LAKE TAHOE NUTRIENT AND SEDIMENT TOTAL MAXIMUM DAILY LOAD

WINTER 2005-06 NEWSLETTER

Nevada Division of Environmental Protection Lahontan Regional Water Quality Control Board

The Lake Tahoe Total Maximum Daily Load (TMDL) newsletter is back after a break since last winter. During the past year, Lahontan Regional Water Quality Control Board and Nevada Division of Environmental Protection (NDEP) staff have focused on two areas, corresponding to the first two phases of TMDL development: 1) completing the estimates of existing pollutant loads and sources impacting Lake clarity and the combinations of pollutant load reductions that will restore Tahoe's exceptional historic clarity (Phase 1), and 2) preparing for the next phase of the TMDL, load allocation and implementation planning (Phase 2).

This edition will report on a final Phase 1 research project contributing to the estimate of clarity-reducing pollutant sources: analyzing the bioavailable phosphorus in sediment inputs to the Lake. It will also review the status and expected schedule for developing the final product of Phase 1, the Technical TMDL. In addition, we describe two projects that constitute the core of Phase 2: development of an integrated water quality management strategy (IWQMS) that will achieve the TMDL, and exploring the feasibility of trading between the variety of pollution control projects that will be undertaken to meet the TMDL's load allocations, to reach the most efficient, lowest-cost overall solution to restoring Lake Tahoe's great transparency. Finally, we are pleased to announce the formation of the Lake Tahoe TMDL Unit, as a result of an internal re-organization at the Lahontan Water Board.

AVAILABILITY OF PHOSPHORUS FOR ALGAL GROWTH IN SEDIMENT INPUTS TO LAKE TAHOE

A key objective of current TMDL research and monitoring at Lake Tahoe is to determine the sources of nutrient and sediment loads to the lake and their relative importance. We know that phosphorus (P) is an important nutrient that often limits algal growth in Lake Tahoe. We also know that the main sources of P pollution to the Lake are from stream loading, direct (urban) runoff, groundwater and atmospheric deposition.

However, there are differences between the total-P load and the portion of that load actually capable of being utilized to support biological growth. A substantial portion of the total P load to lakes may be unavailable and thus have little direct impact on phytoplankton growth. To determine how much algae may be produced by P entering Lake Tahoe, it was necessary to quantify the "bioavailable-P" in the most significant sources to the Lake. Bioavailable-P is defined as the sum of immediately available (dissolved) P and the P that can be transformed into an available form by naturally occurring physical (e.g. desorption), chemical (e.g. dissolution), and biological processes (e.g. enzymatic degradation).

Prior to the initiation of the TMDL Research Program, there were no reliable estimates for bioavailable phosphorus (BAP) loading to Lake Tahoe based on field testing using state-of-the-art research methods. While the amount of BAP is somewhere between the total-P and dissolved-P values, the specific BAP contribution from the most significant sources remained unknown. These data are needed as updated input to the Lake Tahoe Clarity Model currently

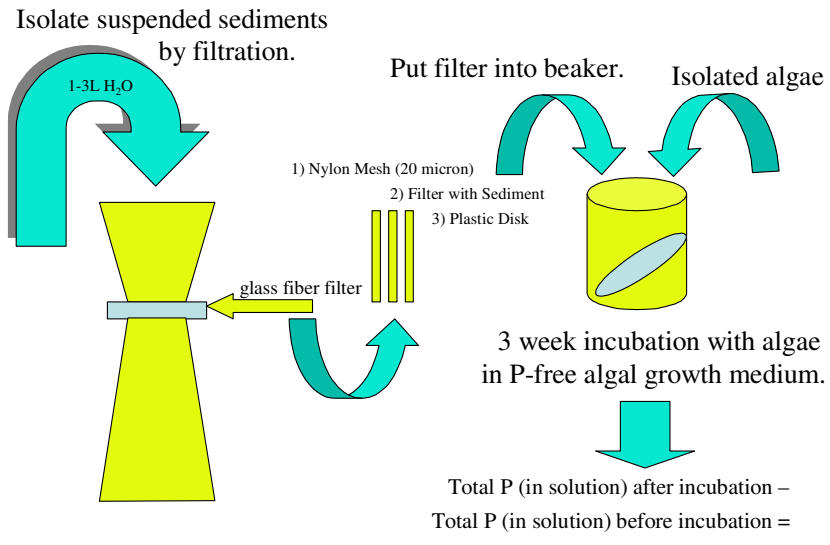
under development (see http://www.waterboards.ca.gov/lahontan/TMDL/Tahoe/Spring_2003_TMDL_Newsletter.pdf).

While it might be assumed that most of the dissolved P entering Lake Tahoe could be converted to a "bioavailable" form, P adsorbed to inorganic soil particles may or may not be released into the water column before settling to the bottom of the Lake. Early, preliminary studies suggested that approximately 30% of the total-P that enters Lake Tahoe is in the dissolved form. What then is the fate of the remaining 70% - or that phosphorus associated with particles? If total-P arrives bound to sediment and other particulate matter that settles out rapidly after entering the Lake, the contribution to primary productivity may not be great. However, the smaller particles that are transported into the water column and settle out slowly may still be a source of BAP. The long settling time for particles, biological processes, and considerations of long-term chemical equilibrium can contribute to P bioavailability.

As part of the TMDL Phase 1 research program, the Lahontan Water Board funded the first study ever at Tahoe looking at BAP. The project was conducted by Dr. Robert G. (Jerry) Qualls and Joseph Ferguson of the University of Nevada – Reno's Department of Natural Resources and Environmental Sciences. The primary goal of this project was to quantify bioavailable forms of phosphorus that are loaded to Lake Tahoe in stream water, urban runoff, and watershed. Based on this information, the loading budget and the Lake Clarity Model will account for BAP.

An additional objective of the study was to develop a quicker and cheaper chemical test procedure that could serve as a substitute to the laborious bioassay methodology currently used to measure BAP. Bioassays require that test organisms such as algae be exposed to source-water samples for periods of up to three weeks (Fig. 1). The amount of P they consume (the BAP of that particular pollutant source) is determined by measuring the quantities of P in the samples both before and after the test period. In contrast, a chemical extraction or fractionation method that is a surrogate for the organisms' uptake of P may be performed almost instantaneously, at far lower cost. The chemical fractionation procedure included an anion exchange membrane, followed by sequential chemical extracts of sodium bicarbonate ($NaHCO_3$), sodium hydroxide (NaOH), and hydrochloric acid (HCl).

Fig. 1: Laboratory Bioassay Procedure for Determining BAP



Prof. Qualls' team collected sediment samples seasonally in 2003 from five major tributary streams and during summer and fall 2003

from five areas of major direct urban runoff in Lake Tahoe Basin. They also collected soils in fall 2003 from erodable banks of the nine major tributary streams for analysis. They employed a chemical fractionation method to determine how much P each sediment sample contained, and an algal bioassay method to determine how much of the total P was available for algal growth.

When the data were combined, it was found that there was slightly more bioavailable P per milligram of sediment in the urban runoff sediments; however, sediments from stream water and urban runoff were similar and much (100 times) higher than erodabe streambank sediments (see Table 1). Similarly, it was found that the percentage of BAP relative to total particulate P was higher in both the urban runoff sediments (~20%) and the suspended stream sediments (~35%) than in the erodable streambank sediments (~5%). This was most likely due to the fact that the erodable streambank soils were of a coarser texture.

Table 1. Concentration and percentage of BAP in various sediment sources in surface runoff.

Sediment Source	Concentration of BAP (µg P/mg sediment)	Percent of Particulate-P that is Bioavailable
Suspended Stream Sediments (n=20)	0.65±0.63 (0.04-2.35)	21±8 (3-46)
Urban Runoff (n=10)	0.91±1.6 (0.01-5.27)	36±14 (3-48)
Erodable Streambanks (n=9)	0.008±0.008 (<0.001-0.25)	5±4 (<1-13)

Values are expressed as the mean±standard deviation, with the range in parentheses. The symbol 'n' refers to the number of bioassay samples.

Five streams (Upper Truckee River, General Creek, Ward Creek, Incline Creek and Edgewood Creek) were sampled seasonally for BAP associated with suspended sediments. Results are shown in Fig. 2. While there was variation between the five streams, the mean annual values for each of these tributaries was relatively uniform at 15%-34% with most values between 15%-23%. Interestingly, these results matched findings from the scientific literature where stream sediments taken from diverse regions such as New York, the mid-west, and Montana Those reported values ranged from 5%-45% with values of 20%-30% very typical. The Lake Tahoe results were also somewhat variable between seasons when the average of all five streams was considered, but the range of 16% (Fall) to 25% (Winter) was not very large.

The study team found a fairly strong relationship between the sodium bicarbonate chemical extract and the amount of P that is bioavailable. This means that a simple $NaHCO_3$ extraction test could be used as a surrogate for the time-intensive bioassay procedure to determine the bioavailability of P in a given sediment sample, a fact that could greatly facilitate future BAP monitoring.

The results presented above apply only to the contribution of biologically available-P in sediment or particulate-P. The Lake Clarity Model; however, requires estimates of BAP in the dissolved-P fractions as well as BAP associated with groundwater loading, atmospheric deposition and shoreline erosion. Based on existing literature and the best professional judgment of Prof. Qualls and the TMDL Science Team, the following adjustments to P values as measured in the field (soluble reactive-P, and dissolved organic P) were recommended. The soluble reactive-P fraction (large ortho-P contribution) was considered to be 95%-100% bioavailable. A value of 5%-15% is being used for the bioavailability of the dissolved organic-P fraction. It is

assumed that all the phosphorus loading associated with groundwater occurs as dissolved-P. Therefore, the values for soluble reactive-P and dissolved organic-P will be applied to groundwater P measurements. Atmospheric deposition contains both these soluble fractions as well as a particulate-P component. Based on literature values, the combined BAP in all these fractions may be in the range of 25%-40% of the total-P measured. Early estimates for Lake Tahoe based on atmospheric deposition bucket samples suggests a BAP:TP ratio of 40% is appropriate to apply to measured air P concentrations. Finally, studies at Lake Tahoe indicate that the amount of water extractable-P in shoreline sediments is much less than 1% of the total-P. Consequently, an estimate of 1% BAP in erodable shoreline sediments is considered conservative.

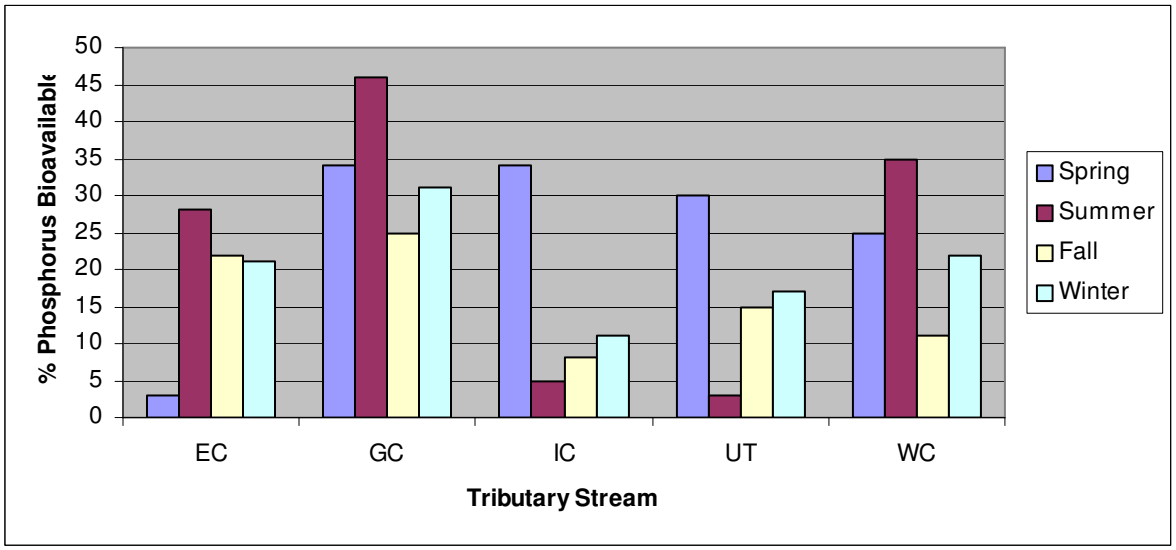


Fig. 2 Percent Phosphorus Bioavailable in the Stream Sediments of Five Tributaries of Lake Tahoe in 2003, by season. EC is Edgewood Creek, GC-General Creek, IC-Incline Creek, UT-Upper Truckee River, and WC-Ward Creek.

COMPLETING PHASE 1: THE TECHNICAL TMDL

The first phase of the Lake Tahoe TMDL has been oriented toward answering two critical questions: 1) where are the sediments and nutrients that are causing Lake clarity to decline coming from, and in what quantities? And: 2) what overall nutrient and sediment load reductions are needed to restore the Lake's historic clarity? Much of the research reported in these pages during the past three years has focused on determining these values. The two primary tools being employed by the Lahontan Water Board and NDEP to quantify these values are the Watershed Model and the Lake Clarity Model, respectively. Although the technical challenges of characterizing the ecological processes that govern Lake clarity are enormous, the final stage of combining these products is now getting underway, and results of this research are anticipated in Spring 2006. Figure 3 presents a flow chart of how Phase 1 research has been integrated.

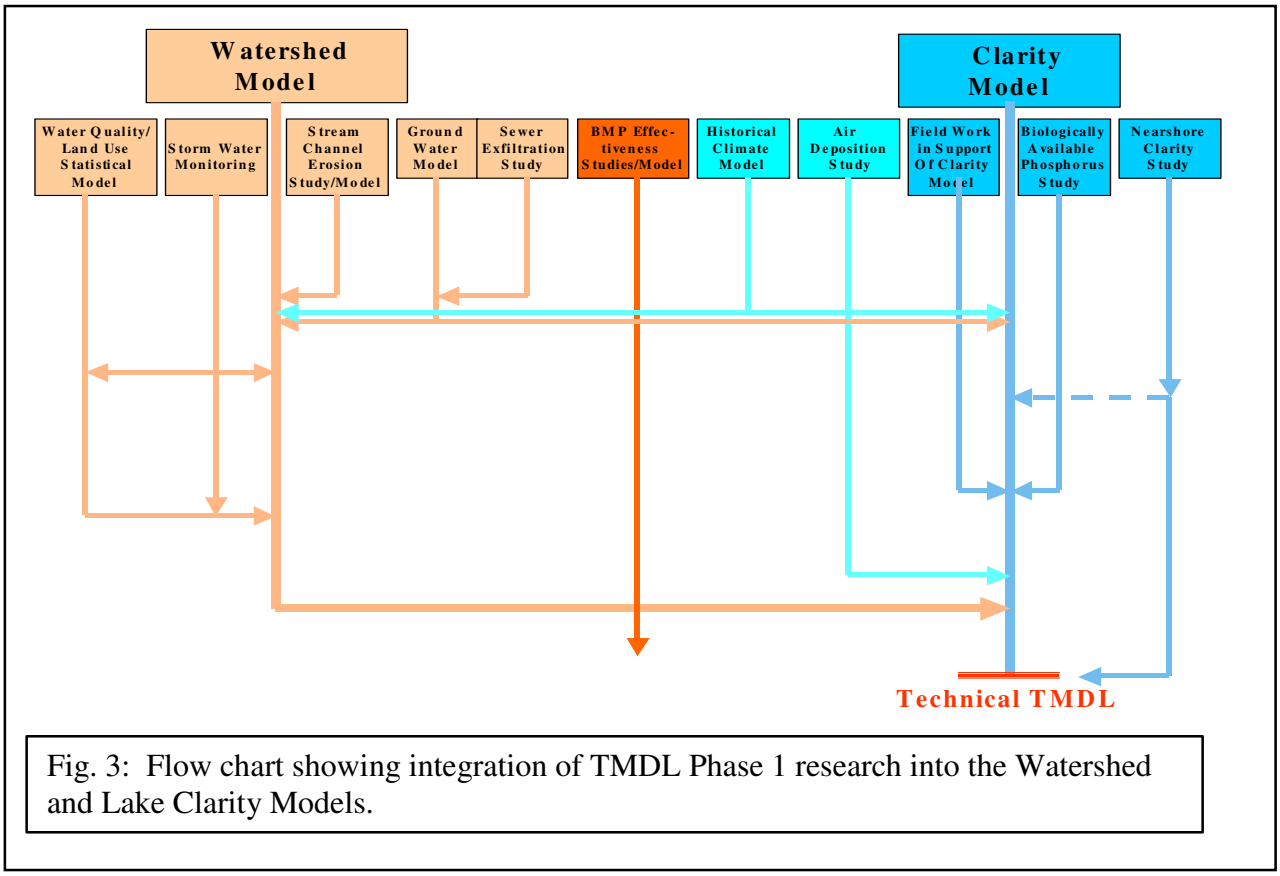


Fig. 3: Flow chart showing integration of TMDL Phase 1 research into the Watershed and Lake Clarity Models.

In order to calibrate the Watershed Model, it was necessary to represent the complex meteorology and hydrology of a high-elevation basin dominated by snowfall. Historical climate modeling (see last article in http://www.waterboards.ca.gov/lahontan/TMDL/Tahoe/Spring_2003_TMDL_Newsletter.pdf) proved to underestimate precipitation, especially snowfall, so model inputs were adjusted upwards to reflect actual snowpack measurements in and around the watershed. Once the basin land use map (see: http://www.waterboards.ca.gov/lahontan/TMDL/Tahoe/winter_04_05_tmdl_newsltr.pdf) was corrected and finalized, initial model calibration was completed in June of this year. Further tasks necessary to complete model calibration, including reviewing land use runoff concentrations and calculating sediment loading rates due to channel erosion, were completed during the summer and fall. Once this important calibration work was complete, the Watershed Model was able to generate loading rates to drive the Lake Clarity Model.

In addition to incorporating Watershed Model output, the Lake Clarity Model includes estimates of pollutant loading from both the groundwater and atmospheric deposition studies (see: http://www.waterboards.ca.gov/lahontan/TMDL/Tahoe/Summer-Fall_2003_TMDL_Newsletter_v2.pdf and http://www.waterboards.ca.gov/lahontan/TMDL/Tahoe/Winter_2003-04_TMDL_Newsletter.pdf, respectively). Dr. Geoff Schladow, with UC Davis, is currently combining atmospheric, groundwater, and surface runoff source loads into the Lake Clarity Model to identify the pollutant load reductions needed to achieve clarity goals. Although estimating pollutant load rates from each of the sources has been challenging, atmospheric phosphorus loads, in particular, have proven extremely difficult to measure precisely due to the

low concentrations present. Final atmospheric phosphorus estimates encompass results obtained in separate studies by the California Air Resources Board and U.C. Davis.

This Winter, the Lake Tahoe Clarity Model will be applied to compute the Linkage Analysis, or the combinations of nitrogen, phosphorus and sediment loads that will achieve desired lake clarity. Results will be presented in the Technical TMDL in Spring 2006. During this period, Lahontan Water Board and NDEP staff will compile the Technical TMDL document, which comprises the Source and Linkage Analyses as well as background descriptions of the existing water quality problem, the standards that the TMDL is intended to achieve, and the physical and institutional setting for this planning effort. The Technical TMDL will also include detailed descriptions of source load estimation methodologies and a Margin of Safety factor that addresses the assumptions used and the inherent uncertainty in our loading calculations. Once completed, the Technical TMDL document will be distributed for scientific and administrative peer review and released for public review and comment within the Pathway 2007 planning process. In response to the anticipated widespread interest, we are planning to conduct a public symposium to accompany release of the document in Summer 2006. We will also present the Technical TMDL to the Pathway 2007 Forum on July 27, 2006.

As we transition from development of the Technical TMDL to crafting an implementation plan to meet load reductions, we expect to regularly inform stakeholders of our progress via the Pathway 2007 process and our own highly public Phase 2 effort.

TWO PROJECTS WILL PLAN TMDL IMPLEMENTATION

As we complete development of the Technical TMDL (Phase 1), the Lahontan Water Board recently selected contractors to lead two projects critical for Phase 2, implementing the Lake Tahoe TMDL. The two projects, and the associated contractors are: 1) development of an Integrated Water Quality Management Strategy, which includes pollutant load allocations and a database tracking system (Tetra Tech, Inc is selected to lead this project), and 2) development of a feasibility analysis for pollutant trading (lead by Environmental Incentives). If water quality trading (WQT) is deemed feasible, Project 2 will provide a step-wise plan for implementing it, tailored specifically to Lake Tahoe Basin environmental, financial, administrative, and political conditions. The projects are expected to get underway in March 2006 and July 2006, respectively. Following are descriptions of both projects.

Project 1: Development of an Integrated Water Quality Management Strategy

Project 1 will integrate ongoing and recently completed TMDL research and modeling efforts to formulate and evaluate management options, enabling decision-makers to select a preferred approach that will form the basis for pollutant load allocations and a TMDL Implementation Plan. Project contractors and agency staff will work cooperatively with the Pathway 2007 Working Groups and Forum members to reach consensus on strategies to achieve desired Lake clarity.

Project 1 will further define four essential implementation plan components: an Integrated Water Quality Management Strategy (IWQMS) to identify potential pollutant control options; a Load Reduction Matrix to evaluate the performance of various control measures; TMDL load

allocations to distribute allowable pollutant loading among various sources and responsible entities; and a load reduction tracking system to measure pollutant reduction progress.

The IWQMS project is a public- and stakeholder-driven process for determining the most effective means of achieving load reductions identified by the Technical TMDL. The feasibility of various pollutant load reduction opportunities will be evaluated for each major source category. Work groups consisting of paid topic experts and facilitators, agency personnel, and stakeholders, will focus on each source category as well as on future growth potential. Between March 2006 and May 2007, Source Category Groups (SCGs) will be tasked with estimating basin-wide pollutant load reductions resulting from identified control measures, or the maximum feasible load reduction (MFLR) achievable for each source category.

The process will generate a spreadsheet model of innovative load reduction opportunities for each major source category and pollutant of concern. We expect an initial report on the Load Reduction Matrix by July 2006, and a final, revised report including the results of the IWQMS process in August 2007. Before Tetra Tech begins this project in March, Lahontan Water Board staff are identifying existing and potential load reduction strategies, including measures, programs, and regulations. Once the contractor begins work they will develop SCGs for each pollutant source category that will include local agency professionals and hired experts. These facilitated groups will identify feasible practices and compile available effectiveness information. The SCGs will then evaluate this information and develop MFLR estimates.

In May and June 2007, a Source Category Integration Committee (SCIC) will review the MFLR evaluation performed by each SCG. The SCIC will help maintain consistency between source groups and assure that an adequate range of opportunities are evaluated during group determination of the MFLR. With input from the Pathway 2007 partner agencies and the Pathway 2007 Forum, the SCIC will develop a series of alternative management strategies that integrate control measure opportunities identified by each SCG. Once this process is complete, it will form the basis for development of appropriate programs, regulations and indicators to implement the strategy and achieve lake clarity objectives.

Following the work of the SCGs and the SCIC, Tetra Tech will work with the Pathway 2007 Steering Team and the TMDL Team to develop recommended load allocations (or needed load reductions) among the responsible entities while accounting for uncertainties and future growth. There are numerous approaches to establishing load allocations to meet required pollutant load reductions. Based on an analysis of these options, Tetra Tech's load allocation effort, and Pathway 2007 input, a preferred strategy will be selected. The TMDL Team expects final load allocations to be developed between July-October 2007 with a final report due in December 2007.

Finally, it will be necessary to develop a system to track load reductions achieved by implemented control measures. The final component of this project will develop this critical tracking system while ensuring its compatibility with existing Lake Tahoe Basin information management technologies. This work will be conducted between July and September 2007 with a final product due in November 2007.

Project 2: Water Quality Trading Feasibility Study and System Design Options

This study will evaluate the feasibility of employing water quality trading (WQT) between pollutant load reduction projects to help achieve the Lake Tahoe TMDL and, if feasible, to develop WQT system design options for the basin. The study will provide the protocols and rules for creation and operation of a WQT program that incorporates the use of the Watershed and Lake Clarity models to link land use, atmospheric deposition, groundwater and stream channel erosion with BMPs that address each of these sources. Project 2 will incorporate the results of Project 1 and the methodologies to estimate load reductions from pollutant control projects that the U.S. Army Corps of Engineers, Sacramento District, is currently developing to propose units of trade and trading areas that could be incorporated into an eventual basin-wide WQT system.

This work will be conducted with a great deal of public participation through the Pathway 2007 process, and in consultation with a Project Advisory Committee. A final report will describe development of the trading program and process, including guidelines and administrative, technical, and policy recommendations. All project tasks are scheduled to occur between July 2006 and August 2007, with a presentation of draft report findings and recommendations to Pathway 2007 in late September 2007 and a final report due in November 2007.

NEW TAHOE TMDL UNIT CREATED AT LAHONTAN

Effective August 2006, the Lahontan Water Board has reorganized its functions to provide greater visibility, importance and resources to the Lake Tahoe TMDL by creating a new Tahoe TMDL Unit. Senior Engineering Geologist Doug Smith, a six-year Lahontan employee who previously worked for the Tahoe Regional Planning Agency and is very familiar with Lake Tahoe Basin environmental regulation and management, is the new unit chief. Before taking on this assignment, Doug was chief of Lahontan's Tahoe Watershed Unit, where he was responsible for project review and approval, permit issuance, and compliance and enforcement within the California portion of Lake Tahoe Basin.

Other members of the unit include: Environmental Scientists Dave Roberts, Bob Larsen, and Kim Gorman, and Water Resource Control Engineers Erich Simon and Jack Landy. Dave is the TMDL Project Lead and has coordinated, developed scopes of work for, and managed Phase 1 research contracts since 2002. Prior to joining the TMDL team last summer, Bob worked with local jurisdictions to develop and implement erosion control projects and update their municipal storm water discharge permits. Kim, who recently joined the Lake Tahoe TMDL Unit, has provided contract assistance to Lahontan for over five years. During this time she sampled urban storm water and compiled data for the TMDL, as well as worked with Lahontan's surface water monitoring team. Erich, the latest addition to our team, has consulted for municipal storm water permittees, assisted with their storm water management programs and regulatory compliance, and helped develop California storm water BMP guidance manuals. Jack is a U.S. Environmental Protection Agency employee on loan to the Board since 2002 to work on drafting the Technical TMDL, developing Phase 2 projects and contracts, and coordinating the inter-agency TMDL Development Team.

Environmental scientist Jason Kuchnicki provides invaluable assistance to the Lake Tahoe TMDL Unit as the TMDL lead, Pathway 2007 representative, and Lake Tahoe Basin contact for the Nevada Division of Environmental Protection.

The new unit reports to Division Manager Lauri Kemper, Supervising Water Resources Control Engineer. Lauri also serves as a Pathway 2007 Steering Team member and will assist in integrating the Lake Tahoe TMDL into the Pathway 2007 process. Please see the following page for contact information.

HAPPY HOLIDAYS
and NEW YEAR from
The Lake Tahoe TMDL Unit (+ Jason)

Pictured from left are unit members Erich Simon, Bob Larsen, Jason Kuchnicki (with NDEP), Doug Smith (Unit Chief), Dave Roberts, Kim Gorman, Lauri Kemper (Division Manager), and Jack Landy.

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