Prepared in cooperation with the U.S. Army Corps of Engineers, St. Paul District

Sediment Loads in the Red River of the North and Selected Tributaries near Fargo, North Dakota, 2010–2011

Scientific Investigations Report 2012–5111

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

Cover photograph. Stream bank failure on the Red River of the North near Christine, N.Dak. (Photograph by Joel M. Galloway, U.S. Geological Survey).

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KEN SALAZAR, Secretary

U.S. Geological Survey
Marcia K. McNutt, Director

U.S. Geological Survey, Reston, Virginia: 2012

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Conversion Factors and Datums

[Inch/Pound to SI]

Multiply	By	To obtain
	Length	
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
	Area	
square mile (mi^2)	259.0	hectare (ha)
	Volume	
pint (pt)	0.4732	liter (L)
quart (qt)	0.9464	liter (L)
gallon (gal)	3.785	liter (L)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)
	Mass	
ton per day (ton/d)	0.9072	metric ton per day
ton per year (ton/yr)	0.9072	metric ton per year

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

$$°F=(1.8\times°C)+32$$

Vertical coordinate information is referenced to North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to North American Datum of 1983 (NAD 83).

Sediment Loads in the Red River of the North and Selected Tributaries near Fargo, North Dakota, 2010–2011

By Joel M. Galloway and Rochelle A. Nustad

Abstract

Natural-resource agencies are concerned about possible geomorphic effects of a proposed diversion project to reduce the flood risk in the Fargo-Moorhead metropolitan area. The U.S. Geological Survey in cooperation with the U.S. Army Corps of Engineers collected data in the spring of 2010 and 2011, and from June to November 2011, during rainfall-runoff events and base-flow conditions to provide information on sediment transport. The data were used to examine sediment concentrations, loads, and particle-size distributions at nine selected sites in the Red River and its tributaries near the Fargo-Moorhead metropolitan area.

Suspended-sediment concentration varied among sites in 2010 and 2011. The least suspended-sediment concentrations were measured at the Red River (site 1) and the Buffalo River (site 9), and the greatest concentrations were measured at the two Sheyenne River sites (sites 3 and 4).

Estimated daily suspended-sediment loads were highly variable in 2010 and 2011 in the Red River and its tributaries, with the greatest loads occurring in the spring and the smallest loads occurring in the winter. For the Red River, daily suspended-sediment loads ranged from 26 to 3,500 tons per day at site 1 and from 30 to 9,010 tons per day at site 2. For the Sheyenne River, daily loads ranged from less than 10 to 10,200 tons per day at site 3 and from less than 10 to 4,530 tons per day at site 4. The mean daily load was 191 tons per day in 2010 and 377 tons per day in 2011 for the Maple River, and 610 tons per day in 2011 for the Wild Rice River (annual loads were not computed for 2010). For the three sites that were only sampled in 2011 (sites 7, 8 and 9), the mean daily suspended-sediment loads ranged from 40 tons per day at the Lower Branch Rush River (site 8) to 118 tons per day at the Buffalo River (site 9).

For sites that had estimated loads in 2010 and 2011 (sites 1–5), estimated annual (March–November) suspended-sediment loads were greater in 2011 compared to 2010. In 2010, annual loads ranged from 68,650 tons per year at the Maple River (site 5) to 249,040 tons per year at the Sheyenne River (site 3). In 2011, when all nine sites were sampled, annual loads ranged from 8,716 tons per year at the Lower Branch Rush River (site 8) to 552,832 tons per year at the Sheyenne River (site 3). With the exception of the Sheyenne River (site 4), the greatest monthly loads occurred in March for 2010, with as little as 27 percent (site 1) and as much as 42 percent (site 3) of the annual load occurring in March. For 2011, the greatest monthly loads occurred in April, ranging from 33 percent (site 1) to 63 percent (site 7) of the 2011 annual load.

A relatively small amount of sediment was transported past the nine sites as bedload in 2010 and 2011. For most of the samples collected at the nine sites, the bedload composed less than 1 percent of the calculated daily total sediment load.

Introduction

The Red River of the North (Red River) has exceeded the National Weather Service flood stage of 18 feet (ft) in 47 of the past 108 years for the Fargo-Moorhead metropolitan area and every year from 1993 through 2011. To investigate measures to reduce flood risk and analyze the potential for Federal participation in implementing a flood-risk management project, a feasibility study was begun in the Fargo-Moorhead metropolitan area in 2008, under direction of the U.S Army Corps of Engineers (USACE), St. Paul District, and the sponsor cities of Fargo, N. Dak., and Moorhead, Minn. The study analyzed several possible types of measures and alternative plans that could reduce the flood risk in the Fargo-Moorhead metropolitan area. An array of potential alternatives was considered, including nonstructural flood proofing, diversion channels, levee/floodwall systems, and flood storage. Construction of a North Dakota Diversion Channel around the Fargo-Moorhead metropolitan area was chosen from these plans for further analysis (Blanchard and others, 2011).

Natural-resource agencies are concerned about possible geomorphic effects of the proposed diversion project in the Fargo-Moorhead metropolitan area (U.S. Army Corps of Engineers, 2010). Site-specific information on sediment transport and riverine geomorphic processes was limited, and has prevented accurate geomorphic modeling to address those concerns. To provide accurate and reliable information on sediment transport, the U.S. Geological Survey (USGS) in cooperation with the USACE, St. Paul District, conducted a study in the spring (March–May) of 2010 (Blanchard and others, 2011) and the spring of 2011 (Galloway and others, 2011) to examine sediment concentrations, loads, and particle-size distributions in the Red River and its tributaries near the Fargo-Moorhead metropolitan area during the spring high-flow conditions. The USGS collected samples of suspended sediment, bed material, and bedload at 6 sites during the 2010 spring high-flow event (Blanchard and others, 2011) and at an additional 3 sites in 2011 (Galloway and others, 2011). To further describe the sediment dynamics through the range of flow conditions in the Red River and its tributaries, additional samples were collected from June through November 2011 during rainfall-runoff events and base-flow conditions.

Description of Study Area

The Red River begins at Wahpeton, N. Dak., at the confluence of the Otter Tail River and the Bois de Sioux River, and flows north into Canada before emptying into Lake Winnipeg, Manitoba. The drainage area for the Red River Basin is about 45,000 square miles (mi^2) (excluding the Assiniboine River) and encompasses parts of eastern North Dakota and northwestern Minnesota in the United States, and southern Manitoba in Canada. The Red River flows through several urban areas along its path, including the cities of Fargo, N. Dak.; Moorhead, Minn.; Grand Forks, N. Dak.; East Grand Forks, Minn.; and Winnipeg, Manitoba. Tributaries to the Red River near the Fargo-Moorhead metropolitan area include the Sheyenne, Maple, Wild Rice, Rush, Lower Branch Rush, and Buffalo Rivers (fig. 1).

Purpose and Scope

The purpose of this report is to describe sediment characteristics and estimates of daily, monthly, and annual loads for suspended sediment from March 2010 to November 2011 at nine selected sites in the Fargo-Moorhead metropolitan area. Data collected during the 2010 spring high-flow event (March through April; Blanchard and others, 2011) and the 2011 spring high-flow event (April through May; Galloway and others, 2011) were used with sediment data from samples collected during rainfall-runoff events and base-flow conditions from June to November 2011. The data provided information on transport and distribution of sediment at the nine sites and were used to develop regression models for the estimation of daily and monthly suspended-sediment loads.

Methods of Study

The following sections describe methods used for the collection and analysis of sediment samples and measurement of streamflow. Data were collected by the USGS in the general vicinity of the Fargo-Moorhead metropolitan area and included selected sites at or near USGS streamgages. A total of nine sites were sampled, including two sites on the Red River, upstream and downstream from the Fargo-Moorhead metropolitan area; two sites on the Sheyenne River, one upstream from the Sheyenne River Diversion channel and one site below the Diversion channel; and one site on the Maple River, Wild Rice River, Rush River, Lower Branch Rush River, and Buffalo River (fig. 1, table 1). Sampling sites on the Red River and its tributaries were selected at USGS streamgage locations so that sediment data could be related to streamflow data. One exception was the sediment data-collection site at the Red River near Christine, N. Dak., which was upstream from the streamgage near Hickson, N. Dak. (USGS station number 05051522) (table 1, fig. 1).

Sediment Data Collection

Samples of suspended sediment, bed material, and bedload were collected at nine sites near the Fargo-Moorhead metropolitan area at various time intervals during the open-water period in 2010 and 2011. Sampling began at each site as soon as ice cover or ice jamming (accumulation of broken ice) was not present at the site during the spring high-flow conditions. In general, suspended-sediment and bed-material samples were collected every day or every 2 days during the rise and peak of the streamflow hydrograph at each site, and at a less frequent interval during the recession of the streamflow hydrograph at each site during the 2010 and 2011 spring events (Blanchard and others, 2011; Galloway and others, 2011). Samples also were collected on the rise, peak, and fall of the streamflow hydrograph during summer rainfall-runoff events, when possible, and at selected intervals during low-flow conditions in 2011. Bedload samples were collected on a less frequent basis than the suspended-sediment and bed-material samples. Suspended-sediment, bedload, and bed-material samples were collected using equipment and methods described by Blanchard and others (2011), and Galloway and others (2011).

All samples of suspended sediment, bed material, and bedload were analyzed for particle-size distribution and concentration at the USGS Iowa Water Science Center Sediment Laboratory in Iowa City, Iowa, using methods described in Guy (1969). Some suspended-sediment samples were not analyzed for a full particle-size distribution because of insufficient sediment mass present in the sample. Results from the analysis were stored in the USGS National Water Information System (NWIS) database (*http://nwis.waterdata.usgs.gov/nd/nwis/qw*).

Field quality-assurance procedures included the collection of sequential and concurrent replicates of suspended-sediment and sequential replicates of bedload samples. Sequential replicates were collected immediately after the primary sample, and concurrent replicates were collected by removing a representative volume of water from the compositing container concurrently with the regular sample. Absolute percent differences between suspended-sediment replicate and primary

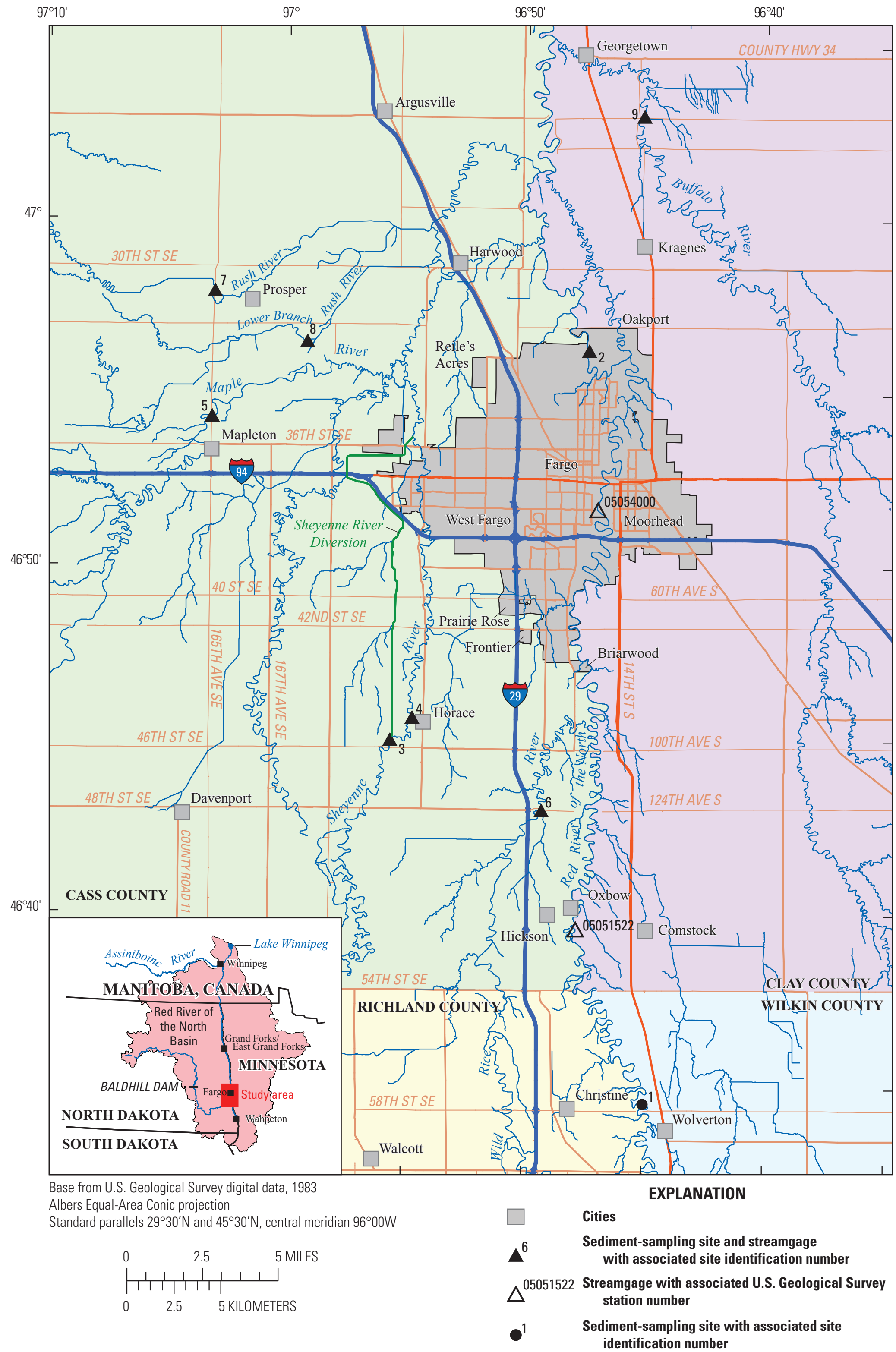

Figure 1. Location of selected sites in the study area.

Table 1. Streamflow and sediment data-collection sites for the Red River of the North and selected tributaries near Fargo, North Dakota, 2011.

Site identification or station number (fig. 1)	USGS station number	Site description	Data collected
1	463421096451000	Red River of the North near Christine, N. Dak.	Sediment
05051522	05051522	Red River of the North near Hickson, N. Dak.	Streamflow
05054000	05054000	Red River of the North at Fargo, N. Dak.	Streamflow
2	465603096472900	Red River of the North at County Road 20 near Fargo, N. Dak.	Streamflow, sediment
3	05059300	Sheyenne River above Diversion near Horace, N. Dak.	Streamflow, sediment
4	05059330	Sheyenne River at Horace, N. Dak. (below diversion)	Streamflow, sediment
5	05060100	Maple River below Mapleton, N. Dak.	Streamflow, sediment
6	464243096495100	Wild Rice River near St. Benedict, N. Dak.	Streamflow, sediment
7	05060550	Rush River near Prosper, N. Dak.	Streamflow, sediment
8	465752096573000	Lower Branch Rush River east of Prosper, N. Dak.	Streamflow, sediment
9	465839096412800	Buffalo River east of Kragnes, Minn.	Streamflow, sediment

samples ranged from 0 to 39 percent in suspended-sediment concentration (SSC), and absolute percent differences between bedload replicate and primary samples ranged from 3 to 182 percent in bedload mass (appendix table 1–1).

Streamflow Data Collection

Streamflow data were collected for use with the sediment-concentration data to calculate sediment loads. Stream stage was measured continuously at all the sampling sites except the Red River of the North near Christine, N. Dak. (table 1, fig. 1). The continuous stage data were used with instantaneous discharge measurements to compute the continuous streamflow from stage-discharge rating curves using methods described in Rantz and others (1982a and 1982b). Data for stream stage and streamflow were stored in the USGS NWIS database (*http://nwis.waterdata.usgs.gov/nd/nwis*). Computed streamflow from the streamgage at the Red River of the North near Hickson, N. Dak. (USGS station number 05051522) was used to compute loads for site 1 (Red River of the North near Christine).

Load Estimation

Constituent load (L) is a function of the volumetric rate of water passing a point in the stream (Q) and the constituent concentration within the water (C). Suspended-sediment loads were estimated using S-LOADEST, a software program based on the FORTRAN version developed by Runkel and others (2004). The S-LOADEST program uses time series streamflow data and SSC to calibrate a regression model that describes suspended-sediment loads in terms of streamflow and various time functions. The software then uses the regression to estimate loads during a specified time period. Regression methods within S-LOADEST used to estimate constituent loads can account for non-normal data distributions, seasonal and long-term cycles, censored data, biases associated with using logarithmic transformations (retransformation bias), and serial correlations of the residuals (Runkel and others, 2004). The regression method uses discrete suspended-sediment samples often collected during several years and a daily streamflow hydrograph. A typical log-linear regression model for estimating load can be expressed with four explanatory variables as:

$$ln\,(L) = \beta_0 + \beta_1 ln(Q_d) + \beta_2 T + \beta_3 sin(2\pi T) + \beta_4\, cos(2\pi T) \qquad (1)$$

where

$ln\,(\,)$ represents the natural logarithm function;
β_0, β_1, β_2, β_3, and β_4 are the coefficients of the model;
Q_d is the daily mean streamflow; and
T is decimal time.

In this model, if a relation between discharge and load exists, then the β_1 coefficient will be significantly (p less than 0.05) different from zero. Temporal trends are identified by β_2, and seasonal effects are identified by β_3 and β_4.

Time (*T*) was not included in the regression analysis as a separate explanatory variable described in this report because the period of data collection was too short (2 years) to describe or identify temporal trends in the data for the regression model. Therefore, for most sites, relations between natural logarithmic transformed *L*, *Q*, and seasonality were used:

$$ln\,(L) = \beta_0 + \beta_1 ln(Q_d) + \beta_3 \sin(2\pi T) + \beta_4\, cos(2\pi T) \qquad (2)$$

For sites 7, 8, and 9, seasonal effects were not included in regressions because only one open-water period of data was collected (2011). Relations between natural logarithmic transformed *L* and *Q* were used for these sites.

As a measure of the fit of the S-LOADEST models, coefficients of determination (R^2) were computed and expressed as a percentage. R^2 is a number, 0 through 1, that when multiplied by 100 is interpreted as the percentage of the variability in the dependent variable, explained by the independent variable(s) and the regression equation (Ryberg, 2006). Generally, a higher R^2 value indicates a better relation. For example, an R^2 of 100 percent indicates that all of the variability in the dependent variable is explained by the independent variable(s); however, a high R^2 does not guarantee the relation is useful (Neter and others, 1996). For example, if estimates require extrapolation outside of the observed independent variables, the estimates may not be accurate. In addition, because the S-LOADEST models were developed in terms of load, and load is a function of flow, R^2 values were expected to be high unless concentrations were highly variable. As a measure of uncertainty in the load estimates, the standard error of prediction (SEP) is provided in S-LOADEST output (Runkel and others, 2004). To compare among sites with large differences in loads, the SEP was expressed as a percentage of the total load for the period.

Suspended-Sediment Concentrations

SSC varied spatially among sites in 2010 and 2011. The least SSC were measured at the Red River (site 1) and the Buffalo River (site 9), and the greatest SSC were measured at the two Sheyenne River sites (sites 3 and 4) (fig. 2; appendix table 1–2). Median SSC ranged from 52 milligrams per liter (mg/L) (site 9) to 476 mg/L (site 3). The greatest range in SSC was measured at the Sheyenne River (site 3) where SSC ranged from 46 to 1,180 mg/L.

SSC varied temporally over the range of hydrologic conditions in 2010 and 2011. The SSCs generally were greatest during the spring events in 2010 and 2011 at the Red River (site 2), the Sheyenne River (sites 3 and 4), the Rush River (site 7), and Lower Branch Rush River (site 8), when the streamflow was the greatest (fig. 3); however, SSC tended to frequently be greater during rainfall-runoff events in the summer months in 2011 than during the spring high-flow events in 2010 and 2011 at the Red River (site 1), Maple River (site 5), Wild Rice River (site 6), and Buffalo River (site 9) (fig. 3). Although SSC was greater during rainfall-runoff events compared to the spring high-flow events , in many instances, the streamflow during the rainfall-runoff events was much less than during the spring high-flow events at these sites. For example, at the Red River (site 1), the greatest measured SSC

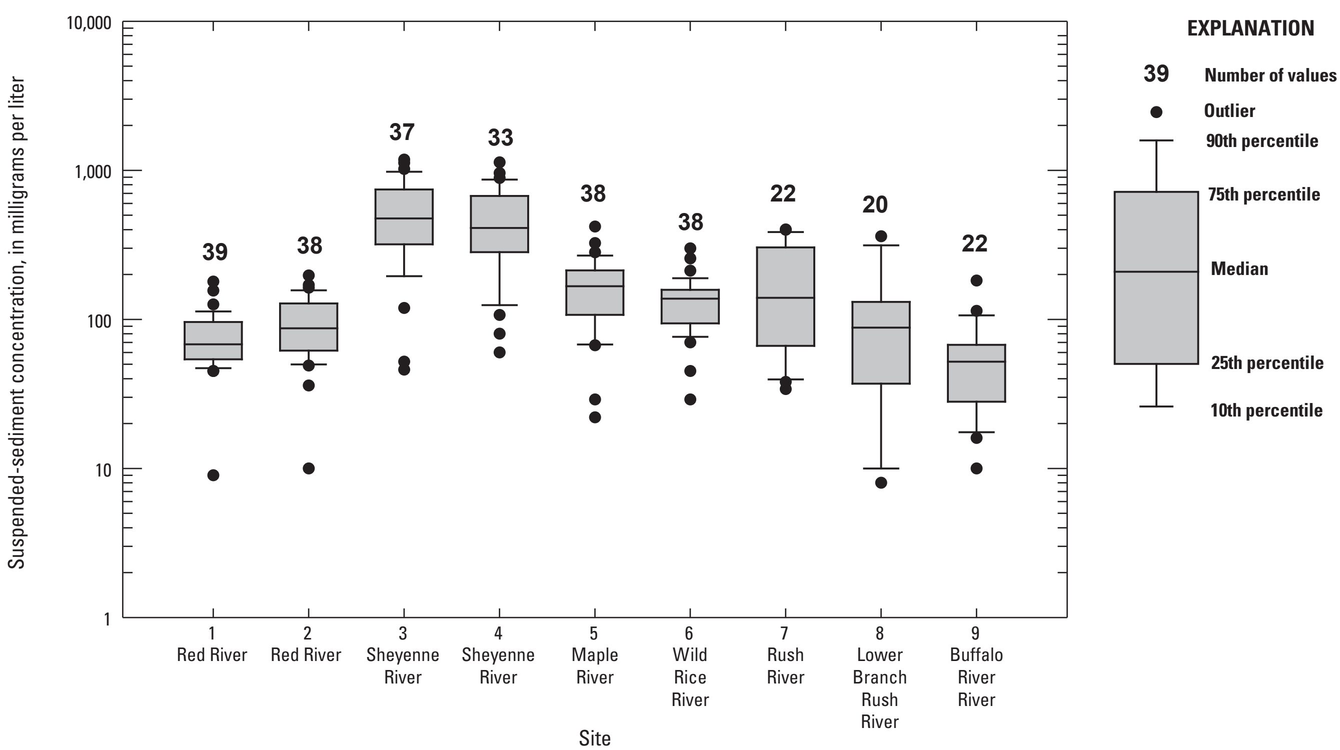

Figure 2. Suspended-sediment concentrations in the Red River of the North and selected tributaries near Fargo, North Dakota, in 2010 and 2011.

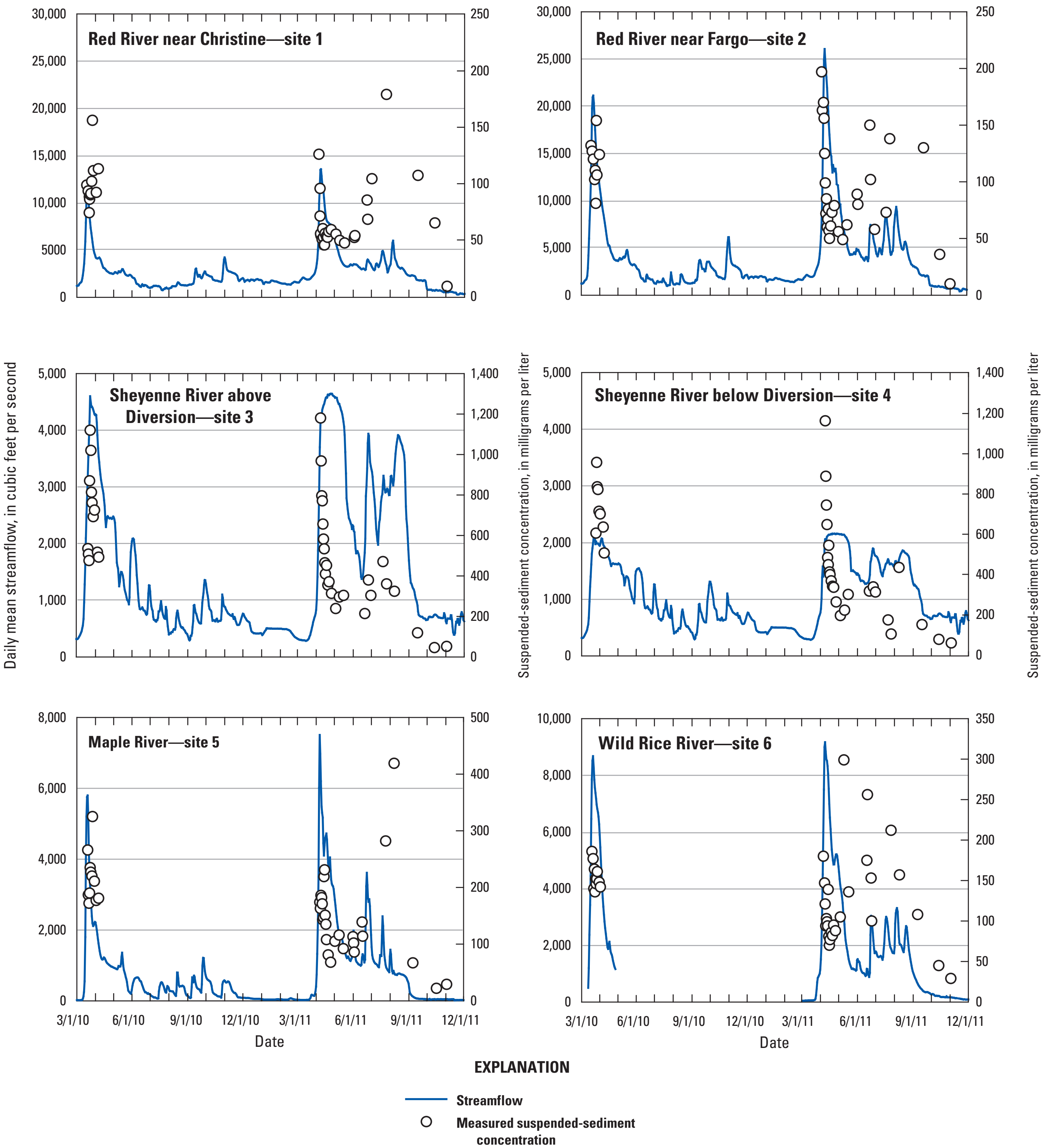

Figure 3. Time series of streamflow and suspended-sediment concentrations in the Red River of the North and selected tributaries near Fargo, North Dakota, in 2010 and 2011.

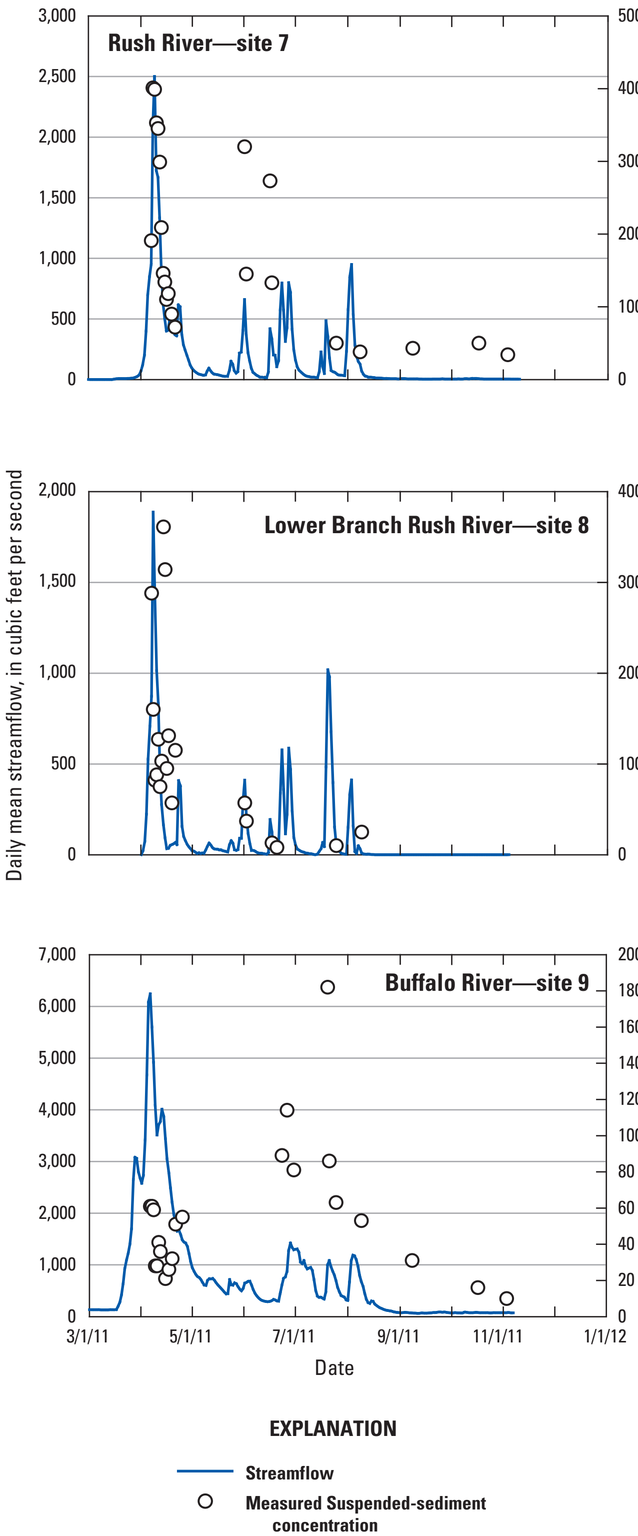

Figure 3. Time series of streamflow and suspended-sediment concentrations in the Red River of the North and selected tributaries near Fargo, North Dakota, in 2010 and 2011.—Continued

(179 mg/L) occurred on July 25, 2011 during a rainfall event at a streamflow of 3,390 cubic feet per second(ft^3/s) compared to the greatest measured SSC during the spring events in 2010 and 2011 (156 mg/L), measured on March 27, 2010 at a streamflow of 5,800 ft^3/s. This occurrence could be attributed to a number of factors. First, rainfall impact can dislodge sediment from the landscape more readily than melting snow (Guy, 1970). This process is dependent on rainfall intensity and rates of rainfall runoff. The relation between streamflow and sediment transport during snowmelt events is less predictable than for rainfall-runoff events, and is more dependent on the distance of the source of sediment to the sampling point than on the rate of runoff as for rainfall events (Porterfield, 1972). Another reason for more sediment movement from rainfall events could be that rainfall events, in general, can more rapidly cause overland flow than snowmelt, which can create more energy to transport sediment from the landscape to the stream channels (Guy, 1970).

Because of the influence of Baldhill Dam near Valley City, N. Dak., an instance of deviation from the typical relation between SSC and streamflow was evident at the Sheyenne River sites (sites 3 and 4) in spring 2011. Unlike most sites, the peak in SSC at the Sheyenne River sites (sites 3 and 4), was sharp even though the streamflow peaks were subdued and prolonged (fig. 3). Streamflow at the Sheyenne River sites is strongly controlled by upstream releases from Baldhill Dam, which alters the natural streamflow hydrograph. Despite the altered streamflow hydrograph, the pattern of SSC was more similar to the other sites, suggesting that the greatest source of sediment during this period was associated with snowmelt, and even though streamflow was increasing upstream, the upstream sediment sources were decreasing.

Estimated Suspended-Sediment Loads

Regression model characteristics varied among the nine sites on the Red River and its tributaries (table 2). Independent variables of streamflow and season explained most of the variability in suspended-sediment loads, as indicated by R^2 values that ranged from 78 percent at the Red River at Christine (site 1) to 98 percent at the Rush River (site 7). As indicated by the SEP, uncertainty in the total load estimates were least at Wild Rice River (site 6, 4.9 percent), and greatest at the Lower Branch Rush River (site 8, 39.0 percent). The Lower Branch Rush River and the Buffalo River had the greatest amount of uncertainty in load estimates, as indicated by SEP's of 13.8 and 39.0 percent of the total load, respectively. The higher SEP at these sites may be partially attributed to the shorter period of record compared to the other sites. The higher SEP also may be attributed to backwater conditions that occurred during the spring snowmelt event in 2011, when velocities needed to transport suspended sediment at the sites were greatly reduced at the higher streamflow conditions, therefore altering the relation between streamflow and SSC.

The daily loads estimated using the regressions developed in S-LOADEST also were compared to the measured daily load, which was calculated by multiplying the measured SSC times the daily mean streamflow (and a unit conversion factor) on days when samples were collected. Mean differences were 10 percent or less between the daily load estimates from S-LOADEST and the calculated measured daily loads for all of the sites, with the exception of the Lower Branch Rush River (site 8) and Buffalo River (site 9), which had mean differences of 41 percent and 18 percent, respectively (table 2).

Estimated daily suspended-sediment loads were highly variable in 2010 and 2011 in the Red River and its tributaries, with the greatest loads occurring in the spring and the smallest loads occurring in the winter (fig. 4). Although suspended-sediment samples were not collected during the winter, for sites where daily streamflow was available throughout the winter, daily loads were estimated. As a measure of error associated with daily load estimates, the upper and lower 95-percent confidence intervals are presented on figure 4. For the Red River, daily suspended-sediment loads ranged from 26 to 3,500 tons per day (tons/d) at site 1 and from 30 to 9,010 tons/d at site 2. The mean daily load was 356 tons/d in 2010 and 574 tons/d in 2011 for site 1, and 574 tons/d in 2010 and 931 tons/d in 2011 for site 2. For the Sheyenne River, daily suspended-sediment loads ranged from less than 10 to 10,200 tons/d at site 3, and from less than 10 to 4,530 tons/d at site 4. The mean daily load was 695 tons/d in 2010 and 1,530 tons/d in 2011 for site 3, and 509 tons/d in 2010 and 704 tons/d in 2011 for site 4. Estimated daily loads ranged from less than 10 to 5,440 tons/d at the Maple River (site 5), and from less than 10 to 3,360 at the Wild Rice River (site 6). The mean daily load was 191 tons/d in 2010 and 377 tons/d in 2011 for the Maple River, and 610 tons/d in 2011 for the Wild Rice River (annual loads were not computed for 2010). For the three sites that were only sampled in 2011 (sites 7, 8 and 9), the mean daily suspended-sediment loads ranged from 40 tons/d at the Lower Branch Rush River (site 8) to 118 tons/d at the Buffalo River (site 9). Estimated daily loads ranged from less than 10 to 2,160 tons/d at the Rush River (site 7), from less than 10 to 1,120 tons/d at the Lower Branch Rush River (site 8), and from less than 10 to 1,140 tons/d at the Buffalo River (site 9) in 2011. Although SSC measured during rainfall-runoff events were greater than SSC measured during the spring snowmelt periods in 2010 and 2011 at many of the sites (fig. 3), the estimated daily loads were greatest during the spring snowmelt periods at all of the sites, mainly because of the larger volume of streamflow that occurred at the sites in the spring compared to the summer events (fig. 4).

In spring 2011, instances of deviation from the typical relation between SSC and streamflow were evident for the Sheyenne River (sites 3 and 4), the Lower Branch Rush River (site 8), and the Buffalo River (site 9), which resulted in higher variability in the estimated daily load, as indicated by large confidence intervals (fig. 4). The daily suspended-sediment loads estimated using S-LOADEST for the Sheyenne River (sites 3 and 4) did not accurately reflect the measured

Table 2. Regression model characteristics and results for estimates of suspended-sediment loads for the Red River of the North and selected tributaries near Fargo, North Dakota for 2010 and 2011.

[ID, identification; ft^3/s, cubic feet per second; tons/d, tons per day]

Site ID number (fig. 1)	Site description	Number of samples	Range of streamflow (in ft^3/s) for developing regression	Coefficient of determination	Standard error of prediction as a percent of total load from March 2010 through November 2011	Mean difference in daily loads from calculated loads (calculated-estimated loads), in tons/d	Mean percent difference in daily loads from calculated loads
1	Red River of the North near Christine, N. Dak.	39	526–13,550	78	6.0	146	10
2	Red River of the North at County Road 20 near Fargo, N. Dak.	38	692–26,100	85	6.5	338	10
3	Sheyenne River above Diversion near Horace, N. Dak.	37	595–4,640	90	6.5	169	7
4	Sheyenne River at Horace, N. Dak. (below Diversion)	33	595–2,160	81	6.5	52	8
5	Maple River below Mapleton, N. Dak.	38	41–7,510	93	6.9	225	9
6	Wild Rice River near St. Benedict, N. Dak.	38	165–9,170	90	4.9	57	6
7	Rush River near Prosper, N. Dak.	22	4–2,500	98	[1]11.5	-74	7
8	Lower Branch Rush River east of Prosper, N. Dak.	20	7–1,770	80	[1]39.0	53	41
9	Buffalo River east of Kragnes, Minn.	22	76–6,360	85	[1]13.8	74	18

[1]Standard error of prediction only computed from April to November 2011.

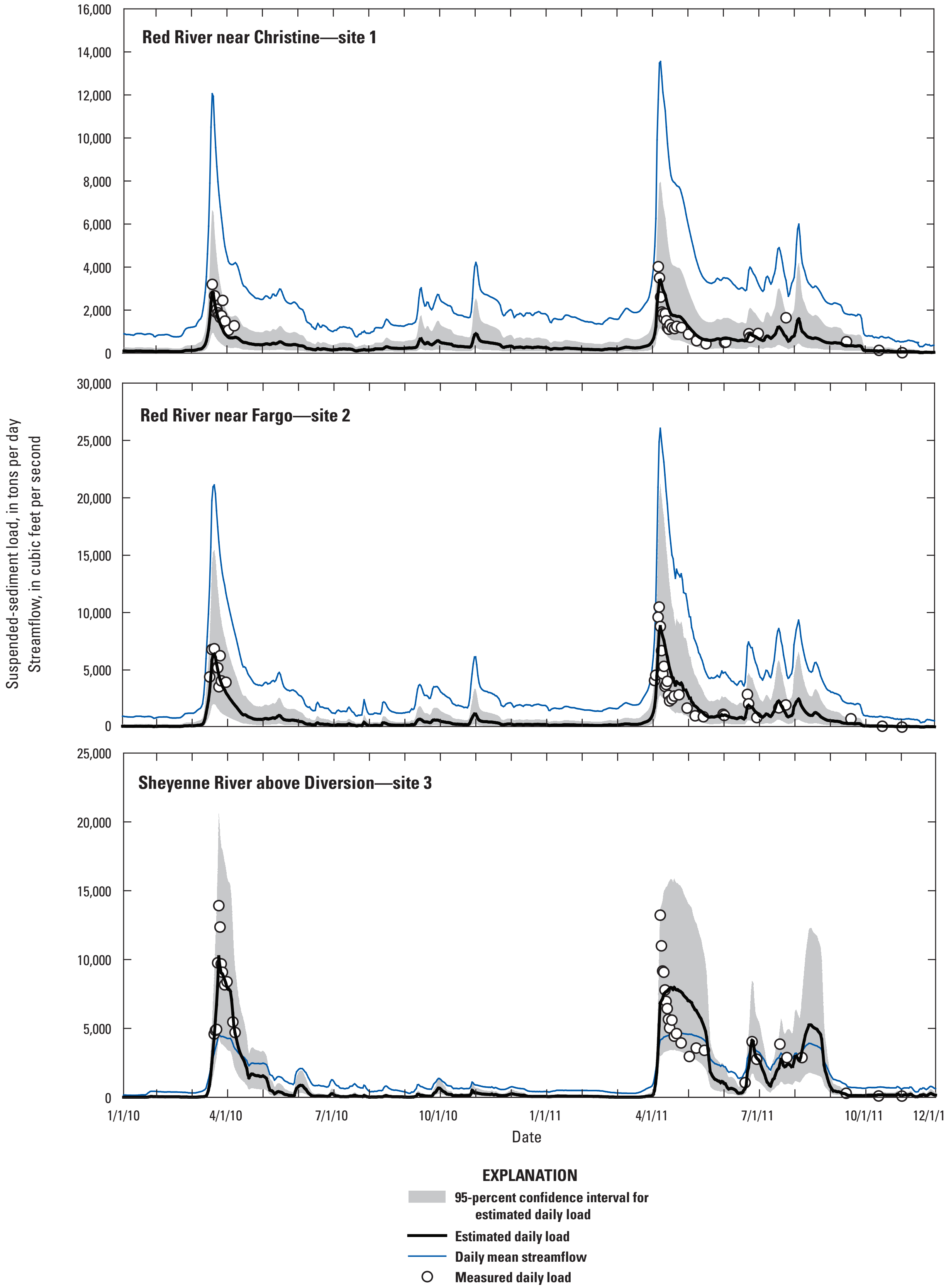

Figure 4. Streamflow and estimated daily suspended-sediment loads for the Red River of the North and selected tributaries near Fargo, North Dakota for 2010 and 2011.

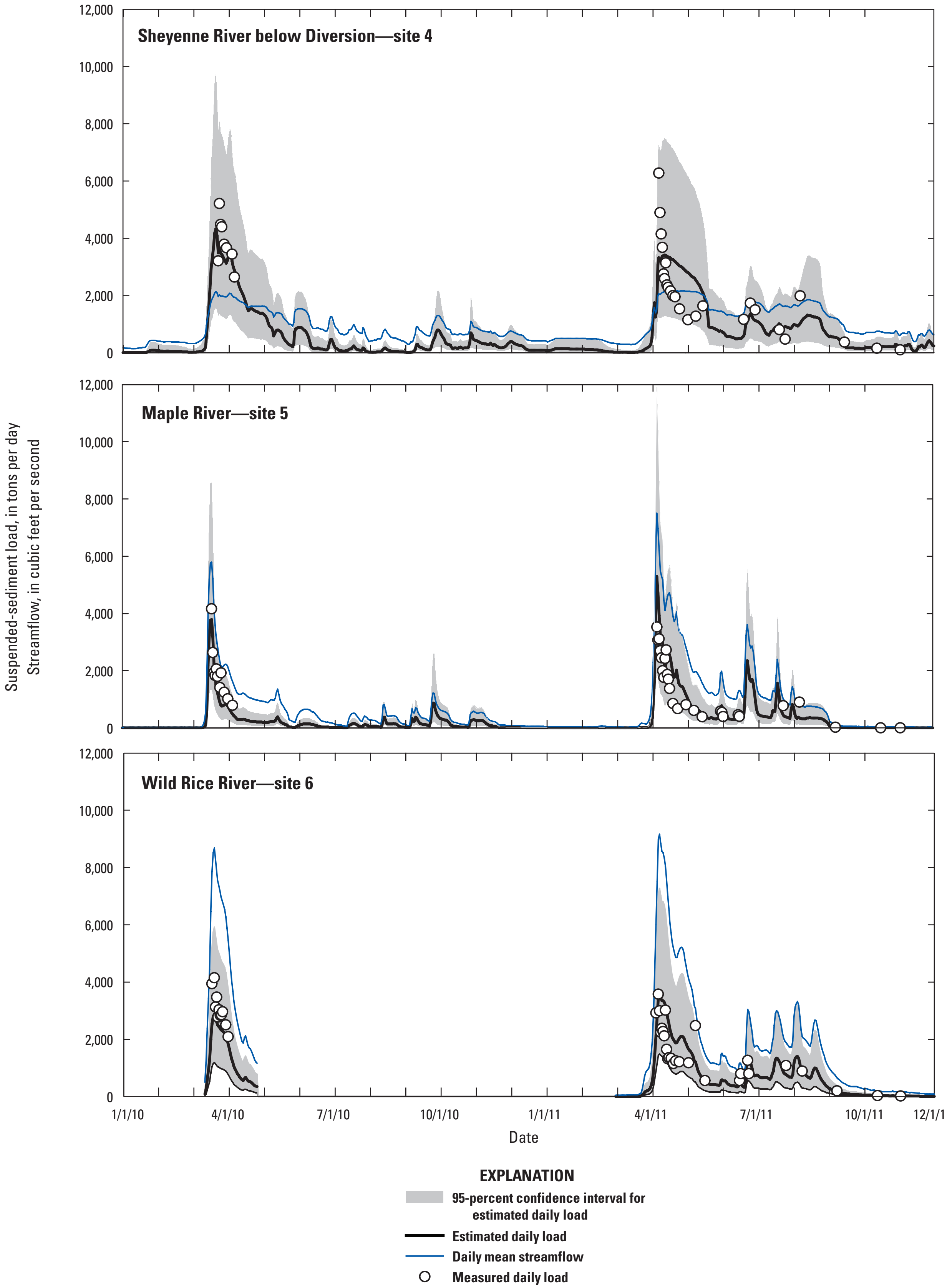

Figure 4. Streamflow and estimated daily suspended-sediment loads for the Red River of the North and selected tributaries near Fargo, North Dakota for 2010 and 2011.—Continued

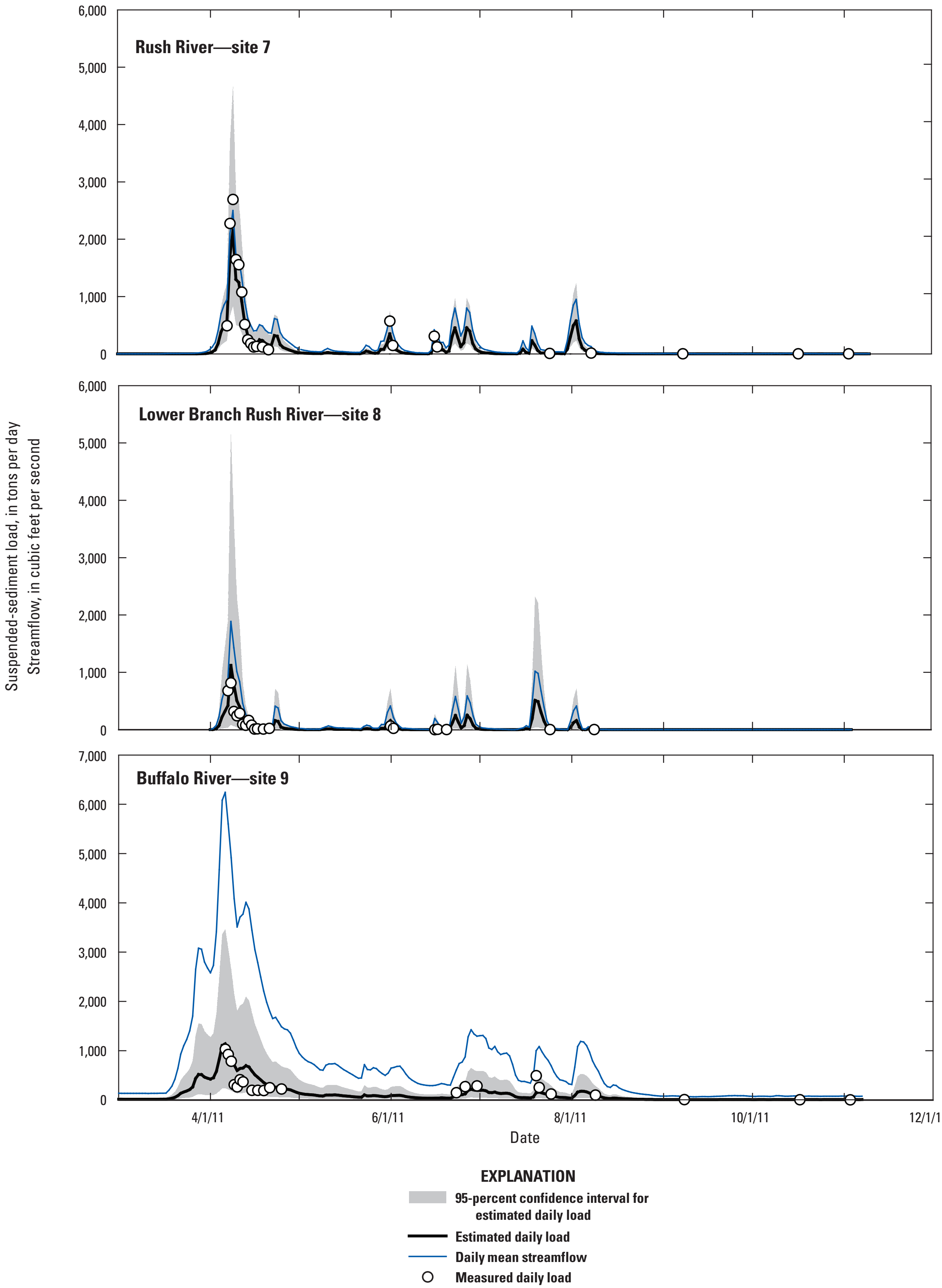

Figure 4. Streamflow and estimated daily suspended-sediment loads for the Red River of the North and selected tributaries near Fargo, North Dakota for 2010 and 2011.—Continued

sediment load during the spring high-flow events, particularly in 2011, because of the influence of regulated flows (fig. 4). For these sites, within S-LOADEST, streamflow and seasonality were used to estimate the daily sediment load. Although the measured sediment load indicated a similar rise, peak, and fall during the spring high-flow event as the other sites, the estimated suspended-sediment load using S-LOADEST followed a different pattern because of the influence of releases from Baldhill Dam. As a result, daily loads were underestimated on the rise in the streamflow hydrograph and overestimated for the remainder of the spring high-flow event (fig. 4). Similarly, the daily suspended-sediment load using S-LOADEST for the Lower Branch of the Rush River and the Buffalo River did not accurately reflect the measured sediment load during the spring high-flow event in 2011 because of the influence of backwater conditions (fig. 4). Backwater conditions occurred shortly after the peak in the streamflow hydrograph, which resulted in a considerable decrease in measured suspended-sediment loads, but estimated loads were much higher, resulting in an overestimation of loads for the remainder of the spring high-flow event (fig. 4). High variability in the estimated daily loads as demonstrated by the confidence interval during certain periods in 2010 and 2011 (fig. 4), particularly at the Sheyenne River (sites 3 and 4), the Lower Branch of the Rush River (site 8), and the Buffalo River (site 9), may be reduced by including additional explanatory variables into the regression analyses used for estimating the daily loads.

One variable that has been frequently used to explain the variability in SSC and load is turbidity (Ryberg, 2006; Uhrich and Bragg, 2003; Galloway and others, 2008; Christensen and others, 2000). Turbidity is an expression of the optical properties of a sample that cause light rays to be scattered and absorbed (Gray and Glysson, 2003). Turbidity of water is caused by the presence of suspended and dissolved inorganic matter, such as clay and silt; suspended and dissolved organic matter, such as plankton, microscopic organisms, small terrestrial organic material, and organic acids; and water color. Turbidity may provide an additional explanatory variable for SSC, and under backwater conditions and controlled releases, may reflect the decreasing concentration of SSC, resulting in an overall improved daily load estimation.

Monthly suspended-sediment loads were computed from the estimated daily loads for the open-water period (March-November) at the nine sites on the Red River and its tributaries for 2010 and 2011 (table 3). With the exception of the Sheyenne River (site 4), the greatest monthly loads occurred in March for 2010, with as little as 27 percent (site 1) and as much as 42 percent (site 3) of the 2010 annual load occurring in March. For 2011, the greatest monthly loads occurred in April, ranging from 33 percent (site 1) to 63 percent (site 7) of the 2011 annual load. The least loads generally occurred in July and August in 2010, and in October and November in 2011 (table 3).

For sites that had estimated loads in 2010 and 2011 (sites 1–5), estimated annual (March-November) suspended-sediment loads were greater in 2011 compared to 2010 (table 3). Annual loads were greater in 2011 primarily because annual streamflow was greater in 2011 than in 2010 at most sites. In 2010, annual loads ranged from 68,650 tons per year (tons/yr) at the Maple River (site 5) to 249,040 tons/yr at the Sheyenne River (site 3). In 2011, when all nine sites were sampled, annual loads ranged from 8,716 tons/yr at the Lower Branch Rush River (site 8) to 552,832 tons/yr at the Sheyenne River (site 3). Annual loads in 2011 at the Sheyenne River (site 3) and at the Maple River (site 5) were more than twice the annual loads estimated for those sites in 2010.

Bedload

A relatively small amount of sediment was transported past the nine sites as bedload in 2010 and 2011 (appendix table 1–3). Bedload was greater than 10 tons/d in about 70 percent of the samples collected at the Red River (site 1), 9 percent of the samples at the Red River (site 2), 10 percent of the samples at the Sheyenne River (site 4), 15 percent of the samples at the Maple River (site 5), and 20 percent of the samples at the Wild Rice River (site 6). The remaining sites (sites 3, 7, 8, and 9) did not have any measured bedload greater than 10 tons/d (appendix table 1–3). For most of the samples collected at the nine sites, bedload contributed less than 1 percent of the calculated daily total sediment load. For a few samples collected at the Red River (site 1), which generally had the greatest bedload among the sites, the bedload composed from 10 to 50 percent of the calculated daily total sediment load (appendix tables 1–2 and 1–3). The amount of material transported in a stream as bedload is largely dependent on the velocities in the stream cross-section and the size of the sediment particles in the bed material available for transport. Although bed material large enough to be transported in the bedload was measured in the streambed at many of the sites (appendix table 1–4), the low transport rates may be attributed to the low gradients in the basin, and therefore, low stream velocities that generally would not generate enough energy to move a substantial amount of sediment in the bedload.

Table 3. Estimated monthly and annual loads for the Red River of the North and selected tributaries near Fargo, North Dakota during 2010 and 2011.

[--, not computed; <, less than]

Month	Estimated monthly loads, in tons (site numbers from fig. 1 and table 1)								
	Red River site 1	Red River site 2	Sheyenne River site 3	Sheyenne River site 4	Maple River site 5	Wild Rice River site 6	Rush River site 7	Lower Branch Rush River site 8	Buffalo River site 9
March 2010	31,000	77,000	105,000	55,800	29,700	39,200	--	--	--
April 2010	16,100	41,200	97,800	64,000	10,400	20,200	--	--	--
May 2010	13,100	22,900	15,800	22,700	5,140	--	--	--	--
June 2010	6,260	9,450	8,590	11,600	2,550	--	--	--	--
July 2010	4,910	6,650	2,450	3,740	1,860	--	--	--	--
August 2010	6,710	6,560	1,300	1,610	3,390	--	--	--	--
September 2010	12,400	13,300	4,910	6,260	7,420	--	--	--	--
October 2010	12,600	13,000	7,310	9,810	4,690	--	--	--	--
November 2010	13,500	13,800	5,880	8,560	3,500	--	--	--	--
March 2011	8,450	9,850	812	1,460	138	1,520	27	--	3,770
April 2011	58,800	140,000	187,000	83,400	65,400	67,800	12,600	4,700	15,200
May 2011	23,600	47,000	131,000	56,800	18,000	26,100	712	296	2,740
June 2011	20,300	33,600	40,700	22,600	23,800	18,300	3,740	1,550	2,410
July 2011	24,600	40,500	60,600	27,100	17,400	25,200	905	1,780	3,280
August 2011	25,100	41,500	116,000	33,500	11,600	25,200	1,940	390	1,690
September 2011	11,200	12,000	8,240	9,720	801	4,030	12	<1	225
October 2011	2,980	3,160	4,920	6,600	176	936	15	<1	235
November 2011	1,480	1,830	4,560	6,650	101	336	--	--	--
Annual load 2010 (March–November)	116,580	203,860	249,040	184,080	68,650	--	--	--	--
Annual load 2011 (March–November)	176,510	329,440	553,832	247,830	137,416	169,422	19,952	8,716	29,550

Summary

Natural-resource agencies are concerned about possible geomorphic effects of a proposed diversion project to reduce the flood risk in the Fargo-Moorhead metropolitan area. The U.S. Geological Survey in cooperation with the U.S. Army Corps of Engineers collected data in the spring of 2010 and 2011, and from June to November 2011, during rainfall-runoff events and base-flow conditions to provide information on sediment transport. The data were used to examine sediment concentrations, loads, and particle-size distributions at nine selected sites in the Red River and its tributaries near the Fargo-Moorhead metropolitan area.

Suspended-sediment concentration varied spatially among sites in 2010 and 2011. The least suspended-sediment concentrations were measured at the Red River (site 1) and the Buffalo River (site 9), and the greatest concentrations were measured at the two Sheyenne River sites (sites 3 and 4).

Suspended-sediment concentration varied temporally over the range of hydrologic conditions in 2010 and 2011. The suspended-sediment concentrations generally were greatest during the spring events in 2010 and 2011 at the Red River (site 2), the Sheyenne River (sites 3 and 4), the Rush River (site 7), and Lower Branch Rush River (site 8), when the streamflow was the greatest; however, suspended-sediment concentration tended to frequently be greater during rainfall-runoff events in the summer months in 2011 than during the spring high-flow events in 2010 and 2011 at the Red River (site 1), Maple River (site 5), Wild Rice River (site 6), and Buffalo River (site 9).

Estimated daily suspended-sediment loads were highly variable in 2010 and 2011 in the Red River and its tributaries, with the greatest loads occurring in the spring and the smallest loads occurring in the winter. For the Red River, daily suspended-sediment loads ranged from 26 to 3,500 tons per day at site 1 and from 30 to 9,010 tons per day at site 2. For the Sheyenne River, daily loads ranged from less than 10 to 10,200 tons per day at site 3 and from less than 10 to 4,530 tons per day at site 4. The mean daily load was 191 tons per day in 2010 and 377 tons per day in 2011 for the Maple River, and 610 tons per day in 2011 for the Wild Rice River (annual loads were not computed for 2010). For the three sites that were only sampled in 2011 (sites 7, 8 and 9), the mean daily suspended-sediment loads ranged from 40 tons per day at the Lower Branch Rush River (site 8) to 118 tons per day at the Buffalo River (site 9).

Monthly suspended-sediment loads were computed from the estimated daily loads for the open-water period (March–November) at the nine sites on the Red River and its tributaries for 2010 and 2011. With the exception of the Sheyenne River (site 4), the greatest monthly loads occurred in March for 2010, with as little as 27 percent (site 1) and as much as 42 percent (site 3) of the 2010 annual load occurring in March. For 2011, the greatest monthly loads occurred in April, ranging from 33 percent (site 1) to 63 percent (site 7) of the 2011 annual load. The least loads generally occurred in July and August in 2010 and in October and November in 2011.

For sites that had estimated loads in 2010 and 2011 (sites 1–5), estimated annual (March–November) suspended-sediment loads were greater in 2011 compared to 2010. Annual loads were greater in 2011 primarily because the annual streamflow was greater in 2011 than in 2010 at most sites. In 2010, annual loads ranged from 68,650 tons per year at the Maple River (site 5) to 249,040 tons per year at the Sheyenne River (site 3). In 2011, when all nine sites were sampled, annual loads ranged from 8,716 tons per year at the Lower Branch Rush River (site 8) to 552,832 tons per year at the Sheyenne River (site 3). Annual loads in 2011 at the Sheyenne River (site 3) and at the Maple River (site 5) were more than twice the annual loads estimated for those sites in 2010.

A relatively small amount of sediment was transported past the nine sites as bedload in 2010 and 2011. For most of the samples collected at the nine sites, the bedload composed less than 1 percent of the calculated daily total sediment load. For a few samples collected at the Red River (site 1), which generally had the greatest bedload among the sites, bedload contributed from 10 to 50 percent of the calculated daily total sediment load. Although material large enough to be transported in the bedload was measured in the streambed at many of the sites, the low transport rates may be attributed to the low gradients in the basin, and therefore, low stream velocities that generally would not generate enough energy to move a substantial amount of sediment in the bedload.

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Appendix 1

Table 1–1. Results of quality-assurance samples for suspended-sediment concentration and bedload mass for selected samples collected during 2010 and 2011 at the Red River of the North and selected tributaries near Fargo, North Dakota.

Site	Date	Sample	Replicate	Replicate type	Absolute percent difference[1]
Bedload mass (grams)					
Sheyenne River above Diversion near Horace (site 3)	04/05/2010	56	410	Sequential	152
Maple River below Mapleton (site 5)	04/02/2010	140	451	Sequential	105
Wild Rice River near St. Benedict (site 6)	03/30/2010	3	7	Sequential	80
Rush River near Prosper (site 7)	04/11/2011	279	102	Sequential	93
Red River of the North near Christine (site 1)	04/11/2011	1,133	905	Sequential	22
Sheyenne River below Diversion at Horace (site 4)	04/12/2011	1,298	892	Sequential	37
Sheyenne River above Diversion near Horace (site 3)	04/16/2011	49	24	Sequential	69
Sheyenne River below Diversion at Horace (site 4)	04/18/2011	200	16	Sequential	170
Red River of the North near Christine (site 1)	05/02/2011	310	354	Sequential	13
Sheyenne River below Diversion at Horace (site 4)	05/03/2011	43	53	Sequential	21
Sheyenne River below Diversion at Horace (site 4)	05/03/2011	43	911	Sequential	182
Sheyenne River below Diversion at Horace (site 4)	05/10/2011	343	363	Sequential	5
Maple River below Mapleton (site 5)	06/16/2011	49	24	Sequential	68
Red River of the North near Christine (site 1)	06/23/2011	661	788	Sequential	18
Sheyenne River above Diversion near Horace (site 3)	06/30/2011	294	88	Sequential	108
Sheyenne River below Diversion at Horace (site 4)	07/21/2011	181	34	Sequential	137
Maple River below Mapleton (site 5)	08/08/2011	200	47	Sequential	124
Wild Rice River near St. Benedict (site 6)	08/09/2011	8.5	2.8	Sequential	101
Wild Rice River near St. Benedict (site 6)	09/08/2011	32	78	Sequential	83
Red River of the North near Christine (site 1)	09/15/2011	750	774	Sequential	3
Red River of the North at County Road 20 near Fargo (site 2)	09/20/2011	4	6	Sequential	42
Suspended-sediment concentration (milligrams per liter)					
Red River of the North near Christine (site 1)	04/06/2010	113	116	Concurrent	3
Red River of the North near Fargo (site 2)	03/27/2010	106	107	Concurrent	1
Sheyenne River above Diversion near Horace (site 3)	03/29/2010	693	1030	Concurrent	39
Sheyenne River above Diversion near Horace (site 3)	04/05/2010	517	529	Concurrent	2
Sheyenne River at Horace (site 4)	03/27/2010	821	825	Concurrent	0
Maple River below Mapleton (site 5)	03/27/2010	325	318	Concurrent	2
Maple River below Mapleton (site 5)	04/02/2010	177	174	Concurrent	2
Wild Rice River near St. Benedict (site 6)	03/30/2010	148	151	Concurrent	2
Maple River below Mapleton (site 5)	04/11/2011	171	162	Concurrent	5
Red River of the North at County Road 20 near Fargo (site 2)	04/12/2011	85	80	Sequential	6
Red River of the North near Christine (site 1)	04/16/2011	57	56	Concurrent	2
Red River of the North near Christine (site 1)	04/18/2011	54	55	Sequential	2
Red River of the North near Christine (site 1)	04/20/2011	53	41	Concurrent	26
Rush River near Prosper (site 7)	04/21/2011	72	66	Concurrent	9
Lower Branch Rush River east of Prosper (site 8)	04/21/2011	115	96	Sequential	18
Maple River below Mapleton (site 5)	05/09/2011	116	119	Sequential	3
Wild Rice River near St. Benedict (site 6)	05/17/2011	136	134	Concurrent	1
Red River of the North near Christine (site 1)	06/03/2011	54	51	Concurrent	6
Wild Rice River near St. Benedict (site 6)	06/17/2011	256	263	Concurrent	3

Table 1–1. Results of quality-assurance samples for suspended-sediment concentration and bedload mass for selected samples collected during 2010 and 2011 at the Red River of the North and selected tributaries near Fargo, North Dakota.—Continued

Site	Date	Sample	Replicate	Replicate type	Absolute percent difference[1]
Suspended-sediment concentration (milligrams per liter)—Continued					
Red River of the North at County Road 20 near Fargo (site 2)	06/24/2011	102	98	Sequential	4
Buffalo River east of Kragnes (site 9)	06/30/2011	81	76	Concurrent	6
Sheyenne River above Diversion near Horace (site 3)	07/20/2011	471	469	Concurrent	0
Maple River below Mapleton (site 5)	07/25/2011	282	294	Sequential	4
Sheyenne River below Diversion at Horace (site 4)	07/26/2011	107	122	Sequential	13
Rush River near Prosper (site 7)	08/08/2011	38	41	Concurrent	8
Lower Branch Rush River east of Prosper (site 8)	08/09/2011	25	18	Sequential	33
Buffalo River east of Kragnes (site 9)	09/08/2011	31	28	Concurrent	10
Sheyenne River below Diversion at Horace (site 4)	09/15/2011	151	151	Concurrent	0
Maple River below Mapleton (site 5)	11/03/2011	29	26	Sequential	11

[1]Calculation of absolute percent difference is: $|(x_1-x_2)/(x_1+x_2)/2|(100)$, where x_1 = sample, x_2 = sequential or concurrent samples.

Table 1–2. Streamflow, suspended-sediment concentrations, loads, fall diameters, and sieve diameters for the Red River of the North and selected tributaries near Fargo, North Dakota for 2010 and 2011.

[ft^3/s, cubic feet per second; mg/L, milligram per liter; tons/d, tons per days; mm, millimeter; --, no value; IM, insufficient material for analysis; <, less than]

Date	Daily mean streamflow (ft^3/s)	Suspended-sediment concentration (mg/L)	Calculated suspended-sediment load (tons/d)	Suspended-sediment fall diameter (percent in range)							Percent finer than suspended-sediment sieve diameter of 0.062 mm
				0.002–.004 mm	0.004–.008 mm	0.008–.016 mm	0.016–.0062 mm	0.062–.125 mm	0.125–.250 mm	0.250–.500 mm	
Red River of the North near Christine (site 1)											
03/18/2010	12,000	98	3,180	--	--	--	--	IM	IM	IM	96
03/20/2010	10,600	93	2,660	--	--	--	--	IM	IM	IM	99
03/21/2010	9,550	74	1,910	--	--	--	--	IM	IM	IM	95
03/22/2010	8,660	87	2,030	--	--	--	--	IM	IM	IM	97
03/23/2010	7,960	87	1,870	--	--	--	--	IM	IM	IM	97
03/24/2010	7,340	89	1,760	--	--	--	--	IM	IM	IM	96
03/25/2010	6,790	90	1,650	--	--	--	--	IM	IM	IM	95
03/26/2010	6,290	102	1,730	--	--	--	--	IM	IM	IM	95
03/27/2010	5,800	156	2,440			[1]83		13	4	0	--
03/29/2010	4,960	111	1,490			[1]90		7	2	1	--
04/01/2010	4,260	92	1,060			[1]93		6	1	0	--
04/06/2010	4,160	113	1,270			[1]89		8	2	1	--
04/06/2011	11,800	126	4,010			[1]99		0	0	1	--
04/07/2011	13,500	96	3,500			[1]96		2	2	0	--
04/08/2011	13,600	71	2,610	IM	IM	IM	IM	IM	IM	IM	99
04/09/2011	12,900	55	1,920	IM	IM	IM	IM	IM	IM	IM	98
04/10/2011	12,100	56	1,830	IM	IM	IM	IM	IM	IM	IM	99
04/11/2011	11,700	51	1,610	IM	IM	IM	IM	IM	IM	IM	96
04/12/2011	11,200	60	1,810	IM	IM	IM	IM	IM	IM	IM	95
04/13/2011	10,500	53	1,500	IM	IM	IM	IM	IM	IM	IM	95
04/14/2011	9,730	45	1,180	IM	IM	IM	IM	IM	IM	IM	98
04/15/2011	9,120	45	1,110	IM	IM	IM	IM	IM	IM	IM	96
04/16/2011	8,600	57	1,320	IM	IM	IM	IM	IM	IM	IM	97
04/18/2011	8,050	54	1,170	IM	IM	IM	IM	IM	IM	IM	96
04/20/2011	7,920	53	1,130	IM	IM	IM	IM	IM	IM	IM	96
04/22/2011	7,780	59	1,240			[1]92		2	6	0	--

Table 1–2. Streamflow, suspended-sediment concentrations, loads, fall diameters, and sieve diameters for the Red River of the North and selected tributaries near Fargo, North Dakota for 2010 and 2011.—Continued

[ft³/s, cubic feet per second; mg/L, milligram per liter; tons/d, short tons per days; mm, millimeter; IM, insufficient material for analysis; --, no value; <, less than]

Date	Daily mean streamflow (ft³/s)	Suspended-sediment concentration (mg/L)	Calculated suspended-sediment load (tons/d)	Suspended-sediment fall diameter (percent in range)							Percent finer than suspended-sediment sieve diameter of 0.062 mm
				0.002–.004 mm	0.004–.008 mm	0.008–.016 mm	0.016–.0062 mm	0.062–.125 mm	0.125–.250 mm	0.250–.500 mm	
Red River of the North near Christine (site 1)—Continued											
04/26/2011	7,430	59	1,180	IM	IM	IM	IM	IM	IM	IM	96
05/02/2011	5,920	55	879	IM	IM	IM	IM	IM	IM	IM	87
05/09/2011	4,300	49	569	IM	IM	IM	IM	IM	IM	IM	89
05/17/2011	3,360	47	426	IM	IM	IM	IM	IM	IM	IM	82
06/02/2011	3,500	52	491	IM	IM	IM	IM	IM	IM	IM	89
06/03/2011	3,480	54	507	IM	IM	IM	IM	IM	IM	IM	90
06/23/2011	3,860	86	896	IM	IM	IM	IM	IM	IM	IM	100
06/24/2011	3,990	68	733	IM	IM	IM	IM	IM	IM	IM	92
07/01/2011	3,240	104	910	IM	IM	IM	IM	IM	IM	IM	97
07/25/2011	3,390	179	1,640	IM	IM	IM	IM	IM	IM	IM	95
09/15/2011	1,820	107	526	IM	IM	IM	IM	IM	IM	IM	96
10/13/2011	706	65	124	IM	IM	IM	IM	IM	IM	IM	98
11/02/2011	526	9	13	IM	IM	IM	IM	IM	IM	IM	83
Mean	**7,241**	**77**	**1,484**	**92**	**--**	**--**	**--**	**5**	**2**	**0**	**95**
Median	**7,430**	**68**	**1,320**	**92**	**--**	**--**	**--**	**6**	**2**	**0**	**96**
Red River of the North at County Road 20 near Fargo (site 2)											
03/17/2010	12,300	132	4,380	--	--	--	--	IM	IM	IM	96
03/19/2010	19,800	127	6,790	--	--	--	--	IM	IM	IM	97
03/21/2010	21,100	120	6,840	--	--	--	--	IM	IM	IM	97
03/23/2010	18,900	102	5,200	--	--	--	--	IM	IM	IM	96
03/23/2010	17,500	112	5,290	--	--	--	--	IM	IM	IM	100
03/24/2010	16,100	110	4,780	--	--	--	--	IM	IM	IM	96
03/25/2010	15,000	81	3,280	--	--	--	--	IM	IM	IM	97
03/26/2010	14,100	154	5,860			[1]97		2	1	0	--
03/27/2010	11,700	106	3,350				IM	IM	IM	IM	96
03/31/2010	11,800	124	3,950				IM	IM	IM	IM	98

Table 1–2. Streamflow, suspended-sediment concentrations, loads, fall diameters, and sieve diameters for the Red River of the North and selected tributaries near Fargo, North Dakota for 2010 and 2011.—Continued

[ft^3/s, cubic feet per second; mg/L, milligram per liter; tons/d, short tons per days; mm, millimeter; IM, insufficient material for analysis; --, no value; <, less than]

Date	Daily mean streamflow (ft^3/s)	Suspended-sediment concentration (mg/L)	Calculated suspended-sediment load (tons/d)	Suspended-sediment fall diameter (percent in range)							Percent finer than suspended-sediment sieve diameter of 0.062 mm
				0.002–.004 mm	0.004–.008 mm	0.008–.016 mm	0.016–.0062 mm	0.062–.125 mm	0.125–.250 mm	0.250–.500 mm	
Red River of the North at County Road 20 near Fargo (site 2)—Continued											
04/04/2011	7,660	197	4,070		[1]99			1	0	0	--
04/05/2011	10,300	163	4,530		[1]99			0	1	0	--
04/07/2011	20,900	170	9,590		[1]98			1	1	0	--
04/08/2011	24,900	156	10,500		[1]99			1	0	0	--
04/09/2011	26,000	125	8,780	IM	IM	IM	IM	IM	IM	IM	100
04/10/2011	25,000	99	6,680	IM	IM	IM	IM	IM	IM	IM	99
04/11/2011	24,000	72	4,670	IM	IM	IM	IM	IM	IM	IM	98
04/12/2011	23,100	85	5,300	IM	IM	IM	IM	IM	IM	IM	99
04/13/2011	22,000	60	3,560	IM	IM	IM	IM	IM	IM	IM	99
04/14/2011	20,600	67	3,730	IM	IM	IM	IM	IM	IM	IM	96
04/15/2011	19,500	76	4,000	IM	IM	IM	IM	IM	IM	IM	97
04/16/2011	18,100	57	2,790	IM	IM	IM	IM	IM	IM	IM	95
04/17/2011	17,000	50	2,300	IM	IM	IM	IM	IM	IM	IM	92
04/19/2011	15,000	61	2,470	IM	IM	IM	IM	IM	IM	IM	94
04/21/2011	13,800	73	2,720	IM	IM	IM	IM	IM	IM	IM	99
04/25/2011	13,300	79	2,840	IM	IM	IM	IM	IM	IM	IM	100
05/02/2011	11,000	56	1,660	IM	IM	IM	IM	IM	IM	IM	89
05/09/2011	7,550	49	999	IM	IM	IM	IM	IM	IM	IM	98
05/16/2011	5,480	62	917	IM	IM	IM	IM	IM	IM	IM	97
06/02/2011	4,720	89	1,130	IM	IM	IM	IM	IM	IM	IM	99
06/03/2011	4,780	80	1,030	IM	IM	IM	IM	IM	IM	IM	100
06/23/2011	7,080	150	2,870	IM	IM	IM	IM	IM	IM	IM	100
06/24/2011	7,440	102	2,050	IM	IM	IM	IM	IM	IM	IM	100
07/01/2011	5,390	58	844	IM	IM	IM	IM	IM	IM	IM	97
07/20/2011	8,610	73	1,700	IM	IM	IM	IM	IM	IM	IM	98
07/26/2011	5,210	138	1,940	IM	IM	IM	IM	IM	IM	IM	97

Table 1–2. Streamflow, suspended-sediment concentrations, loads, fall diameters, and sieve diameters for the Red River of the North and selected tributaries near Fargo, North Dakota for 2010 and 2011.—Continued

[ft³/s, cubic feet per second; mg/L, milligram per liter; tons/d, short tons per days; mm, millimeter; IM, insufficient material for analysis; --, no value; <, less than]

Date	Daily mean streamflow (ft³/s)	Suspended-sediment concentration (mg/L)	Calculated suspended-sediment load (tons/d)	Suspended-sediment fall diameter (percent in range)							Percent finer than suspended-sediment sieve diameter of 0.062 mm
				0.002–.004 mm	0.004–.008 mm	0.008–.016 mm	0.016–.0062 mm	0.062–.125 mm	0.125–.250 mm	0.250–.500 mm	
Red River of the North at County Road 20 near Fargo (site 2)—Continued											
09/20/2011	2,100	130	737	IM	IM	IM	IM	IM	IM	IM	98
10/17/2011	914	36	89	IM	IM	IM	IM	IM	IM	IM	98
11/03/2011	692	10	19	IM	IM	IM	IM	IM	IM	IM	99
Mean	**13,601**	**97**	**3,698**	**98**	**--**	**--**	**--**	**1**	**1**	**0**	**97**
Median	**13,800**	**89**	**3,350**	**99**	**--**	**--**	**--**	**1**	**1**	**0**	**98**
Sheyenne River above Sheyenne River Diversion near Horace (site 3)											
03/20/2010	3,180	535	4,590		[1]82			14	3	1	--
03/21/2010	3,530	508	4,840		[1]78			12	10	0	--
03/22/2010	3,830	476	4,920		[1]80			12	7	1	--
03/23/2010	4,160	870	9,770		[1]74			16	10	0	--
03/24/2010	4,600	1,120	13,900		[1]71			18	11	0	--
03/25/2010	4,490	1,020	12,400		[1]71			15	13	1	--
03/26/2010	4,410	813	9,680		[1]76			14	9	1	--
03/27/2010	4,410	762	9,070		[1]73			15	11	1	--
03/29/2010	3,460	693	6,470		[1]70			16	12	2	--
03/31/2010	4,280	725	8,380		[1]76			11	13	0	--
04/05/2010	3,910	517	5,460		[1]82			9	7	2	--
04/07/2010	3,530	493	4,700		[1]84			10	6	0	--
04/08/2011	4,150	1,180	13,200	0	1	15	37	11	8	0	--
04/09/2011	4,210	968	11,000	2	1	17	30	11	10	0	--
04/10/2011	4,260	796	9,160	3	7	7	24	13	9	0	--
04/11/2011	4,360	771	9,080	5	4	7	24	24	0	1	--
04/12/2011	4,400	656	7,790	6	1	4	26	15	14	0	--
04/13/2011	4,430	582	6,960	5	9	3	15	34	3	0	--
04/14/2011	4,460	534	6,430		[1]68			15	16	1	--
04/15/2011	4,500	465	5,650		[1]65			16	17	2	--

Table 1–2. Streamflow, suspended-sediment concentrations, loads, fall diameters, and sieve diameters for the Red River of the North and selected tributaries near Fargo, North Dakota for 2010 and 2011.—Continued

[ft³/s, cubic feet per second; mg/L, milligram per liter; tons/d, short tons per days; mm, millimeter; IM, insufficient material for analysis; --, no value; <, less than]

Date	Daily mean streamflow (ft³/s)	Suspended-sediment concentration (mg/L)	Calculated suspended-sediment load (tons/d)	Suspended-sediment fall diameter (percent in range)							Percent finer than suspended-sediment sieve diameter of 0.062 mm
				0.002–.004 mm	0.004–.008 mm	0.008–.016 mm	0.016–.0062 mm	0.062–.125 mm	0.125–.250 mm	0.250–.500 mm	
Sheyenne River above Sheyenne River Diversion near Horace (site 3)—Continued											
04/16/2011	4,540	410	5,030		[1]68			15	16	1	--
04/18/2011	4,580	452	5,590		[1]60			18	20	2	--
04/20/2011	4,630	355	4,440		[1]74			12	13	1	--
04/22/2011	4,620	371	4,630		[1]67			14	19	0	--
04/26/2011	4,640	314	3,930		[1]66			17	17	0	--
05/03/2011	4,580	239	2,960		[1]63			9	26	2	--
05/09/2011	4,460	296	3,560		[1]57			20	18	5	--
05/16/2011	4,150	304	3,410		[1]67			12	20	1	--
06/20/2011	1,840	214	1,060		[1]97			1	2	0	--
06/26/2011	3,940	380	4,040		[1]82			5	13	0	--
06/30/2011	3,360	304	2,760		[1]80			13	5	2	--
07/20/2011	3,030	471	3,850	IM	IM	IM	IM	IM	IM	IM	73
07/26/2011	2,950	361	2,880	IM	IM	IM	IM	IM	IM	IM	74
08/08/2011	3,290	324	2,880		[1]73			18	9	0	--
09/15/2011	907	119	291	IM	IM	IM	IM	IM	IM	IM	86
10/13/2011	742	46	92	IM	IM	IM	IM	IM	IM	IM	97
11/02/2011	595	52	84	IM	IM	IM	IM	IM	IM	IM	96
Mean	**3,768**	**527**	**5,809**	**60**	**4**	**9**	**26**	**14**	**11**	**1**	**85**
Median	**4,210**	**476**	**4,920**	**71**	**3**	**7**	**25**	**14**	**11**	**1**	**86**
Sheyenne River at Horace (site 4)											
03/24/2010	1,970	602	3,200	--	--	--	IM	IM	IM	IM	95
03/25/2010	2,020	957	5,220		[1]78			16	5	1	--
03/26/2010	1,980	836	4,470		[1]77			17	6	0	--
03/27/2010	1,980	821	4,390		[1]79			9	8	4	--
03/29/2010	1,970	714	3,800		[1]78			16	6	0	--
03/31/2010	1,940	699	3,660		[1]83			12	5	0	--

Table 1–2. Streamflow, suspended-sediment concentrations, loads, fall diameters, and sieve diameters for the Red River of the North and selected tributaries near Fargo, North Dakota for 2010 and 2011.—Continued

[ft^3/s, cubic feet per second; mg/L, milligram per liter; tons/d, short tons per days; mm, millimeter; IM, insufficient material for analysis; --, no value; <, less than]

Date	Daily mean streamflow (ft^3/s)	Suspended-sediment concentration (mg/L)	Calculated suspended-sediment load (tons/d)	Suspended-sediment fall diameter (percent in range)							Percent finer than suspended-sediment sieve diameter of 0.062 mm
				0.002–.004 mm	0.004–.008 mm	0.008–.016 mm	0.016–.0062 mm	0.062–.125 mm	0.125–.250 mm	0.250–.500 mm	
Sheyenne River at Horace (site 4)—Continued											
04/05/2010	2,000	636	3,430			[1]83		12	4	1	--
04/07/2010	1,940	505	2,640			[1]82		13	5	0	--
04/08/2011	2,060	1,130	6,280	10	5	14	31	7	5	0	--
04/09/2011	2,040	888	4,890	3	3	18	29	4	6	0	--
04/10/2011	2,060	745	4,140	6	7	16	20	7	3	1	--
04/11/2011	2,100	648	3,670	2	1	12	31	10	3	0	--
04/12/2011	2,110	483	2,750	5	5	5	29	9	5	2	--
04/13/2011	2,130	451	2,590	3	4	11	24	11	5	1	--
04/14/2011	2,140	545	3,150			[1]71		10	6	9	--
04/15/2011	2,140	410	2,370			[1]74		15	10	1	--
04/16/2011	2,140	395	2,280			[1]76		16	7	1	--
04/18/2011	2,150	372	2,160			[1]73		14	13	0	--
04/20/2011	2,160	342	2,000			[1]79		12	9	0	--
04/22/2011	2,160	336	1,960			[1]76		15	9	0	--
04/26/2011	2,150	264	1,530			[1]77		14	5	4	--
05/03/2011	2,150	199	1,160			[1]72		18	9	1	--
05/10/2011	2,130	222	1,280			[1]75		19	6	0	--
05/16/2011	2,020	301	1,640			[1]70		12	18	0	--
06/20/2011	1,360	318	1,170			[1]78		12	8	1	--
06/26/2011	1,890	338	1,720			[1]85		12	3	0	--
06/30/2011	1,800	313	1,520			[1]80		15	5	0	--
07/21/2011	1,700	174	799	IM	IM	IM	IM	IM	IM	IM	39
07/26/2011	1,630	107	471	IM	IM	IM	IM	IM	IM	IM	44
08/08/2011	1,690	435	1,980			[1]79		12	8	1	--
09/15/2011	907	151	370	IM	IM	IM	IM	IM	IM	IM	77
10/13/2011	742	80	160	IM	IM	IM	IM	IM	IM	IM	86

Table 1–2. Streamflow, suspended-sediment concentrations, loads, fall diameters, and sieve diameters for the Red River of the North and selected tributaries near Fargo, North Dakota for 2010 and 2011.—Continued

[ft³/s, cubic feet per second; mg/L, milligram per liter; tons/d, short tons per days; mm, millimeter; IM, insufficient material for analysis; --, no value; <, less than]

Date	Daily mean streamflow (ft³/s)	Suspended-sediment concentration (mg/L)	Calculated suspended-sediment load (tons/d)	Suspended-sediment fall diameter (percent in range)							Percent finer than suspended-sediment sieve diameter of 0.062 mm
				0.002–.004 mm	0.004–.008 mm	0.008–.016 mm	0.016–.0062 mm	0.062–.125 mm	0.125–.250 mm	0.250–.500 mm	
Sheyenne River at Horace (site 4)—Continued											
11/02/2011	595	60	96	IM	IM	IM	IM	IM	IM	IM	81
Mean	**1,877**	**469**	**2,514**	**61**	**4**	**13**	**27**	**13**	**7**	**1**	**70**
Median	**2,020**	**410**	**2,280**	**76**	**5**	**13**	**29**	**12**	**6**	**0**	**79**
Maple River below Mapleton (site 5)											
03/19/2010	5,800	266	4,170	--	--	--	--	IM	IM	IM	98
03/20/2010	5,220	187	2,640	--	--	--	--	IM	IM	IM	98
03/21/2010	4,150	172	1,930	--	--	--	--	IM	IM	IM	97
03/22/2010	3,580	190	1,840	--	--	--	--	IM	IM	IM	97
03/23/2010	3,250	235	2,060	--	--	--	--	IM	IM	IM	93
03/24/2010	2,940	227	1,800	--	--	--	--	IM	IM	IM	97
03/26/2010	2,380	220	1,410	--	--	--	--	IM	IM	IM	97
03/27/2010	2,190	325	1,920	--	--	--	--	IM	IM	IM	86
03/30/2010	2,190	211	1,250	--	--	--	--	IM	IM	IM	98
04/02/2010	2,130	177	1,020	--	--	--	--	IM	IM	IM	98
04/06/2010	1,620	181	792			[1]95		3	2	0	--
04/07/2011	7,510	174	3,530	3	4	2	8	1	1	0	--
04/08/2011	6,970	163	3,070	IM	IM	IM	IM	IM	IM	IM	99
04/09/2011	6,200	186	3,110	3	1	2	10	5	1	8	--
04/10/2011	5,480	182	2,690			[1]93		4	2	1	--
04/11/2011	5,300	171	2,450			[1]98		0	1	1	--
04/12/2011	5,170	143	2,000	IM	IM	IM	IM	IM	IM	IM	98
04/13/2011	4,450	147	1,800			[1]98		1	0	1	--
04/14/2011	4,100	219	2,420	IM	IM	IM	IM	IM	IM	IM	99
04/15/2011	4,370	231	2,730	IM	IM	IM	IM	IM	IM	IM	99
04/16/2011	4,590	151	1,870	IM	IM	IM	IM	IM	IM	IM	97
04/17/2011	4,660	135	1,700	IM	IM	IM	IM	IM	IM	IM	98

Table 1–2. Streamflow, suspended-sediment concentrations, loads, fall diameters, and sieve diameters for the Red River of the North and selected tributaries near Fargo, North Dakota for 2010 and 2011.—Continued

[ft^3/s, cubic feet per second; mg/L, milligram per liter; tons/d, short tons per days; mm, millimeter; IM, insufficient material for analysis; --, no value; <, less than]

Date	Daily mean streamflow (ft^3/s)	Suspended-sediment concentration (mg/L)	Calculated suspended-sediment load (tons/d)	Suspended-sediment fall diameter (percent in range)							Percent finer than suspended-sediment sieve diameter of 0.062 mm
				0.002–.004 mm	0.004–.008 mm	0.008–.016 mm	0.016–.0062 mm	0.062–.125 mm	0.125–.250 mm	0.250–.500 mm	
Maple River below Mapleton (site 5)—Continued											
04/18/2011	4,720	108	1,380	IM	IM	IM	IM	IM	IM	IM	98
04/21/2011	3,900	81	853	IM	IM	IM	IM	IM	IM	IM	93
04/25/2011	3,680	68	676	IM	IM	IM	IM	IM	IM	IM	94
05/02/2011	2,850	105	808	IM	IM	IM	IM	IM	IM	IM	96
05/09/2011	1,940	116	608	IM	IM	IM	IM	IM	IM	IM	94
05/16/2011	1,570	92	390			[1]97		1	2	0	--
06/01/2011	1,900	113	580	IM	IM	IM	IM	IM	IM	IM	99
06/02/2011	1,980	102	545	IM	IM	IM	IM	IM	IM	IM	96
06/03/2011	1,700	86	395			[1]99		0	0	1	--
06/16/2011	1,220	139	458			[1]97		1	2	0	--
06/17/2011	1,310	114	403			[1]99		1	0	0	--
07/25/2011	1,020	282	777	IM	IM	IM	IM	IM	IM	IM	96
08/08/2011	784	419	887	IM	IM	IM	IM	IM	IM	IM	100
09/08/2011	113	67	20	IM	IM	IM	IM	IM	IM	IM	99
10/17/2011	41	22	2	IM	IM	IM	IM	IM	IM	IM	97
11/03/2011	45	29	4	IM	IM	IM	IM	IM	IM	IM	98
Mean	**3,237**	**164**	**1,500**	**78**	**3**	**2**	**9**	**2**	**1**	**1**	**97**
Median	**3,095**	**167**	**1,395**	**97**	**3**	**2**	**9**	**1**	**1**	**1**	**98**
Wild Rice River near St. Benedict (site 6)											
03/18/2010	7,860	186	3,950	--	--	--	--	IM	IM	IM	98
03/20/2010	8,670	177	4,140	--	--	--	--	IM	IM	IM	98
03/21/2010	8,260	140	3,120	--	--	--	--	IM	IM	IM	97
03/22/2010	7,840	164	3,470			[1]94		1	5	0	--
03/23/2010	7,550	136	2,770	--	--	--	--	IM	IM	IM	100
03/24/2010	7,370	152	3,020	--	--	--	--	IM	IM	IM	96
03/25/2010	7,180	146	2,830	--	--	--	--	IM	IM	IM	99

Table 1–2. Streamflow, suspended-sediment concentrations, loads, fall diameters, and sieve diameters for the Red River of the North and selected tributaries near Fargo, North Dakota for 2010 and 2011.—Continued

[ft³/s, cubic feet per second; mg/L, milligram per liter; tons/d, short tons per days; mm, millimeter; IM, insufficient material for analysis; --, no value; <, less than]

Date	Daily mean streamflow (ft³/s)	Suspended-sediment concentration (mg/L)	Calculated suspended-sediment load (tons/d)	Suspended-sediment fall diameter (percent in range)							Percent finer than suspended-sediment sieve diameter of 0.062 mm
				0.002–.004 mm	0.004–.008 mm	0.008–.016 mm	0.016–.0062 mm	0.062–.125 mm	0.125–.250 mm	0.250–.500 mm	
Wild Rice River near St. Benedict (site 6)—Continued											
03/26/2010	6,960	152	2,860	--	--	--	--	IM	IM	IM	99
03/27/2010	6,820	161	2,960	--	--	--	--	IM	IM	IM	99
03/30/2010	6,270	148	2,500	--	--	--	--	IM	IM	IM	97
04/01/2010	5,460	142	2,090	--	--	--	--	IM	IM	IM	97
04/05/2011	6,000	180	2,920	IM	IM	IM	IM	IM	IM	IM	98
04/07/2011	9,000	147	3,570	IM	IM	IM	IM	IM	IM	IM	98
04/08/2011	9,170	121	3,000	IM	IM	IM	IM	IM	IM	IM	97
04/09/2011	8,850	94	2,250	IM	IM	IM	IM	IM	IM	IM	97
04/10/2011	8,570	103	2,380	IM	IM	IM	IM	IM	IM	IM	97
04/11/2011	8,510	99	2,280	IM	IM	IM	IM	IM	IM	IM	97
04/12/2011	8,340	94	2,120	IM	IM	IM	IM	IM	IM	IM	98
04/13/2011	8,040	139	3,020	IM	IM	IM	IM	IM	IM	IM	99
04/14/2011	7,530	81	1,650	IM	IM	IM	IM	IM	IM	IM	95
04/15/2011	6,980	70	1,320	IM	IM	IM	IM	IM	IM	IM	91
04/16/2011	6,510	77	1,350	IM	IM	IM	IM	IM	IM	IM	93
04/18/2011	5,740	86	1,330	IM	IM	IM	IM	IM	IM	IM	92
04/20/2011	5,180	82	1,150	IM	IM	IM	IM	IM	IM	IM	93
04/22/2011	4,850	95	1,240	IM	IM	IM	IM	IM	IM	IM	94
04/25/2011	5,110	88	1,210	IM	IM	IM	IM	IM	IM	IM	95
05/03/2011	4,100	105	1,160	IM	IM	IM	IM	IM	IM	IM	93
05/09/2011	2,850	299	2,300	IM	IM	IM	IM	IM	IM	IM	98
05/17/2011	1,410	136	518			[1]99		0	1	0	--
06/16/2011	1,170	175	553	IM	IM	IM	IM	IM	IM	IM	99
06/17/2011	1,160	256	802	IM	IM	IM	IM	IM	IM	IM	99
06/23/2011	3,040	153	1,260	IM	IM	IM	IM	IM	IM	IM	99
06/24/2011	2,960	100	799	IM	IM	IM	IM	IM	IM	IM	98

Table 1–2. Streamflow, suspended-sediment concentrations, loads, fall diameters, and sieve diameters for the Red River of the North and selected tributaries near Fargo, North Dakota for 2010 and 2011.—Continued

[ft³/s, cubic feet per second; mg/L, milligram per liter; tons/d, short tons per days; mm, millimeter; IM, insufficient material for analysis; --, no value; <, less than]

Date	Daily mean streamflow (ft³/s)	Suspended-sediment concentration (mg/L)	Calculated suspended-sediment load (tons/d)	Suspended-sediment fall diameter (percent in range)							Percent finer than suspended-sediment sieve diameter of 0.062 mm
				0.002–.004 mm	0.004–.008 mm	0.008–.016 mm	0.016–.0062 mm	0.062–.125 mm	0.125–.250 mm	0.250–.500 mm	
Wild Rice River near St. Benedict (site 6)—Continued											
07/26/2011	1,880	212	1,080	IM	IM	IM	IM	IM	IM	IM	98
08/09/2011	2,090	157	886	IM	IM	IM	IM	IM	IM	IM	100
09/08/2011	656	108	191	IM	IM	IM	IM	IM	IM	IM	99
10/13/2011	212	45	26	IM	IM	IM	IM	IM	IM	IM	96
11/02/2011	165	29	13	IM	IM	IM	IM	IM	IM	IM	97
Mean	**5,535**	**133**	**1,950**	**97**	**--**	**--**	**--**	**1**	**3**	**0**	**97**
Median	**6,390**	**138**	**2,105**	**97**	**--**	**--**	**--**	**1**	**3**	**0**	**98**
Rush River near Prosper (site 7)											
04/07/2011	950	191	490	8	2	2	12	3	5	1	--
04/08/2011	2,100	401	2,270		[1]92			1	7	0	--
04/09/2011	2,500	399	2,690	7	0	4	13	4	5	0	--
04/10/2011	1,720	353	1,640	6	3	3	13	3	10	3	--
04/11/2011	1,670	345	1,660	94				3	2	1	--
04/12/2011	1,330	299	1,070	84				8	4	3	--
04/13/2011	910	209	514	98				2	0	0	--
04/14/2011	623	146	246	IM	IM	IM	IM	IM	IM	IM	95
04/15/2011	500	134	181	IM	IM	IM	IM	IM	IM	IM	95
04/16/2011	400	110	119		[1]98			1	1	0	--
04/17/2011	408	118	130		[1]91			1	5	3	--
04/19/2011	486	90	118	IM	IM	IM	IM	IM	IM	IM	94
04/21/2011	371	72	72	IM	IM	IM	IM	IM	IM	IM	92
06/01/2011	660	320	570		[1]99			1	0	0	--
06/02/2011	374	145	146	IM	IM	IM	IM	IM	IM	IM	100
06/16/2011	419	273	309		[1]99			0	1	0	--
06/17/2011	338	133	121		[1]97			1	1	1	--
07/25/2011	50	50	7	IM	IM	IM	IM	IM	IM	IM	98

Table 1–2. Streamflow, suspended-sediment concentrations, loads, fall diameters, and sieve diameters for the Red River of the North and selected tributaries near Fargo, North Dakota for 2010 and 2011.—Continued

[ft^3/s, cubic feet per second; mg/L, milligram per liter; tons/d, short tons per days; mm, millimeter; IM, insufficient material for analysis; --, no value; <, less than]

Date	Daily mean streamflow (ft^3/s)	Suspended-sediment concentration (mg/L)	Calculated suspended-sediment load (tons/d)	Suspended-sediment fall diameter (percent in range)							Percent finer than suspended-sediment sieve diameter of 0.062 mm
				0.002–.004 mm	0.004–.008 mm	0.008–.016 mm	0.016–.0062 mm	0.062–.125 mm	0.125–.250 mm	0.250–.500 mm	
Rush River near Prosper (site 7)—Continued											
08/08/2011	128	38	13	IM	IM	IM	IM	IM	IM	IM	98
09/08/2011	5	43	1	IM	IM	IM	IM	IM	IM	IM	97
10/17/2011	7	50	1	IM	IM	IM	IM	IM	IM	IM	99
11/03/2011	4	34	<1	IM	IM	IM	IM	IM	IM	IM	99
Mean	**725**	**180**	**589**	**73**	**2**	**3**	**13**	**2**	**3**	**1**	**97**
Median	**453**	**140**	**181**	**93**	**2**	**3**	**13**	**2**	**3**	**1**	**98**
Lower Branch Rush River east of Prosper (site 8)											
04/07/2011	873	288	679	7	8	2	11	1	0	0	--
04/08/2011	1,890	160	816	IM	IM	IM	IM	IM	IM	IM	99
04/09/2011	1,430	82	317	IM	IM	IM	IM	IM	IM	IM	97
04/10/2011	1,010	88	240			[1]87		4	4	5	--
04/11/2011	833	127	286	IM	IM	IM	IM	IM	IM	IM	96
04/12/2011	460	75	93	IM	IM	IM	IM	IM	IM	IM	98
04/13/2011	275	103	76	IM	IM	IM	IM	IM	IM	IM	98
04/14/2011	166	361	162	6	7	1	12	1	0	0	--
04/15/2011	93	314	79	IM	IM	IM	IM	IM	IM	IM	100
04/16/2011	34	95	9	IM	IM	IM	IM	IM	IM	IM	92
04/17/2011	36	131	13	IM	IM	IM	IM	IM	IM	IM	99
04/19/2011	56	57	9	IM	IM	IM	IM	IM	IM	IM	100
04/21/2011	68	115	21	IM	IM	IM	IM	IM	IM	IM	96
06/01/2011	411	57	63	IM	IM	IM	IM	IM	IM	IM	99
06/02/2011	215	37	21			[1]65		7	14	14	--
06/17/2011	126	13	4	IM	IM	IM	IM	IM	IM	IM	83
06/20/2011	16	8	<1	IM	IM	IM	IM	IM	IM	IM	97
07/25/2011	59	10	<1	IM	IM	IM	IM	IM	IM	IM	94
08/09/2011	10	25	1	IM	IM	IM	IM	IM	IM	IM	96

Table 1–2. Streamflow, suspended-sediment concentrations, loads, fall diameters, and sieve diameters for the Red River of the North and selected tributaries near Fargo, North Dakota for 2010 and 2011.—Continued

[ft³/s, cubic feet per second; mg/L, milligram per liter; tons/d, short tons per days; mm, millimeter; IM, insufficient material for analysis; --, no value; <, less than]

Date	Daily mean streamflow (ft³/s)	Suspended-sediment concentration (mg/L)	Calculated suspended-sediment load (tons/d)	Suspended-sediment fall diameter (percent in range)							Percent finer than suspended-sediment sieve diameter of 0.062 mm
				0.002–.004 mm	0.004–.008 mm	0.008–.016 mm	0.016–.0062 mm	0.062–.125 mm	0.125–.250 mm	0.250–.500 mm	
Lower Branch Rush River east of Prosper (site 8)—Continued											
Mean	**424**	**113**	**170**	**41**	**8**	**2**	**12**	**3**	**5**	**5**	**96**
Median	**166**	**88**	**76**	**36**	**8**	**2**	**12**	**3**	**2**	**3**	**97**
Buffalo River east of Kragnes (site 9)											
04/06/2011	6,240	61	1,030	IM	IM	IM	IM	IM	IM	IM	97
04/07/2011	5,600	61	922	IM	IM	IM	IM	IM	IM	IM	96
04/08/2011	4,920	59	784	IM	IM	IM	IM	IM	IM	IM	96
04/09/2011	4,090	28	309	IM	IM	IM	IM	IM	IM	IM	90
04/10/2011	3,500	28	265	IM	IM	IM	IM	IM	IM	IM	86
04/11/2011	3,710	41	411	IM	IM	IM	IM	IM	IM	IM	98
04/12/2011	3,770	36	366	IM	IM	IM	IM	IM	IM	IM	96
04/15/2011	3,450	21	196	IM	IM	IM	IM	IM	IM	IM	80
04/17/2011	2,780	26	195	IM	IM	IM	IM	IM	IM	IM	81
04/19/2011	2,210	32	191	IM	IM	IM	IM	IM	IM	IM	80
04/21/2011	1,800	51	248	IM	IM	IM	IM	IM	IM	IM	95
04/25/2011	1,490	55	221	IM	IM	IM	IM	IM	IM	IM	96
06/23/2011	609	89	146	IM	IM	IM	IM	IM	IM	IM	99
06/26/2011	874	114	269	IM	IM	IM	IM	IM	IM	IM	98
06/30/2011	1,300	81	284	IM	IM	IM	IM	IM	IM	IM	97
07/20/2011	1,000	182	491	IM	IM	IM	IM	IM	IM	IM	95
07/21/2011	1,080	86	251	IM	IM	IM	IM	IM	IM	IM	95
07/25/2011	697	63	119	IM	IM	IM	IM	IM	IM	IM	94
08/09/2011	680	53	97	IM	IM	IM	IM	IM	IM	IM	97
09/08/2011	70	31	6	IM	IM	IM	IM	IM	IM	IM	97
10/17/2011	80	16	3	IM	IM	IM	IM	IM	IM	IM	90
11/03/2011	78	10	2	IM	IM	IM	IM	IM	IM	IM	95

Table 1–2. Streamflow, suspended-sediment concentrations, loads, fall diameters, and sieve diameters for the Red River of the North and selected tributaries near Fargo, North Dakota for 2010 and 2011.—Continued

[ft³/s, cubic feet per second; mg/L, milligram per liter; tons/d, short tons per days; mm, millimeter; IM, insufficient material for analysis; --, no value; <, less than]

Date	Daily mean streamflow (ft³/s)	Suspended-sediment concentration (mg/L)	Calculated suspended-sediment load (tons/d)	Suspended-sediment fall diameter (percent in range)							Percent finer than suspended-sediment sieve diameter of 0.062 mm
				0.002–.004 mm	0.004–.008 mm	0.008–.016 mm	0.016–.0062 mm	0.062–.125 mm	0.125–.250 mm	0.250–.500 mm	
Buffalo River east of Kragnes (site 9)—Continued											
Mean	**2,274**	**56**	**309**	--	--	--	--	--	--	--	**93**
Median	**1,645**	**52**	**249**	--	--	--	--	--	--	--	**96**

[1]For some samples, only a percent range for combined fall diameters of 0.002 to 0.062 millimeters were available.

Table 1–3. Sieve diameters of bedload samples for the Red River of the North and selected tributaries near Fargo, North Dakota during 2010 and 2011.

[mm, millimeter; tons/d, tons per day; IM, insufficient material; --, not calculated; <, less than]

Date	Bedload-sediment fall diameter (percent in size range)								Measured bedload (tons/d)
	0.062–.125 mm	0.125–.250 mm	0.250–.500 mm	0.500–1 mm	1–2 mm	2–4 mm	4–8 mm	8–16 mm	
Red River of the North near Christine (site 1)									
03/18/2010	1	1	43	38	6	2	0	8	61
03/22/2010	1	6	11	11	15	8	6	21	1
03/25/2010	2	4	26	35	15	8	6	2	3
03/29/2010	1	4	20	19	19	16	12	8	1
04/01/2010	2	5	53	16	7	6	6	3	1
04/06/2010	2	15	42	9	8	11	6	4	3
04/06/2011	0	1	30	44	16	3	1	4	50
04/08/2011	1	2	49	35	6	3	3	1	6
04/09/2011	1	1	17	38	29	10	3	1	21
04/10/2011	0	2	19	28	30	13	3	4	11
04/11/2011	0	1	35	48	11	2	1	1	36
04/12/2011	1	2	12	28	31	16	6	0	27
04/13/2011	2	2	21	35	21	6	1	3	17
04/14/2011	0	0	22	46	22	6	2	1	37
04/18/2011	0	1	42	43	11	2	1	0	4
04/22/2011	1	1	11	26	29	9	6	16	15
05/02/2011	4	6	25	33	18	7	2	1	20
05/17/2011	1	9	67	13	6	1	1	0	15
06/02/2011	1	4	46	36	9	2	1	0	58
06/03/2011	1	3	47	42	4	1	0	0	112
06/23/2011	0	3	28	41	21	5	1	0	170
06/24/2011	1	1	41	39	11	3	2	1	268
07/01/2011	3	21	45	15	8	4	2	0	19
07/25/2011	4	4	24	39	13	5	3	3	163
09/15/2011	1	2	42	33	18	3	0	0	518
10/13/2011	2	4	31	49	11	0	0	0	11
11/02/2011	IM	IM	IM	IM	IM	IM	IM	IM	--
Mean	**1**	**4**	**33**	**32**	**15**	**6**	**3**	**3**	**63**
Median	**1**	**3**	**31**	**35**	**14**	**5**	**2**	**1**	**19**
Red River of the North at County Road 20 near Fargo (site 2)									
03/17/2010	2	4	11	20	22	21	10	6	6
03/23/2010	1	3	7	41	40	4	0	0	2
03/25/2010	7	15	48	18	0	0	0	0	1
03/31/2010	IM	IM	IM	IM	IM	IM	IM	IM	--
04/05/2011	2	6	23	33	23	7	2	0	7
04/08/2011	6	10	21	27	13	3	1	0	33
04/09/2011	2	5	22	30	14	7	10	5	3
04/12/2011	3	5	36	29	12	5	7	0	1
04/16/2011	0	29	57	0	0	0	0	0	<1

Table 1–3. Sieve diameters of bedload samples for the Red River of the North and selected tributaries near Fargo, North Dakota during 2010 and 2011.—Continued

[mm, millimeter; tons/d, tons per day; IM, insufficient material; --, not calculated; <, less than]

Date	Bedload-sediment fall diameter (percent in size range)								Measured bedload (tons/d)
	0.062–.125 mm	0.125–.250 mm	0.250–.500 mm	0.500–1 mm	1–2 mm	2–4 mm	4–8 mm	8–16 mm	
Red River of the North at County Road 20 near Fargo (site 2)—Continued									
04/21/2011	16	34	16	17	0	0	0	0	<1
05/02/2011	IM	IM	IM	IM	IM	IM	IM	IM	--
05/16/2011	5	9	15	34	23	2	0	0	1
06/02/2011	23	16	23	23	0	0	0	0	<1
06/03/2011	6	12	12	16	18	24	8	0	<1
06/23/2011	6	12	19	32	15	1	0	0	2
06/24/2011	8	11	20	32	5	0	0	0	1
07/01/2011	3	8	23	28	14	12	7	0	4
07/20/2011	3	7	15	35	23	7	2	0	11
07/26/2011	7	18	27	34	0	0	0	0	<1
09/20/2011	5	13	26	40	13	0	0	0	<1
10/17/2011	4	5	33	43	8	1	0	0	2
11/03/2011	IM	IM	IM	IM	IM	IM	IM	IM	--
Mean	**6**	**12**	**24**	**28**	**13**	**5**	**2**	**1**	**6**
Median	**5**	**10**	**22**	**30**	**13**	**2**	**0**	**0**	**2**
Sheyenne River above Sheyenne River Diversion near Horace (site 3)									
03/20/2010	4	16	21	10	8	6	1	28	1
03/23/2010	8	35	29	7	8	1	2	0	1
03/25/2010	3	21	26	19	8	4	4	9	3
03/29/2010	3	16	44	21	6	2	2	0	1
03/31/2010	3	19	37	21	6	3	4	3	4
04/05/2010	4	21	40	8	5	4	6	9	4
04/07/2010	1	17	29	17	13	7	5	7	1
04/08/2011	16	37	19	9	4	2	1	0	9
04/09/2011	6	26	31	13	11	5	0	0	1
04/10/2011	6	25	43	13	4	1	0	0	1
04/11/2011	7	21	35	15	4	1	1	0	2
04/12/2011	5	18	40	19	9	1	1	0	2
04/13/2011	5	31	33	13	8	0	0	0	<1
04/14/2011	2	5	27	28	22	8	6	0	3
04/15/2011	1	5	35	31	18	6	3	0	3
04/16/2011	1	9	50	19	11	5	4	0	2
04/18/2011	1	8	45	24	14	4	1	1	2
04/20/2011	2	10	49	24	9	3	1	0	2
04/26/2011	6	24	36	14	10	1	0	0	2
05/03/2011	5	29	41	13	5	1	0	0	1
05/16/2011	2	27	50	10	5	2	2	0	5
06/20/2011	15	37	25	8	5	0	0	0	1
06/26/2011	10	21	38	10	7	2	0	0	2
06/30/2011	2	7	6	43	25	6	4	6	10

Table 1–3. Sieve diameters of bedload samples for the Red River of the North and selected tributaries near Fargo, North Dakota during 2010 and 2011.—Continued

[mm, millimeter; tons/d, tons per day; IM, insufficient material; --, not calculated; <, less than]

Date	Bedload-sediment fall diameter (percent in size range)								Measured bedload (tons/d)
	0.062–.125 mm	0.125–.250 mm	0.250–.500 mm	0.500–1 mm	1–2 mm	2–4 mm	4–8 mm	8–16 mm	
Sheyenne River above Sheyenne River Diversion near Horace (site 3)—Continued									
07/20/2011	5	20	49	9	6	3	2	2	2
07/26/2011	7	35	31	8	7	3	1	0	1
08/08/2011	4	23	48	12	6	2	0	0	2
09/15/2011	10	30	50	0	0	0	0	0	<1
10/13/2011	6	12	73	0	0	0	0	0	<1
11/02/2011	IM	IM	IM	IM	IM	IM	IM	IM	--
Mean	**5**	**21**	**37**	**15**	**8**	**3**	**2**	**2**	**2**
Median	**5**	**21**	**37**	**13**	**7**	**2**	**1**	**0**	**2**
Sheyenne River at Horace (site 4)									
03/24/2010	12	38	16	6	7	10	3	0	1
03/25/2010	9	35	32	7	10	1	0	0	<1
03/27/2010	4	36	28	13	9	0	0	0	<1
03/29/2010	6	39	30	12	8	0	0	0	<1
03/31/2010	4	25	28	16	15	1	0	0	<1
04/05/2010	6	17	29	28	13	1	0	0	<1
04/07/2010	4	13	29	28	16	3	2	0	4
04/09/2011	7	26	35	11	7	3	1	0	3
04/10/2011	6	15	30	16	15	8	2	0	2
04/11/2011	10	16	25	23	7	0	0	0	8
04/12/2011	13	28	25	17	4	0	0	0	41
04/13/2011	4	8	32	28	19	3	0	0	2
04/14/2011	5	16	34	23	13	4	0	0	14
04/15/2011	4	13	39	24	14	0	0	0	1
04/18/2011	2	7	37	24	21	5	1	0	7
04/20/2011	3	5	12	36	35	5	0	0	6
04/26/2011	15	20	24	8	1	0	0	0	1
05/03/2011	11	33	29	5	1	0	0	0	2
05/10/2011	13	31	25	14	5	1	0	0	13
05/16/2011	16	26	20	6	3	0	5	0	<1
06/20/2011	3	20	42	18	10	4	1	0	6
06/26/2011	11	25	25	18	4	0	0	0	1
06/30/2011	10	14	27	22	12	4	1	0	2
07/21/2011	5	21	35	20	9	1	1	0	7
07/26/2011	4	16	22	8	15	14	15	2	2
08/08/2011	13	34	25	9	0	0	0	0	<1
09/15/2011	19	17	23	10	4	0	0	0	<1
10/13/2011	36	12	7	4	2	0	0	0	2
11/02/2011	IM	IM	IM	IM	IM	IM	IM	IM	--
Mean	**9**	**22**	**27**	**16**	**10**	**2**	**1**	**0**	**6**
Median	**7**	**20**	**28**	**16**	**9**	**1**	**0**	**0**	**2**

Table 1–3. Sieve diameters of bedload samples for the Red River of the North and selected tributaries near Fargo, North Dakota during 2010 and 2011.—Continued

[mm, millimeter; tons/d, tons per day; IM, insufficient material; --, not calculated; <, less than]

Date	Bedload-sediment fall diameter (percent in size range)								Measured bedload (tons/d)
	0.062–.125 mm	0.125–.250 mm	0.250–.500 mm	0.500–1 mm	1–2 mm	2–4 mm	4–8 mm	8–16 mm	
Maple River below Mapleton (site 5)									
03/19/2010	2	6	15	24	22	10	9	5	1
03/22/2010	9	13	27	25	16	0	0	0	<1
03/26/2010	1	4	8	18	38	25	1	1	5
03/30/2010	2	4	17	26	25	19	4	0	5
04/02/2010	3	4	25	27	22	11	3	1	7
04/06/2010	2	5	15	24	22	16	8	4	3
04/07/2011	4	5	9	15	23	19	9	1	23
04/09/2011	7	11	25	31	11	2	0	0	2
04/10/2011	7	11	21	28	17	3	0	0	3
04/11/2011	9	13	22	25	9	3	0	0	3
04/12/2011	7	10	21	28	16	3	0	0	7
04/13/2011	1	2	7	15	53	16	4	0	6
04/14/2011	3	6	32	38	12	3	0	0	7
04/18/2011	15	26	16	9	0	0	0	0	<1
04/21/2011	8	17	35	20	0	0	0	0	<1
05/02/2011	11	27	28	16	0	0	0	0	<1
05/16/2011	8	19	37	19	2	0	0	0	3
06/01/2011	5	12	41	25	8	1	0	0	16
06/02/2011	3	4	13	23	29	21	3	0	19
06/03/2011	5	9	20	33	21	3	0	0	21
06/16/2011	5	14	29	23	16	4	0	0	2
06/17/2011	2	6	28	38	17	5	1	0	7
07/25/2011	5	11	34	23	14	5	1	0	3
08/08/2011	3	6	26	29	21	11	2	0	6
09/08/2011	7	17	45	10	0	0	0	0	<1
10/17/2011	10	25	45	0	0	0	0	0	<1
11/03/2011	IM	IM	IM	IM	IM	IM	IM	IM	--
Mean	**6**	**11**	**25**	**23**	**16**	**7**	**2**	**0**	**7**
Median	**5**	**11**	**25**	**24**	**16**	**3**	**0**	**0**	**5**
Wild Rice River near St. Benedict (site 6)									
03/18/2010	2	4	8	15	21	30	15	1	10
03/22/2010	8	16	26	16	0	0	1	0	1
03/25/2010	15	30	30	10	0	0	0	0	<1
03/30/2010	24	26	37	0	0	0	0	0	<1
04/01/2010	6	11	16	21	12	2	0	11	1
04/05/2011	15	8	12	15	21	19	6	4	23
04/08/2011	1	5	17	40	30	4	0	0	<1
04/11/2011	15	21	43	0	0	0	0	0	<1
04/15/2011	1	3	13	33	43	5	0	0	5

Table 1–3. Sieve diameters of bedload samples for the Red River of the North and selected tributaries near Fargo, North Dakota during 2010 and 2011.—Continued

[mm, millimeter; tons/d, tons per day; IM, insufficient material; --, not calculated; <, less than]

Date	Bedload-sediment fall diameter (percent in size range)								Measured bedload (tons/d)
	0.062–.125 mm	0.125–.250 mm	0.250–.500 mm	0.500–1 mm	1–2 mm	2–4 mm	4–8 mm	8–16 mm	
Wild Rice River near St. Benedict (site 6)—Continued									
05/03/2011	8	15	27	35	0	0	0	0	<1
05/17/2011	7	14	26	32	6	0	0	0	17
06/16/2011	9	26	30	15	4	0	0	0	3
06/17/2011	14	28	19	2	0	0	0	0	5
06/23/2011	8	13	20	25	15	2	0	0	19
06/24/2011	8	11	22	26	12	2	0	0	23
07/26/2011	9	14	23	22	11	1	0	0	5
08/09/2011	8	14	13	10	0	0	2	30	<1
09/08/2011	14	23	18	2	0	0	0	0	1
10/13/2011	9	14	28	19	0	0	0	0	<1
11/02/2011	IM	IM	IM	IM	IM	IM	IM	IM	--
Mean	**10**	**16**	**23**	**18**	**9**	**3**	**1**	**2**	**9**
Median	**8**	**14**	**22**	**16**	**4**	**0**	**0**	**0**	**5**
Rush River near Prosper (site 7)									
04/07/2011	4	8	19	23	22	13	6	0	<1
04/09/2011	3	5	10	23	32	16	7	0	2
04/10/2011	5	10	19	24	23	12	1	0	4
04/11/2011	8	13	22	23	14	6	1	0	3
04/13/2011	6	13	28	27	11	3	1	0	1
04/14/2011	4	8	30	34	14	3	1	0	1
04/15/2011	4	8	24	30	20	7	1	0	1
04/16/2011	4	10	24	29	21	5	0	0	<1
04/21/2011	7	15	37	24	4	0	0	0	<1
06/01/2011	10	16	33	19	3	0	0	0	1
06/02/2011	14	19	26	11	2	0	0	0	<1
06/16/2011	11	25	28	16	3	0	0	0	<1
06/17/2011	11	16	30	17	2	1	0	0	3
07/25/2011	0	8	25	33	17	0	0	0	<1
08/08/2011	7	22	35	29	0	0	0	0	<1
09/08/2011	IM	IM	IM	IM	IM	IM	IM	IM	--
10/17/2011	IM	IM	IM	IM	IM	IM	IM	IM	--
11/03/2011	IM	IM	IM	IM	IM	IM	IM	IM	--
Mean	**7**	**13**	**26**	**24**	**13**	**4**	**1**	**0**	**2**
Median	**7**	**13**	**27**	**24**	**12**	**4**	**1**	**0**	**2**
Lower Branch Rush River east of Prosper (site 8)									
04/07/2011	5	9	25	39	14	0	0	0	<1
04/09/2011	2	3	5	14	34	28	9	0	<1
04/10/2011	IM	IM	IM	IM	IM	IM	IM	IM	--
04/13/2011	IM	IM	IM	IM	IM	IM	IM	IM	--

Table 1–3. Sieve diameters of bedload samples for the Red River of the North and selected tributaries near Fargo, North Dakota during 2010 and 2011.—Continued

[mm, millimeter; tons/d, tons per day; IM, insufficient material; --, not calculated; <, less than]

Date	Bedload-sediment fall diameter (percent in size range)								Measured bedload (tons/d)
	0.062–.125 mm	0.125–.250 mm	0.250–.500 mm	0.500–1 mm	1–2 mm	2–4 mm	4–8 mm	8–16 mm	
Lower Branch Rush River east of Prosper (site 8)—Continued									
Mean	**4**	**6**	**15**	**27**	**24**	**14**	**5**	**0**	--
Median	**4**	**6**	**15**	**27**	**24**	**14**	**5**	**0**	--
Buffalo River east of Kragnes (site 9)									
04/06/2011	8	8	16	19	7	2	1	0	2
04/09/2011	6	5	11	15	13	8	5	11	4
04/12/2011	7	9	17	22	8	0	0	0	1
04/15/2011	7	9	11	18	13	7	0	0	1
04/21/2011	4	16	36	24	0	0	0	0	<1
06/23/2011	0	18	28	27	0	0	0	0	<1
06/26/2011	4	11	15	18	22	19	0	0	<1
06/30/2011	8	8	8	9	14	6	3	3	3
07/20/2011	25	18	24	12	15	6	0	0	1
07/21/2011	8	13	20	21	14	4	0	0	1
07/25/2011	6	11	21	18	20	10	0	0	<1
08/09/2011	5	11	23	27	17	0	0	0	<1
09/08/2011	IM	IM	IM	IM	IM	IM	IM	IM	--
10/17/2011	IM	IM	IM	IM	IM	IM	IM	IM	--
11/03/2011	IM	IM	IM	IM	IM	IM	IM	IM	--
Mean	**7**	**11**	**19**	**19**	**12**	**5**	**1**	**1**	**2**
Median	**7**	**11**	**19**	**19**	**12**	**5**	**1**	**1**	**2**

Table 1–4. Sieve diameters of bed-material samples for the Red River of the North and selected tributaries near Fargo, North Dakota during 2010 and 2011.

[mm, millimeter; IM, insufficient material]

Date	Bed-material fall diameter (percent in size range)							
	0.062–.125 mm	0.125–.250 mm	0.250–.500 mm	0.500–1 mm	1–2 mm	2–4 mm	4–8 mm	8–16 mm
Red River of the North near Christine (site 1)								
03/18/2010	0	1	38	26	5	4	6	19
03/20/2010	1	0	4	8	10	8	13	56
03/21/2010	4	4	14	10	7	8	15	30
03/22/2010	4	5	7	12	33	25	6	0
03/23/2010	2	2	17	17	8	10	11	31
03/24/2010	2	5	9	13	15	16	18	18
03/25/2010	0	3	8	30	30	8	5	13
03/26/2010	1	3	13	24	15	9	9	25
03/27/2010	4	4	23	20	22	12	4	0
03/29/2010	1	2	16	33	15	6	7	19
04/01/2010	2	7	28	21	9	4	11	16
04/06/2010	1	3	28	24	10	6	13	14
04/06/2011	1	0	1	6	18	11	13	42
04/07/2011	1	1	35	29	8	8	10	8
04/08/2011	3	4	7	10	13	12	13	23
04/09/2011	2	2	12	15	9	7	9	25
04/10/2011	3	5	5	17	25	16	7	2
04/11/2011	1	3	28	28	9	3	5	14
04/12/2011	5	4	6	8	10	9	13	20
04/13/2011	3	4	14	10	6	6	12	31
04/14/2011	0	2	8	6	8	10	22	41
04/15/2011	2	3	35	45	8	1	1	2
04/16/2011	2	5	16	5	8	9	20	31
04/18/2011	0	2	14	29	17	8	13	12
04/20/2011	2	4	17	22	15	5	10	21
04/22/2011	1	2	18	31	11	4	10	12
04/26/2011	1	2	3	4	8	9	11	61
05/02/2011	3	4	7	7	23	39	13	2
05/09/2011	12	18	10	8	7	5	8	19
05/17/2011	10	24	17	35	10	1	0	0
06/02/2011	3	3	30	37	7	2	3	2
06/03/2011	2	4	34	40	6	4	2	6
06/23/2011	21	29	6	6	13	8	0	0
06/24/2011	1	3	16	35	13	7	11	8
07/01/2011	11	83	5	0	0	0	0	0
07/25/2011	1	1	10	64	20	2	0	0
09/15/2011	2	3	4	17	23	11	6	24
10/13/2011	4	13	14	11	31	9	5	4
11/02/2011	4	10	10	14	42	10	4	1

Table 1–4. Sieve diameters of bed-material samples for the Red River of the North and selected tributaries near Fargo, North Dakota during 2010 and 2011.—Continued

[mm, millimeter; IM, insufficient material]

Date	Bed-material fall diameter (percent in size range)							
	0.062–.125 mm	0.125–.250 mm	0.250–.500 mm	0.500–1 mm	1–2 mm	2–4 mm	4–8 mm	8–16 mm
Red River of the North near Christine (site 1)—Continued								
Mean	**3**	**7**	**15**	**20**	**14**	**9**	**9**	**17**
Median	**2**	**3**	**14**	**17**	**10**	**8**	**9**	**14**
Red River of the North at County Road 20 near Fargo (site 2)								
03/17/2010	2	6	10	24	28	17	8	2
03/19/2010	2	3	10	29	29	17	6	1
03/21/2010	5	9	15	22	26	11	2	0
03/23/2010	3	5	10	18	29	24	4	1
03/24/2010	0	1	5	32	41	15	4	0
03/25/2010	1	2	17	12	8	10	16	32
03/26/2010	2	8	32	30	18	6	1	0
03/27/2010	9	9	14	23	16	3	0	0
03/31/2010	12	17	10	15	15	8	0	1
04/04/2011	8	12	14	22	19	11	9	1
04/05/2011	3	10	20	31	20	9	5	1
04/07/2011	1	1	27	45	17	6	2	0
04/08/2011	17	21	12	13	11	9	2	0
04/09/2011	0	9	12	12	9	10	13	12
04/10/2011	5	11	20	16	13	10	12	7
04/11/2011	5	7	13	16	11	5	8	20
04/12/2011	8	11	14	14	11	8	5	8
04/13/2011	11	22	13	12	6	2	7	4
04/14/2011	9	18	22	17	5	1	1	1
04/15/2011	6	10	13	17	10	5	8	13
04/16/2011	8	12	14	14	7	2	2	15
04/17/2011	7	11	16	20	14	8	3	1
04/19/2011	11	14	16	16	6	2	0	0
04/21/2011	7	12	13	16	19	11	5	2
04/25/2011	6	8	9	17	26	12	2	0
05/02/2011	13	19	16	13	4	1	0	0
05/09/2011	14	20	20	5	1	0	0	0
05/16/2011	13	21	16	8	4	2	0	0
06/02/2011	0	2	5	9	8	9	25	41
06/03/2011	12	19	22	7	0	0	0	0
06/23/2011	2	4	8	36	28	13	6	0
06/24/2011	5	8	21	48	9	0	0	0
07/01/2011	19	12	11	8	1	0	0	0
07/20/2011	9	14	13	19	11	1	3	2
07/26/2011	2	3	8	34	30	14	5	1
09/20/2011	4	7	13	20	14	4	8	16

Table 1–4. Sieve diameters of bed-material samples for the Red River of the North and selected tributaries near Fargo, North Dakota during 2010 and 2011.—Continued

[mm, millimeter; IM, insufficient material]

Date	Bed-material fall diameter (percent in size range)							
	0.062–.125 mm	0.125–.250 mm	0.250–.500 mm	0.500–1 mm	1–2 mm	2–4 mm	4–8 mm	8–16 mm
Red River of the North at County Road 20 near Fargo (site 2)—Continued								
10/17/2011	4	9	15	9	6	5	0	42
11/03/2011	8	7	24	31	11	5	14	0
Mean	**7**	**10**	**15**	**20**	**14**	**7**	**5**	**6**
Median	**6**	**10**	**14**	**17**	**11**	**7**	**4**	**1**
Sheyenne River above Sheyenne River Diversion near Horace (site 3)								
03/20/2010	18	63	13	2	0	0	0	0
03/21/2010	26	50	10	2	1	1	0	1
03/22/2010	7	11	13	17	5	2	0	0
03/23/2010	16	50	17	0	0	0	0	0
03/24/2010	10	29	8	12	19	10	6	3
03/25/2010	10	36	28	18	1	0	0	2
03/26/2010	5	21	10	18	22	5	11	0
03/27/2010	5	23	34	23	7	2	2	0
03/29/2010	3	21	26	25	17	4	1	0
03/31/2010	6	24	27	22	10	4	3	1
04/05/2010	5	20	30	30	10	0	0	0
04/07/2010	1	5	9	22	27	14	8	13
04/08/2011	18	24	12	15	10	0	0	0
04/09/2011	18	33	8	8	7	6	5	1
04/10/2011	21	56	7	2	3	1	0	0
04/11/2011	11	30	20	19	10	2	1	1
04/12/2011	19	19	9	14	8	1	0	0
04/13/2011	10	26	10	18	22	7	0	3
04/14/2011	11	27	10	18	22	8	1	0
04/15/2011	20	27	33	0	0	0	0	0
04/16/2011	14	57	16	5	2	2	1	0
04/18/2011	17	51	12	10	5	1	1	0
04/20/2011	9	58	25	0	0	0	0	0
04/22/2011	13	44	22	17	0	0	0	0
04/26/2011	35	25	5	3	0	0	0	0
05/03/2011	14	42	8	7	20	5	1	0
05/09/2011	24	13	3	4	3	2	8	19
05/16/2011	22	47	12	2	1	1	0	4
06/20/2011	21	69	3	1	0	1	0	0
06/26/2011	26	68	3	0	0	0	0	0
06/30/2011	1	2	17	31	34	10	4	0
07/20/2011	22	70	4	1	0	0	0	0
07/26/2011	26	69	3	0	0	0	0	0
08/08/2011	31	65	1	0	0	0	0	0

Table 1–4. Sieve diameters of bed-material samples for the Red River of the North and selected tributaries near Fargo, North Dakota during 2010 and 2011.—Continued

[mm, millimeter; IM, insufficient material]

Date	Bed-material fall diameter (percent in size range)							
	0.062–.125 mm	0.125–.250 mm	0.250–.500 mm	0.500–1 mm	1–2 mm	2–4 mm	4–8 mm	8–16 mm
Sheyenne River above Sheyenne River Diversion near Horace (site 3)—Continued								
09/15/2011	23	72	2	0	0	0	0	0
10/13/2011	17	72	6	1	0	0	0	0
11/02/2011	22	55	10	2	1	1	0	0
Mean	**16**	**40**	**13**	**10**	**7**	**2**	**1**	**1**
Median	**17**	**36**	**10**	**7**	**3**	**1**	**0**	**0**
Sheyenne River at Horace (site 4)								
03/24/2010	31	54	4	1	0	0	0	0
03/25/2010	46	25	5	3	2	0	0	0
03/26/2010	37	34	7	6	2	0	0	0
03/27/2010	23	39	12	7	2	0	0	0
03/29/2010	9	46	18	0	0	0	0	0
03/31/2010	33	25	5	4	2	0	0	0
04/05/2010	21	31	5	7	9	15	7	1
04/07/2010	42	43	2	1	0	1	0	0
04/08/2011	5	74	17	1	1	0	0	0
04/09/2011	30	27	1	1	2	1	1	0
04/10/2011	13	28	19	15	9	4	2	1
04/11/2011	10	24	29	15	8	4	3	2
04/12/2011	26	42	10	6	2	0	0	0
04/13/2011	19	28	23	10	3	1	1	0
04/14/2011	25	28	8	6	3	1	2	3
04/15/2011	29	23	9	14	8	1	0	0
04/16/2011	28	22	12	8	2	0	0	0
04/18/2011	27	32	10	7	3	1	0	0
04/20/2011	24	30	11	7	1	0	0	0
04/22/2011	15	13	8	10	14	13	2	0
04/26/2011	24	38	13	3	1	1	0	0
05/03/2011	37	45	4	1	2	1	2	1
05/10/2011	22	42	14	11	5	3	0	0
05/16/2011	27	43	9	6	4	1	1	0
06/20/2011	13	55	13	5	6	1	2	3
06/26/2011	13	79	6	0	0	0	0	0
06/30/2011	21	48	16	4	2	2	1	1
07/21/2011	17	50	16	5	5	1	1	1
07/26/2011	8	35	37	10	7	1	0	0
08/08/2011	19	56	12	4	3	1	0	0
09/15/2011	52	14	5	3	2	3	1	0
10/13/2011	56	13	3	0	0	0	0	0
11/02/2011	65	3	1	1	0	0	0	0

Table 1–4. Sieve diameters of bed-material samples for the Red River of the North and selected tributaries near Fargo, North Dakota during 2010 and 2011.—Continued

[mm, millimeter; IM, insufficient material]

Date	Bed-material fall diameter (percent in size range)							
	0.062–.125 mm	0.125–.250 mm	0.250–.500 mm	0.500–1 mm	1–2 mm	2–4 mm	4–8 mm	8–16 mm
Sheyenne River at Horace (site 4)—Continued								
Mean	**26**	**36**	**11**	**6**	**3**	**2**	**1**	**0**
Median	**24**	**34**	**10**	**5**	**2**	**1**	**0**	**0**
Maple River below Mapleton (site 5)								
03/19/2010	10	12	11	13	18	11	9	1
03/20/2010	12	4	10	6	18	26	16	0
03/21/2010	6	6	6	6	9	5	0	47
03/22/2010	13	24	19	13	12	1	0	0
03/23/2010	3	7	21	38	19	5	2	0
03/24/2010	3	7	22	34	23	5	1	0
03/26/2010	0	17	16	34	16	0	17	0
03/27/2010	4	9	23	32	21	5	0	0
03/30/2010	2	6	23	32	23	8	2	0
04/02/2010	4	7	28	32	17	6	1	0
04/06/2010	4	7	34	30	15	4	1	0
04/07/2011	9	10	11	16	18	9	2	0
04/08/2011	15	14	17	31	18	2	0	0
04/09/2011	11	11	13	17	14	4	0	0
04/10/2011	9	12	21	32	6	1	0	0
04/11/2011	5	7	14	28	29	7	1	0
04/12/2011	5	7	31	38	8	1	0	0
04/13/2011	6	9	33	31	7	1	0	0
04/14/2011	6	9	34	34	6	0	0	0
04/15/2011	7	11	31	26	7	1	1	0
04/16/2011	9	12	23	26	12	1	1	0
04/17/2011	5	9	33	30	11	2	0	0
04/18/2011	3	6	25	31	21	7	1	0
04/21/2011	12	22	30	11	2	0	0	0
04/25/2011	1	2	6	29	39	16	2	3
05/02/2011	13	15	19	12	8	2	0	0
05/09/2011	17	22	14	11	3	0	0	0
05/16/2011	3	13	53	21	4	0	0	0
06/01/2011	12	15	17	5	0	0	0	0
06/02/2011	7	11	23	28	14	3	0	0
06/03/2011	3	7	25	34	18	6	2	0
06/16/2011	5	11	51	22	0	0	0	0
06/17/2011	2	11	49	28	4	0	0	0
07/25/2011	3	10	39	27	13	3	0	0
08/08/2011	3	12	44	25	8	3	1	0
09/08/2011	4	14	43	20	7	2	1	1

Table 1–4. Sieve diameters of bed-material samples for the Red River of the North and selected tributaries near Fargo, North Dakota during 2010 and 2011.—Continued

[mm, millimeter; IM, insufficient material]

Date	Bed-material fall diameter (percent in size range)							
	0.062–.125 mm	0.125–.250 mm	0.250–.500 mm	0.500–1 mm	1–2 mm	2–4 mm	4–8 mm	8–16 mm
Maple River below Mapleton (site 5)—Continued								
10/17/2011	7	29	50	0	0	0	0	0
11/03/2011	4	8	33	31	14	3	0	0
Mean	**7**	**11**	**26**	**24**	**13**	**4**	**2**	**1**
Median	**5**	**11**	**23**	**28**	**13**	**3**	**0**	**0**
Wild Rice River near St. Benedict (site 6)								
03/18/2010	3	4	3	5	34	26	18	2
03/20/2010	4	8	17	21	18	12	7	7
03/21/2010	3	5	13	24	28	15	4	4
03/22/2010	6	19	22	12	14	5	1	3
03/23/2010	4	6	8	13	17	19	16	6
03/24/2010	12	38	12	25	0	0	0	0
03/25/2010	2	4	6	9	15	30	18	10
03/26/2010	1	4	7	10	17	24	20	9
03/27/2010	7	14	19	12	16	16	2	2
03/30/2010	5	11	14	17	24	14	2	0
04/01/2010	6	6	9	13	17	13	10	9
04/05/2011	8	14	18	21	15	2	1	0
04/07/2011	9	19	20	15	14	3	1	0
04/08/2011	3	5	10	20	29	19	3	4
04/09/2011	13	20	21	18	6	1	0	0
04/10/2011	2	4	5	5	9	11	21	24
04/11/2011	1	1	1	3	7	10	24	48
04/12/2011	3	4	8	9	9	6	12	22
04/13/2011	13	24	19	12	3	0	0	0
04/14/2011	12	23	20	13	4	0	0	0
04/15/2011	14	22	22	9	2	1	0	3
04/16/2011	8	11	13	16	14	6	9	9
04/18/2011	12	21	19	16	6	1	0	0
04/20/2011	14	20	25	12	1	0	0	0
04/22/2011	14	25	25	13	1	0	0	0
04/25/2011	0	15	14	28	29	0	0	0
05/03/2011	14	22	21	11	4	1	0	0
05/09/2011	10	30	31	5	3	1	0	0
05/17/2011	7	37	39	4	2	1	0	0
06/16/2011	14	33	17	7	2	0	0	0
06/17/2011	15	34	18	5	0	0	0	0
06/23/2011	6	54	26	4	1	1	0	0
06/24/2011	5	14	53	16	2	1	0	0
07/26/2011	3	12	12	5	6	9	12	39

Table 1–4. Sieve diameters of bed-material samples for the Red River of the North and selected tributaries near Fargo, North Dakota during 2010 and 2011.—Continued

[mm, millimeter; IM, insufficient material]

Date	Bed-material fall diameter (percent in size range)							
	0.062–.125 mm	0.125–.250 mm	0.250–.500 mm	0.500–1 mm	1–2 mm	2–4 mm	4–8 mm	8–16 mm
Wild Rice River near St. Benedict (site 6)—Continued								
08/09/2011	8	42	36	2	0	0	0	0
09/08/2011	11	22	34	8	0	1	0	0
10/13/2011	9	19	34	16	3	1	0	0
11/02/2011	9	59		13	2	1	0	0
Mean	**8**	**19**	**19**	**12**	**10**	**7**	**5**	**5**
Median	**8**	**19**	**18**	**12**	**6**	**1**	**0**	**0**
Rush River near Prosper (site 7)								
04/08/2011	7	12	22	20	14	12	5	0
04/09/2011	2	3	5	21	42	16	8	3
04/10/2011	6	9	30	37	8	2	0	0
04/11/2011	11	17	24	25	0	0	0	0
04/12/2011	10	15	27	25	5	0	0	0
04/13/2011	9	18	45	16	0	0	0	0
04/14/2011	12	19	29	15	3	0	0	0
04/15/2011	10	17	37	17	1	0	0	0
04/16/2011	10	17	37	14	0	0	0	0
04/17/2011	9	13	26	35	13	0	0	0
04/19/2011	11	28	39	0	0	0	0	0
04/21/2011	25	0	0	0	0	0	0	0
06/01/2011	12	20	33	12	1	0	0	0
06/02/2011	5	12	42	31	2	0	0	0
06/16/2011	5	11	51	22	0	0	0	0
06/17/2011	2	11	49	28	4	0	0	0
07/25/2011	IM	IM	IM	IM	IM	IM	IM	IM
08/08/2011	IM	IM	IM	IM	IM	IM	IM	IM
09/08/2011	IM	IM	IM	IM	IM	IM	IM	IM
10/17/2011	IM	IM	IM	IM	IM	IM	IM	IM
11/03/2011	IM	IM	IM	IM	IM	IM	IM	IM
Mean	**9**	**14**	**31**	**20**	**6**	**2**	**1**	**0**
Median	**10**	**14**	**32**	**21**	**2**	**0**	**0**	**0**
Lower Branch Rush River east of Prosper (site 8)								
04/07/2011	5	14	22	19	8	1	25	0
04/08/2011	0	4	15	26	19	9	24	0
04/09/2011	IM	IM	IM	IM	IM	IM	IM	IM
04/10/2011	IM	IM	IM	IM	IM	IM	IM	IM
04/11/2011	IM	IM	IM	IM	IM	IM	IM	IM
04/12/2011	IM	IM	IM	IM	IM	IM	IM	IM
04/13/2011	IM	IM	IM	IM	IM	IM	IM	IM
04/14/2011	IM	IM	IM	IM	IM	IM	IM	IM

Table 1–4. Sieve diameters of bed-material samples for the Red River of the North and selected tributaries near Fargo, North Dakota during 2010 and 2011.—Continued

[mm, millimeter; IM, insufficient material]

Date	Bed-material fall diameter (percent in size range)							
	0.062–.125 mm	0.125–.250 mm	0.250–.500 mm	0.500–1 mm	1–2 mm	2–4 mm	4–8 mm	8–16 mm
Lower Branch Rush River east of Prosper (site 8)—Continued								
04/15/2011	IM	IM	IM	IM	IM	IM	IM	IM
04/16/2011	IM	IM	IM	IM	IM	IM	IM	IM
04/17/2011	IM	IM	IM	IM	IM	IM	IM	IM
04/19/2011	50	0	0	0	0	0	0	0
04/21/2011	IM	IM	IM	IM	IM	IM	IM	IM
Mean	**18**	**6**	**12**	**15**	**9**	**3**	**16**	**0**
Median	**5**	**4**	**15**	**19**	**8**	**1**	**24**	**0**
Buffalo River east of Kragnes (site 9)								
04/06/2011	8	8	16	18	8	4	1	1
04/07/2011	5	5	7	10	10	6	8	15
04/08/2011	11	8	11	11	1	1	0	0
04/09/2011	7	9	17	19	6	1	0	0
04/10/2011	9	9	10	12	10	6	6	8
04/11/2011	11	6	7	10	5	3	2	1
04/12/2011	11	8	12	16	4	2	1	1
04/15/2011	10	8	10	8	3	3	3	4
04/17/2011	10	9	10	12	7	3	3	1
04/19/2011	10	10	8	7	11	10	7	5
04/21/2011	9	11	7	8	8	9	10	14
04/25/2011	11	15	7	7	10	5	4	12
06/23/2011	10	7	10	12	5	2	3	14
06/26/2011	12	8	9	8	1	0	0	0
06/30/2011	9	15	18	20	13	2	0	0
07/20/2011	7	6	10	14	9	3	1	4
07/21/2011	9	7	8	13	9	3	2	2
07/25/2011	16	8	8	10	4	0	0	0
08/09/2011	8	7	9	3	1	0	0	0
09/08/2011	13	16	11	8	3	3	2	6
10/17/2011	12	11	11	11	7	3	2	0
11/03/2011	9	7	13	14	13	9	6	2
Mean	**10**	**9**	**10**	**11**	**7**	**4**	**3**	**4**
Median	**10**	**8**	**10**	**11**	**7**	**3**	**2**	**2**

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