A Study of Seven Minnesota River Basin Lakes
Le Sueur County, Rice County
Fall 2004

Cody Lake
Duban Lake
Lake Pepin
Phelps Lake
Rice Lake
Lake Sanborn
Union Lake

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Introduction

The purpose of this study is to determine the water quality of seven Rice and Le Sueur County lakes: Union Lake, Rice Lake, Cody Lake, Phelps Lake, Sanborn Lake, Duban Lake, and Pepin Lake (see map, fig. 1). In our study we use the Cannon River as a "dirty water body" to which to compare our lakes. In contrast, Kelly-Dudly Lake has significantly low levels of most contaminants and so we use it as a "clean water body" to which to compare our lakes. We sampled the lakes between one and three times each from during the months of October and November, 2004. Many of these lakes have never been studied in great depth. Assessing water quality is necessary because these lakes are used by humans, and because water quality has a significant impact on the ecosystem. Because these lakes are in a populous area of the state, they are likely to be contaminated by the effects of human habitation. As urban growth from Minneapolis and Saint Paul encroaches upon Rice and Le Sueur Counties and the Rice County towns of Northfield, Dundas, and Faribault expand (Rebecca Farley, et al., 124), water quality is likely to change, as the land in the Lower Cannon River Watershed begins to be used differently. In this study, we hope to present a data set detailing the water quality and composition of the lakes under current land use conditions as a basis for comparison should currently projected land use changes occur. Our study draws on data collected in studies of Rice Lake in 2003 and Union Lake in 2003 and 1999 by other Carleton College geology students.

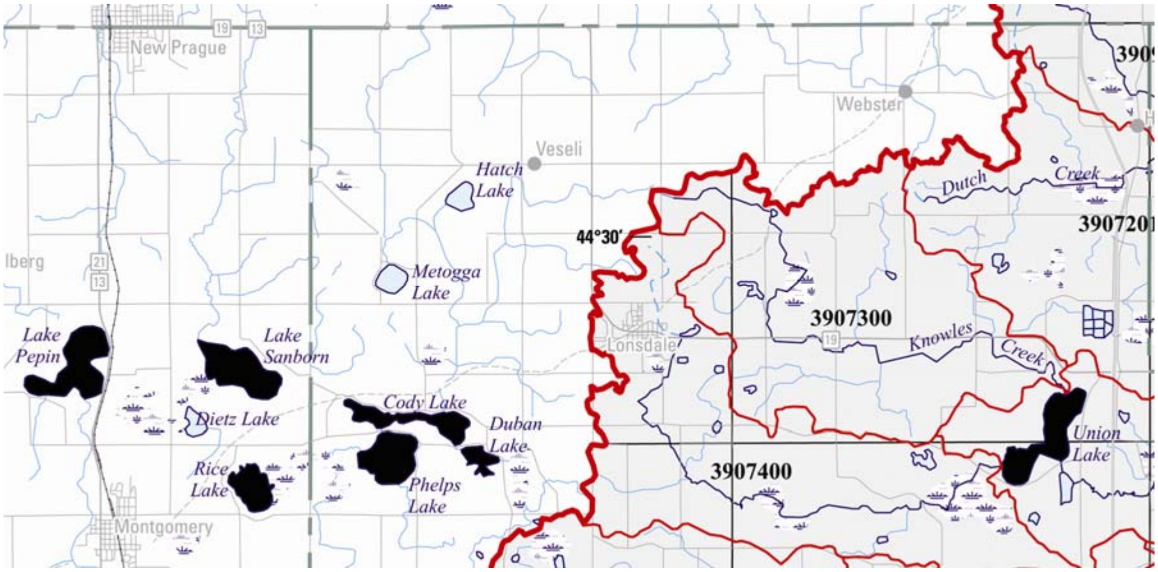


Figure 1. Location map of field area. Lakes sampled are shaded in black.

Our lakes are surrounded by farm land, grazing pasture, roads, residential houses, forest, and wetlands. Based on these surroundings, we suspect that we will find the following chemicals in the lakes that we sampled: nitrates and nitrites, chloride, sulfates, fecal coliform bacteria, phosphorus, herbicides, and pesticides. We also expect high turbidity levels, and a low concentration of dissolved oxygen because high concentrations of nitrogen and phosphorus cause algal blooms (Balmm, 54-61). Unfortunately, we will only be able to test our samples for nitrate and nitrite, chloride, sulfate, and turbidity.

Urban nitrogen sources pertinent to this study include lawns and grain elevators, both which could be found in close proximity to our sampling sites. (Kolpin et al., 29) Other sources of nitrates to surface water include the application of manure (Balmm, 54) subsurface tile systems common in Rice County (Rebecca Farley, et al., 124), erosion of natural deposits (US Environmental Protection Agency website) and organic soil matter, nitrogen fertilizer and nutrients applied to row crops, and legumes (Balmm, 54). Nitrate and nitrite can be harmful, especially to young children, because they cause shortness of breath and blue-baby syndrome (US Environmental Protection Agency).

While water naturally contains some chloride and sulfate (APEC website), in excess they can be harmful. Chloride, which enters water through road salt runoff, fertilizers, animal sewage, septic systems, and industrial waste, can cause “high blood pressure [in humans], salty taste, corroded pipes, fixtures and appliances, [and] blackening and pitting of stainless steel” (Secondary Drinking Water Standards website). Sulfate, which enters water sources from animal sewage, septic systems, industrial waste, coal mining, and natural deposits, has laxative effects and a bitter, medicinal taste, and it can corrode metal or leave scaly deposits (Secondary Drinking Water Standards website).

High turbidity levels, attributed to soil runoff, are “often associated with higher levels of disease-causing microorganisms such as viruses, parasites and some bacteria. These organisms can cause symptoms such as nausea, cramps, diarrhea, and associated headaches” (EPA website). Although we would like to be able to compare our data to past data collected from these lakes, this is not feasible for the majority of the lakes because we do not have access to any data for those lakes.

Methods

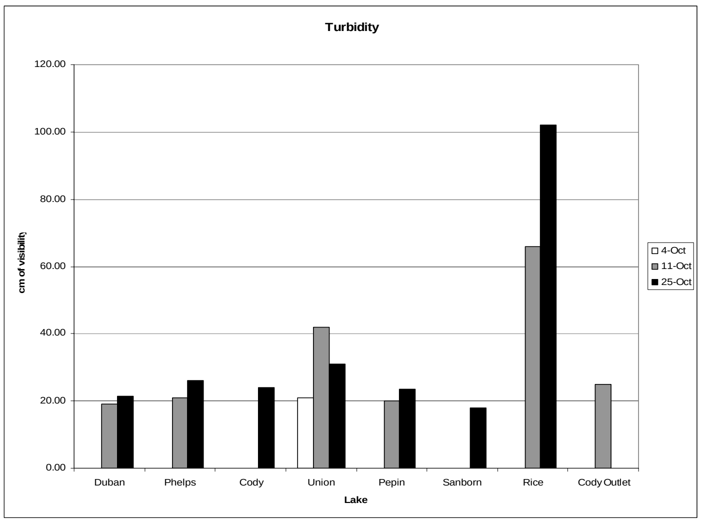
On two Monday afternoons in October, 2004, we took measurements and water samples from Rice Lake, Pepin Lake, Duban Lake, Cody Lake, Phelps Lake, and Lake Sanborn, all located in Rice and Le Sueur counties, Minnesota. We took samples from Union Lake, also located in Rice County, on one additional Monday in October. Using a Yellow Springs Instruments model 85 meter, we recorded measurements of temperature, dissolved oxygen concentration, salinity, and conductivity. We also recorded water depth at the sampling site and water turbidity using a secchi disk tube and noted weather conditions, the longitude and latitude of the sampling site, and the local environment surrounding the site, paying particular attention to factors likely to influence water quality (e.g. farms, residential areas, livestock, roads, etc.). Samples were taken in shallow water (~15–60 cm. deep), near the lake shore, frequently at public water access points, docks, and fishing piers.

We analyzed our water samples for Chloride, Sulfate, Nitrite, Nitrate, and Phosphate concentrations using a Dionex Level 2 DX-500/600 ion chromatograph and compared these results to each other. All fell well within EPA drinking water contaminant standards. Rather than extensively comparing our data to previous data, we focus on the differences in water quality between the lakes and the possible environmental causes of these differences because we collected a relatively small number of samples from a relatively large number of lakes and there is little past data from these lakes.

Results

Generally, the water quality in the lakes that we studied remained fairly constant over time. Turbidity, for the most part, fell between 18 and 26 centimeters, excepting Union Lake and Rice Lake, which were noticeably higher. Rice Lake reached as high as 102 cm of Secchi Disk visibility and Union Lake reached 42 cm (fig. 2a). The conductivity readings we collected averaged 417.55 μS (adjusted for temperature) on October 25 and 376.57 adjusted μS on October 4 (fig. 2b). Salinity was 0.2 ppt for all the samples we collected except for the sample taken from Union Lake on October 4. On average, the temperature lowered as winter approached, remaining generally similar for all lakes in a given day. On a single day (October 11), temperature varied only 3.2°C between lakes. Dissolved oxygen levels fluctuated frequently during testing. They remained approximately between 3 and 16.5 mg/L, but varied significantly within individual lakes on different test dates. (See appendix for graphs of temperature and dissolved oxygen.)

2a:



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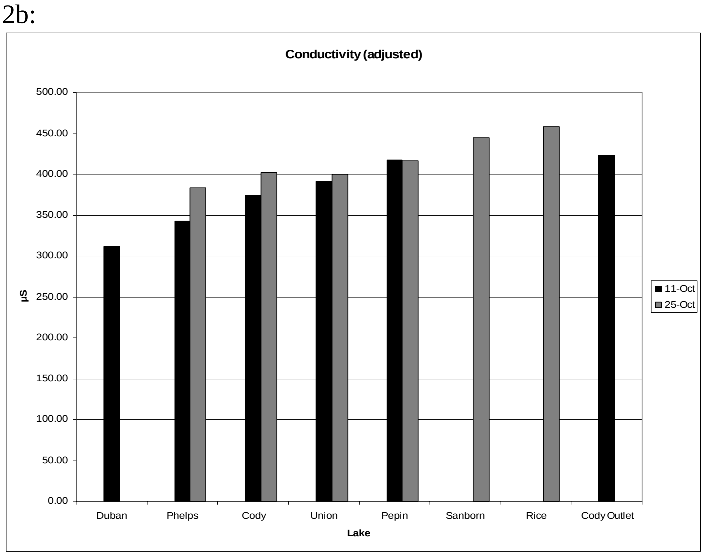
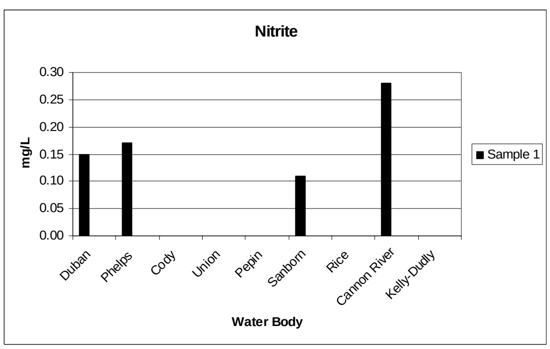


Figure 2a: Turbidity readings. b: Adjusted conductivity

Only Rice Lake contained phosphate (0.68 and 0.39 mg/L). Only Lakes Sanborn Duban and Phelps contained Nitrite and only in trace amounts (0.11, 0.15 and 0.17 mg/L, respectively, fig. 3a). Nitrate was present in all lakes but Union, in an average concentration of 1.07 mg/L. Duban lake had consistently higher nitrate concentration than all other lakes (1.72 and 2.30 mg/L) and, of those lakes containing nitrate, Phelps had the lowest concentration (0.36 mg/L) (fig. 3b). The nitrate content in our samples ranged from 0 to 2.3 mg/L. All the lakes that we tested contained Chloride, divided into two groups, averaging 14.55 mg/L in lakes Duban Phelps Cody and Sanborn and 24.6 mg/L in lakes Union Pepin and Rice (3c). Sulfate concentrations were generally between 25-30 with half of that amount found in Lake Sanborn and an average of 26.23 mg/L in all of the lakes or 27.81 mg/L with Lake Sanborn removed (3d).

3a:



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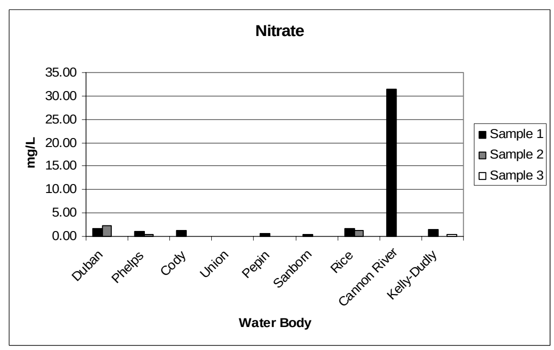

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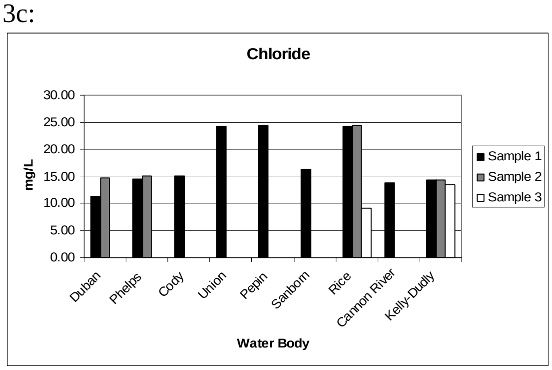

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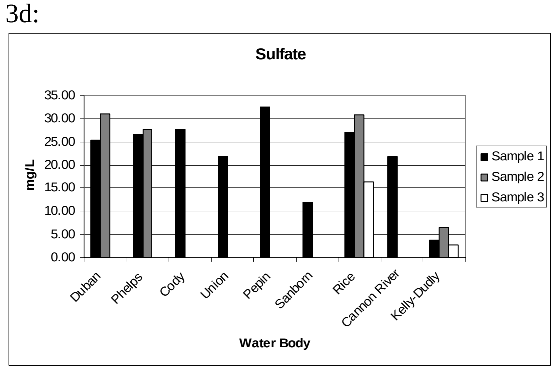

Figure 3a-d: Anion concentrations.

Discussion

The graphs reveal relatively low levels of contaminants. We found these levels to be comparable to those of Kelly-Dudly Lake and significantly lower than those of the Cannon River. This suggests that our lakes are relatively clean, however the chloride and sulfate content were two exceptions.

Nitrate content in our lakes is significantly lower than that of the Cannon River, and roughly corresponds to Kelly-Dudly. Duban, Phelps, and Sanborn had nitrite in very low levels. This is not particularly significant as they were only half those of the Cannon River.

Chloride content was stratified into two levels. Kelly-Dudly and the Cannon River had approximately 15 mg/L, which is similar to our lower level lakes. Union, Pepin, and Rice almost doubled these other levels. A possible explanation for this phenomenon is the proximity of these lakes, especially Lake Pepin, to major roads. This would increase the potential for highly chlorinated road salt runoff in the water samples. Similarly, we had far higher sulfate levels in our lakes (excepting Union and one Rice sample) than were present in the Cannon River. Union Lake's concentrations were similar to those in the Cannon River. All were higher than in Kelly-Dudly. These exceptions do not pose a severe threat as sulfate is a secondary drinking water contaminant and was not present in levels approaching the EPA maximum contaminant level (Secondary Drinking Water Standards). Sulfate occurs naturally in soil and the sulfate levels that we observed do not indicate any significant non-natural contamination.

Another factor that contributed to the health of our lakes was the sampling season. We collected our samples in late fall after farms had already fertilized their crops. By this time, plants had absorbed much of the fertilizer, preventing it from infiltrating nearby water sources. Had we taken samples in the spring, nitrate and nitrite levels would most likely have been higher. Cody Lake, Duban Lake, and Phelps Lake are surrounded by areas zoned by Rice County as “natural environment shoreland,” which act as buffer zones, separating the lakes from the agricultural areas surrounding them. In addition to absorbing water contaminants from farms, buffer zones around the lakes prevent seepage of chemicals into water bodies. Notably, these lakes have lower turbidity than all other lakes in our study. Union lake, also in Rice County, is surrounded by an area zoned as “recreational development shoreland,” which has a similar effect. The lakes in our study located in Le Sueur county (Rice, Sanborn, and Pepin) follow different zoning standards than those in Rice County.

Conclusion

Overall we feel that our results show this grouping of lakes to be quite clean. None have exceeded EPA standards for the presence of anions, and our salinity, conductivity and turbidity readings show our lakes to be suitable for plant and animal life. It is our conclusion that buffer zones, such as those surrounding lakes Cody, Duban and Phelps are serving their purpose effectively and we feel this group of lakes could serve as a template for the protection of other lakes located in close proximity to areas of agriculture.

On a methodological note, we feel that our study is valid and valuable overall, however we had several possible sources of error that may have affected our data. When using the YSI, we did not standardize the amount of time we waited for the instrument to adjust to the water. On our second trip to the field, the YSI was accidentally turned off in between samples and only had about twenty minutes to recalibrate. The fluctuating dissolved oxygen readings which we received on almost every test forced us to choose an average value. Therefore, for future studies, we would be careful to standardize the amount of time that we leave the meter in the water before taking readings and, similarly for dissolved oxygen, the time after the initial reading at which we would record a value for the site. In addition to sources of error related to the YSI, we also had possible sources of error in that the measurements and samples were taken very close to shore. These were not necessarily the most representative sites we could have chosen. The lakes' bottoms were sometimes stirred up as we waded out to take samples, which may have affected turbidity readings, though generally we waited for the water to settle before taking our sample. Turbidity measurements were taken by different members of the group, who may have had varying eyesight. One way to solve this problem would be to have multiple turbidity readings taken at each site by multiple group members to control quality in the sampling. Finally, we do not have as much data as we would like to have due to the short time window for sampling. The sample numbers that we had indicated on our water samples were lost during water sample analysis, so we were unable to connect our water composition analyses directly to measurements taken on site. We would recommend that future studies have a standardized labling system so that water samples can be easily identified after analysis. Despite these possible sources of error, we feel our data does accurately reflect the state of these lakes as generally healthy bodies of water.

Acknowledgements

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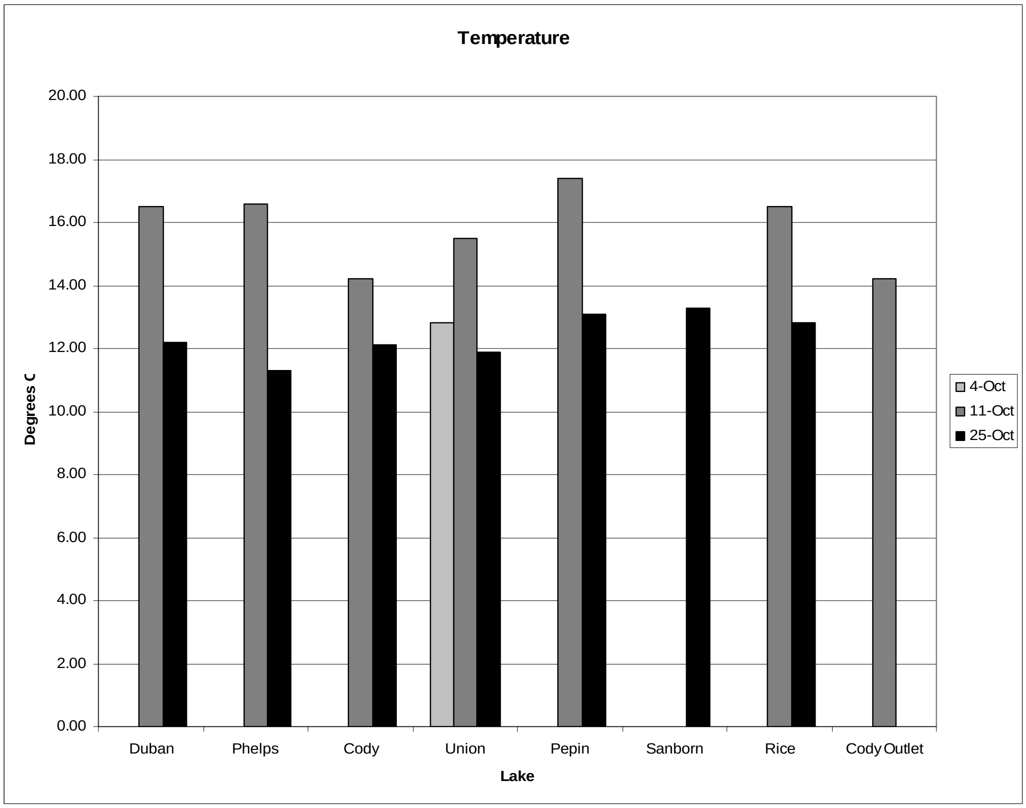
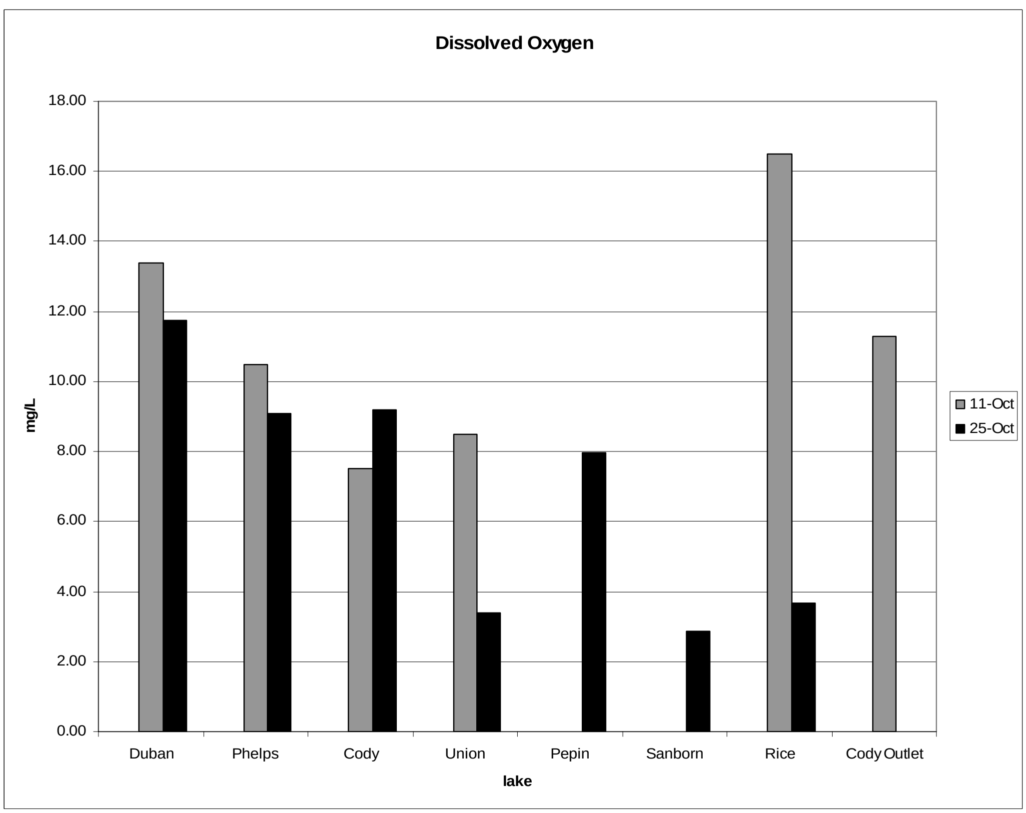
Appendix



Temperature
Degrees C
20.00
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Duban
Phelps
Cody
Union
Pepin
Sanborn
Rice
Cody Outlet
Lake
4-Oct
11-Oct
25-Oct



Dissolved Oxygen
mg/L
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Duban
Phelps
Cody
Union
Pepin
Sanborn
Rice
Cody Outlet
lake
11-Oct
25-Oct

Table 1: On-site measurements.

Turbidity (cm)	4-Oct	11-Oct	25-Oct
Duban		19.00	21.50
Phelps		20.95	26.10
Cody			24.00
Union	21.00	42.00	31.00
Pepin		20.15	23.50
Sanborn			18.00
Rice		66.00	102.00
Cody Outlet		25.00	

Conductivity (µS)	4-Oct	11-Oct	25-Oct
Duban		259.00	
Phelps		250.00	282.70
Cody		298.00	301.50
Union	192.80	319.00	300.00
Pepin		356.90	322.20
Sanborn			346.20
Rice		351.00	351.50
Cody Outlet		354.50	

Conductivity (adj. µS)	4-Oct	11-Oct	25-Oct
Duban		311.30	
Phelps		343.00	383.10
Cody		374.00	402.10
Union		391.00	400.00
Pepin		417.20	416.90
Sanborn			444.80
Rice			458.40
Cody Outlet		422.90	

Salinity (ppt)	4-Oct	11-Oct	25-Oct
Duban		0.20	0.20
Phelps		0.20	0.20
Cody		0.20	0.20
Union	0.10	0.20	0.20
Pepin		0.20	0.20
Sanborn		0.10	0.20
Rice		0.20	0.20
Cody Outlet		0.20	

Temperature (°C)	4-Oct	11-Oct	25-Oct
Duban		16.50	12.20
Phelps		16.60	11.30
Cody		14.20	12.10
Union	12.80	15.50	11.90
Pepin		17.40	13.10
Sanborn			13.30
Rice		16.50	12.80
Cody Outlet		14.20	

Dissolved Ox. (mg/L)	4-Oct	11-Oct	25-Oct
Duban		13.40	11.75
Phelps		10.50	9.10
Cody		7.50	9.19
Union		8.50	3.40
Pepin			7.98
Sanborn			2.85
Rice		16.50	3.68
Cody Outlet		11.30	

Depth (cm)	4-Oct	11-Oct	25-Oct
Duban		30.00	20.00
Phelps		20.00	
Cody		60.00	54.00
Union	50.00	40.00	
Pepin		66.00	30.00
Sanborn			13.00
Rice		20.00	30.00
Cody Outlet		13.00	

Table 2: Anion concentrations

Nitrate

	Sample 1	Sample 2	Sample 3
Duban	1.72	2.30	
Phelps	1.01	0.36	
Cody	1.18		
Union	0.00		
Pepin	0.67		
Sanborn	0.49		
Rice	1.65	1.30	0.00
Cannon River	31.46		
Kelly-Dudly	1.48	0.00	0.43

Nitrite

	Sample 1	Sample 2	Sample 3
Duban	0.15	0.00	
Phelps	0.17	0.00	
Cody	0.00		
Union	0.00		
Pepin	0.00		
Sanborn	0.11		
Rice	0.00	0.00	0.00
Cannon River	0.28		
Kelly-Dudly	0.00	0.00	0.00

Chloride

	Sample 1	Sample 2	Sample 3
Duban	11.35	14.79	
Phelps	14.56	15.08	
Cody	15.11		
Union	24.25		
Pepin	24.41		
Sanborn	16.41		
Rice	24.30	24.45	9.09
Cannon River	13.75		
Kelly-Dudly	14.34	14.31	13.48

Sulfate

	Sample 1	Sample 2	Sample 3
Duban	25.26	30.98	
Phelps	26.56	27.67	
Cody	27.58		
Union	21.83		
Pepin	32.57		
Sanborn	11.99		
Rice	26.99	30.86	16.29
Cannon River	21.90		
Kelly-Dudly	3.74	6.41	2.65

Phosphate

	Sample 1	Sample 2	Sample 3
Duban	0.00	0.00	
Phelps	0.00	0.00	
Cody	0.00		
Union	0.00		
Pepin	0.00		
Sanborn	0.00		
Rice	0.68	0.39	0.00
Cannon River	0.00		
Kelly-Dudly	0.00	0.00	0.00