APPENDIX C – 2010/2011 SEDIMENT AND HABITAT DATA COLLECTION METHODS AND DATA SUMMARY – BEAVERHEAD TPA

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C1.0 INTRODUCTION

The majority of the Beaverhead TMDL Planning Area (TPA) is located within Beaverhead County and encompasses the entire Beaverhead River watershed below Clark Canyon Reservoir. The Beaverhead River within the TPA begins at the outlet of the Clark Canyon Reservoir and flows northeast for 79.5 miles before its confluence with the Big Hole River. The watershed drains an area 3,619 square miles (2,316,160 acres), coinciding with the fourth-code hydrologic unit code (HUC) 10020002.

Under Montana law, an impaired waterbody is defined as a waterbody for which sufficient and credible data indicates non-compliance with applicable water quality standards (MCA 75-5-103 (2011)). Section 303 of the Federal Clean Water Act requires states to submit a list of impaired waterbodies or stream segments to the U.S. Environmental Protection Agency (EPA) every two years in an “Integrated Report” (formerly referred to as the “303(d) list”). The Montana Water Quality Act further directs states to develop TMDLs for all waterbodies appearing on the 303(d) list as impaired or threatened by “pollutants” (MCA 75-5-703).

Within the Beaverhead TPA, 17 stream segments are listed as impaired due to sediment in the 2010 Integrated Report. These streams include *West Fork Dyce Creek, West Fork Blacktail Deer Creek, Taylor Creek, Stone Creek (two listed segments), Steel Creek, Spring Creek, Scudder Creek, Reservoir Creek, Rattlesnake Creek (two segments), French Creek, Farlin Creek, Dyce Creek, Clark Canyon Creek, Blacktail Deer Creek* and the *Beaverhead River segment from Grasshopper Creek to the Big Hole River* (referred to as “lower Beaverhead”).

A detailed sediment and habitat assessment of streams in the Beaverhead TPA was conducted to facilitate the development of sediment TMDLs. During this assessment, streams were first analyzed in GIS using color aerial imagery and broken into similar reaches based on landscape characteristics. Following the aerial assessment reach stratification process, field data were collected at 32 monitoring sites during September of 2010 and April of 2011. Field data were then used to quantify stream condition variables at assessment reaches within the Beaverhead TPA and to estimate sediment loads from eroding streambanks to facilitate the development of sediment TMDLs. On STEL 10-01, which was a dry channel, field notes were taken, but no data were collected. CLCK 18-02 was only assessed for BEHI. A list of data collected for each monitored reach is included in **Section C3.1**.

The following sections are descriptions of two main components of this project: the aerial assessment reach stratification and the sediment and habitat assessment. The sections are excerpts from the *Analysis of Base Parameter Data and Erosion Inventory Data for Sediment TMDL Development within the Beaverhead TPA* (Watershed Consulting, LLC, 2011), which is on file at the DEQ and contains the complete assessment database.

C2.0 AERIAL ASSESSMENT REACH STRATIFICATION

C2.1 METHODS

An aerial assessment of streams in the Beaverhead TPA was conducted using National Agricultural Imagery Program (NAIP) color imagery from 2009 in GIS along with other relevant data layers, including the National Hydrography Dataset (NHD) 1:100,000 stream layer and United States Geological Survey

1:24,000 Topographic Quadrangle Digital Raster Graphics. GIS data layers were used to stratify streams into distinct reaches based on landscape and land-use factors following techniques described in *Watershed Stratification Methodology for TMDL Sediment and Habitat Investigations* (Montana Department of Environmental Quality, 2008).

The reach stratification methodology involves breaking a waterbody stream segment into stream reaches and sub-reaches. Montana DEQ tracks stream water quality status by stream segment, which may encompass the entire stream or just a portion of the stream. Each of the stream segments in the Beaverhead TPA was initially divided into distinct reaches based on four landscape factors: ecoregion, valley gradient, Strahler stream order, and valley confinement. Stream reaches classified by these four criteria were then further divided into sub-reaches based on the surrounding vegetation and land-use characteristics, including predominant vegetation type, adjacent land-use, riparian area condition, anthropogenic (human) influences on streambank erosion, level of development, and the presence of anthropogenic activity within 100 feet of the stream channel. This stratification resulted in a series of stream reaches and sub-reaches delineated based on landscape and land-use factors which were compiled into an Aerial Assessment Database for the Beaverhead TPA.

C2.1.1 Reach Types

As described above, the aerial assessment reach stratification process involved dividing each stream segment into distinct reaches based on ecoregion, valley gradient, Strahler stream order, and valley confinement. Each individual combination of the four landscape factors is referred to as a "**reach type**" in this report. Reach types were labeled using the following naming convention based on landscape features in the order listed below:

Level III Ecoregion – Valley Gradient – Strahler Stream Order – Confinement

Landscape feature values and associated reach type identifiers are presented in **Table C-1**:

Table C-1. Reach Type Identifiers

Landscape Factor	Stratification Category	Reach Type Identifier
Level III Ecoregion	Middle Rockies	MR
Valley Gradient	0-<2%	0
	2-<4%	2
	4-<10%	4
	>10%	10
Strahler Stream Order	first order	1
	second order	2
	third order	3
	fourth order	4
	fifth order	5
	sixth order	6
	seventh order	7
Confinement	unconfined	U
	confined	C

Thus, a stream reach identified as MR-2-2-U is a mid gradient (2-<4%), 2rd order, unconfined stream in the Middle Rockies Level III ecoregion.

C2.2 REACH STRATIFICATION RESULTS

A total of 612 reaches were delineated during the aerial assessment reach stratification process covering 321.3 miles of stream in the Beaverhead TPA (**Table C-2**). These reaches were divided further into a total of 610 subreaches (**Table C-2**) based on vegetation and land use, as described in **Section C.1**. Based on the reach type identifiers listed in **Table C-1**, 27 distinct reach types were delineated in the Beaverhead TPA and field data were collected in ten of these reach types. The complete Aerial Assessment Database is provided in *Analysis of Base Parameter Data and Erosion Inventory Data for Sediment TMDL Development within the Beaverhead TPA (Watershed Consulting, LLC, 2011)*, which is on file at the DEQ

Table C-2. Aerial Assessment Stream Segments

Stream Segment	Number of Reaches	Number of Reaches and Sub-Reaches	Length (Miles)
Beaverhead River	9	34	74.4
Blacktail Deer Creek	2	38	39.9
East Fork Blacktail Deer Creek	28	38	19.4
West Fork Blacktail Deer Creek	8	19	15.9
Clark Canyon Creek	32	35	8.4
Dyce Creek	5	8	4.1
East Fork Dyce Creek	20	21	4.7
West Fork Dyce Creek	18	20	4.6
Farlin Creek	29	32	6.0
French Creek	34	37	6.5
Grasshopper Creek	20	64	47.5
Indian Creek	18	18	2.7
Rattlesnake Creek	60	77	27.0
Reservoir Creek	20	28	12.2
Scudder Creek	14	17	4.7
Spring Creek	33	51	14.9
Steel Creek	11	12	3.8
Stone Creek	22	26	13.4
Taylor Creek	32	35	11.4

C3.0 SEDIMENT AND HABITAT ASSESSMENT

C3.1 METHODS

Sediment and habitat data were collected following the methodology described in *Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments (Montana Department of Environmental Quality, 2010)*. Additional methods were developed for non-wadeable reaches, as discussed in **Section C3.1.5**. Field monitoring sites were selected in relatively low-gradient segments of the study streams where sediment deposition is likely to occur. Other considerations in selecting field monitoring sites included representativeness of the reach to other reaches of the same slope, order, confinement and ecoregion, the extent of anthropogenic impacts relative to other reaches, and ease of access.

Sediment and habitat assessments were performed at 32 field monitoring sites, which were selected based on the aerial assessment in GIS and on-the-ground reconnaissance conducted in August, 2010.

Sediment and habitat data were collected within ten reach types (**Table C-3**, **Figure C-1)**.

Table C-3. Reach Types and Monitoring Sites

Reach Type	Number of Reaches	Sites Monitored	Methods Used
MR_2_1_U	14	SCUD 11-01	All Sed/Hab Methods
MR_4_1_U	48	STEL 05-01	All Sed/Hab Methods
		WFDY 17-01	All Sed/Hab Methods
MR_0_2_U	53	CLKC 32-01	All Sed/Hab Methods
		DYCE 02-02	All Sed/Hab Methods
		SPRG 31-01	All Sed/Hab Methods
		STON 20-02	All Sed/Hab Methods
		STON 22-02	All Sed/Hab Methods
		STON 22-02B	All Sed/Hab Methods
		TAYL 32-01	All Sed/Hab Methods
MR_2_2_C	29	FREN 23-01	All Sed/Hab Methods
MR_2_2_U	51	CLKC 19-02	All Sed/Hab Methods
		FARL 28-01	All Sed/Hab Methods
		RESR 11-01	All Sed/Hab Methods
		STON 05-01	All Sed/Hab Methods
		TAYL 27-01	All Sed/Hab Methods
MR_4_2_U	26	CLKC 18-02	BEHI Only
MR_0_3_U	62	RATT 54-04	All Sed/Hab Methods
		RATT 60-04	All Sed/Hab Methods
		WFBK 08-04	All Sed/Hab Methods
MR_0_4_U	34	GRAS 12-01	All Sed/Hab Methods
		GRAS 20-11	All Sed/Hab Methods
MR_0_5_U	30	BLKD 02-08	All Sed/Hab Methods
		BLKD 02-14	All Sed/Hab Methods
		BLKD 02-30	All Sed/Hab Methods
MR_0_7_U	32	BEAV 04-02	Cross-sections only
		BEAV 04-05	Cross-sections only
		BEAV 09-04	Non-wadeable reach methods
		BEAV 09-06	Non-wadeable reach methods with std. cross-sections
		BEAV 09-11	Non-wadeable reach methods
		BEAV 09-14	Non-wadeable reach methods
		BEAV 09-15	Non-wadeable reach methods

The length of the monitoring site was based on the bankfull channel width. A monitoring site length of 500 feet was used at 18 sites in which the bankfull width was less than 10 feet and a monitoring site length of 1,000 feet was used at 9 sites in which the bankfull width was between 10 feet and 50 feet. A monitoring site length of 1500 was used at two sites in which the bankfull width was between 50 and 60 feet. A monitoring site length of 2000 feet was used a three sites in which the bankfull width was greater than 60 feet. Each monitoring site was divided into five equally sized study cells numbered 1 through 5 progressing in an upstream direction. Sites were evaluated from downstream to upstream.

The following sections provide brief descriptions of the field methodologies employed during this assessment. A more in-depth description is available in *Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments* (Montana Department of Environmental Quality, 2010).

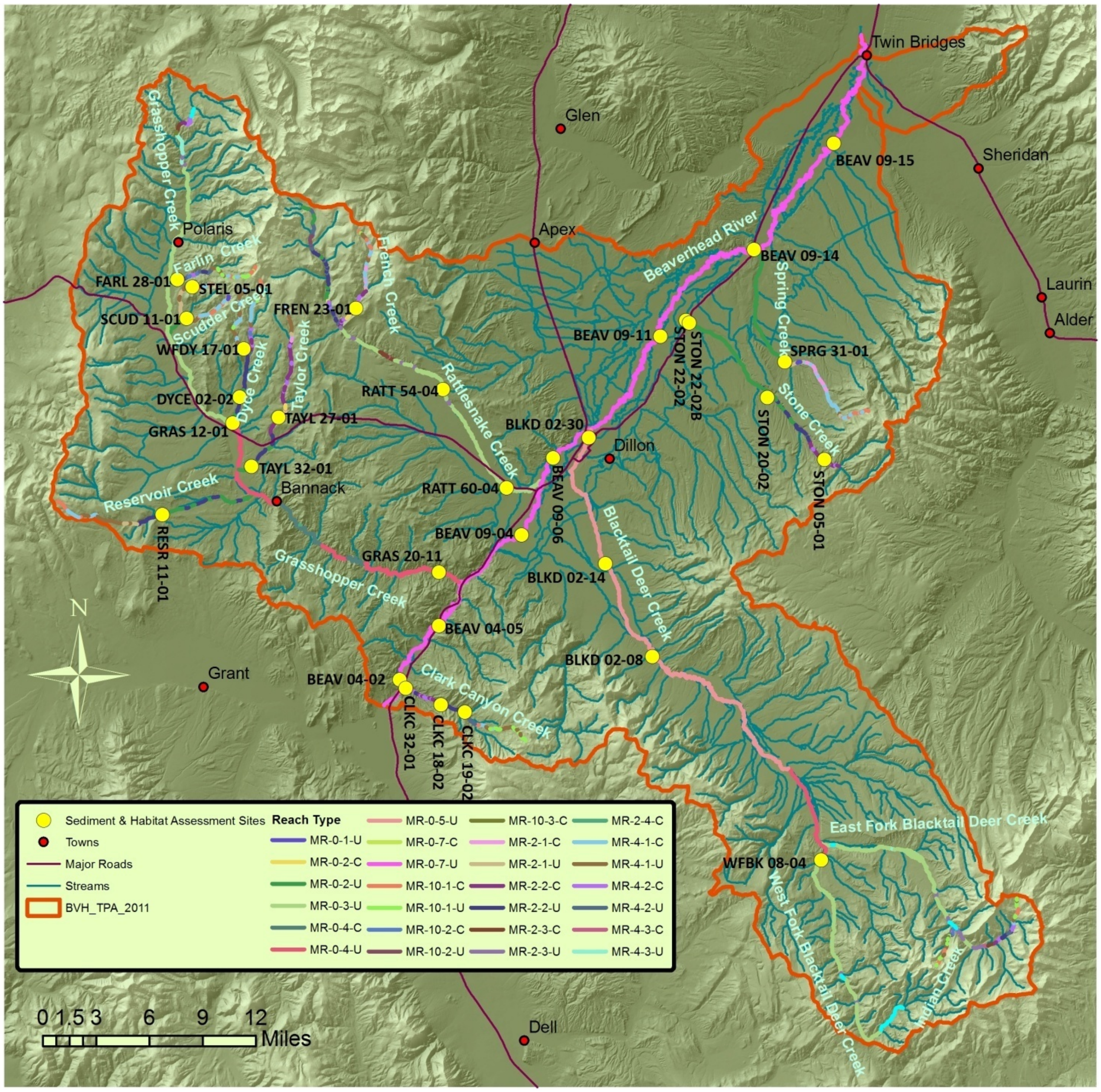

Figure C-1. Aerial Assessment Reach Type Stratification.

C3.1.1 Channel Form and Stability Measurements

Channel form and stability measurements include the field determination of bankfull, channel cross-sections, floodprone width, and surface water slope.

C3.1.1.1 Field Determination of Bankfull

The bankfull elevation was determined for each monitoring site. Bankfull is a concept used by hydrologists to define a regularly occurring channel-forming high flow. One of the first generally accepted definitions of bankfull was provided by Dunne and Leopold (1978):

> "The bankfull stage corresponds to the discharge at which channel maintenance is the most effective, that is, the discharge at which moving sediment, forming or removing bars, forming or changing bends and meanders, and generally doing work that results in the average morphologic characteristics of channels."

Indicators that were used to estimate the bankfull elevation included scour lines, changes in vegetation types, tops of point bars, changes in slope, changes in particle size and distribution, staining of rocks, and inundation features. Multiple locations and bankfull indicators were examined at each site to determine the bankfull elevation, which was then applied during channel cross-section measurements.

C3.1.1.2 Channel Cross-sections

Channel cross-section measurements were performed at the first riffle in each cell using a line level and a measuring rod. At each cross-section, depth measurements at bankfull were performed across the channel at regular intervals, which varied depending on channel width. The thalweg depth was recorded at the deepest point of the channel independent of the regularly spaced intervals.

C3.1.1.3 Floodprone Width Measurements

The floodprone elevation was determined by multiplying the maximum depth value by two (Rosgen, 1996). The floodprone width was then measured by stringing a tape from the bankfull channel margin on both the right and left banks until the tape (pulled tight and "flat") touched the ground at the floodprone elevation. When dense vegetation or other features prevented a direct line of tape from being strung, the floodprone width was estimated by pacing or making a visual estimate.

C3.1.1.4 Water Surface Slope

Water surface slope measurements were estimated using a clinometer. This measurement was used to evaluate the slope assigned in GIS based on the aerial assessment. The field measured slope was used when evaluating the Rosgen stream type at each monitoring site.

C3.1.2 Fine Sediment Measurements

Channel cross-section measurements were performed at the first riffle in each cell using a leveled tape and a measuring rod. At each cross-section, depth measurements at bankfull were performed across the channel at regular intervals, which varied depending on channel width. The thalweg depth was recorded at the deepest point of the channel independent of the regularly spaced intervals.

C3.1.2.1 Riffle Pebble Count

One Wolman pebble count (Wolman, 1954) was performed at the first riffle encountered in four cells, providing a minimum of 400 particles measured within each assessment reach. Particle sizes were measured along their intermediate length axis (b-axis) using a gravelometer and results were grouped into size categories. The pebble count was performed from bankfull to bankfull using the "heel to toe" method.

C3.1.2.2 Riffle Grid Toss

The riffle grid toss was performed at the same location as the pebble count measurement. The riffle grid toss measures fine sediment accumulation on the surface of the streambed. Grid tosses were performed prior to the pebble count to avoid disturbances to surface fine sediments.

C3.1.2.3 Pool Tail-out Grid Toss

A measurement of the percent of fine sediment in pool tail-outs was taken using the grid toss method at each pool in which potential spawning gravels were identified. Three measurements were taken in each pool with appropriate sized spawning gravels using a 49-point grid. The spawning potential was recorded as “Yes” (Y) or “No” (N), in cases where gravels of appropriate size were scarce or not available. No grid toss measurements were made when the substrate was observed to be too large to support spawning. Grid toss measurements were performed when the substrate was observed to be too fine to support spawning since the goal of this assessment is to quantify fine sediment accumulation in spawning areas.

C3.1.2.4 Riffle Stability Index

A Riffle Stability Index (RSI) evaluation was performed in streams that had well-developed point bars. For assessment sites in which well-developed point bars were present, a total of three RSI measurements were taken, which consisted of the intermediate axis (b-axis) measurements of 15 particles determined to be among the largest size group of recently deposited particles that occur on over 10% of the point bar. During post-field data processing, the riffle stability index was determined by calculating the geometric mean of the dominant bar particle size measurements and comparing the result to the cumulative particle distribution from the riffle pebble count in an adjacent or nearby riffle.

C3.1.3 Instream Habitat Measurements

Instream habitat measurements include channel bed morphology, residual pool depth and width, and pool habitat quality (cover type and woody debris quantification).

C3.1.3.1 Channel Bed Morphology

The length of each monitoring site occupied by pools and riffles was recorded progressing in an upstream direction. The upstream and downstream stations of “dominant” riffle features were recorded. A riffle is considered “dominant” when occupying over 50% of the bankfull channel width (Heitke, et al., 2006). Pools were documented if they were concave in profile, bounded by and “head crest” at the upstream end and a “tail crest” at the downstream end, and had a maximum depth at least 1.5 times the pool-tail depth (Kershner, et al., 2004). Dammed pools were also assessed; backwater pools were not assessed.

C3.1.3.2 Residual Pool Depth

At each pool encountered, the maximum depth and the depth of the pool tail crest at its deepest point was measured. The difference between the maximum depth and the tail crest depth is considered the residual pool depth. No pool tail crest depth was recorded for dammed pools.

C3.1.3.3 Pool Habitat Quality

Qualitative assessments of each pool feature were undertaken, including pool type, size, formative feature, and cover type, along with the depth of any undercut banks associated with the pool. The total number of pools was also quantified.

C3.1.3.4 Woody Debris Quantification

The amount of large woody debris (LWD) within each monitoring site was recorded. Large pieces of woody debris located within the bankfull channel that were relatively stable so as to influence the channel form were counted as either single, aggregate or “willow bunch”. The term “willow bunch” refers to dead, decadent or living riparian shrubs (not just willows) that are influencing the channel bed morphology. A single piece of large woody debris was counted when it was greater than 9 feet long or spanned two-thirds of the wetted stream width, and 4 inches in diameter at the small end (Overton, et al., 1997).

C3.1.4 Riparian Health Measurements

Riparian health was quantified using the riparian greenline assessment.

C3.1.4.1 Riparian Greenline Assessment

Along each monitoring site, an assessment of riparian vegetation cover was performed. Vegetation types were recorded at 10-foot intervals, with the number of sampled points depending on the bankfull channel width. The riparian greenline assessment described the general vegetation community type of the groundcover, understory and overstory on both banks. At 50-foot intervals, the riparian buffer width was estimated on either side of the channel. The riparian buffer width corresponds to the belt of vegetation buffering the stream from adjacent land uses.

C3.1.5 Methods for Non-wadeable Reaches

Assessment of sediment sources and habitat conditions on tributaries of the Beaverhead River followed Standard Operating Procedures (SOPs) described in *Field Methodology for the Assessment of TMDL Sediment and Habitat Impairments* (Montana Department of Environmental Quality, 2010). Some methods in these SOPs, which are for wadeable streams, were not feasible in many areas of the Beaverhead River where high flows prevented wading during the assessment period. In some reaches, deep water prevented collection of pebble counts, grid toss fine sediment counts, precise cross-sectional measurements, and detailed habitat longitudinal profile.

Collection of less detailed cross-sectional measurements was accomplished in September 2010 by setting up a rope and tag line across the channel in reaches downstream of Barretts in a process described in more detail in following sections. Channel longitudinal profile measurements were collected in downstream reaches using a personal cataraft with a safety line held by crew on the shoreline to help slow the craft. The same method was not feasible in upstream reaches because the dense willow cover along reaches upstream of Barretts and the deep water next to shore in those reaches prevented any sampling requiring access to the lower bank. However, in April of 2011 during lower flow, two cross-section measurements and pebble counts were taken in two reaches upstream of Barretts, using the methodology for wadeable streams.

Field crews conducted sediment source and habitat assessments throughout the Beaverhead watershed below Clark Canyon Reservoir during September of 2010 and April 2010. Sampling followed the SOPs for wadeable streams to the extent possible, with modifications implemented as site conditions dictated. Generally, crews were able to collect greenline, a less precise cross-section with categorical estimated substrate data, BEHI bank erosion data, and a longitudinal profile of channel depth and estimated substrate category (muck, sand, gravel, and cobble) following the thalweg as closely as possible.

Water safety is a prime consideration whenever crews work on large rivers. All crew working along the river wore a personal floatation device (pfd) at all times. . All crew were instructed on how to float properly with feet up and facing downstream and how to ferry to shore in the event anyone lost footing. A crew member with a throw rope was posted on the streambank downstream of the measuring crew whenever crew were working from the cataraft, even though water was seldom deeper than five feet in the assessment reaches.

The longitudinal profile methods required using a rope attached to the raft to slow downstream progression. The rope was clipped to the cataraft with a carabiner to allow the rope to be disconnected if necessary and was held and kept clear of obstacles by two crew members on shore. At no time was the raft tied to any object while crew members were on board.

Cross-sectional data fit into the existing data management structure with only minor modification in some instances. Cross-sectional data from Beaverhead River assessment reaches also were plotted in Excel with substrate size categorical data to illustrate variation in substrate size with channel depth among cross-sections and reaches. Longitudinal profile data collected with the non-wadeable stream methods were also plotted in Excel to show stream depth and corresponding substrate size class over the length of the reach. In some instances two floats were needed to access the deepest part of the channel. In these cases the data were entered into Excel and the deepest measurement with corresponding substrate size class at each station was used in the longitudinal profile plot.

C3.1.5.1 Greenline

Greenline inventory was completed in all reaches except in two upstream reaches where dense willow cover and deep water near shore prevented movement along the lower bank. In many cases the vegetation category along the bank opposite the investigator was estimated due to limited access. The only instances in which this estimated data may have increased error are those where grasses and wetland graminoids dominate the greenline and are mixed, making it difficult to tell which category occupied the measurement point. Vegetation was classified as ‘Wetland’ where both grass and wetland graminoid species occupied the measurement point. Banks were not accessible in the two upstream-most reaches due to dense willow cover and deep water near the bank, thus greenline was not inventoried in those reaches in either the September 2010 or April 2011 sampling effort.

C3.1.5.2 Cross-sections

Cross-sectional measurements were collected in non-wadeable reaches (BEAV 09-04, BEAV 09-11, BEAV 09-14, and BEAV 09-15) below Barretts with use of a personal cataraft guided along a rope and tagline strung across the stream. The guide rope and tag line marked with feet and tenths were secured to 6 foot T posts driven into both streambanks, or were tied to branches of willows growing along the streambank. One person guided the cataraft, one person collected measurements, and one person recorded data. The data recorder called out the measurement intervals based on the width of the channel, as in the SOPs. One person on the cataraft sat in the seat of the craft and held the rope, guiding the cataraft to the needed intervals and across the stream. The data collector sat on the cargo rack of the cataraft and held an 8 foot long rebar marked in 1 foot intervals (**Figure C-2**). The data collector called out stream depths at the given intervals and gave an estimate of the size class of stream substrate, generally easily determined by sound and feel of the substrate against the rebar. Floodprone width was estimated based on the maximum depth collected and all other cross-section variables were collected following the standard calculations specified in the SOPs.

Figure C-2. Cross-sectional measurement using cataraft.

C3.1.5.3 Longitudinal Profile

Field crews measured depth and substrate profiles at a coarse scale by floating down the length of the reach and recording data every 20 feet. The crew for these measurements included one person to call out every 20 feet and record data, two people managing the safety rope, and two people on the cataraft (**Figure C-3**). One person on the raft served as oarsman, rowing upstream to slow the downstream progression and guide the raft to the thalweg. The other person on the raft measured stream depth and estimated substrate size class using an 8 foot length of rebar marked in foot increments. The two crew members holding the rope slowed progression of the raft when necessary and otherwise maintained contact with the raft to avoid obstacles. The crew holding the rope worked together to keep the rope free of obstacles and help direct the raft to the thalweg.

Figure C-3. Longitudinal profile measurement using cataraft and marked rebar.

C3.1.5.4 Bank Stability using Bank Erosion Hazard Index (BEHI)

Collection of BEHI data followed the SOP even in non-wadeable streams, except that the bankfull mean depth measurements used to calculate near-bank stress were not collected where wading was not possible. BEHI measurements were collected in all reaches sampled in September 2010, but were not collected in the upper reaches of the Beaverhead in April 2011 because of dense willow cover at the bank's edge and deep instream flow.

C3.1.5.5 Large Woody Debris

Large woody debris was recorded on the Beaverhead River in the rare case where any was present. Generally the valley bottom and streambanks are grass- and willow-dominated, and no large woody debris was found.

C3.2 RESULTS

In the Beaverhead TPA, sediment and habitat parameters were assessed in September 2010 at 29 monitoring sites. An additional three sites (STEL 05_01, BEAV 04_02 and BEAV 04_05) were visited in April 2011 at low flow. Sediment and habitat assessments were performed in ten reach types out of the 28 reach types delineated in the GIS-based stratification, with a focus on low gradient reach types. A statistical analysis of the sediment and habitat data is presented by reach type and for individual monitoring sites in the following sections. The complete sediment and habitat dataset is presented in *Analysis of Base Parameter Data and Erosion Inventory Data for Sediment TMDL Development within the Beaverhead TPA (Watershed Consulting, LLC, 2011)*, on file at DEQ**.**

C3.2.1 Reach Type Analysis

This section presents a statistical analysis of sediment and habitat base parameters for each of the reach types assessed in the Beaverhead TPA. Reach type discussions are based on mean values, while summary statistics for the minimum, 25th percentile, median, 75th percentile and maximum values are also provided since these may be more applicable for developing sediment TMDL targets. Sediment and habitat analysis is provided by reach type for the following metrics:

- width/depth ratio
- entrenchment ratio riffle pebble count <2mm
- riffle pebble count <6mm
- riffle grid-toss <6mm
- pool tail-out grid toss <6mm
- residual pool depth
- pool frequency
- LWD frequency
- greenline understory shrub cover
- greenline bare ground

Only BEHI data were collected for reach CLCK 18-02. Because this was the only reach visited in reach type MR_4_2_U, this reach type is not included in data summaries in the sections that follow.

C3.2.1.1 Width/Depth Ratio

The channel width/depth ratio is defined as the channel width at bankfull height divided by the mean bankfull depth (Rosgen, 1996). The channel width/depth ratio is one of several standard measurements used to classify stream channels, making it a useful variable for comparing conditions between reaches with the same stream type (Rosgen, 1996). A comparison of observed and expected width/depth ratios is also a useful indicator of channel overwidening and aggradation, which are often linked to excess streambank erosion and/or sediment inputs from sources upstream of the study reach. Channels that are overwidened are often associated with excess sediment deposition and streambank erosion, contain shallower and warmer water, and provide fewer deepwater habitat refugia for fish.

Figure C-4 illustrates trends in width/depth ratio among reach types. Mean width/depth ratios for assessed reach types ranged from 7.6 in MR_4_1_U to 39.1 in MR_0_7_U (**Table C-4**). A higher stream order indicates a larger, thus generally wider, stream.

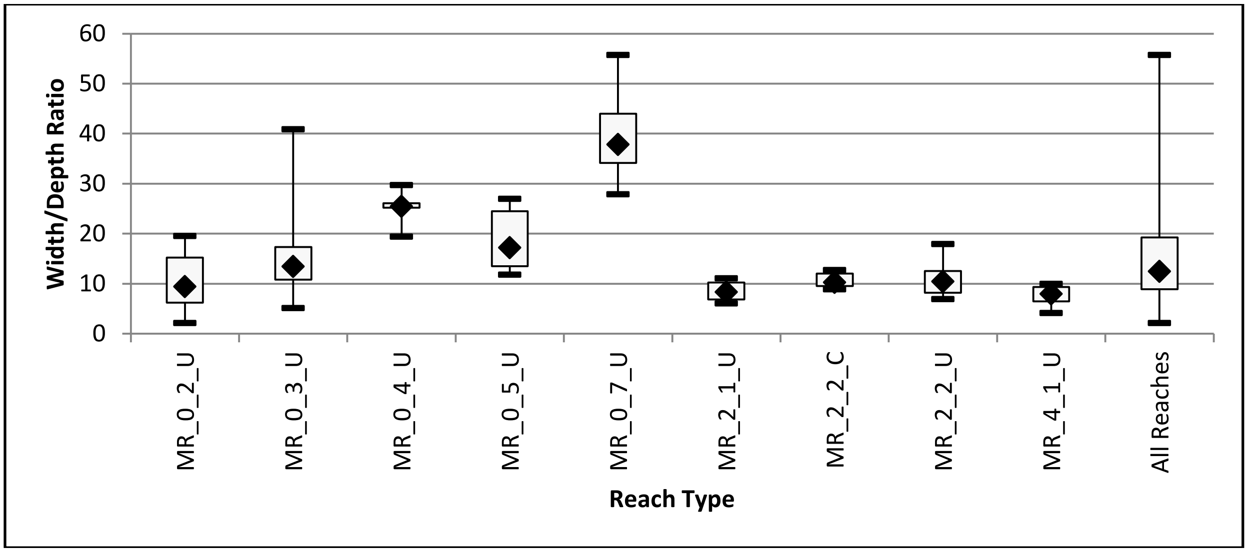

Figure C-4. Width/Depth Ratio.

Table C-4. Width/Depth Ratio.

	Reach Types									
Statistic	**MR_0_2_U**	**MR_0_3_U**	**MR_0_4_U**	**MR_0_5_U**	**MR_0_7_U**	**MR_2_1_U**	**MR_2_2_C**	**MR_2_2_U**	**MR_4_1_U**	**All Reaches**
Number of Reaches	7	3	2	3	7	1	1	5	2	32
Sample Size	34	14	8	13	17	5	5	25	8	129
Minimum	2.17	5.16	19.44	11.84	27.91	6.09	8.91	6.95	4.17	2.17
25th Percentile	6.22	10.8	25.19	13.5	34.17	6.83	9.55	8.21	6.48	8.91
Median	9.46	13.48	25.5	17.24	37.87	8.37	10.3	10.48	8	12.5
Mean	10.39	14.94	25.35	18.65	39.13	8.53	10.71	10.90	7.61	16.29
75th Percentile	15.23	17.33	26.12	24.48	44	10.27	12.03	12.56	9.37	19.44
Maximum	19.57	40.91	29.75	27	55.76	11.11	12.76	17.96	10	55.76

Based on data from assessed reaches in the Beaverhead TPA, the width/depth ratio generally increases as stream order increases, with the exception of fourth vs. fifth order streams.

C3.2.1.2 Entrenchment Ratio

A stream's entrenchment ratio is equal to the floodprone width divided by the bankfull width (Rosgen, 1996). The entrenchment ratio is used to help determine if a stream shows departure from its natural stream type and is an indicator of stream incision that describes how easily a stream can access its floodplain. Streams can become incised due to detrimental land management activities or may be naturally incised due to landscape characteristics. A stream that is overly entrenched generally is more prone to streambank erosion due to greater energy exerted on the banks during flood events. Greater scouring energy along incised channels results in higher sediment loads derived from eroding banks. If the stream is not actively degrading (downcutting), the sources of human caused incision may be historical in nature, though sediment loading may continue to occur. The entrenchment ratio is an important measure of channel conditions since it relates to sediment loading and habitat condition.

Figure C-5 illustrates the distribution of values for entrenchment ratio among reach types. The mean entrenchment ratio for assessed reach types ranged from 2.1 in MR_2_2_C to 8.5 in MR_0_2_U (**Table C-5**).

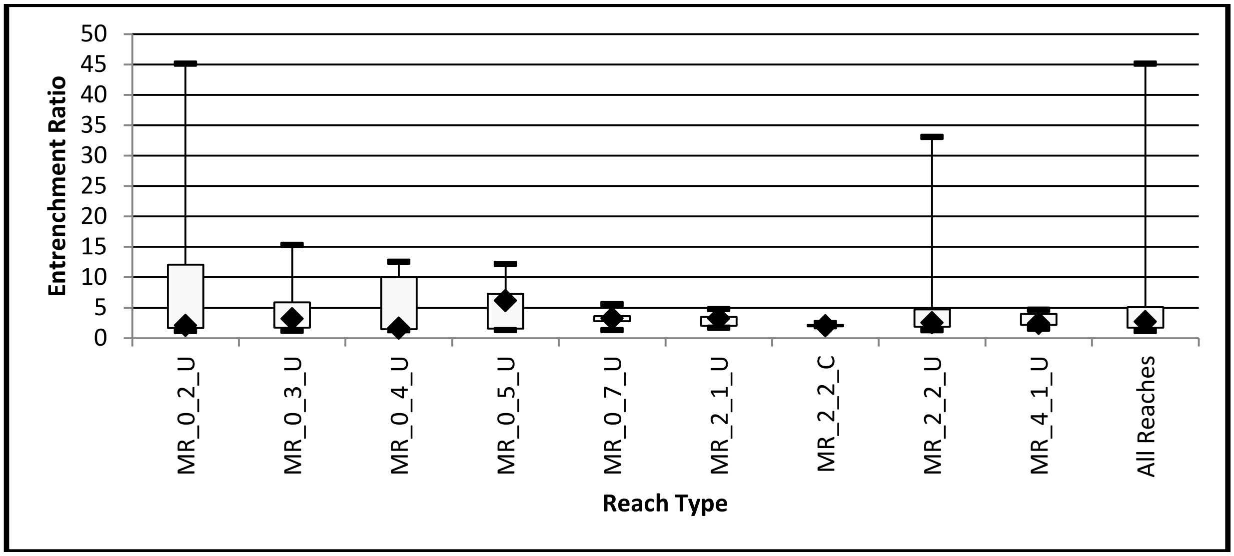

Figure C-5. Entrenchment Ratio.

Table C-5. Entrenchment Ratio.

	Reach Types									
Statistic	**MR_0_2_U**	**MR_0_3_U**	**MR_0_4_U**	**MR_0_5_U**	**MR_0_7_U**	**MR_2_1_U**	**MR_2_2_C**	**MR_2_2_U**	**MR_4_1_U**	**All Reaches**
Number of Reaches	7	3	2	3	7	1	1	5	2	32
Sample Size	34	14	8	13	17	5	5	25	8	129
Minimum	1.16	1.21	1.29	1.31	1.31	1.71	1.95	1.3	1.56	1.16
25th Percentile	1.65	1.7	1.47	1.58	2.77	2.03	1.95	1.73	2.22	1.74
Median	2.09	3.19	1.64	6.17	3.24	3.25	2.04	2.14	2.43	2.71
Mean	8.52	4.30	5.60	5.38	3.34	3.05	2.12	5.21	3.04	5.44
75th Percentile	12.06	5.87	10.09	7.3	3.61	3.5	2.18	3.15	4	5.07
Maximum	45.12	15.33	12.55	12.19	5.59	4.78	2.49	33.1	4.67	45.12

C3.2.1.3 Riffle Pebble Count <2mm

Percent surface fine sediment provides a good measure of the siltation occurring in a river system. Surface fine sediment measured using the Wolman (1954) pebble count method is one indicator of aquatic habitat condition and can signify excessive sediment loading. The Wolman pebble count provides a survey of the particle distribution of the entire channel width, allowing investigators to calculate a percentage of the surface substrate (as frequency of occurrence) composed of fine sediment.

Figure C-6 illustrates the distribution of values for substrate size < 2mm from riffle pebble count among reach types. Mean values for the percent of fine sediment <2mm based on riffle pebble counts ranged from 14% in MR_0_4_U to 43% in MR_4_1_U (**Table C-6**). Reaches documented as an E Rosgen channel type were removed from this analysis because E channels inherently have a higher percentage of fine sediment.

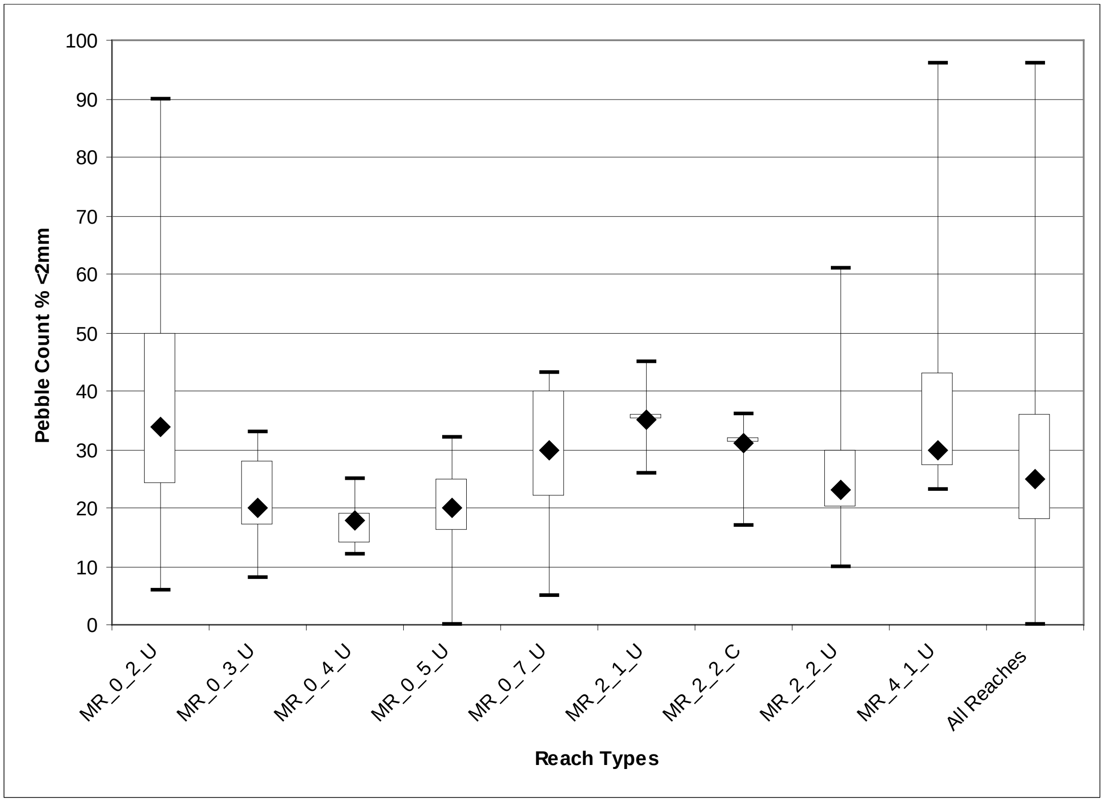

Figure C-6. Riffle Pebble Count <2mm.

Table C-6. Riffle Pebble Count <2mm

	Reach Types									
Statistic	**MR_0_2_U**	**MR_0_3_U**	**MR_0_4_U**	**MR_0_5_U**	**MR_0_7_U**	**MR_2_1_U**	**MR_2_2_C**	**MR_2_2_U**	**MR_4_1_U**	**All Reaches**
Number of Reaches	5	3	1	3	5	1	1	4	2	26
Sample Size	20	12	4	13	9	4	4	16	8	90
Minimum	6	8	12	0	5	26	17	10	23	0
25th Percentile	16	17	12	16	22	35	31	23	27	17
Median	33	20	12	20	30	35	31	25	30	25
Mean	41	21	14	18	28	36	29	29	43	30
75th Percentile	55	28	14	25	40	36	32	33	43	36
Maximum	90	33	18	32	43	45	36	61	96	96

C3.2.1.4 Riffle Pebble Count <6mm

As with surface fine sediment <2mm, an accumulation of surface fine sediment <6mm may indicate excess sedimentation and be detrimental to coldwater fish spawning. **Figure C-7** illustrates the distribution of values for surface fine sediment < 6mm from riffle pebble counts. Mean values for the percent of fine sediment <6mm based on pebble counts conducted in riffles ranged from 25% in MR_0_5_U to 79% in MR_2_1_U (**Table C-7**). The smallest order streams, even those with relatively high stream gradient, had high percent fines < 6mm compared to larger streams; this trend is unexpected for headwaters streams. Reaches documented as an E Rosgen channel type were removed from this analysis because E channels inherently have a higher percentage of fine sediment.

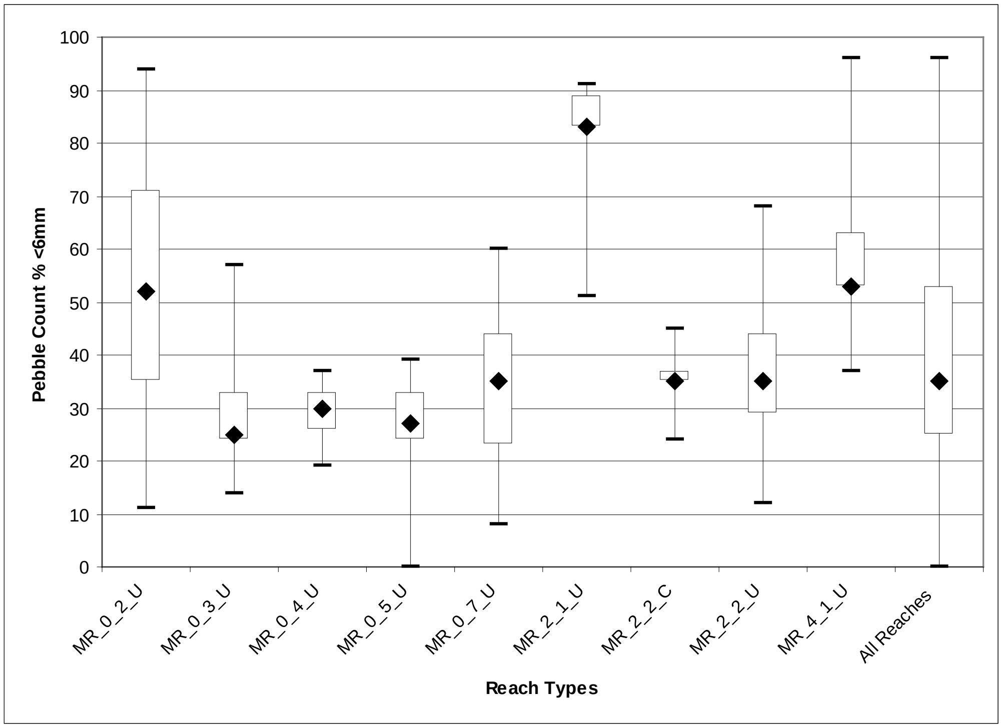

Figure C-7. Riffle Pebble Count %<6mm.

Table C-7. Riffle Pebble Count %<6mm.

	Reach Types									
Statistic	**MR_0_2_U**	**MR_0_3_U**	**MR_0_4_U**	**MR_0_5_U**	**MR_0_7_U**	**MR_2_1_U**	**MR_2_2_C**	**MR_2_2_U**	**MR_4_1_U**	**All Reaches**
Number of Reaches	5	3	1	3	5	1	1	4	2	26
Sample Size	20	12	4	13	9	4	4	16	8	90
Minimum	11	14	19	0	8	51	24	12	37	0
25th Percentile	30	24	23	24	23	83	35	31	53	25
Median	44	25	23	27	35	83	35	37	53	36
Mean	53	30	28	25	33	79	35	40	61	41
75th Percentile	71	33	33	33	44	89	37	54	63	53
Maximum	94	57	37	39	60	91	45	68	96	96

C3.2.1.5 Riffle Grid Toss %<6mm

The riffle grid toss is a standard procedure frequently used in aquatic habitat assessment that provides complimentary information to the Wolman pebble count. **Figure C-8** illustrates the distribution of values for substrate < 6mm from riffle grid toss. Mean values for riffle grid toss fine sediment <6mm range from 0% in MR_0_7_U to 23.5% in MR_0_2_U **(Table C-8).** Reaches documented as an E Rosgen channel type were removed from this analysis because E channels inherently have a higher percentage of fine sediment.

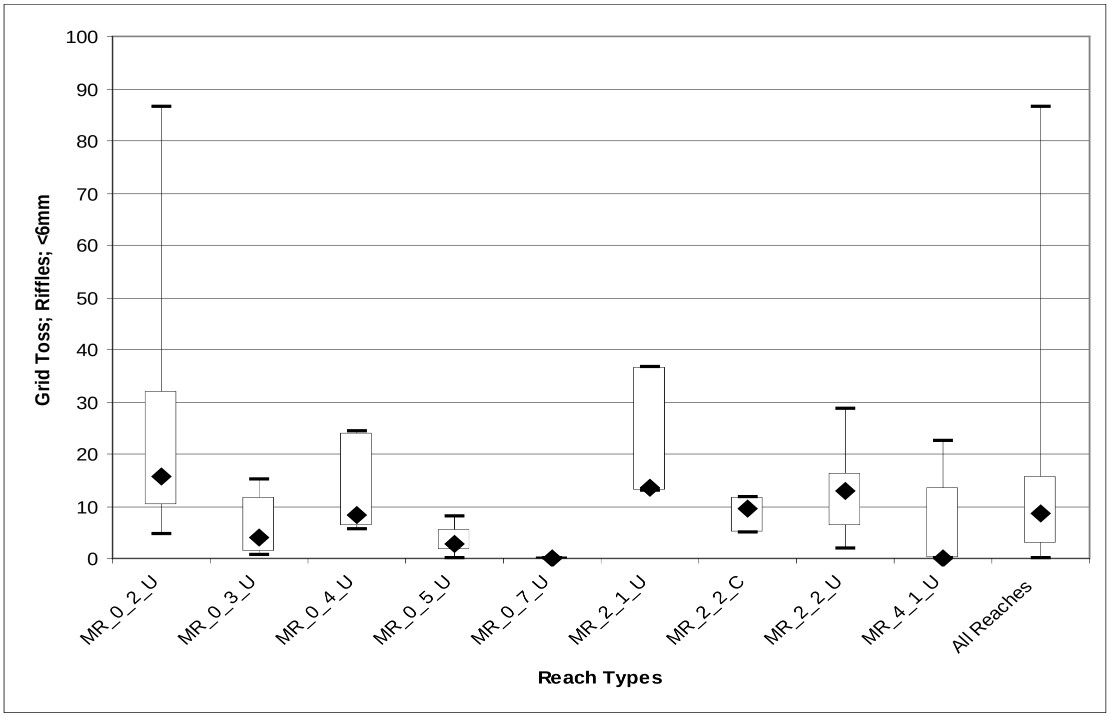

Figure C-8. Riffle Grid Toss Fine Sediment %<6mm.

Table C-8. Riffle Grid Toss Fine Sediment %<6mm

	Reach Types									
Statistic	**MR_0_2_U**	**MR_0_3_U**	**MR_0_4_U**	**MR_0_5_U**	**MR_0_7_U**	**MR_2_1_U**	**MR_2_2_C**	**MR_2_2_U**	**MR_4_1_U**	**All Reaches**
Number of Reaches	5	3	1	3	2	1	1	4	2	23
Sample Size	15	9	3	9	4	3	3	12	7	65
Minimum	0.7	0.7	18.3	0	0	12.9	4.8	2	0	0
25th Percentile	6.4	1.3	18.3	1.4	0	12.9	4.8	6.5	0	2
Median	13.6	4	24	2.7	0	13.4	9.5	12.9	0	7.5
Mean	23.5	6.1	22.2	3.3	0	21	8.6	12.7	5.5	12.1
75th Percentile	32.7	11.6	24.4	5.4	0	36.7	11.6	16.3	13.6	15.2
Maximum	86.4	15.2	24.4	8.1	0	36.7	11.6	28.6	22.4	86.4

C3.2.1.6 Pool Tail-out Grid Toss % <6mm

Grid toss measurements in pool tail-outs provide a measure of fine sediment accumulation in potential spawning sites, which may have detrimental impacts on aquatic habitat by cementing spawning gravels, preventing flushing of toxins in egg beds, reducing oxygen and nutrient delivery to eggs and embryos, and impairing emergence of fry (Meehan, 1991). Weaver and Fraley (1991) observed a significant inverse relationship between the percentage of material less than 6.35mm and the emergence success of westslope cutthroat trout and bull trout.

Figure C-9 illustrates the distribution of values for substrate < 6mm from pool tail-out grid toss among reach types. Mean values for pool tail-out grid toss fine sediment <6mm range from 9.8% in MR_2_2_C to 86.6% in MR_2_1_U **(Table C-9**). Reaches documented as an E Rosgen channel type were removed from this analysis because E channels inherently have a higher percentage of fine sediment.

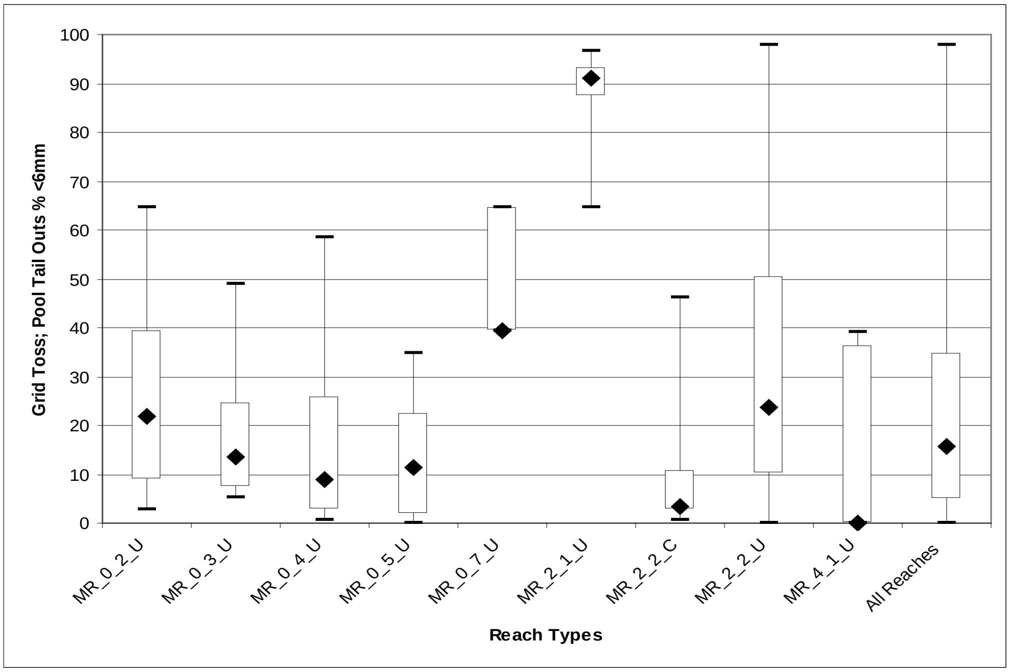

Figure C-9. Pool Tail-out Grid Toss % <6mm.

Table C-9. Grid Toss; Pool Tail Outs: <6mm

	Reach Types									
Statistic	**MR_0_2_U**	**MR_0_3_U**	**MR_0_4_U**	**MR_0_5_U**	**MR_0_7_U**	**MR_2_1_U**	**MR_2_2_C**	**MR_2_2_U**	**MR_4_1_U**	**All Reaches**
Number of Reaches	5	3	1	3	1	1	1	4	2	22
Sample Size	17	19	9	23	2	5	9	29	10	123
Minimum	2.7	5.1	0.7	0	39.4	64.6	0.7	0	0	0
25th Percentile	11.1	7.5	1.3	2	39.4	87.4	2.7	10.2	0	4.7
Median	19.7	13.6	2.7	11.5	39.4	91.1	3.4	28.6	0	14.3
Mean	23.6	17.8	5.8	13.1	52	86.6	9.8	35	17.7	23.6
75th Percentile	30.6	24.5	8.8	22.4	64.6	93.2	10.9	51.7	36.4	31.3
Maximum	64.6	49	22.4	34.7	64.6	96.6	46.2	98	39	98

C3.2.1.7 Residual Pool Depth

Residual pool depth, defined as the difference between the maximum depth and the tail crest depth, is a discharge-independent measure of pool depth and an indicator of the quality of pool habitat. Deep pools are important resting and hiding habitat for fish, and provide refugia during temperature extremes and high flow periods. Residual pool depth is also an indirect measurement of sediment inputs to streams because an increase in sediment loading can cause pools to fill, thus decreasing residual pool depth over time.

Figure C-10 illustrates the distribution of values for residual pool depth among reach types. Mean residual pool depths ranged from 0.4 feet in MR_2_1_U to 1.5 feet in MR_0_4_U (**Table C-10**). In general, residual pool depths were greater for reaches on lower-gradient, larger streams, as would be expected.

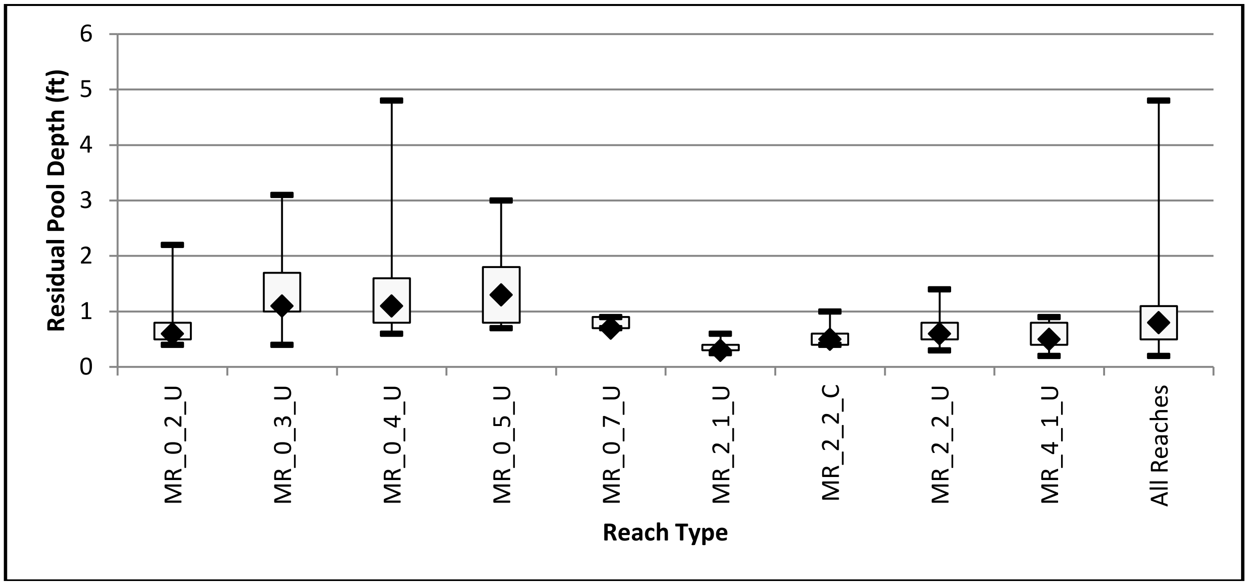

Figure C-10. Residual Pool Depth.

Table C-10. Residual Pool Depth.

	Reach Types									
Statistic	**MR_0_2_U**	**MR_0_3_U**	**MR_0_4_U**	**MR_0_5_U**	**MR_0_7_U**	**MR_2_1_U**	**MR_2_2_C**	**MR_2_2_U**	**MR_4_1_U**	**All Reaches**
Number of Reaches	7	3	2	3	1	1	1	5	2	26
Sample Size	34	28	20	30	2	12	12	53	14	205
Minimum	0.4	0.4	0.6	0.7	0.7	0.25	0.4	0.3	0.2	0.2
25th Percentile	0.5	1	0.8	0.8	0.7	0.3	0.4	0.5	0.4	0.5
Median	0.6	1.1	1.1	1.3	0.7	0.3	0.5	0.6	0.5	0.8
Mean	0.8	1.4	1.5	1.4	0.8	0.4	0.6	0.7	0.6	0.9
75th Percentile	0.8	1.7	1.6	1.8	0.9	0.4	0.6	0.8	0.8	1.1
Maximum	2.2	3.1	4.8	3	0.9	0.6	1	1.4	0.9	4.8

C3.2.1.8 Pool Frequency

Pool frequency is a measure of the availability of pools to provide rearing habitat, cover, and refugia for salmonids. Pool frequency is related to channel complexity, availability of stable obstacles, and sediment supply. Excessive erosion and sediment deposition can reduce pool frequency by filling in smaller pools. Pool frequency can also be adversely affected by riparian habitat degradation resulting in a reduced supply of large woody debris or less scouring from stable root masses in streambanks.

Figure C-11 illustrates the distribution of values for pool frequency among reach types. The mean value for the number of pools per 1,000 feet ranged from one in MR_0_7_U to 24 in MR_2_2_C and MR_2_1_U (**Table C-11**). In the Beaverhead watershed, pool frequency was notably higher in reach types with 2-4% slope than in reach types of higher or lower slope; however, it should be noted that pools were not measured using the standard protocols on many of the reaches on the Beaverhead River, which results in a sample size of one for reach type MR_0_7_U.

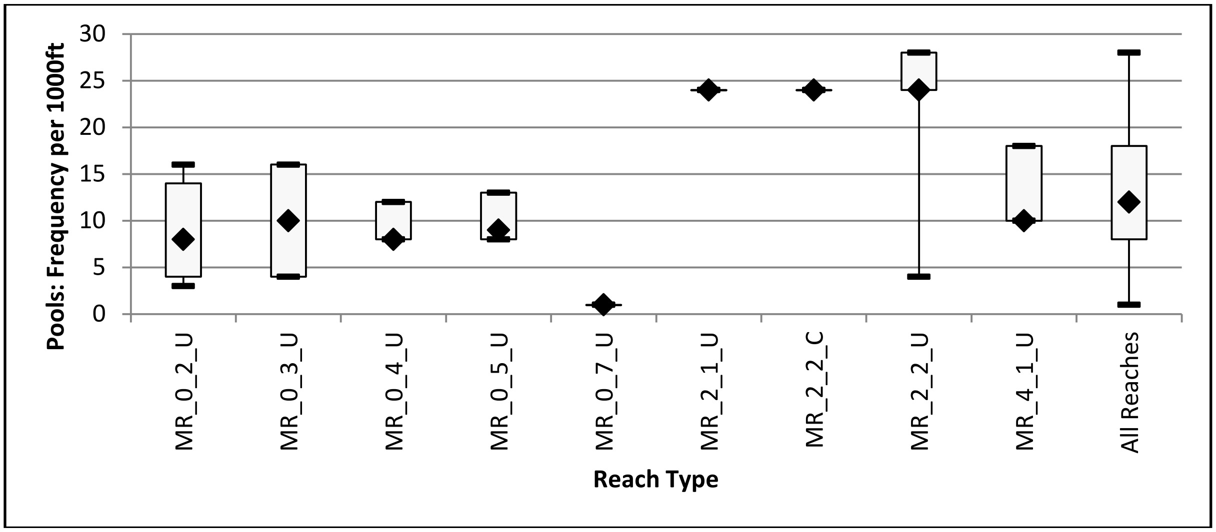

Figure C-11. Pools per 1000 Feet.

Table C-11. Pools per 1000 feet.

	Reach Types									
Statistic	**MR_0_2_U**	**MR_0_3_U**	**MR_0_4_U**	**MR_0_5_U**	**MR_0_7_U**	**MR_2_1_U**	**MR_2_2_C**	**MR_2_2_U**	**MR_4_1_U**	**All Reaches**
Number of Reaches	7	3	2	3	1	1	1	5	2	26
Sample Size*	7	3	2	3	1	1	1	5	2	25
Minimum	3	4	8	8	1	24	24	4	10	1
25th Percentile	4	4	8	8	1	24	24	24	10	8
Median	8	10	8	9	1	24	24	24	10	12
Mean	9	10	10	10	1	24	24	22	14	13
75th Percentile	14	16	12	13	1	24	24	28	18	18
Maximum	16	16	12	13	1	24	24	28	18	28

*Sample sizes for pool frequency are lower than for pool residual depth because pool frequency is a metric calculated for the entire reach; thus, for certain reach types in which only one reach was assessed the sample size is 1.

C3.2.1.9 Large Woody Debris Frequency

Large woody debris (LWD) is a critical component of high-quality salmonid habitat, providing habitat complexity, quality pool habitat, cover, and long-term nutrient inputs. LWD also constitutes a primary influence on stream function, including sediment and organic material transport, channel form, bar formation and stabilization, and flow dynamics (Bilby and Ward, 1989). LWD frequency can be measured and compared to reference reaches or literature values to determine if more or less LWD is present than would be expected under optimal conditions.

Figure C-12 illustrates the distribution of values for LWD frequency among reach types. The mean value for the amount of LWD per 1,000 feet ranged from two in MR_2_1_U to 54 in MR_2_2_C **(Table C-12).** LWD per mile is provided in **Table C-13**. LWD was not tallied on some reach types, specifically the non-wadeable reaches on the Beaverhead River. “Willow bunches” recorded in the field were not tallied with large woody debris; thus, these results do not include reaches in which the only LWD recorded were willow bunches.

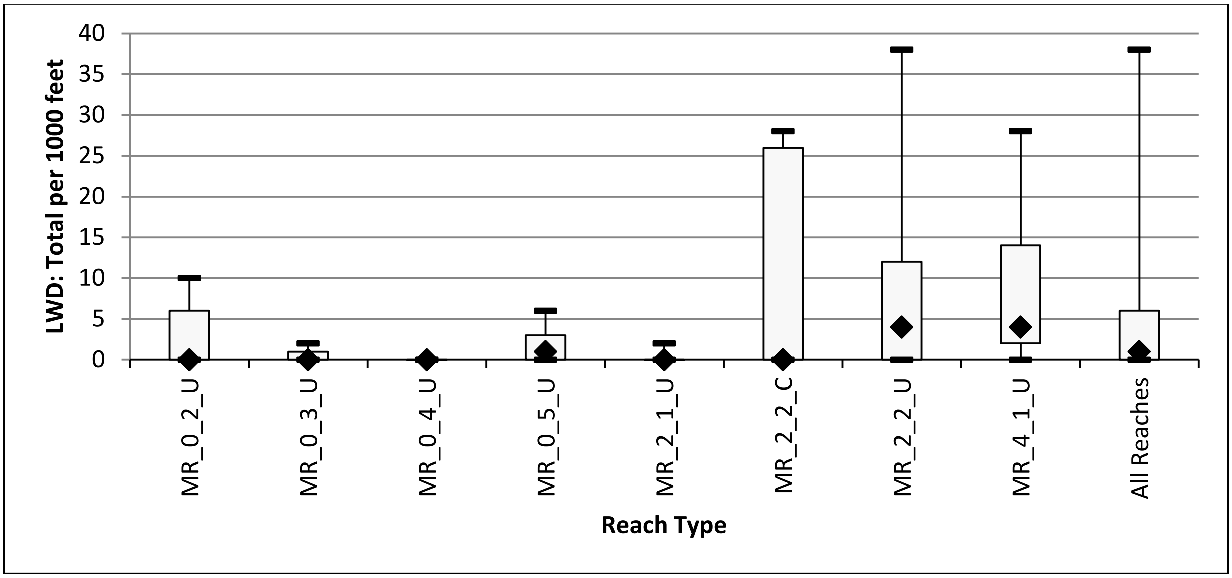

Figure C-12. Large Woody Debris per 1000 Feet.

Table C-12. Large Woody Debris per 1000 Feet.

	Reach Types								
Statistic	**MR_0_2_U**	**MR_0_3_U**	**MR_0_4_U**	**MR_0_5_U**	**MR_2_1_U**	**MR_2_2_C**	**MR_2_2_U**	**MR_4_1_U**	**All Reaches**
Number of Reaches	3	2	2	3	1	1	4	2	19
Sample Size	11	10	6	6	5	4	15	10	67
Minimum	0	0	0	0	0	0	0	0	0
25th Percentile	0	0	0	0	0	0	0	2	0
Median	0	0	0	1	0	0	4	4	1
Mean	3	0.5	0	2	0.4	14	10	9	5
75th Percentile	6	1	0	3	0	26	12	14	6
Maximum	10	2	0	6	2	28	38	28	38

Table C-13. Large Woody Debris per Mile.

Statistic	Reach Types								
	MR_0_2_U	**MR_0_3_U**	**MR_0_4_U**	**MR_0_5_U**	**MR_2_1_U**	**MR_2_2_C**	**MR_2_2_U**	**MR_4_1_U**	**All Reaches**
Number of Reaches	1	2	0	2	1	1	3	2	12
Sample Size	1	2	0	2	1	1	3	2	12
Minimum	0	0	0	0	0	0	0	0	0
25th Percentile	0	0	0	1	0	0	0	11	0
Median	0	0	0	11	0	69	21	26	0
Mean	14	3	0	11	2	71	51	50	0
75th Percentile	26	5	0	16	0	140	58	74	32
Maximum	53	11	0	32	10.56	148	201	147	201

C3.2.1.10 Greenline Understory Shrub Cover

Riparian shrub cover is one of the most important influences on streambank stability. Removal of riparian shrub cover can dramatically increase streambank erosion and increase channel width/depth ratios. Shrubs stabilize streambanks by holding soil and armoring lower banks with their roots, and reduce scouring energy of water by slowing flows with their branches.

Good riparian shrub cover is also important for fish habitat. Riparian shrubs provide shade, reducing solar inputs and increases in water temperature. The dense network of fibrous roots of riparian shrubs allows streambanks to remain intact while water scours the lowest portion of streambanks, creating important fish habitat in the form of overhanging banks and lateral scour pools. Overhanging branches of riparian shrubs provide important cover for aquatic species. In addition, riparian shrubs provide critical inputs of food for fish and their feed species. Terrestrial insects falling from riparian shrubs provide one of the main food sources for fish. Organic inputs from shrubs, such as leaves and small twigs, provide food for aquatic macroinvertebrates, which are also an important food source for fish.

Figure C-13 illustrates the distribution of values greenline understory shrub cover among reach types. The mean value for greenline understory shrub cover ranged from 17% in MR_0_2_U to 70% in MR_2_2_C (**Table C-14**).

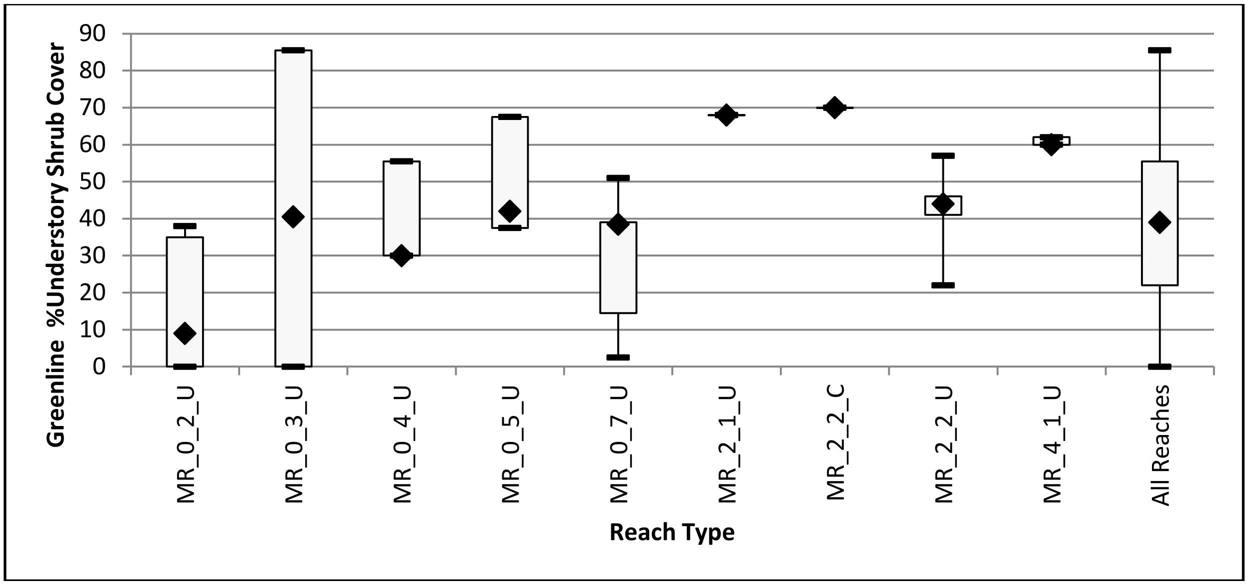

Figure C-13. Greenline % Understory Shrub Cover.

Table C-14. Greenline % Understory Shrub Cover

	Reach Types									
Statistic	**MR_0_2_U**	**MR_0_3_U**	**MR_0_4_U**	**MR_0_5_U**	**MR_0_7_U**	**MR_2_1_U**	**MR_2_2_C**	**MR_2_2_U**	**MR_4_1_U**	**All Reaches**
Number of Reaches	7	3	2	3	5	1	1	5	2	30
Sample Size	7	3	2	3	5	1	1	5	2	29
Minimum	0	0	30	37.5	2.5	68	70	22	60	0
25th Percentile	0	0	30	37.5	14.5	68	70	41	60	22
Median	9	40.5	30	42	38.5	68	70	44	60	39
Mean	17	42	42.8	49	29.1	68	70	42	33.3	37.6
75th Percentile	35	85.5	55.5	67.5	39	68	70	46	62	55.5
Maximum	38	85.5	55.5	67.5	51	68	70	57	62	85.5

C3.2.1.11 Greenline Bare Ground

Percent bare ground is an important indicator of erosion potential, as well as an indicator of land management influences on riparian habitat. Bare ground was noted in the greenline inventory in cases where recent ground disturbance has resulted in exposed bare soil. Bare ground is often caused by trampling from livestock or wildlife, fallen trees, recent bank failure, new sediment deposits from overland or overbank flow, or severe disturbance in the riparian area, such as from past mining, road-building, or fire. Ground cover on streambanks is important to prevent sediment recruitment to stream channels since sediment can wash in from unprotected areas during snowmelt, storm runoff and flooding. Bare areas are also much more susceptible to erosion from hoof shear. Most stream reaches have a small amount of naturally-occurring bare ground. As conditions are highly variable, this measurement is most useful when compared to reference values from best available conditions within the study area or literature values.

Figure C-14 illustrates the distribution of values for bare ground among reach types. The mean value for greenline bare ground ranged from 5% in MR_0_7_U to 21.3% in MR_0_4_U (**Table C-15**). Reach type MR_0_7_U represents many of the reaches on the lower Beaverhead River, which generally supported dense cover of riparian graminoid (grass-like) species or shrubs.

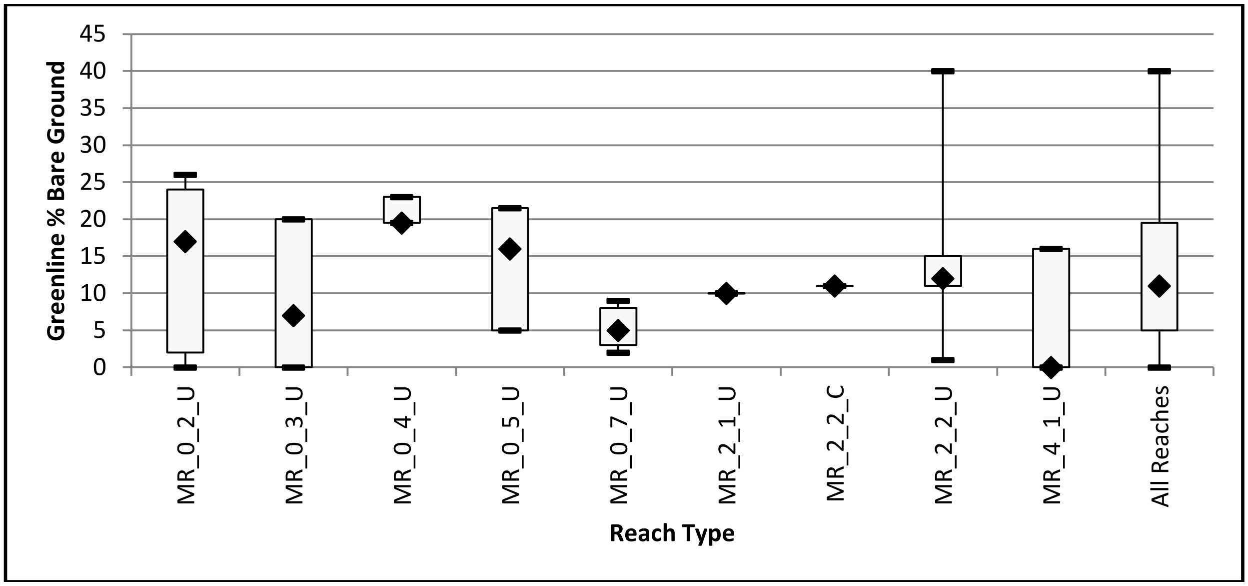

Figure C-14. Greenline Bare Ground.

Table C-15. Greenline Bare Ground.

	Reach Types									
Statistic	**MR_0_2_U**	**MR_0_3_U**	**MR_0_4_U**	**MR_0_5_U**	**MR_0_7_U**	**MR_2_1_U**	**MR_2_2_C**	**MR_2_2_U**	**MR_4_1_U**	**All Reaches**
Number of Reaches	7	3	2	3	5	1	1	5	2	30
Sample Size	7	3	2	3	5	1	1	5	2	29
Minimum	0	0	19.5	5	2	10	11	1	0	0
25th Percentile	2	0	19.5	5	3	10	11	11	0	5
Median	17	7	19.5	16	5	10	11	12	0	11
Mean	14.6	9	21.3	14.2	5.4	10	11	15.8	8	12.3
75th Percentile	24	20	23	21.5	8	10	11	15	16	19.5
Maximum	26	20	23	21.5	9	10	11	40	16	40

C3.2.2 Monitoring Site Analysis

Sediment and habitat data collected at each monitoring site were reviewed individually in the following sections. Monitoring site discussions are based on median values, referencing the box plot statistics shown. Summary statistics for the minimum, 25th percentile, 75th percentile and maximum values are presented graphically, since these may be more applicable for developing sediment TMDL criteria.

Reach STEL 10-01 was a dry channel, so data was not collected aside from field notes. For reach CLKC 18-02, only BEHI data were collected; therefore, this reach does not have data associated with it in several of the following figures. As noted in the previous section, healthy E-type channels often have higher levels of fine sediment than other channel types. Statistics from these channels are included in the following analysis. **Table C-16** outlines reaches by current channel type.

Table C-16 Reaches by Rosgen Stream Type

Existing Rosgen Stream Type	REACH_ID
A	STEL 05-01
B	FREN 23-01
	SCUD 11-01
C	BEAV 04-02
	BEAV 04-05
	BEAV 09-04
	BEAV 09-06
	BEAV 09-14
	BEAV 09-15
	BLKD 02-08
	BLKD 02-14
	BLKD 02-30
	CLKC 18-02
	FARL 28-01
	GRAS 12-01
	RATT 54-04
	STON 22-02
	TAYL 27-01
	WFBK 08-04
E	BEAV 09-11
	DYCE 02-02
	GRAS 20-11
	RESR 11-01
	TAYL 32-01
F	SPRG 31-01
	STON 22-02B
Undetermined	CLKC 19-02
	CLKC 32-01
	RATT 60-04
	STON 05-01
	STON 20-02
	WFDY 17-01

C3.2.2.1 Width/Depth Ratio

The highest median width/depth ratio was observed in BEAV 09-14, a reach in the lower Beaverhead River (**Figure C-15)**. TAYL-32-01, which is a stable E channel on Taylor Creek, had the lowest width/depth ratio. Width/depth ratio did not show a trend increasing from upstream to downstream sites on streams in the Beaverhead TPA.

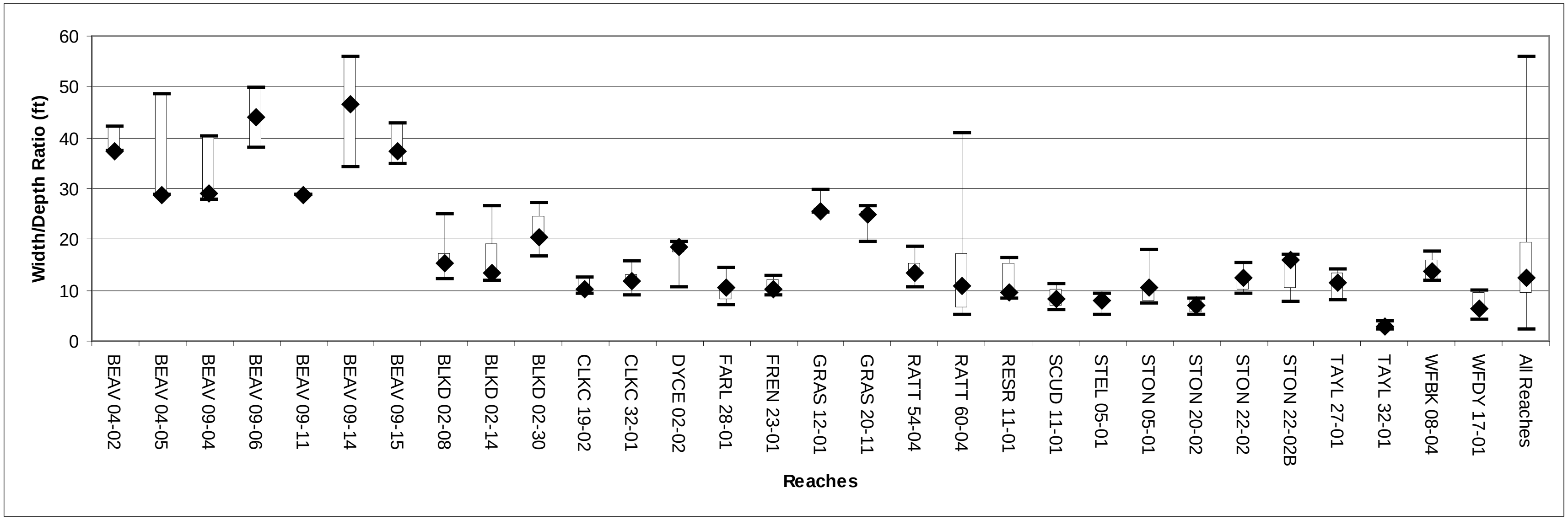

Figure C-15. Width/Depth Ratio.

C3.2.2.2 Entrenchment Ratio

Entrenchment ratio data collected within the Beaverhead River TPA indicates the following (**Figure C-16**):

1. TAYL 32-01 has the greatest amount of floodplain access out of the sites assessed. This reach also had the lowest width/depth ratio (**Figure C-16**).
2. Variation in entrenchment ratio was generally low within reaches.

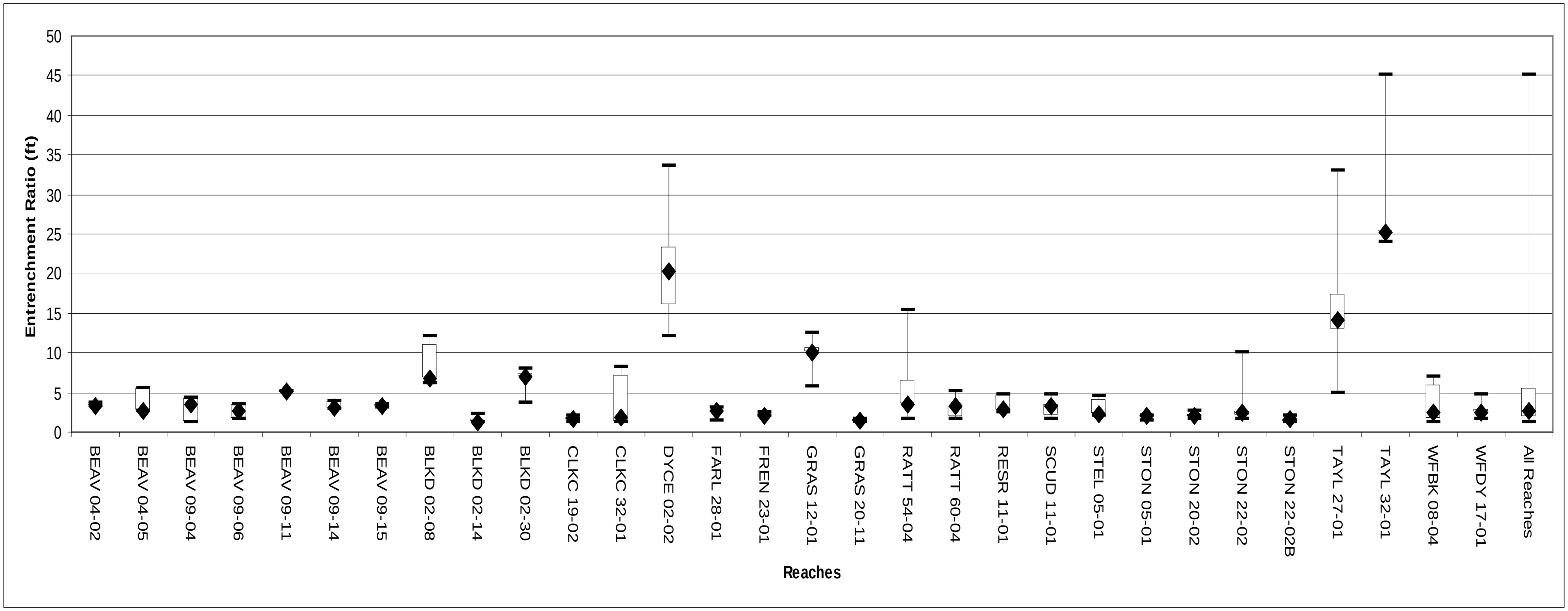

Figure C-16. Entrenchment Ratio.

C3.2.2.3 Riffle Pebble Count <2mm

The median percent of fine sediment in riffles <2mm as measured by a pebble count was highest in STON 22-02, and all STON reaches had relatively high fine sediment <2mm compared to other reaches. (**Figure C-17**).

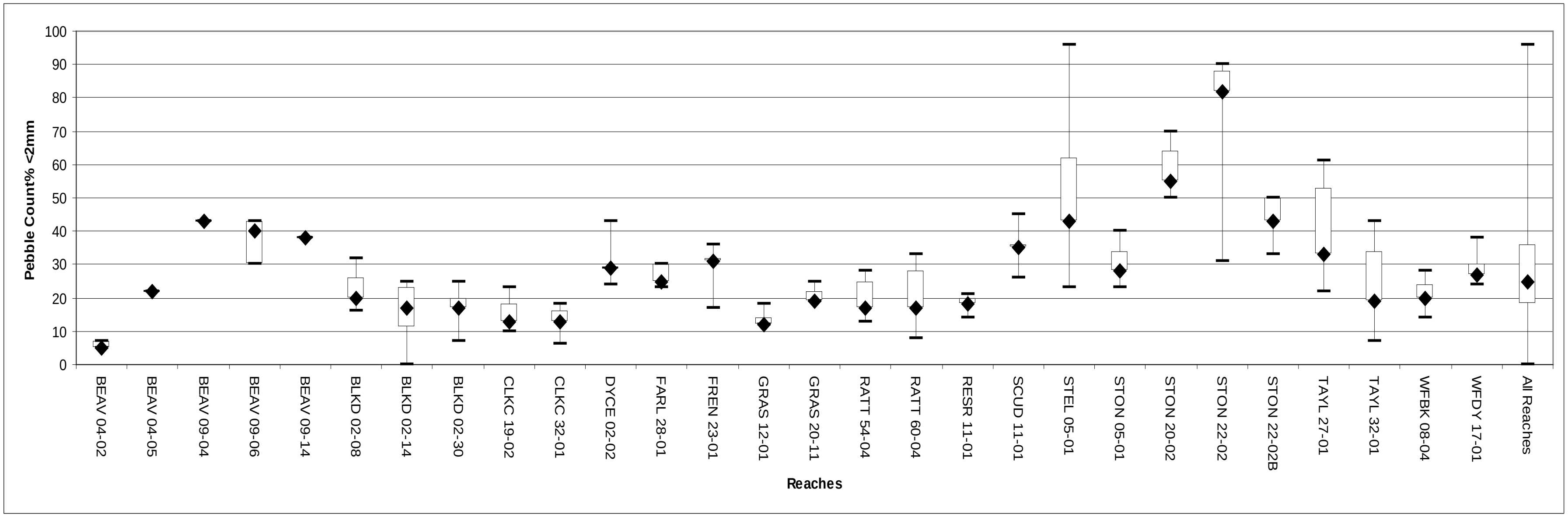

Figure C-17. Riffle Pebble Count <2mm

C3.2.2.4 Riffle Pebble Count <6mm

The percent of fine sediment in riffles <6mm as measured by a pebble count followed a similar trend as the percent of fine sediment <2mm, with the highest median value in STON 22-02. SCUD 11-01 also demonstrated a high median percentage (**Figure C-18**).

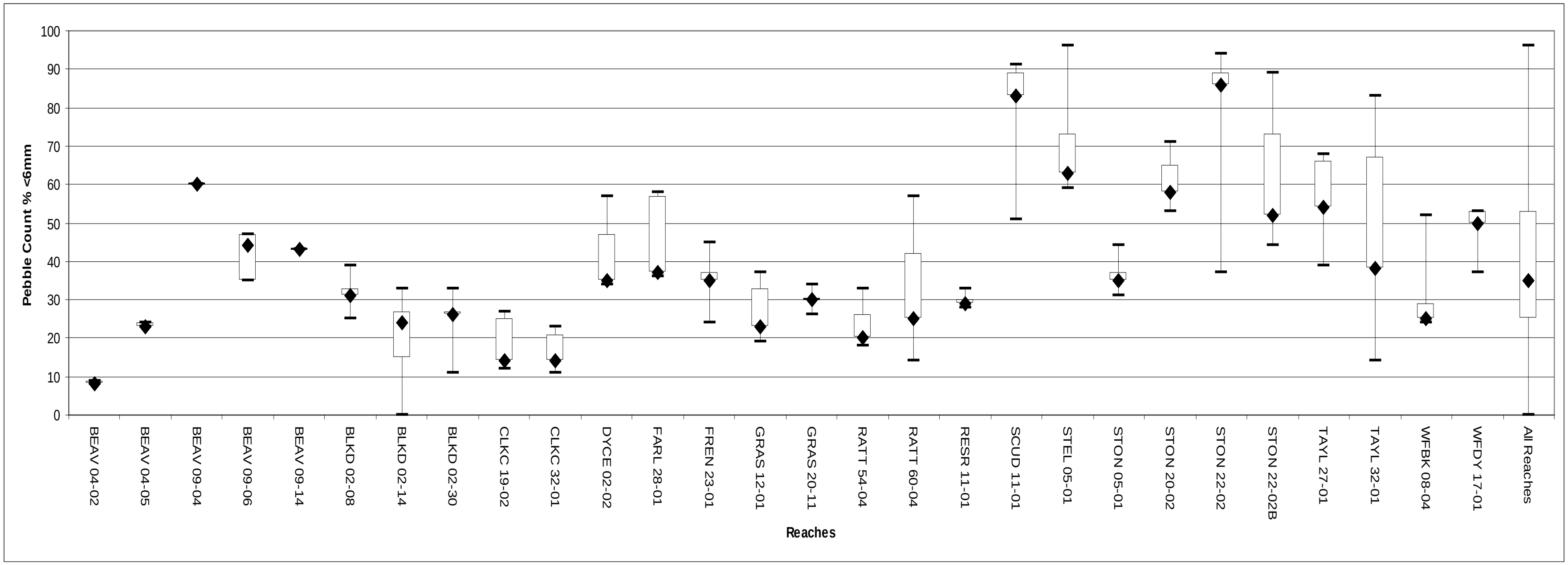

Figure C-18. Riffle Pebble Count <6mm.

C3.2.2.5 Riffle Grid Toss %<6mm

The median percent of fine sediment in riffles <6mm as measured by a grid toss was highest in STON 22-02 (**Figure C-19**). Grid toss was not conducted on most reaches of the Beaverhead River.

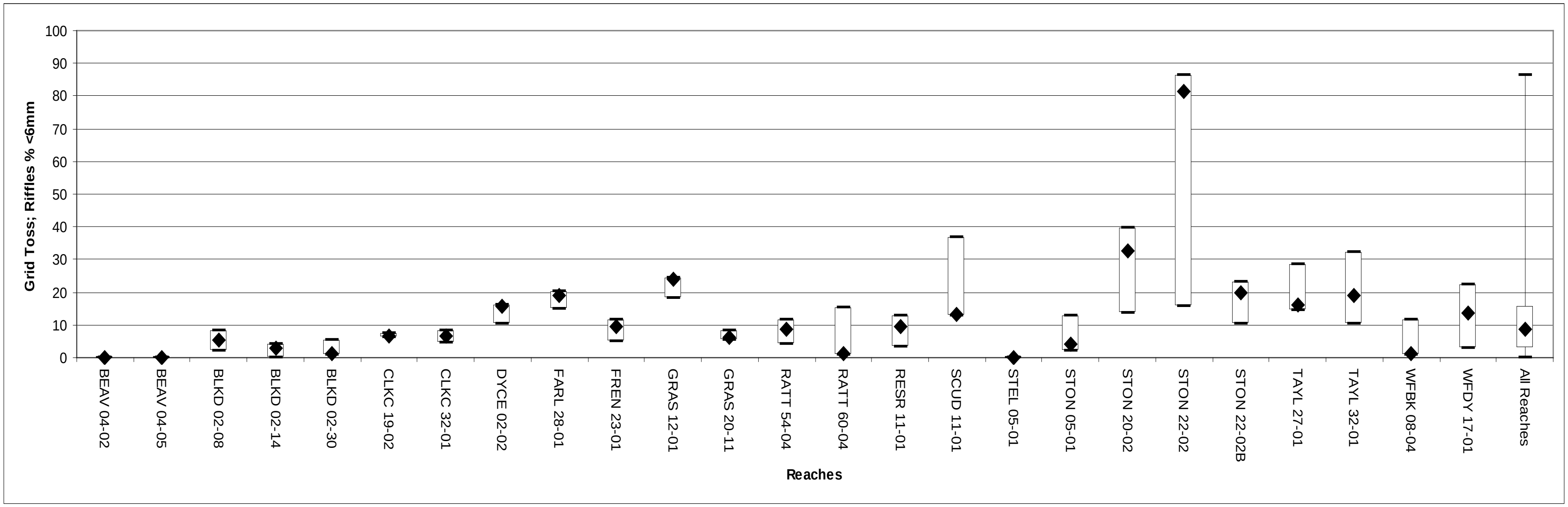

Figure C-19. Riffle Grid Toss %<6mm.

C3.2.2.6 Riffle Stability Index

The mobile percentile of particles on the riffle is termed "Riffle Stability Index" (RSI) and provides a useful estimate of the degree of increased sediment supply to riffles. The RSI addresses situations in which increases in gravel bedload from headwater activities is depositing material on riffles and filling pools, and it reflects qualitative differences between reference and managed watersheds. In the Beaverhead TPA, very few gravel bars were encountered. RSI evaluations were, therefore, only performed in CLKC 19-02, CLKC 32-01, CLKC 32-01, GRAS 12-01 and BLKD 02-14, as outlined in **Table C-17**. The D50 is the median pebble size encountered in the pebble count taken in closest proximity to the gravel bar used for RSI, and is used in calculating the RSI value.

Table C-17. Riffle Stability Index Summary

	Pebble Count Analysis		RSI
	Cell	D50	
CLKC 19-02	3	19	111.56
CLKC 32-01	5	54.5	104.97
CLKC 32-01	1	27	104.97
GRAS 12-01	4	19	79.67
BLKD 02-14	4*	22.6	67.26

* D50 based on median from neighboring cell; no pebble count in cell 4.

C3.2.2.7 Pool Tail-out Grid Toss %<6mm

The median percent of fine sediment in pool tail-outs as measured with the grid toss was highest in SCUD 11-01, with FARL 28-01 only slightly lower. (**Figure C-20**).

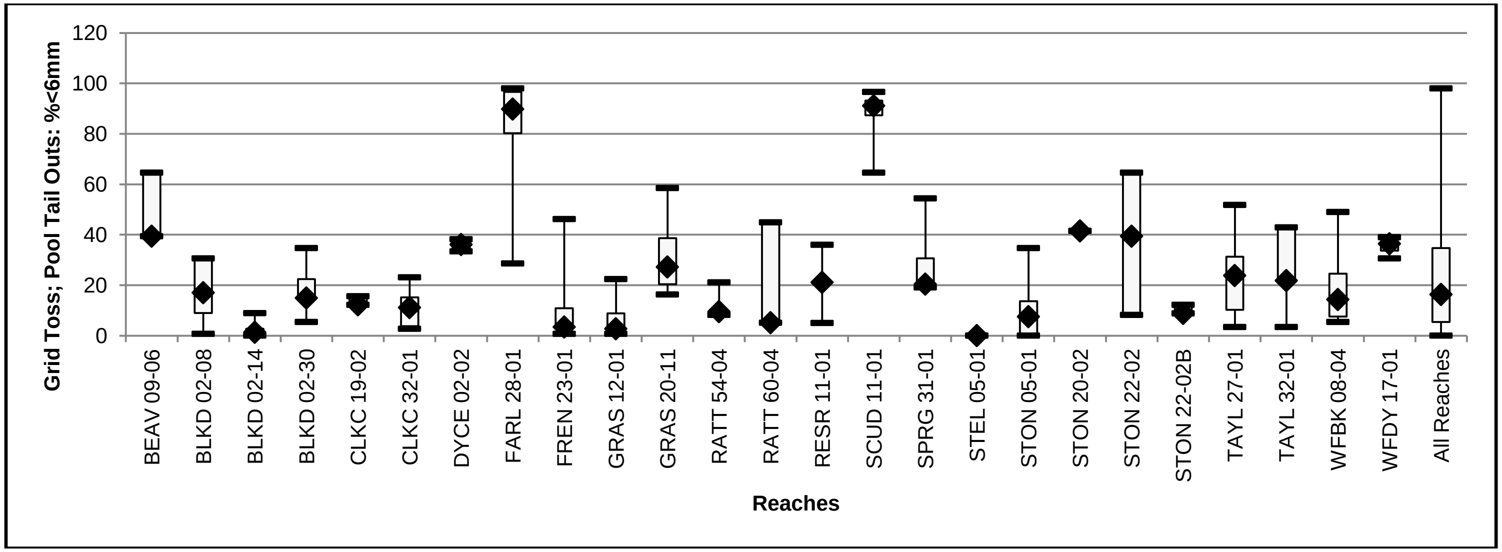

Figure C-20. Pool Tail-out Grid Toss %<6mm.

C3.2.2.8 Residual Pool Depth

The greatest median residual pool depth was measured in BLKD 02-08 (**Figure C-21**). The lowest residual pool depth was found in SCUD 11-01. Residual pool depths do not reliably increase in the downstream direction within the assessed streams, as they do for greater stream orders among reach types, indicating possible degradation of pools in some stream reaches.

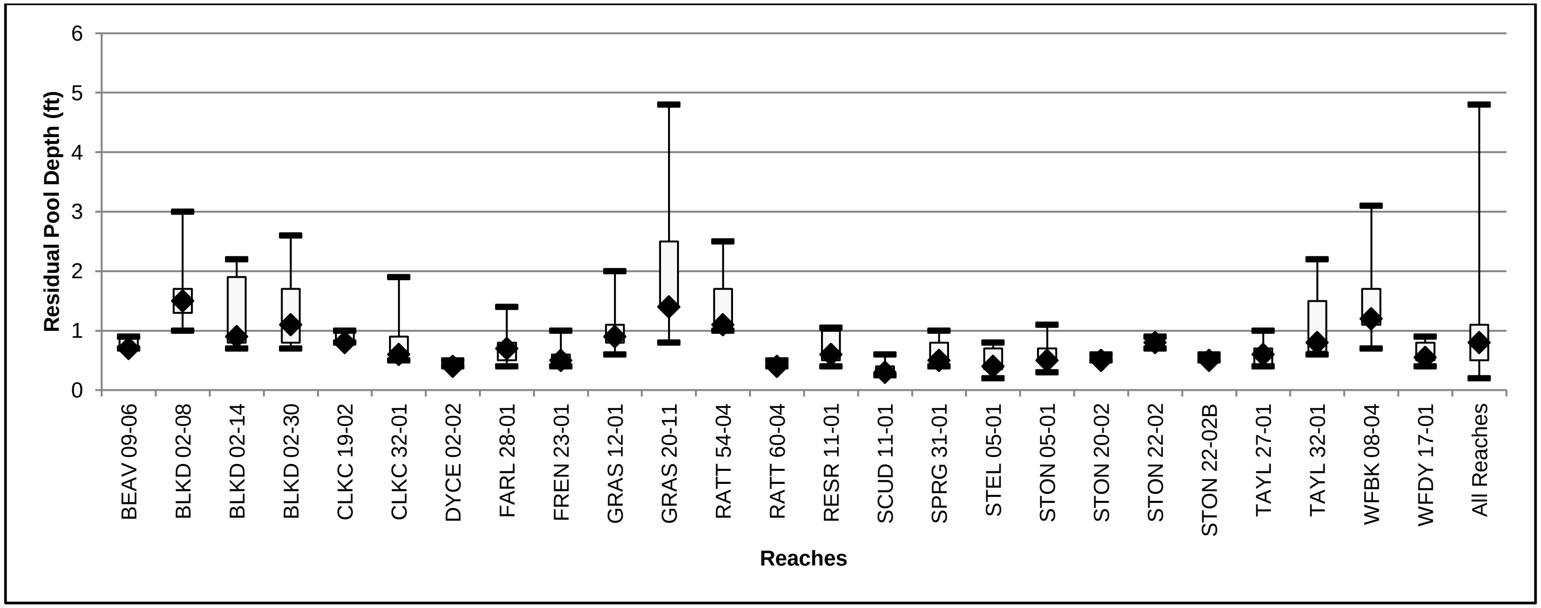

Figure C-21. Residual Pool Depth.

C3.2.2.9 Pool Frequency

The greatest number of pools per 1000 feet was found in FARL 28-01 and TAYL 27-01 (**Figure C-22**). However, FARL 28-01 displayed obvious signs of impairment, such as significant bank erosion and reduced riparian community structure; therefore pool frequency needs to be examined with other parameters in order to assess habitat condition. Pool frequency was not assessed in several reaches, specifically the non-wadeable reaches of the Beaverhead River.

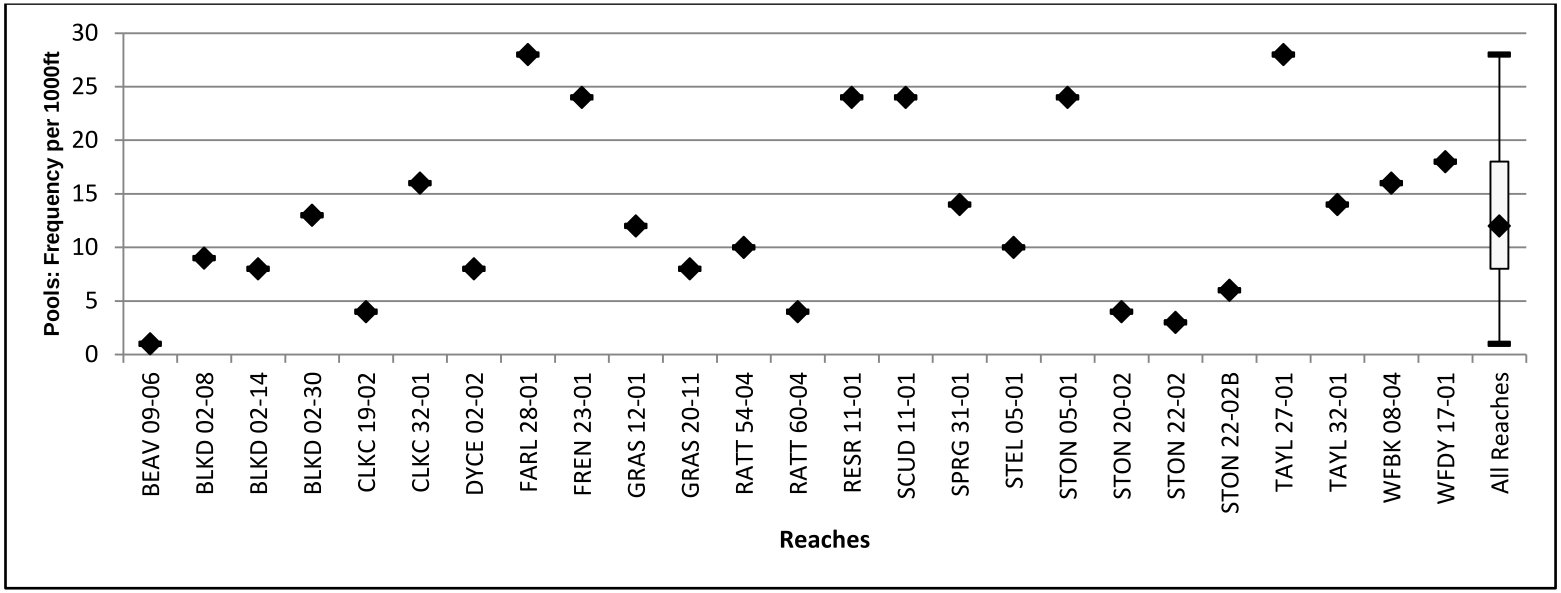

Figure C-22. Pool Frequency.

C3.2.2.10 Large Woody Debris Frequency

The greatest concentration of large woody debris was found in STON 05-01. Large woody debris was not sampled for most of the reaches on the Beaverhead River. (**Figure C-23**).

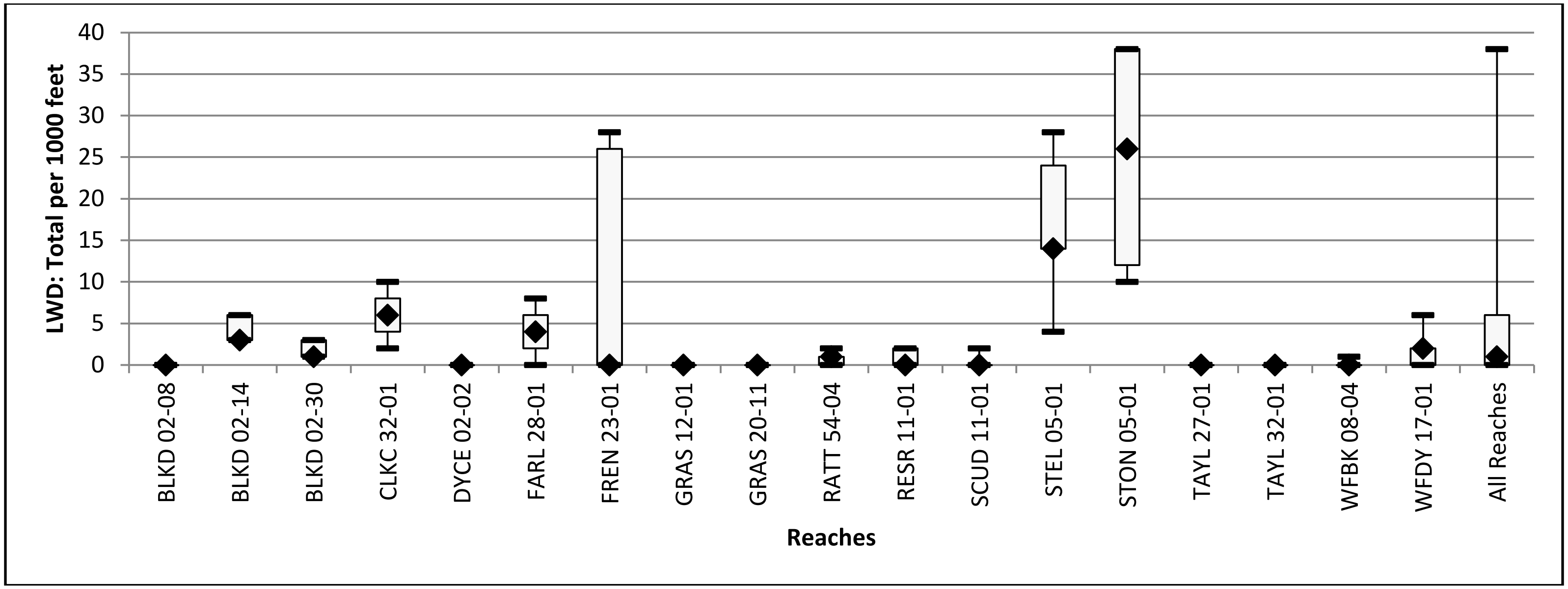

Figure C-23. Large Woody Debris Frequency.

C3.2.2.11 Greenline Understory Shrub Cover

RATT 54_04 had the highest percentage of understory shrub cover at 85.5%. Nineteen of the 33 reaches sampled (58%) had less than 50% shrub cover. Five of the 33 reaches sampled (15%) had less than 20% shrub cover. **(Figure C-24)**

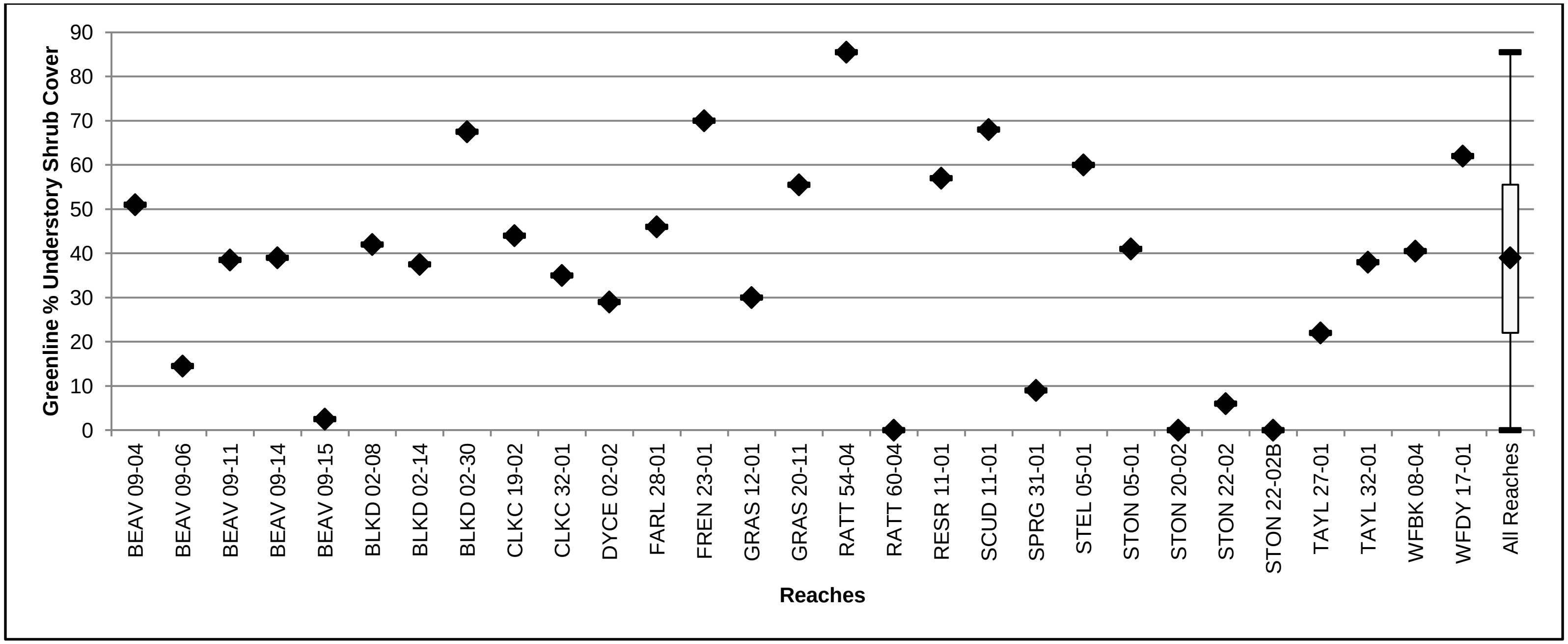

Figure C-24. Greenline Understory Shrub Cover

C3.2.2.12 Greenline Bare Ground

The highest percentage of bare ground was found at CLCK19_02. Six of the 29 sites surveyed (21%) had 20% or more bare ground, while approximately one-third of the reaches had lower than 10% bare ground **(Figure C-25)**.

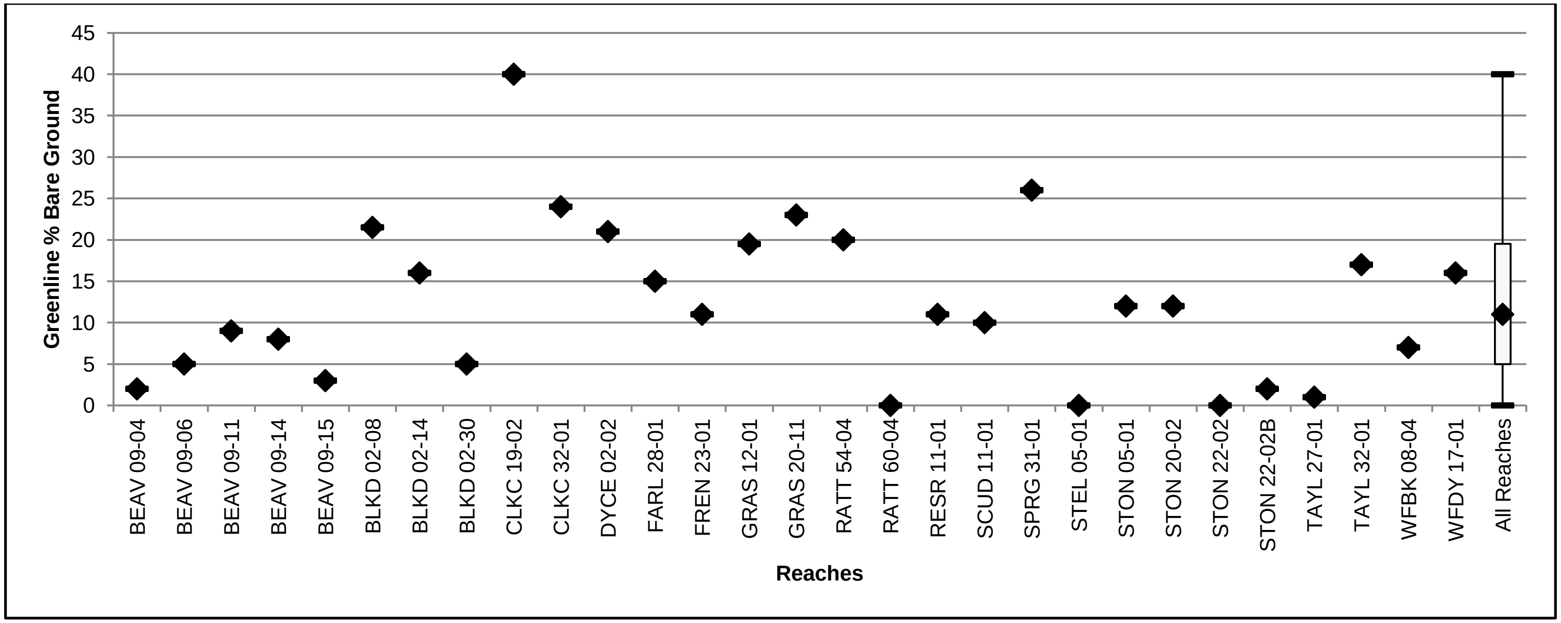

Figure C-25. Greenline Bare Ground

C3.2.2.13 Other Data from Non-Wadeable Reaches

Assessment methods were revised for some measurement variables to allow sampling in non-wadeable reaches. Categorical data for channel substrate collected on non-wadeable reaches of the Beaverhead River are summarized in **Table C-18**. These data provide a general picture of the size class of substrate in assessed non-wadeable reaches, but are not directly comparable to percent fine sediment data collected by Wolman pebble count.

Table C-18. Percent of Substrate by Reach for each Cross-section per Substrate Type

Reach Id	Substrate	% of Substrate			Reach Average
		XS1	XS2	XS3	
BEAV_09_04	Silt / Clay	5	23	1	10
	Sand	60	33	44	45
	Gravel	32	35	31	32
	Cobble	3	9	25	12
BEAV_09_11	Silt / Clay	12	-	-	12
	Sand	60	-	-	60
	Gravel	28	-	-	28
	Cobble	0	-	-	0
BEAV_09_14	Silt / Clay	9	1	20	10
	Sand	42	53	43	46
	Gravel	47	39	29	38
	Cobble	2	7	8	6
BEAV_09_15	Silt / Clay	26	19	15	20
	Sand	45	31	33	36
	Gravel	28	46	46	40
	Cobble	1	4	6	4

Additional data and data summaries for longitudinal profiles and channel cross-sections from non-wadeable reaches are included below (**Figures C26 – C41**). Few trends are evident from the data, but review of the cross-section plots reveals a high proportion of fine sediment in the downstream Beaverhead River reaches, and in some cross-sections of reaches further upstream.

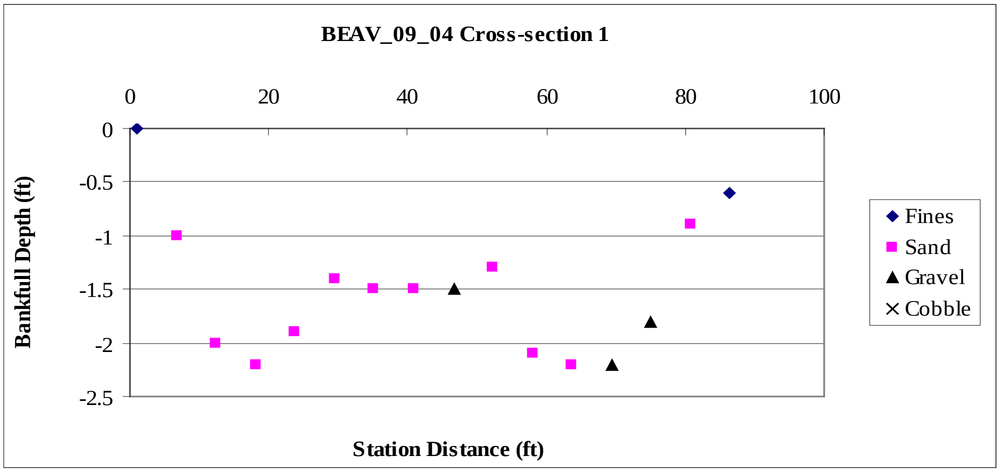

Figure C-26. Cross-Sections for Non-Wadeable Reach BEAV 09-04 XS1

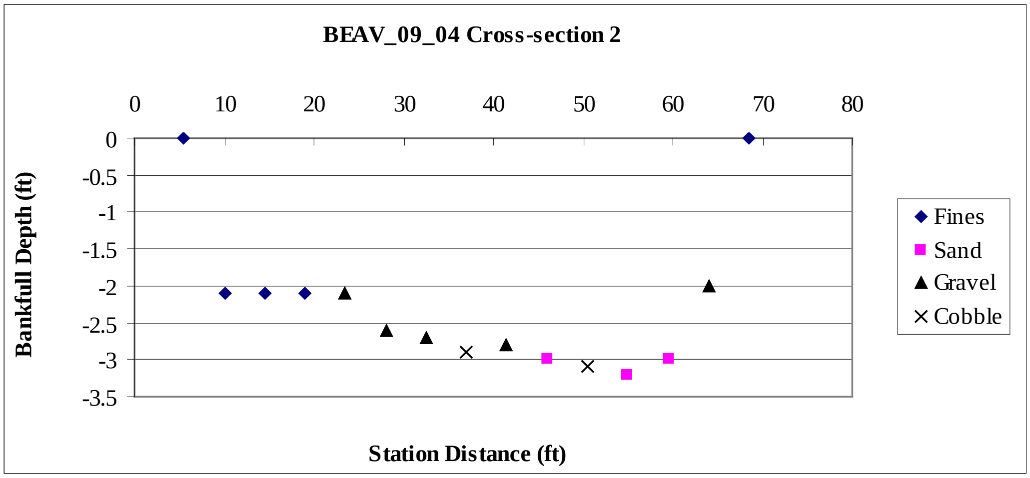

Figure C-27. Cross-Sections for Non-Wadeable Reach BEAV 09-04 XS2

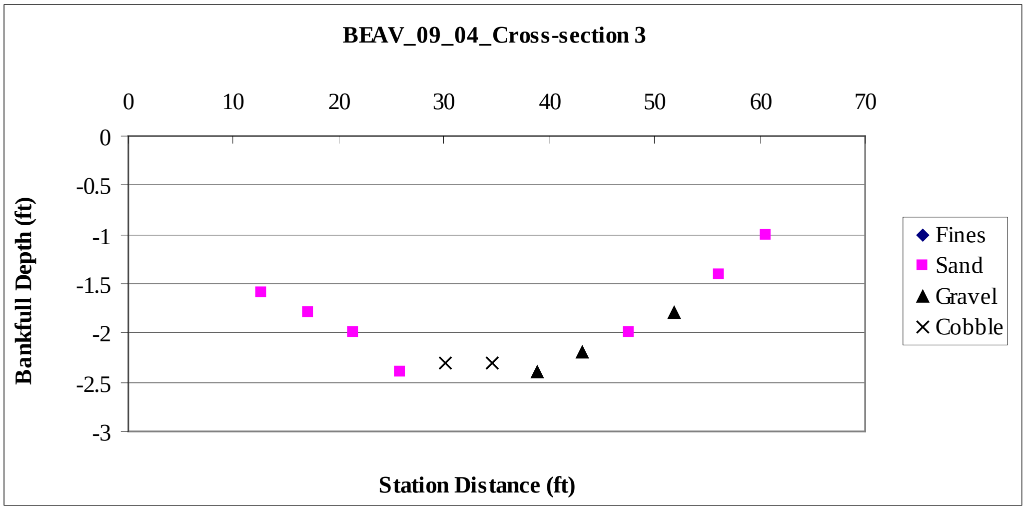

Figure C-28. Cross-Sections for Non-Wadeable Reach BEAV 09-04 XS3

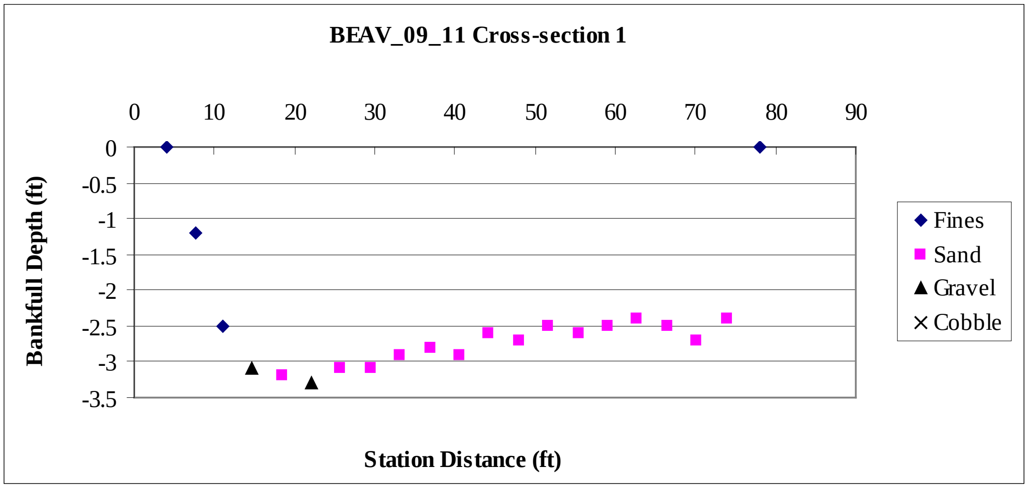

Figure C-29. Cross-Sections for Non-Wadeable Reach BEAV 09-11 XS1

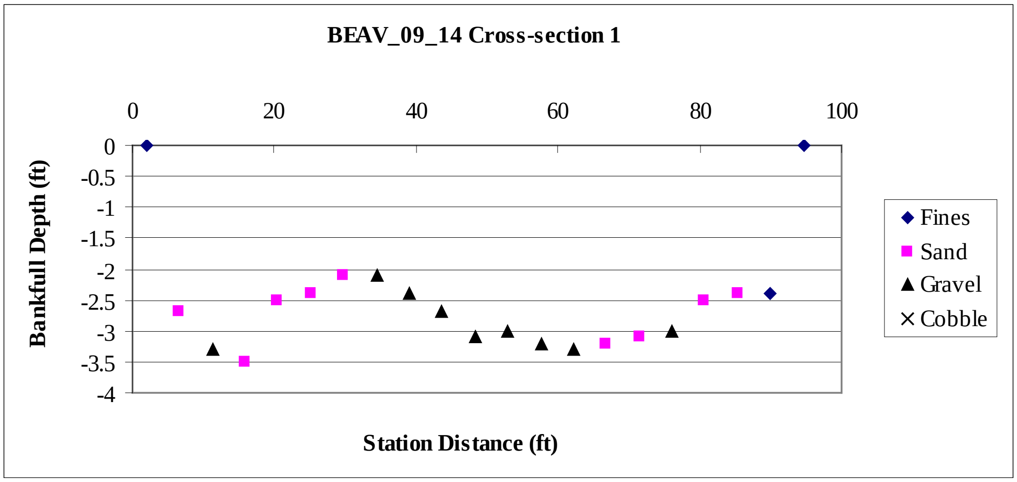

Figure C-30. Cross-Sections for Non-Wadeable Reach BEAV 09-14 XS1

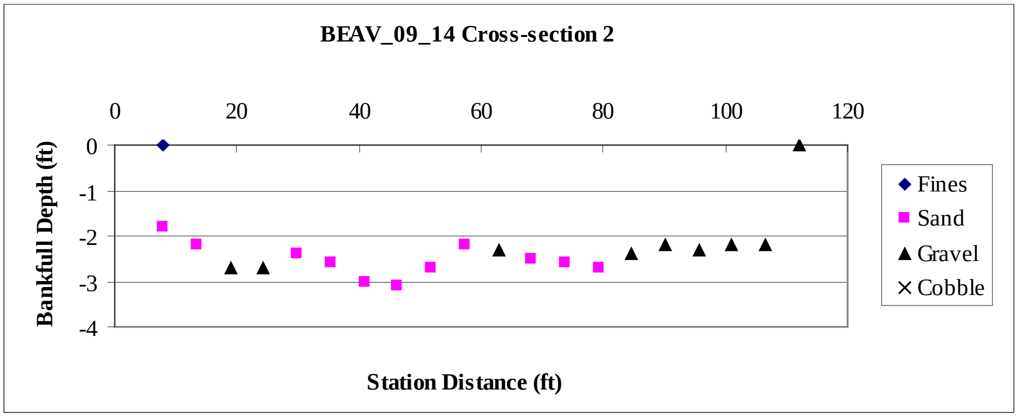

Figure C-31. Cross-Sections for Non-Wadeable Reach BEAV 09-14 XS2

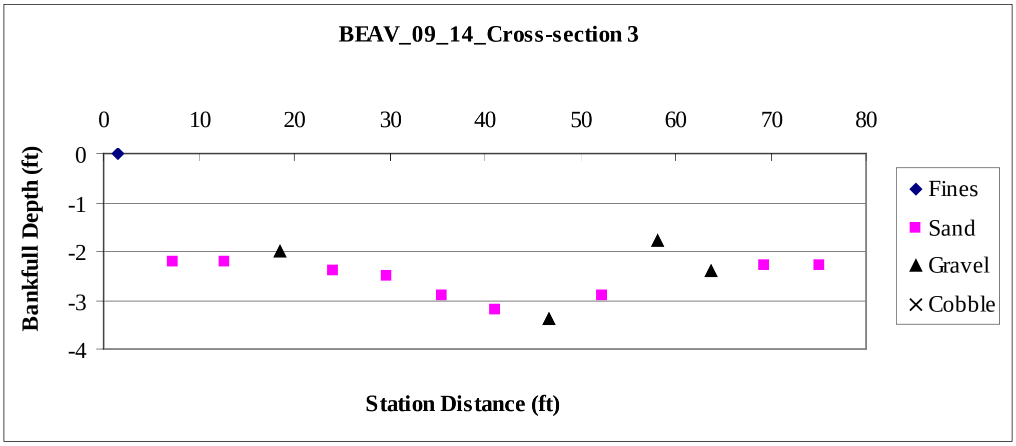

Figure C-32. Cross-Sections for Non-Wadeable Reach BEAV 09-14 XS3

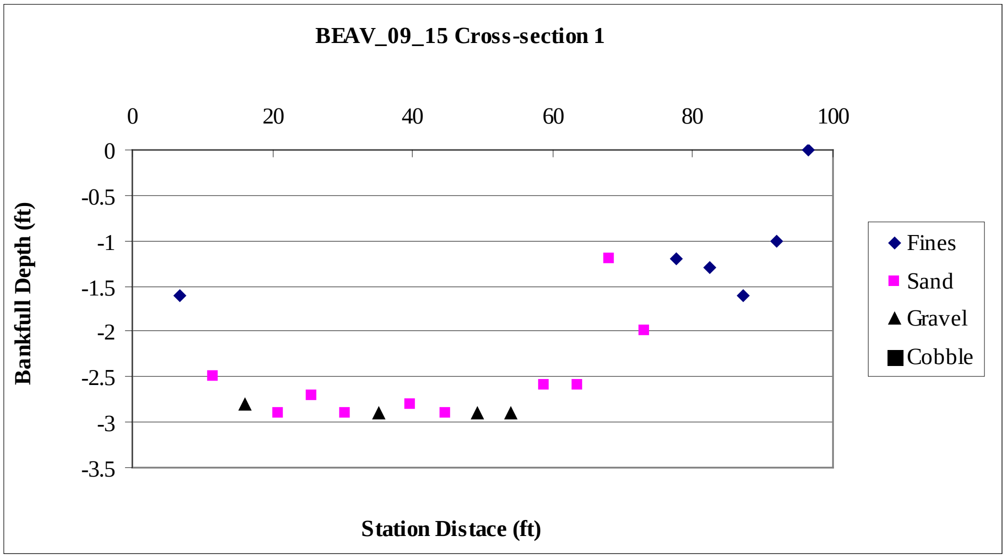

Figure C-33. Cross-Sections for Non-Wadeable Reach BEAV 09-15 XS1

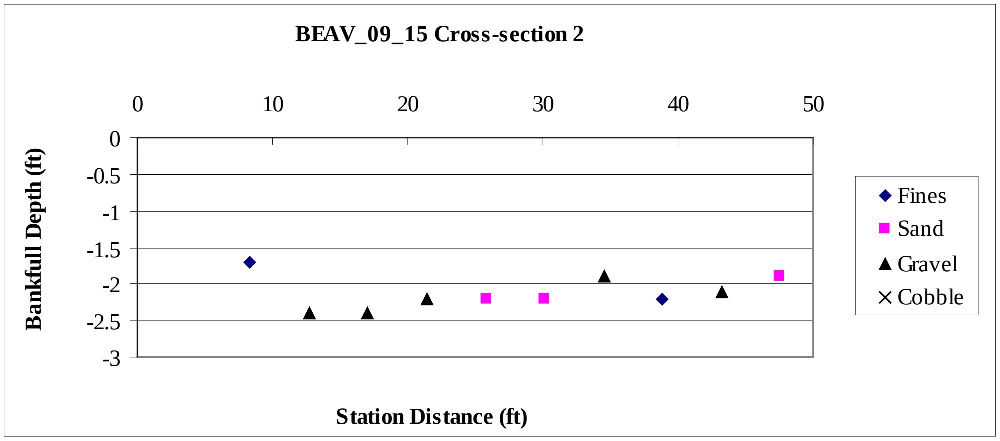

Figure C-34. Cross-Sections for Non-Wadeable Reach BEAV 09-15 XS2

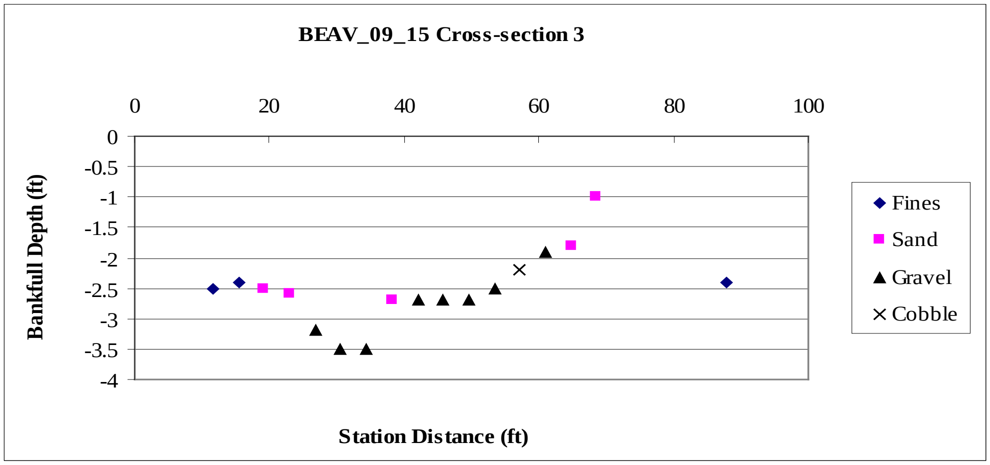

Figure C-35. Cross-Sections for Non-Wadeable Reach BEAV 09-15 XS3

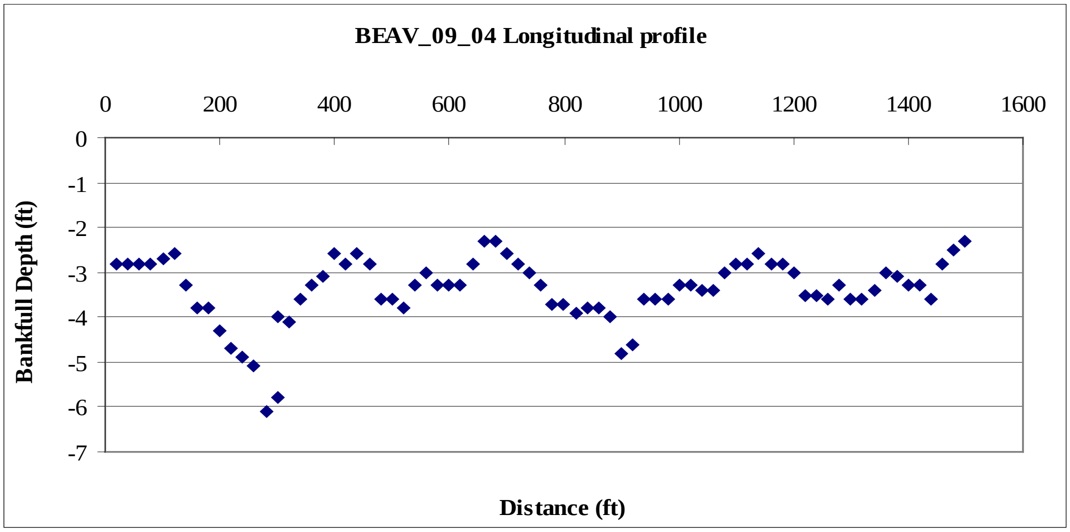

Figure C-36. Longitudinal Profile for Non-Wadeable Reach BEAV 09-04

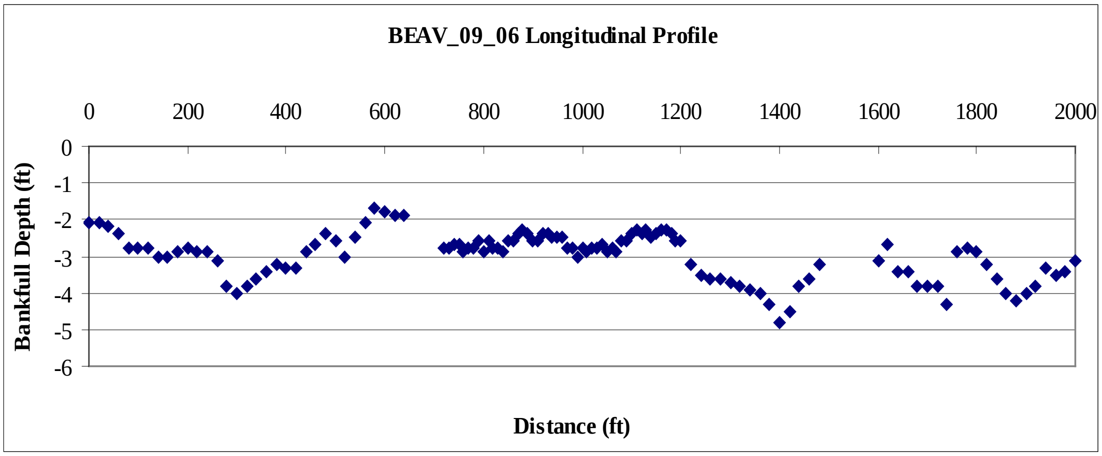

Figure C-37. Longitudinal Profile for Non-Wadeable Reach BEAV 09-06

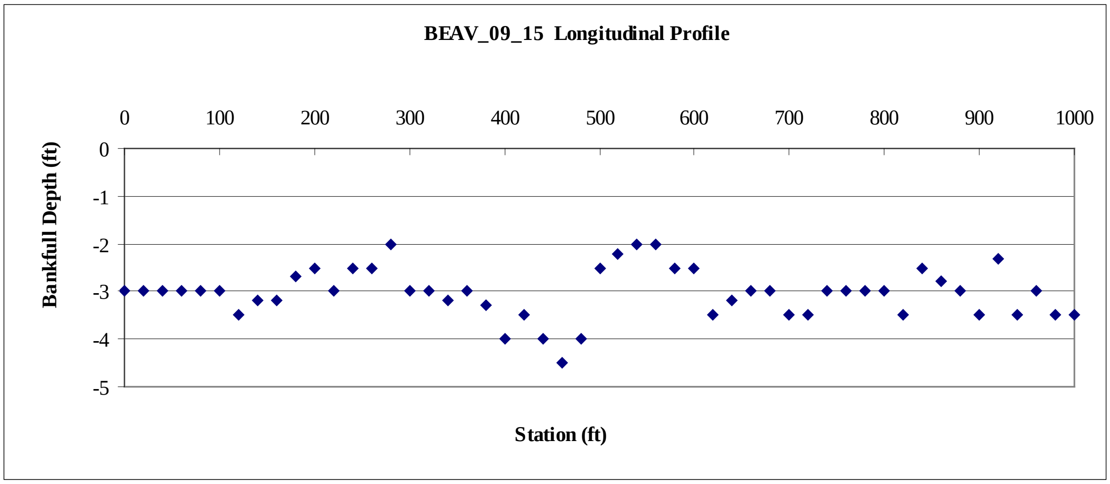

Figure C-38. Longitudinal Profile for Non-Wadeable Reach BEAV 09-15 Upstream of Bridge

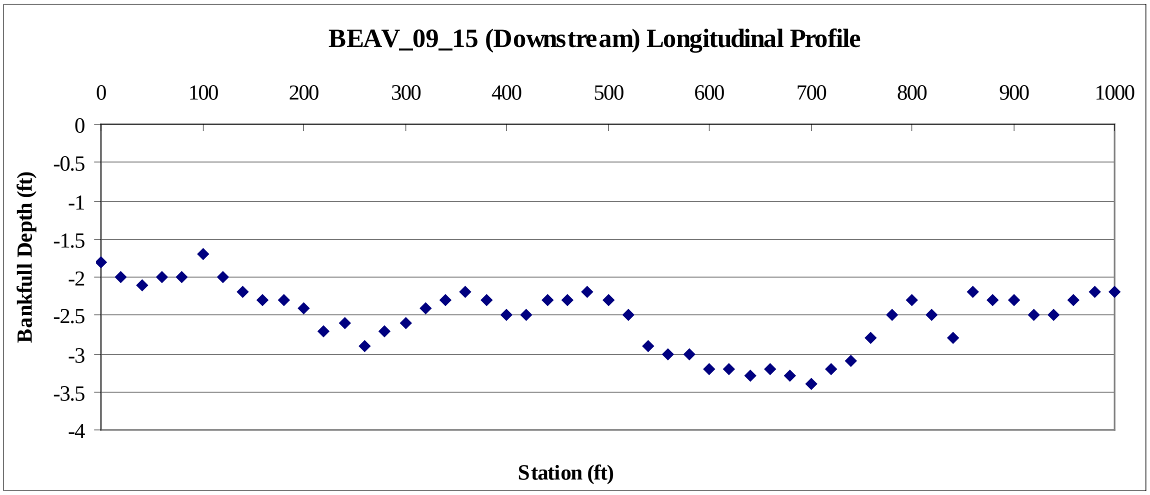

Figure C-39. Longitudinal Profile for Non-Wadeable Reach BEAV 09-15 Downstream of Bridge

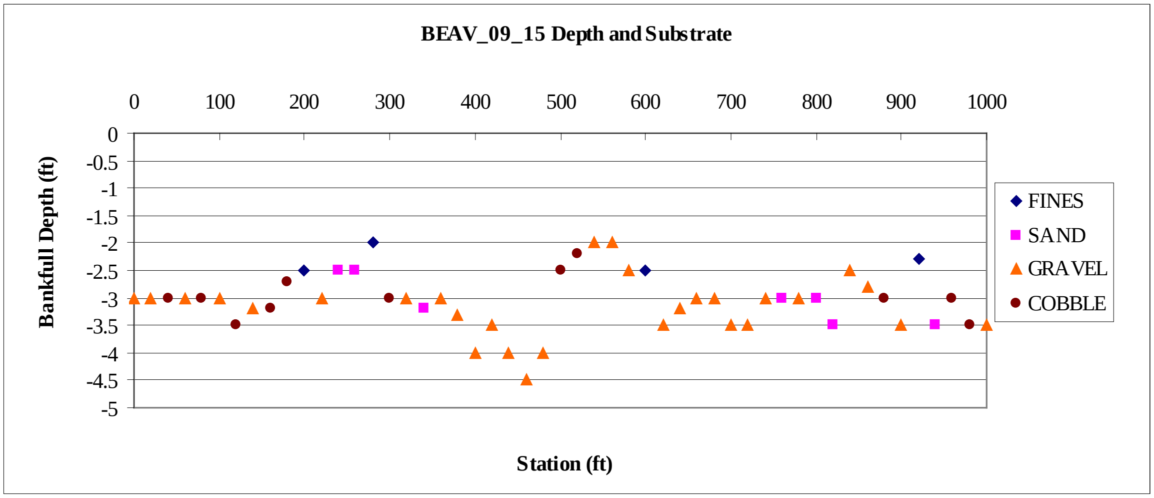

Figure C-40. Depth and Substrate for Non-Wadeable Reach BEAV 09-15 Upstream of Bridge

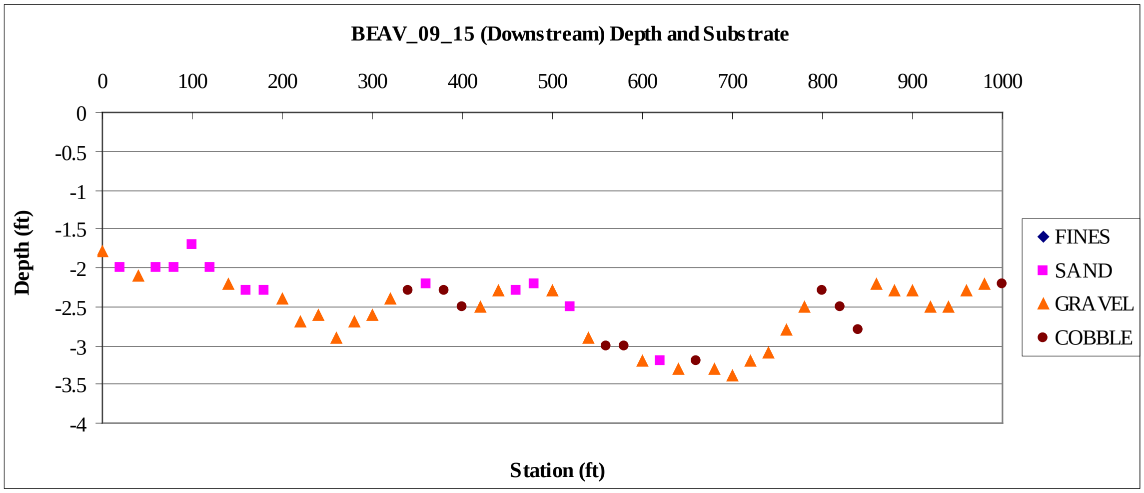

Figure C-41. Depth and Substrate for Non-Wadeable Reach BEAV 09-15 Downstream of Bridge

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