Mississippi Valley Division

Engineer Research and Development Center

US Army Corps of Engineers®

2016 Old River Control Complex Sedimentation Data

Supplement to Old River Control Complex Sedimentation Investigation (MRG&P Report No. 6)

by Keaton E. Jones, David D. Abraham, Tate O. McAlpin, and Naveen B. Ganesh

MRG&P Tech Note No. 5 • April 2018

MRG&P
Mississippi River Geomorphology & Potamology Program

Approved for public release; distribution is unlimited.

Report prepared for the Mississippi River Commission

INTRODUCTION: The Old River Control Complex (ORCC) was designed and constructed to regulate the flow diversion from the Mississippi River to the Atchafalaya River. The amount of sediment diverted through the structures is also an important concern for all stakeholders. A 2011 U.S. Army Corps of Engineers (USACE) report from the New Orleans District (MVN) states in section 1.4.1 “House Document No. 478 of the 83rd Congress, 2nd Session dated 1954 stated that the distribution of flow and sediment in the Mississippi and Atchafalaya Rivers was in desirable proportions and should be so maintained. The controlled distribution for future major flows in approximately the same proportions as that which occurred in 1950 was authorized. That is, 70 percent of flow would be carried by the Mississippi River and 30 percent would be carried by the Atchafalaya River of the total annual Old River latitude flow” (USACE 2011). Many studies have been conducted to help determine how the structures impact the sediment regime in the vicinity of the ORCC and the corresponding impacts to downstream river reaches. Heath et al. (2015) provided an evaluation of the sediment diverted by using data collection, geomorphic analysis, and multi-dimensional numerical models. The data collection effort for that report consisted of seven data collection trips between early February of 2010 and late May of 2011 (Table 1). Data were collected at 11 locations including sites on the Mississippi, Red, and Atchafalaya Rivers. Descriptions of the sites are provided in Table 2 along with the number of data collections for each site and a map of the sites in Figure 1. Data were not collected at every site for every trip.

The data reported in Heath et al (2015) consisted of water and suspended sediment flux measurements, bottom bed samples, and bed-load measurements. In late 2015, the MVN and Mississippi Valley Division funded an additional data collection effort during the winter 2016 flood. These new data are reported below and are meant to supplement and expand the data provided in Heath et al. (2015).

Table 1. Heath et al. (2015) data collection trips.

Heath et al. Data Collection Dates	
Trip 1	9–10 Feb 2010
Trip 2	3–4 Mar 2010
Trip 3	29–30 Apr 2010
Trip 4	1–3 Jul 2010
Trip 5	1 Sep 2010
Trip 6	9 Mar 2011
Trip 7	23 May 2011

Table 2. Site descriptions and number of collection dates.		
Site	**Description**	**Collection Events**
1	Mississippi River downstream of auxiliary structure	6
2	Mississippi River downstream of low sill structure	3
3	Mississippi River downstream of hydropower structure	6
4	Mississippi River upstream of hydropower structure	7
5	Outflow channel	7
6	Red River just upstream of confluence with Atchafalaya	5
7	Atchafalaya just downstream of confluence with Red	5
8	Diversion channel downstream of auxiliary structure	2
9	Diversion channel downstream of low sill structure	1
10	Diversion channel downstream of hydropower structure	2
11	Confluence of low sill and auxiliary diversion channels	1

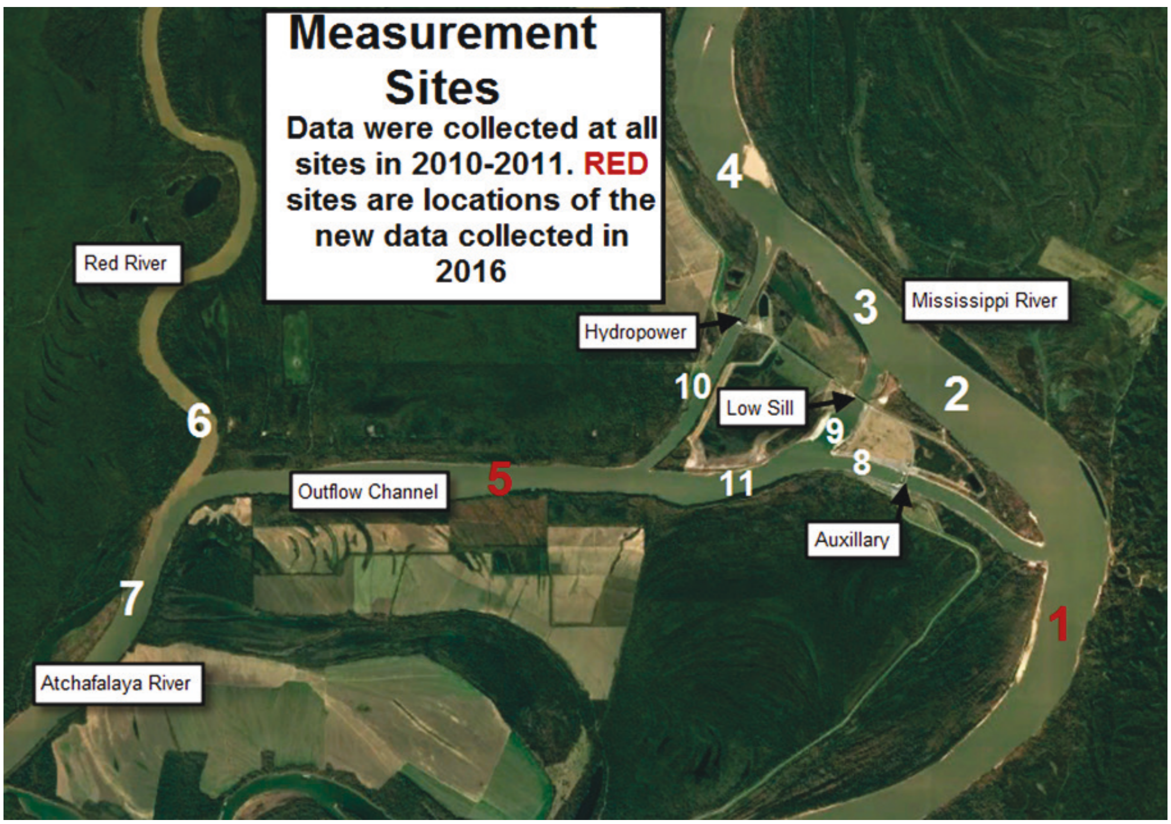

Figure 1. Measurement locations.

DATA COLLECTION: The new data were collected on three different trips. Since the previous study reported in Heath et al. (2015) ended with Trip 7, the data obtained in 2016 continued with that numbering convention, thus starting with Trip 8. Trip 8 data were obtained on 13 January 2016; Trip 9 on 19–20 January 2016; and Trip 10 on 9 February 2016. Measurements were taken in the outflow channel (Site 5) for all three trips while measurements in the Mississippi River just downstream of the auxiliary structure (Site 1) were only taken during Trip 9 on January 20. The locations for Site 1 and Site 5 were previously shown in Figure 1. The data collected included flow measurements, bed sediment samples, suspended sediment samples, and bathymetric data to be used for bed-load transport measurements.

Flow and suspended sediment measurements. On each survey, acoustic Doppler current profile (ADCP) measurements were collected to determine water and sediment fluxes. Global Positioning System (GPS) was used as a reference for the velocity measurements. The same procedure of calibrating the ADCP backscatter to measured suspended concentrations as in Heath et al. (2015) were utilized to produce sediment flux results. The 2016 measured flow and sediment rates are reported below in Table 3. Images of the velocity and suspended sediment profiles are shown in Figure 2 through Figure 17. There are two profiles for each location (a and b) because measurements were taken from both right to left bank (a) and from left to right bank (b). Note in the a profiles that the *x*-axis values are flipped to make the plots comparable as the data were collected from both directions. Also, by taking multiple measurements, it is possible to infer an uncertainty in the data measurements.

Table 3. Measured discharges and suspended sediment load (tons per day [tpd]) by grain size.													
Measurement Designation	Date	Discharge cfs**	Grain Size (µm*)										
			0-4	4-8	8-16	16-31	31-63	63-125	125-250	250-500	500-1000	1000-2000	Total
Site 5a	13 January 2016	447,567	27,806	30,239	32,062	33,334	20,281	11,567	51,035	45,229	3,003	2,367	256,923
Site 5b	13 January 2016	463,994	28,210	30,677	32,527	33,818	20,575	11,735	51,775	45,885	3,046	2,401	260,649
Site 5a	19 January 2016	448,721	20,207	22,950	22,768	14,414	3,767	523	18,164	25,563	1,904	2,487	132,747
Site 5b	19 January 2016	451,037	20,181	22,920	22,738	14,395	3,762	522	18,140	25,530	1,901	2,483	132,572
Site 5a	9 February 2016	164,444	3,801	5,427	6,603	6,455	4,102	1,896	1,363	138	0	0	29,785
Site 5b	9 February 2016	162,189	3,855	5,503	6,696	6,546	4,160	1,923	1,383	140	0	0	30,206
Site 1a	20 January 2016	1,323,974	71,682	86,857	77,970	50,920	22,053	10,769	192,434	284,352	22,051	0	819,088
Site 1b	20 January 2016	1,258,127	54,877	66,494	59,691	38,982	16,883	8,244	147,320	217,690	16,881	0	627,062

* micron
** cubic feet per second

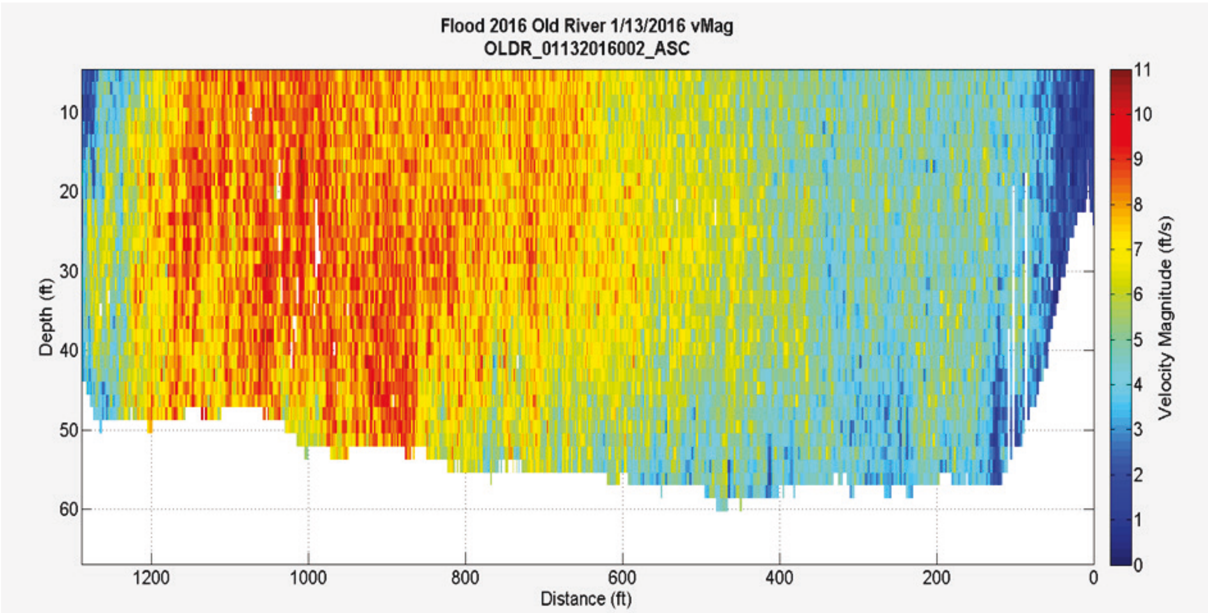

Figure 2. 13 January 2016 Site 5 velocity profile (a).

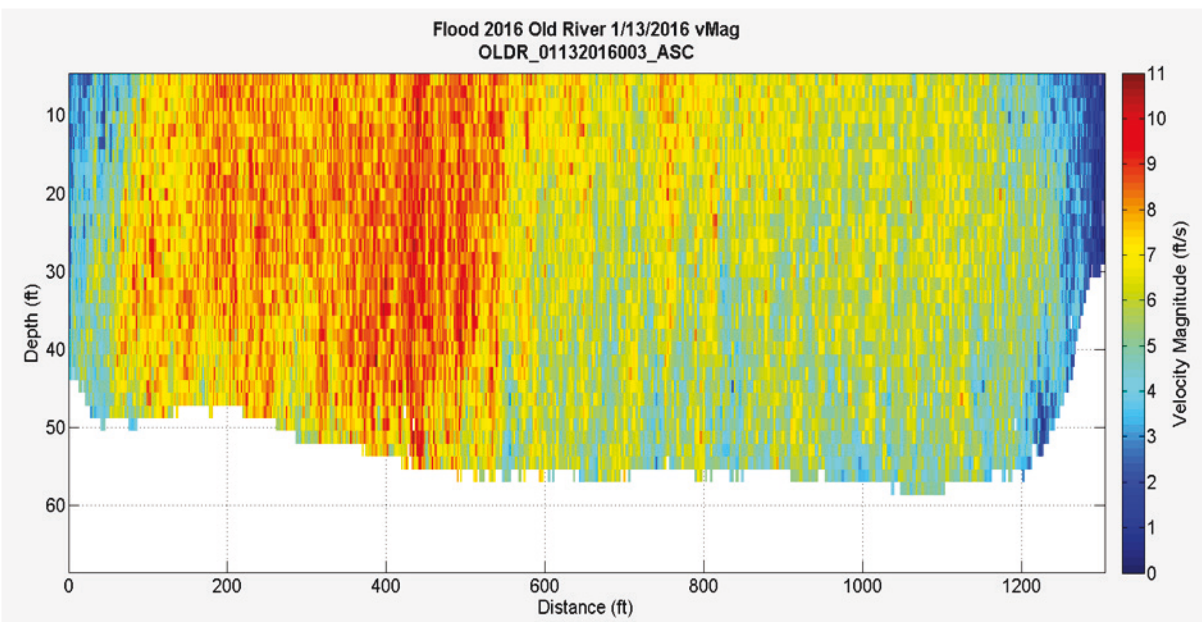

Figure 3. 13 January 2016 Site 5 velocity profile (b).

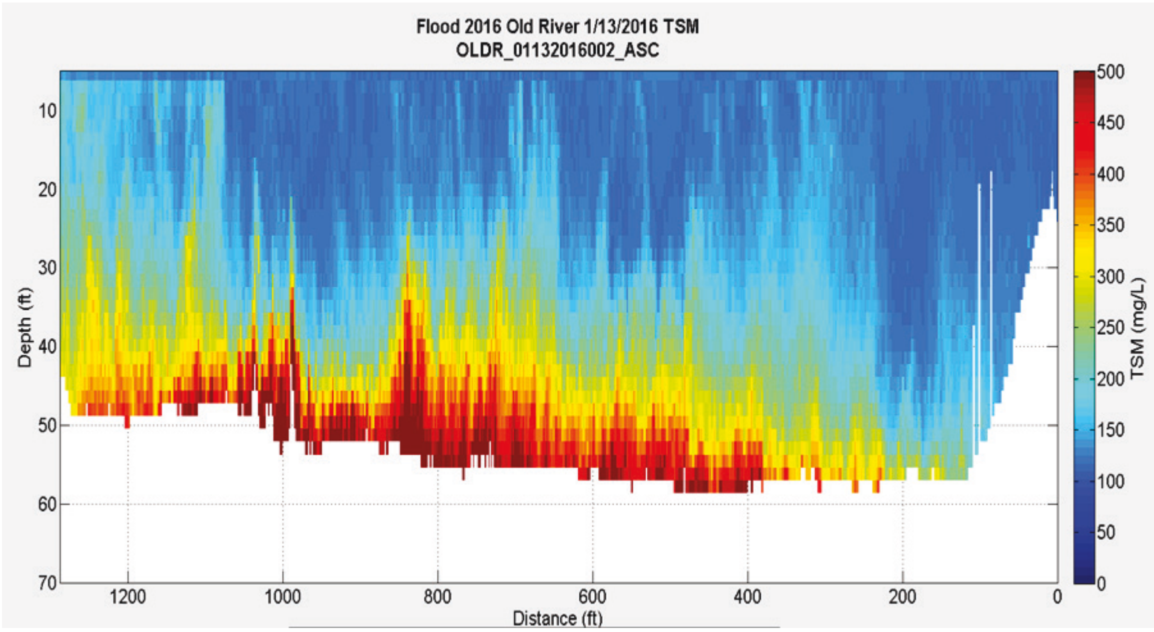

Figure 4. 13 January 2016 Site 5 total suspended material (TSM) profile (a).

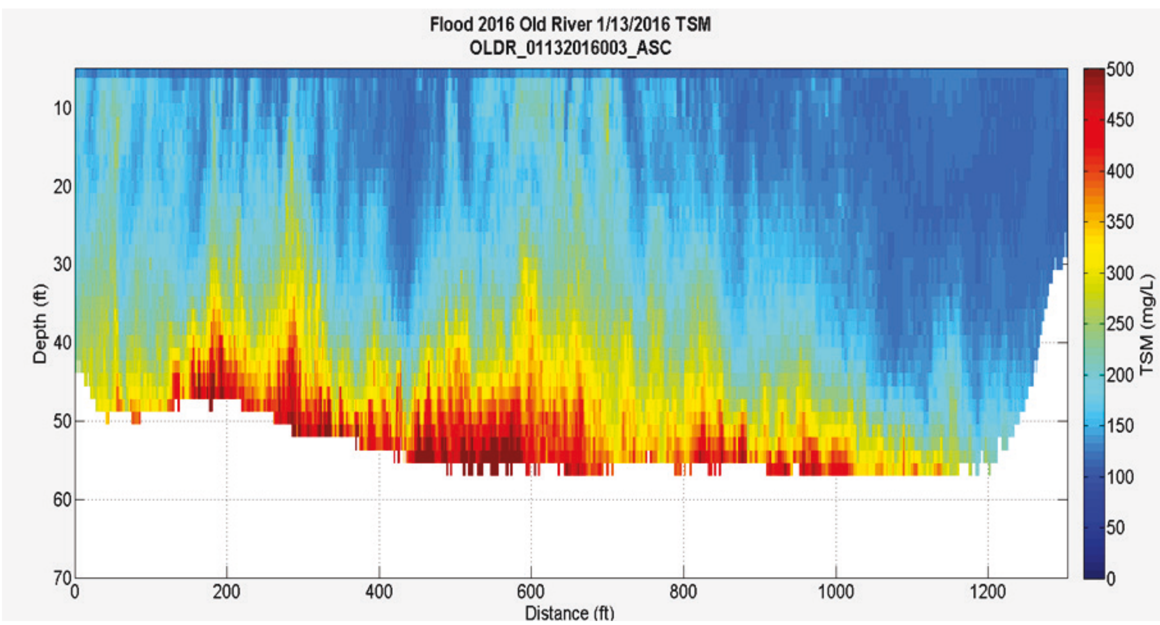

Figure 5. 13 January 2016 Site 5 TSM profile (b).

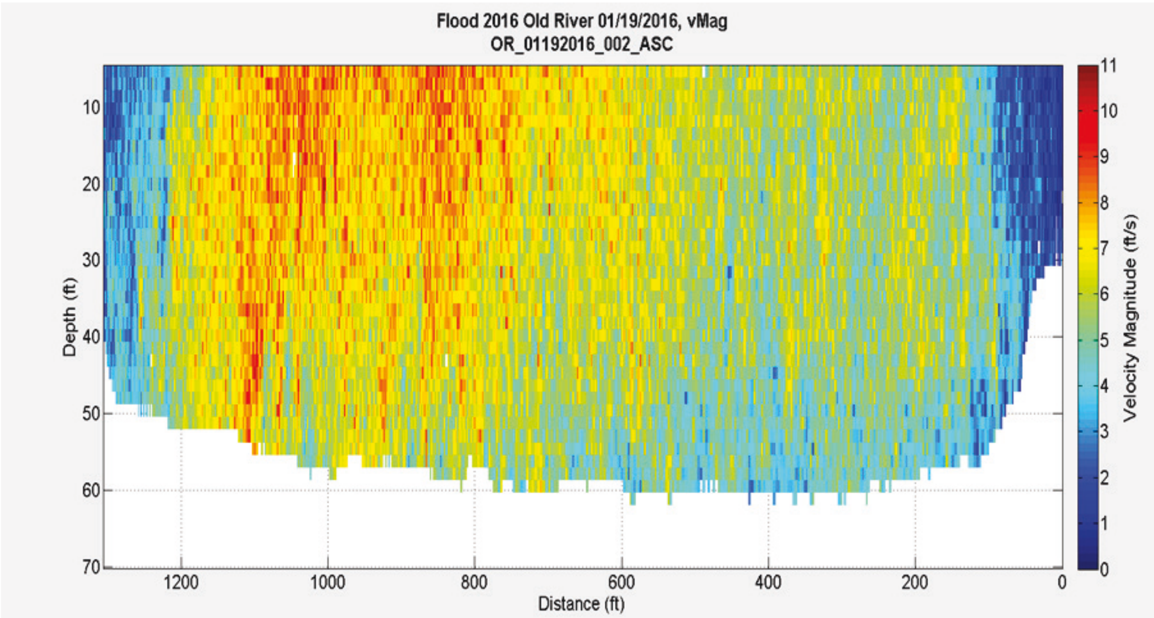

Figure 6. 19 January 2016 Site 5 velocity profile (a).

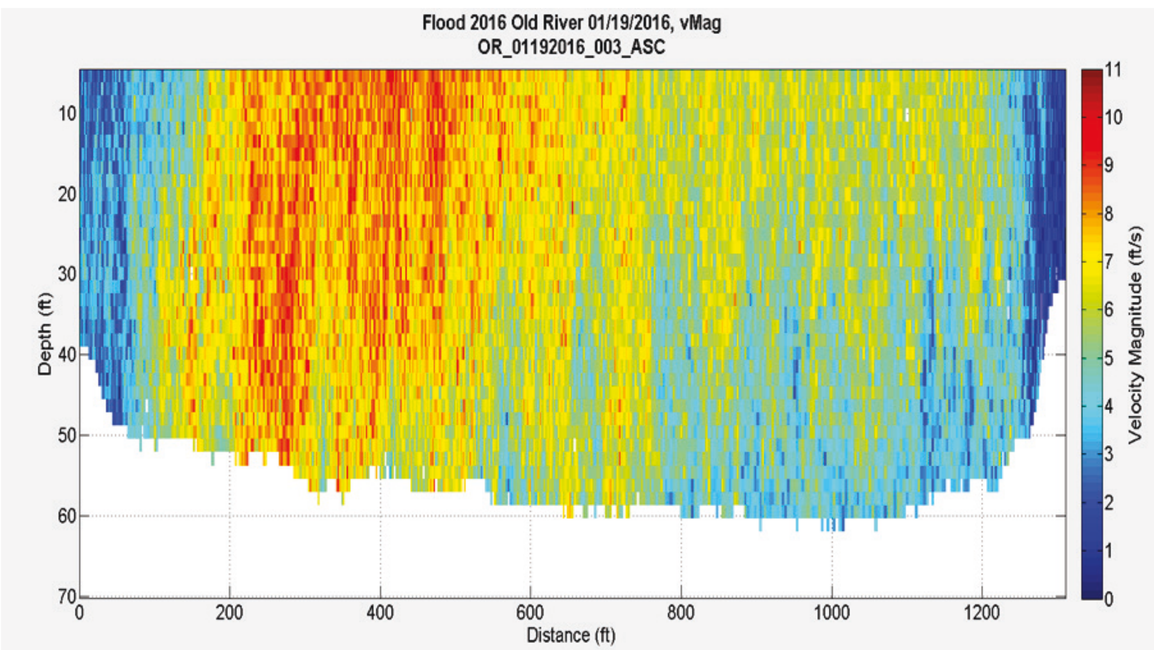

Figure 7. 19 January 2016 Site 5 velocity profile (b).

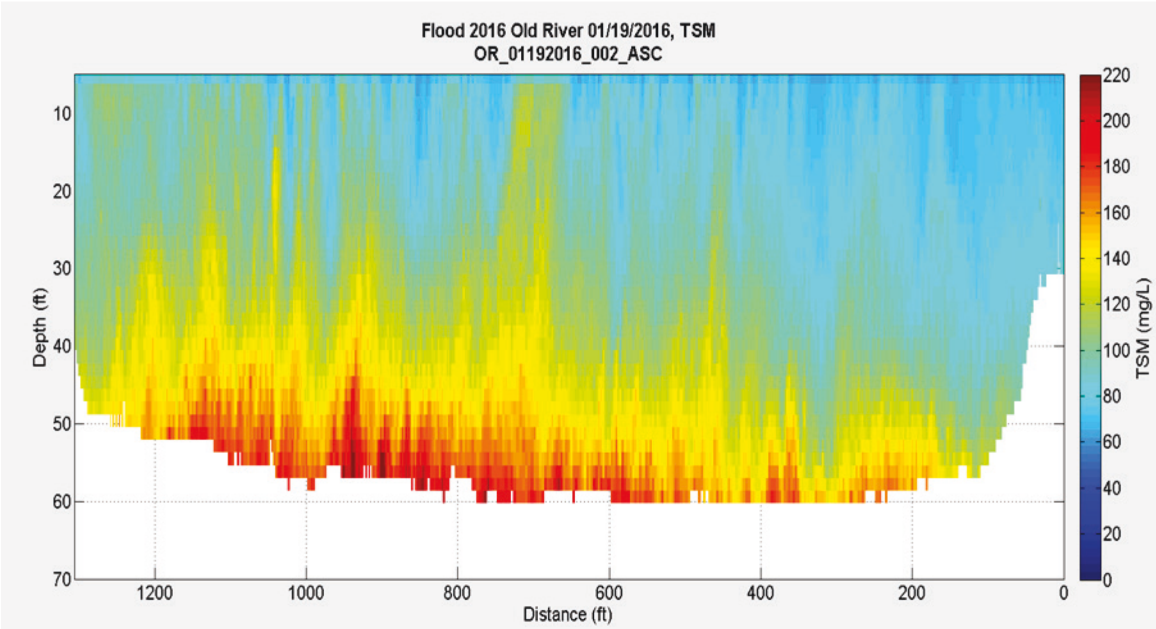

Figure 8. 19 January 2016 Site 5 TSM profile (a).

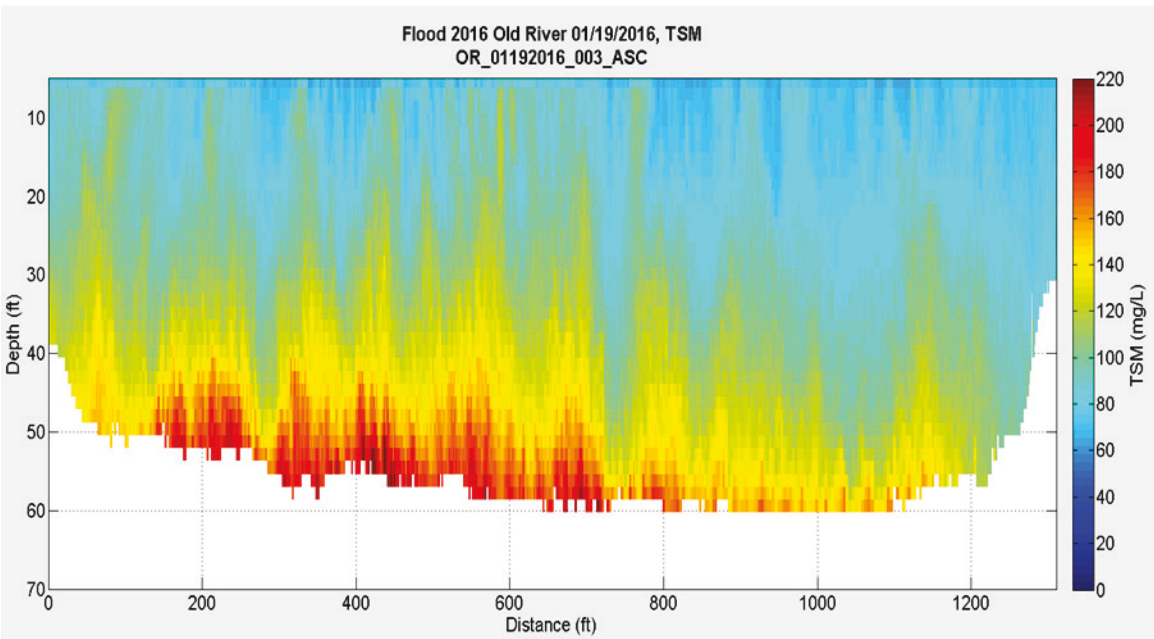

Figure 9. 19 January 2016 Site 5 TSM profile (b).

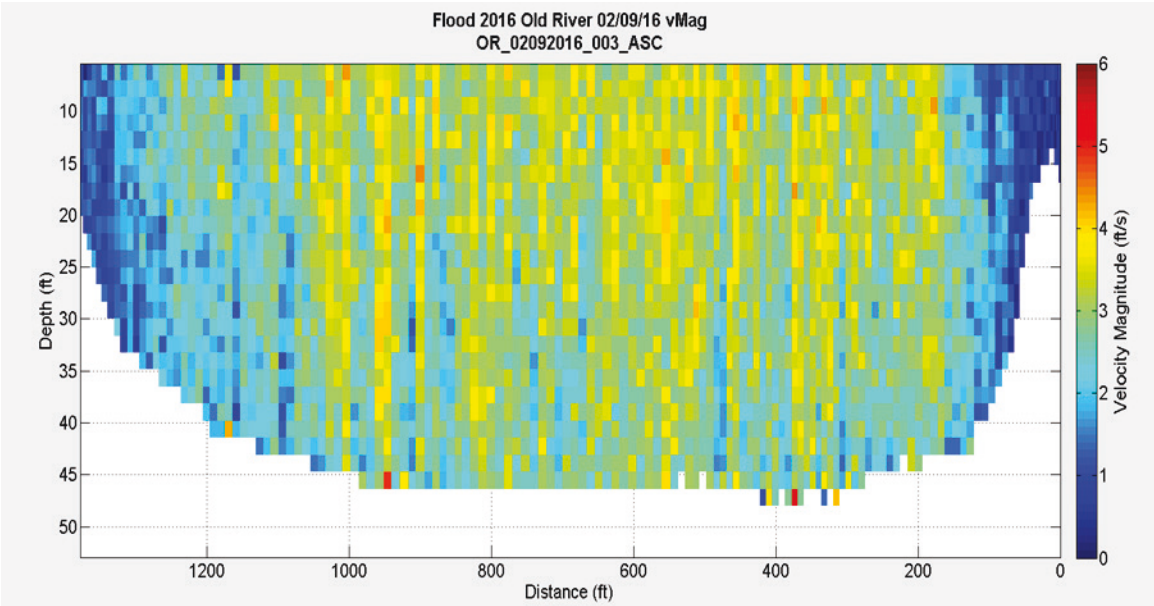

Figure 10. 09 February 2016 Site 5 velocity profile (a).

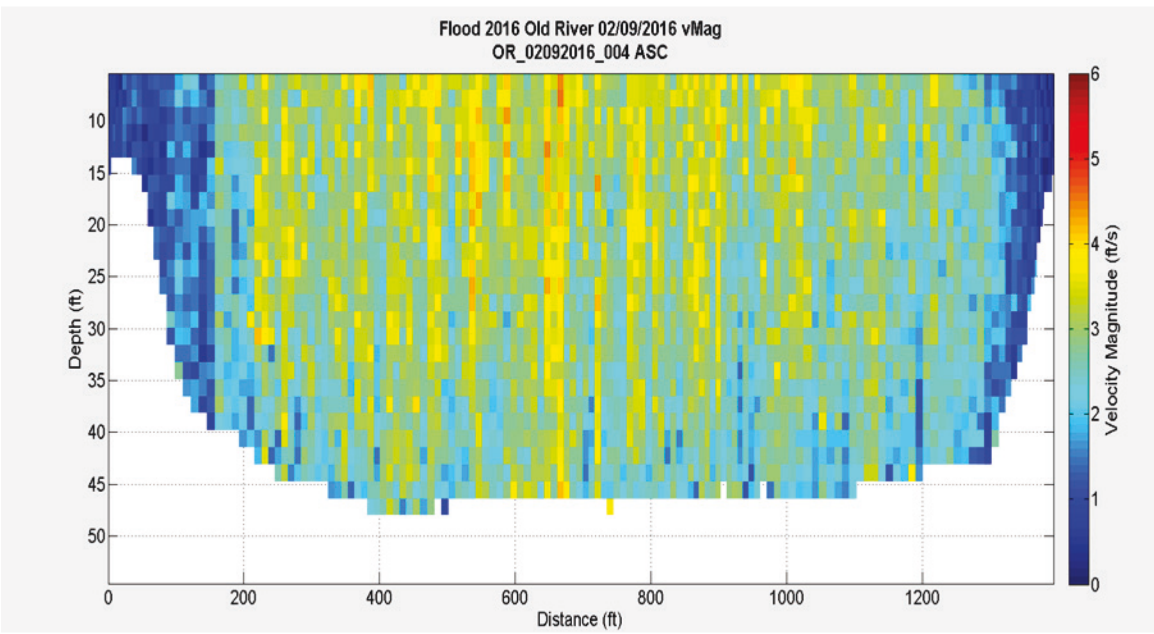

Figure 11. 09 February 2016 Site 5 velocity profile (b).

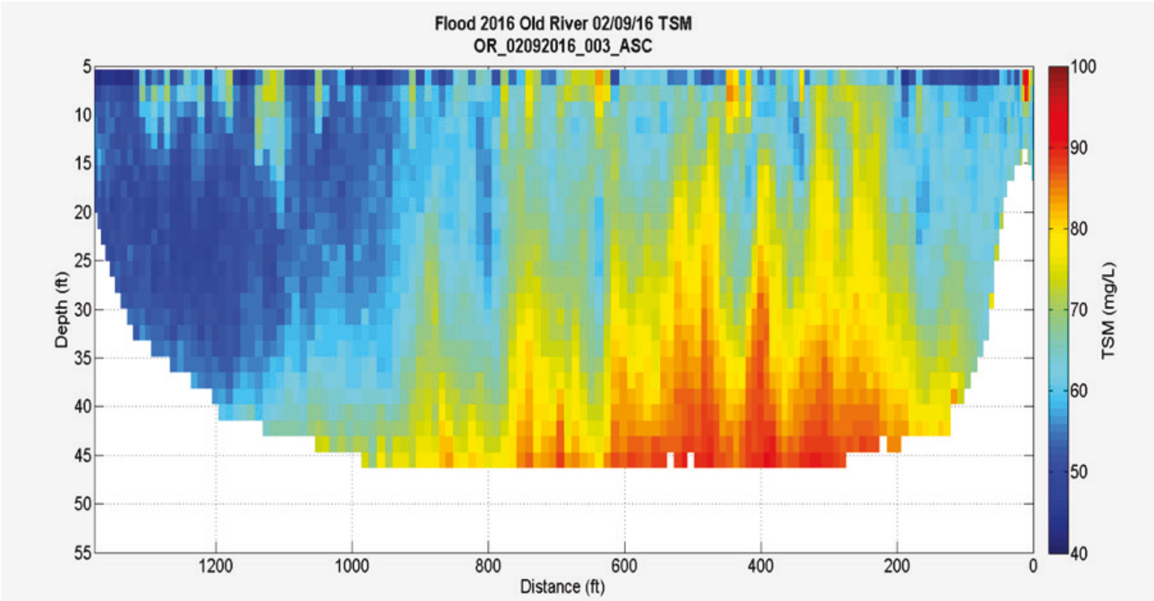

Figure 12. 09 February 2016 TSM profile (a).

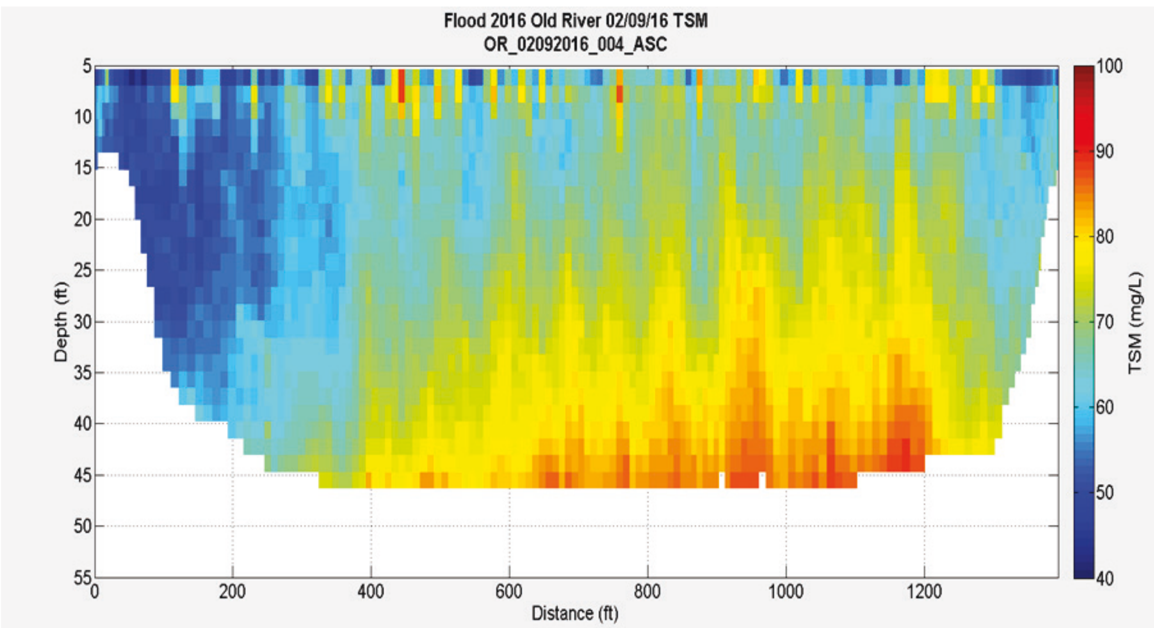

Figure 13. 09 February 2016 suspended sediment profile (b).

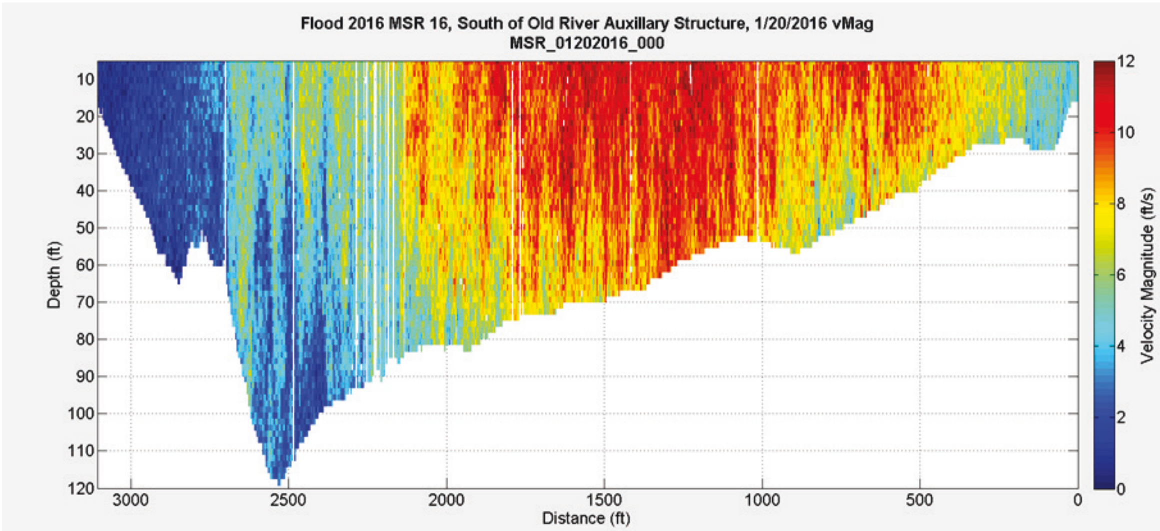

Figure 14. 20 January 2016 Site 1 velocity profile (a).

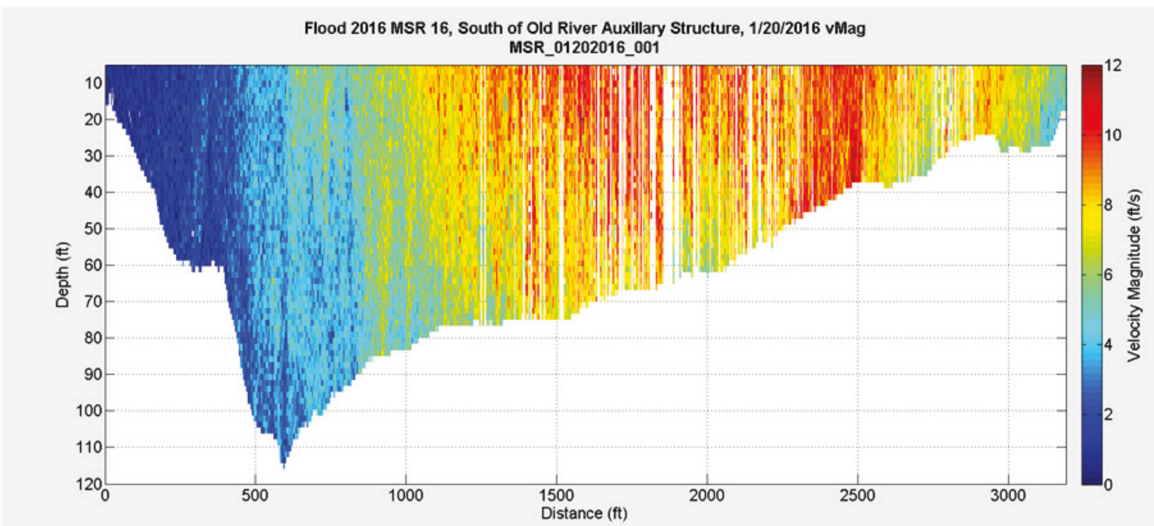

Figure 15. 20 January 2016 Site 1 velocity profile (b).

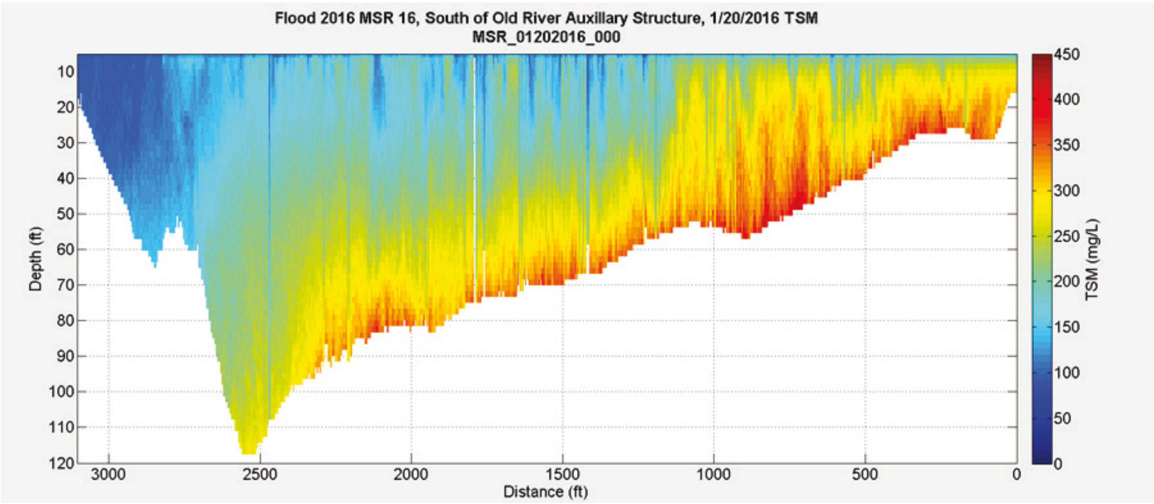

Figure 16. 20 January 2016 Site 1 TSM profile (a).

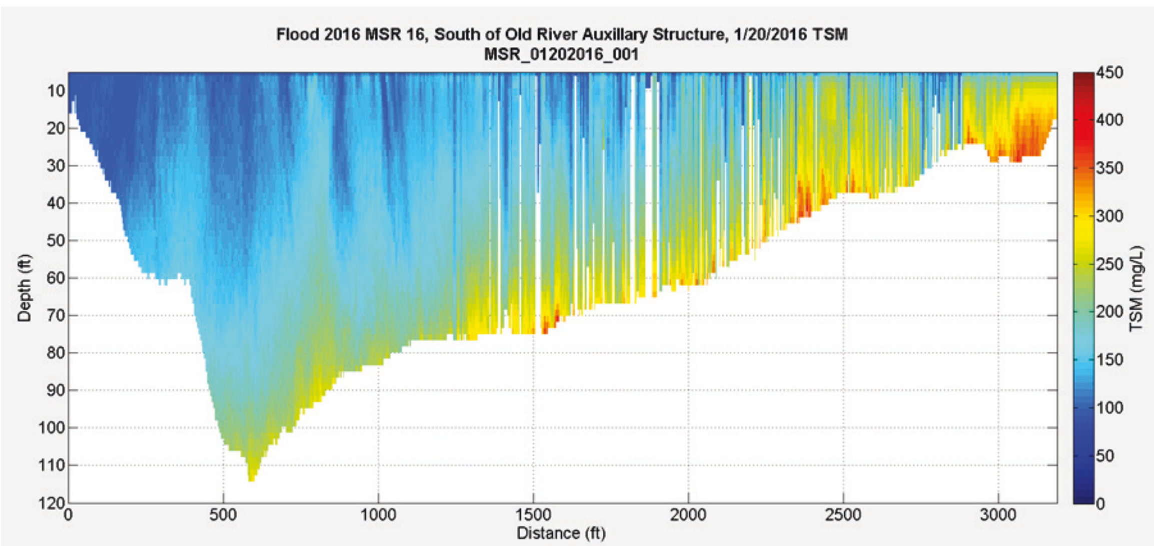

Figure 17. 20 January 2016 Site 1 TSM profile (b).

Bottom (Bed) Sediment Sampling. Bottom bed samples were also collected on each site trip and analyzed in the lab using a laser to determine grain sizes. Samples were collected using a box core or a bed drag sampler. Details of these same samplers and methods are documented in Heath et al. (2015). Figure 18 through Figure 25 show the resulting grain size spectrums and distribution graphs. In the legends of all these graphs, the OR16 represents Old River 2016, the alphabetic label indicates the transverse location (A-E) in the cross section, and the last number represents the water depth in feet at that location. Table 4 includes a summary of all of the bed samples.

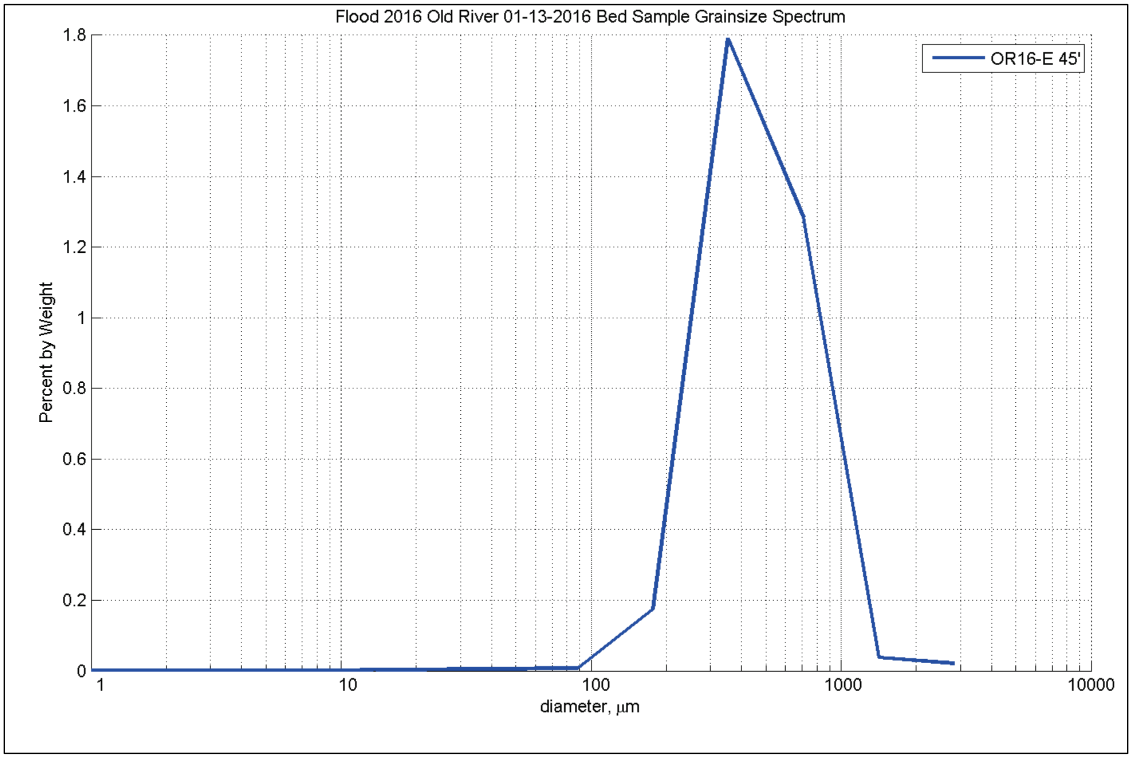

Figure 18. 13 January 2016 Site 5 grain size spectrum.

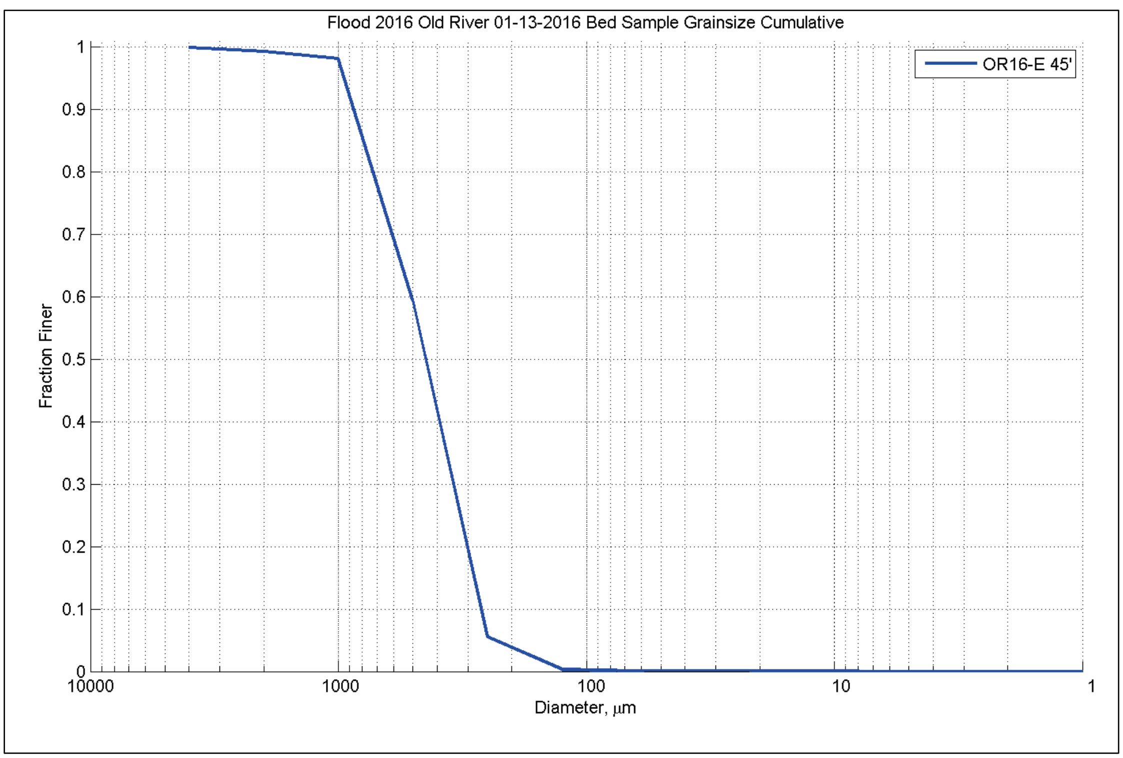

Figure 19. 13 January 2016 Site 5 grain size distribution.

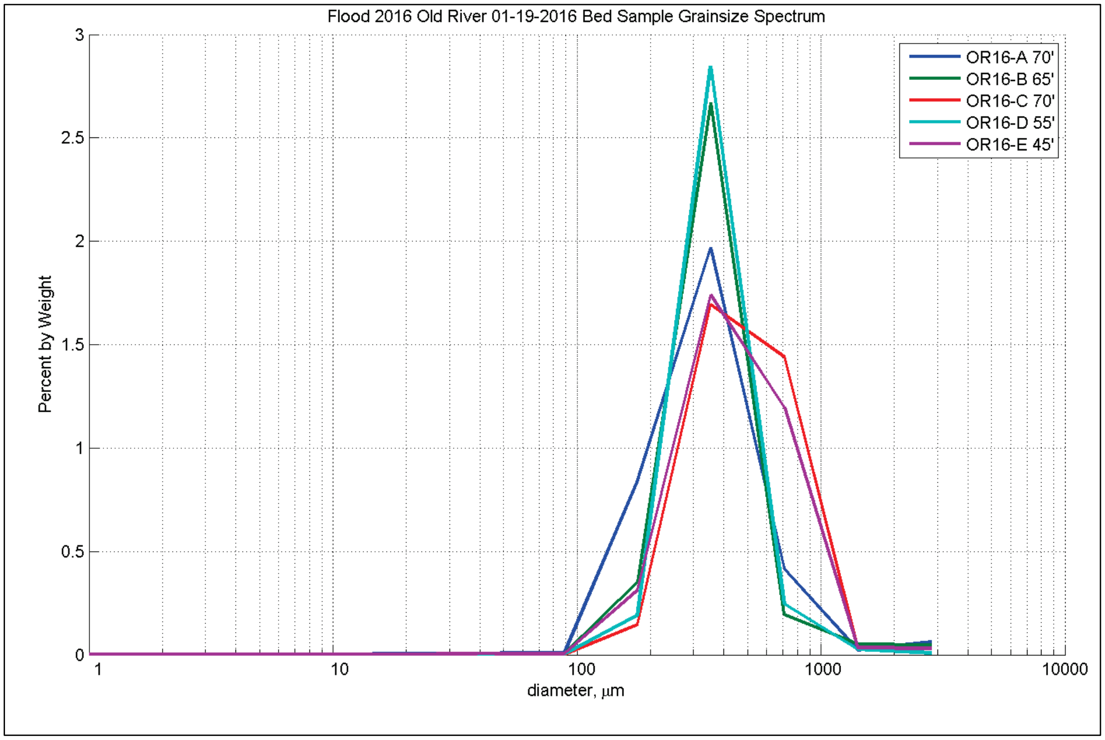

Figure 20. 19 January 2016 Site 5 grain size spectrum.

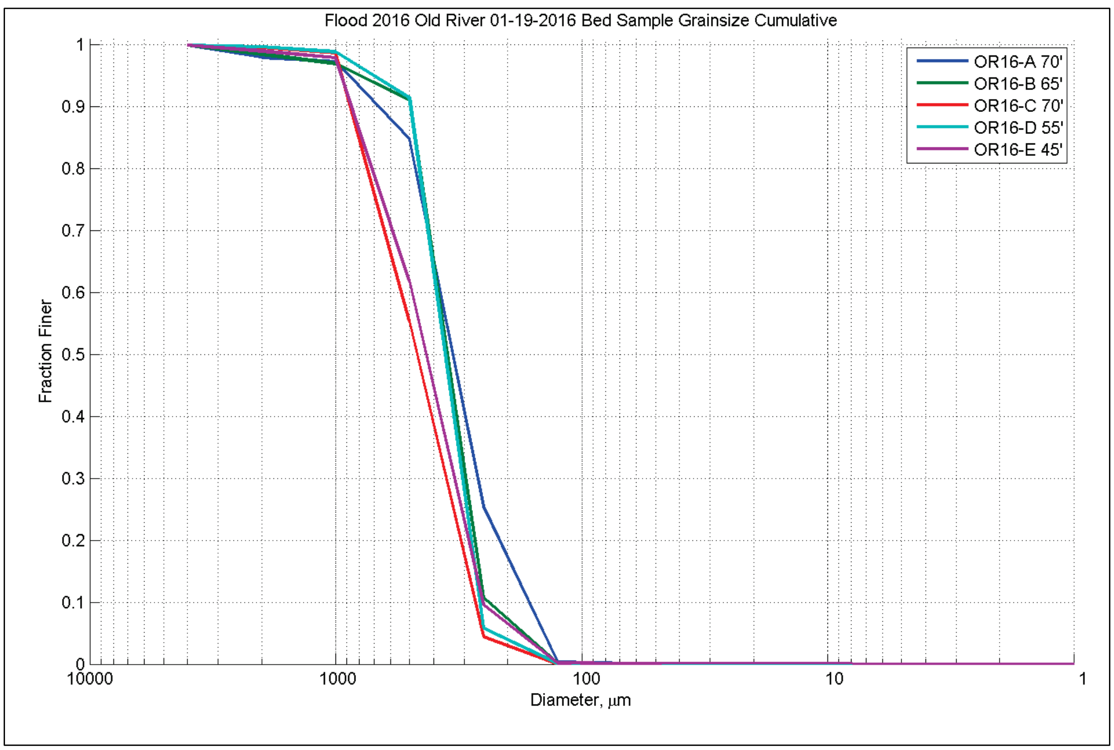

Figure 21. 19 January 2016 Site 5 grain size distribution.

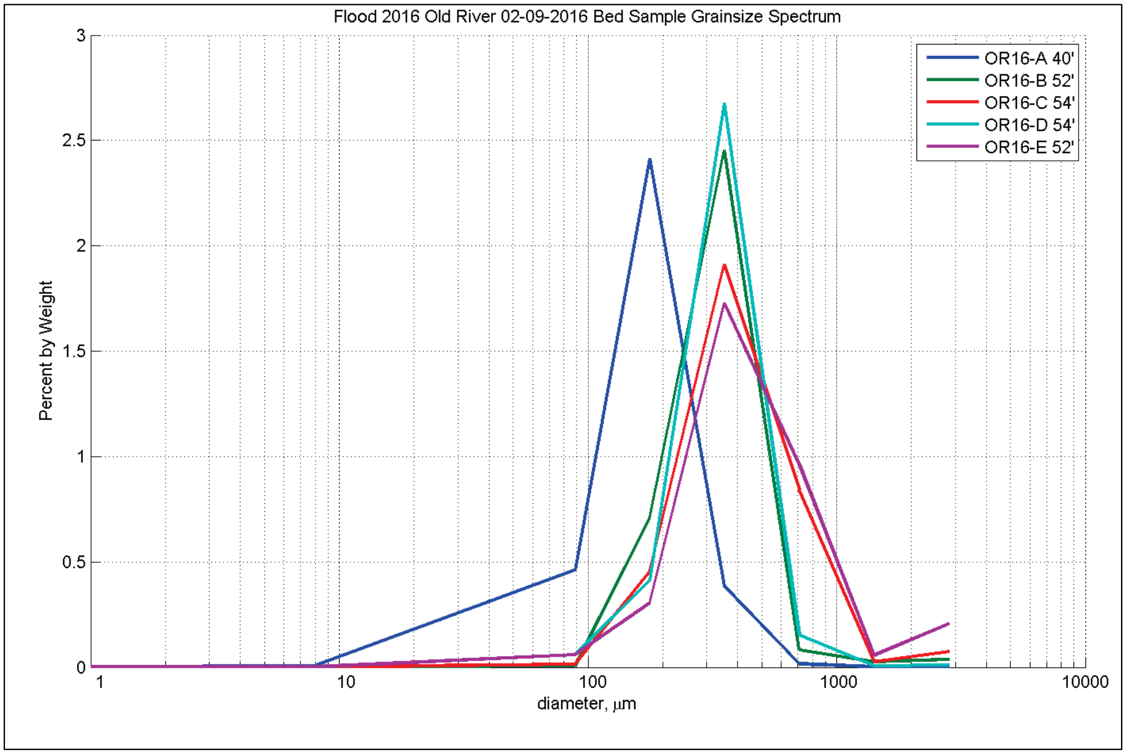

Figure 22. 09 February 2016 Site 5 grain size spectrum.

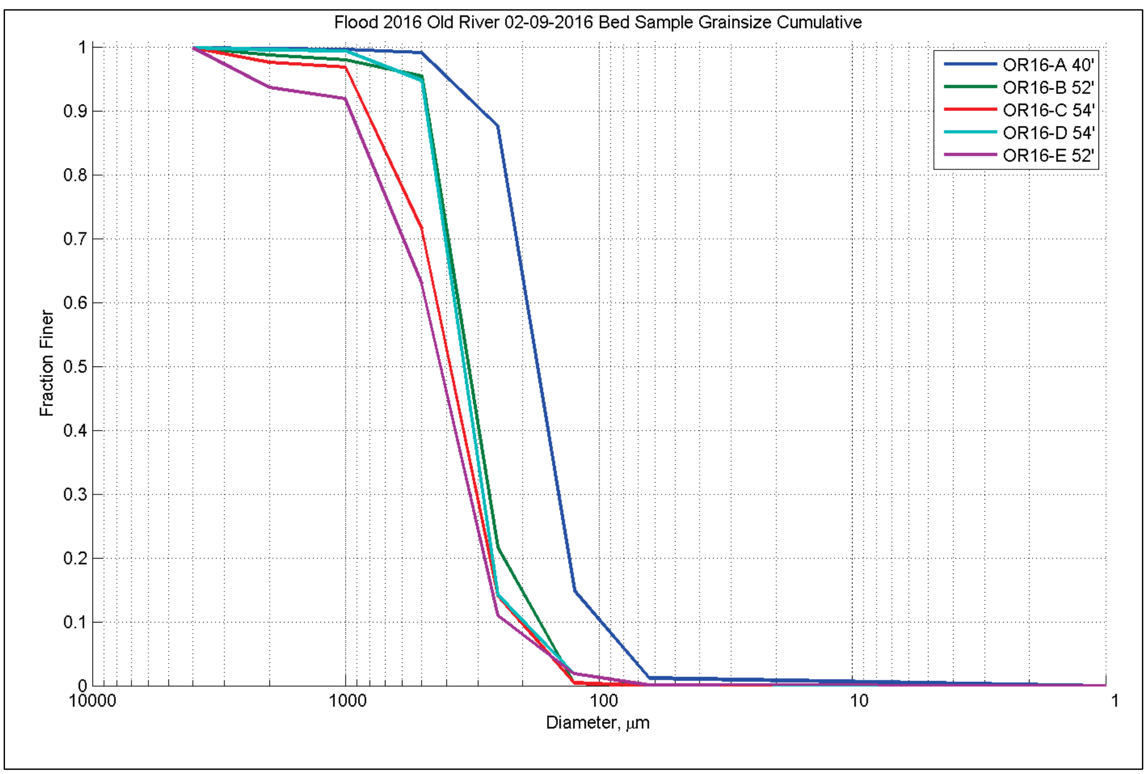

Figure 23. 09 February 2016 Site 5 grain size distribution.

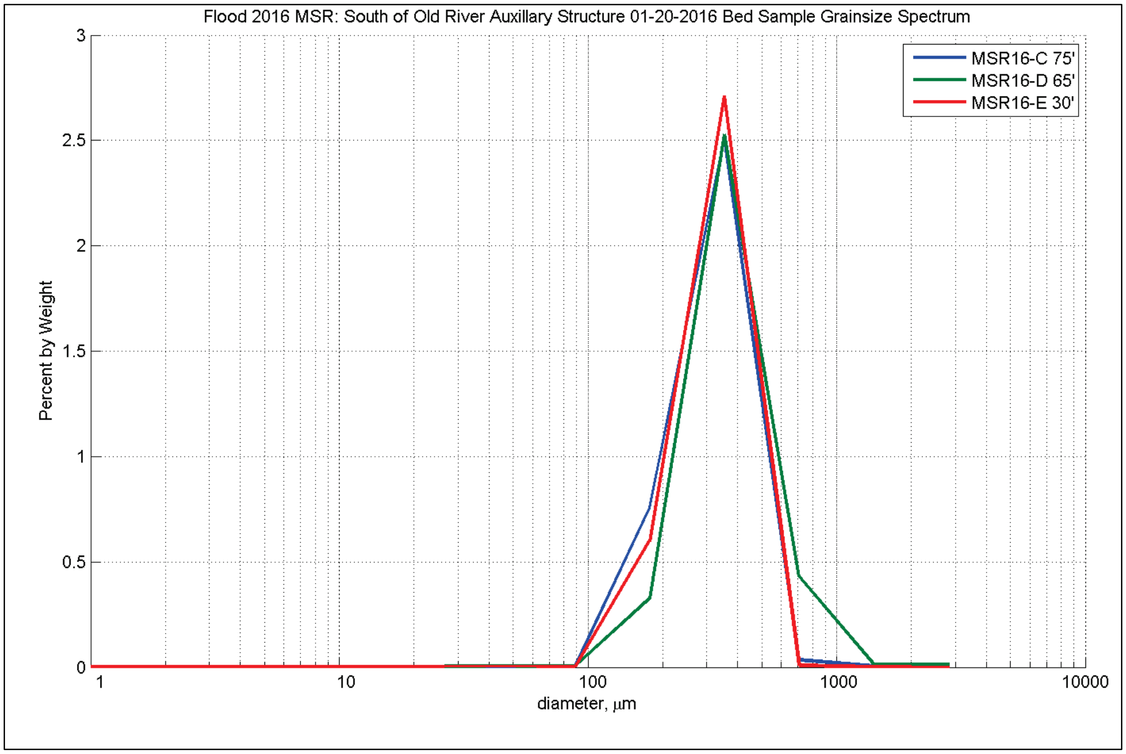

Figure 24. 20 January 2016 Site 1 grain size spectrum.

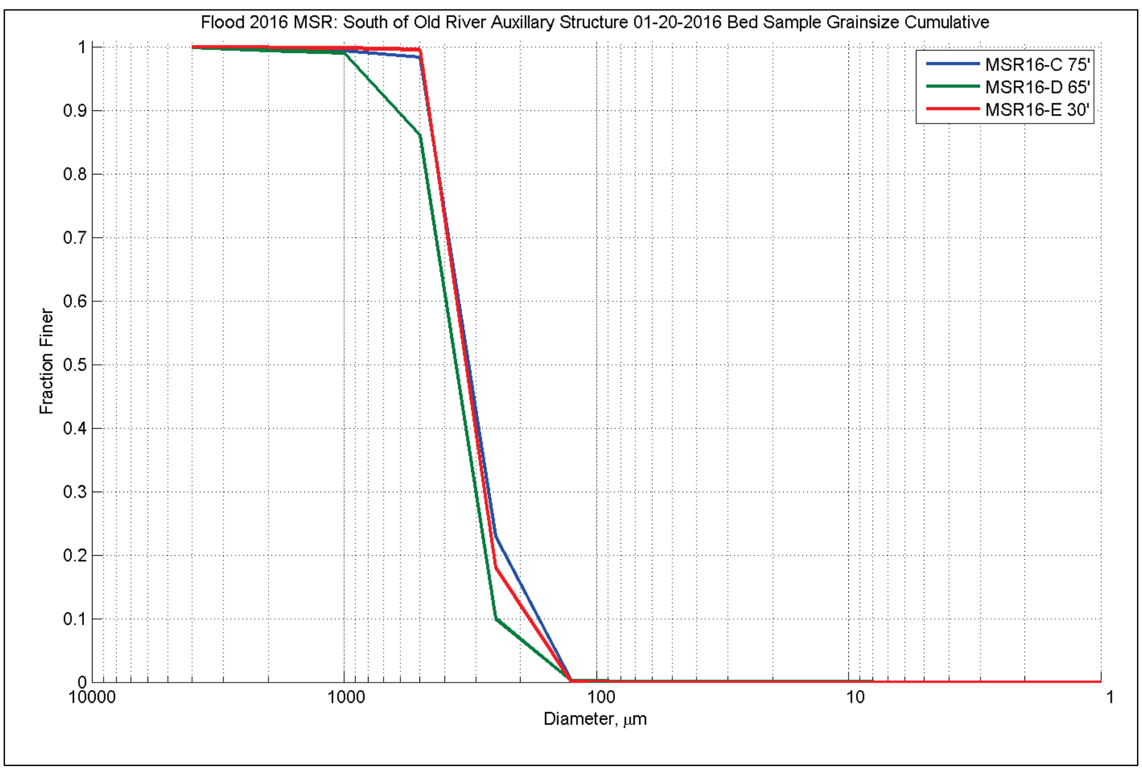

Figure 25. 20 January 2016 Site 1 grain size spectrum.

Table 4. Bottom bed material sample classification.								
Sample	%Fines	%Sand	% Gravel	%Very Fine Sand	%Fine Sand	%Med Sand	%Coarse Sand	%Very Coarse Sand
Site5 13Jan2016-E	0.13	99.25	0.62	0.22	5.25	53.93	38.69	1.15
Site5 19Jan2016-A	0.13	97.95	1.92	0.25	25.15	59.30	12.56	0.70
Site5 19Jan2016-B	0.04	98.55	1.41	0.15	10.57	80.35	5.91	1.56
Site5 19Jan2016-C	0.02	99.70	0.28	0.05	4.43	50.97	43.35	0.91
Site5 19Jan2016-D	0.02	99.75	0.24	0.09	5.76	85.68	7.39	0.81
Site5 19Jan2016-E	0.07	99.02	0.91	0.15	9.40	52.38	36.03	1.07
Site5 09Feb2016-A	1.26	98.59	0.16	13.73	72.67	11.62	0.48	0.09
Site5 09Feb2016-B	0.15	98.74	1.11	0.27	21.31	73.86	2.51	0.79
Site5 09Feb2016-C	0.02	97.71	2.26	0.43	13.67	57.53	25.33	0.74
Site5 09Feb2016-D	0.14	99.58	0.28	1.75	12.37	80.61	4.65	0.20
Site5 09Feb2016-E	0.07	93.68	6.24	1.78	9.11	52.02	29.04	1.73
Site1 20Jan2016-C	0.01	99.71	0.28	0.19	22.76	75.53	1.04	0.19
Site1 20Jan2016-D	0.10	99.46	0.44	0.14	9.82	76.12	12.99	0.40
Site1 20Jan2016-E	0.01	99.99	0.00	0.07	18.00	81.61	0.28	0.03

Bed-Load Transport Measurements. Bed-load transport rates were calculated using the Integrated Section Surface Difference over Time version 2 method (ISSDOTv2). ISSDOTv2 uses time-sequenced bathymetric surveys to calculate a bed-load transport rate. The method is documented in more detail in Abraham et al. (2011). Table 5 lists the dates measurements were taken for each trip at the ORCC since Trip 1 in 2010.

Table 5. ISSDOTv2 data collection trip dates.	
Data Collection Dates	
Trip 1	9–10 Feb 2010
Trip 2	3–4 Mar 2010
Trip 3	29–30 Apr 2010
Trip 4	1–3 Jul 2010
Trip 5	1 Sep 2010
Trip 6	9 Mar 2011
Trip 7	23 May 2011
Trip 8	13 Jan 2016
Trip 9	19–20 Jan 2016
Trip 10	9 Feb 2016

Compilation of Measurements at Sites 1 and 5 through 2016. The 2016 data were collected on trips 8, 9, and 10. Trips 1–7 that were collected during 2011 for Sites 1 and 5 were rerun with the newest version of the code to maintain consistency with the 2016 data and are reported in the tables and graphs below along with the newest 2016 data.

Site 1 measurements are shown in Table 6 and Figure 26 while Site 5 measurements are in Table 7 and Figure 27. Power or polynomial equations are used for the bed-load rating curves as opposed to linear curves as in Heath et al. 2015. This is the result of more analysis and observations since the previous study resulting in a power or polynomial fit being considered more appropriate at this time. The following abbreviations and definitions apply to the graphs and tables.

- Wash Load = Fine sediments not found in appreciable quantities in the bed.
- Bed Material Load (BML) = Sediment sizes normally found in the bed whether transported in bed-forms or in suspension.
- Bedload (BL) = BML moving in bed-forms
- SusBML = The suspended portion of the BML
- %BL = The portion of the BML that moves in the bed forms as bedload.
- Suspended Load = Wash Load + SusBML.
- Total Load = BML + Wash Load.
- Values are in tons per day unless otherwise noted. (Heath et al. 2015)

Table 6. Flow and sediment computations at Site 1.

Site 1								
	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6	Trip 7	Trip 9
Flow (cfs)	955,000	744,000	510,000	651,000	330,000		1,590,000	1,415,000
BL	27,438	14,194	4,645	5,672	8,685		66,757	93,577
SusBML	281,905	170,020	14,088	39,650	5,899			449,871
BML	309,343	184,214	18,733	45,322	14,584			543,448
%BL	8.9%	7.7%	24.8%	12.5%	59.6%			17.2%
Wash Load	369,979	191,071	98,059	357,069	83,062			273,205
Total Load	679,322	375,285	116,792	402,391	97,646			816,653

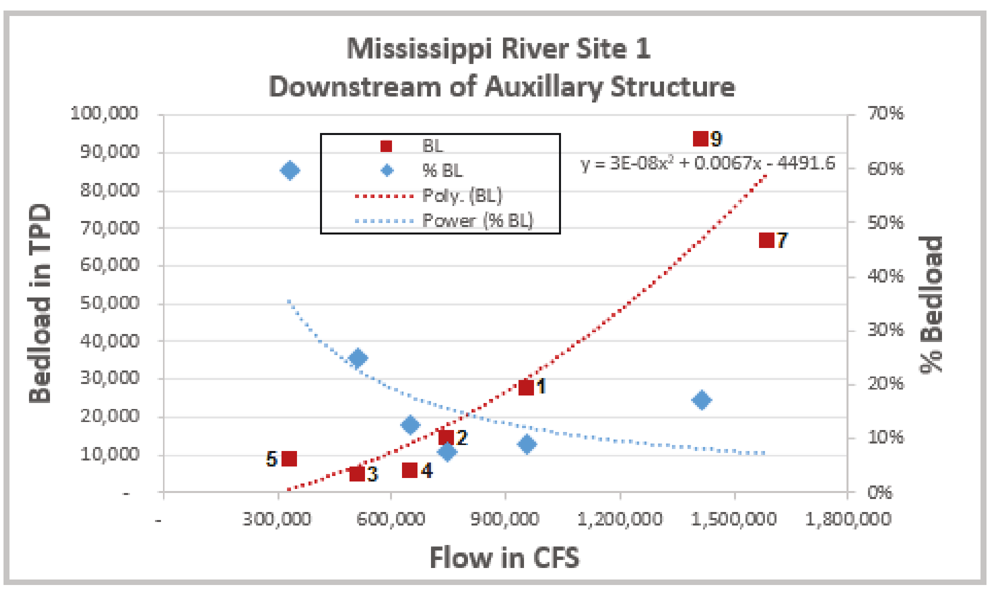

Figure 26. Bedload and percent bedload vs. flow at Site 1 (measurement data points are labeled with corresponding trip number).

As can be seen in Figure 26 and Table 6, the measurement in 2016 (9) added a second data point at a high flow. It shows the continuation of the trend towards much higher bed-load transport at extreme flows. In this case a bed-load transport rate of over 90,000 TPD was observed at a flowrate of just over 1.4 million cfs.

Table 7. Flow and sediment computations at Site 5.

Site 5										
	Trip 1	Trip 2	Trip 3	Trip 4	Trip 5	Trip 6	Trip 7	Trip 8	Trip 9	Trip 10
Flow (cfs)	263,000	123,858	155,000	262,000	130,000	318000	660,000	470,000	476,000	151,000
BL	2,347	1,651	1,343	15,625	1,072	7,847	39,083	22,529	12,456	Bad Data
SusBML						76,591	51,092	114,021	48,609	3,422
BML						84,438	90,175	136,550	61,065	
%BL						9.3%	43.3%	16.5%	20.4%	
Wash Load						304,303	47,614	144,765	84,051	26,575
Total Load						388,741	137,789	281,315	145,116	

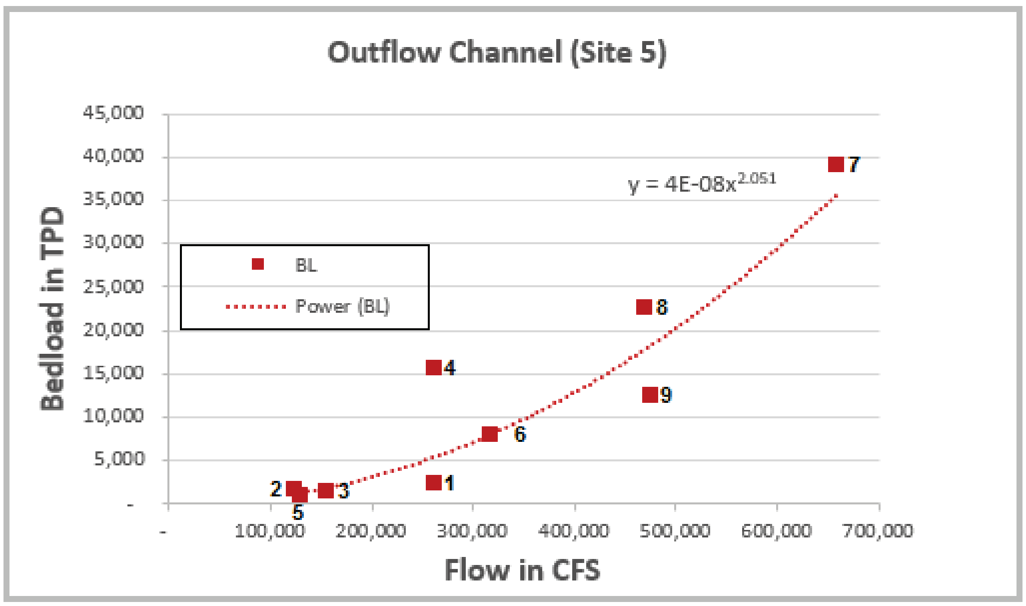

Figure 27. Bedload vs. flow at Site 5 (points are labeled with trip number).

In Table 5 and Figure 27, the 2016 values have been added to the previous values for Site 5 (outflow channel). The new points are numbers 8 and 9 in the graph. In this case, measurements 8 and 9 were at similar flow rates (approximately 470,000 cfs). Their values are consistent with the earlier measurements lying near the developed power curve, which adds validity and confidence to the curve for higher flow rates.

Applications of these data. Using these updated and augmented measurements, the bed-load rating curve for the Mississippi River at ORCC was updated (Figure 28). All sites are located on the Mississippi River in the vicinity of the ORCC. Site 2 is located between the auxiliary and low sill channels, Site 3 is between the hydropower and low sill channels, and Site 4 is upstream of hydropower.

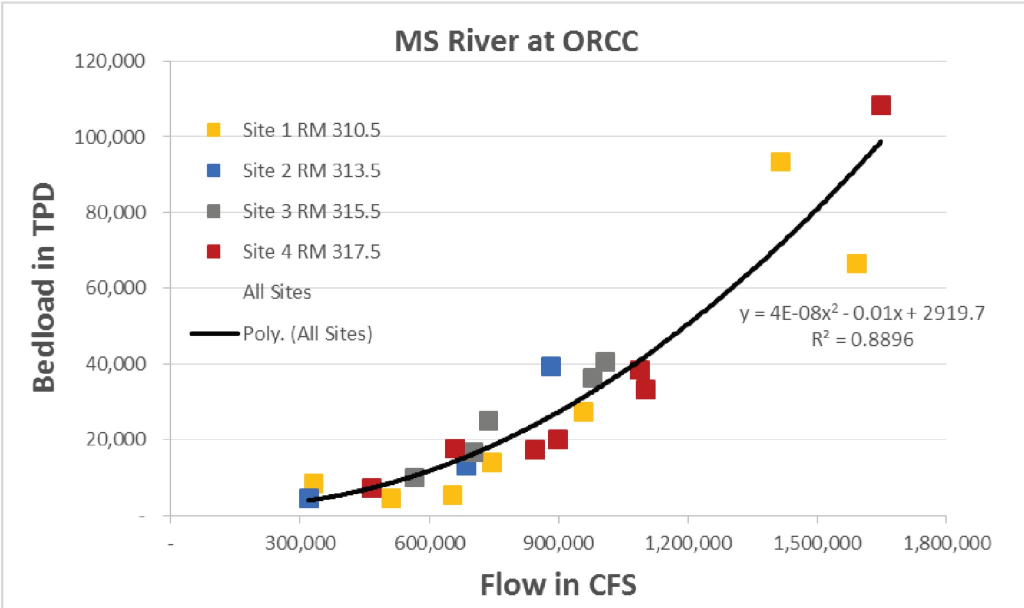

Figure 28. Bed load rating curve for Mississippi River at ORCC.

Using this rating curve and a known hydrograph, the total bed-load transport for the time period in question can be determined. This is a powerful and useful tool. With it one can examine historical hydrographs and estimate past sediment delivery, or one can project a future hydrograph and predict future bed-load sediment delivery. Consider the following example using the rating curve above (Figure 28) and a 1-year hydrograph from Tarbert Landing, shown in Figure 29. The hydrograph consists of flows for water year (WY) 1998 obtained from the USACE site Rivergages.com (*http://rivergages.mvr.usace.army.mil/WaterControl/new/layout.cfm*).

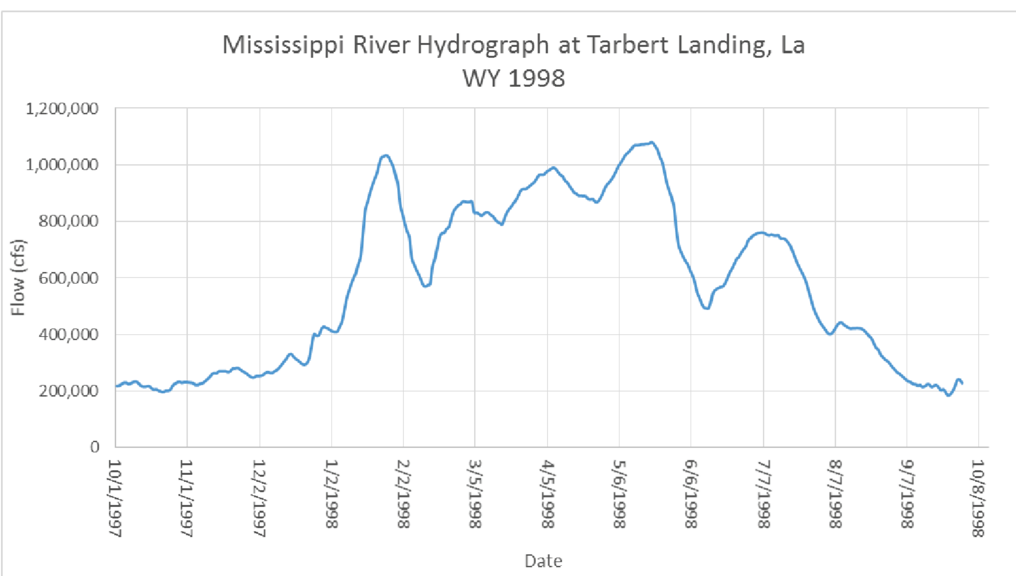

Figure 29. WY 1998 hydrograph at Tarbert Landing.

Using the equation from the best fit line for the bed-load rating curve in Figure 28, bed-load transport values can be determined for each daily flow and plotted to produce a bedload vs. time graph (Figure 30). Integrating under this curve or summing daily transport values for a certain length of time determines a total amount of bedload transported for that time period. This method calculates 5,059,331 tons were transport as bedload past Tarbert Landing for WY 1998.

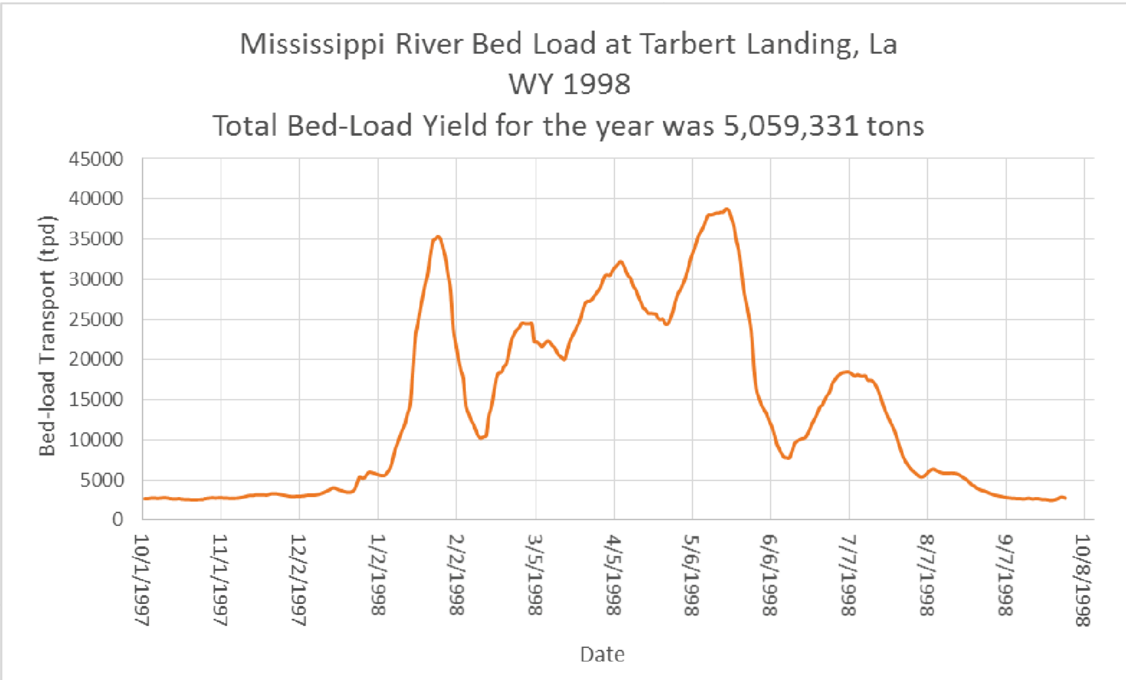

Figure 30. Bed-load transport at Tarbert Landing for WY 1998.

This method can be used for any time period if the rating curve is determined to be valid for that time as river conditions such as slope and bed gradations can change, thereby impacting the accuracy of a rating curve. In Figure 31, this method is used to look at yearly values from WY 1998 to WY 2016.

Approximately 78.7 million tons were transported over these 19 years. The variation on a year-to-year basis is evident with some years transporting three times the amount of other years. A linear line was fit to the data and shows an increasing trend over this time period. The rating curve is a function of flow, so these values are heavily dependent on the hydrology for these years. One should be careful attempting to extrapolate this trend outside the bounds of this data without additional analysis to determine the statistical significance of this line. Note also that several of the later years in this plot were considered significant flood years with higher-than-usual flows (2008, 2010, 2011, and 2016, in particular).

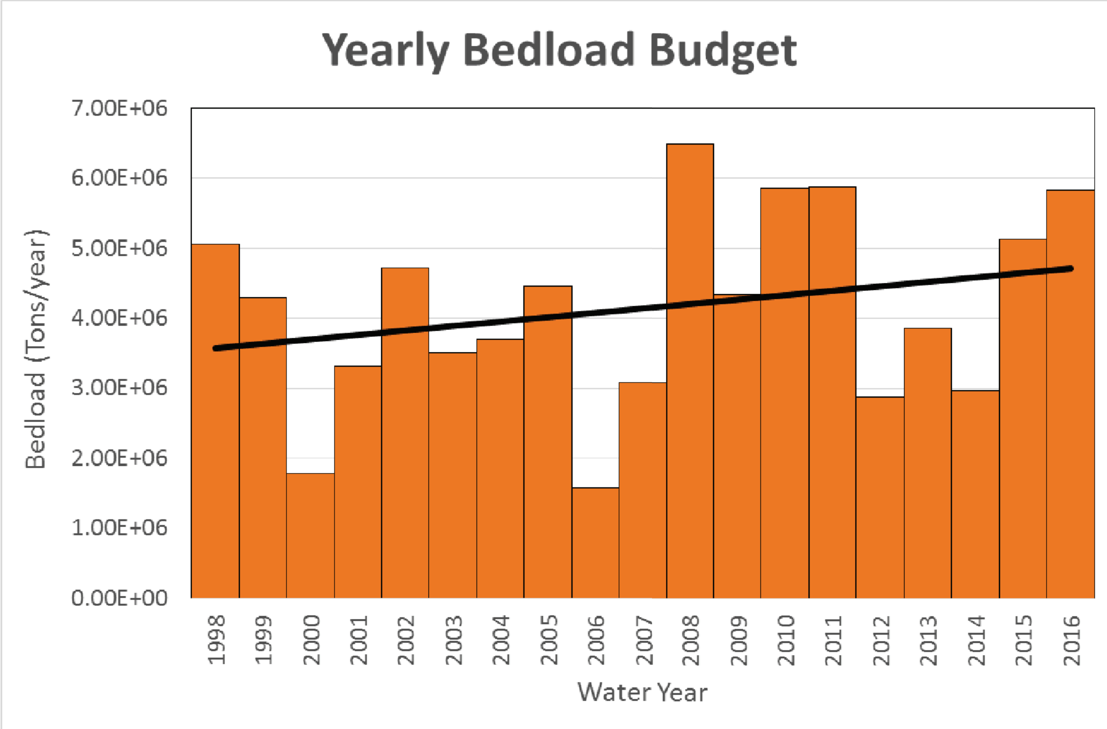

Figure 31. Calculated bedload for WY 1998–2016.

SUMMARY: The new data collected in 2016 are useful in helping to more fully understand the sediment picture at the ORCC. The 2016 bed-load data were consistent with the previous 2011 data. This is a trend that has recently been observed at numerous sites using ISSDOTv2 measurements where bed-load transport correlates closely to discharge for the Lower Mississippi River. These new 2016 data combined with the 2011 data cover a wide range of flows and structure operations and allow the creation of site-specific bedload rating curves. Bed-load rating curves can be a powerful tool in predicting and modeling sediment movement. The rating curve for the Mississippi River at ORCC was used to calculate past bed-load delivery for the previous 19 years.

RECOMMENDATIONS: Data collection for Heath et al. (2015), as discussed previously, included 11 sites while this 2016 data were only collected at two sites. Collecting more measurements on the Red River (Site 6) and the Atchafalaya River at Simmesport below Site 7 would create more data and a better understanding of the bedload on the Atchafalaya side of the ORCC. Also, well-developed rating curves at Simmesport and Tarbert Landing, where suspended measurements exist and the latitude flow split is measured, could be created. This would be the first time that the full sediment picture including measured bedload would be available to examine the distribution of the total sediment load between the Atchafalaya and Mississippi River.

REFERENCES

Abraham D., R. Kuhnle, and A. J. Odgaard. 2011. "Validation of Bed Load Transport Measurements with Time Sequenced Bathymetric Data." *Journal of Hydraulic Engineering, ASCE* 137(7):723–728.

Heath, Ronald E., Gary L. Brown, Charles D. Little, Thad C. Pratt, Jay J. Ratcliff, David D. Abraham, David Perkey, Naveen B. Ganesh, Keith Martin, and David P. May. 2015. *Old River Control Complex Sedimentation Investigation*. MRG&P Report No. 6. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

U.S. Army Corps of Engineers (USACE), New Orleans District. 2011. *Mississippi River and Tributaries Atchafalaya Basin, Louisiana. FINAL 2010 Refined Project Flood Flow Line Hydraulic Design*, Revised February 2011, Volume 1. New Orleans, LA: U.S. Army Corps of Engineers, New Orleans District.