Study No. 15

Mystic Hydroelectric Project Water Quality Studies

Mystic Lake Hydroelectric Project FERC No. 2301

Mystic Lake, Montana

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Executive Summary

During 2005 PPL Montana conducted studies to evaluate whether the Mystic Lake Dam and/or re-regulation dam were increasing total dissolved gas (TDG) and turbidity in West Rosebud Creek. In addition, PPL Montana collected limnological and water quality data to further describe the aquatic resources of West Rosebud and Emerald lakes.

Water quality studies were also conducted in 2004. Results from the 2004 sampling were reported in six reports filed with the Federal Energy Regulatory Commission (FERC) within the March 1, 2005 Final Study Plan. These reports were titled: 1) 2004 Investigation of Total Dissolved Gases, 2) 2004 Investigation of Metals in Mystic Lake and the Effect of Mystic Flow Line on Metals in West Rosebud Creek, 3) 2004 Aquatic Macroinvertebrates in West Rosebud Creek, 4) 2004 Investigation of PCBs in Fish, 5) 2004 Survey for Tubifex Worms in West Rosebud Creek, and 6) 2004 Investigation of Resource Description of Mystic Lake. These reports are available on the Mystic Re-licensing Project website: http://www.mysticlakeproject.com/mystic_project_pad.htm

Results from the 2005 TDG study indicate that the Project is not creating TDG levels that would be considered harmful to aquatic life in West Rosebud Creek or West Rosebud Lake.

Results from the turbidity study are complicated by problems associated with the data logging turbidity units. High levels of turbidity were recorded below the re-regulation dam prior to spring runoff. Similarly, very high peaks in turbidity were recorded for the site just below the powerhouse discharge. Through comparison with manual turbidity measurements at the powerhouse discharge and turbidity data from West Rosebud Lake, it is apparent that some of the data collected are flawed. A careful examination of the data led to the conclusion that no noticeable increase in turbidity occurs in West Rosebud Creek when Mystic Lake is at its lowest lake elevation and only a slight increase occurs during spring runoff, something that would be expected even in an unaltered system.

Zooplankton, phytoplankton, nutrient, and other water quality data were collected in West Rosebud and Emerald Lakes during August of 2005. Nothing out the ordinary was identified from the data collected in 2005. The two lakes are healthy and support healthy populations of phytoplankton and zooplankton, and support vibrant fisheries.

1.0 Introduction

During 2005 PPL Montana collected various water quality data on West Rosebud Creek and both West Rosebud and Emerald lakes. These data collected during 2005 were collected to fulfill Study No. 15 from the *Mystic Lake Hydroelectric Project Final Study Plan* (FSP). The FSP was provided to the FERC on March 1, 2005. The Mystic Lake Interagency Water Quality Resource group evaluated and approved Study No. 15.

Three objectives were outlined in Study No 15. titled *Mystic Project Effects on Water Quality*. The first objective was to identify if the re-regulation dam is creating unnaturally high total dissolved gas (TDG) concentrations in West Rosebud Lake. The total dissolved gas study is presented in Appendix I titled Total Dissolved Gas Study. This report contains all information pertaining to the other two objectives, which are described below.

Water quality studies were also conducted in 2004. Results from the 2004 sampling were reported in six reports filed with the Federal Energy Regulatory Commission (FERC) within the March 1, 2005 Final Study Plan. These reports were titled: 1) 2004 Investigation of Total Dissolved Gases, 2) 2004 Investigation of Metals in Mystic Lake and the Effect of Mystic Flow Line on Metals in West Rosebud Creek, 3) 2004 Aquatic Macroinvertebrates in West Rosebud Creek, 4) 2004 Investigation of PCBs in Fish, 5) 2004 Survey for Tubifex Worms in West Rosebud Creek, and 6) 2004 Investigation of Resource Description of Mystic Lake. These reports are available on the Mystic Re-licensing Project website: http://www.mysticlakeproject.com/mystic_project_pad.htm

1.1 West Rosebud Creek Turbidity Study

The second objective of Study No. 15 was to determine if the Mystic Lake winter drawdown period is creating excessive sediment inputs to West Rosebud Creek and if the re-regulation dam is creating excessive sediment in West Rosebud Creek downstream. To evaluate these questions, PPL Montana collected turbidity data in three locations during 2005; below the powerhouse, within West Rosebud Lake, and directly downstream of West Rosebud Lake. The specific time periods of interest as laid out in the FSP were from April 5 to May 4 and June 25 to July 27. The first time period being when Mystic Lake is at its lowest elevation and the second time period concurring with the normal periods of spill over Mystic Lake Dam.

1.2 Description of Aquatic Resource of West Rosebud and Emerald Lakes

The third objective of Study No. 15 was to further describe the aquatic resources in West Rosebud and Emerald Lakes. Zooplankton, phytoplankton, chlorophyll *a*, and nutrients were sampled during the summer of 2005 in both West Rosebud and Emerald Lakes. Fisheries data pertaining to these lakes can be found in the *Mystic Lake Hydroelectric Project Pre-Application Document*, which was filed at the FERC on July 1, 2004.

2.0 Methods

All water quality studies conducted during 2005 where performed by PPL Montana's senior aquatic ecologist Frank Pickett. PPL Montana relied on consultation from the Mystic Lake Project Water Quality Resource Group to derive study methods.

2.1 West Rosebud Creek Turbidity Study

DataSonde® 4 water quality multi probe data loggers manufactured by Hydrolab® were used to measure turbidity (nephelometric turbidity units (NTU)), temperature (C), and dissolved oxygen (mg/l) in three locations within the Mystic Project Area. Units were placed in West Rosebud Creek just downstream of the powerhouse discharge and just downstream of the re-regulation dam on March 10, 2005. The unit in West Rosebud Lake was deployed on June 15, 2005 to evaluate the differences in turbidity between West Rosebud Lake and downstream during spill conditions. All units in West Rosebud Creek were removed on August 2, 2005. The units were set to record turbidity, temperature, and dissolved oxygen on an hourly basis.

In addition to DataSonde® loggers, PPL Montana staff manually obtained turbidity measurements below the powerhouse discharge using a Hach Model 2100 portable turbidity meter . Manual turbidity measurements were made from March 11 to August 2, 2005. Along with On the dates that manual turbidity samples were taken, PPL Montana staff recorded the volume of spill occurring over Mystic Dam on the dates when turbidity samples were made.

The DataSonde® loggers were periodically checked and calibrated throughout the study season. In total, the loggers were calibrated nine times between March 22 and August 2, 2005. No turbidity data was collected for the logger located below the powerhouse from 9 am on April 4 to 1 pm April 19, 2005. Due to a calibration error, no turbidity data was collected for the logger below the re-regulation dam or for the unit below the powerhouse from 6pm on April 3 to 3 pm on April 19, 2005.

2.2.2 Description of Aquatic Resource of West Rosebud and Emerald Lakes

Limnological sampling of West Rosebud and Emerald Lakes occurred on August 2, 2005. Sampling was preformed by Frank Pickett, PPL Montana's senior aquatic ecologist. Zooplankton and phytoplankton tows were made using a 80 µm mesh Wisconsin style plankton net and were collected in the same manner. Since the depth in West Rosebud Lake was only 10 ft at the sample location, two tows of 9.5 ft each were made, which is equivalent to 359 liters of lake water. The depth of Emerald Lake at the sampling site was 3.5 ft, therefore five tows of 3.5 ft were made, which is equivalent to 331 liters of lake water.

Zooplankton and phytoplankton samples were preserved and sent to EcoAnalysts, Inc., for identification and enumeration.

Secchi depth was measured at 10:40 am in West Rosebud Lake and at 11:30 am in Emerald Lake. Chlorophyll *a* samples were collected in both lakes using a Van Dorn discrete water sampler. A total of 2.5 liters of water from a depth of 5 ft was filtered for West Rosebud Lake and a total of 2.5 liters of water from a depth of 2 ft was filtered for Emerald Lake. Water samples were placed on ice and sent to Energy Laboratories, Inc. Billings, MT for nutrient and metals analysis.

Turbidity, dissolved oxygen, temperature, pH, and specific conductance were all measured in both lakes using a Hydrolab® multi probe water analysis unit. In addition, temperature and dissolved oxygen were recorded on an hourly basis in West Rosebud Lake and West Rosebud Creek below the powerhouse discharge are and downstream of the re-regulation dam using data logging DataSonde® multi probe Hydrolab® units from the middle of March through the beginning of August.

3.0 Results

3.1 West Rosebud Creek Turbidity Study

Overall turbidity was measured at the site just downstream of the powerhouse discharge and downstream of the re-regulation dam on an hourly basis from March 10 to August 2, 2005, with no data available from April 3 to April 19 due to a calibration error (Figure 2). The West Rosebud Lake site was sampled on an hourly basis from June 15 to August 2, 2005, with no wholes in the data set. The only unit that recorded consistent measurements throughout the sampling period was the West Rosebud Lake site, with both the powerhouse and re-regulation sites most likely lending spurious data.

From March to early April turbidity in West Rosebud Creek was usually recorded at below 1.0 NTU, with a few short spikes into the 2.0 to 3.0 NTU range (Figure 3). These spikes only occurred at the powerhouse discharge site for brief periods of time (~ 1 hr) and are therefore not thought to be representative of the stream as a whole.

Starting around April 23, 2005 recorded turbidity at the powerhouse discharge area began to fluctuate on a more continuous basis, most likely due to peaking operations at the power plant. These peaking operations are visible in the discharge shown on Figure 3., since flow was measured as average daily flow and not actual hourly flow. Turbidity below the re-regulation dam stayed below 1.0 NTU during April.

More spurious data arose in late may, where turbidity was measured at over 250 NTU (Figure 4). These high turbidity readings are unexplainable. Turbidity of 250 NTU is extremely turbid, something that no one from PPL Montana has ever seen at the site. Therefore, these data are most likely false due to either equipment limitations from agitated water, or from the equipment losing its calibration. These extremely high turbidity records continued into early June. Although the turbidity readings from approximately June 5 to June 30, decreased significantly, they were still recorded between 2.0 to 8.9 NTU, still very high.

During July into early August, a similar pattern to the previous months was observed for turbidity at the powerhouse discharge site (Figure 5). The site below the re-regulation dam showed a steady increase in turbidity until July 20 when it was calibrated, thereafter it decreased. Turbidity in West Rosebud Lake was for the most part consistently below 1.0 NTU for July.

From when turbidity began being measured within West Rosebud Lake on June 15, 2005 till it was pulled on August 2, 2005, turbidity was never recorded at a level higher than 4.0 NTU with an average of 0.3 NTU and a median of 0.0 NTU. Therefore, it is unlikely that the

turbidity readings occurring below the re-regulation dam are from suspended sediments in waters leaving West Rosebud Creek.

Turbidity measured manually by PPL Montana staff just below the powerhouse discharge was never higher than 1.4 NTU from March through July (Figure 6). When comparing the data recorded by the portable turbidity meter and the data logging Hydrolab® at the same site, it is evident that the Hydrolab® had much higher turbidity measurements (Figure 7). Since the Hydrolab® was recording such extremely high turbidity at times, and that the manual turbidity meter was recording turbidity at what common for clear mountain streams, it is believed that the manual meter more likely recorded true data when compared to the Hydrolab®.

When all samples for each site were summed, it is apparent that data collected at the re-regulation dam site was erroneous. The mean turbidity for the sampling period was 3.2, 0.3, and 13.8 NTU for the powerhouse discharge, West Rosebud Lake, and the re-regulation dam sites, respectively. Similarly, the median turbidity measurements were 2.0, 0.0, and 3.8 NTU for powerhouse discharge, West Rosebud Lake, and re-regulation dam sites, respectively.

3.2 Description of Aquatic Resource of West Rosebud and Emerald Lakes

Water quality parameters were similar for both West Rosebud and Emerald Lakes sampled on August 2, 2005 (Table 1.0). The waters of each lake were very clear, with both having a Secchi depth to the bottom and turbidity of 0.0 NTU. Similarly, analysis of nutrients were also very comparable between the two lakes (Table 2.0).

The specific zooplankton species and their densities for both West Rosebud and Emerald Lakes are described in Table 3. Overall, West Rosebud Lake had much higher cladoceran, copepod, rotifer, and protozoan densities than Emerald Lake. Total cladoceran densities were estimated at 90.6/m^3 for Emerald Lake and 7955/m^3 for West Rosebud Lake.

The density of cladocerans in West Rosebud Lake was significantly higher in the August 2005 sample than that of the August 6, 2003 sample (Figure 10). Conversely, the August 7, 2003 sample for Emerald Lake was higher than that of the 2005 sample, although both were below 200/m^3. Total copepod densities were similar for each lake for the 2003 and 2005 samples (Figure 10).

Chlorophyll *a* concentrations were significantly higher during August 2, 2005 in Emerald Lake when compared to West Rosebud Lake (Figure 11). This may be due to the large zooplankton bloom found in West Rosebud Lake during this time. The high densities of zooplankton likely cropped down the phytoplankton in West Rosebud Lake. Chlorophyll *a*

was much higher in West Rosebud Lake during the August 2003 sample when compared to the same time period in 2005.

Relatively few organisms classified as phytoplankton were observed in water samples from both Emerald and West Rosebud Lake during 2005 (Table 4). This may be due to the cropping of phytoplankton by zooplankton or the sampling method. Phytoplankton were captured using a 80 µm Wisconsin style plankton net, which would allow a large portion of the phytoplankton community to pass through without being captured.

Dissolved oxygen concentrations in West Rosebud Lake were adequate for salmonid fishes from the middle of June until August 2, when data was available (Figure 8). Since the dissolved oxygen of West Rosebud Lake mirrored the same pattern as was seen at the powerhouse discharge site and below the re-regulation dam, we can assume that dissolved oxygen was maintained above 5 mg/L throughout the summer , which commonly thought of as the minimum concentration needed for salmonid fishes.

Similarly to dissolved oxygen, the temperature regime of West Rosebud Lake mimicked the temperature of West Rosebud Creek from June 15 to August 2 (Figure 9). Temperatures did not exceed the thermal limits of salmonid fishes during the study period.

4.0 Discussion

4.1 West Rosebud Creek Turbidity Study

Turbidity data taken at the powerhouse discharge and the re-regulation site using the data logging Hydrolabs were likely flawed. For Hydrolabs to correctly measure turbidity, the units need to be in relatively calm water, which was not the case at the powerhouse discharge and the re-regulation dam sites. The specific location of the Hydrolab placed below the re-regulation dam is shown in Photograph 1. Note the turbulent nature of the stream where the Hydrolab was installed. Furthermore, the site at the powerhouse discharge is shown in Photograph 2. Although this site looks relatively calm, whenever power production is increased the site becomes very agitated and air bubbles form. Air bubbles can cause high turbidity readings since the light being transmitted by the unit is deflected in a similar manner as it is reflected when encountering TSS.

Nevertheless, since water samples were taken manually at the powerhouse discharge site on 35 occasions during the sampling period and no problems arose with the West Rosebud Lake site, it is possible to make inferences from the data obtained.

Because the timing of the lowest elevation of Mystic Lake usually occurs from early April to early May, if increased sediment loads coming out of Mystic Lake were to occur they would likely be seen as an increase in turbidity in the powerhouse discharge area. During this period of time, turbidity samples were taken manually at the powerhouse discharge site and no samples were recorded higher than 0.6 NTU. Therefore, it is believed that no noticeable change in total suspended sediments (TSS) occurred in West Rosebud Creek due to the drawdown of Mystic Lake during 2005.

Similarly, if West Rosebud Lake was creating excess sedimentation of West Rosebud Creek during spring runoff, it would likely be visible by increased turbidity in West Rosebud Lake. Since turbidity at the powerhouse discharge site and in West Rosebud Lake were consistently low during the runoff period, it is unlikely that the project is creating excess sedimentation in West Rosebud Creek.

If another year of turbidity studies are needed, it is recommended that the either manual turbidity sampling occur at all sites during the sampling period or that data logging Hydrolabs are placed in areas that the water column is relatively calm, when compared to the sites used during 2005.

4.2 Description of Aquatic Resource of West Rosebud and Emerald Lakes

No data collected during the 2005 sampling period give any indication that either West Rosebud Lake or Emerald Lake are being impaired by the Mystic Lake Hydroelectric Project. Data collected during 2005 when comparable to previous years is relatively similar, all within the natural variability of aquatic systems. These data, in conjunction with aquatic habitat data and fisheries data collected in other studies during the re-licensing process lend evidence that West Rosebud and Emerald Lakes are healthy and sustain various forms of aquatic life from phytoplankton up the food chain to brown trout highly sought after by anglers.

5.0 Tables

Table 1.0 Water quality parameters measured on August 2, 2005 for West Rosebud and Emerald Lakes.

	Total Depth (ft)	Secchi Depth	pH	Sp Cond (µS)	DO (mg/l)	Turb (NTU)
West Rosebud Lake	10.0	10.0	7.6	29.0	8.2	0.0
Emerald Lake	3.5	3.5	7.7	30.1	7.8	0.0

Table 2.0. Nutrient and metal analysis for West Rosebud and Emerald Lakes, samples taken on August 2, 2005. Samples analyzed by Energy Laboratories, Inc, Billings, MT.

	West Rosebud Lake	Emerald Lake	Units	Reporting Limit
INORGANICS				
Alkalinity, Total as CaCo3	13	15	mg/L	3
Chloride	ND	ND	mg/L	1
Sulfate	3	3	mg/L	1
NUTRIENTS				
Nitrogen, Nitrate + Nitrite as N, dissolved	0.12	0.11	mg/L	0.05
Nitrogen, Nitrate + Nitrite as N	0.12	0.11	mg/L	0.05
Phosphorus, Dissolved as P	0.002	0.002	mg/L	0.001
Phosphorus, Total as P	0.01	0.01	mg/L	0.01
Metals, Dissolved				
Calcium	8	5	mg/L	1
Magnesium	1	1	mg/L	1
Potassium	ND	ND	mg/L	1
Sodium	ND	ND	mg/L	1

Table 3.0 Zooplankton and miscellaneous aquatic organism identification and density estimates for West Rosebud and Emerald Lakes. Samples were taken on August 2, 2005 using a 80 µm mesh Wisconsin style plankton net. SE = standard error.

	Emerald Lake		West Rosebud Lake	
CLADOCERA	**Density #/m^3**	**SE**	**Density (#/m^3)**	**SE**
Daphnia ambigua	6	4.3	44.6	31.5
Echinisco rosea	9.1	5.2	0	
Chydorus sphaericus	60.4	13.5	5660.2	355.2
Eurycercus lamellatus	15.1	6.8	2250.7	224
Total cladocerans	**90.6**	**16.5**	**7955.4**	**421**
COPEPODA				
Diaptomus copepodite	63.4	13.8	156	59
Microcyclops varicans	193.4	24.2	690.8	124.1
cyclopoid copepodites	184.3	23.6	1047.4	152.8
harpacticoid	0		22.3	22.3
copepod nauplii	129.9	19.8	66.9	38.6
Total copepods	**571**	**41.5**	**1983.3**	**210.2**
MISC. ORGANISMS				
Hydra sp.	30.2	9.6	89.1	44.6

	Emerald Lake		West Rosebud Lake	
aquatic oligochaete	21.1	8	356.5	89.1
Cypridopsis vidua	6	4.3	0	
chironomid larvae *	84.6	16	1782.7	199.3
water boatman *	9.1	5.2	0	
mayfly larvae *	3	3	0	
Hyalella azteca *	42.3	11.3	22.3	22.3
Total Misc.	**196.4**	**24.4**	**2250.7**	**224**
ROTIFERA & PROTOZOA				
Euchlanis dilatata	6	4.3	0	NA
Keratella bostonensis	6	4.3	0	NA
Mytilina ventralis	3	3	0	NA
Filinia terminalis	3	3	0	NA
Testudinella patina	3	3	0	NA
Difflugia sp.1	60.4	13.5	0	NA
Total rotifers & protozoans	**81.6**	**15.7**	**0**	NA
Total Density	**939.6**	**53.3**	**12189.4**	**521.2**

Table 4.0. Phytoplankton counts from West Rosebud and Emerald Lakes, August 2, 2005. Counts are made from 359 liters of filtered water for West Rosebud Lake and 331 liters of filtered water for Emerald Lake.

	Genera	Emerald Lake	West Rosebud Lake
		Count	Count
Diatom Count	Achnanthes	4	7
	Achnanthidium	2	4
	Cyclotella	0	1
	Cymbella	1	3
	Diatoma	0	11
	Didymosphenia	0	4
	Gomphonema	16	20
	Hannaea	0	1
	Navicula	3	8
	Nitzschia	0	2
	Pinnularia	1	0
	Synedra	19	4
	Diatom Count	**46**	**65**
		Count	Count
Soft Body Count	Aphanochaete	0	0
	Bulbochaete	0	38
	Chara	0	0
	Chlorella	3	2
	Cladophora	5	0
	Cosmarium	2	0
	Mougeotia	0	18
	Oedogeonium	0	7
	Oocystis	0	5
	Scendesmus	3	0
	Spirogyra	153	94
	Ulothrix	0	71
	Zygnema	88	0
	Soft Body Count	**254**	**235**
	Total Count	**346**	**365**

6.0 Figures

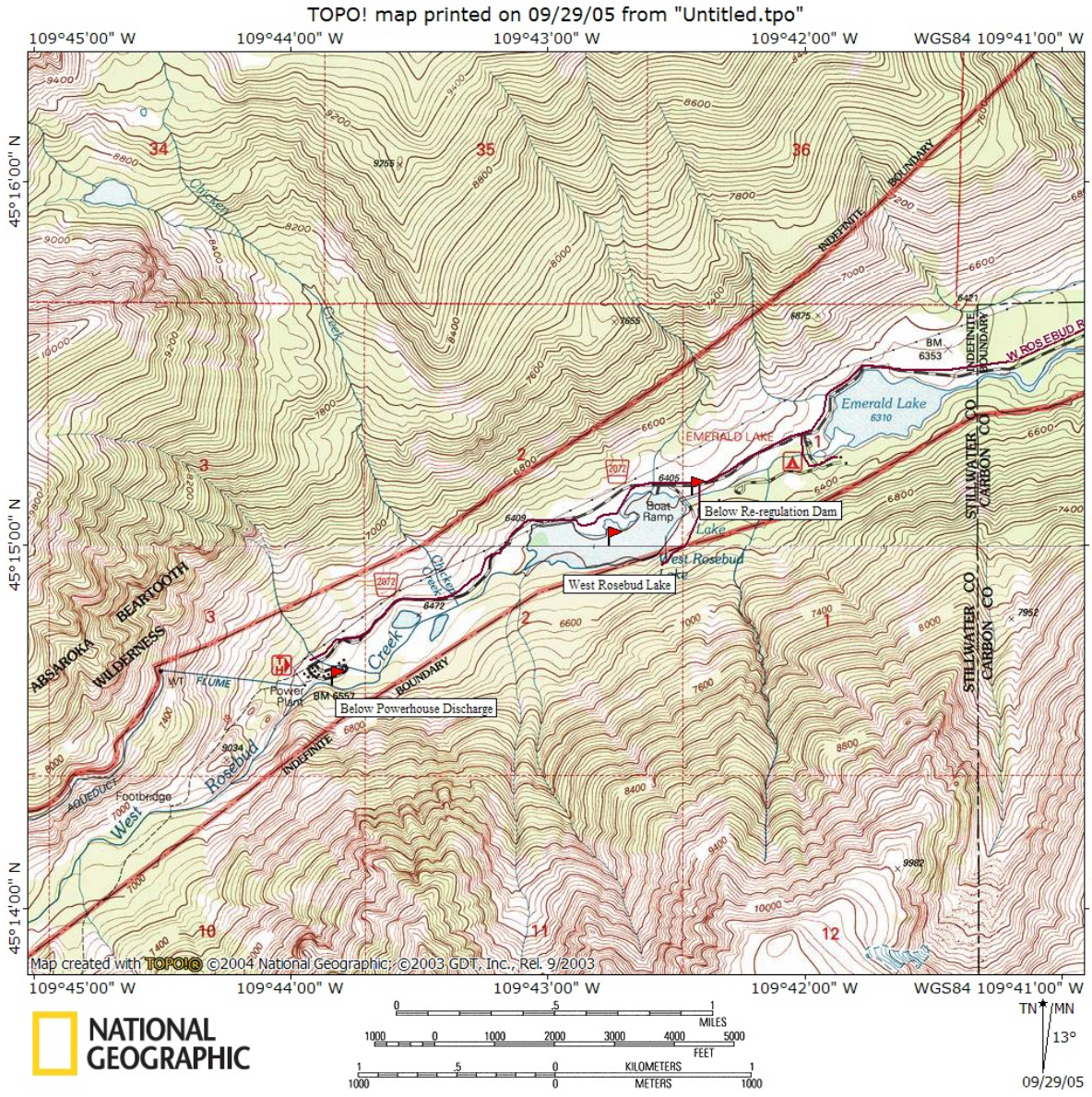


Figure 1. Map indicating the three sites where turbidity measurements were taken during 2005.

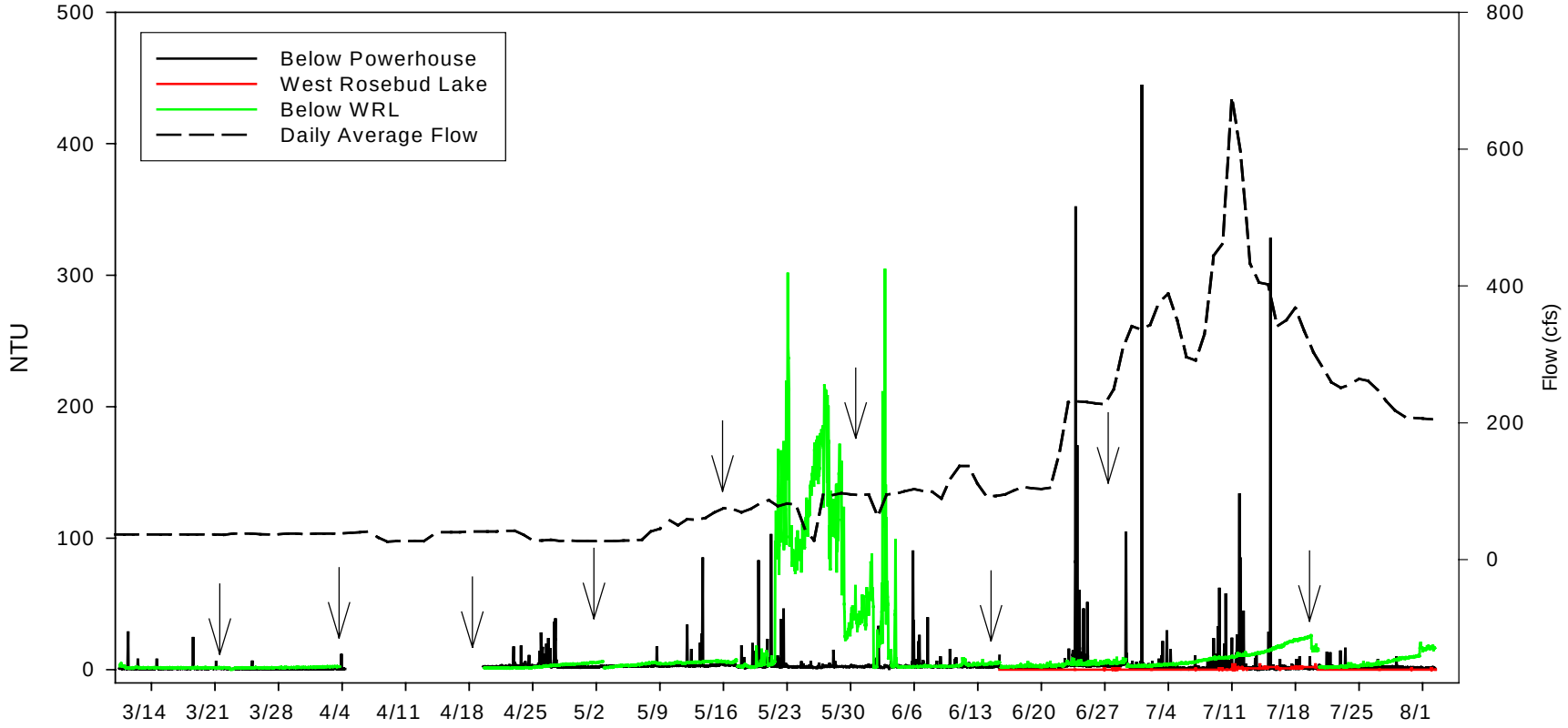


Figure 2. Turbidity measurements taken by data loggers in West Rosebud Creek downstream of the powerhouse and downstream of the re-regulation dam (West Rosebud Lake) and in West Rosebud Lake. Turbidity is on the left Y-axis and flow from the West Rosebud Creek USGS gauge is on the right Y-axis. Arrows represent times that the loggers were recalibrated. Note: Peaks in turbidity at the powerhouse discharge and below the re-regulation dam are believed to be erroneous data due to problems associated with the Hydrolabs as discussed in the results and discussion sections.

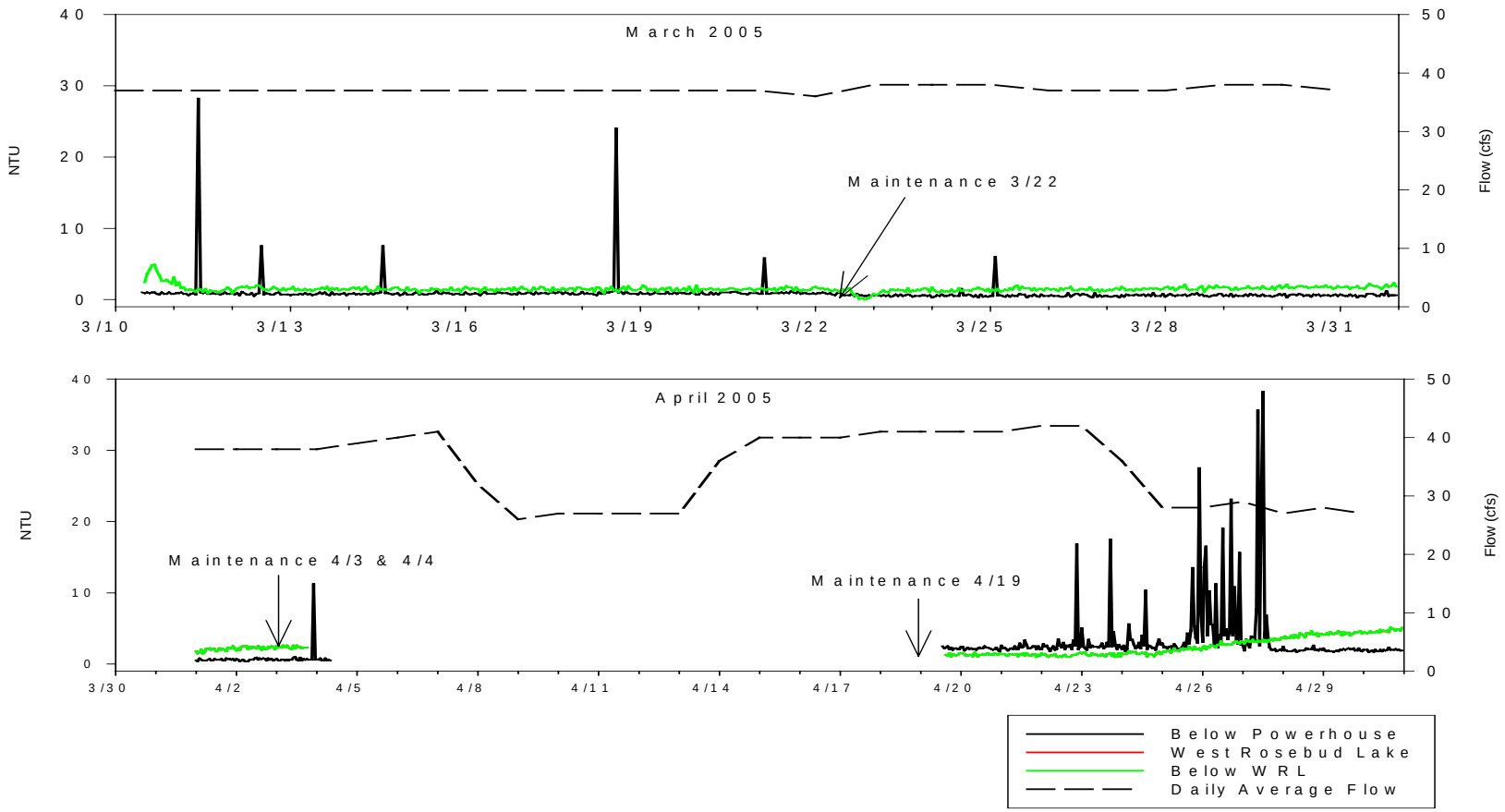


Figure 3. Turbidity measurements for March and April, 2005 recorded by data loggers in West Rosebud Creek downstream of the powerhouse and downstream of the re-regulation dam (West Rosebud Lake) and in West Rosebud Lake. Turbidity is on the left Y-axis and flow from the West Rosebud Creek USGS gauge is on the right Y-axis. Note: Peaks in turbidity at the powerhouse discharge and below the re-regulation dam are believed to be erroneous data due to problems associated with the Hydrolabs as discussed in the results and discussion sections.

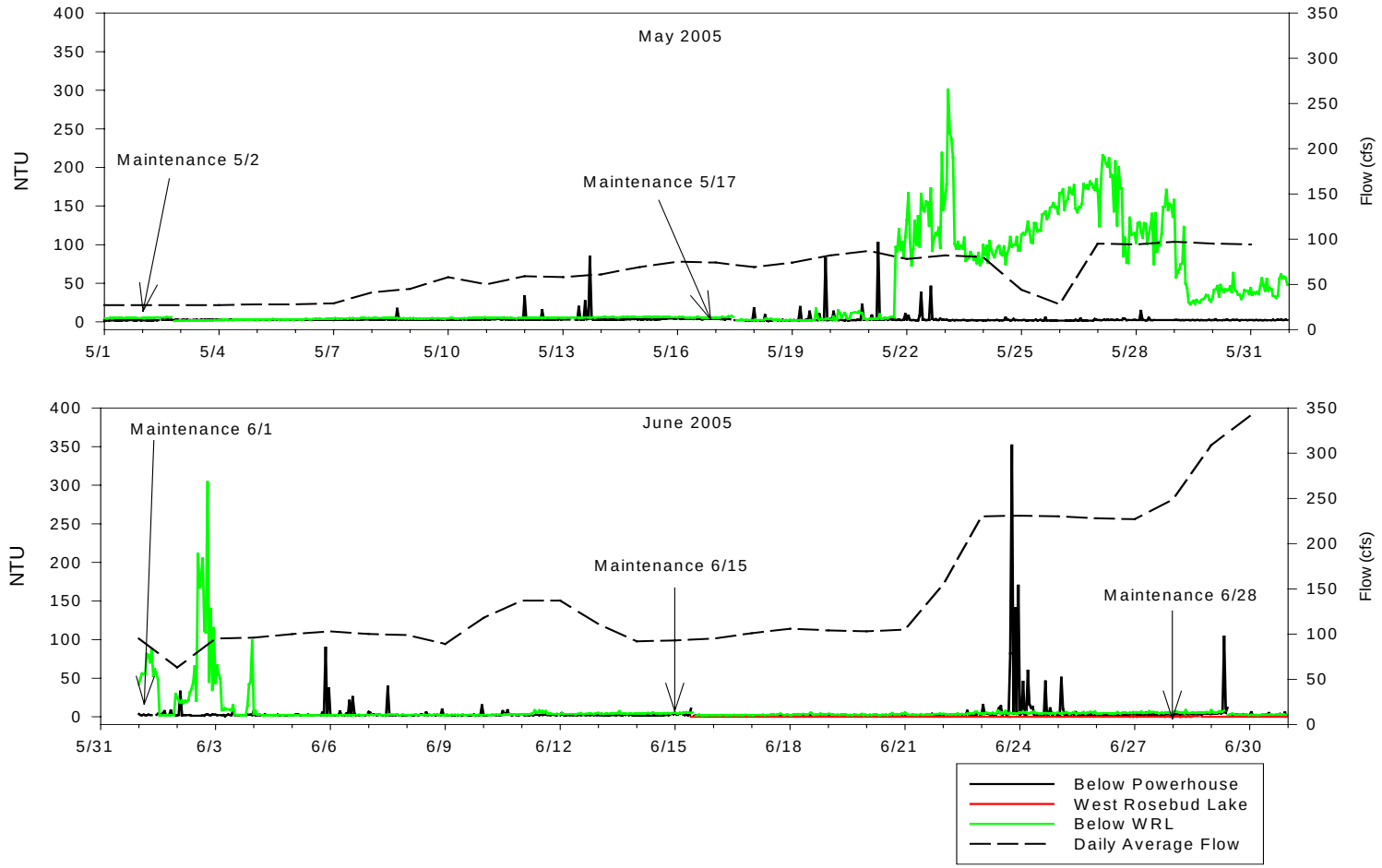


Figure 4. Turbidity measurements for May and June, 2005 recorded by data loggers in West Rosebud Creek downstream of the powerhouse and downstream of the re-regulation dam (West Rosebud Lake) and in West Rosebud Lake. Turbidity is on the left Y-axis and flow from the West Rosebud Creek USGS gauge is on the right Y-axis. Note: Peaks in turbidity at the powerhouse discharge and below the re-regulation dam are believed to be erroneous data due to problems associated with the Hydrolabs as discussed in the results and discussion sections.

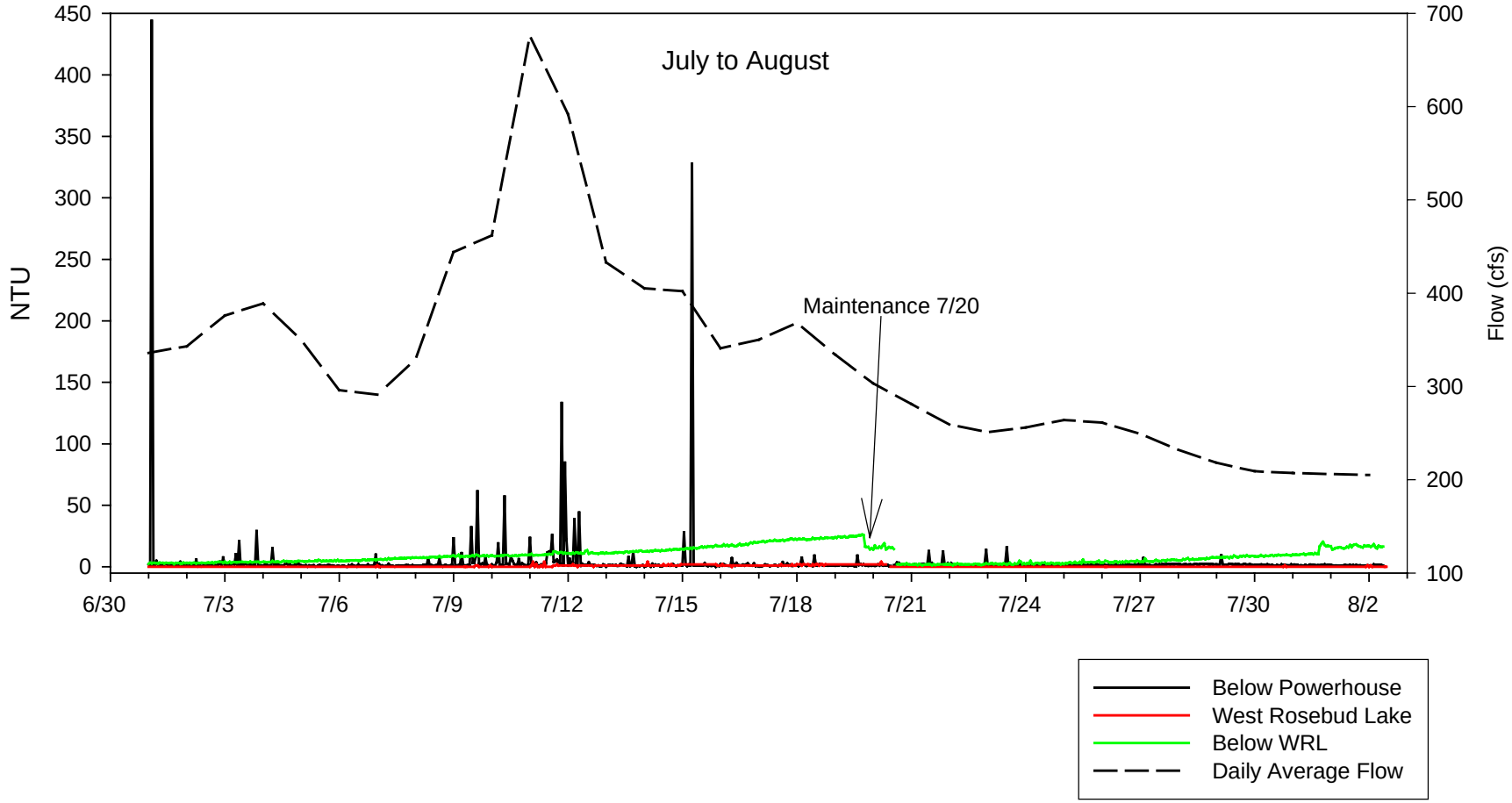


Figure 5. Turbidity measurements for July 1 to August 2, 2005 recorded by data loggers in West Rosebud Creek downstream of the powerhouse and downstream of the re-regulation dam (West Rosebud Lake) and in West Rosebud Lake. Turbidity is on the left Y-axis and flow from the West Rosebud Creek USGS gauge is on the right Y-axis. Note: Peaks in turbidity at the powerhouse discharge and below the re-regulation dam are believed to be erroneous data due to problems associated with the Hydrolabs as discussed in the results and discussion sections.

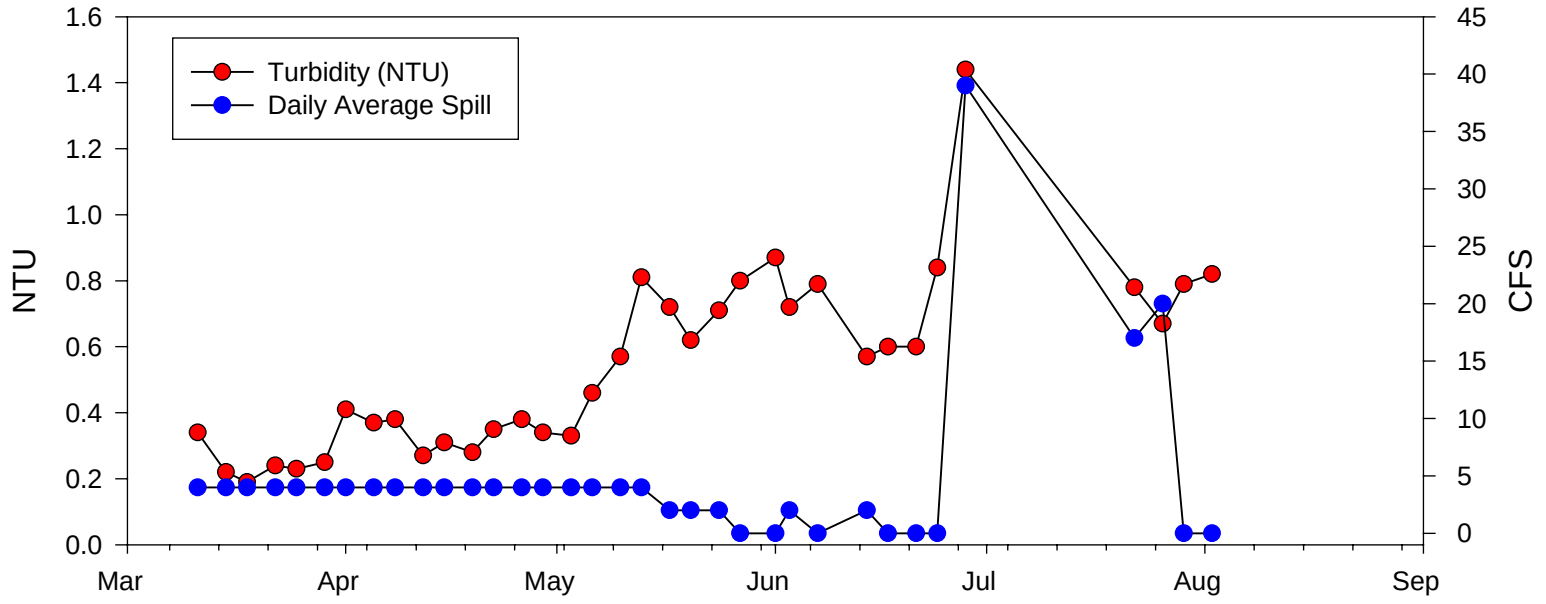


Figure 6. Turbidity measurements taken by manual turbidity meter just downstream of the powerhouse during 2005. Turbidity is on the left Y-axis and average daily spill is on the right Y-axis.

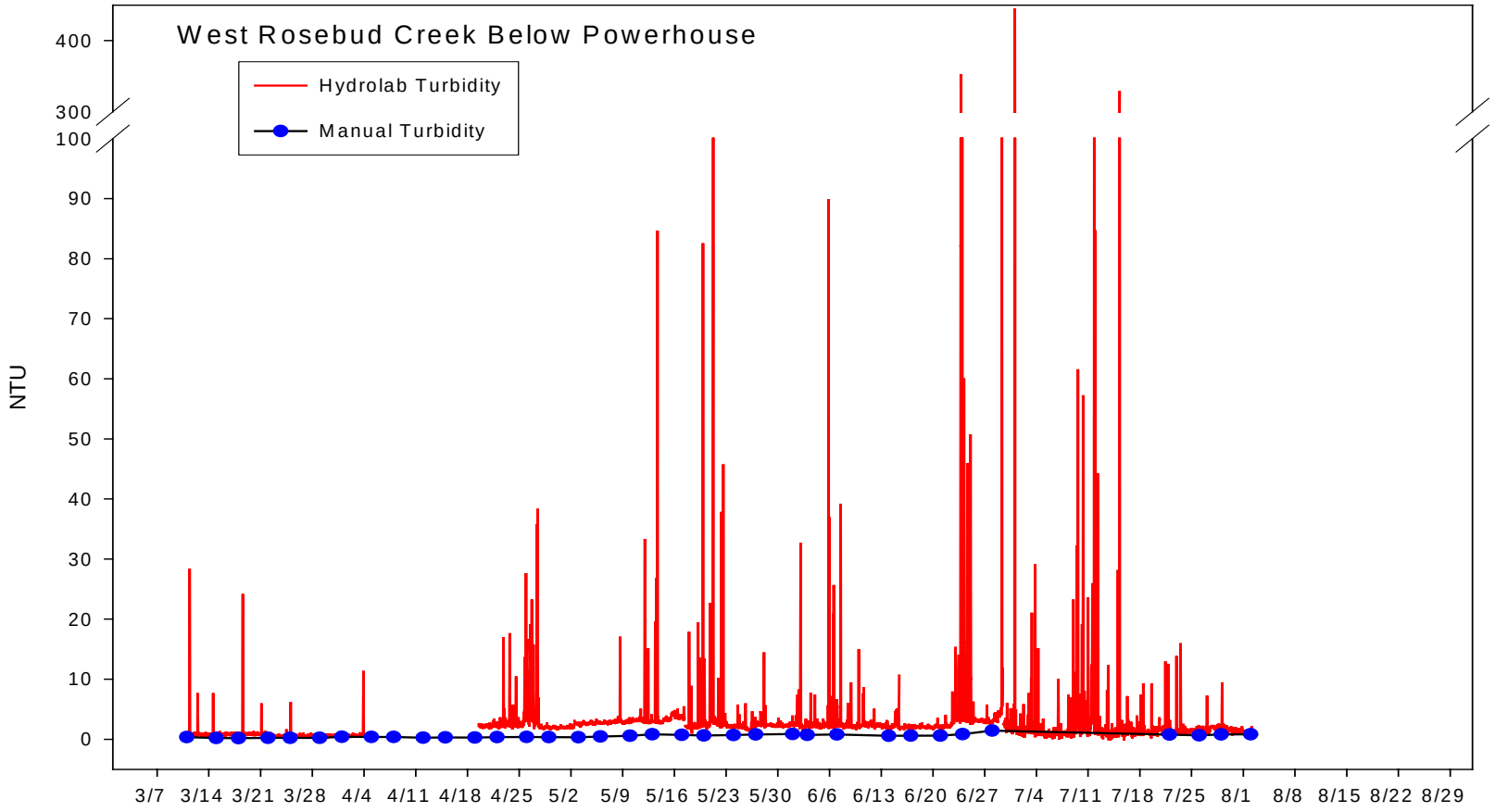


Figure 7. Comparison of Hydrolab and manual turbidity measurements for just downstream of the powerhouse, 2005. Note the break in scale along the Y-axis. Note: Peaks in turbidity at the powerhouse discharge site are believed to be erroneous data due to problems associated with the Hydrolabs as discussed in the results and discussion sections.

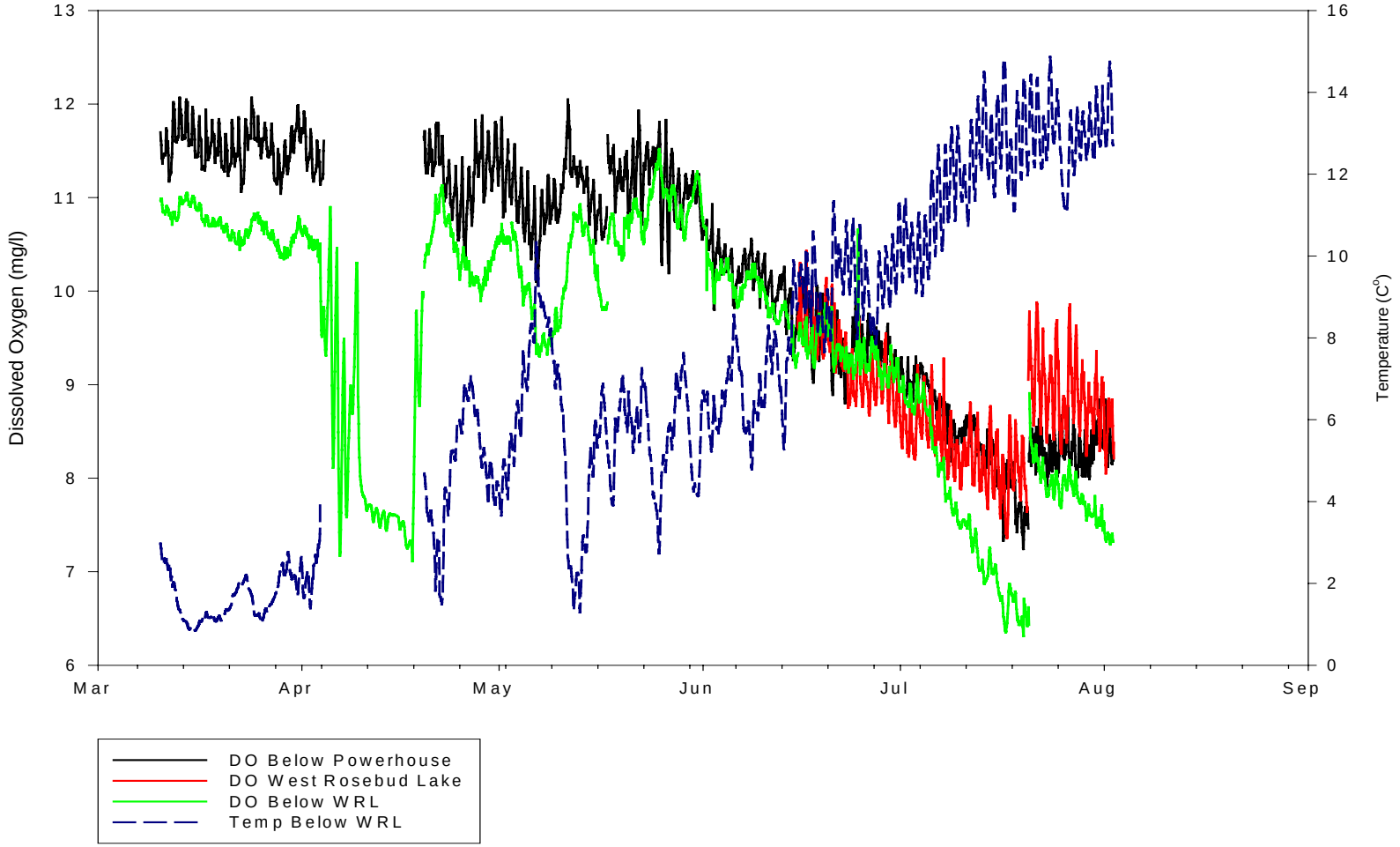


Figure 8. Dissolved oxygen and temperature measured by the data logging probes during 2005. Dissolved oxygen is on the left Y-axis and temperature is on the right Y-axis.

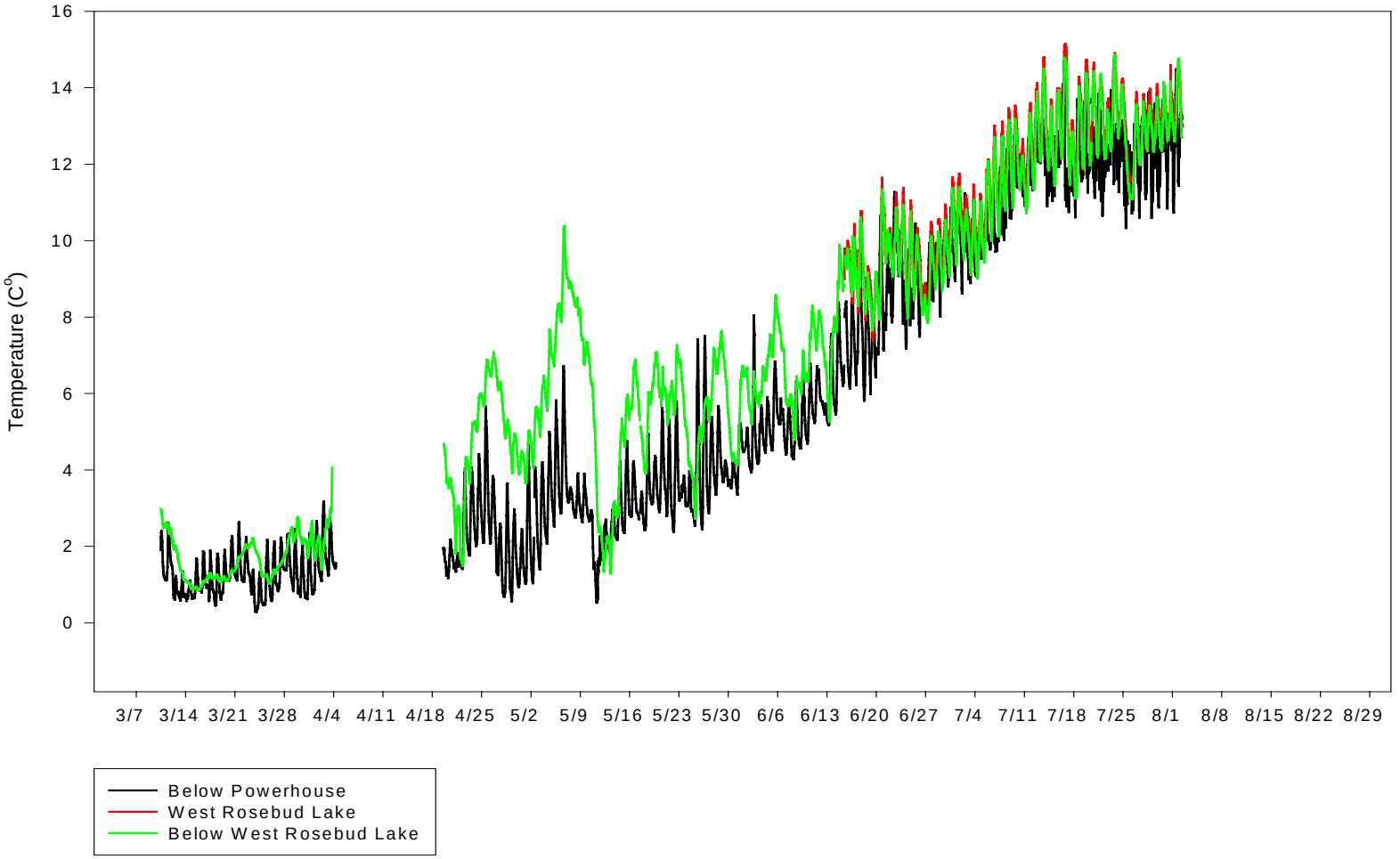


Figure 9. Temperature measured by data loggers in the three sampled sites for 2005. Note the missing data in early April and that the West Rosebud Lake data does not start until June 15, 2005.

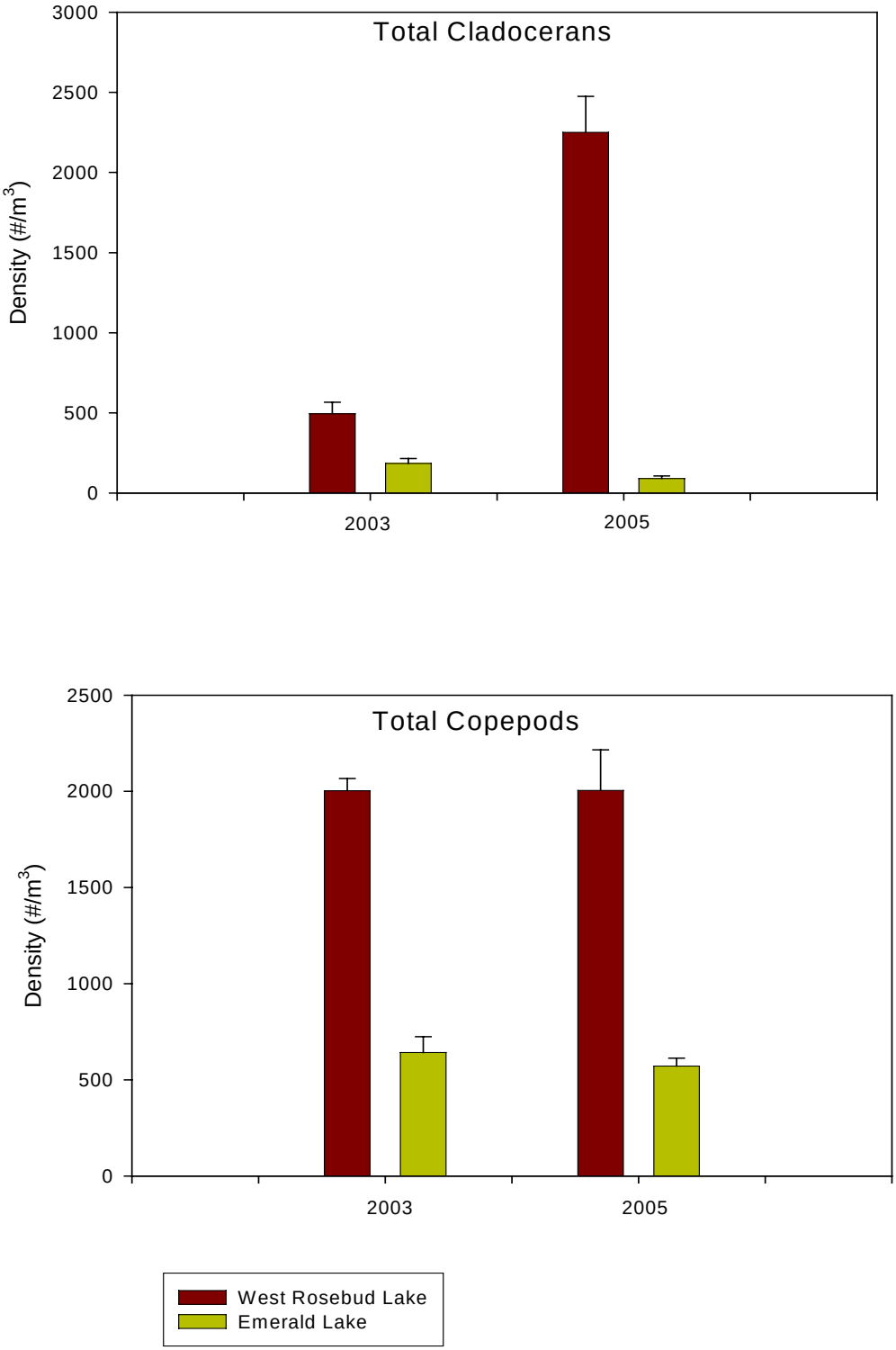


Figure 10. Cladoceran and copepod total density for West Rosebud and Emerald Lakes taken during August of 2003 and 2005. Error bars represent one standard error.

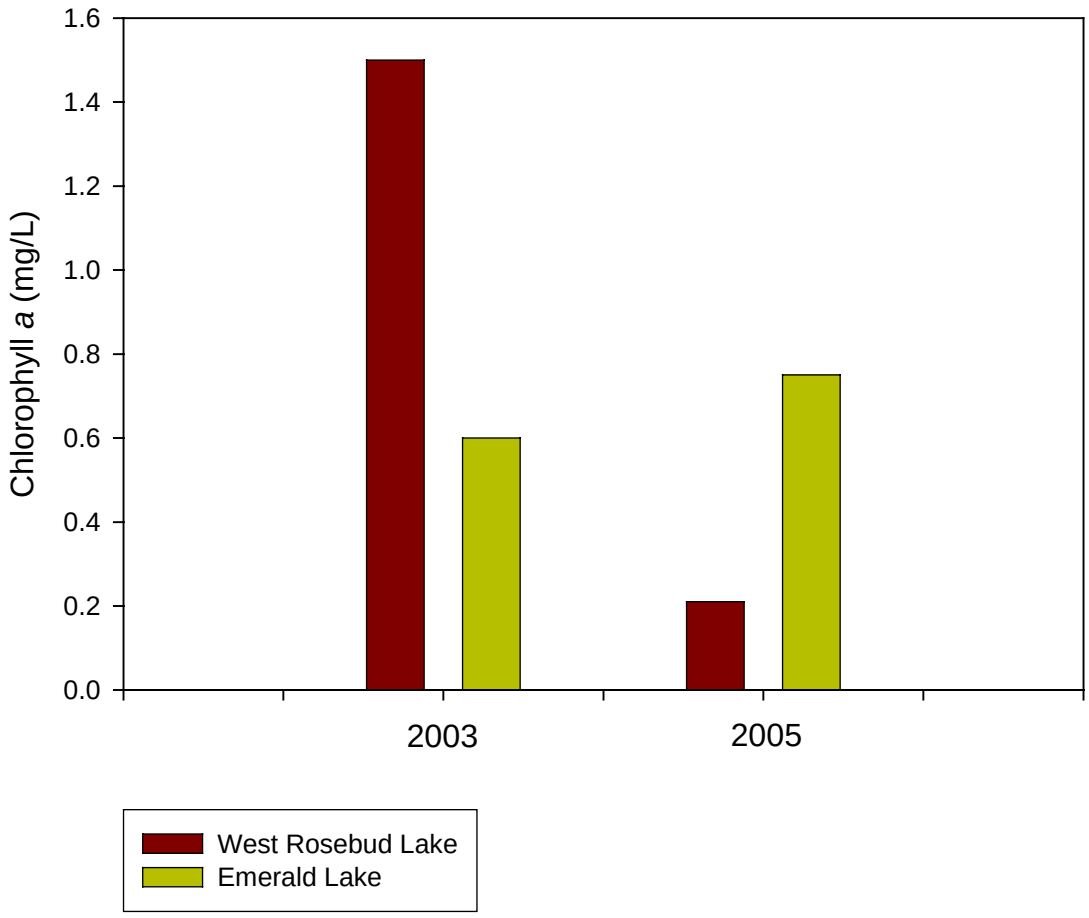


Figure 11. Chlorophyll *a* concentrations for West Rosebud and Emerald Lakes taken in August of 2003 and 2005.

7.0 Photographs

Photograph 1. Location of the Hydrolab for measuring turbidity downstream of the re-regulation dam. Photograph taken on June 15, 2005.

Photograph 2. Location of the Hydrolab for measuring turbidity downstream of the powerhouse discharge. Photograph taken on June 15, 2005.

Appendix 1.0 Total Dissolved Gas Study

PPL Montana
Mystic Licensing Project
2005 Report of the Investigation of Total Dissolved Gases

1.0 Introduction

This report documents TDG monitoring completed in 2005 and is a continuation of work in 2003 and 2004 by PPL Montana.

Total Dissolved Gas is a measurement of the total amount of nitrogen gas, oxygen gas, argon gas, carbon dioxide gas and water vapor dissolved in water. Water becomes supersaturated when more gas is dissolved than would be normal, i.e. 100%, under the existing atmospheric pressure. This issue focuses on the potential for water spilled over the Mystic Dam and the Regulation Dam (West Rosebud Lake) to enter plunge pools and to become supersaturated to levels that would be harmful to fish.

The bottom of the Mystic Dam spillway does not have a plunge pool. The Regulation Dam does not have a spillway but does have a small plunge pool at the bottom of the dam weir as seen in the photo in Figure 1.

The purpose of this work in 2005 is to investigate the behavior of TDG below the West Rosebud Lake (Regulating) Dam. The 2004 investigation showed that TDG was not a detrimental factor to fish at the Powerhouse, but that the TDG level at the West Rosebud Lake Dam did exhibit a potential to rise. The TDG increase measured in 2004 would not be a problem for fish however.

2.0 Methods

Water quality parameters (date, time, temperature, pH, specific conductivity, dissolved oxygen, turbidity, depth, and TDG) were measured with Hydrolab DataSonde Series 4 equipment programmed to read at hourly intervals. All equipment time was calibrated to +/- one minute. At each site, a DataSonde was deployed on the stream bottom.

Deployment intervals between cleaning and calibration of the DataSondes were about two weeks. Data was downloaded from the DataSondes and Surveyors to an MS Excel spreadsheet and stored in electronic files at PPLM offices in Butte.

TDG is measured in pressure units of mm Hg. It is then converted to a percentage of the saturated value as it relates to the local barometric pressure. For example, at a location that has a barometric pressure of 700 mm Hg, a total gas pressure of 770 mm Hg is equal to 110% TDG saturation or 10% over the saturation value that would normally exist at 700 mm Hg.

2.**1 Monitoring Site Locations**

TDG was measured at three locations:

1. Below the Powerhouse (location moved downstream .8 miles from 2004 site)
   N 45° 14.688', W 109° 43.606'

2. In West Rosebud Lake at the Boat Barrier in front of the Dam (new for 2005)
   N 45° 15.113', W 109° 42.476'

3. Below the West Rosebud Dam (same general location as 2004 site)
   N 45° 15.149', W 109° 42.430'

2.2 **Deployment and Service History**

Below Powerhouse	3/10/05	1018	Deployed DataSonde #5
	3/22/05	1020	Cleaned, calibrated, downloaded file
	4/4/05	0920	Serviced, downloaded, changed batteries
	4/19/05	1130	Serviced, downloaded file, reinstalled
	5/2/05	1005	Serviced, downloaded, changed batteries
	5/17/05	0950	Serviced, downloaded file, reinstalled
	6/1/05	0901	Found battery compartment broken- loss of power, repaired bat comp, serviced, changed batteries, reinstalled
	6/15/05	1005	Serviced, downloaded file, reinstalled
	6/29/05	1010	Found algae around probes, serviced, downloaded, changed batteries
	7/20/05	1101	Serviced, downloaded, changed batteries
	8/2/05	0930	Removed #5, end of monitoring period
West Rosebud Lake	6/15/05	0914	Installed DataSonde #1
	6/28/05	1645	Serviced, downloaded, reinstalled
	7/20/05	0850	Serviced, downloaded, changed battery., reinstalled

	8/2/05	1110	Removed #1, end of monitoring period
Below WRL	3/10/05	1140	Deployed DataSonde #3
	3/22/05	1210	Serviced, calibrated, downloaded file
	4/3/05	1915	Serviced, downloaded, changed Li and C bats.
	4/19/05	1302	Serviced, downloaded file, reinstalled
	5/2/05	1840	Serviced, downloaded, changed batteries
	5/17/05	1150	Serviced, downloaded file, reinstalled
	6/1/05	1210	Serviced, downloaded file, reinstalled
	6/15/05	1125	Serviced, downloaded, changed batteries
	6/29/05	0840	Serviced, downloaded file, reinstalled
	7/20/05	1301	Found disturbed, serviced, downloaded, changed batteries
	8/2/05	0910	Removed #3, end of monitoring period

3.0 Results and Discussion

Figure 1 is a picture of the spillway below the West Rosebud Lake Dam.

The purpose of this study was to investigate the behavior of TDG at the West Rosebud Lake Dam. The 2004 study reported a sharp increase in TDG of about 3% on June 29, 2004from the site below the Dam. This increase could not be explained by increased Powerhouse flow.

Figure 2 is a graph depicting mean daily TDG data for the 2005 study at three sites and mean daily flow as measured by the USGS at the lower weir below the Powerhouse. Mean TDG was generally within non-armful levels at all three sites. TDG is slightly higher the West Rosebud Lake Dam than above it. The TDG values were averaged from June 15, 2005 to August 2, 2005 resulting in an average 104.8% TDG above the Dam to 105.6% TDG below the Dam. This is an average increase of .8% mean daily TDG across the Dam.

Below the Powerhouse, the chart shows a sharp increase in mean daily TDG from 101.8% on July 9 to 109.0% on July 10 to 11.4% that coincides with the beginning of spill over Mystic Dam. TDG was above 110% for four days peaking at 111.4% on July 12th. The lack of a similar trend in TDG at the lower stations indicates that natural equilibrium of the water took place as it flowed to West Rosebud Lake.

The location of the Below Powerhouse monitoring site was changed this year from immediately below the Powerhouse to .8 miles downstream. The course of the stream in the section below the Powerhouse is very turbulent. In looking downstream from the Powerhouse, the stream appears white from bank to bank. Because the 2004 study did not

reveal significant increased TDG as a result of the spilling of water over Mystic Dam, it is believed that the turbulence caused by the high gradient stream channel below the Powerhouse seems to be the reason for the increase in TDG at this site.

It was thought that perhaps solar warming of the water may be a cause for some of the increase in TDG that have been measured in the stream. Figure 3 is a plot of stream temperatures from below the Powerhouse and the West Rosebud Lake Dam. This record does not indicate any sudden changes in temperature occurred in 2005 that would trigger an associated sudden rise in TDG.

4.0 Conclusions

These data support the conclusion that TDG caused by spill at these levels over West Rosebud Lake Dam does not present a water quality issue of concern. A deep plunge pool at the toe of the spillway of this dam does not exist.

These data would support the conclusion that temperature does not play a causative role in sudden increases TDG at West Rosebud Lake Dam.

TDG does not seem to be elevated to harmful levels by spill over either Mystic Dam (2004 report) or West Rosebud Lake Dam as presented in this report.

Figure 1. West Rosebud Lake Dam Spillway

Figure 2.

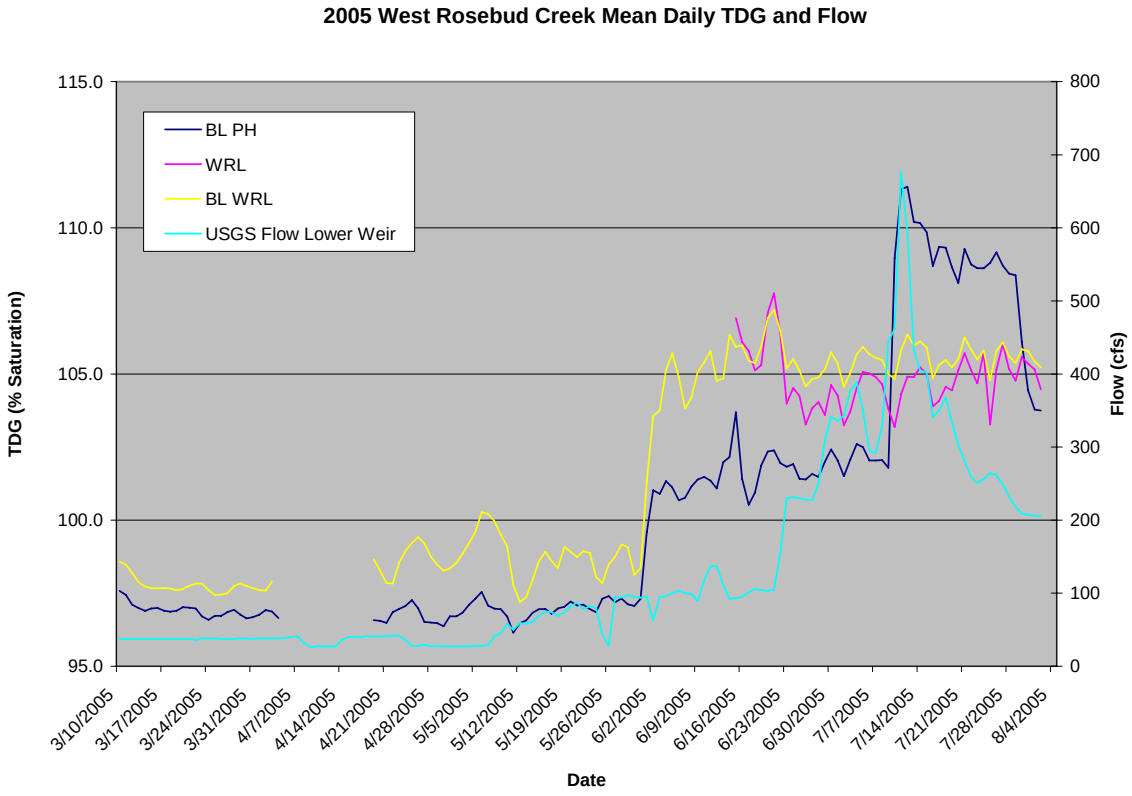
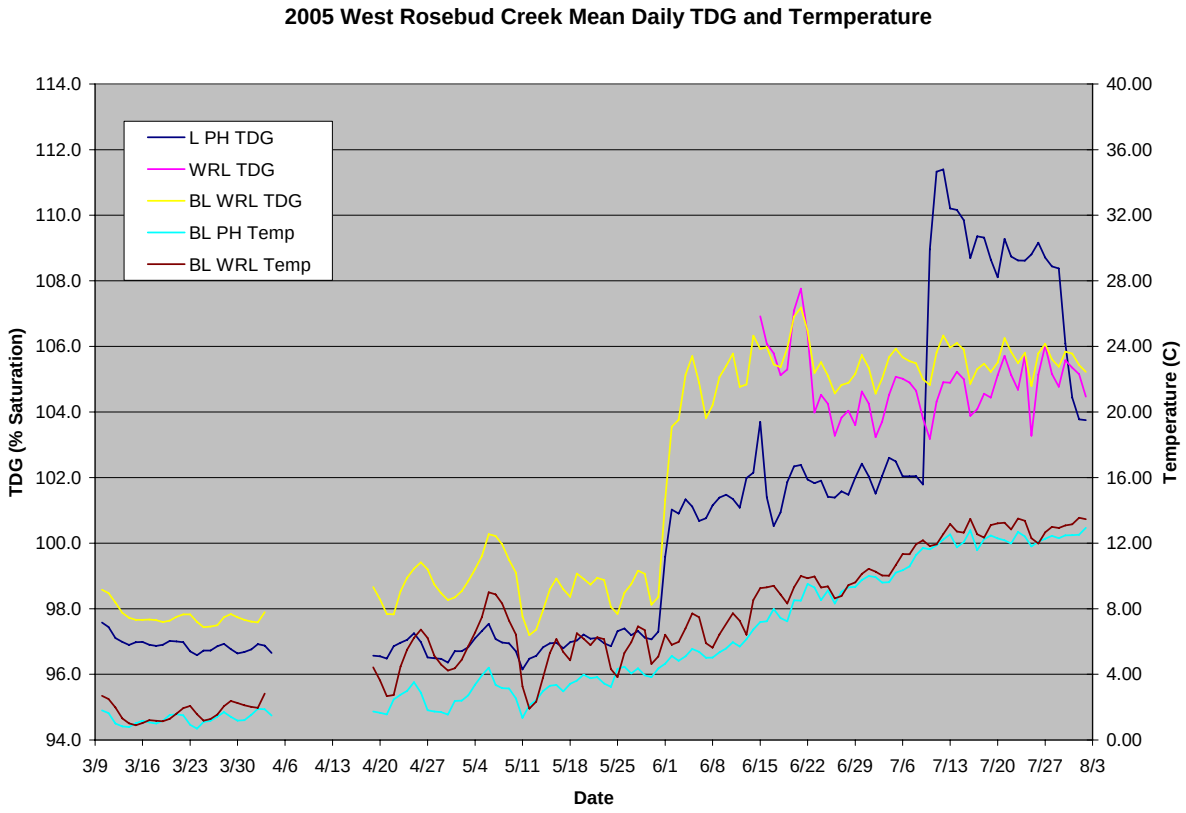

2005 West Rosebud Creek Mean Daily TDG and Flow
BL PH
WRL
BL WRL
USGS Flow Lower Weir
TDG (% Saturation)
Flow (cfs)
115.0
110.0
105.0
100.0
95.0
800
700
600
500
400
300
200
100
0
3/10/2005
3/17/2005
3/24/2005
3/31/2005
4/7/2005
4/14/2005
4/21/2005
4/28/2005
5/5/2005
5/12/2005
5/19/2005
5/26/2005
6/2/2005
6/9/2005
6/16/2005
6/23/2005
6/30/2005
7/7/2005
7/14/2005
7/21/2005
7/28/2005
8/4/2005
Date

Figure 3.


2005 West Rosebud Creek Mean Daily TDG and Termperature
L PH TDG
WRL TDG
BL WRL TDG
BL PH Temp
BL WRL Temp
TDG (% Saturation)
Temperature (C)
Date
114.0
112.0
110.0
108.0
106.0
104.0
102.0
100.0
98.0
96.0
94.0
40.00
36.00
32.00
28.00
24.00
20.00
16.00
12.00
8.00
4.00
0.00
3/9
3/16
3/23
3/30
4/6
4/13
4/20
4/27
5/4
5/11
5/18
5/25
6/1
6/8
6/15
6/22
6/29
7/6
7/13
7/20
7/27
8/3