ATMOSPHERIC POLLUTANT DEPOSITION MONITORING

NITROGEN AND PHOSPHORUS DEPOSITION AT THE MID-LAKE STATION OF LAKE TAHOE

DATA SUMMARY:

OCTOBER 1, 2019 – SEPTEMBER 30, 2020

SUBMITTED TO:

TAHOE REGIONAL PLANNING AGENCY

SUBMITTED BY:

TAHOE ENVIRONMENTAL RESEARCH CENTER

UNIVERSITY OF CALIFORNIA, DAVIS

BRANDON BERRY
SHOHEI WATANABE
GEOFF SCHLADOW

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WY 2020 Mid-lake Atmospheric Deposition Data Summary

This document presents data and a brief summary of results for atmospheric deposition monitoring of nitrogen (N) and phosphorus (P) at TERC's mid-lake atmospheric deposition station for the period October 1, 2019 – September 30, 2020. It includes results for water year (WY) 2020 N and P loads. PM2.5 data from the CARB monitoring station in Tahoe City are also presented. A spreadsheet accompanying this document "WY2020_TERC_Mid-lake_AD_FINAL" presents summaries of the mid-lake atmospheric deposition data back through July, 2013, along with QA/QC data, estimated WY loading for N and P, and loading rate information.

This report forms part of Deliverable 2 under Contract #20C00008 between the TRPA and the Regents of the University of California.

Sampling Methods

Samples of atmospheric deposition to the lake were collected from mid-lake buoy TB1, in the north central portion of the lake (coordinates 39.1550000°N, 120.0041670°W). The collector consists of a modified 3 ½ gallon HDPE plastic bucket with reduced (6 inch) side-wall height, with 2.75 inch high removable plastic baffles inside (which dampen splash from the bucket). The bucket is partially filled with 4 liters of deionized water and placed on the buoy for a sampling period typically of 1-2 weeks. The collector at mid-lake is considered a "bulk collector" since it collects both wet deposition (precipitation) and dry deposition (settling particles, as well as gases and very small particles which are deposited due to their solubility or other physical or chemical attractions with the surface).

After boat retrieval of the bucket, it is returned to the lab where final volume is measured and concentrations of NO_3-N, NH_4-N, TKN, SRP and TP determined. Loading (g/ha) and loading rate (g/ha/day) for sample nutrients are calculated. Samples with contamination or otherwise compromised data were censored from the dataset (see QA/QC section). Total Water Year (WY) load (g/ha/yr) at mid-lake was estimated from the average loading for uncensored data. Dissolved inorganic nitrogen (DIN) (NO_3-N + NH_4-N) loading and total nitrogen (TN) (NO_3-N + TKN) loading were also determined.

For QA/QC samples, source deionized water samples and equipment blanks were analyzed. The source deionized water consisted of ultra-pure water collected from the deionized water system (Milli-Q System). The equipment blank consisted of 4 liters of ultra-pure water added to a cleaned plastic bulk-deposition bucket, the bucket was enclosed in a plastic bag and held overnight in a cold room, then processed as a typical atmospheric deposition sample.

Data Summarized in Spreadsheet: "2019 TERC Mid-lake AD Final"

Data are summarized in the spreadsheet "2020_TERC_Mid-lake_AD_FINAL". 29 new mid-lake atmospheric deposition samples were collected during October 1, 2019 – September 30, 2020. The data for these samples are summarized in Table A along with data collected for samples back to June 27, 2013. Table B presents the data for 1 source blank, 1 equipment blank 1 field blank, QA/QC samples collected during the period along with all QA/QC values back through 2013. Table C presents a summary of estimated WY2020 DIN, TN, SRP and TP atmospheric deposition in loads per year (grams/hectare/year) along with the historical WY values. Table D in the spreadsheet presents a summary of atmospheric deposition as average daily loading rates of DIN, TN, SRP, TP (grams/hectare/day) for WY 2020 along with the historical values.

Project Quality Assurance

Standardized QA/QC practices for chemical analyses were followed as specified in the TERC QA/QC manual (Liston et al., 2013). For QA/QC in atmospheric deposition monitoring, a primary objective was to check for contamination associated with field monitoring equipment. Nutrient levels in equipment blanks were compared with a source deionized water (ultra-pure Milli-Q deionized water) and also compared with the Method Detection Levels (MDLs) to check for contamination.

One source blank and one cleaned plastic bulk-deposition bucket field blank were collected during the year and these showed very low or no contamination with N and P (Table B in the spreadsheet). One additional equipment blank using the deionized field transport carboy was collected with very low or no N and P contamination

The atmospheric deposition data were reviewed and data subjected to quality control prior to calculation of loads. Atmospheric deposition samples may be contaminated with bugs, bird droppings, lake water splash or material from the buoy surfaces. Samples may be lost due to sample splash out of the bucket during very rough lake conditions. Samples may also sit for prolonged periods when researchers are unable to get to the buoy due to extended periods of rough lake conditions. When the buckets go dry, the deposition collection efficiency can change. Values censored from the data included mid-lake samples which: (1) had collection periods >30 days. In WY 2020 one sample was censored. The censored data in WY 2020 was during December 17, 2019 through January 29, 2020. The corresponding sample was during a period of no smoke and likely lower N and P concentrations, leading to a potential bias in higher loading rates for the WY 2020.

Monitoring Results:

Dissolved Inorganic Nitrogen (DIN) Loading

Figure 1 shows the patterns for DIN loading rate (g/ha/d) from July 2013 through September 2020. In WY 2020, DIN loading was estimated to be 1696 g ha^{-1} or 4.64 g/ha/d (Tables C and D in spreadsheet data summary). DIN loading in WY 2020 increased compared to loading rates in WY 2019 (1334 g/ha/yr or 3.66 g/ha/d). WY 2020 included the largest estimated yearly load and highest daily loading rate for DIN since 2015.

Major sources of atmospheric nitrogen pollutants in the basin have been identified in other research studies. Motor vehicle emissions are thought to be the largest contributor to atmospheric nitrogen pollutants in the basin (Gertler et al., 2006; CARB, 2006 referenced in

NDEP, 2011). However, increased loading rates in WY 2020 are likely associated with increased wildfires in California and surrounding areas. The 2020 California wildfire season comprised a record breaking year of wildfires that burned across the state. Over 4 million acres burned throughout the year, including the largest recorded wildfire in California's history (Cal Fire. *2020 Fire Season.*). Extreme periods of wildfire smoke in the Lake Tahoe basin could heavily contribute to the increase in DIN loading rates.

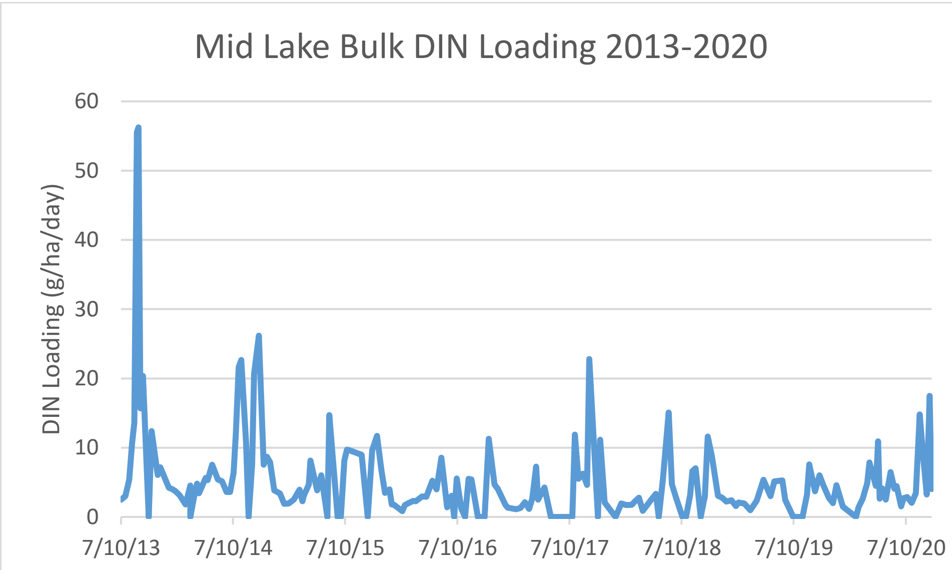

Figure 1. Loading rate of DIN (NO_3-N + NH_4-N) in bulk atmospheric deposition at mid-lake station during July 2013 – September 2020.

Total Nitrogen (TN) Loading

Figure 2 shows the patterns for TN loading rate (g/ha/d) from July, 2013 through September, 2020. In WY 2020, TN loading was estimated to be 2530 g ha^{-1} or 6.91 g/ha/d (Tables C and D in spreadsheet data summary). TN loading in WY 2020 increased compared to loading rates in WY 2019 (2092 g/ha/yr or 5.73 g/ha/d).

Similar to DIN, TN levels are impacted by N from motor vehicle emissions, particulate-associated N (which may include such sources as inorganic and organic N associated with wind-blown dust, pollen, and wind-blown organic matter from forests), TN from thunderstorms and smoke inputs. Past data indicates that spikes in TN loading are associated with wildfire smoke affecting the Lake Tahoe basin. For example, the summer of 2013 had a noticeable peak in TN due to the Rim Fire in Yosemite with smoke reaching the Tahoe basin. Increased loading of TN in the WY 2020 is also likely due to impacts from wildfire smoke. There is a distinct correlation between increases in TN loading and increases in PM2.5 during August – October, 2020 (Figure 3). In wildfire smoke, small particulate matter (PM2.5) is one of the principal air pollutants and a good indicator of smoke related air quality. The PM2.5 concentrations displayed in Figure 3 are the average PM2.5 concentration during the atmospheric deposition sample period. Daily average PM2.5 concentrations were recorded at the Tahoe City – 221 Fairway Drive site (CARB. Air Quality and Meteorological Information). Above average wildfire smoke likely contributed to elevated levels of TN loading during the WY 2020.

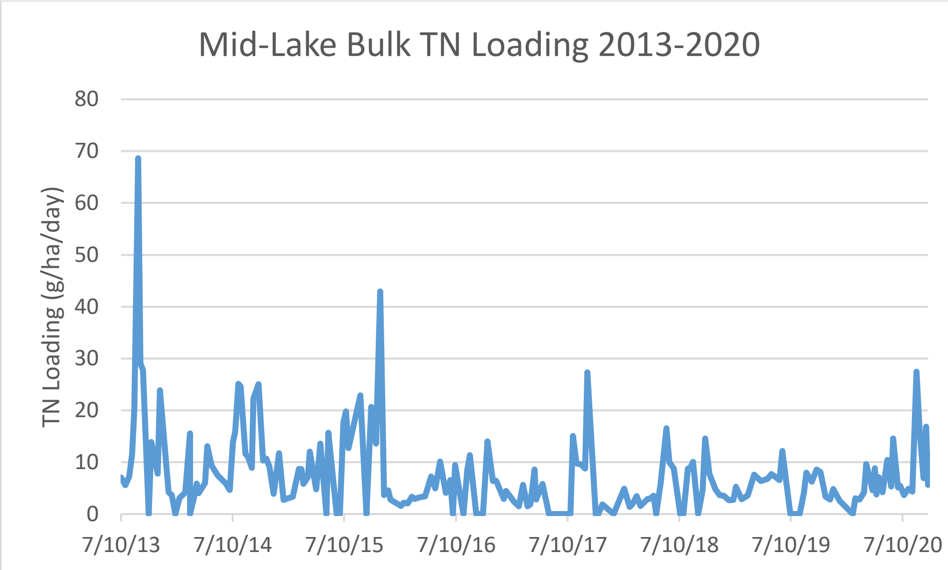

Figure 2. Loading rate of TN (NO_3-N + TKN) in bulk atmospheric deposition at mid-lake station during July 2013 – September 2020.

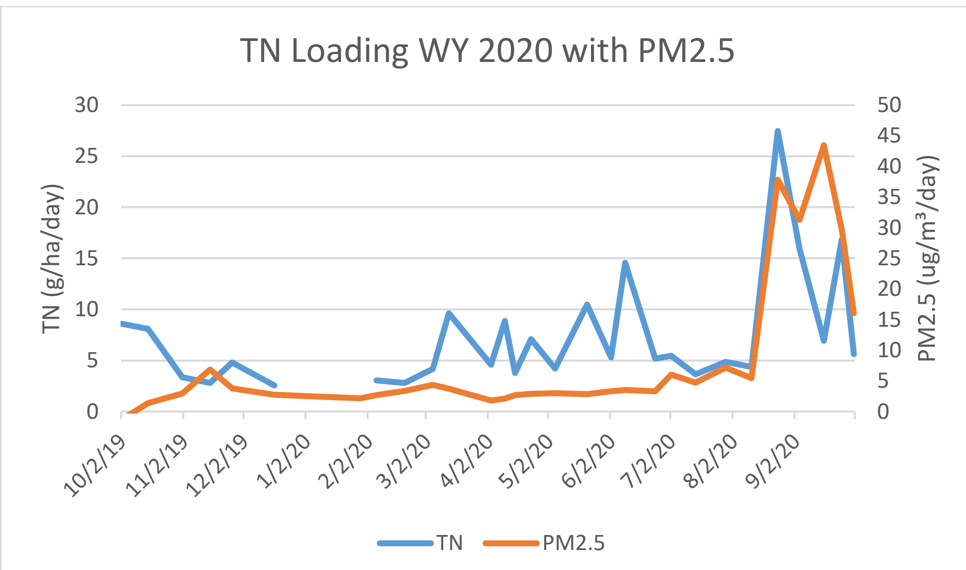

Figure 3. Loading rate of TN (NO_3-N + TKN) at mid-lake station for WY 2020 compared to average daily PM2.5 concentrations.

Soluble Reactive Phosphorus (SRP) Loading

Figure 4 shows the patterns for SRP loading rate (g/ha/d) from July 2013 through September 2020. In WY 2020, SRP loading in bulk atmospheric deposition at mid-lake was an estimated 42.69 g/ha/yr or 0.12 g/ha/d (Tables C and D in spreadsheet data summary). SRP loading in WY 2020 increased compared to loading rates in WY 2019 (20.56 g/ha/yr or 0.06 g/ha/d). SRP loading rates in WY 2020 more than doubled from WY 2019.

WY 2020 exhibited significant increases in SRP loading when compared to recent years. 2013 was the last year that displayed similar loading levels to those recorded in WY 2020. Prior to this year, the most notable peak for SRP occurred associated with the smoky period in the basin resulting from the Rim Fire near Yosemite in 2013. SRP daily loading rates for the period from September 4 – 16, 2020 were the highest in the last decade. Loading rates during the WY 2020 are very similar to 2008 when the Lake Tahoe basin experienced increased wildfire smoke due to the American River Complex fire. The large increase in SRP loading within the Tahoe basin can likely be attributed to the record breaking 2020 wildfires and associated wildfire smoke.

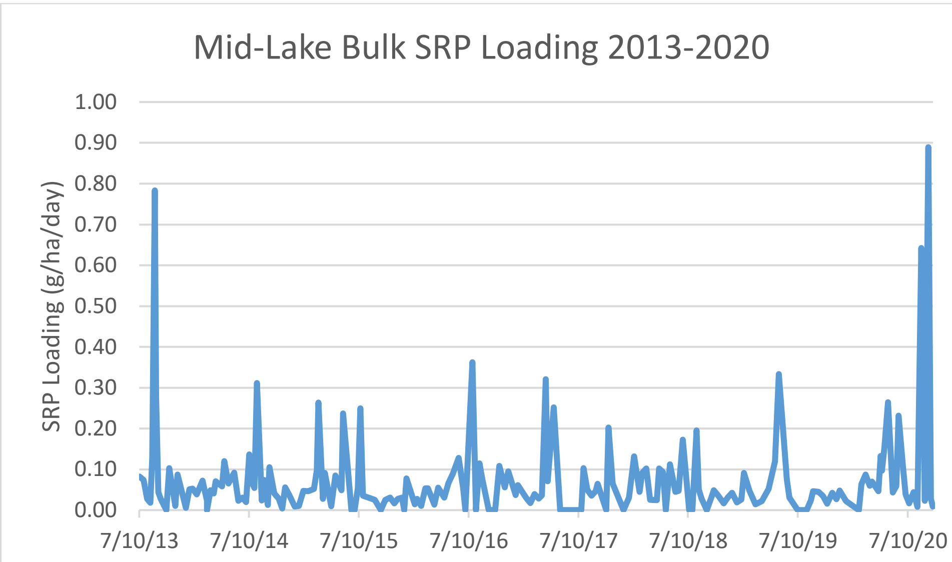

Figure 4. Loading rate of SRP in bulk atmospheric deposition at mid-lake station during July 2013 - September 2020.

Total Phosphorus (TP) Loading

Figure 5 shows the patterns for TP loading rate from July, 2013 through September 2020. In WY 2020, TP loading in bulk atmospheric deposition at mid-lake was an estimated 141.15 g/ha/yr or 0.39 g/ha/d (Tables C and D in spreadsheet data summary). TP loading in WY 2020 increased compared to loading rates in WY 2019 (83.89 g/ha/yr or 0.23 g/ha/d). Both TP daily loading rates and yearly load were the highest levels on record back through 2013.

A variety of factors may impact levels of TP in atmospheric deposition samples in the basin. Gertler et al. (2006) indicate the primary factors affecting P deposition in the Tahoe Basin are the mobilization of local sources from roadway sanding and salting in the winter, and from local soils in the summer and vehicle exhaust. Observations of material deposited in buckets indicates that wind-blown dust, pollen, wind-blown organic matter from the forests may also be potential sources of TP, along with TP contributed with smoke and ash. Significant increases in TP loading in the WY 2020 are likely attributed to wildfire smoke. Similarly, in WY 2008 there were elevated TP values which were very close to the loading rates in WY 2020. These were associated with periods of heavy smoke in the basin due to the American River Complex fire.

The data for WY 2020 contains the highest yearly TP load on record for the monitoring program. It should be reiterated that the yearly load calculation may be biased towards a higher value because of the censored sample in December 2019 – January 2020. However, the correlation between significant TP increases in the late summer of WY 2020 are directly related to increases in PM2.5 within the basin (Figure 6). It is largely apparent that the 2020 wildfires contributed to a significant increase in TP loading in the Tahoe basin.

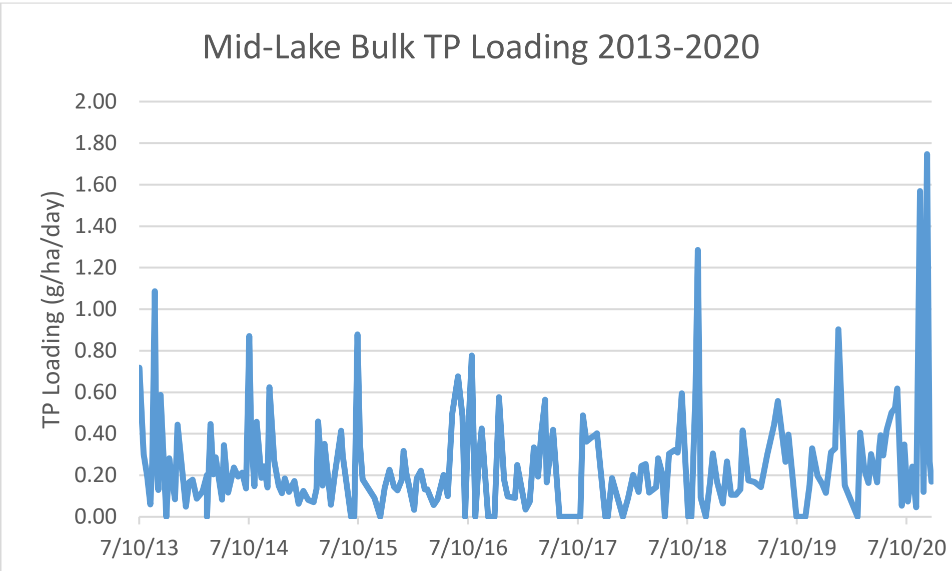

Figure 5. Loading rate of TP in bulk atmospheric deposition at mid-lake station during July 2013 – September 2020.

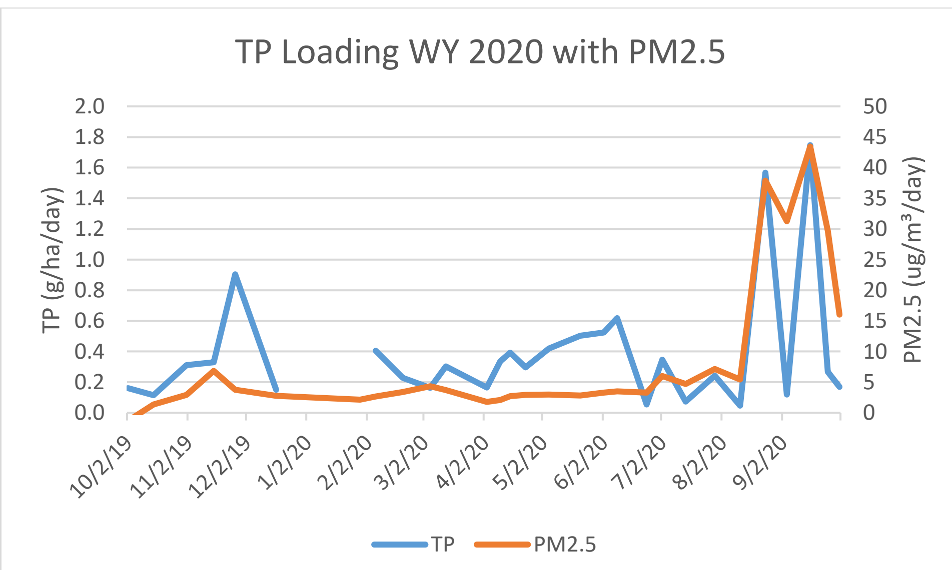

Figure 6. Loading rate of TP at mid-lake station for WY 2020 compared to average daily PM2.5 concentrations.

References

CARB (California Air Resources Board). 2006. Lake Tahoe Atmospheric Deposition Study (LTADS). Final Report – August, 2006. Atmospheric Processes Research Section, California EPA, Sacramento, CA.

Gertler, A.W., Bytnerowicz, A., Cahill, T.A., Arbaugh, M., Cliff, S., Kahyaoglu-Koracin, J., Tarnay, L., Alonso, R. and W. Fraczek. 2006. Local air pollutants threaten Lake Tahoe's clarity. California Agriculture 60(2):53-58.

Liston, A., T. Hammell, V. Edirveerasingam, B. Allen, S. Hackley, J. Reuter and G. Schladow. 2013 Updated June 24, 2014). *Laboratory Procedure, Field Protocol and Quality Assurance Manual*, Tahoe Environmental Research Center, University of California, Davis. 158 p.

NDEP (Nevada Division of Environmental Protection). 2011. Final Lake Tahoe Total Maximum Daily Load. NDEP, Carson City, NV.

CARB (California Air Resources Board). Air Quality and Meteorological Information. Tahoe City – 221 Fairway Dr Site #31819. 20 Jan. 2021: https://www.arb.ca.gov/aqmis2/.

Cal Fire. *2020 Fire Season.* 22 Feb. 2021: https://www.fire.ca.gov/incidents/2020/.