ATTACHMENT A – BEAVERHEAD RIVER FLUSHING FLOW STUDY

RECLAMATION

Managing Water in the West

Beaverhead River Flushing Flow Study

Clark Canyon Dam, Montana
Montana Area Office
Billings, Montana

U.S. Department of the Interior
Bureau of Reclamation

September 2010

Mission Statements

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The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

BUREAU OF RECLAMATION
Technical Service Center, Denver, Colorado
Group, D86-68240

Beaverhead River Flushing Flow Study

Clark Canyon Dam
Montana Area Office
Billings, Montana

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Introduction

The Montana Area Office has requested that the Technical Service Center (TSC) perform a qualitative study to estimate the discharge necessary to remove fine sediment below Clark Canyon Reservoir on the Beaverhead River (Figure 1). Clark Canyon Creek flows into the Beaverhead River below Clark Canyon Reservoir approximately 1.5 miles below the dam. The creek delivers a great deal of fine sediment to the river. The Montana Area Office provided bed material size data for Clark Canyon Creek and the Beaverhead River. This report summarizes the results of the flushing flow analysis.

Clark Canyon Creek delivers a large load of fine sediment into the Beaverhead River each spring (Figures 2 through 5). This large sediment load has affected fisheries during years when storage and releases from Clark Canyon Dam are limited. Limited releases in the spring have resulted in deposition of fine sediment, which has affected the trout fishery just downstream of the dam. The purpose of this study was to investigate flow releases from Clark Canyon Dam that would help mobilize and move fine sediment downstream. The Beaverhead River is listed as “impaired” for TMDL for heavy metals. The lower sections of the Beaverhead River below Grasshopper Creek are impaired for sedimentation and temperature (http://montanatmdlflathead.pbworks.com/Beaverhead-TMDL-Planning-Area). Regular high flow releases could result in improvement and maintenance of the channel and could be effective in moving fine sediments downstream from Clark Canyon Creek.

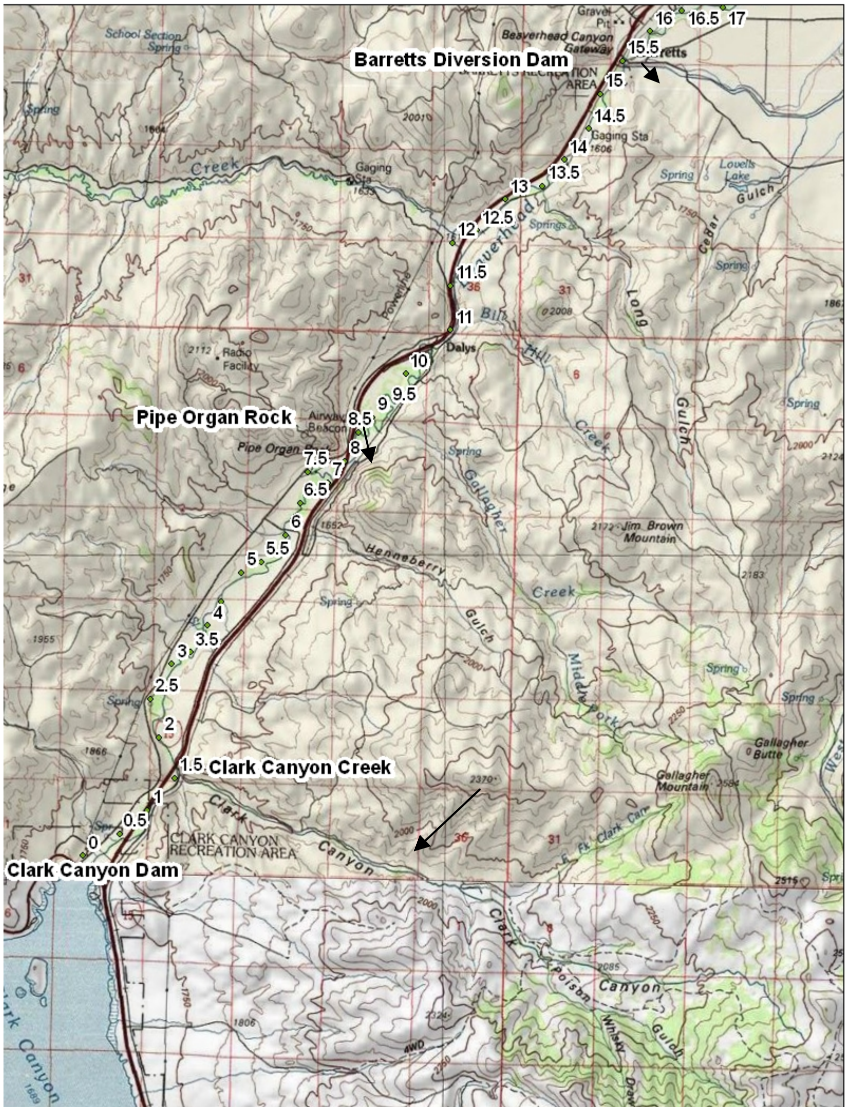

Figure 1-Location Map with River Miles as distance downstream of dam.

Figure 2-Fine sediment entering the Beaverhead River at Clark Canyon Creek

Figure 3-Different view of fine sediment entering the Beaverhead River at Clark Canyon Creek.

Figure 4-Clark Canyon Creek looking upstream about one quarter mile above the mouth.

Figure 5-Typical sediment sizes on the Beaverhead River just below Clark Canyon Creek.

Literature Review

Flushing flows are defined as releases of water from water control structures that produce high flows that remove or flush deposited sediment from flow-regulated streams (Reiser et al. 1989). In streams inhabited by salmonids, flushing flows can remove fine sediments from gravels and can be used for spawning, survival and recruitment.

Simkins and Wesch studied flushing flows on the Big Horn River, downstream from Boysen Dam in west-central Wyoming. The release from Boysen Dam provides a coldwater fishery that extends approximately 90 km downstream. Simkins and Wesch evaluated the movement of juvenile rainbow trout in a portion of the reach downstream of Boysen Dam. The river slope was 0.5 percent in this reach. Radio transmitters were used to capture and tag juvenile fish.. Flushing flows were approximately three times the mean annual flow. The dam released 300 cfs for a 24 hour period in March 1988. The results of the study indicated that flushing flows can enhance spawning without causing extensive downstream movements or habitat displacement of juvenile rainbow trout.

The State of Oregon (Robson, 2007) completed an information document on elevated flows. Elevated flows can have many objectives. Specific channel maintenance objectives include;

1. Move existing streambeds and gravels allowing for cleaning of gravels that have been intruded with fines, which includes spawning habitat and food sources in the medium and long term.
2. Scour and fill against encroaching riparian vegetation, which allows a stream to maintain its bedform.
3. Assist in retention of bed configuration including the formation of riffles, pools and other channel unit habitats.
4. Create conditions for replenishment of streamside vegetation such as cottonwoods.

To determine trigger levels or flows that will activate the gravel, gravel bed versus stream characteristics are analyzed for each stream. This could vary from 80 percent of the bankfull discharge to a streamflow that only occurs once every two years or more.

Model Development

The HEC-RAS program was used to create a model of the Clark Canyon Dam to Barretts Diversion Dam (U.S. Corps of Engineers, 2010). HEC-RAS is a one-dimensional computer program that models the hydraulics of water flow. HEC-GeoRAS is a set of procedures, tools and utilities used for processing geospatial data in ArcGIS 9.3 (ESRI, 2009). The geometry for this study utilized a USGS 10-meter digital elevation model (DEM). The data is available on the USGS website.

The DEM data was used as a topographic representation in ArcGIS. Inherent errors were apparent in the DEM because of the large grid cell size of 10 meters (approximately 30 feet). HEC-RAS model data was developed using HEC-GeoRAS. Pre-processing GIS data consists of creating line themes that represent the center of the channel, river banks, overbank flow paths and cross-sections. HEC-GeoRAS was utilized to digitize 52 cross sections with an approximate spacing of 1500 feet (Figures 6 and 7). The 16 mile reach from Clark Canyon Dam to Barrett's Diversion Dam included additional cross-sections interpolated in HEC-RAS. The total cross-sections equaled 354. Additional cross-sections were interpolated in the hydraulic model to improve accuracy of hydraulic calculations.

The DEM data were limited because of the large grid cell size and because bathymetric data are usually not captured in a DEM. To improve model geometry, the three measured cross-sections provided by the state were entered manually into each of the 52 digitized cross sections in HEC-RAS, prior to developing interpolated cross sections. The measured cross-sections provided by the state and locations where they were used are shown in Figures 8-10 (Montana Department of Environmental Quality, Watershed Management Section, 2010). The area office and the TSC agreed on this approach. A model Manning's n roughness of 0.04 was selected for the main channel and a roughness of 0.06 for the overbanks. A series of flows were modeled based on historical releases from Clark Canyon Dam.

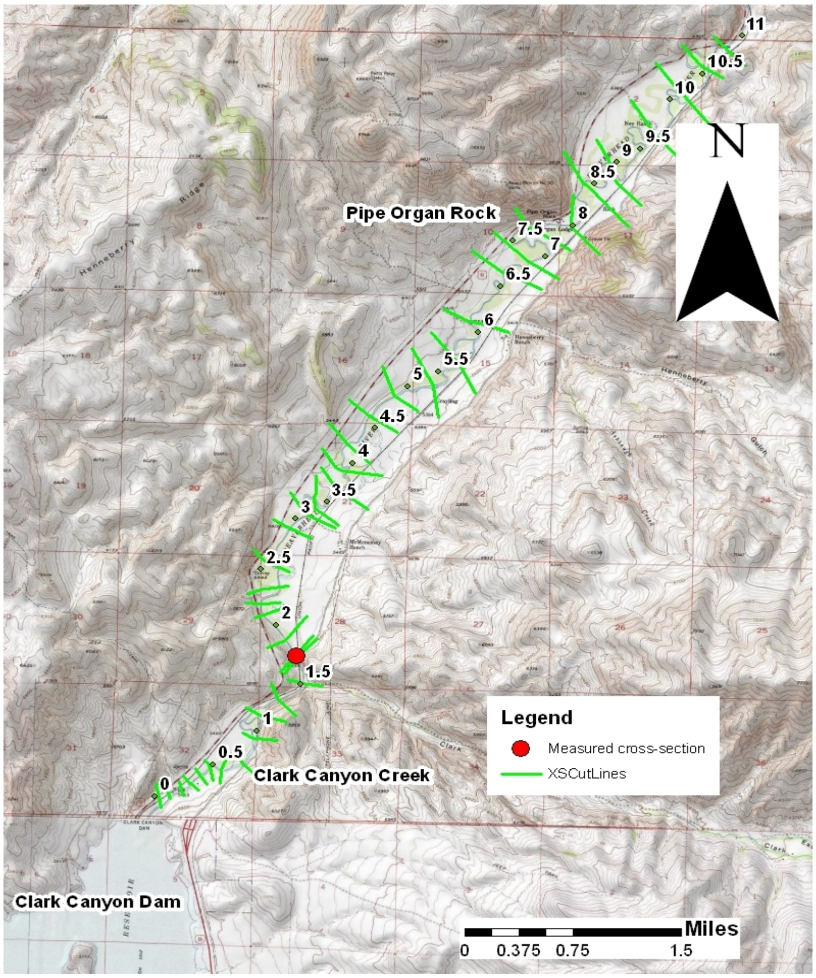

Figure 6-Cross-section layout for the upstream portion of the reach

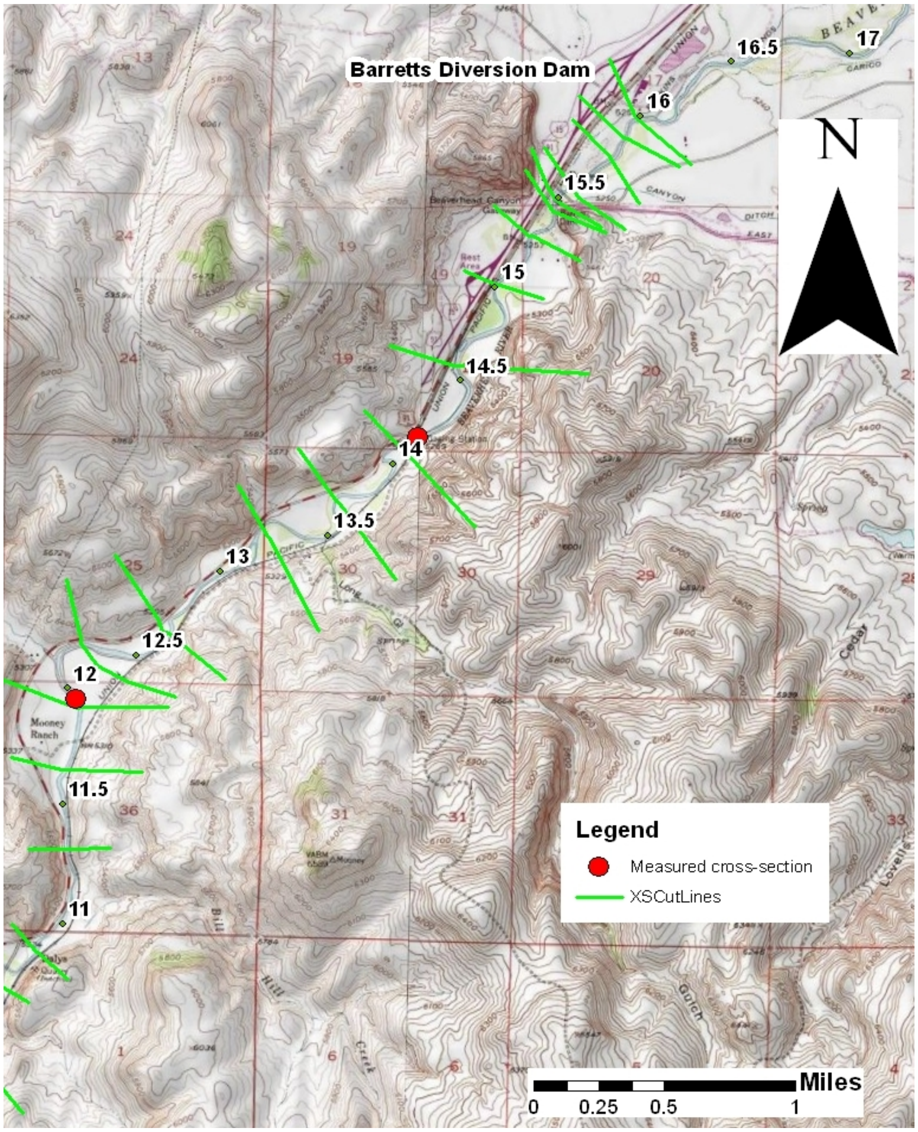

Figure 7- Cross-section layout for the downstream portion of the reach

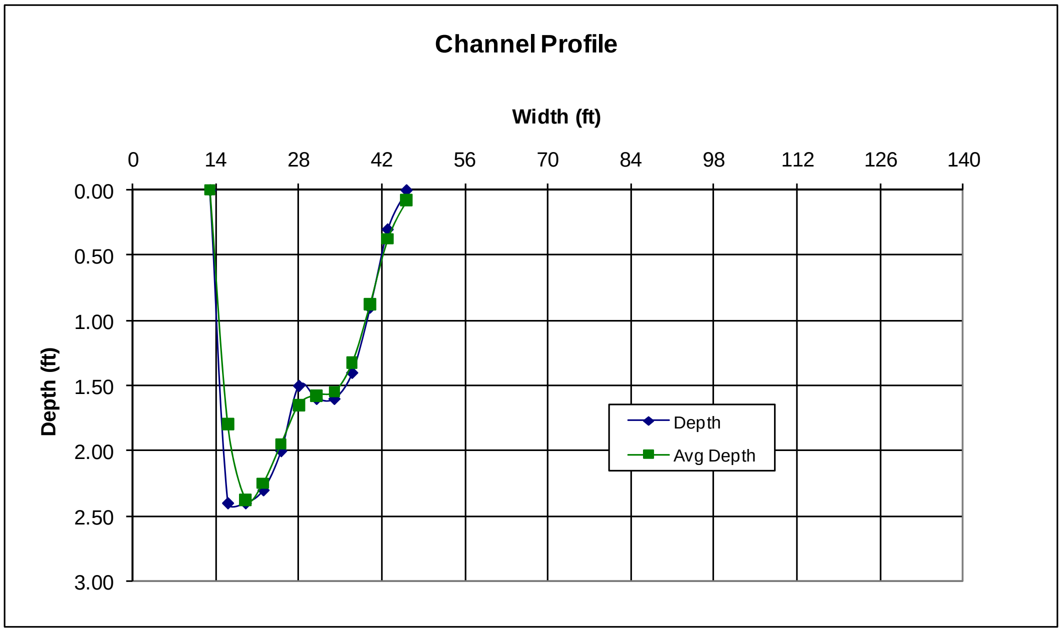

Figure 8-BVHR 2 used in the HEC-RAS model from river miles 0 to 2

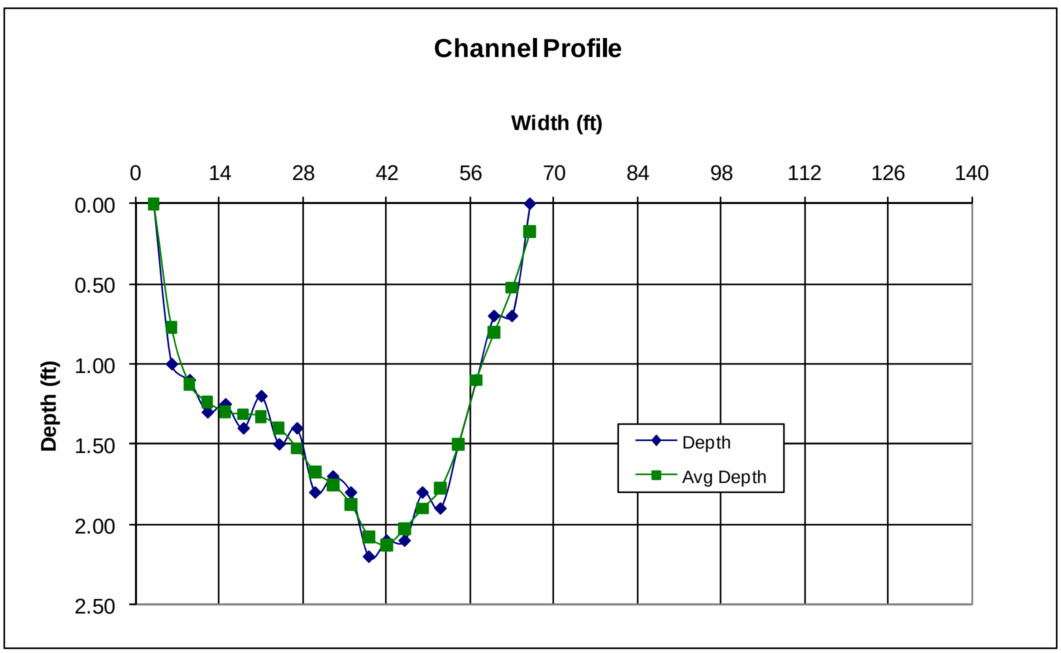

Figure 9-BVHR 3 used in the model from river miles 2 to 13

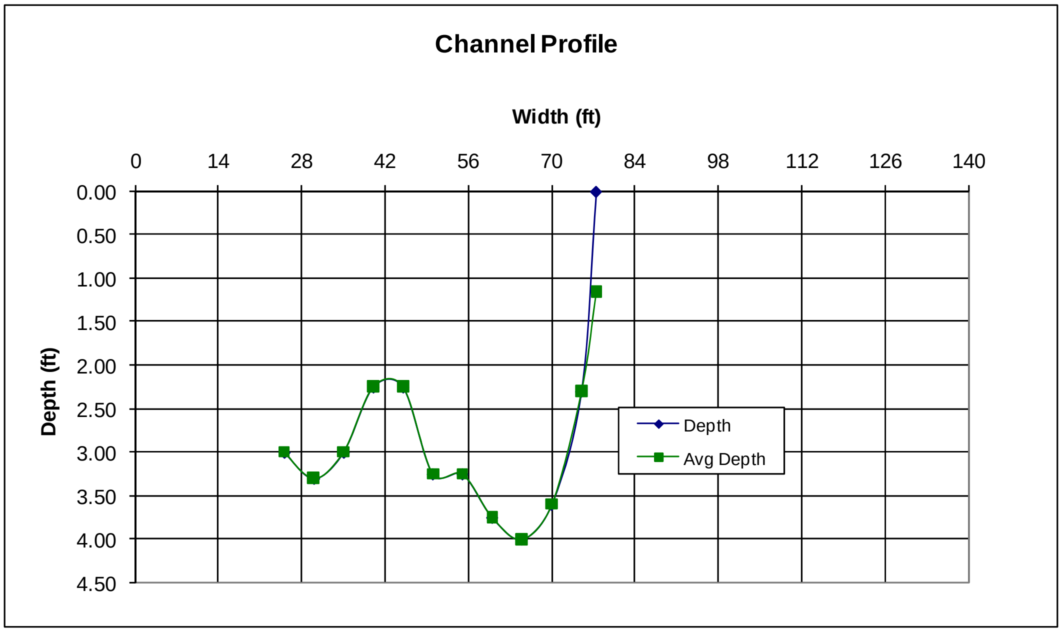

Figure 10-BVHR 3A used in the model from river mile 14 to river mile 16.

Historical Releases from Clark Canyon Dam

Clark Canyon Creek historically discharges large amounts of sediment into the Beaverhead River during spring runoff (typically April and early May). This has included very large volumes of sediment that have created sediment plugs, especially during rain on snow events. The reservoir releases from Clark Canyon Dam have not been timed with sediment discharges into the Beaverhead River from Clark Canyon Creek. Reservoir releases have remained small even with large sediment deposition causing little mobilization of the sediment.

Chuck Heinje of the area office provided historical releases from Clark Canyon dam. These data were sorted and graphed to look at the historical range of flows, especially during April and early May. The data were also plotted seasonally because the potential time period for release is after the start of irrigation season (April 1st). Seasonal historic release data for 2005-2009 are shown in Figure 1111. A review of the data show flow minimums of less than 100 cfs up to a maximum release of nearly 900 cfs in 2007.

A reasonable range of flows for the low flows would be peak discharges from 200 cfs to 800 cfs. These discharges were utilized based on discussions with Reclamation staff in the reservoir operations group in Montana. The flow hydrographs that were used in the model were based on the 2010 Clark Canyon dam flow release data for April and early May provided by the area office. The portion of the hydrograph used in the model was from around May 1st to May 21st. A comparison of the April 2010 monthly to the other years is shown in Figure 12. Two of the hydrographs used in the HEC-RAS model are shown in

Figure 13; 275 cfs peak flow and 800 cfs peak flow. The peak of the April 2010 release was 277 cfs, which was rounded to 275 cfs.

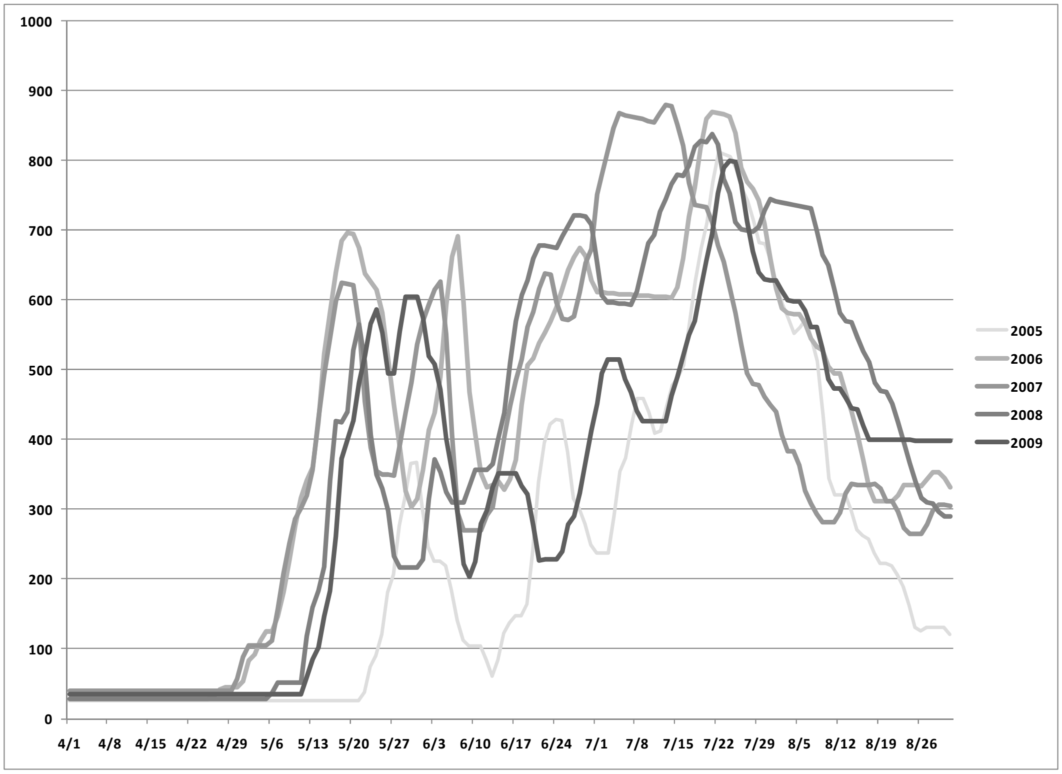

Figure 11-Historical releases from Clark Canyon Dam from 2005 to 2009.

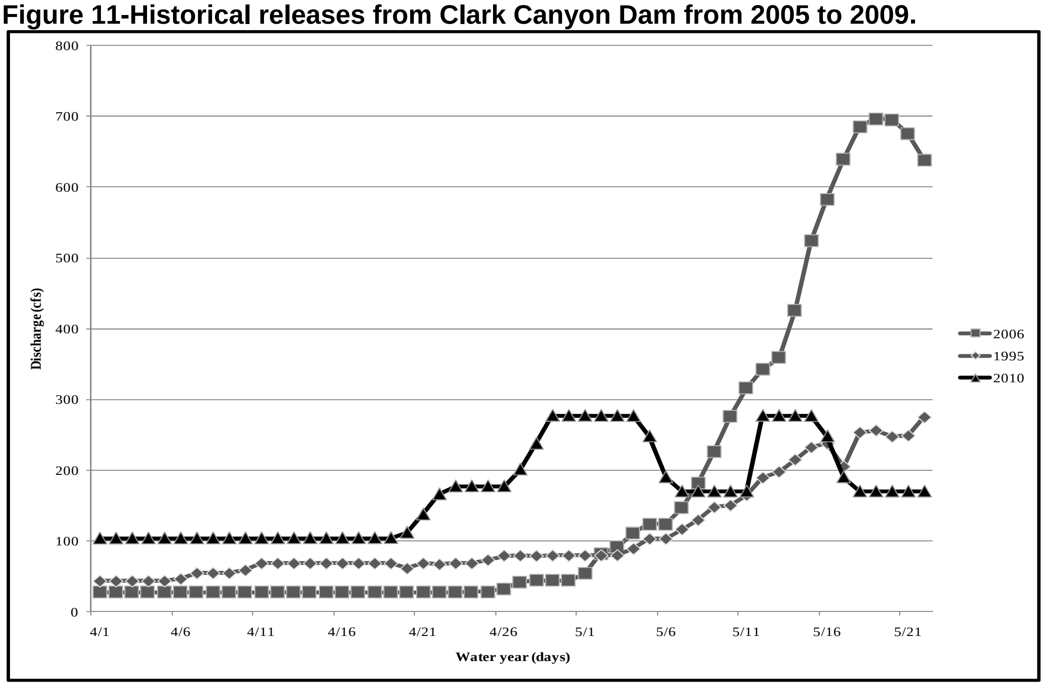

Figure 12-Example historic releases for April and May only (darkened line represents 2010).

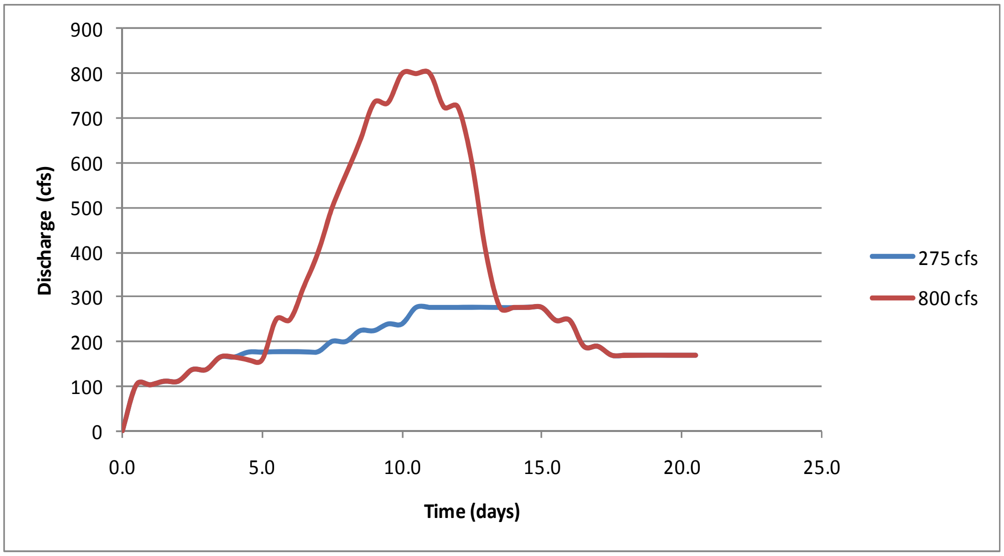

Figure 13-Typical hydrographs used in model

Hydraulic Model Results

The HEC-RAS model was used to determine the hydraulics of the reach at specific cross-sections. The hydraulic model results utilized in the flushing flow analysis included slope, velocity, and hydraulic radius. The model was run as an unsteady flow model for a range of hydrographs, with the maximum peak discharge for all hydrographs being 800 cfs.

The model runs utilized the unsteady flow module. This module requires input of an upstream and downstream boundary condition. Boundary conditions for the unsteady flow model included the assumption of an inflow hydrograph for the upstream boundary and normal depth for the downstream boundary assuming a friction slope of 0.0008 ft/ft. Inflow hydrographs were based on the 2010 release from April 1st to May 22nd and a range of flows from 200 to 800 cfs (Figure 13).

This study was focused on the smaller discharges to determine what minimum flow could flush the fine sediments downstream. Hydraulic results were coupled with sediment calculations to determine the possibility of particle mobilization or possible sediment movement downstream. Typical HEC-RAS results for select cross sections are shown in Tables 1 and 2. Channel velocities range between 1 and 4 ft/s for a discharge of 275 cfs. Channel velocities range from 2 to 5 ft/s for a discharge of 800 cfs. Additional hydraulic data is shown in Appendix A for four of the discharges (200, 400. 600 and 800 cfs).

Table 1-HEC-RAS results at select cross sections for an approximate discharge of 275 cfs

River	River Sta	Q Total	Min Ch El	W.S. Elev	Vel Chnl
		(cfs)	(ft)	(ft)	(ft/s)
Beaverhead	25550.6	277	5460.6	5463.81	2.22
Beaverhead	23172.0	277	5436.5	5439.31	3.5
Beaverhead	19788.5	277	5399.77	5402.88	2.03
Beaverhead	18719.1	277	5393.77	5397.24	2.96
Beaverhead	16527.4	277	5378.06	5380.73	3.4
Beaverhead	15075.9	277	5363.69	5367.14	2.79
Beaverhead	12853.3	277	5354.31	5357.1	3.29
Beaverhead	11341.2	277	5340.7	5342.92	3.07
Beaverhead	9492.8	277	5327.89	5330.3	2.64
Beaverhead	7021.2	277	5304.92	5307.46	2.13
Beaverhead	3097.1	277	5260.86	5264.4	1.76
Beaverhead	2321.8	277	5259.31	5261.89	2.86
Beaverhead	1173.3	277	5245.91	5250.76	1.12
Beaverhead	831.7	277	5245	5249.73	2.28

Table 2-HEC-RAS results at select cross sections for a discharge of 800 cfs

River	River Sta	Q Total	Min Ch El	W.S. Elev	Vel Chnl
		(cfs)	(ft)	(ft)	(ft/s)
Beaverhead	25550.6	800	5460.6	5465.27	3.74
Beaverhead	23172.0	800	5436.5	5440.95	5.13
Beaverhead	19788.5	800	5399.77	5403.66	3.27
Beaverhead	18719.1	799	5393.77	5399.26	4.42
Beaverhead	16527.4	800	5378.06	5381.78	5.59
Beaverhead	15075.9	800	5363.69	5368.86	4.36
Beaverhead	12853.3	800	5354.31	5358.24	4.39
Beaverhead	11341.2	800	5340.7	5343.91	4.83
Beaverhead	9492.8	800	5327.89	5331.39	3.63
Beaverhead	7021.2	800	5304.92	5308.7	3.15
Beaverhead	3097.1	800	5260.86	5266.32	2.71
Beaverhead	2321.8	800	5259.31	5263.26	4.22
Beaverhead	1173.3	801	5245.91	5254.89	1.41
Beaverhead	831.7	800	5245	5254.1	2.55

Bed Material Data

The Reclamation Montana Area Office collected bed material samples along the Beaverhead River in January 2010. The samples were taken at 4 locations near the edge of the river. Because of the time of year and water temperature, shovel samples were taken rather than pebble counts. Dowl HKM Engineering (Material Laboratory for Dowl HKM Engineering, 2010) analyzed the samples. Dowl HKM also provided a particle size distribution report on the samples. Figure 14 shows bed material sampling locations. The river locations near Clark Canyon Dam and Pipe Organ contain the coarsest material (Figure 1515 through Figure 1818, Table 3). The finest material is coming out of Clark Canyon Creek. The average bed material size decreases in the downstream direction except where Clark Canyon Creek enters the river.

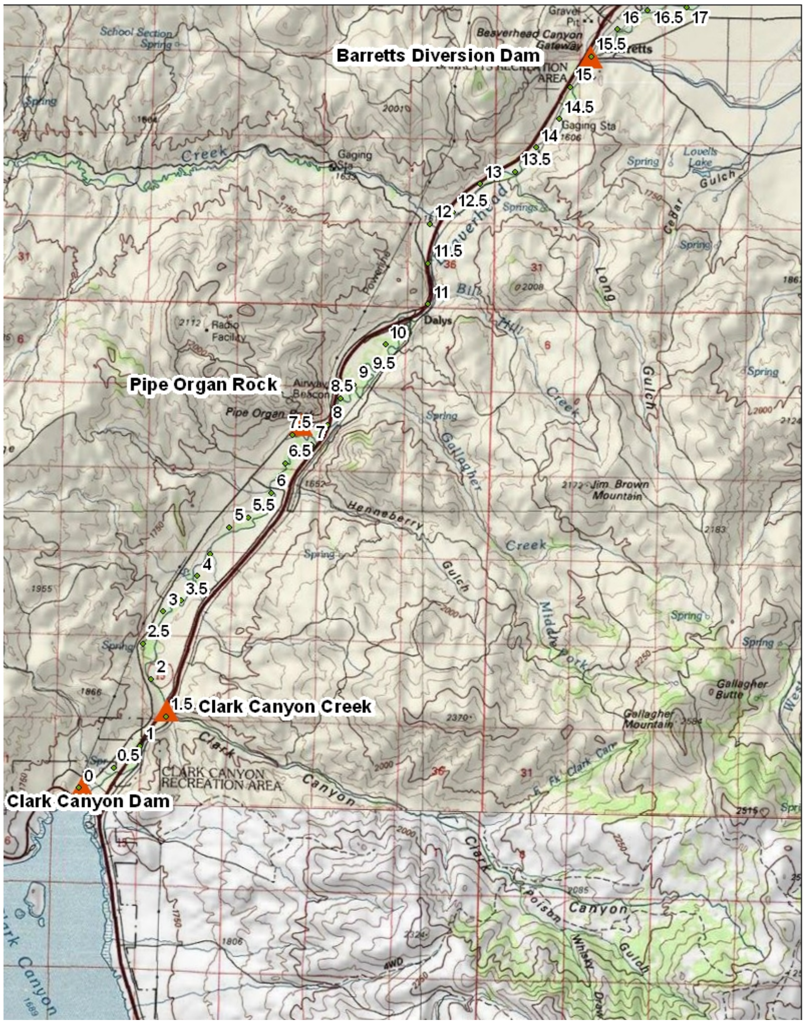

Figure 14-Bed material sampling locations

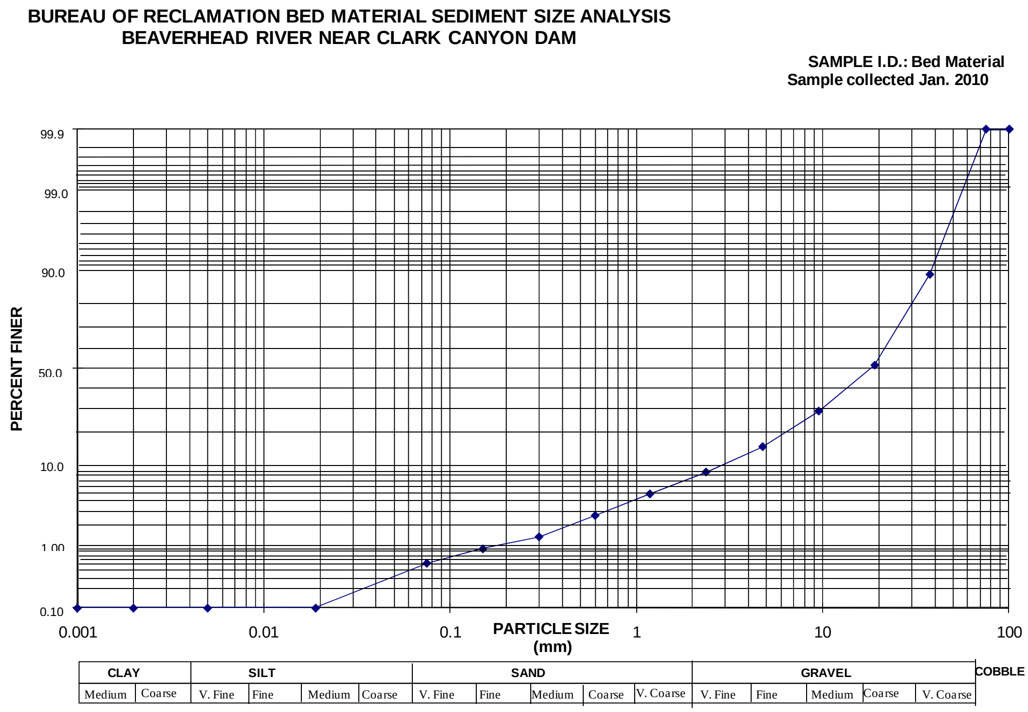

Figure 15-Bed Material Sediment Size Analysis near Clark Canyon Dam.

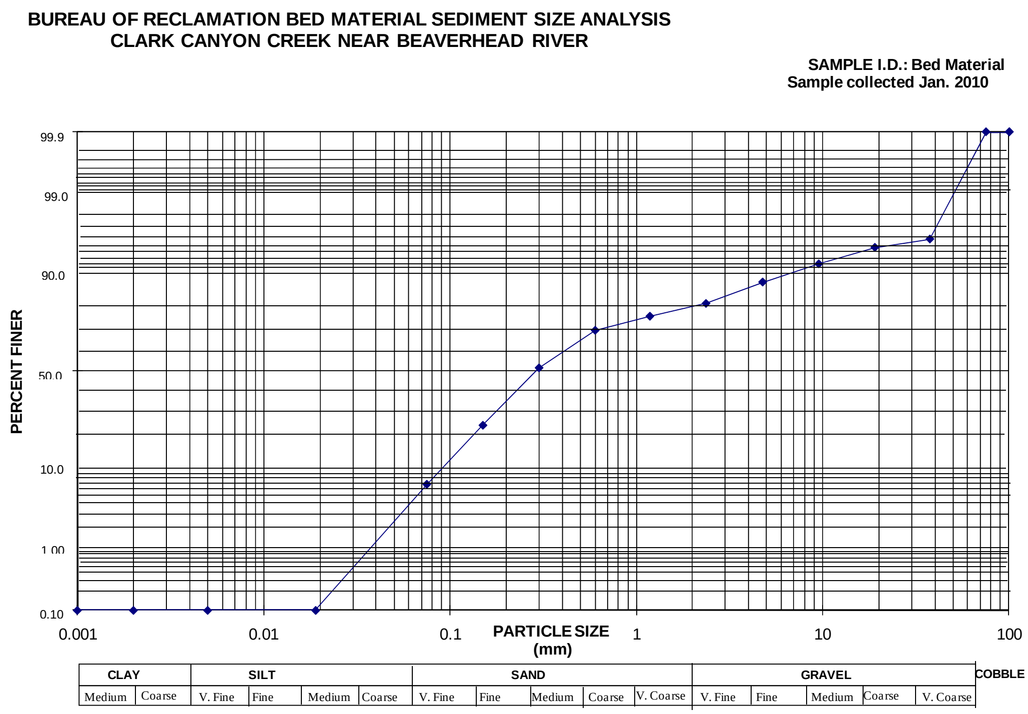

Figure 16- Bed Material Sediment Size Analysis near the mouth of Clark Canyon Creek .

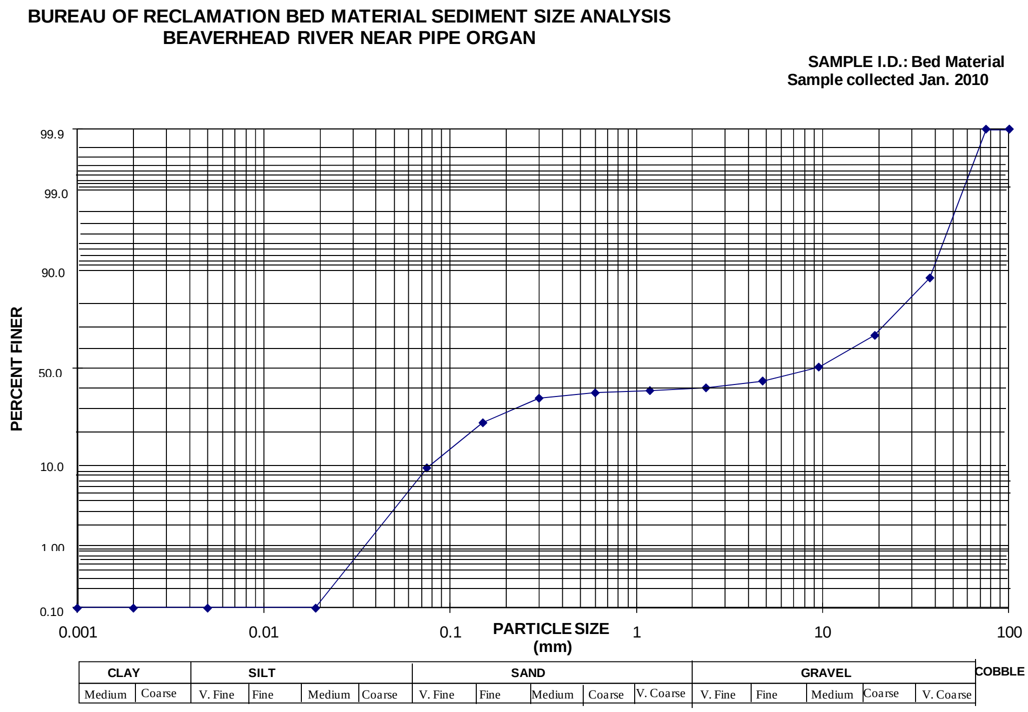

Figure 17- Bed Material Sediment Size Analysis near Pipe Organ

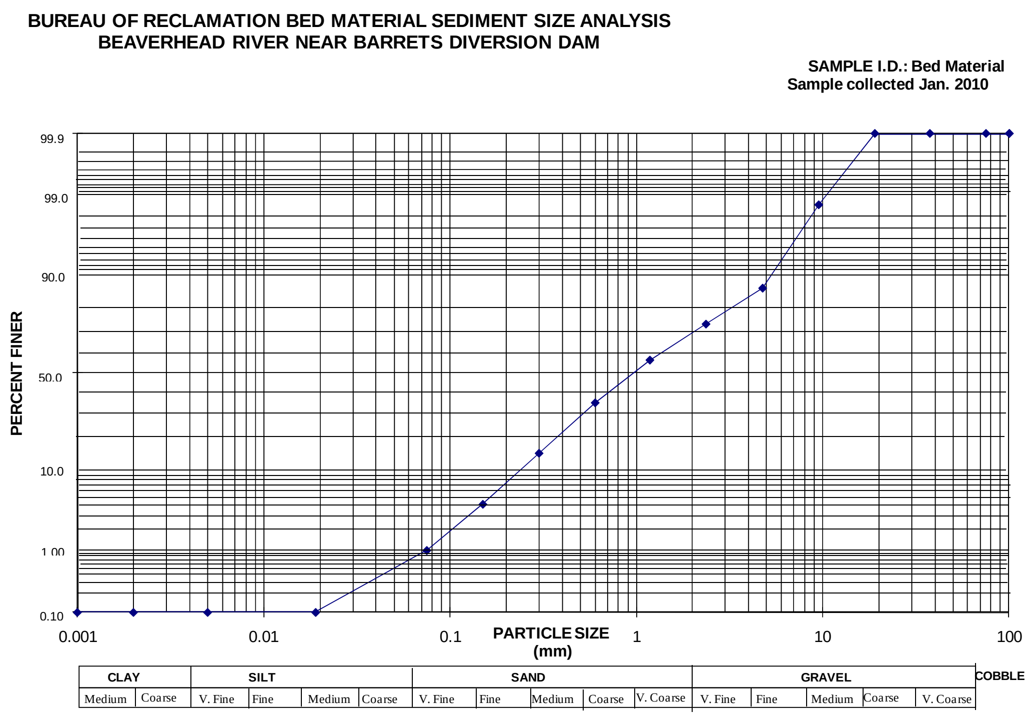

Figure 18- Bed Material Sediment Size Analysis near Barretts Diversion Dam.

Table 3-Bed Material Size Analysis

Location	D_{50}	D_{90}
Clark Canyon Dam	18.3	39.3
Clark Canyon Creek	0.3	6.7
Pipe Organ	9	41.4
Barrets	1	5.7

Initial Motion or Incipient Motion of Bed Material and Flushing Flow

Incipient motion or initial motion can be described as the point when a sediment particle will begin to move. The determination of incipient or beginning motion was utilized to determine the potential for different bed material sizes to move. The concept of beginning motion is difficult to quantify, but is dependent on a particle's location with respect to other different sized particles as well as bed forms. Clark Canyon Creek enters the Beaverhead River about 1.5 miles downstream from the dam. All of the particles from the creek are deposited in the upper layer of the sediment. The assumption is that if the underlying bed material will mobilize then it will also carry the smaller size particles downstream allowing flushing of the sediment.

The methodology used in this section is the determination of the particle size that would form an armor layer (Strand and Pemberton, 1982). The method includes the computation of a particle size for which any greater size particle would not move. After computing the particle size, the particle diameter was compared to the median size or 90th percentile size of the bed material data at each of the four locations in Table 3. If the measured bed material size data were smaller than the computed armoring size, then the particle would be able to move downstream. Several different methods were computed to determine initiation of movement including Shields Diagram, Meyer-Peter and Muller Bedload Transport Equation, Competent Velocity, and Yang's critical velocity criteria (Yang, 1996).

The methods utilize the hydraulic data from the HEC-RAS model (velocity, slope, hydraulic radius). The analysis utilized two reaches: Clark Canyon Dam to Pipe Organ (river miles 0 to 8) and Pipe Organ to Barrets Diversion Dam (8 to 16). The results were averaged on the reaches identified to equalize the results. The assumption seemed reasonable because of the coarseness of the geometry data.

The Shields Method utilizes the d_{50} particle size for the analysis. Meyer-Peter and Müller bed load equation is based on the d_{90} particle size. Competent Velocity and Yang's critical velocity criteria are based on hydraulics alone and do not use bed material information to solve for the critical sediment size.

The Shields method for bed material great than 1 mm and shear velocity Reynold's numbers greater that 500 is equal to:

$$D_c = \frac{\tau_c}{.06(\gamma_s - \gamma_w)}$$

Where τ_c = critical shear stress = $\gamma_w RS$ (lb/ft^2)

γ_s = unit weight of the particle (165 lb/ft^3)

γ_w= unit weight of water (62.4 lb/ ft^3)

R = hydraulic radius (ft)

D_c = critical particle diameter (ft)

S = slope (ft/ft)

Calculations were made to determine the critical diameter using the Shields parameter to determine whether particles of various size in the Beaverhead River would move at various cross sections during a flow event to potentially flush sediment downstream.

From Meyer-Peter and Müller (1948 and Yang, 1996) bed load equation, the sediment size at incipient motion can be determined as:

$$D = \frac{SR}{K_1\left(\frac{n}{D_{90}^{\frac{1}{6}}}\right)^{1.5}}$$

Where D= sediment size at beginning of motion (meters)

S= channel slope

R= hydraulic radius (meters)

K_1= .058

n= Manning's roughness coefficient (0.04)

d_{90} = bed material size (mm)where 90% of the particles are finer

Competent velocity (Yang, 1996) was calculated based on the equation:

$$D_c = 1.88V^2$$

Where V=mean channel velocity (unit) and

D_c = (mm) critical diameter at beginning of motion.

Finally, Yang's critical velocity (Yang, 1996) criteria are based on the following equation:

$$D_c = .00659V^2$$

Where V=mean channel velocity (ft/s), and
D_c= critical diameter (mm) at beginning of motion.

Variables from the HEC-RAS runs were utilized along with D_{50} and D_{90} bed material results to determine the beginning of motion based on the four equations. The hydraulic and sediment parameters were used for each cross-section to calculate the critical particle diameter. The data were then averaged to determine critical particle diameters for two reaches: Clark Canyon Dam to Pipe Organ and Pipe Organ to Barretts Diversion Dam for three of the methods (Shield's Parameter, Competent Velocity and Yang). Table 4 summarizes the results.

For Meyer-Peter and Müller, the calculations were more site specific based on the D90 particle diameter. Four reaches were utilized. The first reach was from the dam to river mile 1.4 (Clark Canyon Dam). The second site was right at the confluence of Clark Canyon Creek and the mainstem (river mile 1.5). The third reach was river mile 5 to 12 (Pipe Organ) and the fourth reach was river miles 12 to 16 (Barrets) (Table 5).

The Shields Method is valid for the data based on the bed material sizes. The competent velocity and Yang's method are valid for particle sizes greater than 1 mm. With this assumption, the critical sediment size for the upper reach at a discharge of 350 cfs is 20.4 mm based on the Shields Method. This is greater than the size of the d_{50} sediment that was collected near Clark Canyon Dam (18.3 mm) indicating that the sediment could be mobilized for this discharge or any greater discharge. For the reach from Pipe Organ to Barretts Dam, the results indicate that the sediment could be mobilized for a smaller discharge (200 cfs and an estimated diameter 14.1 mm). When this diameter is compared to the d_{50} particle size collected at Pipe Organ (9 mm), then the material could mobilize. Because of the sedimentation issues at Clark Canyon Creek, the more conservative estimate of minimum needed release from Clark Canyon Dam is based on the results at Clark Canyon Cree. (river mile 1.5).

The results for the Meyer-Peter and Müller are similar, except sediment mobilization indicates a smaller discharge may mobilize the sediment at Clark Canyon Dam (particle diameter 16.5-17 mm, Table 5). This is compared to the d_{90} bed material size with a size of 39 mm. Calculations for Meyer-Peter and Müller are based on the D_{90} particle size. This would indicate that a flow of 200 cfs could mobilize particles in both reaches. Both sets of results are valid for the Clark Canyon Dam data and the Pipe Organ data. The data from Clark Canyon Creek and the diversion dam are outside the applicable range for Meyer-Peter and Müller.

Table 4-Summary Result for Initiation of Sediment Movement for both Reaches

Location	Discharge (cfs)	Shield's Method (Diameter mm)	Competent Bottom Velocity (Diameter mm)	Yang's Incipient Motion (Diameter mm)
Upper Reach	200	14.2	18.1	19.2
Lower Reach	200	13.1	10.6	11.3
Upper Reach	225	15.0	19.2	20.5
Lower Reach	225	13.3	14.2	15.2
Upper Reach	275	16.0	21.8	23.3
Lower Reach	275	15.3	15.7	16.8
Upper Reach	300	17.3	23.0	24.5
Lower Reach	300	15.6	13.4	14.3
Upper Reach	350	19.7	27.5	29.3
Lower Reach	350	15.9	14.1	15.1
Upper Reach	400	20.2	27.9	29.8
Lower Reach	400	18.2	24.9	26.6
Upper Reach	600	26.7	38.2	40.7
Lower Reach	600	26.4	27.0	28.8
Upper Reach	800	26.7	41.6	44.4
Lower Reach	800	26.4	29.9	32.0

Table 5-Summary Results for Initiation of Sediment Movement at four sites.

Meyer-Peter, Müller (Diameter, mm)								
Discharge (cfs)	200	225	275	300	350	400	600	800
Clark Canyon Dam	16.5	17.1	17.6	17.7	17.2	20.5	21.6	22.4
Creek	10.4	14.6	10.4	12.2	17.2	17.0	17.4	18.0
Pipe Organ	9.7	9.9	10.0	11.3	12.1	12.9	14.5	15.7
Barrets	6.7	6.9	6.7	7.2	7.2	7.8	8.9	9.9

Summary and Conclusions

Clark Canyon Creek delivers a large load of fine sediment into the Beaverhead River each spring. This large sediment load has affected fisheries during years when storage and releases from Clark Canyon Dam are limited. Limited releases in the spring have resulted in deposition of fine sediment, which has affected the trout fishery just downstream of the dam. Katie Tackett from the Beaverhead Watershed Group has observed sediment deposition from the creek when the timing between dam release and the creek flow are not coordinated. It is difficult to predict when the creek will flow from snowmelt runoff. The purpose of this study was to investigate flow releases from Clark Canyon Dam that would help mobilize and move fine sediment downstream.

Hydraulic variables were determined with a HEC-RAS model for a range of discharges between 200 and 800 cfs. Model results were utilized with sediment mobilization equations to determine what flow could mobilize sediment downstream. The results of the analysis indicate that a flow of 350 cfs may mobilize the sediment in the upper reach near the dam based on the Shields Method. Alternatively, Meyer-Peter and Müller results show that the sediment may mobilize for a discharge of 200 cfs. The conservative assumption is that the larger discharge would be an estimate of the flow necessary to mobilize the sediment. Results of the study are limited because of the resolution of the DEM and the subsequent geometric data, which is based on only three measured cross-sections within the 16 mile reach. Measured cross-sections every 2000 feet through the reach would improve model results. Additional collection of bed material data at key locations annually would help determine sediment deposition and mobilization.

A one dimensional sediment transport model would provide more detailed, quantitative results of sediment mobilization along the Beaverhead River. The model can be run as either a steady state discharge model with flows ranging from 200-800 cfs or could be based on typical hydrographs like the 2010 release flows. Utilizing bed material data, Clark Canyon Dam releases, and sediment inflow from Clark Canyon Creek, the sediment model could provides a more concise answer of the type of flows necessary to mobilize and flush the sediment downstream. The one dimensional transport model could also provides answers on the spatial distribution and movement of sediment downstream.

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Appendix A

Table 6-Hydraulic data for 200 cfs

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Hydr Radius C	Frctn Slope	Shear Chan	S_0 (ft/ft)	t_o(lb/ft$^{2)}$
25550.59	200.00	5460.60	5463.47		5463.53	0.00	1.84	108.98	112.46	0.21	0.12	2.25	0.00084	0.120	0.003	0.373
25434.88	200.04	5460.08	5463.01		5463.10	0.00	2.47	96.64	269.36	0.33	0.23	1.66	0.00201	0.230	0.003	0.275
25281.99	200.06	5459.11	5462.19		5462.25	0.00	2.08	114.91	202.69	0.27	0.16	1.83	0.00153	0.160	0.003	0.304
25159.76	200.01	5458.60	5461.17		5461.37	0.01	3.55	58.21	91.75	0.50	0.50	1.50	0.00518	0.500	0.003	0.249
25003.31	199.99	5456.10	5458.67		5458.86	0.01	3.50	58.44	95.85	0.52	0.50	1.37	0.00534	0.500	0.003	0.227
24849.91	200.03	5453.66	5456.31		5456.47	0.01	3.23	67.43	78.71	0.50	0.43	1.29	0.00539	0.430	0.003	0.214
24691.63	200.03	5451.46	5454.69		5454.75	0.00	2.11	136.29	416.43	0.24	0.15	2.21	0.00108	0.150	0.003	0.367
24436.65	200.05	5450.83	5453.25		5453.44	0.01	3.54	57.21	625.26	0.54	0.52	1.33	0.00383	0.520	0.003	0.221
24098.59	199.53	5447.09	5452.22		5452.22	0.00	0.32	1217.76	579.68	0.03	0.00	3.76	0.00001	0.000	0.003	0.624
23809.35	200.07	5446.60	5450.45	5450.13	5451.11	0.02	6.53	30.65	21.97	0.97	1.79	1.25	0.00505	1.790	0.003	0.207
23515.53	200.01	5441.66	5444.20		5444.42	0.01	3.73	53.87	35.32	0.51	0.54	1.61	0.00491	0.540	0.003	0.267
23171.99	200.02	5436.50	5439.00		5439.15	0.00	3.03	66.08	44.28	0.43	0.36	1.52	0.00392	0.360	0.003	0.252
22861.21	199.96	5432.21	5436.30		5436.36	0.00	1.99	114.60	195.55	0.20	0.13	2.90	0.00146	0.130	0.003	0.481
22823.47	199.88	5433.26	5435.89		5436.04	0.00	3.12	64.07	53.84	0.47	0.40	1.33	0.00443	0.400	0.003	0.221
22593.14	199.79	5430.33	5434.27		5434.31	0.00	1.50	133.44	244.86	0.16	0.07	2.75	0.00035	0.070	0.003	0.456
22204.23	201.02	5430.48	5433.04		5433.25	0.00	3.73	58.31	601.86	0.49	0.52	1.74	0.00416	0.520	0.003	0.289
22058.46	200.97	5428.43	5431.01		5431.20	0.01	3.51	58.23	728.28	0.55	0.52	1.23	0.00647	0.520	0.003	0.204
21869.39	203.39	5424.78	5427.36		5427.57	0.01	3.63	57.54	694.59	0.50	0.51	1.59	0.00528	0.510	0.003	0.264
21471.82	207.03	5418.97	5421.65		5421.81	0.00	3.29	69.88	905.67	0.46	0.42	1.53	0.00440	0.420	0.003	0.254
20909.86	204.84	5411.91	5414.40		5414.60	0.01	3.62	56.63	131.03	0.62	0.58	1.05	0.00889	0.580	0.003	0.174

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Hydr Radius C	Frctn Slope	Shear Chan	S_0 (ft/ft)	t_o(lb/ft^2)
20649.23	202.31	5407.10	5409.78		5409.94	0.00	3.26	65.34	67.85	0.47	0.42	1.46	0.00482	0.420	0.003	0.242
20295.12	201.85	5402.90	5406.01		5406.11	0.00	2.52	88.16	771.27	0.34	0.24	1.69	0.00227	0.240	0.003	0.280
19788.48	201.88	5399.77	5402.67		5402.70	0.00	1.85	180.24	881.59	0.25	0.13	1.69	0.00147	0.130	0.003	0.280
19395.33	201.70	5398.54	5401.34		5401.41	0.00	2.27	156.49	574.95	0.34	0.21	1.39	0.00244	0.210	0.003	0.231
18719.05	201.62	5393.77	5396.82		5396.93	0.00	2.64	76.32	62.81	0.34	0.26	1.79	0.00231	0.260	0.003	0.297
18222.59	201.85	5390.24	5392.83		5393.03	0.00	3.58	57.01	722.97	0.49	0.49	1.63	0.00499	0.490	0.003	0.270
17823.87	201.78	5384.78	5387.75		5387.86	0.00	2.75	92.14	107.86	0.35	0.28	1.87	0.00233	0.280	0.003	0.310
17238.95	201.81	5381.27	5384.36		5384.43	0.00	2.12	109.03	264.69	0.27	0.17	1.82	0.00149	0.170	0.003	0.302
16527.38	201.74	5378.06	5380.51		5380.62	0.00	2.93	83.31	292.25	0.44	0.35	1.35	0.00332	0.350	0.003	0.224
15829.81	201.70	5371.54	5374.32		5374.45	0.00	2.87	72.50	123.93	0.42	0.33	1.42	0.00369	0.330	0.003	0.236
15075.90	201.73	5363.69	5366.76		5366.85	0.00	2.45	84.59	192.31	0.31	0.22	1.92	0.00180	0.220	0.003	0.319
14657.52	201.70	5361.45	5364.49		5364.55	0.00	2.07	110.72	145.04	0.27	0.16	1.73	0.00158	0.160	0.003	0.287
13349.66	201.41	5354.96	5358.12		5358.13	0.00	0.91	269.30	597.47	0.11	0.03	1.97	0.00027	0.030	0.003	0.327
12853.27	201.75	5354.31	5356.83		5356.97	0.00	3.12	82.59	282.50	0.44	0.38	1.54	0.00381	0.380	0.003	0.255
12202.33	201.72	5347.61	5349.74		5349.82	0.00	2.33	94.74	110.55	0.35	0.22	1.35	0.00260	0.220	0.003	0.224
11341.18	201.61	5340.70	5342.69		5342.80	0.00	2.65	76.53	62.89	0.42	0.30	1.23	0.00235	0.300	0.003	0.204
10205.43	201.63	5335.01	5336.93		5337.04	0.00	2.64	79.10	697.50	0.43	0.30	1.16	0.00347	0.300	0.003	0.192
9492.80	201.72	5327.89	5329.95		5330.05	0.00	2.51	80.28	62.02	0.39	0.26	1.29	0.00323	0.260	0.003	0.214
8715.94	201.67	5321.34	5323.35		5323.45	0.00	2.60	77.45	62.66	0.41	0.29	1.23	0.00382	0.290	0.003	0.204
8284.83	201.65	5316.37	5319.22		5319.25	0.00	1.56	129.46	217.49	0.19	0.09	2.05	0.00070	0.090	0.003	0.340
7539.84	201.72	5315.05	5315.67	5316.45	5325.33	2.05	24.94	8.09	25.08	7.74	41.10	0.32	1.35484	41.100	0.003	0.053
7021.16	201.70	5304.92	5307.12		5307.18	0.00	2.01	117.04	104.30	0.30	0.16	1.41	0.00201	0.160	0.003	0.234
6597.77	201.66	5302.25	5304.13		5304.26	0.00	2.93	73.82	74.70	0.47	0.36	1.22	0.00474	0.360	0.003	0.202

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Hydr Radius C	Frctn Slope	Shear Chan	S_0 (ft/ft)	t_o(lb/ft$^{2)}$
6003.30	201.70	5294.93	5297.24		5297.30	0.00	2.07	108.66	127.53	0.30	0.17	1.52	0.00185	0.170	0.003	0.252
5397.06	201.76	5291.59	5293.55		5293.62	0.00	2.29	106.88	104.24	0.36	0.22	1.22	0.00288	0.220	0.003	0.202
4455.76	201.73	5284.05	5286.02		5286.18	0.01	3.28	63.61	70.06	0.57	0.49	1.00	0.00779	0.490	0.003	0.166
3688.93	201.77	5270.25	5272.33		5272.47	0.01	3.02	66.92	60.73	0.51	0.40	1.09	0.00543	0.400	0.003	0.181
3097.11	201.68	5260.86	5263.97		5264.00	0.00	1.55	131.35	63.49	0.19	0.08	2.09	0.00066	0.080	0.003	0.347
2321.82	201.76	5259.31	5261.58		5261.68	0.00	2.60	78.89	64.90	0.40	0.28	1.29	0.00341	0.280	0.003	0.214
1608.91	201.61	5252.24	5254.36		5254.46	0.00	2.66	82.26	81.10	0.44	0.31	1.12	0.00471	0.310	0.003	0.186
1173.31	202.00	5245.91	5250.05		5250.07	0.00	1.02	199.02	515.18	0.10	0.03	2.91	0.00043	0.030	0.003	0.483
915.60	201.84	5245.02	5249.02		5249.08	0.00	1.92	104.86	26.64	0.17	0.11	3.10	0.00062	0.110	0.003	0.514
831.68	201.71	5245.00	5248.84	5246.27	5248.90	0.00	2.05	98.29	26.14	0.19	0.13	2.99		0.130	0.003	0.496

Table 7-Hydraulic data for 400 cfs

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Hydr Radius C	Frctn Slope	Shear Chan	S_0 (ft/ft)	t_0(lb/ft^{2})
25550.59	400.00	5460.60	5464.25		5464.36	0.0013	2.68	154.01	182.39	0.27	0.23	2.80	0.0011	0.23	0.0027	0.46
25434.88	400.14	5460.08	5463.74		5463.87	0.0022	3.09	165.54	283.13	0.35	0.32	2.38	0.0017	0.32	0.0027	0.39
25281.99	400.00	5459.11	5462.96		5463.06	0.0015	2.72	187.11	299.33	0.29	0.24	2.58	0.0017	0.24	0.0027	0.43
25159.76	400.15	5458.60	5461.90		5462.15	0.0046	4.25	119.79	247.66	0.50	0.63	2.20	0.0049	0.63	0.0027	0.36
25003.31	400.02	5456.10	5459.25		5459.58	0.0067	4.73	93.87	134.79	0.59	0.81	1.94	0.0056	0.81	0.0027	0.32
24849.91	400.08	5453.66	5456.92		5457.13	0.0054	3.87	122.52	202.00	0.52	0.57	1.70	0.0050	0.57	0.0027	0.28
24691.63	399.80	5451.46	5455.50		5455.57	0.0011	2.57	247.88	568.13	0.26	0.21	2.99	0.0010	0.21	0.0027	0.50
24436.65	401.16	5450.83	5453.89		5454.21	0.0064	4.65	95.63	644.97	0.58	0.78	1.95	0.0009	0.78	0.0027	0.32
24098.59	393.79	5447.09	5453.27		5453.27	0.0000	0.39	1833.56	600.07	0.03	0.00	4.75	0.0000	0.00	0.0027	0.79
23809.35	546.48	5446.60	5451.26	5451.90	5453.05	0.0427	10.73	50.91	27.71	1.40	4.41	1.66	0.0043	4.41	0.0027	0.28
23515.53	541.90	5441.66	5445.34		5445.83	0.0070	5.70	99.65	76.62	0.62	1.08	2.50	0.0054	1.08	0.0027	0.41
23171.99	541.06	5436.50	5440.24		5440.54	0.0038	4.47	127.85	57.44	0.47	0.64	2.74	0.0039	0.64	0.0027	0.45
22861.21	530.37	5432.21	5437.50		5437.65	0.0013	3.38	197.43	218.66	0.29	0.32	4.04	0.0022	0.32	0.0027	0.67
22823.47	528.74	5433.26	5437.01		5437.32	0.0045	4.50	120.07	169.49	0.50	0.68	2.42	0.0040	0.68	0.0027	0.40
22593.14	481.37	5430.33	5435.42		5435.52	0.0008	2.55	188.49	249.09	0.23	0.19	3.89	0.0006	0.19	0.0027	0.65
22204.23	446.92	5430.48	5433.92		5434.21	0.0045	4.72	125.19	610.98	0.51	0.73	2.59	0.0045	0.73	0.0027	0.43
22058.46	420.04	5428.43	5431.63		5431.94	0.0068	4.61	109.31	776.27	0.59	0.78	1.83	0.0067	0.78	0.0027	0.30
21869.39	415.43	5424.78	5428.13		5428.41	0.0047	4.46	120.65	868.88	0.51	0.68	2.34	0.0047	0.68	0.0027	0.39
21471.82	412.10	5418.97	5422.29		5422.51	0.0043	4.06	145.08	1076.91	0.48	0.58	2.16	0.0042	0.58	0.0027	0.36
20909.86	410.49	5411.91	5414.97		5415.30	0.0081	4.62	98.51	196.49	0.63	0.82	1.62	0.0065	0.82	0.0027	0.27
20649.23	407.16	5407.10	5410.38		5410.59	0.0045	4.03	148.60	184.15	0.49	0.58	2.04	0.0045	0.58	0.0027	0.34
20295.12	405.00	5402.90	5406.61		5406.76	0.0027	3.37	180.80	1039.61	0.39	0.39	2.28	0.0026	0.39	0.0027	0.38

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Hydr Radius C	Frctn Slope	Shear Chan	S_0 (ft/ft)	t_o(lb/ft^{2})
19788.48	402.74	5399.77	5403.09		5403.15	0.0016	2.44	269.63	976.37	0.29	0.21	2.11	0.0015	0.21	0.0027	0.35
19395.33	402.33	5398.54	5401.99		5402.02	0.0008	1.73	468.82	667.34	0.21	0.11	2.03	0.0012	0.11	0.0027	0.34
18719.05	401.06	5393.77	5397.81		5397.99	0.0022	3.40	120.27	518.96	0.36	0.37	2.73	0.0022	0.37	0.0027	0.45
18222.59	400.80	5390.24	5393.62		5393.95	0.0050	4.70	91.73	1044.49	0.53	0.75	2.39	0.0049	0.75	0.0027	0.40
17823.87	400.87	5384.78	5388.49		5388.61	0.0021	3.18	183.03	129.84	0.35	0.34	2.52	0.0021	0.34	0.0027	0.42
17238.95	400.64	5381.27	5385.10		5385.21	0.0017	2.81	166.11	274.78	0.31	0.26	2.54	0.0015	0.26	0.0027	0.42
16527.38	400.79	5378.06	5381.02		5381.23	0.0053	4.09	121.57	495.69	0.52	0.62	1.85	0.0037	0.62	0.0027	0.31
15829.81	400.61	5371.54	5375.08		5375.27	0.0032	3.54	130.09	414.05	0.42	0.44	2.17	0.0032	0.44	0.0027	0.36
15075.90	400.67	5363.69	5367.67		5367.83	0.0019	3.24	133.71	204.45	0.34	0.34	2.81	0.0019	0.34	0.0027	0.47
14657.52	400.55	5361.45	5365.30		5365.40	0.0014	2.61	205.13	225.04	0.29	0.23	2.53	0.0015	0.23	0.0027	0.42
13349.66	400.68	5354.96	5358.96		5358.98	0.0003	1.34	370.30	797.67	0.14	0.06	2.79	0.0004	0.06	0.0027	0.46
12853.27	400.67	5354.31	5357.43		5357.59	0.0035	3.63	159.59	306.67	0.44	0.46	2.14	0.0034	0.46	0.0027	0.36
12202.33	400.26	5347.61	5350.18		5350.33	0.0035	3.20	153.85	261.47	0.42	0.38	1.77	0.0036	0.38	0.0027	0.29
11341.18	400.56	5340.70	5343.22		5343.42	0.0046	3.65	115.35	97.92	0.49	0.50	1.74	0.0024	0.50	0.0027	0.29
10205.43	400.58	5335.01	5337.36		5337.58	0.0058	3.82	109.78	892.03	0.54	0.57	1.57	0.0038	0.57	0.0027	0.26
9492.80	400.53	5327.89	5330.59		5330.73	0.0029	3.05	159.95	143.70	0.39	0.34	1.89	0.0029	0.34	0.0027	0.31
8715.94	400.67	5321.34	5323.88		5324.05	0.0040	3.41	141.27	151.37	0.45	0.44	1.75	0.0040	0.44	0.0027	0.29
8284.83	400.62	5316.37	5320.23		5320.30	0.0007	2.07	193.66	231.28	0.21	0.13	3.07	0.0007	0.13	0.0027	0.51
7539.84	400.53	5313.44	5316.20	5316.66	5317.65	0.0892	9.66	41.46	50.14	1.87	4.52	0.81	0.0720	4.52	0.0027	0.13
7021.16	400.52	5304.92	5307.80		5307.88	0.0017	2.48	198.22	133.76	0.30	0.22	2.09	0.0018	0.22	0.0027	0.35
6597.77	400.51	5302.25	5304.79		5304.98	0.0040	3.56	130.22	95.16	0.46	0.47	1.85	0.0041	0.47	0.0027	0.31
6003.30	400.48	5294.93	5297.94		5298.03	0.0016	2.49	199.68	130.93	0.29	0.21	2.20	0.0017	0.21	0.0027	0.36
5397.06	400.50	5291.59	5294.24		5294.33	0.0024	2.67	183.87	115.64	0.35	0.27	1.80	0.0024	0.27	0.0027	0.30

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Hydr Radius C	Frctn Slope	Shear Chan	S_0 (ft/ft)	t_o(lb/ft$^{2)}$
4455.76	400.48	5284.05	5286.67		5286.88	0.0057	3.81	113.42	146.58	0.53	0.56	1.60	0.0057	0.56	0.0027	0.27
3688.93	400.60	5270.25	5272.96		5273.18	0.0052	3.77	106.20	62.64	0.51	0.54	1.67	0.0052	0.54	0.0027	0.28
3097.11	400.48	5260.86	5264.99		5265.05	0.0007	2.06	199.27	92.74	0.21	0.13	3.03	0.0007	0.13	0.0027	0.50
2321.82	400.47	5259.31	5262.26		5262.43	0.0033	3.32	126.02	72.98	0.42	0.40	1.92	0.0033	0.40	0.0027	0.32
1608.91	400.54	5252.24	5254.97		5255.13	0.0039	3.28	135.05	88.64	0.44	0.41	1.67	0.0042	0.41	0.0027	0.28
1173.31	400.50	5245.91	5252.41		5252.42	0.0001	1.09	368.10	532.34	0.09	0.03	4.60	0.0002	0.03	0.0027	0.76
915.60	400.84	5245.02	5251.82		5251.90	0.0005	2.22	180.19	27.23	0.15	0.13	4.56	0.0005	0.13	0.0027	0.76
831.68	400.44	5245.00	5251.67	5247.01	5251.75	0.0007	2.22	180.35	41.94	0.19	0.15	3.35		0.15	0.0027	0.56

Table 8-Hydraulic data for 600 cfs

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Hydr Radius C	Frctn Slope	Shear Chan	S_0 (ft/ft)	t_0(lb/ft^{2})
25550.59	600	5460.6	5464.81		5464.97	0.0016	3.31	206.38	255.47	0.31	0.33	3.32	0.0012	0.33	0.0027	0.55
25434.88	599.84	5460.08	5464.29		5464.45	0.0022	3.56	221.75	307.94	0.36	0.4	2.91	0.0016	0.4	0.0027	0.48
25281.99	600.03	5459.11	5463.54		5463.66	0.0016	3.16	248.24	361.52	0.31	0.31	3.15	0.0018	0.31	0.0027	0.52
25159.76	600.15	5458.6	5462.43		5462.71	0.0043	4.72	167.28	280.32	0.5	0.72	2.72	0.0045	0.72	0.0027	0.45
25003.31	600.04	5456.1	5459.66		5460.13	0.0075	5.67	120.51	323.45	0.64	1.09	2.34	0.0058	1.09	0.0027	0.39
24849.91	600.02	5453.66	5457.33		5457.6	0.0055	4.5	163.16	210.72	0.54	0.71	2.09	0.0044	0.71	0.0027	0.35
24691.63	600.1	5451.46	5456.17		5456.25	0.0010	2.76	372.77	758.9	0.25	0.22	3.64	0.0009	0.22	0.0027	0.60
24436.65	600.15	5450.83	5454.06		5454.65	0.0106	6.3	107.39	645.89	0.75	1.4	2.12	0.0017	1.4	0.0027	0.35
24098.59	600.15	5447.09	5453.17		5453.17	0.0000	0.39	1775.93	598.2	0.03	0	4.66	0.0000	0	0.0027	0.77
23809.35	600.15	5446.6	5451.41	5451.9	5454.11	0.0604	13.2	55.13	28.59	1.67	6.55	1.74	0.0046	6.55	0.0027	0.29
23515.53	600.15	5441.66	5445.72		5446.35	0.0076	6.5	115.97	79.24	0.66	1.35	2.86	0.0056	1.35	0.0027	0.47
23171.99	600.15	5436.5	5440.69		5441.06	0.0038	4.94	154.87	62.36	0.49	0.75	3.19	0.0039	0.75	0.0027	0.53
22861.21	600.15	5432.21	5437.87		5438.06	0.0015	3.79	224.2	222.72	0.31	0.4	4.39	0.0024	0.4	0.0027	0.73
22823.47	600.15	5433.26	5437.34		5437.71	0.0046	4.92	137.88	171.28	0.52	0.78	2.75	0.0038	0.78	0.0027	0.46
22593.14	600.15	5430.33	5435.88		5436.01	0.0008	2.85	210.76	343.16	0.24	0.22	4.35	0.0006	0.22	0.0027	0.72
22204.23	600.04	5430.48	5434.28		5434.63	0.0047	5.24	153.93	611.77	0.53	0.87	2.94	0.0046	0.87	0.0027	0.49
22058.46	600.22	5428.43	5432.05		5432.38	0.0060	4.92	157.33	785.14	0.57	0.84	2.25	0.0060	0.84	0.0027	0.37
21869.39	600.12	5424.78	5428.54		5428.88	0.0049	5.08	159.06	879.97	0.53	0.84	2.74	0.0049	0.84	0.0027	0.45
21471.82	600.39	5418.97	5422.72		5422.94	0.0038	4.28	213.28	1079.68	0.46	0.6	2.58	0.0038	0.6	0.0027	0.43
20909.86	599.88	5411.91	5415.34		5415.72	0.0078	5.17	141.52	214.14	0.64	0.96	1.97	0.0067	0.96	0.0027	0.33
20649.23	599.92	5407.1	5410.71		5410.95	0.0046	4.48	211.58	195.49	0.51	0.68	2.37	0.0047	0.68	0.0027	0.39
20295.12	600.16	5402.9	5407.01		5407.16	0.0025	3.59	312.5	1180.36	0.38	0.42	2.67	0.0026	0.42	0.0027	0.44

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Hydr Radius C	Frctn Slope	Shear Chan	S_0 (ft/ft)	t_o(lb/ft^{2})
19788.48	600.17	5399.77	5403.41		5403.49	0.0018	2.87	336.5	1049.76	0.32	0.28	2.42	0.0014	0.28	0.0027	0.40
19395.33	600.49	5398.54	5402.46		5402.48	0.0006	1.61	714.69	682.58	0.18	0.09	2.49	0.0007	0.09	0.0027	0.41
18719.05	596.45	5393.77	5398.58		5398.82	0.0021	3.94	156.36	620.77	0.37	0.46	3.48	0.0022	0.46	0.0027	0.58
18222.59	604.62	5390.24	5394.21		5394.67	0.0053	5.57	118.76	1247.44	0.56	0.98	2.97	0.0051	0.98	0.0027	0.49
17823.87	607.75	5384.78	5389.03		5389.17	0.0021	3.54	251.92	572.41	0.35	0.39	3.05	0.0020	0.39	0.0027	0.51
17238.95	600.09	5381.27	5385.64		5385.8	0.0019	3.38	207.62	282.4	0.34	0.36	3.07	0.0015	0.36	0.0027	0.51
16527.38	599.93	5378.06	5381.47		5381.76	0.0056	4.82	157.49	793.06	0.55	0.8	2.29	0.0035	0.8	0.0027	0.38
15829.81	600.08	5371.54	5375.59		5375.83	0.0033	4.11	180.16	439.24	0.44	0.55	2.67	0.0033	0.55	0.0027	0.44
15075.9	600.07	5363.69	5368.34		5368.55	0.0020	3.83	175.38	265.65	0.36	0.44	3.46	0.0020	0.44	0.0027	0.57
14657.52	600.18	5361.45	5365.92		5366.01	0.0012	2.79	304.37	326.31	0.28	0.24	3.13	0.0014	0.24	0.0027	0.52
13349.66	599.72	5354.96	5359.58		5359.61	0.0004	1.67	446.3	959.59	0.16	0.08	3.4	0.0004	0.08	0.0027	0.56
12853.27	599.9	5354.31	5357.87		5358.05	0.0033	4.03	217.21	319.31	0.44	0.54	2.58	0.0034	0.54	0.0027	0.43
12202.33	599.97	5347.61	5350.52		5350.71	0.0038	3.78	200.89	588.46	0.46	0.5	2.1	0.0035	0.5	0.0027	0.35
11341.18	599.94	5340.7	5343.59		5343.88	0.0051	4.36	159.65	138.36	0.53	0.67	2.11	0.0025	0.67	0.0027	0.35
10205.43	599.9	5335.01	5337.66		5337.99	0.0071	4.75	139.12	1063.38	0.61	0.83	1.87	0.0039	0.83	0.0027	0.31
9492.8	599.8	5327.89	5331.02		5331.2	0.0030	3.57	243.11	290.19	0.41	0.44	2.32	0.0030	0.44	0.0027	0.38
8715.939	599.69	5321.34	5324.32		5324.5	0.0035	3.71	208.37	154.32	0.44	0.48	2.19	0.0035	0.48	0.0027	0.36
8284.83	599.97	5316.37	5321.04		5321.13	0.0007	2.46	244.2	234.99	0.22	0.17	3.87	0.0007	0.17	0.0027	0.64
7539.836	599.84	5313.44	5317.01	5317.01	5317.75	0.0215	6.91	86.82	59.57	1.01	1.92	1.43	0.0163	1.92	0.0027	0.24
7021.157	599.99	5304.92	5308.36		5308.46	0.0015	2.76	279.79	158.04	0.3	0.25	2.65	0.0016	0.25	0.0027	0.44
6597.772	600.04	5302.25	5305.16		5305.44	0.0049	4.4	172.56	146.58	0.52	0.67	2.2	0.0049	0.67	0.0027	0.36
6003.298	599.93	5294.93	5298.52		5298.62	0.0014	2.75	276.42	135.91	0.29	0.24	2.77	0.0015	0.24	0.0027	0.46
5397.061	599.92	5291.59	5294.71		5294.83	0.0024	3.05	239.09	118.29	0.36	0.32	2.19	0.0024	0.32	0.0027	0.36

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Shear Chan	Hydr Radius C	Frctn Slope	Shear Chan	S_0 (ft/ft)	$t_o(lb/ft^{2})$
4455.757	599.78	5284.05	5287.07		5287.37	0.0059	4.48	148.82	165.01	0.56	0.73	1.96	0.0059	0.73	0.0027	0.33
3688.934	599.88	5270.25	5273.48		5273.77	0.0050	4.32	138.86	64.18	0.52	0.66	2.12	0.0050	0.66	0.0027	0.35
3097.111	599.72	5260.86	5265.73		5265.81	0.0007	2.43	275.66	113.64	0.22	0.17	3.76	0.0008	0.17	0.0027	0.62
2321.815	599.85	5259.31	5262.83		5263.04	0.0032	3.77	169.41	79.7	0.42	0.48	2.43	0.0032	0.48	0.0027	0.40
1608.905	599.92	5252.24	5255.45		5255.65	0.0037	3.74	177.84	90.02	0.45	0.49	2.12	0.0035	0.49	0.0027	0.35
1173.305	600.13	5245.91	5253.85		5253.87	0.0001	1.25	492.99	537.77	0.09	0.04	6.01	0.0002	0.04	0.0027	1.00
915.5991	599.88	5245.02	5253.28		5253.39	0.0006	2.73	220.12	27.54	0.17	0.19	5.19	0.0006	0.19	0.0027	0.86
831.679	599.74	5245	5253.15	5247.54	5253.23	0.0007	2.33	257.74	58.47	0.2	0.16	3.51		0.16	0.0027	0.58

Table 9-Hydraulic data for 800 cfs

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Hydr Radius C	Frctn Slope	Shear Ch	S_0 (ft/ft)	t_o(lb/ft$^{2)}$
25550.59	800	5460.6	5465.27		5465.47	0.00175	3.74	267.95	289.82	0.33	3.75	0.0012	0.41	0.0027	0.62
25434.88	800.04	5460.08	5464.76		5464.95	0.00227	3.98	302.85	362.51	0.38	3.37	0.0014	0.48	0.0027	0.56
25281.99	800.27	5459.11	5464.02		5464.17	0.00161	3.51	301.22	369.11	0.32	3.62	0.0019	0.36	0.0027	0.60
25159.76	800	5458.6	5462.87		5463.19	0.00414	5.13	207.55	322.45	0.5	3.15	0.0042	0.81	0.0027	0.52
25003.31	800.06	5456.1	5459.98		5460.59	0.00846	6.54	140.95	355.75	0.7	2.65	0.0063	1.4	0.0027	0.44
24849.91	799.84	5453.66	5457.66		5458.04	0.00613	5.25	201.5	257.8	0.59	2.42	0.0045	0.93	0.0027	0.40
24691.63	800.04	5451.46	5456.73		5456.8	0.00086	2.82	482.95	763.45	0.24	4.17	0.0008	0.22	0.0027	0.69
24436.65	800.07	5450.83	5454.39		5455.11	0.01112	7.1	130.14	647.63	0.79	2.44	0.0017	1.69	0.0027	0.40
24098.59	800.07	5447.09	5453.29		5453.3	0.00002	0.46	1850.86	600.63	0.04	4.77	0.0000	0.01	0.0027	0.79
23809.35	799.83	5446.6	5451.45	5451.9	5454.58	0.06865	14.19	56.35	28.84	1.79	1.76	0.0033	7.55	0.0027	0.29
23515.53	800.2	5441.66	5445.91		5446.62	0.00770	6.84	124.53	80.59	0.67	3.04	0.0056	1.46	0.0027	0.50
23171.99	800.07	5436.5	5440.95		5441.34	0.00366	5.13	171.6	65.22	0.48	3.45	0.0038	0.79	0.0027	0.57
22861.21	800.15	5432.21	5438.31		5438.53	0.00153	4.14	260.34	241.76	0.32	4.81	0.0023	0.46	0.0027	0.80
22823.47	800.07	5433.26	5437.8		5438.2	0.00401	5.11	163.05	175.22	0.5	3.2	0.0035	0.8	0.0027	0.53
22593.14	799.74	5430.33	5436.45		5436.62	0.00098	3.36	237.99	382.25	0.27	4.91	0.0007	0.3	0.0027	0.81
22204.23	800.02	5430.48	5434.71		5435.12	0.00479	5.76	188.31	612.71	0.54	3.35	0.0049	1	0.0027	0.56
22058.46	799.93	5428.43	5432.4		5432.77	0.00583	5.35	196.94	785.99	0.58	2.59	0.0062	0.94	0.0027	0.43
21869.39	800.38	5424.78	5428.97		5429.34	0.00473	5.49	199.67	891.52	0.54	3.15	0.0046	0.93	0.0027	0.52
21471.82	800.37	5418.97	5423.02		5423.27	0.00394	4.71	261.09	1080.07	0.48	2.87	0.0039	0.71	0.0027	0.48
20909.86	800.13	5411.91	5415.63		5416.08	0.00798	5.72	177.06	234.93	0.66	2.26	0.0063	1.13	0.0027	0.37
20649.23	799.93	5407.1	5410.87		5411.2	0.00600	5.34	244.25	209.91	0.58	2.53	0.0053	0.95	0.0027	0.42
20295.12	799.96	5402.9	5407.25		5407.41	0.00267	3.91	449.25	1393	0.4	2.91	0.0027	0.48	0.0027	0.48
19788.48	799.84	5399.77	5403.66		5403.76	0.00211	3.27	388.72	1052.02	0.35	2.66	0.0013	0.35	0.0027	0.44

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Hydr Radius C	Frctn Slope	Shear Ch	S_0 (ft/ft)	t_o(lb/ft$^{2)}$
19395.33	800.62	5398.54	5402.84		5402.86	0.00046	1.61	916.28	758.53	0.17	2.86	0.0006	0.08	0.0027	0.47
18719.05	793.98	5393.77	5399.26		5399.55	0.00212	4.39	188.29	733.3	0.37	4.12	0.0022	0.54	0.0027	0.68
18222.59	804.28	5390.24	5394.68		5395.26	0.00563	6.33	140.49	1248.12	0.59	3.42	0.0054	1.2	0.0027	0.57
17823.87	804.48	5384.78	5389.46		5389.62	0.00203	3.83	307.83	860.81	0.36	3.47	0.0020	0.44	0.0027	0.58
17238.95	799.99	5381.27	5386.1		5386.3	0.00201	3.85	242.88	293.99	0.36	3.52	0.0015	0.44	0.0027	0.58
16527.38	800.26	5378.06	5381.78		5382.16	0.00636	5.59	183.17	797.4	0.6	2.59	0.0039	1.03	0.0027	0.43
15829.81	800.09	5371.54	5376.07		5376.33	0.00306	4.41	233.78	471.38	0.43	3.14	0.0031	0.6	0.0027	0.52
15075.9	800.17	5363.69	5368.86		5369.13	0.00220	4.36	214.03	393.5	0.38	3.97	0.0022	0.54	0.0027	0.66
14657.52	799.8	5361.45	5366.43		5366.55	0.00130	3.16	436.03	525.11	0.29	3.64	0.0014	0.29	0.0027	0.60
13349.66	800.24	5354.96	5360.11		5360.15	0.00045	1.96	509.73	1036.14	0.17	3.91	0.0005	0.11	0.0027	0.65
12853.27	799.93	5354.31	5358.24		5358.45	0.00330	4.39	266.15	326.06	0.45	2.95	0.0033	0.61	0.0027	0.49
12202.33	799.19	5347.61	5350.84		5351.06	0.00389	4.17	245.38	626.8	0.47	2.42	0.0032	0.59	0.0027	0.40
11341.18	800.09	5340.7	5343.91		5344.24	0.00519	4.83	205.9	182.45	0.54	2.42	0.0025	0.79	0.0027	0.40
10205.43	800.13	5335.01	5337.89		5338.34	0.00825	5.53	167.81	1185.93	0.67	2.1	0.0039	1.08	0.0027	0.35
9492.8	799.51	5327.89	5331.39		5331.55	0.00256	3.63	373.96	408.29	0.39	2.68	0.0027	0.43	0.0027	0.44
8715.939	799.78	5321.34	5324.63		5324.83	0.00349	4.03	283.12	320.12	0.45	2.49	0.0035	0.54	0.0027	0.41
8284.83	800.22	5316.37	5321.75		5321.87	0.00074	2.78	289.11	238.32	0.23	4.57	0.0007	0.21	0.0027	0.76
7539.836	800.01	5315.05	5317.83		5318.49	0.01211	6.48	123.52	62.97	0.8	2	0.0092	1.51	0.0027	0.33
7021.157	799.93	5304.92	5308.7		5308.83	0.00167	3.15	336.6	172.95	0.32	2.99	0.0017	0.31	0.0027	0.50
6597.772	799.86	5302.25	5305.54		5305.83	0.00460	4.69	239.38	198.35	0.51	2.54	0.0045	0.73	0.0027	0.42
6003.298	799.96	5294.93	5298.94		5299.05	0.00145	3.06	333.99	139.53	0.3	3.19	0.0016	0.29	0.0027	0.53
5397.061	800.04	5291.59	5295.14		5295.28	0.00228	3.34	290.87	119.85	0.36	2.59	0.0023	0.37	0.0027	0.43
4455.757	800.01	5284.05	5287.49		5287.82	0.00553	4.83	190.37	190.79	0.55	2.32	0.0053	0.8	0.0027	0.38
3688.934	800.04	5270.25	5273.89		5274.25	0.00502	4.83	165.69	65.42	0.53	2.48	0.0050	0.78	0.0027	0.41

River Sta	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl	Hydr Radius C	Frctn Slope	Shear Ch	S_0 (ft/ft)	t_o(lb/ft^2)
3097.111	800.02	5260.86	5266.32		5266.42	0.00075	2.71	348.17	132.63	0.23	4.34	0.0008	0.2	0.0027	0.72
2321.815	800.03	5259.31	5263.26		5263.53	0.00325	4.22	206.23	109.91	0.44	2.81	0.0033	0.57	0.0027	0.47
1608.905	800.1	5252.24	5255.94		5256.16	0.00330	4.01	221.83	91.43	0.44	2.57	0.0028	0.53	0.0027	0.43
1173.305	800.82	5245.91	5254.74		5254.77	0.00012	1.45	570.43	538.4	0.1	6.87	0.0002	0.05	0.0027	1.14
915.5991	800.32	5245.02	5254.02		5254.19	0.00083	3.33	240.59	27.7	0.2	5.48	0.0007	0.28	0.0027	0.91
831.679	799.98	5245	5253.88	5248.13	5253.99	0.00081	2.66	300.64	59.07	0.21	4.01		0.2	0.0027	0.67

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