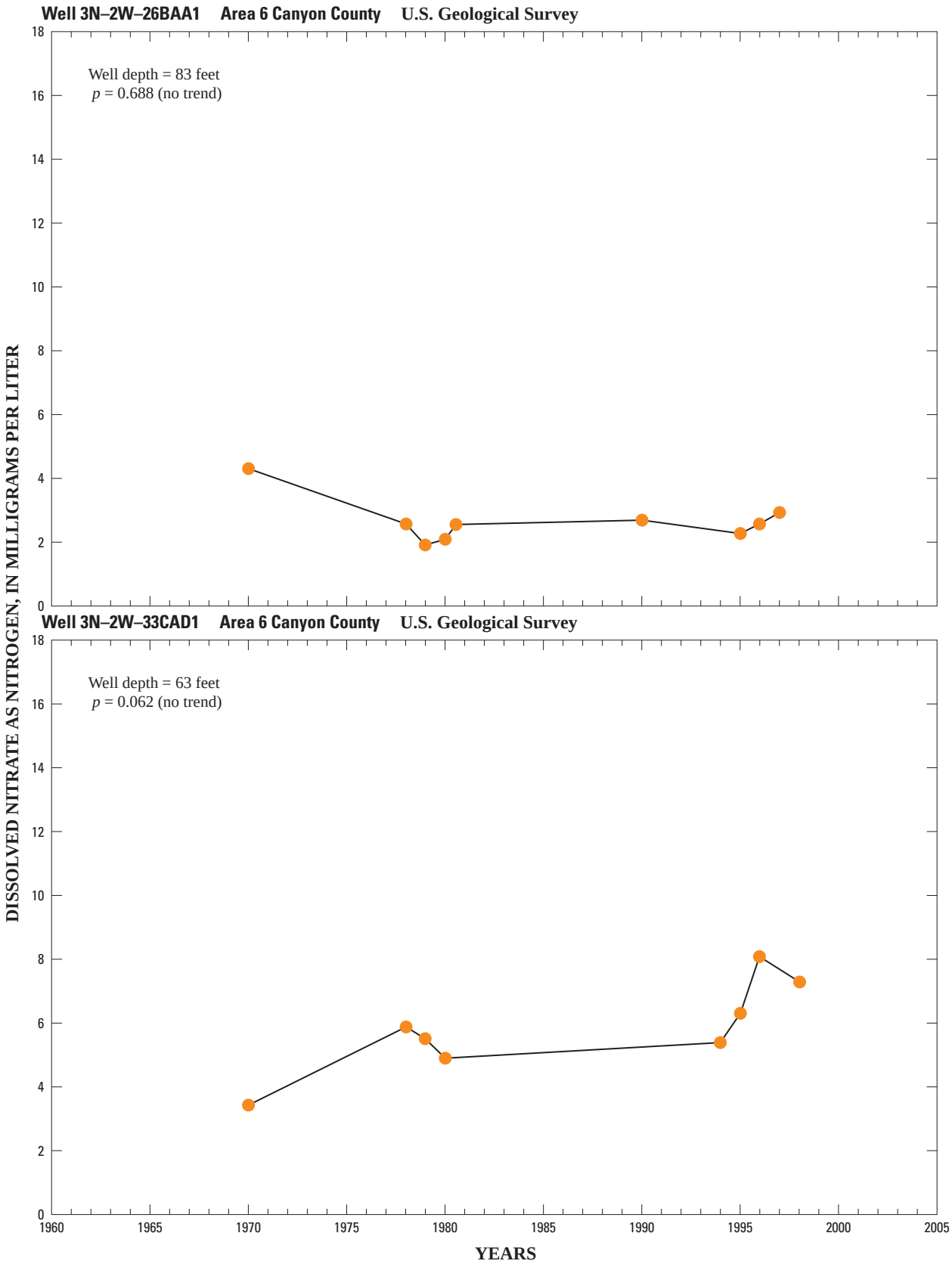
Mann-Whitney test

Decade or range of years	*p*-value	Decade or range of years	*p*-value
1970 to 1980	0.214	1980 to 1990	0.270
1970 to 1990	.000	1980 to 1991–94	.707
1970 to 1991–94	.045	1980 to 1995–98	.195
1970 to 1995–98	.000	1980 to 1999–2000	.468
1970 to 1999–2000	.001	1991–94 to 1995–98	.075
		1991–94 to 1999–2000	.311

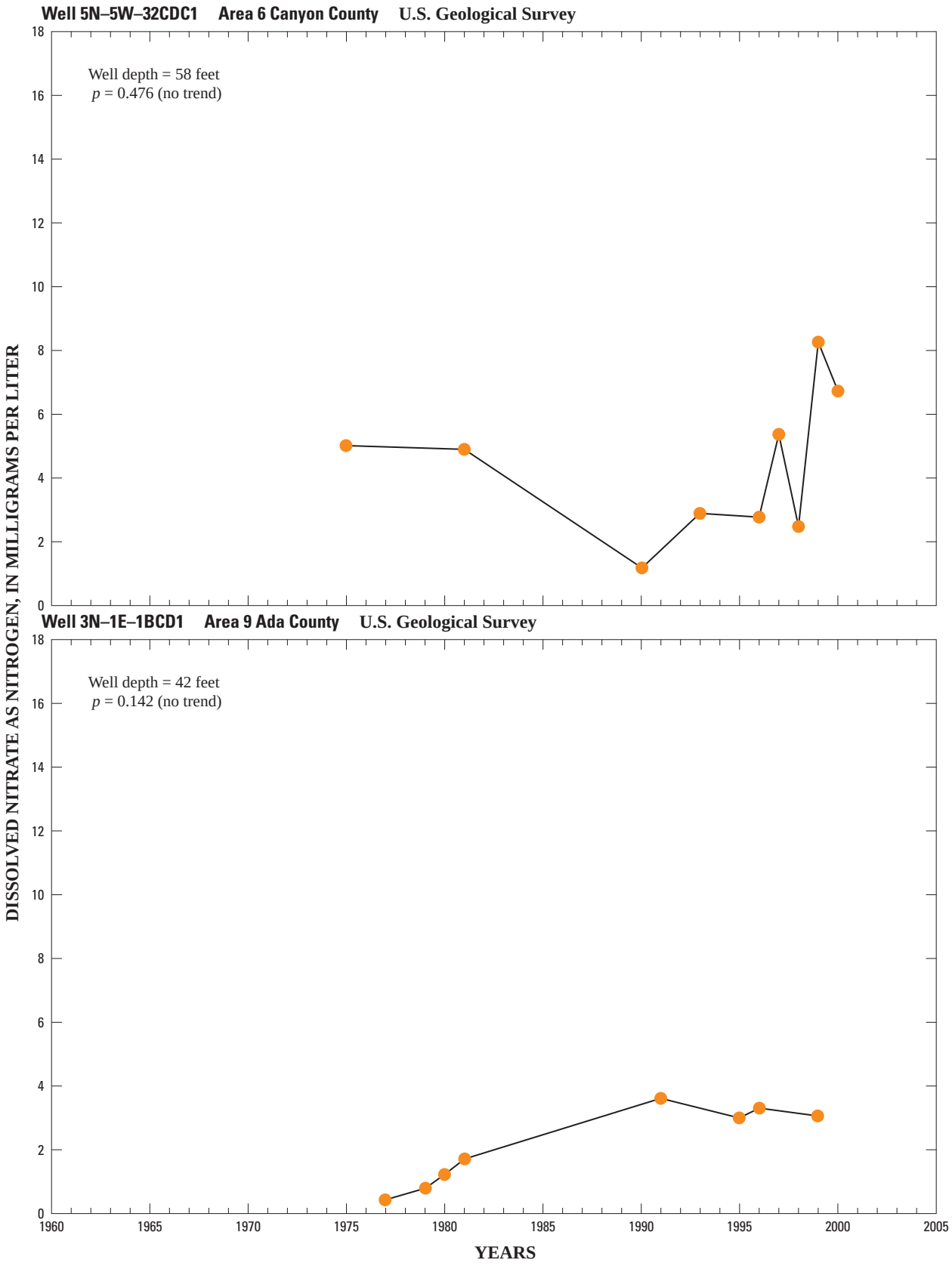
Appendix B. Nitrate trend analyses for selected wells in ground-water-quality management areas in Idaho, 1961 to 2001



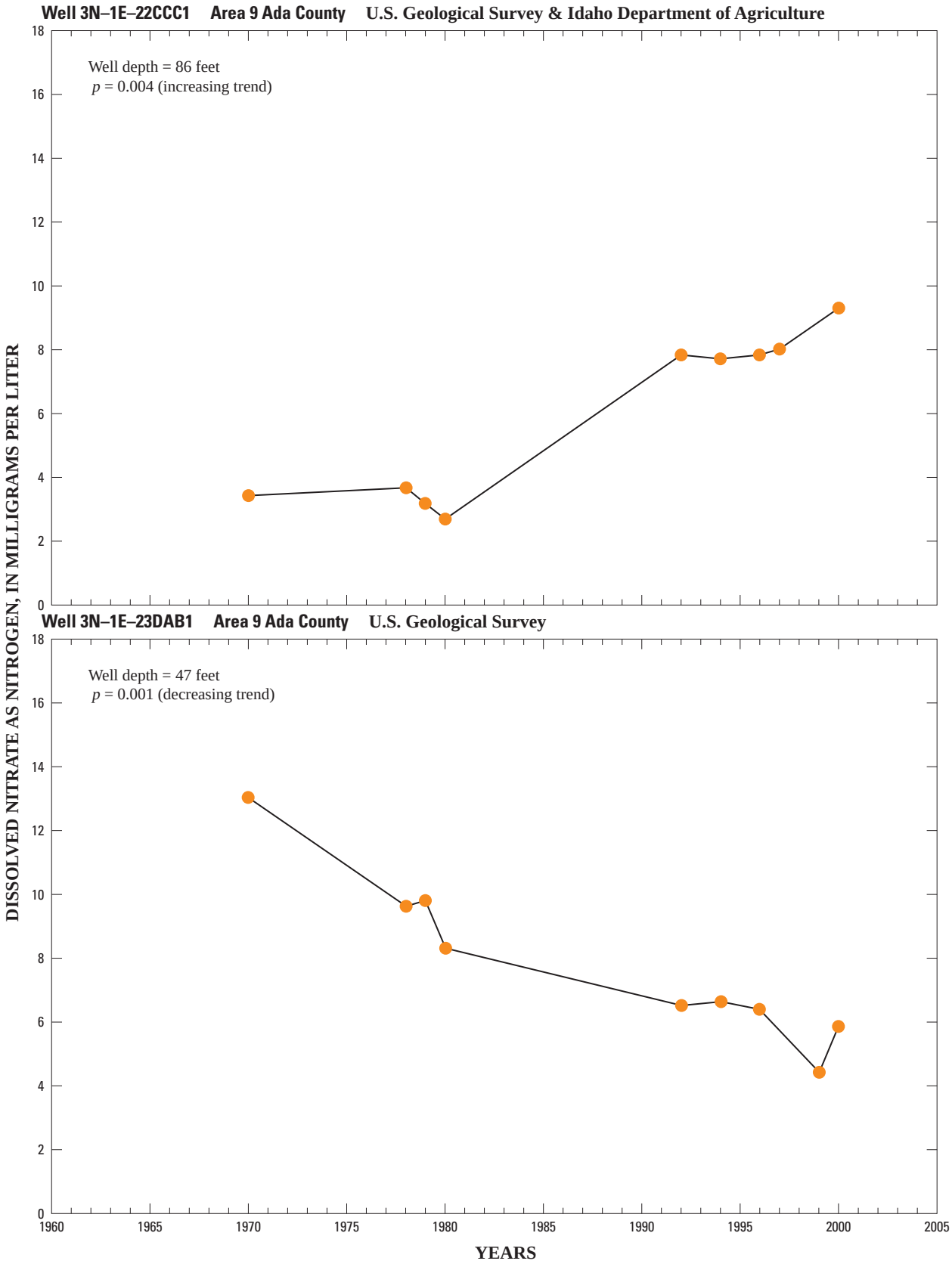
Appendix B. Nitrate trend analyses for selected wells in ground-water-quality management areas in Idaho, 1961–2001.



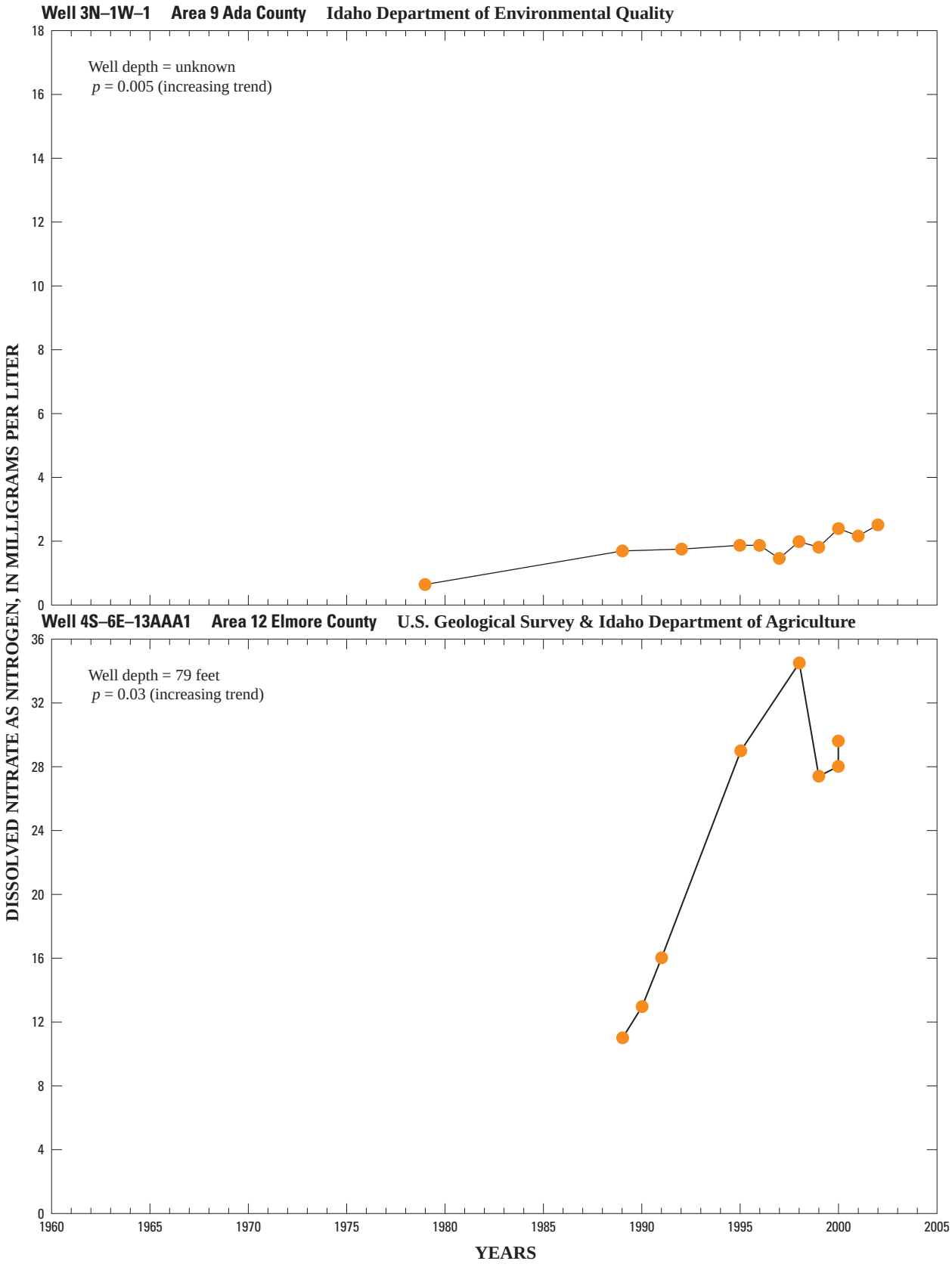
Appendix B. Nitrate trend analyses for selected wells in ground-water-quality management areas in Idaho, 1961–2001—Continued.



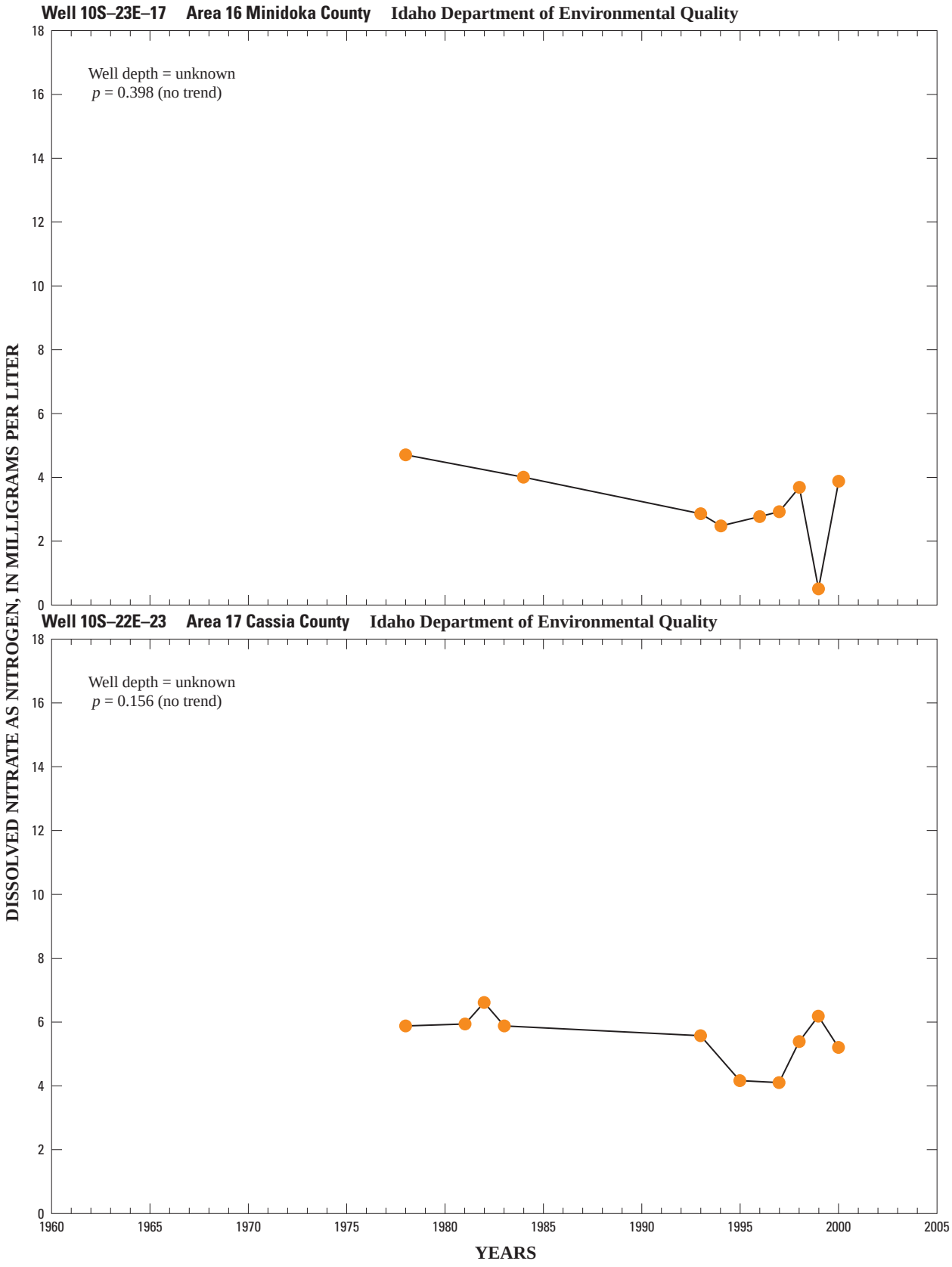
Appendix B. Nitrate trend analyses for selected wells in ground-water-quality management areas in Idaho, 1961–2001—Continued



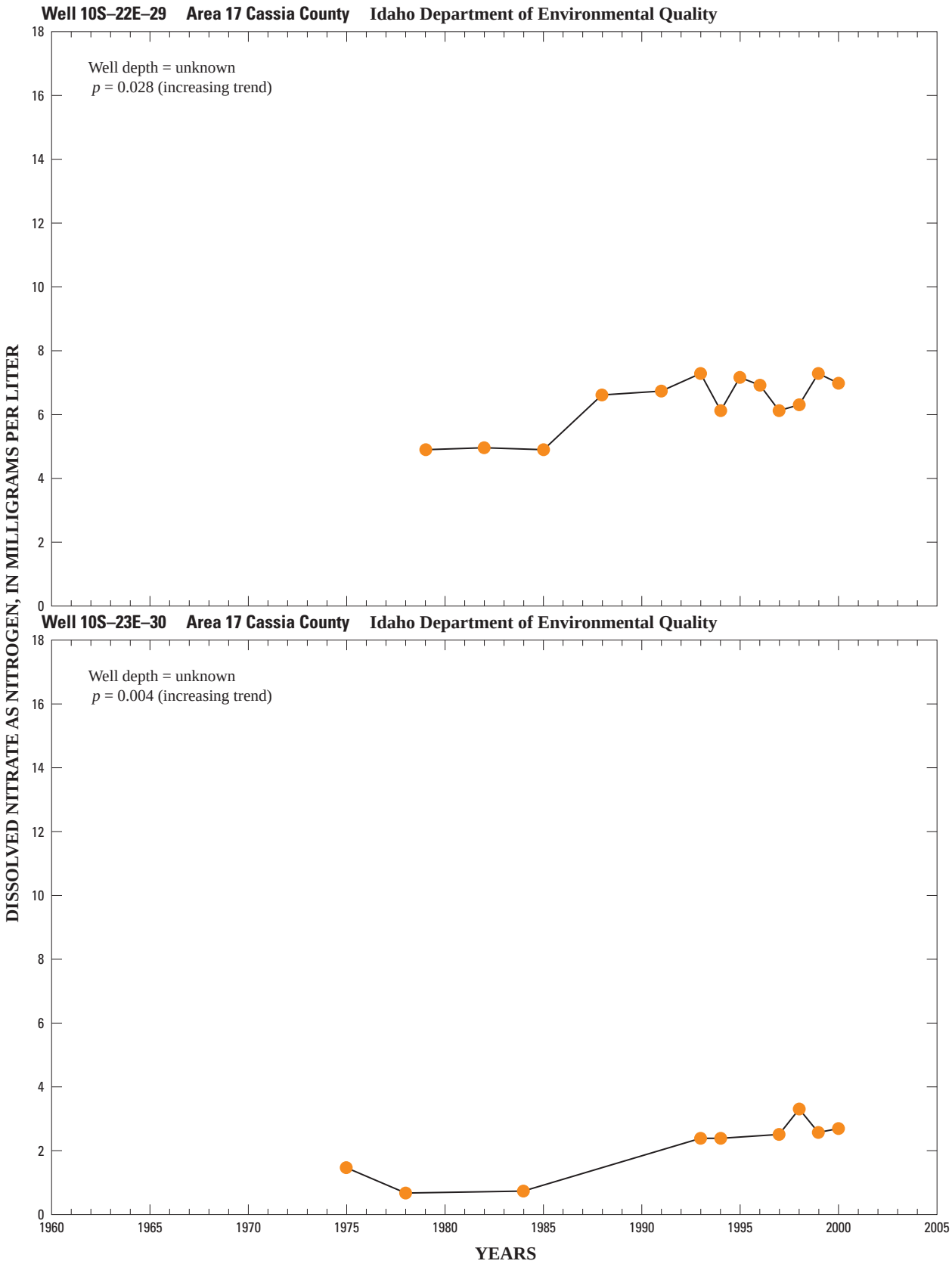
Appendix B. Nitrate trend analyses for selected wells in ground-water-quality management areas in Idaho, 1961–2001—Continued



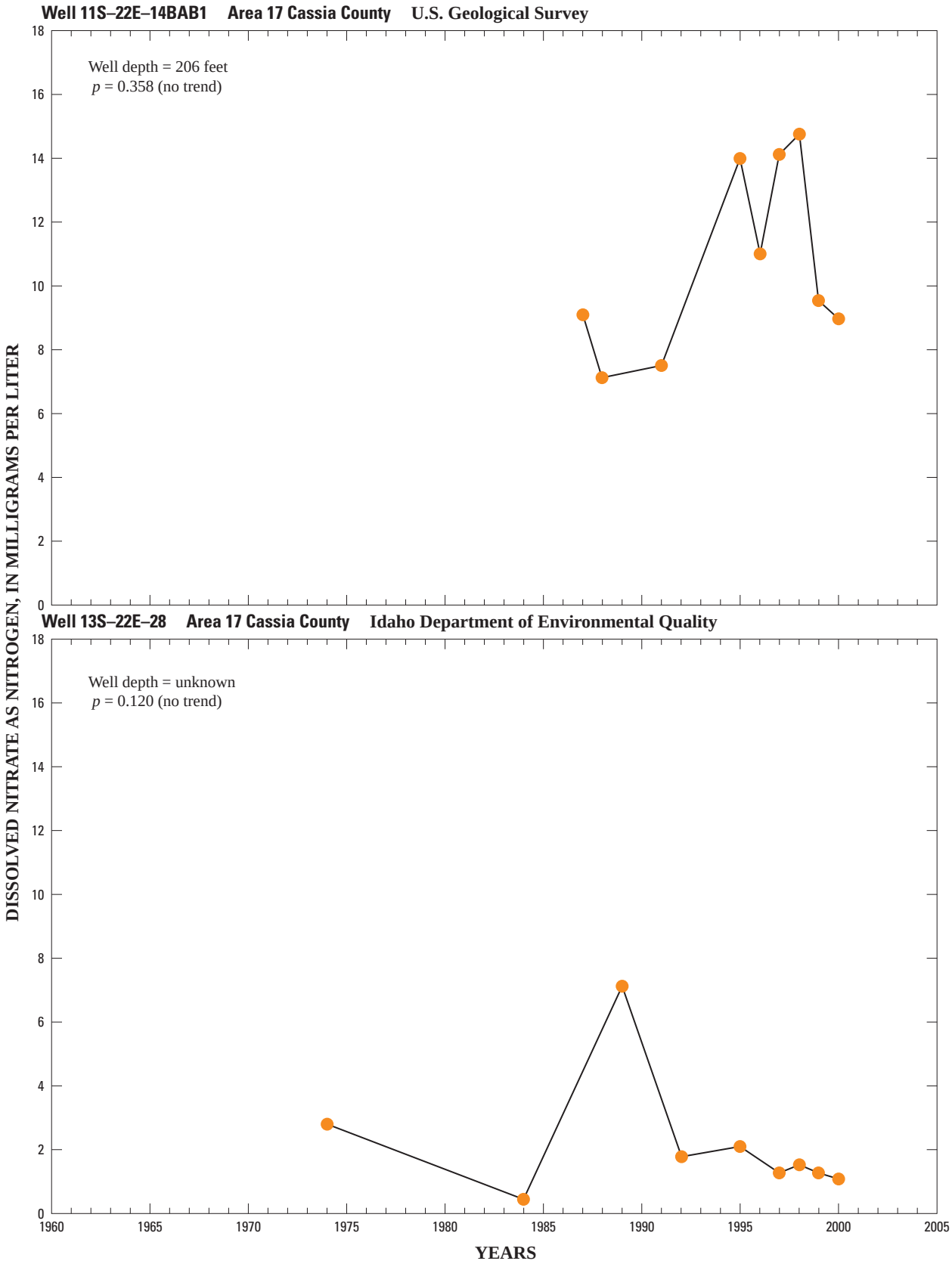
Appendix B. Nitrate trend analyses for selected wells in ground-water-quality management areas in Idaho, 1961–2001—Continued



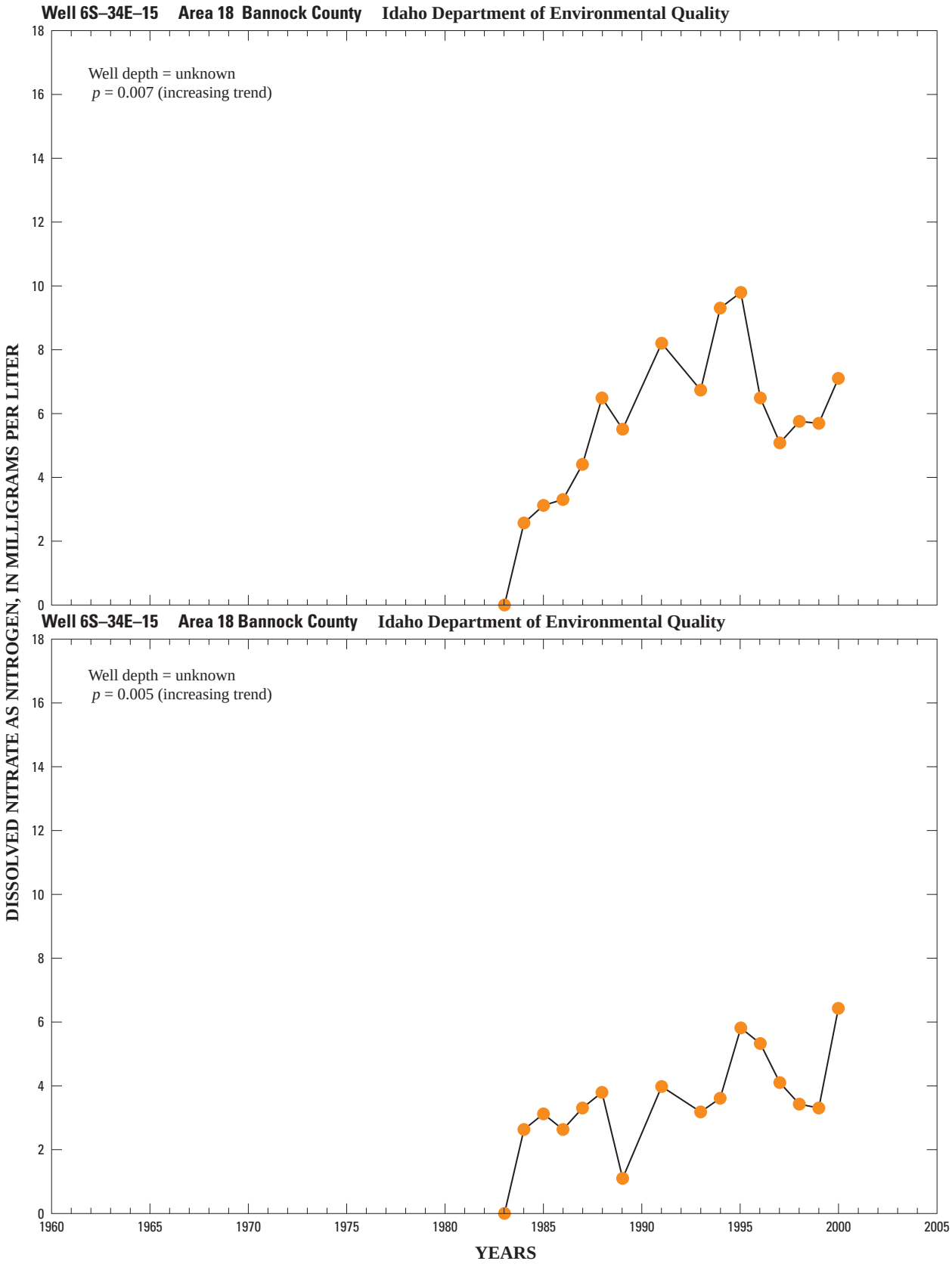
Appendix B. Nitrate trend analyses for selected wells in ground-water-quality management areas in Idaho, 1961–2001—Continued



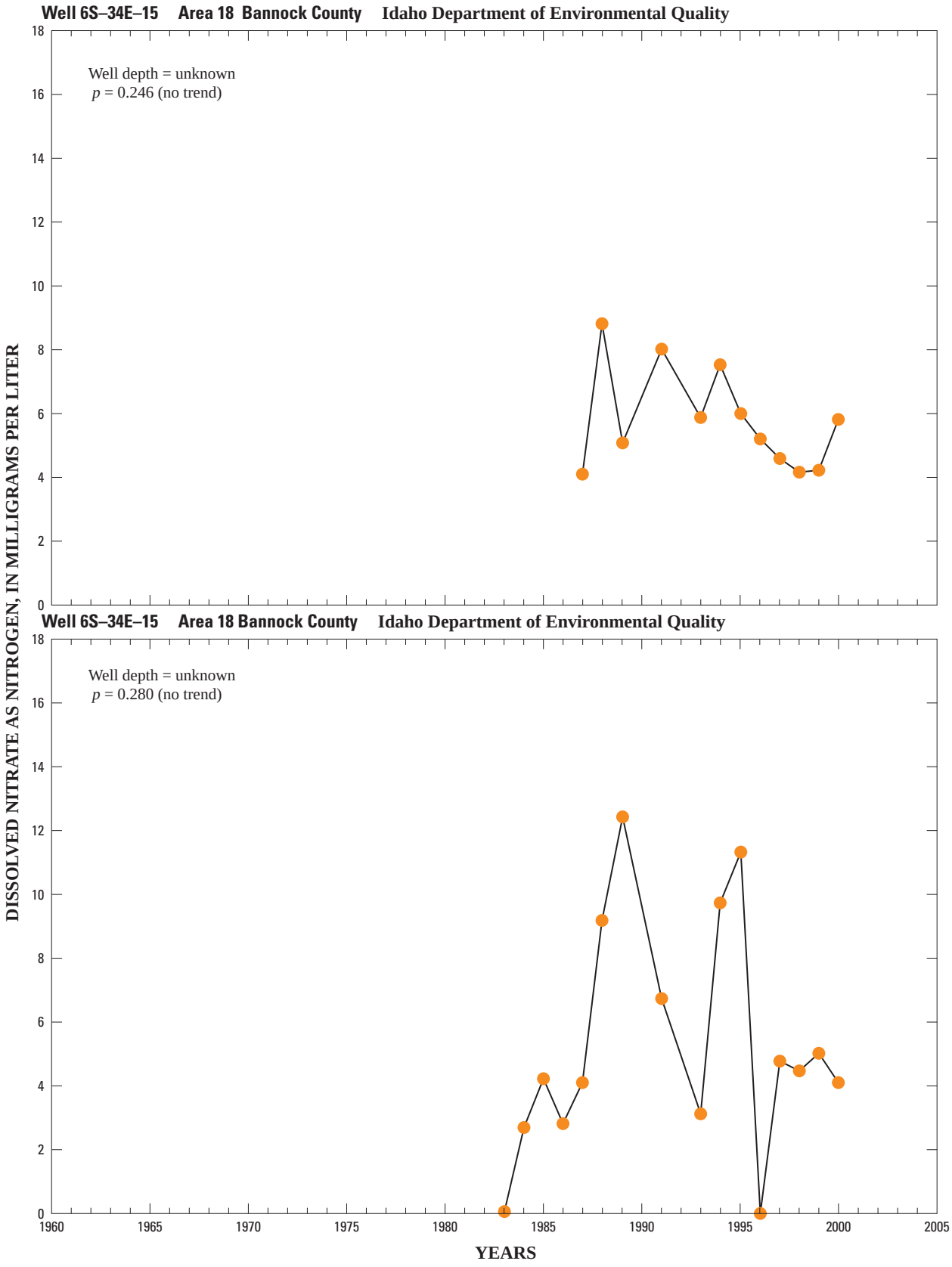
Appendix B. Nitrate trend analyses for selected wells in ground-water-quality management areas in Idaho, 1961–2001—Continued



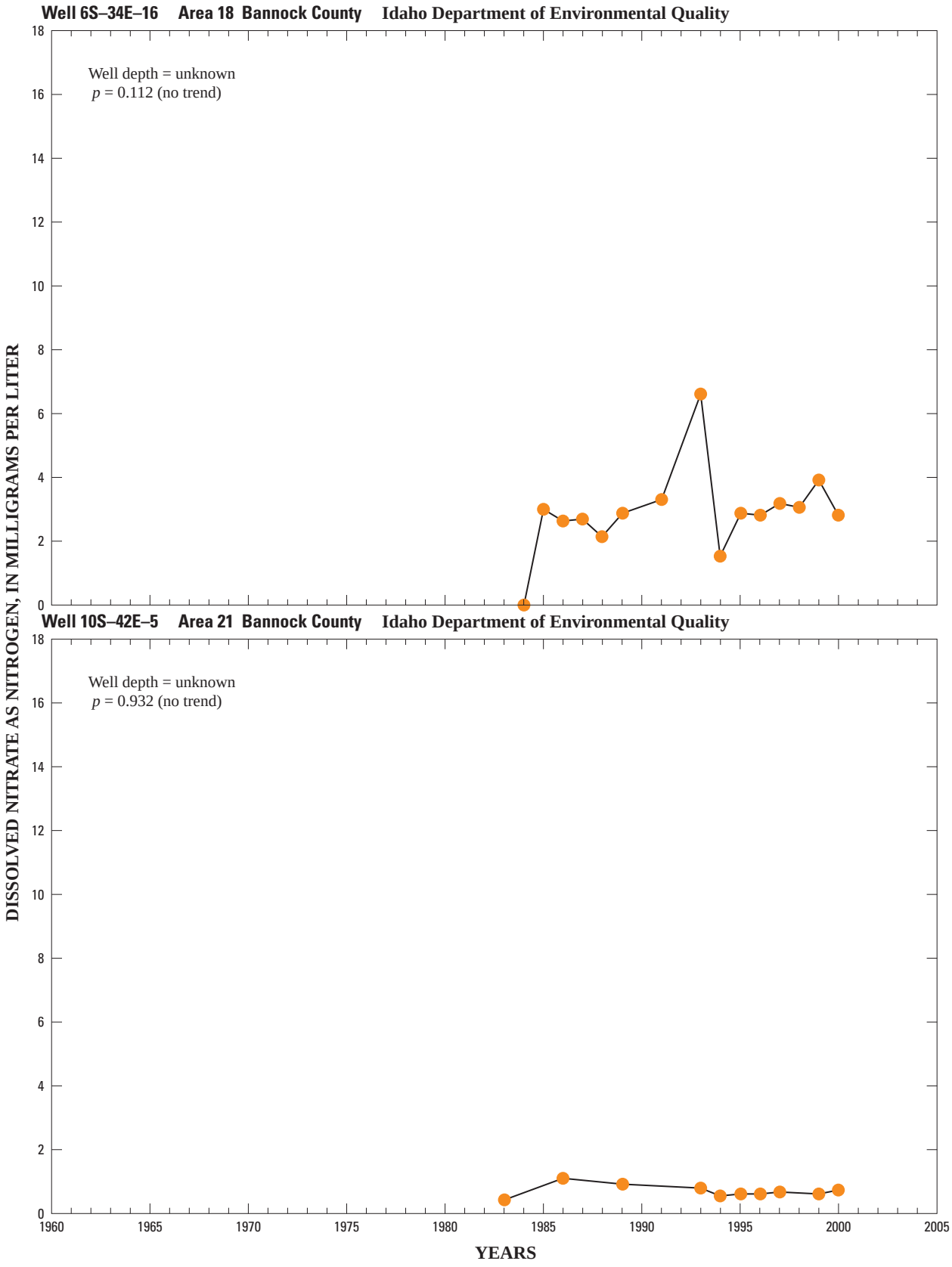
Appendix B. Nitrate trend analyses for selected wells in ground-water-quality management areas in Idaho, 1961–2001—Continued



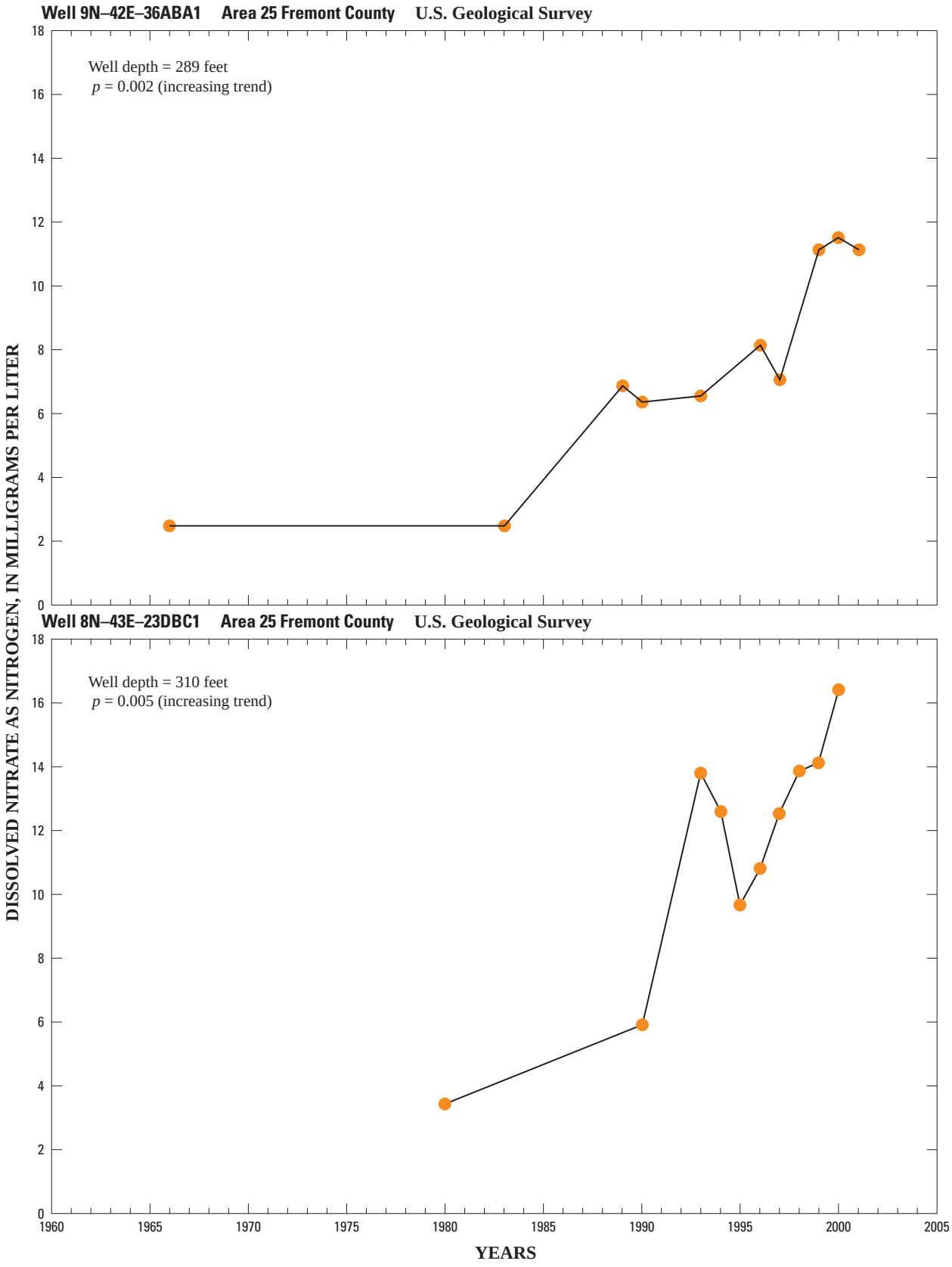
Appendix B. Nitrate trend analyses for selected wells in ground-water-quality management areas in Idaho, 1961–2001—Continued



Appendix B. Nitrate trend analyses for selected wells in ground-water-quality management areas in Idaho, 1961–2001—Continued



Appendix B. Nitrate trend analyses for selected wells in ground-water-quality management areas in Idaho, 1961–2001—Continued



Appendix B. Nitrate trend analyses for selected wells in ground-water-quality management areas in Idaho, 1961–2001—Continued