Charting a course to -

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How are we going to restore Lake Tahoe's famed clarity?



Charting a Course to Clarity is a publication of the Lahontan Water Board and the Nevada Division of Environmental Protection.



How are we going to restore Lake Tahoe's famed clarity?

Scientists have conducted considerable research to identify what is causing Lake Tahoe to lose clarity and how it can be restored to the legal transparency standard of 97.4 feet. Their work reveals that many possible strategies could reach the goal. Practically, however, the only strategies that might succeed are ones you and your fellow citizens think make sense.

Your input is the critical next step in developing the Lake Tahoe Total Maximum Daily Load (TMDL). A TMDL is a plan for restoring water quality that identifies existing sources of pollutants and the maximum amount that can be discharged if the water is to continue providing its beneficial uses. A TMDL also describes how much the pollutants must be curtailed to achieve water quality standards and the strategies for getting there. *Charting a Course to Clarity* will help you consider what strategies might make sense. It summarizes what scientists have learned so far to answer four questions:

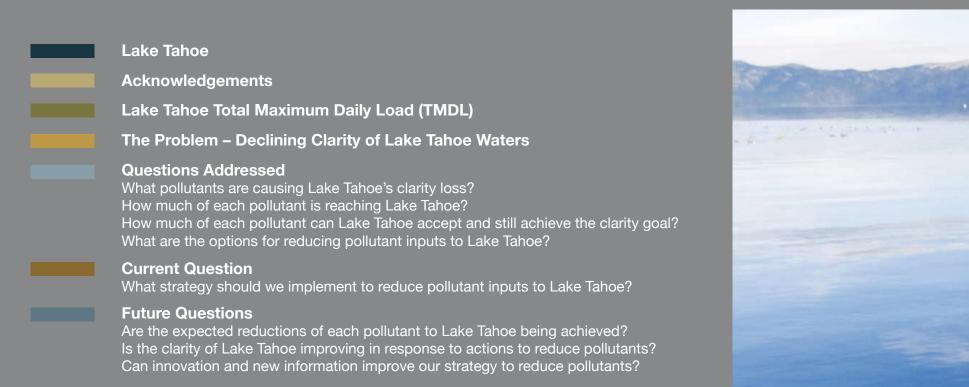
- 1. What pollutants are causing Lake Tahoe's clarity loss?
- 2. How much of each pollutant is reaching Lake Tahoe?
- 3. How much of each pollutant can Lake Tahoe accept and still achieve the clarity goal?
- 4. What are the options for reducing pollutant inputs to Lake Tahoe?

Between September 2007 and February 2008, the responsible agencies are conducting a series of workshops for stakeholders and holding discussions with local governments. What the agencies hear will guide them as they draft several approaches for improving Lake Tahoe's clarity—approaches that ideally are both technically feasible and politically acceptable. These draft approaches will then be further evaluated in the context of the Environmental Impact Statement (EIS) process for the Tahoe Regional Plan Update. Within the next couple of years, the agencies will select a strategy for reducing inputs to restore Lake Tahoe's famed clarity.

For more information on the U.S. Environmental Protection Agency TMDL program, visit: www.epa.gov/owow/tmdl



Contents





For PDF versions of TMDL documents, go to the Lahontan Water Board Web site: http://www.waterboards.ca.gov/lahontan/TMDL/Tahoe/Tahoe_Index.htm





Lake Tahoe

Lake Tahoe

Spectacularly blue Lake Tahoe is situated between the crest of the Sierra Nevada mountains on the west and the Carson range on the east, with an average surface elevation of 6,225 feet above sea level. The geologic basin that cradles the Lake is dominated by impressive mountains, steep slopes and erosive, nutrientpoor granitic soils as well as volcanic rocks and soils. The Lake's montane-subalpine watershed is predominantly vegetated by mixed conifer forests that shelter the 63 streams that flow into Lake Tahoe. The Lake has one outlet, the Truckee River, which ultimately drains to Pyramid Lake, a terminal lake in Nevada.

Lake Tahoe is the eleventh-deepest lake in the world with a depth of 1,645 feet—more than a quarter of a mile. The California–Nevada state line splits the Lake Tahoe watershed. Approximately onequarter of the watershed area and one-third of the Lake area are within Nevada, and the remainder is in California. At nearly 200 square miles, the surface area of the lake covers nearly three-fifths of the watershed. The lake holds nearly 39 trillion gallons of water. So much water resides in Lake Tahoe that it takes nearly 700 years for the average drop of water entering the lake to travel through and out to the Truckee River.

Lake Tahoe is prized for the remarkable blue of its waters. It is designated an Outstanding National Resource Water by the state of California and a "water of extraordinary ecological or aesthetic value" by the state of Nevada. Non-contact recreation—aesthetic enjoyment of the clarity of Lake Tahoe's waters—is the beneficial use that triggers the TMDL for Lake clarity. The Lake Tahoe Basin is a summer and winter destination for millions of visitors annually and is home to approximately 60,000 year-round residents. The Lake is prized as a recreation venue, with people swimming, fishing, kayaking, skiing and boating in and on its waters. Above all, people like to take in the view of Lake Tahoe's famed crystal clear, blue waters. The scale of the commitment to finding a solution to Lake Tahoe's clarity decline illustrates the importance of the Lake to the people of Nevada, California, and the nation.



Acknowledgements



Acknowledgements

The following contributors and committees are doing the work of the TMDL:

California Air Resources Board California Regional Water Quality Control Board, Lahontan Region California Tahoe Conservancy Desert Research Institute Environmental Incentives, LLC Lake Tahoe Interagency Monitoring Program Committee Nevada Division of Environmental Protection (NDEP) PATHWAY Forum members Storm Water Quality Improvement Committee Tahoe Regional Planning Agency (TRPA) Tetra Tech, Inc. TMDL Focus Team Members U.S. Army Corps of Engineers U.S. Department of Agriculture, National Sedimentation Laboratory



U.S. Forest Service, Lake Tahoe Basin Management Unit U.S. Geological Survey University of California at Davis, Tahoe Environmental Research Center (UC Davis)

The scale of effort applied to the Lake Tahoe TMDL Program reflects one of the most comprehensive scientific commitments applied to any TMDL, nationwide. This would not be possible without the support of U.S. Senators Harry Reid and John Ensign of Nevada, U.S. Senators Barbara Boxer and Dianne Feinstein of California, and the U.S. Environmental Protection Agency.

The TMDL would not be possible without the participation and support of PATHWAY partner agencies, the Tahoe Regional Planning Agency and the U.S. Forest Service. Nor would it be possible without local jurisdictions: City of South Lake Tahoe, El Dorado County, Placer County, Carson City, Douglas County, Washoe County and their General Improvement Districts, as well as the Nevada Department of Transportation and the California Transportation Department.



Lake Tahoe Total Maximum Daily Load (TMDL)



Lake Tahoe Total Maximum Daily Load (TMDL)

The Lake Tahoe TMDL is the scientific effort at the forefront of the campaign to stem the decline of Lake Tahoe's water clarity. The Tahoe TMDL to-date has involved:

- Research efforts by nearly 200 scientists
- More than a \$10-million investment by the federal government and the states of Nevada and California
- Design of cutting-edge technologies to address Tahoe-specific questions
- Cooperation and participation by Tahoe resource management agencies, local governments and the public

This scale of effort is significant when compared with other TMDL endeavors nationwide.

The Clean Water Act establishes water quality standards and the TMDL program. Waters of the United States are assigned beneficial uses—such as drinking water supply, water contact recreation, or aquatic life support—according to the beneficial ways that these waters are used by



Total Maximum Daily Load Results To-Date

Results: broad estimates Scale: entire Lake Tahoe watershed Intent: to inform policy-level decision making

people, animals, and the environment. One of the beneficial uses of Lake Tahoe is termed "recreation (water contact and non-water contact)." This beneficial use is also referred to as, "aesthetic enjoyment of Lake Tahoe clarity." This aesthetic enjoyment is impaired by the declining clarity of the Lake waters. When the water quality standards that describe a minimum requirement for a beneficial use are not being met, a TMDL is required.

The Lahontan Water Board and NDEP are developing a sediment and nutrient TMDL—a plan for achieving the transparency water quality standard governing Lake Tahoe clarity. Results, to-date, provide an understanding of the magnitude of reduction of fine sediment and nutrients needed to achieve 97.4 feet of clarity. At this stage, TMDL results are a valuable starting point for developing and prioritizing

additional research and monitoring as well as for focusing policy updates to the resource management plans for the Tahoe Basin. While the efforts will help focus the project-specific design needed to achieve water quality standards, the TMDL effort should be considered at the watershed level. A continual improvement and adaptive management process will routinely incorporate the latest information from scientific research and monitoring, adjust when necessary the plans of Basin management agencies, and involve the public in the design and implementation of the course to clarity.

The Problem - Declining Clarity of Lake Tahoe Waters



The Problem – Declining Clarity of Lake Tahoe Waters

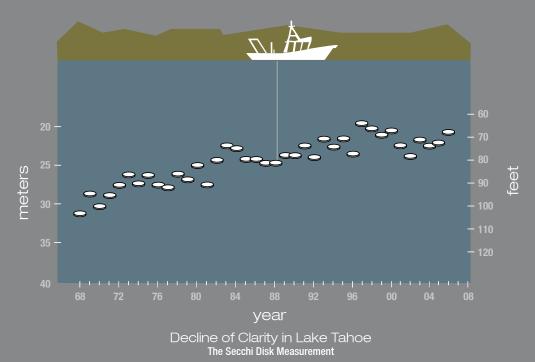
The Lake Tahoe water transparency goal is 97.4 feet. This is based on the 1967–1971 Secchi depth measurements whose mean annual values were 97.4 feet. Lake Tahoe clarity declined at an average rate of three-quarters of a foot per year between 1968 and 2006. One-third of Lake Tahoe's unique clarity has been lost during this period. The transparency standard has not been achieved since the standard was adopted in 1975.

Water clarity is measured using a tool called a Secchi disk—a device used to measure water transparency in open waters. It is a circular, white disk that is mounted on a rope and lowered slowly in the water. The depth at which the disk is no longer visible is the measure of the transparency of the water. The clearer the water is, the greater the depth at which the Secchi disk can be seen. The measure is known as Secchi depth. Secchi depth data show a significant relationship between the measured number of sediment particles in Lake Tahoe, and to a lesser extent, algal density, and the corresponding Secchi depth.

Lake Tahoe Transparency Standard

"Transparency, as measured by Secchi disk observations, shall not be decreased below the levels recorded in 1967-71, based on a statistical comparison of seasonal and annual mean values. According to data collected by the UC Davis Tahoe Research Group (TRG), the mean annual values are 1968-71 annual mean Secchi depth, being 97.4 feet (29.7 meters)."







Standardized methods for measuring Secchi depth at Lake Tahoe have been applied since the 1960s. The Lake Tahoe numeric target for Secchi depth—97.4 feet—is the annual mean Secchi depth measured between 1967 and 1971. In 1975, Lahontan Water Board adopted this value as a standard in the Water Quality Control Plan for the Lahontan Region.

Courtesy of UC Davis



Questions Addressed



What pollutants are causing Lake Tahoe's clarity loss? How much of each pollutant is reaching Lake Tahoe? How much of each pollutant can Lake Tahoe accept and still achieve the clarity goal?

What are the options for reducing pollutant inputs to Lake Tahoe?

Causes of clarity decline: fine sediment particles, algae

The objectives of TMDL research, to-date, have been to answer: (1) What pollutants are causing Lake Tahoe's clarity loss; (2) How much of each pollutant is reaching Lake Tahoe; (3) How much of each pollutant can Lake Tahoe accept and still achieve the clarity goal; and (4) What are the options for reducing pollutant inputs to Lake Tahoe? Scientists have developed the Lake Tahoe Clarity and Watershed models to help investigate these issues. These models run complex, computer-based scenarios depicting the Tahoe lake and watershed environments. Extensive records and data resulting from years of data collection and observation provide the basis for developing these models and justify their use to estimate future, Tahoe-specific environmental dynamics.

What pollutants are causing Lake Tahoe's clarity loss?

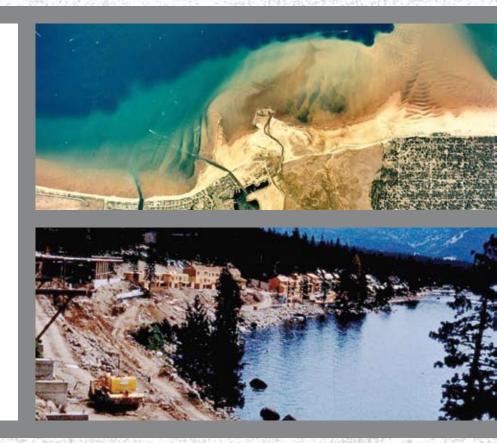
Scientific research reveals that declining clarity is attributable to both the increase in inputs of fine sediment and the increase in algae production from nitrogen and phosphorus inputs. Secchi depth in Lake Tahoe is controlled by the scattering of light by fine sediment particles (fine particles) in the water and absorption of light by algae in the water. As Secchi depth decreases, the blue color of Lake Tahoe begins to disappear.

Fine Sediment Particles

Fine Sediment Particles

Fine particles originate in the watershed when soil disturbance and other activities mobilize these particles. Once mobilized, they enter the Lake through direct runoff, streams, and air deposition. Lake Tahoe's great size and depth cause fine particles to remain in the water column for many years.

TMDL research indicates that the smallest of the fine particles—those smaller than 20 micrometers in diameter (smaller diameter than a human hair)—are a major culprit in impairing Lake Tahoe clarity. They reduce the amount of light penetration when light is scattered off the particle surfaces, adversely affecting Secchi depth. TMDL research indicates that the increasing quantity of particles of this size in the Lake water warrants concern.

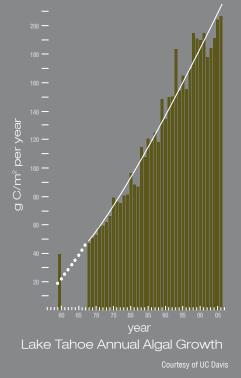


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Algae Production

Algae Production

Algae are water plants with no true leaves or stems. *Primary productivity*—the rate at which plants produce biomass through photosynthesis—increases in relation to the availability of nitrogen and phosphorus. The rise in algae production in Lake Tahoe is attributed to the rise of nitrogen and phosphorus levels in Lake Tahoe. Higher amounts of *phytoplankton*—free-floating algae—in the water absorb more light and reduce light penetration into deeper waters. The following graph illustrates how algae production in Lake Tahoe has dramatically increased in recent years.





The accumulation of attached algae on rocks, piers, boats and other hardbottomed substrates is a striking indicator of Lake Tahoe's declining water quality. Thick expanses of periphyton biomass often coat the shoreline in portions of the lake during the spring.

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How much of each pollutant is reaching Lake Tahoe?

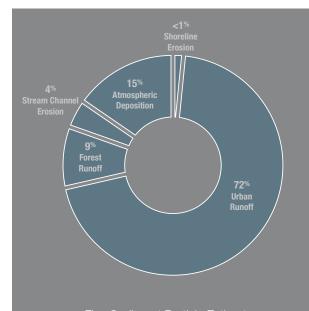
How much of each pollutant is reaching Lake Tahoe?

A significant amount of data has been collected within the Lake Tahoe Basin to help estimate the existing fine particle, nitrogen, and phosphorus inputs to the Lake from each of five primary pollutant sources: urban runoff, forest runoff, stream channel erosion, atmospheric deposition, and groundwater.

Many findings are the result of simulations performed by scientific modeling tools and estimates developed from monitoring results. Three pie charts display the modeling estimates of inputs of fine particles, nitrogen, and phosphorus to the Lake. Nitrogen and phosphorus inputs are estimated in terms of mass, because it is the mass of these nutrients that affects algae growth and the clarity measurement. Meanwhile, fine sediment particle amounts are estimated in terms of number of particles because it is the number of fine particles, not the mass, that affects clarity. The fine particle values presented are primarily based on data collected largely since 2000 and, therefore, reflect recent development of the science and current land use conditions. The Lake Tahoe TMDL Technical Report provides in-depth explanation of these findings.

Total fine sediment particles reaching Lake Tahoe

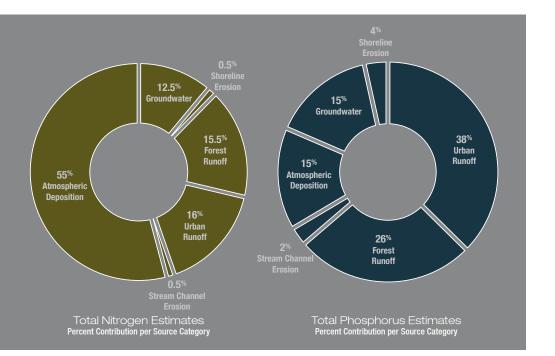
The majority of fine particles smaller than 20 micrometers are generated in urban areas. Commercial, residential, and roadway areas all contribute to the fine particle input from the urban source. Road dust and wood burning are also sources of fine particles, some of which make it to Lake Tahoe via urban (stormwater) transport and some of which make it to the Lake via atmospheric transport and deposition.



Fine Sediment Particle Estimates Percent Contribution per Source Category







Total nitrogen reaching Lake Tahoe

While atmospheric deposition is the prime mechanism by which nitrogen enters Lake Tahoe, this pollutant input is generated primarily in the urban environment. Vehicle emissions are a known source of nitrogen pollution within the Basin. The majority of the nitrogen that enters the Lake via atmospheric deposition comes from within the Tahoe Basin, as opposed to originating from sources outside the Basin.

Total phosphorus reaching Lake Tahoe

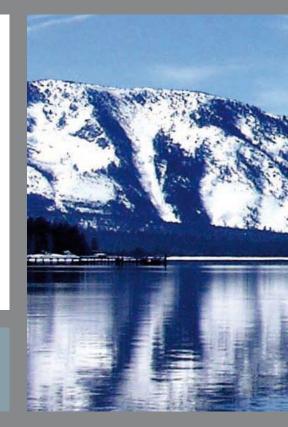
Urban runoff is the prime mechanism by which phosphorus enters Lake Tahoe. Suspended road dust is a significant source of phosphorus and travels to the Lake primarily via atmospheric deposition. Runoff from forest areas is also estimated to be a significant source of phosphorus to the Lake. Forests represent more than 80 percent of the land within the Lake Tahoe Basin and include the non-urbanized areas.



How much of each pollutant can Lake Tahoe accept and still achieve the clarity goal?

How much of each pollutant can Lake Tahoe accept and still achieve the clarity goal?

Research and scientific modeling indicate that it is possible to achieve the 97.4 foot Secchi depth in Lake Tahoe. The key to reaching this goal is significantly reducing the inputs of fine particles, nitrogen, and phosphorus. The most recent estimate is that an approximate 25-percent reduction of current inputs is needed to reverse the clarity decline, and significantly more reduction of inputs is needed to improve clarity to the 97.4-foot goal. Evidence shows that Lake Tahoe clarity can recover over relatively short time frames—as short as 20 years. Data shows that when pollutant input is reduced, Secchi depth can increase by many feet over a period of just a few years. In this way, data support the idea that Lake Tahoe can return to 97.4 feet of clarity. However, the significant amount of fine particles, nitrogen, and phosphorus reduction that is needed should not be underestimated.



The Lake Tahoe TMDL Technical Report is posted on the Lahontan Web site: http://www.waterboards.ca.gov/lahontan/TMDL/Tahoe/Tahoe_Index.htm



The Lake Tahoe Total Maximum Daily Load

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What are the options for reducing pollutant inputs to Lake Tahoe?



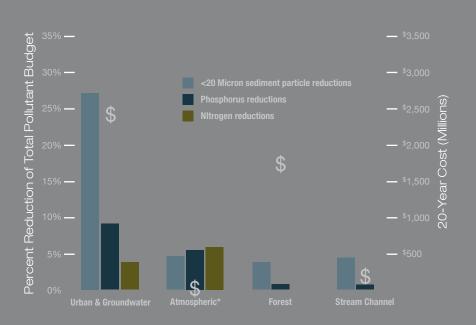
What are the options for reducing pollutant inputs to Lake Tahoe?

What are the potential options for reducing pollutant inputs to Lake Tahoe? Answering this question has been the focus of the most-recent TMDL efforts. Experts in groundwater, urban runoff, forest runoff, stream channel erosion, and atmospheric deposition conducted preliminary research to inform discussion focused on addressing TMDL questions.

Researchers investigated ways that inputs of fine particles, phosphorus, and nitrogen to Lake Tahoe can be reduced. Their findings indicate that efforts to reduce fine particles delivered via urban sources show significant promise for improving Lake clarity. Efforts to reduce nitrogen delivered via atmospheric sources show significant potential. Full descriptions of the approach to this research and its findings can be found in the *Lake Tahoe TMDL Pollutant Reduction Opportunity Report.*

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Pollutant Source Category



Opportunities to reduce pollutant inputs to Lake Tahoe are summarized in the bar chart on the facing page. Approximate costs are estimated in millions of dollars over a 20-year time frame. Note that reductions and costs are averages of several approaches analyzed. The atmospheric deposition cost* represents a combination of costs and revenues. Detailed pollutant reduction and cost information can be found in the full *Lake Tahoe TMDL Pollutant Reduction Opportunity Report*.



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Urban runoff and groundwater

Substantial effort to control sources of sediment and nutrients in the urban area can significantly reduce pollutant inputs from urban sources. Current pollutant-reduction methods constructed as part of area-wide stormwater treatment and erosion control projects could, with greater application or enhanced methods, significantly reduce pollutant inputs to Lake Tahoe. One of the methods for reducing pollutant inputs that was analyzed is called Pump and Treat. This refers to a process of capturing urban runoff water and treating it using advanced techniques before returning it to its natural course into Lake Tahoe. The Pump and Treat approach has great potential for reducing pollutant inputs from urban sources. However, this pollutant-reduction approach is cost effective only in large areas of concentrated development. Pump and Treat technologies for urban settings with concentrated impervious coverage have significantly higher input-reduction potential than treatments to areas with dispersed impervious coverage.

Atmospheric deposition

Inventories indicate that more than half of the nitrogen reaching the Lake is delivered from atmospheric sources. Motor vehicle emissions, wood burning, and road dust are significant sources of nitrogen. Controlling these emissions can result in significant reductions. Further, research indicates that reducing wood combustion, sweeping streets, adding gravel or pavement to unpaved roads, providing shuttle services and public transit incentives (to reduce use of vehicles) are among the suite of pollutant-reducing mechanisms that can address atmospheric deposition.

Forest runoff

Although unpaved roads represent a tiny fraction of forested land uses in the Basin, per–acre-sediment loading rates from unpaved roads are roughly double that from ski slopes and 20 to 40 times greater than loading rates from less-disturbed forest

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areas. Focusing controls on unpaved roads and ski slopes will provide the most cost-effective input reductions in this pollutant source category. Wildfire issues require additional research.

Stream channel erosion

Restoring Lake Tahoe's streams may reduce pollutant inputs from failing stream banks and eroding stream beds. The real benefit from stream restoration, however, comes from enhancing riparian habitat and improving floodplain function. Reconnecting disturbed rivers and streams with their natural floodplain allows the stream system to serve as a natural filter for pollutants coming from upland areas.

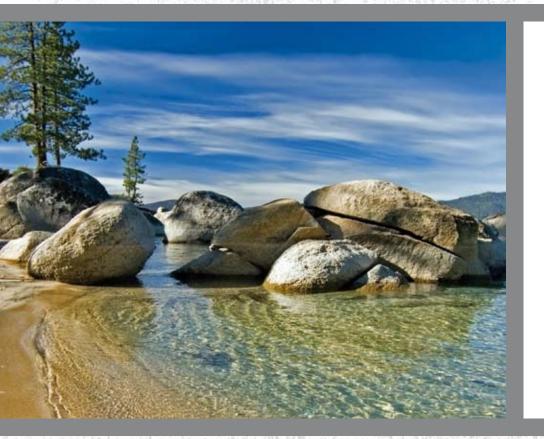
In summary, research indicates that the most significant potential for reducing the finest particles (< 20 micrometers) to Lake Tahoe is from urban sources. Some additional sediment reductions can be expected from implementing pollutant-control measures in the other pollutant source categories. Nitrogen and phosphorus reduction potential is also significant from the urban sources and atmospheric sources.



The Lake Tahoe TMDL Pollutant Reduction Opportunity Report is posted online on the Lahontan Water Board Web site: http://www.waterboards.ca.gov/lahontan/TMDL/Tahoe/Tahoe_Index.htm



Current Question



What strategy should we implement to reduce pollutant inputs to Lake Tahoe?

The work of the fall–winter 2007/2008 season is to develop approaches that articulate a variety of ways to reduce pollutant inputs. This effort will use completed research and scientific modeling tools to inform, and as part of, public discourse. A series of workshops and discussions will solicit valuable input from engaged public stakeholders, local governments, and the Pathway Forum. Decision makers — primarily the executives of NDEP; the Lahontan Water Board; the TRPA; and the U.S. Forest Service, Lake Tahoe Basin Management Unit — will use public input and further research results to help guide them to draft several approaches for improving Lake Tahoe clarity. These draft approaches will then be further evaluated in the context of the EIS process for the Tahoe Regional Plan Update.

Load allocations

Load allocations are assignments of allowable loads and load-reduction requirements allocated to activities and to appropriate agencies, programs,





business sectors, or other entities. Results from stakeholder and public participation will inform decision makers' approach to determining allocations. The sum of all Tahoe Basin allocations must result in attainment of the 97.4-foot clarity standard over time. Load allocations are expected to satisfy principles of cost-effectiveness, equitability, public acceptance, and accountability.

Final TMDL

A complete description of the TMDL elements is presented in the Lake Tahoe TMDL Technical Report. Under the federal Clean Water Act, a final TMDL must contain all the elements completed to-date. Additionally, the TMDL must include development of load allocations, an implementation plan, and a monitoring plan.

The Tahoe TMDL implementation plan will present a process for achieving load reductions beginning with current loads and resulting in achievement of 97.4 feet of clarity over a specified time frame. Preparation for developing the implementation plan is ongoing, but

several expectations have emerged among TMDL collaborating agencies. TRPA will incorporate TMDL input-reduction policies, targets, and implementation approaches into the TRPA Goals and Policies and Code of Ordinances. The TMDL will also inform the update of the U.S. Forest Service Land and Resource Management Plan. Lahontan Water Board and NDEP will incorporate the TMDL implementation plans into their Basin Plan and continuous planning process documents, respectively.

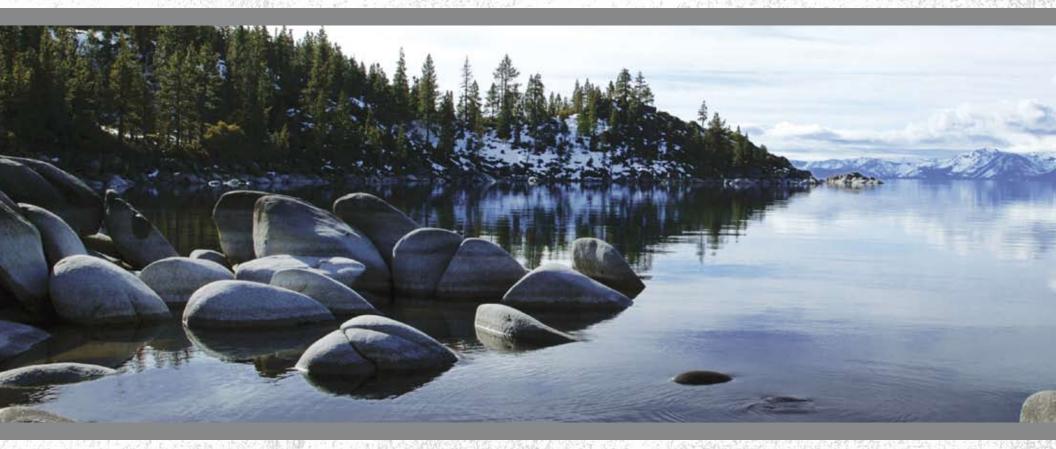
The TMDL monitoring plan will describe how project effectiveness will be measured and how input reductions and milestone achievement will be tracked over time. The monitoring plan will become the basis for scientific input to the continual improvement and adaptive management process.

All elements will be packaged in a final TMDL document. Following adoption of this document, the agencies will initiate the implementation, monitoring, and adaptive management of the TMDL.





Future Questions





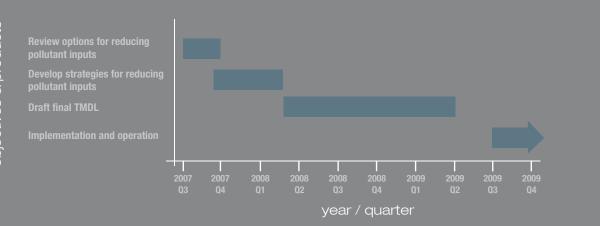


Are the expected reductions of each pollutant to Lake Tahoe being achieved? Is the clarity of Lake Tahoe improving in response to actions to reduce pollutants? Can innovation and new information improve our strategy to reduce pollutants?

The TMDL will be implemented through projects, programs, and regulations included in the TRPA Regional Plan and the Environmental Improvement Program (EIP), the U.S. Forest Service Land and Resource Management Plan, state funding agency programs, and permits issued through the Lahontan Water Board and NDEP. Potential inputreduction credits related to projects and programs will be tracked and effectiveness monitored. Ongoing research and monitoring will improve the scientific basis for management actions over time. A continual improvement and adaptive management system will provide the platform for tracking progress, improving pollutant-reduction estimates, and focusing implementation on effective and appropriate pollutant controls.







Tahoe TMDL Schedule

This timeline gives an overview of the anticipated continuation of the Lake Tahoe TMDL. In the near term, development of draft strategies to reduce pollutant inputs will take place during the fall–winter 2007/2008 months. Draft allocations will be reviewed during the spring and summer of 2008. A final TMDL is anticipated in early 2009, following TRPA adoption of the *Regional Plan*. Finally, the implementation and operation of the TMDL is expected to begin in 2009. Current discussions concerning likely time frames for achieving 97.4 feet of clarity range from 30 to 100 years.











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Charting a course to Clarity

The Lake Tahoe Total Maximum Daily Load

Document production assistance provided by Allegro Communication Consulting.

PATHWAY Forum Lake Tahoe Total Maximum Daily Load (TMDL)

Fall–Winter Stakeholder Sessions All Forum sessions are Thursdays, 8:30 a.m. – 4:30 p.m.

> September 27, 2007 Lake Tahoe Community College One College Drive (just off of Al Tahoe Boulevard) Library Building, Aspen Room South Lake Tahoe, California

December 6, 2007 Lake Tahoe Community College One College Drive (just off of Al Tahoe Boulevard) Library Building, Aspen Room South Lake Tahoe, California

October 25, 2007 North Tahoe Conference Center 8318 North Lake Boulevard (Highway 28) Kings Beach, California February 7, 2008 Location to be determined