Mystic Lake Hydroelectric Project
FERC Project Number 2301

2010 Annual Fisheries Monitoring Report
Public

Submitted to:
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1.0 Executive Summary

The Mystic Lake Hydroelectric Project No. 2301 (Project) is operated and owned by PPL Montana, LLC (PPL Montana). On December 17, 2007 the Federal Energy Regulatory Commission (FERC or Commission) issued a new license to PPL Montana for the Mystic Lake Hydroelectric Project No. 2301 effective January 1, 2010. The new license includes U.S. Forest Service (USFS) Section 4(e) Terms and Conditions filed on May 3, 2007. Section 4(e) Condition 16 requires PPL Montana to prepare and implement a Fisheries Monitoring Plan that must be approved by the Mystic Lake Fisheries, Aquatic Habitats, and Water Quality Technical Advisory committee known as the TAC.

On August 2, 2010, PPL Montana filed the TAC-approved Fisheries Monitoring Plan (PPL Montana, 2010) with FERC. This report summarizes the following monitoring activities completed in cooperation with Montana Fish, Wildlife and Parks (FWP) and USFS in 2010.

- West Rosebud and Emerald Lakes Fisheries ï Gillnetting
- West Rosebud Creek Temperature Monitoring
- West Rosebud Creek (Mackay Flat) Fisheries ï Electrofishing
- West Rosebud Creek Redd Counts
- West Rosebud Creek Habitat ï Macroinvertebrates and Sediment Core Sampling

In West Rosebud Lake, spring (May, 2010) gillnetting efforts captured between 116 and 185 fish annually in 2006, 2008, and 2010. In Emerald Lake, May gillnetting efforts captured between 50 and 58 fish annually in 2006, 2008, and 2010. In both lakes, gillnetting efforts in 2006, 2008, and 2010 consistently captured five species, including *Salvelinus fontinalis* (brook trout), *Salmo trutta* (brown trout), *Oncorhynchus mykiss* (rainbow trout), *Prosopium williamsoni* (mountain whitefish), and *Catostomus catostomus* (longnose sucker) with one exception. In 2008, no rainbow trout was captured in Emerald Lake. Additionally, in 2010, there were also a few *Thymallus arcticus* (arctic grayling) observed in West Rosebud Lake.

In the Mackay section of West Rosebud Creek, FWP completed electrofishing and redd counts (spring and fall). In West Rosebud Creek downstream in the Mackay section, there were an estimated 704 brown trout (age 2 and older) per mile in 2010. This is an increase from brown trout populations estimates taken since 1986. Too few rainbow (n=52) and brook trout (n=30) were captured to provide accurate population estimates.

Redd counts completed in the spring 2010 estimated as many as 18 individual rainbow trout redds, which was an increase from the previous 2 years where little to no spring spawning activity was observed. Fall redd counts for brown trout estimated 34 redds in the same section of stream in 2009. Early ice conditions prevented surveys in 2010.

The maximum water temperature recorded in West Rosebud Creek (upper bypass, below the powerhouse, and below Emerald Lake) was 61 degrees Fahrenheit (°F) (16 degrees Celsius [°C]) in 2010. The data collected in all three locations indicate water temperatures, specifically summer temperatures, are in the preferred range for salmonids in West Rosebud Creek and not limiting for the salmonid species present.

In 2010, the core sampling data illustrated that the Pine Grove Campground site has both larger particle sizes and a smaller percentage of fine sediment than the Allen Grade Bridge site. The Pine Grove Campground site is further upstream and would be expected to have larger sized substrate compared to the Allen Grade Bridge site.

Macroinvertebrate indices analyzed at both sites in West Rosebud Creek met the stream-quality assessment criteria for high quality and non-impacted site (taxa richness greater than 30, Ephemeroptera, Plecoptera, Trichoptera [EPT] richness greater than 10, biotic index between zero and 4.5). In 2008, the overall taxa richness for the two sites was 52, with 40 unique taxa identified at each site, EPT taxa richness ranged between 14 and 23, and the biotic index was no greater than 3.2 per sample at either site. In 2010, the overall taxa richness for the two sites was 50, with 39 unique taxa identified at Pine Grove Campground and 42 unique taxa identified at Allen Grade Bridge. EPT taxa richness ranged between 19 and 21 and the biotic index was no greater than 2.4 per sample at either site in 2010.

In 2011, there are two monitoring activities scheduled:

- Electrofishing in West Rosebud Creek between Mystic Dam and the powerhouse
- Redd counts in the Mackay section of West Rosebud Creek

PPL Montana will continue to prepare annual reports that summarize the previous yearôs (2011) work and the proposed plan for the next year (2012). Annual reports will be submitted to the Mystic TAC and posted on the Mystic Lake Hydroelectric Project website.

2.0 Introduction

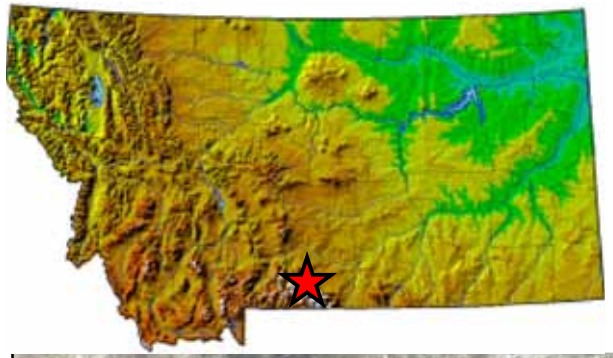
The Mystic Lake Hydroelectric Project No. 2301 (Project) is situated in south-central Montana, primarily located in Stillwater County with a very small portion within Carbon County. The Project is located in the Beartooth Mountain Range and surrounded on three sides by the Absaroka-Beartooth Wilderness Area. Mystic Lake is located at the head of a high mountain canyon at an elevation of 7,673.5 feet above mean sea level in the upper reaches of West Rosebud Creek. Within West Rosebud Creek drainage (213.4 square miles), Mystic Lake is the fourth and largest lake in a chain of six hydraulically connected lakes (listed in order going downstream: Star, Silver, Island, Mystic, West Rosebud, and Emerald lakes). The Beartooth Ranger District of the Custer National Forest manages approximately 124.7 square miles of the West Rosebud Creek drainage while the remaining 88.7 square miles is privately-owned land.

On December 17, 2007 the FERC issued a new license to PPL Montana for the Mystic Lake Hydroelectric Project No. 2301 effective January 1, 2010. The new license includes the USFS Section 4(e) Terms and Conditions filed on May 3, 2007. Section 4(e) Condition 16 requires PPL Montana to prepare and implement a Fisheries Monitoring Plan that must be approved by the Mystic Lake Fisheries, Aquatic Habitats, and Water Quality Technical Advisory committee known as the TAC.

On August 2, 2010, PPL Montana filed the TAC-approved Fisheries Monitoring Plan (PPL Montana 2010) with FERC. The Fisheries Monitoring Plan outlines a 6-year cycle of fisheries monitoring activities. Every 6 years, the TAC will re-evaluate and update the Fisheries Monitoring Plan as necessary for the term of the Project license (40 years). PPL Montana will prepare and submit annually a report summarizing the previous yearôs monitoring activities to the TAC and the FERC, as well as a 6-year summary report with an updated Fisheries Monitoring Plan in 2016. This report summarizes the following monitoring activities completed in cooperation with the FWP and the USFS in 2010:

- West Rosebud and Emerald Lakes Fisheries ï Gillnetting
- West Rosebud Creek Temperature Monitoring
- West Rosebud Creek (Mackay Flat) Fisheries ï Electrofishing
- West Rosebud Creek Redd Counts
- West Rosebud Creek Habitat ï Macroinvertebrates and Sediment Core Sampling

The locations of monitoring and sample sites for the activities listed above are illustrated in Figure 1.



PPL Montana, LLC
Mystic Lake Hydroelectric Project
FERC No. 2301
Stillwater and Carbon County, Montana

Allen Grade Bridge Site

Pine Grove Campground Site

Emerald Lake

West Rosebud Lake

West Rosebud Creek

Below Emerald Lake

Below Powerhouse

Upper Bypass

Mystic Lake

N

Legend

- Core and Macroinvertebrate Sampling Locations
- Water Temperature Monitoring Locations
- Mystic Lake Powerhouse
- Electrofishing and Redd Count Reach
- Gill Netting Locations
- FERC Project Boundary
- Stream/Lakes

Montana 2009 Color NAIP Orthophoto

Scale 1:94,000

0 0.5 1 1.5 Miles

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APPR. BY:
DATE:

Mystic Lake Hydroelectric Project
Stillwater and Carbon County MT

PROJECT NO.
M:\4421.002.03A

2010 Sampling Locations

FIGURE NUMBER
FIG. 1

M:\4421\002-03\GIS

3.0 West Rosebud Lake and Emerald Lake Fisheries

As outlined in the Fisheries Monitoring Plan, West Rosebud Lake and Emerald Lake fish populations were scheduled to be sampled biannually starting in 2010. Data collected in 2010 are summarized below along with data collected from 2006 and 2008.

PPL Montana, FWP, and USFS personnel sampled fish populations in West Rosebud and Emerald lakes in May of 2006, 2008, and 2010 (Figure 1). Sampling was completed using floating and sinking experimental gillnets in standardized locations. Biological data collected includes species length and weight. Scales for age composition were not collected.

3.1 West Rosebud Lake Fisheries

In West Rosebud Lake gillnetting efforts captured a total of 116, 185, and 149 fish in 2006, 2008, and 2010, respectively. Five species, including *Salvelinus fontinalis* (brook trout), *Salmo trutta* (brown trout), *Oncorhynchus mykiss* (rainbow trout), *Prosopium williamsoni* (mountain whitefish), and *Catostomus catostomus* (longnose sucker) were observed each sampling year with the addition of *Thymallus arcticus* (arctic grayling) also observed in 2010. A summary of the gillnetting data including the species, number of fish captured, catch rate (per hour), average length, range of lengths, average weight, and range of weights from 2006, 2008, and 2010 is provided in Table 1.

The presence of arctic grayling in 2010 is most likely attributed to the previous yearôs stocking efforts. In August 2009 approximately 270 arctic grayling (average 9.5 inches) were stocked in West Rosebud Lake (*see* Table 2 for 2005 through 2009 stocking records). In previous years (2005-2009), only rainbow trout were stocked in West Rosebud Lake. Approximately 3,000 rainbow trout were stocked in West Rosebud Lake annually between 2005 and 2009. During the same time period (2005-2009), a total of 14,931 rainbow trout (2,437 pounds) with an average size of 7 inches were stocked in West Rosebud Lake.

The number of fish captured per hour via gillnetting in West Rosebud Lake varied by species and years (Figure 2). The catch rate was lowest in 2006 for all species (range 0.2 to 0.7 fish per hour) with the exception of rainbow trout. Catch per hour for brook trout and brown trout increased in 2008 (1.06 and 1.21 fish per hour, respectively) from 2006 (0.72 and 0.39 fish per hour, respectively). While the catch rate for brown trout in 2010 remained similar to 2008 (1.21 fish per hour), the catch rate for brook trout declined to 0.51 fish per hour in 2010 from 1.06 fish per hour in 2008.

Table 1: Summary of gillnetting data, including species (LL=brown trout, EB=brook trout, RB=rainbow trout, MWF=mountain whitefish, GR=arctic grayling, LN SU=longnose sucker), number captured, net hours, catch rate per hour, average length, range of lengths, average weight, range of weight, collected in May 2006, 2008, and 2010 in West Rosebud Lake. Range of weights for fish captured in 2006 was not available. (Source: FWP)

2006

Species	Number Caught	Net hours	No. Fish/hour	Avg. Length (inches)	Range Length (inches)	Avg. Weight (lbs)
LL	21	54	0.39	12.20	8.6-18.1	0.67
EB	39	54	0.72	12.76	8.7-15.7	0.85
RB	14	54	0.26	10.39	9.3-11.9	0.43
MWF	33	54	0.61	14.22	9.6-19.6	1.06
LN SU	9	54	0.17	13.44	9.7-17.4	0.99

2008

Species	Number Caught	Net hours	No. Fish/hour	Avg. Length (inches)	Range Length (inches)	Avg. Weight (lbs)	Range Weight (lbs)
LL	67	55.5	1.21	11.70	6.0-21.3	0.68	0.14-3.38
EB	59	55.5	1.06	11.67	7.3-14.7	0.70	0.08-1.48
RB	7	55.5	0.13	10.51	10.4-10.8	0.41	0.36-0.58
MWF	30	55.5	0.54	13.20	9.3-19.6	0.84	0.16-2.39
LN SU	22	55.5	0.40	14.05	7.4-19.1	1.33	0.20-2.95

2010

Species	Number Caught	Net hours	No. Fish/hour	Avg. Length (inches)	Range Length (inches)	Avg. Weight (lbs)	Range Weight (lbs)
LL	63	53.41	1.18	11.80	8.8-15.2	0.52	0.23-1.19
EB	27	53.41	0.51	10.60	7.4-13.3	0.44	0.12-0.80
RB	7	53.41	0.13	10.53	9.5-11.4	0.42	0.27-0.55
MWF	31	53.41	0.58	13.23	11.6-15.8	0.75	0.47-1.22
GR	5	53.41	0.09	10.70	9.7-11.5	0.36	0.26-0.48
LN SU	16	53.41	0.30	14.83	11.8-18.0	1.39	0.67-2.38

Table 2: Summary of fish stocking in West Rosebud Lake from 2005 through 2009. (Source: FWP)

Date	Species	Number	Avg. Length (inches)	Total Weight (lbs)
5/19/2005	RB	1,012	7.9	200.0
6/14/2005	RB	1,012	6.9	134.0
7/15/2005	RB	1,137	7.3	174.9
2005 Total		**3,161**		
5/3/2006	RB	1,018	6.9	135.0
6/22/2006	RB	1,000	7.3	137.0
7/21/2006	RB	1,022	7.2	153.0
2006 Total		**3,040**		
5/4/2007	RB	1,036	7.0	143.9
6/20/2007	RB	998	7.4	158.9
7/25/2007	RB	821	8.3	190.9
2007 Total		**2,855**		
5/13/2008	RB	1,002	7.3	153.0
6/24/2008	RB	1,000	7.1	144.9
7/16/2008	RB	855	7.5	144.9
2008 Total		**2,857**		
5/22/2009	RB	1,008	8.1	210.0
6/29/2009	RB	1,006	7.1	142.0
7/20/2009	RB	1,004	8.1	215.0
2009 Total		**3,018**		
8/19/2009	GR	270	9.5	67.5

The average length of all fish species captured in 2006, 2008, and 2010 ranged between 10.39 and 14.83 inches (Figure 3). The average length of brook trout in West Rosebud Lake declined slightly from 12.76 inches in 2006 to 10.60 inches in 2010 while the average length of other trout species remained relatively constant over time. The average size of longnose suckers gradually increased from 13.44 inches in 2006 to 14.83 inches in 2010.

The average weight of fish showed similar trends as the average length with the exception of mountain whitefish (Figure 4). While the average length of mountain whitefish was relatively constant from 2006 to 2010 (average ranging from 13.20 to 14.22 inches), the average weight declined from 1.06 pounds in 2006 to 0.75 pounds in 2010. Between 2008 and 2010 the average weight of brown trout also declined slightly from 0.68 to 0.52 pounds while the average length remained relatively constant (11.7 and 11.8 inches, respectively). The average weight of brook trout declined each year (0.85, 0.70, 0.44 pounds), as well as the average length. The size of rainbow trout remained relatively constant through the years (approximately 0.4 pounds and 10 inches). From 2006 to 2010 the average weight of longnose suckers increased from 0.99 to 1.39 pounds.

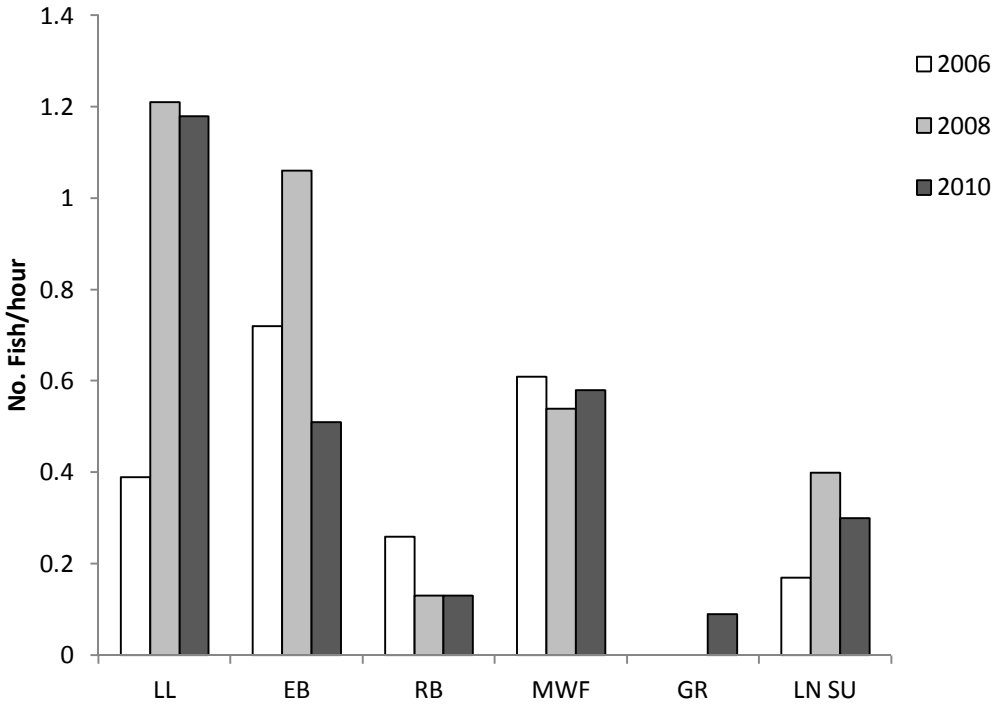

Figure 2: Number of fish, by species, caught per hour gillnetting in 2006, 2008, and 2010 in West Rosebud Lake. (LL=brown trout, EB=brook trout, RB=rainbow trout, MWF=mountain whitefish, GR=arctic grayling, LN SU=longnose sucker)

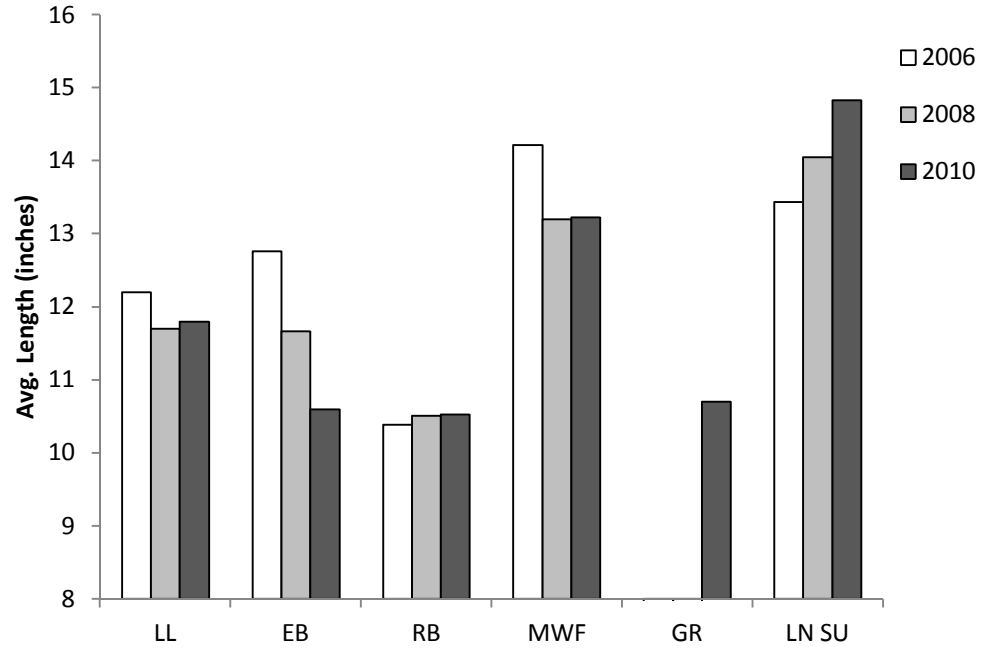

Figure 3: Average length (inches) of each species caught gillnetting in 2006, 2008, and 2010 in West Rosebud Lake.

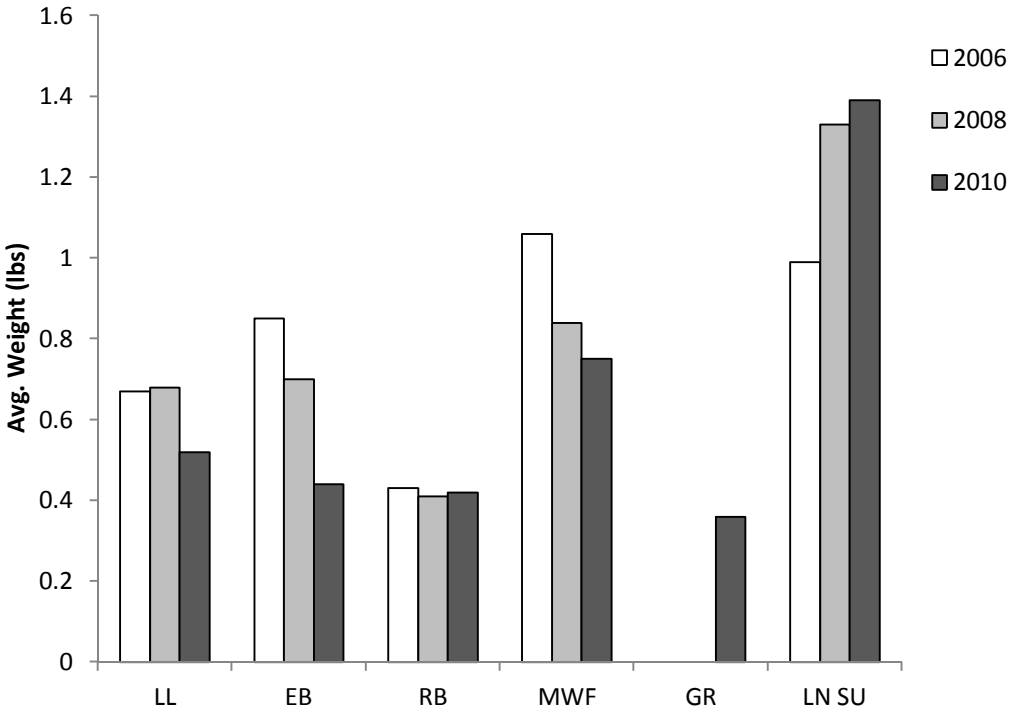

Figure 4: Average weight (lbs) of each species caught gillnetting in 2006, 2008, and 2010 in West Rosebud Lake.

3.2 Emerald Lake Fisheries

In Emerald Lake gillnetting efforts captured a total of 57, 50, and 58 fish in 2006, 2008, and 2010, respectively. Five species, including brook trout, brown trout, rainbow trout, mountain whitefish, and longnose suckers were observed each sampling year, with the exception of 2008 when no rainbow trout was captured. A summary of the gillnetting data including the species, number of fish captured, catch rate (per hour), average length, range of lengths, average weight, and range of weights from 2006, 2008, and 2010 is provided in Table 3.

As in West Rosebud Lake, arctic grayling were also stocked in Emerald Lake in 2009 (200 fish with an average length of 9.5 inches). However, no arctic grayling were observed during gillnetting efforts in Emerald Lake in 2010. Rainbow trout were the only other species stocked in Emerald Lake between 2005 and 2009. Approximately 1,790 rainbow trout with an average length of 7.4 inches were stocked annually between 2005 and 2009. During this time period, a grand total of 8,965 rainbow trout (1,456 pounds) were stocked in Emerald Lake. A summary of stocking data between 2005 and 2009 in Emerald Lake is provided in Table 4.

Table 3: Summary of gillnetting data, including species (LL=brown trout, EB=brook trout, RB=rainbow trout, MWF=mountain whitefish, LN SU=longnose sucker), number captured, net hours, catch rate per hour, average length, range of lengths, average weight, range of weight, collected in May 2006, 2008, and 2010 in Emerald Lake. (Source: FWP)

2006

Species	Number Caught	Net hours	No. Fish/hour	Avg. Length (inches)	Range Length (inches)	Avg. Weight (lbs)	Range Weight (lbs)
LL	30	21	1.43	14.20	7.7-19.3	1.41	0.16-13.7
EB	15	21	0.71	12.63	9.7-14.6	0.78	0.38-1.19
RB	2	21	0.10	12.20	10.6-13.8	0.75	0.46-1.04
MWF	9	21	0.43	14.11	12.4-16.1	0.94	0.64-1.32
LN SU	1	21	0.05	15	15	1.43	1.43

2008

Species	Number Caught	Net hours	No. Fish/hour	Avg. Length (inches)	Range Length (inches)	Avg. Weight (lbs)	Range Weight (lbs)
LL	15	21.5	0.70	14.08	4.4-24.6	1.29	0.03-5.00
EB	13	21.5	0.60	12.44	8.7-15.2	0.76	0.13-1.29
MWF	20	21.5	0.93	14.53	8.0-18.5	1.22	0.26-2.29
LN SU	2	21.5	0.09	15.25	14.0-16.5	1.56	1.07-2.04

2010

Species	Number Caught	Net hours	No. Fish/hour	Avg. Length (inches)	Range Length (inches)	Avg. Weight (lbs)	Range Weight (lbs)
LL	6	17.5	0.34	11.03	7.2-13.7	0.56	0.13-0.88
EB	21	17.5	1.20	11.19	4.9-15.7	0.66	0.05-1.56
RB	2	17.5	0.11	10.50	8.9-12.1	0.50	0.27-0.73
MWF	18	17.5	1.03	15.57	13.5-19.9	1.37	0.92-2.57
LN SU	11	17.5	0.63	14.95	13.6-17.1	1.50	0.92-2.18

The number of fish captured per hour via gillnetting in Emerald Lake varied by species and year (Figure 5). Catch per hour for brook trout, mountain whitefish, and longnose suckers increased from 2006 to 2010. Catch per hour for brown trout declined from 1.4 fish per hour in 2006 to less than 0.4 fish per hour in 2010. Catch per hour for rainbow trout was similar in 2006 and 2010, with no rainbow trout captured in 2008.

The average length of all species captured in 2006, 2008, and 2010 ranged between 10.5 inches and 15.6 inches (Figure 6). The average length of brook, brown, and rainbow trout was lower in 2010 compared to previous sampling years, while the average length of mountain whitefish increased slightly from 2006 (14.11 inches) to 2010 (15.57 inches). The average size of longnose suckers remained relatively constant (range 15 to 15.57 inches).

Table 4: Summary of fish stocking in Emerald Lake from 2005 through 2009. (Source: FWP)

Date	Species	Number	Avg. Length (inches)	Total Weight (lbs)
5/19/2005	RB	607	7.9	120.0
6/14/2005	RB	604	6.9	80.0
7/15/2005	RB	682	7.3	104.9
2005 Total		**1,893**		
5/3/2006	RB	603	6.9	80.0
6/22/2006	RB	606	7.0	83.0
7/21/2006	RB	614	7.2	91.9
2006 Total		**1,823**		
5/4/2007	RB	612	7.0	85.0
6/20/2007	RB	603	7.4	96.0
7/25/2007	RB	495	8.3	115.1
2007 Total		**1,710**		
5/13/2008	RB	812	7.3	124.0
6/24/2008	RB	800	7.1	115.9
7/16/2008	RB	118	7.5	20.0
2008 Total		**1,730**		
5/22/2009	RB	600	8.1	125.0
6/29/2009	RB	602	7.1	85.0
7/20/2009	RB	607	8.1	130.0
2009 Total		**1,809**		
8/19/2009	GR	200	9.5	50.0

The average weight and length of fish captured in Emerald Lake showed similar trends between 2006 and 2010. When the average length of a fish declined or increased, the average weight also declined or increased (Figure 7). Between 2006 and 2010, the average weight for brook trout ranged bewteen 0.78 and 0.66 pounds. The average weight of brown trout declined slightly bewteen 2006 (1.41 pounds) and 2008 (1.29 pounds) and then more substantially in 2010 (0.56 pounds). Corresponding to the decline in weight, brown trout were on average about 3 inches shorter in 2010 (11.03 inches) than 2008 (14.20 inches). Rainbow trout were present in 2006 and 2010, but none were observed in 2008. Rainbow trout captured in 2010 (average weight 0.50 pounds, average length 10.5 inches) were on average smaller in weigth and length compared to 2006 (average weight 0.75 pounds, average length 12.20 inches). Longnose suckers remained simliar size (weight and length) among years (average weight ranged 1.42 to 1.56 pounds, average length ranged 14.95 to 15.25 inches).

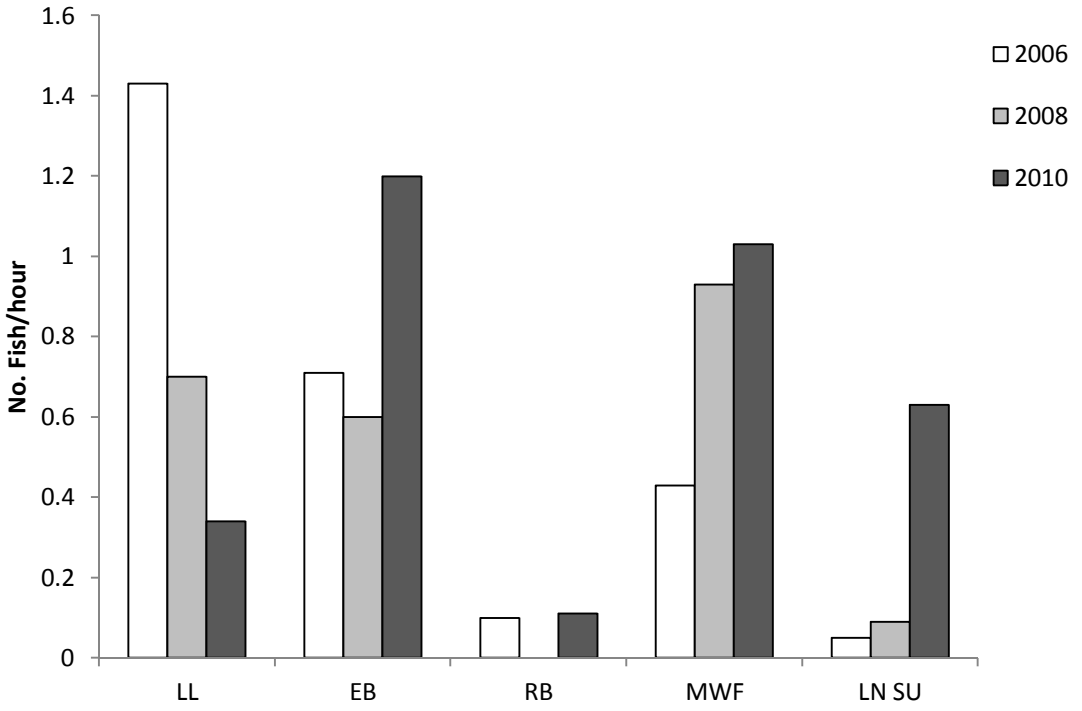

Figure 5: Number of fish, by species, caught per hour gillnetting in 2006, 2008, and 2010 in Emerald Lake.

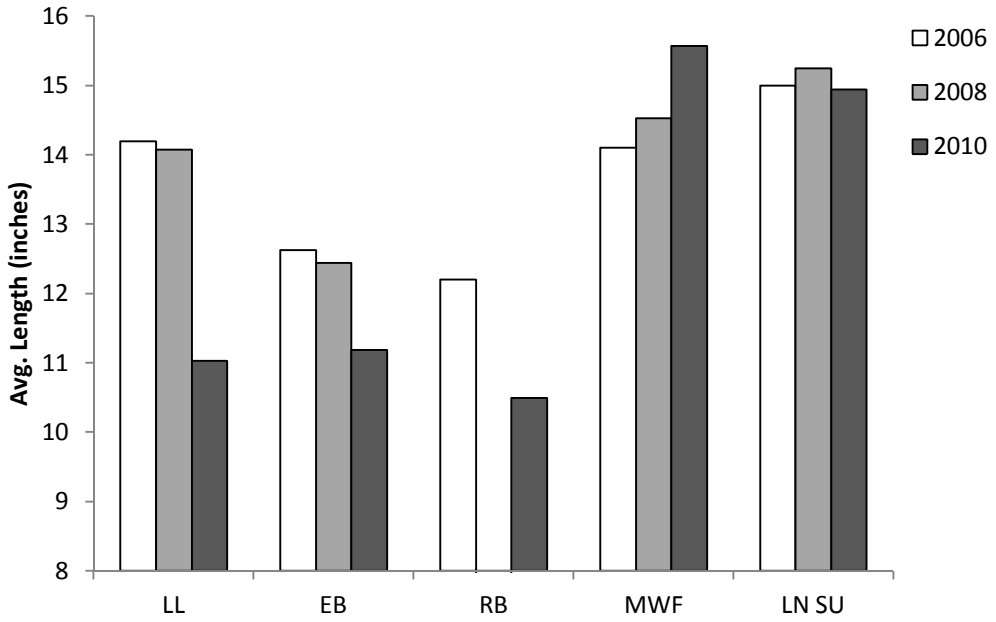

Figure 6: Average length (inches) of each species caught gillnetting in 2006, 2008, and 2010 in Emerald Lake.

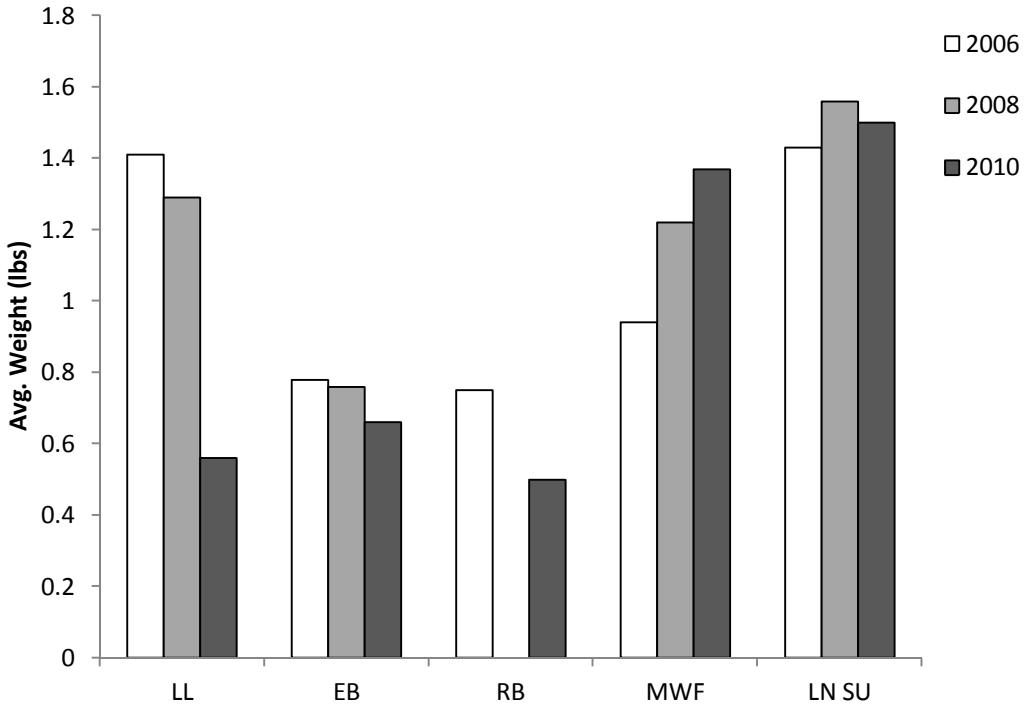

Figure 7: Average weight (lbs) of each species caught for the 2006, 2008, and 2010 gillnetting efforts in Emerald Lake.

4.0 West Rosebud Creek Water Temperature

West Rosebud Creek temperature monitoring is scheduled to occur concurrently with West Rosebud Lake and Emerald Lake fish surveys. The water temperature monitoring time period extends from April to late October at four designated sites, including West Rosebud Creek in the upper bypass (below Mystic Lake), West Rosebud Creek above the powerhouse, West Rosebud Creek below the powerhouse, and West Rosebud Creek below West Rosebud Re-regulation Dam. In 2010, there were some issues with the temperature loggers used to collect temperature data from above the powerhouse and below the Re-regulation Dam; thus alternative locations (upper bypass and the USGS station below Emerald Lake) were used to best represent these water stations. In this report, 2010 water temperature data are available from three locations, including the upper bypass (instead of above the powerhouse), West Rosebud Creek below the powerhouse, and the USGS gage station (#06204070 at West Rosebud Creek) below Emerald Lake (instead of below the Re-regulation Dam) (*see* Figure 1 for monitoring locations and Figure 8 for temperature data).

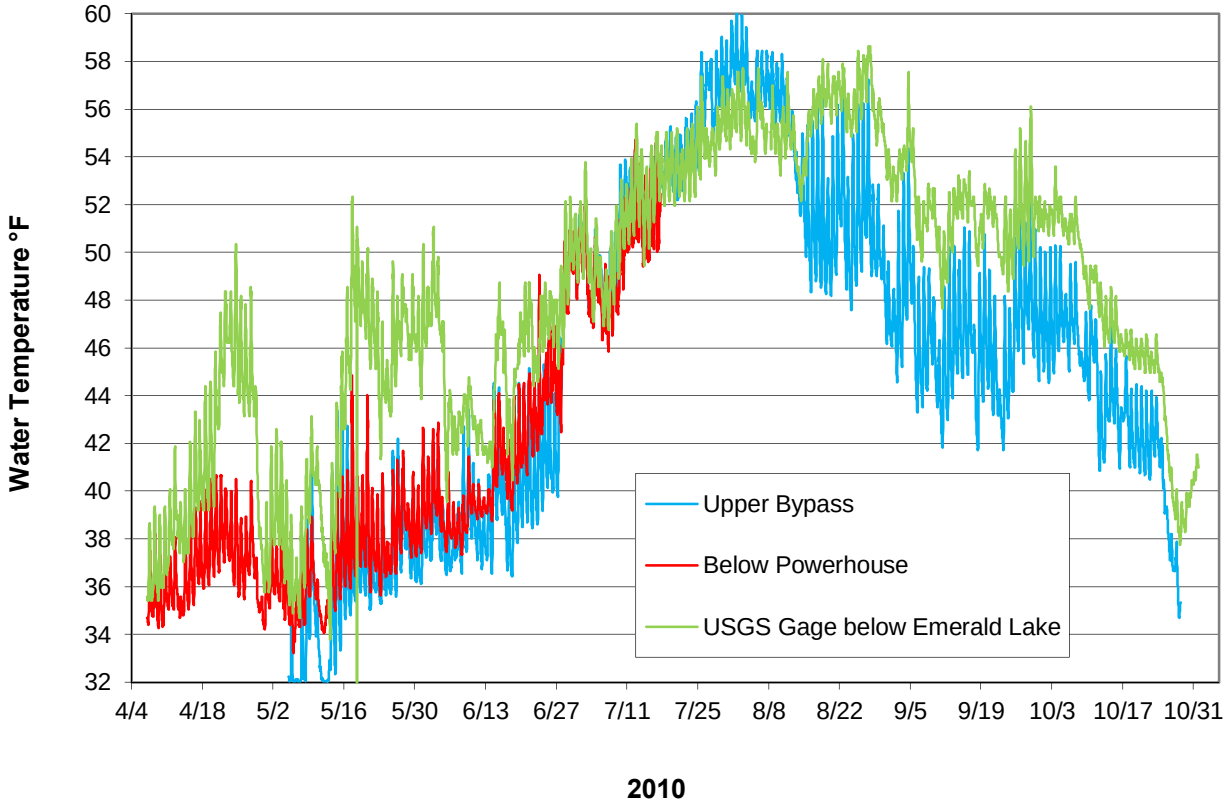

Figure 8: Water temperature recorded between April 7 and October 31, 2010 in West Rosebud Creek in the upper bypass channel, below the powerhouse, and below Emerald Lake at the USGS gage.

Temperature data in the upper bypass was collected between May 5 and October 28, 2010. The average temperature in the upper bypass was 46 °F (7.9 °C) and ranged between 32 °F (0 °C) and 61 °F (16 °C). Temperature data downstream of the powerhouse was recorded between April 7 and July 17, 2010. The average temperature below the powerhouse was 41 °F (5 °C) and ranged between 33 °F (0.6 °C) and 55 °F (12.8 °C). Temperature data recorded at the USGS gage station (below Emerald Lake) was available from April 7 and October 31, 2010. The average temperature below Emerald Lake was 48 °F (8.9 °C) with a range between 32 °F (0 °C) and 59 °F (15 °C).

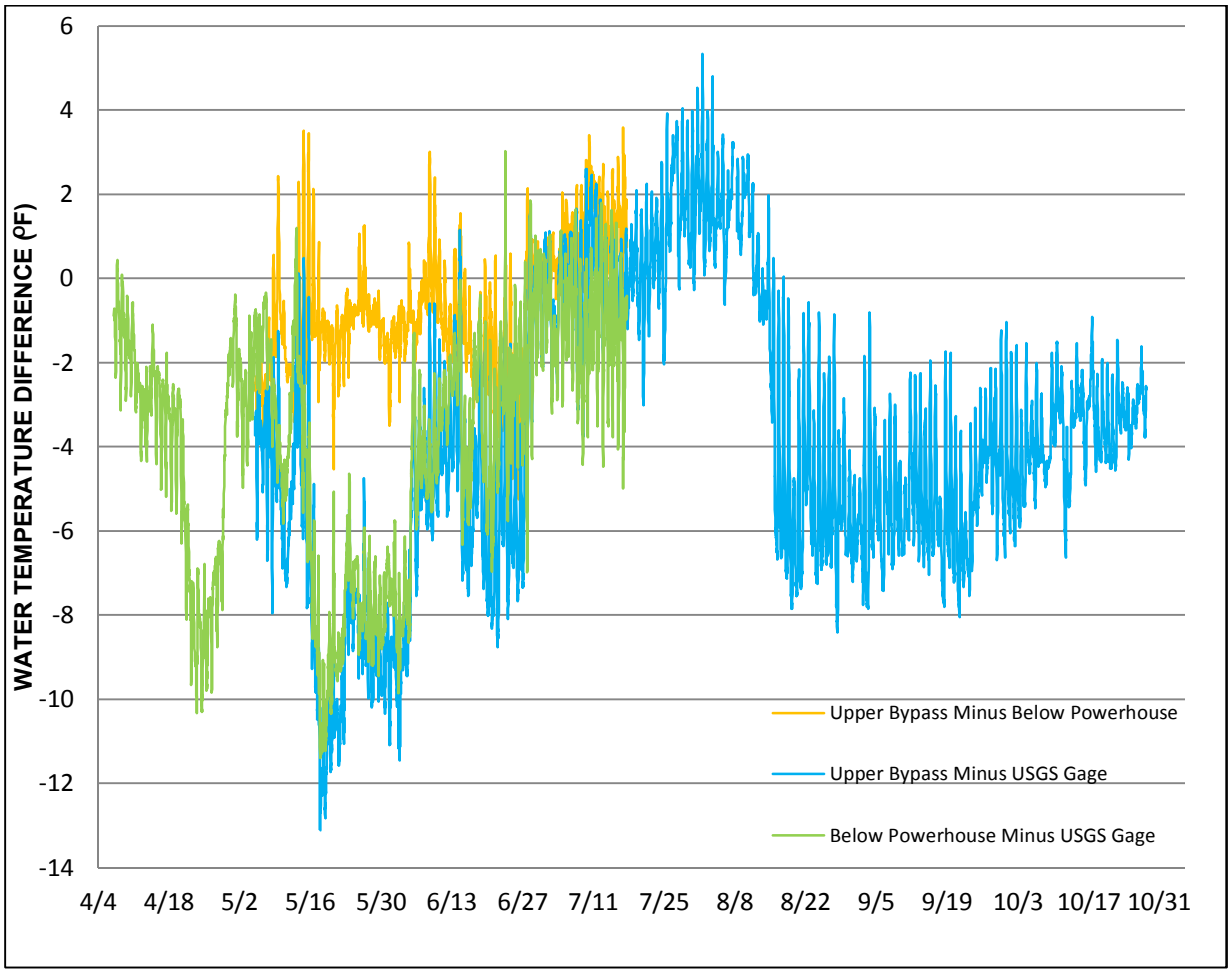

Figure 9: Summary of temperature differences between the water monitoring locations in West Rosebud Creek from April to October in 2010.

The difference in temperature (degrees Fahrenheit) was calculated between the monitoring stations and is illustrated in Figure 9. Water temperatures during spring 2010 (April to June) were warmer in West Rosebud Creek downstream of Emerald Lake compared to the upper bypass and below the powerhouse. In the summer, the warmest water (61 °F or 16 °C) was recorded in the upper bypass in late July and early August. Between August and October,

water temperatures below Emerald Lake were warmer than water temperatures in the upper bypass.

When evaluating the difference between the upper bypass and below the powerhouse, a positive value (water temperature difference) indicates the upper bypass was warmer than below the powerhouse and a negative value indicates the upper bypass was cooler than below the powerhouse (Figure 9). The maximum fluctuations (negative and positive) between water temperatures in the upper bypass and below the powerhouse were negative 5 degrees and positive 3.5 degrees. On June 26 the upper bypass was 5 degrees cooler than below the powerhouse and on May 14 water in the upper bypass was 3.5 degrees warmer than water below the powerhouse. Between May and the end of June nighttime water temperatures in the upper bypass were cooler than water below the powerhouse, while some daytime water temperatures in the upper bypass were above water temperatures below the powerhouse. In July, daytime water temperatures in the upper bypass were on average warmer than water below the powerhouse, while nighttime temperatures were more similar in both locations.

When evaluating the difference between the upper bypass and below the Emerald Lake (Figure 9), a positive value (water temperature difference) indicates the upper bypass was warmer than water below Emerald Lake and a negative value indicates the upper bypass was cooler than below Emerald Lake. Measurements were available between May and end of October 2010. The data indicate water temperatures in the upper bypass were generally cooler than below Emerald Lake in the spring (May and June) and late summer (mid/late August) and fall months (September and October). Between late June and early July, water temperature in both locations were very similar with an approximately 2 to 3 degrees variation (positive and negative). Water temperatures in the upper bypass were warmer than water below Emerald Lake in mid/late July and early August with a maximum difference of 5 degrees recorded on August 1, 2010.

When evaluating the difference between water temperature below the powerhouse and below Emerald Lake (Figure 9), a positive value (water temperature difference) indicates the water below the powerhouse was warmer than water below Emerald Lake and a negative value indicates the water below the powerhouse was cooler than below Emerald Lake. Data was available at both monitoring locations between April and July 2010. Between April and late June, water temperatures below the powerhouse were generally cooler than below Emerald Lake with the exception of one daytime measurement in May (Figure 9).

Water temperature is of interest primarily because of its potential to influence salmonidsô behavior and survival. Salmonids are coldwater fish with specific temperature requirements. Although some populations of salmonids have adapted to warmer temperatures, in general salmonids are not present if summer water temperatures consistently exceed 71.6 °F (22 °C) (Griffith 1999). Brown trout can survive and thrive in warmer waters 64 °F to 75 °F (18 to 24 °C) compared to other species of trout (Wydoski and Whitney 2003). Rainbow trout generally prefer cooler temperatures less than 70 °F (21 °C) and brook trout prefer

temperatures less than 68 °F (20 °C) (Wydoski and Whitney 2003). In general, the upper lethal limit for brook, brown, and rainbow trout is when water temperatures are equal to or greater than 77 °F and less than 80 °F (approximately Ó25 °C and < 30 °C) (Bjornn and Reiser 1991).

The maximum water temperature recorded in West Rosebud Creek (upper bypass, below the powerhouse, and below Emerald Lake) was 61 °F (16 °C) in 2010. The data collected in all three locations indicate water temperatures, specifically summer temperatures, are in the preferred range for salmonids in West Rosebud Creek and not limiting for the salmonid species present (Eaton et al. 1995). However, growth and condition of fish are related to both food and temperature and there is evidence that stream trout may be frequently food-limited in nature (Filbert and Hawkins 1995). Maximum growth temperatures based on literature growth data for brook trout, brown trout, and rainbow trout are 57.9 °F (14.4 °C), 64.4 °F (18 °C), and 64.6 °F (18.1 °C), respectively (Eaton et al. 1995). These maximum growth temperatures indicate stream temperatures in West Rosebud Creek were optimal for brook trout during the summer months, but slightly lower than the optimal growth temperature for brown trout and rainbow trout. In conclusion, temperatures appear to be within the optimal range for salmonids in West Rosebud Creek; however, growth may be limited for some species as a result of food availability and/or temperature.

5.0 West Rosebud Creek (Mackay Flat) Fisheries

In 2010, the FWP electrofished the Mackay section of West Rosebud Creek located downstream of Emerald Lake (Figure 1). A fish population was calculated from electrofishing efforts and will be repeated every 3 years. The data will be used to evaluate changes or trends in the fish community over time.

The Mackay section of West Rosebud Creek is located near the Custer National Forest boundary where the stream leaves the steep face of the Beartooth Mountains. This 7,900-foot section extends from the Pine Grove Campground (N45.27567 W109.64538) downstream to the first set of cabins and bridge at the Mackay Ranch (N45.28834, W109.62402). Brown trout, rainbow trout, brook trout, mountain whitefish, and *Cottus* sp. (sculpin) are present in the section with brown trout being the predominant fish. Fishing pressure within this section, particularly on the upstream end near the Pine Grove Campground, is relatively heavy. The section is also known to be an important spawning area for both resident fish and migratory rainbow and brown trout from the Yellowstone and Stillwater rivers. Many of the larger fish caught in this section may have spent at least a portion of their lives in the Yellowstone or Stillwater rivers.

In September 2010, a brown trout population estimate was completed (Table 5) for the Mackay section. There were approximately 705 brown trout (age 2 and older) per mile estimated in this section of West Rosebud Creek. This estimate is higher than all of the other estimates from 1986 and 2007 (Figure 10). However, due to the low number of recaptured fish in 2010, the estimate may be somewhat unreliable for close comparison. Regardless, it appears that brown trout population in West Rosebud Creek continues to be healthy and robust.

Rainbow and brook trout were also captured in the Mackay section in 2010, but too few were collected to obtain a reliable estimate. Fifty-two rainbow trout and 30 brook trout were captured. Rainbow trout averaged 6.7 inches long (range 1.7 to 12.3 inches), and brook trout averaged 6.7 inches long (range 2.7 to 11.7 inches).

The population of catchable brown trout in the MacKay section of West Rosebud Creek appears to have increased steadily between 1986 (approximately 400 fish per mile) and 2010 (approximately 700 fish per mile) (Figure 10). Local citizens, landowners, and anglers have expressed the opinion that the West Rosebud fishery was once much better than it is today. Unfortunately, FWP fish population sampling does not date back to the early days of this fishery, and therefore we are unable to address claims of local fishermen. However, the FWP has made a commitment to monitor the MacKay section more frequently to detect future changes in the fishery due to a number of potential impacts, including fishing pressure, changes in habitat, and potential influences from operations at Mystic Lake Hydroelectric Project.

Table 5: Population data and estimated abundance of catchable (age 2 and older) brown trout per mile from the Mackay section of West Rosebud Creek, 2010. (CI=confidence interval) (Source: FWP)

Age Class	Avg Length (in)	Avg Weight (lb)	#/mile (CI)	Biomass (lb/mi)
0	3.5	-	-	-
1	7.5	0.14	-	-
2	8.7	0.25	308 (59)	77.1
3	12.1	0.68	169 (26)	115.4
4	14.4	1.1	155 (24)	170.6
5	17	1.76	40 (16)	70.7
6 +	17.3	1.86	33 (15)	61.2
		Totals	**705**	**496.6**

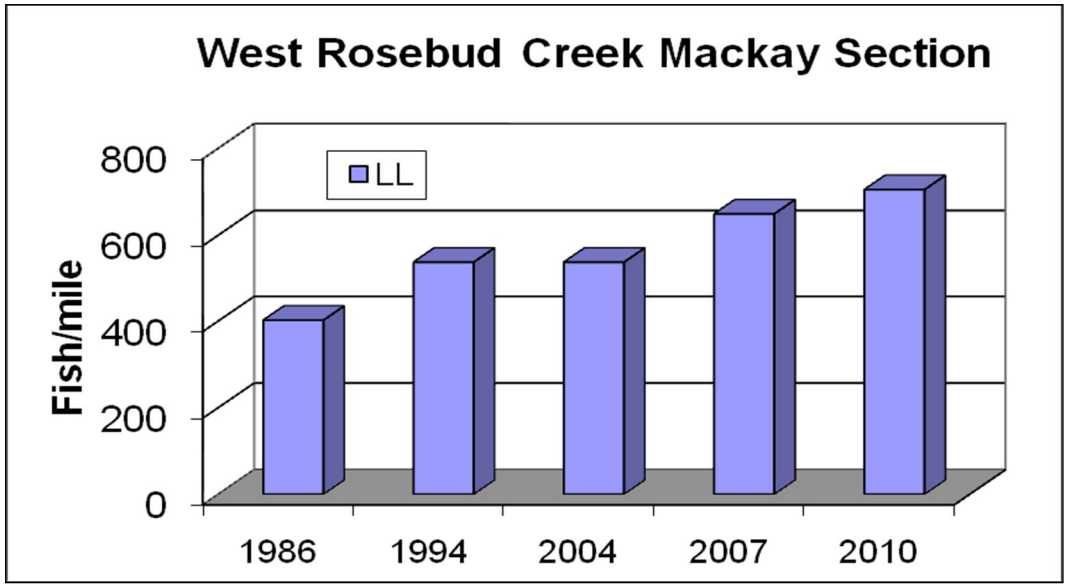

Figure 10: Population estimate of brown trout (LL) age 2 and older from the Mackay section in West Rosebud Creek between 1986 and 2010. (Source: FWP)

6.0 West Rosebud Creek Redd Counts

The FWP completes annual redd counts in West Rosebud Creek between the bridge near the Pine Grove Campground and the bridge on Mackayôs property. Below is a summary of redd count data from 2008, 2009, and 2010 for the Mackay section.

The approximately 1.5 mile reach of West Rosebud Creek surveyed for redds is shown in Figure 1 (same as the electrofishing reach discussed in Section 4.0). This reach is often referred to as the Mackay section. The Mackay section serves as an important spawning area for both resident West Rosebud fish and migratory rainbow and brown trout from the Stillwater and Yellowstone rivers. Redd counts preformed in the spring evaluated rainbow trout spawning and counts in the fall evaluate brown trout spawning. A summary of redd counts completed in the Mackay section is provided in Table 6.

In November 2009, approximately 34 brown trout redds were counted in the Mackay section. Early ice conditions prevented redd counts during fall 2010. Many of the fish constructing redds in this reach were large, older fish most likely from the Yellowstone and Stillwater rivers. Following spawning, embryos incubate in the gravels until hatching, emerging in April and May. Some of the emerging fish remain in West Rosebud Creek for a year or more, while others migrate downstream to the Yellowstone and Stillwater rivers.

In spring of 2010, a minimum of 14 rainbow trout redds were identified in the Mackay section. Three redd count events (April 26, May 3 and 13) identified 13, 14, and 14 redds on each trip, respectively. FWP estimated that as many as 18 individual redds were present. During the previous 2 years, little to no spring spawning activity was observed in this historic rainbow trout spawning area (Table 6). It is uncertain as to why the rainbow trout redd count numbers have been so low in past years, but it appears there may be an increase in spawning activity in this reach. Redd counts in coming years will help evaluate spring spawning trends.

Table 6: Summary of redd counts from 2008 to 2010 in West Rosebud Creek. Spring counts represent rainbow trout redds. Fall counts represent brown trout redds.

Stream	2008		2009		2010			
West Rosebud Creek	15-May	23-May	5-May	11-Nov	26-Apr	3-May	13-May	5-Oct
	1	1	6	34	13	14	14	5

7.0 West Rosebud Creek Habitat

In 2010, PPL Montana completed the fish habitat monitoring in West Rosebud Creek. The habitat monitoring efforts include the following:

- Sampling of aquatic insects to monitor health and temporal changes that maybe occurring in the macroinvertebrate community.
- Measurements of embeddedness and streambed substrate (Pine Grove Campground and Allen Grade Bridge) to monitor temporal changes in streambed habitat.
- Core sampling at two established locations (Pine Grove Campground and Allen Grade Bridge) to monitor temporal changes in sediment deposition in spawning gravels.

Data collected from 2008 and 2010 are presented for comparison in the following sections when available. Macroinvertebrates were sampled in 2008 and 2010. Visual observations of embeddedness were available for 2008 and visual observations of streambed substrate composition were available for 2010. Core sampling data was available for 2010.

7.1 Methods

On October 2, 2008 and October 6, 2010 PPL Montana collected macroinvertebrate samples in West Rosebud Creek at two sites (Figure 1): Pine Grove Campground and Allen Grade Bridge. The 2008 macroinvertebrate data collection also included visual observations of embeddedness and the 2010 macroinvertebrate data collection efforts also included streambed substrate measurements. Sediment core samples were also gathered on October 6, 2010.

Macroinvertebrates were collected with a Hess sampler enclosing 0.1 square meters (m^2, 390 micron mesh). A scrub brush was used to dislodge macroinvertebrates from stones in the sampler. The number of cobbles, large gravels, and medium gravels removed from the sampler was recorded. The remaining substrate was stirred and sifted by hand to transport organisms into the collection net. Three samples per site were collected, preserved, and analyzed by Dan McGuire, McGuire Consulting (Appendix A). In 2008, water depth and velocity were measured and streambed substrate composition was visually estimated at each sample location (Tables A-5 and A-6 in Appendix A).

An estimate of embeddedness, as defined by Platts et al. (1983) was performed at each location where macroinvertebrates were sampled in 2008. Embeddedness was visually estimated (0, 25, 50, 75, or 100%) as the percentage of the surface the dominant particle size covered by fine sediment within 1 meter of the sample location.

Core samples were completed using a 12-inch diameter McNeil sampler at individually selected salmonid spawning habitats. In 2010, five samples were taken at both the Pine Grove Campground and Allen Grade Bridge sites. The depth of the core and the depth of the water (either below or above the rim of the sampler) were recorded for each sample. All sediments within the core were then removed and placed in 5 gallon buckets. A sample of the water within the core was taken using a 2 liter bottle. The position of each sample was fixed with a handheld GPS unit and recorded. A narrative description of the location of the sample site in relation to other obvious landmarks was also recorded. The sediment and the water samples from each core were labeled and sent to Piedmont Engineering in Belgrade, Montana for particle size analysis (Appendix B). An estimate of embeddedness was also recorded at each core sample location.

7.2 Core Sampling

In October 2010, PPL Montana collected a total of 10 core samples along West Rosebud Creek at two sites (5 samples from Pine Grove Campground and 5 samples from Allen Grade Bridge). Both sites are located downstream of Emerald Lake with the Pine Grove Campground located further upstream (*see* Figure 1). Piedmont Engineering, Inc. (PEI) provided PPL Montana with the results of the laboratory analysis (Appendix B). Results of the core sample analysis were plotted logarithmically for each study site (Figures 11 and 12). It is apparent from the plots that there is more variability among smaller particle sizes (less than 10mm) at Allen Grade Bridge and more variability among larger particle sizes (greater than 10mm) at Pine Grove Campground.

Figure 13 shows an average of the five core samples taken at each site. From this plot, it is clear that the Pine Grove Campground site has both larger particle sizes and a smaller percentage of fine sediment than the Allen Grade Bridge site. These results are consistent with visual stream substrate composition recorded in 2008 (see Tables A-5 and A-6 in Appendix A) and core samples taken in 2005 (data presented in PPL Montana 2006). In 2008, streambed substrate composition was estimated to be larger at the Pine Grove Campground site with 70% cobble and 30% gravel and smaller at the Allen Grade Bridge site with 48% cobble, 28% gravel, and 13% sand (see Appendix A).

In order to compare the distributions of gravel sizes, the median particle diameter (d_{50}) was estimated for each core sample as well as an average d_{50} for the two sample sites. Further, the d_{16} and d_{84} values for each sample were estimated. These two values represent the gravel sizes at which 16 percent and 84 percent of the sample, respectively, are finer and a higher number indicates larger particle sizes. Based on this data as shown in Table 7, Pine Grove Campground has larger particle sizes than Allen Grade Bridge.

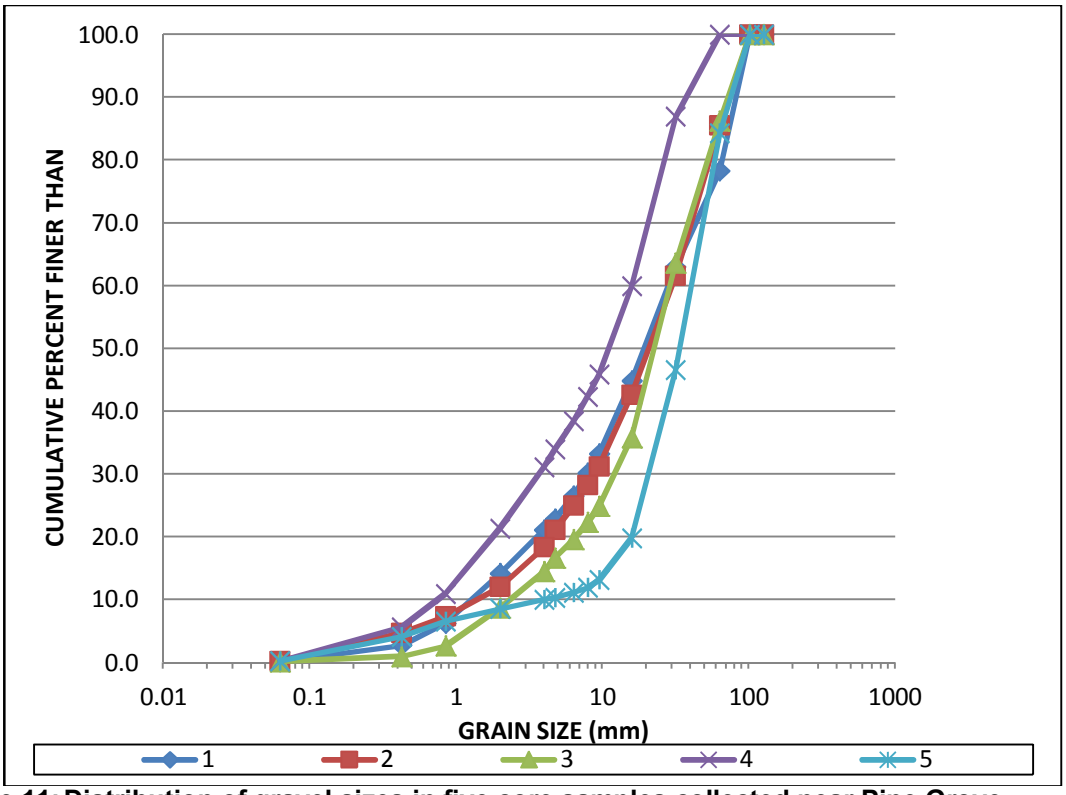

Figure 11: Distribution of gravel sizes in five core samples collected near Pine Grove Campground along West Rosebud Creek.

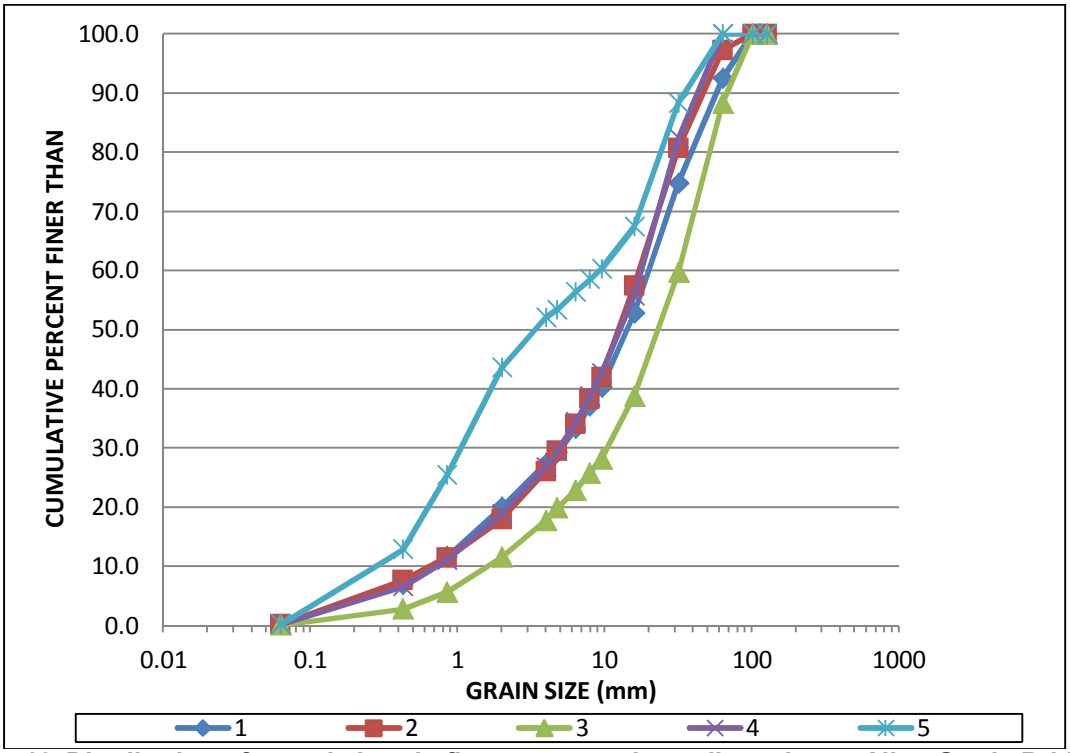

Figure 12: Distribution of gravel sizes in five core samples collected near Allen Grade Bridge along West Rosebud Creek.

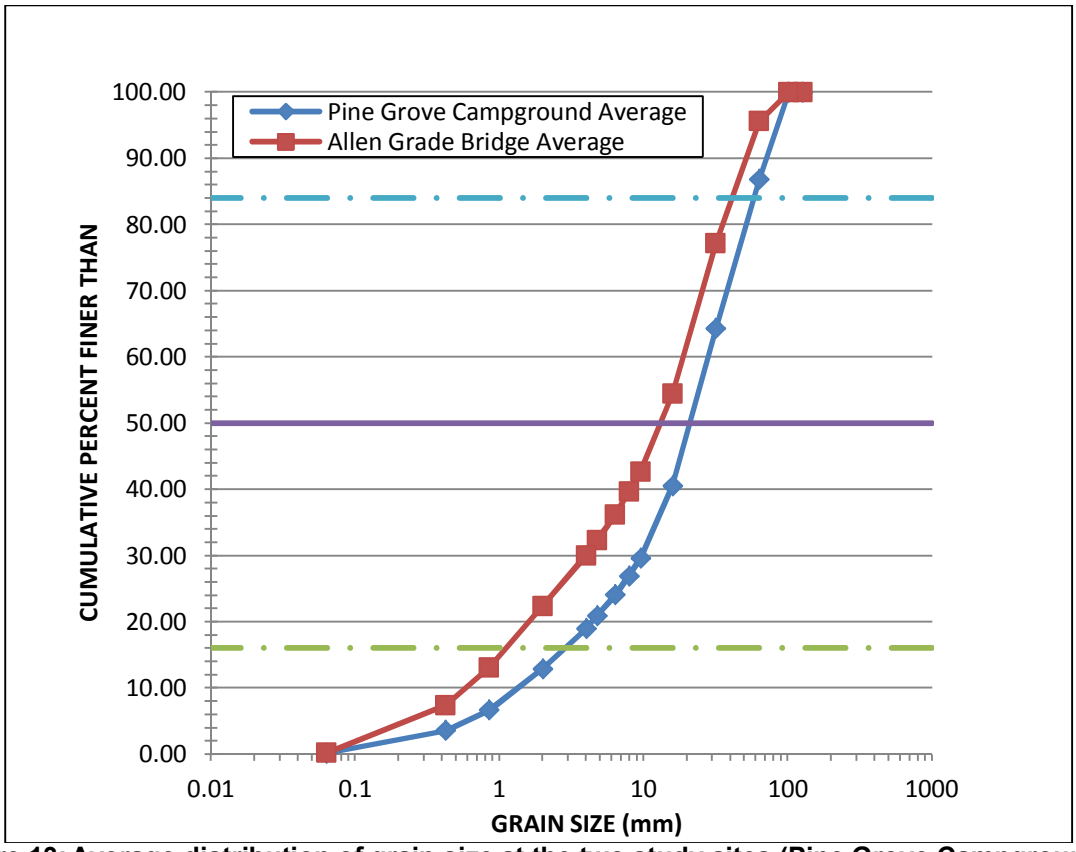

Figure 13: Average distribution of grain size at the two study sites (Pine Grove Campground and Allen Grade Bridge) along West Rosebud Creek in 2010.

Table 7: Summary of substrate characteristics from Pine Grove Campground and Allen Grade Bridge, West Rosebud Creek, 2010.

SITE	Core #	d_{16} (mm)	d_{50} (mm)	d_{84} (mm)	F_i
Pine Grove Campground	1	2.4	19.0	71.1	4.1
	2	3.3	21.2	61.2	5.2
	3	4.5	22.9	59.8	7.6
	4	1.3	11.4	29.3	2.1
	5	12.7	33.9	63.2	17.0
Allen Grade Bridge	1	1.3	14.4	44.5	2.4
	2	1.5	12.7	35.5	2.8
	3	3.4	12.7	57.0	5.6
	4	1.5	12.7	33.4	2.5
	5	0.6	12.7	27.6	0.8
Pine Grove Campground Average		4.9	21.7	56.9	7.2
Allen Grade Bridge Average		1.7	13.4	39.6	2.8

Additionally, PEI provided PPL Montana with Fredle Index values for each core sample and an average for each study site (Table 7 and Appendix B). Lotspeich and Everest (1981) proposed the Fredle Index as a means to evaluate the reproductive potential of spawning gravel for salmonids and to provide comparisons of gravel quality between and within streams. Lotspeich and Everestôs (1981) analysis of existing data estimates that a Fredle Index of 4 is equivalent to a survival-to-emergence of 60 percent for Coho salmon and 75 percent for steelhead trout and that the larger Fredle Indices are indicative of better conditions for salmonid survival.

At the Pine Grove Campground site, the average Fredle Index was 7.2 (range 2.1 to 17) and at the Allen Grade Bridge site, the average was 2.8 (range 0.8 to 5.6) (Table 7). This indicates that the Pine Grove Campground site has substrate composition that is likely more compatible with high salmonid survival-to-emergence than the Allen Grade Bridge site.

Kondolf et al. (2008) reviewed literature documenting salmonid incubation and emergence success as it relates to substrate size. For fine sediments, Kondolf et al. (2008) calculated the maximum percentage present that corresponds to 50 percent emergence of salmonids. The maximum percentage of grains finer than 0.84mm, 2.0mm, 3.35mm, and 6.35mm corresponding to 50 percent emergence, as cited in Kondolf et al. (2008), are presented in Table 8. Additionally, Table 8 contains the corresponding percentage of fines for each sediment level measured at the two West Rosebud Creek study sites in 2010.

Table 8: Fine sediment percentages corresponding to 50 percent emergence of salmonids in various studies, from Kondolf et al (2008) and comparison to fine sediment levels measured in West Rosebud Creek, 2010. Bold indicate values that are higher than mean values from the literature.

	Maximum percentage of grains finer than:			
	0.84mm	**2.0mm**	**3.35mm**	**6.35mm**
LITERATURE REVIEW – Recommended Threshold				
Kondolf et al. (2008)	13.6	15.0	29.5	30.3
MYSTIC LAKE SITES				
Pine Grove Campground (2010)	6.6	12.9	17.9	24.2
Allen Grade Bridge (2010)	13.0	**22.4**	28.0	**36.3**

Fine sediments in West Rosebud Creek at Pine Grove Campground measured below thresholds presented by Kondolf et al. (2008) identified for 50 percent emergence success of salmonid. The percentage of fines per category (in Table 8) at the Allen Grade Bridge site were nearly double the amount measured at Pine Grove Campground and exceed recommended thresholds by Kondolf et al. (2008) in two of the four categories. The data indicate spawning habitat is of better quality in Pine Grove Campground site *versus* the Allen Grade Bridge site.

Core sediment data collected in 2010 is consistent with core sediment data collected in 2005 (PPL Montana 2006). In 2005, substrate measured at the Pine Grove Campground site was generally larger than substrate measured at the Allen Grade Bridge site. Although overall percentage of fines per category (as shown in Table 8) was generally lower for both sites in 2005 compared to 2010, the same trend was observed with the percentage of fines at the Allen Grade Bridge site always greater than percentage fines measured at Pine Grove Campground and, in some cases, exceeding the recommended threshold by Kondolf et al. (2008).

7.3 Embeddedness

Embeddedness was estimated at the location of each core sample taken at the Pine Grove Campground and Allen Grade Bridge sampling sites in October 2010 (Table 9). Values of embeddedness varied from 0 to 25 percent. At the Pine Grove Campground site there was zero embeddedness with the exception of one of the five core sample areas, which measured 25 percent embeddedness. At the Allen Grade Bridge site, three of the five core sample areas measured 25 percent embeddedness and two areas measured zero embeddedness. In general, embeddedness appeared to be higher at the Allen Grade Bridge than at Pine Grove Campground.

Table 9: Estimates of embeddedness based on visual estimates of core samples at each study site, West Rosebud Creek, 2010.

Site	Date	Core Sample	GPS Coordinates		Embeddedness Rating (%)
Pine Grove Campground	10/6/2010	1	N 45° 16.760'	W 109° 38.274'	25
	10/6/2010	2	N 45° 16.741'	W 109° 38.331'	0
	10/6/2010	3	N 45° 16.733'	W 109° 38.312'	0
	10/6/2010	4	N 45° 16.734'	W 109° 38.313'	0
	10/6/2010	5	N 45° 16.758'	W 109° 38.253'	0
Allen Grade Bridge	10/6/2010	1	N 45° 20.190'	W 109° 36.310'	0
	10/6/2010	2	N 45° 20.190'	W 109° 36.311'	25
	10/6/2010	3	N 45° 20.167'	W 109° 36.302'	25
	10/6/2010	4	N 45° 20.162'	W 109° 36.320'	0
	10/6/2010	5	N 45° 20.164'	W 109° 36.319'	25

7.4 Macroinvertebrates

Identifications, enumerations, and metric values, and substrate estimates for each sample collected in October 2008 and 2010, along with summary statistics for each site, are presented in Appendix A. Results from the 2008 sampling were reported in full by McGuire (2009), which was included in Appendix F of the *Mystic Lake Hydroelectric Project FERC Project Number 2301 Water Quality Monitoring Plan* (PPL Montana 2010a).

7.4.1 Macroinvertebrate Taxa

A total of 40 unique macroinvertebrate taxa from the Pine Grove Campground and Allen Grade Bridge sites were identified in 2008, with a combined total of 52 unique macroinvertebrate taxa from both sites (Table 10). In 2008, there were 38 insect taxa and 2 non-insect taxa identified from each site. Non-insect taxa included flatworms and fingernail clams at Pine Grove Campground and segmented worms at Allen Grade Bridge.

In 2010 a total of 39 and 42 unique macroinvertebrate taxa were identified from the Pine Grove Campground and the Allen Grade Bridge sites, respectively. There was a combined total of 50 unique taxa from both sites (Table 10). In 2010, there were 37 insect taxa and 2 non-insect taxa identified from the Pine Grove Campground site while there were 38 insect taxa and 4 non-insect taxa identified from the Allen Grade Bridge site. Non-insect taxa included segmented worms and flatworms at Pine Grove Campground and segmented worms, flatworms, fingernail clams, and cress bugs at Allen Grade Bridge. Overall, taxa identified at the two sites remained relatively consistent between 2008 and 2010.

Table 10: Number of unique taxa for each site, Pine Grove Campground (PGC) and Allen Grade Bridge (AGB) and for both sites combined in 2008 and 2010.

Taxonomic Group	2008			2010		
	PGC	AGB	Combined	PGC	AGB	Combined
Coleoptera	4	3	5	3	3	4
Diptera	10	9	12	9	8	11
Ephemeroptera	9	8	11	9	10	11
Plecoptera	5	7	8	7	7	9
Trichoptera	10	11	12	9	10	11
Non-insect	2	2	4	2	4	4
Total	**40**	**40**	**52**	**39**	**42**	**50**

In 2008, taxa richness per sample ranged from 23 to 32 taxa at the Pine Grove Campground site and between 25 and 33 taxa at the Allen Grade Bridge site (Appendix A). The average taxa richness was 29 per sample at the Pine Grove Campground site and 30 per sample at the Allen Grade Bridge site.

In 2010, taxa richness per sample was similar to the 2008 values at both sampling locations. The taxa richness ranged from 27 to 32 taxa at the Pine Grove Campground site and between 27 and 29 taxa at the Allen Grade Bridge site (see Appendix A). The average taxa richness was 29 per sample at Pine Grove Campground and 28 per sample at Allen Grade Bridge. Table 11 provides a comparison of aquatic macroinvertebrates identified in 2008 and 2010.

Table 11: Checklist of aquatic macroinvertebrates, by taxonomic rank (family or subfamily), collected from Pine Grove Campground (PGC) and Allen Grade Bridge (AGB) in West Rosebud Creek, Stillwater County, Montana during October, 2008 and 2010.

Order	Family (subfamily)	Distribution			
		2008		2010	
		PGC	AGB	PGC	AGB
Coleoptera					
	Elmidae	X	X	X	X
Diptera					
	Ceratopgonidae (Ceratopogoninae)			X	
	Chironomidae (Chironominae)		X		
	(Diamesinae)	X	X	X	
	(Orthocladiinae)	X	X	X	X
	(Tanypodinae)	X	X	X	
	Limoniidae			X	X
	Tipulidae	X	X	X	X
	Simuliidae	X			X
Ephemeroptera					
	Ameletidae	X			X
	Baetidae	X	X	X	X
	Ephemerellidae	X	X	X	X
	Heptageniidae	X	X	X	X
	Leptophlebiidae	X	X	X	X
Plecoptera					
	Capniidae		X		X
	Leuctridae		X	X	X
	Nemouridae	X	X	X	X
	Chloroperlidae	X	X	X	X
	Perlodidae	X			X
	Perlidae	X	X	X	X
Trichoptera					
	Hydropsychidae	X	X	X	X
	Philopotamidae	X	X	X	X
	Hydroptilidae	X	X	X	
	Brachycentridae	X	X	X	X
	Lepidostomatidae	X	X	X	X
	Glossosomatidae	X	X	X	X
	Rhyacophilidae	X	X	X	X
Phylum Annelida					
	Enchytraeidae		X	X	X
	Megadrili		X		
Other					
	Planaridae	X		X	X
	Sphaeriidae	X			X
	Asellidae				X

7.4.2 Community Composition and Density

The composition of the macroinvertebrate community (Trichoptera, Plecoptera, Ephemeroptera, Diptera, Coleopteran, and others) sampled at both sites in 2008 and 2010 is shown in Figure 14. In 2008, Ephemeroptera (37%) and Trichoptera (33%) were the

predominant macroinvertebrate orders present at the Pine Grove Campground site. In 2010, Ephemeroptera (45%) and Plecoptera (34%) were the predominant orders in Pine Grove Campground. In 2008 at Allen Grade Bridge, Trichoptera (31%) were most common with a relatively equal representation of Plecoptera (20%), Ephemeroptera (21%), and Coleoptera (19%). In 2010, Ephemeroptera (55%) was the predominant order present with Plecoptera (16%) and Trichoptera (13%) the next dominant orders at Allen Grade Bridge.

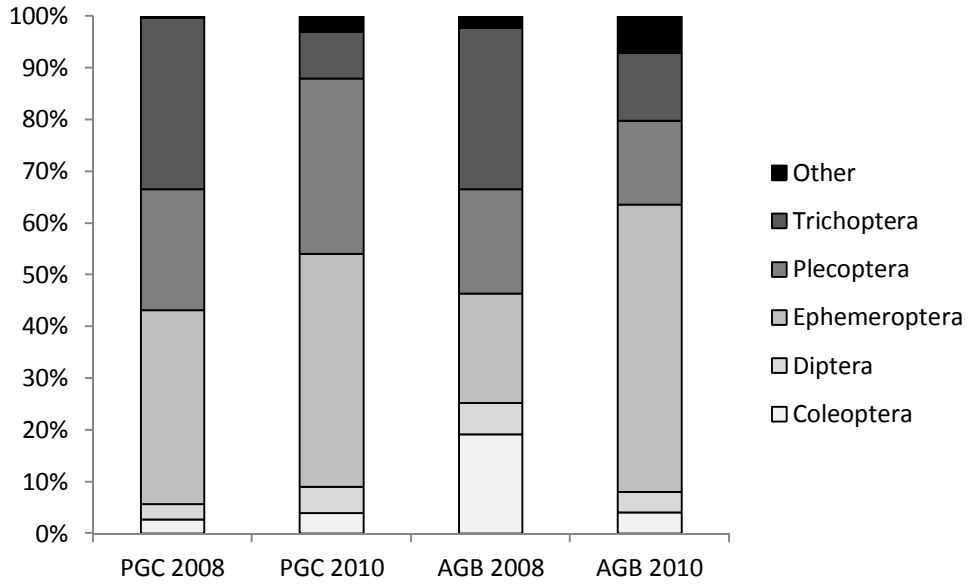

Figure 14: Mean percent relative abundance of major macroinvertebrate groups at two sites on West Rosebud Creek, October 2008 and 2010.

Macroinvertebrate community density from the two sampling sites ranged from 205 to 596 organism per Hess sample (0.1 square meter) in 2008 and from 335 to 659 in 2010 (Appendix A). In 2008, the average community density was 444 organisms per Hess sample at the Pine Grove Campground site and 288 organisms per Hess sample at the Allen Grade Bridge site. In 2010, the average community density was 563 organisms per Hess sample at the Pine Grove Campground site and 360 organisms per Hess sample at the Allen Grade Bridge site.

7.4.3 Functional Feeding Groups

Functional feeding groups provide information regarding the balance of feeding strategies within the benthic macroinvertebrate community. An imbalance in functional feeding groups may indicate stressed conditions or unstable food supply (Plafkin et al. 1989).

Organisms sampled at the Pine Grove Campground and Allen Grade Bridge sites in 2008 and 2010 were classified into five functional feeding groups (collector-gatherers, shredders,

scrapers, filterers, and predators).The mean composition of the functional feeding groups observed at each site in 2008 and 2010 is shown in Figure 15.

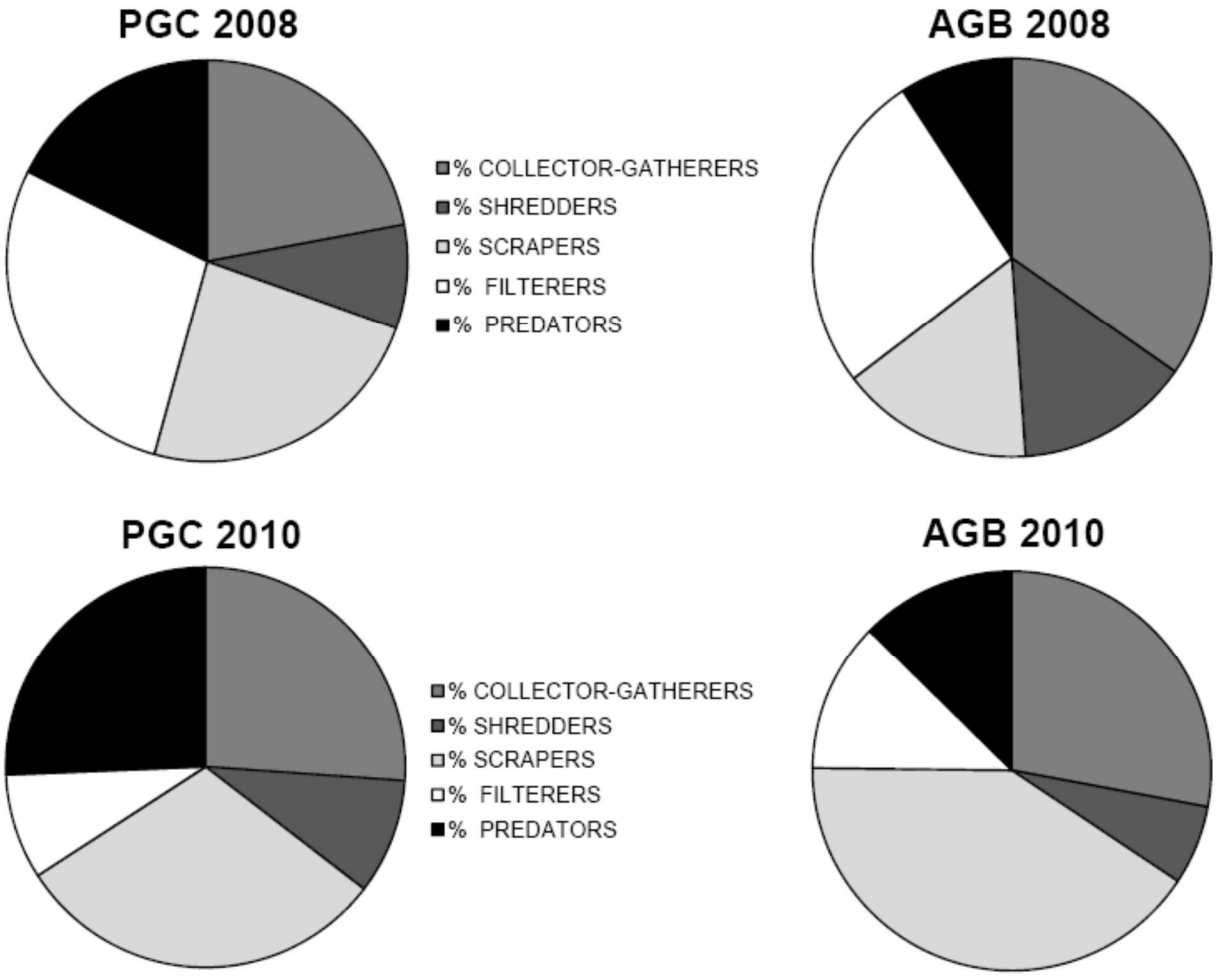

Figure 15: Mean representation of each functional feeding group (collector-gatherers, shredders, scrapers, filterers, and predators) at the Pine Grove Campground (PGC) and Allen Grade Bridge (AGB) sites in 2008 and 2010. Mean percentage is based on the three samples collected at each site.

In 2008, filterers (28%) were the most common feeding group at Pine Grove Campground while collector-gatherers (35%) were the most common feeding group at Allen Grade Bridge. In 2010, scrapers (30% at Pine Grove Campground and 41% at Allen Grade Bridge) were the most common feeding group at both sites.

In 2008 at the Pine Grove Campground site, the percentage of the collector-gatherers (22%), scrapers (24%), filterers (28%), and predators (18%) was very similar with shredders representing the remaining 8 percent of the total functional feed group composition (Figure 15). In 2010, the percentage of collector-gatherers (26%), scrapers (30%), and predators (26%) remained the predominant functional feeding groups while the presence of filterers

declined to 8 percent at the Pine Grove Campground site. Shredders represented 9 percent of the functional feeding groups, which was similar to 2008.

In 2008 at the Allen Grade Bridge site, the dominant functional feeding group were the collector-gatherers (35%) followed by the filterers (26%), scrapers (16%), and shredders (14%), and predators (9%). In 2010, the composition of functional feeding groups shifted and the most dominant group at Allen Grade Bridge were the scrapers (41%) followed by the collector-gatherers (28%), predators (13%), filterers (12%), and the shredders (6%).

Although there is variability in composition between years and between sites (Figure 15), there appears to be a healthy mix of functional feeding groups present each year and at each site and no indications of stress or imbalance are indicated through this metric.

7.4.4 Percent EPT and EPT Taxa Richness

EPT refers to the composition of taxa in ñpollution sensitiveò orders, including, mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera). These three orders are typically the most dominate macroinvertebrate faunas found in mountain streams and are strong indicators of aquatic ecosystem health. The percent EPT is the total number of EPT individuals divided by the total number of individuals in the sample. The percent EPT is a standard community composition metric used to evaluate water and habitat quality (Bukantis 1997). Environmental stress or pollution may be indicated when EPT comprise less than about 50 percent of the fauna.

EPT taxa richness represents the number of taxa within the orders. Typically a non-impacted will have more than 10 EPT taxa represented and a stream severely impacted will have 0 to 1 EPT taxa (Bode 1993). Percent EPT and EPT taxa richness will decrease with decreasing water quality (Weber 1973). Therefore EPT indices such as the percent EPT and EPT taxa richness are commonly used to assess the biological condition of a stream.

In 2008, the percent EPT values ranged from 90 to 98 percent in the Pine Grove Campground samples and from 61 to 81 percent in the Allen Grade Bridge samples (Appendix A). In 2008, EPT richness ranged from 16 to 21 taxa in the Pine Grove Campground samples and from 14 to 23 taxa in the Allen Grade Bridge samples (Appendix A). In 2010, the percent EPT values ranged from 85 to 91 percent in the Pine Grove Campground samples and from 82 to 89 percent in the Allen Grade Bridge samples (Appendix A). In 2010, EPT richness ranged from 19 to 21 in both the Pine Grove Campground and Allen Grade Bridge samples. Both indices from 2008 and 2010 data indicate a dominant and diverse presence of EPT organisms in West Rosebud Creek as well as high stream quality.

7.4.5 Biotic Index

The biotic index was developed as a measure of organic pollution (Hilsenhoff 1987) or organismôs relative sensitivity to stream quality conditions. The State of Montanaôs version

of this index (Bukantis 1997) is an excellent indicator of a streamôs trophic status and also tends to be correlated with water temperature, substrate embeddedness, and the percentage of fine sediments (Bollman 1998). On a scale of 0 to 10 (0 assigned to organisms that are least tolerant to organic pollution and 10 assigned to organisms most tolerant of organic pollution), with higher values indicating increasingly eutrophic conditions, healthy mountain streams in Montana typically have biotic index values of 4 or less (McGuire 1992).

In West Rosebud Creek biotic index values were low and on average less than 2.8 at both sampling sites in 2008 and 2010 (Table 12). At the Pine Grove Campground site, the biotic index ranged from 2.1 to 2.5 with an average biotic index of 2.3 in 2008. In 2010, the biotic index ranged from 1.7 to 2.3 with an average biotic index of 2.0. At the Allen Grade Bridge site, the biotic index ranged from 2.5 to 3.2 with an average biotic index of 2.8 in 2008. In 2010, the biotic index ranged from 1.6 to 2.4, with an average biotic index of 2.0. The biotic index values in West Rosebud Creek measured in 2008 and 2010 indicated good to excellent water quality conditions.

Table 12: Summary of metrics for the 2008 and 2010 Pine Grove Campground (PGC) and Allen Grade Bridge (AGB) macroinvertebrate samples. The values provided in the table are the means of each metric calculated from the three samples taken at each site.

	PGC		AGB	
Metrics	**2008**	**2010**	**2008**	**2010**
Community Density (organisms/0.1m^2)	444	563	288	360
Taxa Richness	29	29	30	28
Percent EPT (%)	93	88	70	85
EPT Richness	19	20	19	20
Biotic Index	2.3	2.0	2.8	2.0

7.4.6 Summary

Macroinvertebrate data collected from 2008 and 2010 in West Rosebud Creek indicate healthy stream conditions at both the Pine Grove Campground and Allen Grade Bridge sites based on taxa richness, EPT taxa richness, and biotic index (Bode 1993). Criteria for a healthy/non-impacted site include taxa richness greater than 30, EPT taxa richness greater than 10, and a biotic index between 0 and 4.5 (Bode 1993). A non-impacted site is referring to a stream of high quality that has a diverse macroinvertebrate community that is dominated by ñpollution sensitiveò organisms and that the macroinvertebrate community is not limited by water quality or habitat conditions. All macroinvertebrate indices analyzed at both sites in West Rosebud Creek met the stream-quality assessment criteria for a non-impacted site based on the results from 2008 and 2010.

In 2008, the overall taxa richness for the two sites was 52, with 40 unique taxa identified at each site. EPT taxa richness ranged between 14 and 23, and the biotic index was no greater than 3.2 per sample at either site. In 2010, the overall taxa richness for the two sites was 50, with 39 unique taxa identified at Pine Grove Campground and 42 unique taxa identified at

Allen Grade Bridge. EPT taxa richness ranged between 19 and 21 and the biotic index was no greater than 2.4 per sample at either site in 2010.

8.0 2011 Monitoring Activities

In 2010, PPL Montana developed the Fisheries Monitoring Plan for the Mystic Lake Project. Cooperative fisheries monitoring efforts will continue on a 6-year cycle as described below with the exception that West Rosebud Creek redd counts (*see* column F) will be done annually *versus* every other year.

Mystic License Proposed Fisheries Monitoring 6-Year Schedule

	Sampling Effort						
Year	**A**	**B**	**C**	**D**	**E**	**F**	**G**
2010			X	X	X		X
2011		X				X	
2012	X		X				X
2013				X	X	X	
2014		X	X				X
2015	X					X	

A= Mystic Lake monitoring
B= West Rosebud Creek between the dam and powerhouse
C= West Rosebud and Emerald lakes fish monitoring
D= West Rosebud Creek below Emerald Lake electrofishing
E= West Rosebud Creek habitat monitoring
F= West Rosebud Creek redd counts
G= Water Temperature monitoring

In 2011, there are two monitoring activities scheduled:

- Electrofishing in West Rosebud Creek between Mystic Dam and the powerhouse
- Redd counts in the Mackay section of West Rosebud Creek

Electrofishing efforts will be completed in August or September in two established locations: 1) a 200-foot section at the downstream end of the reach and 2) a 350-foot section below the falls. Data collected will be used to estimate and report fish populations. This sampling data will be used to evaluate relative change in the fish community over time.

Annual reports will be prepared which summarize the previous yearôs (2011) work and the proposed plan for the next year (2012). Reports will be submitted to the Mystic TAC and posted on the Mystic Lake Hydroelectric Project website.

PPL Montana proposes to file an updated Mystic Monitoring Fisheries Plan, including a summary report on progress under the previous Plan, with the FERC in 2016 and every 6 years thereafter for the term of the Mystic Lake Hydroelectric Project License.

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Appendix A – Macroinvertebrate and Substrate Data

Table A-1: Summary of macroinvertebrate data collected in October 2008 at Pine Grove Campground

West Rosebud Creek,	**Stillwater County, MT**						
PPL-MT:	**Site: Pine Grove CG**						
2-Oct-08	**HESS SAMPLES 0.1 M2**						
Hess sample (0.1m2):	1	2	3	MEAN	ST. DEV.	TOT #	%RA
Taxon							
COLEOPTERA				12		36	3%
Heterlimnius corpulentus	2	4	1	2.3	1.5	7	0.5%
Lara avara	0	0	1	0.3	0.6	1	0.1%
Narpus concolor	1	0	0	0.3	0.6	1	0.1%
Optioservus sp.	2	14	11	9.0	6.2	27	2.0%
DIPTERA				13		40	3%
Thienemannimyia gp.	0	1	0	0.3	0.6	1	0.1%
Pagastia sp.	0	0	1	0.3	0.6	1	0.1%
Eukiefferiella spp.	1	1	1	1.0	0.0	3	0.2%
Orthocladius sp.	1	4	0	1.7	2.1	5	0.4%
Rheocricotopus sp.	0	2	1	1.0	1.0	3	0.2%
Tvetenia sp.	2	0	5	2.3	2.5	7	0.5%
Dicranota sp.	0	0	1	0.3	0.6	1	0.1%
Hexatoma sp.	1	3	11	5.0	5.3	15	1.1%
Rhabdomastix sp.	1	0	0	0.3	0.6	1	0.1%
Simulium spp. (Eusimulium)	1	0	2	1.0	1.0	3	0.2%
EPHEMEROPTERA				166		499	37%
Baetis tricaudatus	88	51	81	73.3	19.7	220	16.5%
Drunella doddsi	1	0	2	1.0	1.0	3	0.2%
Ephemerella sp.	3	0	1	1.3	1.5	4	0.3%
Seratella sp.	1	1	0	0.7	0.6	2	0.2%
Cinygmula spp.	24	29	22	25.0	3.6	75	5.6%
Epeorus sp.	0	1	0	0.3	0.6	1	0.1%
Rhithrogena sp.	7	21	8	12.0	7.8	36	2.7%
Paraleptophlebia sp.	43	44	70	52.3	15.3	157	11.8%
Ameletus sp.	0	0	1	0.3	0.6	1	0.1%
PLECOPTERA				104		311	23%
Zapada cinctipes	73	9	37	39.7	32.1	119	8.9%
Chloroperlinae*	49	45	72	55.3	14.6	166	12.5%
Skwala sp.	0	0	1	0.3	0.6	1	0.1%
Claassina sabulosa	2	7	2	3.7	2.9	11	0.8%
Hesperoperla pacifica	5	4	5	4.7	0.6	14	1.1%
TRICHOPTERA				148		443	33%
Arctopsyche sp.	14	9	6	9.7	4.0	29	2.2%
Hydropsyche (C) oslari	239	29	93	120	107.6	361	27.1%

West Rosebud Creek,	**Stillwater County, MT**						
PPL-MT:	**Site: Pine Grove CG**						
2-Oct-08	**HESS SAMPLES 0.1 M2**						
Hess sample (0.1m2):	1	2	3	MEAN	ST. DEV.	TOT #	%RA
Taxon							
Dolophilodes sp.	12	0	5	5.7	6.0	17	1.3%
Agraylea sp.	1	0	1	0.7	0.6	2	0.2%
Brachycentrus americanus	9	1	4	4.7	4.0	14	1.1%
Micrasema sp.	1	0	0	0.3	0.6	1	0.1%
Lepidostoma sp.	1	1	2	1.3	0.6	4	0.3%
Glossosoma sp.	5	2	2	3.0	1.7	9	0.7%
Rhyacophila brunnea gp.	3	1	1	1.7	1.2	5	0.4%
Rhyacophila sibirica gp.	1	0	0	0.3	0.6	1	0.1%
OTHER				1		3	0%
Polycelis sp.	1	0	1	0.7	0.6	2	0.2%
Pisidium sp.	1	0	0	0.3	0.6	1	0.1%
IDs by D. McGuire							
TOTAL ORGANISMS	596	284	452	444	156.2	1332	
TAXA RICHNESS	32	23	31	28.7	4.9	40	
EPT RICHNESS	21	16	20	19.0	2.6	24	
BIOTIC INDEX	2.53	2.08	2.30	2.30	0.23	2.36	
% DOMINANT TAXON	40%	18%	21%	26%	12%		
% COLLECTORS (g+f)	63%	40%	47%	50%	12%	53%	
% SCRAPER+SHREDDER	27%	38%	32%	32%	6%	31%	
%EPT	98%	90%	92%	93%	4%	94%	
SHANNON DIVERSITY	2.99	3.53	3.39	3.30	0.28	3.40	
EPT/(EPT + Chironomidae)	0.99	0.97	0.98	0.98	0.01	0.99	
% COLLECTOR-GATHERERS	17%	27%	23%	22%	5%	21%	
% SHREDDERS	13%	4%	9%	8%	5%	9%	
% SCRAPERS	14%	35%	23%	24%	10%	21%	
% FILTERERS	46%	14%	24%	28%	17%	32%	
% PREDATORS	11%	21%	21%	18%	6%	16%	
% CHIRONOMIDAE	1%	3%	2%	2%	1%	2%	
% TANYTARSINI	0%	0%	0%	0%	0%	0%	
Baetidae/EPHEMEROPTERA	53%	35%	44%	44%	9%	44%	
METALS TOLERANCE INDEX	4.09	2.93	3.36	3.46	0.59	3.60	
*notes: Chloroperlinae mostly early instar- both Sweltsa and Suwallia present.							

Table A-2: Summary of macroinvertebrate data collected in October 2008 at Allen Grade Bridge.

West Rosebud Creek,	**Stillwater County, MT**						
PPL-MT:	**Site: Allen Grade Bridge**						
2-Oct-08	**HESS SAMPLES 0.1 M2**						
Hess sample (0.1m2):	1	2	3	MEAN	ST. DEV.	TOT #	%RA
Taxon							
COLEOPTERA				55		165	19%
Narpus concolor	0	1	2	1.0	1.0	3	0.3%
Optioservus sp.	58	48	53	53.0	5.0	159	18.4%
Zaitzevia sp.	3	0	0	1.0	1.7	3	0.3%
DIPTERA				18		55	6%
Thienemannimyia gp.	2	1	0	1.0	1.0	3	0.3%
Pagastia sp.	1	0	1	0.7	0.6	2	0.2%
Brillia sp.	0	1	0	0.3	0.6	1	0.1%
Eukiefferiella spp.	1	0	1	0.7	0.6	2	0.2%
Orthocladius sp.	4	2	8	4.7	3.1	14	1.6%
Rheocricotopus sp.	2	1	1	1.3	0.6	4	0.5%
Tvetenia sp.	2	9	1	4.0	4.4	12	1.4%
Micropsectra spp.	3	2	4	3.0	1.0	9	1.0%
Hexatoma sp.	5	2	1	2.7	2.1	8	0.9%
EPHEMEROPTERA				61		184	21%
Acentrella sp.	1	3	0	1.3	1.5	4	0.5%
Baetis tricaudatus	14	14	13	13.7	0.6	41	4.8%
Drunella doddsi	2	1	0	1.0	1.0	3	0.3%
Drunella grandis	0	1	0	0.3	0.6	1	0.1%
Ephemerella sp.	1	4	4	3.0	1.7	9	1.0%
Cinygmula spp.	11	9	3	7.7	4.2	23	2.7%
Rhithrogena sp.	29	37	9	25.0	14.4	75	8.7%
Paraleptophlebia sp.	8	12	8	9.3	2.3	28	3.2%
PLECOPTERA				57		172	20%
Capniidae	0	4	0	1.3	2.3	4	0.5%
Leuctridae	0	1	0	0.3	0.6	1	0.1%
Zapada cinctipes	31	55	17	34.3	19.2	103	11.9%
Chloroperlinae*	27	16	9	17.3	9.1	52	6.0%
Kathroperla sp.	1	0	0	0.3	0.6	1	0.1%
Claassina sabulosa	2	1	4	2.3	1.5	7	0.8%
Hesperoperla pacifica	2	2	0	1.3	1.2	4	0.5%
TRICHOPTERA				89		267	31%
Arctopsyche sp.	3	26	12	13.7	11.6	41	4.8%
Hydropsyche (C) oslari	47	83	26	52.0	28.8	156	18.1%
Dolophilodes sp.	1	7	0	2.7	3.8	8	0.9%
Agraylea sp.	0	0	1	0.3	0.6	1	0.1%
Brachycentrus americanus	3	22	6	10.3	10.2	31	3.6%

West Rosebud Creek,	**Stillwater County, MT**						
PPL-MT:	**Site: Allen Grade Bridge**						
2-Oct-08	**HESS SAMPLES 0.1 M2**						
Hess sample (0.1m2):	1	2	3	MEAN	ST. DEV.	TOT #	%RA
Taxon							
Brachycentrus occidentalis	2	2	0	1.3	1.2	4	0.5%
Micrasema sp.	1	1	0	0.7	0.6	2	0.2%
Lepidostoma sp.	1	0	10	3.7	5.5	11	1.3%
Glossosoma sp.	2	3	4	3.0	1.0	9	1.0%
Rhyacophila coloradensis gp.	1	2	0	1.0	1.0	3	0.3%
Rhyacophila sibirica gp.	0	1	0	0.3	0.6	1	0.1%
ANNELIDA				7		20	2%
Enchytraeidae	10	3	6	6.3	3.5	19	2.2%
Megadrilli	0	0	1	0.3	0.6	1	0.1%
IDs by D. McGuire							
TOTAL ORGANISMS	281	377	205	288	86.2	863	
TAXA RICHNESS	32	33	25	30.0	4.4	40	
EPT RICHNESS	21	23	14	19.3	4.7	26	
BIOTIC INDEX	2.78	2.50	3.15	2.81	0.33	2.74	
% DOMINANT TAXON	21%	22%	26%	23%	3%		
% COLLECTORS (g+f)	56%	60%	67%	61%	6%	60%	
% SCRAPER+SHREDDER	30%	33%	26%	30%	3%	31%	
%EPT	68%	81%	61%	70%	10%	72%	
SHANNON DIVERSITY	3.77	3.76	3.80	3.78	0.02	3.93	
EPT/(EPT + Chironomidae)	0.93	0.95	0.89	0.92	0.03	0.96	
% COLLECTOR-GATHERERS	36%	23%	45%	35%	11%	32%	
% SHREDDERS	12%	17%	14%	14%	2%	14%	
% SCRAPERS	19%	16%	12%	16%	3%	16%	
% FILTERERS	20%	37%	21%	26%	10%	28%	
% PREDATORS	14%	7%	7%	9%	4%	9%	
% CHIRONOMIDAE	5%	4%	8%	6%	2%	5%	
% TANYTARSINI	1%	1%	2%	1%	1%	1%	
Baetidae/EPHEMEROPTERA	23%	21%	35%	26%	8%	24%	
METALS TOLERANCE INDEX	3.59	3.67	3.72	3.66	0.07	3.65	
*notes: Chloroperlinae mostly early instar- both Sweltsa and Suwallia present.							

Table A-3: Summary of macroinvertebrate data collected in October 2010 at Pine Grove Campground.

West Rosebud Creek,	**Stillwater County, MT**						
PPL-MT:	**Site: Pine Grove CG**						
6-Oct-10	**HESS SAMPLES 0.1 M2**						
Hess sample (0.1m2):	1	2	3	MEAN	ST. DEV.	TOT #	%RA
Taxon							
COLEOPTERA				20		60	4%
Heterlimnius corpulentus	18	14	3	11.7	7.8	35	2.1%
Optioservus sp.	5	12	7	8.0	3.6	24	1.4%
Zaitzevia sp.	1	0	0	0.3	0.6	1	0.1%
DIPTERA				29		87	5%
Thienemannimyia gp.	1	0	1	0.7	0.6	2	0.1%
Pagastia sp.	0	0	2	0.7	1.2	2	0.1%
Eukiefferiella spp.	1	2	2	1.7	0.6	5	0.3%
Orthocladius sp.	16	19	31	22.0	7.9	66	3.9%
Tvetenia sp.	2	0	0	0.7	1.2	2	0.1%
Antocha sp.	0	1	1	0.7	0.6	2	0.1%
Dicranota sp.	0	0	1	0.3	0.6	1	0.1%
Hexatoma sp.	3	1	2	2.0	1.0	6	0.4%
Ceratopogoninae	0	1	0	0.3	0.6	1	0.1%
EPHEMEROPTERA				252		757	45%
Acentrella insignificans	0	0	2	0.7	1.2	2	0.1%
Baetis tricaudatus	40	40	99	59.7	34.1	179	10.6%
Caudatella hystrix	0	0	1	0.3	0.6	1	0.1%
Drunella doddsi	3	6	2	3.7	2.1	11	0.7%
Ephemerella sp.	33	14	16	21.0	10.4	63	3.7%
Cinygmula spp.	47	21	28	32.0	13.5	96	5.7%
Epeorus longimanus	2	4	1	2.3	1.5	7	0.4%
Rhithrogena sp.	22	23	5	16.7	10.1	50	3.0%
Paraleptophlebia sp.	181	71	96	116	57.7	348	20.6%
PLECOPTERA				192		577	34%
Leuctridae	1	0	0	0.3	0.6	1	0.1%
Zapada cinctipes	87	55	18	53.3	34.5	160	9.5%
Chloroperlinae*	136	101	125	121	17.9	362	21.4%
Kathroperla sp.	1	0	0	0.3	0.6	1	0.1%
Claassina sabulosa	2	4	2	2.7	1.2	8	0.5%
Doroneuria sp.	0	1	0	0.3	0.6	1	0.1%
Hesperoperla pacifica	20	18	6	14.7	7.6	44	2.6%
TRICHOPTERA				53		158	9%
Arctopsyche sp.	2	8	4	4.7	3.1	14	0.8%
Hydropsyche (C) oslari	9	54	20	27.7	23.5	83	4.9%
Dolophilodes sp.	1	12	2	5.0	6.1	15	0.9%
Agraylea sp.	0	2	0	0.7	1.2	2	0.1%
Brachycentrus americanus	12	6	6	8.0	3.5	24	1.4%
Lepidostoma sp.	1	0	1	0.7	0.6	2	0.1%

West Rosebud Creek,	**Stillwater County, MT**						
PPL-MT:	**Site: Pine Grove CG**						
6-Oct-10	**HESS SAMPLES 0.1 M2**						
Hess sample (0.1m2):	1	2	3	MEAN	ST. DEV.	TOT #	%RA
Taxon							
Glossosoma sp.	2	7	4	4.3	2.5	13	0.8%
Rhyacophila brunnea gp.	0	0	2	0.7	1.2	2	0.1%
Rhyacophila coloradensis gp.	0	1	2	1.0	1.0	3	0.2%
ANNELIDA				16		49	3%
Enchytraeidae	10	14	25	16.3	7.8	49	2.9%
OTHER				1		2	0%
Polycelis sp.	0	0	2	0.7	1.2	2	0.1%
IDs by D. McGuire							
TOTAL ORGANISMS	659	512	519	563	82.9	1690	
TAXA RICHNESS	28	27	32	29.0	2.6	39	
EPT RICHNESS	19	19	21	19.7	1.2	25	
BIOTIC INDEX	1.69	2.06	2.25	2.00	0.29	1.97	
% DOMINANT TAXON	27%	20%	24%	24%	4%		
% COLLECTORS (g+f)	23%	38%	43%	35%	10%	34%	
% SCRAPER+SHREDDER	53%	37%	30%	40%	12%	41%	
%EPT	91%	88%	85%	88%	3%	88%	
SHANNON DIVERSITY	3.32	3.84	3.45	3.54	0.27	3.65	
EPT/(EPT + Chironomidae)	0.97	0.96	0.92	0.95	0.02	0.97	
% COLLECTOR-GATHERERS	19%	23%	36%	26%	9%	26%	
% SHREDDERS	14%	11%	4%	9%	5%	10%	
% SCRAPERS	39%	26%	26%	30%	7%	31%	
% FILTERERS	4%	16%	6%	8%	6%	8%	
% PREDATORS	25%	25%	28%	26%	2%	26%	
% CHIRONOMIDAE	3%	4%	7%	5%	2%	5%	
% TANYTARSINI	0%	0%	0%	0%	0%	0%	
Baetidae/EPHEMEROPTERA	12%	22%	40%	25%	14%	24%	
METALS TOLERANCE INDEX	2.13	2.78	2.73	2.55	0.36	2.51	
*notes: Chloroperlinae mostly early instar- both Sweltsa and Suwallia present.							

Table A-4: Summary of macroinvertebrate data collected in October 2010 at Allen Grade Bridge.

West Rosebud Creek,	**Stillwater County, MT**						
PPL-MT:	**Site: Allen Grade Bridge**						
6-Oct-10	**HESS SAMPLES 0.1 M2**						
Hess sample (0.1m2):	1	2	3	MEAN	ST. DEV.	TOT #	%RA
Taxon							
COLEOPTERA				15		44	4%
Narpus concolor	4	1	0	1.7	2.1	5	0.5%
Optioservus sp.	12	15	11	12.7	2.1	38	3.5%
Zaitzevia sp.	0	0	1	0.3	0.6	1	0.1%
DIPTERA				13		38	4%
Eukiefferiella spp.	1	0	0	0.3	0.6	1	0.1%
Orthocladius sp.	2	14	1	5.7	7.2	17	1.6%
Rheocricotopus sp.	2	0	0	0.7	1.2	2	0.2%
Tvetenia sp.	1	1	1	1.0	0.0	3	0.3%
Antocha sp.	0	1	0	0.3	0.6	1	0.1%
Dicranota sp.	0	1	0	0.3	0.6	1	0.1%
Hexatoma sp.	0	4	0	1.3	2.3	4	0.4%
Simulium spp. (Eusimulium)	0	0	9	3.0	5.2	9	0.8%
EPHEMEROPTERA				199		597	55%
Baetis tricaudatus	53	18	71	47.3	27.0	142	13.2%
Caudatella hystrix	0	0	1	0.3	0.6	1	0.1%
Drunella doddsi	4	0	16	6.7	8.3	20	1.9%
Ephemerella sp.	6	5	2	4.3	2.1	13	1.2%
Cinygmula spp.	30	66	3	33.0	31.6	99	9.2%
Epeorus grandis	0	0	2	0.7	1.2	2	0.2%
Epeorus longimanus	0	0	7	2.3	4.0	7	0.6%
Rhithrogena sp.	69	19	49	45.7	25.2	137	12.7%
Paraleptophlebia sp.	32	125	18	58.3	58.2	175	16.2%
Ameletus sp.	0	1	0	0.3	0.6	1	0.1%
PLECOPTERA				59		178	16%
Capniidae	0	1	0	0.3	0.6	1	0.1%
Leuctridae	1	2	0	1.0	1.0	3	0.3%
Zapada cinctipes	19	26	13	19.3	6.5	58	5.4%
Chloroperlinae*	28	29	34	30.3	3.2	91	8.4%
Skwala sp.	0	2	0	0.7	1.2	2	0.2%
Claassina sabulosa	1	3	5	3.0	2.0	9	0.8%
Hesperoperla pacifica	6	4	4	4.7	1.2	14	1.3%
TRICHOPTERA				47		142	13%
Arctopsyche sp.	3	3	11	5.7	4.6	17	1.6%
Hydropsyche (C) oslari	36	18	35	29.7	10.1	89	8.2%
Dolophilodes sp.	1	3	1	1.7	1.2	5	0.5%
Brachycentrus americanus	3	3	2	2.7	0.6	8	0.7%
Micrasema sp.	1	0	0	0.3	0.6	1	0.1%
Lepidostoma sp.	1	0	1	0.7	0.6	2	0.2%

West Rosebud Creek,	**Stillwater County, MT**						
PPL-MT:	**Site: Allen Grade Bridge**						
6-Oct-10	**HESS SAMPLES 0.1 M2**						
Hess sample (0.1m2):	1	2	3	MEAN	ST. DEV.	TOT #	%RA
Taxon							
Glossosoma sp.	5	0	1	2.0	2.6	6	0.6%
Rhyacophila brunnea gp.	2	2	4	2.7	1.2	8	0.7%
Rhyacophila coloradensis gp.	1	0	1	0.7	0.6	2	0.2%
Rhyacophila sibirica gp.	0	4	0	1.3	2.3	4	0.4%
ANNELIDA				26		77	7%
Enchytraeidae	43	5	29	25.7	19.2	77	7.1%
OTHER				1		3	0%
Polycelis sp.	1	0	0	0.3	0.6	1	0.1%
Pisidium sp.	0	0	1	0.3	0.6	1	0.1%
Caecidotea sp.	0	0	1	0.3	0.6	1	0.1%
IDs by D. McGuire							
TOTAL ORGANISMS	368	376	335	360	21.7	1079	
TAXA RICHNESS	28	27	29	28.0	1.0	42	
EPT RICHNESS	20	19	21	20.0	1.0	27	
BIOTIC INDEX	2.04	1.59	2.39	2.01	0.40	1.99	
% DOMINANT TAXON	19%	33%	21%	24%	8%		
% COLLECTORS (g+f)	44%	23%	53%	40%	15%	40%	
% SCRAPER+SHREDDER	45%	64%	33%	47%	16%	48%	
%EPT	82%	89%	84%	85%	4%	85%	
SHANNON DIVERSITY	3.68	3.37	3.75	3.60	0.20	3.90	
EPT/(EPT + Chironomidae)	0.98	0.96	0.99	0.98	0.02	0.98	
% COLLECTOR-GATHERERS	33%	16%	35%	28%	10%	28%	
% SHREDDERS	7%	8%	4%	6%	2%	6%	
% SCRAPERS	38%	56%	29%	41%	14%	41%	
% FILTERERS	12%	7%	18%	12%	5%	12%	
% PREDATORS	11%	13%	14%	13%	2%	13%	
% CHIRONOMIDAE	2%	4%	1%	2%	2%	2%	
% TANYTARSINI	0%	0%	0%	0%	0%	0%	
Baetidae/EPHEMEROPTERA	27%	8%	42%	26%	17%	24%	
METALS TOLERANCE INDEX	2.66	1.95	3.04	2.55	0.55	2.53	
*notes: Chloroperlinae mostly early instar- both Sweltsa and Suwallia present.							

Table A-5: Summary of streambed substrate collected in October 2008 at Pine Grove Campground.

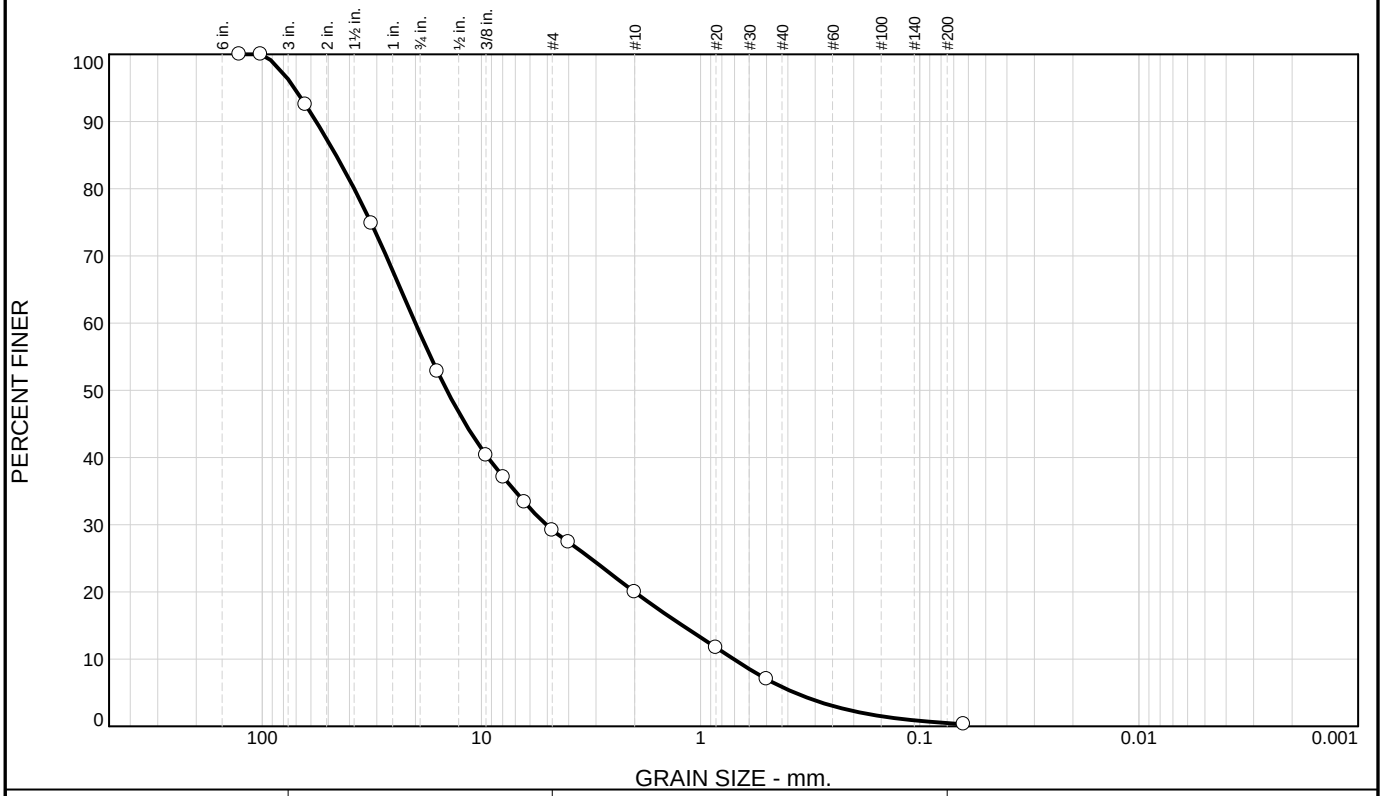
West Rosebud Creek, PPL-MT: 2-Oct-08	**Stillwater County, MT Site: Pine Grove CG Corresponding Sediment Samples**			
	1	2	3	MEAN
Water depth (ft)	0.8	0.75	0.8	0.78
Water velocity (ft/sec)	1.23	1.56	1.92	1.57
Streambed % composition (visual estimate of substrate surface)				
Cobble	70	75	65	70
Gravel	30	25	35	30
Sand	0	0	0	0
Fines	0	0	0	0

Table A-6: Summary of streambed substrate collected in October 2008 at Allen Grade Bridge.

West Rosebud Creek, PPL-MT: 2-Oct-08	**Stillwater County, MT Site: Allen Grade Bridge Corresponding Sediment Samples**			
	1	2	3	MEAN
Water depth (ft)	0.8	0.55	0.65	0.67
Water velocity (ft/sec)	1.58	0.85	1.41	1.28
Streambed % composition (visual estimate of substrate surface)				
Cobble	40	55	50	48
Gravel	50	35	30	38
Sand	10	10	20	13
Fines	0	0	0	0

Appendix B – Sediment Coring Data

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
3.7	37.9	29.2	9.2	14.2	5.3	0.5	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
5"	100.0		
4"	100.0		
2.5"	92.5		
1.25"	74.8		
5/8"	52.8		
3/8"	40.3		
5/16"	37.1		
1/4"	33.4		
#4	29.2		
#5	27.4		
#10	20.0		
#20	11.7		
#35	7.0		
#230	0.3		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 46.0708 D_{60}= 20.0115 D_{50}= 14.3857
D_{30}= 5.0773 D_{15}= 1.2081 D_{10}= 0.7067
C_u= 28.32 C_c= 1.82

Classification

USCS= GW AASHTO=

Remarks

Sample Number: 1
Source of Sample: Allen Grade Bridge **Date:** 10/06/10

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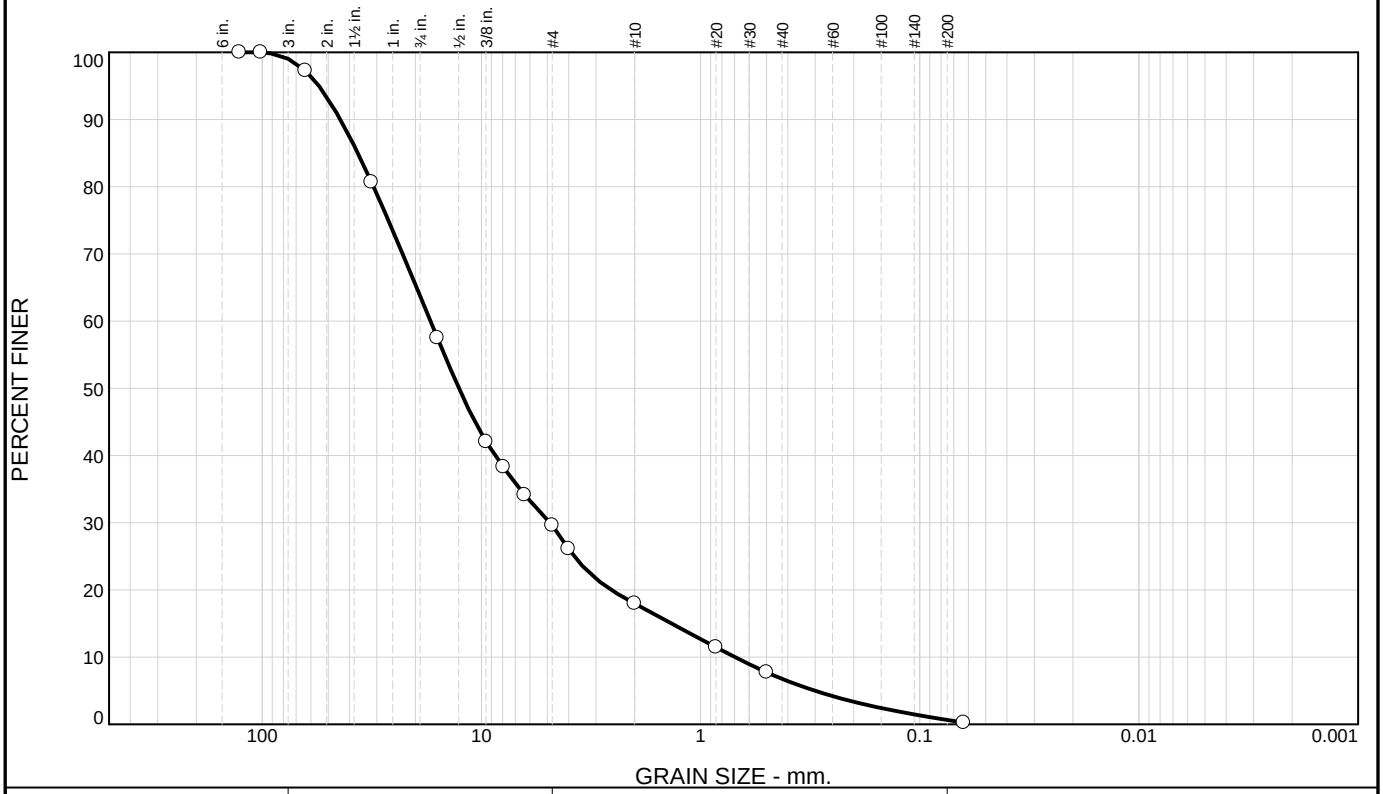
Ph. 406-388-8578 - Fax 406-388-8579

Client: PPL Montana
Project: West Rosebud Creek
Project No: 500753 **Figure**

Tested By: NKG

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
1.0	35.2	34.2	11.6	11.2	6.2	0.6	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
5"	100.0		
4"	100.0		
2.5"	97.3		
1.25"	80.7		
5/8"	57.5		
3/8"	42.0		
5/16"	38.3		
1/4"	34.1		
#4	29.6		
#5	26.1		
#10	18.0		
#20	11.5		
#35	7.7		
#230	0.2		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 36.6247 D_{60}= 17.0743 D_{50}= 12.6729
D_{30}= 4.8587 D_{15}= 1.3565 D_{10}= 0.6963
C_u= 24.52 C_c= 1.99

Classification

USCS= GW AASHTO=

Remarks

Sample Number: 2
Source of Sample: Allen Grade Bridge **Date:** 10/06/10

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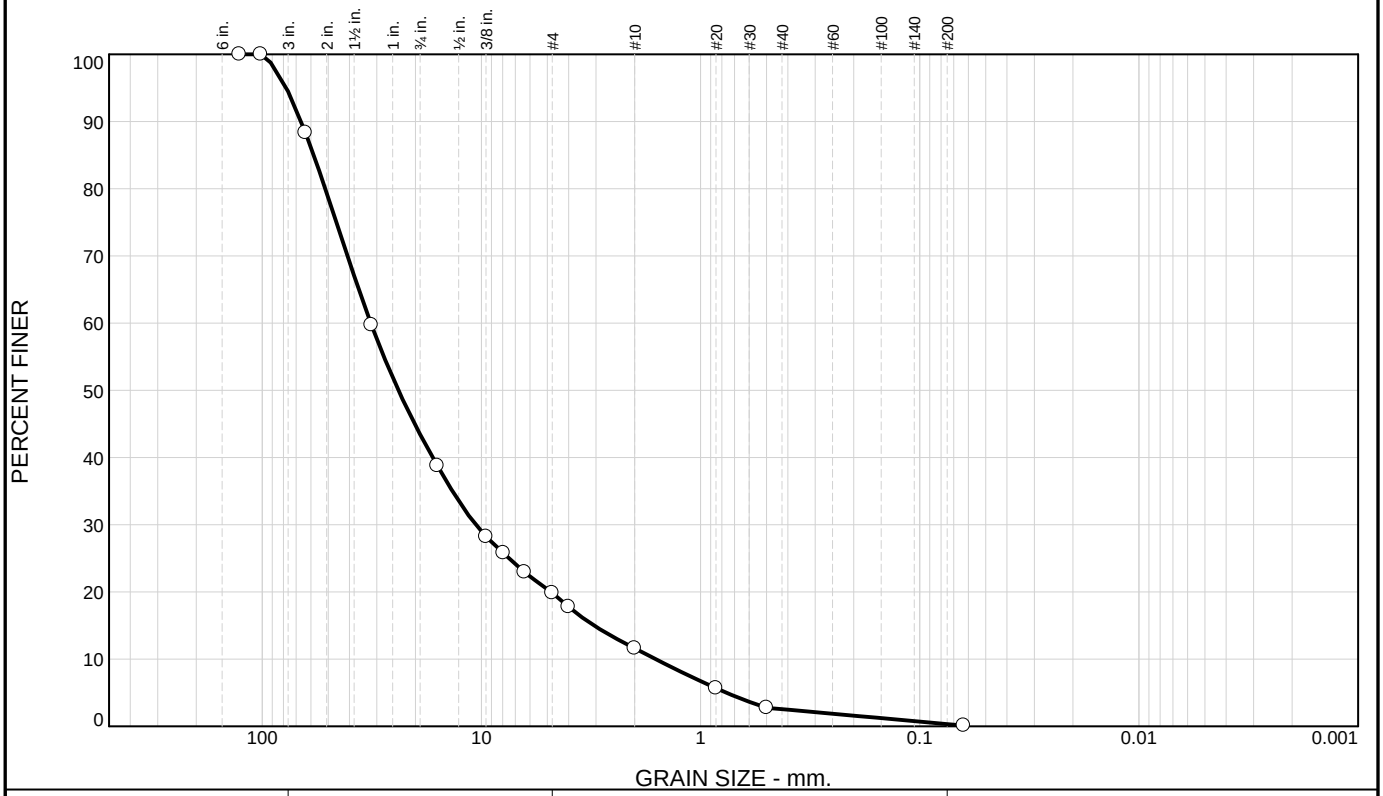
Client: PPL Montana
Project: West Rosebud Creek
Project No: 500753 **Figure**

Tested By: NKG

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
5.5	51.0	23.6	8.3	9.1	2.2	0.3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
5"	100.0		
4"	100.0		
2.5"	88.3		
1.25"	59.7		
5/8"	38.8		
3/8"	28.2		
5/16"	25.8		
1/4"	22.9		
#4	19.9		
#5	17.8		
#10	11.6		
#20	5.7		
#35	2.8		
#230	0.1		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 58.2461 D_{60}= 31.9956 D_{50}= 23.9251
D_{30}= 10.6307 D_{15}= 3.0661 D_{10}= 1.6039
C_u= 19.95 C_c= 2.20

Classification

USCS= GW AASHTO=

Remarks

Sample Number: 3
Source of Sample: Allen Grade Bridge **Date:** 10/06/10

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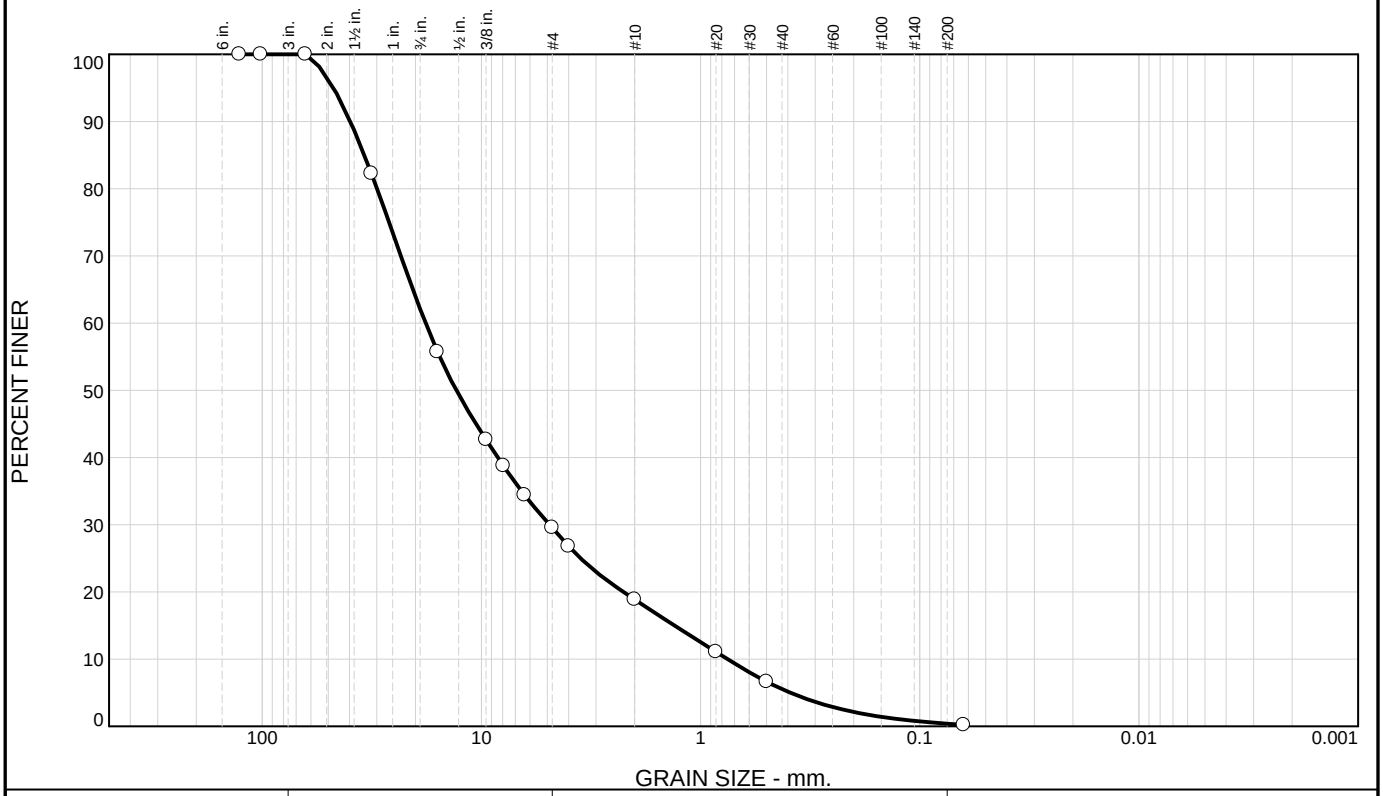
Client: PPL Montana
Project: West Rosebud Creek
Project No: 500753 **Figure**

Tested By: NKG

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	37.9	32.6	10.6	13.4	5.1	0.4	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
5"	100.0		
4"	100.0		
2.5"	100.0		
1.25"	82.3		
5/8"	55.7		
3/8"	42.7		
5/16"	38.8		
1/4"	34.4		
#4	29.5		
#5	26.8		
#10	18.9		
#20	11.1		
#35	6.6		
#230	0.2		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 34.1980 D_{60}= 17.9878 D_{50}= 13.0274
D_{30}= 4.8859 D_{15}= 1.3158 D_{10}= 0.7537
C_u= 23.87 C_c= 1.76

Classification

USCS= GW AASHTO=

Remarks

Sample Number: 4
Source of Sample: Allen Grade Bridge **Date:** 10/06/10

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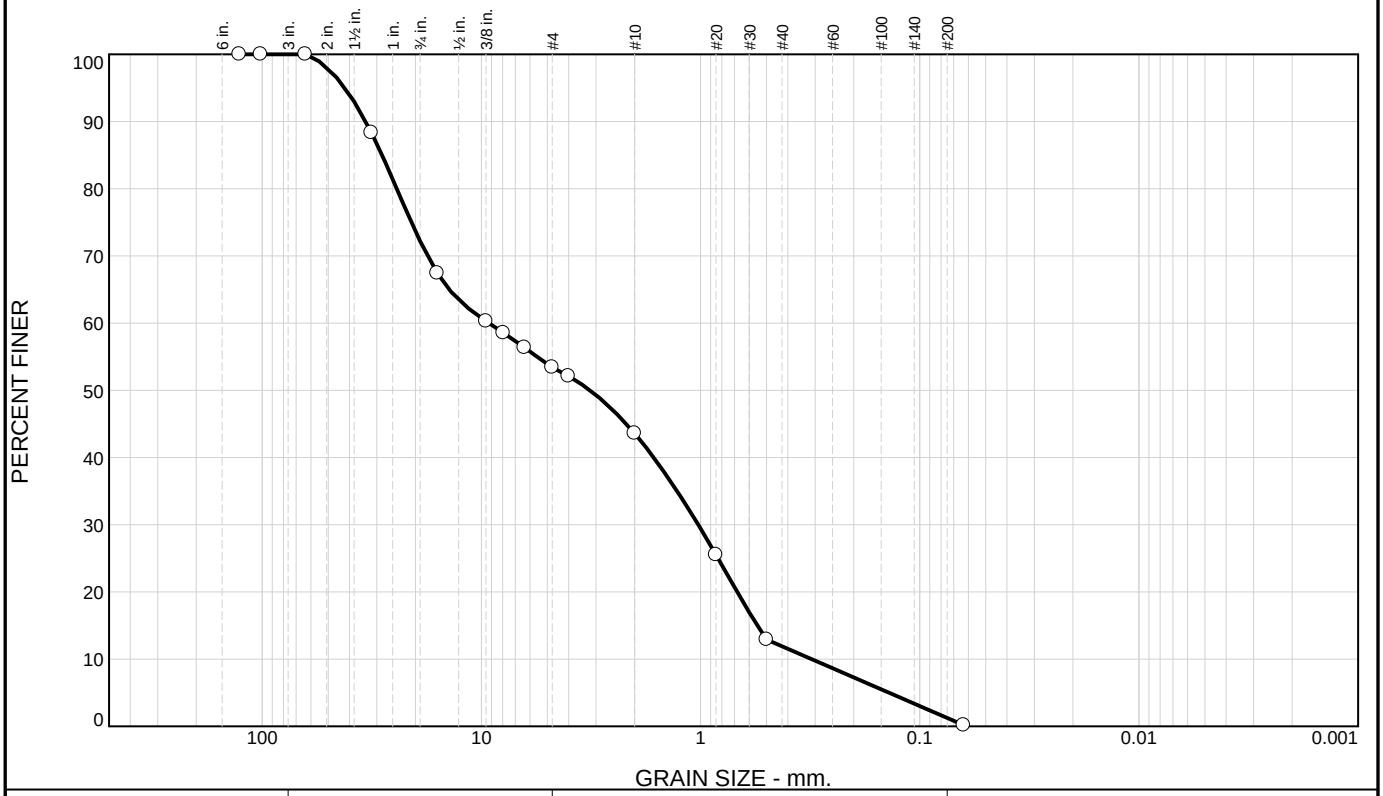
Client: PPL Montana
Project: West Rosebud Creek
Project No: 500753 **Figure**

Tested By: NKG

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	27.8	18.8	9.8	31.7	10.7	1.2	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
5"	100.0		
4"	100.0		
2.5"	100.0		
1.25"	88.3		
5/8"	67.4		
3/8"	60.3		
5/16"	58.5		
1/4"	56.4		
#4	53.4		
#5	52.1		
#10	43.6		
#20	25.5		
#35	12.9		
#230	0.2		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 28.4089 D_{60}= 9.2431 D_{50}= 3.1942
D_{30}= 1.0247 D_{15}= 0.5512 D_{10}= 0.3117
C_u= 29.65 C_c= 0.36

Classification

USCS= SP AASHTO=

Remarks

Sample Number: 5
Source of Sample: Allen Grade Bridge **Date:** 10/06/10

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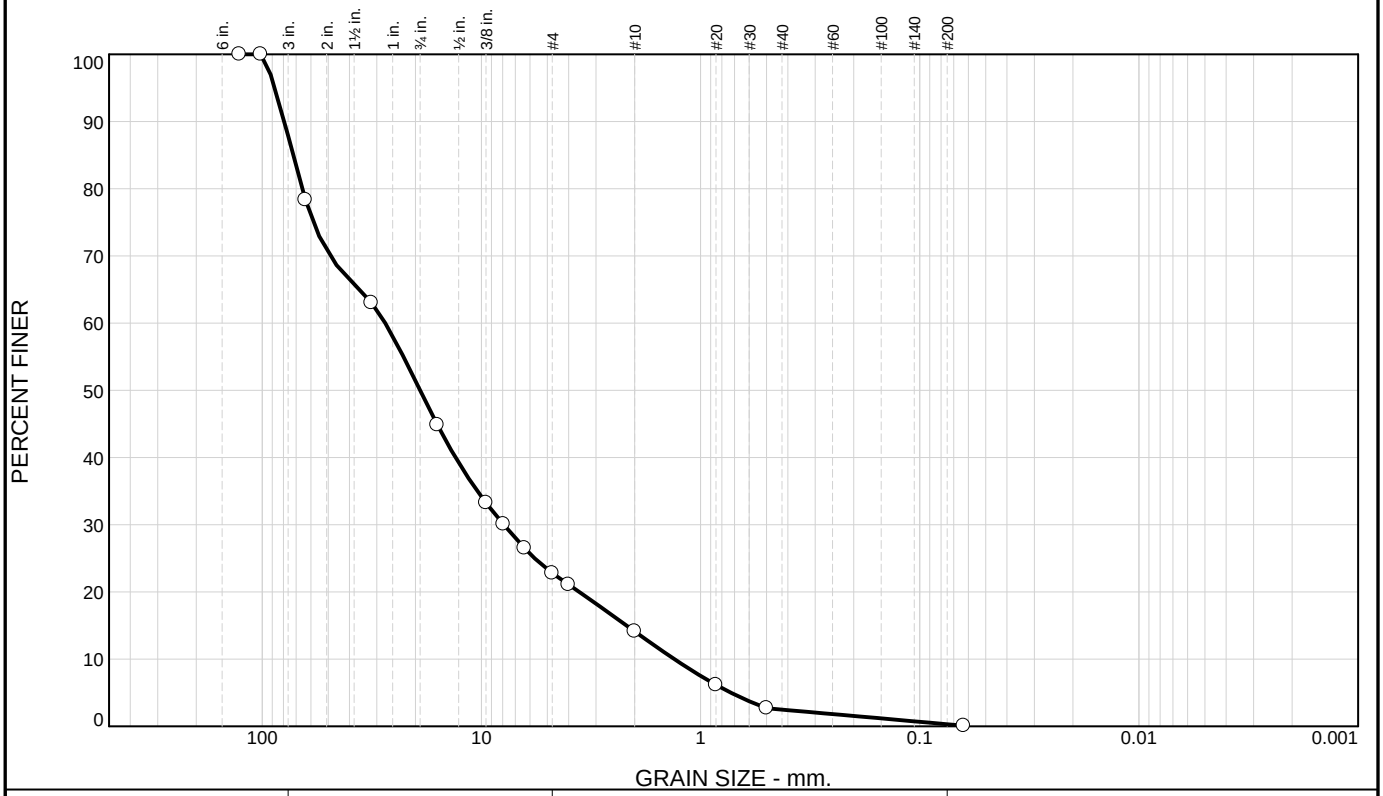
Client: PPL Montana
Project: West Rosebud Creek
Project No: 500753 **Figure**

Tested By: NKG

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
12.1	37.9	27.2	8.7	11.6	2.2	0.3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
5"	100.0		
4"	100.0		
2.5"	78.3		
1.25"	63.0		
5/8"	44.8		
3/8"	33.2		
5/16"	30.1		
1/4"	26.5		
#4	22.8		
#5	21.1		
#10	14.1		
#20	6.2		
#35	2.7		
#230	0.1		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 72.2966 D_{60}= 27.4784 D_{50}= 19.0452
D_{30}= 7.8985 D_{15}= 2.1799 D_{10}= 1.3177
C_u= 20.85 C_c= 1.72

Classification

USCS= GW AASHTO=

Remarks

Sample Number: 1
Source of Sample: Pine Grove **Date:** 10/06/10

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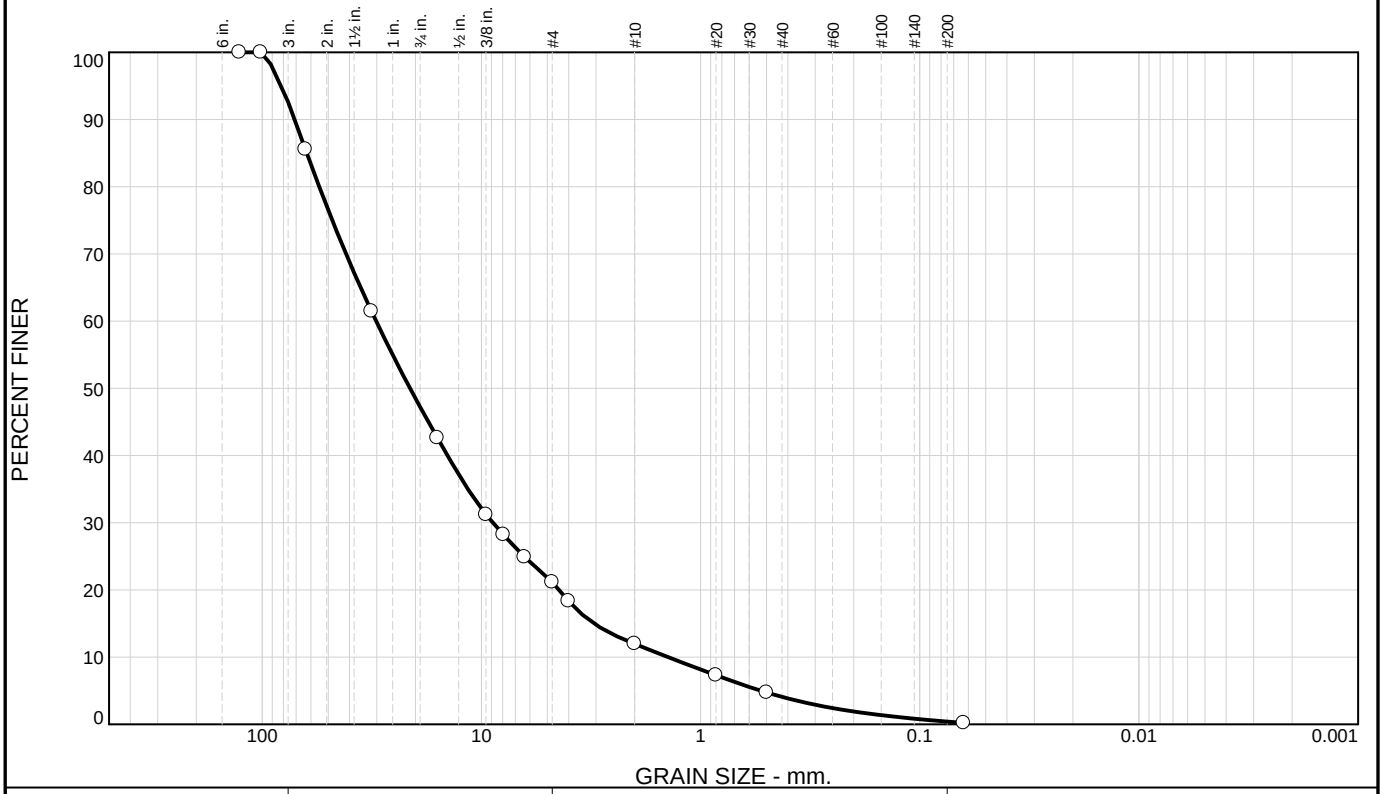
Client: PPL Montana
Project: West Rosebud Creek
Project No: 500753 **Figure**

Tested By: NKG

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
7.4	45.4	26.1	9.1	7.9	3.7	0.4	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
5"	100.0		
4"	100.0		
2.5"	85.5		
1.25"	61.5		
5/8"	42.6		
3/8"	31.2		
5/16"	28.2		
1/4"	24.9		
#4	21.1		
#5	18.3		
#10	12.0		
#20	7.3		
#35	4.7		
#230	0.2		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 62.6451 D_{60}= 30.2403 D_{50}= 21.1649
D_{30}= 8.8781 D_{15}= 3.0627 D_{10}= 1.4069
C_u= 21.49 C_c= 1.85

Classification

USCS= GW AASHTO=

Remarks

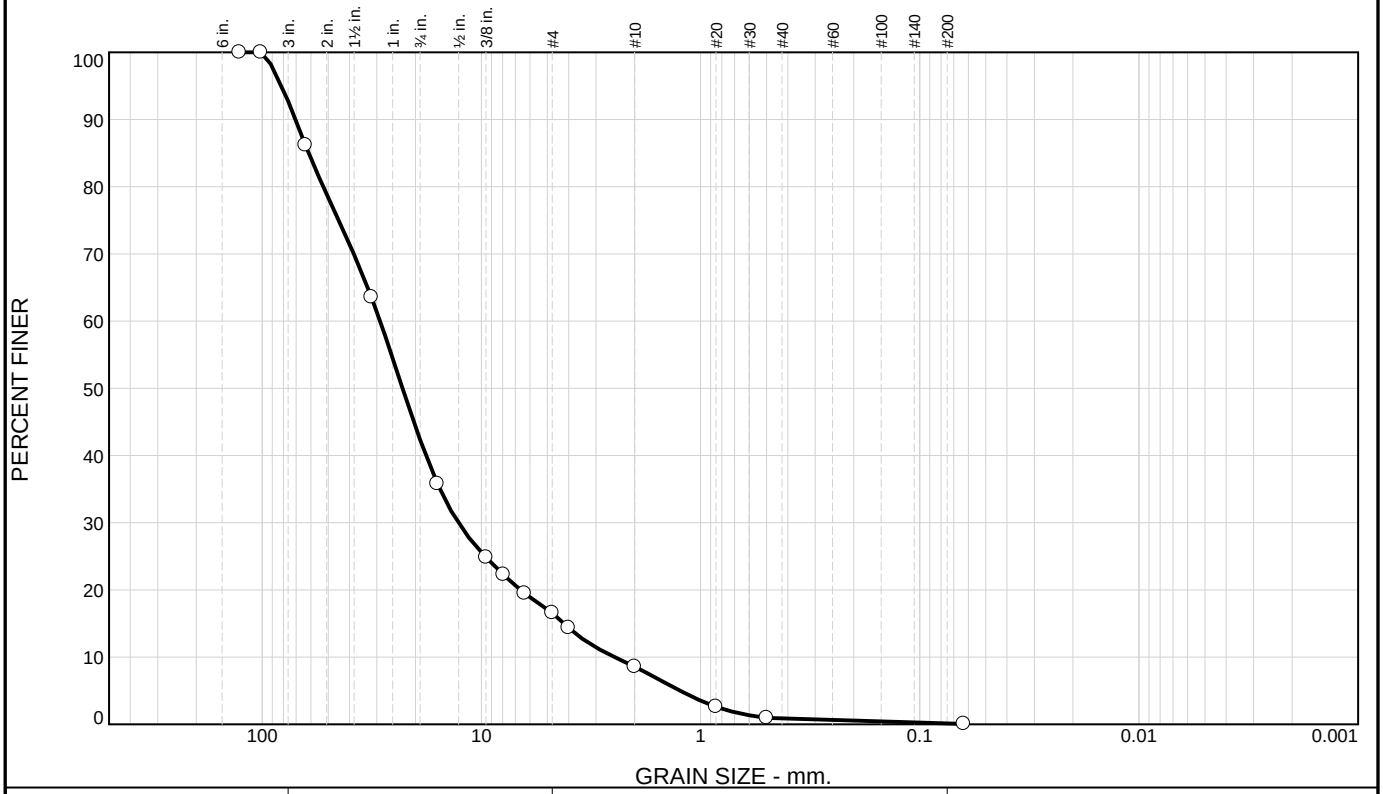
Sample Number: 2
Source of Sample: Pine Grove **Date:** 10/06/10

PIEDMONT ENGINEERING, INC.
1215 Apple's Way - Belgrade, MT 59714
Ph. 406-388-8578 - Fax 406-388-8579

Client: PPL Montana
Project: West Rosebud Creek
Project No: 500753 **Figure**

Tested By: NKG

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
7.2	50.4	25.8	8.0	7.7	0.8	0.1	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
5"	100.0		
4"	100.0		
2.5"	86.2		
1.25"	63.6		
5/8"	35.8		
3/8"	24.8		
5/16"	22.3		
1/4"	19.5		
#4	16.6		
#5	14.4		
#10	8.6		
#20	2.6		
#35	0.9		
#230	0.1		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 61.4128 D_{60}= 28.9922 D_{50}= 22.8962
D_{30}= 12.7557 D_{15}= 4.2047 D_{10}= 2.4675
C_u= 11.75 C_c= 2.27

Classification

USCS= GW AASHTO=

Remarks

Sample Number: 3
Source of Sample: Pine Grove **Date:** 10/06/10

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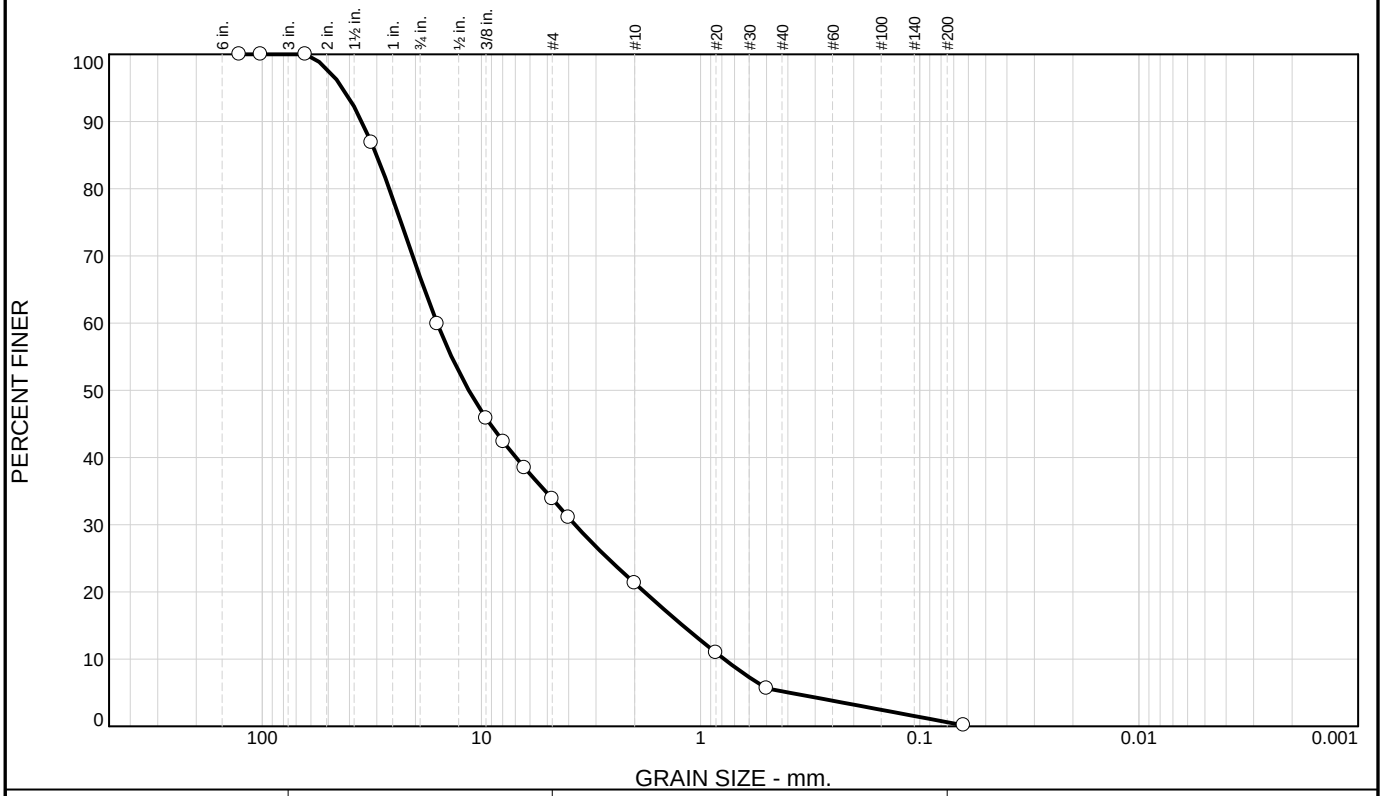
Ph. 406-388-8578 - Fax 406-388-8579

Client: PPL Montana
Project: West Rosebud Creek
Project No: 500753 **Figure**

Tested By: NKG

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
0.0	33.2	32.9	12.6	16.1	4.6	0.6	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
5"	100.0		
4"	100.0		
2.5"	100.0		
1.25"	86.9		
5/8"	59.9		
3/8"	45.8		
5/16"	42.3		
1/4"	38.4		
#4	33.9		
#5	31.1		
#10	21.3		
#20	10.9		
#35	5.6		
#230	0.2		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 30.0740 D_{60}= 15.9365 D_{50}= 11.4299
D_{30}= 3.7424 D_{15}= 1.2053 D_{10}= 0.7805
C_u= 20.42 C_c= 1.13

Classification

USCS= GW AASHTO=

Remarks

Sample Number: 4
Source of Sample: Pine Grove **Date:** 10/06/10

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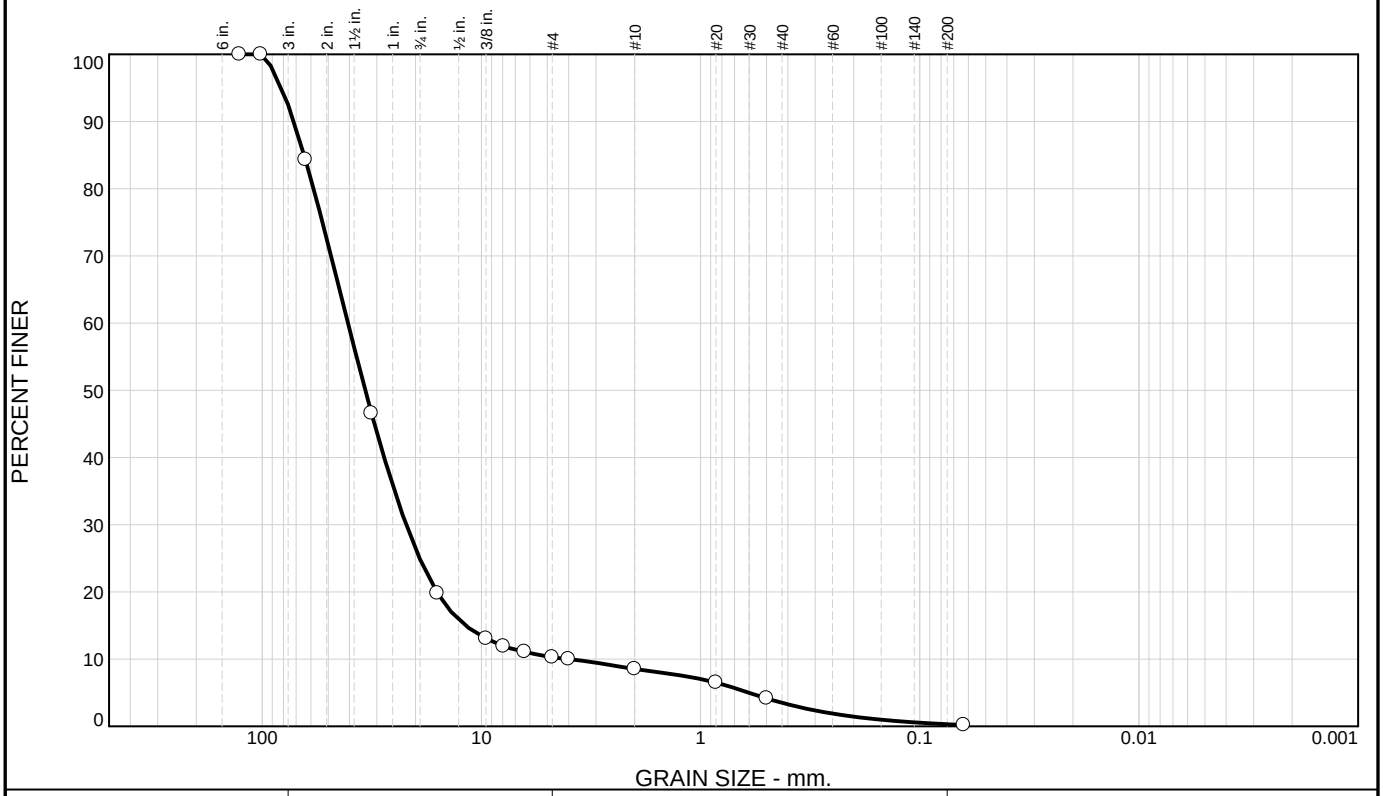
Client: PPL Montana
Project: West Rosebud Creek
Project No: 500753 **Figure**

Tested By: NKG

Particle Size Distribution Report



% +3"	% Gravel		% Sand			% Fines	
	Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
7.5	67.7	14.5	1.8	5.0	3.2	0.3	

SIEVE SIZE	PERCENT FINER	SPEC.* PERCENT	PASS? (X=NO)
5"	100.0		
4"	100.0		
2.5"	84.3		
1.25"	46.6		
5/8"	19.8		
3/8"	13.1		
5/16"	11.9		
1/4"	11.1		
#4	10.3		
#5	10.0		
#10	8.5		
#20	6.5		
#35	4.1		
#230	0.2		

* (no specification provided)

Material Description

Atterberg Limits

PL= LL= PI=

Coefficients

D_{85}= 64.3858 D_{60}= 40.6220 D_{50}= 33.8803
D_{30}= 22.0481 D_{15}= 11.8321 D_{10}= 3.9827
C_u= 10.20 C_c= 3.00

Classification

USCS= GP AASHTO=

Remarks

Sample Number: 5
Source of Sample: Pine Grove **Date:** 10/06/10

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Client: PPL Montana
Project: West Rosebud Creek
Project No: 500753 **Figure**

Tested By: NKG

PIEDMONT ENGINEERING, Inc.

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Project: West Rosebud Creek 500753 Client: PPL MT
Sample: Pine Grove-1 Sampled 10/6/2010

Grain Sizes:

$D_{15.9}$	2.3811	mm
D_{25}	5.7104	mm
D_{50}	19.0452	mm
D_{75}	58.5380	mm
$D_{84.1}$	71.1219	mm

Geometric Mean Diameter (D_g): 13.013 mm

Sorting Coefficient (S_o): 3.202 mm

Fredle Index (Fi): 4.064 mm

% Finer:
6.4mm: 26.6%
0.84mm: 6.1%

PIEDMONT ENGINEERING, Inc.

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Project: West Rosebud Creek 500753 Client: PPL MT
Sample: Pine Grove-2 Sampled 10/6/2010

Grain Sizes:

$D_{15.9}$	3.3381	mm
D_{25}	6.4068	mm
D_{50}	21.1649	mm
D_{75}	47.9221	mm
$D_{84.1}$	61.2167	mm

Geometric Mean Diameter (D_g): 14.295 mm

Sorting Coefficient (S_o): 2.735 mm

Fredle Index (Fi): 5.227 mm

% Finer:
6.4mm: 25.0%
0.84mm: 7.2%

PIEDMONT ENGINEERING, Inc.

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Project: West Rosebud Creek 500753 Client: PPL MT
Sample: Pine Grove -3 Sampled 10/6/2010

Grain Sizes:

$D_{15.9}$	4.5013	mm
D_{25}	9.6315	mm
D_{50}	22.8962	mm
D_{75}	44.8011	mm
$D_{84.1}$	59.8115	mm

Geometric Mean Diameter (D_g): 16.408 mm

Sorting Coefficient (S_o): 2.157 mm

Fredle Index (Fi): 7.608 mm

% Finer:
6.4mm: 19.6%
0.84mm: 2.5%

PIEDMONT ENGINEERING, Inc.

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Project: West Rosebud Creek 500753 Client: PPL MT
Sample: Pine Grove -4 Sampled 10/6/2010

Grain Sizes:

$D_{15.9}$	1.2985	mm
D_{25}	2.6487	mm
D_{50}	11.4299	mm
D_{75}	23.2542	mm
$D_{84.1}$	29.3292	mm

Geometric Mean Diameter (D_g): 6.171 mm

Sorting Coefficient (S_o): 2.963 mm

Fredle Index (Fi): 2.083 mm

% Finer:
6.4mm: 38.6%
0.84mm: 10.8%

PIEDMONT ENGINEERING, Inc.

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Project: West Rosebud Creek 500753 Client: PPL MT
Sample: Pine Grove -5 Sampled 10/6/2010

Grain Sizes:

$D_{15.9}$	12.7366	mm
D_{25}	19.1464	mm
D_{50}	33.8803	mm
D_{75}	53.1206	mm
$D_{84.1}$	63.2204	mm

Geometric Mean Diameter (D_g): 28.376 mm

Sorting Coefficient (S_o): 1.666 mm

Fredle Index (Fi): 17.036 mm

% Finer:
6.4mm: 11.1%
0.84mm: 6.5%

PIEDMONT ENGINEERING, Inc.

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Project: West Rosebud Creek 500753 Client: PPL MT
Sample: Allen Grade Bridge-1 Sampled 10/6/2010

Grain Sizes:

$D_{15.9}$	1.3285	mm
D_{25}	3.1747	mm
D_{50}	14.3857	mm
D_{75}	31.9365	mm
$D_{84.1}$	44.4500	mm

Geometric Mean Diameter (D_g): 7.685 mm

Sorting Coefficient (S_o): 3.172 mm

Fredle Index (Fi): 2.423 mm

% Finer:
6.4mm: 33.5%
0.84mm: 11.6%

PIEDMONT ENGINEERING, Inc.

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Project: West Rosebud Creek 500753 Client: PPL MT
Sample: Allen Grade Bridge-2 Sampled 10/6/2010

Grain Sizes:

$D_{15.9}$	1.5263	mm
D_{25}	3.7740	mm
D_{50}	12.6729	mm
D_{75}	26.5909	mm
$D_{84.1}$	35.5215	mm

Geometric Mean Diameter (D_g): 7.363 mm

Sorting Coefficient (S_o): 2.654 mm

Fredle Index (Fi): 2.774 mm

% Finer:
6.4mm: 34.2%
0.84mm: 11.4%

PIEDMONT ENGINEERING, Inc.

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Project: West Rosebud Creek 500753 Client: PPL MT
Sample: Allen Grade Bridge-3 Sampled 10/6/2010

Grain Sizes:

$D_{15.9}$	3.3697	mm
D_{25}	7.4769	mm
D_{50}	23.9251	mm
D_{75}	45.8655	mm
$D_{84.1}$	56.9523	mm

Geometric Mean Diameter (D_g): 13.853 mm

Sorting Coefficient (S_o): 2.477 mm

Fredle Index (Fi): 5.593 mm

% Finer:
6.4mm: 23.0%
0.84mm: 5.6%

PIEDMONT ENGINEERING, Inc.

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Project: West Rosebud Creek 500753 Client: PPL MT
Sample: Allen Grade Bridge-4 Sampled 10/6/2010

Grain Sizes:

$D_{15.9}$	1.4523	mm
D_{25}	3.5274	mm
D_{50}	13.0274	mm
D_{75}	26.3866	mm
$D_{84.1}$	33.3625	mm

Geometric Mean Diameter (D_g): 6.961 mm

Sorting Coefficient (S_o): 2.735 mm

Fredle Index (Fi): 2.545 mm

% Finer:
6.4mm: 34.5%
0.84mm: 11.0%

PIEDMONT ENGINEERING, Inc.

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Project: West Rosebud Creek 500753 Client: PPL MT
Sample: Allen Grade Bridge-5 Sampled 10/6/2010

Grain Sizes:

$D_{15.9}$	0.5735	mm
D_{25}	0.8325	mm
D_{50}	3.1942	mm
D_{75}	20.8696	mm
$D_{84.1}$	27.6113	mm

Geometric Mean Diameter (D_g): 3.979 mm

Sorting Coefficient (S_o): 5.007 mm

Fredle Index (Fi): 0.795 mm

% Finer:
6.4mm: 56.4%
0.84mm: 25.2%