Water Quality of Watersheds of Little Millers Bay, West Okoboji Lake, Summer 2018

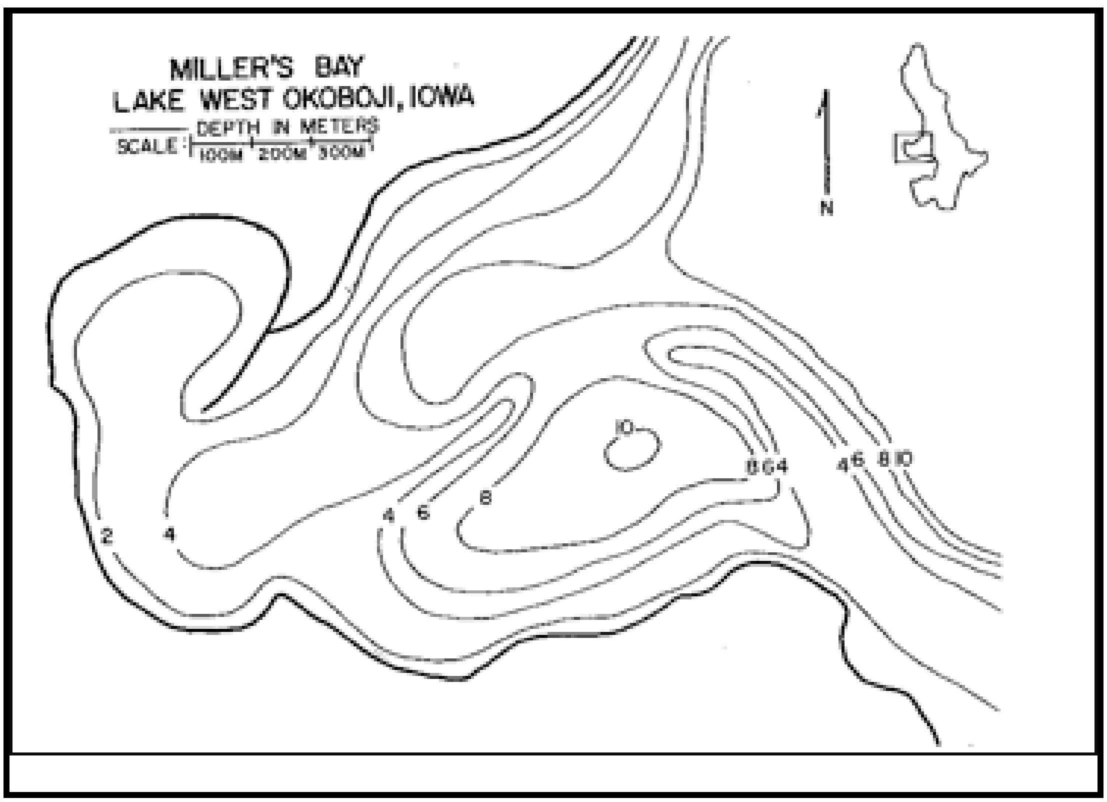
Joann Kenny and Megan Bezdicek

Introduction

The Iowa Lakeside Laboratory is located on a 147 acre plot in Wahpeton, Iowa on the banks of West Okoboji Lake, which is a glacial lake in Dickenson County. Millers Bay is a small bay on the western side of the lake (Figure 1). The bay is about 1.4 kilometers in length and 1.2 kilometers across the mouth (Stromsten, 1927). Little Millers Bay is a shallow pond-like bay, separated from Millers Bay by a long sandpit (Cooke, 1964). The Lakeside Lab property is located adjacent to Little Millers Bay and has four watersheds that flow through it and into the bay. Site 1 is a wetland. Site 2 is a field drainage tile, and Sites 3 and 4 are groundwater seeps.

This study was conducted to evaluate the quality of the the water in the watersheds of Littler Millers Bay as well as the aquatic invertebrate populations in these watersheds. There were other similar study done on these watersheds by Mary Krull (2009) and by Roger W. Bachmann and John R. Jones (1974). These studies were done to gather baseline data on the watersheds.

Figure 1. Map of Millers Bay, West Okoboji Lake, Iowa



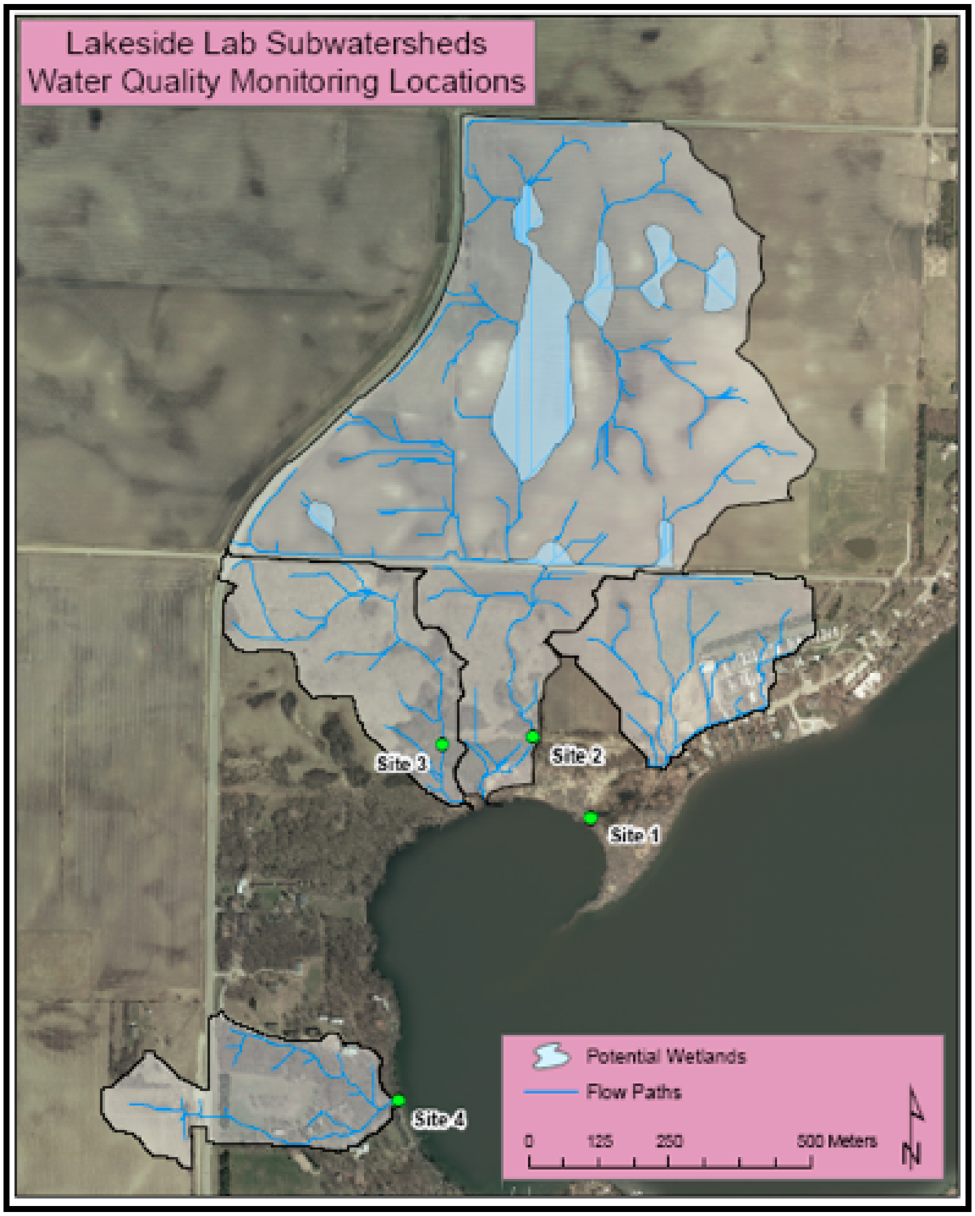


Figure 2. Map of Watersheds evaluated in Littler Millers Bay, West Okoboji Lake, Iowa

Lakeside Watershed

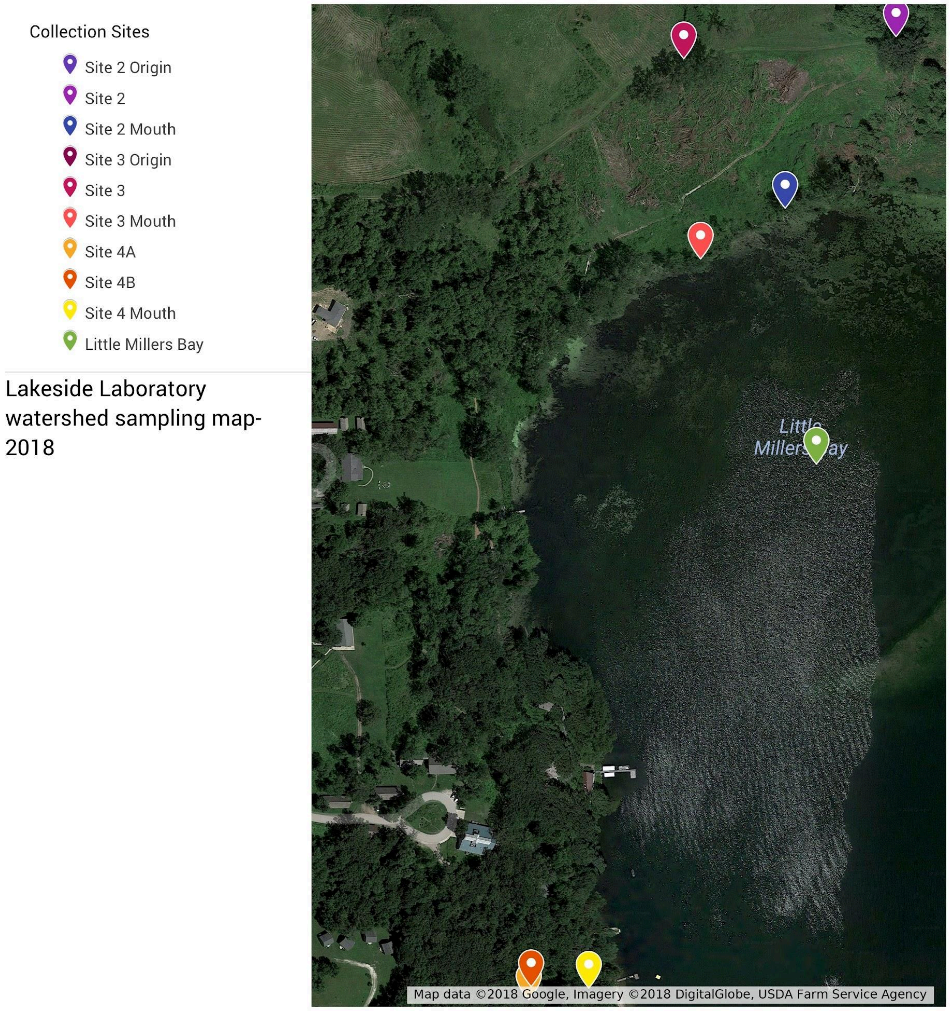


Figure 3. Collection point of samples in the watersheds evaluated on Lakeside Laboratory Campus, West Okoboji Lake, Iowa

Method

A total of 36 water samples were collected from sites 2, 3, and 4 indicated in Figure 2 once a week and once after a rainfall event from June 14th to July 3rd, 2018. In addition to the rain event, the sites experienced a flash flood event on June 24, 2018. The specific sites used for measurement can be found in Figure 3. Field measurements taken at each site were turbidity, dissolved oxygen, barometric pressure, conductivity, TDS, and pH; they were later recorded on a spreadsheet. At each site a one liter HDPE water container was triple rinsed and then filled with a sample. Samples were then taken back to the Iowa Lakeside Lab/State Hygienic Lab to test for total phosphorus, orthophosphate, nitrate, and turbidity. Lab testing procedures followed Hach DR/2000 Spectrophotometer Manual (Hach Company, 1993).

Dissolved oxygen, both percent and mg/L, were found using an YSI meter. The YSI meter also gave readings on temperature and barometric pressures. The YSI was calibrated in the field before each sampling event. The pH was found using a Thermoworks 8689 pH Meter; it also read out temperature. The pH meter was calibrated and tested for accuracy before each sampling event. Conductivity and total dissolved solids was found using a Hach Conductivity/TDS Meter 44600. It also recorded the temperature of the sample. The Hach

44600 was calibrated and tested for accuracy before each sampling event. The final temperature recorded was an average of collected temperatures from the YSI meter, Hach Conductivity/TDS Meter, and Thermoworks pH meter.

Flow was calculated using an object, a plastic small ball or a tennis ball, depending on the water's depth. The flow was calculated using a procedure from the Oklahoma Conservation Commission Water Quality Division and was calculated with the book,The Streamkeeper's Field Guide: Watershed Inventory and Stream Monitoring Methods.

During the first week of testing, June 14, 2018, Hester-Dendy multi-plate invertebrate samplers were placed at sites 2, 2 mouth, 3, and 4 mouth and left for four weeks. The plates were pulled after approximately four weeks, July 10, 2018, and aquatic invertebrates were taken back to the lab to be identified.

Results

All raw data can be found in Appendix A.

A. Total Phosphorus

Phosphorus provides nutrients to our lakes which then contributes to plant and algae growth. Total phosphorus is the combination of soluble phosphorus that plants and algae use easily and particulate phosphorus that is found in plant material and attached to sediment. Total phosphorus was measured in milligrams per liter (Krull, 2009).

Site 2 and Site 2 mouth consistently had the largest amounts of Total Phosphorus present in the samples. Site 2 had an average of .214 mg/L P. Site 2 Mouth had an average of 0.1725 mg/L P.

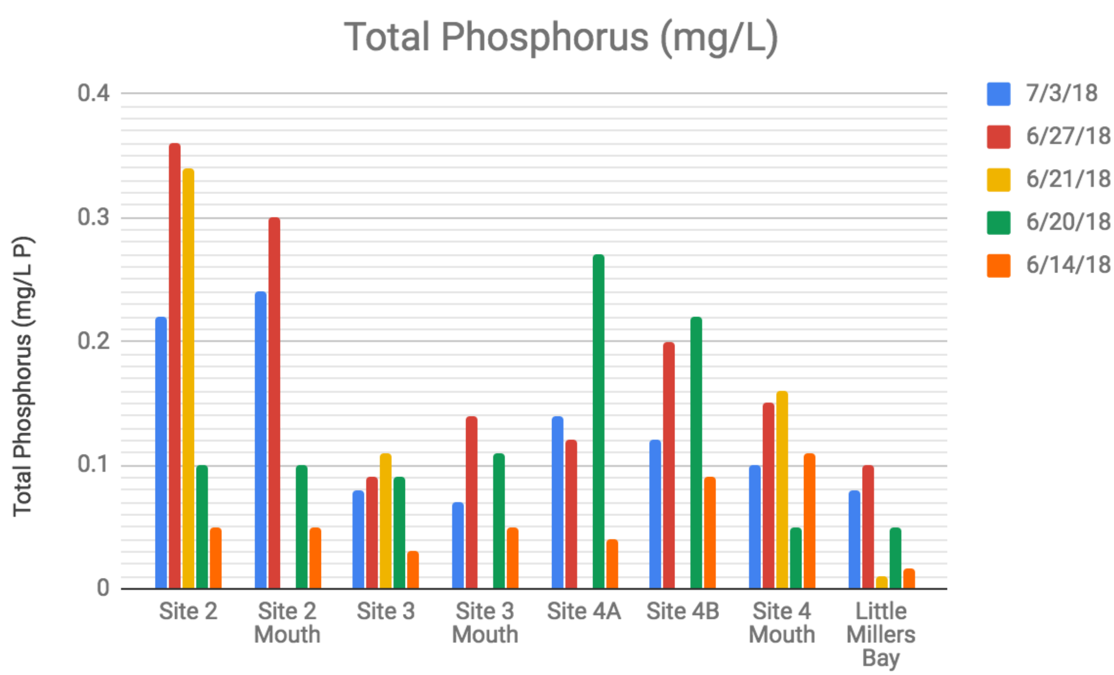


Figure 4. Lakeside Laboratory Watershed Total Phosphorus Results

B. Ortho-phosphate

Ortho-phosphate is the phosphate bound to plant tissue, waste solids, and other organic material. Ortho-phosphate comes from several sources including untreated sewage, runoff from agricultural sites, and lawn fertilizers. This parameter was measured in in milligrams per liter (Krull, 2009).

Like Total Phosphorus, Site 2 and Site 2 Mouth average the largest amount of orthophosphate present in the collected samples. Site 2 had an average of 0.178 mg/L P; Site 2 Mouth had an average of 0.11 mg/L P.

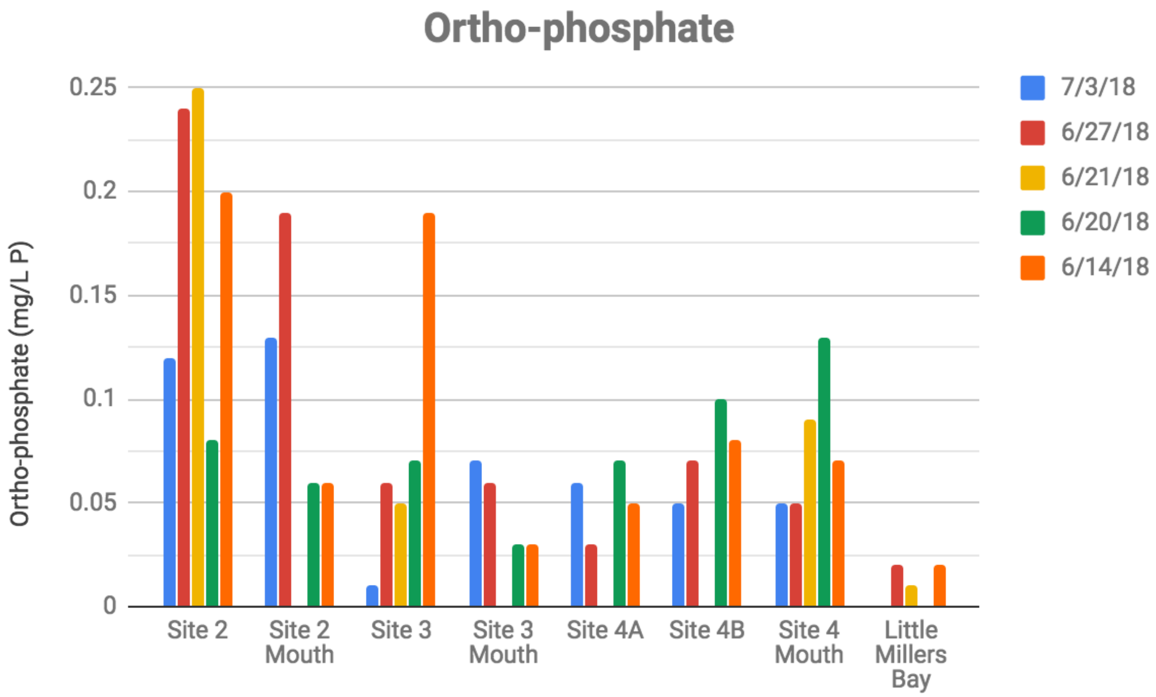


Figure 5. Lakeside Laboratory Watershed Ortho-phosphate Results

C. Nitrate

Nitrate is a common indicator of water quality and is measured in milligrams per liter. Nitrate inhibits the growth of aquatic systems and causes algae blooms (Krull, 2009).

Site 2 and Site 2 Mouth was significantly higher than all the other sites. Site 2 had an average reading of 9.4 mg/L NO_3^- - N. Site 2 Mouth averaged 8.5 mg/L NO_3^- - N.

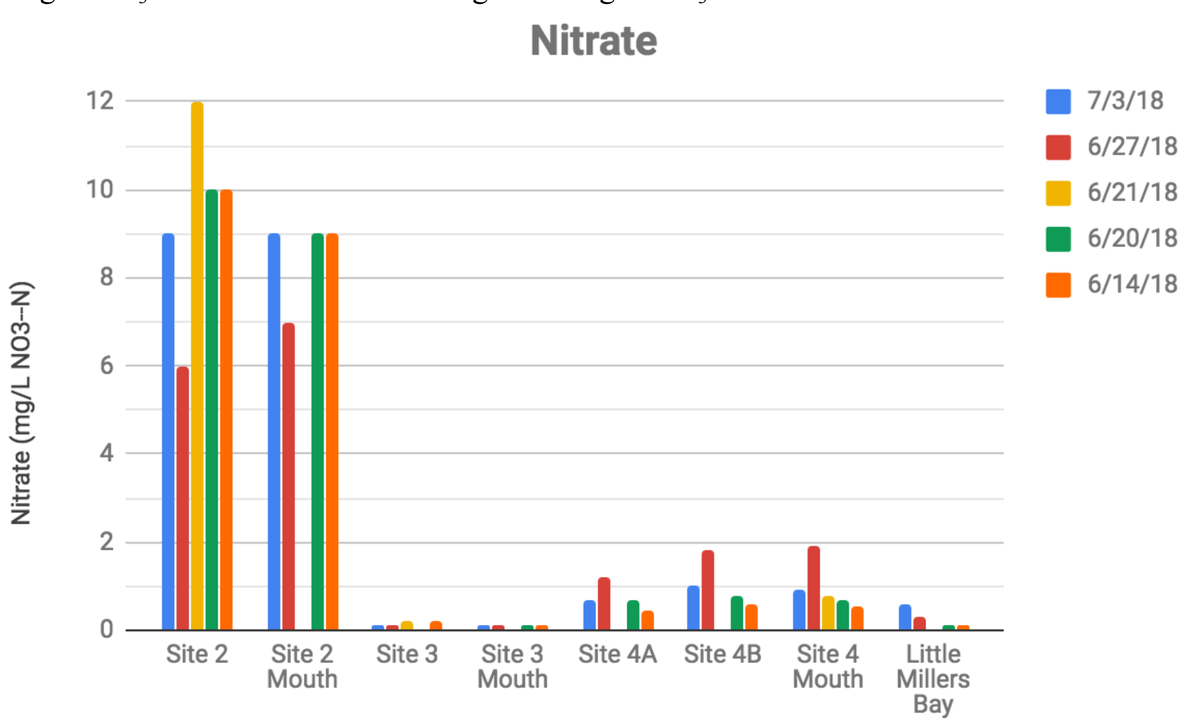


Figure 6: Lakeside Laboratory Watershed Nitrate Results

D. Turbidity

Turbidity is a measure of the degree to which water loses its transparency due to suspended particles. Turbidity can be caused by plankton, sediments from shoreline erosion, re-suspended sediments from the bottom, urban runoff, and algae. Turbidity measures the scattering effect that suspended solids have on light. Turbidity was measured in Nephelometric Turbidity Units (NTU) (Krull, 2009).

The turbidity measurements were completed in the lab. Site 2 and Site 2 Mouth was the most turbid. Site 2 and Site 2 Mouth both avered 15.4 NTU. The turbidity increased at the rain event and flash flooding events in June.

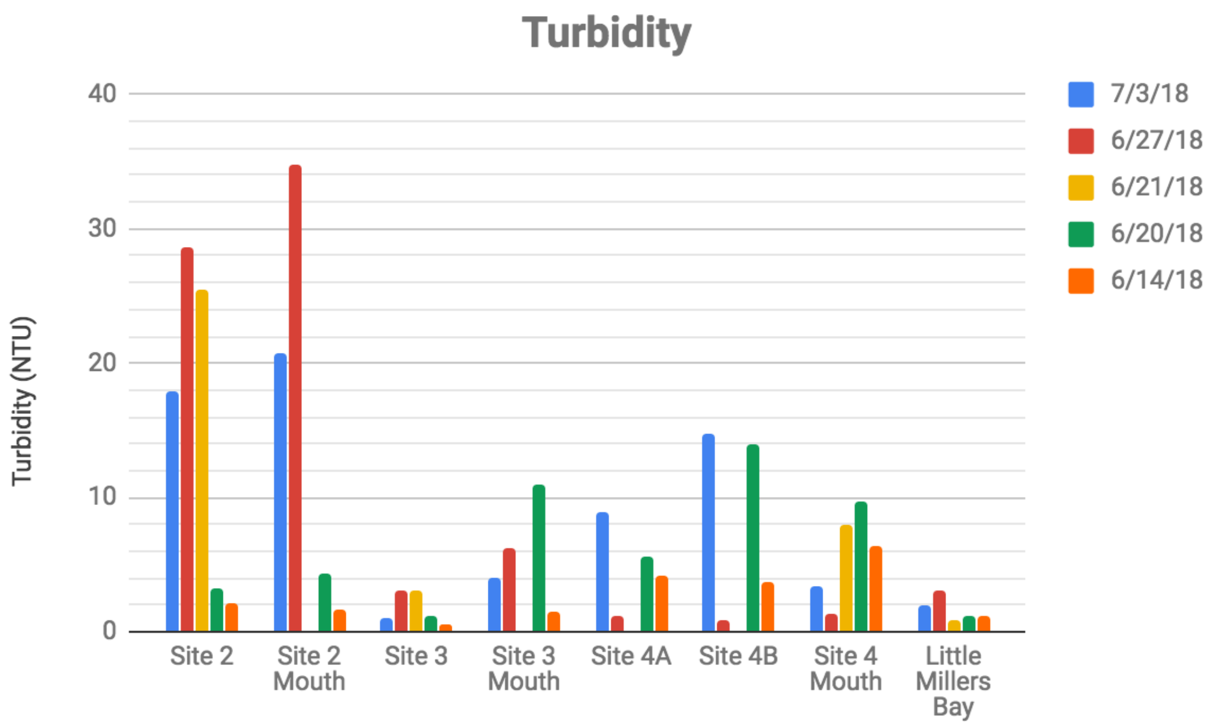


Figure 7. Lakeside Laboratory Watershed Turbidity Results

E. Secchi Tube

Secchi tube, maximum reading of 60cm, was used in the field to look at water clarity. If the site recorded a greater than 60 reading, it is recorded as 60 cm on the chart.

Most of the sites recorded greater than 60cm readings. Only Site 2, Site 2 Mouth, and all of Site 4 recorded readings of less than 60 cm. A decrease in water clarity was present after the rain event on June 21 and the flash flooding event on June 24. Site 2 and Site 2 mouth experiences the worst water clarity experiencing averages of 40.3cm and 38.55cm respectively.

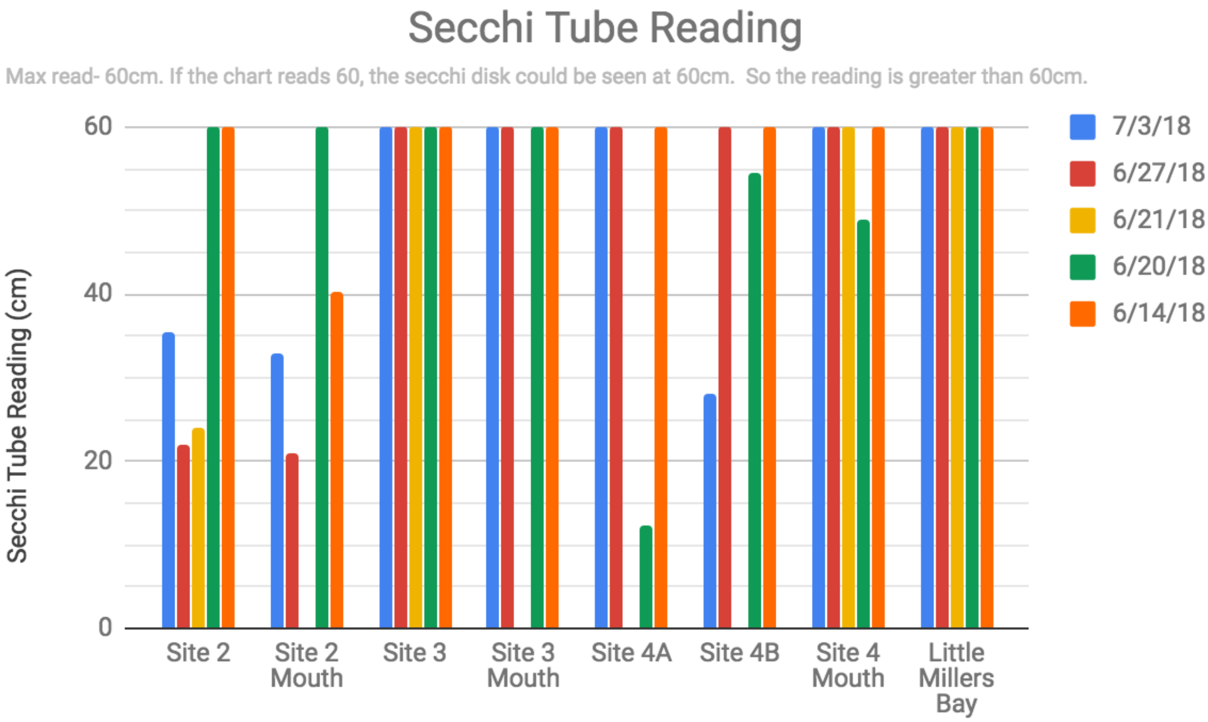


Figure 8. Lakeside Laboratory Watershed Secchi Tube Results

F. pH

pH is the measure of how acidic or basic water is. The pH range is from 0 to 14 with 7 being neutral. A pH less than 7 indicates an acid while a pH greater than 7 indicates a base. pH is a measure of the relative amount of free hydrogen and hydroxyl ions in the water. Water that has more free hydrogen ions is acidic, whereas water that has more free hydroxyl ions is basic (Krull, 2009).

All sites ranged between 7.4 and 8.9. Little Millers Bay was the most alkaline of the tested water.

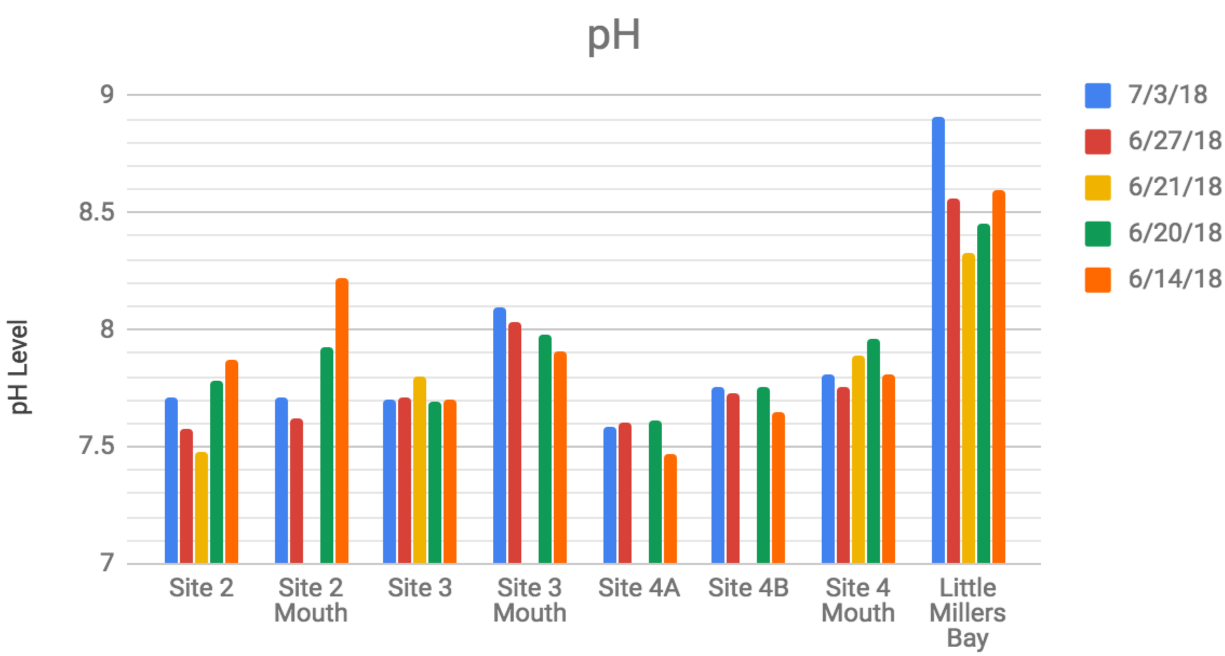


Figure 9. Lakeside Laboratory Watershed pH Results

G. Temperature

Temperature can impact levels of other substances in the water, like dissolved oxygen (EPA, 1997). The ranged slightly throughout the 4 weeks. Site 3 mouth had the greatest change in temperature.

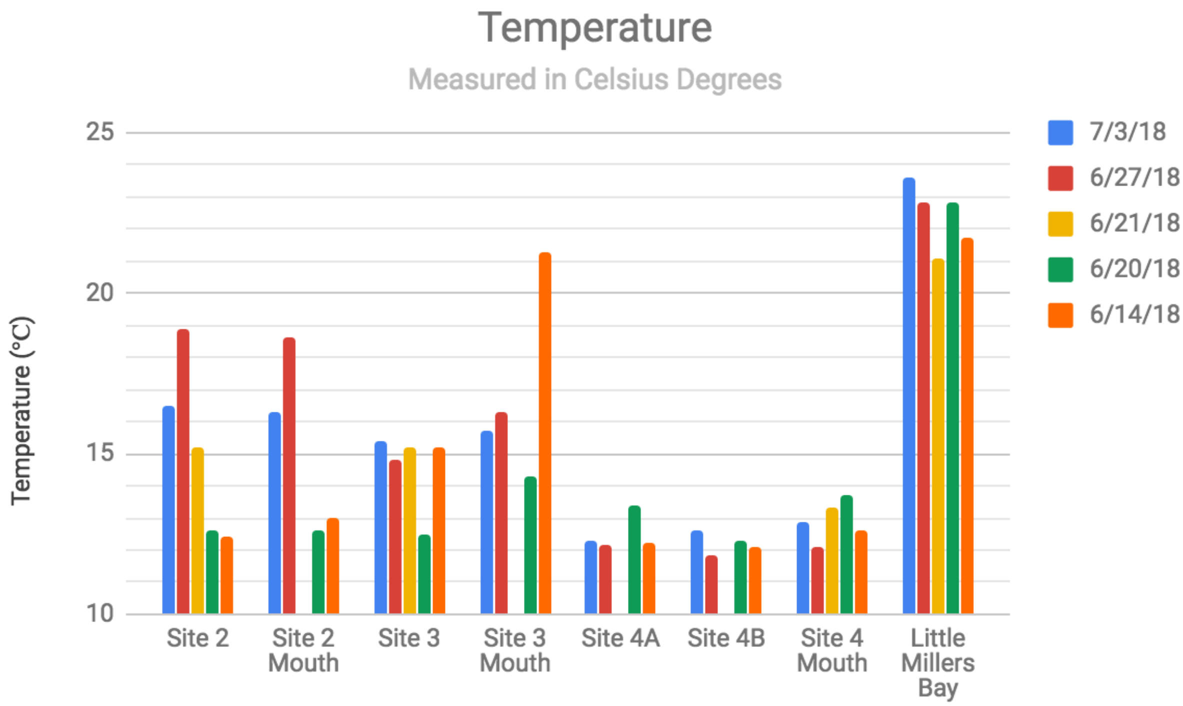


Figure 10. Lakeside Laboratory Watershed Average Temperature Results

H. Flow

Flow is used to help determine the amount of water off a watershed and into a another body of water. Flow uses both water volume and velocity. “It is important because of its impact on water quality and on the living organisms and habitats in the stream” (EPA, 1997).

Site 2 and Site 2 Mouth had the largest amount of water moving through it. The amounts of flow dramatically increased after the rain event and flash flooding event. Site 3 Mouth was unable to be calculated at various times due to low amount of flow or a higher lake level which caused flooding. Site 4A was never deep enough to carry an object to test for flow.

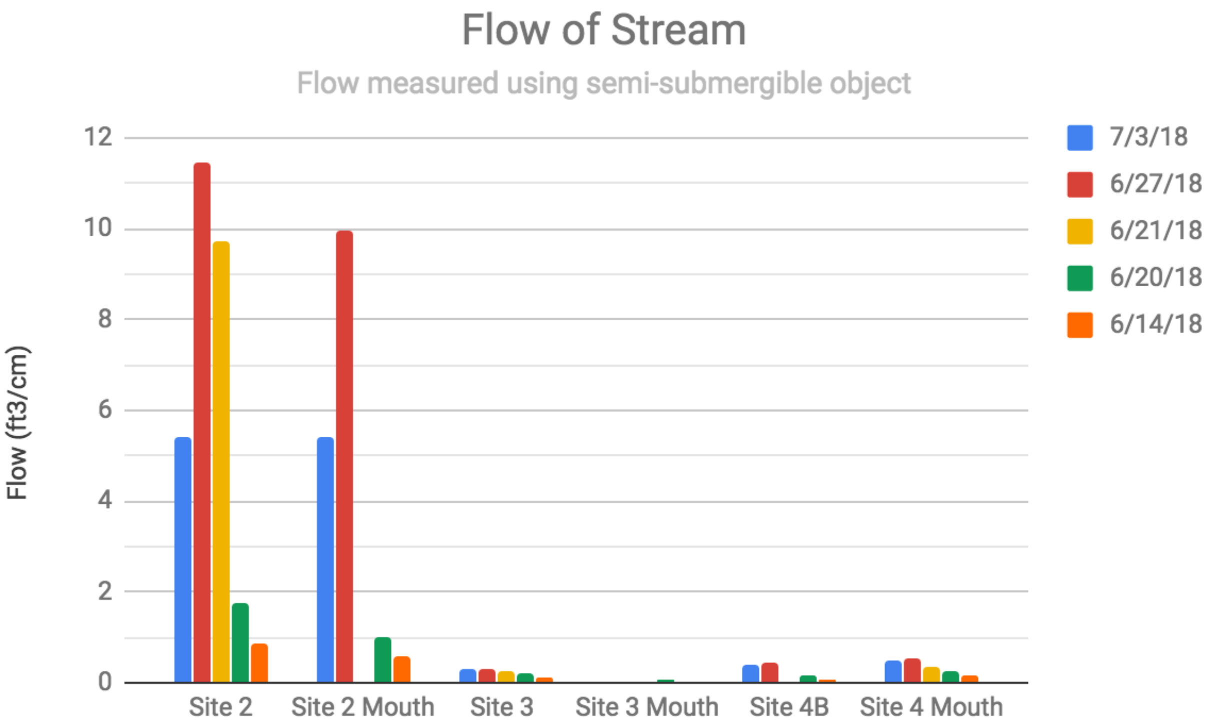


Figure 11. Lakeside Laboratory Watershed Flow Results

I. Dissolved Oxygen

Dissolved oxygen, DO, in a watershed and streams is important. The levels can fluctuate and impact aquatic organisms; as DO levels decrease some animals may move away, weaken, or even die. Amounts of dissolved oxygen can increase with the churning of water and through photosynthesis. DO amounts decrease because of decomposition, aquatic animals, and chemical reactions that require oxygen. The oxygen can be depleted in the water by microorganisms decomposing wasteware. "Other sources of oxygen-consuming waste include stormwater runoff from farmland or urban streets, feedlots, and failing septic systems" (EPA, 1997).

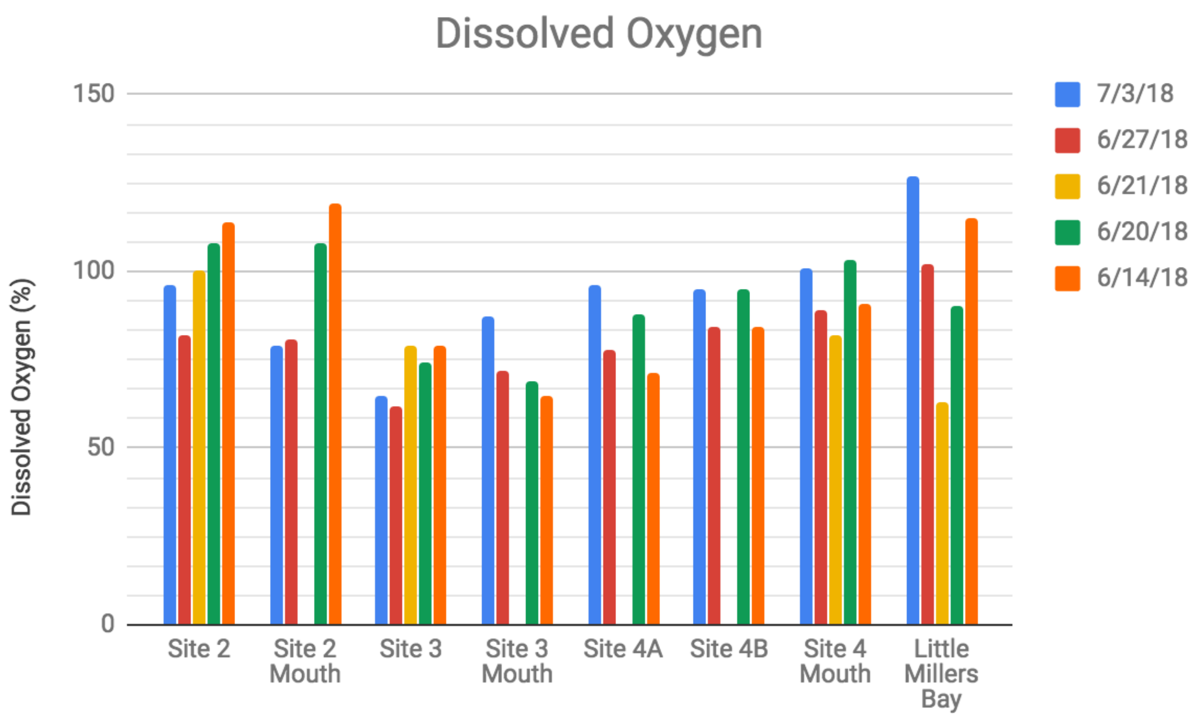


Figure 12. Lakeside Laboratory Watershed Dissolved Oxygen Percent Results

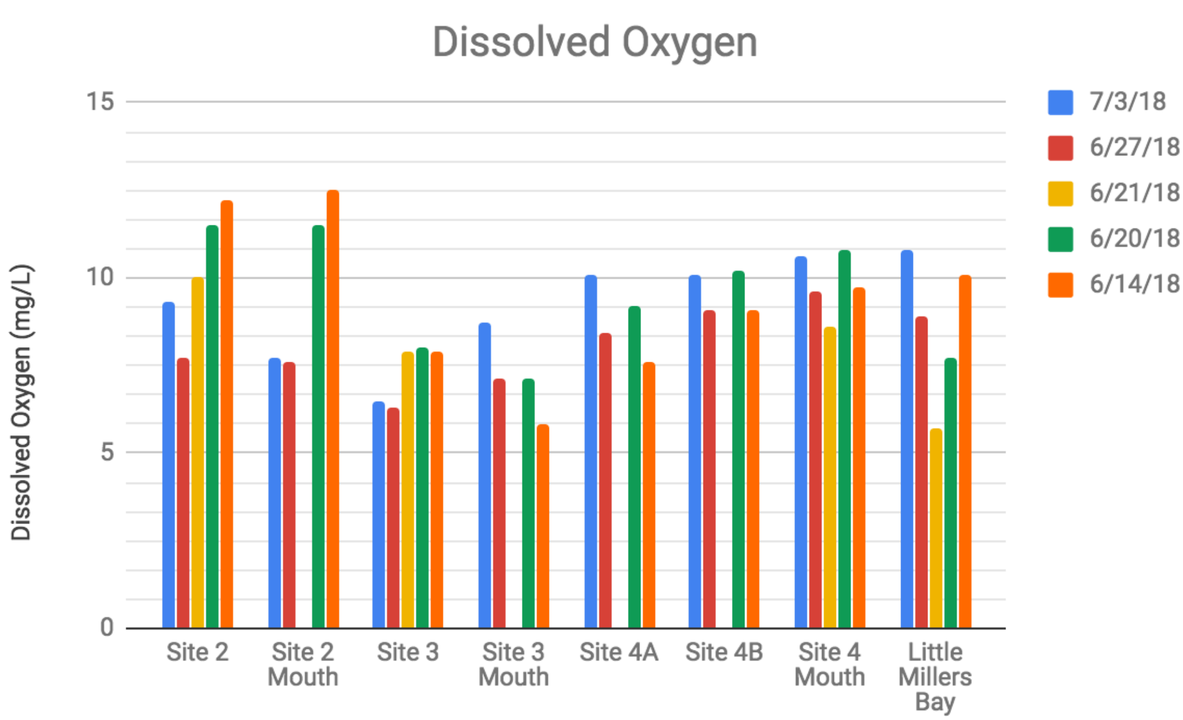


Figure 13. Lakeside Laboratory Watershed Dissolved Oxygen mg/L Results

J. Barometric Pressure

Barometric pressure was recorded with each collection event. Only the first set of samples was not collected on the same day. All the other samples were collected on during a 8 hour period.

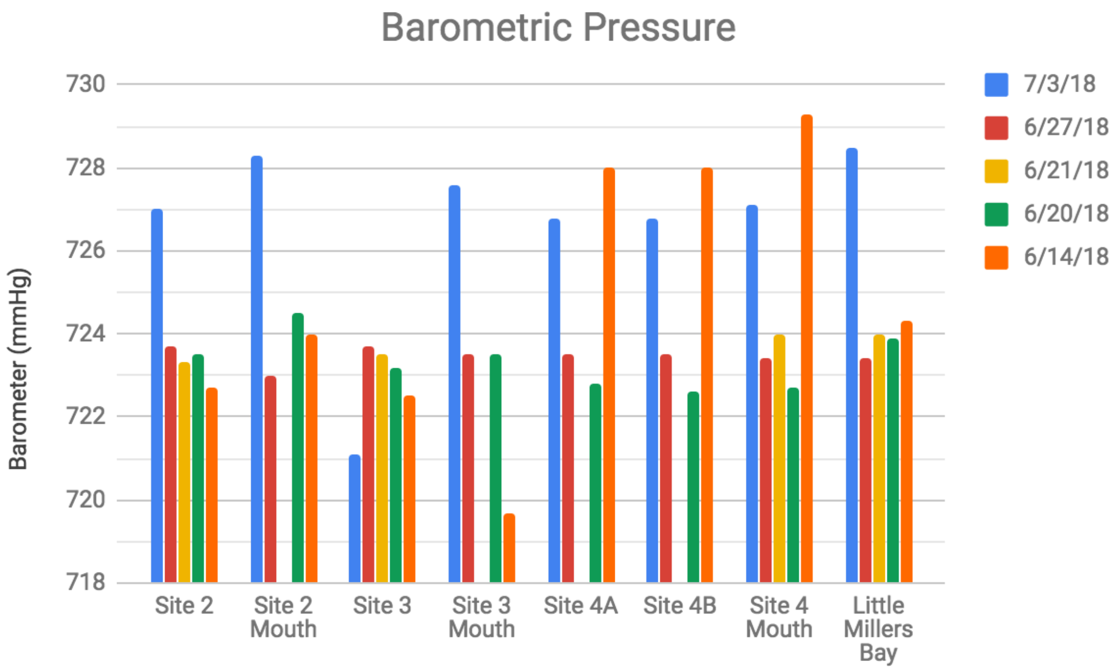


Figure 14. Lakeside Laboratory Watershed Barometric Pressure

K. Conductivity and Total Dissolved Solids

Conductivity is a measure of the ability of water to conduct an electrical current. The specific conductance depends on the amount of dissolved solids in the water. High specific conductance indicates a high-solid concentration. Specific conductance is measured in micro-Siemens per centimeter (Krull, 2009).

The conductivity and total dissolved solids, TDS, varied throughout the collection time. Site 4A, Site 4B, and Site 4 Mouth had the highest conductivity and TDS.

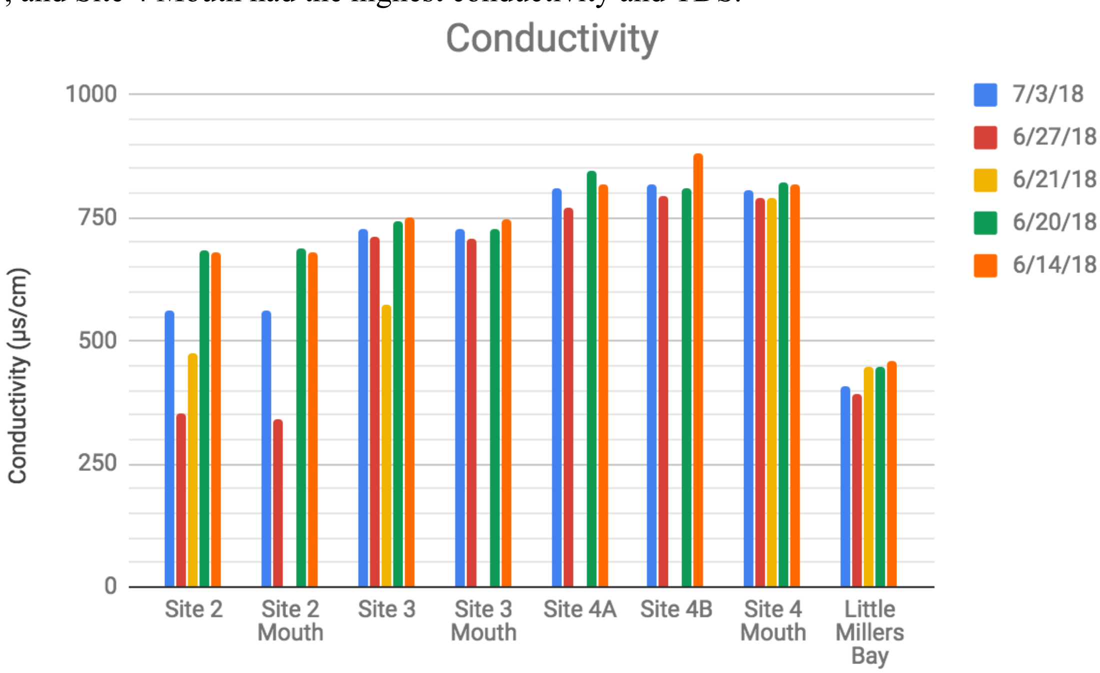


Figure 15. Lakeside Laboratory Watershed Conductivity Results

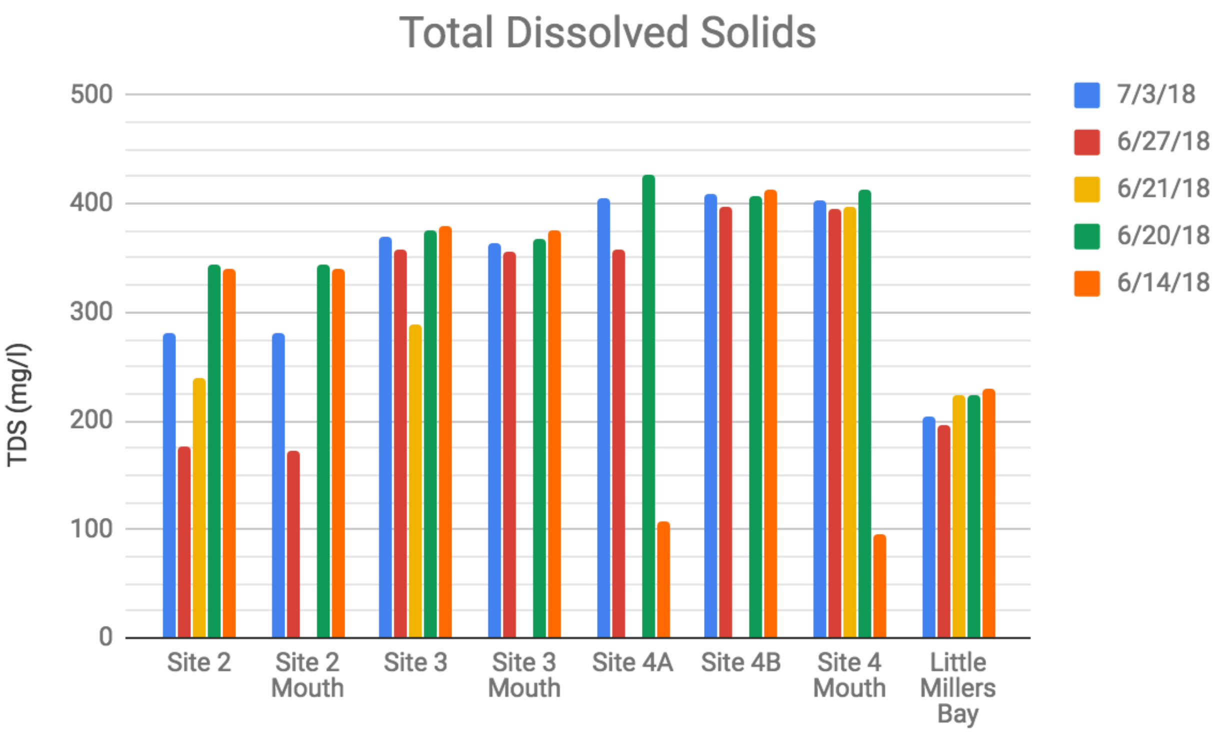


Figure 16. Lakeside Laboratory Watershed Total Dissolved Solids Results

L. *Aquatic Invertebrates*

In addition to chemical water quality data, Hester-Dendy multi-plate invertebrate samplers were placed in four locations: Site 2, Site 2 Mouth, Site 3, and Site 4 Mouth. The samplers were placed on June 14, 2018 and removed on July 10, 2018. Due to the flash flooding event on June 24, 2018, only two of the devices were able to be recovered, Site 3 and Site 4 Mouth. Site 4 Month was buried in sand and sediment and had to be uncovered multiple times; many of the organisms on Site 4 were dead. After removal of the devices, the organisms found on the samplers were keyed.

Site 3 Organisms found and quantity:

-6- *Baetidae* (minnow mayfly)
-1- *Amphipoda* (scud)
-2- *Chironomidae* (midge fly)
-2- *Sphaeriidae* (fingernail clam)
-1- *Limnephilidae* (caddisfly)

Site 4 Organism found and quantity:

-15- *Amphiphoda* (scud)
-1- *Lumbricidae* (earthworm)
-1- *Chironomidae* (midge fly)

Conclusion

Site 2 and Site 2 Mouth, the field drainage, was characterized by high levels of total phosphorus, ortho-phosphate and nitrate (Figure 4, Figure 5, and Figure 6). These high levels may be a result of the large draining area of this watershed, which mostly came from agricultural fields. These sites also the highest turbidity (Figure 7) and the lowest Secchi tube readings (Figure 8). Site 2 and Site 2 mouth recorded the highest average dissolved oxygen readings throughout the 5 sampling times (Figure 12 and Figure 13). Site 2 and Site 2 Mouth had the most water moving through them as determined by flow (Figure 11).

Site 3 and Site 3 Mouth, one of the groundwater seeps, showed the lowest values for dissolved oxygen (Figure 12 and Figure 13). Site 3 had the lowest level of nitrate (Figure 6).

Site 4A, Site 4B, and Site 4 Mouth, the second groundwater seep, had the second high levels of nitrate (Figure 6). The specific conductance and total dissolved solids of Site 4 were significantly higher than the other sites (Figure 15 an Figure 16). Site 4 recorded the lowest temperature (Figure 10) of the multiple sampling sites.

Little Millers Bay, in West Lake Okoboji, showed the lowest value of total phosphorus and a low level of ortho-phosphate (Figure 4 and Figure 5). Little Millers Bay was the most alkaline of the test water (Figure 9). Little Millers Bay recorded the warmest average temperatures throughout the testing (Figure 10).

Works Cited

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Appendix A. Raw Data of Lakeside Laboratory Watersheds

Site	Date	Start Time	End Time	Total Phosphorus*	Ortho-Phosphate-P	Nitrate-N	Turbidity	Secchi Tube Reading	pH	Temperature (℃)	Flow (ft3/cm)	Dissolved Oxygen (%)	Dissolved Oxygen (mg/L)	Barometer (mmHg)	Conductivity (µs/cm)	TDS (mg/l)	Current Lake Level (Feet)	Current Lake Temp (℃)
2	6-14-18	3:58 PM	4:21 PM	0.05	0.2#	10.00	2.05	>60	7.87	12.4	0.858	114	12.2	722.7	680	340	4.92	22.6
2	6-20-18	11:34 AM	11:46 AM	0.1	0.08	10.00	3.29	>60	7.78	12.6	1.752	108	11.5	723.5	684	344	4.98	22.5
2	6-21-18	1:18 PM	1:37 PM	0.34	0.25	12.00	25.4	24	7.48	15.2	9.729	100	10	723.3	477	240	5.37	20.6
2	6-27-18	2:37 PM	2:55 PM	0.36	0.24	6.00	28.6	22	7.58	18.9	11.45	82	7.7	723.7	353	177	6.23	23.2
2	7-3-18	2:22 PM	2:37 PM	0.22	0.12	9.00	17.9	35.5	7.71	16.5	5.398	96	9.3	727	560	281	6.43	23.7
2-mouth	6-14-18	11:38 AM	12:03 PM	0.05	0.06	9.00	1.71	40.2	8.22	13	0.602	119	12.5	724	680	340	4.92	22.6

2-mouth	6-20-18	9:55 AM	10:10 AM	0.1	0.06	9.00	4.33	>60	7.93	12.6	0.996	108	11.5	724.4	689	345	4.98	22.5
2-mouth	6-27-18	10:51 AM	11:18 AM	0.3	0.19	7.00	34.8	21	7.62	18.6	9.95	81	7.6	723	342	173	6.23	23.2
2-mouth	7-3-18	10:30 AM	10:52 AM	0.24	0.13	9.00	20.8	33	7.71	16.3	5.398	79	7.7	728.3	560	280	6.43	23.7
3	6-14-18	3:37 PM	3:53 PM	0.03	0.19#	0.20	0.601	>60	7.7	15.2	0.0931	79	7.9	722.5	750	380	4.92	22.6
3	6-20-18	11:48 AM	12:00 PM	0.09	0.07	0.00	1.21	>60	7.69	12.5	0.222	74	8	723.2	743	375	4.98	22.5
3	6-21-18	1:41 PM	1:53 PM	0.11	0.05	0.20	3.12	>60	7.8	15.2	0.255	79	7.9	723.5	574	288	5.37	20.6
3	6-27-18	2:19 PM	2:30 PM	0.09	0.06	0.10	3.06	>60	7.71	14.8	0.292	62	6.3	723.7	713	358	6.23	23.2
3	7-3-18	2:02 PM	2:14 PM	0.08	0.01	0.10	1.02	>60	7.7	15.4	0.32	65	6.5	721.1	738	370	6.43	23.7
3-mouth	6-15-18	1:02 PM	1:16 PM	0.05	0.03	0.10	1.45	>60	7.91	21.3	0.0437	65	5.8	719.7	749	376	4.87	22.4
3-mouth	6-20-18	11:17 AM	11:28 AM	0.11	0.03	0.10	10.9	>60	7.98	14.3	0.0769	69	7.1	723.5	729	367	4.98	22.5
3-mouth	6-27-18	11:29 PM	11:35 PM	0.14	0.06	0.10	6.24	>60	8.03	16.3	N/A	72	7.1	723.5	707	355	6.23	23.2
3-mouth	7-3-18	11:18 AM	11:23 AM	0.07	0.07	0.10	4.01	>60	8.1	15.7	N/A	87	8.7	727.6	727	363	6.43	23.7
4a	6-13-18	1:18 PM	1:37 PM	0.04	0.05	0.45	4.23	>60	7.47	12.2	N/A	71	7.6	728	820	106.5	4.96	23.5

4a	6-20-18	1:56 PM	2:04 PM	0.27	0.07	0.7	55.9	12.2	7.61	13.4	NA	88	9.2	722.8	846	427	4.99	22.4
4a	6-27-18	3:29 PM	3:40 PM	0.12	0.03	1.2	1.11	>60	7.6	12.17	NA	78	8.4	723.5	772	387	6.23	23.2
4a	7-3-18	3:33 PM	3:38 AM	0.14	0.06	0.70	8.95	>60	7.59	12.3	N/A	96	10.1	726.8	809	405	6.43	23.7
4b	6-13-18	1:40 PM	1:52 PM	0.09	0.08	0.60	3.68	>60	7.65	12.1	0.09	84	9.1	728	880	413	4.96	23.5
4b	6-20-18	2:06 PM	2:15 PM	0.22	0.10	0.80	13.9	54.4	7.76	12.3	0.153	95	10.2	722.6	811	408	4.99	22.4
4b	6-27-18	3:41 PM	3:50 PM	0.20	0.07	1.80	0.817	>60	7.73	11.83	0.44	84	9.1	723.5	794	398	6.23	23.2
4b	7-3-18	3:40 PM	3:48 PM	0.12	0.05	1.00	14.7	28	7.76	12.6	0.38	95	10.1	726.8	818	410	6.43	23.7
4-mouth	6-13-18	10:58 AM	11:27 AM	0.109	0.07	0.55	6.34	>60	7.81	12.6	0.162	91	9.7	729.3	820	96	4.96	23.5
4-mouth	6-20-18	1:40 PM	1:53 PM	0.05#	0.13	0.7	9.65	49	7.96	13.7	0.141	103	10.8	722.7	822	413	4.99	22.4
4-mouth	6-21-18	2:28 PM	2:39 PM	0.16	0.09	0.8	8.01	>60	7.89	13.3	0.358	82	8.6	724	791	397	5.37	20.6
4-mouth	6-27-18	3:17 PM	3:26 PM	0.15	0.05	1.9	1.38	>60	7.76	12.07	0.557	89	9.6	723.4	790	396	6.23	23.2
4-mouth	7-3-18	3:14 PM	3:30 PM	0.10	0.05	0.90	3.35	>60	7.81	12.9	0.504	101	10.6	727.1	806	403	6.43	23.7
Little Mill	6-14-18	11:01 AM	11:10 AM	0.016	0.02	0.10	1.25	>60	8.6	21.7	small rolli	115	10.1	724.3	460	230	4.92	22.6

ers Bay											*ng waves*							
Little Millers Bay	*6-20-18*	*9:42 AM*	*9:48 AM*	*0.05*	*0*	*0.10*	*1.18*	*>60*	*8.45*	*22.8*	*calm*	*90*	*7.7*	*723.9*	*446*	*223*	*4.98*	*22.5*
Little Millers Bay	*6-21-18*	*2:07 PM*	*2:16 AM*	*0.01*	*0.01*	*0.00*	*0.916*	*>60*	*8.33*	*21.1*	*small rolling waves*	*63*	*5.7*	*724*	*447*	*223*	*5.37*	*20.6*
Little Millers Bay	*6-27-18*	*10:25 AM*	*10:31 AM*	*0.10*	*0.02*	*0.30*	*3*	*>60*	*8.56*	*22.8*	*calm water*	*102*	*8.9*	*723.4*	*394*	*197*	*6.23*	*23.3*
Little Millers Bay	*7-3-18*	*10:04 AM*	*10:10 AM*	*0.08*	*0.0*	*0.60*	*1.97*	*>60*	*8.91*	*23.6*	*small rolling waves*	*127*	*10.8*	*728.5*	*410*	*205*	*6.43*	*23.7*