

TAHOE:  
STATE  
OF THE  
LAKE  
REPORT  
2011

A PORTION OF THE FUNDING USED TO ASSEMBLE AND DISTRIBUTE  
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## INTRODUCTION

The University of California, Davis, has conducted continuous monitoring of Lake Tahoe since 1968, amassing a unique record of change for one of the world's most beautiful and vulnerable lakes.

In the UC Davis Tahoe: State of the Lake Report, we summarize how natural variability, long term change and human activity have affected the lake's clarity, physics, chemistry and biology over that period. We also present the data collected in 2010. The data shown reveal a unique record of trends and patterns – the result of natural forces and human actions that operate at time scales ranging from days to decades. These patterns tell us that Lake Tahoe is a complex ecosystem, behaving in ways we don't always expect. This was never truer than in this last year. While Lake Tahoe is unique, the forces and processes that shape it are the same as those acting in all natural ecosystems. As such, Lake Tahoe is an analog for other systems both in the western US and worldwide.

Our role is to explore this complexity and to use our advancing knowledge to suggest options for ecosystem restoration and management. Choosing among those options and implementing them is the role of those outside the scientific community and needs to take account of a host of other considerations. This annual

report is intended to inform non-scientists about the most important variables that affect lake health. Until recently, only one indicator of Lake Tahoe's health status was widely used: the annual clarity (often called the Secchi depth, after the instrument used to collect the clarity data). In this report we publish many other environmental and water quality factors that all provide indicators of the lake's condition.

This report sets the context for understanding the changes that are seen from year to year and those that are observed over a time scale of decades: Was Lake Tahoe warmer or cooler than the historical record last year? Are the inputs of algal nutrients to the lake declining? How much are invasive species affecting Lake Tahoe? And, of course, how do all these changes affect the lake's famous clarity?

The data we present are the result of efforts by a great many scientists, students and technicians who have worked at Lake Tahoe throughout the decades since sampling commenced. I would, however, like to acknowledge (in alphabetical order) the contributions of Veronica Alumbaugh, Brant Allen, Nancy Alvarez, Stephen Andrews, Patty Arneson, Sudeep Chandra, Bob Coats, Bill Fleenor, Alex Forrest, Allison Gamble, Charles Goldman, Scott Hackley, Tina Hammell, Alan Heyvaert, Simon Hook,

Debbie Hunter, Peter Hunter, Anne Liston, George Malyj, Dan Nover, Andrea Parra, Kristin Reardon, John Reuter, Bob Richards, Heather Segale, Steve Sesma, Nicole Shaw, Travis Shuler, Todd Steissberg, Collin Strassenburgh, Raph Townsend, Katie Webb and Monika Winder, to this year's report.

Funding for the actual data collection and analysis comes from many sources. While many additional water quality variables could be tracked, funding ultimately limits what we measure. Current funding for the long-term monitoring and analysis is provided by the Lahontan Regional Water Quality Control Board, the Tahoe Regional Planning Agency, the U.S. Forest Service, the U.S. Geological Survey and UC Davis. Our monitoring is frequently done in collaboration with other research institutions and agencies. In particular we would like to acknowledge the U.S. Geological Survey (USGS), the National Aeronautics and Space Administration (NASA), the Desert Research Institute (DRI), and the University of Nevada, Reno (UNR). Some data are also collected as part of research projects funded through a variety of sources. Without these data there are many questions that could not even be asked let alone answered.

This year we are featuring a review of the clarity of Lake Tahoe. Recent trends

in clarity and other key variables are suggesting that the transparency of the lake's water is increasingly being influenced by a new set of factors. While the clarity data alone tells us that things are changing, it is only through the analysis of other data that we can understand what is driving the change in clarity. While there are never enough data to remove all uncertainty, this year more than ever, the value of long term monitoring data should be clear to all.

Part of the cost for the production of Tahoe: State of the Lake Report this year was provided through a gift by the Tahoe Fund. We gratefully acknowledge that gift and the role that private sector giving has to play at Lake Tahoe.

Sincerely,



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## EXECUTIVE SUMMARY

The long-term data set collected on the Lake Tahoe ecosystem by the University of California, Davis, and its research collaborators is an invaluable tool for understanding ecosystem function and change. It has become essential for responsible management by public agencies tasked with restoring and managing the Tahoe ecosystem, in part because it provides a basis for monitoring of progress toward reaching Tahoe's restoration goals and desired conditions.

This annual *Tahoe: State of the Lake Report* presents data from 2010 in the context of the long-term record. While the focus is on data collected as part of our ongoing, decades-long, long-term measurement programs, this year we have also included several detailed sections on lake clarity,

trophic status and progress on the efforts to control Asian clams. Last year's report provided similar detailed information on the expected effects of climate change in the Lake Tahoe Basin during the 21st Century on meteorology, hydrology, sediment and nutrient loading, BMP capabilities, lake mixing and downstream water supply.

This year's report also includes data about changes in the algae composition and concentration, lake clarity, and the current effects of climate change on precipitation, lake water temperature and density stratification. The UC Davis Tahoe Environmental Research Center (TERC) has developed sophisticated computer models that help scientists predict and understand how Lake Tahoe's

ecosystem behaves. Long-term data sets are essential to refine the accuracy of those models and to develop new models as knowledge increases and new challenges arise. In times of rapid change, reliable predictive models are indispensable tools for Lake Tahoe Basin resource managers.

This report is available on the UC Davis Tahoe Environmental Research Center website (<http://terc.ucdavis.edu>).

In many respects 2010 was an average year for Lake Tahoe. From the point of view of weather, precipitation and air temperature were very close to average. More of the precipitation occurred as snow than has been the trend lately, and the spring snowmelt timing was relatively late.

Lake level was very low at the beginning of 2010, but by the end of the year it had risen by over 22 inches. The average surface water temperatures fell from the levels of a few years ago, even in July, the warmest month at Lake Tahoe. As a result, the density stratification of the surface waters, while higher than it had been ten or twenty years ago, was significantly lower than last year. A factor similar to last year was the depth of mixing. This year it only extended to 550 feet, a far cry from the complete mixing that homogenizes water down the entire 1645-foot depth of the lake.

Despite these seemingly "normal" appearances, Lake Tahoe was very different in 2010. The factor that was most different was its famed clarity. The annual

**(CONTINUED ON NEXT PAGE)**

<sup>1</sup>"Previous year" for some parameters means data collated in terms of the water year, which runs from October 1 through September 30; for other parameters, it means data for the calendar year, January 1 through December 31. Therefore, for this 2011 report, water year data are from Oct. 1, 2009 through Sept. 30, 2010. Calendar year data are from Jan. 1, 2010 through Dec. 31, 2010.

## EXECUTIVE SUMMARY

(CONTINUED FROM PAGE 2.1)

average Secchi depth in Lake Tahoe decreased in 2010 by 3.7 feet from last year's value. Such a large interannual rate of change is not remarkable on its own, although the low clarity is unusual. Analysis of the data has shown that underlying the long-term trend in the annual average Secchi depth includes both a general improvement in winter clarity and a continued decline in summer clarity. The annual average is a combination of both these factors.

The improvement in winter clarity may be due to recent efforts to reduce urban stormwater flows to the lake. However, an independent, comprehensive urban stormwater monitoring program is

needed to establish reliable data to substantiate this hypothesis. The decline in summer clarity may be related to the impacts of climate change. Stabilizing of the water column is producing conditions that strongly favor *Cyclotella*, a tiny (4-10 micron) diatom-algae cell. Numbers of *Cyclotella* have grown exponentially in the last four years. This year in particular they were concentrated very close to the surface, thereby having an unusually large impact on clarity. These small cells strongly scatter light, producing lower Secchi disk values. While some of the conclusions presented herein are still working hypotheses, they serve to remind us of the importance of controlling both

inorganic particles and nutrients to Lake Tahoe.

For the first time, clarity data derived from remote sensing are presented. Unlike the regular clarity measurements, remotely sensed data are available over the entire lake. Of particular interest is clarity in the nearshore (one mile or less out into the Lake). The remotely sensed clarity data indicates that clarity on the eastern shore is significantly lower than the west shore for most of the year. It also shows that lake-wide, clarity is typically better at a distance of one mile offshore than at 0.5 miles offshore, highlighting the importance of managing nearshore water quality. This conclusion

is based on eight years of data, and is an important new finding. Differences are currently being studied, but it appears to be closely linked to the patterns of water movements around the lake. While land use activities, resource management activities and policy can be controlled to conform to geopolitical boundaries, the waters of Lake Tahoe are not constrained by these human boundaries. What happens in the waters of Lake Tahoe is a direct reflection of activities in both states. If a concrete example of why Lake Tahoe needs to be managed jointly by the two states is needed, then this is one.

## ABOUT LAKE TAHOE AND THE TAHOE BASIN

- Maximum depth: 1,645 feet (501 meters), making it the 11th deepest lake in the world and 2nd deepest lake in the United States
- Average depth: 1,000 feet (305 meters)
- Lake surface area: 191 square miles (495 square kilometers)
- Watershed area: 312 square miles (800 square kilometers)
- Length: 22 miles (35 kilometers)
- Width: 12 miles (19 kilometers)
- Length of shoreline: 72 miles (116 kilometers)
- Volume of water: 39 trillion gallons
- Number of inflowing streams: 63, the largest being the Upper Truckee River
- Number of outflowing streams: one, the Truckee River, which leaves the lake at Tahoe City, Calif., flows through Truckee and Reno, and terminates in Pyramid Lake, Nev.
- Average residence time of water in the lake: about 600 years
- Average elevation of lake surface: 6,225 feet (1,897 meters)
- Highest peak in basin: Freel Peak, 10,891 feet (3,320 meters)
- Latitude: 39 degrees North
- Longitude: 120 degrees West
- Age of the lake: about 2 million years
- Permanent population: 66,000 (2000 Census)
- Number of visitors: 3,000,000 annually



## ABOUT THE UC DAVIS TAHOE ENVIRONMENTAL RESEARCH CENTER (TERC)

The UC Davis Tahoe Environmental Research Center (TERC) is a world leader in research, education and public outreach on lakes, their surrounding watersheds and airsheds, and the human systems that both depend on them and impact them. TERC provides critical scientific information to help understand, restore and sustain the Lake Tahoe Basin and other lake systems worldwide. We partner closely with other institutions, organizations and agencies to deliver solutions that help protect Lake Tahoe and other lakes around the world.

TERC's activities are based at permanent research facilities in the Tahoe Basin and at the University's main campus in Davis, California, about 90 miles west of the lake.

Our main laboratories and offices

are in Incline Village, Nevada, on the third floor of the Tahoe Center for Environmental Sciences building. On the first floor, we operate the Thomas J. Long Foundation Education Center, a learning resource that is free and open to the public.

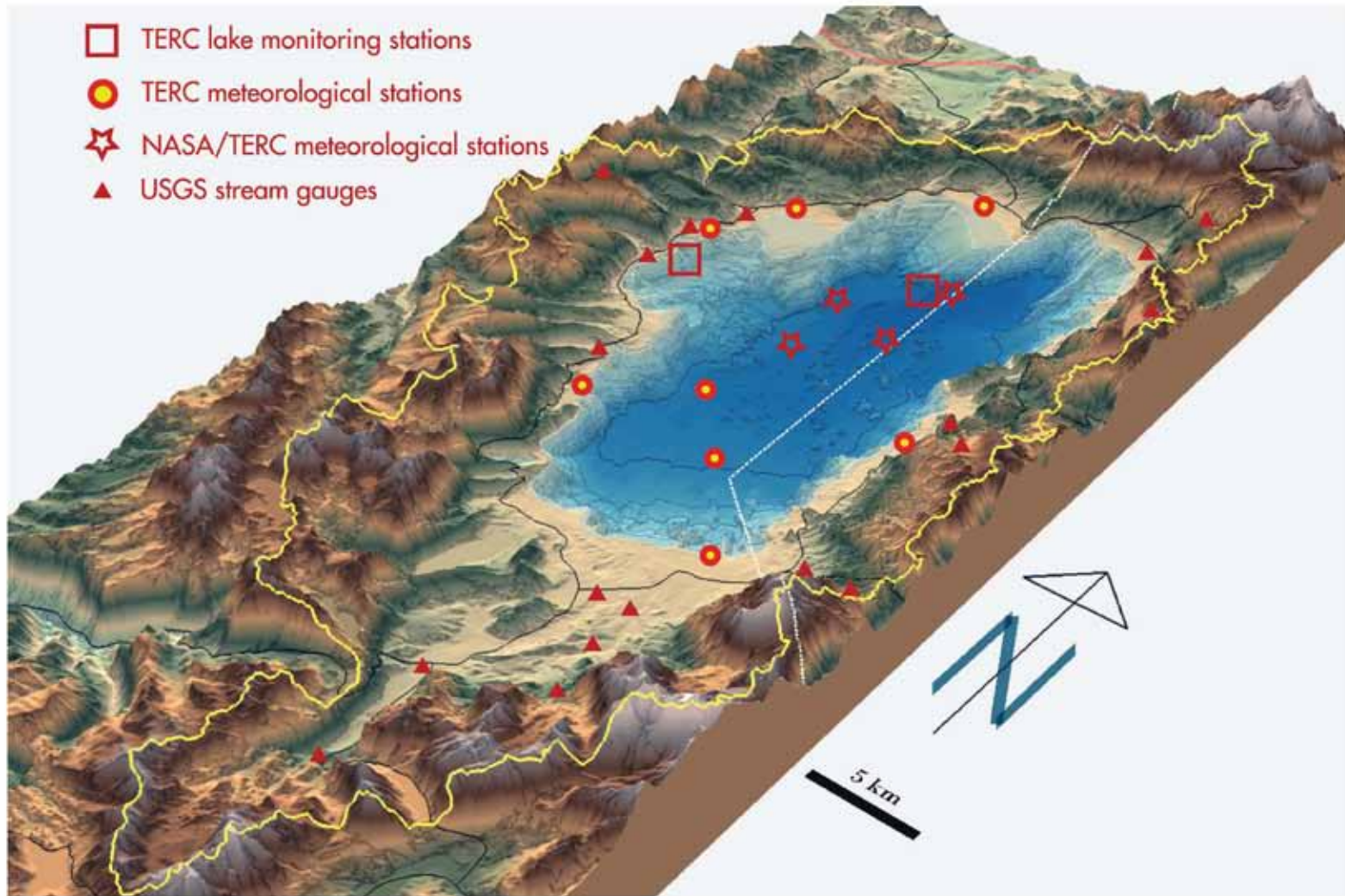
In Tahoe City, Calif., we operate a field station (housed in a fully renovated, former state fish hatchery) and the Eriksson Education Center (opened in July 2010). Tahoe City is also the mooring site for our three research vessels, the John LeConte, the Bob Richards and the Ted Frantz.

Our secondary laboratories and offices are located on the UC Davis campus at the Center for Watershed Sciences.

Our website ([terc.ucdavis.edu](http://terc.ucdavis.edu)) has more information about our programs, including:

- Information for potential students, staff, faculty, and research collaborators;
- Access to near-real-time meteorological data gathered by our network of sensors;
- A list of publications;
- Exhibits and events at the Education Centers; and
- Information about supporting our research and teaching programs.

## MAP OF TAHOE BASIN DATA COLLECTION SITES



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2011

**RECENT RESEARCH  
UPDATES**

## RECENT RESEARCH UPDATES

### Overview

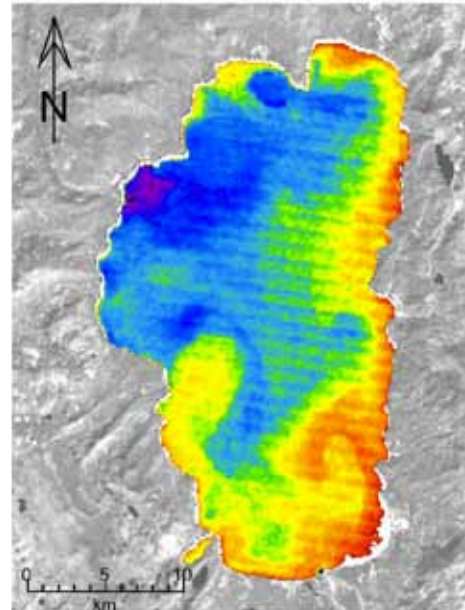
Each year different research areas emerge as the most topical in the State of the Lake Report. In past years we have focused on topics such as the Angora Fire, Climate Change, and the emergence of Asian clams as a major threat to Lake Tahoe's ecosystem. This year we are stepping back and looking at clarity, the issue

that has most symbolized Lake Tahoe in the eyes of the world. The recent changes in lake clarity highlight the complexity of natural systems, and the extent to which monitoring is needed to understand and best protect our natural resources. As a result of the SNPLMA science grant, we are able for the first time to present

clarity information from all around the lake. We also introduce the concept of the "trophic status" of the lake. Finally, we provide an update on the continuing efforts of researchers and agencies toward controlling the spread of Asian clams.



The Secchi disk has been used to measure clarity at Lake Tahoe since 1968 with measurements taken every 10-14 days



Satellite images of Lake Tahoe showing areas of different water temperature



Asian clams (*Corbicula fluminea*)

**RECENT RESEARCH UPDATES: CLARITY**

**Lake Tahoe clarity 1968 - 2010**

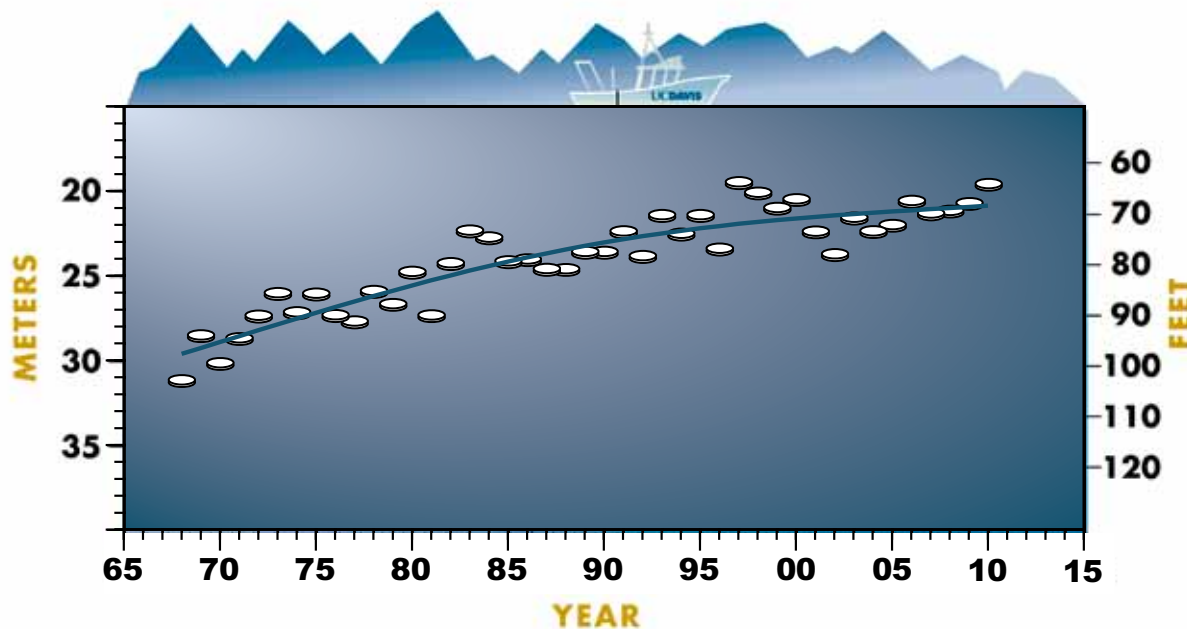
2010 was a low year (less clear) for annual average Secchi depth, with the depth of 64.4 feet measured from the surface being the second lowest ever recorded (the lowest was 64.1 feet in 1997). It represents a decrease of 3.7 feet from the previous year. It is important to understand the possible causes and to see what they tell us about past actions and future investments. Long-term monitoring data, such as that summarized in the State of the Lake Report, provides

part of the information needed, but not all. Some of the critical knowledge gaps are in the monitoring of urban stormwater flows, where an independent and comprehensive monitoring program needs to be established to evaluate the status and trends of this important source of fine sediment and nutrients.

Even though 2010 was less clear, the overall trend of a slowing decline in clarity continues. Looking at

the long-term record, interannual clarity changes of this magnitude are common. Over 50 percent of the 43 years with Secchi depth measurements have seen interannual differences (both positive and negative) in excess of this year's change. Insights into the status and trends of lake transparency are evident by examining both the long-term winter and summer Secchi depth values as well as the individual Secchi depths for recent years.

**ANNUAL AVERAGE SECCHI DEPTH**



## RECENT RESEARCH UPDATES: CLARITY

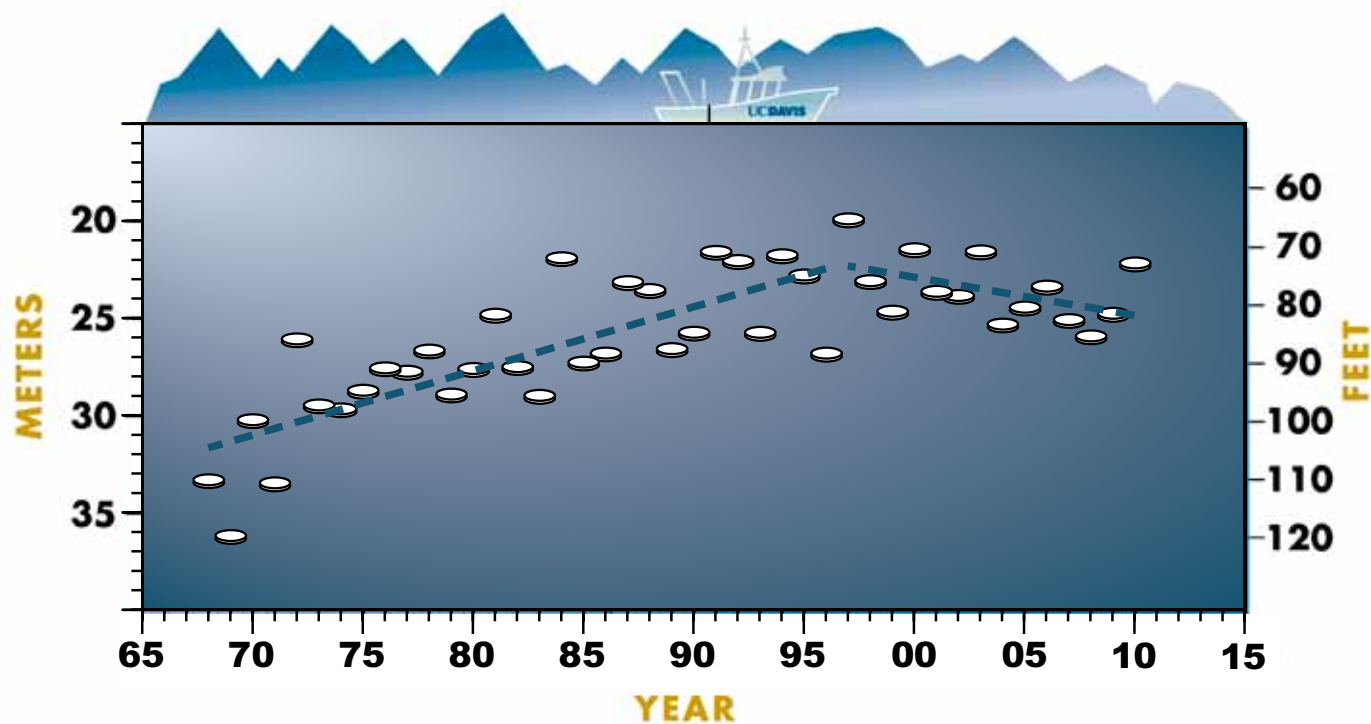
### Winter clarity

Annual winter (December-March) Secchi depth measurements from 1968 to the present indicate that the long-term decline in winter clarity at Lake Tahoe is beginning to show an improvement (dashed lines). The

reasons behind this are not fully understood. One hypothesis is that there has been a reduction in the load of fine particles from urban stormwater. Urban stormwater is the largest source of fine particles to Lake

Tahoe, and generally enters the lake in winter. A comprehensive, regional urban stormwater monitoring plan is needed to determine if recent capital investments in stormwater projects have indeed reduced these loads.

WINTER SECCHI DEPTH



## RECENT RESEARCH UPDATES: CLARITY

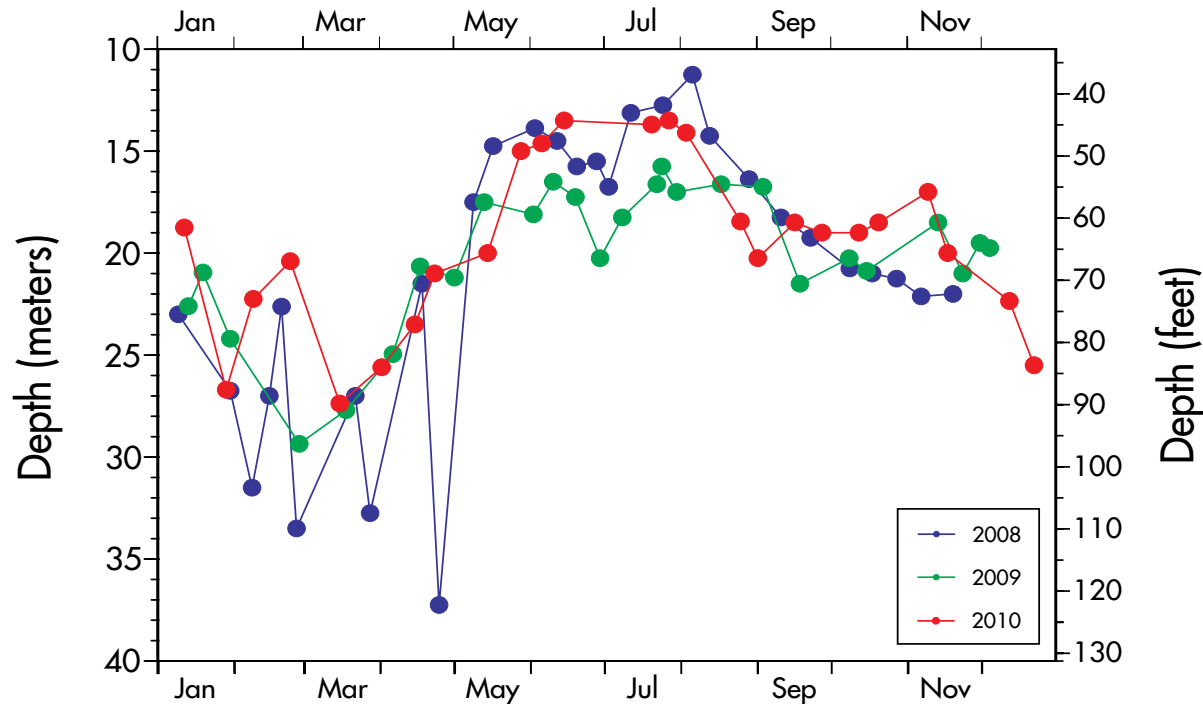
### Winter clarity, continued

Of the last three years, 2008 had the greatest winter Secchi depths, with two measurements in February exceeding 97 feet, the California water quality standard. These high clarity events are the result of circulation patterns called “upwellings”, when westerly winds cause clear bottom water to rise up to the surface. In early spring of 2008

there were two additional upwelling events. By contrast, 2010 had no upwelling events that affected the annual average measurement.

A second factor in the lower (less clear) winter clarity in 2010 was the absence of deep mixing (see Page 8.9). In 2010, the lake only mixed to a depth of 550 feet, slightly less than

the 700 feet that occurred in 2009 and considerably less than the complete 1,645 foot mixing that occurred in 2008. The deeper the mixing, the greater is the dilution of the upper waters, leading to improved winter clarity. The two low Secchi depth measurements in February-March 2010 are likely a consequence of the lack of deep mixing.



## RECENT RESEARCH UPDATES: CLARITY

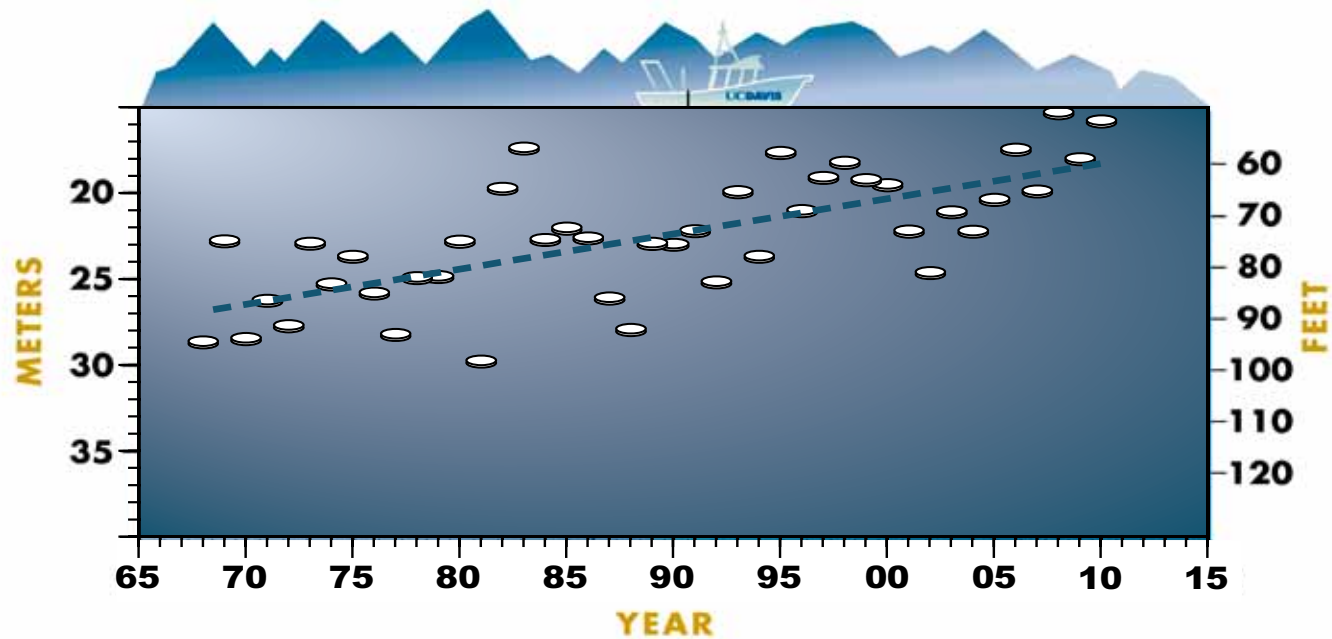
### Summer clarity

Summer clarity in Lake Tahoe in 2008 and 2010 were the lowest values ever recorded (50.4 feet and 51.9 feet respectively). Unlike the winter clarity pattern, where there is a long-term trend of declining and then improving clarity, the summer trend

is dominated by a consistent long-term decline (dashed line) but with a noticeable 10-15 year cyclic pattern. This is clearly visible in 1968-1983, 1984-1997 and 2000-2010. For about the last decade there has been a near-continuous decline in summer clarity.

The reasons behind this periodicity are being investigated, however, there is some evidence pointing towards a possible cause of the most recent decline.

SUMMER SECCHI DEPTH





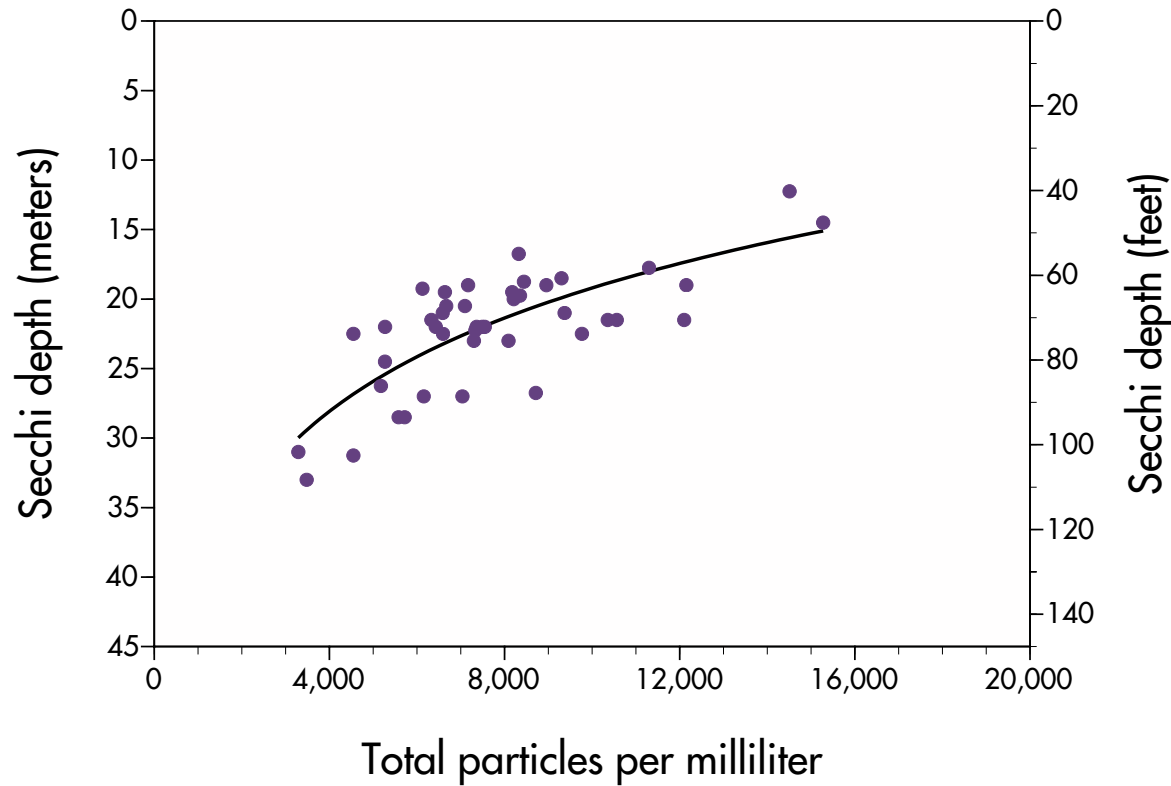
**RECENT RESEARCH UPDATES: CLARITY**

**Summer clarity, continued**

As our research has shown, increasing concentrations of fine particles is one of the principal factors affecting Lake Tahoe's clarity. While light

scattering by fine inorganic particles introduced by urban stormwater is a major concern, the production of algal cells, and especially diatoms that

both scatter and absorb light, is also important. The presence of excess nutrients is a factor that will influence their abundance.



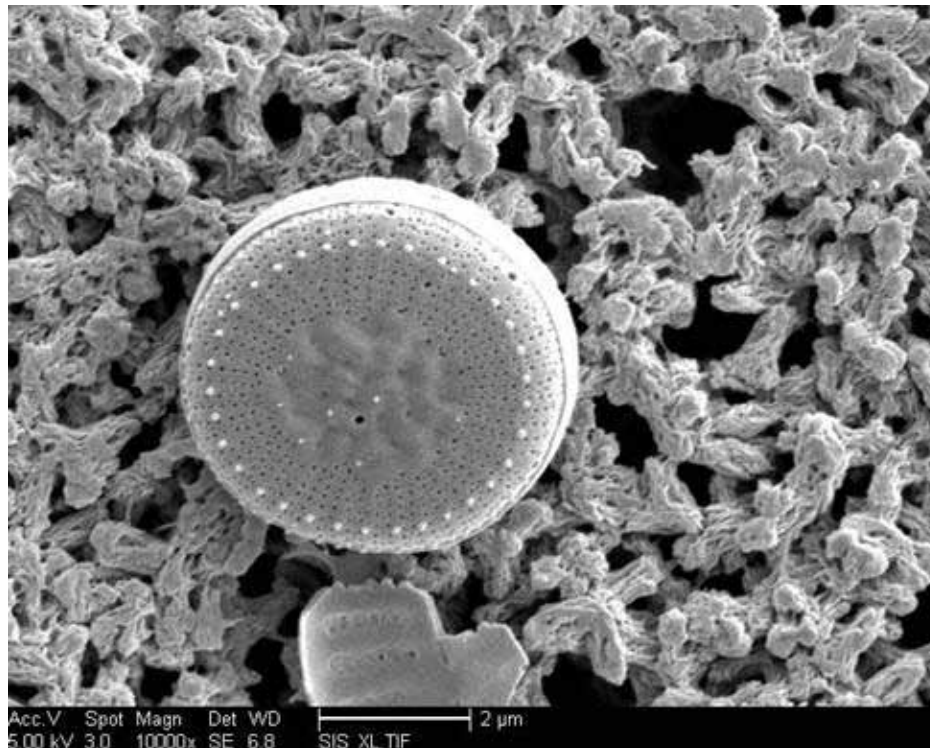
## RECENT RESEARCH UPDATES: CLARITY

### Summer clarity, continued

Approximately one third of all the particles close to the surface in summer 2010 were in fact algal cells, dominated by the small, centric diatom *Cyclotella gordonensis* (see image below). Cells ranged from 4-10  $\mu\text{m}$  in diameter, within the maximum scattering range for visible light. The peak abundance was in

the upper 16 feet of the water column but the population extended down to greater depths. The abundance of *C. gordonensis* was remarkable, with cell counts of over 6,000 cells per milliliter (mL). In a sample from the 16 foot depth, *C. gordonensis* accounted for 99 percent of the algae present. The dominance of this

diatom species during July 2010 was not unique nor without precedence. In July 2009 a similar event occurred, but the algae were concentrated deeper in the water column and therefore did not affect the Secchi depth readings as much.



*Cyclotella gordonensis*  
dominated particles  
sampled in summer 2010

**RECENT RESEARCH UPDATES: CLARITY**

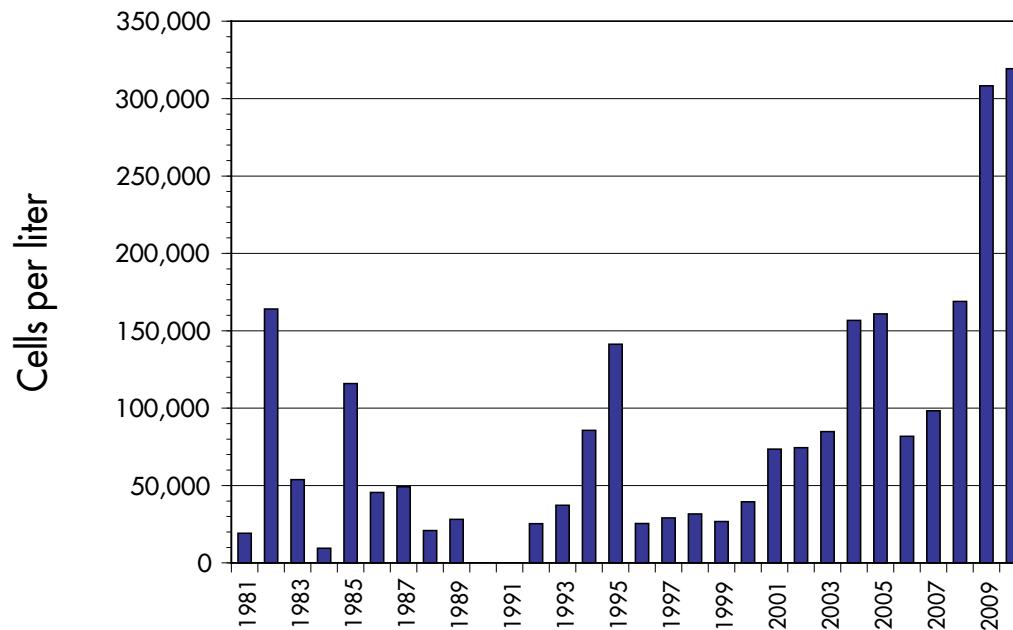
**Summer clarity, continued**

It is reasonable to ask why there is this recent increase in small diatoms. In a recent paper, (Winder, M., Reuter, J. E. and Schladow, S. G. 2009. "Lake warming favors small-sized planktonic diatom species". Proc. Royal Society B. 276, 427-435.), it was argued that climate change was warming and stabilizing the upper waters in Lake Tahoe (see Page 8.8). The greater the density

difference between shallow and deep water, the greater is the resistance to mixing. This physical phenomenon in turn imparts a competitive advantage to the smallest algal species, such as the diatom *Cyclotella*, that sink slowly and therefore can stay suspended in the light for a long period of time.

The increase in the annual average

numbers of *Cyclotella* from 1982 to 2010 in the upper 100 m of Lake Tahoe are plotted below. While high values occur in several years through the record, there is a clear upward trend from about 2000, coinciding with the start of the most recent period of decline in summer clarity.



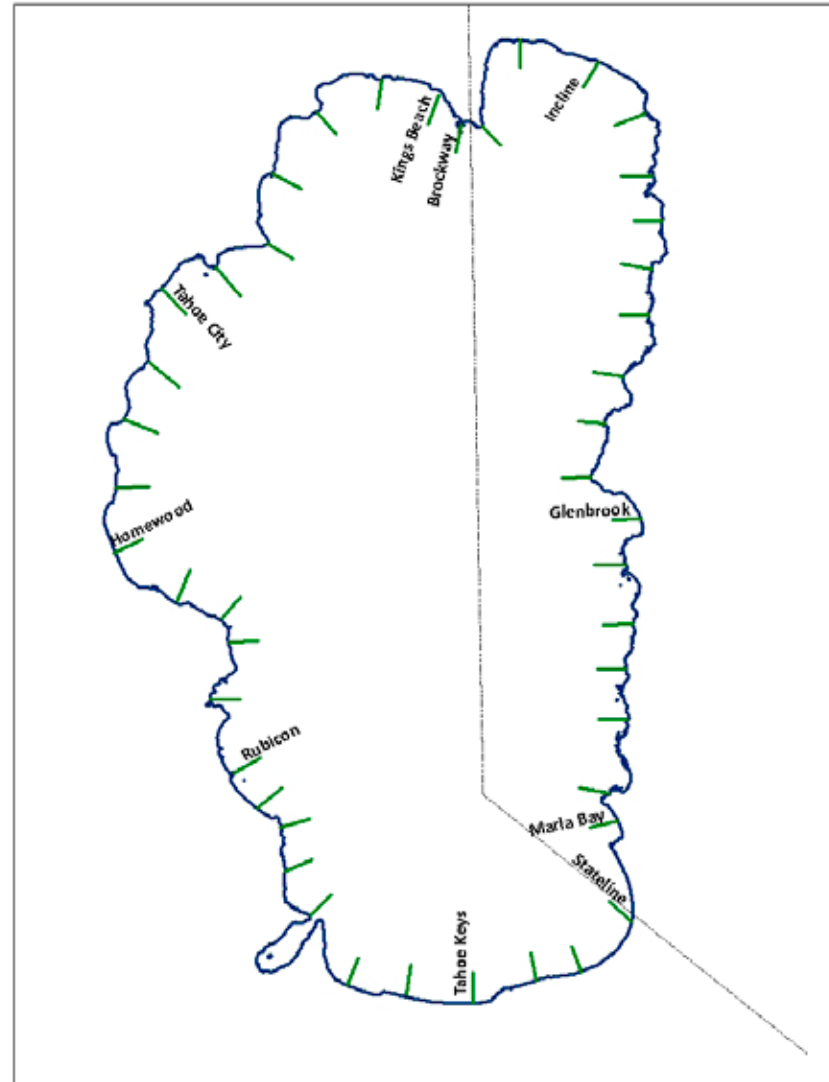
## RECENT RESEARCH UPDATES: CLARITY

### Spatial variations in clarity

TERC and NASA recently completed a study (funded through the Southern Nevada Public Lands Management Act) to demonstrate the use of Remote Sensing for measuring water quality at Lake Tahoe. The advantages of remote sensing are that it allows collection of data on every cloud-free day, and it measures everywhere on the lake. These data were used to create estimates of water clarity close to the shoreline over a yearly cycle.

The lines around the edge of the map show the locations of 45 “virtual” monitoring points around the shoreline where clarity was calculated using remotely sensed data. To quantify the annual cycle of the distribution and changes of nearshore water quality, the combined average monthly Secchi Depth measured by the MODIS satellite at 0.5 miles and 1.0 miles from the shoreline were computed for the period 2002 – 2010.

To see the full report visit <http://terc.ucdavis.edu/publications/publications.html>.



## RECENT RESEARCH UPDATES: CLARITY

### Spatial variations in clarity, continued

The monthly graphs highlight the variation of Secchi depth around the lake, the improvement in clarity as you move from near the shore (0.5 miles) to away from shore (1.0 miles), and the annual cycle of variation in the water clarity.

Generally for all times of year and for all locations, there is an improvement in clarity as one moves away from shore. This is most evident outside of winter, as for example in the periods April through September. The greater site-to-site variability displayed in the near shore (0.5 miles from shore) record is a reflection of the contribution from local sources such as streams and urban runoff.

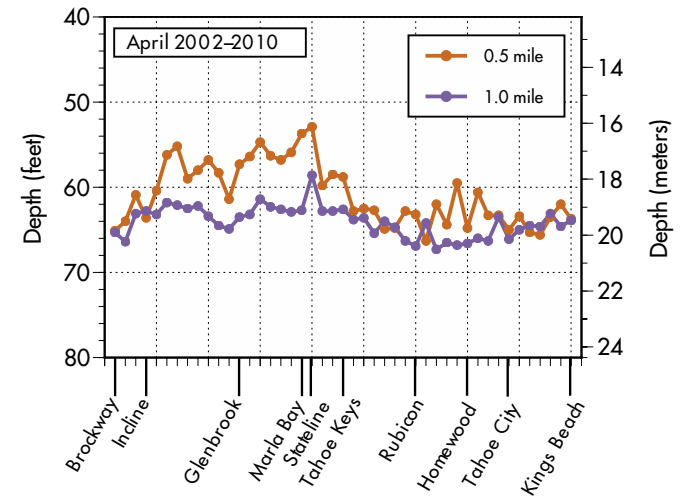
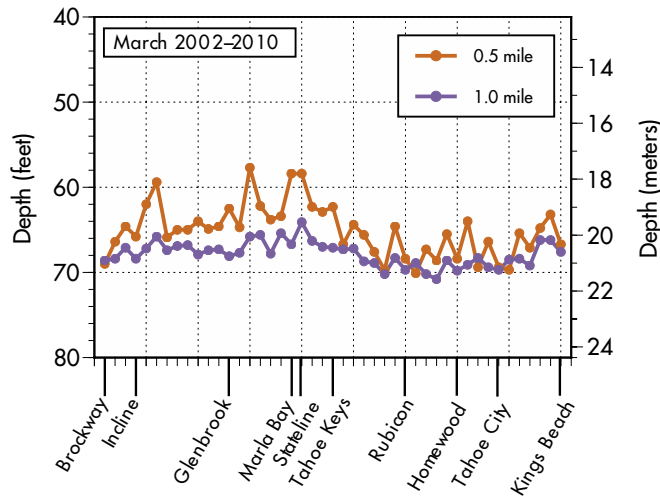
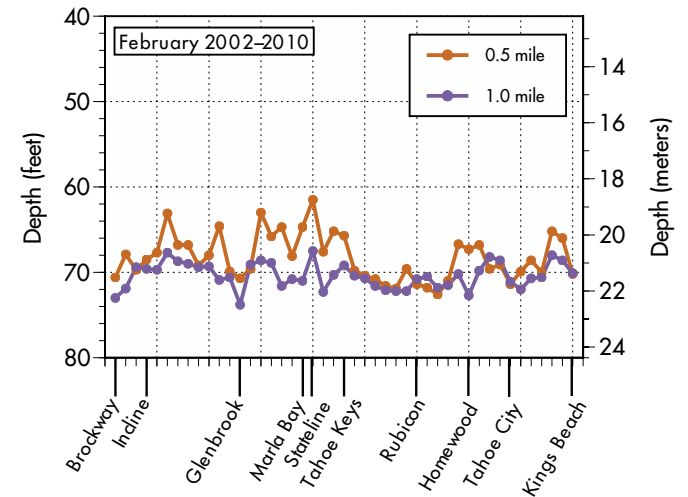
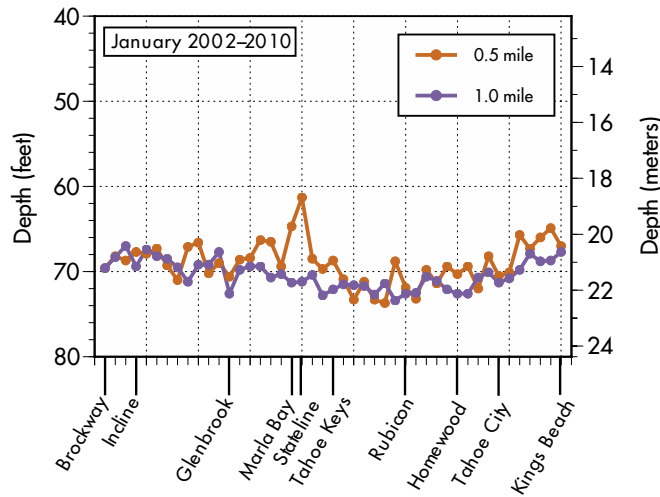
Winter clarity, December through March, is typically the highest. At this time of year the clarity is most uniform around the lake, with typical values being in the range of 65 to 70 feet (20 to 22 m).

The most startling revelation in the data is the spatial variation in nearshore clarity as we move around the shoreline. The eastern side of the lake, particularly from Stateline Point in the north to the eastern end of South Lake Tahoe, consistently shows the lowest Secchi depth values (lowest transparency). Looking, for example, at the plots for May and June, the region from just south of Glenbrook to Stateline has nearshore Secchi depths in the range of 45 feet to 53 feet (14 to 16 m) compared to values of 60 feet to 63 feet (18 to 19 m) around Rubicon in California.

The causes of these spatial differences are currently being studied, but it appears to be closely linked to the patterns of water movements around the lake. What happens in the waters of Lake Tahoe is a direct reflection of activities in both states. If a concrete example of why Lake Tahoe needs to be managed jointly by the two states is needed, then this is one.

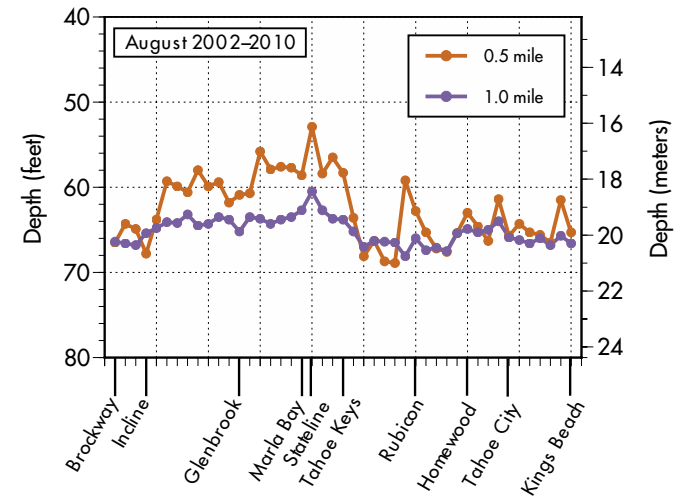
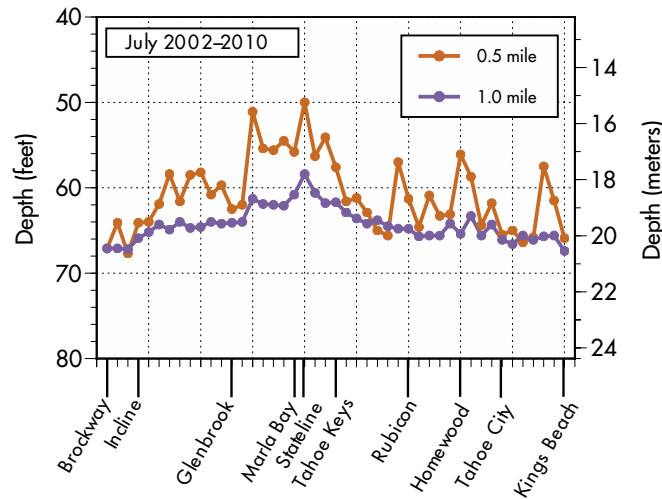
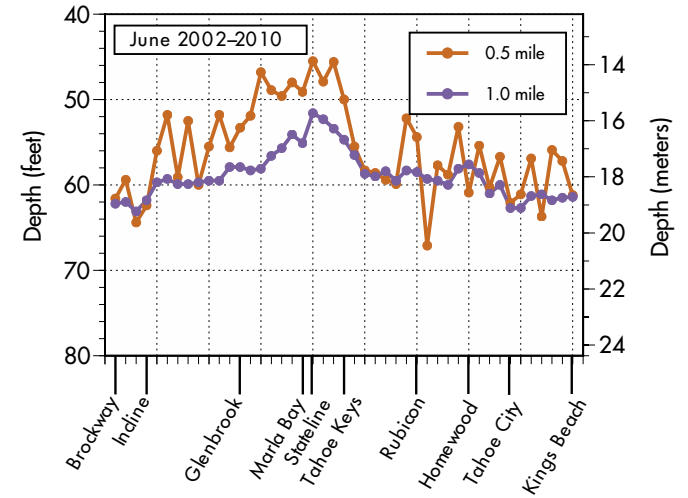
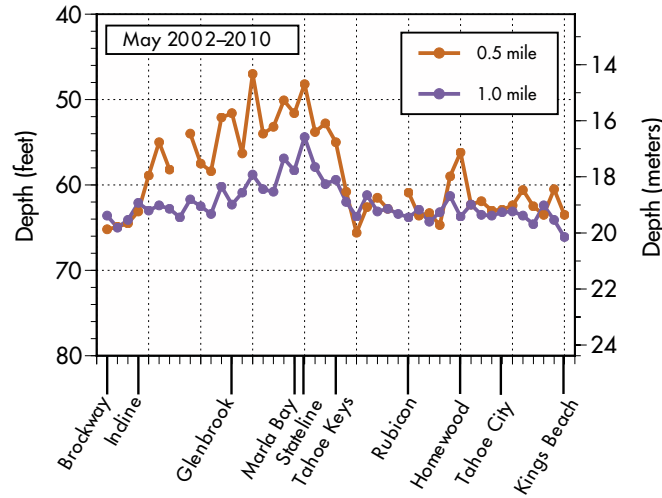
## RECENT RESEARCH UPDATES: CLARITY

### Spatial variations in clarity: January - April



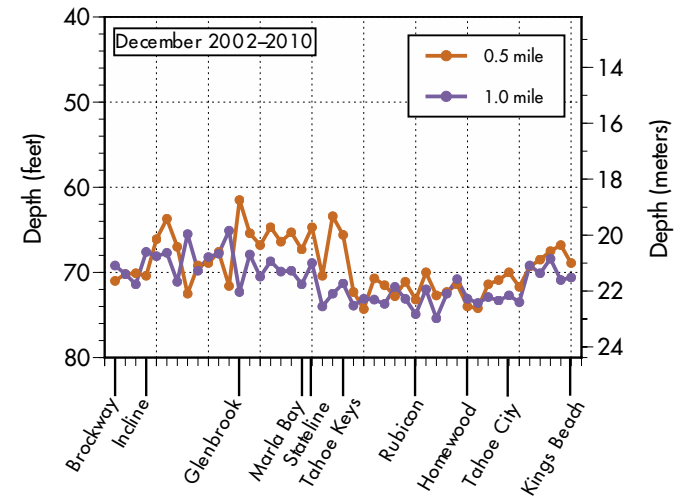
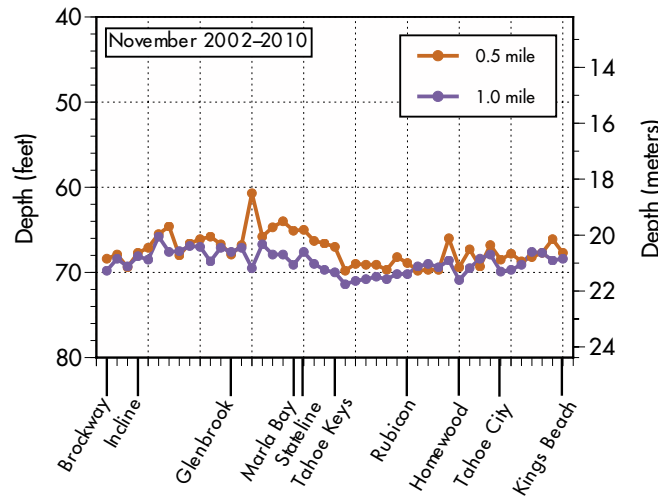
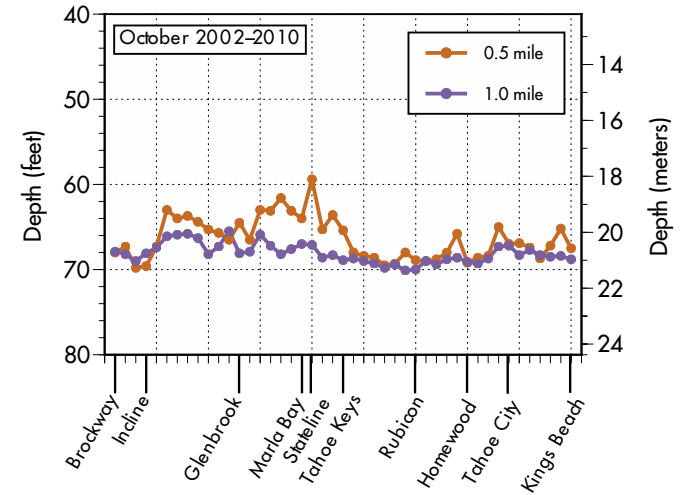
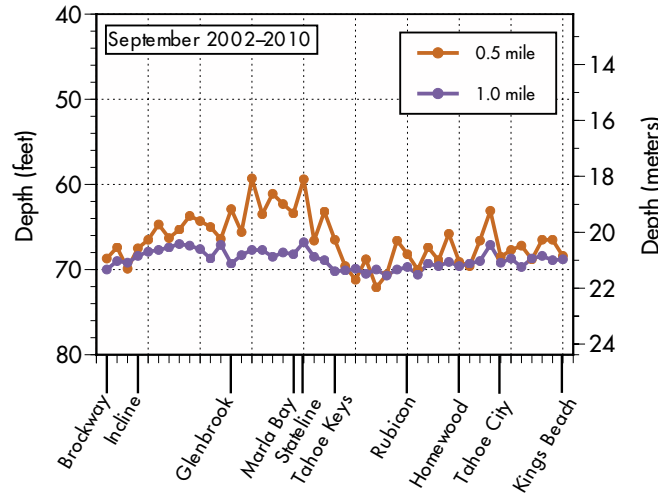
**RECENT RESEARCH UPDATES: CLARITY**

## Spatial variations in clarity: May - August



**RECENT RESEARCH UPDATES: CLARITY**

## Spatial variations in clarity: September - December





## RECENT RESEARCH UPDATES: CLARITY

### Clarity summary

- The annual average Secchi depth in Lake Tahoe declined in 2010 by 3.7 feet from last year's value. Such a large interannual rate of change is not unusual, although the low clarity is unusual.
- Underlying the trend in the annual average Secchi depth is both a general improvement in winter clarity and a continued decline in summer clarity. The annual average is a combination of both these factors.
- The improvement in winter clarity may be due to recent efforts to reduce urban stormwater flows to the lake, however, comprehensive data on urban stormwater loads to the lake are needed to substantiate this.
- The decline in summer clarity may be related to the impacts of climate change, in stabilizing the water column. This is producing conditions that strongly favor small diatom-algae cells very close to the surface. These strongly scatter light producing lower Secchi disk values.
- While some of the conclusions presented herein are still working-hypotheses, they highlight the importance of controlling both inorganic particles and nutrients to Lake Tahoe.
- Remote sensing of the nearshore indicates that clarity on the eastern shore is significantly lower than the west shore for most of the year.
- Long-term monitoring data is essential to be able to both track progress toward improved clarity and to understand the changing conditions.

The trajectory of the Secchi depth curve into the future is uncertain. The investment to date in water quality control projects cannot be underestimated. Reduction in nutrients and fine sediment load is clearly in the best interest of lake clarity. There is every reason to believe that if it were not for the decades of watershed management, development policy and water quality restoration projects, the Lake's transparency would be worse than it is today.

## RECENT RESEARCH UPDATES: TROPHIC STATUS

### Lake Tahoe's trophic status

The term *trophic status* defines lake condition based on biological productivity - where a lake lies along a continuum between extremely pristine to choked with excessive plant growth.

Three general categories of trophic status are commonly used: oligotrophic, mesotrophic and eutrophic. Lake Tahoe is classified as oligotrophic, implying clear water, containing few nutrients with little algae and rooted-plant life, rich in dissolved oxygen, and supporting a healthy diversity of fish and other

aquatic animals. Oligotrophic lakes are typically deep with rocky or sandy shorelines, with limited land disturbance or urbanization in its drainage basin. Ultra-oligotrophic status is reserved for those lakes that are nearly pristine.

Eutrophic lakes are usually shallow, biologically productive with murky green water, high levels of nutrients and algal growth, oxygen-free conditions in deep water during the summer, and occasional fish-kills due to a lack of oxygen. The bottom

sediment in eutrophic lakes is typically rich in thick, organic ooze and at times there can be odor problems and algal blooms that cover the surface and can release toxic compounds into the water.

Mesotrophic lakes lie in between oligotrophic and eutrophic lake and are characterized by moderate levels of nutrients and algae. During the summer, the deep water can lose its oxygen thereby limiting cold-water fish. Mesotrophic lakes are usually good lakes for fishing.



Oligotrophic Lake Tahoe



Eutrophic Lake Erie

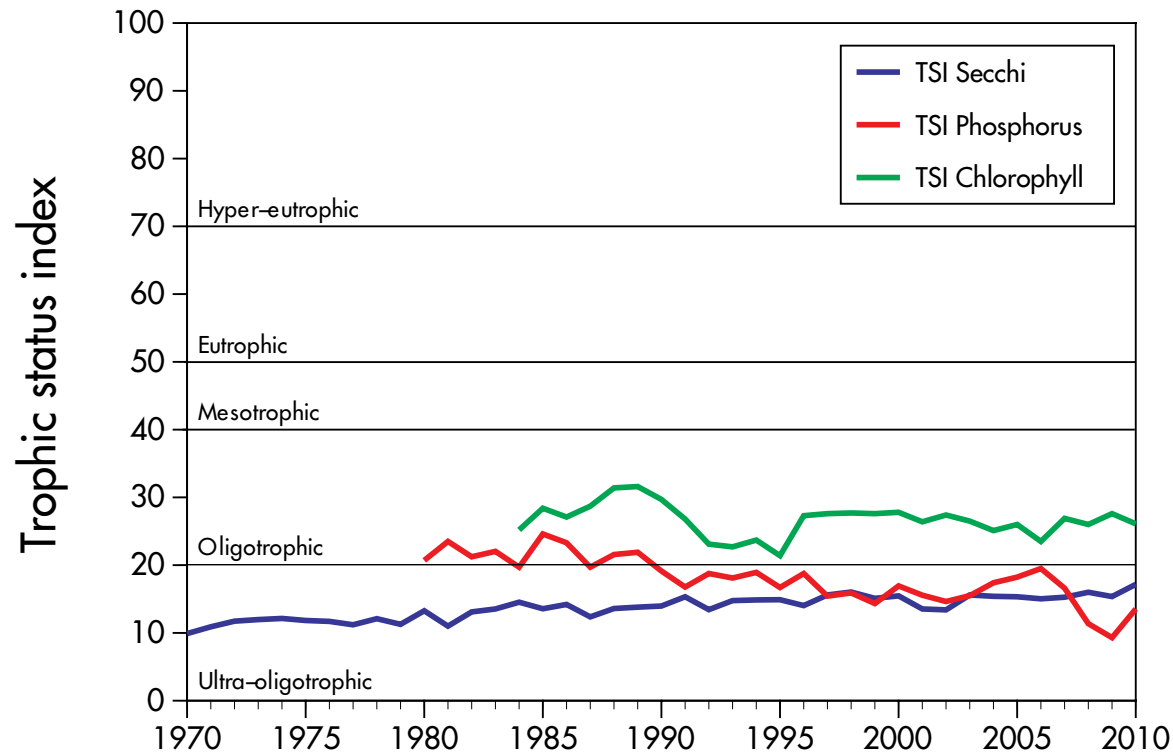
## RECENT RESEARCH UPDATES: TROPHIC STATUS

### Trophic status, continued

To make the determination of lake trophic status more objective, Dr. Robert Carlson (Kent State University) developed a multi-parameter numeric trophic status index (TSI). TSI values range from 0 to greater than 100, with each 10

units representing either a doubling or halving of a particular parameter. Trophic status indexes for Lake Tahoe from 1970 to the present, based on Secchi depth, phosphorus and chlorophyll are shown, along with the demarcation between different

trophic states. During this time Lake Tahoe's trophic status has decreased on the basis of clarity (Secchi depth), while it has actually improved for phosphorus, and stayed similar based on chlorophyll concentration.



## RECENT RESEARCH UPDATES: AQUATIC INVASIVE SPECIES

### Asian clams

In spring 2008 UC Davis researchers discovered extensive beds of an invasive bivalve, the Asian clam (*Corbicula fluminea*), in the nearshore of Lake Tahoe along the southeastern edge of Lake Tahoe. Clam densities reach over 6,000 per square meter and

are among the highest anywhere in the world. In Lake Tahoe Asian clams can affect plankton levels and food webs, outcompete native species, and cause attached algae to form nuisance blooms.



Researcher Marion Wittmann measures Asian clam shells from Lake Tahoe. In Lake Tahoe the Asian clams grow to be as large as 28 millimeters, but in other warmer systems can be as large as 55 mm. They are found in Lake Tahoe at water depths of 5 to 100 feet (2 to 30 meters), and within the sediments buried in up to 7 inches below the surface.



Lake Tahoe underwater landscape without non-native Asian clam invasion



Lake Tahoe underwater landscape following non-native Asian clam invasion. Dead clam shells rise to the surface of the sediment and clam densities below the surface can reach over 6,000 clams per square meter. Green filamentous algae (*Zygnema* and *Chladophora*) blooms above the clam beds.

## RECENT RESEARCH UPDATES: AQUATIC INVASIVE SPECIES

### Asian clams: 2009 small-scale experiment

In 2009 a small-scale experiment to manage Asian clams showed that laying rubber bottom barriers on the lake sediment resulted in a dramatic reduction in clam density within a

month after its installation. This is a new method that was developed in Lake Tahoe by UC Davis and University of Nevada Reno scientists in close collaboration with resource

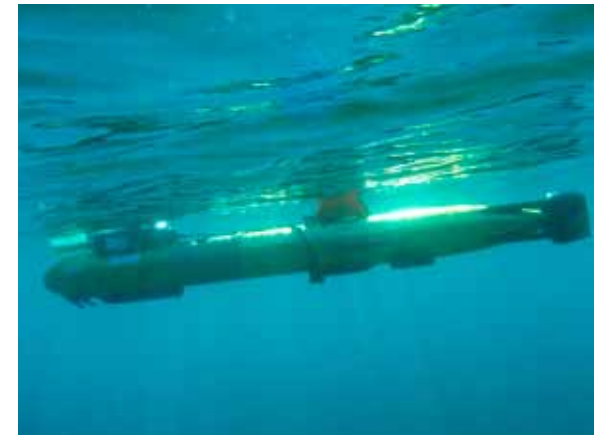
managers including the Tahoe Regional Planning Agency, the Tahoe Resource Conservation District and the US Fish and Wildlife Service and others.



10-foot by 10-foot rubber bottom barriers were tested as a strategy for managing Asian clam populations



Researchers sampled Asian clam densities before and after rubber bottom barrier experiment



Autonomous Underwater Vehicle (AUV) is used to map clam beds around Lake Tahoe

## RECENT RESEARCH UPDATES: AQUATIC INVASIVE SPECIES

### Asian clams: 2010 large-scale experiment

In the summer of 2010, two sets of half-acre barriers were installed to test whether large-scale application of this experimental method is a feasible option. The bottom barriers were installed in Marla Bay, NV, and Lakeside, CA, and consisted of 20 rolls of 10 foot wide and 100 foot long high density polyethylene.

The installation and removal of

large areas of bottom barriers was found to be practical using SCUBA and specially engineered equipment operated from a working barge. Asian clams populations in treated areas were reduced by 98%, while native bottom dwelling invertebrates were reduced by 96%. The time it takes for Asian clams to recolonize the treated areas is currently being studied; this knowledge will determine the true

treatment costs and influence long-term management strategy decisions. This new technique was transferred to lake managers at Lake George, NY, where bottom barriers were deployed to treat a large Asian clam infestation in 2011. This is yet another example of where science at Lake Tahoe is having an impact nationally and globally.



Release mechanism on barge helps researchers to lower barriers into water



UC Davis scientists roll out bottom barriers on the lake bottom



The large (one-half acre) bottom barrier deployed in Marla Bay is visible from the air

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**METEOROLOGY**

## METEOROLOGY

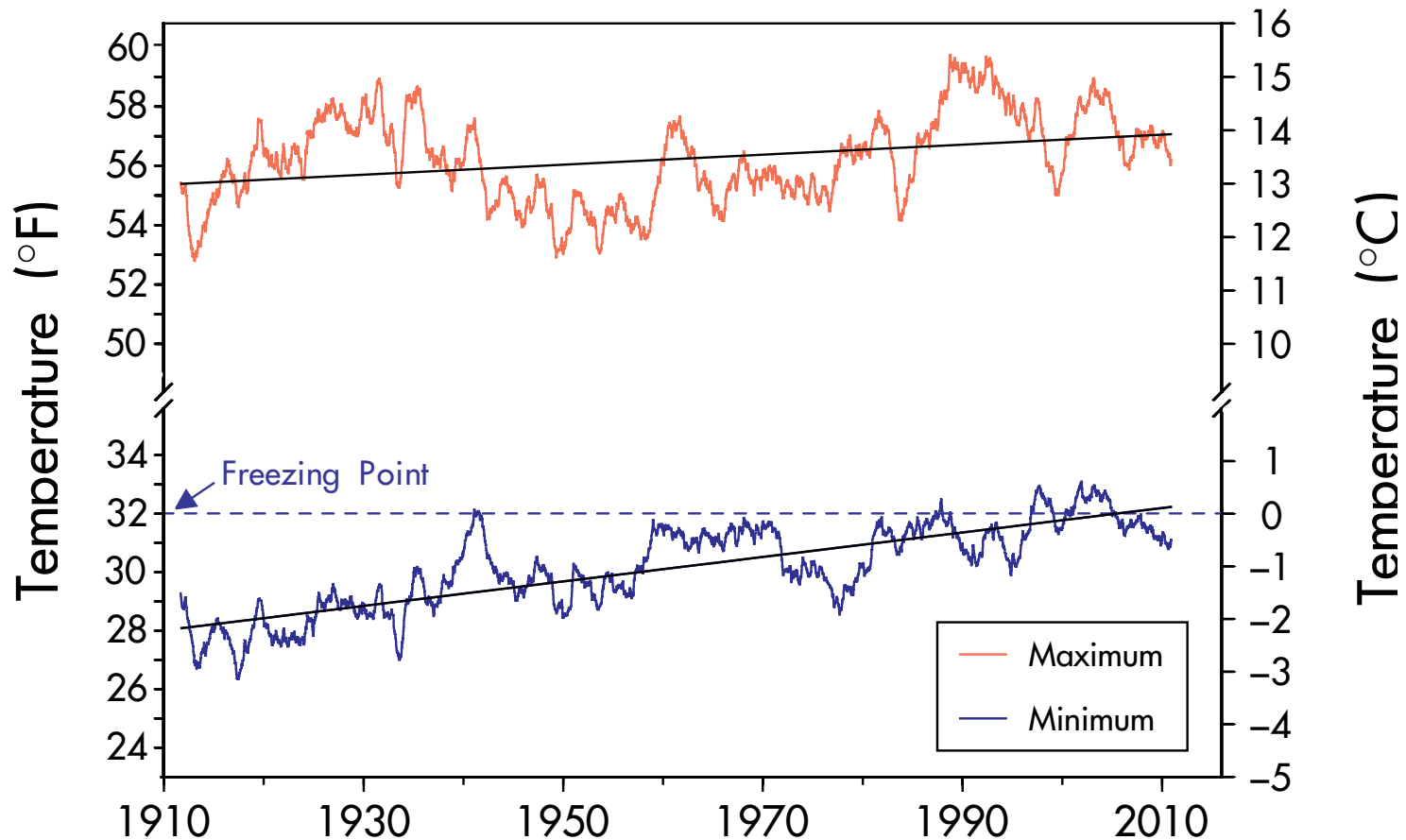
### Air temperature

Daily since 1911

Daily air temperatures have increased over the 99 years measured at Tahoe City. The trend in daily minimum temperature has increased by more than 4 degrees F. (2.2 degrees C),

and the trend in daily maximum temperature has risen by less than 2 degrees F. The average minimum air temperature now exceeds the freezing temperature of water, which points

to more rain and less snow, as well as earlier snowmelt. These data have been smoothed by using a two-year running average to remove daily and seasonal fluctuations.





## METEOROLOGY

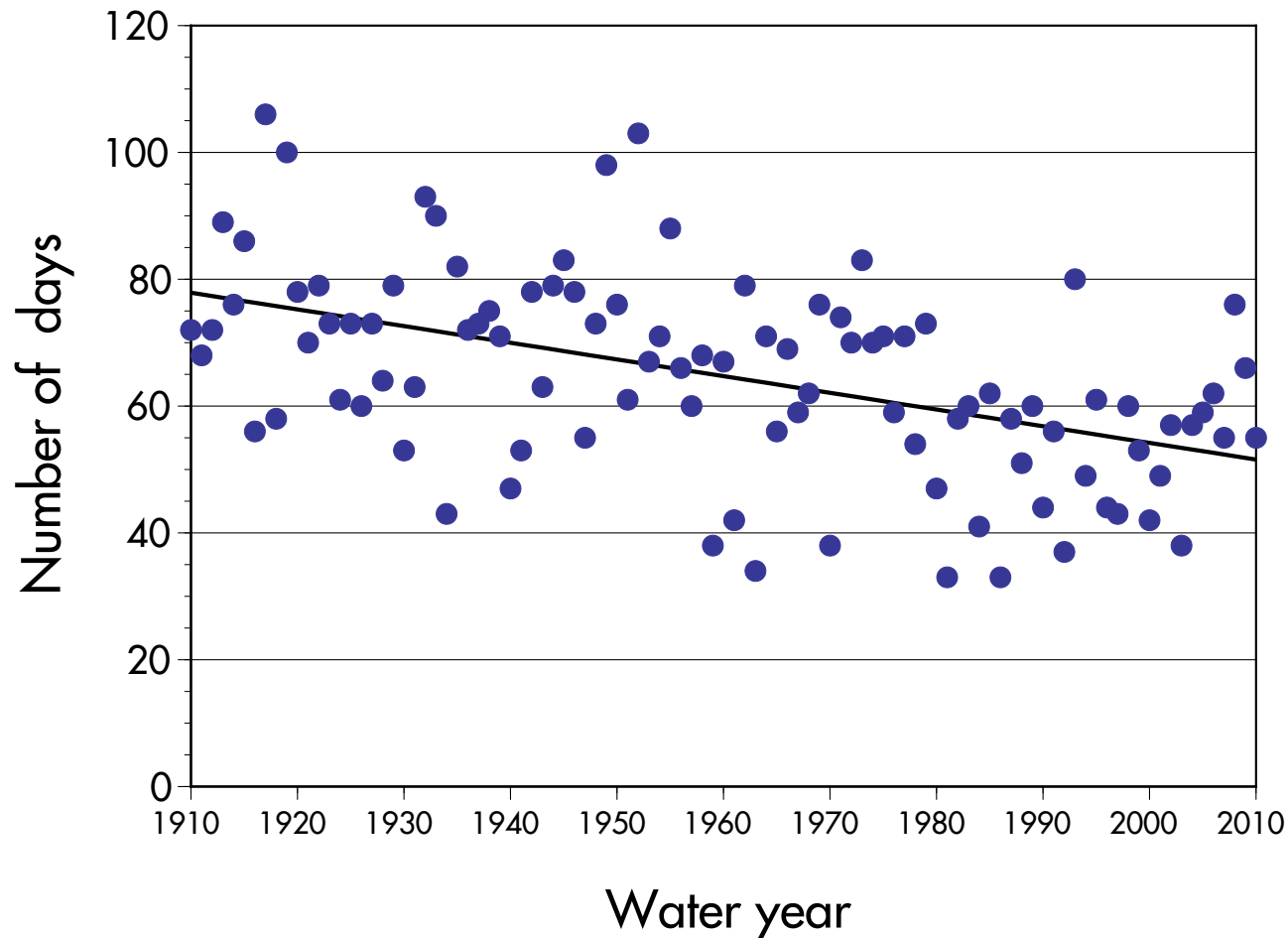
### Below-freezing air temperatures

Yearly since 1910

Although year-to-year variability is high, the number of days when air temperatures averaged below freezing

(32 degrees F) has declined by about 30 days since 1911. In 2010, the number of freezing days was slightly

above the long-term trend at 55 days.



## METEOROLOGY

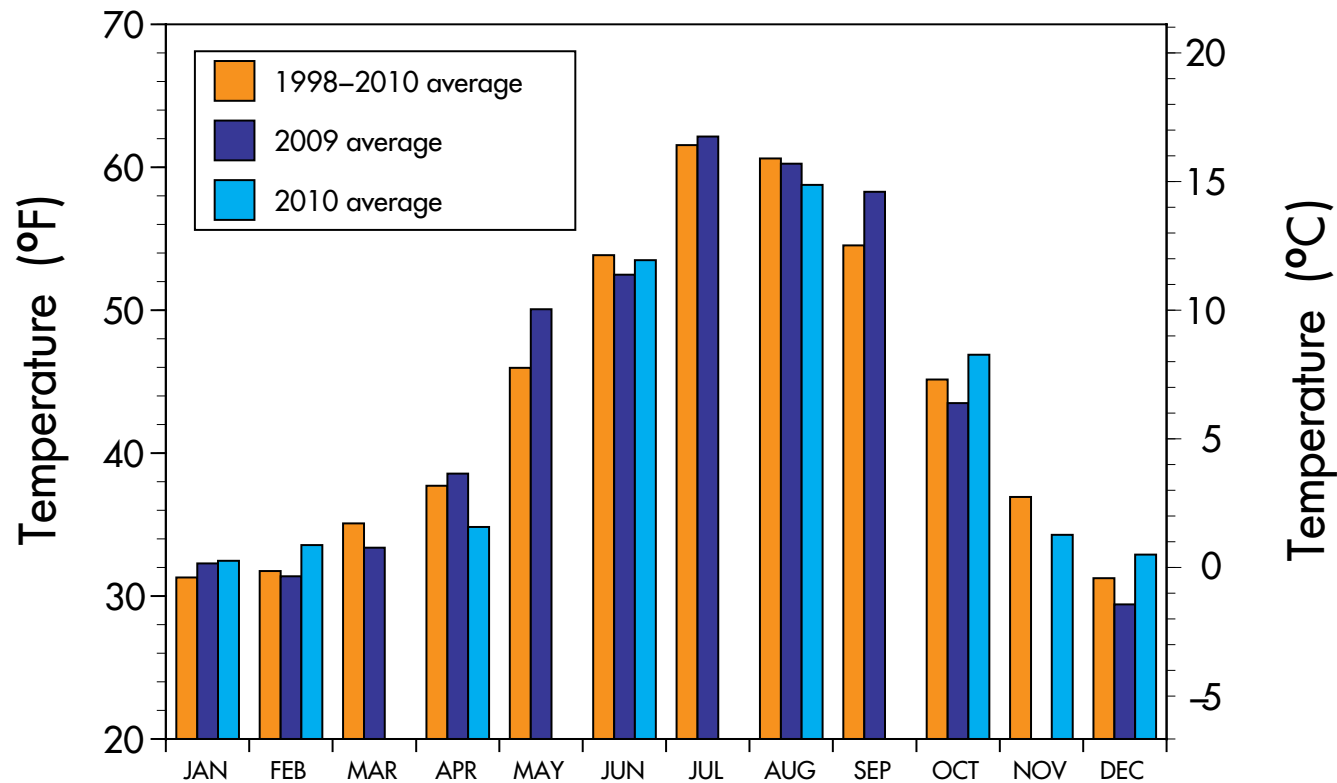
### Monthly air temperature

Since 1998

In 2010, January, February, October and December were warmer than either the previous year or the twelve-year

average. The months of April, and August were cooler than the previous year and the twelve-year average.

Missing bars represent months where there was insufficient data to calculate a representative monthly average.



## METEOROLOGY

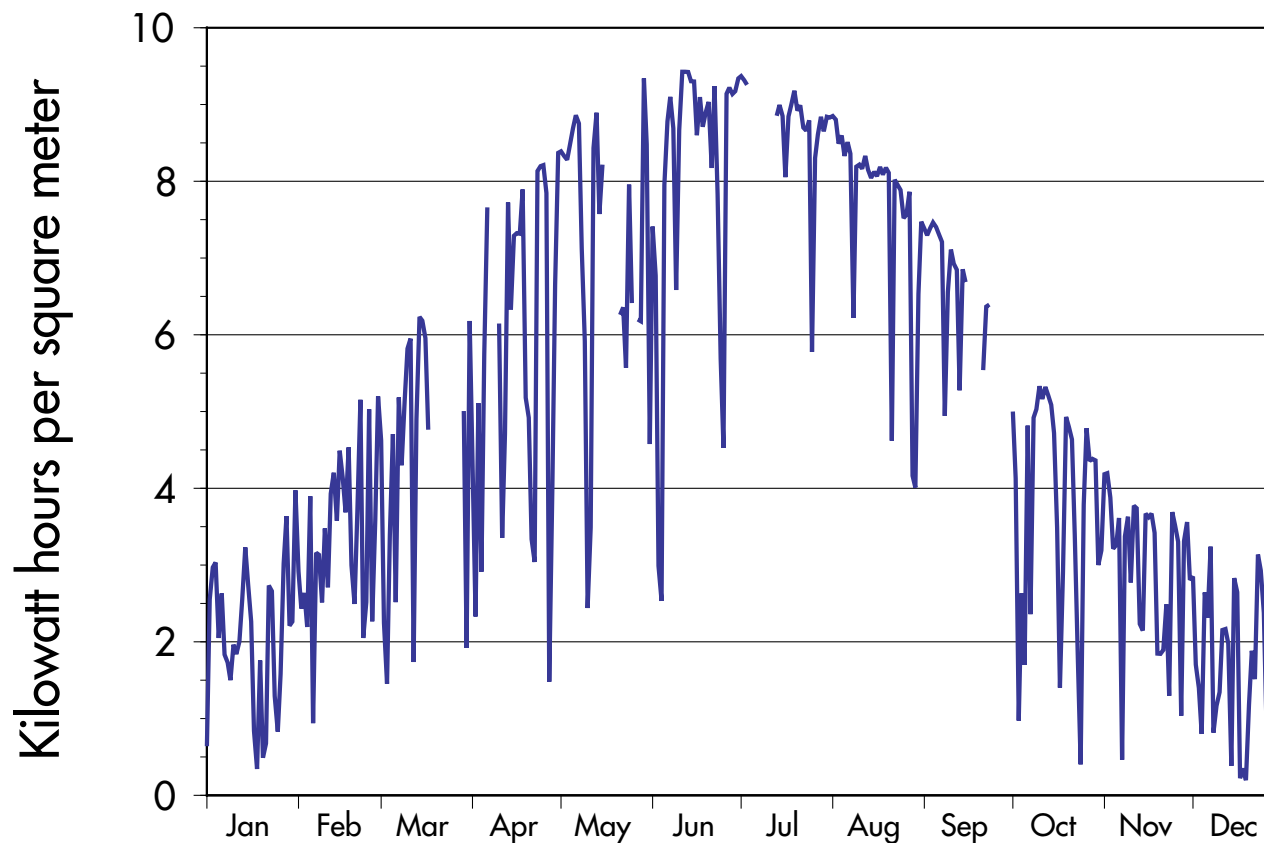
### Daily Solar Radiation

Daily in 2010

Solar radiation showed the typical annual pattern of increasing then decreasing, peaking at the summer solstice on June 21 or 22. Dips in daily

solar radiation are due primarily to clouds. Smoke and other atmospheric constituents play a smaller role. It is noteworthy that solar radiation on a

clear day in mid-winter can exceed that of a cloudy day in mid-summer.



**METEOROLOGY**

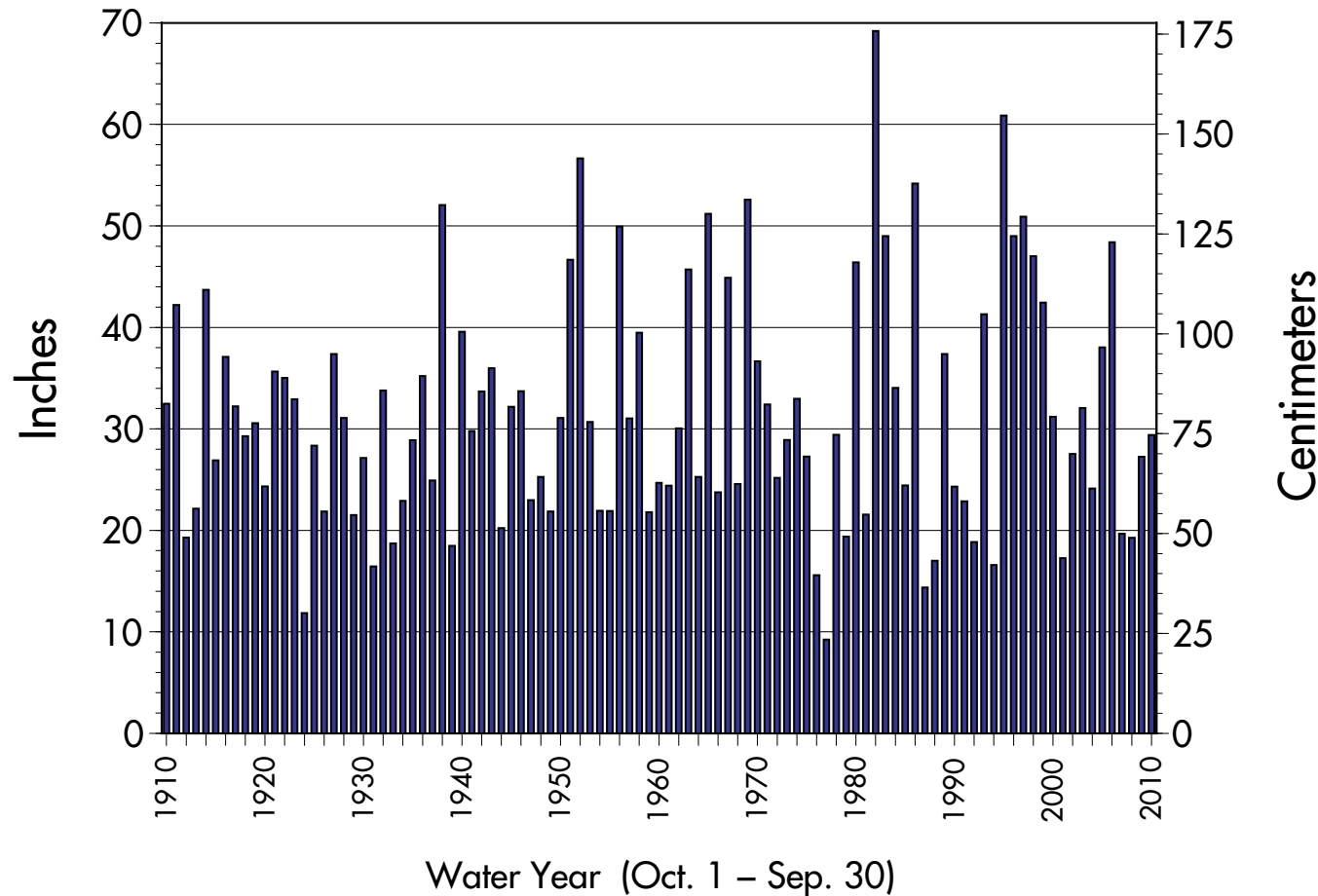
**Annual precipitation**

Yearly since 1910

From 1910 to 2010, average annual precipitation (water equivalent of rain and snow) at Tahoe City was 31.5 inches. The maximum was 69.2 inches in 1982. The minimum was

9.2 inches in 1977. 2010 was slightly below average, with 29.4 inches of precipitation. Generally there is a gradient in precipitation from west to east across Lake Tahoe, with almost

twice as much precipitation falling on the west side of the lake. (Precipitation is summed over the Water Year, which extends from October 1 through September 30.)



## METEOROLOGY

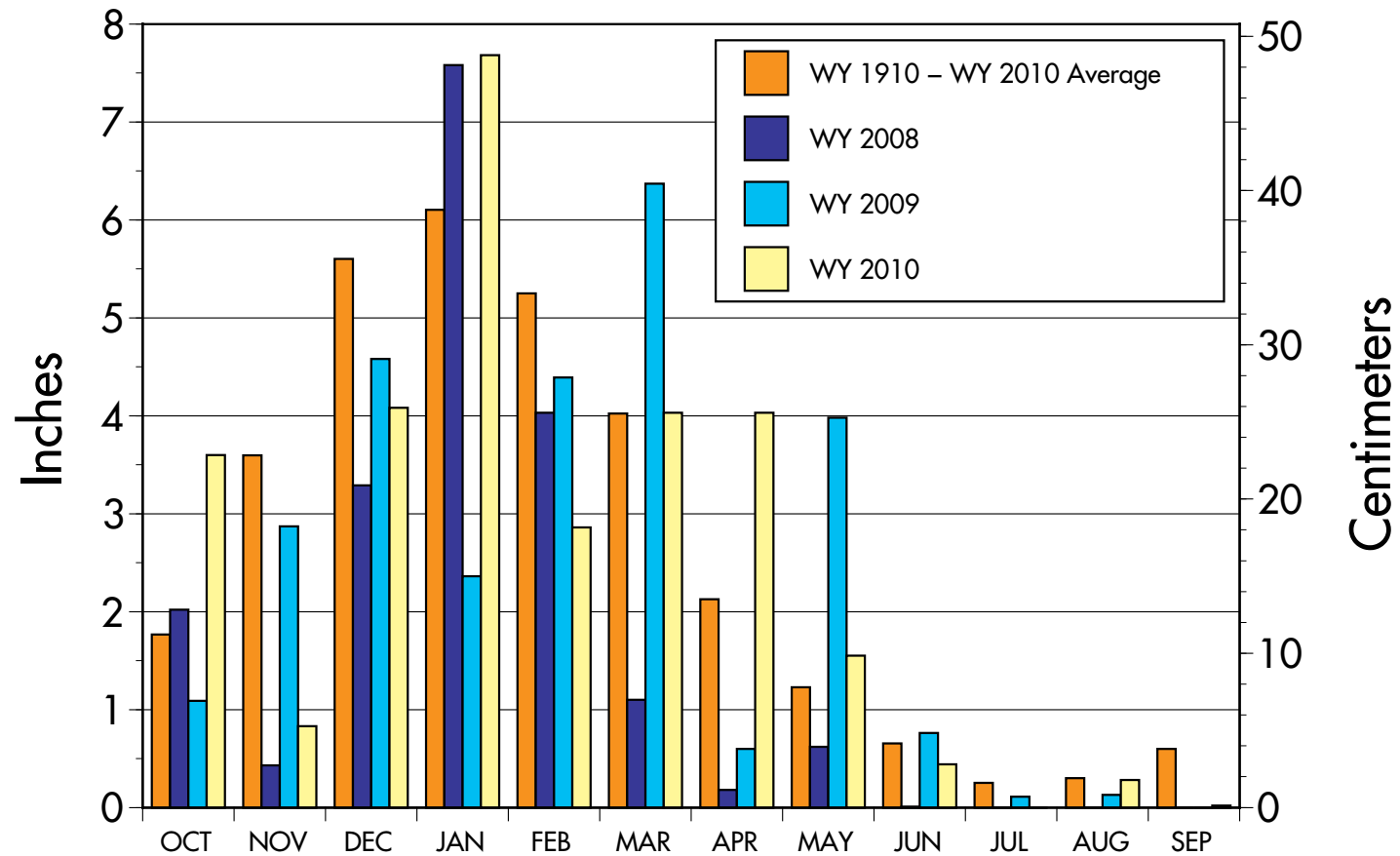
### Monthly precipitation

2008, 2009, 2010 and 1910 to 2010 Average

2010 was almost an average year in total precipitation. However, five months were below the long-term

average precipitation. October, January, April and May all had above average precipitation. Summer of 2010 was dry.

The 2010 Water Year extended from October 1, 2009, through September 30, 2010.



## METEOROLOGY

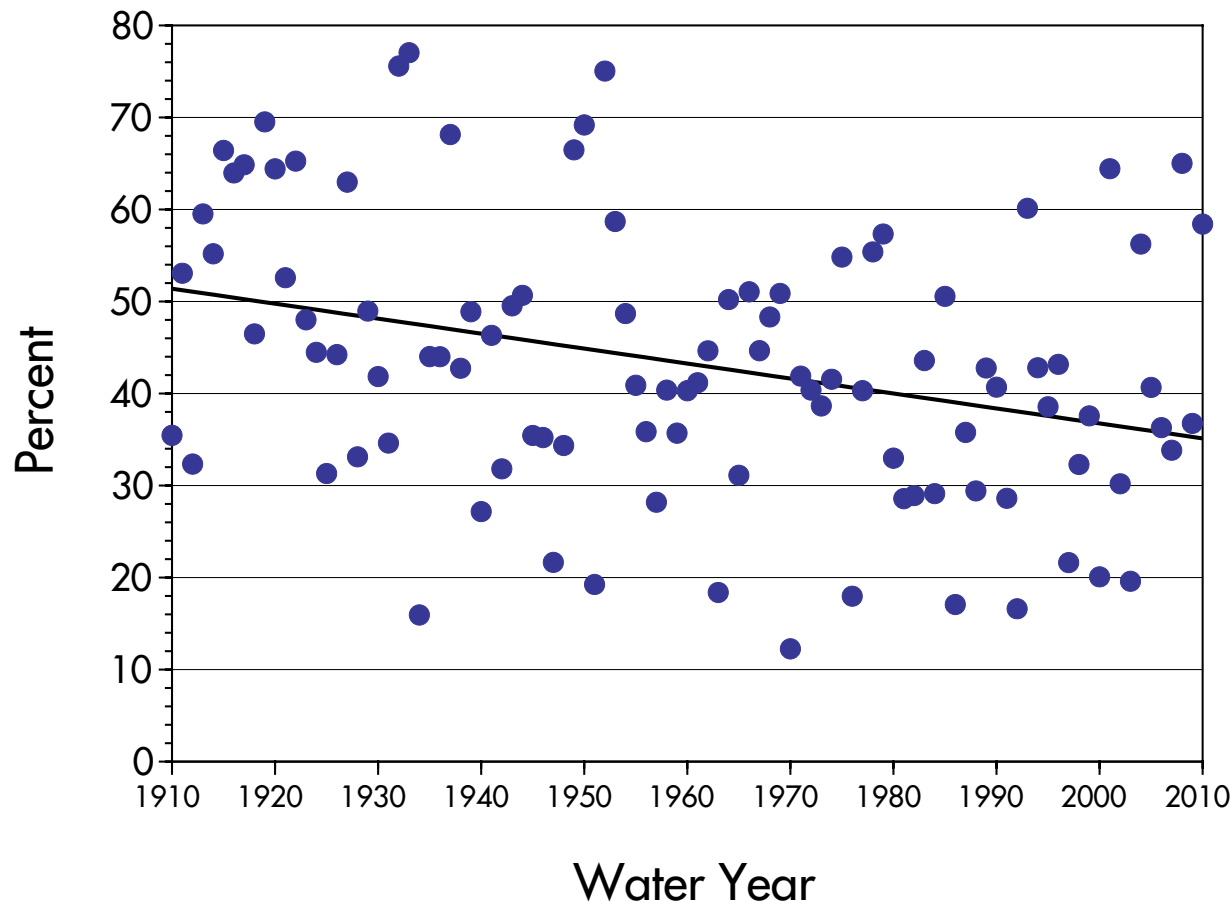
### Snow as a fraction of annual precipitation

Yearly since 1910

Snow has declined as a fraction of total precipitation, from an average of 52 percent in 1910 to 34 percent in present times. In Tahoe City, snow represented

59 percent of 2010 total precipitation, much higher than the long-term trend. These data assume precipitation falls as snow whenever the average daily

air temperature is below freezing. (Precipitation is summed over the Water Year, which extends from October 1 through September 30.)



## METEOROLOGY

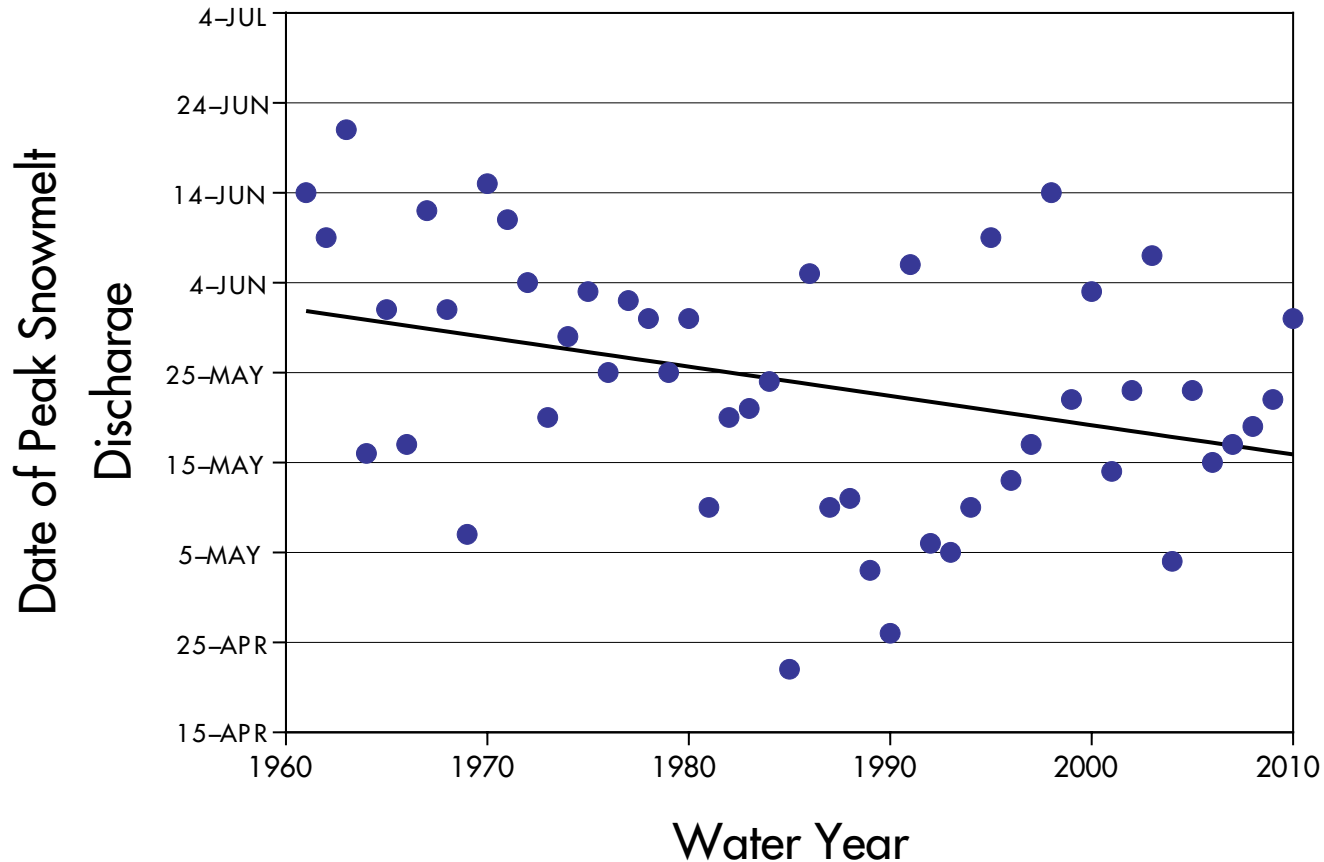
### Shift in snowmelt timing

Yearly since 1961

Although the date on which peak snowmelt occurs varies from year to year, since 1961 it has shifted earlier an average of 2 ½ weeks. This shift is statistically significant and is one effect of climate change on Lake Tahoe. In 2010, peak discharge

occurred closer to historical timing. Peak snowmelt is defined as the date when daily river flows reach their yearly maximum. Daily river flows increase throughout spring as the snow melts because of rising air temperatures, increasing solar radiation

and longer days. The data here are based on the average from the Upper Truckee River, Trout Creek, Blackwood Creek, Ward Creek, and Third Creek.



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**PHYSICAL  
PROPERTIES**



## PHYSICAL PROPERTIES

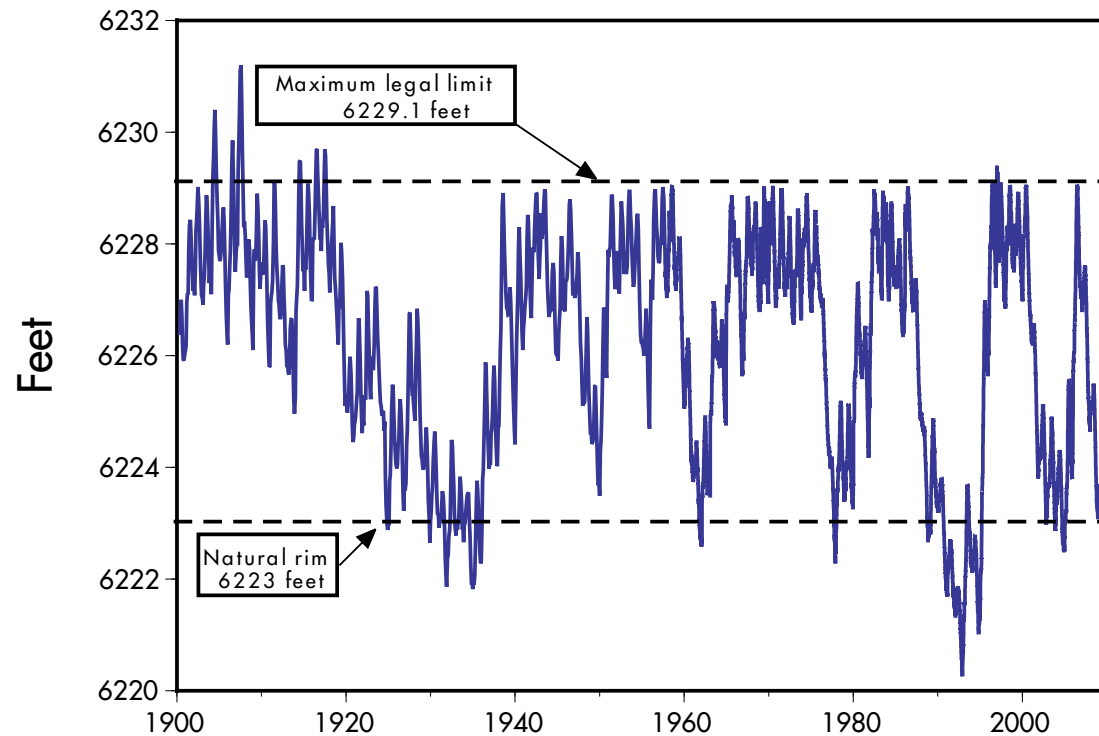
### Lake surface level

Daily since 1900

Lake surface level varies throughout the year. It rises due to high stream inflow, groundwater inflow and precipitation directly onto the lake surface. It falls due to evaporation, in-basin water withdrawals,

groundwater outflows, and outflow via the Truckee River at Tahoe City. Despite the near-average precipitation, lake level remained low in 2010. In 2010, the lake level rose by 22.6 inches during snowmelt, compared with

several feet in normal runoff years. The highest lake level was 6224.65 feet on July 6, and the lowest was 6222.77 feet on January 1, almost three inches below the natural rim.



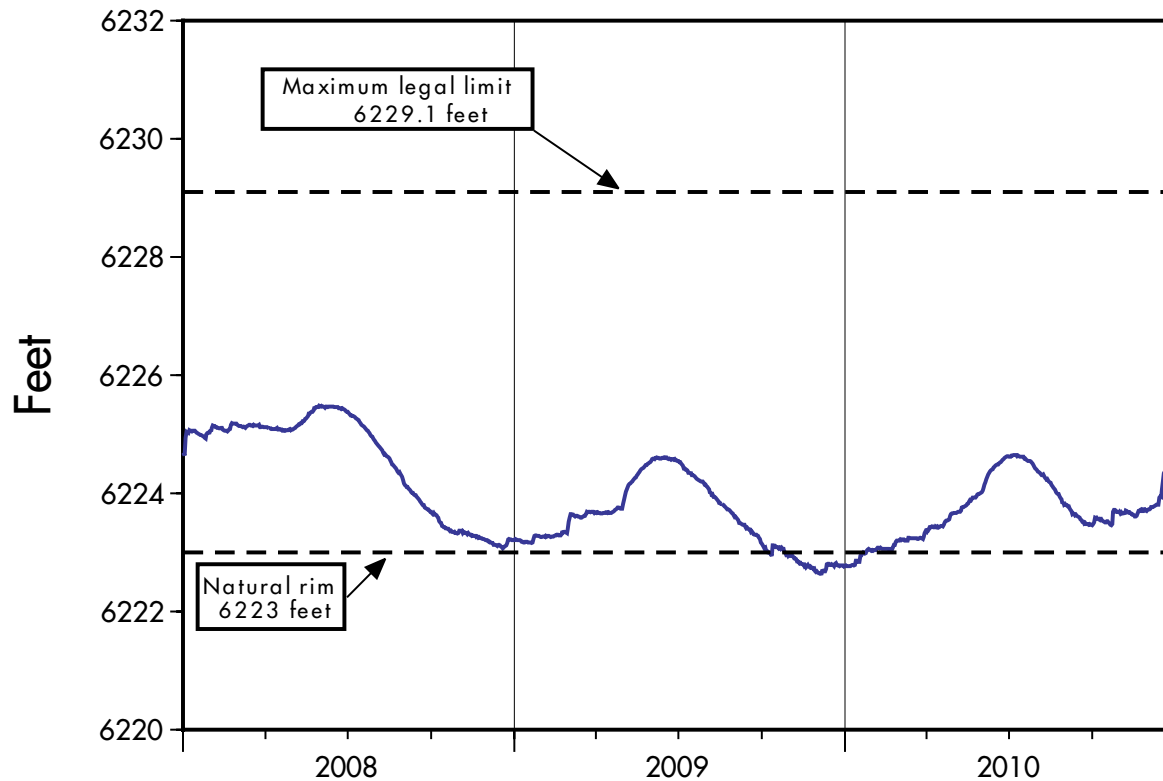
## PHYSICAL PROPERTIES

### Lake surface level

Daily since 2008

Identical data as used on page 8.1 except the period displayed is shortened to 2008-2010. This more time resolved presentation of recent lake level data allows us to see the

seasonal patterns in higher definition. Data clearly show the lake level below the natural rim at the end of 2009 and early 2010 as well as the annual periods of highest lake level (generally in June).



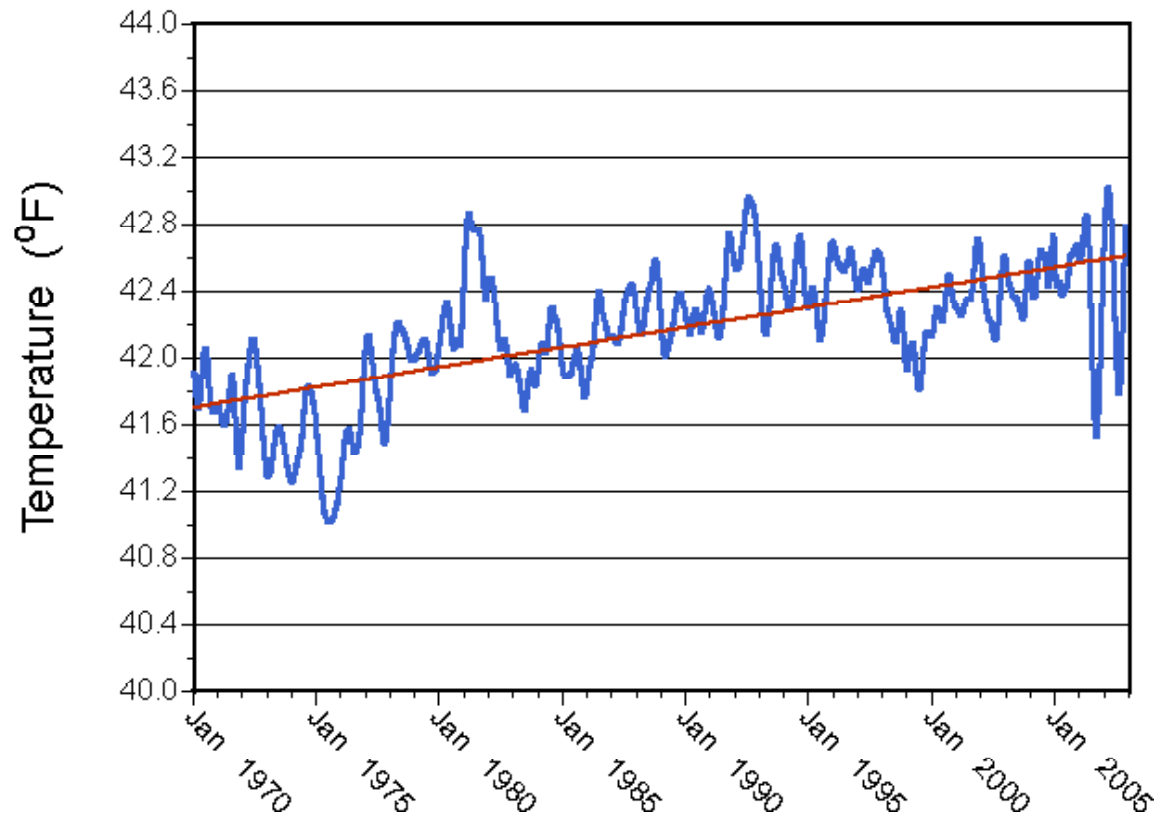
## PHYSICAL PROPERTIES

### Average water temperature

Since 1970

The volume-averaged temperature of Lake Tahoe has increased nearly a full degree since 1970, from 41.7 degrees F to 42.6 degrees F. (The monthly

temperature profile data from the lake has been smoothed and deseasonalized to best show the long-term trend.)



## PHYSICAL PROPERTIES

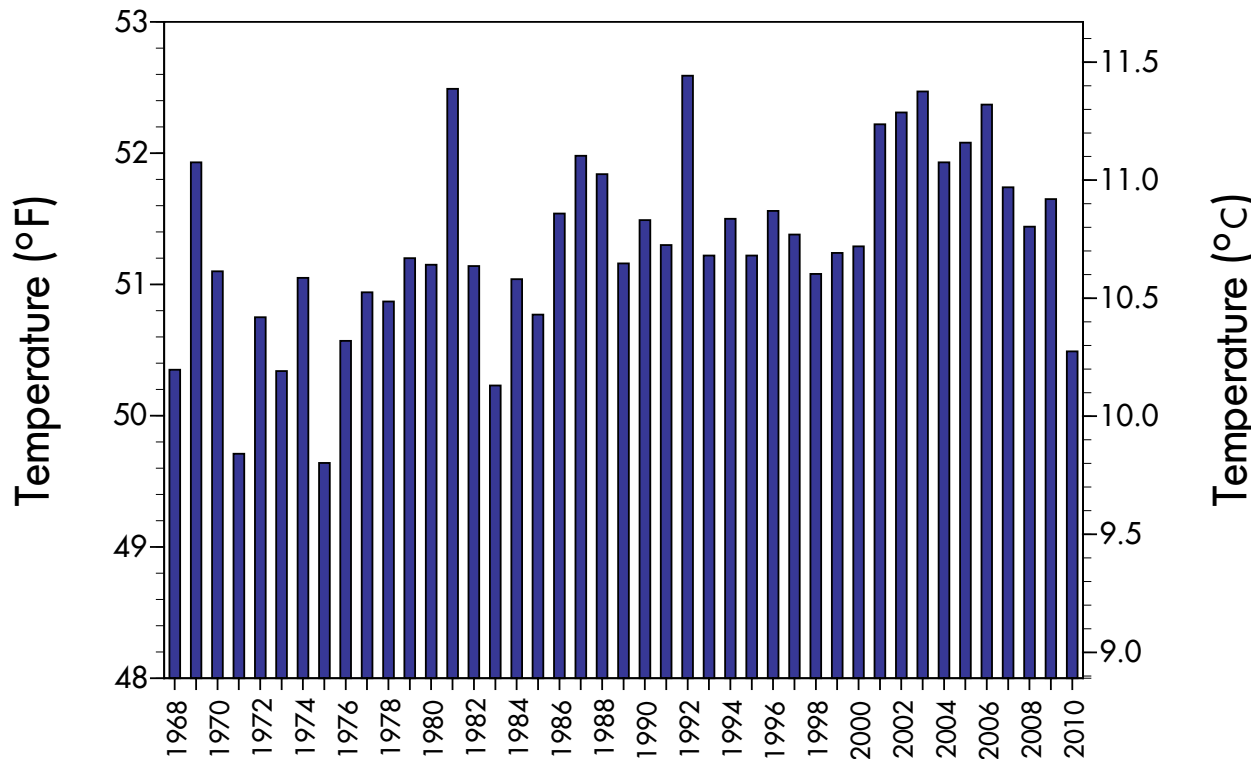
### Surface water temperature

Yearly since 1968

Surface water temperatures have been recorded at the mid-lake station since 1968. Despite year-to-year variability,

water temperatures show an increasing trend. The average temperature in 1968 was 50.3 degrees F. For 2010,

the average surface water temperature was 50.5 degrees F down from 51.6 in 2009.



**PHYSICAL PROPERTIES**

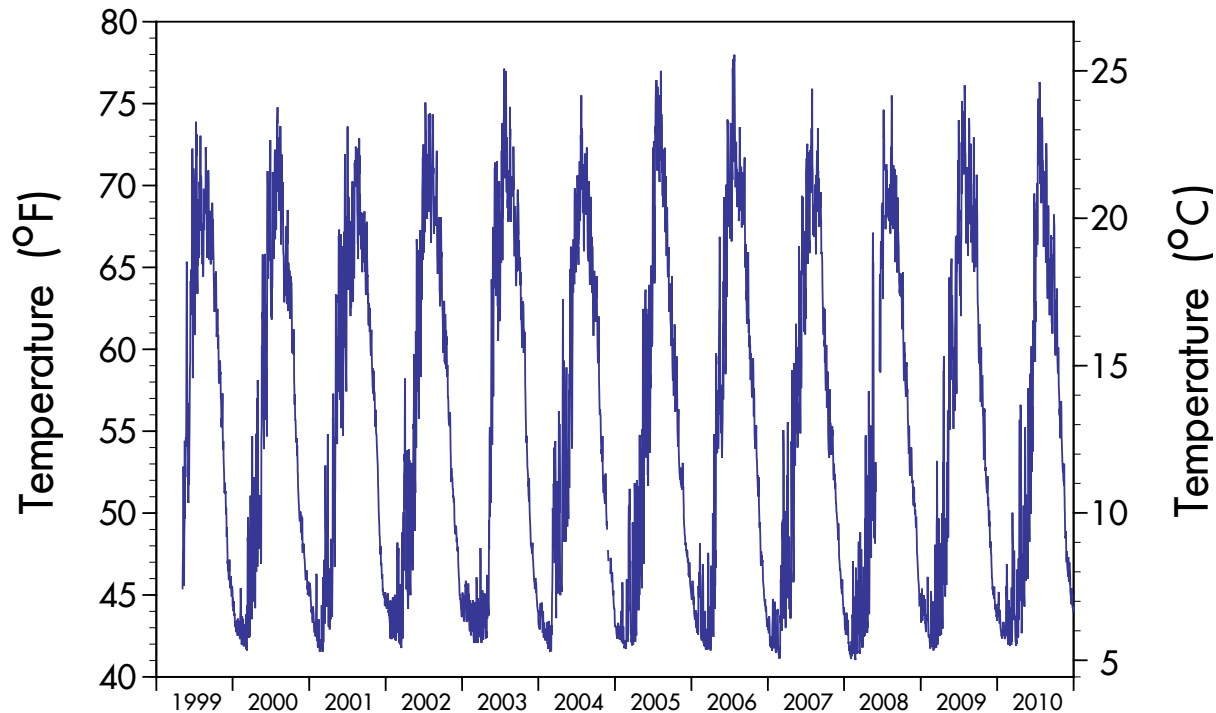
**Maximum daily surface water temperature**

Every 15 minutes since 1999

Maximum daily surface water temperatures were similar in 2010 to the 2007, 2008, and 2009 values, although summer surface water temperatures continue to show a long-term increase. Since May 1999, the highest maximum daily surface temperature was 77.99 degrees F on

July 26, 2006. The lowest maximum daily surface water temperature was 41.02 degrees F on Feb. 25, 2008. In the last decade, the 28 lowest maximum daily surface water temperatures occurred in 2007 and 2008. This may be attributable to the deep mixing that occurred

in both those years. Surface water temperatures in winter were warmer in 2010 because of the absence of deep mixing (see Figure 8.9). These data are collected by NASA and UC Davis from a buoy located near the center of the lake.



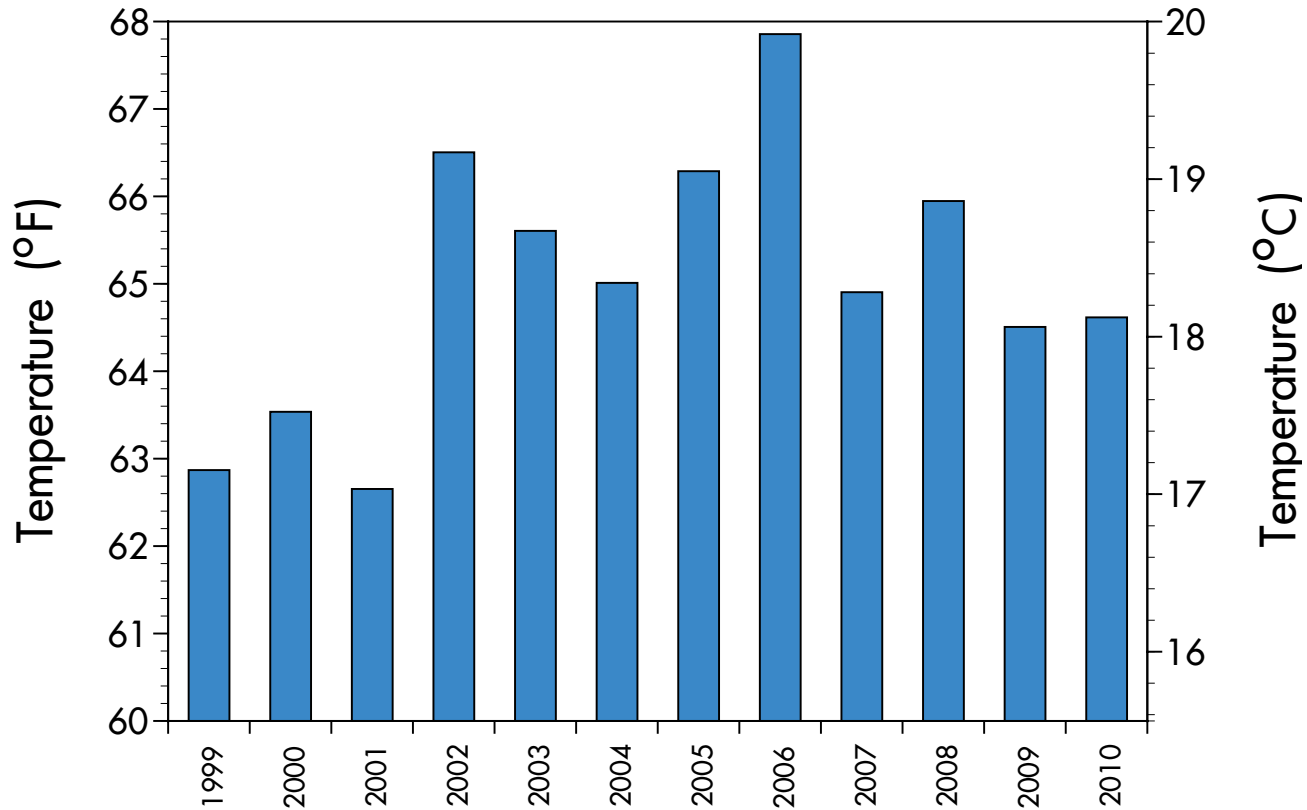
**PHYSICAL PROPERTIES**

**July average surface water temperature**

Since 1999

Since 1999, surface water temperature has been recorded every two minutes from four NASA/UC Davis buoys. Shown here are 12 years of average surface water temperatures

in the month of July when water temperatures are typically warmest. In 2010, July surface water temperature averaged 64.6 degrees F, slightly warmer than in 2009.



## PHYSICAL PROPERTIES

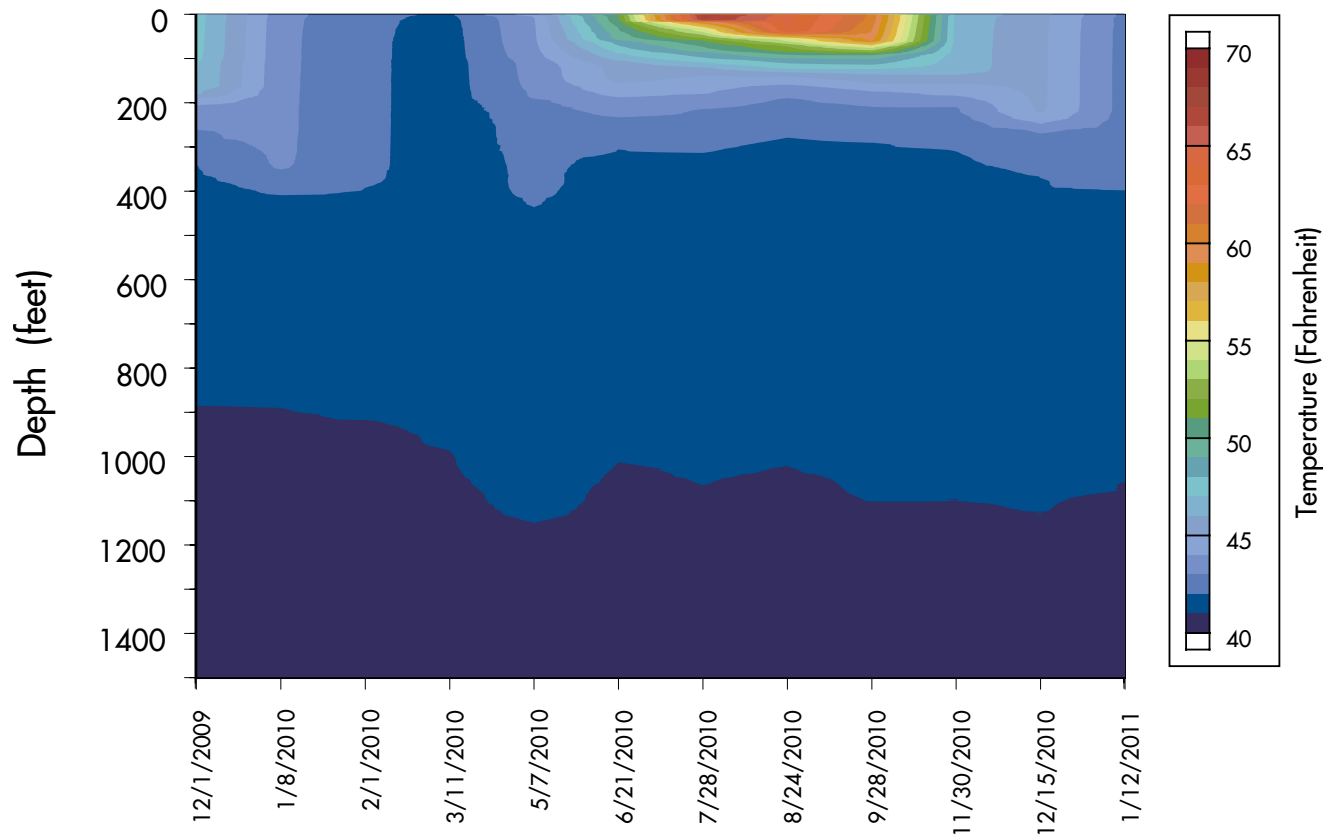
### Water temperature profile

In 2010

Water temperatures are measured continuously in the lake by a set of 20 thermistors, which are positioned on a taut, vertical mooring line from the lake bottom to the surface. These instruments record temperature to an accuracy of 0.005 degrees F every

2 minutes. Here the temperature is displayed as a color contour plot. In 2010, the lake temperature followed a typical seasonal pattern. In early March, the lake surface was at its coldest. However, the lake did not mix throughout its depth (as evidenced by

the color banding present throughout the year). The maximum depth of mixing was approximately 550 feet, well short of the lake's maximum depth of 1645 feet.



**PHYSICAL PROPERTIES**

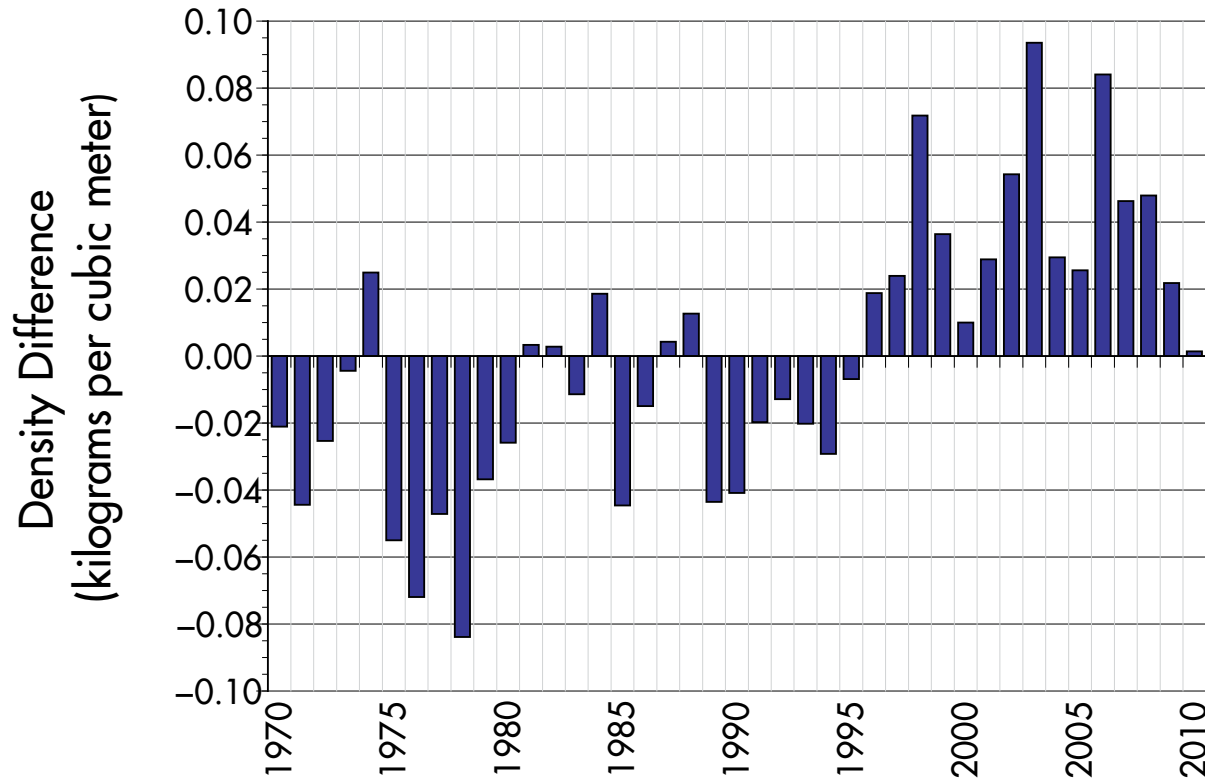
**Density stratification**

Since 1970

Density stratification in Lake Tahoe has generally increased since 1970, as shown by the trend below. Each bar represents the annual average density difference between deep (100 to 165 feet) and shallow (0 to 33 feet)

water, subtracted from the mean density. Density differences increase as Lake Tahoe's surface waters warm, making them less dense or lighter. Increasing density stratification makes deep mixing of the lake occur

less frequently. Density stratification is an indicator of resistance to deep lake mixing. 2010 had relatively low stratification, however it came at the end of a decade of higher than average stratification.





## PHYSICAL PROPERTIES

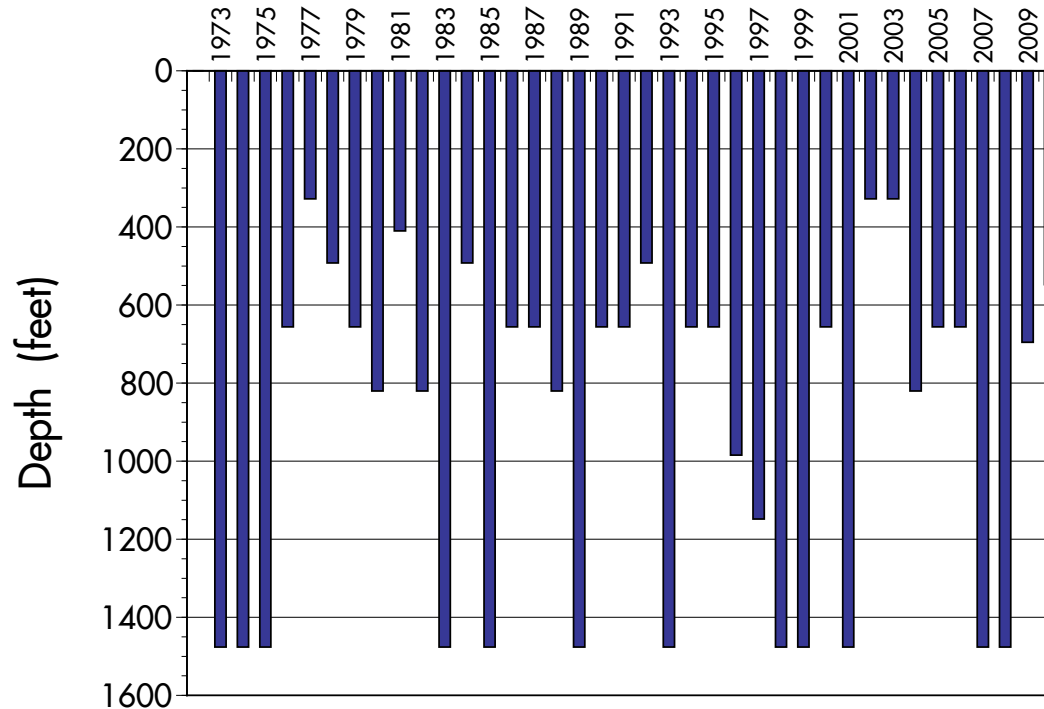
### Depth of mixing

Yearly since 1973

Lake Tahoe mixes each winter as surface waters cool and sink downward. In a lake as deep as Tahoe, the wind energy and intense cooling of winter storms helps to determine how deeply the lake mixes. Mixing depth

has profound impacts on lake ecology and water quality. Deep mixing brings nutrients to the surface, where they promote algae growth. It also moves oxygen to deep waters, promoting aquatic life throughout the water

column. The deepest mixing typically occurs in late February to early March. In 2010, Lake Tahoe mixed to a depth of approximately 550 feet, the shallowest mixing depth in the last seven years.



**PHYSICAL PROPERTIES**

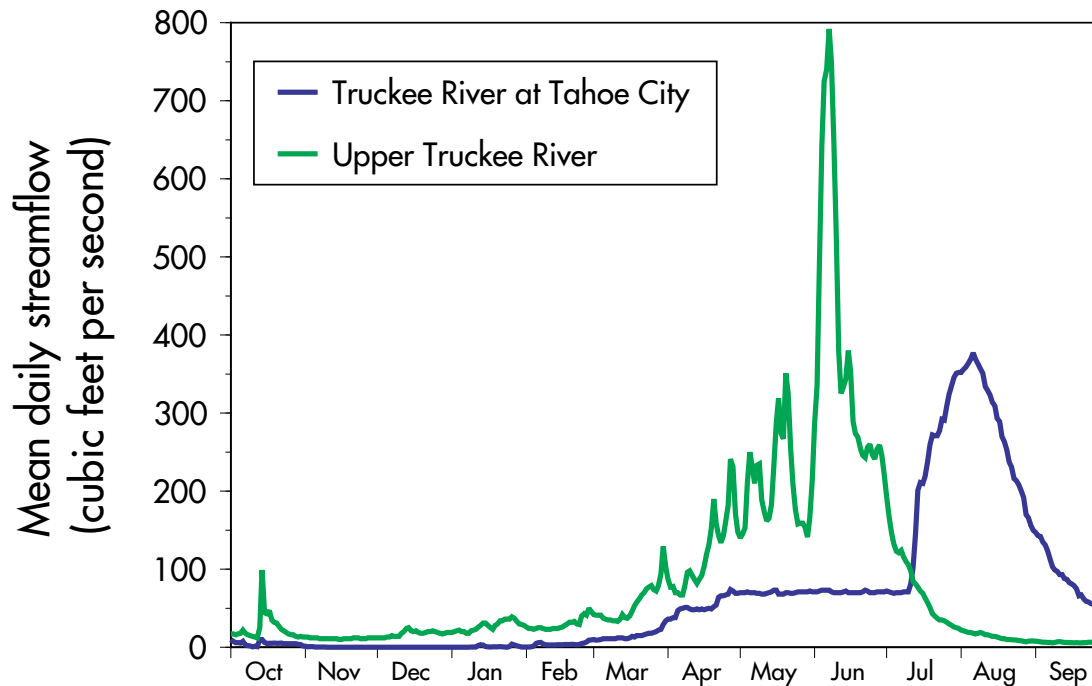
**Mean Daily Streamflow of Upper Truckee River vs. Truckee River**

**Water Year 2010**

The Upper Truckee River, the largest stream to flow into Lake Tahoe, has a natural annual hydrograph for a snow-fed stream. The small peaks in the hydrograph represent rain events or short warm periods in spring. The major peak in the hydrograph represents the maximum spring

snowmelt. The peak in 2010 was 792 cubic feet per second on June 7, well above the median peak of 250 cubic feet per second. The Truckee River is the only outflow from Lake Tahoe. The streamflow in the Truckee River is a regulated flow, with release quantity controlled by the Federal water master.

The release rates are set according to downstream demands for water. The maximum discharge in 2010 was 77 cubic feet per second on August 6. Streamflow data are collected by the Lake Tahoe Interagency Monitoring Program (LTIMP).



**PHYSICAL PROPERTIES**

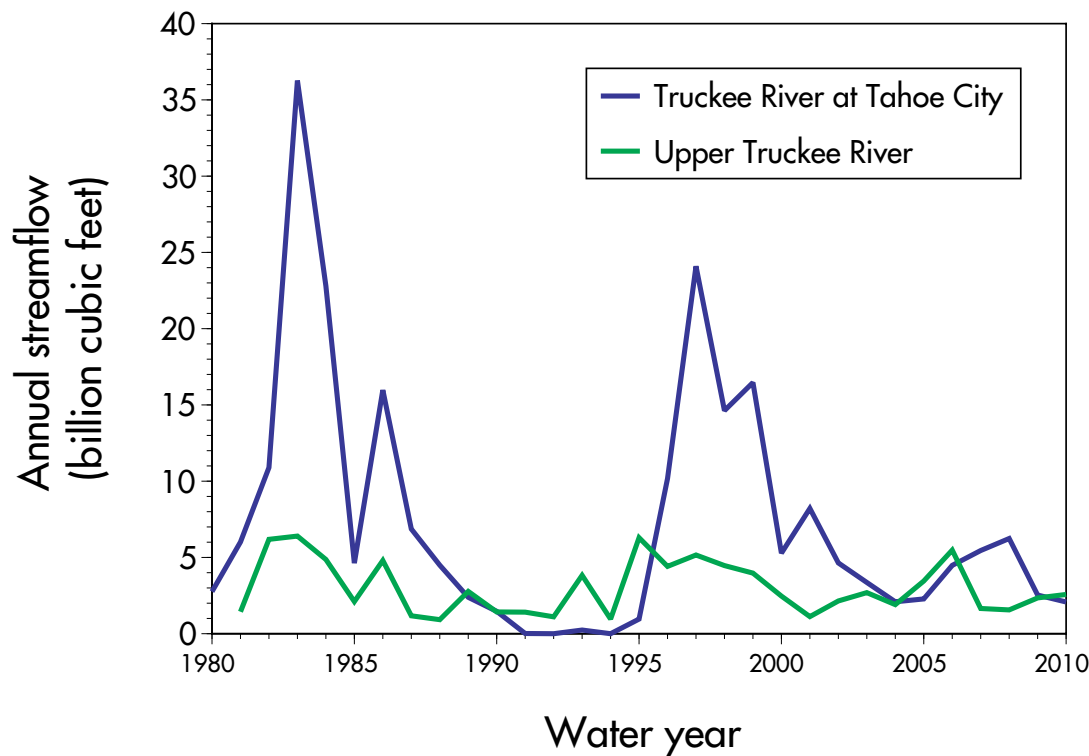
**Annual Discharge Volume for Upper Truckee River and Truckee River**

Since 1980

Flow into Lake Tahoe (e.g. Upper Truckee River) and discharge out of Lake Tahoe (Truckee River at Tahoe City) have shown considerable variation since 1980. The large peaks in discharge from the lake correspond

to years when precipitation (and therefore total inflow) was the greatest, e.g. 1982-1983, 1986, 1995-1999. Similarly, the drought-like conditions in the early 1990s and the low precipitation years in the

beginning of the 2000s also stand out. Since many of the pollutants of concern for Lake Tahoe's clarity enter along with surface flow, year-to-year changes in clarity are influenced by precipitation and runoff.



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**NUTRIENTS AND  
PARTICLES**

## NUTRIENTS AND PARTICLES

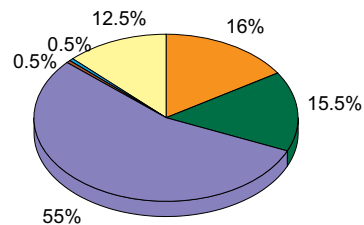
### Sources of clarity-reducing pollutants

Previous research has quantified the primary sources of nutrients (nitrogen and phosphorus) and particulate material that are causing Lake Tahoe to lose clarity in its upper waters. Extremely fine particles, the major contributor to clarity decline, primarily originate from the urban watershed (70-75 percent), even though these areas cover only 10

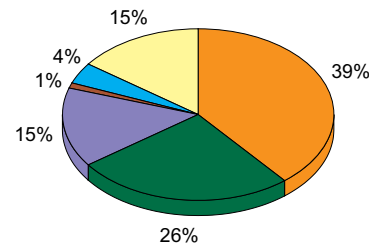
percent of the land area. For nitrogen, atmospheric deposition is the major source (55 percent). Phosphorus is primarily introduced by the urban (39 percent) and non-urban (26 percent) watersheds. These categories of pollutant sources form the basis of a strategy to restore Lake Tahoe's open-water clarity by agencies including the Lahontan

Regional Water Quality Control Board, the Nevada Division of Environmental Protection, and the Tahoe Regional Planning Agency. (Data were generated for the Lake Tahoe TMDL Program and this figure also appeared in previous year's State of the Lake Reports 2009 and 2010.)

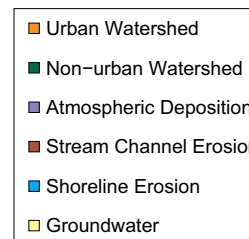
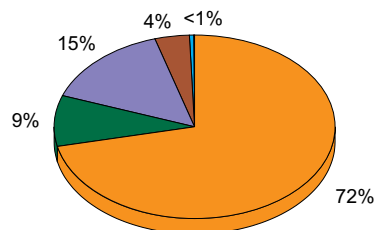
**Total Nitrogen**



**Total Phosphorus**



**Fine Sediment Particles**



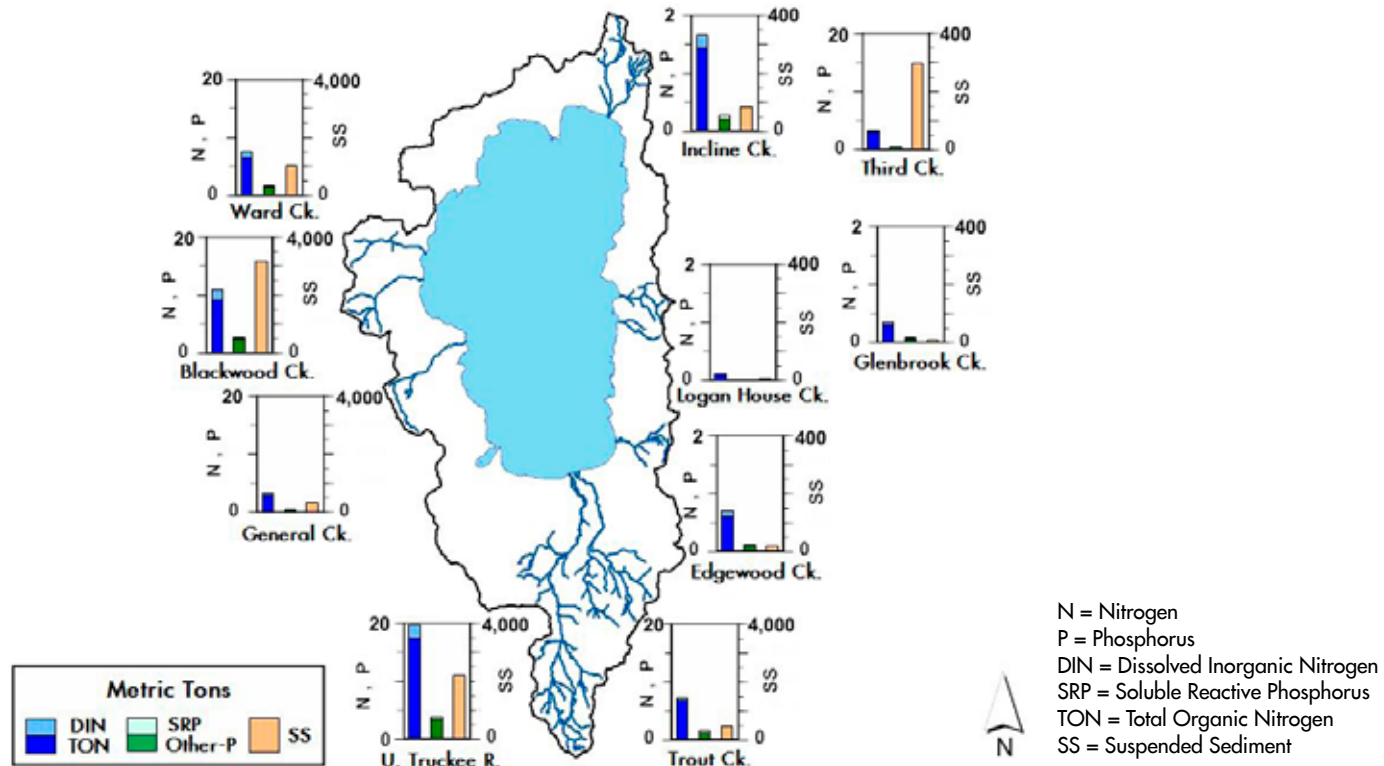
## NUTRIENTS AND PARTICLES

### Pollutant loads from 10 watersheds

The Lake Tahoe Interagency Monitoring Program (LTIMP) measures nutrient and sediment input from 10 of the 63 watershed streams – these account for approximately half of all stream flow into the lake. Most of the suspended sediment contained in the 10 LTIMP streams is from the Upper Truckee River, Blackwood Creek, Trout Creek and Ward Creek,

with the first two being the largest contributors. Over 75 percent of the phosphorus and nitrogen comes from the Upper Truckee River, Trout Creek and Blackwood Creek. Pollutant loads from the west-side streams were again high in 2010. Blackwood Creek suspended sediment loads have exceeded those of the Upper Truckee River for the last three years, highly

unusual for low flow years. The east-side stream loads were similar to the previous year. The LTIMP stream water quality program is managed by the U.S. Geological Survey in Carson City, Nevada, UC Davis TERC and the Tahoe Regional Planning Agency. Additional funding was provided by the USFS – Lake Tahoe Basin Management Unit.



**NUTRIENTS AND PARTICLES**

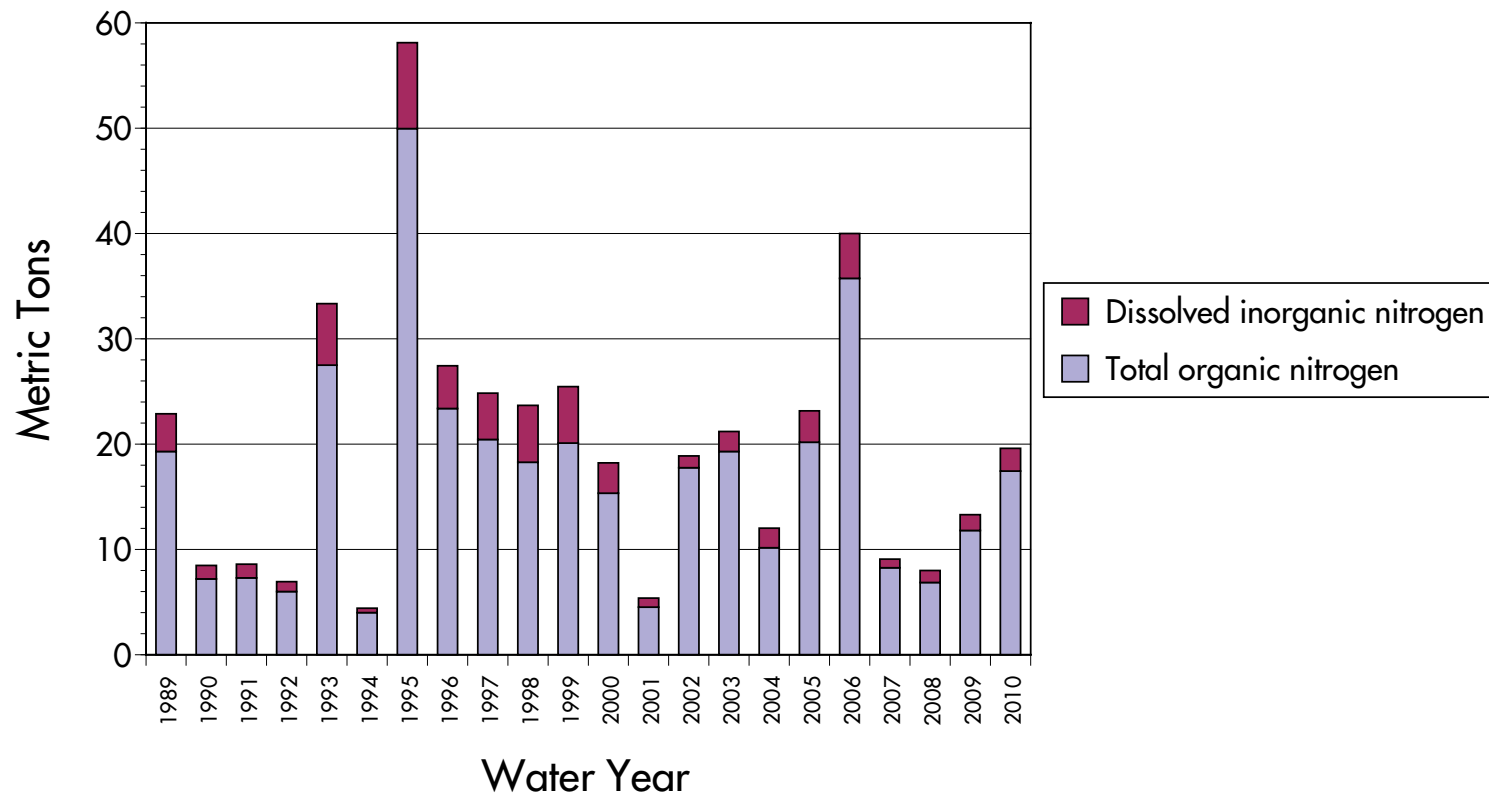
**Nitrogen contribution by Upper Truckee River**

Since 1989

Nitrogen (N) is important because it, along with phosphorus (P), stimulates algal growth (Fig. 9.1 shows the major sources of N and P to Lake Tahoe). 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 inorganic nitrogen (nitrate and ammonium) and total organic nitrogen loads are shown here. The year-to-year variations primarily reflect changes in precipitation. For example, 1994 had 16.6 inches of precipitation and a low nitrogen load, while 1995 had

60.8 inches of precipitation and a very high nitrogen load. Near-average precipitation in 2010 resulted in a nitrogen load that was larger than the previous year. (One metric ton = 2,205 pounds.)



**NUTRIENTS AND PARTICLES**

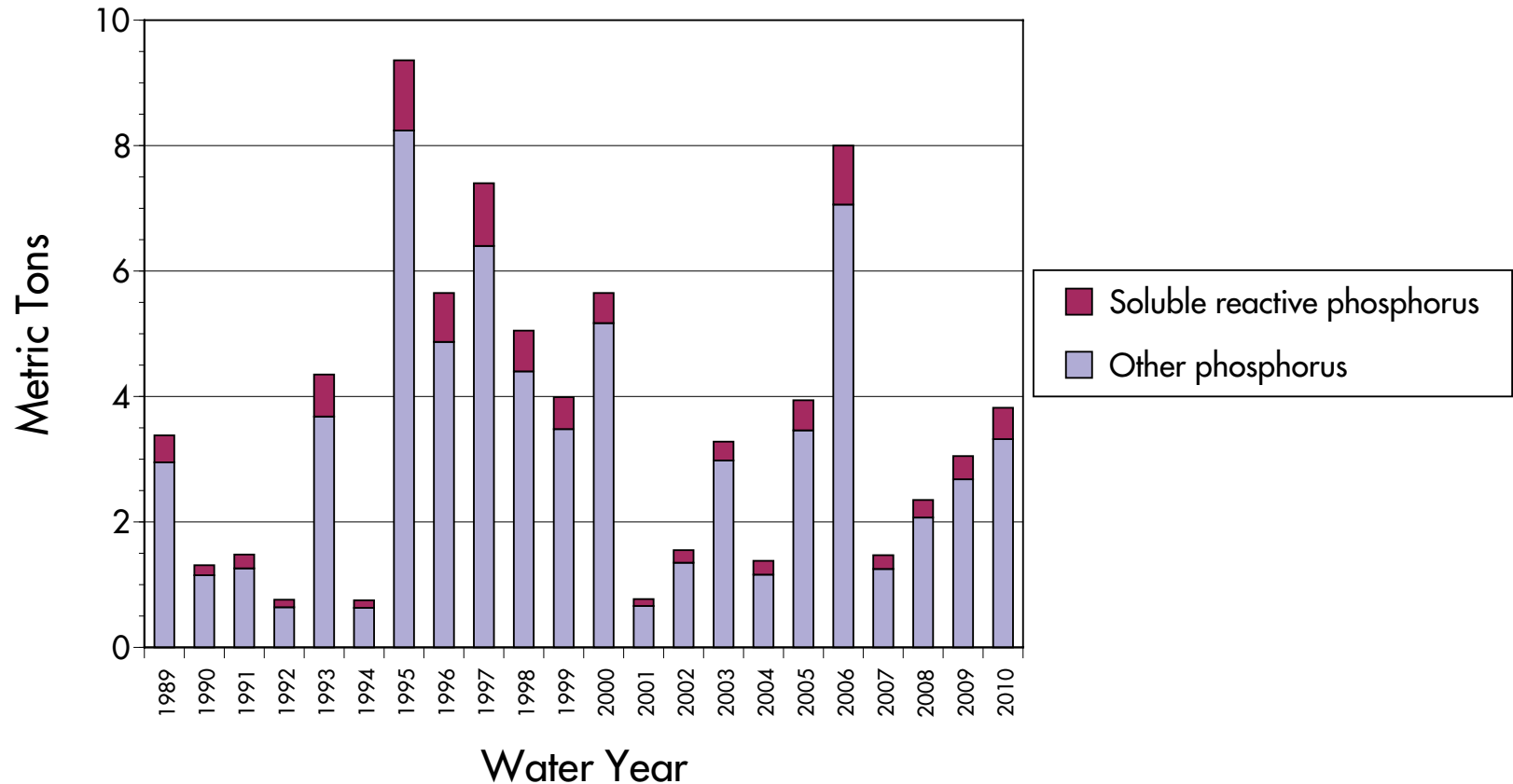
**Phosphorus contribution by Upper Truckee River**

Yearly since 1989

Soluble reactive phosphorus (SRP) is that 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. Near-average precipitation in 2010 resulted in an increase in phosphorus load over the previous year. Total phosphorus is the sum of SRP and other phosphorus,

which includes organic phosphorus and phosphorus associated with particles. (One metric ton = 2,205 pounds.)





**NUTRIENTS AND PARTICLES**

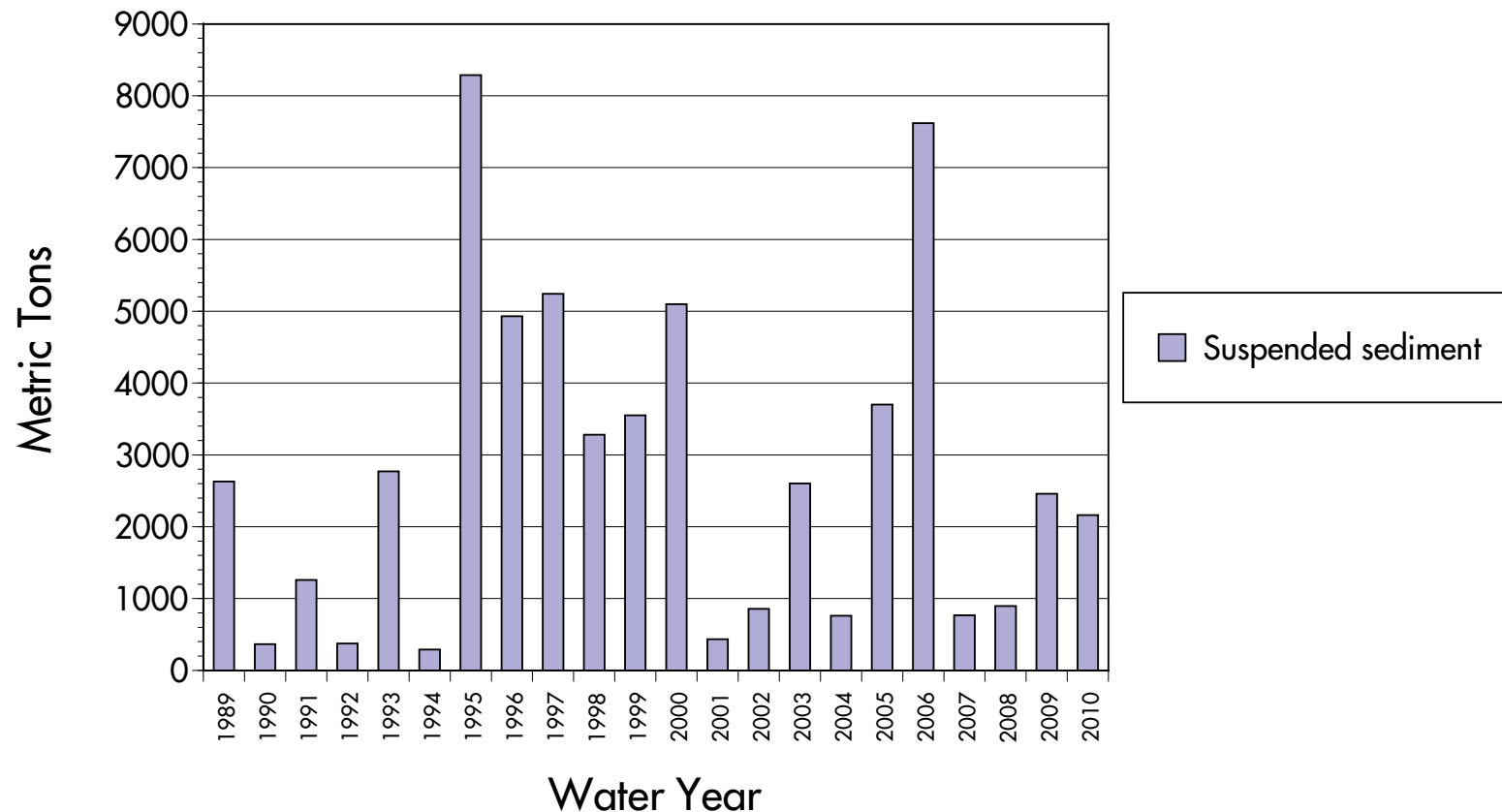
**Suspended sediment contribution by Upper Truckee River**

Yearly since 1989

The load of suspended sediment delivered to the lake by the Upper Truckee is related to landscape condition and erosion as well as to precipitation and stream flow. Certainly, interannual variation in sediment load over shorter time scales

is more related to the latter. Near-average precipitation in 2010 resulted in a similar suspended sediment load to prior years. This and the previous two figures illustrate how greatly changes in hydrological conditions affect pollutant loads. Plans to restore

lake clarity emphasize reducing loads of very fine suspended sediment (less than 20 microns in diameter). Efforts to restore natural stream function and watershed condition focus on reducing loads of total sediment regardless of size.



**NUTRIENTS AND PARTICLES**

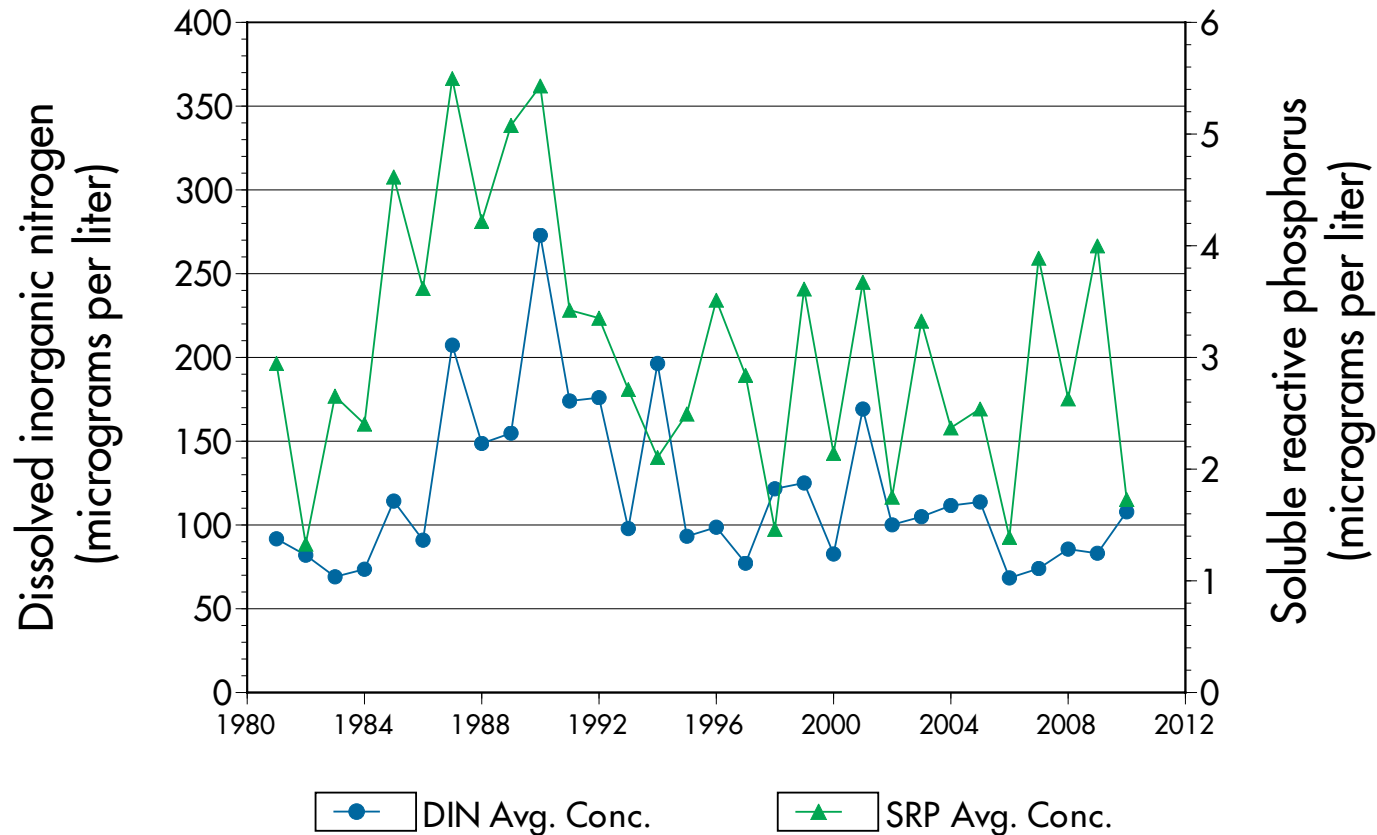
**Nutrient concentrations in rain and snow**

Yearly since 1981

Nutrients in rainwater and snow (called wet deposition) contribute large amounts of nitrogen, but also significant phosphorus, to Lake Tahoe. Nutrients in precipitation have been measured near Ward Creek since 1981, and show no consistent

upward or downward trend. Annual concentrations in precipitation of dissolved inorganic nitrogen (DIN) and soluble reactive phosphorus (SRP) vary from year to year. In 2010, concentrations of DIN in precipitation were slightly higher than the 2009

value, whereas the SRP concentration decreased by 50 percent. A high degree of interannual variation in SRP concentration has been a common feature of the long term data set.



## NUTRIENTS AND PARTICLES

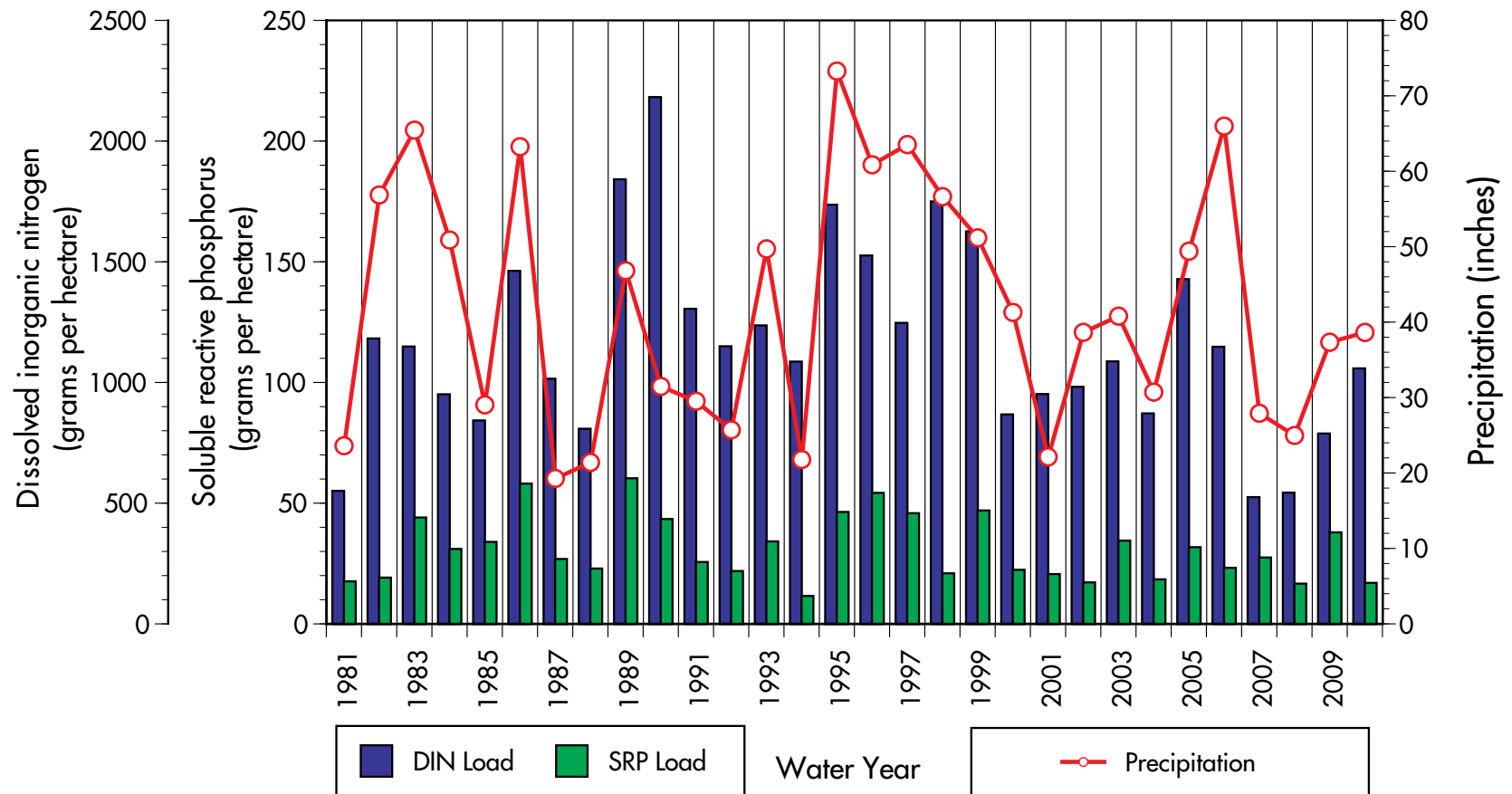
### Nutrient loads in rain and snow

Since 1981

The annual load for wet deposition is calculated by multiplying the concentration of dissolved inorganic nitrogen (nitrate and ammonium) and soluble reactive phosphorus (in

the previous graph) by total annual precipitation. While nitrogen and phosphorus loads from precipitation have varied from year to year at the Ward Creek monitoring site, no

obvious long-term trend has emerged. In 2010, the nitrogen and phosphorus loads were close to the long-term averages.



**NUTRIENTS AND PARTICLES**

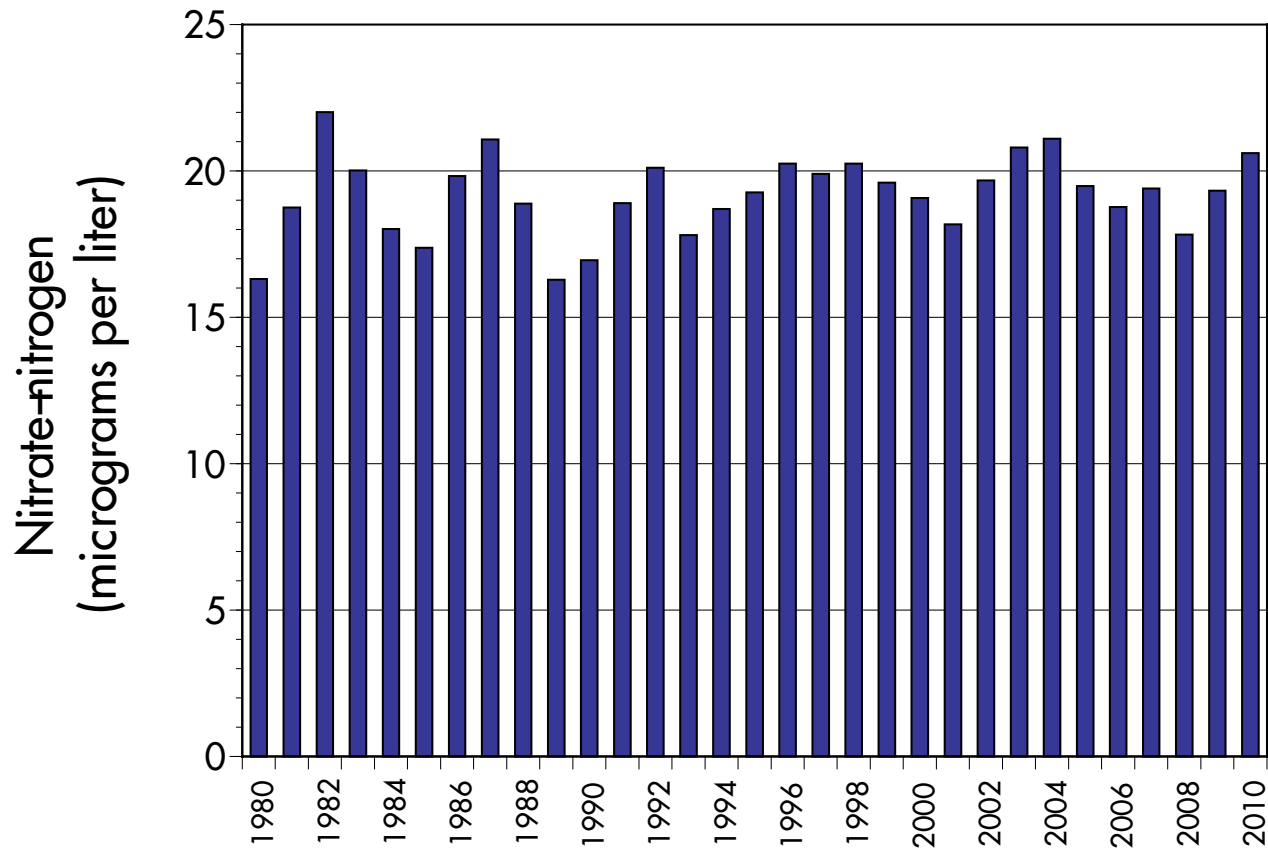
**Lake nitrate concentration**

Yearly since 1980

Since 1980, the lake nitrate concentration has remained relatively constant, ranging between 16 and 22 micrograms per liter. In 2010, the

volume-weighted annual average concentration of nitrate-nitrogen was approximately 20.6 micrograms per liter which is at the higher end of the

long-term record. These measurements are taken at the MLTP (mid-lake) station. Water samples could not be collected in April and October 2010.



## NUTRIENTS AND PARTICLES

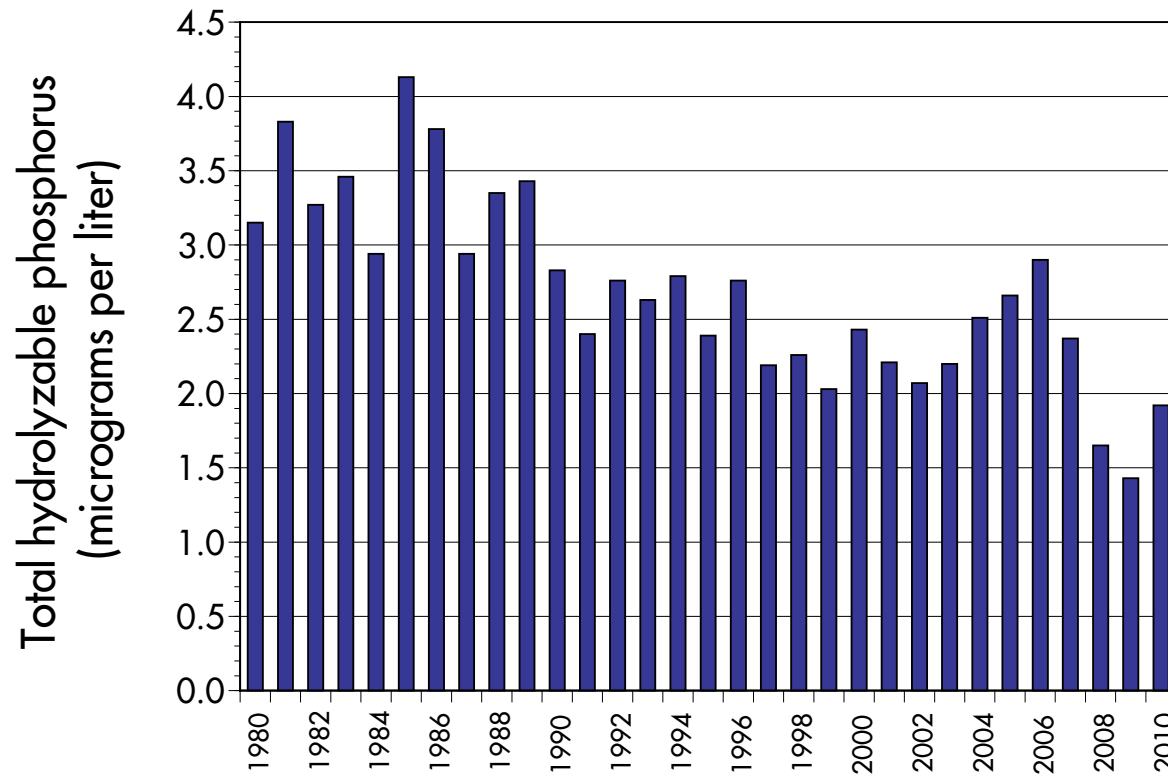
### Lake phosphorus concentration

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 algae can use to grow. It is similar to the SRP that is measured in the streams. Since 1980, THP has tended to decline. In 2010, the volume-weighted annual

average concentration of THP was approximately 1.9 micrograms per liter, an increase over the previous year. Water samples could not be collected in April and October 2010.



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**BIOLOGY**

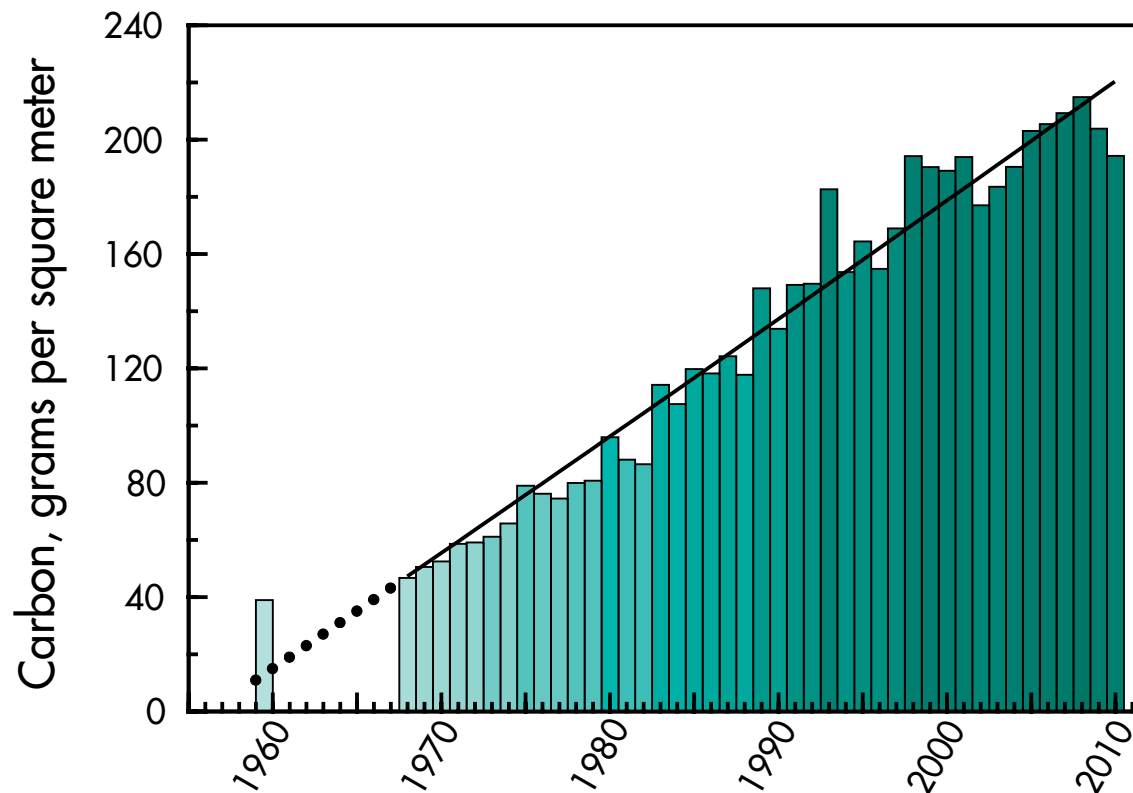
## BIOLOGY

### Algae growth (primary productivity)

Yearly since 1959

Primary productivity is a measure of the rate at which algae produce biomass through photosynthesis. It was first measured at Lake Tahoe in 1959 and has been continuously measured since 1968. Primary productivity has generally increased over that time, promoted by nutrient

loading to the lake, changes in the underwater light environment and a succession of algae species. In 2010, primary productivity was 194.3 grams of carbon per square meter. This represented the third straight year of decrease in primary productivity, although the degree of decrease is small.



**BIOLOGY**

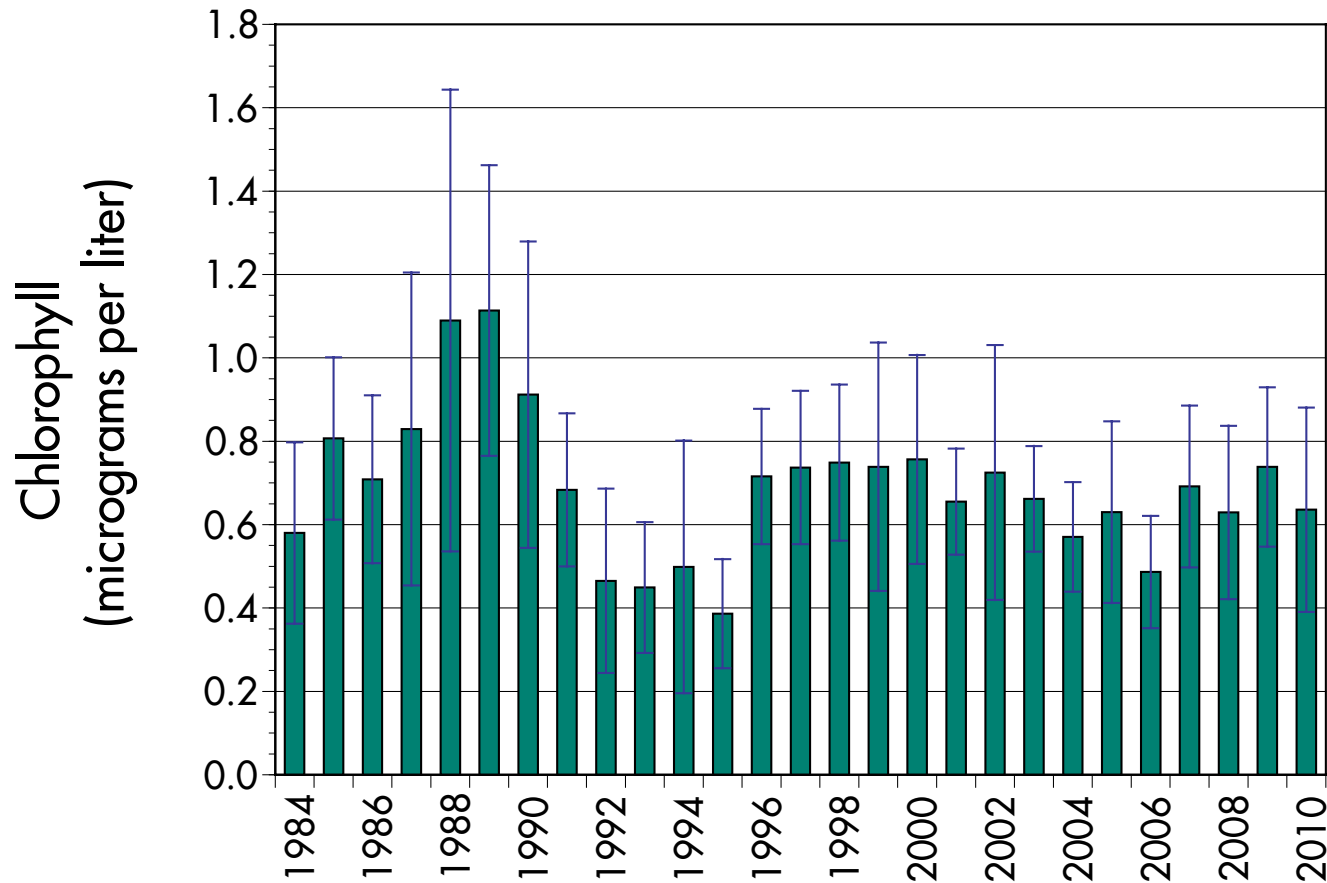
**Algae abundance**

Yearly since 1984

The amount of free-floating algae (phytoplankton) in the water is determined by measuring the concentration of chlorophyll *a*. Chlorophyll *a* is a common measure

of phytoplankton biomass. Though algae abundance varies annually, it has not shown a long-term increase since measurements began in 1984.

The annual average value for 2010 was 0.64 micrograms per liter. The average annual chlorophyll *a* level in Lake Tahoe has remained relatively uniform since 1996.





**BIOLOGY**

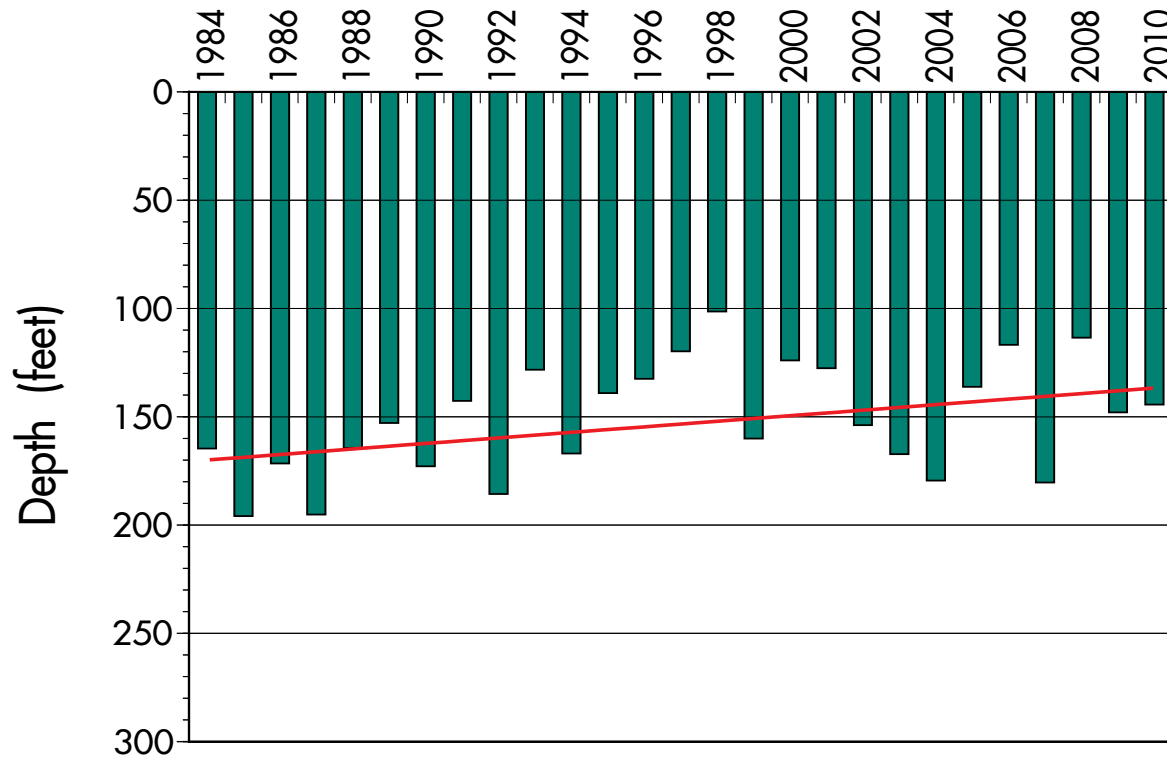
**Depth of chlorophyll maximum**

Yearly since 1984

The depth at which the deep chlorophyll maximum occurs varies from year to year. In 2010, the deep chlorophyll maximum was at about

144 feet, similar to the 2009 value of 146 feet and considerably deeper than the 2008 value of 115 feet. The deep chlorophyll maximum depth

has generally been shoaling (getting shallower) over time, a trend believed to be linked to the decline in water clarity.



## BIOLOGY

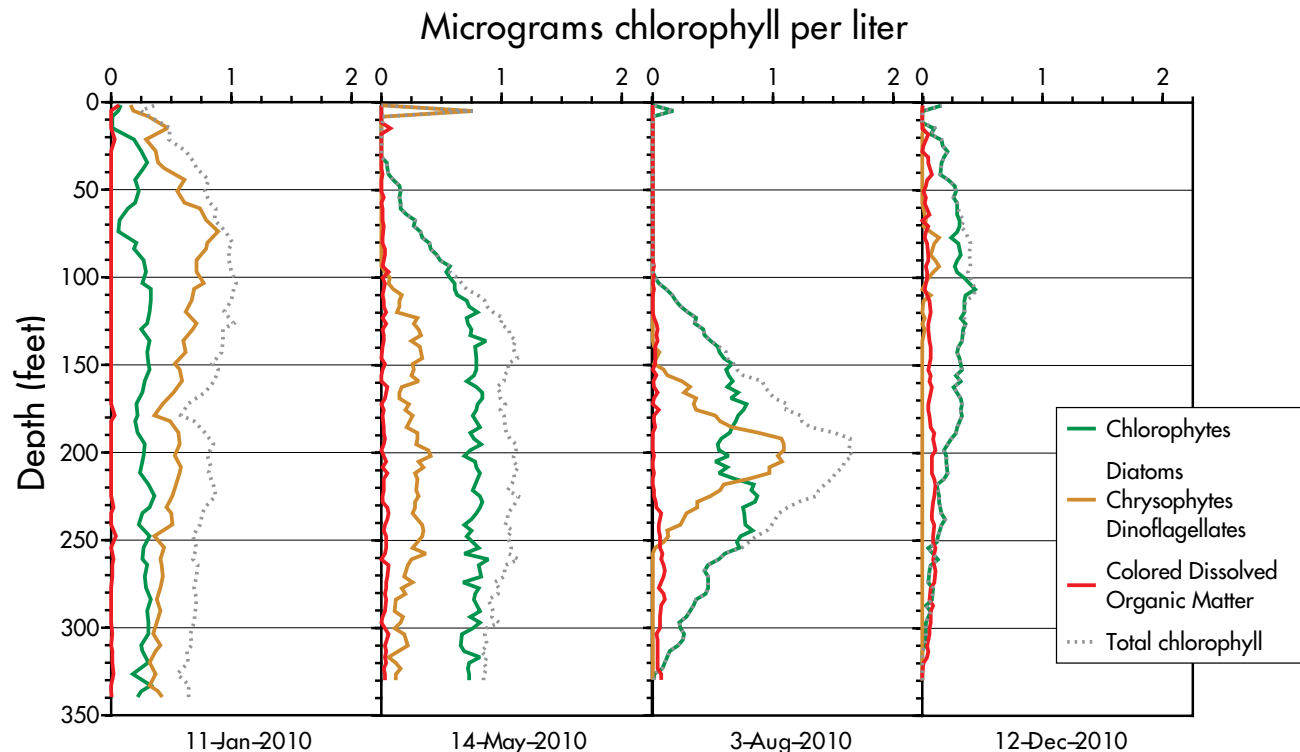
### Algae group distribution by depth

In 2010

Lake Tahoe supports many types of algae. Different groups grow at various depths below the lake surface, depending on their specific requirements for light and nutrient resources. The four profiles below show how the distributions

develop throughout the year. Two algal groups, chlorophytes (green algae) and diatoms, were dominant. Notice the separation in depth between these two groups. In August for example, diatoms peaked at a depth of 200 feet, while

chlorophytes had a bimodal distribution with peaks at 170 and 230 feet. The profile from May clearly shows the near-surface diatom population referenced in the Recent Research Clarity section (pages 6.6 - 6.8).



**BIOLOGY**

**Algae groups as a fraction of total population**

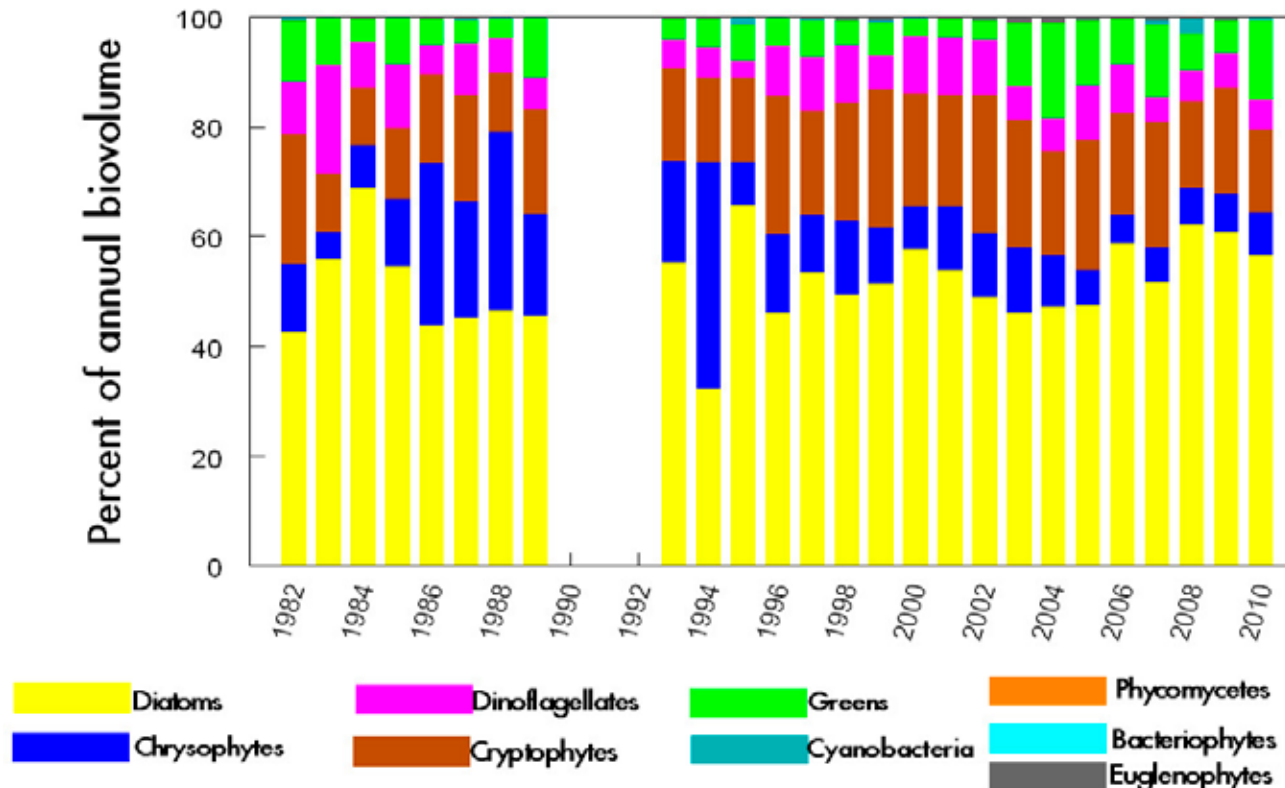
Yearly since 1982

The population, or biovolume, of algal cells from different groups varies from year to year. Diatoms are the most common type of alga, comprising 40 to 60 percent of the total biovolume

each year. Chrysophytes and cryptophytes are next, comprising 10 to 30 percent of the total. While the major algal groups show a degree of consistency from year-to-year,

TERC research has shown that the composition of individual species within the major groups is changing in response to lake condition.

Lake Tahoe, 1982-2010



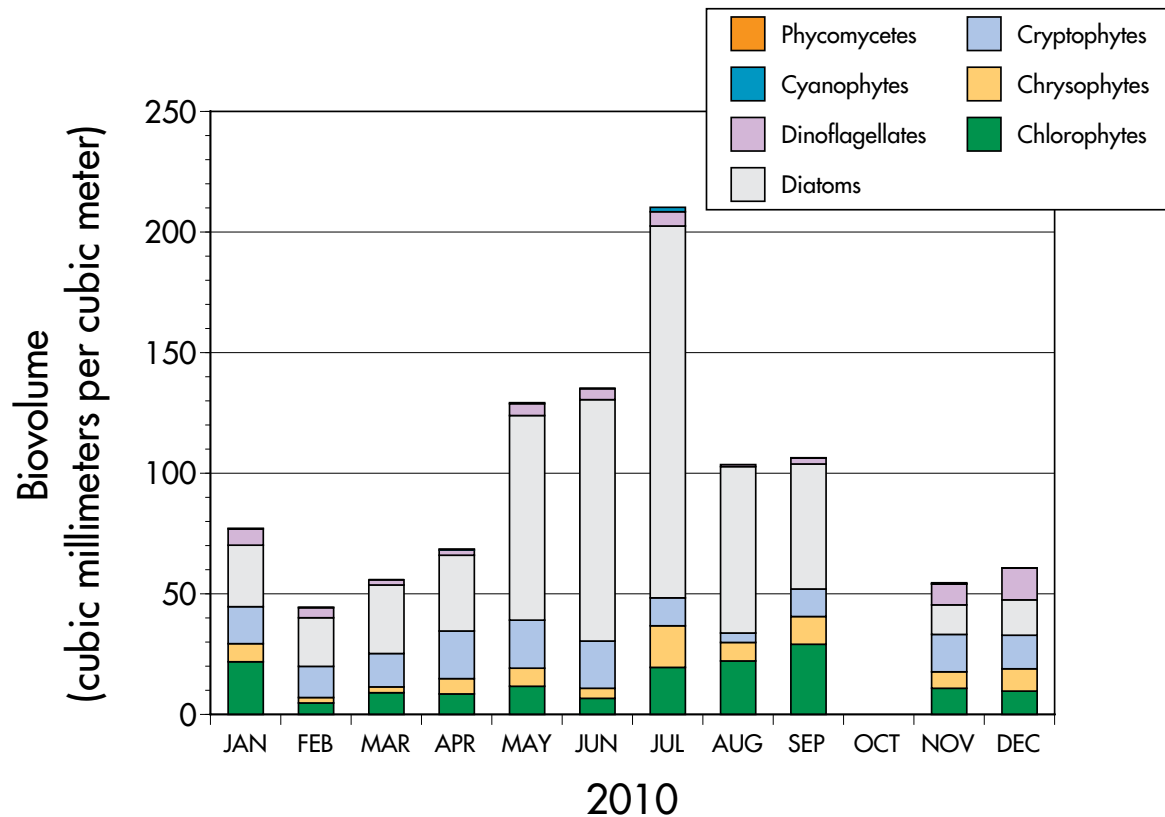
## BIOLOGY

### Algae groups as a fraction of total population

Monthly in 2010

Algae populations vary month to month, as well as year to year. In 2010, diatoms again dominated the

phytoplankton community, especially in April-September when their biovolume was particularly high.



## BIOLOGY

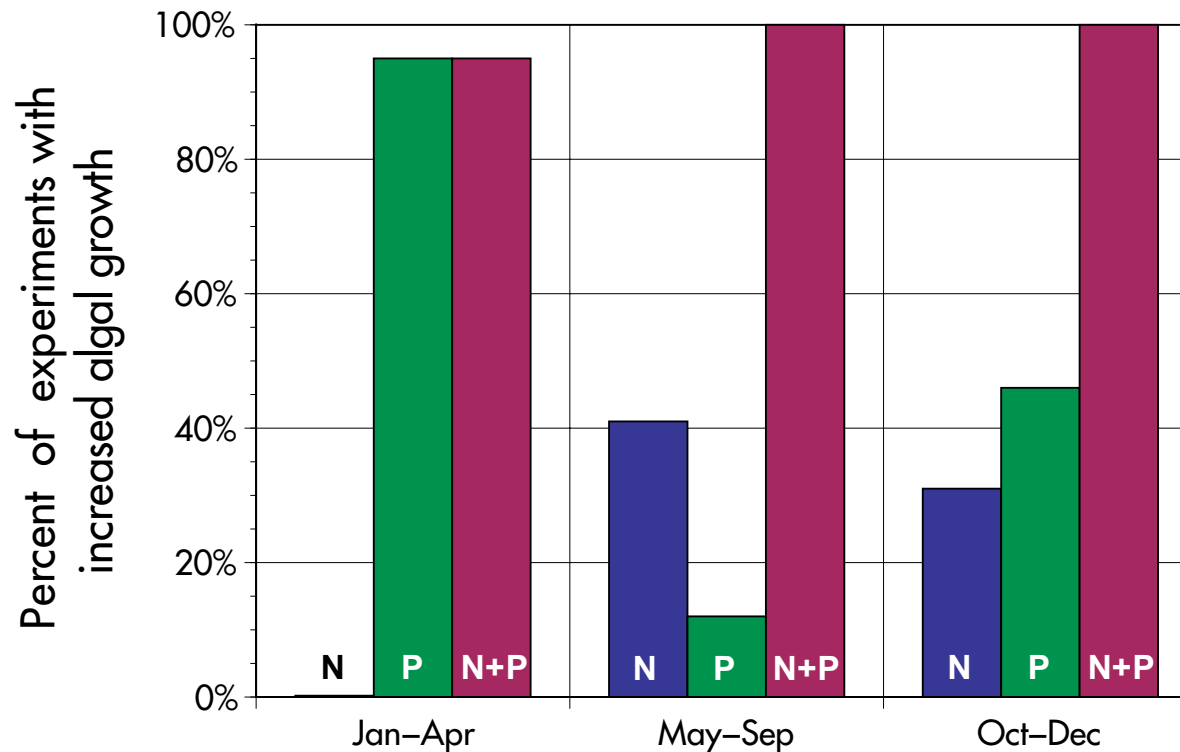
### Nutrient limitation of algal growth

For 2002 - 2010

Bioassays determine the nutrient requirements of phytoplankton. In these experiments, nutrients are added to lake water samples and algal biomass is measured. These tests document both seasonal and long-term changes in nutrient limitation. Phytoplankton response to nutrient addition for the period

2002-2010 is summarized in the panels below. Between January and April, algal growth was limited purely by phosphorus (P). From May to September, Nitrogen (N) added by itself was more stimulatory, but the lake was co-limited, as shown by the greater response to adding both nutrients.

Phosphorus was more stimulatory from October to December, but co-limitation was again the dominant condition. These results highlight the role of nutrients in controlling algal growth. They also underscore the synergistic effect when both are available.



**BIOLOGY**

**Shoreline algae populations**

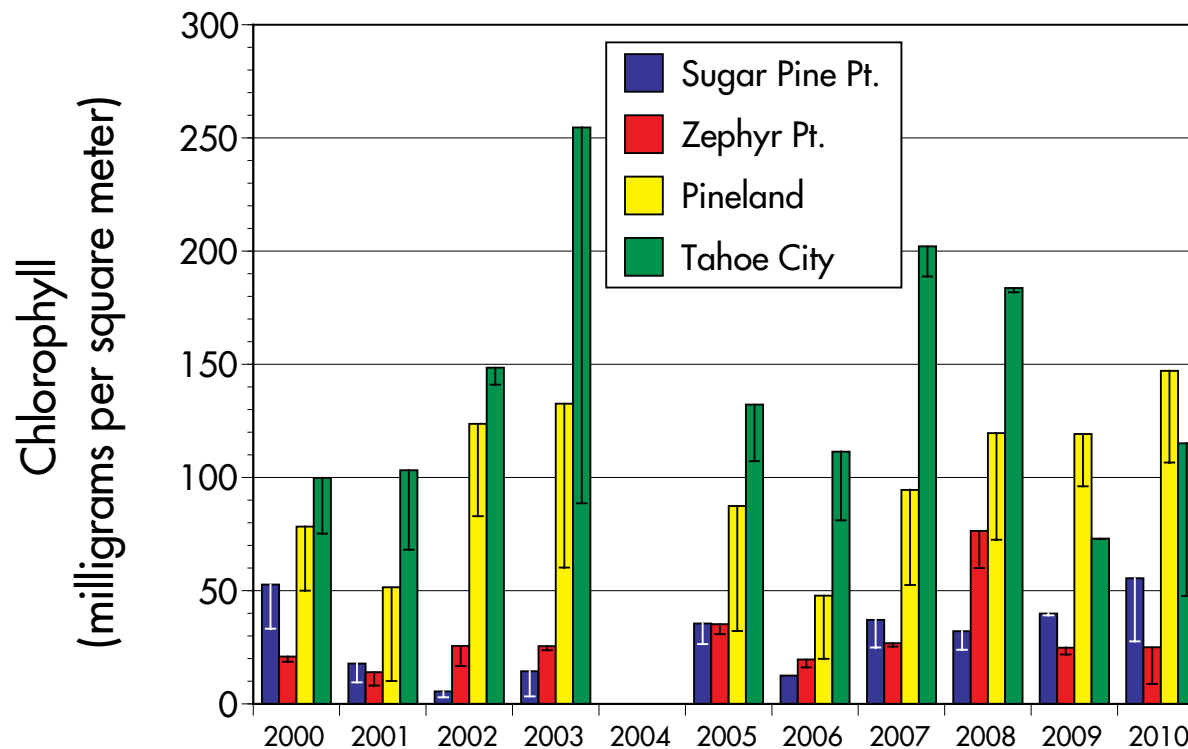
Yearly since 2000

Periphyton, or attached algae, makes rocks around the shoreline of Lake Tahoe green and slimy, or sometimes like a very plush white carpet.

Periphyton is measured eight times each year, and this graph shows the maximum biomass measured at four sites. In 2010, concentrations were near

or above average. The two sites with the most periphyton (Pineland and Tahoe City) are closest to urban areas. Tahoe City was higher than the previous year but down from high values in 2007 and 2008 and remained lower than Pineland. Peak annual biomass at the less urbanized Zephyr Point site

remained down to the usual level, from the high value experienced in 2008. To date, no statistically significant long-term trend in maximum periphyton biomass has been detected at any of these individual locations. However, the higher biomass at the more urban sites has been dramatic year after year.

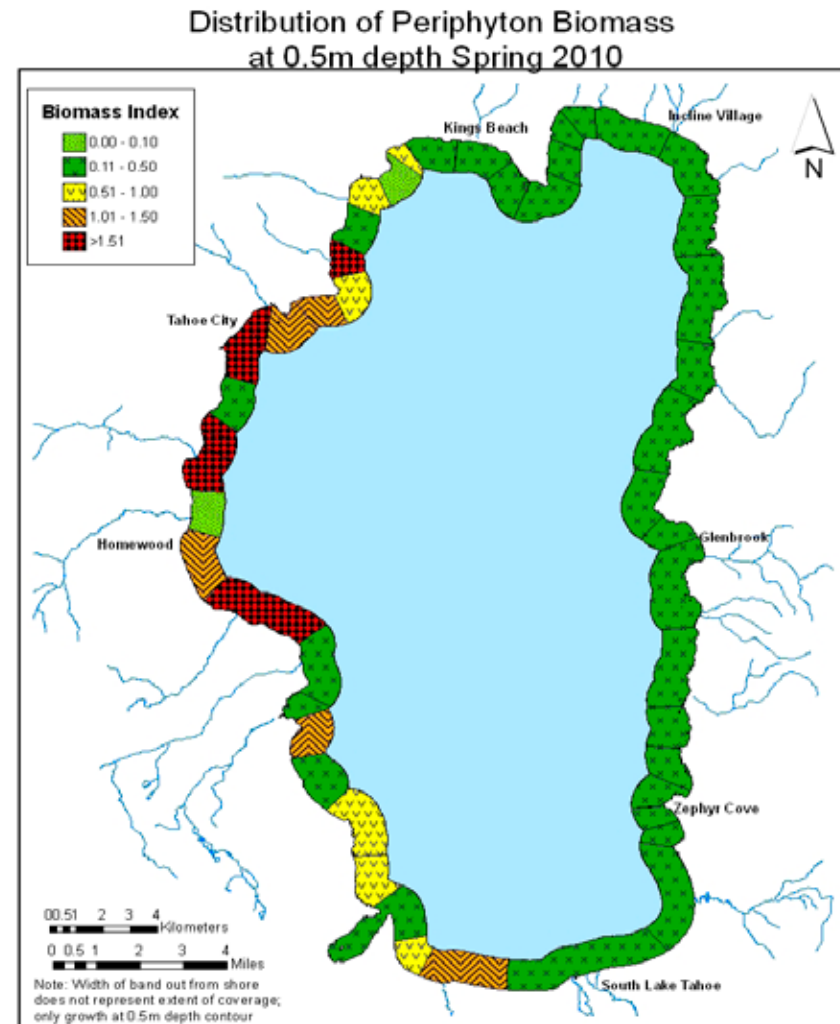


## BIOLOGY

### Shoreline algae distribution

In 2010

Periphyton biomass was surveyed around the lake during the spring of 2010, when it was at its annual maximum. Nearly 45 locations were surveyed by snorkel in 1.5 feet of water. A Periphyton Biomass Index (PBI) was developed as an indicator to reflect what the casual observer would visually detect looking into the lake from the shoreline. The PBI is defined as the percent of the local bottom area covered by periphyton multiplied by the average length of the algal filaments (cm). Zones of elevated PBI are clearly seen. (The width of the colored band does not represent the actual dimension of the onshore-offshore distribution.) Compared with 2008, there were higher concentrations of periphyton particularly in the north-east.



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**CLARITY**



**CLARITY**

**Annual average Secchi depth**

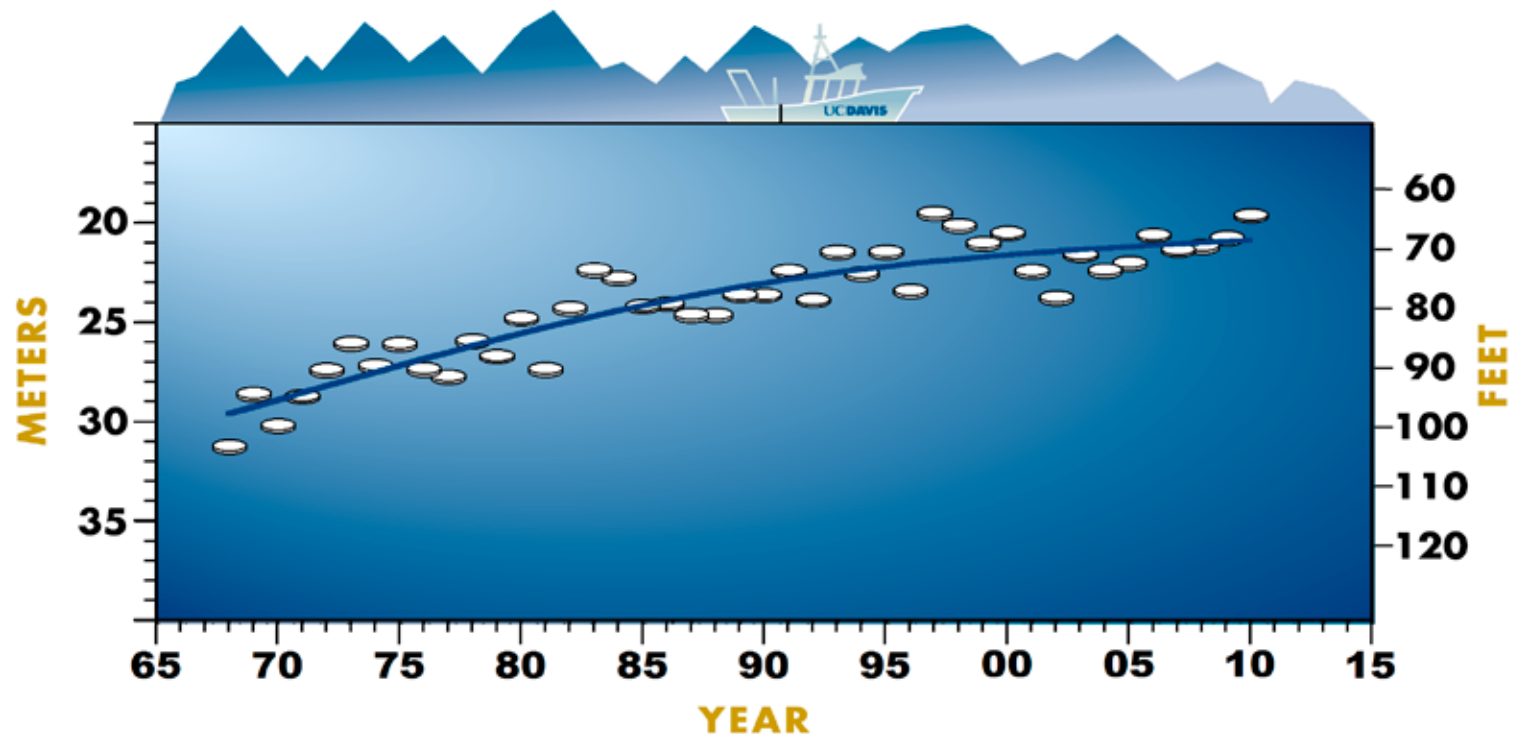
Yearly since 1968

Secchi depth (the point below the lake surface at which a 10-inch white disk disappears from view) is the longest continuous measurement of Lake Tahoe clarity. The annual Secchi depth is the average of 20 to 25 readings made throughout the year. While lake clarity has improved for brief

periods since 1968, the overall long-term trend has shown a significant decline. In the last decade, Secchi depth measurements have been better than predicted by the long-term linear trend. Statistical analysis suggests that the decline in Lake Tahoe's clarity has slowed, and is now better represented

by the curve below than a straight line. 2010 was a low year for annual average Secchi depth, with the depth of 64.4 feet being the second lowest ever recorded (the lowest was 64.1 feet in 1997). It represents a decrease of 3.7 feet from the previous year. See Pages 6.2 - 6.13 for additional details.

**DECLINE OF WATER CLARITY AT LAKE TAHOE**



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**EDUCATION AND  
OUTREACH**

**EDUCATION AND OUTREACH**

**TERC Outreach**

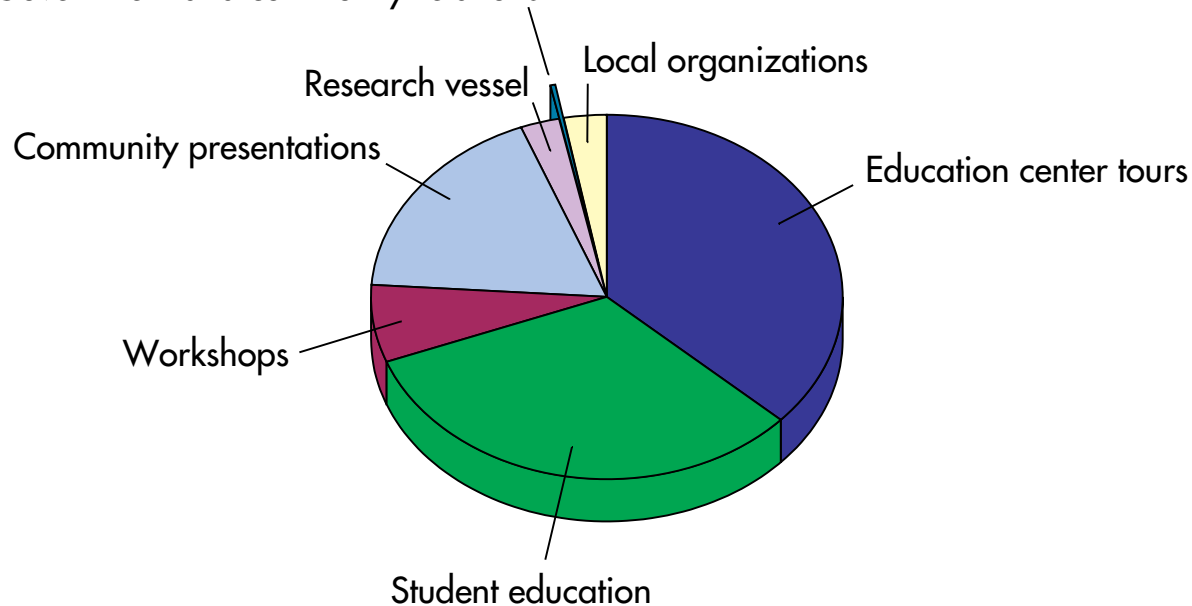
**In 2010**

Part of TERC's mission is education and outreach. During 2010, TERC recorded 10,176 individual visitor contacts. The majority represented student field trips and visitors to the Thomas J. Long Foundation Education Center at Incline Village. In addition, TERC hosts monthly public lectures and workshops, makes

presentations to local organizations and takes a limited number of visitors out on our research vessels. TERC organizes and hosts annual events and programs including Children's Environmental Science Day, Science Expo, Youth Science Institute, Trout in the Classroom program, Project WET workshops, Summer Tahoe

Teacher Institute and a volunteer docent training program. TERC also partners with numerous groups to deliver education in the Tahoe basin. In 2010, these included AmeriCorps, COSMOS, Sierra Watershed Education Partnerships (SWEP), Space Science for Schools, Young Scholars and many others.

Government and community relations



**TOTAL NUMBER OF CONTACTS: 10,176**

## EDUCATION AND OUTREACH

### TERC Educational Exhibits

In 2010

Several new exhibits were developed in 2010 including upgrades to the interpretive signage located in the Native Plant Demonstration Garden outside the Tahoe City Field Station; addition of two aquariums at the

Eriksson Education Center in Tahoe City; a new Clarity Model Interactive exhibit in Incline Village; and most notably working on the 3D movie “Lake Tahoe in Depth” for viewing in the Otellini 3D Visualization Lab in

Incline Village. Thanks to computer graphic artist Steven McQuinn, the 3D movie has the potential to greatly expand engagement with the public and school groups.



Aquariums at the Eriksson Education Center in Tahoe City highlight native and non-native aquatic species



Native plant demonstration garden outside the Tahoe City Field Station boasts newly designed interpretive signs and the garden is in full bloom



“Lake Tahoe in Depth” 3D movie screening in the Otellini 3D Visualization Lab in Incline Village

## EDUCATION AND OUTREACH

### TERC Educational Programs

In 2010

In addition to providing education center tours for the general public, the TERC Education Team also provides high quality informal science education to 3,000 - 4,000 fifth- and sixth-grade students by hosting 60 - 70 field trips each year.

A small group of select high school students participate in the afterschool Youth Science Institute from January through May. Participants work with scientists, conduct science experiments and share science activities with other students.

For the past several years, TERC has hosted a summer Tahoe Teacher Institute for educators from both California and Nevada.



School groups visit for informal science education programs on water, geology and biology



Youth Science Institute participants conduct science activities to improve their confidence in various scientific fields



Teachers come to Lake Tahoe for the Tahoe Summer Institute to improve their proficiency in environmental science topics and learn new science activities

## EDUCATION AND OUTREACH

### TERC Special Events

In 2010

TERC hosts monthly lectures throughout the year on various environmental issues, new scientific research and related regional topics of interest.

Special events hosted annually include Project WET training workshops (February), Science Expo (March), Green Thumb Tuesdays (July - August), Children's Environmental

Science Day (August), Earth Science Day (October), and Family Science Day (December)



The annual Science Expo held each March brings in more than 400 third-, fourth- and fifth-grade students for science activities



Monthly lectures are held at both the Incline Village and Tahoe City locations



Children's Environmental Science Day is held annually each August with hands-on science activities designed for kids ages six and up

**FULL REPORT AVAILABLE AT**  
**[HTTP://TERC.UCDAVIS.EDU/STATEOFTHELAKE/](http://terc.ucdavis.edu/stateofthelake/)**