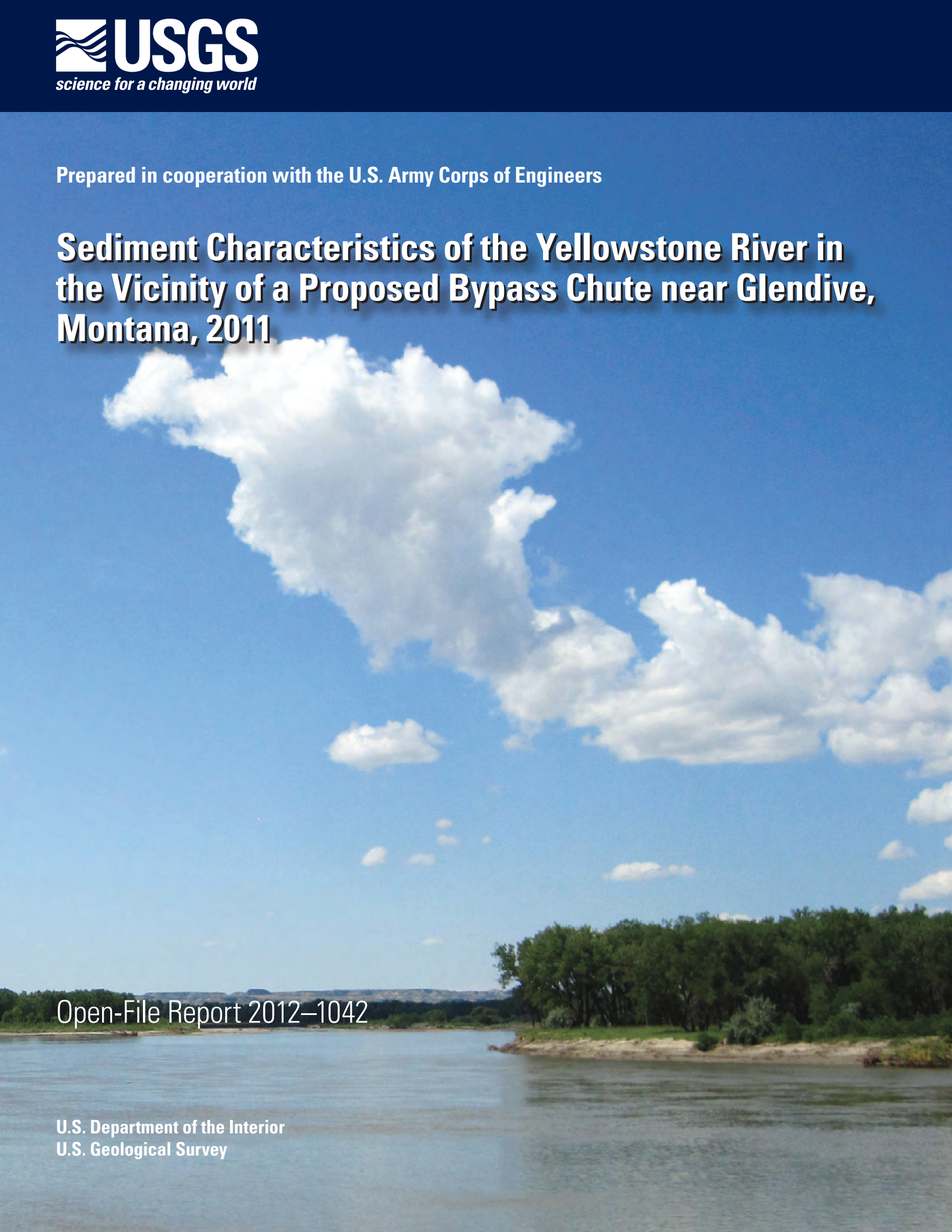
USGS
science for a changing world

Prepared in cooperation with the U.S. Army Corps of Engineers

Sediment Characteristics of the Yellowstone River in the Vicinity of a Proposed Bypass Chute near Glendive, Montana, 2011



Open-File Report 2012–1042

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

Cover. Yellowstone River, August 2011.

Sediment Characteristics of the Yellowstone River in the Vicinity of a Proposed Bypass Chute near Glendive, Montana, 2011

By Brent R. Hanson and Joel M. Galloway

Prepared in cooperation with the U.S. Army Corps of Engineers

Open-File Report 2012–1042

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

U.S. Department of the Interior
KEN SALAZAR, Secretary

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

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

For more information on the USGS—the Federal source for science about the Earth, its natural and living resources, natural hazards, and the environment, visit http://www.usgs.gov or call 1–888–ASK–USGS.

For an overview of USGS information products, including maps, imagery, and publications, visit http://www.usgs.gov/pubprod

To order this and other USGS information products, visit http://store.usgs.gov

Any use of trade, product, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

Although this report is in the public domain, permission must be secured from the individual copyright owners to

reproduce any copyrighted materials contained within this report.

Suggested citation:
Hanson, B.R., and Galloway, J.M., 2012, Sediment characteristics of the Yellowstone River in the vicinity of a proposed bypass chute near Glendive, Montana, 2011: U.S. Geological Survey Open-File Report 2012–1042, 19 p.

Contents

Abstract....1
Introduction....1
Methods of Data Collection....1
Sediment Characteristics....3
    Suspended-Sediment Concentration....4
    Particle-Size Distribution of Suspended Sediment and Bedload....4
    Sediment loads....5
Summary....18
References Cited....18

Figures

1. Map showing location of study area and sample sites....2
2. Graph showing daily mean streamflow for the Yellowstone River near Glendive, Montana (U.S. Geological Survey station number 06327500) and sample collection dates near a proposed bypass chute, 2011....3
3. Cross section showing distribution of suspended-sediment concentrations from point samples collected on the Yellowstone River above a proposed bypass chute near Glendive, Montana, August, 2011....5
4. Cross section showing distribution of suspended-sediment concentrations from point samples collected on the Yellowstone River adjacent to a proposed bypass chute near Glendive, Montana, July and August, 2011....6
5. Cross section showing distribution of suspended-sediment concentrations from point samples collected on the Yellowstone River below a proposed bypass chute near Glendive, Montana, July and August, 2011....7
6. Cross section showing distribution of suspended-sediment particle sizes from point samples collected on the Yellowstone River above a proposed bypass chute near Glendive, Montana, August, 2011....15
7. Cross section showing distribution of suspended-sediment particle sizes from point samples collected on the Yellowstone River adjacent to a proposed bypass chute near Glendive, Montana, July and August, 2011....16
8. Cross section showing distribution of suspended-sediment particle sizes from point samples collected on the Yellowstone River below a proposed bypass chute near Glendive, Montana, July and August, 2011....17

Tables

1. Measured streamflow, suspended-sediment concentrations, and fall diameters for three sites near the proposed bypass chute on the Yellowstone River near Glendive, Montana, July and August, 2011 4
2. Suspended-sediment concentration, fall diameter, and sieve diameter for samples collected at discrete vertical depths at three sites near the proposed bypass chute on the Yellowstone River near Glendive, Montana, July and August, 2011 8
3. Sieve diameters and mass of bedload samples for three sites near a proposed bypass chute on the Yellowstone River near Glendive, Montana, July and August, 2011 18
4. Sediment loads for three sites near a proposed bypass chute on the Yellowstone River near Glendive, Montana, July and August, 2011 18

Conversion Factors and Datums

Inch/Pound to SI

Multiply	By	To obtain
	Length	
inch (in)	2.54	centimeter (cm)
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

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

$$°F=(1.8\times°C)+32$$

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

$$°C=(°F-32)/1.8$$

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

Horizontal coordinate information is referenced to the World Geodetic System of 1984 (WGS 84).

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

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

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

Sediment Characteristics of the Yellowstone River in the Vicinity of a Proposed Bypass Chute near Glendive, Montana, 2011

By Brent R. Hanson and Joel M. Galloway

Abstract

In 2011, sediment data were collected by the U.S. Geological Survey in cooperation with the U.S. Army Corps of Engineers on the Yellowstone River at the location of a proposed bypass chute. The sediment data were collected to provide an understanding of the sediment dynamics of the given reach of the Yellowstone River. Suspended-sediment concentrations collected at the three sites generally decreased with decreasing streamflow. In general, the highest suspended-sediment concentrations were found near the channel bed and towards the center of the channel with lower suspended-sediment concentrations near the channel banks and water surface. Suspended sediment was the primary component of the total sediment load for all three sampling locations on the Yellowstone River and contributed at least 98 percent of the total sediment load at each of the three sites. The amount of bedload measured at the three sites was a smaller load in comparison with the suspended-sediment load.

Introduction

As of 2011, a diversion dam located on the Yellowstone River near Glendive, Montana (fig.1) impedes the upstream migration of the endangered *Scaphirhynchus albus*, commonly known as the pallid sturgeon (Bureau of Reclamation, 2011). A bypass chute around the diversion dam is proposed that would improve passage for the pallid sturgeon and other fish in the Yellowstone River as they proceed with their upstream migrations. Development of the bypass chute would result in the excavation of parts of an existing high-flow side channel on the Yellowstone River, with the remaining part of the bypass chute being excavated across the island formed by the existing high-flow side channel. The proposed bypass chute will exit just below the diversion dam (Curtis J. Miller, U.S. Army Corps of Engineers, written commun., 2011). These excavations may affect sediment movement in the Yellowstone River and bypass chute.

In 2011, sediment and streamflow data were collected by the U.S. Geological Survey (USGS) in cooperation with the U.S. Army Corps of Engineers (USACE) on the Yellowstone River in the vicinity of the proposed bypass chute near Glendive, Montana. The sediment data were collected to provide an understanding of the sediment dynamics of the Yellowstone River reach above and below the bypass chute. The USACE will use the sediment data with hydraulic modeling to evaluate the potential degradation and aggradation effects the bypass chute may have within the Yellowstone River reach (Curtis J. Miller, U.S. Army Corps of Engineers, written commun., 2011). The models will be used to select a favorable channel configuration for the bypass that will minimize the effects of sediment transport that may be generated.

Methods of Data Collection

Sediment samples and streamflow measurements were collected by the USGS at three sites on the Yellowstone River in the vicinity of the proposed bypass chute near Glendive, Montana (fig. 1) Samples of suspended sediment (point and integrated) and bedload were collected at the three sites; one site upstream from the bypass chute entrance (above bypass chute), one site at the entrance of the bypass chute (adjacent to bypass chute) and one site downstream from the bypass chute entrance (below bypass chute) (fig. 1). Streamflow was measured at each site before collection of the sediment samples. Samples were collected during July 19–21, August 9–11, and August 23–24, 2011 (fig. 2).

Integrated suspended-sediment concentration (SSC) samples were collected three times in 2011 to estimate the amount of suspended material being transported past the three sites during different streamflow conditions. To collect samples that represent the vertical and horizontal variability of suspended sediment in the stream channel, samples were collected using depth-integrated samplers (D-96 and DH-2) (Davis, 2005) and the equal-discharge increment (EDI) method (Edwards and Glysson, 1999). The EDI method involved the collection of vertically integrated, isokinetic (velocity entering the sampler

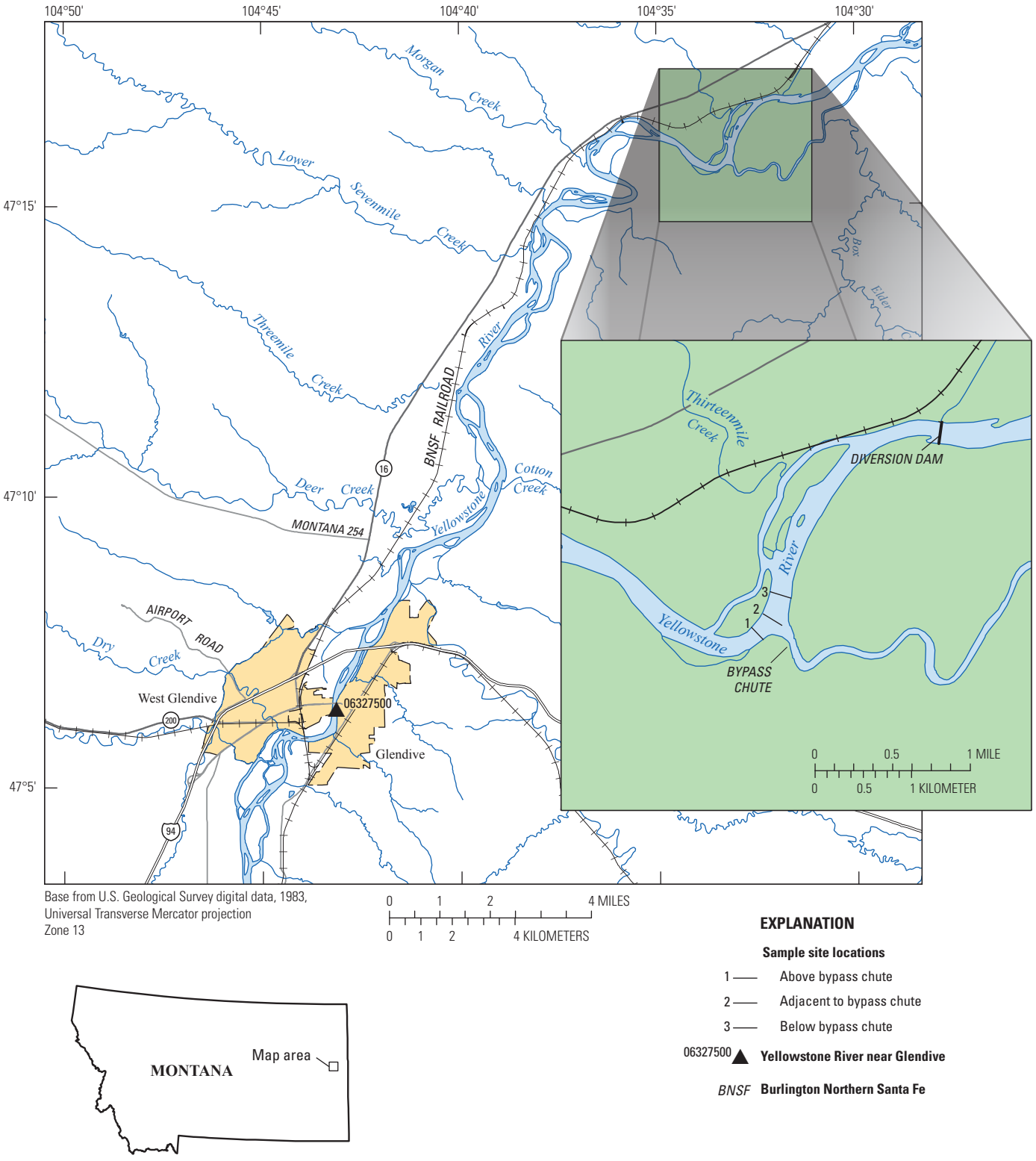


Figure 1. Map showing location of study area and sample sites.

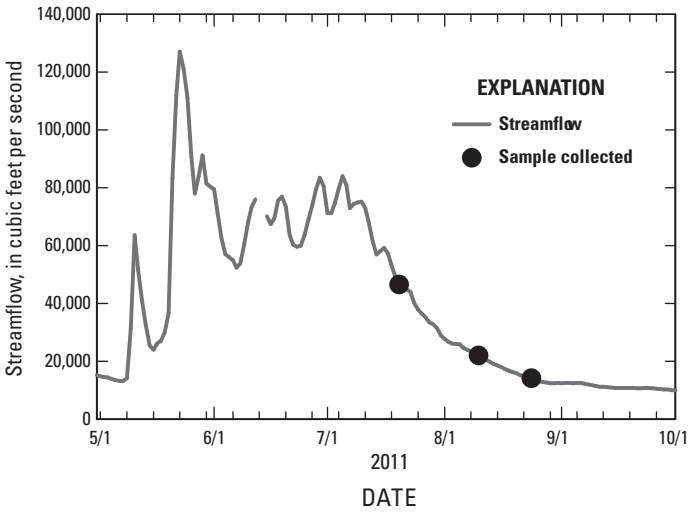


Figure 2. Graph showing daily mean streamflow for the Yellowstone River near Glendive, Montana (U.S. Geological Survey station number 06327500) and sample collection dates near a proposed bypass chute, 2011.

nozzle was the same as the velocity of the stream) samples at 5 intervals representing equal percentages of the total streamflow across the stream cross section (20 percent of the total streamflow in each section).

Suspended-sediment samples also were collected at discrete vertical points (point samples) at each site to estimate the vertical distribution of particle sizes and concentrations at the three sites. Point samples were collected using a US P-61-A1 suspended-sediment sampler that is designed to open and close at varying depths in the water column (Davis, 2005). Samples were collected at six different depths including near the water surface, 1 foot above the channel bottom, and at four evenly spaced points in the vertical between those points at each of the five EDI sample collection locations at each site.

Bedload samples were collected to estimate the sediment transport along or near the streambed at the three sites. Bedload samples were collected using a cable-suspended Helley-Smith Model 8035 sampler (Davis, 2005). For each sampling site, bedload samples were collected at 20 equal-width sections across the channel according to methods described by Edwards and Glysson (1999). The bedload samples were then composited in a 1-liter plastic container.

All samples of suspended sediment (integrated and point) and bedload were analyzed for concentration and particle-size distribution at the USGS Iowa Water Science Center Sediment Laboratory in Iowa City, Iowa, using methods described by Guy (1969). Some suspended-sediment samples were not analyzed for the complete 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*).

Streamflow data were collected for use with the sediment concentration data to calculate sediment loads. Streamflow was measured using an acoustic Doppler current profiler (ADCP) with the methods and procedures described in Mueller and Wagner (2009). Streamflow was measured at each sampling site before the collection of sediment samples.

Suspended-sediment loads were estimated for the three sites using the measured streamflow data and SSC data collected during the three sampling events. Loads were estimated using equation 1 (Porterfield, 1972):

$$Q_s = Q_w \text{ x } C_s \text{ x } K \quad (1)$$

where

Q_s is the suspended-sediment load (sediment discharge), in tons (short tons) per day (tons/day);

Q_w is the instantaneous streamflow (water discharge), in cubic feet per second (ft^3/s);

C_s is the SSC, in milligrams per liter (mg/L); and

K is a coefficient (0.0027) to convert the units of measurement of water discharge and SSC into tons/day and assumes a specific gravity of 2.65 for sediment.

The bedload was calculated from the measured data using equation 2 (Edwards and Glysson, 1999):

$$Q_b = K \times (W_T / t_T) \times M_T \quad (2)$$

where

Q_b is the bedload discharge, in tons/day;

K is a conversion factor (0.381 for a 3-inch nozzle);

W_T is the total width of the stream from which samples were collected, in feet, and is equal to the increment width times the total number of vertical samples;

t_T is the total time the sampler was on the streambed, in seconds, computed by multiplying the individual sample time by the total number of vertical samples; and

M_T is the total mass of sample collected from all verticals sampled in the cross section, in grams.

Sediment Characteristics

The three locations on the Yellowstone River were sampled for suspended sediment and bedload during three different hydrologic flow conditions (fig. 2; table 1) Streamflow ranged from 49,900 (above bypass chute) to 46,200 cubic feet per second (ft^3/s) (adjacent to bypass chute) for the July 19–21 samples, and from 22,800 (above bypass chute) to 20,100 (ft^3/s) (adjacent to bypass chute) for the

Table 1. Measured streamflow, suspended-sediment concentrations, and fall diameters for three sites near the proposed bypass chute on the Yellowstone River near Glendive, Montana, July and August, 2011.

[ft above NAVD88, feet above North American Vertical Datum 88; ft³/s, cubic feet per second; mS/cm, microsiemens per centimeter; °C, degrees Celsius; mg/L, milligram per liter; mm, millimeter]

Dates	Water surface elevation (ft above NAVD88)	Measured streamflow (ft³/s)	Specific conductance (mS/cm at 25 °C)	Water temperature (°C)	Suspended-sediment concentration (mg/L)	Suspended-sediment fall diameter (values in percent finer than size)			
						0.062 mm	0.125 mm	0.250 mm	0.500 mm
Above bypass chute									
7/19/2011	1,995.12	49,900	337	23.9	428	73	81	95	100
8/10/2011	1,992.24	22,800	452	21.6	134	77	88	98	99
8/24/2011	1,990.20	13,400	505	22.0	72	82	93	100	100
Adjacent to bypass chute									
7/21/2011	1,994.70	46,200	345	22.0	438	71	79	95	100
8/11/2011	1,992.06	20,100	453	22.0	117	79	92	100	100
8/24/2011	1,990.92	13,400	505	22.5	83	84	98	100	100
Below bypass chute									
7/20/2011	1,994.84	46,900	354	23.4	452	69	80	96	100
8/09/2011	1,992.34	22,700	456	21.6	151	78	91	99	100
8/23/2011	1,990.99	13,400	500	23.8	75	81	93	100	100

August 9–11 samples. During the August 23–24 sampling, all three sites had the same streamflow of 13,400 ft³/s. Because of safety and timing constraints, the suspended samples were collected during the falling limb of the above average high flows during the summer of 2011.

Suspended-Sediment Concentration

SSC in the integrated samples collected at three sites on the Yellowstone River in 2011 decreased with decreasing streamflow (table 1). The SSC was 428 milligrams per liter (mg/L) above the bypass chute during the highest streamflow (July 19, 2011), and 72 mg/L at the lowest streamflow (August 24, 2011). The SSC for samples collected at the locations adjacent to bypass chute and below bypass chute had similar results ranging from 438 to 83 mg/L and 452 to 75 mg/L, respectively.

Point samples collected at the three sites indicated the variability of SSC in the cross section at each site (figs. 3–5 and table 2). In general, the largest SSC were found near the channel bed and towards the center of the channel with smaller SSCs near the channel banks and water surface (figs. 3–5 and table 2). The maximum SSC for the point samples was found above the bypass chute, 1 foot above the channel bed near the center of the channel at 694 mg/L on July 19, 2011, (table 2) at a measured streamflow of 49,900 ft³/s (table 1). The minimum SSC was 32 mg/L below the bypass chute near the right edge of water on August 23, 2011, with a measured streamflow of 13,400 ft³/s.

Because of equipment malfunction, the full point sample set was not collected for the above bypass chute on July 19, 2011. Because of the incomplete sample set, a concentration contour graph was not prepared for the July 19, 2011, point sample data.

Particle-Size Distribution of Suspended Sediment and Bedload

The particle-size distribution of suspended sediment from point samples collected at three sites on the Yellowstone River in 2011 indicated similar distributions at each site for the three sampling periods (figs, 6–8 and table 2). Most of the suspended sediment was smaller than 0.062 mm in size. At the highest measured flows of 49,900 to 46,200 ft³/s (July 19–21, 2011; table 1), 50 to 95 percent of the suspended sediment in the Yellowstone River was finer than 0.062 mm across the channel with an average of 77 percent finer than 0.062 mm. At the lowest measured flows of 13,400 ft³/s (August 23–24, 2011), the amount of suspended sediment finer than 0.062 mm increased to an average of 89 percent ranging from 58 to 99 percent finer than 0.062 mm across the channel. In general, the coarsest material for each sample was found near the center of the channel and near the channel bed (figs. 6–8). For all three sampling visits, the suspended-sediment size generally tended to decrease near the channel banks and the surface of the water column.

Because of equipment malfunction, the full point sample set was not collected for the above bypass chute

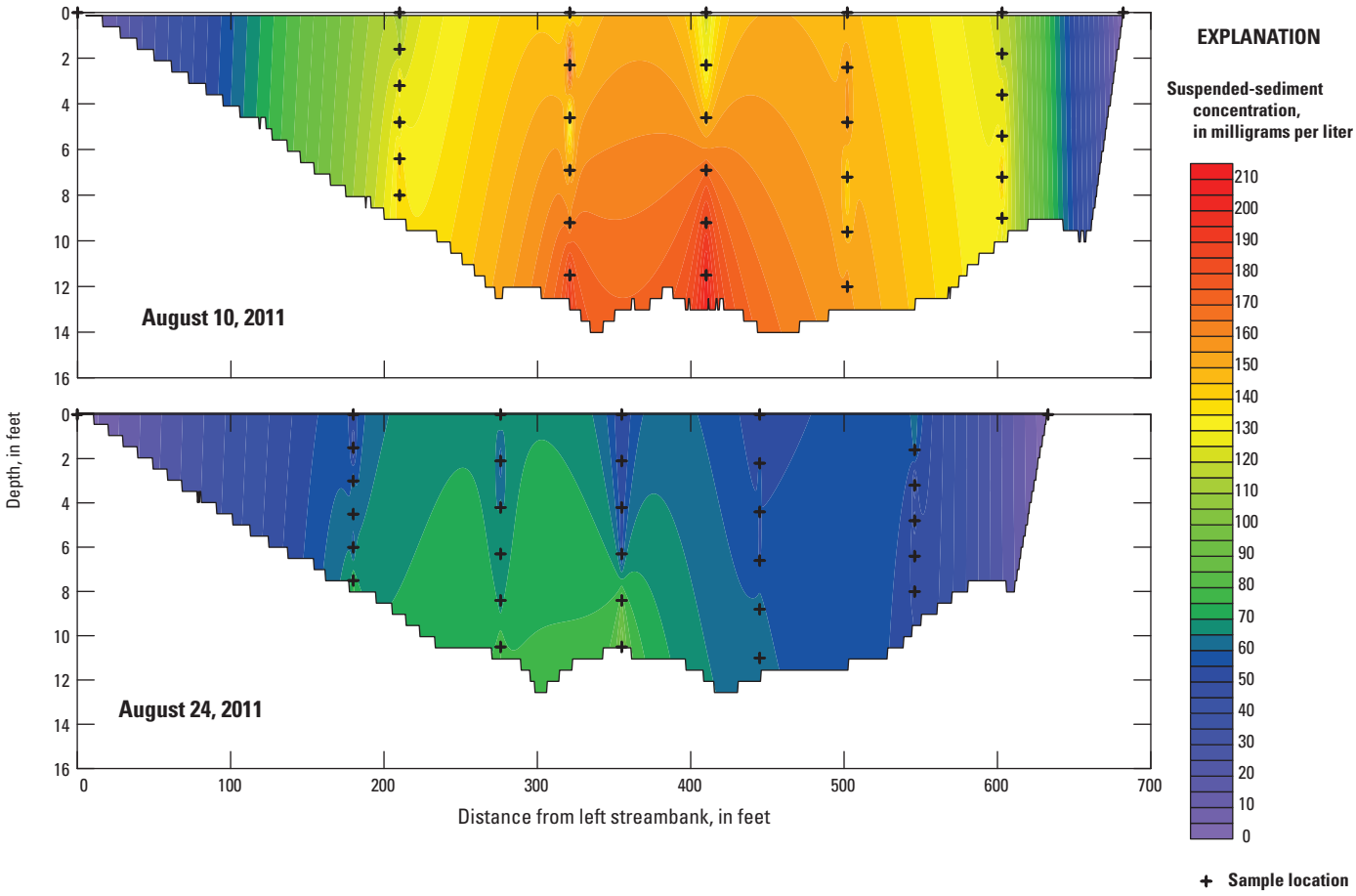


Figure 3. Cross section showing distribution of suspended-sediment concentrations from point samples collected on the Yellowstone River above a proposed bypass chute near Glendive, Montana, August, 2011.

on July 19, 2011. Because of the incomplete sample set, a particle-size distribution contour graph was not prepared for the July 19, 2011, point sample data.

Overall, the bedload sediment had a particle size less than 16 mm (table 3). Most of the bedload particles sizes measured were between 0.25 to 0.50 mm. For the site above bypass chute, 41 to 85 percent of the bedload material was between 0.25 to 0.50 mm in the three samples. For the site adjacent to the bypass chute, 54 to 60 percent of the bedload material was between 0.25 to 0.50 mm in the three samples. The bedload at the site below the bypass chute had 37 to 58 percent of the material between 0.25 to 0.50 mm in the three samples.

Sediment loads

Suspended sediment was the primary component of the total sediment load for all three sampling locations on the Yellowstone River during July and August, 2011 (table 4). Suspended sediment contributed at least 98 percent of the total sediment load at each of the three sites.

The sampling location above the bypass chute had the greatest suspended-sediment load among the three sites at the highest streamflow and least suspended-sediment load among the three sites at the lowest measured streamflow. At the highest measured streamflow of 49,900 ft^3/s (July 19, 2011; table 1), the site above the bypass chute had a suspended-sediment load of 57,700 tons/day and at the lowest measured streamflow of 13,400 ft^3/s (August 24, 2011) the same sampling location had a suspended load of 2,600 tons/day (table 4).

The amount of bedload measured at the three sites on the Yellowstone River in 2011 was a smaller load in comparison with the suspended-sediment load and generally decreased as streamflow decreased. At the highest measured streamflow (July 19–21, 2011; table 1), the measured bedload amount ranged from 254 tons/day above bypass chute to 301 ton/day below bypass chute (table 4). At the lowest measured streamflow (August 23–24, 2011), the measured bedload ranged from 5 tons/day above bypass chute to 55 ton/day below bypass chute.

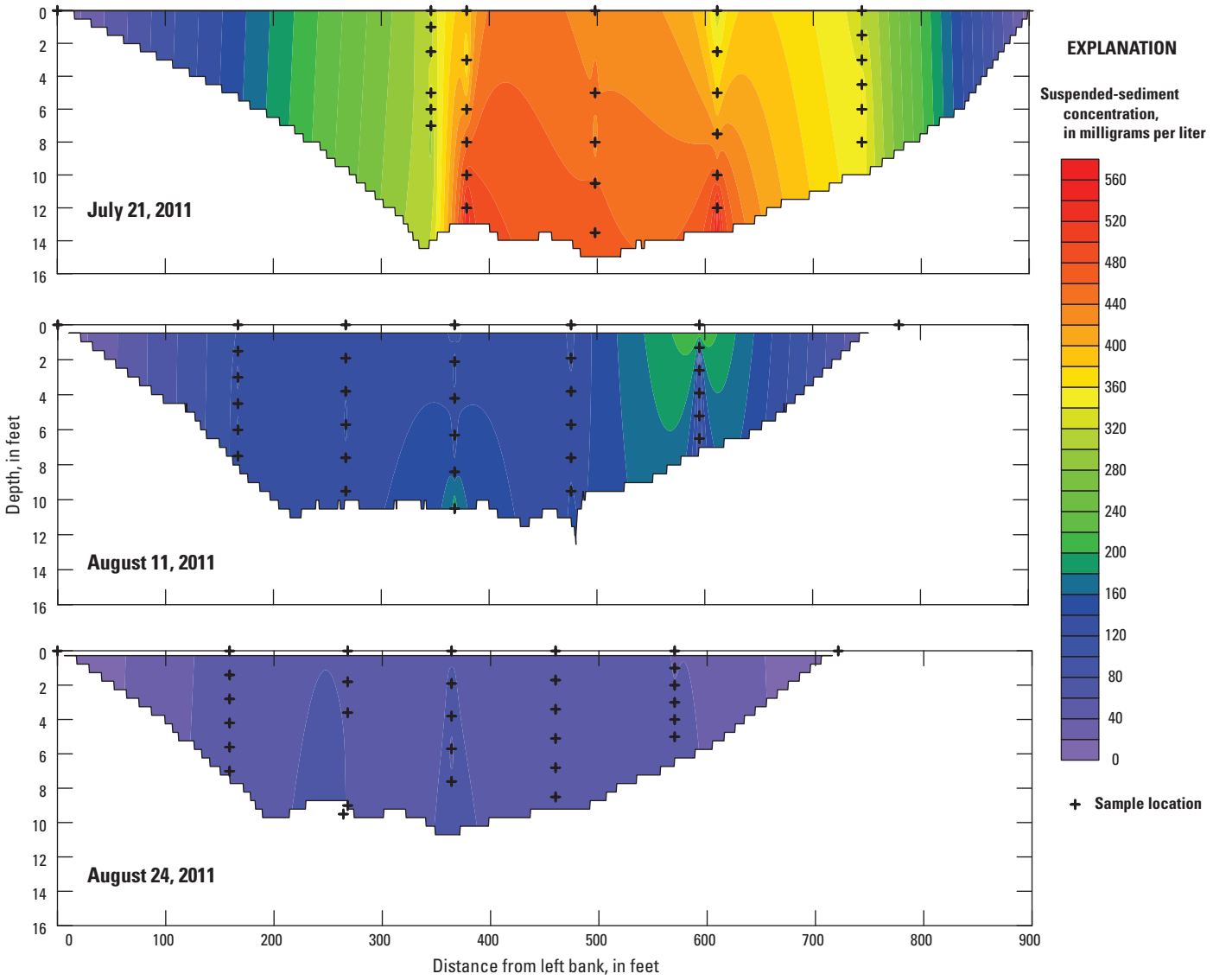


Figure 4. Cross section showing distribution of suspended-sediment concentrations from point samples collected on the Yellowstone River adjacent to a proposed bypass chute near Glendive, Montana, July and August, 2011.

The total sediment load within the channel consists of the suspended-sediment load and the bedload. The highest total sediment load was detected during the highest measured streamflow of 49,900 ft^3/s above the bypass chute on July 19, 2011, with a total load of 57,954 tons/day (table 4). The lowest total sediment load also was detected above the bypass chute with 2,605 tons/day at a streamflow of 13,400 ft^3/s on August 24, 2011.

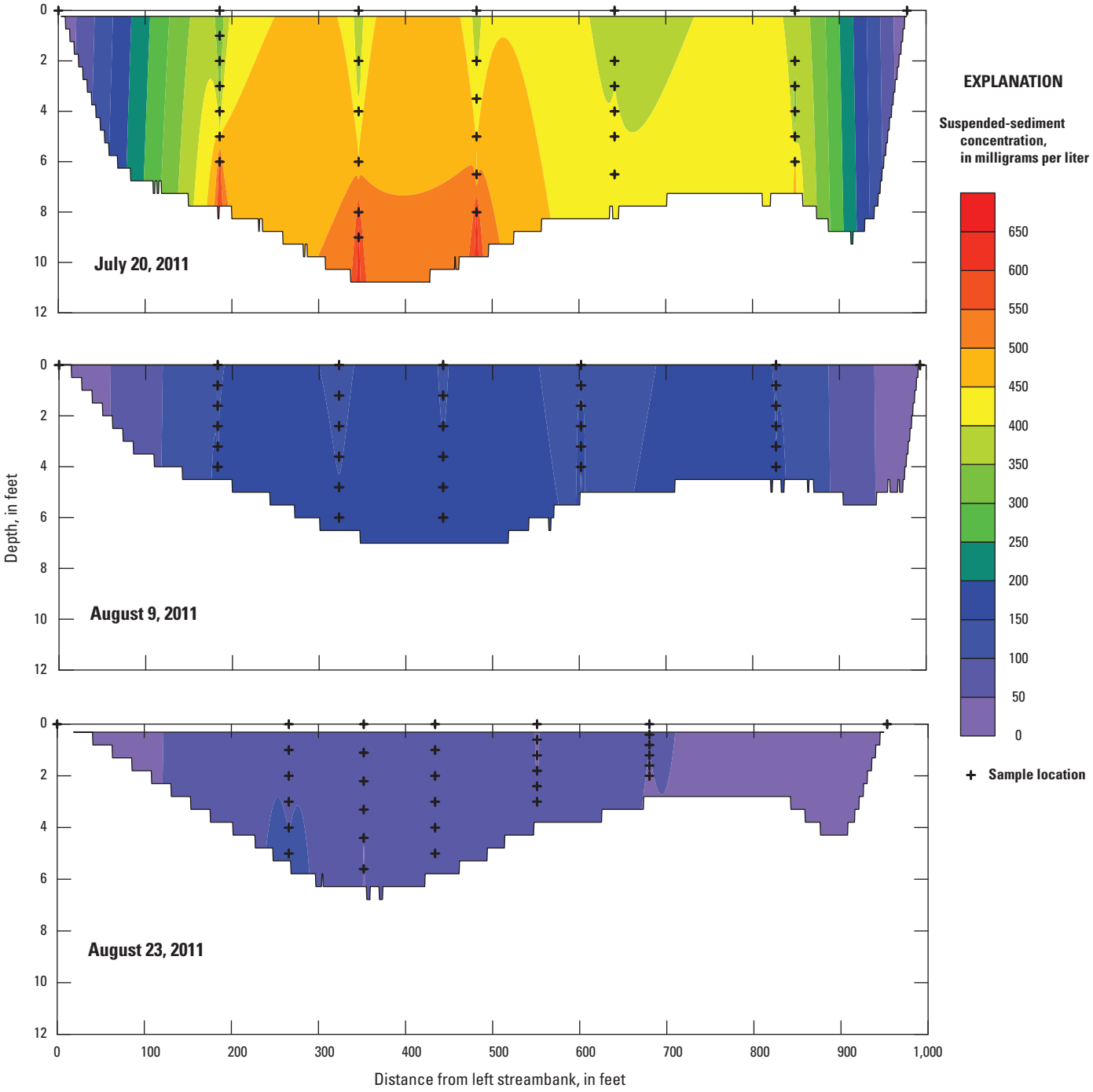


Figure 5. Cross section showing distribution of suspended-sediment concentrations from point samples collected on the Yellowstone River below a proposed bypass chute near Glendive, Montana, July and August, 2011.

Table 2. Suspended-sediment concentration, fall diameter, and sieve diameter for samples collected at discrete vertical depths at three sites near the proposed bypass chute on the Yellowstone River near Glendive, Montana, July and August, 2011.

[DD, decimal degrees; ft, feet; mg/L, milligram per liter; mm, millimeter; --, no data; IM, Insufficient Material]

Dates	Latitude (DD)	Longitude (DD)	Location in cross section, distance from left bank looking downstream (ft)	Sampling depth (ft)	Suspened-sediment concentration (mg/L)	Suspended-sediment fall diameter (values in percent finer than size)				Percent finer than suspended-sediment sieve diameter of 0.062 mm
						0.062 mm	0.125 mm	0.250 mm	0.500 mm	
Above bypass chute										
7/19/2011	47.261	104.555	344	0.0	352	87	94	100	100	--
	47.261	104.555	344	3.0	454	72	79	100	100	--
	47.261	104.555	344	6.0	467	68	75	97	100	--
	47.261	104.555	344	9.0	511	59	72	97	100	--
	47.261	104.555	344	12.0	577	58	73	96	100	--
	47.261	104.555	344	15.0	694	50	61	95	100	--
	47.261	104.555	426	0.0	450	79	89	100	100	--
	47.261	104.555	426	3.0	555	62	76	97	100	--
8/10/2011	47.261	104.555	210	0.0	112	93	94	100	100	--
	47.261	104.555	210	1.6	113	96	99	100	100	--
	47.261	104.555	210	3.2	136	87	94	100	100	--
	47.261	104.555	210	4.8	118	85	94	100	100	--
	47.261	104.555	210	6.4	145	82	95	100	100	--
	47.261	104.555	210	8.0	136	74	91	100	100	--
	47.261	104.555	321	0.0	131	87	95	100	100	--
	47.261	104.555	321	2.3	184	81	91	100	100	--
	47.261	104.555	321	4.6	123	87	93	100	100	--
	47.261	104.555	321	6.9	155	80	94	100	100	--
	47.261	104.555	321	9.2	159	71	84	100	100	--
	47.261	104.555	321	11.5	187	65	81	99	100	--
	47.261	104.555	410	0.0	122	84	93	100	100	--
	47.261	104.555	410	2.3	129	91	96	100	100	--
	47.261	104.555	410	4.6	146	74	85	100	100	--
	47.261	104.555	410	6.9	170	68	83	100	100	--
	47.261	104.555	410	9.2	187	70	82	94	100	--
	47.261	104.555	410	11.5	202	59	69	100	100	--
	47.261	104.554	502	0.0	145	84	93	100	100	--
	47.261	104.554	502	2.4	154	80	86	100	100	--
	47.261	104.554	502	4.8	159	83	90	100	100	--
	47.261	104.554	502	7.2	138	88	93	100	100	--
	47.261	104.554	502	9.6	148	75	86	100	100	--
	47.261	104.554	502	12.0	158	76	84	95	100	--
	47.261	104.554	603	0.0	119	87	91	100	100	--
	47.261	104.554	603	1.8	114	90	92	100	100	--

Table 2. Suspended-sediment concentration, fall diameter, and sieve diameter for samples collected at discrete vertical depths at three sites near the proposed bypass chute on the Yellowstone River near Glendive, Montana, July and August, 2011.—Continued

[DD, decimal degrees; ft, feet; mg/L, milligram per liter; mm, millimeter; --, no data; IM, Insufficient Material]

Dates	Latitude (DD)	Longitude (DD)	Location in cross section, distance from left bank looking downstream (ft)	Sampling depth (ft)	Suspened-sediment concentration (mg/L)	Suspended-sediment fall diameter (values in percent finer than size)				Percent finer than suspended-sediment sieve diameter of 0.062 mm
						0.062 mm	0.125 mm	0.250 mm	0.500 mm	
Above bypass chute—Continued										
	47.261	104.554	603	3.6	132	81	92	100	100	--
	47.261	104.554	603	5.4	123	97	99	100	100	--
	47.261	104.554	603	7.2	148	87	97	100	100	--
	47.261	104.554	603	9.0	125	93	97	100	100	--
8/24/2011	47.261	104.555	180	0.0	56	94	98	100	100	--
	47.261	104.555	180	1.5	43	IM	IM	IM	IM	98
	47.261	104.555	180	3.0	65	90	97	100	100	--
	47.261	104.555	180	4.5	63	87	98	100	100	--
	47.261	104.555	180	6.0	57	90	99	100	100	--
	47.261	104.555	180	7.5	76	92	97	100	100	--
	47.261	104.555	276	0.0	70	98	98	100	100	--
	47.261	104.555	276	2.1	56	95	95	100	100	--
	47.261	104.555	276	4.2	67	90	92	100	100	--
	47.261	104.555	276	6.3	65	93	95	100	100	--
	47.261	104.555	276	8.4	66	90	93	100	100	--
	47.261	104.555	276	10.5	80	92	95	100	100	--
	47.261	104.555	355	0.0	52	97	98	100	100	--
	47.261	104.555	355	2.1	50	92	95	100	100	--
	47.261	104.555	355	4.2	55	91	95	100	100	--
	47.261	104.555	355	6.3	51	93	94	100	100	--
	47.261	104.555	355	8.4	86	93	95	100	100	--
	47.261	104.555	355	10.5	93	71	77	100	100	--
	47.261	104.554	445	0.0	49	IM	IM	IM	IM	94
	47.261	104.554	445	2.2	56	93	94	100	100	--
	47.261	104.554	445	4.4	55	92	99	100	100	--
	47.261	104.554	445	6.6	54	91	92	100	100	--
	47.261	104.554	445	8.8	63	93	96	100	100	--
	47.261	104.554	445	11.0	64	84	91	100	100	--
	47.261	104.554	546	1.6	64	IM	IM	IM	IM	94
	47.261	104.554	546	3.2	39	IM	IM	IM	IM	99
	47.261	104.554	546	4.8	54	96	96	100	100	--
	47.261	104.554	546	6.4	44	IM	IM	IM	IM	99
	47.261	104.554	546	8.0	50	94	94	100	100	--

Table 2. Suspended-sediment concentration, fall diameter, and sieve diameter for samples collected at discrete vertical depths at three sites near the proposed bypass chute on the Yellowstone River near Glendive, Montana, July and August, 2011.—Continued

[DD, decimal degrees; ft, feet; mg/L, milligram per liter; mm, millimeter; --, no data; IM, Insufficient Material]

Dates	Latitude (DD)	Longitude (DD)	Location in cross section, distance from left bank looking downstream (ft)	Sampling depth (ft)	Suspened-sediment concentration (mg/L)	Suspended-sediment fall diameter (values in percent finer than size)				Percent finer than suspended-sediment sieve diameter of 0.062 mm
						0.062 mm	0.125 mm	0.250 mm	0.500 mm	
Adjacent to bypass chute										
7/21/2011	47.263	104.554	346	0.0	336	91	99	99	100	--
	47.263	104.554	346	1.0	305	92	96	100	100	--
	47.263	104.554	346	2.5	311	95	97	100	100	--
	47.263	104.554	346	5.0	348	88	94	97	100	--
	47.263	104.554	346	6.0	325	91	94	98	100	--
	47.263	104.554	346	7.0	292	85	91	97	100	--
	47.263	104.553	379	0.0	397	75	83	96	100	--
	47.263	104.553	379	3.0	362	82	89	96	100	--
	47.263	104.553	379	6.0	414	76	81	94	100	--
	47.263	104.553	379	8.0	459	64	72	94	100	--
	47.263	104.553	379	10.0	479	62	71	91	100	--
	47.263	104.553	379	12.0	537	57	64	83	100	--
	47.262	104.553	498	0.0	417	75	83	95	100	--
	47.262	104.553	498	5.0	455	73	79	97	100	--
	47.262	104.553	498	8.0	422	77	85	96	100	--
	47.262	104.553	498	10.5	472	74	78	97	100	--
	47.262	104.553	498	13.5	478	69	75	96	100	--
	47.262	104.552	611	0.0	320	85	93	100	100	--
	47.262	104.552	611	2.5	370	86	92	97	100	--
	47.262	104.552	611	5.0	373	78	84	97	100	--
	47.262	104.552	611	7.5	422	75	81	97	100	--
	47.262	104.552	611	10.0	451	69	81	98	100	--
	47.262	104.552	611	12.0	543	61	72	97	100	--
	47.262	104.552	745	0.0	321	91	96	100	100	--
	47.262	104.552	745	1.5	307	93	99	100	100	--
	47.262	104.552	745	3.0	331	91	95	97	100	--
	47.262	104.552	745	4.5	357	88	93	100	100	--
	47.262	104.552	745	6.0	369	90	97	100	100	--
	47.262	104.552	745	8.0	345	89	96	98	100	--
8/11/2011	47.263	104.553	167	0.0	115	94	98	100	100	--
	47.263	104.553	167	1.5	136	89	96	100	100	--
	47.263	104.553	167	3.0	108	95	98	100	100	--
	47.263	104.553	167	4.5	134	81	93	100	100	--
	47.263	104.553	167	6.0	147	75	90	97	100	--
	47.263	104.553	167	7.5	123	86	96	98	100	--

Table 2. Suspended-sediment concentration, fall diameter, and sieve diameter for samples collected at discrete vertical depths at three sites near the proposed bypass chute on the Yellowstone River near Glendive, Montana, July and August, 2011.—Continued

[DD, decimal degrees; ft, feet; mg/L, milligram per liter; mm, millimeter; --, no data; IM, Insufficient Material]

Dates	Latitude (DD)	Longitude (DD)	Location in cross section, distance from left bank looking downstream (ft)	Sampling depth (ft)	Suspened-sediment concentration (mg/L)	Suspended-sediment fall diameter (values in percent finer than size)				Percent finer than suspended-sediment sieve diameter of 0.062 mm
						0.062 mm	0.125 mm	0.250 mm	0.500 mm	
Adjacent to bypass chute—Continued										
	47.263	104.553	267	0.0	123	85	95	100	100	--
	47.263	104.553	267	1.9	128	80	92	97	100	--
	47.263	104.553	267	3.8	139	79	93	99	100	--
	47.263	104.553	267	5.7	143	83	94	100	100	--
	47.263	104.553	267	7.6	137	75	86	100	100	--
	47.263	104.553	267	9.5	137	76	92	100	100	--
	47.262	104.553	368	0.0	92	96	98	100	100	--
	47.262	104.553	368	2.1	154	71	82	95	100	--
	47.262	104.553	368	4.2	134	72	87	100	100	--
	47.262	104.553	368	6.3	128	79	90	100	100	--
	47.262	104.553	368	8.4	147	69	83	100	100	--
	47.262	104.553	368	10.5	198	59	70	93	100	--
	47.262	104.552	476	0.0	115	86	89	100	100	--
	47.262	104.552	476	1.9	114	86	92	100	100	--
	47.262	104.552	476	3.8	129	83	89	100	100	--
	47.262	104.552	476	5.7	134	71	85	97	100	--
	47.262	104.552	476	7.6	132	79	88	100	100	--
	47.262	104.552	476	9.5	143	61	77	100	100	--
	47.262	104.552	595	0.0	323	96	98	100	100	--
	47.262	104.552	595	1.3	85	95	98	100	100	--
	47.262	104.552	595	2.6	105	96	100	100	100	--
	47.262	104.552	595	3.9	117	96	98	100	100	--
	47.262	104.552	595	5.2	116	94	100	100	100	--
	47.262	104.552	595	6.5	113	94	97	100	100	--
8/24/2011	47.263	104.553	159	0.0	46	IM	IM	IM	IM	91
	47.263	104.553	159	1.4	62	89	97	100	100	--
	47.263	104.553	159	2.8	45	IM	IM	IM	IM	94
	47.263	104.553	159	4.2	56	IM	IM	IM	IM	88
	47.263	104.553	159	5.6	55	96	99	100	100	--
	47.263	104.553	159	7.0	55	90	96	100	100	--
	47.263	104.553	268	0.0	43	IM	IM	IM	IM	91
	47.263	104.553	268	1.8	53	IM	IM	IM	IM	89
	47.263	104.553	268	3.6	55	IM	IM	IM	IM	85
	47.263	104.553	268	9.0	51	IM	IM	IM	IM	95
	47.262	104.553	364	0.0	51	IM	IM	IM	IM	86

Table 2. Suspended-sediment concentration, fall diameter, and sieve diameter for samples collected at discrete vertical depths at three sites near the proposed bypass chute on the Yellowstone River near Glendive, Montana, July and August, 2011.—Continued

[DD, decimal degrees; ft, feet; mg/L, milligram per liter; mm, millimeter; --, no data; IM, Insufficient Material]

Dates	Latitude (DD)	Longitude (DD)	Location in cross section, distance from left bank looking downstream (ft)	Sampling depth (ft)	Suspened-sediment concentration (mg/L)	Suspended-sediment fall diameter (values in percent finer than size)				Percent finer than suspended-sediment sieve diameter of 0.062 mm
						0.062 mm	0.125 mm	0.250 mm	0.500 mm	
Adjacent to bypass chute—Continued										
	47.262	104.553	364	1.9	69	94	95	100	100	--
	47.262	104.553	364	3.8	73	87	91	100	100	--
	47.262	104.553	364	5.7	52	IM	IM	IM	IM	95
	47.262	104.553	364	7.6	65	83	89	100	100	--
	47.262	104.553	364	9.5	71	79	84	100	100	--
	47.262	104.552	460	0.0	51	IM	IM	IM	IM	94
	47.262	104.552	460	1.7	49	IM	IM	IM	IM	93
	47.262	104.552	460	3.4	40	IM	IM	IM	IM	95
	47.262	104.552	460	5.1	52	86	89	100	100	--
	47.262	104.552	460	6.8	53	92	94	100	100	--
	47.262	104.552	460	8.5	54	92	92	100	100	--
	47.262	104.552	570	0.0	35	IM	IM	IM	IM	97
	47.262	104.552	570	1.0	35	IM	IM	IM	IM	92
	47.262	104.552	570	2.0	43	IM	IM	IM	IM	97
	47.262	104.552	570	3.0	48	IM	IM	IM	IM	93
	47.262	104.552	570	4.0	43	IM	IM	IM	IM	96
	47.262	104.552	570	5.0	55	IM	IM	IM	IM	89
Below bypass chute										
7/20/2011	47.265	104.553	186	0.0	304	92	95	97	100	--
	47.265	104.553	186	1.0	315	92	96	100	100	--
	47.265	104.553	186	2.0	323	89	95	98	100	--
	47.265	104.553	186	3.0	335	90	92	97	100	--
	47.265	104.553	186	4.0	350	82	89	98	100	--
	47.265	104.553	186	5.0	409	76	85	93	100	--
	47.265	104.553	186	6.0	597	60	70	92	100	--
	47.265	104.552	346	0.0	369	82	87	96	100	--
	47.265	104.552	346	2.0	355	83	89	99	100	--
	47.265	104.552	346	4.0	419	70	78	97	100	--
	47.265	104.552	346	6.0	452	68	76	97	100	--
	47.265	104.552	346	8.0	587	54	64	91	100	--
	47.265	104.552	346	9.0	611	52	62	95	100	--
	47.265	104.551	482	0.0	357	81	88	96	100	--
	47.265	104.551	482	2.0	396	77	86	100	100	--
	47.265	104.551	482	3.5	417	72	82	95	100	--
	47.265	104.551	482	5.0	454	68	79	93	100	--

Table 2. Suspended-sediment concentration, fall diameter, and sieve diameter for samples collected at discrete vertical depths at three sites near the proposed bypass chute on the Yellowstone River near Glendive, Montana, July and August, 2011.—Continued

[DD, decimal degrees; ft, feet; mg/L, milligram per liter; mm, millimeter; --, no data; IM, Insufficient Material]

Dates	Latitude (DD)	Longitude (DD)	Location in cross section, distance from left bank looking downstream (ft)	Sampling depth (ft)	Suspened-sediment concentration (mg/L)	Suspended-sediment fall diameter (values in percent finer than size)				Percent finer than suspended-sediment sieve diameter of 0.062 mm
						0.062 mm	0.125 mm	0.250 mm	0.500 mm	
Below bypass chute—Continued										
	47.265	104.551	482	6.5	443	70	77	97	100	--
	47.265	104.551	482	8.0	625	51	61	94	100	--
	47.265	104.551	641	0.0	355	87	93	100	100	--
	47.265	104.551	641	2.0	355	87	94	98	100	--
	47.265	104.551	641	3.0	408	79	86	96	100	--
	47.265	104.551	641	4.0	409	78	87	100	100	--
	47.265	104.551	641	5.0	441	73	85	99	100	--
	47.265	104.551	641	6.5	429	71	81	99	100	--
	47.265	104.550	849	0.0	370	87	92	94	100	--
	47.265	104.550	849	2.0	386	84	93	100	100	--
	47.265	104.550	849	3.0	333	95	98	100	100	--
	47.265	104.550	849	4.0	304	85	94	97	100	--
	47.265	104.550	849	5.0	377	84	93	100	100	--
	47.265	104.550	849	6.0	470	79	91	98	100	--
8/9/2011	47.265	104.553	183	0.0	143	85	97	100	100	--
	47.265	104.553	183	0.8	153	86	97	100	100	--
	47.265	104.553	183	1.6	154	85	93	100	100	--
	47.265	104.553	183	2.4	140	84	94	97	100	--
	47.265	104.553	183	3.2	144	84	92	100	100	--
	47.265	104.553	183	4.0	163	76	90	96	100	--
	47.265	104.552	323	0.0	138	87	95	100	100	--
	47.265	104.552	323	1.2	132	91	96	100	100	--
	47.265	104.552	323	2.4	136	81	91	100	100	--
	47.265	104.552	323	3.6	140	85	94	100	100	--
	47.265	104.552	323	4.8	157	82	94	98	100	--
	47.265	104.552	323	6.0	170	74	84	100	100	--
	47.265	104.552	443	0.0	142	90	93	100	100	--
	47.265	104.552	443	1.2	115	83	90	100	100	--
	47.265	104.552	443	2.4	151	82	87	96	100	--
	47.265	104.552	443	3.6	180	74	85	100	100	--
	47.265	104.552	443	4.8	159	80	88	100	100	--
	47.265	104.552	443	6.0	183	72	81	96	100	--
	47.265	104.551	602	0.0	143	90	93	100	100	--
	47.265	104.551	602	0.8	152	87	93	100	100	--
	47.265	104.551	602	1.6	138	87	92	100	100	--

Table 2. Suspended-sediment concentration, fall diameter, and sieve diameter for samples collected at discrete vertical depths at three sites near the proposed bypass chute on the Yellowstone River near Glendive, Montana, July and August, 2011.—Continued

[DD, decimal degrees; ft, feet; mg/L, milligram per liter; mm, millimeter; --, no data; IM, Insufficient Material]

Dates	Latitude (DD)	Longitude (DD)	Location in cross section, distance from left bank looking downstream (ft)	Sampling depth (ft)	Suspened-sediment concentration (mg/L)	Suspended-sediment fall diameter (values in percent finer than size)				Percent finer than suspended-sediment sieve diameter of 0.062 mm
						0.062 mm	0.125 mm	0.250 mm	0.500 mm	
Below bypass chute—Continued										
	47.265	104.551	602	2.4	173	81	85	100	100	--
	47.265	104.551	602	3.2	161	83	91	100	100	--
	47.265	104.551	602	4.0	148	86	92	100	100	--
	47.265	104.550	827	0.0	142	96	99	100	100	--
	47.265	104.550	827	0.8	146	91	97	100	100	--
	47.265	104.550	827	1.6	157	91	96	100	100	--
	47.265	104.550	827	2.4	135	93	97	100	100	--
	47.265	104.550	827	3.2	156	85	93	100	100	--
	47.265	104.550	827	4.0	173	90	93	100	100	--
8/23/2011	47.265	104.552	266	0.0	68	91	93	100	100	--
	47.265	104.552	266	1.0	60	95	95	100	100	--
	47.265	104.552	266	2.0	64	92	95	100	100	--
	47.265	104.552	266	3.0	64	95	97	99	100	--
	47.265	104.552	266	4.0	89	83	92	100	100	--
	47.265	104.552	266	5.0	151	81	87	100	100	--
	47.265	104.552	352	0.0	85	94	97	100	100	--
	47.265	104.552	352	1.1	92	IM	IM	IM	IM	79
	47.265	104.552	352	2.2	68	94	95	100	100	--
	47.265	104.552	352	3.3	63	IM	IM	IM	IM	68
	47.265	104.552	352	4.4	50	IM	IM	IM	IM	77
	47.265	104.552	352	5.6	48	IM	IM	IM	IM	94
	47.265	104.552	434	0.0	49	IM	IM	IM	IM	85
	47.265	104.552	434	1.0	53	IM	IM	IM	IM	70
	47.265	104.552	434	2.0	51	IM	IM	IM	IM	85
	47.265	104.552	434	3.0	52	IM	IM	IM	IM	88
	47.265	104.552	434	4.0	54	IM	IM	IM	IM	83
	47.265	104.552	434	5.0	71	92	99	100	100	--
	47.265	104.551	551	0.0	50	IM	IM	IM	IM	81
	47.265	104.551	551	0.6	41	IM	IM	IM	IM	94
	47.265	104.551	551	1.2	39	IM	IM	IM	IM	91
	47.265	104.551	551	1.8	55	IM	IM	IM	IM	74
	47.265	104.551	551	2.4	49	IM	IM	IM	IM	91
	47.265	104.551	551	3.0	61	80	87	100	100	--
	47.265	104.551	680	0.0	79	IM	IM	IM	IM	58
	47.265	104.551	680	0.4	72	IM	IM	IM	IM	63

Table 2. Suspended-sediment concentration, fall diameter, and sieve diameter for samples collected at discrete vertical depths at three sites near the proposed bypass chute on the Yellowstone River near Glendive, Montana, July and August, 2011.—Continued

[DD, decimal degrees; ft, feet; mg/L, milligram per liter; mm, millimeter; --, no data; IM, Insufficient Material]

Dates	Latitude (DD)	Longitude (DD)	Location in cross section, distance from left bank looking downstream (ft)	Sampling depth (ft)	Suspened-sediment concentration (mg/L)	Suspended-sediment fall diameter (values in percent finer than size)				Percent finer than suspended-sediment sieve diameter of 0.062 mm
						0.062 mm	0.125 mm	0.250 mm	0.500 mm	
Below bypass chute—Continued										
	47.265	104.551	680	0.8	46	IM	IM	IM	IM	96
	47.265	104.551	680	1.2	53	IM	IM	IM	IM	93
	47.265	104.551	680	1.6	46	IM	IM	IM	IM	88
	47.265	104.551	680	2.0	32	81	93	100	100	88

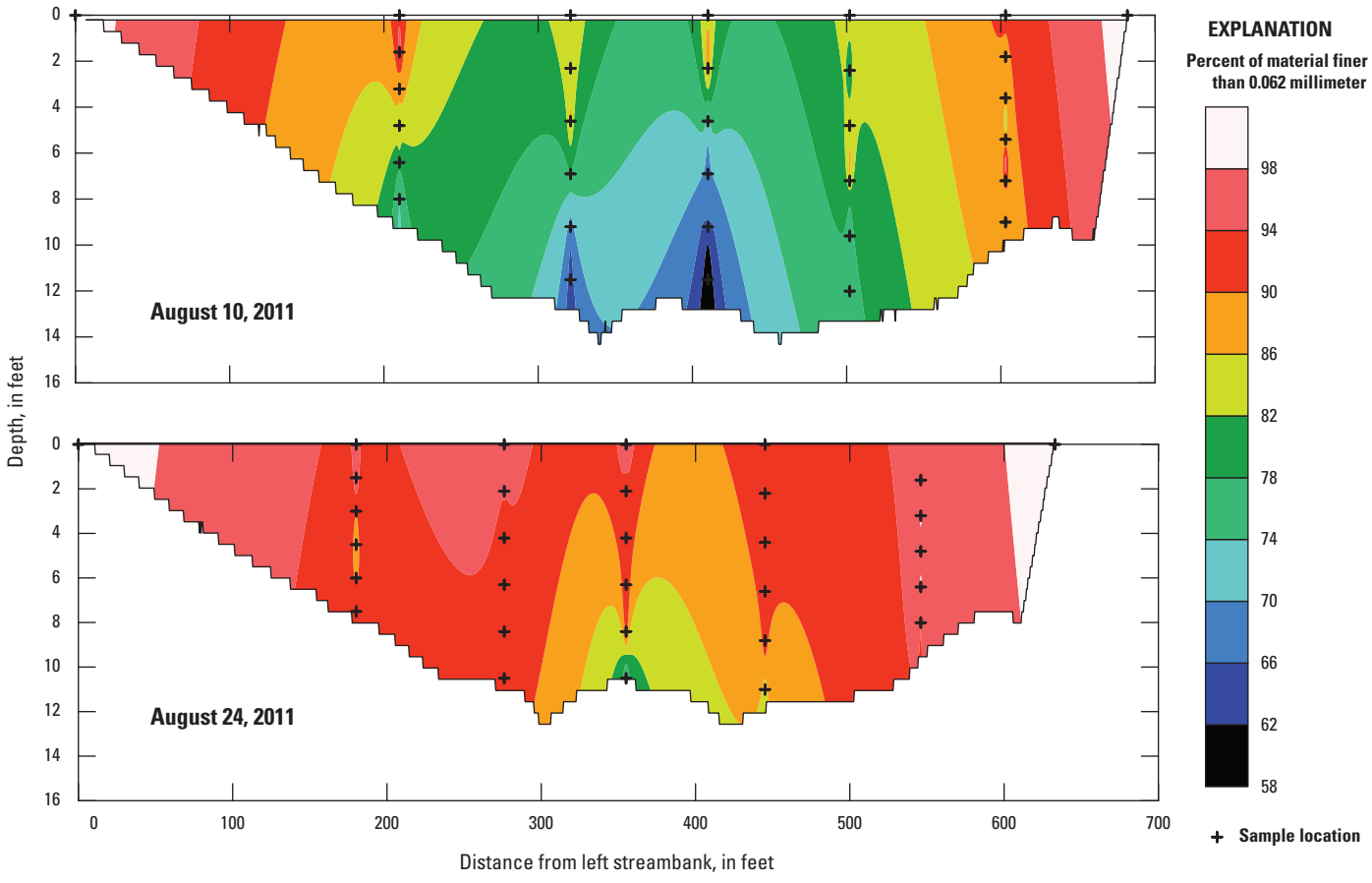


Figure 6. Cross section showing distribution of suspended-sediment particle sizes from point samples collected on the Yellowstone River above a proposed bypass chute near Glendive, Montana, August, 2011.

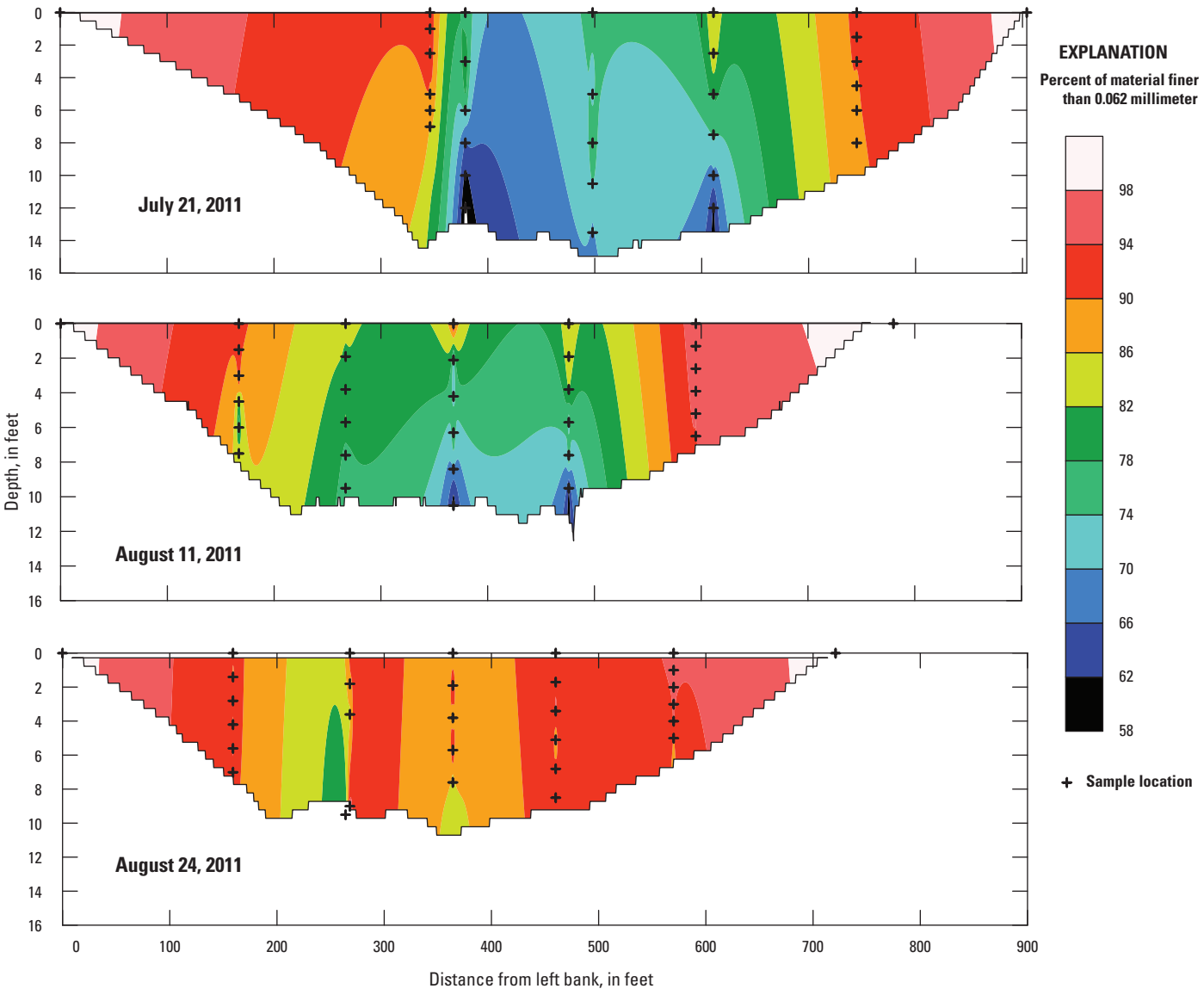


Figure 7. Cross section showing distribution of suspended-sediment particle sizes from point samples collected on the Yellowstone River adjacent to a proposed bypass chute near Glendive, Montana, July and August, 2011.

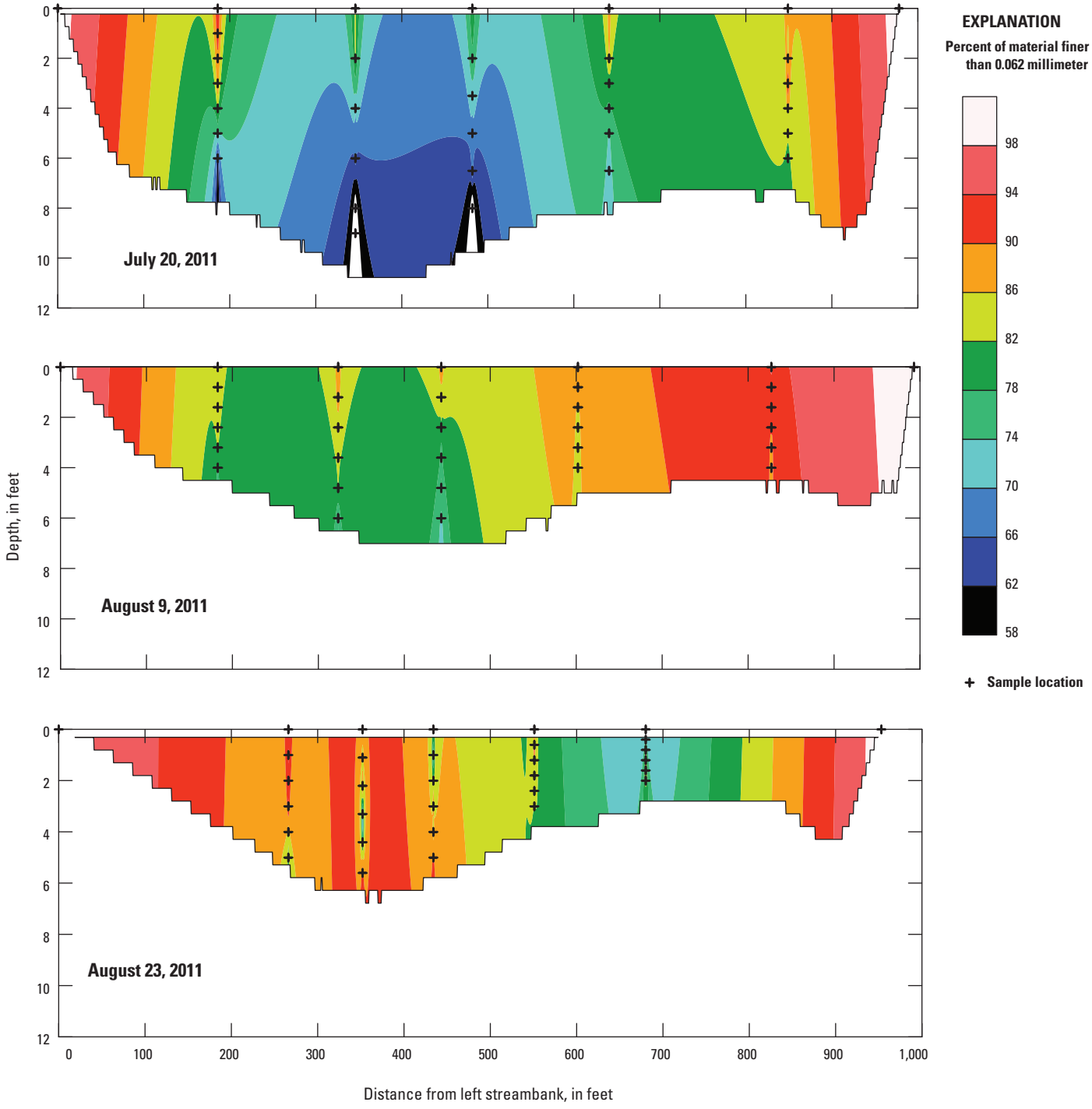


Figure 8. Cross section showing distribution of suspended-sediment particle sizes from point samples collected on the Yellowstone River below a proposed bypass chute near Glendive, Montana, July and August, 2011.

Table 3. Sieve diameters and mass of bedload samples for three sites near a proposed bypass chute on the Yellowstone River near Glendive, Montana, July and August, 2011.

[mm, millimeters]

Date	Bedload-sediment fall diameter (values in percent finer than size)										Mass (grams)
	0.062 mm	0.125 mm	0.25 mm	0.5 mm	1 mm	2 mm	4 mm	8 mm	16 mm	32 mm	
Above bypass chute											
7/19/2011	0	1	32	73	77	79	81	83	87	100	375.4
8/10/2011	0	0	2	87	95	96	97	98	100	100	167.8
8/24/2011	1	1	6	63	69	73	79	93	100	100	35.5
Adjacent to bypass chute											
7/21/2011	0	0	2	62	73	76	80	88	94	100	295.3
8/11/2011	0	0	1	55	70	76	81	87	100	100	221.3
8/24/2011	0	1	8	67	74	76	78	80	100	100	138.0
Below bypass chute											
7/20/2011	0	0	20	72	78	81	85	91	96	100	322.1
8/09/2011	0	0	1	59	72	78	82	87	96	100	308.8
8/23/2011	0	0	1	38	52	63	70	75	87	100	275.5

Table 4. Sediment loads for three sites near a proposed bypass chute on the Yellowstone River near Glendive, Montana, July and August, 2011.

Date	Load, in tons per day		
	Suspended sediment	Measured bedload	Measured total sediment
Above bypass chute			
7/19/2011	57,700	254	57,954
8/10/2011	8,250	36	8,286
8/24/2011	2,600	5	2,605
Adjacent to bypass chute			
7/21/2011	54,600	255	54,855
8/11/2011	6,350	53	6,403
8/24/2011	3,000	20	3,020
Below bypass chute			
7/20/2011	57,200	301	57,501
8/09/2011	9,260	96	9,356
8/23/2011	2,710	55	2,765

Summary

In 2011, sediment data were collected by the U.S. Geological Survey in cooperation with the U.S. Army Corps of Engineers on the Yellowstone River at the location of a proposed bypass chute. The sediment data were collected to provide an understanding of the sediment dynamics of the given reach of the Yellowstone River. Samples of suspended sediment (point and integrated) and bedload were collected at three sites during July 19–21, August 9–11, and August 23–24, 2011. Suspended-sediment concentrations in the integrated samples collected at the three sites generally decreased with decreasing streamflow. Point samples collected at the three sites indicated the variability of suspended-sediment concentrations in the cross section at each site. In general, the highest suspended-sediment concentrations were found near the channel bed and towards the center of the channel with lower suspended-sediment concentrations near the channel banks and water surface. The particle sizes of suspended sediment from point samples indicated similar distributions at each site for the three sampling periods. Most of sediment in the bedload had a particle size smaller than 16 mm. Suspended sediment was the primary component of the total sediment load for all three sampling locations on the Yellowstone River during the late summer of 2011. Suspended sediment contributed at least 98 percent of the total sediment load at each of the three sites. The amount of bedload measured at the three sites was a smaller load in comparison with the suspended-sediment load.

References Cited

Bureau of Reclamation, 2011, Lower Yellowstone project, accessed December 2011, at *http://www.usbr.gov/gp/mtao/loweryellowstone/index.html*.

Davis, B.E., 2005, A guide to the proper selection and use of federally approved sediment and water-quality samplers: U.S. Geological Survey Open-File Report 2005–1087, 26 p.

Edwards, T.K., and Glysson, G.D., 1999, Field methods for measurement of fluvial sediment: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. C2, 89 p.

Guy, H.P., 1969, Laboratory theory and methods for sediment analysis: U.S. Geological Survey Techniques of Water-Resources Investigations, book 5, chap. C1, 58 p.

Mueller, D.S., and Wagner, C.R., 2009, Measuring discharge with acoustic Doppler current profilers from a moving boat: U.S. Geological Survey Techniques and Methods 3A–22, 72 p.

Porterfield, George, 1972, Computation of fluvial-sediment discharge: U.S. Geological Survey Techniques of Water-Resources Investigations, book 3, chap. C3, 66 p.

Publishing support provided by:
Rolla Publishing Service Center

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

Or visit the North Dakota Water Science Center Web site at:
http://nd.water.usgs.gov/

Hanson and Galloway—**Sediment Characteristics of the Yellowstone River in the Vicinity of a Proposed Bypass Chute near Glendive, Montana, 2011**—OFR 2012–1042