NORTHEAST OHIO REGIONAL SEWER DISTRICT

2013 Greater Cleveland Area Lake Erie Nutrient Study

Prepared by
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Introduction

Over the last few years, there has been a significant increase in the occurrence of harmful algal blooms within the central basin of Lake Erie. In 2011, an algal bloom, the majority of which consisted of *Microcystis*, spread east of Cleveland and persisted there until the middle of October. The increase in algae throughout the lake is thought to be due to increases in dissolved reactive phosphorus (Ohio EPA, 2011) coupled with favorable weather conditions. 2012 had significantly less rainfall, runoff and, subsequently, a much smaller algae bloom. Northeast Ohio Regional Sewer District (NEORSD) facilities, such as its wastewater treatment plants and the combined sewer overflows (CSOs), could be a potential source of nutrients to the lake. The extent to which these potential sources, along with other ones within the study area, are contributing to the problem is not well known.

The purpose of the 2013 study was to continue to monitor the levels of nutrients and algae in Lake Erie near the greater Cleveland area from April through October and further attempt to establish temporal and spatial trends and potentially relate them to level of precipitation. Chlorophyll *a* was measured as a means of determining the total quantity of algae present. Nutrient analyses included both phosphorus and nitrogen. Other water quality parameters that may also influence algal production were also measured. Sampling was conducted by NEORSD Level 3 Qualified Data Collectors certified by Ohio Environmental Protection Agency (EPA) in Chemical Water Quality as explained in the NEORSD study plan *2013 Greater Cleveland Area Lake Erie Nutrient Study* approved by the Ohio EPA on July 10, 2013.

Figure 1 is a map of the sampling locations evaluated on Lake Erie during the study, and Table 1 indicates the sampling locations with respect to latitude/longitude and description. A digital photo catalog of the sampling locations is available upon request by contacting the NEORSD's Water Quality and Industrial Surveillance Division (WQIS).

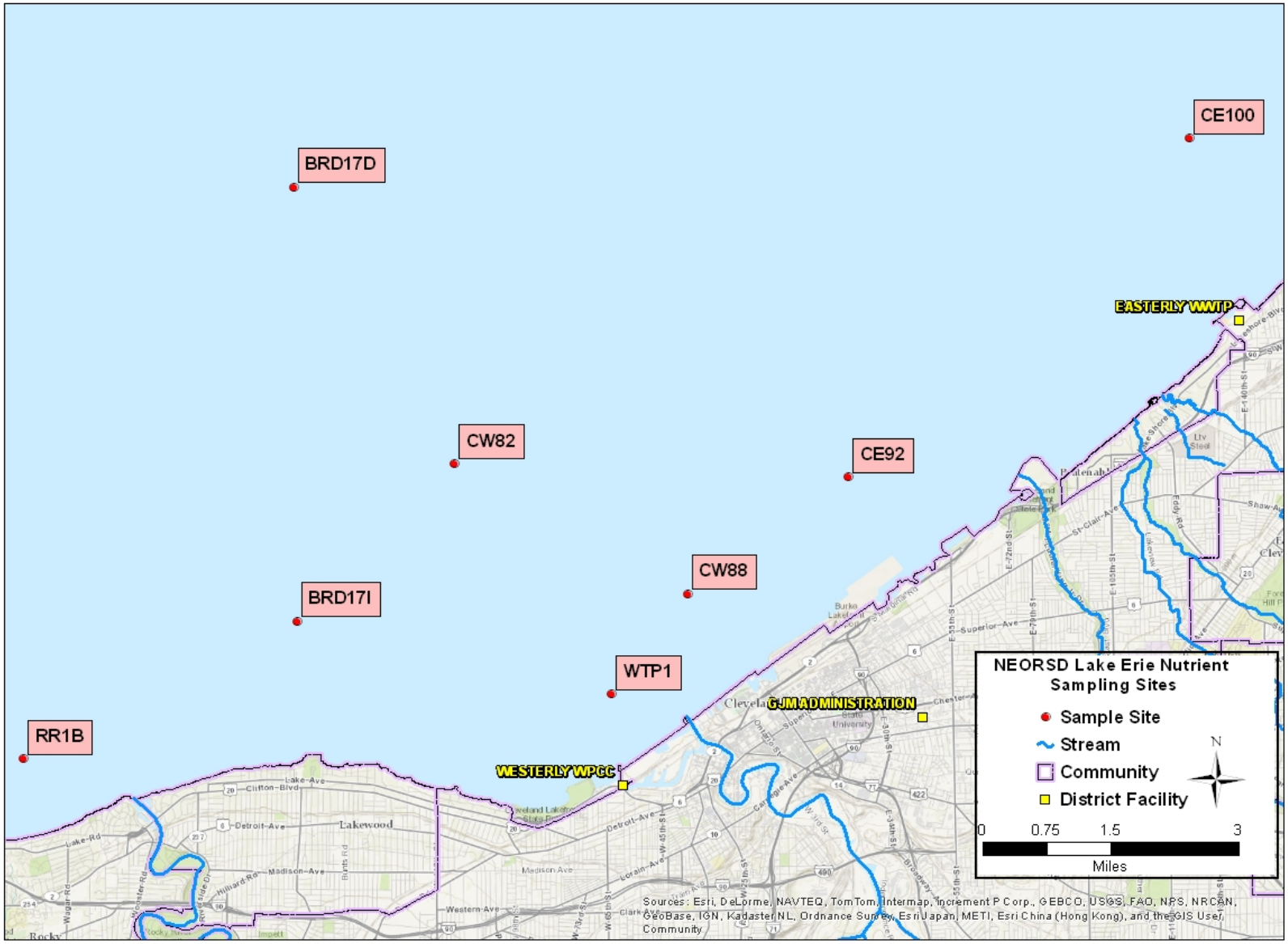


Figure 1. Sampling Locations

Table 1. Sample Locations			
Latitude	Longitude	Station ID	Location Information
41.49720	-81.86200	RR1B	Near Rocky River
41.59630	-81.80000	BRD17D	About 7 miles off shore of Lakewood
41.52080	-81.80000	BRD17I	Near Lakewood
41.54800	-81.76400	CW82	Near Garrett Morgan Water Intake
41.50765	-81.72907	WTP1	Near Westerly WWTC Diffusers
41.52500	-81.71170	CW88	Outside the City of Cleveland's Breakwall
41.54500	-81.67500	CE92	Outside the City of Cleveland's Breakwall
41.60333	-81.59717	CE100	2 miles north of Easterly WWTP outfall

Water Chemistry Sampling

Methods

Water chemistry sampling was conducted at most of the sites twelve times between April 22nd and October 8th. One site, WTP1, was sampled a total of twenty-six times from April 22nd to October 28th. This site was selected for more frequent sampling because, in 2012, the highest chlorophyll *a* and nutrient concentrations were measured there. Techniques used for sampling and analyses followed the Ohio EPA *Surface Water Field Sampling Manual* (2013). Chemical water quality samples from each site were collected with one 4-liter disposable polyethylene cubitainer with disposable polypropylene lid, two 473-mL plastic bottles, one 1-liter amber glass jar, and one 100-mL plastic bottle. One of the 473-mL plastic bottles was field preserved with trace sulfuric acid. Filtering of the dissolved reactive phosphorus (DRP) sample was done in the field. All water quality samples were collected as grab samples. At the time of sampling, measurements for dissolved oxygen, pH, temperature, and conductivity were collected using a YSI 600XL sonde, YSI 556 water quality meter, or Hach HQ30d meter with LDO101 probe. Duplicate samples and field blanks were collected at randomly selected sites at a frequency not less than 5% of the total samples collected. Relative

percent difference (RPD) was used to determine the degree of discrepancy between the primary and duplicate sample. The acceptable relative percent difference (RPD) for field duplicate samples was less than or equal to $[(0.9465x^{-0.344})*100]+5$, where x = sample result/detection limit. Those that are higher may indicate potential problems with sample collection and, as a result, the data was not used for comparison to the water quality standards.

Results and Discussion

A copy of all analyses is available upon request by contacting the NEORSD's WQIS division.

Eight sets of duplicate samples and six field blanks were collected during the study. For the field blanks, there were five parameters that showed possible contamination. It is unclear how the field blanks became contaminated and may be due to inappropriate sample collection, handling, contaminated blank water and/or interference during chlorophyll *a* analysis. Table 2 lists water quality parameters that were rejected, estimated, or downgraded from Level 3 to Level 2 data based on Ohio EPA data validation protocol.

Table 2. Parameters affected by possible blank contamination
Chlorophyll *a*
DRP
NH_3
NO_2+NO_3
TP

Nine instances occurred in which the RPD between duplicate samples was greater than acceptable (Table 3). There may be numerous reasons for why a large number of parameters were rejected, such as a lack of precision and consistency in sample collection and/or analytical procedures, improper handling of samples and/or environmental heterogeneity, especially for chlorophyll *a*.

Table 3. Duplicate samples with greater than acceptable RPDs				
Site	Date	Parameter	Acceptable RPD	Actual RPD
BRD17D	4/22/2013	Chlorophyll *a*	99.7	114.9
CW88	5/20/2013	NH_3	30.2	64.2
BRD17I	6/17/2013	Chlorophyll *a*	91.5	135.0
BRD17I	6/17/2013	DRP	59.0	61.5
CW82	7/15/2013	Chlorophyll *a*	18.0	19.9
CW82	7/15/2013	NH_3	47.9	152.9

Table 3. Duplicate samples with greater than acceptable RPDs				
Site	Date	Parameter	Acceptable RPD	Actual RPD
CW82	7/15/2013	TP	69.9	142.9
CW88	7/30/2013	Chlorophyll *a*	14.9	15.7
CE92	8/19/2013	NH_3	50.0	81.1

The final QA/QC check for the samples that were collected was for paired parameters, or those parameters in which one of them is a subset of the other. For this study, only total phosphorus and dissolved reactive phosphorus fell into this category. During five different sampling events, these parameters needed to be listed as estimated or rejected for at least one of the sites sampled. In all of these instances, at least one of the parameters was at or below the practical quantitation limit, which could account for the deviation from acceptable differences between them.

Table 4. Paired parameter comparisons with greater than acceptable RPDs			
Date	Parameters	Site(s)	Qualifier
6/3/2013	TP/DRP	BRD17D	J
6/17/2013	TP/DRP	CW88	J
6/17/2013	TP/DRP	RR1B, BRD17D, BRD17I, CW82, WTP1, CE100	R
7/15/2013	TP/DRP	CW82	J
7/30/2013	TP/DRP	CE100	R
8/19/2013	TP/DRP	BRD17D	R
J = estimated R = rejected			

In 2013, the average highest nutrient and total suspended solids (TSS) concentrations were measured at WTP1 (Table 5), which is located near the Westerly WWTC discharge. Of these, ammonia (NH_3) was the only one in which the concentration at WTP1 was statistically higher than all other sites[1]. For total phosphorus (TP) and TSS, although all of the other sites had concentrations that were lower than those at WTP1, not all were significantly so. Finally, no significant differences existed among the sites as a whole for DRP and nitrite + nitrate ($NO_2 + NO_3$).

Currently, a target of 0.01 mg/L exists for TP in the central basin of Lake Erie (Lake Erie Nutrient Science Task Group, 2009). The average concentration at all of the

[1] Differences among groups of data were evaluated using the Kruskal-Wallis Test with an alpha of 0.05. Differences between two groups were evaluated using the Mann-Whitney Test, also with an alpha of 0.05.

sites was above this target in 2013; however, there were six sampling dates throughout the study in which at least some of the measured concentrations met the target or were close to meeting it. The overall average in 2013 was slightly higher than in 2012. No concentration targets currently exist for DRP. Harmful algal blooms have been found, though, at DRP concentrations around 0.006 mg/L (Lake Erie Phosphorus Task Force, 2013). WTP1 was the only site with an average concentration that exceeded this level, although all of the sites exceeded it during at least one sampling event; the average overall concentration in 2013 was the same as in 2012. Based on these measured phosphorus concentrations, it could be expected that elevated chlorophyll *a* levels may be found in the lake.

Table 5. 2013 Lake Erie Average Values

	TP	DRP	NO_3-NO_2	NH_3	Alkalinity	TSS	pH	Conductivity	DO	Temperature	Turbidity
Site	mg/L	mg/L	mg/L	mg/L	mg/L CaCO3	mg/L	S.U.	uS/cm	mg/L	°C	NTU
RR1B	0.02	0.004	0.45	0.03	87.20	4.58	8.29	267.0	9.67	18.2	7.26
BRD17D	0.02	0.005	0.28	0.03	88.02	2.72	8.32	248.7	10.07	17.4	7.48
BRD17I	0.02	0.004	0.39	0.03	87.08	3.73	8.36	261.5	9.81	18.2	5.38
CW82	0.02	0.004	0.36	0.03	87.51	3.02	8.35	254.9	9.75	18.0	5.45
WTP1	0.03	0.007	0.57	0.09	89.82	5.00	8.21	304.4	9.26	18.9	6.55
CW88	0.02	0.004	0.47	0.03	87.77	4.52	8.30	277.3	9.56	18.0	5.83
CE92	0.02	0.004	0.38	0.05	87.32	3.42	8.31	259.6	9.59	18.0	5.03
CE100	0.02	0.005	0.36	0.03	87.82	3.12	8.31	250.8	9.81	17.5	4.37

As in the 2012, the highest average 2013 chlorophyll *a* concentrations were measured at site WTP1 (Figure 2); however, no significant differences were found when comparing the sites as a whole. Overall concentrations in 2013 were higher than the previous year, with all greater than the Great Lakes Water Quality Agreement target of 2.6 ug/L (Lake Erie Nutrient Science Task Group, 2009). Some individual samples did meet this target, but these were limited to three sampling dates in late June and early July (Table 3).

Although there were no significant differences among the sites as a whole, there were some when looking at sample results by date. The highest average concentration occurred during the beginning of August while the lowest was in late June. During 2012, the highest chlorophyll *a* concentrations were measured in samples collected two or three days following a heavy rainfall. It was thought that, possibly, input from nutrients as a result of the rain events were responsible for the increase in algal production. Based on the 2013 data, the relationship between weather and chlorophyll *a* was not clear, as neither air temperature nor rainfall preceding sampling appeared to be directly related. One possible explanation for this is that 2012 was a relatively dry year, while 2013 was

not. Steady inputs of nutrients throughout the study instead of just a few large loading events following rain could account for the differences between the years.

Figure 2. Average Lake Erie Chlorophyll *a* Concentrations (ug/L)

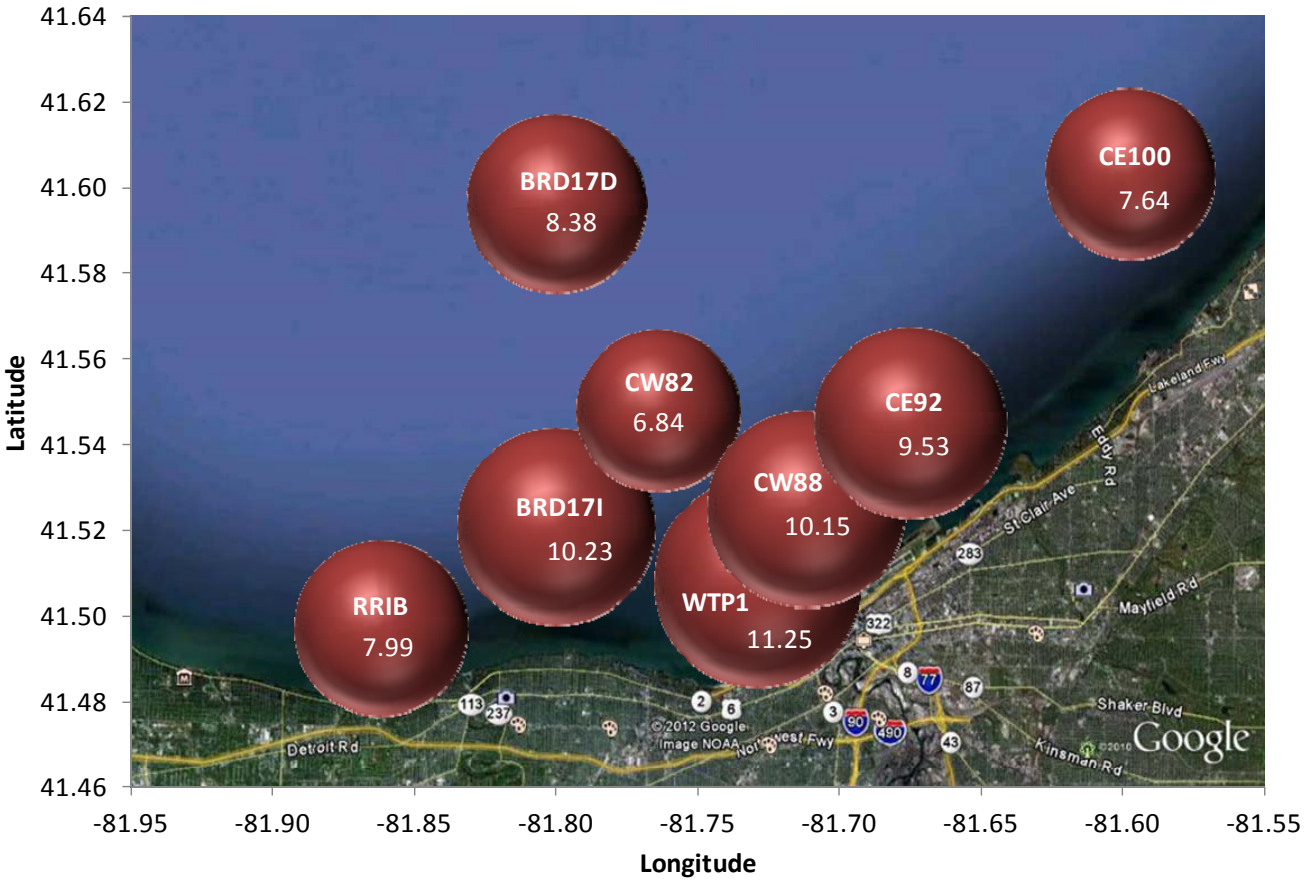


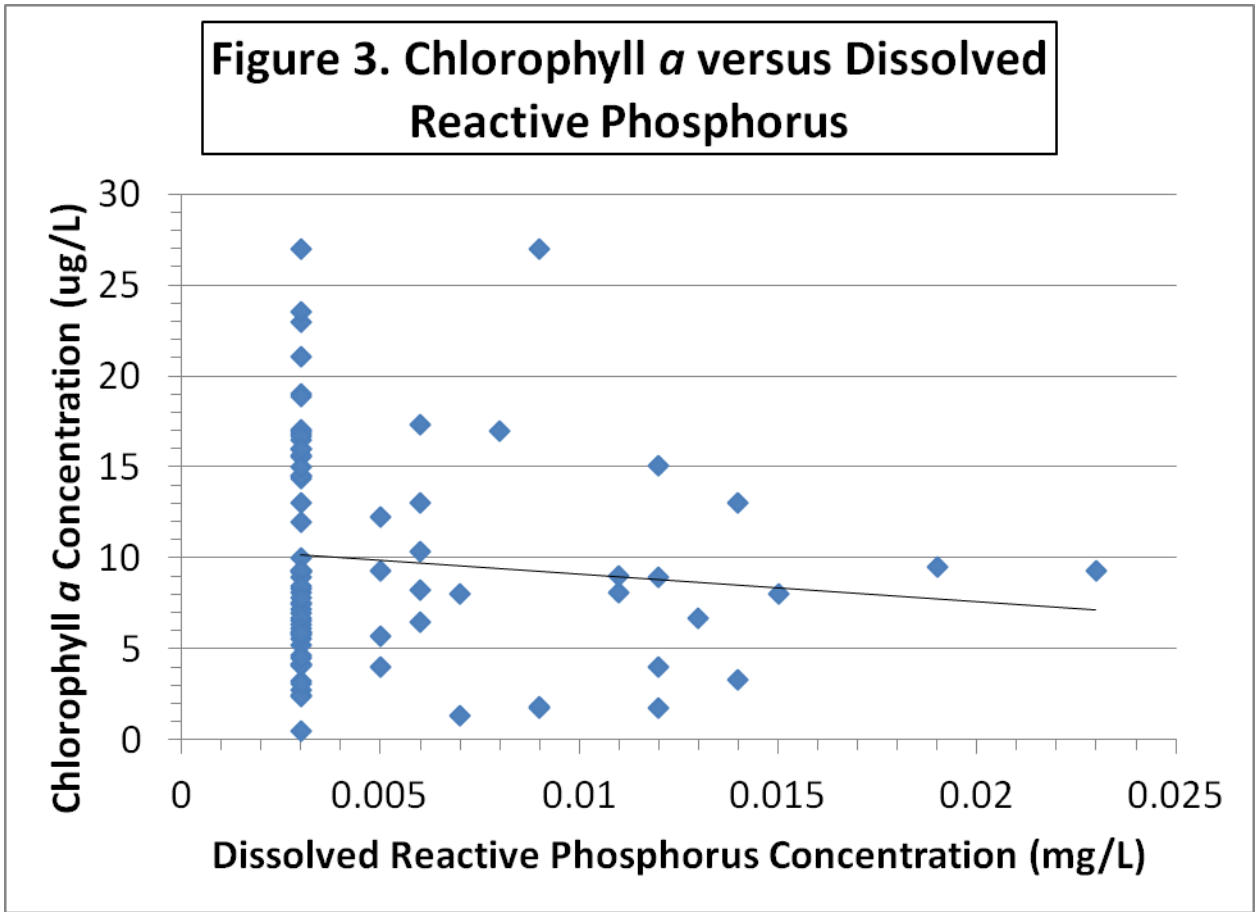
Table 6. 2013 Chlorophyll *a* Concentrations (ug/L)									
	RR1B	BRD17D	BRD17I	CW82	WTP1	CW88	CE92	CE100	Average:
4/22/2013	4.00	-	8.00	6.70	9.30	27.00	8.00	13.00	9.79
4/30/2013	-	-	-	-	3.30	-	-	-	3.30
5/14/2013	-	-	-	-	17.00	-	-	-	17.00
5/20/2013	13.00	12.00	19.00	13.00	27.00	14.50	16.00	16.00	16.31
5/30/2013	-	-	-	-	17.00	-	-	-	17.00
6/11/2013	-	-	-	-	9.30	-	-	-	9.30
6/17/2013	5.30	8.00	-	2.70	1.30	4.00	9.30	2.70	4.66
6/24/2013	-	-	-	-	0.50	-	-	-	0.50
7/2/2013	1.78	3.26	2.45	2.35	1.80	1.73	1.33	-	2.10
7/8/2013	-	-	-	-	15.57	-	-	-	15.57

Table 6. 2013 Chlorophyll *a* Concentrations (ug/L)									
	RR1B	BRD17D	BRD17I	CW82	WTP1	CW88	CE92	CE100	Average:
7/15/2013	5.94	14.47	22.99	-	6.49	6.55	21.08	6.15	14.90
7/22/2013	-	-	-	-	8.95	-	-	-	8.95
7/30/2013	10.01	4.09	2.70	3.08	16.51	-	4.13	3.02	7.37
8/5/2013	-	-	-	-	23.50	-	-	-	23.50
8/12/2013	-	-	-	-	9.21	-	-	-	9.21
8/19/2013	5.72	5.81	7.50	6.36	15.66	4.61	4.49	5.76	6.99
8/26/2013	-	-	-	-	8.24	-	-	-	8.24
9/3/2013	-	-	-	-	5.92	-	-	-	5.92
9/9/2013	9.26	5.18	8.29	5.52	8.93	7.16	6.71	5.86	7.11
9/16/2013	-	-	-	-	9.50	-	-	-	9.50
9/23/2013	16.81	12.25	17.03	14.35	17.34	18.86	15.00	8.46	15.01
9/30/2013	-	-	-	-	16.71	-	-	-	16.71
10/8/2013	8.12	10.34	4.14	7.49	8.12	6.96	9.26	7.79	7.78
10/14/2013	-	-	-	-	15.07	-	-	-	15.07
10/28/2013	-	-	-	-	9.00	-	-	-	9.00
Average:	7.99	7.77	9.61	9.71	11.25	10.68	9.53	7.64	

Meets GLWQA Target

Data from all the sites was pooled to determine any correlations[2] between the parameters. From this analysis, significant correlations were found between chlorophyll *a* and TP, TSS, and turbidity. For these parameters, though, the relationships did not appear to be as strong as in 2012. This could be due to the much larger number of samples that were collected in 2013 and the associated variability in this type of sampling. No significant correlations were found between chlorophyll *a* and DRP, NO_2 + NO_3, and NH_3. For DRP, many of the samples had concentrations below the method detection limit, which could have masked any underlying relationships (Figure 3). Removal of those points, however, did not improve the correlation. In both cases, there was a slightly inverse relationship between DRP and chlorophyll *a*; an increase in the former resulted in a decrease in latter. This was contrary to previous monitoring by other agencies and institutions that has suggested increases in DRP have caused increases in algal production in the lake in recent years (Lake Erie Phosphorus Task Force, 2010). These results possibly indicate that nutrients may not be the limiting factor in the part of the lake in which the study was conducted or there are interactions with other factors that are not yet understood.

[2] Correlations were evaluated using Kendall's Tau and an alpha level of 0.05.



Conclusions

Sampling conducted in 2013 showed that generally, chlorophyll *a* concentrations in Lake Erie were above targets set by the Great Lakes Water Quality Agreement. Location did not appear to have a significant effect on the concentrations that were measured, but there were differences among the sampling dates. While the highest chlorophyll *a* concentrations in 2012 occurred two to three days after a significant rainfall, the same was not true in 2013. Some of the differences between the two years could be attributed to differences in weather conditions; 2012 was relatively dry, while there was a greater amount of rainfall in 2013.

No significant correlations were found between chlorophyll *a* and either nitrite + nitrate or ammonia. For total phosphorus and dissolved reactive phosphorus, both had concentrations that were generally above set targets and those levels that have been found when harmful algal blooms are present. Of these two parameters, only total phosphorus showed a significant correlation with chlorophyll *a* concentrations, and the strength of that relationship was lower than in 2012. Based on these findings, uncertainty still exists in the exact mechanisms in which algal blooms are produced in Lake Erie; nutrient

concentrations do not appear to be the only controlling factor. Because these mechanisms appear to be more dependent on weather than location, additional sampling in 2014 under a variety of conditions may help to provide a better understanding of what is occurring.

References

Lake Erie Nutrient Science Task Group. (2009). *Status of Nutrients in the Lake Erie Basin*.

Ohio Environmental Protection Agency. (2009). *Ohio EPA manual of surveillance methods and quality assurance practices*. Columbus, OH: Divisions of Surface Water and Environmental Services.

Ohio Environmental Protection Agency. (2011). *Draft Nutrient Reduction Strategy Framework for Ohio Waters*. Columbus, OH: Division of Surface Water.

Ohio Lake Erie Phosphorus Task Force. (2010). Ohio Lake Erie Phosphorus Task Force Final Report.

Ohio Lake Erie Phosphorus Task Force. (2013). Ohio Lake Erie Phosphorus Task Force II Final Report.