

Prepared in cooperation with the Bureau of Reclamation, U.S. Department of the Interior

Summary and Analysis of Water-Quality Data for the Arrowwood National Wildlife Refuge, East-Central North Dakota, 1987–2004

Scientific Investigations Report 2009–5017

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

Cover photograph: Arrowwood National Wildlife Refuge, Jim Lake drawdown channel, looking north.
Photograph by Karen R. Ryberg, U.S. Geological Survey, June 21, 2008.

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By Karen R. Ryberg and Gregory Hiemenz

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Conversion Factors

Multiply	By	To obtain
Length		
mile (mi)	1.609	kilometer (km)
Area		
acre	4,047	square meter (m ²)
acre	0.4047	hectare (ha)
acre	0.4047	square hectometer (hm ²)
acre	0.004047	square kilometer (km ²)
square mile (mi ²)	259.0	hectare (ha)
square mile (mi ²)	2.590	square kilometer (km ²)
Flow rate		
cubic foot per second (ft ³ /s)	0.02832	cubic meter per second (m ³ /s)

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

$$^{\circ}\text{F}=(1.8\times^{\circ}\text{C})+32$$

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

$$^{\circ}\text{C}=(^{\circ}\text{F}-32)/1.8$$

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

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) or micrograms per liter (μg/L).

Summary and Analysis of Water-Quality Data for the Arrowwood National Wildlife Refuge, East-Central North Dakota, 1987–2004

By Karen R. Ryberg¹ and Gregory Hiemenz²

Abstract

The Bureau of Reclamation collected water-quality samples at 16 sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., as part of its refuge-monitoring program from 1987–93 and as part of an environmental impact statement commitment from 1999–2004.

Climatic and hydrologic conditions varied greatly during both sampling periods. The first period was dominated by drought conditions, which abruptly changed to cooler and wetter conditions in 1992–93. During the second period, conditions were near normal to very wet and included higher inflow from the James River into the refuge. The two periods also differed in the sites sampled, seasons sampled, and properties and constituent concentrations measured.

Summary statistics were reported separately for the two sampling periods for all physical properties and constituents. Nonparametric statistical tests were used to further analyze some of the water-quality data.

During the first sampling period, 1987–93, specific conductance, turbidity, hardness, alkalinity, total dissolved solids, total suspended solids, nonvolatile suspended solids, calcium, magnesium, sodium, potassium, sulfate, chloride, phosphate, total phosphorus, total organic carbon, chlorophyll *a*, and arsenic were determined to have significantly different medians among the sites tested. During the second sampling period, 1999–2004, the medians of pH, sodium, chloride, barium, and boron varied significantly among sites.

Sites sampled and period of record varied between the two sampling periods and the period of record varied among the sites. Also, some constituents analyzed during the first period (1987–93) were not analyzed during the second period (1999–2004), and winter sampling was done during the second sampling period only. This variability reduces the number of direct comparisons that can be made between the two periods. Three sites had complete periods of record for both sampling periods and were compared. Differences in variability and

median concentration were identified between the two time periods.

Sites representing inflow to the refuge and outflow were compared statistically for the period when data were available for both sites, 1999–2004. Of the nutrients tested—ammonia plus organic nitrogen, phosphate, and total phosphorus—no significant statistical differences were found between the inflow samples and the outflow samples. Statistically significant differences were found for pH, sulfate, chloride, barium, and manganese.

Nutrients are of particular interest in the refuge because of the aquatic plant and animal life and the use of the wetland resources by waterfowl. However, the nutrient data were highly censored and there were differences in the seasonal timing of sample collection between the two sampling periods. Therefore, the nutrient data were examined graphically with stripplots that highlighted differences in the seasonal timing of sample collection and concentration differences likely related to the differences in climatic and hydrologic conditions between the two periods.

Introduction

The Bureau of Reclamation (Reclamation) collected water-quality samples at 16 sites on the James River and the Arrowwood National Wildlife Refuge (Arrowwood NWR), N. Dak. (fig. 1 and table 1), as part of its refuge-monitoring program from 1987–93 and as part of an environmental impact statement (EIS) commitment from 1999–2004. Refuge monitoring was conducted by Reclamation under authority of the Garrison Diversion Unit (GDU). The U.S. Congress created the GDU in 1965 with the intent of providing water for agricultural irrigation in North Dakota (U.S. Congress, 2000). As part of the GDU, Missouri River water would be diverted to the James River and used for irrigation. Because the James River flows through Arrowwood NWR, sampling was conducted to collect baseline water-quality information for assessing the potential implications of the new flow pattern.

In 1991, Reclamation initiated construction of bypass channels, subimpoundments, and new control structures on

¹ U.S. Geological Survey.

² Bureau of Reclamation.

the refuge to improve the refuge's ability to control water levels. Construction was temporarily halted while an EIS was done, and water-quality sampling stopped in 1993. The final EIS analyzed "the need to provide Arrowwood National Wildlife Refuge with water management capability to mitigate for restrictions on water management capability imposed by Jamestown Reservoir" (U.S. Department of the Interior, Bureau of Reclamation, Dakotas Area Office, 1997). The EIS was completed in 1997, construction resumed in 1998, and water-quality sampling resumed in 1999 at five of the previously sampled sites and at two new sites. This sampling was done because of the EIS requirements to monitor the effects of the construction. Construction was substantially completed in 2007, and the project was completed in 2008 (Pirkel, 2008). A cooperative project between the U.S. Geological Survey (USGS) and Reclamation was conducted in 2008 to summarize, evaluate, and publish the Arrowwood NWR water-quality data.

Purpose and Scope

Presented in the report are summary statistics for water-quality physical properties, dissolved and suspended solids, nutrients, major ions, carbon, chlorophyll, and trace elements from samples collected by the Bureau of Reclamation at 16 sites on the James River and the Arrowwood NWR from 1987–93 and 1999–2004. This report also presents the results of statistical analyses of selected physical properties and constituents for samples from the 16 sites. The data used for the statistical summaries and analyses are provided in supplements at the end of the report.

Description of Study Area

The James River, a tributary of the Missouri River, originates in central North Dakota and flows southeast into South Dakota. The James River valley includes numerous natural lakes, low-head dams, and regulated reservoirs. The Arrowwood NWR encompasses 15,973 acres along 14 miles of the James River, approximately 30 miles north of Jamestown, North Dakota (fig. 1; U.S. Fish and Wildlife Service, 2007). Downstream from the refuge, and upstream from the town of Jamestown, is the Jamestown Dam and Reservoir, constructed primarily for flood control (Simonds, 1996). Arrowwood NWR lies within the flood-control pool of Jamestown Reservoir, and refuge impoundments may be inundated by the reservoir during flood-control operations.

In response to the drought of the 1930s, low waterfowl numbers, and an economic downturn, the Arrowwood Migratory Waterfowl Refuge, now called Arrowwood NWR, was established in 1935 for use by migratory birds (the refuge is in the Central Flyway migration corridor), for conservation of wildlife resources, and for refuge and breeding ground for migratory birds and other wildlife (U.S. Fish and Wildlife Service, 2007). Prairie grassland and wetland habitats provide

feeding and nesting resources for resident wildlife and for waterfowl that spend spring and summer in the area, as well as spring and fall feeding and resting habitat for migratory waterfowl (U.S. Fish and Wildlife Service, 2007).

The refuge contains approximately 3,850 acres of wetlands. In the 1930s, the Civilian Conservation Corps constructed low-head dams on three naturally occurring riverine lakes to store water and enable the refuge to manage water levels. A fourth impoundment (Depuy Marsh) was created by construction of a dike and control structure. Approximately 3,430 acres of the refuge wetlands are managed impoundments and pools (U.S. Fish and Wildlife Service, 2007).

The refuge pools are eutrophic and highly productive. External nutrient inputs include agricultural runoff, bird droppings, and decaying plants and rough fish. Concentrations of nutrients are similar to values reported from other refuges in North Dakota and South Dakota. Major constituents, chlorophyll *a*, pH, conductivity, and dissolved oxygen show seasonal variations consistent with data reported from other prairie wetlands (U.S. Department of the Interior, Bureau of Reclamation, Dakotas Area Office, 1997).

The Flood Control Act of 1944 authorized construction of dams and other water control features to manage the Missouri River Basin for flood control, navigation, and power. The Garrison Diversion Unit (GDU) was developed as part of this public works project, later renamed the Pick-Sloan Missouri Basin Program. The Jamestown Dam, part of the GDU, was completed in 1954 and the Jamestown Reservoir filled to normal operating levels in 1965 (Simonds, 1996; U.S. Fish and Wildlife Service, 2007). The Jamestown Reservoir backed water onto the Arrowwood NWR and prevented ideal water management in most years. "Higher water levels were not conducive to production of vegetation preferred by waterfowl * * *. In addition, Jamestown Reservoir supports rough fish such as carp and big mouth buffalo that invade the refuge during high-water periods. Rough fish can cause extensive damage to aquatic resources important for migratory and nesting waterfowl" (U.S. Fish and Wildlife Service, 2007). When water in the reservoir receded, excess water often remained "in the refuge because of poor pool drainage and channel obstructions below the lowermost refuge pool (Depuy Marsh)" (U.S. Department of the Interior, Bureau of Reclamation, Dakotas Area Office, 1997).

The Garrison Diversion Unit Reformulation Act of 1986 required mitigation for impacts to refuge operations caused by features of the GDU project. The EIS "analyzed the need to provide the Arrowwood NWR with water management capability to mitigate for high water levels imposed by the Jamestown Reservoir. The EIS presents an incremental series of actions that can provide various levels of water management capability. The preferred alternative selected was the 'Mud and Jim Lakes Bypass—Lower Joint Use Pool Alternative.' This alternative consisted of downstream channel improvements,

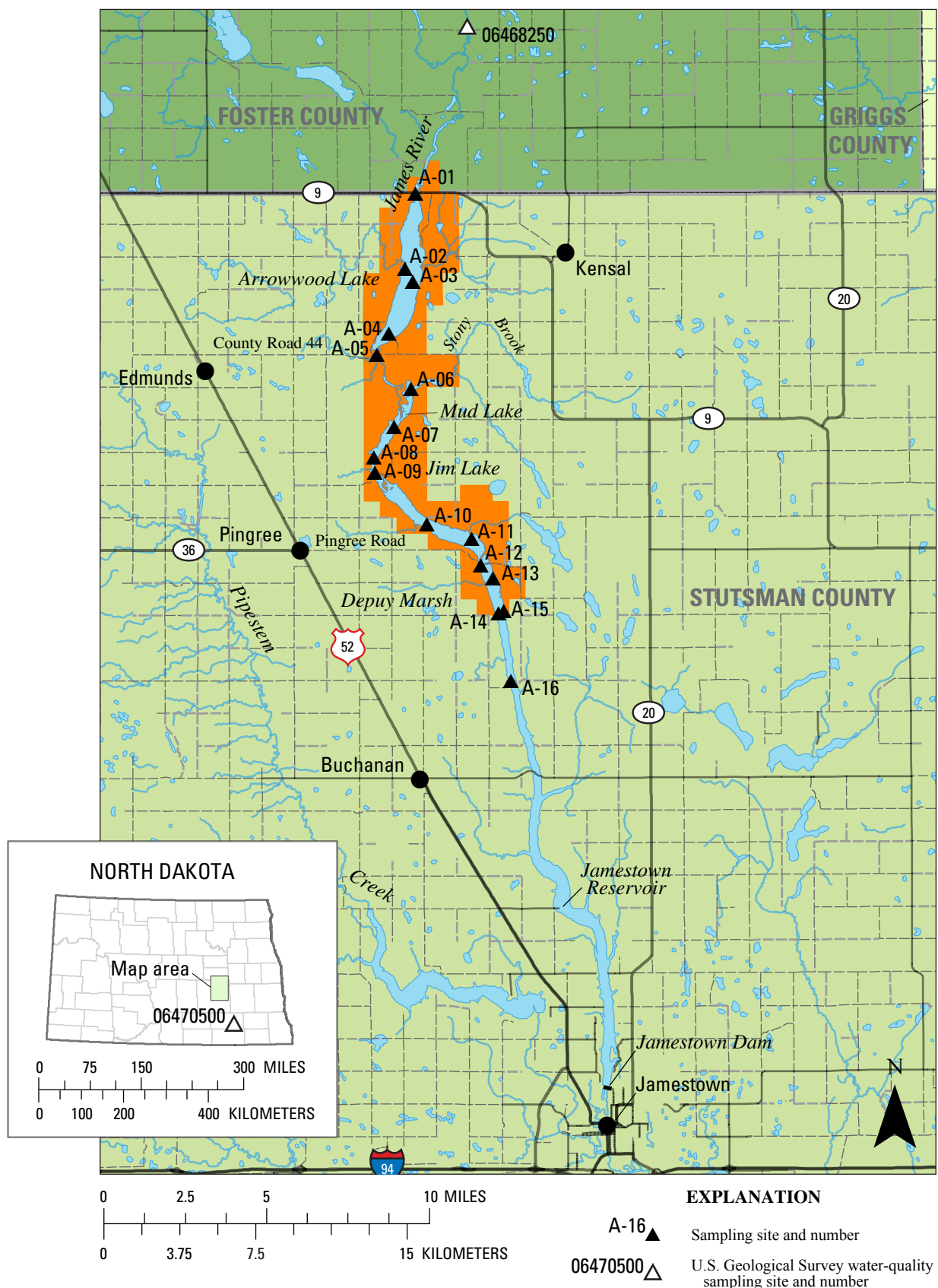


Figure 1. Locations of Arrowwood National Wildlife Refuge and the Bureau of Reclamation water-quality sampling sites along the James River, east-central North Dakota.

4 Summary and Analysis of Water-Quality Data for the Arrowwood National Wildlife Refuge, East-Central North Dakota

Table 1. Bureau of Reclamation water-quality sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93 and 1999–2004.

[Sites are listed in downstream order; --, not applicable]

Site	Site description	Latitude (decimal degrees)	Longitude (decimal degrees)	Periodic water-quality measurement dates			
				Refuge monitoring program		Environmental impact statement (EIS) monitoring	
				Begin	End	Begin	End
A-01	James River inflow to Arrowwood National Wildlife Refuge at State Highway 9	47.3268	-98.8319	04/1987	09/1993	03/1999	10/2004
A-02	Arrowwood Lake	47.2931	-98.8386	04/1987	10/1989	--	--
A-03	Arrowwood Lake	47.2875	-98.8337	04/1987	09/1993	--	--
A-04	Arrowwood Lake	47.2642	-98.8493	--	--	03/1999	07/2004
A-05	James River below Arrowwood Lake at County Road 44	47.2549	-98.8571	04/1987	09/1993	03/1999	10/2004
A-06	Stony Brook Arm of Mud Lake	47.2396	-98.8347	04/1987	09/1989	--	--
A-07	Mud Lake	47.2228	-98.8461	04/1987	09/1992	--	--
A-08	Mud Lake	47.2093	-98.8594	04/1987	04/1989	--	--
A-09	James River at Mud Lake Dike	47.2026	-98.8588	04/1987	08/1993	03/1999	10/2004
A-10	Jim Lake	47.1795	-98.8247	04/1987	08/1993	--	--
A-11	Jim Lake	47.1731	-98.7956	07/1992	09/1993	03/1999	10/2004
A-12	James River at Pingree Road Bridge	47.1610	-98.7897	04/1987	08/1989	--	--
A-13	Depuy Marsh	47.1553	-98.7817	04/1987	06/1989	--	--
A-14	James River at Depuy Marsh Dam	47.1407	-98.7747	07/1992	09/1993	03/1999	10/2004
A-15	Jim Lake drawdown channel at control structure	47.1399	-98.7783	04/1987	06/1989	--	--
A-16	James River below Arrowwood National Wildlife Refuge	47.1097	-98.7700	--	--	03/1999	10/2004

improved water control structures, fish barriers, a 2.5-mile channel around Jim Lake, a 7-mile channel around Mud Lake, a dike and water control structure at Stony Brook, and subimpoundments within Mud and Jim lakes. The alternative also called for the reduction of the Jamestown Reservoir 'Joint Use Pool' elevation by 1.8 feet" (U.S. Fish and Wildlife Service, 2007). Features of the mitigation project, including bypass channels and water control structures are shown in figures 2–4.

The series of channels, capable of passing flood waters in 7 of 10 years, will also allow managers to perform water level manipulations on all pools independently of the other pools, both upstream and downstream" (U.S. Fish and Wildlife Service, 2007). The EIS states, "Little change in water quality is expected under any of the action alternatives. Better pool drainage following floods would decrease early

summer water depths, favoring production of submergent plants. Increased production of submergent plants could decrease the severity of algal blooms. Fish barriers would decrease rough fish-induced turbidity and nutrient inputs from decaying fish. Increased use by waterfowl would increase nutrient inputs from bird droppings (U.S. Department of the Interior, Bureau of Reclamation, Dakotas Area Office, 1997).

The Bureau of Reclamation sampling at Arrowwood NWR took place as part of two different programs. The first sampling period was part of Reclamation's refuge monitoring program, which collected baseline information at Arrowwood NWR and other refuges in anticipation of proposed water deliveries for irrigation along the James River. The second sampling period involved sampling to monitor the effects of



Figure 2. Outflow from Arrowwood Lake in Arrowwood Lake drawdown channel, Arrowwood Lake National Wildlife Refuge, October 2006.



Figure 3. Jim Lake drawdown channel and DePuy control structure near south end of Arrowwood National Wildlife Refuge, October 2006.



Figure 4. Depuy control structure on Jim Lake drawdown channel near south end of Arrowwood National Wildlife Refuge, October 2006.

the construction of the structures described in the EIS. The sampling for the first program was done from 1987–93. This encompassed the drought period as well as the dramatic shift to cooler, wet conditions in 1992–93. The sampling for the second program was done from 1999–2004, during which hydrologic conditions varied from mild/moderate drought to extreme wetness.

Climatic and Hydrologic Conditions

The Arrowwood NWR has a continental climate characterized by relatively warm, short summers; long cold winters; and rapidly changing weather patterns. January is the coldest month and July is the warmest. The average growing season ranges from 98 to 106 days * * *. The coldest temperatures vary from -40°F to -60°F, with summertime highs up to 112°F * * *. Average annual precipitation is 18.36 inches, more than half of which falls between May and July. Recorded amounts vary greatly, from less than 10 inches to more than 30 inches. The average annual snowfall ranges from 30 to 40 inches, but can vary from 7 inches to more than 100 inches * * *. The frost-free season generally runs from May 20 to September 15 (U.S. Fish and Wildlife Service, 2007).

The climatic and hydrologic conditions in the study area were variable over the sampling period of record. North Dakota experienced generally warm, dry conditions that resulted in low runoff during 1988–92. These conditions changed in 1993 to generally cool, wet conditions with high runoff and flooding (Williams-Sether, 1999). Total precipitation for the Edmunds Arrowwood climate station, 1985–2005, is shown in figure 5. During the first sampling period (1987–93), total precipitation was below average for Arrowwood Wildlife Refuge (18.36 inches) in 1988, 1990, and 1991. The total precipitation for Edmunds Arrowwood is missing in the annual climatological summaries for 1992–94 and 1998–2002 (National Climatic Data Center, variously dated). During the second sampling period (1999–2004), only 2 years of precipitation were available, 2003 being below normal precipitation and 2004 being above normal precipitation.

The Arrowwood NWR and Edmunds Arrowwood climate station are in the central climatic division of North Dakota (ND-05). Data for the central climatic division are shown in figures 6 and 7. Figure 6 shows monthly precipitation and monthly average temperature for the climatic division. High precipitation is noticeable for 1993, and relatively lower temperatures for 1992 and 1993. Figure 7 is the Palmer Hydrological Drought Index (PHDI) for the central climatic division. The PHDI index indicates the severity of a wet or dry period based on the balance between moisture supply and

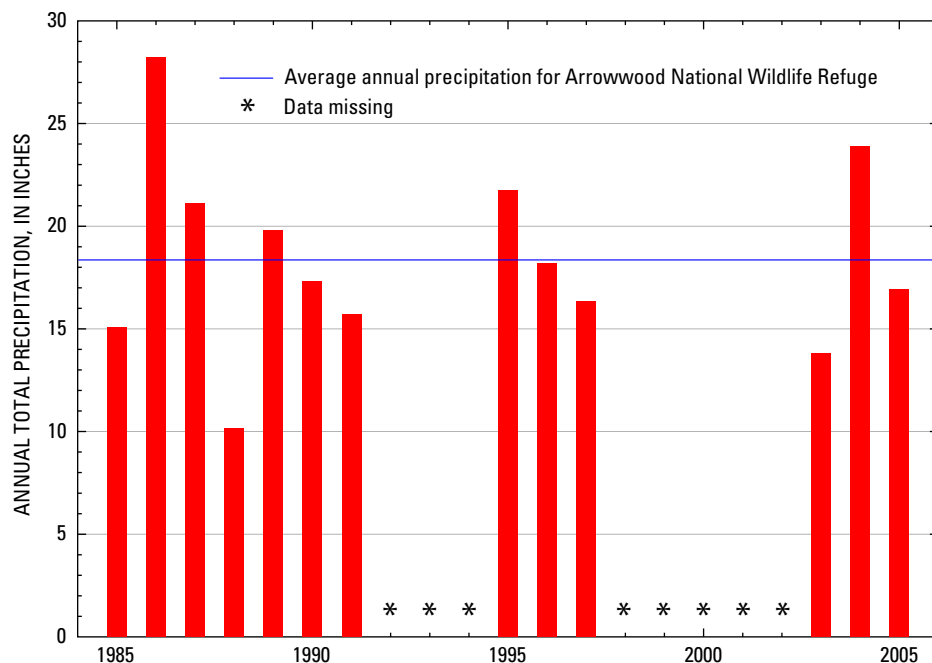


Figure 5. Annual total precipitation for the Edmunds Arrowwood station, 1985 through 2005 (National Climatic Data Center, variously dated), and average annual precipitation for Arrowwood National Wildlife Refuge (U.S. Fish and Wildlife Service, 2007).

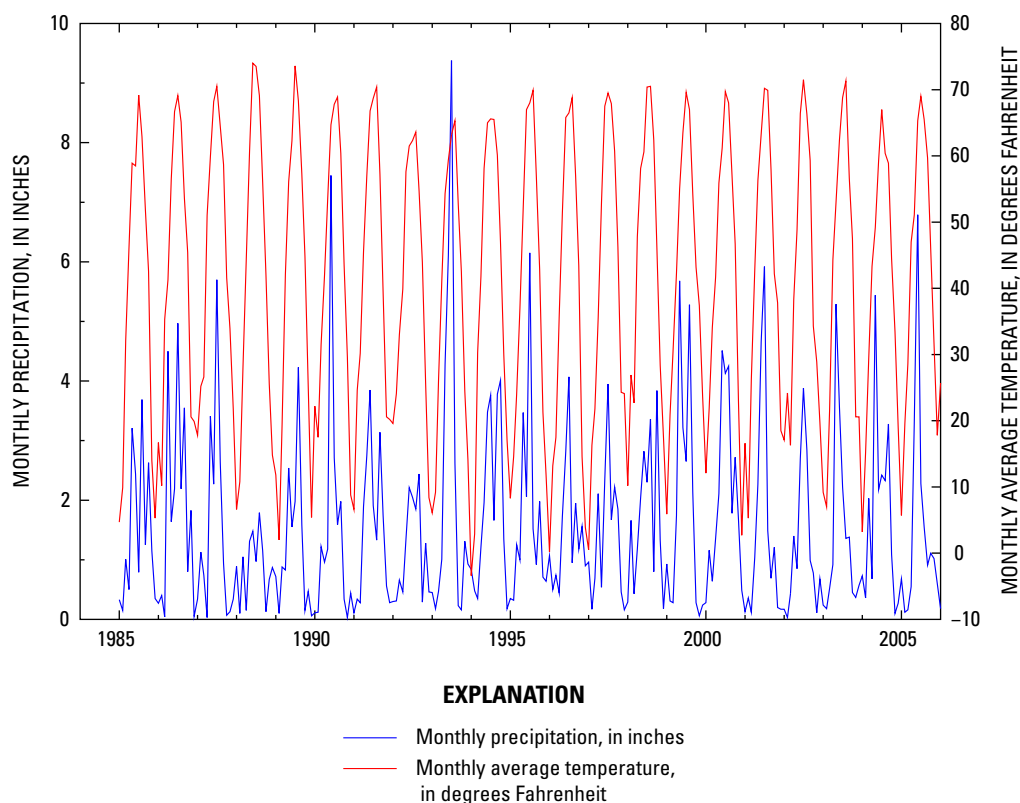


Figure 6. Monthly precipitation and monthly average temperature for the central climatic division of North Dakota (ND-05), 1985 to 2005 (National Climatic Data Center, 2008).

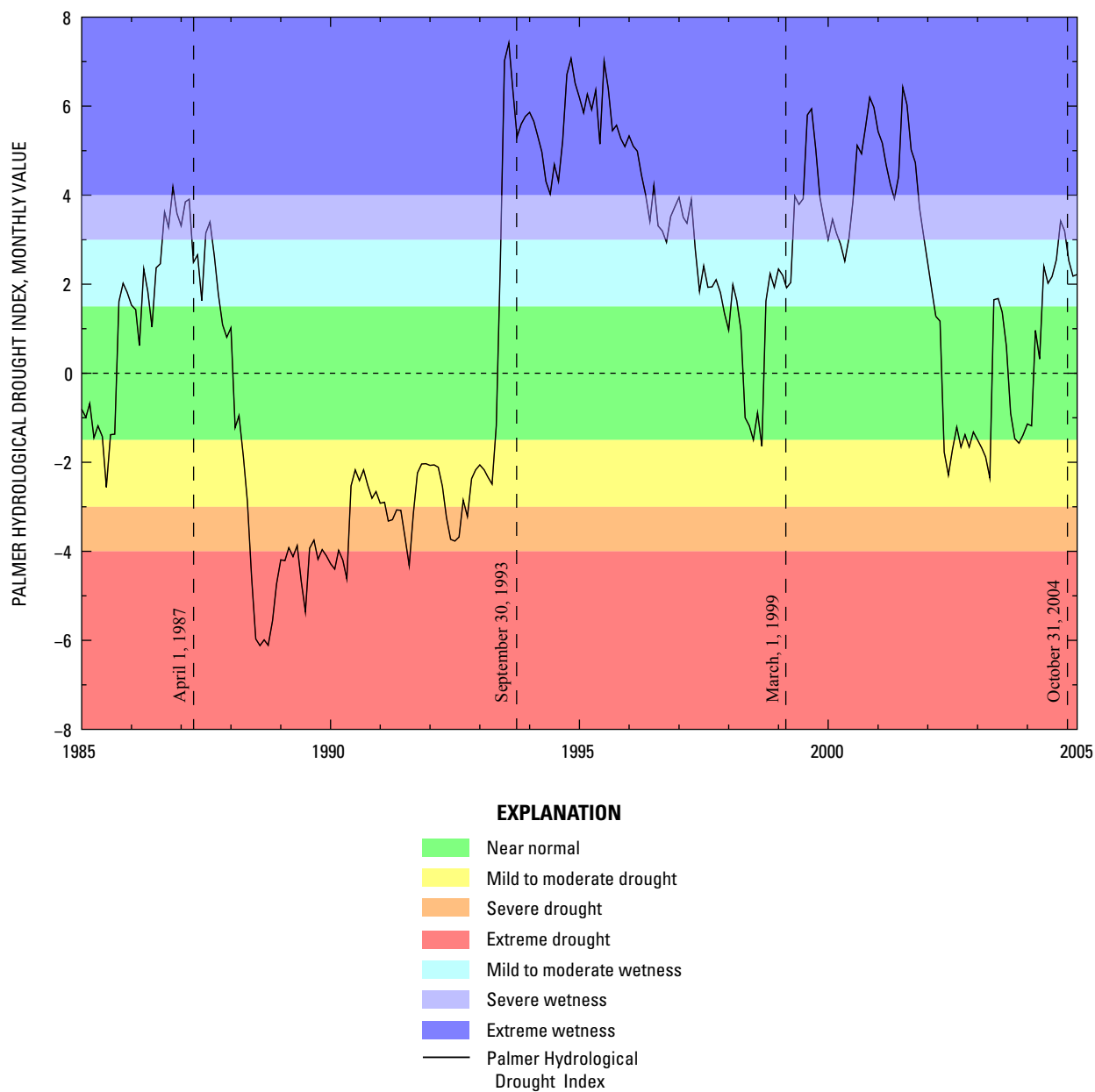


Figure 7. Monthly Palmer Hydrological Drought Index (PHDI) for the central climatic division of North Dakota (ND-05), 1985 to 2005 (National Climatic Data Center, 2008).

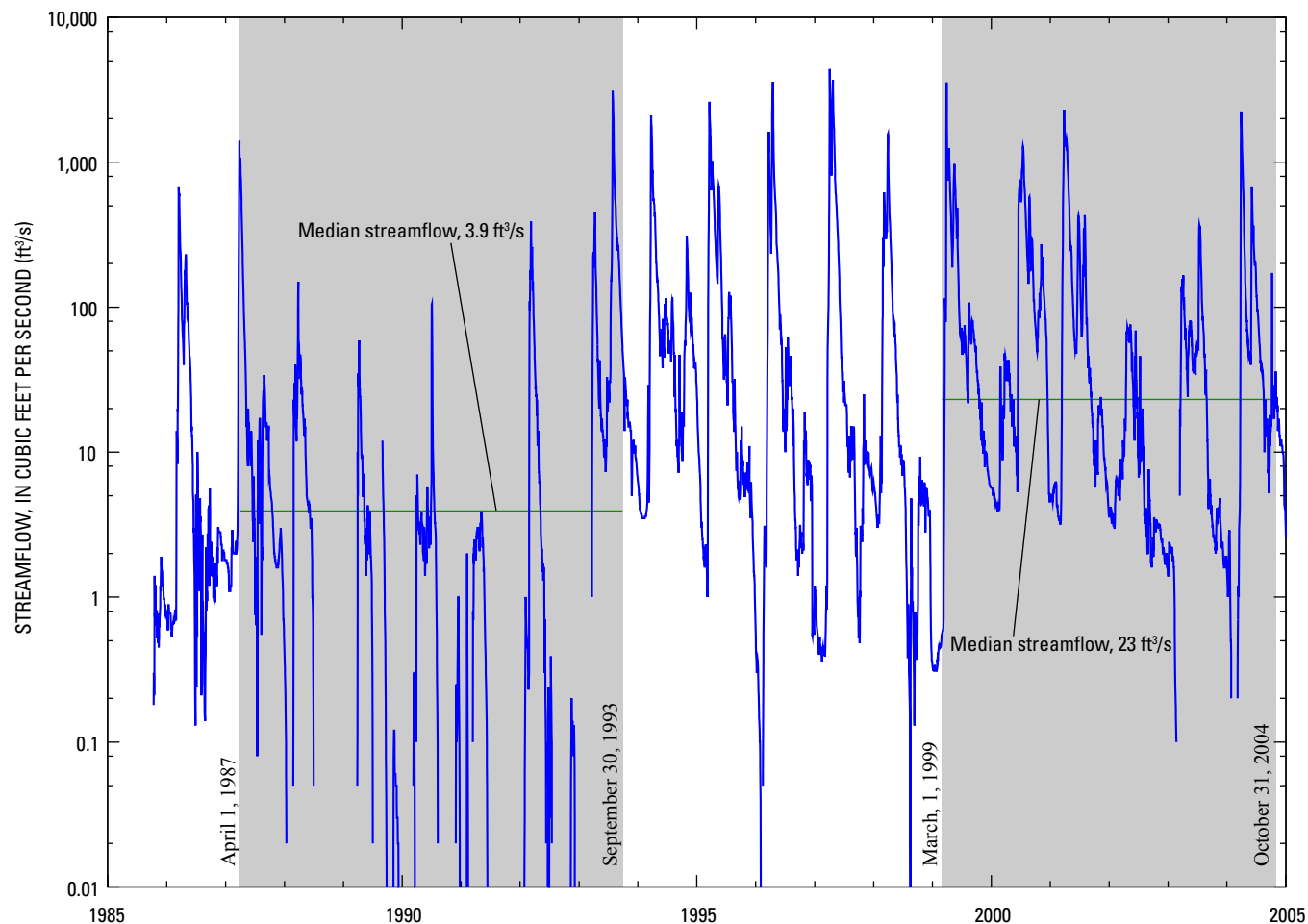


Figure 8. Daily streamflow for James River above Arrowwood Lake near Kensal, N. Dak., January 1, 1985, through December 31, 2004, representing inflow to Arrowwood National Wildlife Refuge.

demand. Anthropogenic changes such as increased irrigation were not included in the computation of the index (National Climatic Data Center, 2007). The 1987–92 warm, dry period is characterized by drought conditions. There is a sudden and dramatic change to very wet conditions in 1993. Near normal to extreme wet conditions continued until 2002.

Daily streamflow at the USGS gaging station on the James River above Arrowwood Lake near Kensal, N. Dak. from 1985 to 2005 is shown in figure 8. This represents the inflow to the Arrowwood NWR. The two different sampling periods are highlighted in gray. Streamflow values of 0.00 were treated as missing data because of the logarithmic scale. Both periods show a great deal of variability in streamflow, and streamflow is noticeably higher during the second period.

Methods

The Bureau of Reclamation collected all water-quality samples and used weighted bottles to obtain depth-integrated samples. For quality assurance, periodic duplicate samples were collected from the same location, and periodic split samples were collected and filtered into one bottle and then split into two different bottles prior to preservation and analysis. Nutrient samples were preserved (either by acidification or the use of mercuric chloride) and were promptly refrigerated (either on ice or in a portable refrigerator at the field site). Chlorophyll samples were immediately frozen and stored in the dark prior to analysis. All sampling, preservation, storage, and analysis followed U.S. Environmental Protection Agency (USEPA) approved methods, including maximum holding times prior to analysis (D. Hartman, Bureau of Reclamation, written commun., 2007; Protection of Environment [variously dated]; U.S. Geological Survey [variously dated], National field manual).

The Bureau of Reclamation Dakotas Area Office Water and Soil Laboratory in Bismarck, N. Dak., analyzed all water-quality samples. All the reported values (except total organic carbon) were from filtered samples. Laboratory methods used were those of the manufacturer of the analyzing equipment and were based on USEPA approved methods (Protection of Environment [variously dated]). Quality-control methods in the laboratory included the analysis of blank, duplicate, and split samples. Other quality-control measures included the use of check standards, control samples, analytical spikes and duplicates, and cation/anion balance comparison. The data are on file at the Bureau of Reclamation Dakotas Area Office in Bismarck, N. Dak.

Summary statistics were calculated for physical properties, dissolved and suspended solids, major ions, nutrients, and trace elements. Some nutrient and trace element values were censored. Censored values represent concentrations that are known to be less than a certain laboratory reporting level (LRL), but for which the exact value is not known. Summary statistics were estimated for constituents with censored values if less than 50 percent of the values were censored. For constituents with less than 50-percent censoring, the maximum concentration was reported, the minimum concentration was reported as less than the lowest LRL, and the percentiles and mean were estimated by the nonparametric Kaplan-Meier method (Helsel, 2005). For constituents with 50-percent or more censoring, the maximum concentration was reported, the minimum concentration was reported as less than the lowest LRL, and the 95th and 75th percentiles were reported if there were sufficient data. If a particular site had no censored concentrations for a constituent, the summary statistics reported are actual concentrations, not estimated values. The data set used to calculate the summary statistics and for statistical analysis is presented in Supplements 1–5 at the end of the report.

Nonparametric statistical tests were used to examine differences among sites and between the two sampling

periods. Nonparametric methods are resistant to outliers and can be used with skewed distributions, common features of water-quality data (Helsel and Hirsch, 1992; Higgins, 2004). Nonparametric tests also can be used with censored values by treating censored values as ties at the lowest value. When there is severe censoring, however, nonparametric tests have little power to detect differences. Helsel and Hirsch (1992) define severe censoring as near 50 percent or more. Therefore, statistical tests were performed in this study only when data for all sites/constituents/periods involved had less than 40-percent censoring.

The sites examined are on features that are part the same body of water, the James River; therefore, the concentration at a site may be dependent on the concentration at an upstream site at some previous time. Because of this possible dependence among the sites, the Friedman rank sum test, or Friedman test, a nonparametric test used for randomized complete block design that is applicable to water-quality concentrations at numerous sites along a water body (Helsel and Hirsch, 1992), was used to examine differences among water-quality physical properties and constituents at the sites. The Friedman test computes the ranks of the data (constituent concentrations at each site) within each block (a sampling date) and does not make comparisons between blocks (sampling dates). The within-block-only comparisons are the reason the Friedman test was chosen for this study. The null hypothesis of the Friedman test is that the median values for the groups of data compared are identical, and the alternative hypothesis is that at least one of the medians is significantly different than the others (Helsel and Hirsch, 1992). The Friedman test requires equal sample sizes for each block; therefore, for each set of samples to be compared, a value is needed for each site. That was not the case for every sampling time, so the Friedman test was performed on a subset of the available data.

The Friedman test identifies the likelihood of a statistical difference in a property or constituent concentration among the sites examined; however, it does not identify which site or sites may differ from the others. Therefore, when the Friedman test resulted in a statistically significant p-value (less than 0.05), pairwise sign tests were used in an attempt to identify the differing site(s).

The sign test uses the difference of data pairs (concentrations at two sites) to determine if one site tends to have larger concentrations than the other. The null hypothesis is that the probability of one site having a higher concentration than the other is 50 percent. The alternative hypothesis is that one site tends to have higher concentrations than the other (Helsel and Hirsch, 1992).

Conducting the pairwise comparison tests at the level of significance used for the overall test (the Friedman test in this study) has an undesirable consequence. For k treatments (sites), there are $k(k-1)/2$ pairwise comparisons. For example, if the Friedman test was used to test for differences at 7 sites and a statistically significant result (p-value less than 0.05) was followed up with pairwise comparison tests, there would be 21 pairwise comparisons. By doing so many pairwise

comparisons, the probability of declaring at least two sites to be different, even when they are not, would be considerably greater than 5 percent (this is the type I error determined by the choice of significance level to be 0.05). “If k is large enough, it is virtually certain that we will find at least one statistically significant difference just by chance” (Higgins, 2004). Therefore, with multiple comparisons, an overall experiment-wise error rate is used rather than a pairwise error rate.

The significance level (or type I error rate) used throughout the rest of the study was 0.05. To obtain an experiment-wise error rate no greater than 0.05, the Bonferroni adjustment was used to determine statistically significant results in the pairwise comparisons (Higgins, 2004). The Bonferroni adjustment is:

$$\alpha' = \frac{\alpha}{\frac{k(k-1)}{2}},$$

where

- α' is the adjusted significance level for the pairwise comparisons;
- α is the experiment-wise significance level or error rate, 0.05 in this study; and
- k is the number of groups being compared, sites in this study.

The Kolmogorov-Smirnov test is an omnibus test for two-sample data that checks for differences in the variability, magnitude (observations in one group might tend to be larger than observation in the other group), and shape of two distributions (Higgins, 2004), for example the distributions of a constituent concentration from the 1987–93 sampling period and from the 1999–2004 sampling period. The test assumes the samples are mutually independent random samples (Insightful Corporation, 2005). The null hypothesis is that both distributions are the same, and the alternative hypothesis is that the two distributions are not the same (Insightful Corporation, 2005).

The Wilcoxon rank-sum test is the nonparametric alternative to the parametric t-test for two-sample data. The t-test is parametric in that it assumes the data have a particular distribution, specifically a normal distribution, whereas the Wilcoxon rank-sum test does not assume the data follow a particular distribution. The null hypothesis of the Wilcoxon rank-sum test is that the location, or median, of the two distributions is the same. The alternative hypothesis is that the locations of the distributions of the two samples differ (Insightful Corporation, 2005). In the context of this report, the two distributions tested by the Kolmogorov-Smirnov and Wilcoxon rank-sum tests are the samples from the 1987–93 sampling period and the samples from the 1999–2004 sampling period.

Summary Statistics

Summary statistics of the physical properties and constituents for the first sampling period, 1987–93, are listed in table 2, including summary statistics for censored concentrations. The summary statistics of the physical properties and constituents for the second sampling period, 1999–2004, are listed in table 3, including summary statistics for censored concentrations. Censored values are indicated by the number of censored values for each site/constituent combination and the LRLs. An LRL of 0.10 indicates that one or more values were censored at 0.10 and recorded as <0.10. Multiple LRLs occur for some constituents, such as ammonia at site 1 (tables 2 and 3), which has LRLs of 0.01, 0.02, 0.05, and 0.10. Multiple LRLs may reflect changes in laboratory methods or equipment.

Manganese concentration, which ranged from censored values to 4,500 $\mu\text{g/L}$ (tables 2 and 3), was notable for its variability. In particular there were three very high outliers that were examined as potential data entry errors. The three outlier manganese concentrations occurred March 2, 1999, at sites A-04 (3,900 $\mu\text{g/L}$), A-05 (3,200 $\mu\text{g/L}$), and A-09 (4,500 $\mu\text{g/L}$). According to Hem (1985), during periods of ice cover when dissolved-oxygen concentration is depleted, which happens in the Arrowwood NWR lakes, manganese oxide in bottom sediments may be reduced and dissolved. Manganese also plays a role in photosynthesis (Schlesinger, 1997) and “organic circulation of manganese can influence its occurrence in natural water” (Hem, 1985).

Because of the timing of the three samples, they likely represent anoxic conditions under ice cover. However, dissolved oxygen concentration was not measured on March 2, 1999. Samples collected by the USGS on the James River that were analyzed for both manganese and dissolved oxygen concentrations were compared to the Bureau of Reclamation data to examine the possible range of manganese when dissolved oxygen is depleted. The USGS sampled the James River above Arrowwood Lake near Kensal, N. Dak. (USGS station number 06468250, http://nwis.waterdata.usgs.gov/nwis/nwisman/?site_no=06468250), on January 13, 1994. The recorded dissolved-oxygen concentration was 0.6 mg/L and the manganese concentration was 4,800 $\mu\text{g/L}$. The USGS sampled the James River at LaMoure, N. Dak. (USGS station number 06470500, http://nwis.waterdata.usgs.gov/nwis/nwisman/?site_no=06470500), 85 miles downstream from the Jamestown Reservoir, on February 24, 1993. The recorded dissolved-oxygen concentration was 0.5 mg/L and the sampled manganese concentration was 4,800 $\mu\text{g/L}$. Therefore the three outlier manganese concentrations were retained for calculating summary statistics and doing statistical analyses.

Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown						Period of record			
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date	
Site A-01															
Properties															
A-01	Depth, water	29	0	--	3.36	0.41	1.12	2.43	1.34	0.94	0.65	0.46	04/21/1987	09/02/1992	
A-01	Specific conductance	35	0	--	1,390	300	816	1,210	948	790	695	437	04/21/1987	09/09/1993	
A-01	pH	33	0	--	9.3	7.1	8.2	9.1	8.6	8.3	7.8	7.3	06/10/1987	09/09/1993	
A-01	Turbidity	27	0	--	140	5.2	36	110	45	26	12	5.6	04/21/1987	09/02/1992	
A-01	Transparency, secchi disk	26	0	--	1.4	.1	.5	1.0	.6	.4	.2	.2	04/21/1987	09/02/1992	
A-01	Depth of photic zone	21	0	--	3.7	.3	1.4	3.6	1.8	1.0	.7	.3	06/10/1987	09/02/1992	
A-01	Dissolved oxygen	30	0	--	15.2	2.5	8.6	13.1	11.3	8.5	6.5	3.0	04/21/1987	09/02/1992	
A-01	Hardness	36	0	--	310	110	240	300	270	240	200	150	04/21/1987	09/09/1993	
A-01	Alkalinity	36	0	--	540	120	300	460	340	300	240	170	04/21/1987	09/09/1993	
Dissolved and suspended solids															
A-01	Total dissolved solids, calculated, sum of constituents	36	0	--	942	173	498	788	577	484	410	257	04/21/1987	09/09/1993	
A-01	Total suspended solids at 105°C	34	0	--	388	0	48	178	56	27	9	3	04/21/1987	08/04/1993	
A-01	Nonvolatile suspended solids at 505°C	34	0	--	256	0	30	134	34	15	3	0	04/21/1987	08/04/1993	
A-01	Volatile suspended solids, calculated by subtraction	34	0	--	132	0	18	44	22	12	5	2	04/21/1987	08/04/1993	

Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record		
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05			Begin date
Site A-01—Continued															
Major Ions															
A-01	Calcium	36	0	--	62	23	40	59	47	38	31	26	04/21/1987	09/09/1993	
A-01	Magnesium	36	0	--	54	11	33	44	39	35	27	17	04/21/1987	09/09/1993	
A-01	Sodium	36	0	--	260	16	94	190	120	84	64	28	04/21/1987	09/09/1993	
A-01	Potassium	36	0	--	26	.7	14	22	16	14	12	8.8	04/21/1987	09/09/1993	
A-01	Sulfate	36	0	--	210	33	110	180	140	120	74	48	04/21/1987	09/09/1993	
A-01	Chloride	36	0	--	100	4.1	28	66	34	23	15	8.2	04/21/1987	09/09/1993	
Nutrients															
A-01	Nitrate	36	35	0.10	0.11	0.10	--	--	--	--	--	--	04/21/1987	09/09/1993	
A-01	Nitrite	36	31	.02	.02	.02	--	0.02	--	--	--	--	04/21/1987	09/09/1993	
A-01	Ammonia	36	11	.10	1.5	<0.10	0.26	.92	0.23	0.14	0.08	0.02	04/21/1987	09/09/1993	
A-01	Ammonia plus organic nitrogen	22	0	.20	14	0.66	2.7	5.3	2.8	1.8	1.4	.81	04/21/1987	09/09/1991	
A-01	Phosphate	36	3	.01	.58	<0.01	.17	.52	.26	.16	.05	.01	04/21/1987	09/09/1993	
A-01	Phosphorus, total	36	1	.01	.61	<0.01	.21	.48	.31	.20	.09	.01	04/21/1987	09/09/1993	
Carbon and chlorophyll															
A-01	Total organic carbon	33	0	1	49	13	20	34	22	18	16	13	04/21/1987	09/09/1993	
A-01	Chlorophyll <i>a</i>	36	0	--	880	1.4	74	160	79	35	7.4	3.5	04/21/1987	09/09/1993	
Trace elements															
A-01	Aluminum	0	0	10, 25	--	--	--	--	--	--	--	--	--	--	
A-01	Antimony	0	0	2, 20, 25, 50	--	--	--	--	--	--	--	--	--	--	
A-01	Arsenic	36	1	1, 2, 25	17	<1	5	14	6	4	3	2	04/21/1987	09/09/1993	

Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date
Site A-01—Continued														
Trace elements—Continued														
A-01	Barium	0	0	--	--	--	--	--	--	--	--	--	--	--
A-01	Beryllium	0	0	0.1, 0.2, 1, 5, 25	--	--	--	--	--	--	--	--	--	--
A-01	Boron	0	0	2	--	--	--	--	--	--	--	--	--	--
A-01	Cadmium	35	22	0.2, 1, 5, 10	0.7	<0.2	--	--	--	--	--	--	04/21/1987	09/09/1993
A-01	Chromium	9	9	1, 2, 6, 10	<1.0	<1.0	--	--	--	--	--	--	04/16/1992	09/09/1993
A-01	Cobalt	0	0	2, 5, 10	--	--	--	--	--	--	--	--	--	--
A-01	Copper	36	24	1, 2, 5, 10, 20	30	<1	--	--	--	--	--	--	04/21/1987	09/09/1993
A-01	Iron	31	11	10, 20, 25	110	<10	30	80	40	20	7	1	04/13/1988	09/09/1993
A-01	Lead	35	20	1, 2, 5, 25	4	<1	--	--	--	--	--	--	04/21/1987	09/09/1993
A-01	Lithium	0	0	25	--	--	--	--	--	--	--	--	--	--
A-01	Manganese	31	4	5, 10, 25	360	<10	66	260	60	40	20	4	04/13/1988	09/09/1993
A-01	Mercury	36	31	0.1	.2	<.1	--	--	--	--	--	--	04/21/1987	09/09/1993
A-01	Molybdenum	0	0	2, 10	--	--	--	--	--	--	--	--	--	--
A-01	Nickel	0	0	10, 12, 20, 25	--	--	--	--	--	--	--	--	--	--
A-01	Selenium	35	32	0.5, 1, 2	1.4	<.5	--	--	--	--	--	--	04/21/1987	09/09/1993
A-01	Silver	0	0	0.2, 1, 10, 25	--	--	--	--	--	--	--	--	--	--
A-01	Thallium	0	0	2, 25	--	--	--	--	--	--	--	--	--	--
A-01	Vanadium	0	0	10, 20, 25	--	--	--	--	--	--	--	--	--	--
A-01	Zinc	36	31	10, 20, 25	20	<10	--	--	--	--	--	--	04/21/1987	09/09/1993

Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maxi- mum	Mini- mum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date
Site A-02														
Properties														
A-02	Depth, water	15	0	--	2.97	0.57	1.05	2.14	1.19	0.79	0.66	0.58	04/22/1987	10/23/1989
A-02	Specific conduc- tance	13	0	--	987	307	727	983	829	700	630	477	04/22/1987	10/23/1989
A-02	pH	12	0	--	8.8	7.8	8.3	8.7	8.5	8.2	8.0	7.8	04/22/1987	10/23/1989
A-02	Turbidity	13	0	--	120	19	60	100	75	55	33	24	04/22/1987	10/23/1989
A-02	Transparency, secchi disk	15	0	--	.6	.2	.3	.5	.3	.2	.2	.2	04/22/1987	10/23/1989
A-02	Depth of photic zone	13	0	--	1.3	.4	.6	1.1	.8	.6	.4	.4	06/16/1987	10/23/1989
A-02	Dissolved oxygen	13	0	--	12.8	5.8	8.6	12.6	10.0	7.9	6.8	6.1	04/22/1987	10/23/1989
A-02	Hardness	15	0	--	300	150	240	290	270	240	220	170	04/22/1987	10/23/1989
A-02	Alkalinity	15	0	--	390	150	270	390	310	250	220	180	04/22/1987	10/23/1989
Dissolved and suspended solids														
A-02	Total dissolved solids, calcu- lated, sum of constituents	15	0	--	634	226	451	627	517	440	388	300	04/22/1987	10/23/1989
A-02	Total suspended solids at 105°C	15	0	--	101	9	51	89	73	47	32	15	04/22/1987	10/23/1989
A-02	Nonvolatile sus- pended solids at 505°C	15	0	--	63	4	30	57	40	26	17	7	04/22/1987	10/23/1989
A-02	Volatile suspended solids, calculated by subtraction	15	0	--	42	5	22	42	28	20	13	8	04/22/1987	10/23/1989

Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date
Site A-02—Continued														
Trace elements—Continued														
A-02	Beryllium	0	0	0.1, 0.2, 1, 5, 25	--	--	--	--	--	--	--	--	--	--
A-02	Boron	0	0	2	--	--	--	--	--	--	--	--	--	--
A-02	Cadmium	15	7	0.2, 1, 5, 10	0.4	<0.2	0.2	0.3	0.3	0.2	0.1	<0.1	04/22/1987	10/23/1989
A-02	Chromium	0	0	1, 2, 6, 10	--	--	--	--	--	--	--	--	--	--
A-02	Cobalt	0	0	2, 5, 10	--	--	--	--	--	--	--	--	--	--
A-02	Copper	15	13	1, 2, 5, 10, 20	30	<20	--	--	--	--	--	--	04/22/1987	10/23/1989
A-02	Iron	10	2	10, 20, 25	70	<10	30	70	40	30	20	2	04/14/1988	10/23/1989
A-02	Lead	15	5	1, 2, 5, 25	5	<1	2	4	2	1	1	<1	04/22/1987	10/23/1989
A-02	Lithium	0	0	25	--	--	--	--	--	--	--	--	--	--
A-02	Manganese	10	6	5, 10, 25	14	<10	--	--	--	--	--	--	04/14/1988	10/23/1989
A-02	Mercury	15	14	0.1	.1	.1	--	--	--	--	--	--	04/22/1987	10/23/1989
A-02	Molybdenum	0	0	2, 10	--	--	--	--	--	--	--	--	--	--
A-02	Nickel	0	0	10, 12, 20, 25	--	--	--	--	--	--	--	--	--	--
A-02	Selenium	15	15	0.5, 1, 2	1.0	<.5	--	--	--	--	--	--	04/22/1987	10/23/1989
A-02	Silver	0	0	0.2, 1, 10, 25	--	--	--	--	--	--	--	--	--	--
A-02	Thallium	0	0	2, 25	--	--	--	--	--	--	--	--	--	--
A-02	Vanadium	0	0	10, 20, 25	--	--	--	--	--	--	--	--	--	--
A-02	Zinc	15	15	10, 20, 25	<20	<20	--	--	--	--	--	--	04/22/1987	10/23/1989

Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date
Site A-03														
Properties														
A-03	Depth, water	30	0	--	3.40	0.63	1.27	2.09	1.51	1.09	0.96	0.75	04/21/1987	09/03/1992
A-03	Specific conductance	33	0	--	1,330	290	792	1,220	910	790	630	486	04/21/1987	09/09/1993
A-03	pH	33	0	--	9.6	7.3	8.4	9.3	8.7	8.4	8.2	7.7	04/21/1987	09/09/1993
A-03	Turbidity	26	0	--	400	3.6	70	140	85	40	23	7.2	04/21/1987	09/03/1992
A-03	Transparency, secchi disk	30	0	--	1.5	.1	.4	1.1	.5	.3	.2	.1	04/21/1987	09/03/1992
A-03	Depth of photic zone	17	0	--	3.7	.2	1.2	2.9	1.4	1.0	.5	.3	06/16/1987	09/03/1992
A-03	Dissolved oxygen	29	0	--	15.3	5.8	9.3	12.7	10.4	8.9	7.7	6.6	04/21/1987	09/03/1992
A-03	Hardness	34	0	--	300	130	230	290	260	220	200	150	04/21/1987	09/09/1993
A-03	Alkalinity	34	0	--	540	140	290	460	330	280	240	180	04/21/1987	09/09/1993
Dissolved and suspended solids														
A-03	Total dissolved solids, calculated, sum of constituents	34	0	--	880	220	486	780	557	469	385	284	04/21/1987	09/09/1993
A-03	Total suspended solids at 105°C	34	0	--	350	1	69	285	84	30	12	4	04/21/1987	09/09/1993
A-03	Nonvolatile suspended solids at 505°C	34	0	--	255	0	43	195	55	17	6	1	04/21/1987	09/09/1993
A-03	Volatile suspended solids, calculated by subtraction	34	0	--	128	1	25	83	29	14	6	3	04/21/1987	09/09/1993

Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; -, no data; statistics are rounded

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Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05		
Site A-03—Continued														
Trace elements—Continued														
A-03	Beryllium	0	0	0.1, 0.2, 1, 5, 25	--	--	--	--	--	--	--	--	--	--
A-03	Boron	0	0	2	--	--	--	--	--	--	--	--	--	--
A-03	Cadmium	33	21	0.2, 1, 5, 10	1	<0.2	--	--	--	--	--	--	04/21/1987	09/09/1993
A-03	Chromium	7	7	1, 2, 6, 10	<1	<1	--	--	--	--	--	--	04/16/1992	09/09/1993
A-03	Cobalt	0	0	2, 5, 10	--	--	--	--	--	--	--	--	--	--
A-03	Copper	34	21	1, 2, 5, 10, 20	40	<1	--	--	--	--	--	--	04/21/1987	09/09/1993
A-03	Iron	29	9	10, 20, 25	230	<10	50	140	60	30	8	2	04/14/1988	09/09/1993
A-03	Lead	33	20	1, 2, 5, 25	5	<1	--	--	--	--	--	--	04/21/1987	09/09/1993
A-03	Lithium	0	0	25	--	--	--	--	--	--	--	--	--	--
A-03	Manganese	29	17	5, 10, 25	90	6	--	--	--	--	--	--	04/14/1988	09/09/1993
A-03	Mercury	34	30	0.1	.1	<.1	--	--	--	--	--	--	04/21/1987	09/09/1993
A-03	Molybdenum	0	0	2, 10	--	--	--	--	--	--	--	--	--	--
A-03	Nickel	0	0	10, 12, 20, 25	--	--	--	--	--	--	--	--	--	--
A-03	Selenium	33	28	0.5, 1, 2	3.0	<.5	--	--	--	--	--	--	04/21/1987	09/09/1993
A-03	Silver	0	0	0.2, 1, 10, 25	--	--	--	--	--	--	--	--	--	--
A-03	Thallium	0	0	2, 25	--	--	--	--	--	--	--	--	--	--
A-03	Vanadium	0	0	10, 20, 25	--	--	--	--	--	--	--	--	--	--
A-03	Zinc	34	31	10, 20, 25	20	<10	--	--	--	--	--	--	04/21/1987	09/09/1993

Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date
Site A-05														
Properties														
A-05	Depth, water	27	0	--	3.88	0.44	1.49	2.29	1.85	1.47	1.02	0.47	04/21/1987	09/02/1992
A-05	Specific conductance	33	0	--	1,570	270	921	1,570	1,320	726	600	398	04/21/1987	09/09/1993
A-05	pH	33	0	--	9.2	7.1	8.1	8.9	8.3	8.1	7.7	7.4	04/21/1987	09/09/1993
A-05	Turbidity	25	0	--	80	4.3	24	60	31	20	9.0	5.3	04/21/1987	09/02/1992
A-05	Transparency, secchi disk	27	0	--	1.8	.2	.6	1.4	.7	.5	.4	.2	04/21/1987	09/02/1992
A-05	Depth of photic zone	17	0	--	3.1	.6	1.5	3.0	2.3	1.1	.8	.7	06/10/1987	09/02/1992
A-05	Dissolved oxygen	28	0	--	15.8	1.3	8.5	14.5	11.2	8.4	6.0	4.3	04/21/1987	09/02/1992
A-05	Hardness	34	0	--	650	91	300	580	390	250	190	140	04/21/1987	09/09/1993
A-05	Alkalinity	33	0	--	540	110	270	470	300	250	210	150	04/21/1987	09/09/1993
Dissolved and suspended solids														
A-05	Total dissolved solids, calculated, sum of constituents	34	0	--	1,130	161	585	1,110	846	455	341	229	04/21/1987	09/09/1993
A-05	Total suspended solids at 105°C	34	0	--	132	2	30	70	39	23	9	2	04/21/1987	09/09/1993
A-05	Nonvolatile suspended solids at 505°C	34	0	--	44	0	13	44	18	9	3	1	04/21/1987	09/09/1993
A-05	Volatile suspended solids, calculated by subtraction	34	0	--	88	1	17	48	22	11	6	2	04/21/1987	09/09/1993

(Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; no data; statistics are rounded)

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Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record			
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05			Begin date	End date
Site A-05—Continued																
Trace elements—Continued																
A-05	Beryllium	0	0	0.1, 0.2, 1, 5, 25	--	--	--	--	--	--	--	--	--	--	--	--
A-05	Boron	0	0	2	--	--	--	--	--	--	--	--	--	--	--	--
A-05	Cadmium	33	21	0.2, 1, 5, 10	0.4	0.2	--	--	--	--	--	--	04/21/1987	09/09/1993		
A-05	Chromium	9	9	1, 2, 6, 10	<1	<1	--	--	--	--	--	--	04/16/1992	09/09/1993		
A-05	Cobalt	0	0	2, 5, 10	--	--	--	--	--	--	--	--	--	--	--	--
A-05	Copper	34	24	1, 2, 5, 10, 20	80	1	--	--	--	--	--	--	04/21/1987	09/09/1993		
A-05	Iron	29	8	10, 20, 25	90	<10	40	90	40	30	9	2	04/13/1988	09/09/1993		
A-05	Lead	33	19	1, 2, 5, 25	4	1	--	--	--	--	--	--	04/21/1987	09/09/1993		
A-05	Lithium	0	0	25	--	--	--	--	--	--	--	--	--	--	--	--
A-05	Manganese	29	3	5, 10, 25	1,100	<10	200	920	250	86	23	9	04/13/1988	09/09/1993		
A-05	Mercury	34	29	0.1	.2	<.1	--	--	--	--	--	--	04/21/1987	09/09/1993		
A-05	Molybdenum	0	0	2, 10	--	--	--	--	--	--	--	--	--	--	--	--
A-05	Nickel	0	0	10, 12, 20, 25	--	--	--	--	--	--	--	--	--	--	--	--
A-05	Selenium	33	29	0.5, 1, 2	3.0	<.5	--	--	--	--	--	--	04/21/1987	09/09/1993		
A-05	Silver	0	0	0.2, 1, 10, 25	--	--	--	--	--	--	--	--	--	--	--	--
A-05	Thallium	0	0	2, 25	--	--	--	--	--	--	--	--	--	--	--	--
A-05	Vanadium	0	0	10, 20, 25	--	--	--	--	--	--	--	--	--	--	--	--
A-05	Zinc	34	30	10, 20, 25	20	<10	--	--	--	--	--	--	04/21/1987	09/09/1993		

Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date
Site A-06														
Properties														
A-06	Depth, water	13	0	--	2.69	0.22	0.82	2.11	0.92	0.57	0.44	0.24	04/22/1987	09/12/1989
A-06	Specific conductance	13	0	--	2,390	293	1,230	2,230	1,790	1,020	870	489	04/22/1987	09/12/1989
A-06	pH	13	0	--	9.5	7.4	8.6	9.5	9.1	8.9	8.1	7.6	04/22/1987	09/12/1989
A-06	Turbidity	12	0	--	70	5.0	24	55	31	17	12	6.6	04/22/1987	09/12/1989
A-06	Transparency, secchi disk	13	0	--	.7	.2	.4	.7	.5	.4	.3	.2	04/22/1987	09/12/1989
A-06	Depth of photic zone	7	0	--	2.2	.5	1.4	2.0	1.5	1.4	1.2	.7	06/11/1987	06/28/1989
A-06	Dissolved oxygen	13	0	--	12.6	3.3	8.9	12.0	11.3	10.4	7.3	4.3	04/22/1987	09/12/1989
A-06	Hardness	13	0	--	660	130	360	650	560	290	230	140	04/22/1987	09/12/1989
A-06	Alkalinity	13	0	--	360	110	240	350	310	240	140	120	04/22/1987	09/12/1989
Dissolved and suspended solids														
A-06	Total dissolved solids, calculated, sum of constituents	13	0	--	1,650	208	825	1,630	1,280	638	481	295	04/22/1987	09/12/1989
A-06	Total suspended solids at 105°C	13	0	--	90	8	35	88	47	31	15	8	04/22/1987	09/12/1989
A-06	Nonvolatile suspended solids at 505°C	13	0	--	62	3	23	59	35	19	6	4	04/22/1987	09/12/1989
A-06	Volatile suspended solids, calculated by subtraction	13	0	--	29	4	12	28	13	10	6	4	04/22/1987	09/12/1989

Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

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Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date
Site A-06—Continued														
Trace elements—Continued														
A-06	Beryllium	0	0	0.1, 0.2, 1, 5, 25	--	--	--	--	--	--	--	--	--	--
A-06	Boron	0	0	2	--	--	--	--	--	--	--	--	--	--
A-06	Cadmium	13	6	0.2, 1, 5, 10	0.4	<0.2	0.2	0.3	0.2	0.2	0.1	<0.1	04/22/1987	09/12/1989
A-06	Chromium	0	0	1, 2, 6, 10	--	--	--	--	--	--	--	--	--	--
A-06	Cobalt	0	0	2, 5, 10	--	--	--	--	--	--	--	--	--	--
A-06	Copper	13	12	1, 2, 5, 10, 20	20	<20	--	--	--	--	--	--	04/22/1987	09/12/1989
A-06	Iron	9	1	10, 20, 25	80	<10	30	80	50	20	20	4	04/14/1988	09/12/1989
A-06	Lead	13	4	1, 2, 5, 25	12	<1	3	7	3	1	1	<1	04/22/1987	09/12/1989
A-06	Lithium	0	0	25	--	--	--	--	--	--	--	--	--	--
A-06	Manganese	9	0	5, 10, 25	110	10	34	86	45	20	16	12	04/14/1988	09/12/1989
A-06	Mercury	13	9	0.1	.2	.1	--	--	--	--	--	--	04/22/1987	09/12/1989
A-06	Molybdenum	0	0	2, 10	--	--	--	--	--	--	--	--	--	--
A-06	Nickel	0	0	10, 12, 20, 25	--	--	--	--	--	--	--	--	--	--
A-06	Selenium	13	12	0.5, 1, 2	1.1	<.5	--	--	--	--	--	--	04/22/1987	09/12/1989
A-06	Silver	0	0	0.2, 1, 10, 25	--	--	--	--	--	--	--	--	--	--
A-06	Thallium	0	0	2, 25	--	--	--	--	--	--	--	--	--	--
A-06	Vanadium	0	0	10, 20, 25	--	--	--	--	--	--	--	--	--	--
A-06	Zinc	13	12	10, 20, 25	20	<20	--	--	--	--	--	--	04/22/1987	09/12/1989

Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date
Site A-07														
Properties														
A-07	Depth, water	22	0	--	2.79	0.34	0.83	1.49	1.16	0.59	0.42	0.35	04/22/1987	09/03/1992
A-07	Specific conductance	23	0	--	1,490	280	925	1,320	1,230	830	725	571	04/22/1987	09/03/1992
A-07	pH	23	0	--	9.0	7.5	8.4	8.9	8.7	8.4	8.1	8.0	04/22/1987	09/03/1992
A-07	Turbidity	20	0	--	130	4.1	28	80	29	19	11	4.5	04/22/1987	09/03/1992
A-07	Transparency, secchi disk	22	0	--	1.2	.2	.5	1.2	.6	.4	.3	.2	04/22/1987	09/03/1992
A-07	Depth of photic zone	8	0	--	3.1	.9	2.0	3.0	2.4	2.0	1.6	1.0	06/11/1987	09/03/1992
A-07	Dissolved oxygen	22	0	--	13.6	3.7	8.2	12.3	9.6	8.6	6.6	4.0	04/22/1987	09/03/1992
A-07	Hardness	23	0	--	430	130	290	430	340	270	230	150	04/22/1987	09/03/1992
A-07	Alkalinity	23	0	--	510	130	330	480	420	310	250	190	04/22/1987	09/03/1992
Dissolved and suspended solids														
A-07	Total dissolved solids, calculated, sum of constituents	23	0	--	976	198	577	846	789	523	433	319	04/22/1987	09/03/1992
A-07	Total suspended solids at 105°C	22	0	--	116	3	30	64	37	27	13	3	04/22/1987	09/03/1992
A-07	Nonvolatile suspended solids at 505°C	22	0	--	73	0	15	35	20	10	6	0	04/22/1987	09/03/1992
A-07	Volatile suspended solids, calculated by subtraction	22	0	--	55	3	15	42	18	12	6	3	04/22/1987	09/03/1992

(Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; -, no data; statistics are rounded)

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Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date
Site A-07 —Continued														
Trace elements—Continued														
A-07	Beryllium	0	0	0.1, 0.2, 1, 5, 25	--	--	--	--	--	--	--	--	--	--
A-07	Boron	0	0	2	--	--	--	--	--	--	--	--	--	--
A-07	Cadmium	22	14	0.2, 1, 5, 10	0.4	0.2	--	--	--	--	--	--	04/22/1987	09/03/1992
A-07	Chromium	4	4	1, 2, 6, 10	<1	<1	--	--	--	--	--	--	04/17/1992	09/03/1992
A-07	Cobalt	0	0	2, 5, 10	--	--	--	--	--	--	--	--	--	--
A-07	Copper	22	16	1, 2, 5, 10, 20	40	1	--	--	--	--	--	--	04/22/1987	09/03/1992
A-07	Iron	18	3	10, 20, 25	100	<10	40	70	40	40	20	3	04/14/1988	09/03/1992
A-07	Lead	22	12	1, 2, 5, 25	4	1	--	--	--	--	--	--	04/22/1987	09/03/1992
A-07	Lithium	0	0	25	--	--	--	--	--	--	--	--	--	--
A-07	Manganese	18	3	5, 10, 25	520	<10	110	420	98	39	26	3	04/14/1988	09/03/1992
A-07	Mercury	22	18	0.1	.2	<.1	--	--	--	--	--	--	04/22/1987	09/03/1992
A-07	Molybdenum	0	0	2, 10	--	--	--	--	--	--	--	--	--	--
A-07	Nickel	0	0	10, 12, 20, 25	--	--	--	--	--	--	--	--	--	--
A-07	Selenium	22	22	0.5, 1, 2	<1.0	<.5	--	--	--	--	--	--	04/22/1987	09/03/1992
A-07	Silver	0	0	0.2, 1, 10, 25	--	--	--	--	--	--	--	--	--	--
A-07	Thallium	0	0	2, 25	--	--	--	--	--	--	--	--	--	--
A-07	Vanadium	0	0	10, 20, 25	--	--	--	--	--	--	--	--	--	--
A-07	Zinc	22	21	10, 20, 25	20	<10	--	--	--	--	--	--	04/22/1987	09/03/1992

Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown						Period of record		
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date
Site A-08														
Properties														
A-08	Depth, water	9	0	--	2.50	0.28	0.87	2.06	1.05	0.69	0.30	0.29	04/22/1987	04/26/1989
A-08	Specific conductance	9	0	--	870	263	678	863	800	700	640	386	04/22/1987	04/26/1989
A-08	pH	9	0	--	9.6	7.6	8.3	9.4	8.5	8.2	7.9	7.7	04/22/1987	04/26/1989
A-08	Turbidity	8	0	--	130	6.5	32	95	24	20	15	8.4	04/22/1987	04/26/1989
A-08	Transparency, secchi disk	9	0	--	.7	.1	.4	.7	.5	.3	.3	.2	04/22/1987	04/26/1989
A-08	Depth of photic zone	3	0	--	1.3	.8	1.0	1.3	1.2	1.0	.9	.8	06/11/1987	08/19/1987
A-08	Dissolved oxygen	9	0	--	12.4	5.6	8.6	11.5	9.9	8.1	7.4	6.3	04/22/1987	04/26/1989
A-08	Hardness	9	0	--	300	130	230	280	250	230	220	150	04/22/1987	04/26/1989
A-08	Alkalinity	9	0	--	340	120	240	330	270	230	220	140	04/22/1987	04/26/1989
Dissolved and suspended solids														
A-08	Total dissolved solids, calculated, sum of constituents	9	0	--	520	194	411	519	504	416	353	249	04/22/1987	04/26/1989
A-08	Total suspended solids at 105°C	9	0	--	265	10	47	173	25	20	15	11	04/22/1987	04/26/1989
A-08	Nonvolatile suspended solids at 505°C	9	0	--	225	3	33	141	15	9	8	4	04/22/1987	04/26/1989
A-08	Volatile suspended solids, calculated by subtraction	9	0	--	40	7	14	32	17	11	8	7	04/22/1987	04/26/1989

Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05		
Site A-08 —Continued														
Trace elements—Continued														
A-08	Beryllium	0	0	0.1, 0.2, 1, 5, 25	--	--	--	--	--	--	--	--	--	--
A-08	Boron	0	0	2	--	--	--	--	--	--	--	--	--	--
A-08	Cadmium	9	4	0.2, 1, 5, 10	0.3	<0.2	0.2	0.3	0.3	0.2	0.1	<0.1	04/22/1987	04/26/1989
A-08	Chromium	0	0	1, 2, 6, 10	--	--	--	--	--	--	--	--	--	--
A-08	Cobalt	0	0	2, 5, 10	--	--	--	--	--	--	--	--	--	--
A-08	Copper	9	9	1, 2, 5, 10, 20	20	20	--	--	--	--	--	--	04/22/1987	04/26/1989
A-08	Iron	5	1	10, 20, 25	40	<10	30	40	40	30	30	2	04/14/1988	04/26/1989
A-08	Lead	9	4	1, 2, 5, 25	5	<1	2	4	3	1	1	<1	04/22/1987	04/26/1989
A-08	Lithium	0	0	25	--	--	--	--	--	--	--	--	--	--
A-08	Manganese	5	1	5, 10, 25	450	<10	200	430	340	200	10	2	04/14/1988	04/26/1989
A-08	Mercury	9	8	0.1	.1	.1	--	--	--	--	--	--	04/22/1987	04/26/1989
A-08	Molybdenum	0	0	2, 10	--	--	--	--	--	--	--	--	--	--
A-08	Nickel	0	0	10, 12, 20, 25	--	--	--	--	--	--	--	--	--	--
A-08	Selenium	9	9	0.5, 1, 2	1.0	.5	--	--	--	--	--	--	04/22/1987	04/26/1989
A-08	Silver	0	0	0.2, 1, 10, 25	--	--	--	--	--	--	--	--	--	--
A-08	Thallium	0	0	2, 25	--	--	--	--	--	--	--	--	--	--
A-08	Vanadium	0	0	10, 20, 25	--	--	--	--	--	--	--	--	--	--
A-08	Zinc	9	9	10, 20, 25	20	20	--	--	--	--	--	--	04/22/1987	04/26/1989

Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date
Site A-09														
Properties														
A-09	Depth, water	27	0	--	3.12	0.20	0.67	1.95	0.63	0.46	0.31	0.22	04/22/1987	09/02/1992
A-09	Specific conductance	31	0	--	2,080	270	947	1,730	1,190	837	645	410	04/22/1987	08/04/1993
A-09	pH	32	0	--	9.1	7.2	8.3	9.0	8.7	8.4	7.9	7.5	04/22/1987	08/04/1993
A-09	Turbidity	26	0	--	160	2.9	31	75	37	24	16	3.3	04/22/1987	09/02/1992
A-09	Transparency, secchi disk	25	0	--	.7	.1	.4	.5	.4	.4	.3	.2	04/22/1987	09/02/1992
A-09	Depth of photic zone	7	0	--	1.8	.5	1.2	1.7	1.5	1.2	.9	.5	06/11/1987	04/17/1990
A-09	Dissolved oxygen	29	0	--	14.5	.1	8.2	13.7	11.2	8.2	6.0	2.4	04/22/1987	09/02/1992
A-09	Hardness	33	0	--	490	98	290	430	370	280	220	150	04/22/1987	08/04/1993
A-09	Alkalinity	33	0	--	780	110	350	590	440	320	230	160	04/22/1987	08/04/1993
Dissolved and suspended solids														
A-09	Total dissolved solids, calculated, sum of constituents	33	0	--	1,330	173	611	1,160	801	524	392	253	04/22/1987	08/04/1993
A-09	Total suspended solids at 105°C	33	0	--	127	1	30	83	40	19	7	2	04/22/1987	08/04/1993
A-09	Nonvolatile suspended solids at 505°C	33	0	--	94	0	16	55	21	9	2	0	04/22/1987	08/04/1993
A-09	Volatile suspended solids, calculated by subtraction	33	0	--	56	1	14	36	19	10	5	2	04/22/1987	08/04/1993

(Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; -, no data; statistics are rounded)

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Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date
Site A-09 —Continued														
Trace elements—Continued														
A-09	Beryllium	0	0	0.1, 0.2, 1, 5, 25	--	--	--	--	--	--	--	--	--	--
A-09	Boron	0	0	2	--	--	--	--	--	--	--	--	--	--
A-09	Cadmium	32	20	0.2, 1, 5, 10	0.4	0.2	--	--	--	--	--	--	04/22/1987	08/04/1993
A-09	Chromium	8	8	1, 2, 6, 10	<1	<1	--	--	--	--	--	--	04/16/1992	08/04/1993
A-09	Cobalt	0	0	2, 5, 10	--	--	--	--	--	--	--	--	--	--
A-09	Copper	33	23	1, 2, 5, 10, 20	40	1	--	--	--	--	--	--	04/22/1987	08/04/1993
A-09	Iron	28	7	10, 20, 25	60	<20	30	50	40	30	20	4	04/14/1988	08/04/1993
A-09	Lead	32	20	1, 2, 5, 25	3	1	--	--	--	--	--	--	04/22/1987	08/04/1993
A-09	Lithium	0	0	25	--	--	--	--	--	--	--	--	--	--
A-09	Manganese	28	2	5, 10, 25	720	<10	140	640	97	67	24	7	04/14/1988	08/04/1993
A-09	Mercury	33	27	0.1	.2	.1	--	--	--	--	--	--	04/22/1987	08/04/1993
A-09	Molybdenum	0	0	2, 10	--	--	--	--	--	--	--	--	--	--
A-09	Nickel	0	0	10, 12, 20, 25	--	--	--	--	--	--	--	--	--	--
A-09	Selenium	32	28	0.5, 1, 2	2.0	<.5	--	--	--	--	--	--	04/22/1987	08/04/1993
A-09	Silver	0	0	0.2, 1, 10, 25	--	--	--	--	--	--	--	--	--	--
A-09	Thallium	0	0	2, 25	--	--	--	--	--	--	--	--	--	--
A-09	Vanadium	0	0	10, 20, 25	--	--	--	--	--	--	--	--	--	--
A-09	Zinc	33	33	10, 20, 25	<20	<10	--	--	--	--	--	--	04/22/1987	08/04/1993

Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date
Site A-10														
Properties														
A-10	Depth, water	26	0	--	3.80	0.14	1.30	3.27	1.58	1.07	0.80	0.39	04/23/1987	09/03/1992
A-10	Specific conductance	28	0	--	2,520	320	989	1,660	1,230	887	679	524	04/23/1987	08/04/1993
A-10	pH	27	0	--	9.3	7.3	8.5	9.2	8.8	8.5	8.2	7.7	04/23/1987	08/04/1993
A-10	Turbidity	23	0	--	170	8.4	60	150	80	45	27	11	04/23/1987	09/03/1992
A-10	Transparency, secchi disk	26	0	--	1.1	.1	.4	.9	.3	.3	.2	.1	04/23/1987	09/03/1992
A-10	Depth of photic zone	16	0	--	2.0	.3	.8	1.6	1.0	.7	.5	.3	06/12/1987	06/26/1990
A-10	Dissolved oxygen	26	0	--	14.5	1.5	9.0	13.2	11.5	9.2	7.0	4.5	04/23/1987	09/03/1992
A-10	Hardness	28	0	--	450	130	270	400	330	260	210	180	04/23/1987	08/04/1993
A-10	Alkalinity	28	0	--	990	120	300	590	300	260	230	180	04/23/1987	08/04/1993
Dissolved and suspended solids														
A-10	Total dissolved solids, calculated, sum of constituents	28	0	--	1,660	190	622	1,060	786	536	403	295	04/23/1987	08/04/1993
A-10	Total suspended solids at 105°C	28	0	--	218	5	53	128	70	42	20	7	04/23/1987	08/04/1993
A-10	Nonvolatile suspended solids at 505°C	28	0	--	165	1	34	94	41	22	13	4	04/23/1987	08/04/1993
A-10	Volatile suspended solids, calculated by subtraction	28	0	--	53	2	19	47	26	15	9	4	04/23/1987	08/04/1993

Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

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Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date
Site A-10 —Continued														
Trace elements—Continued														
A-10	Beryllium	0	0	0.1, 0.2, 1, 5, 25	--	--	--	--	--	--	--	--	--	--
A-10	Boron	0	0	2	--	--	--	--	--	--	--	--	--	--
A-10	Cadmium	27	17	0.2, 1, 5, 10	0.4	0.2	--	--	--	--	--	--	04/23/1987	08/04/1993
A-10	Chromium	4	4	1, 2, 6, 10	<1	<1	--	--	--	--	--	--	06/25/1992	08/04/1993
A-10	Cobalt	0	0	2, 5, 10	--	--	--	--	--	--	--	--	--	--
A-10	Copper	28	15	1, 2, 5, 10, 20	40	1	--	--	--	--	--	--	04/23/1987	08/04/1993
A-10	Iron	23	5	10, 20, 25	130	<10	40	90	50	20	10	4	04/14/1988	08/04/1993
A-10	Lead	27	14	1, 2, 5, 25	4	1	--	--	--	--	--	--	04/23/1987	08/04/1993
A-10	Lithium	0	0	25	--	--	--	--	--	--	--	--	--	--
A-10	Manganese	23	7	5, 10, 25	230	<10	48	190	60	20	8	2	04/14/1988	08/04/1993
A-10	Mercury	28	22	0.1	.2	.1	--	--	--	--	--	--	04/23/1987	08/04/1993
A-10	Molybdenum	0	0	2, 10	--	--	--	--	--	--	--	--	--	--
A-10	Nickel	0	0	10, 12, 20, 25	--	--	--	--	--	--	--	--	--	--
A-10	Selenium	27	23	0.5, 1, 2	2.0	<.5	--	--	--	--	--	--	04/23/1987	08/04/1993
A-10	Silver	0	0	0.2, 1, 10, 25	--	--	--	--	--	--	--	--	--	--
A-10	Thallium	0	0	2, 25	--	--	--	--	--	--	--	--	--	--
A-10	Vanadium	0	0	10, 20, 25	--	--	--	--	--	--	--	--	--	--
A-10	Zinc	28	26	10, 20, 25	20	<10	--	--	--	--	--	--	04/23/1987	08/04/1993

Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05		
Site A-11														
Properties														
A-11	Depth, water	2	0	--	1.02	1.00	1.01	1.02	1.02	1.01	1.00	1.00	07/29/1992	09/02/1992
A-11	Specific conductance	7	0	--	1,570	500	843	1,560	1,080	630	525	503	07/29/1992	09/09/1993
A-11	pH	7	0	--	8.5	7.4	7.8	8.4	7.9	7.7	7.5	7.4	07/29/1992	09/09/1993
A-11	Turbidity	2	0	--	13	7.3	10	13	12	10	8.8	7.6	07/29/1992	09/02/1992
A-11	Transparency, secchi disk	1	0	--	.9	.9	.9	.9	.9	.9	.9	.9	07/29/1992	07/29/1992
A-11	Depth of photic zone	0	0	--	--	--	--	--	--	--	--	--	--	--
A-11	Dissolved oxygen	2	0	--	7.9	5.8	6.9	7.8	7.4	6.9	6.4	5.9	07/29/1992	09/02/1992
A-11	Hardness	7	0	--	520	160	280	510	350	210	190	160	07/29/1992	09/09/1993
A-11	Alkalinity	7	0	--	250	150	210	250	230	210	190	160	07/29/1992	09/09/1993
Dissolved and suspended solids														
A-11	Total dissolved solids, calculated, sum of constituents	7	0	--	1,170	284	554	1,140	725	362	306	288	07/29/1992	09/09/1993
A-11	Total suspended solids at 105°C	7	0	--	111	4	29	90	33	8	8	5	07/29/1992	09/09/1993
A-11	Nonvolatile suspended solids at 505°C	7	0	--	88	0	21	70	23	5	3	1	07/29/1992	09/09/1993
A-11	Volatile suspended solids, calculated by subtraction	7	0	--	23	3	8	20	10	6	4	3	07/29/1992	09/09/1993

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; no data; statistics are rounded]

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Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date
Site A-11 —Continued														
Trace elements—Continued														
A-11	Beryllium	0	0	0.1, 0.2, 1, 5, 25	--	--	--	--	--	--	--	--	--	--
A-11	Boron	0	0	2	--	--	--	--	--	--	--	--	--	--
A-11	Cadmium	6	6	0.2, 1, 5, 10	<0.2	<0.2	--	--	--	--	--	--	07/29/1992	09/09/1993
A-11	Chromium	6	5	1, 2, 6, 10	1	<1	--	--	--	--	--	--	07/29/1992	09/09/1993
A-11	Cobalt	0	0	2, 5, 10	--	--	--	--	--	--	--	--	--	--
A-11	Copper	7	4	1, 2, 5, 10, 20	1	1	--	--	--	--	--	--	07/29/1992	09/09/1993
A-11	Iron	7	6	10, 20, 25	30	<20	--	--	--	--	--	--	07/29/1992	09/09/1993
A-11	Lead	6	5	1, 2, 5, 25	1	<1	--	--	--	--	--	--	07/29/1992	09/09/1993
A-11	Lithium	0	0	25	--	--	--	--	--	--	--	--	--	--
A-11	Manganese	7	0	5, 10, 25	440	26	200	390	270	240	83	40	07/29/1992	09/09/1993
A-11	Mercury	7	7	0.1	.10	.10	--	--	--	--	--	--	07/29/1992	09/09/1993
A-11	Molybdenum	0	0	2, 10	--	--	--	--	--	--	--	--	--	--
A-11	Nickel	0	0	10, 12, 20, 25	--	--	--	--	--	--	--	--	--	--
A-11	Selenium	6	6	0.5, 1, 2	<1.0	<1.0	--	--	--	--	--	--	07/29/1992	09/09/1993
A-11	Silver	0	0	0.2, 1, 10, 25	--	--	--	--	--	--	--	--	--	--
A-11	Thallium	0	0	2, 25	--	--	--	--	--	--	--	--	--	--
A-11	Vanadium	0	0	10, 20, 25	--	--	--	--	--	--	--	--	--	--
A-11	Zinc	7	7	10, 20, 25	<10	<10	--	--	--	--	--	--	07/29/1992	09/09/1993

Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date
Site A-12														
Properties														
A-12	Depth, water	14	0	--	3.42	0.54	1.27	2.77	1.47	0.94	0.72	0.59	04/21/1987	08/01/1989
A-12	Specific conductance	14	0	--	1,870	290	886	1,710	927	731	595	418	04/21/1987	08/01/1989
A-12	pH	13	0	--	9.8	7.8	8.7	9.5	8.9	8.8	8.4	7.9	04/21/1987	08/01/1989
A-12	Turbidity	12	0	--	200	3.0	45	130	45	24	12	3.6	04/21/1987	08/01/1989
A-12	Transparency, secchi disk	13	0	--	.9	.2	.5	.9	.6	.5	.3	.2	04/21/1987	08/01/1989
A-12	Depth of photic zone	7	0	--	3.3	.3	1.2	2.8	1.5	.9	.5	.3	10/28/1987	08/01/1989
A-12	Dissolved oxygen	14	0	--	13.1	4.7	9.8	12.8	11.1	10.2	9.2	5.5	04/21/1987	08/01/1989
A-12	Hardness	14	0	--	580	120	290	570	280	260	200	160	04/21/1987	08/01/1989
A-12	Alkalinity	14	0	--	330	79	220	300	270	230	190	100	04/21/1987	08/01/1989
Dissolved and suspended solids														
A-12	Total dissolved solids, calculated, sum of constituents	14	0	--	1,300	182	563	1,180	588	442	359	241	04/21/1987	08/01/1989
A-12	Total suspended solids at 105°C	14	0	--	195	2	47	129	55	32	15	3	04/21/1987	08/01/1989
A-12	Nonvolatile suspended solids at 505°C	14	0	--	133	0	28	84	30	19	9	1	04/21/1987	08/01/1989
A-12	Volatile suspended solids, calculated by subtraction	14	0	--	62	1	19	59	18	12	8	2	04/21/1987	08/01/1989

Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; -, no data; statistics are rounded

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Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05		
Site A-12 —Continued														
Trace elements—Continued														
A-12	Beryllium	0	0	0.1, 0.2, 1, 5, 25	--	--	--	--	--	--	--	--	--	--
A-12	Boron	0	0	2	--	--	--	--	--	--	--	--	--	--
A-12	Cadmium	14	8	0.2, 1, 5, 10	0.4	0.2	--	--	--	--	--	--	04/21/1987	08/01/1989
A-12	Chromium	0	0	1, 2, 6, 10	--	--	--	--	--	--	--	--	--	--
A-12	Cobalt	0	0	2, 5, 10	--	--	--	--	--	--	--	--	--	--
A-12	Copper	14	13	1, 2, 5, 10, 20	40	20	--	--	--	--	--	--	04/21/1987	08/01/1989
A-12	Iron	9	2	10, 20, 25	90	<10	30	70	40	30	20	2	04/14/1988	08/01/1989
A-12	Lead	14	5	1, 2, 5, 25	4	<1	2	3	2	1	1	<1	04/21/1987	08/01/1989
A-12	Lithium	0	0	25	--	--	--	--	--	--	--	--	--	--
A-12	Manganese	9	2	5, 10, 25	330	<10	77	250	95	30	25	2	04/14/1988	08/01/1989
A-12	Mercury	14	11	0.1	.3	.1	--	--	--	--	--	--	04/21/1987	08/01/1989
A-12	Molybdenum	0	0	2, 10	--	--	--	--	--	--	--	--	--	--
A-12	Nickel	0	0	10, 12, 20, 25	--	--	--	--	--	--	--	--	--	--
A-12	Selenium	14	11	0.5, 1, 2	1.2	.5	--	1.14	--	--	--	--	04/21/1987	08/01/1989
A-12	Silver	0	0	0.2, 1, 10, 25	--	--	--	--	--	--	--	--	--	--
A-12	Thallium	0	0	2, 25	--	--	--	--	--	--	--	--	--	--
A-12	Vanadium	0	0	10, 20, 25	--	--	--	--	--	--	--	--	--	--
A-12	Zinc	14	13	10, 20, 25	20	20	--	--	--	--	--	--	04/21/1987	08/01/1989

Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05		
Site A-13														
Properties														
A-13	Depth, water	9	0	--	2.97	0.25	1.00	2.43	1.43	0.74	0.27	0.25	04/23/1987	06/28/1989
A-13	Specific conductance	10	0	--	2,110	320	977	2,000	1,220	730	543	401	04/23/1987	06/28/1989
A-13	pH	10	0	--	9.5	8.0	8.5	9.1	8.6	8.5	8.3	8.0	04/23/1987	06/28/1989
A-13	Turbidity	9	0	--	70	7.0	36	65	45	34	26	9.9	04/23/1987	06/28/1989
A-13	Transparency, secchi disk	9	0	--	.8	.2	.3	.6	.4	.3	.3	.2	04/23/1987	06/28/1989
A-13	Depth of photic zone	6	0	--	1.8	.5	1.0	1.6	1.0	1.0	.9	.6	04/23/1987	06/03/1988
A-13	Dissolved oxygen	10	0	--	12.9	5.7	9.2	12.5	11.3	9.7	7.0	6.0	04/23/1987	06/28/1989
A-13	Hardness	10	0	--	770	120	360	750	420	260	210	150	04/23/1987	06/28/1989
A-13	Alkalinity	10	0	--	350	86	230	320	260	250	200	100	04/23/1987	06/28/1989
Dissolved and suspended solids														
A-13	Total dissolved solids, calculated, sum of constituents	10	0	--	1,510	189	639	1,420	795	444	318	232	04/23/1987	06/28/1989
A-13	Total suspended solids at 105°C	10	0	--	129	8	49	104	63	43	26	14	04/23/1987	06/28/1989
A-13	Nonvolatile suspended solids at 505°C	10	0	--	103	5	33	82	39	26	14	5	04/23/1987	06/28/1989
A-13	Volatile suspended solids, calculated by subtraction	10	0	--	28	2	16	27	18	17	13	6	04/23/1987	06/28/1989

(Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; -, no data; statistics are rounded)

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Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date
Site A-13 —Continued														
Trace elements—Continued														
A-13	Beryllium	0	0	0.1, 0.2, 1, 5, 25	--	--	--	--	--	--	--	--	--	--
A-13	Boron	0	0	2	--	--	--	--	--	--	--	--	--	--
A-13	Cadmium	10	6	0.2, 1, 5, 10	0.3	0.2	--	--	--	--	--	--	04/23/1987	06/28/1989
A-13	Chromium	0	0	1, 2, 6, 10	--	--	--	--	--	--	--	--	--	--
A-13	Cobalt	0	0	2, 5, 10	--	--	--	--	--	--	--	--	--	--
A-13	Copper	10	10	1, 2, 5, 10, 20	20	20	--	--	--	--	--	--	04/23/1987	06/28/1989
A-13	Iron	6	1	10, 20, 25	100	<10	40	90	50	30	20	3	04/15/1988	06/28/1989
A-13	Lead	10	5	1, 2, 5, 25	3	1	--	--	--	--	--	--	04/23/1987	06/28/1989
A-13	Lithium	0	0	25	--	--	--	--	--	--	--	--	--	--
A-13	Manganese	6	2	5, 10, 25	200	<10	60	170	90	19	8	2	04/15/1988	06/28/1989
A-13	Mercury	10	9	0.1	.1	.1	--	--	--	--	--	--	04/23/1987	06/28/1989
A-13	Molybdenum	0	0	2, 10	--	--	--	--	--	--	--	--	--	--
A-13	Nickel	0	0	10, 12, 20, 25	--	--	--	--	--	--	--	--	--	--
A-13	Selenium	10	7	0.5, 1, 2	1.5	.5	--	--	--	--	--	--	04/23/1987	06/28/1989
A-13	Silver	0	0	0.2, 1, 10, 25	--	--	--	--	--	--	--	--	--	--
A-13	Thallium	0	0	2, 25	--	--	--	--	--	--	--	--	--	--
A-13	Vanadium	0	0	10, 20, 25	--	--	--	--	--	--	--	--	--	--
A-13	Zinc	10	10	10, 20, 25	20	20	--	--	--	--	--	--	04/23/1987	06/28/1989

Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date
Site A-14														
Properties														
A-14	Depth, water	2	0	--	1.18	1.06	1.12	1.17	1.15	1.12	1.09	1.07	07/29/1992	09/02/1992
A-14	Specific conductance	7	0	--	1,620	510	884	1,600	1,120	640	595	522	07/29/1992	09/09/1993
A-14	pH	7	0	--	8.6	7.4	7.9	8.6	8.2	7.8	7.6	7.4	07/29/1992	09/09/1993
A-14	Turbidity	2	0	--	4.9	4.7	4.8	4.9	4.8	4.8	4.8	4.7	07/29/1992	09/02/1992
A-14	Transparency, secchi disk	2	0	--	1.2	1.1	1.1	1.2	1.2	1.1	1.1	1.1	07/29/1992	09/02/1992
A-14	Depth of photic zone	0	0	--	--	--	--	--	--	--	--	--	--	--
A-14	Dissolved oxygen	2	0	--	9.7	7.7	8.7	9.6	9.2	8.7	8.2	7.8	07/29/1992	09/02/1992
A-14	Hardness	7	0	--	500	180	290	490	350	220	200	190	07/29/1992	09/09/1993
A-14	Alkalinity	7	0	--	240	150	190	240	220	200	150	150	07/29/1992	09/09/1993
Dissolved and suspended solids														
A-14	Total dissolved solids, calculated, sum of constituents	7	0	--	1,180	282	585	1,170	785	372	346	295	07/29/1992	09/09/1993
A-14	Total suspended solids at 105°C	7	0	--	25	4	11	23	16	8	5	4	07/29/1992	09/09/1993
A-14	Nonvolatile suspended solids at 505°C	7	0	--	20	1	6	17	9	3	1	1	07/29/1992	09/09/1993
A-14	Volatile suspended solids, calculated by subtraction	7	0	--	8	2	5	7	6	5	4	2	07/29/1992	09/09/1993

Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; -, no data; statistics are rounded

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Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date
Site A-14 —Continued														
Trace elements—Continued														
A-14	Beryllium	0	0	0.1, 0.2, 1, 5, 25	--	--	--	--	--	--	--	--	--	--
A-14	Boron	0	0	2	--	--	--	--	--	--	--	--	--	--
A-14	Cadmium	6	5	0.2, 1, 5, 10	0.4	0.2	--	--	--	--	--	--	07/29/1992	09/09/1993
A-14	Chromium	6	6	1, 2, 6, 10	1	1	--	--	--	--	--	--	07/29/1992	09/09/1993
A-14	Cobalt	0	0	2, 5, 10	--	--	--	--	--	--	--	--	--	--
A-14	Copper	7	2	1, 2, 5, 10, 20	1	<1	1	1	1	1	1	<1	07/29/1992	09/09/1993
A-14	Iron	7	6	10, 20, 25	20	20	--	--	--	--	--	--	07/29/1992	09/09/1993
A-14	Lead	6	5	1, 2, 5, 25	1	<1	--	--	--	--	--	--	07/29/1992	09/09/1993
A-14	Lithium	0	0	25	--	--	--	--	--	--	--	--	--	--
A-14	Manganese	7	0	5, 10, 25	620	17	180	540	250	52	34	20	07/29/1992	09/09/1993
A-14	Mercury	7	7	0.1	.1	.1	--	--	--	--	--	--	07/29/1992	09/09/1993
A-14	Molybdenum	0	0	2, 10	--	--	--	--	--	--	--	--	--	--
A-14	Nickel	0	0	10, 12, 20, 25	--	--	--	--	--	--	--	--	--	--
A-14	Selenium	6	6	0.5, 1, 2	1.0	1.0	--	--	--	--	--	--	07/29/1992	09/09/1993
A-14	Silver	0	0	0.2, 1, 10, 25	--	--	--	--	--	--	--	--	--	--
A-14	Thallium	0	0	2, 25	--	--	--	--	--	--	--	--	--	--
A-14	Vanadium	0	0	10, 20, 25	--	--	--	--	--	--	--	--	--	--
A-14	Zinc	7	7	10, 20, 25	10	10	--	--	--	--	--	--	07/29/1992	09/09/1993

Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date
Site A-15														
Properties														
A-15	Depth, water	11	0	--	2.77	0.29	0.90	2.27	0.94	0.58	0.53	0.37	04/23/1987	06/28/1989
A-15	Specific conductance	11	0	--	1,450	320	759	1,300	878	683	559	415	04/23/1987	06/28/1989
A-15	pH	10	0	--	8.6	7.6	8.1	8.5	8.2	8.1	8.0	7.6	04/23/1987	06/28/1989
A-15	Turbidity	9	0	--	40	3.0	16	35	21	17	6.0	3.0	04/23/1987	06/28/1989
A-15	Transparency, secchi disk	11	0	--	.7	.3	.5	.7	.6	.5	.4	.3	04/23/1987	06/28/1989
A-15	Depth of photic zone	7	0	--	2.1	.8	1.5	2.0	1.7	1.5	1.3	.9	04/23/1987	04/25/1989
A-15	Dissolved oxygen	11	0	--	12.0	.1	7.1	11.9	9.6	7.0	5.8	1.6	04/23/1987	06/28/1989
A-15	Hardness	11	0	--	480	120	260	410	290	250	200	150	04/23/1987	06/28/1989
A-15	Alkalinity	11	0	--	430	120	250	370	280	260	210	140	04/23/1987	06/28/1989
Dissolved and suspended solids														
A-15	Total dissolved solids, calculated, sum of constituents	11	0	--	983	187	464	849	533	413	329	236	04/23/1987	06/28/1989
A-15	Total suspended solids at 105°C	11	0	--	63	3	22	52	23	19	11	3	04/23/1987	06/28/1989
A-15	Nonvolatile suspended solids at 505°C	11	0	--	45	0	12	37	14	6	3	1	04/23/1987	06/28/1989
A-15	Volatile suspended solids, calculated by subtraction	11	0	--	20	2	10	18	13	9	6	2	04/23/1987	06/28/1989

(Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; -, no data; statistics are rounded)

[illegible]

Table 2. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date
Site A-15 —Continued														
Trace elements—Continued														
A-15	Beryllium	0	0	0.1, 0.2, 1, 5, 25	--	--	--	--	--	--	--	--	--	--
A-15	Boron	0	0	2	--	--	--	--	--	--	--	--	--	--
A-15	Cadmium	11	5	0.2, 1, 5, 10	0.5	0.2	0.2	0.4	0.2	0.2	0.2	0.2	04/23/1987	06/28/1989
A-15	Chromium	0	0	1, 2, 6, 10	--	--	--	--	--	--	--	--	--	--
A-15	Cobalt	0	0	2, 5, 10	--	--	--	--	--	--	--	--	--	--
A-15	Copper	11	11	1, 2, 5, 10, 20	20	20	--	--	--	--	--	--	04/23/1987	06/28/1989
A-15	Iron	6	2	10, 20, 25	50	<10	30	50	50	20	8	2	04/15/1988	06/28/1989
A-15	Lead	11	5	1, 2, 5, 25	3	<1	2	3	2	2	1	<1	04/23/1987	06/28/1989
A-15	Lithium	0	0	25	--	--	--	--	--	--	--	--	--	--
A-15	Manganese	6	1	5, 10, 25	520	<10	180	440	180	120	80	3	04/15/1988	06/28/1989
A-15	Mercury	11	9	0.1	.3	.1	--	--	--	--	--	--	04/23/1987	06/28/1989
A-15	Molybdenum	0	0	2, 10	--	--	--	--	--	--	--	--	--	--
A-15	Nickel	0	0	10, 12, 20, 25	--	--	--	--	--	--	--	--	--	--
A-15	Selenium	11	11	0.5, 1, 2	1.0	.5	--	--	--	--	--	--	04/23/1987	06/28/1989
A-15	Silver	0	0	0.2, 1, 10, 25	--	--	--	--	--	--	--	--	--	--
A-15	Thallium	0	0	2, 25	--	--	--	--	--	--	--	--	--	--
A-15	Vanadium	0	0	10, 20, 25	--	--	--	--	--	--	--	--	--	--
A-15	Zinc	11	9	10, 20, 25	30	20	--	--	--	--	--	--	04/23/1987	06/28/1989

(Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; no data; statistics are rounded)

[illegible]

Table 3. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1999–2004.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics			Percent of samples in which values were less than or equal to those shown							Period of record			
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date	
Site A-01—Continued															
Major ions															
A-01	Calcium	26	0	--	170	18	69	120	80	65	46	33	03/02/1999	10/19/2004	
A-01	Magnesium	26	0	--	130	7.9	50	78	58	50	37	22	03/02/1999	10/19/2004	
A-01	Sodium	26	0	--	270	9.0	90	180	110	77	48	34	03/02/1999	10/19/2004	
A-01	Potassium	26	0	--	24	5.3	13	19	16	13	11	8.0	03/02/1999	10/19/2004	
A-01	Sulfate	26	0	--	620	24	230	410	280	220	150	90	03/02/1999	10/19/2004	
A-01	Chloride	26	0	--	80	1.6	23	50	27	21	12	8.9	03/02/1999	10/19/2004	
Nutrients															
A-01	Nitrate	27	15	0.10	1.8	<0.10	0.31	1.2	0.22	--	--	--	03/02/1999	10/19/2004	
A-01	Nitrite	27	15	.02	.09	<.02	.03	.06	.02	--	--	--	03/02/1999	10/19/2004	
A-01	Ammonia	26	17	.10	1.2	<.10	.21	.60	.19	--	--	--	03/02/1999	10/19/2004	
A-01	Ammonia plus organic nitrogen	25	0	.20	6.6	1.4	2.5	4.9	2.6	2.1	1.8	1.6	03/02/1999	10/19/2004	
A-01	Phosphate	26	3	.01	.47	<.01	.15	.40	.26	.11	.03	<.01	03/31/1999	10/19/2004	
A-01	Phosphorus, total	25	0	.01	.58	.03	.31	.54	.41	.32	.16	.09	03/02/1999	10/19/2004	
Carbon and chlorophyll															
A-01	Total organic carbon	1	0	1	19	19	19	19	19	19	19	19	07/22/2004	07/22/2004	
A-01	Chlorophyll <i>a</i>	0	0	--	--	--	--	--	--	--	--	--	--	--	
Trace elements															
A-01	Aluminum	24	19	10, 25	90	16	--	--	--	--	--	--	03/02/1999	04/06/2004	
A-01	Antimony	26	25	2, 20, 25, 50	<50	<2	--	--	--	--	--	--	03/02/1999	10/19/2004	
A-01	Arsenic	26	8	1, 2, 25	55	1	5	10	4	2	1	1	03/02/1999	10/19/2004	

Table 3. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1999–2004.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date
Site A-01—Continued														
Trace elements—Continued														
A-01	Barium	26	0	--	170	46	80	110	87	75	63	57	03/02/1999	10/19/2004
A-01	Beryllium	25	24	0.1, 0.2, 1, 5, 25	72	<.1	--	--	--	--	--	--	03/02/1999	10/19/2004
A-01	Boron	26	1	2	300	<2	130	240	170	120	89	43	03/02/1999	10/19/2004
A-01	Cadmium	25	22	0.2, 1, 5, 10	<10	<.2	--	--	--	--	--	--	03/02/1999	10/19/2004
A-01	Chromium	26	22	1, 2, 6, 10	16	<1	--	--	--	--	--	--	03/02/1999	10/19/2004
A-01	Cobalt	25	25	2, 5, 10	<10	<2	--	--	--	--	--	--	03/02/1999	10/19/2004
A-01	Copper	26	23	1, 2, 5, 10, 20	<10	2	--	--	--	--	--	--	03/02/1999	10/19/2004
A-01	Iron	26	12	10, 20, 25	150	<10	40	130	70	20	10	3	03/02/1999	10/19/2004
A-01	Lead	26	25	1, 2, 5, 25	<25	<1	--	--	--	--	--	--	03/02/1999	10/19/2004
A-01	Lithium	21	1	25	140	<25	60	110	80	60	40	30	11/23/1999	10/19/2004
A-01	Manganese	26	3	5, 10, 25	770	<25	150	760	200	38	26	11	03/02/1999	10/19/2004
A-01	Mercury	0	0	0.1	--	--	--	--	--	--	--	--	--	--
A-01	Molybdenum	26	23	2, 10	110	<2	--	--	--	--	--	--	03/02/1999	10/19/2004
A-01	Nickel	26	21	10, 12, 20, 25	45	4	--	--	--	--	--	--	03/02/1999	10/19/2004
A-01	Selenium	26	23	0.5, 1, 2	5	<1	--	--	--	--	--	--	03/02/1999	10/19/2004
A-01	Silver	24	24	0.2, 1, 10, 25	<25	<.2	--	--	--	--	--	--	07/27/1999	10/19/2004
A-01	Thallium	21	18	2, 25	140	<2	--	--	--	--	--	--	02/28/2000	10/15/2003
A-01	Vanadium	26	23	10, 20, 25	<25	2	--	--	--	--	--	--	03/02/1999	10/19/2004
A-01	Zinc	26	20	10, 20, 25	28	<10	--	--	--	--	--	--	03/02/1999	10/19/2004

Table 3. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1999–2004.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date
Site A-04 —Continued														
Major Ions														
A-04	Calcium	23	0	--	160	13	66	150	73	64	42	26	03/02/1999	07/22/2004
A-04	Magnesium	23	0	--	360	13	63	100	63	48	38	16	03/02/1999	07/22/2004
A-04	Sodium	23	0	--	780	11	110	160	100	69	55	31	03/02/1999	07/22/2004
A-04	Potassium	23	0	--	64	3.5	15	22	16	13	11	6.6	03/02/1999	07/22/2004
A-04	Sulfate	23	0	--	1,900	42	300	510	290	230	150	80	03/02/1999	07/22/2004
A-04	Chloride	23	0	--	200	6.1	27	39	25	18	13	8.6	03/02/1999	07/22/2004
Nutrients														
A-04	Nitrate	23	16	0.10	1.8	<0.10	0.21	0.44	0.12	--	--	--	03/02/1999	07/22/2004
A-04	Nitrite	23	15	.02	.11	<.02	.02	.04	.02	--	--	--	03/02/1999	07/22/2004
A-04	Ammonia	23	12	.10	7.8	<.10	.64	2.7	.24	--	--	--	03/02/1999	07/22/2004
A-04	Ammonia plus organic nitrogen	22	0	.20	28	1.0	3.7	5.7	3.5	2.0	1.6	1.1	03/02/1999	07/22/2004
A-04	Phosphate	22	4	.01	2.0	<.01	.26	.79	.32	.12	.01	<.01	07/27/1999	07/22/2004
A-04	Phosphorus, total	22	2	.01	2.8	<.01	.51	2.4	.48	.33	.14	<.01	03/02/1999	07/22/2004
Carbon and chlorophyll														
A-04	Total organic carbon	1	0	1	18	18	18	18	18	18	18	18	07/22/2004	07/22/2004
A-04	Chlorophyll <i>a</i>	0	0	--	--	--	--	--	--	--	--	--	--	--
Trace elements														
A-04	Aluminum	21	17	10, 25	84	<25	--	--	--	--	--	--	03/02/1999	07/23/2003
A-04	Antimony	22	19	2, 20, 25, 50	70	<2	--	--	--	--	--	--	03/02/1999	07/22/2004
A-04	Arsenic	22	8	1, 2, 25	53	<2	6	8	6	3	1	1	03/02/1999	07/22/2004

Table 3. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1999–2004.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date
Site A-04 —Continued														
Trace elements—Continued														
A-04	Barium	22	0	--	330	30	87	160	87	71	59	33	03/02/1999	07/22/2004
A-04	Beryllium	23	22	0.1, 0.2, 1, 5, 25	48	<.1	--	--	--	--	--	--	03/02/1999	07/22/2004
A-04	Boron	22	0	2	550	2	120	180	140	110	90	35	03/02/1999	07/22/2004
A-04	Cadmium	23	21	0.2, 1, 5, 10	10	<.2	--	--	--	--	--	--	03/02/1999	07/22/2004
A-04	Chromium	22	19	1, 2, 6, 10	18	<1	--	--	--	--	--	--	03/02/1999	07/22/2004
A-04	Cobalt	22	22	2, 5, 10	<10	<2	--	--	--	--	--	--	03/02/1999	07/22/2004
A-04	Copper	22	21	1, 2, 5, 10, 20	<10	<2	--	--	--	--	--	--	03/02/1999	07/22/2004
A-04	Iron	22	15	10, 20, 25	120	<10	--	--	--	--	--	--	03/02/1999	07/22/2004
A-04	Lead	22	21	1, 2, 5, 25	<25	<1	--	--	--	--	--	--	03/02/1999	07/22/2004
A-04	Lithium	19	3	25	410	<25	70	130	60	50	30	8	11/23/1999	07/22/2004
A-04	Manganese	22	6	5, 10, 25	3,900	<25	370	1,800	150	34	20	3	03/02/1999	07/22/2004
A-04	Mercury	0	0	0.1	--	--	--	--	--	--	--	--	--	--
A-04	Molybdenum	22	19	2, 10	78	<2	--	--	--	--	--	--	03/02/1999	07/22/2004
A-04	Nickel	22	20	10, 12, 20, 25	<25	4	--	--	--	--	--	--	03/02/1999	07/22/2004
A-04	Selenium	22	19	0.5, 1, 2	8	<1	--	--	--	--	--	--	03/02/1999	07/22/2004
A-04	Silver	21	21	0.2, 1, 10, 25	<25	<.2	--	--	--	--	--	--	07/27/1999	07/22/2004
A-04	Thallium	18	15	2, 25	82	<2	--	--	--	--	--	--	02/28/2000	03/26/2003
A-04	Vanadium	22	20	10, 20, 25	25	1	--	--	--	--	--	--	03/02/1999	07/22/2004
A-04	Zinc	22	21	10, 20, 25	25	4	--	--	--	--	--	--	03/02/1999	07/22/2004

Table 3. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1999–2004.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date
Site A-05 —Continued														
Major ions														
A-05	Calcium	25	0	--	170	24	69	150	86	63	43	29	03/02/1999	10/19/2004
A-05	Magnesium	25	0	--	250	13	62	110	63	52	44	25	03/02/1999	10/19/2004
A-05	Sodium	25	0	--	550	20	100	160	110	91	67	34	03/02/1999	10/19/2004
A-05	Potassium	25	0	--	50	8.0	15	23	15	14	11	8.5	03/02/1999	10/19/2004
A-05	Sulfate	25	0	--	1,300	51	300	570	290	240	160	100	03/02/1999	10/19/2004
A-05	Chloride	25	0	--	140	4.8	25	42	25	19	15	8.8	03/02/1999	10/19/2004
Nutrients														
A-05	Nitrate	26	21	0.10	1.8	<0.10	--	0.42	--	--	--	--	03/02/1999	10/19/2004
A-05	Nitrite	26	20	.02	.11	<.02	--	.03	--	--	--	--	03/02/1999	10/19/2004
A-05	Ammonia	25	15	.10	8.4	<.10	0.67	3.0	0.25	--	--	--	03/02/1999	10/19/2004
A-05	Ammonia plus organic nitrogen	24	0	.20	19	.90	3.3	6.5	3.3	2.1	1.9	1.2	03/02/1999	10/19/2004
A-05	Phosphate	25	3	.01	2.1	<.01	.22	.51	.28	.08	.02	<.01	03/31/1999	10/19/2004
A-05	Phosphorus, total	24	0	.01	3.3	.02	.46	2.0	.38	.28	.16	.04	03/02/1999	10/19/2004
Carbon and chlorophyll														
A-05	Total organic carbon	1	0	1	20	20	20	20	20	20	20	20	07/22/2004	07/22/2004
A-05	Chlorophyll <i>a</i>	0	0	--	--	--	--	--	--	--	--	--	--	--
Trace elements														
A-05	Aluminum	23	19	10, 25	84	<10	--	--	--	--	--	--	03/02/1999	04/06/2004
A-05	Antimony	25	22	2, 20, 25, 50	70	<2	--	--	--	--	--	--	03/02/1999	10/19/2004
A-05	Arsenic	25	8	1, 2, 25	36	<1	5	9	5	2	1	1	03/02/1999	10/19/2004

Table 3. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1999–2004.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date
Site A-05—Continued														
Trace elements—Continued														
A-05	Barium	25	0	--	180	44	89	180	100	73	64	51	03/02/1999	10/19/2004
A-05	Beryllium	25	24	0.1, 0.2, 1, 5, 25	70	<.1	--	--	--	--	--	--	03/02/1999	10/19/2004
A-05	Boron	25	0	2	460	6	120	180	140	120	93	50	03/02/1999	10/19/2004
A-05	Cadmium	25	23	0.2, 1, 5, 10	<10	<.2	--	--	--	--	--	--	03/02/1999	10/19/2004
A-05	Chromium	25	22	1, 2, 6, 10	14	1	--	--	--	--	--	--	03/02/1999	10/19/2004
A-05	Cobalt	25	25	2, 5, 10	<10	<2	--	--	--	--	--	--	03/02/1999	10/19/2004
A-05	Copper	25	24	1, 2, 5, 10, 20	<10	2	--	--	--	--	--	--	03/02/1999	10/19/2004
A-05	Iron	25	16	10, 20, 25	120	<10	--	--	--	--	--	--	03/02/1999	10/19/2004
A-05	Lead	25	23	1, 2, 5, 25	<25	<1	--	--	--	--	--	--	03/02/1999	10/19/2004
A-05	Lithium	20	2	25	290	<25	70	120	70	60	40	12	11/23/1999	10/19/2004
A-05	Manganese	25	6	5, 10, 25	3,200	<25	300	1,000	260	64	26	5	03/02/1999	10/19/2004
A-05	Mercury	0	0	0.1	--	--	--	--	--	--	--	--	--	--
A-05	Molybdenum	25	22	2, 10	290	<2	--	--	--	--	--	--	03/02/1999	10/19/2004
A-05	Nickel	25	22	10, 12, 20, 25	25	3	--	--	--	--	--	--	03/02/1999	10/19/2004
A-05	Selenium	25	21	0.5, 1, 2	7	<1	--	--	--	--	--	--	03/02/1999	10/19/2004
A-05	Silver	23	23	0.2, 1, 10, 25	<25	<.2	--	--	--	--	--	--	07/27/1999	10/19/2004
A-05	Thallium	20	18	2, 25	79	<2	--	--	--	--	--	--	02/28/2000	07/23/2003
A-05	Vanadium	25	22	10, 20, 25	<25	1	--	--	--	--	--	--	03/02/1999	10/19/2004
A-05	Zinc	25	22	10, 20, 25	<25	4	--	--	--	--	--	--	03/02/1999	10/19/2004

Table 3. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1999–2004.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date
Site A-09 —Continued														
Major Ions														
A-09	Calcium	26	0	--	170	36	68	110	75	62	46	39	03/02/1999	10/19/2004
A-09	Magnesium	26	0	--	120	23	55	110	62	52	41	25	03/02/1999	10/19/2004
A-09	Sodium	26	0	--	300	34	96	160	110	94	66	36	03/02/1999	10/19/2004
A-09	Potassium	26	0	--	28	7.9	15	22	16	13	12	9.6	03/02/1999	10/19/2004
A-09	Sulfate	26	0	--	860	99	280	560	310	260	180	120	03/02/1999	10/19/2004
A-09	Chloride	26	0	--	87	7.8	24	41	27	21	17	8.7	03/02/1999	10/19/2004
Nutrients														
A-09	Nitrate	27	19	0.10	1.6	<0.10	0.25	1.0	0.17	--	--	--	03/02/1999	10/19/2004
A-09	Nitrite	27	21	.02	.11	<.02	--	.04	--	--	--	--	03/02/1999	10/19/2004
A-09	Ammonia	26	14	.10	4.1	<.10	.48	2.7	.17	--	--	--	03/02/1999	10/19/2004
A-09	Ammonia plus organic nitrogen	25	0	.20	7.2	1.2	2.8	5.3	4.2	2.0	1.8	1.5	03/02/1999	10/19/2004
A-09	Phosphate	26	2	.01	.59	<.01	.18	.47	.30	.10	.03	.01	03/31/1999	10/19/2004
A-09	Phosphorus, total	25	0	.01	.94	.02	.33	.66	.39	.30	.19	.06	03/02/1999	10/19/2004
Carbon and chlorophyll														
A-09	Total organic carbon	1	0	1	20	20	20	20	20	20	20	20	07/22/2004	07/22/2004
A-09	Chlorophyll <i>a</i>	0	0	--	--	--	--	--	--	--	--	--	--	--
Trace elements														
A-09	Aluminum	24	18	10, 25	51	11	--	--	--	--	--	--	03/02/1999	04/06/2004
A-09	Antimony	26	25	2, 20, 25, 50	<50	<2	--	--	--	--	--	--	03/02/1999	10/19/2004
A-09	Arsenic	26	7	1, 2, 25	25	1	4	7	6	3	2	1	03/02/1999	10/19/2004

Table 3. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1999–2004.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics			Percent of samples in which values were less than or equal to those shown							Period of record			
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date	
Site A-09 —Continued															
Trace elements—Continued															
A-09	Barium	26	0	--	170	37	78	140	86	68	60	44	03/02/1999	10/19/2004	
A-09	Beryllium	26	25	0.1, 0.2, 1, 5, 25	68	<.1	--	--	--	--	--	--	03/02/1999	10/19/2004	
A-09	Boron	26	0	2	250	6	120	170	140	120	93	46	03/02/1999	10/19/2004	
A-09	Cadmium	26	22	0.2, 1, 5, 10	<10	<.2	--	--	--	--	--	--	03/02/1999	10/19/2004	
A-09	Chromium	26	24	1, 2, 6, 10	19	2	--	--	--	--	--	--	03/02/1999	10/19/2004	
A-09	Cobalt	26	26	2, 5, 10	<10	<2	--	--	--	--	--	--	03/02/1999	10/19/2004	
A-09	Copper	26	24	1, 2, 5, 10, 20	<10	<2	--	--	--	--	--	--	03/02/1999	10/19/2004	
A-09	Iron	26	17	10, 20, 25	110	<10	--	--	--	--	--	--	03/02/1999	10/19/2004	
A-09	Lead	26	23	1, 2, 5, 25	<25	<1	--	--	--	--	--	--	03/02/1999	10/19/2004	
A-09	Lithium	21	2	25	170	<25	60	120	70	60	40	10	11/23/1999	10/19/2004	
A-09	Manganese	26	3	5, 10, 25	4,500	<5	320	650	260	75	40	3	03/02/1999	10/19/2004	
A-09	Mercury	0	0	0.1	--	--	--	--	--	--	--	--	--	--	
A-09	Molybdenum	26	24	2, 10	320	<2	--	--	--	--	--	--	03/02/1999	10/19/2004	
A-09	Nickel	26	23	10, 12, 20, 25	<25	3	--	--	--	--	--	--	03/02/1999	10/19/2004	
A-09	Selenium	26	23	0.5, 1, 2	4	<1	--	--	--	--	--	--	03/02/1999	10/19/2004	
A-09	Silver	24	23	0.2, 1, 10, 25	<25	<2	--	--	--	--	--	--	07/27/1999	10/19/2004	
A-09	Thallium	21	19	2, 25	90	<2	--	--	--	--	--	--	02/28/2000	10/15/2003	
A-09	Vanadium	26	23	10, 20, 25	<25	2	--	--	--	--	--	--	03/02/1999	10/19/2004	
A-09	Zinc	26	24	10, 20, 25	<25	4	--	--	--	--	--	--	03/02/1999	10/19/2004	

(Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; no data; statistics are rounded)

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Table 3. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1999–2004.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics			Percent of samples in which values were less than or equal to those shown							Period of record			
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date	
Site A-11 —Continued															
Major Ions															
A-11	Calcium	24	0	--	180	21	68	140	77	61	43	29	03/02/1999	10/19/2004	
A-11	Magnesium	24	0	--	120	18	51	100	60	49	37	21	03/02/1999	10/19/2004	
A-11	Sodium	24	0	--	250	34	95	180	110	95	60	35	03/02/1999	10/19/2004	
A-11	Potassium	24	0	--	25	4.5	13	18	15	13	11	7.1	03/02/1999	10/19/2004	
A-11	Sulfate	24	0	--	640	100	270	480	330	250	180	120	03/02/1999	10/19/2004	
A-11	Chloride	24	0	--	170	7.2	29	44	32	20	14	8.3	03/02/1999	10/19/2004	
Nutrients															
A-11	Nitrate	25	20	0.10	0.98	<0.10	--	0.41	--	--	--	--	03/02/1999	10/19/2004	
A-11	Nitrite	25	22	.02	.07	<.02	--	.03	--	--	--	--	03/02/1999	10/19/2004	
A-11	Ammonia	24	17	.10	.53	<.10	0.15	.39	0.13	0.10	0.10	0.10	03/02/1999	10/19/2004	
A-11	Ammonia plus organic nitrogen	23	0	.20	8.3	1.4	2.6	4.0	2.5	2.3	2.0	1.4	03/02/1999	10/19/2004	
A-11	Phosphate	24	4	.01	.53	<.01	.13	.42	.18	.09	.02	<.01	03/31/1999	10/19/2004	
A-11	Phosphorus, total	23	0	.01	1.0	.02	.30	.76	.33	.26	.16	.03	03/02/1999	10/19/2004	
A-11	Total organic carbon	1	0	1	18	18	18	18	18	18	18	18	07/22/2004	07/22/2004	
A-11	Chlorophyll <i>a</i>	0	0	--	--	--	--	--	--	--	--	--	--	--	
Carbon and chlorophyll															
A-11	Aluminum	22	19	10, 25	27	22	--	--	--	--	--	--	03/02/1999	04/06/2004	
A-11	Antimony	24	22	2, 20, 25, 50	<50	<2	--	--	--	--	--	--	03/02/1999	10/19/2004	
A-11	Arsenic	24	8	1, 2, 25	25	<2	4	10	6	2	2	1	03/02/1999	10/19/2004	

Table 3. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1999–2004.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05		
Site A-11 —Continued														
Trace elements—Continued														
A-11	Barium	24	0	--	180	39	70	120	74	64	47	42	03/02/1999	10/19/2004
A-11	Beryllium	24	23	0.1, 0.2, 1, 5, 25	43	<.1	--	--	--	--	--	--	03/02/1999	10/19/2004
A-11	Boron	24	1	2	470	<2	130	180	160	130	97	45	03/02/1999	10/19/2004
A-11	Cadmium	24	21	0.2, 1, 5, 10	<10	<2	--	--	--	--	--	--	03/02/1999	10/19/2004
A-11	Chromium	24	21	1, 2, 6, 10	14	<1	--	--	--	--	--	--	03/02/1999	10/19/2004
A-11	Cobalt	24	24	2, 5, 10	<10	<2	--	--	--	--	--	--	03/02/1999	10/19/2004
A-11	Copper	24	22	1, 2, 5, 10, 20	<10	<2	--	--	--	--	--	--	03/02/1999	10/19/2004
A-11	Iron	24	18	10, 20, 25	60	<10	--	--	--	--	--	--	03/02/1999	10/19/2004
A-11	Lead	24	23	1, 2, 5, 25	<25	<1	--	--	--	--	--	--	03/02/1999	10/19/2004
A-11	Lithium	19	0	25	120	20	60	100	80	60	40	30	11/23/1999	10/19/2004
A-11	Manganese	24	5	5, 10, 25	1,700	<25	220	750	240	40	18	7	03/02/1999	10/19/2004
A-11	Mercury	0	0	0.1	--	--	--	--	--	--	--	--	--	--
A-11	Molybdenum	24	23	2, 10	220	<2	--	--	--	--	--	--	03/02/1999	10/19/2004
A-11	Nickel	24	19	10, 12, 20, 25	43	4	--	--	--	--	--	--	03/02/1999	10/19/2004
A-11	Selenium	24	22	0.5, 1, 2	3	<1	--	--	--	--	--	--	03/02/1999	10/19/2004
A-11	Silver	22	21	0.2, 1, 10, 25	<25	<2	--	--	--	--	--	--	07/27/1999	10/19/2004
A-11	Thallium	19	18	2, 25	66	<2	--	--	--	--	--	--	02/28/2000	07/23/2003
A-11	Vanadium	24	21	10, 20, 25	<25	3	--	--	--	--	--	--	03/02/1999	10/19/2004
A-11	Zinc	24	22	10, 20, 25	<25	3	--	--	--	--	--	--	03/02/1999	10/19/2004

Table 3. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1999–2004.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date
Site A-14 —Continued														
Major ions														
A-14	Calcium	24	0	--	180	28	68	120	77	63	44	36	03/02/1999	10/19/2004
A-14	Magnesium	24	0	--	120	20	50	87	57	47	38	24	03/02/1999	10/19/2004
A-14	Sodium	24	0	--	330	35	97	170	110	95	59	38	03/02/1999	10/19/2004
A-14	Potassium	24	0	--	25	3.4	13	18	16	13	11	7.4	03/02/1999	10/19/2004
A-14	Sulfate	24	0	--	710	92	260	460	330	240	180	110	03/02/1999	10/19/2004
A-14	Chloride	24	0	--	200	8.1	29	43	30	21	14	9.1	03/02/1999	10/19/2004
Nutrients														
A-14	Nitrate	25	17	0.10	1.6	0.10	0.20	0.41	0.12	0.10	0.10	0.10	03/02/1999	10/19/2004
A-14	Nitrite	25	23	.02	.11	<.02	--	.03	--	--	--	--	03/02/1999	10/19/2004
A-14	Ammonia	24	17	.10	.30	<.10	.13	.26	--	--	--	--	03/02/1999	10/19/2004
A-14	Ammonia plus organic nitrogen	23	0	.20	6.3	1.0	2.4	4.3	2.7	1.9	1.8	1.1	34759.00	36817.00
A-14	Phosphate	24	3	.01	.48	<.01	.14	.42	.23	.12	.03	<.01	03/31/1999	10/19/2004
A-14	Phosphorus, total	23	0	.01	.84	.02	.31	.56	.41	.28	.18	.06	03/02/1999	10/19/2004
Carbon and chlorophyll														
A-14	Total organic carbon	1	0	1	18	18	18	18	18	18	18	18	07/22/2004	07/22/2004
A-14	Chlorophyll <i>a</i>	0	0	--	--	--	--	--	--	--	--	--	--	--
Trace elements														
A-14	Aluminum	22	20	10, 25	68	<10	--	--	--	--	--	--	03/02/1999	04/06/2004
A-14	Antimony	24	21	2, 20, 25, 50	<50	<2	--	--	--	--	--	--	03/02/1999	10/19/2004
A-14	Arsenic	24	8	1, 2, 25	25	1	4	9	6	3	2	1	03/02/1999	10/19/2004

Table 3. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1999–2004.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics			Percent of samples in which values were less than or equal to those shown								Period of record			
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date		
Site A-14 —Continued																
Trace elements—Continued																
A-14	Barium	24	0	--	180	40	72	110	77	65	55	42	03/02/1999	10/19/2004		
A-14	Beryllium	24	23	0.1, 0.2, 1, 5, 25	56	<.1	--	--	--	--	--	--	03/02/1999	10/19/2004		
A-14	Boron	24	1	2	700	<2	150	190	160	130	99	47	03/02/1999	10/19/2004		
A-14	Cadmium	24	21	0.2, 1, 5, 10	<10	<.2	--	--	--	--	--	--	03/02/1999	10/19/2004		
A-14	Chromium	24	20	1, 2, 6, 10	12	1	--	--	--	--	--	--	03/02/1999	10/19/2004		
A-14	Cobalt	24	24	2, 5, 10	<10	<2	--	--	--	--	--	--	03/02/1999	10/19/2004		
A-14	Copper	24	22	1, 2, 5, 10, 20	<10	<2	--	--	--	--	--	--	03/02/1999	10/19/2004		
A-14	Iron	24	18	10, 20, 25	110	<10	--	--	--	--	--	--	03/02/1999	10/19/2004		
A-14	Lead	24	21	1, 2, 5, 25	<25	<1	--	--	--	--	--	--	03/02/1999	10/19/2004		
A-14	Lithium	19	2	25	120	20	60	100	70	60	40	20	11/23/1999	10/19/2004		
A-14	Manganese	24	7	5, 10, 25	1,100	20	200	760	260	62	20	20	03/02/1999	10/19/2004		
A-14	Mercury	0	0	0.1	--	--	--	--	--	--	--	--	--	--		
A-14	Molybdenum	24	22	2, 10	150	<2	--	--	--	--	--	--	03/02/1999	10/19/2004		
A-14	Nickel	24	19	10, 12, 20, 25	34	4	--	--	--	--	--	--	03/02/1999	10/19/2004		
A-14	Selenium	24	21	0.5, 1, 2	3	<1	--	--	--	--	--	--	03/02/1999	10/19/2004		
A-14	Silver	22	22	0.2, 1, 10, 25	<25	<.2	--	--	--	--	--	--	07/27/1999	10/19/2004		
A-14	Thallium	19	17	2, 25	78	<2	--	--	--	--	--	--	02/28/2000	07/23/2003		
A-14	Vanadium	24	21	10, 20, 25	<25	2	--	--	--	--	--	--	03/02/1999	10/19/2004		
A-14	Zinc	24	22	10, 20, 25	<25	4	--	--	--	--	--	--	03/02/1999	10/19/2004		

Table 3. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1999–2004.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics				Percent of samples in which values were less than or equal to those shown							Period of record	
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date
Site A-16 —Continued														
Major ions														
A-16	Calcium	25	0	--	180	28	65	100	67	61	50	37	03/02/1999	10/19/2004
A-16	Magnesium	25	0	--	120	24	48	79	55	44	36	25	03/02/1999	10/19/2004
A-16	Sodium	25	0	--	280	35	95	170	100	88	58	42	03/02/1999	10/19/2004
A-16	Potassium	25	0	--	25	7.3	13	17	14	13	11	7.6	03/02/1999	10/19/2004
A-16	Sulfate	25	0	--	600	110	270	550	330	250	190	120	03/02/1999	10/19/2004
A-16	Chloride	25	0	--	180	8.7	28	45	29	21	17	9.6	03/02/1999	10/19/2004
Nutrients														
A-16	Nitrate	26	17	0.10	1.3	<0.10	0.26	0.64	0.46	0.10	0.10	0.10	03/02/1999	10/19/2004
A-16	Nitrite	26	21	.02	.09	<.02	--	.04	--	--	--	--	03/02/1999	10/19/2004
A-16	Ammonia	25	17	.10	1.3	<.10	.19	.37	.17	.10	.10	.10	03/02/1999	10/19/2004
A-16	Ammonia plus organic nitrogen	24	0	.20	5.4	1.5	2.4	3.6	2.9	2.0	1.8	1.6	03/02/1999	10/19/2004
A-16	Phosphate	25	1	.01	.46	<.01	.16	.41	.26	.14	.04	.01	03/31/1999	10/19/2004
A-16	Phosphorus, total	24	0	.01	.57	.01	.32	.55	.46	.31	.22	.03	03/02/1999	10/19/2004
Carbon and chlorophyll														
A-16	Total organic carbon	1	0	1	19	19	19	19	19	19	19	19	07/22/2004	07/22/2004
A-16	Chlorophyll <i>a</i>	0	0	--	--	--	--	--	--	--	--	--	--	--
Trace elements														
A-16	Aluminum	23	18	10, 25	120	<10	--	--	--	--	--	--	03/02/1999	04/06/2004
A-16	Antimony	25	22	2, 20, 25, 50	<50	<2	--	--	--	--	--	--	03/02/1999	10/19/2004
A-16	Arsenic	25	7	1, 2, 25	25	1	4	9	6	3	2	1	03/02/1999	10/19/2004

Table 3. Summary of statistics for water-quality physical properties and constituents at Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1999–2004.—Continued

[Depths in meters; specific conductance in microsiemens per centimeter at 25 degrees Celsius; pH in standard units; turbidity in nephelometric turbidity units, NTU; dissolved oxygen in milligrams per liter; hardness and alkalinity in milligrams per liter as calcium carbonate; dissolved solids, suspended solids, major ion and nutrient concentrations in milligrams per liter; carbon, organic total, in milligrams per liter; °C, degrees Celsius; chlorophyll *a* in micrograms per liter; trace elements in micrograms per liter; major ions, nutrients, and trace elements are dissolved; <, less than; --, no data; statistics are rounded]

Site	Water-quality physical property or constituent	Descriptive statistics			Percent of samples in which values were less than or equal to those shown								Period of record			
		Sample size	Number of censored values	Laboratory reporting levels	Maximum	Minimum	Mean	0.95	0.75	(Median) 0.50	0.25	0.05	Begin date	End date		
Site A-16—Continued																
Trace elements—Continued																
A-16	Barium	25	0	--	180	20	68	120	74	60	52	38	03/02/1999	10/19/2004		
A-16	Beryllium	25	24	0.1, 0.2, 1, 5, 25	54	<.1	--	--	--	--	--	--	03/02/1999	10/19/2004		
A-16	Boron	25	0	2	600	2	130	180	150	130	95	50	03/02/1999	10/19/2004		
A-16	Cadmium	25	21	0.2, 1, 5, 10	<10	<.2	--	--	--	--	--	--	03/02/1999	10/19/2004		
A-16	Chromium	25	20	1, 2, 6, 10	15	1	--	--	--	--	--	--	03/02/1999	10/19/2004		
A-16	Cobalt	25	25	2, 5, 10	<10	<2	--	--	--	--	--	--	03/02/1999	10/19/2004		
A-16	Copper	25	23	1, 2, 5, 10, 20	<10	<2	--	--	--	--	--	--	03/02/1999	10/19/2004		
A-16	Iron	25	15	10, 20, 25	120	<10	--	--	--	--	--	--	03/02/1999	10/19/2004		
A-16	Lead	25	23	1, 2, 5, 25	<25	<1	--	--	--	--	--	--	03/02/1999	10/19/2004		
A-16	Lithium	20	0	25	120	20	60	90	70	50	40	30	11/23/1999	10/19/2004		
A-16	Manganese	25	4	5, 10, 25	810	20	250	750	400	130	38	20	03/02/1999	10/19/2004		
A-16	Mercury	0	0	0.1	--	--	--	--	--	--	--	--	--	--		
A-16	Molybdenum	25	23	2, 10	490	<2	--	--	--	--	--	--	03/02/1999	10/19/2004		
A-16	Nickel	25	21	10, 12, 20, 25	28	4	--	--	--	--	--	--	03/02/1999	10/19/2004		
A-16	Selenium	25	22	0.5, 1, 2	2	<1	--	--	--	--	--	--	03/02/1999	10/19/2004		
A-16	Silver	23	22	0.2, 1, 10, 25	<25	<.2	--	--	--	--	--	--	07/27/1999	10/19/2004		
A-16	Thallium	20	19	2, 25	88	<2	--	--	--	--	--	--	02/28/2000	10/15/2003		
A-16	Vanadium	25	22	10, 20, 25	<25	2	--	--	--	--	--	--	03/02/1999	10/19/2004		
A-16	Zinc	25	22	10, 20, 25	<25	8	--	--	--	--	--	--	03/02/1999	10/19/2004		

Results of Statistical Analysis

Statistical analyses were performed to examine potential differences in physical properties and constituent concentrations related to location, sampling period, and season. The analyses looked at differences among sites within each of the two sampling periods, differences between sites that were sampled during the first sampling period and the second sampling period, differences in Arrowwood NWR inflow and Arrowwood NWR outflow, and differences potentially caused by waterfowl use of the refuge.

Differences Within Each Sampling Period

Sites A-01, A-03, A-05, A-09, and A-10 were all sampled from 1987–93 as part of the refuge monitoring program (sites A-02, A-06, A-07, A-08, and A-11 through A-15 had shorter periods of record, and sites A-04 and A-16 were not sampled during 1987–93). The Friedman test was used to examine whether the medians of water-quality properties and constituents varied among the sites. At a significance level of 0.05, specific conductance, turbidity, hardness, alkalinity, total dissolved solids, total suspended solids, nonvolatile suspended solids, calcium, magnesium, sodium, potassium, sulfate, chloride, phosphate, total phosphorus, total organic carbon, chlorophyll *a*, and arsenic medians were statistically different at one or more sites. For these statistically different properties and constituents, pairwise sign tests were performed to attempt to determine which site or sites differed significantly and if the sites varied in a systematic manner. For example, the test could indicate increased statistically significant differences as the distance between sites increased, such as more statistically significant differences in constituents between site A-01 and A-10 than between A-01 and A-03. Because of the multiple comparisons, an adjusted significance level, or *p*-value was used to determine significance of a pairwise sign test. An overall experiment-wise error rate of 0.05 was desired, so the pairwise error rate was determined by using the Bonferroni adjustment. For the five sites, the pairwise error rate or significance level is $0.05/(5 \times 4)/2$ or 0.005. Therefore, pairwise sign tests were considered statistically significant if the *p*-value was less than 0.005. Results for the Friedman rank sum test and the pairwise sign tests are listed in table 4; the statistically significant *p*-values are highlighted in gray. There is no apparent systematic increase or decrease in concentrations as water moves through the refuge except for potassium as distance increases from site A-01. Potassium concentration at the five sites examined is shown in figure 9. Potassium concentrations are similar at sites A-01 and A-03, which showed no significant difference; however, concentrations appear to be generally higher and more variable at sites A-05, A-09, and A-10.

Sites A-03 and A-09 have the largest number of constituents with significant differences between them. Site A-09 has generally higher concentrations with more variability than site A-03 (table 2 and fig. 9) for specific conductance, hard-

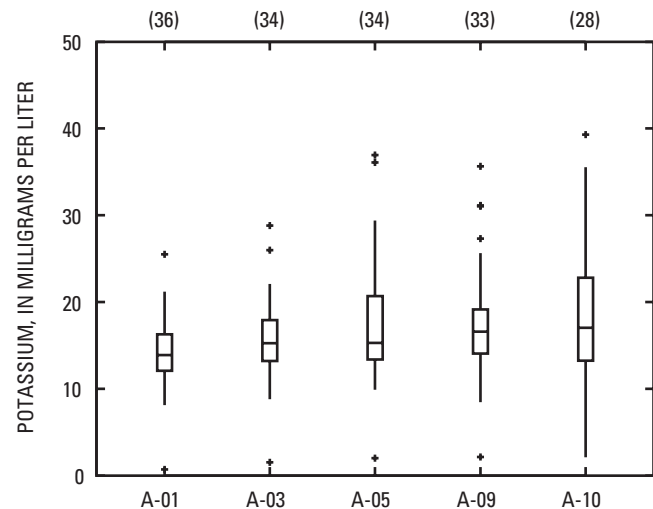


Figure 9. Box plot for potassium at sites A-01, A-03, A-05, A-09, and A-10, James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93.

ness, alkalinity, total dissolved solids, calcium, magnesium, sodium, potassium, phosphate, total phosphorus, and arsenic. Turbidity is generally lower at site A-09 than at site A-03 (table 2). Site A-09 is more sheltered than A-03, and A-03 is on the largest lake in Arrowwood NWR (fig. 1) and subject to more wind and wave action that would increase turbidity.

Sites A-01, A-04, A-05, A-09, A-11, A-14, and A-16 were sampled from 1999–2004. The Friedman test was used to determine whether the distributions of water-quality properties and constituents varied among the sites. At a significance level of 0.05, pH, sodium, chloride, barium, and boron varied significantly among sites (table 5).

For statistically significant differences, pairwise sign tests were performed to determine which site(s) differed. For the seven sites, the pairwise error rate or significance level is $0.05/(7 \times 6)/2$ or 0.0024. Therefore, pairwise sign tests were considered statistically significant if the *p*-value was less than 0.0024. Despite the Friedman test identifying statistical differences, the sign test often was unable to determine which sites differed. All the significant differences identified by the sign tests were for sodium and chloride and were related to site A-04 and sites downstream from it. The box plots for significant differences identified by the pairwise sign tests are shown in figure 10. With the exception of an outlier, sodium concentrations were generally lower at site A-04 than at sites A-09, A-11, A-14, and A-16. Again, with the exception of an outlier, chloride concentrations at site A-04 were generally lower than at sites A-11, A-14, and A-16. The differences are generally small between the sites for both constituents.

Some of the major ions and nutrients that differed significantly during the first sampling period did not differ significantly during the second period. The second period was a time of generally higher streamflow (fig. 8) and much wetter

(Statistically significant results are highlighted in gray. The significance level for the Friedman test is 0.05. The pairwise comparisons were performed only if the Friedman rank sum test indicated a statistically significant difference. Sign test p-values were considered statistically significant if the p-value was less than 0.005. The pairwise comparison significance level was determined by the Bonferroni adjustment to attain the overall experiment-wise significance level of 0.05. n, number of samples (blocks) compared in Friedman test and number of paired differences tested with sign test; °C, degrees Celsius; --, not applicable)

[illegible]

Table 5. Results of Friedman rank sum test and pairwise sign tests for selected water-quality physical properties and constituent concentrations at sites A-01, A-04, A-05, A-09, A-11, A-14, and A-16 on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1999–2004.—Continued

[illegible]

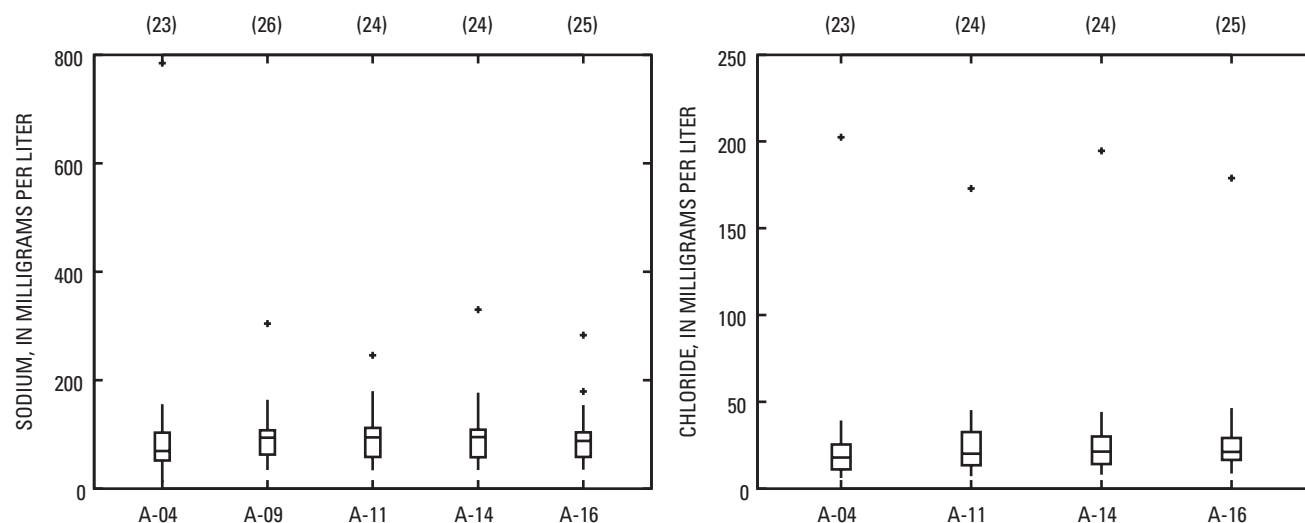


Figure 10. Box plot for sodium at sites A-04, A-09, A-11, A-14, and A-16 and box plot for chloride at sites A-04, A-11, A-14, and A-16, James River and the Arrowwood National Wildlife Refuge, N. Dak., 1999–2004.

conditions (fig. 7) during which more water would be flowing through the refuge resulting in more mixing. During the earlier sampling period there were drought conditions (fig. 7) under which the James River had little to no flow and the lakes acted more as individual lakes with little interaction. Because of differing sampling goals, not all constituents were sampled during both periods, so many cannot be compared from the first sampling period to the second.

Differences Between Sampling Periods

Sites sampled and period of record varied between the two sampling periods. The period of record also varied among the sites. Also, some constituents analyzed during the first period (1987–93) were not analyzed during the second period (1999–2004), and winter sampling was done during the second sampling period only. This variability reduces the number of direct comparisons that can be made between the two periods. Three sites, A-01, A-05, and A-09, had complete periods of record for both sampling periods and were compared for the properties and constituents listed in table 6. Because some constituent concentrations vary greatly in the winter, concentration data from the winter samples were removed before data from the two sites were compared for the two periods.

Site A-01 had numerous statistically significant differences at the 0.05 significance level. Box plots (fig. 11) indicate that hardness, total dissolved solids, calcium, magnesium, sulfate, and phosphorus increased during the second sampling period. Calcium, magnesium, sulfate, and phosphorus have been shown to increase with streamflow at one or both of the Sheyenne River and Red River of the North in North Dakota (Ryberg, 2006; Ryberg, 2007). Streamflow on the James River generally was higher during the second sampling period than

during the first. Increases in calcium and magnesium would increase hardness, and the increases in major ions would increase total dissolved solids.

Site A-05 had reductions in variability and/or significant differences in the median concentration for hardness, magnesium, potassium, sulfate, chloride, and phosphorus (table 6 and fig. 12). The reduction in variability is most likely because of increased inflow to the refuge and increased mixing between the water bodies on the Arrowwood NWR. Chloride variability decreased significantly, although the median did not. Feth (1981) found that Western rivers in the United States generally have increased chloride concentrations in drought years. The drought conditions in the first sampling period likely contributed to the observed higher variability in chloride during this period.

Site A-09 had significant differences in variability and/or in the median concentration for potassium, sulfate, and chloride (table 6 and fig. 13). Potassium concentrations appeared to be less variable and had a lower median in the second period. Sulfate concentrations appeared to be less variable and less skewed and had a higher median in the second period. Chloride concentrations also decreased in variability in the second period, but the median did not vary significantly between the two periods.

Inflow/Outflow Differences, 1999–2004

Site A-01 (fig. 1 and table 1) represents inflow to the Arrowwood NWR, and site A-16 (fig. 1 and table 1) represents outflow from the Arrowwood NWR. Potential changes in water-quality caused by water management on Arrowwood NWR or by large numbers of waterfowl using Arrowwood NWR are of interest because the downstream Jamestown

Table 6. Results of Kolmogorov-Smirnov test and Wilcoxon rank sum test for selected water-quality physical properties and constituent concentrations at sites A-01, A-05, and A-09, James River and Arrowwood National Wildlife Refuge, N. Dak., tested for differences between two sampling periods, 1987–93 and 1999–2004.

[Statistically significant results are highlighted in gray. Result considered significantly different if p-value less than 0.05. Data for winter samples from second sampling period were removed prior to testing]

Water-quality physical property or constituent	Combined number of samples from both sampling periods	p-value for Kolmogorov-Smirnov test	p-value for Wilcoxon rank sum test
Site A-01			
Specific conductance	49	0.159	0.259
pH	47	.877	.727
Hardness	49	.001	.000
Alkalinity	50	.616	.771
Total dissolved solids, calculated, sum of constituents	49	.069	.049
Calcium	49	.004	.001
Magnesium	49	.008	.002
Sodium	49	.790	.760
Potassium	49	.357	.226
Sulfate	49	.000	.000
Chloride	49	.184	.077
Ammonia plus organic nitrogen	35	.252	.274
Phosphate	50	.764	.754
Phosphorus, total	49	.024	.008
Arsenic	49	.632	.497
Manganese	44	.056	.334
Site A-05			
Specific conductance	47	0.152	0.684
pH	47	.086	.071
Hardness	47	.048	.109
Alkalinity	47	.706	.589
Total dissolved solids, calculated, sum of constituents	47	.106	.503
Calcium	47	.229	.426
Magnesium	47	.040	.067
Sodium	47	.218	.730
Potassium	47	.028	.020
Sulfate	47	.016	.036
Chloride	47	.020	.099
Ammonia plus organic nitrogen	34	.754	.415
Phosphate	48	.932	.846
Phosphorus, total	47	.034	.021
Arsenic	47	.860	.793
Manganese	42	.415	.513

Table 6. Results of Kolmogorov-Smirnov test and Wilcoxon rank sum test for selected water-quality physical properties and constituent concentrations at sites A-01, A-05, and A-09, James River and Arrowwood National Wildlife Refuge, N. Dak., tested for differences between two sampling periods, 1987–93 and 1999–2004.—Continued

[Statistically significant results are highlighted in gray. Result considered significantly different if p-value less than 0.05. Data for winter samples from second sampling period were removed prior to testing]

Water-quality physical property or constituent	Combined number of samples from both sampling periods	p-value for Kolmogorov-Smirnov test	p-value for Wilcoxon rank sum test
Site A-09			
Specific conductance	45	0.452	0.883
pH	46	.585	.624
Hardness	46	.067	.060
Alkalinity	47	.108	.147
Total dissolved solids, calculated, sum of constituents	46	.248	.596
Calcium	46	.183	.124
Magnesium	46	.050	.092
Sodium	46	.077	.652
Potassium	46	.002	.006
Sulfate	46	.023	.003
Chloride	46	.021	.107
Ammonia plus organic nitrogen	33	.486	.912
Phosphate	47	.152	.073
Phosphorus, total	46	.189	.534
Arsenic	46	.123	.600
Manganese	41	.807	.705

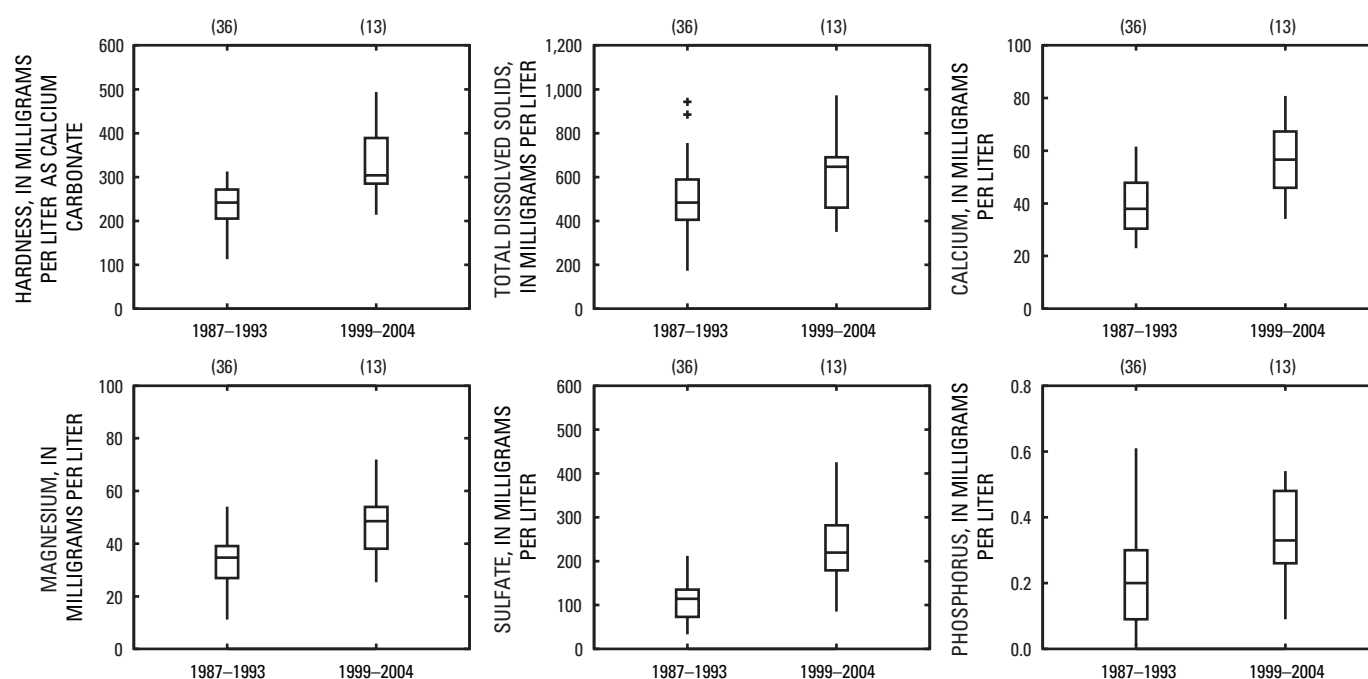


Figure 11. Box plots for constituent concentrations that had significant differences between the two sampling periods at site A-01, James River and the Arrowwood National Wildlife Refuge, N. Dak.

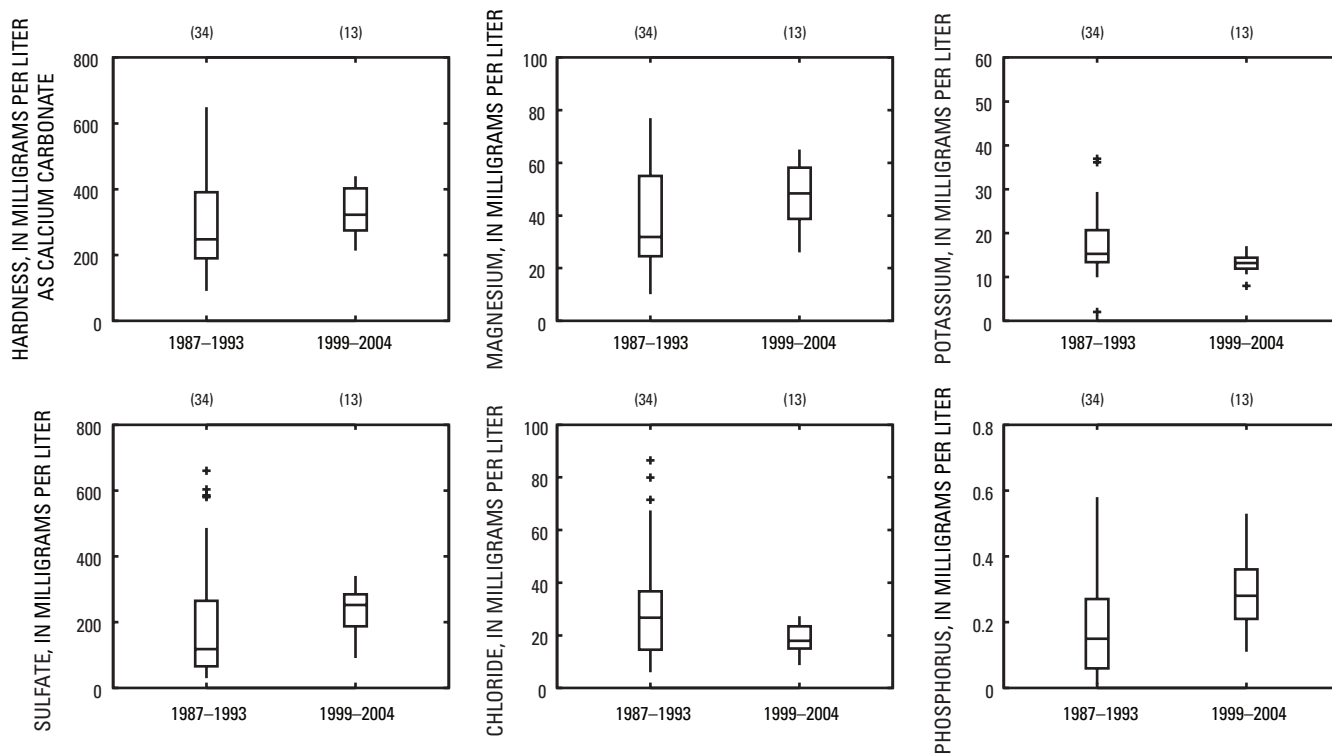


Figure 12. Box plots for constituent concentrations that had significant differences between the two sampling periods at site A-05, James River and the Arrowwood National Wildlife Refuge, N. Dak.

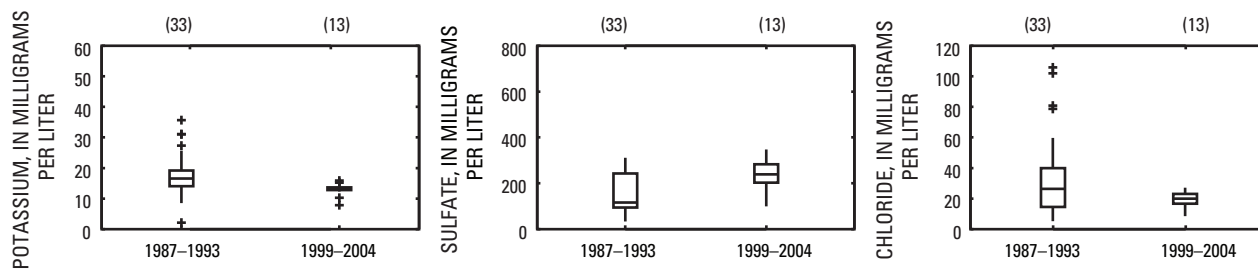


Figure 13. Box plots for constituent concentrations that had significant differences between the two sampling periods at site A-09, James River and the Arrowwood National Wildlife Refuge, N. Dak.

Reservoir is used for recreation and releases from the reservoir are used for irrigation. To examine the effect of Arrowwood NWR on water quality of the James River, water-quality properties and constituents were compared at sites A-01 and A-16 for the period when data were available for both sites, 1999–2004. The sign test was used to check for differences in the distribution of the paired differences of the data at the two sites. The tests resulted in the p-values listed in table 7.

Of those tested (properties and constituents with less than 40-percent censoring at both sites that had matching sample times), five measures of water quality were statistically significantly different at the 0.05 significance level: pH, sulfate, chloride, barium, and manganese (fig. 14). pH, sulfate, chloride, and manganese tended to be higher at site A-16 than at site A-01, whereas barium tended to be higher at site A-01 than at site A-16 (with the exception of some outliers). No significant nutrient differences were detected between sites A-01 and A-16.

Sulfate sources include the weathering of rocks, agricultural runoff, fuel combustion, municipal and industrial effluent, and precipitation (Hem, 1985; Allan, 1995). Chloride sources may include weathering of rocks, ground-water inflow, municipal and industrial effluent, and precipitation (Hem, 1985; Allan, 1995). Given that there is no city or major

tributary between sites A-01 and A-16 and precipitation would virtually be the same at the two sites, it is unlikely that the observed differences for sulfate and chloride are anthropogenically created or are caused by differences in precipitation. The lakes, impoundments, and bypass channels in Arrowwood NWR cause the water to come in contact with more soil, a source of sulfate, chloride, and manganese. As stated previously in this report, manganese may be reduced and mobilized in the dissolved phase under anoxic conditions. The lakes in Arrowwood NWR can become anoxic, and the dissolved manganese could be transported an unknown distance downstream from the lakes.

Graphical Comparison of Nutrients

Nutrients are of particular interest in Arrowwood NWR because of the aquatic plant and animal life and the use of the wetland resources by waterfowl. However, the nutrient data were highly censored (tables 2 and 3). Differences in sampling between the two periods also complicate direct comparison because winter samples were collected during the second period only. Therefore the nutrients were compared graphically. The samples were divided into four time periods: winter

Table 7. Results of matched pair sign test on selected water-quality physical properties and constituent concentrations at sites A-01 and A-16 on the James River, N. Dak., 1999–2004.

[Statistically significant results are highlighted in gray. Result considered statistically significant if p-value less than 0.05]

Water-quality physical property or constituent	Number of matched pairs	p-value for sign test
Specific conductance	26	0.557
pH	26	.002
Hardness	25	1.000
Alkalinity	26	1.000
Total dissolved solids, calculated, sum of constituents	25	.108
Calcium	25	.690
Magnesium	25	1.000
Sodium	25	.108
Potassium	25	.690
Sulfate	25	.043
Chloride	25	.043
Ammonia plus organic nitrogen	24	.152
Phosphate	25	1.000
Phosphorus, total	24	.541
Arsenic	25	.108
Barium	25	.043
Boron	25	.424
Lithium	20	.263
Manganese	25	.043

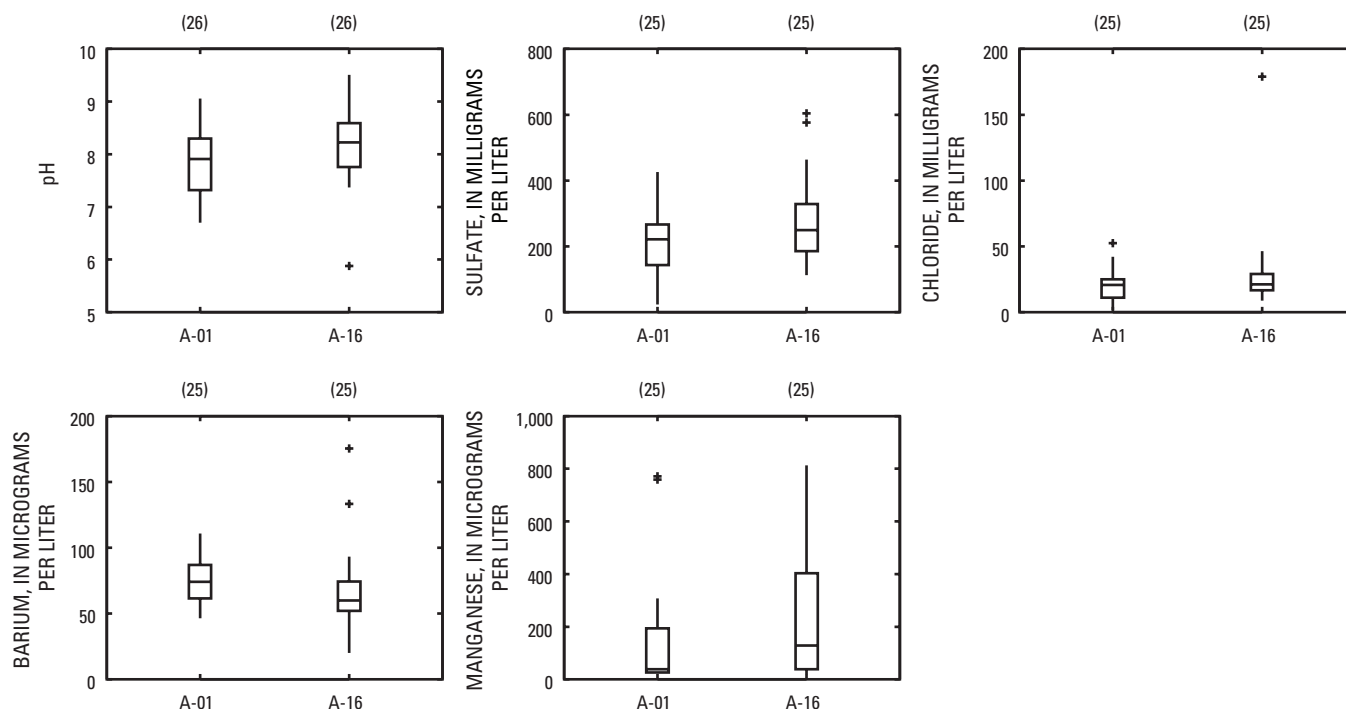


Figure 14. Box plots for constituent concentrations that had significant differences between sites A-01 and A-16, James River and the Arrowwood National Wildlife Refuge, N. Dak., 1999–2004.

(November through March), spring migration (in April, when a high concentration of waterfowl could be expected at the refuge), summer (May through September), and fall migration (in October, when a high concentration of waterfowl could again be expected at the refuge).

The graphical comparisons were made using stripplots (Venables and Ripley, 2002), which enable the examination of a large amount of data that have been grouped by a number of different variables or categories. The stripplots all indicate concentrations of the nutrients at each site with the first sampling period on the left side of the plot and the second sampling period on the right side (figs. 15–19). The sites form rows across the stripplots, and the concentrations are indicated by the x-axis at the top and bottom of the plot. Different colors and symbols are used to plot concentrations for each sampling period. The concentrations were offset vertically slightly to reduce the overlap of the plotted concentrations. However, points cluster where there were many censored values. For example, 15 nitrate concentrations at site A-01 were censored at 0.10, indicating the concentration was less than 0.10 but could not be further quantified; therefore, those 15 points plot at 0.10 on the x-axis making individual points difficult to

identify despite the offset, emphasizing the large amount of censored data.

Nitrate concentrations are shown in figure 15 and nitrite concentrations are shown in figure 16. Only the second sampling period had winter concentrations, which were among the highest of any concentrations. Concentrations of nitrate also were high during spring migration in both sampling periods when waterfowl would be contributing waste. Summer concentrations of both constituents also were high during the first sampling period, which included drought conditions during which summer evaporation of water may have increased concentrations of numerous constituents. There are no nutrient losses associated with evaporative loss from wetlands (U.S. Environmental Protection Agency, 2007).

Ammonia concentrations are shown in figure 17 and ammonia plus organic nitrogen concentrations are shown in figure 18. Ammonia is a decomposition product that tends to accumulate under the ice. The highest concentrations occurred during the winter of the second sampling period.

Phosphate concentrations are shown in figure 19. The highest concentrations occurred in the summer during the first sampling period. This could have been caused by evaporation during the drought (fig. 7) conditions in the first period.

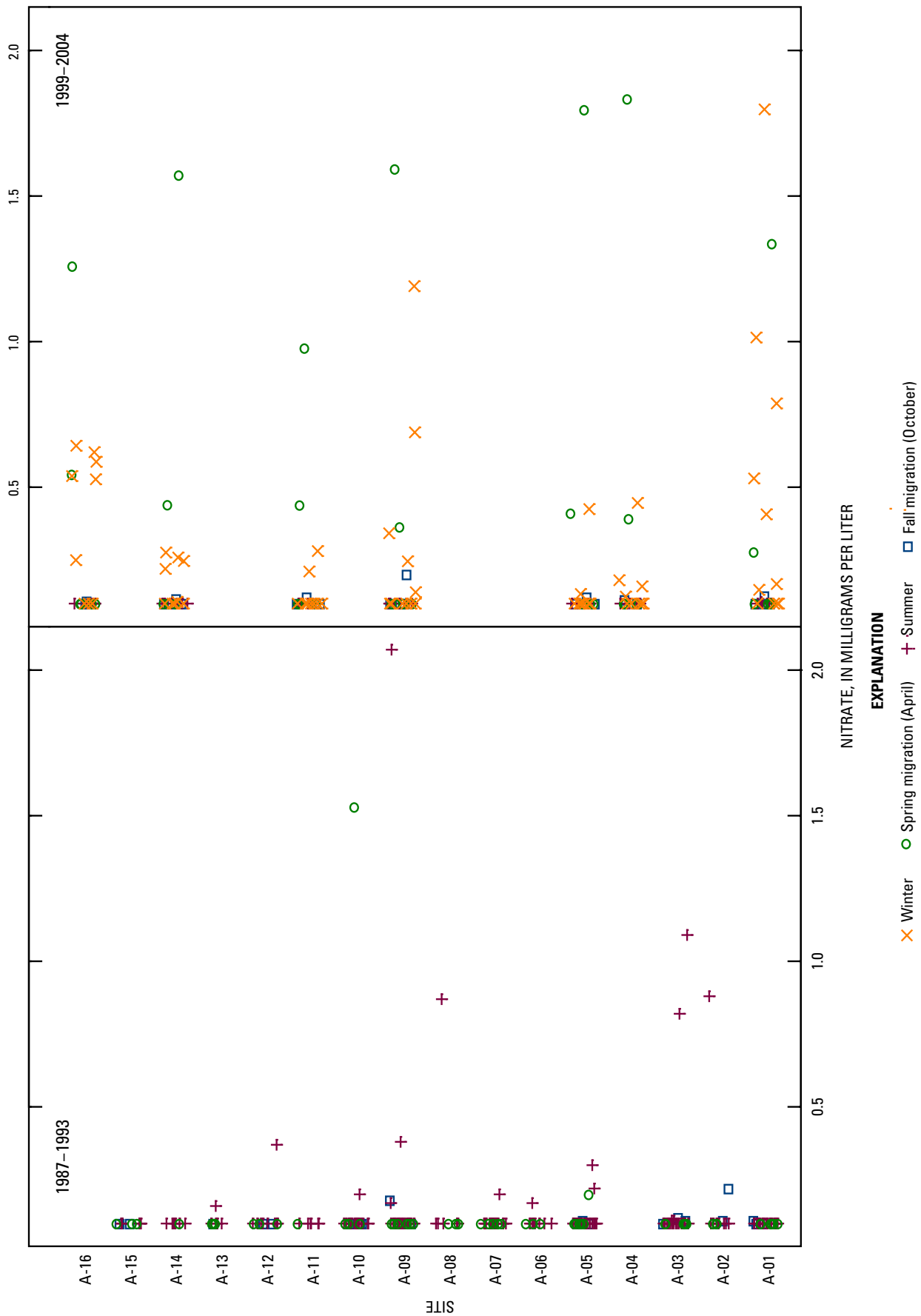


Figure 15. Stripplot for nitrate concentrations at water-quality sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93 and 1999–2004.

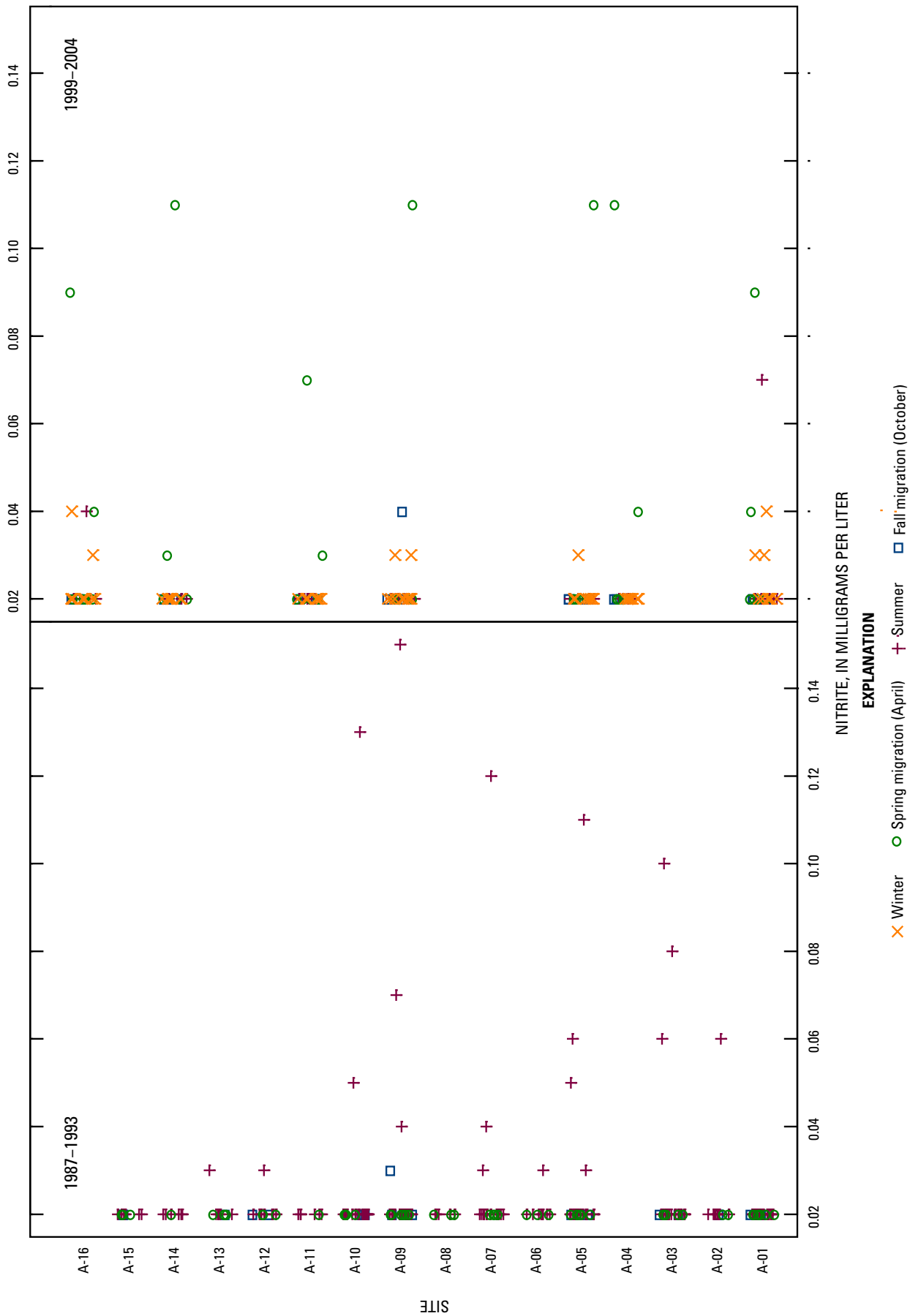


Figure 16. Stripplot for nitrite concentrations at water-quality sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93 and 1999–2004.

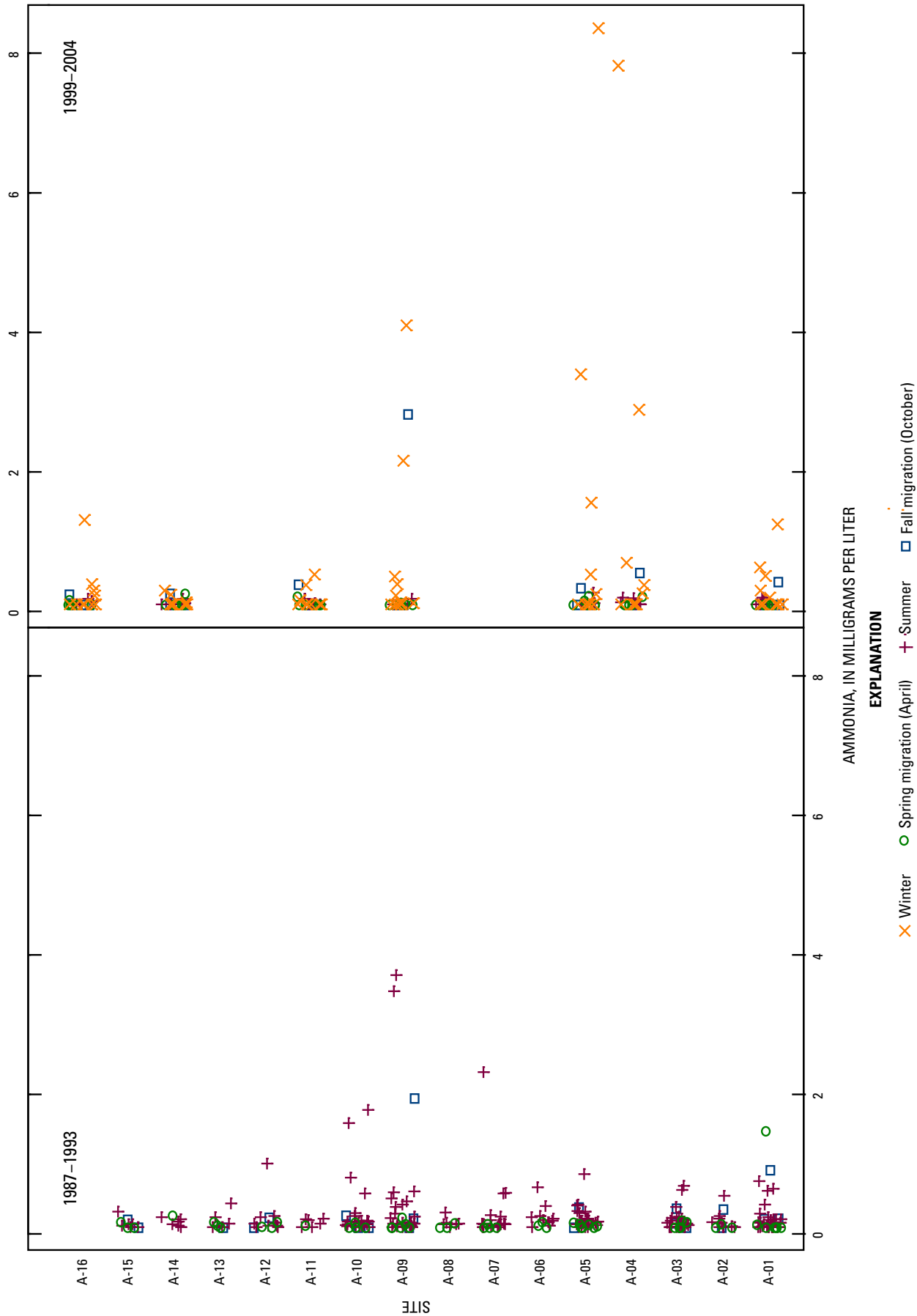


Figure 17. Stripplot for ammonia concentrations at water-quality sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987-93 and 1999-2004.

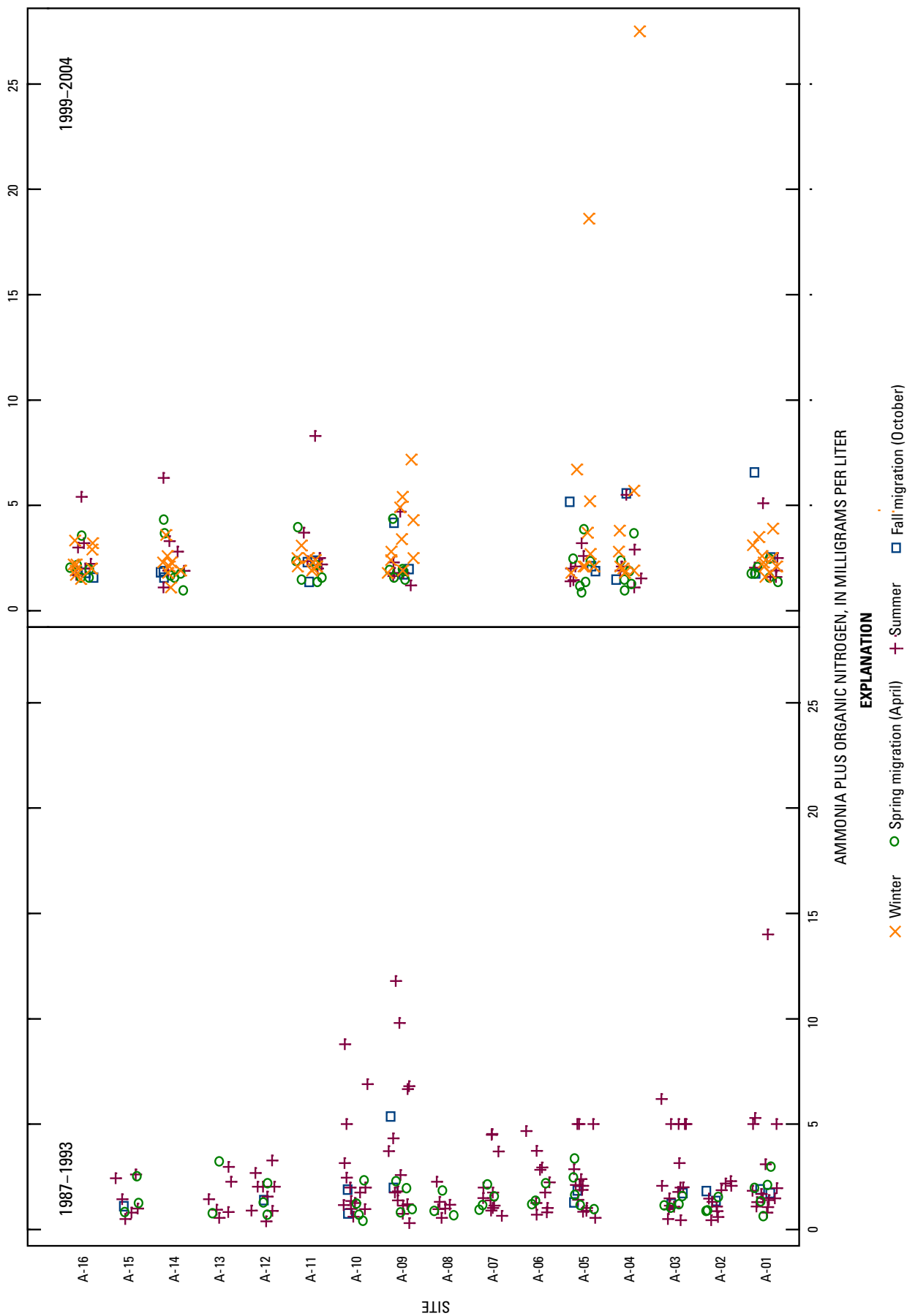


Figure 18. Stripplot for ammonia plus organic nitrogen concentrations at water-quality sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987-93 and 1999-2004.

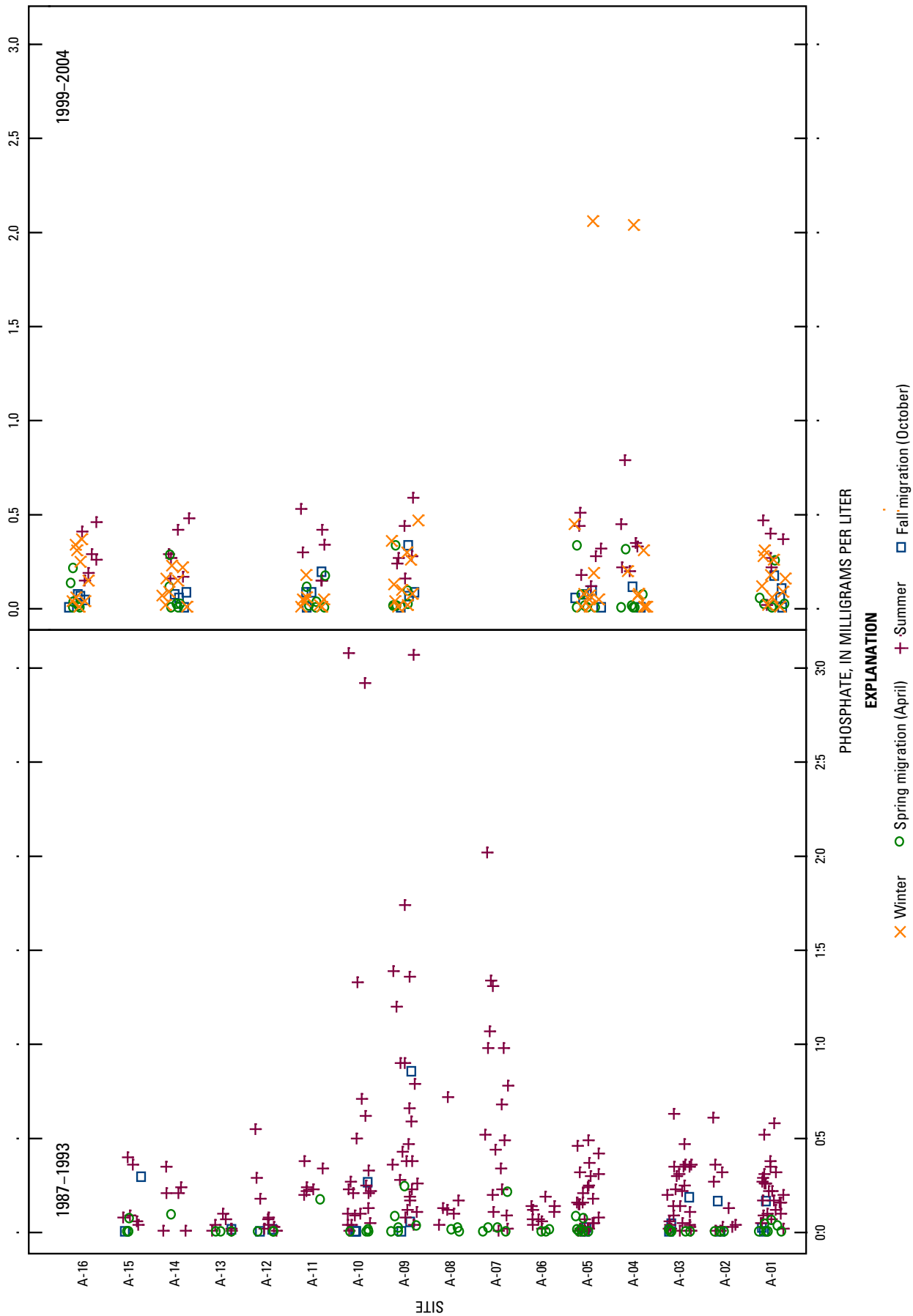


Figure 19. Stripplot for phosphate concentrations at water-quality sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93 and 1999–2004.

Summary

The Bureau of Reclamation collected water-quality samples at 16 sites on the James River and the Arrowwood National Wildlife Refuge (Arrowwood NWR), N. Dak., as part of its refuge-monitoring program from 1987–93 and as part of an environmental impact statement (EIS) commitment from 1999–2004. The EIS presented an incremental series of actions to the Arrowwood NWR for improved water-management capability. Construction of water-management structures began in 1991, and the project was completed in 2008.

Climatic and hydrologic conditions varied greatly during both sampling periods. The first period was dominated by drought conditions, which abruptly changed to cooler and wetter conditions in 1992–93. During the second period, conditions were near normal to very wet with higher inflow from the James River into the Arrowwood NWR.

In addition to the different reasons for sampling and varying climatic and hydrologic conditions, the two periods differed in the sites sampled, seasons sampled, and properties and constituents measured. These differences and comparisons where sites and constituents are available in both sampling periods are documented in this report.

Summary statistics were reported separately for the two sampling periods for all physical properties and constituents. Nonparametric statistical tests were used to further analyze the data. Nonparametric tests were used because they are appropriate for water-quality data that have skewed distribution with outliers and can be used when there is censoring of the data.

During the first sampling period, 1987–93, specific conductance, turbidity, hardness, alkalinity, total dissolved solids, total suspended solids, nonvolatile suspended solids, calcium, magnesium, sodium, potassium, sulfate, chloride, phosphate, total phosphorus, total organic carbon, chlorophyll *a*, and arsenic were determined to have significantly different medians among the sites tested. During the second sampling period, 1999–2004, the medians of pH, sodium, chloride, barium, and boron varied significantly among sites.

Sites sampled and period of record varied between the two sampling periods and the period of record varied among the sites. Also, some constituents analyzed during the first period (1987–93) were not analyzed during the second period (1999–2004), and winter sampling was done during the second sampling period only. This variability reduces the number of direct comparisons that can be made between the two periods. Three sites had complete periods of record for both sampling periods and were compared. Because some constituent concentrations vary greatly in the winter, concentration data from the winter samples were removed before data from the two sites were compared for the two periods. Differences in variability and median concentration were identified between the two time periods.

Potential changes in water quality caused by water management on Arrowwood NWR or by large numbers of waterfowl using Arrowwood NWR are of interest because

the downstream Jamestown Reservoir is used for recreation and releases from the reservoir are used for irrigation. Sites representing inflow to the Arrowwood NWR and outflow were compared statistically for the period when data were available for both sites, 1999–2004. Of the nutrients tested—ammonia plus organic nitrogen, phosphate, and total phosphorus—no significant statistical differences were found between the inflow and outflow samples. Statistically significant differences were found for pH, sulfate, chloride, barium, and manganese. Box plots indicate that pH and sulfate, chloride, and manganese concentrations tended to be higher at site A-16 than at site A-01, whereas barium tended to be lower at site A-16.

Nutrients are of particular interest in Arrowwood NWR because of the aquatic plant and animal life and use of the wetland resources by waterfowl. However, the nutrient data were highly censored and there were seasonal differences in sampling between the two sampling periods. Therefore, nutrients were examined graphically for all sites split into the two sampling periods and four seasons (winter, spring migration, summer, and fall migration). Differences between the two periods can be identified; the main difference being high winter concentrations during the second period, as a result of accumulation under ice. No winter samples were collected during the first period. There were also high summer concentrations of nutrients in the first sampling period, which was characterized by drought conditions.

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Supplements

Supplement 1. Physical properties for Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93 and 1999–2004.

Supplement 2. Dissolved solids, suspended solids, and major ions for Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93 and 1999–2004.

Supplement 3. Nutrients for Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93 and 1999–2004.

Supplement 4. Carbon and chlorophyll for Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93 and 1999–2004.

Supplement 5. Trace elements for Bureau of Reclamation sampling sites on the James River and the Arrowwood National Wildlife Refuge, N. Dak., 1987–93 and 1999–2004.

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For more information concerning this publication, contact:
Director, USGS North Dakota Water Science Center
821 E. Interstate Ave.
Bismarck, ND 58503
(701) 250–7400

Or visit the North Dakota Water Science Center Web site at:
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