Water Quality and Methane Emissions at Lake Mohawk

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1. Background:

The US Environmental Protection Agency (USEPA) is conducting an investigation of methane (CH_4) dynamics in reservoirs. CH_4 is a potent greenhouse gas that is produced by microorganisms in reservoir sediments. The objective is to estimate the magnitude of CH_4 emissions from reservoirs in the United States.

The USEPA measured CH_4 emissions from 32 reservoirs in Ohio, Indiana, and Kentucky during the summer of 2016. We designated a minimum of 15 sampling sites in each reservoir (depending on reservoir size), where we measured CH_4 emissions and several water quality indicators. CH_4 emissions were measured using a device which captures CH_4-rich bubbles as they rise through the water column toward the atmosphere. A sonde was used to measure chlorophyll a, dissolved oxygen, pH, specific conductivity, water temperature, and turbidity just below the water surface at each of the 15 sites. Additionally, nutrient chemistry was analyzed at one shallow and one deep site for each reservoir.

This preliminary report presents results from the USEPA 2016 meausurement campaign relevant to Lake Mohawk. These data will be included in a formal peer-reviewed publication to be submitted for publication in early 2018. This preliminary report includes:

1. This background information
2. A map showing the location of the sampled sites
3. A 3D map of the reservoir showing the measurement results for :
    - CH_4 emissions
    - Chlorophyll a
4. Figures showing how Lake Mohawk compared to the other 31 reservoirs in the study in terms of:
    - CH_4 emissions
    - Total phosphorus
    - Total nitrogen
    - Chlorophyll a
5. Tables summarizing the other measured water quality values at each site within Lake Mohawk

Thank you for your help in including Lake Mohawk in this project.

2. Map of Sampled Sites

We sampled Lake Mohawk on August 29th - 30th of 2016. The sampling sites were chosen using a generalized random tesselation stratified design ("GRTS"), an approach which combines elements of systematic and random survey designs which allows for the random allocation of sampling sites with maximum spatial coverage of the reservoir. We used a GPS and geographic information system (GIS) software to locate each sampling site (+/- 30 meters).

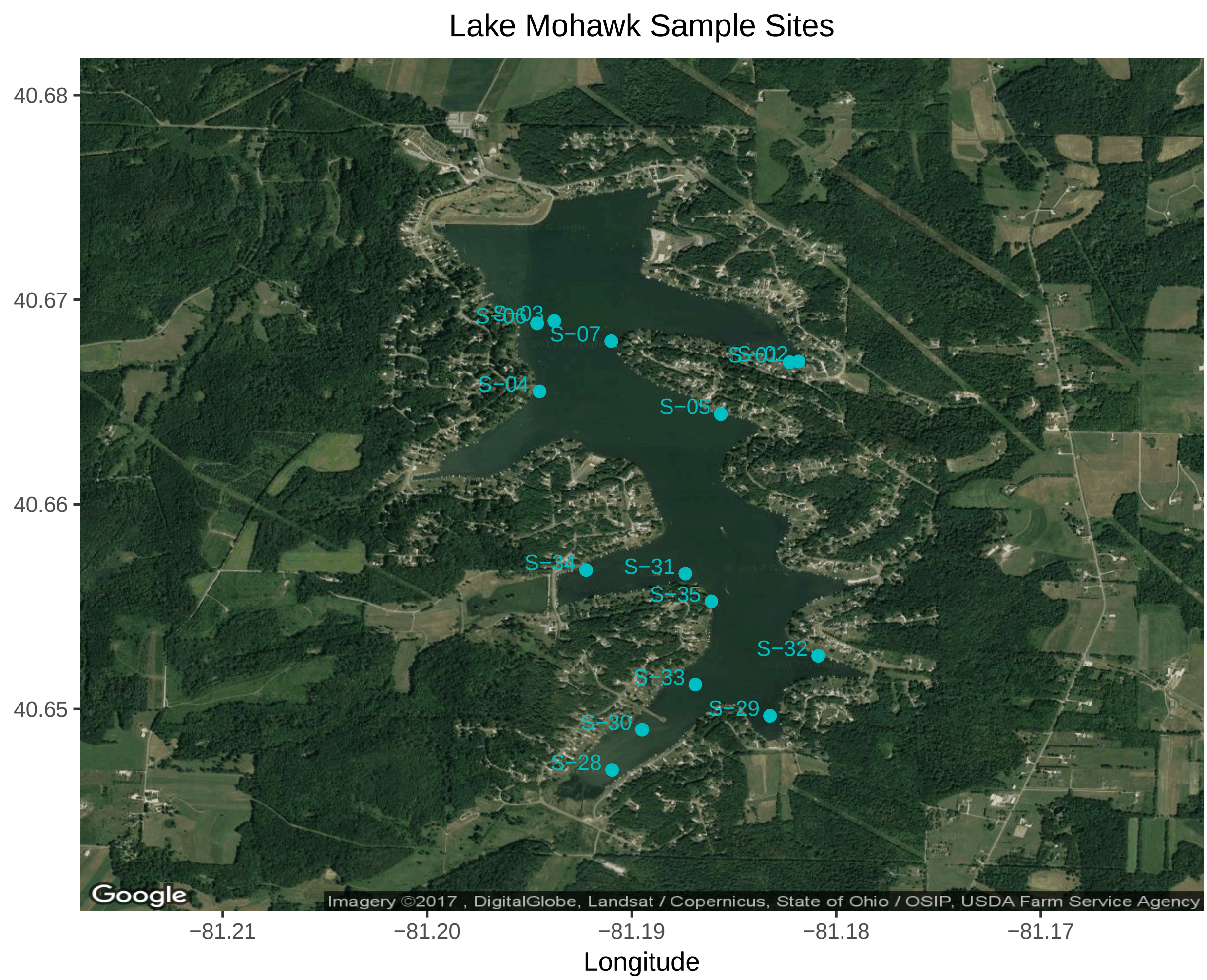

Figure 1: *Location of the fifteen sample sites within Lake Mohawk. Satellite image from Google Maps.*

3. Within-lake values of methane emissions and chlorophyll a concentrations

Previous studies have found a general pattern of higher CH_4 emissions in the river-reservoir transition (tributary) area, and lower emissions in the deeper downstream waters. The two highest rates of CH_4 emissions were observed near the southern tributary, but overall there was not a strong spatial pattern.

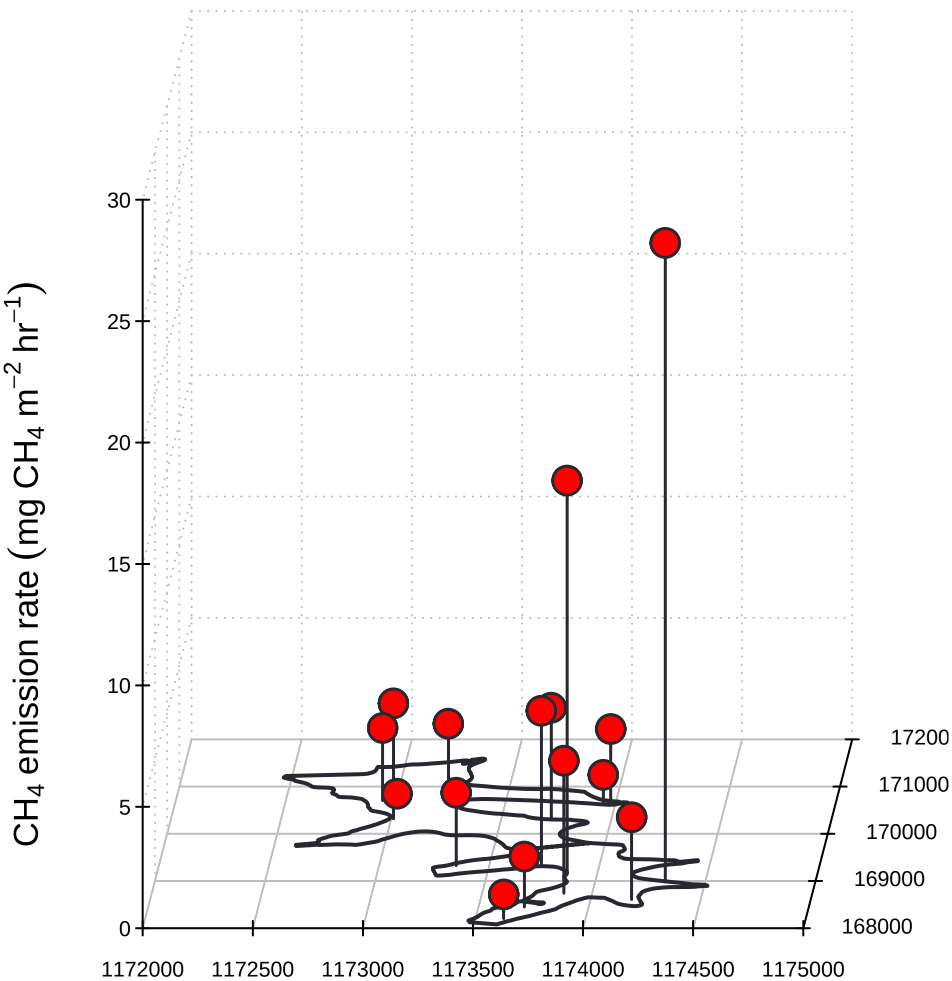

Figure 2: *Methane emissions measured at the 15 sample sites within Lake Mohawk. The height of each "lollipop" corresponds to the emission rate shown on the vertical z-axis in units of milligrams CH_4 per square meter of lake surface per hour.*

Measured chlorophyll a concentrations in Lake Mohawk display a spatial pattern with higher levels to the east and south.

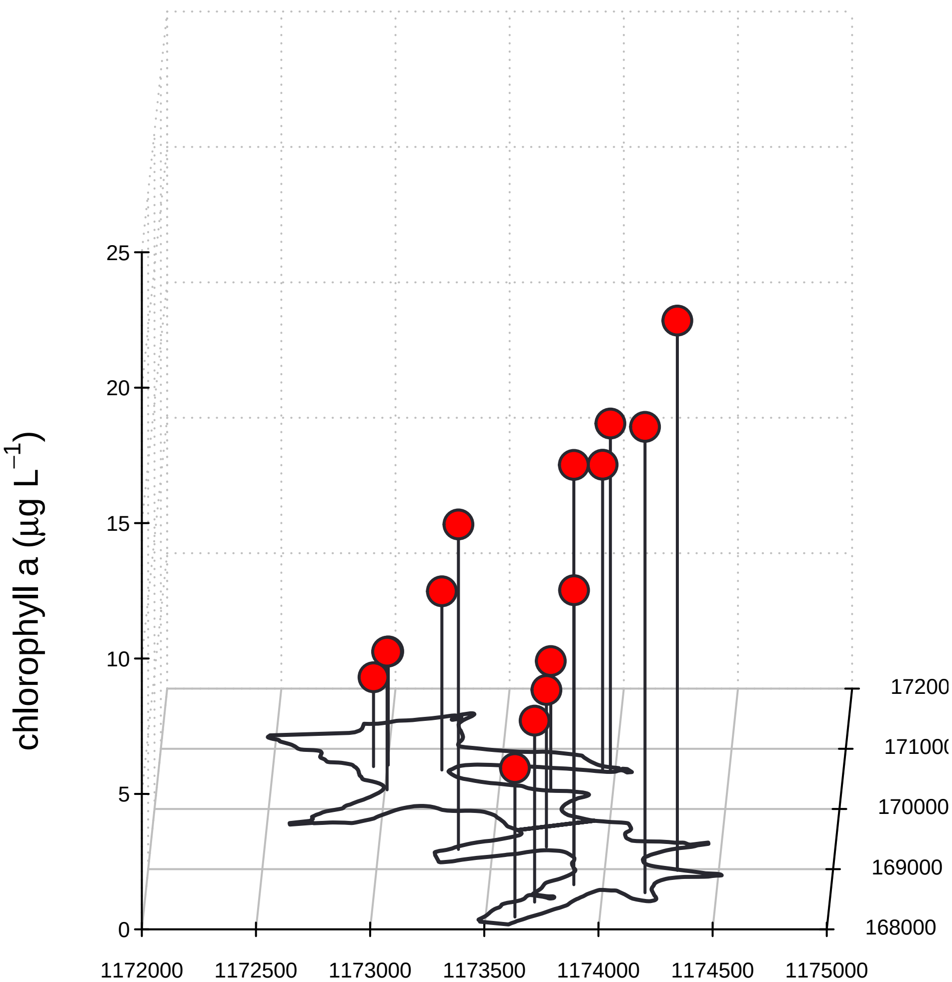

Figure 3: *Chlorophyll a concentrations measured at the 15 sample sites within Lake Mohawk. The height of each "lollipop" corresponds to the concentration shown on the vertical z-axis in units of micrograms per liter of water.*

4. Comparative plots

We used the results from the individual measurement sites to calculate mean values and an uncertainty range for the reservoir. The uncertainty measure we used is the 95% confidence interval (CI), which is similar to two standard deviations (sd) from the mean in a normally distributed data set (where 2*sd = 95.45%). In the case of this study, the majority of the uncertainty is due to the spatial variability of a given parameter within the reservoir, rather than uncertainty due to analytical errors.

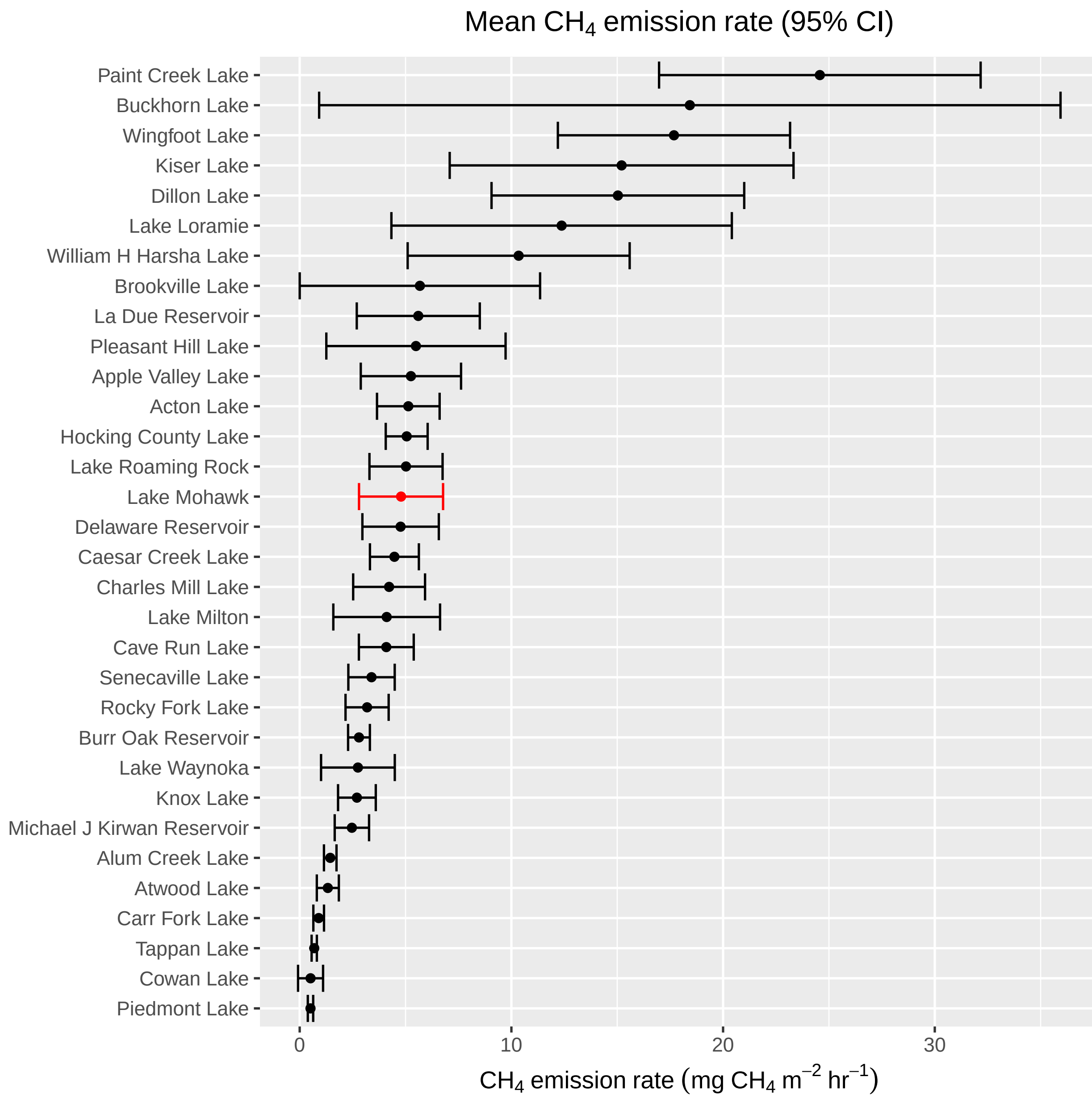

Figure 4: *Mean and 95% confidence interval (CI) of the CH_4 emission rate for each reservoir in this study, calculated from the vaules measured at >=15 sites within each reservoir.*

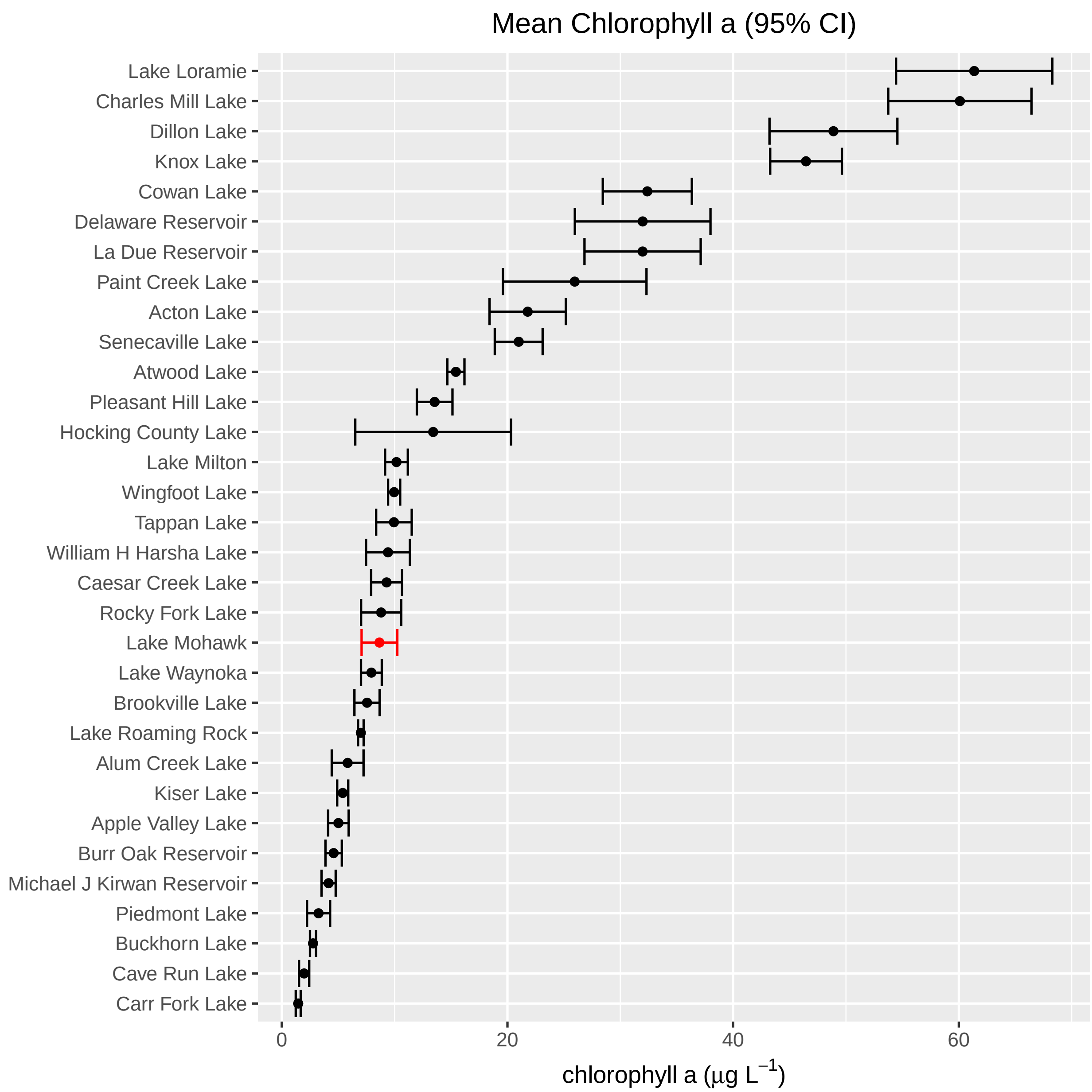

Figure 5: *Mean and 95% confidence interval (CI) of the chlorophyll a concentration for each reservoir in this study, calculated from the vaules measured at >=15 sites within each reservoir.*

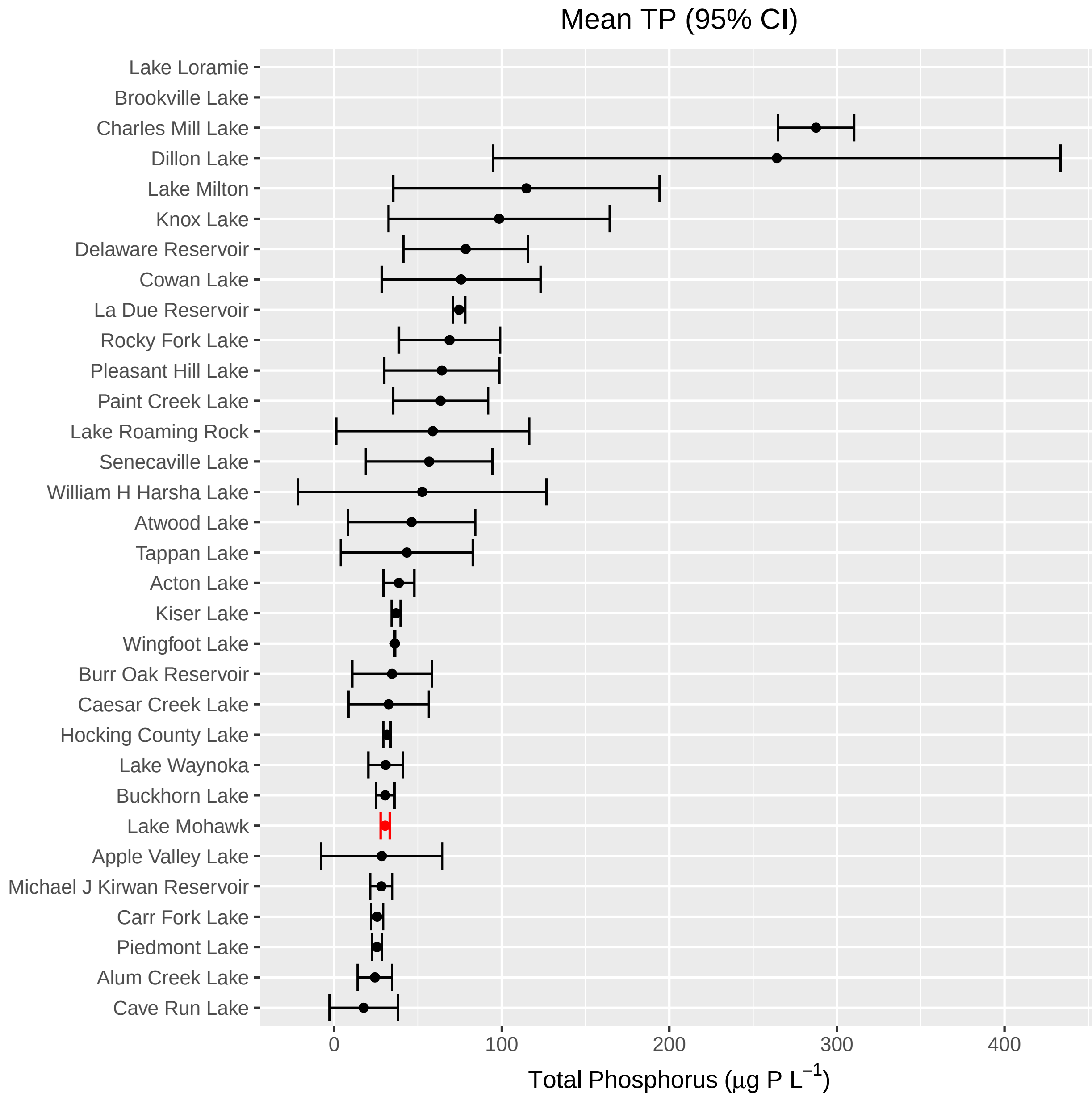

Figure 6: *Mean and 95% confidence interval (CI) of the total phosphorus (TP) concentration for each reservoir in this study, calculated from the vaules measured at >=15 sites within each reservoir.*

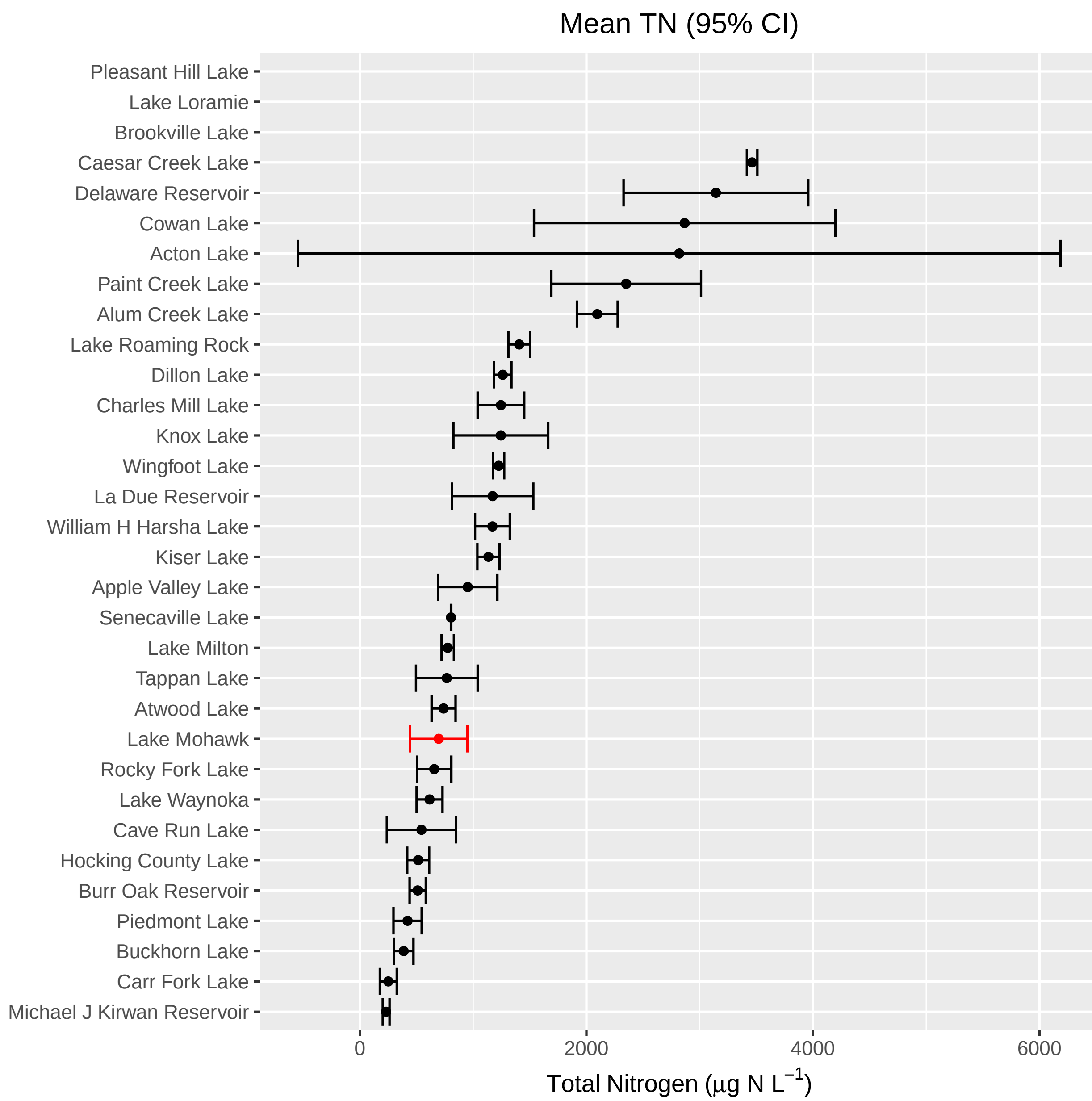

Figure 7: *Mean and 95% confidence interval (CI) of the total nitrogen (TN) concentration for each reservoir in this study, calculated from the vaules measured at >=15 sites within each reservoir.*

5. Tables of measured values at each site

Table 1: Water quality parameters measured via sonde at each site

Site ID	Latitude	Longitude	Depth (m)	Chl a (ug/L)	DO (mg/L)	pH	Sp. Cond	Water Temp (C)	Turbidity
S-01	40.66719	81.18210	0.9	11.3	10.8	8.9	242	29.7	8.5
S-02	40.01703	81.18173	1.4	12.8	10.2	8.9	242	29.9	8.2
S-03	40.13566	81.19384	6.1	4.2	9.0	8.7	243	28.6	8.5
S-04	40.66548	81.19446	3.4	5.1	9.1	8.6	244	29.0	8.2
S-05	40.66427	81.18548	1.4	4.8	9.5	8.8	244	29.3	7.9
S-06	40.11880	81.19475	5.5	3.3	9.2	8.7	243	28.6	8.1
S-07	40.66790	81.19100	3.4	6.6	9.0	8.6	243	28.6	8.5
S-28	40.64700	81.19101	1.4	5.5	8.3	8.1	225	27.9	4.2
S-29	40.64966	81.18339	1.2	17.2	10.3	8.9	239	28.9	8.6
S-30	40.64903	81.18947	1.2	6.7	8.7	8.2	228	28.2	6.9
S-31	40.65656	81.18732	3.0	5.8	9.2	8.6	244	28.7	8.5
S-32	40.65260	81.18097	1.1	20.3	10.2	8.9	240	29.3	7.0
S-33	40.65125	81.18687	2.4	15.5	9.6	8.7	241	28.7	9.6
S-34	40.65671	81.19226	1.5	12.0	9.9	8.8	243	29.4	9.4
S-35	40.65532	81.18603	1.5	9.8	9.4	8.7	243	28.6	9.3

Table 2: Water chemistry parameters measured at one shallow and one deep site

Site ID	Latitude	Longitude	Depth (m)	NH4 (ugN/L)	NO2.3 (ugN/L)	Total N (ugN/L)	Reactive P (ug/L)	Total P (ugP/L)
S-03	40.13566	81.19384	6.1	14	40	794	22	29
S-28	40.64700	81.19101	1.4	13	6	510	13	32

6. EPA disclaimer

The U.S. Environmental Protection Agency, through its Office of Research and Development, participated in the research described herein. It has been subjected to the Agency's administrative review and has been approved for limited external distribution. Any opinions expressed in this article are those of the authors and do not necessarily reflect the views of the Agency, therefore, no official endorsement should be inferred. Any mention of trade names or commercial products does not constitute endorsement or recommendation for use.