TAHOE: STATE OF THE LAKE REPORT 2020

NUTRIENTS AND PARTICLES

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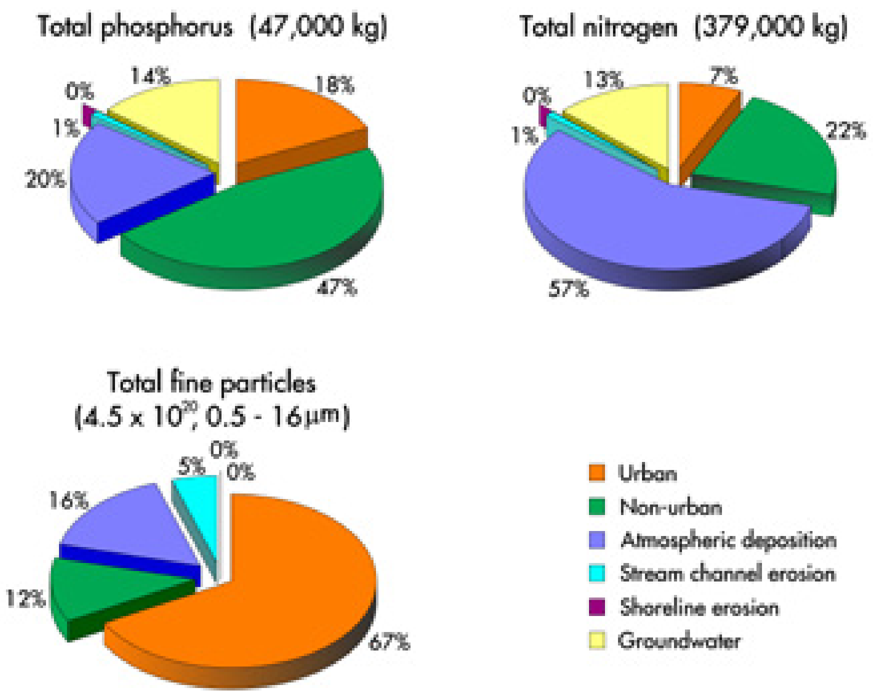
Sources of clarity-reducing and blueness-reducing pollutants

Research has quantified the primary sources of nutrients (nitrogen and phosphorus) and particulate material that are causing Lake Tahoe to lose clarity and blueness in its upper waters. One of the contributors to clarity decline is extremely fine particles in stormwater that originate from the urban watershed (67 percent), even though these areas cover only 10 percent of the basin's land area. Part of the atmospheric particle load is also from these urbanized areas. For nitrogen, atmospheric deposition is the major source (57 percent). Phosphorus is primarily introduced by the urban (18 percent) and non-urban (47 percent) watersheds. These categories of pollutant sources form the basis of a strategy to restore Lake Tahoe's open-water clarity by agencies including the Lahontan Regional Water Quality Control Board, the Nevada Division of Environmental Protection, and the Tahoe Regional Planning Agency. Data were originally generated for the Lake Tahoe TMDL Program. These results are revised from the original estimates as they are based on a longer time series of monitoring data.

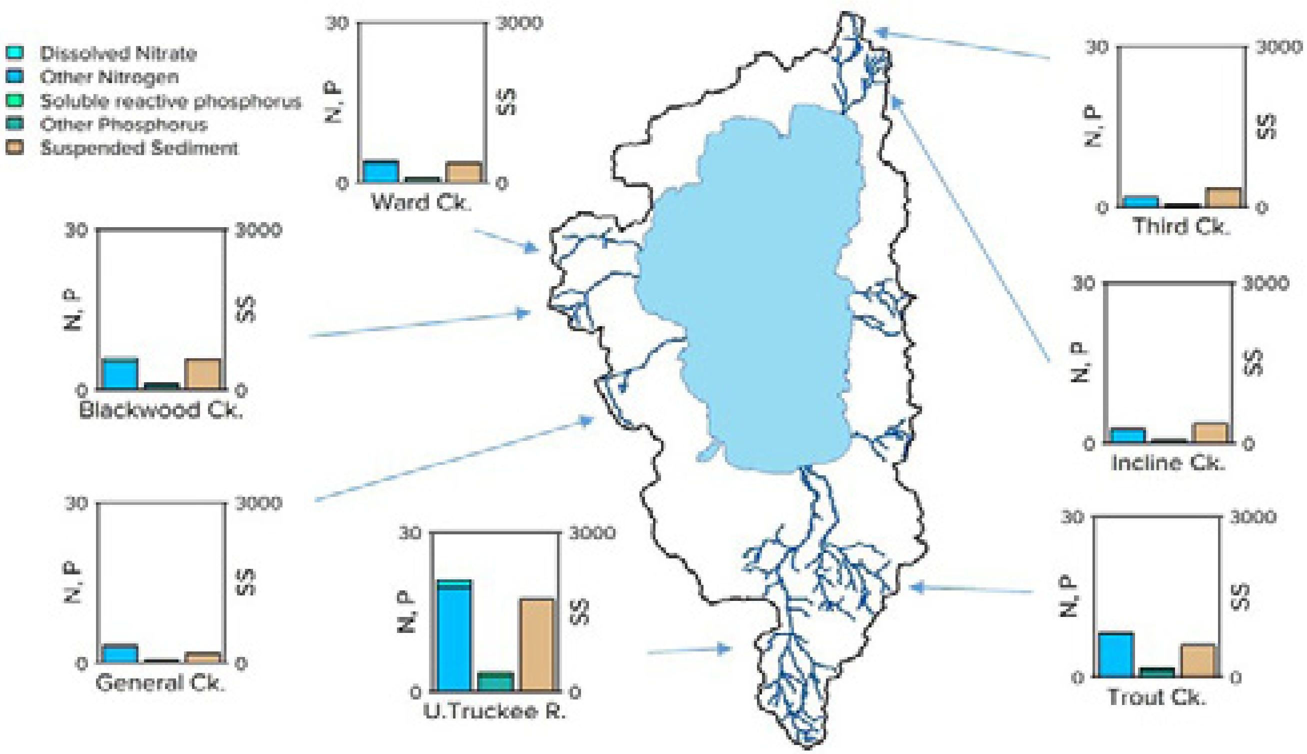


Pollutant loads from seven watersheds

In 2019

The Lake Tahoe Interagency Monitoring Program (LTIMP) measures nutrient and sediment input from seven of the 63 watershed streams. The watersheds are the Upper Truckee River, Trout Creek, Incline Creek, Third Creek, Ward Creek, Blackwood Creek, and General Creek. In 2019, the majority of stream phosphorus and nitrogen, as well as suspended sediments, came from the Upper Truckee River. This is often the case, but in some years, smaller streams, such as Incline Creek and Blackwood Creek, can be very significant contributors.

The LTIMP stream water quality program is supported by the Lahontan Regional Water Quality Control Board, the Tahoe Regional Planning Agency, the California Tahoe Conservancy, the U.S. Geological Survey, and UC Davis TERC.

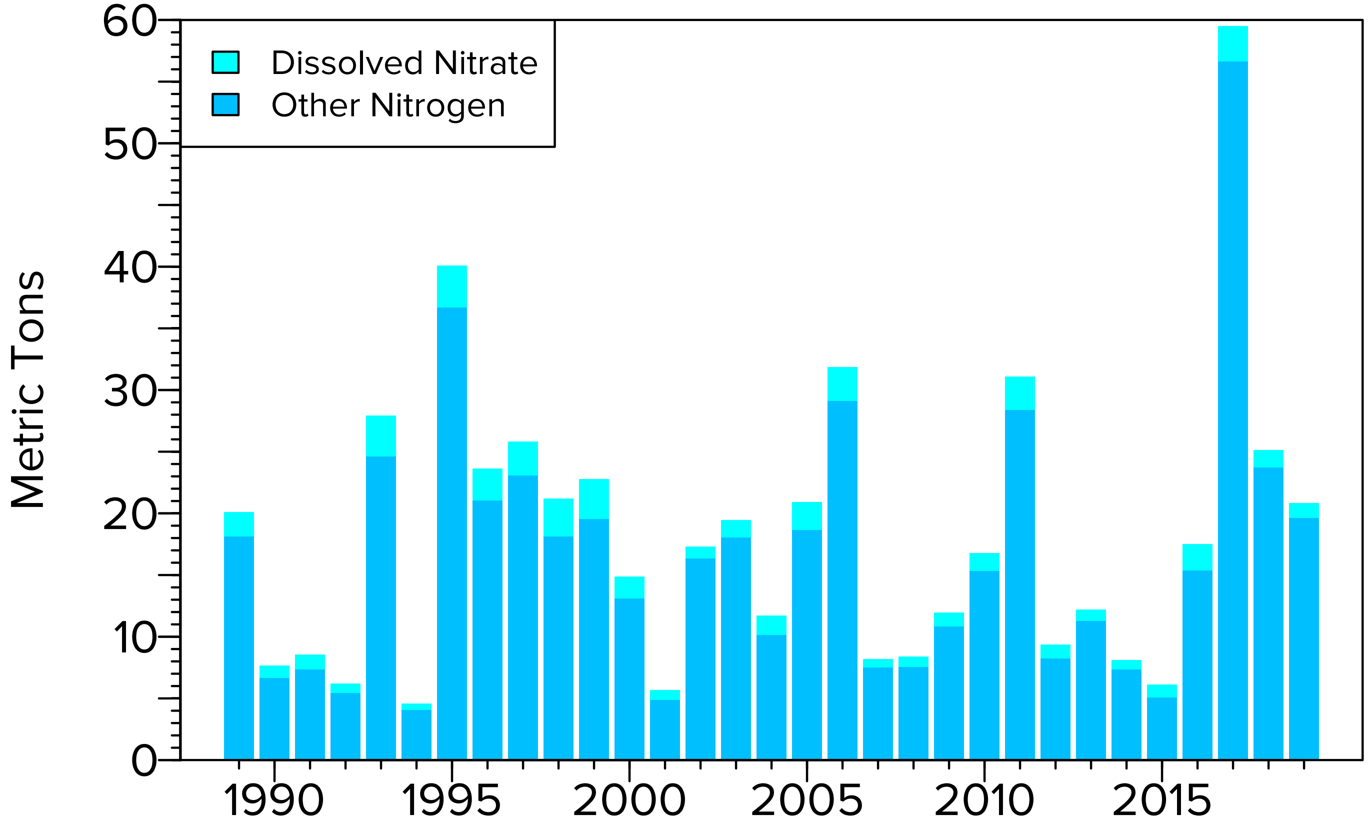


Nitrogen contribution by Upper Truckee River

Yearly since 1989

Nitrogen (N) is important because it, along with phosphorus (P), stimulates algal growth. The Upper Truckee River is the largest of the 63 streams that flow into Lake Tahoe, contributing about 25 percent of the inflowing water. The river's contribution of dissolved nitrate and the remainder of the total nitrogen load are shown here. The year-to-year variations primarily reflect changes in precipitation. For example, 1994 had only 16.6 inches of precipitation and a low total nitrogen load of 4.6 MT, while 2017 had 68.9 inches of precipitation and a record high total nitrogen load of 59.5 MT. In 2019, there was an above average 43.8 inches of precipitation, and an above average total nitrogen load of 20.9 MT. The long-term mean annual total nitrogen load is 18.2 MT/yr.

One metric ton (MT) = 2,205 pounds.

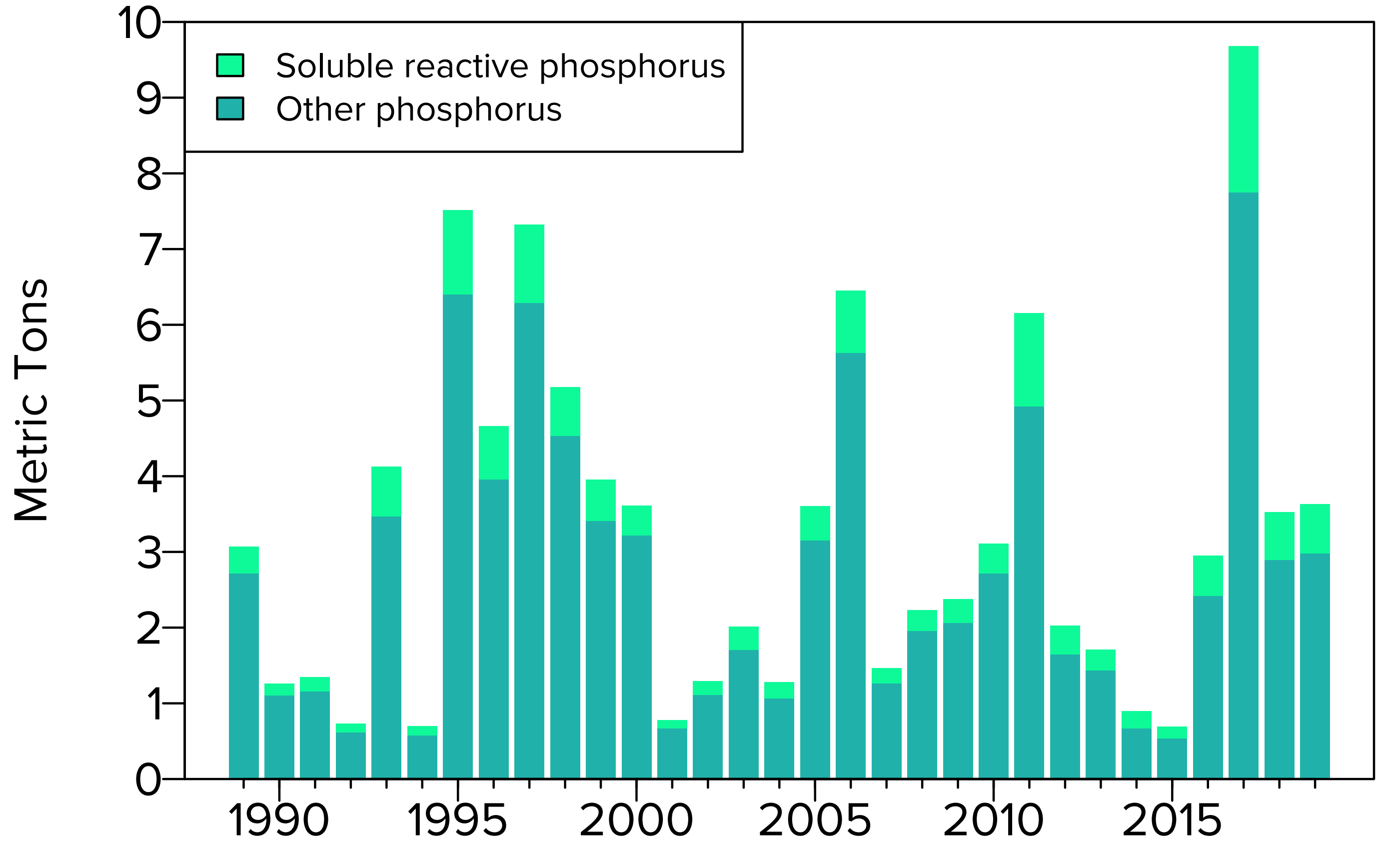


Phosphorus contribution by Upper Truckee River

Yearly since 1989

Soluble reactive phosphorus (SRP) is the fraction of phosphorus immediately available for algal growth. As with nitrogen (Fig. 9.3), the year-to-year variation in load largely reflects the changes in precipitation. Above average precipitation in 2019 resulted in a total phosphorus level of 3.6 MT and SRP load of 0.65 MT. These compare with the long-term averages of 3.2 and 0.49 MT respectively. Decreasing nutrient inputs is fundamental to restoring Lake Tahoe's iconic blueness. Total phosphorus is the sum of SRP and other phosphorus, which includes organic phosphorus and phosphorus associated with particles.

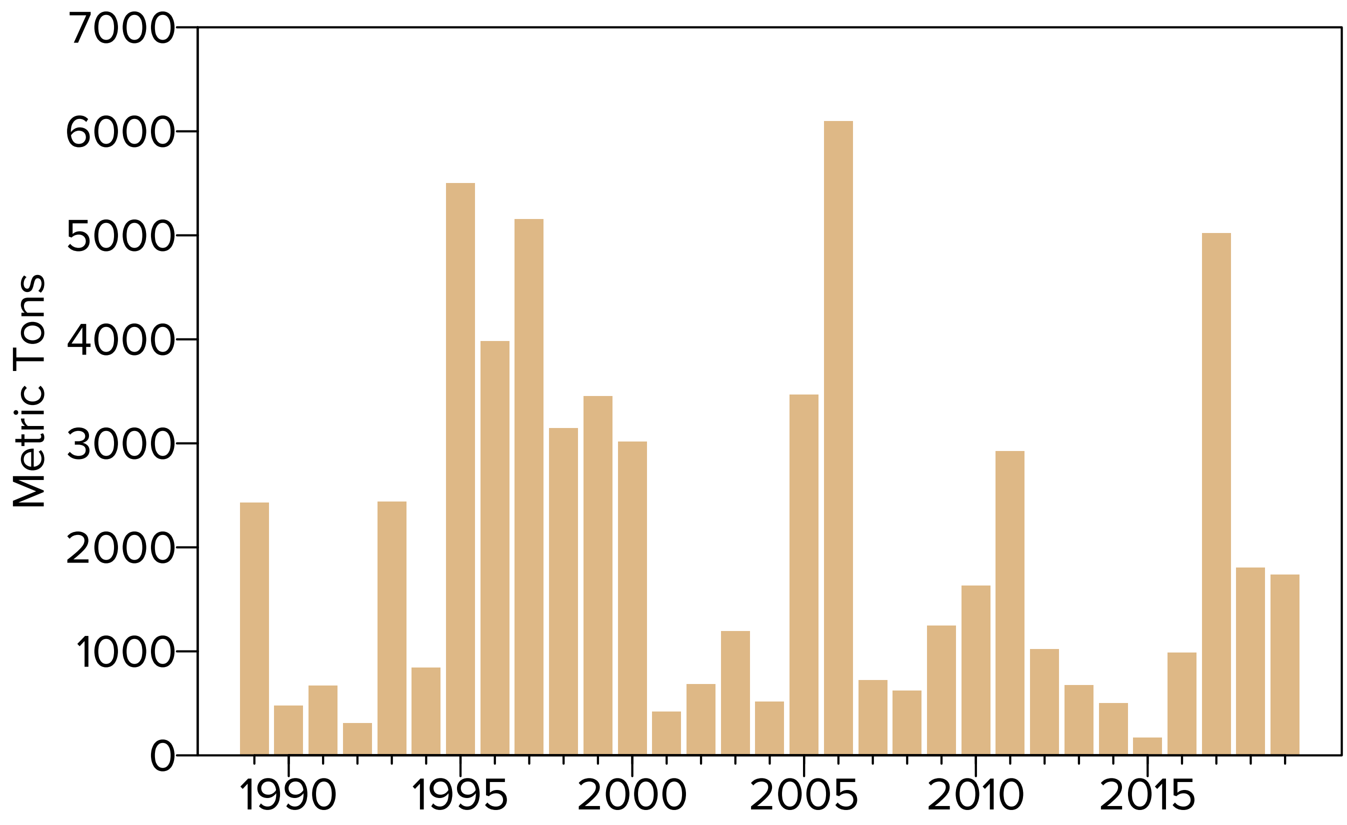
One metric ton (MT) = 2,205 pounds.



Suspended sediment contribution by Upper Truckee River

Yearly since 1989

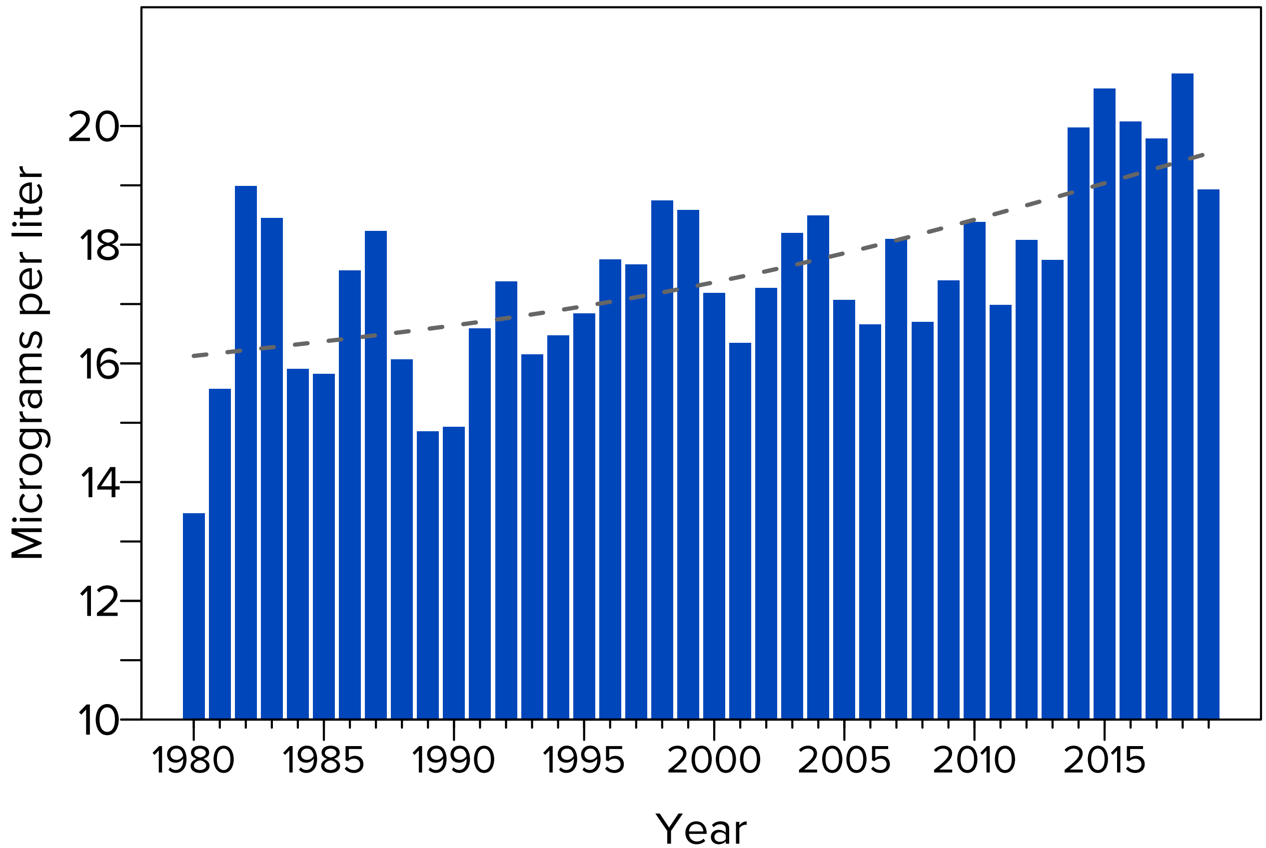
The load of total suspended sediment delivered to the lake by the Upper Truckee River is related to landscape condition and erosion as well as to precipitation and stream flow. Inter-annual variation in sediment load over shorter time scales is more related to the latter. Plans to restore lake clarity emphasize reducing loads of very fine suspended sediment (less than 20 microns in diameter) from urbanized areas. Efforts to restore natural stream function and watershed condition focus on reducing loads of total sediment regardless of size, as well as restoration of habitat for plants and wildlife. In 2019, the suspended sediment load from the Upper Truckee River was 1,739 MT. The highest load ever recorded was 6,100 MT in 2006. The average annual load is 2,028 MT.



Lake nitrate concentration

Yearly since 1980

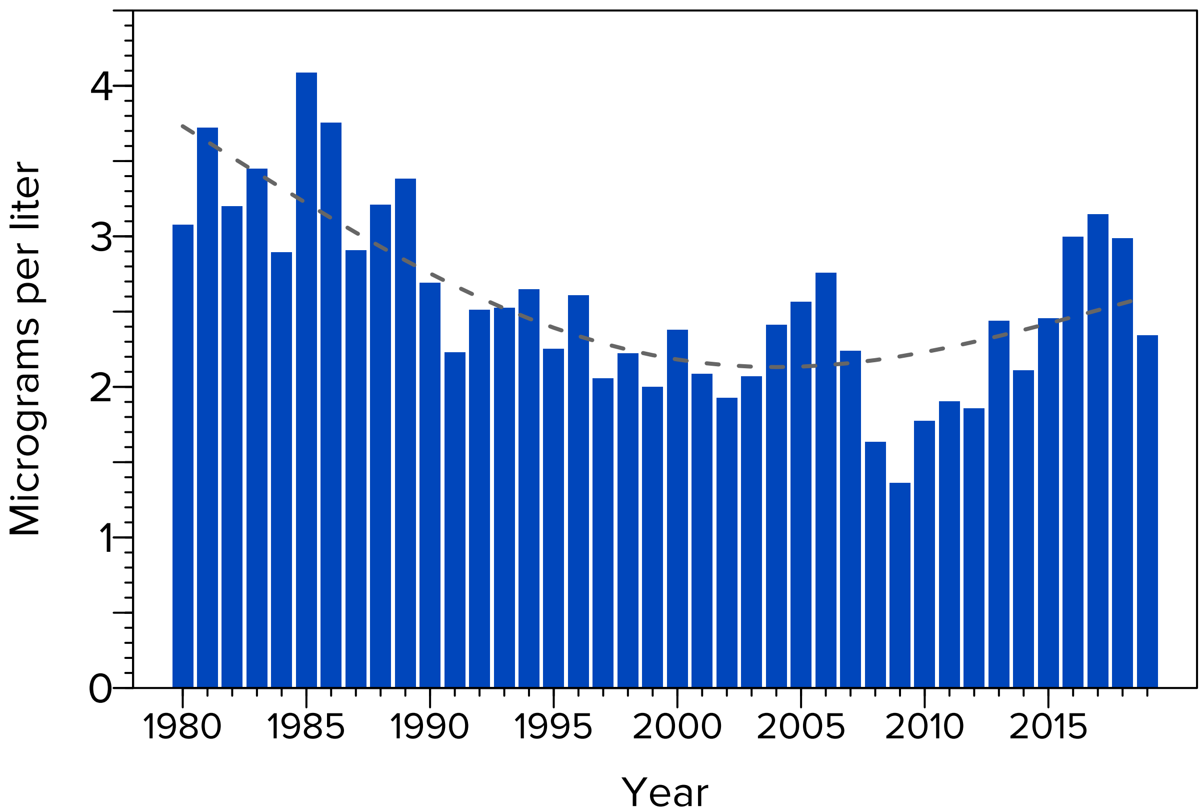
Until 2012, the volume-weighted annual average concentration of nitrate-nitrogen had remained relatively constant, ranging between 13 and 19 micrograms per liter. Since that time, however, the lake's nitrate concentration has been increasing, as evident in the trend line produced with a Generalized Additive Model. In 2019, the volume-weighted annual average concentration of nitrate-nitrogen was 18.9 micrograms per liter. The reduction in concentration was due to the deep mixing that occurred early in 2019 and that redistributed the nitrate that had been accumulating at the bottom of the lake for the previous eight years. This nitrate was subsequently made available for algal uptake, accounting for the increase in algal abundance in 2019 (see Fig. 10.2). The average annual nitrate concentration is 17.5 micrograms per liter. Water samples are taken at the MLTP (mid-lake) station at 13 depths from the surface to 1,480 feet.



Lake total hydrolyzable phosphorus concentration

Yearly since 1980

Phosphorus naturally occurs in Tahoe Basin soils and enters the lake from soil disturbance and erosion. Total hydrolyzable phosphorus, or THP, is a measure of the fraction of phosphorus that algae can use to grow. It is similar to the SRP that is measured in the streams. Since 1980, THP had been declining although in the last 15 years the values have been stabilizing or possibly increasing. In 2019, the volume-weighted annual average concentration of THP was 2.34 micrograms per liter, compared to the long-term average value of 2.57 micrograms per liter. Water samples are taken at the MLTP (mid-lake) station at 13 depths from the surface to 1,480 feet.



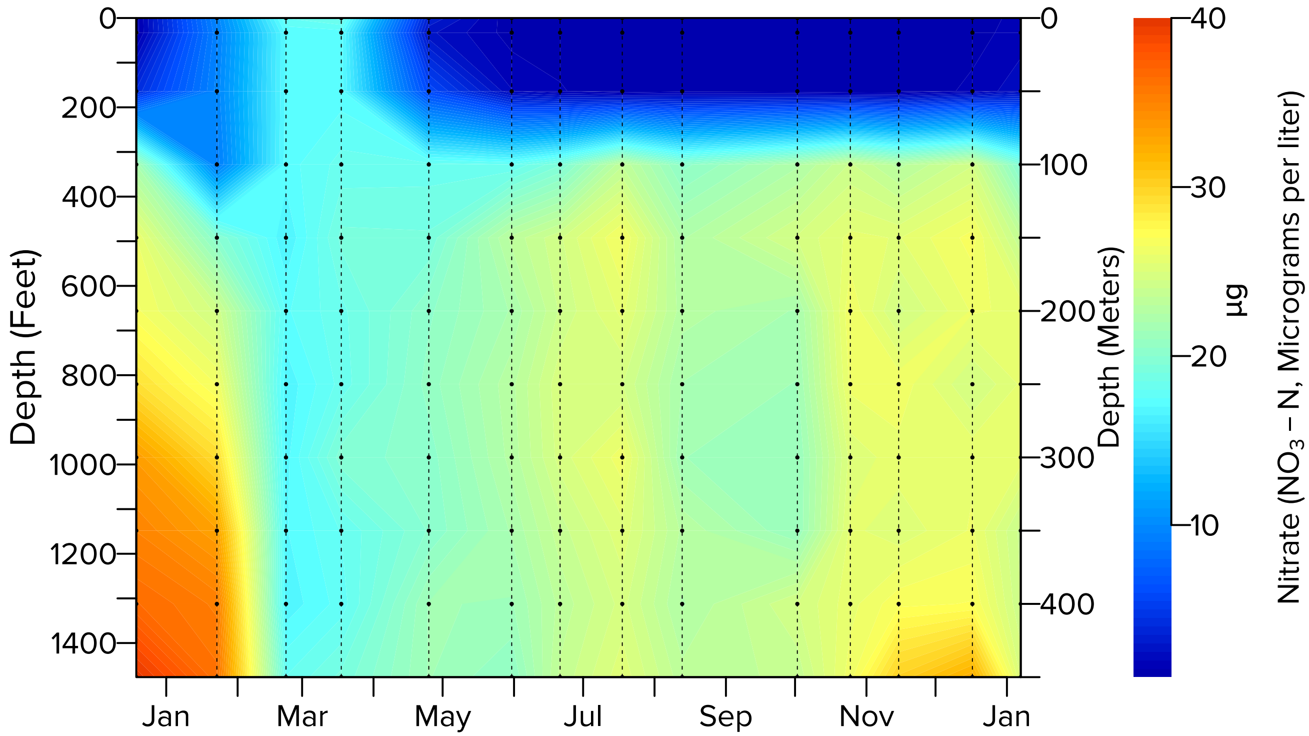
Nitrate distribution

In 2019

Water samples are collected approximately every month (on dates indicated by the dashed lines) at 13 depths (indicated by the dots) at the middle of the lake, and analyzed in the TERC laboratory for nutrient concentrations. Here the nitrate concentration is shown in the form of color contours.

Most evident is the disappearance of the high nitrate region in the bottom half of the lake with deep mixing in February. Initially nitrate was uniformly distributed, but by April the surface of the lake was being depleted and a sharp "nitricline" is evident at a depth of 250 feet.

Although most of the "new" nitrate enters at the surface through atmospheric deposition, it is rapidly taken up by the algae and surface concentrations remain generally low. As algae sink and decompose, the nitrate they consumed reappears deep in the lake. At these depths, however, there is insufficient light for algae to grow and to use these nutrients.

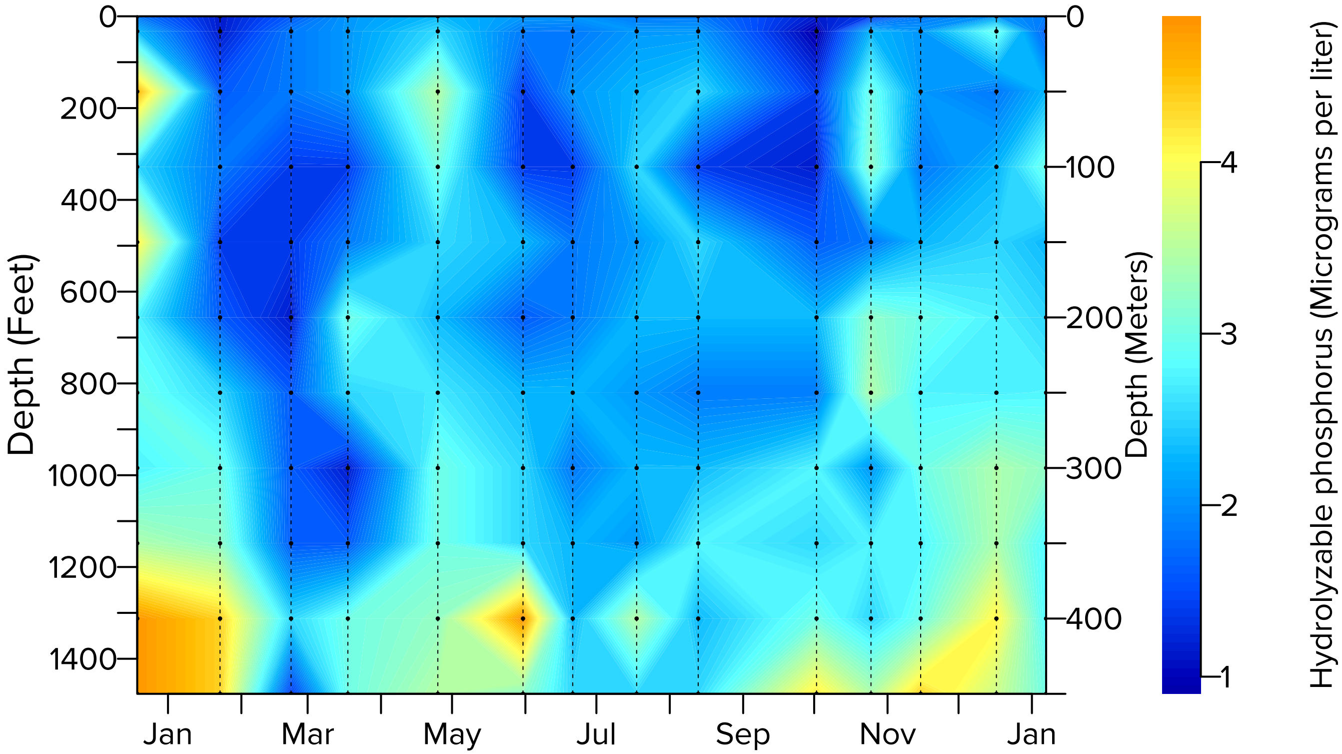


Total hydrolyzable phosphorus distribution

In 2019

Water samples are collected approximately every month (on dates indicated by the dashed lines) at 13 depths (indicated by the dots) at the middle of the lake, and analyzed in the TERC laboratory for nutrient concentrations. Here the total hydrolyzable phosphorus (THP) concentration, the fraction of phosphorus that can be readily used by algae, is shown in the form of color contours.

Phosphorus mainly enters the lake in association with fine particles during runoff events in April and May. The higher values near the surface in spring and summer suggest that in 2019, nitrogen was the nutrient that limited algal growth, rather than phosphorus. The high concentrations of phosphorus deep in the lake during January were the result of the previous eight years of no deep mixing. With deep mixing in February, the high phosphorus levels were rapidly diluted through the entire water column.



Fine particle distribution

In 2019

Water samples are collected approximately monthly (on dates indicated by the dashed lines) at 13 depths (indicated by the dots) at the middle of the lake, and analyzed in the TERC laboratory for the concentration of fine particles in 15 different bin sizes. Here the distributions of the finest particles (in the size range of 1.0 to 8 microns) are shown in the form of color contours. Particles here can be both inorganic particles (such as clay or silt) or very small algal diatom particles.

Unlike the nutrients in Figs. 9.8 and 9.9, fine particles are in low concentrations deep in the lake during January. With deep mixing, however, surface particles are mixed throughout the lake during February. Later in the year the fine particles are largely concentrated in the upper part of the lake (above 200 feet in depth). May and June, when the fine particles in this upper layer are highest, the clarity was lowest. The particles do not decrease in the upper layer as quickly as nitrogen or phosphorus, as they are not taken up by algal growth. The fine inorganic particles gradually clump together (aggregate) and that allows them to more rapidly settle to the lake sediments at the bottom.