Final

Lake Tahoe Total Maximum Daily Load Report

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List of Acronyms and Abbreviations

These acronyms and abbreviations appear in the report. Most are spelled out initially in each chapter, but this list is provided for ease of reference.

AnnAGNPS	Agricultural Non-Point Source Pollutant Version 3.30
BAP	Biologically Available Phosphorus
BMP	Best Management Practice
C	Carbon
^{o}C	Degrees Celsius
CARB	California Air Resources Board
CDM	Camp Dresser and McKee
CDOM	Colored dissolved organic matter
CFR	Code of Federal Regulations
cfs	cubic feet per second
chl-a	Chlorophyll *a*
CONCEPTS	Conservational Channel Evolution and Pollutant Transport System
CWA	Clean Water Act
DCNR	Nevada Department of Conservation and Natural Resources
DIN	Dissolved Inorganic Nitrogen
DON	Dissolved Organic Nitrogen
DOQs	Digital Orthophotographic Quadrangles
DRI	Desert Research Institute
EMC	Event Mean Concentration
ET	Evapotranspiration
ft	Feet
GIS	Geographic Information System
IWQMS	Integrated Water Quality Management Strategy
km	Kilometer
L	Liter
LA	Load Allocation
LC	Loading Capacity
LSPC	Loading Simulation Program in C++ (Lake Tahoe Watershed Model)
LTADS	Lake Tahoe Atmospheric Deposition Study
LTBMU	US Forest Service - Lake Tahoe Basin Management Unit
LTIMP	Lake Tahoe Interagency Monitoring Program
m	Meter
µm	Micrometer
mg	Milligram
mL	Milliliter
MOS	Margin of Safety
MFR	Multi-family Residential
MT	Metric Ton
NAC	Nevada Administrative Code
NDEP	Nevada Division of Environmental Protection

NHD	National Hydrography Dataset
NH_4^+	Ammonium
NOx	Oxides of Nitrogen
NO_3^-	Nitrate
NTU	Nephelometric Turbidity Units
n/y	Number of Particles per Year
ONRW	Outstanding National Resource Water
PCO	Pollutant Control Opportunity
PM	Particulate Matter
PN	Particulate Organic Nitrogen
PP	Particulate Phosphorus
PPr	Primary Productivity
PRO	Pollutant Reduction Opportunity
Q-wtd	Flow weighted
RGAs	Rapid Geomorphic Assessments
RMHQs	Requirements to Maintain Higher Quality
SCG	Source Catagory Group
s.d.	Standard deviation
SFR	Single-family Residential
SNPLMA	Southern Nevada Public Lands Management Act
SRP	Soluble Reactive Phosphorus
SWQIC	Storm Water Quality Improvement Committee
SWRCB	State Water Resources Control Board
TDP	Total Dissolved Phosphorus
TERC	Tahoe Environmental Research Center
THP	Total Acid-Hydrolyzable-Phosphorus
TKN	Total Kjeldahl Nitrogen (all organic nitrogen plus NH_4^+)
TKN + nitrate	Total Dissolved Nitrogen
TMDL	Total Maximum Daily Load
TON	Total Organic Nitrogen
TP	Total Phosphorus
TRG	Tahoe Research Group
TRPA	Tahoe Regional Planning Agency
UC Davis	University of California Davis
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFS	United States Forest Service
USGS	United States Geological Survey
VEC	Vertical Extinction Coefficient
WLA	Waste Load Allocation
WQS	Water Quality Standard

Acknowledgments

From Douglas F. Smith (Water Board) and Jason Kuchnicki (NDEP):

This document represents countless hours of work by Water Board and NDEP staff, scientific advisors, consultants, partner agencies in the Tahoe basin, and input from stakeholders over the past nine years. This TMDL could not be possible without funding from US EPA and the states of California and Nevada. Most importantly, this TMDL could not have been initiated without the vision, guidance, and effort from the "founding fathers" of this TMDL, Dr. John Reuter and David M. Roberts. During the development of the TMDL source and linkage analyses, Dr. Reuter and Dave Roberts worked tirelessly with generous support and scientific and regulatory input from many individuals in the Tahoe basin: Sue Norman (US Forest Service), Larry Benoit (TRPA), and Jack Landy (US EPA), were three key personnel who dedicated much time to this effort..

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The scientific work supporting this TMDL was the product of many individuals who are listed in a separate acknowledgements page in the Technical Report.

Thank you!!!!

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Executive Summary

This document is the Staff Report that summarizes the Numeric Target, Pollutant Source Analysis, Load Allocations, Implementation Plan, Adaptive Management Process, and the required Regulatory Analysis for the Lake Tahoe Total Maximum Daily Load (Lake Tahoe TMDL).

Lake Tahoe is an oligotrophic alpine lake situated on the California-Nevada border at approximately 6223 feet elevation. The lake surface area is 194 mi^2 with a contributing drainage area of 314 mi^2. Lake Tahoe is fed by 63 tributary streams and 52 intervening zones that drain directly to the lake. The largest tributary is the Upper Truckee River, which contributes approximately 25 percent of the lake's annual flow. The Truckee River, Lake Tahoe's one outlet, flows to its terminus in Nevada's Pyramid Lake. The natural rim of Lake Tahoe is at 6223 feet above sea level. A dam regulates water flow from the natural rim to the maximum lake level of 6229.1 feet.

Section 303(d) of the Clean Water Act requires states to compile a list of impaired water bodies that do not meet water quality standards. The Clean Water Act also requires states to establish total maximum daily loads (TMDLs) for such waters. The deep water transparency standard for Lake Tahoe is the average annual Secchi depth measured between 1967 and 1971, an annual average Secchi depth of 29.7 meters (97.4 feet). The deep water transparency standard for Lake Tahoe has not been met since its adoption. In 2008 the annual average Secchi depth was approximately 21.2 meters (70 feet), or 8.5 meters (27.9 feet) from the standard.

The ongoing decline in Lake Tahoe's deep water transparency is a result of light scatter from fine sediment particles (primarily particles less than 16 micrometers in diameter) and light absorption by phytoplankton. The addition of nitrogen and phosphorus to Lake Tahoe contributes to phytoplankton growth. Fine sediment particles are the most dominant pollutant contributing to the impairment of the lake's deep water transparency, accounting for roughly two thirds of the lake's impairment.

Because these three pollutants are responsible for Lake Tahoe's deep water transparency loss, Lake Tahoe is listed under Section 303(d) as impaired by input of nitrogen, phosphorus, and sediment. The goal of the Lake Tahoe TMDL is to set forth a plan to restore Lake Tahoe's historic deep water transparency to 29.7 meters annual average Secchi depth.

A pollutant source analysis conducted by the Water Board and Nevada Division of Environmental Protection identified urban uplands runoff, atmospheric deposition, forested upland runoff, and stream channel erosion as the primary sources of fine sediment particle, nitrogen, and phosphorus loads discharging to Lake Tahoe. The largest source of fine sediment particles to Lake Tahoe is urban stormwater runoff, comprising 72 percent of the total fine sediment particle load. The urban uplands also provide the largest opportunity to reduce fine sediment particle and phosphorus contributions to the lake.

To achieve the transparency standard, estimated fine sediment particle, phosphorus, and nitrogen loads must be reduced by 65 percent, 35 percent, and 10 percent, respectively. Achieving these load reductions is expected to take 65 years.

A 20-year interim transparency goal, known as the Clarity Challenge requires basin-wide pollutant load reductions to be achieved within 15 years, followed by five years of monitoring to confirm that 24 meters of Secchi depth transparency has been reached. Implementation efforts must reduce basin-wide fine sediment particle, phosphorus, and nitrogen loads by 32 percent, 14 percent, and 4 percent, respectively.

The Lake Tahoe TMDL's Pollutant Reduction Opportunity Report identified options for reducing pollutant inputs to Lake Tahoe from the four largest pollutant sources: urban upland runoff, atmospheric deposition, forested upland runoff, and stream channel erosion. The Integrated Water Quality Management Strategy Report combined selected pollutant controls to develop several integrated implementation strategies. Stakeholder input helped guide the development of a single Recommended Strategy to meet the Clarity Challenge goal.

The Recommended Strategy focuses on reducing basin-wide fine sediment particle loading to Lake Tahoe and provides the basis for the Lake Tahoe TMDL pollutant load allocation distribution and for the TMDL implementation plan to achieve the Clarity Challenge. The Recommended Strategy demonstrates that load reductions needed to achieve the Clarity Challenge are possible and are estimated to cost $1.5 billion over a 15 year implementation period.

Implementation actions are required to achieve needed load reductions from each of the four major pollutant source categories. The Lake Tahoe TMDL implementation plan emphasizes ongoing implementation of known technologies while encouraging more advanced and innovative operations, maintenance, and capital improvement efforts to address urban stormwater pollution. Ongoing land management practices and policies are expected to achieve necessary fine sediment particle, nitrogen, and phosphorus load reductions from forested areas. Stream restoration projects will address stream channel bank and bed erosion sources. Measures to reduce dust from paved and unpaved roadways, parking areas, construction sites, and other disturbed lands will reduce fine sediment particle and phosphorus loading from the atmosphere.

The Water Board and Nevada Division of Environmental Protection have developed detailed performance and compliance measures, along with assessment and reporting protocols for the urban pollutant source category. These measures include a Lake Clarity Crediting Program to link actions to expected pollutant load reductions and an Accounting and Tracking Tool to track load reduction progress.

Adaptive management, or periodic evaluation and reassessment, is necessary for the long term success of the Lake Tahoe TMDL. The Lake Tahoe TMDL Management System provides a framework for adaptively managing the implementation of the Lake Tahoe TMDL. This framework guides a continual improvement cycle to track and evaluate project implementation and load reductions, and informs the milestone assessments the Water Board and Nevada Division of Environmental Protection will conduct during the 65 year implementation timeframe of the Lake Tahoe TMDL. Adaptive management will address ongoing changes from climate change, catastrophic wildfires, and other significant events.

1 Introduction

Lake Tahoe is a unique environmental treasure located in the Sierra Nevada mountain range on the California and Nevada border and is known worldwide for its outstanding clear blue waters. The lake was designated in 1980 as an Outstanding National Resource Water by the State of California and the USEPA, a designation reserved for exceptional waters with unique ecological or social significance.

Transparency vs. Clarity

Transparency and clarity are similar expressions concerning the transmission of light through water. Transparency is the depth to which the human eye can see down into the water column, and clarity is the depth light can penetrate the water column. For Lake Tahoe, transparency measurements only can be done in deep water, not in shallow water less than about 70 feet deep. Though clarity and transparency represent different characteristics, this TMDL commonly uses clarity to mean transparency.

Lake Tahoe's famed transparency has shown a significant decline since regular monitoring began in the 1960s. Transparency decline has been attributed to the rapid human population growth that occurred within the basin during this time period. The Clean Water Act requires states to establish water quality objectives for all waterbodies, identify those that fail to meet water quality objectives and develop Total Maximum Daily Loads (TMDLs) to address their impairments. This TMDL has been developed to address Lake Tahoe's transparency impairment and return the transparency, measured as Secchi depth, to the annual average levels recorded in 1967-1971.

1.1 Purpose and Scope

For an impaired water body, the TMDL process identifies one or more numeric targets based upon existing water quality objectives and specifies the maximum amount of pollutant or pollutants a water body can receive and remain in attainment of water quality objectives. The goal of the TMDL, when implemented, is for the waterbody to fully attain its designated beneficial uses. Within this context, a completed TMDL provides the framework for a comprehensive water quality restoration plan to address identified pollutant sources.

The Lake Tahoe TMDL identifies the pollutants responsible for the loss of transparency and their originating sources. Three pollutants — fine sediment particles, nitrogen, and phosphorus — are responsible for the transparency impairment of Lake Tahoe and these three pollutants enter the lake from diverse sources. This TMDL identifies the amount of each pollutant entering the lake from these sources, the reductions needed, the reduction opportunities that are available, and the implementation plan to achieve these reductions.

This TMDL is for Lake Tahoe's deep water transparency impairment and does not address other real or potential problems, such as algae growth in the nearshore or aquatic invasive species.

1.2 Involved Entities

The California Regional Water Quality Control Board, Lahontan Region (Water Board), and the Nevada Department of Environmental Protection (NDEP) cooperatively developed the Lake Tahoe TMDL to address pollutant loading from all sources and to meet the planning and regulatory needs of both states. Additionally, the Lake Tahoe TMDL is developed to meet United States Environmental Protection Agency (USEPA) requirements and support the Tahoe Regional Planning Agency (TRPA) goals and objectives.

Other public agencies and stakeholders were involved during TMDL development through a comprehensive, collaborative effort to update resource management plans and environmental regulations in the Lake Tahoe basin for the next twenty years, known as the Pathway planning process. The Pathway planning process involved meetings and workshops where interested parties have contributed ideas, shared resources and expertise, recommended mutually beneficial options, and created consistency across agencies. Additional information on Pathway is available at www.Pathway2007.org.

1.3 New Research Undertaken for TMDL Development

Numerous state, federal, academic, and private entities conducted new research in the development of this TMDL to provide the most current information possible. The research effort began in 2001 and involved over 100 contributing scientists, with significant combined funding from state and federal agencies. The Lake Tahoe TMDL effort is the most comprehensive evaluation of Lake Tahoe's clarity decline ever completed in the Lake Tahoe basin.

1.4 Phased Approach

The Lake Tahoe TMDL program was divided into three phases that emphasize answering a number of key questions. Phase One initiated the research to determine Lake Tahoe's pollutants, pollutant capacity and existing inputs. Phase Two includes a cooperative process for pollutant reduction analysis and planning. Phase Three involves implementation of the pollutant reduction plan. The products of each phase and related key management questions are summarized in Table 1-1.

Table 1-1. TMDL Phased Development

TMDL phase	Questions	Products
Phase One — Pollutant Capacity and Existing Inputs	**What pollutants are causing Lake Tahoe's clarity loss?**	Research and analysis of fine sediment, nutrients, algae growth, and meteorology
	How much of each pollutant is reaching Lake Tahoe?	Existing pollutant input to Lake Tahoe from major sources
	How much of each pollutant can Lake Tahoe accept and still achieve the clarity goal?	Linkage analysis and determination of needed pollutant reduction
		Document: TMDL Technical Report
Phase Two — Pollutant Reduction Analysis and Planning	**What are the options for reducing pollutant inputs to Lake Tahoe?**	Estimates of potential pollutant input reduction opportunities **Document:** Pollutant Reduction Opportunity Report
	What strategy should we implement to reduce pollutant inputs to Lake Tahoe?	Integrated strategies to control pollutants from all sources **Document:** Integrated Water Quality Management Strategy Project Report
		Pollutant reduction allocations and implementation milestones
		Implementation and Monitoring Plans
		Document: Final TMDL
Phase Three — Implementation and Operation	**Are the expected reductions of each pollutant to Lake Tahoe being achieved?**	Implemented projects & tracked pollutant reductions
	Is the clarity of Lake Tahoe improving in response to actions to reduce pollutants?	Project effectiveness and environmental status monitoring
	Can innovation and new information improve our strategy to reduce pollutants?	TMDL continual improvement and adaptive management system, targeted research
		Document: Periodic Milestone Reports

1.5 Notes

The Lake Tahoe TMDL report summarizes information from three distinct supplementary documents: 1) Lake Tahoe TMDL Technical Report, 2) Pollutant Reduction Opportunity Report, and 3) Integrated Water Quality Management Strategy Report. These three supplementary documents support the scientific and technical conclusions in the Lake Tahoe TMDL report and contain the detail often referenced in the TMDL report.

The Lake Tahoe TMDL Technical Report - June 2010 details the pollutant load source estimates and the lake clarity response modeling analysis. This report was first drafted in September 2007 and circulated to stakeholders and interested parties during 2007-2008. Based on received oral and written comments as well as internal review, scientific peer review and editing, parts of the TMDL Technical Report were updated in June 2010.

The Pollutant Reduction Opportunity Report, V2.0 identifies options for reducing pollutant loads to Lake Tahoe from the major fine sediment particle and nutrient sources. The analysis provides potential pollutant load reduction estimates and associated costs at a basin-wide scale associated with implementation at several levels of effort.

The Integrated Water Quality Management Strategy Report presents a Recommended Strategy for implementation and an evaluation of different options for allocating load reductions throughout the basin. The report summarizes the extensive stakeholder process undertaken to consolidate the load reduction opportunities into a package of preferred methods and approaches that reduce pollutant loads from each of the four source categories to meet the Clarity Challenge target at 20 years

The September 2007 draft Lake Tahoe TMDL Technical Report, Pollutant Reduction Opportunity Report, and Integrated Water Quality Management Strategy Report all describe fine sediment particles as those particles with diameters less than 20 micrometers (μm). That definition is not precise. The correct definition for the pollutant of concern is fine sediment particles less than 16 μm. Although incorrectly noted as < 20 μm in the reference documents, all calculations and data presented in the three supplementary documents were based on a fine sediment particle definition of < 16 μm. The error has been corrected in the June 2010 Lake Tahoe TMDL Technical Report.

Many figures and tables in this report and in the three supplementary documents are best viewed in color, particularly map layers generated from a geographic information system analysis.

Because most research and data collection efforts conducted during the TMDL analysis used the metric system, data and calculation information provided in this report are listed in metric units. Some conversions to standard units have been provided in select chapters.

2 Basin and Lake Characteristics

The Lake Tahoe basin and Lake Tahoe itself have unique, outstanding characteristics compared to other places in California and the country. This chapter describes the physical characteristics of the basin and lake.

2.1 Characteristics of the Lake Tahoe Basin

2.1.1 Location and Topography

The California – Nevada state line splits the Lake Tahoe basin, with about three-quarters of the basin's area and about two-thirds of the lake's area lying in California (Figure 2-1). The geologic basin that cradles the lake is characterized by mountains reaching over 4,003 feet (1,220 meters) above lake level, steep slopes, and erosive granitic soils. Volcanic rocks and soils are also present in some areas.

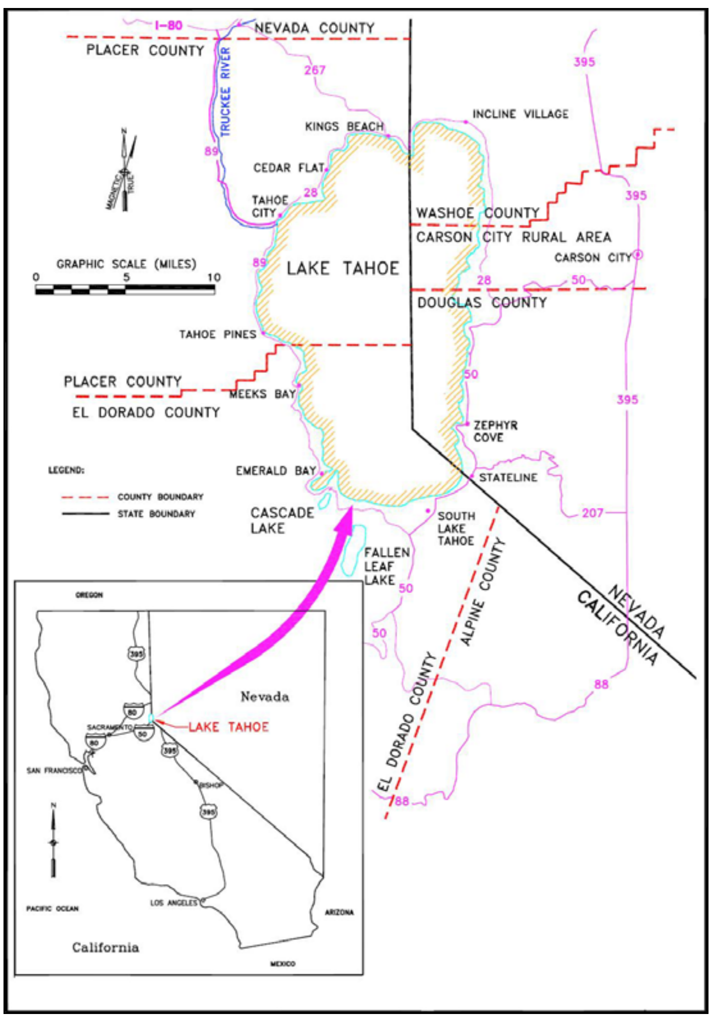

Figure 2-1. Location of the Lake Tahoe basin (USACE 2003).

2.1.2 Geology and Soils

The Lake Tahoe basin was formed approximately 2 to 3 million years ago by geologic faulting that caused large sections of land to move up and down. Uplifted blocks created the Carson Range on the east and the Sierra Nevada on the west while down-dropped blocks created the Lake Tahoe basin in between.

About 2 million years ago, lava from Mt. Pluto on the north side of the basin blocked and dammed the northeastern end of the valley and caused the basin to gradually fill with water. As the lake water level rose, the Truckee River eroded an outlet and a stream course through the andesitic lava flows down to the Great Basin hydrologic area to the east. Subsequent glacial action (between 2 million and 20,000 years ago) temporarily dammed the outlet, causing lake levels to rise as much as 600 feet above the current level. A detailed account of the basin's geology and its effect on groundwater flow and aquifer characteristics is given by USACE (2003).

Nearly all the streams in the basin lie on bedrock, with the exception of some south shore area tributaries and the lower reaches of some streams. Aquifers for the Ward Creek, Trout Creek, and Upper Truckee River watersheds slope toward the lake, which would imply a net flow into the lake (Loeb et al. 1987). However, some recent studies in the Pope Marsh area of the south shore indicate that under the influence of water pumping and seasonal effects, the net flow in some areas may be from the lake into the adjacent aquifer system (Green 1998, Green and Fogg 1998).

Lake Tahoe basin soils are mostly granitic derived soils, while volcanic soils occur in the north and northwestern parts of the basin. Soils near the lake consist of alluvial wash deposits (Crippen and Pavelka 1970). Soils in the basin have a wide range of erosion potential, and soil permeability ranges from moderate to very rapid, with the lowest permeabilities found in the northwest quadrant of the basin (Tetra Tech 2007).

2.1.3 Land Uses

Land uses in the Lake Tahoe basin have an influence on lake clarity and other environmental attributes. A detailed natural and human history of the basin is in the *Lake Tahoe Watershed Assessment* (USDA 2000).

The basin was discovered by European-American explorers in 1844. Since then, the basin has been altered by several significant, anthropogenic influences: clear-cut logging of an estimated 60 percent of the basin during the Comstock-era (1870s-10s), livestock grazing (1900s-1950s), urbanization of the lakeshore and lowest-lying parts of the basin beginning in the 1950s (USDA 2000), and public acquisition and protection of thousands of acres of sensitive lands since the mid-1960s. As of 1996, public ownership represented 85 percent of the total land area of the basin.

More than 80 percent of the watershed is vegetated (montane-subalpine type), covered predominantly by mixed coniferous forests, though bare granite outcrops and meadows are also common. About 2 percent of the watershed is impervious surface associated with urban development (Figure 2-2), which equates to over 5,000 acres (20 km^2) (Minor and Cablk 2004). Much of the impervious land cover is adjacent to the lake or its major tributaries. Additionally, 14 of the 63 individual watersheds have at least 10 percent impervious land area.

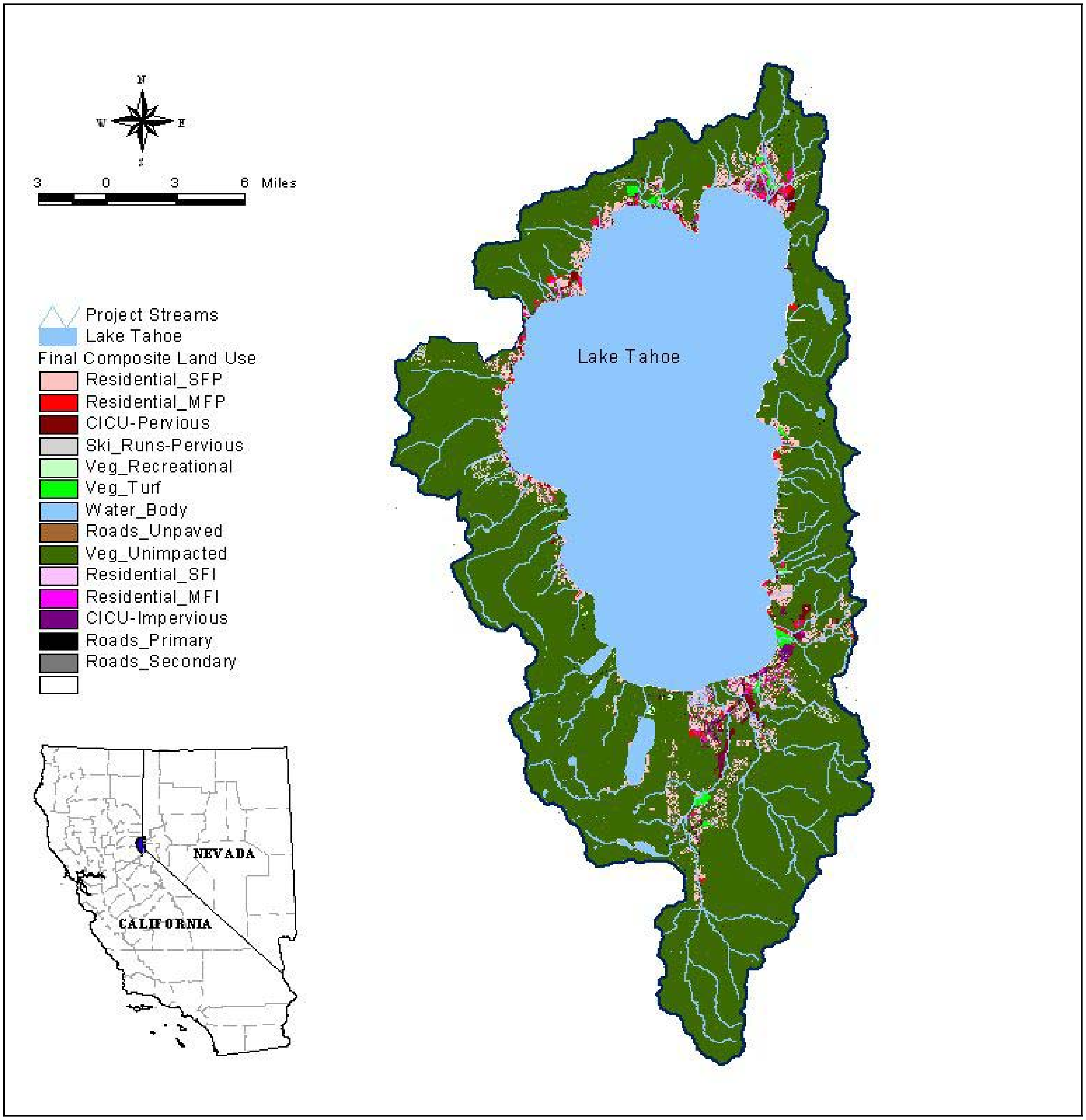

Figure 2-2. Land-uses in the Lake Tahoe basin (Tetra Tech unpublished).

Most urban development exists along the lake's shoreline, with the largest concentrations at South Lake Tahoe in the south, Tahoe City in the northwest, and

Incline Village in the northeast. The north and west shores are less densely populated, and much of the east shore is undeveloped.

2.1.4 Climate and Hydrology

Climate (specifically, precipitation as rain and snow) is the single most important factor influencing pollutant delivery to Lake Tahoe. Precipitation drives the mobilization and transport of pollutants from the landscape into the tributaries or directly into the lake.

The lake's surface area, which is relatively large compared to its watershed area, is an important factor because a significant amount of precipitation (36 percent) enters the lake directly. Therefore significant amounts of airborne pollutants (fine sediment, nitrogen, and phosphorus) enter the lake directly.

The Lake Tahoe basin has a Mediterranean-type climate characterized by wet winters and dry summers. Most precipitation in the basin falls between October and May as snow at higher elevations and as snow/rain at lake level. Over 75 percent of the precipitation is delivered by frontal weather systems from the Pacific Ocean between November and March. However, precipitation timing can vary significantly from year to year (Coats and Goldman 2001, Rowe et al. 2002). Lower elevations receive about 20 inches (51 cm) of annual precipitation, but the upper elevations on the west side of the basin receive about 59 inches (150 cm) (USDA 2000).

The snow pack at higher elevations typically melts and runs off in May and June. However, at lower elevations near the lakeshore, the snow pack typically melts earlier in the spring and can even melt mid-winter if temperature and solar radiation conditions are right. Commonly, the lower elevation snow pack melts completely before the tributaries crest with snowmelt from the higher, colder elevations.

Thunderstorms, especially rain-on-snow events, can lead to high runoff in a short amount of time, contributing to pollutant transport into Lake Tahoe and its tributaries. Thunderstorms in summer or fall can be intense and can generate large loads for short periods of time, typically in isolated geographic locations. However, summer thunderstorms contribute little to annual precipitation and typically are not responsible for significant pollutant loads to tributaries (Hatch et al. 2001, S. Hackley unpublished).

A well-defined rain shadow exists across the lake from west to east (Crippen and Pavelka 1970, Sierra Hydrotech 1986, and Anderson et al. 2004). The west shore averages about 35 inches/year (90 cm/year) of precipitation, while the east shore averages about 20 inches/year (51 cm/year).

2.2 Characteristics of Lake Tahoe

2.2.1 Location and Topography

Lake Tahoe is near the crest of the Sierra Nevada mountain range at an elevation of 6,224 feet (1,897 meters) above sea level. Slopes rise quickly from the lake's shore, reaching 30 to 50 percent slope in many places.

2.2.2 Size

Lake Tahoe is approximately 22 miles (35.5 kilometers) at its maximum length from north to south and 12 miles (19.3 kilometers) at its maximum width from east to west. The surface area of the lake covers nearly two-fifths of the Lake Tahoe basin — at 123,800 acres (501 km^2), the surface area is significantly large for its drainage area of 200,650 acres (812 km^2). Consequently, a significant amount of the precipitation that falls within the basin falls directly on the lake.

Lake Tahoe is the eleventh-deepest lake in the world with a maximum depth of 1,657 feet (505 meters) and an average depth of 1,027 feet (313 meters). The lake holds nearly 39 trillion gallons of water.

2.2.3 Hydrology

Lake Tahoe is fed by 63 tributary streams. The largest tributary is the Upper Truckee River, which contributes approximately 25 percent of the lake's annual in-flow. There are also 52 areas that drain directly to the lake without first entering streams, known as intervening zones. The lake has one outlet on its northwest side, forming the start of the Truckee River, which ultimately drains to Pyramid Lake, a terminal lake in Nevada.

The lake's hydraulic residence time is 650 years, which means that on average it takes 650 years for water that enters the lake to leave the lake. Because of its volume, depth, and geographic location, Lake Tahoe remains ice-free year-round, though Emerald Bay has frozen over during some extreme cold spells.

A concrete dam was completed in 1913 to regulate water outflow at the Truckee River outlet in Tahoe City, California. In 1988, the dam was seismically retrofitted and enlarged to its current configuration. The upper six feet of the lake forms the largest storage reservoir in the Truckee River basin, with an effective capacity of 240 billion gallons (745,000 acre-feet) (Boughton et al. 1997). Since 1987, lake levels have fluctuated from 6,220 feet (about 3 feet below the natural rim) during a prolonged drought in 1992 to 6,229 feet (about 0.2 feet above the legal maximum) during the flood of January 1997 (Boughton et al. 1997). The dam is under federal control.

3 Optical Properties of Lake Tahoe

The clarity and transparency of Lake Tahoe has been the subject of extensive research for many years. The clarity and transparency of water are influenced by many factors, including natural lighting (affected by sun angle, cloud cover, and waves), properties of water molecules, lake mixing, colored dissolved organic matter, and especially, in the case of Lake Tahoe, particulate material in the water. Material in the water can include inorganic particles (soil sediment) and organic particles (such as live suspended algae, suspended detritus or dead organic material) and a combination of these types of particulate matter in the form of aggregations that typically form around a biochemically 'sticky' organic matrix mediated by bacterial excretions. Transparency is most commonly measured as Secchi depth. Secchi depth is measured using a circular plate, known as a Secchi disk, which is lowered into the water until it is no longer visible. High Secchi depths indicate clear water; whereas low Secchi depths indicate cloudy or turbid water. Clarity is recorded by using a submersible photometer to measure the vertical extinction of photosynthetically active light per meter of water.

3.1 Particles Absorb and Scatter Light

Light is absorbed and scattered as it travels through water. The optical properties of water can be divided into apparent and inherent properties. Apparent optical properties are a function of natural lighting and are influenced by sun angle, cloud cover and water surface conditions such as waves. Inherent optical properties depend on the water and the material contained in the water column. An important inherent optical property of water is light attenuation, which is a result of absorption and scattering of light.

Particles in water both absorb and scatter light. In Lake Tahoe, light scattering and absorption are caused by inorganic and organic particles. Absorption also occurs from colored dissolved organic material (CDOM), such as naturally occurring tannins, humics and anthropogenic compounds that enter the lake (Taylor et al. 2003, Swift 2004). While absorption of light by CDOM was measurable in Lake Tahoe, it was a small portion of lake transparency loss in comparison to the fine sediment particles (Swift et al. 2006). CDOM was included in the optical component of the Lake Clarity Model. Also, water molecules themselves absorb and scatter light. Since the contribution of CDOM to light attenuation is so minor at Lake Tahoe and attenuation due to water molecules is an inherent characteristic of all waters, scattering and absorption by particles is dominant in Lake Tahoe. This can be seen in recent Secchi depth data collected in Lake Tahoe (Figure 3-1). These data show the significant relationship between the measured number of particles in Lake Tahoe and the corresponding Secchi depth (Swift 2004).

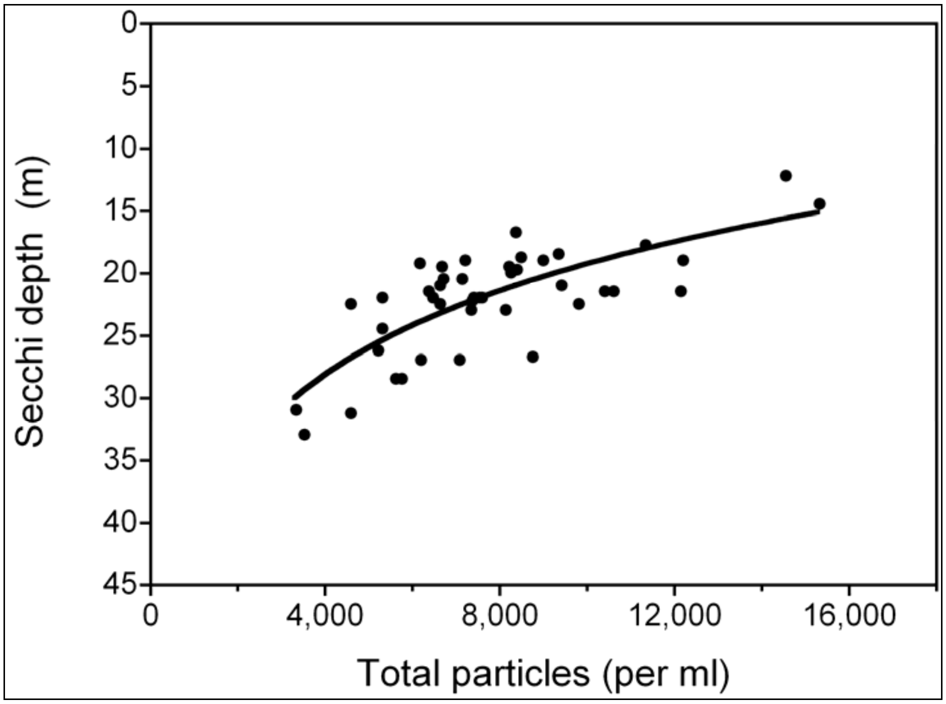

Figure 3-1. Relationship between in-lake particle number (< 16 µm) and Secchi depth with P-value = 0.001 and R^2 = 0.057 (modified from Swift 2004).

3.2 Effect of Particle Size on Lake Transparency

The hypothesis that fine inorganic particles from soil and dust, less than 16 micrometers (µm) in diameter, contribute to measurements of lake clarity loss was first published by Jassby et al. (1999). This was immediately followed by the first comprehensive study of particle number, size, and composition in Lake Tahoe during 1999-2000 (Coker 2000), which determined that the particles from 1 – 10 µm dominate and that in the 10 – 16 µm range, particle numbers are almost negligible. The original 1999-2000 investigation of particle size distribution was followed up by a series of studies including an examination of the spatial and temporal distribution of particle concentration and composition in Lake Tahoe (Sunman 2001), characterization of biotic particles and limnetic aggregates in Lake Tahoe (Terpstra 2005), lake particles and optical modeling (Swift 2004, Swift et al. 2006), and distribution of fine sediment particles in Lake Tahoe streams (Rabidoux 2005). Figure 3-2 is taken from the work of Swift et al. (2006) and shows the percent of the light attenuation due to inorganic particle scattering as a function of the particle size classes used in the Lake Clarity Model. The plot shows little to no impact of inorganic particles > 16 µm on light scattering (the dominant factor influencing attenuation in Lake Tahoe; Swift et al. (2006)). These results come directly from an analysis of Lake Tahoe waters throughout the year. Swift (2004) reported measured concentrations for particulate matter to range from 0.05 - 0.35 mg/L in Lake Tahoe's water column, depending on depth and time of year.

Data from Sunman (2001) suggest that fine sediment particles (less than 16 µm) take approximately 3 months to settle through the upper 100 meters of the water column.

This long retention time, in addition to its dominant role in scattering light, indicates the importance of the fine sediment particle contribution to clarity loss.

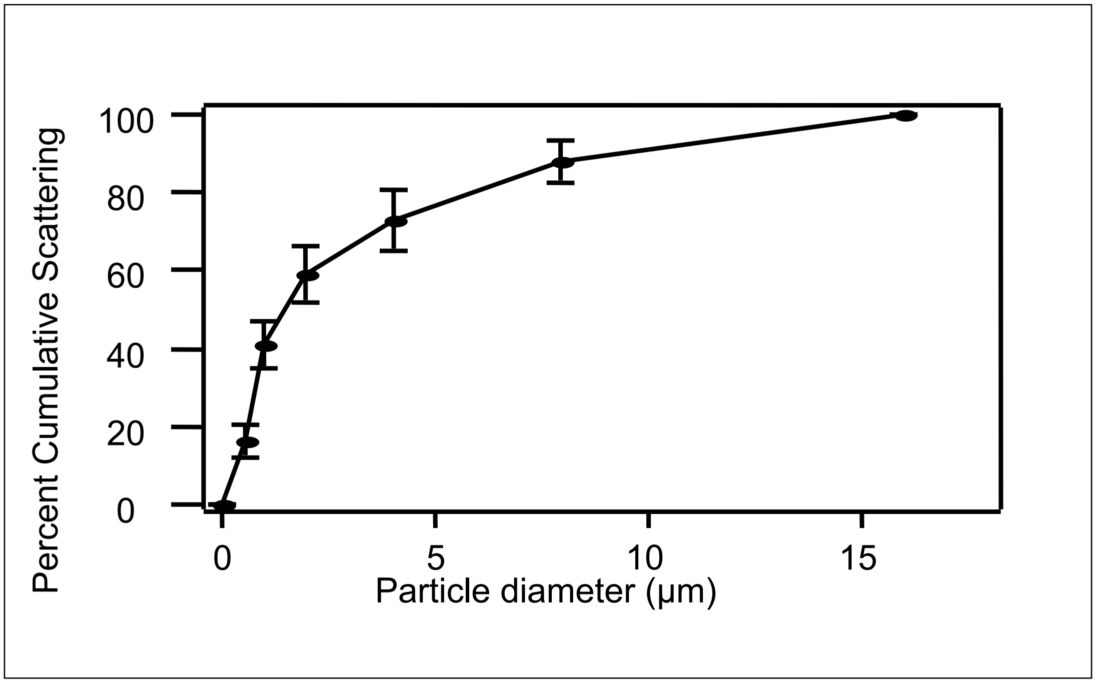

Figure 3-2. Influence of particle size on light scattering (modified from Swift et al. 2006).

3.3 Inorganic Sediment Particles Dominate Clarity Condition

Both inorganic and organic particles contribute to clarity loss in Lake Tahoe (Swift et al. 2006). Earlier investigations (Goldman 1974, 1994) focused primarily on increased phytoplankton productivity and the onset of cultural eutrophication as the dominant cause of clarity loss. However, recent studies at Lake Tahoe now show that inorganic particles have a more significant effect on clarity loss than do organic particles. These studies show that inorganic particles, with their high ability to scatter light, are actually the dominant cause of clarity loss (Swift et al. 2006).

Swift et al. (2006) determined that light scattering by inorganic particles for the period between 1999 and 2002 contributed greater than 55 to 60 percent of light attenuation, while organic particles contributed about 25 percent (Figure 3-3). The remaining 15 to 20 percent of light attenuation was due to absorption by water molecules and, to a much lesser extent, dissolved organic matter. Specifically for Lake Tahoe, these findings lend support to the earlier hypothesis (Jassby et al. 1999) that inorganic particles dominate clarity loss for most of the year.

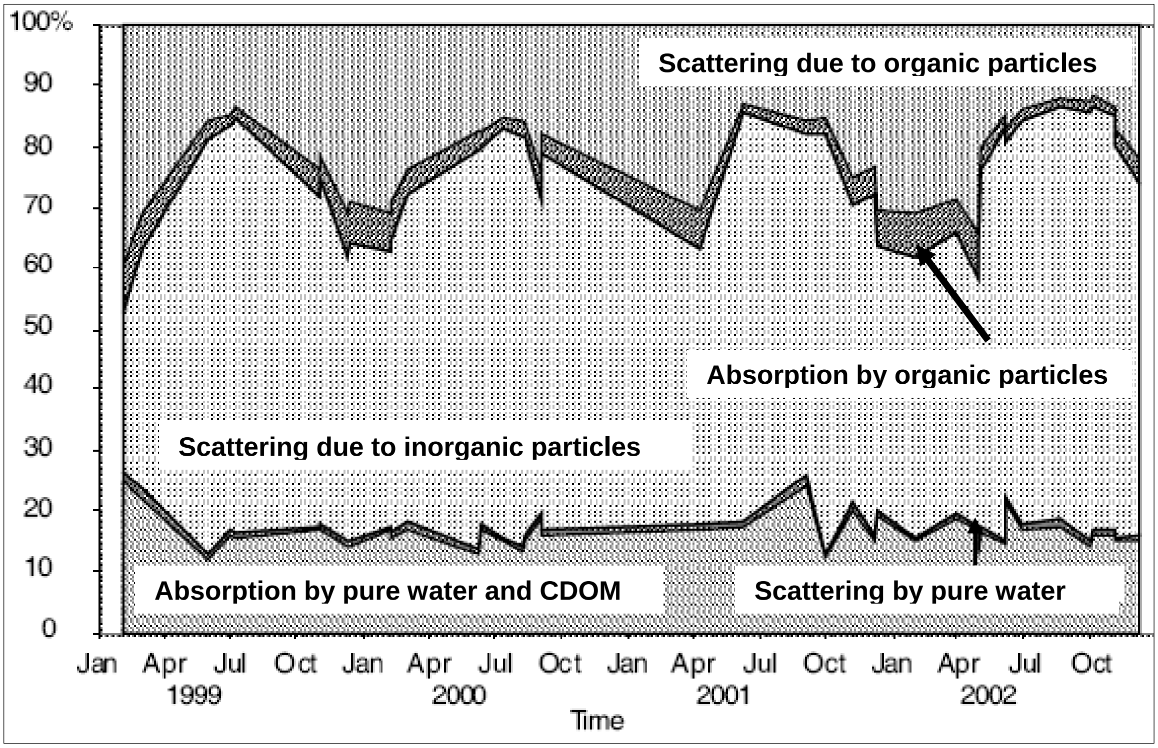

Figure 3-3. Results of an optical model showing the percentage of light absorption and scattering caused by water, CDOM (colored dissolved organic matter), and different types of particles, at different times of the year (modified from Swift et al. 2006). Inorganic particles refer to mineral or soil-based particles while organic particles include both living and dead matter.

3.4 Organic Particles - Algae and Phytoplankton

Algae and phytoplankton are the dominant source of suspended organic particles. Though organic particles are not the main cause of reduced transparency, these particles still contribute to transparency loss by attenuating light.

3.4.1 Increased Primary Productivity of Phytoplankton

The first measurements of phytoplankton (suspended, microscopic algae) growth in Lake Tahoe were made in 1959 (Goldman 1974). At that time, the annual phytoplankton growth rate was slightly less than 40 g C $m^{-2}y^{-1}$ and typical of an ultra-oligotrophic lake. For the years prior to 1959, average annual primary productivity was reconstructed from an analysis of sediment cores. Heyvaert (1998) determined that the baseline, pre-disturbance (prior to 1861 and the Comstock logging period) primary productivity was 28 g C $m^{-2}y^{-1}$. Interestingly, the calculated value from the sediment core analysis for 1900-1970, the period between the effects of the Comstock logging era in the late 1800s and the onset of urbanization of the Tahoe basin, was almost identical at 29 g C

> **Primary productivity** is the rate at which organisms (like phytoplankton) convert inorganic materials and sunlight into organic matter, through the process of photosynthesis. In most aquatic ecosystems, the phytoplankton biomass produced from primary productivity forms the base of the food web.

$m^{-2}y^{-1}$. This shows the ability of Lake Tahoe to return to historic levels following watershed recovery.

The rates of primary productivity recorded in 1959 were only about 30 percent more than the estimated baseline rates. By 2005, measured primary productivity had increased approximately 500 percent over 1959 conditions, to 203 g C $m^{-2}y^{-1}$ (UC Davis – TERC 2008). Although conditions vary year-to-year, the methodology used to measure algal growth has remained consistent over the period of record, and primary productivity data show a highly significant upward trend that continues at a rate of approximately 5 percent per year (Figure 3-4). Goldman (1988) discusses the onset of early cultural eutrophication in Lake Tahoe highlighting the role of nutrients in relation to the measured trend in primary productivity.

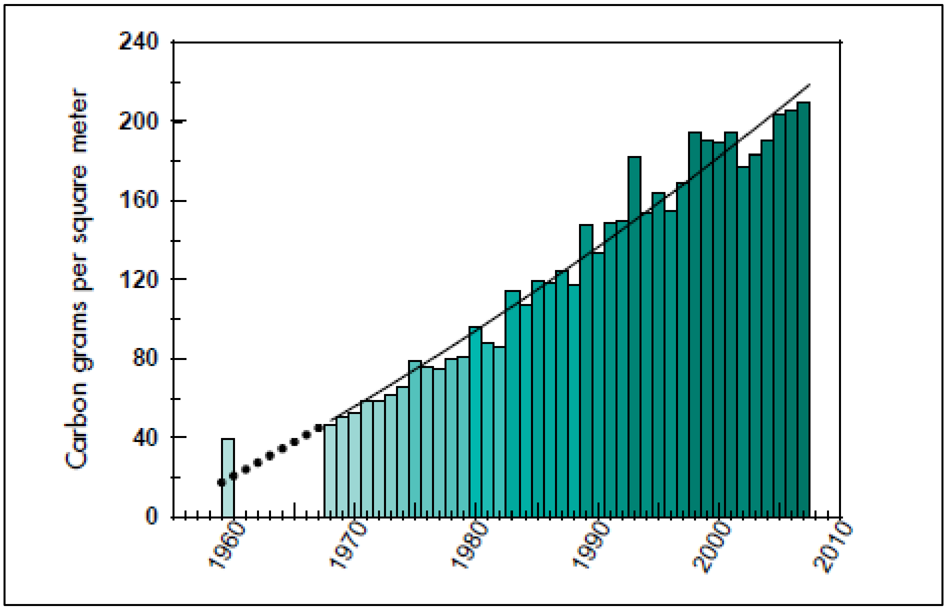

Figure 3-4. Annual average primary productivity in Lake Tahoe from approximately 25-30 measurements per year (UC Davis – TERC 2008).

Chlorophyll Concentrations and Composition of the Phytoplankton Community

The amount of free-floating algae (phytoplankton) in the water is determined by measuring the concentration of chlorophyll *a*. Though algae abundance varies annually, it does not show a long-term increase (Figure 3-5).The average annual chlorophyll *a* level in Lake Tahoe has remained relatively uniform at 0.6-0.7 µg/L since 1996.

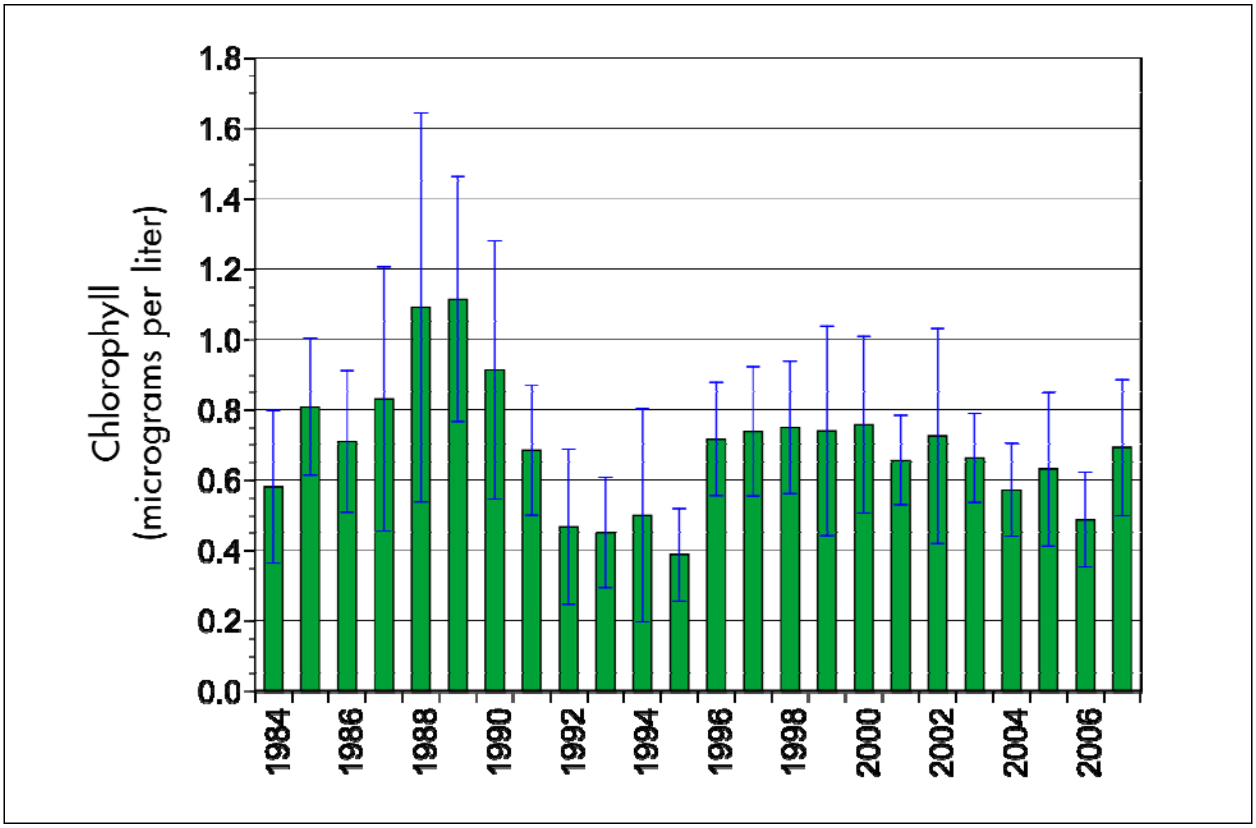

Figure 3-5. Annual chlorophyll *a* concentration in Lake Tahoe. Values represent annual means from approximately 25-30 measurements per year taken in the photic zone and volume averaged (UC Davis - TERC 2008).

Lake Tahoe has a deep-chlorophyll maximum, a common feature in the summer and early autumn, at a depth of 197-328 feet (60-100 meters) below the surface (Coon et al. 1987). While this biomass does not directly influence Secchi depth (20-30 meters deep), it was discussed above that these particles can affect clarity during the initial periods of lake mixing when they are swept up into the surface waters. Over the years the deep-chlorophyll maximum has risen in the water column to a shallower depth (Goldman 1988, Swift 2004).

Over the last four decades, changes have occurred in the standing crop, species composition and richness, and patterns of dominance (Hunter et al. 1990, Hunter 2004). The overall decline in relative abundance of diatoms is indicative of Lake Tahoe's eutrophication, as is an observed increase in araphid pennate diatoms at the expense of centric diatoms. In addition, the disappearance of *Fragilaria crotonensis* after 1980 is attributed to its inability to compete well in phosphorus-limited waters.

3.4.2 Nutrients in Lake Tahoe

Nutrients (nitrogen and phosphorus) stimulate growth of algae and other phytoplankton in Lake Tahoe. Nitrogen and phosphorus come in many different forms, with certain forms being more bioavailable to algae (i.e. more readily usable by algae for growth).

Nitrogen in Lake Tahoe

The average total nitrogen concentration for Lake Tahoe was calculated to be 65 micrograms per liter (µg/L) (Jassby et al. 1995). There are many forms of nitrogen that are measured in lake water. The majority (85 percent) of nitrogen in Lake Tahoe is in the dissolved form as either dissolved organic nitrogen (approximately 60 percent of total nitrogen) or dissolved inorganic nitrogen (approximately 25 percent of total nitrogen). The dissolved inorganic nitrogen consists of both nitrate (NO_3^-) and ammonium (NH_4^+), forms that are typically directly available for algae uptake and growth. Particulate nitrogen comprises approximately 15 percent of the total nitrogen concentration (based on a summary of monitoring and research data by Marjanovic (1989) and is not readily bioavailable.

Phosphorus in Lake Tahoe

Jassby et al. (1995) calculated the average total phosphorus concentration for Lake Tahoe to be 6.3 µg/L. Phosphorus in lake water is typically defined by the analysis method. Particulate phosphorus is approximately 10 percent of the whole-lake total phosphorus. As was observed for nitrogen, most of the lake's phosphorus is in the dissolved form. The total dissolved phosphorus fraction can be further divided into soluble reactive phosphorus and dissolved organic phosphorus. The total acid hydrolyzable-phosphorus (THP) represents the portion of total phosphorus that is converted to ortho-phosphate during chemical analysis. The THP is intended to represent the potentially bioavailable phosphorus.

Long-term Nitrogen and Phosphorus Trends

In the mid-1980s Lake Tahoe began to experience an increase in nitrogen from atmospheric deposition directly onto the lake surface (Jassby et al. 1994). Atmospheric deposition provides most of the dissolved inorganic nitrogen and total nitrogen in the annual nutrient load. Increased amounts of atmospheric nitrogen have caused an observed shift from co-limitation by nitrogen and phosphorus to persistent phosphorus limitation in the phytoplankton community (Jassby et al. 1994, 1995, and 2001).

Algal growth studies also support the finding of increased nitrogen in Lake Tahoe; these long-term bioassay experiments show a shift from co-limitation by both nitrogen and phosphorus, to predominant phosphorus limitation (Goldman et al. 1993).

3.5 Lake Dynamics

Thermal Stratification and Deep Lake Mixing

Thermal stratification and deep lake mixing are common and natural processes in lakes, including Lake Tahoe. In Lake Tahoe between February and April, distinct temperature layers develop at different depths of the lake due to heating by the sun. The layers have different densities that impede top-to-bottom movement of water and pollutants. The thermocline is the zone between the warm, lower density surface layer and the cool, dense lower layer. In Lake Tahoe the thermocline is strongest between late July and early September, at a depth of approximately 21 meters (Coats et al. 2006).

As summer progresses into fall, surface temperature is reduced and the thermocline weakens and deepens slowly until winter when vertical mixing, or turnover, occurs. Mixing, or de-stratification, generally occurs during autumn and winter due to cooling air temperatures and wind (Pamlarsson and Schladow 2000). Lake depth, size, shape, and meteorological conditions also influence mixing and the stratification processes. Deep mixing occurs when the water column is isothermal. The depth of vertical mixing in Lake Tahoe varies from about 100 meters to the bottom of the lake at about 500 meters, depending on the intensity of winter storms. On average, Lake Tahoe mixes to the bottom once every four years, which is a statistical average because mixing does not happen on a regular schedule.

Lake mixing is an important part of nutrient cycling and fine sediment particle dynamics in Lake Tahoe. Mixing brings nutrient-rich waters from deeper portions of the lake up to the surface, where together with pollutants introduced by surface runoff, sub-surface flow, and atmospheric deposition, the nutrients can be utilized by algae and contribute to reduced lake clarity. There is a positive correlation showing that increased depth of mixing during the winter results in increased algal growth the following summer (Goldman and Jassby 1990a, b).

During sustained summer wind events, surface water can be forced downward and, in response, colder, deeper water rises to the surface by a process called upwelling. During summer upwelling events, the Secchi depth often exceeds 30 meters because the water brought to the surface has a low number of fine sediment particles, resulting in an increased transparency (Pamlarsson and Schladow 2000). Lake mixing that occurs following destratification and formation of isothermal conditions affects the entire lake; whereas during upwelling, thermal stratification remains intact with the transport of deep waters. Upwelling is a transient condition that is location-dependent and not a whole-lake phenomenon.

Another important hydrodynamic process in Lake Tahoe occurs as streams discharge to the lake. Water temperature, associated water density, and stream flow have a profound impact on the depth at which stream water is inserted into the lake (Perez-Losada and Schladow 2004). Stream water carries significant sediment loads to Lake Tahoe; therefore, the depth at which stream water mixes in the lake has the potential to significantly affect lake transparency. Cold, dense stream flow and associated sediment loads will insert deeper in the lake while warmer flows will insert at shallower depths and have a more immediate impact on transparency.

Since 1970, Lake Tahoe has warmed at an average rate of 0.015 degrees Celsius per year (Coats et al. 2006). This has increased the thermal stability, increased the resistance to mixing, reduced the depth of the October thermocline, and shifted the onset of stratification toward earlier dates. The continuing impact of warming on biological communities and water quality is a concern. Chapter 12, Adaptive Management, includes additional information regarding climate change and its potential impact on Lake Tahoe's transparency.

A Higher Deep-Chlorophyll Maximum

Over the years, the deep-chlorophyll maximum in Lake Tahoe has risen in the water column to a shallower depth (Goldman 1988, Swift 2004). The deep-chlorophyll maximum (a common feature in summer and early autumn) does not directly influence the Secchi depth of 20 – 30 meters because the deep-chlorophyll maximum is deeper at 60 – 100 meters (Coon et al. 1987). However, the particles of the deep-chlorophyll maximum can affect clarity during the initial periods of lake mixing when they are swept up to the surface waters.

> **The deep-chlorophyll maximum** is the depth where the highest concentrations of chlorophyll *a* are found.

3.6 Nearshore Water Quality

Like the deeper, open waters (mid-lake) of Lake Tahoe, the nearshore area also has water quality problems. The nearshore is the primary point of contact that the residential and tourist populations have with Lake Tahoe. Since nearshore areas are obvious to even the casual observer, and impairment can interfere with aesthetic and recreational enjoyment, scientific data has been collected from the nearshore. However, this TMDL is about the deep water transparency of the lake and does not focus on the nearshore conditions. Consequently, this section provides a cursory view of the nearshore characteristics.

> **The definition of nearshore,** for the purpose of the Lake Tahoe TMDL, is the area that extends from the lake shoreline to about 20 meters of water depth. This definition differs from the TRPA Code of Ordinances definition, which is "the zone extending from the low water elevation of Lake Tahoe (6,223.0 feet Lake Tahoe Datum) to a lake bottom elevation of 6,193.0 feet Lake Tahoe Datum, but in any case, a minimum lateral distance of 350 feet measured from the shoreline."

The nearshore area is affected by surface loading either as direct discharge, tributary inflow, and groundwater loading. Watershed runoff must first pass through the nearshore area on route to the deeper waters. Nearshore water quality is historically indicated by turbidity which is a measurement of cloudiness in the water caused by suspended particles. Turbidity is expressed as nephelometric turbidity units (NTU) with higher values indicating less clarity, or greater cloudiness (Taylor et al. 2003). A Secchi disk is not used to measure nearshore transparency because the water is not deep enough and the disk can be readily seen on the bottom. Another indicator of nearshore water quality is the abundance and distribution of periphyton, or attached algae. These attached algae are typically seen as a filamentous form which often grows at nuisance levels. These filamentous algae also support epiphytic algae which are either single-celled or cell clusters that grow attached to the larger filaments. The growth of both forms of attached algae is stimulated when nitrogen and phosphorus are present in the water column.

Since 1995, Eurasian watermilfoil (*Myriophyllum spicatum*), the rooted aquatic plant, has experienced a dramatic spread in the nearshore region relative to historic conditions (Anderson et al. 2004). Ecosystem impacts related to milfoil in Lake Tahoe have been investigated with respect to water quality and the facilitation of other invasive aquatic species (e.g. Walter 2000, Kamerath et al. 2008).

3.6.1 Turbidity

Stormwater runoff, including spring time snow melt and summer thunderstorms, carries turbid water from the upland into the tributaries or directly into the nearshore. Studies by Taylor, et. al. (2003) showed that turbidity in the nearshore is typically less than 0.15 NTU, but was as high as 20 NTU in certain places. High turbidities, those defined by Taylor et al. (2003) as levels above 0.25 NTU, were directly influenced by runoff from developed areas. Less than five percent of the entire Lake Tahoe shoreline had turbidities above 0.25 NTU during a runoff event. The highest turbidities, which were found along the south shore areas, were influenced by runoff from a developed area. Most of south shore's developed areas drain into either the Upper Truckee River, Trout Creek, or Bijou Creek, and the mouths of these three tributaries were directly associated with the highest turbidities in the nearshore.

The interaction of stream inflows, resuspension of bottom sediments, nearshore processes, and deep water (mid-lake) conditions, is poorly understood. Nearshore turbidity measurements cannot be used to determine the flux of fine sediment particles into the lake and are not substitutes for directly monitoring the streams and culverts that discharge into the lake. Currently, scientists do not know how nearshore turbidity affects deep water transparency (Taylor et al 2003).

3.6.2 Attached Algae

In studying Lake Tahoe's deep water transparency, Goldman (1974) measured initial nearshore conditions and concluded that the first visible evidence of Lake Tahoe's trend towards eutrophication was the increased growth of attached algae along the shoreline in the 1960s. The accumulation of attached algae on rocks, piers, boats, and other hard-bottomed substrates is a striking indicator of Lake Tahoe's declining water quality. Thick, green or white expanses of periphyton biomass often coat the shoreline in portions of the lake during the spring. When this material dies and breaks free, beaches can be littered with mats of algae.

The urbanized northwest area of Lake Tahoe has significantly more growth of attached algae than does the undeveloped east shore area, both recently (2000 – 2003) and historically (1982 – 1985) (Hackley et al. 2004, 2005). Additionally, growth of attached algae exhibits a distinct seasonal pattern:

- In spring and early summer, high biomass accrual occurs because growth is stimulated by elevated nitrogen and phosphorus loads from spring surface runoff and groundwater flow (Loeb 1986, Reuter and Miller 2000).
- In mid-summer, biomass dies-off and sloughs away. By July, biomass returns to near its annual baseline level.

For the past 40 years, attached algae have not received much study while deep water transparency has been the focus of scientific attention. Since it is not known what relationships, effects, or influences attached algae have on the deep water transparency, this TMDL does not address the attached algae issue. Water Board and NDEP staff believe that actions to improve the transparency may have positive effects on the nearshore conditions by indirectly reducing turbidity and attached algal mass. However, additional research is needed to better understand the nearshore conditions and how management actions in the upland areas may influence those conditions.

4 Problem Statement – Transparency Decline

Transparency is expressed as Secchi depth, which is the depth to which an observer can see a 25-cm diameter white disk lowered into the water from the surface.

Continuous long-term evaluation of water quality in Lake Tahoe between 1968 and 2007 has documented a decline of water transparency (commonly referred to as clarity) from an annual average of 31.2 meters to 21.4 meters, respectively (Jassby et al. 1999, 2003, UC Davis - TERC 2008). Transparency is expressed as Secchi depth and is the depth to which an observer can see a 25 cm diameter white disk lowered into the water from the surface. This long-term loss of transparency (Figure 4-1) is both statistically significant ($p < 0.001$) and visually apparent to some users of the lake. Measurements have been taken at the same location since monitoring began with only two observers collecting this data, thereby reducing human variability in the field. Secchi depth is recorded throughout the entire year and each annual average is composed of between 25 to 35 individual readings. Jassby et al. (1999) provides estimates of precision.

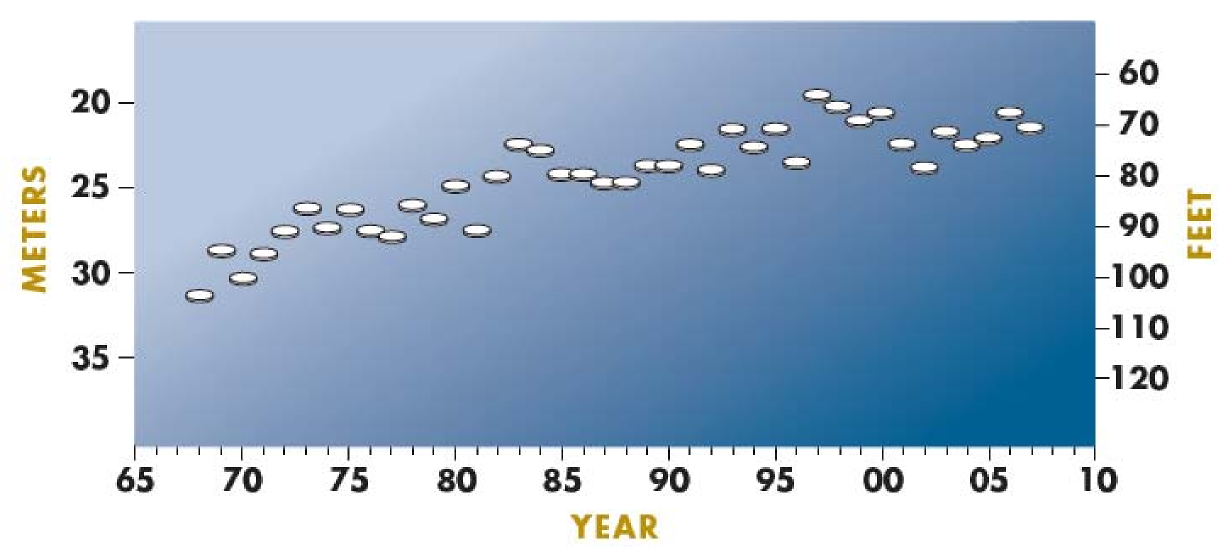

Figure 4-1. Average Annual Secchi Depth measurements (UC Davis – TERC unpublished).

Clarity is expressed as the vertical extinction of light, as measured by a vertical extinction coefficient (VEC), which is the fraction of light held back (or extinguished) per meter of water depth by absorption and scattering.

In addition to a shallower Secchi depth (transparency), Lake Tahoe also now has a shallower depth for the vertical extinction of light (clarity). This means that light cannot penetrate as deep into the water. The light penetration zone (or euphotic zone as defined as the approximate depth where algal photosynthesis and respiration are equal and primary productivity goes to zero), has been as deep as about 100-110 meters at Lake Tahoe (Coon et al. 1987), but over the past decade has largely ranged from 70-80 meters (UC Davis - TERC, unpublished data).

Based on the most recent Secchi depth data for 2007 and applying a more sophisticated statistical approach known as a *generalized additive model*, it was recently reported that between 2001 and 2007 there was an apparent slowing in the rate of clarity loss (UC Davis - TERC 2008). Researchers caution that the rate of clarity loss could change. The seven years of most recent data is insufficient to declare with certainty that the apparent slowing will be sustained into the future. Since even the most recent annual Secchi depth value of 21.2 meters (69.6 feet) measured in 2008 is about 8 meters less than the water quality standard and TMDL target of 29.7 meters (97.4 feet), the impairment to water quality is significant. The steady decline of Secchi depth can be seen with the average annual Secchi depth values from 1968 through 2007 (Table 4-1).

Table 4-1. Annual Average Secchi Depth values for the period of record (UC Davis – TERC unpublished). Measurements are made year-round at a rate of between 25 to 35 times per year.

Year	Secchi Depth (meters)	Year	Secchi Depth (meters)
1968	31.2	1989	23.6
1969	28.6	1990	23.6
1970	30.2	1991	22.4
1971	28.7	1992	23.9
1972	27.4	1993	21.5
1973	26.1	1994	22.6
1974	27.2	1995	21.5
1975	26.1	1996	23.5
1976	27.4	1997	19.5
1977	27.9	1998	20.1
1978	26.0	1999	21.0
1979	26.7	2000	20.5
1980	24.8	2001	22.4
1981	27.4	2002	23.8
1982	24.3	2003	21.6
1983	22.4	2004	22.4
1984	22.8	2005	22.1
1985	24.2	2006	20.6
1986	24.1	2007	21.4
1987	24.7	2008	21.2
1988	24.7		

UC Davis scientists calculate the annual average Secchi depth by using a method commonly referred to as trapezoidal integration. First, linear interpolation is used between sampling points (Secchi depth measurements) to compute daily values. Then the daily values are summed for the year and divided by the number of days in the year to derive the annual average Secchi depth (Arneson 2010 personal communication).

The long-term transparency decline is addressed in several ways. California has a nondegradation policy. Additionally, Lake Tahoe is federally designated as an Outstanding National Resource Water (ONRW). In 1998 Lake Tahoe was listed in

California as water quality-limited, as mandated by the Federal Clean Water Act Section 305(b). That same year, Lake Tahoe was included on California's Section 303(d) list of impaired waterbodies requiring development of TMDLs (SWRCB 2003). In 2002, because of clarity loss, Lake Tahoe was placed on Nevada's Section 303(d) list of impaired waterbodies (NDEP 2002).

5 Water Quality Standards

As required by the federal Clean Water Act, the states of California and Nevada have established beneficial uses, water quality objectives, and non-degradation objectives for Lake Tahoe. Additionally, the Tahoe Regional Planning Agency (TRPA) has developed and implemented goals, threshold standards, and indicators for the Lake Tahoe basin. This chapter summarizes the regulatory framework of the federal Clean Water Act, as well as state and regional regulatory agencies' water quality standards.

5.1 The Federal Clean Water Act

The federal Clean Water Act establishes a regulatory framework to restore degraded surface waterbodies. The act directs the states to adopt water quality standards for waterbodies, subject to USEPA approval. These water quality standards are to protect public health or welfare, to enhance the quality of water, and to serve the purposes of the Clean Water Act by helping to "restore and maintain the chemical, physical and biological integrity" of state waters (Clean Water Act section 101(a)). Accordingly, states must designate beneficial uses of the water, set objectives (numeric or narrative) to protect the uses, and maintain high quality waters by means of non-degradation provisions.

5.2 States of California and Nevada

The state of California protects beneficial uses of waters and water quality through the California Water Code implemented by the State Water Resources Control Board (State Board) and nine California Regional Water Quality Control Boards (Regional Water Boards). The California Regional Water Quality Control Board, Lahontan Region (Water Board) is responsible for the Lake Tahoe basin, as well as areas from the Oregon border to the northern Mojave Desert, east of the Sierra Nevada crest. The State Board sets statewide policy in implementing state and federal laws and regulations, and the nine Regional Water Boards adopt and implement Water Quality Control Plans (Basin Plans).

Basin Plans set forth water quality standards for the surface and groundwater of the region, by establishing designated beneficial uses and the objectives (narrative and/or numerical) that must be attained and maintained to protect beneficial uses. Basin Plans implement a number of state laws and federal programs, the most important of which are the federal National Pollutant Discharge Elimination System Permit program and the state Porter–Cologne Water Quality Control Act (California Water Code § 1300 et seq).

The state of Nevada protects water quality through the Nevada Water Pollution Control Law as implemented by the Department of Conservation and Natural Resources. The Department of Conservation and Natural Resources is responsible for developing and implementing comprehensive plans to reduce or eliminate water pollution, consistent with federal legislation. The Nevada Division of Environmental Protection (NDEP) is the agency that implements the water quality protection programs, including those that affect the Lake Tahoe basin.

5.2.1 Beneficial Uses and Water Quality Objectives

In addition to a number of other designated uses, the states of California and Nevada have identified the visual aesthetics of Lake Tahoe's water (which includes clarity) as a quality to be protected through designation of the following beneficial uses: "non-contact water recreation" (in California) and both "water of extraordinary ecologic or aesthetic value" and "recreation not involving contact with water" (in Nevada). Accordingly, the two states also established numeric water quality objectives to protect the beneficial use of non-contact recreation. Applicable water quality objectives for the protection of the aesthetic beneficial uses include indicators of water column optical properties, nutrient concentrations, and various biological indicators (Table 5-1).

Table 5-1. California and Nevada numeric objectives related to the aesthetic beneficial uses of Lake Tahoe.

Parameter	California[a]	Nevada[b]
Clarity	The vertical extinction coefficient must be less than 0.08 per meter when measured at any depth below the first meter. Turbidity must not exceed 3 NTU at any point of the lake too shallow to determine a reliable extinction coefficient. In addition, turbidity shall not exceed 1 NTU in shallow waters not directly influenced by stream discharges. The Regional Board will determine when water is too shallow to determine a reliable vertical extinction coefficient based upon its review of standard limnological methods and on advice from the UC Davis Tahoe Research Group.	The vertical extinction coefficient must be less than 0.08 per meter when measured at any depth below the first meter. Turbidity must not exceed 3 NTU at any point of the lake too shallow to determine a reliable extinction coefficient.
Transparency	The Secchi disk transparency shall not be decreased below the levels recorded in 1967-1971, based on a statistical comparison of seasonal and annual mean values. The 1967-1971 levels are reported in the annual summary reports of the "California – Nevada – Federal Joint Water Quality Investigation of Lake Tahoe" published by the California Department of Water Resources. [Note: the 1967-1971 annual mean Secchi depth was 29.7 meters.]	NA[c]
Soluble Phosphorus (mg/L)	NA[c]	Annual Average ≤ 0.007
Total Phosphorus (mg/L)	Annual Average ≤ 0.008	NA[c]
Total Nitrogen (as N) (mg/L)	Annual Average ≤ 0.15	Annual Average ≤ 0.25 Single Value ≤ 0.32
Total Soluble Inorganic	NA[c]	Annual Average ≤ 0.025

Parameter	California[a]	Nevada[b]
Nitrogen (mg/L)		
Algal Growth Potential	The mean annual algal growth potential at any point in the lake must not be greater than twice the mean annual algal potential at a limnetic reference station. The limnetic reference station is located in the north central portion of Lake Tahoe. It is shown on maps in annual reports of the Lake Tahoe Interagency Monitoring Program. Exact coordinates can be obtained from the UC Davis Tahoe Research Group.	The mean annual algal growth potential at any point in the lake must not be greater than twice the mean annual algal potential at a limnetic reference station and using analytical methods determined jointly with the EPA, Region IX.
Plankton Count (No./mL)	Mean seasonal $\leq$ 100	Jun – Sep Average $\leq$ 100
	Maximum $\leq$ 500	Single Value $\leq$ 500
Biological Indicators	Algal productivity and the biomass of phytoplankton, zooplankton, and periphyton shall not be increased beyond the levels recorded in 1967-1971 based on statistical comparison of seasonal and annual means. The 1967-1971 levels are reported in the annual summary reports of the "California – Nevada – Federal Joint Water Quality Investigation of Lake Tahoe" published by the California Department of Water Resources. [Note: The numeric criterion for algal productivity (or Primary Productivity, PPr) is 52 g C m^{-2} y^{-1} as an annual mean.]	NA[c]

[a] Provision in State Regulation: Water Quality Control Plan for the Lahontan Region (LRWQCB 1995)
[b] Provision in State Regulation: Nevada Administrative Code 445A.191
[c] No applicable numeric water quality objectives

Water Column Optical Properties

Secchi depth (transparency) is a measure of how far the human eye can see down through the water column and is a measure for deep water. Specifically, Secchi depth is the depth to which an observer can see a 25-cm diameter white disk lowered into the water from the surface. The Water Board has adopted a Secchi depth transparency objective and the NDEP is evaluating the need for a similar objective.

The vertical extinction of light (clarity) is a measure of how far light can penetrate the water column, and thus is also a measure for deep water clarity. The vertical extinction of light is described as a vertical extinction coefficient (VEC), which is the fraction of light held back (or extinguished) per meter of water depth by absorption and scattering. Therefore, higher VEC values indicate less clarity. Light can penetrate the water column farther than the eye can see; thus, the vertical extinction of light extends beyond the Secchi depth. The vertical extinction coefficient was measured using a sensor that captured light in the 400-700 nm range, otherwise known as photosynthetically active radiation.

Turbidity is a measure of water cloudiness primarily caused by suspended sediment. Turbidity standards in the lake have generally been applied in the shallow, nearshore water as turbidity measurements in deep waters are at or below the method detection limits. Neither Secchi depth nor VEC is appropriate for shallow, nearshore water due to the lack of sufficient depth for accurate measurements.

5.2.2 Nondegradation Objectives

All California water bodies are subject to a nondegradation objective that requires continued maintenance of high quality waters. Additionally, in 1980 the Water Board and USEPA designated Lake Tahoe an Outstanding National Resource Water which requires the highest level of protection under the nondegradation objective.

The Regional Board, in its Basin Plan, also emphasizes Lake Tahoe's outstanding qualities (LRWQCB 1995):

> *Lake Tahoe's exceptional recreational value depends on enjoyment of the scenic beauty imparted by its clear, blue waters.*

Nevada has designated Lake Tahoe as Water of Extraordinary Ecological or Aesthetic Value (Nevada Administrative Code 445A.1905.). Lake Tahoe is the only water body in the State of Nevada to receive this designation.

5.3 Tahoe Regional Planning Agency

To protect Lake Tahoe, the California and Nevada legislatures agreed to create the Tahoe Regional Planning Agency (TRPA) in 1969 by adopting the Tahoe Regional Planning Compact. The Compact, as adopted by the 96th Congress of the United States, defines the purpose of the TRPA (TRPA 1980):

> *To enhance governmental efficiency and effectiveness of the Region, it is imperative there be established a Tahoe Regional Planning Agency with the powers conferred by this compact including the power to establish environmental threshold carrying capacities and to adopt and enforce a regional plan and implementing ordinances which will achieve and maintain such capacities while providing opportunities for orderly growth and development consistent with such capacities.*

The Compact also emphasizes minimizing development-related disturbances in the Lake Tahoe basin by calling for a "land use plan for the…standards for the uses of land, water, air space and other natural resources within the Region…" (Article V(c)(1)). The Land Use Element includes the Water Quality sub-element, which is introduced with the following language (TRPA 1980):

> *The purity of Lake Tahoe and its tributary streams helps make the Tahoe basin unique. Lake Tahoe is one of the three clearest lakes of its size in the world. Its unusual water quality contributes to the scenic beauty of the Region, yet it depends today upon a fragile balance among soils, vegetation, and man. The focus of water quality enhancement and protection in the basin is to minimize man-made disturbance to the watershed and to reduce or eliminate the addition of pollutants that result from development.*

5.3.1 Goals

The TRPA Compact established several policies related to water quality planning and implementation programs. Relative to standards, the Compact states that the Regional Plan shall provide for attaining and maintaining federal, state or local water quality standards, whichever are the most stringent.

In addition to the establishment of Numerical, Management and Policy standards for water quality, the TRPA's Regional Plan focuses on two water quality goals:

> *GOAL #1: Reduce loads of sediment and algal nutrients to Lake Tahoe; Meet sediment and nutrient objectives for tributary streams, surface runoff, and subsurface runoff, and restore 80 percent of the disturbed lands.*
>
> *GOAL #2: Reduce or eliminate the addition of other pollutants that affect, or potentially affect, water quality in the Tahoe basin.*

5.3.2 Threshold Standards and Indicators

To achieve its goals, the TRPA established a number of threshold standards and indicators that include numeric objectives for protection of lake clarity. The relevant threshold standards and indicators are listed below.

WQ-1 Littoral (Nearshore) Lake Tahoe

Threshold Standard: Decrease sediment load as required to attain turbidity values not to exceed 3 NTU in littoral Lake Tahoe. In addition, turbidity shall not exceed 1 NTU in shallow waters of Lake Tahoe not directly influenced by stream discharge.

Indicator: Turbidity offshore at the 25-meter depth contour at 8 locations, both near the mouths of tributaries and away from the tributaries.

WQ-2 Pelagic Lake Tahoe, Deep Water

Threshold Standard: Average Secchi depth, December–March, shall not be less than 33.4 meters[1].

Indicator: Secchi depth, winter average; Tahoe Research Group (now Tahoe Environmental Research Center) index stations (meters).

[1] 109.6 feet

The TRPA and California objectives for deep water transparency are different regarding Secchi measurement. The TRPA uses a winter (December – March) average while California uses an annual average.

5.3.3 Regional Plan Update

The TRPA is updating its Regional Plan, Code of Ordinances, and Environmental Threshold Carrying Capacities (thresholds). In its 2006 Threshold Evaluation report, TRPA stated that it will use the recommended threshold updates as the platform to construct the new Regional Plan. The incorporation of recommended threshold updates into the Regional Plan will occur using a phased approach because additional research is required to update standards. Initial updates to thresholds in the first phase will be small, with broader changes anticipated in the second phase. Basic to this strategy is that TRPA and its partners will develop and implement the new Regional Plan Package including the needed institutional relationships, the adaptive management system, and the financing package for the EIP update.

The TRPA 2006 Threshold Evaluation report recommended targeting projects/best management practices for removal of phosphorus and fine sediment, intensifying sweeping and maintenance of road rights-of-way to remove fine sediment, and to shift the management of stormwater discharge limits to TMDL-based pollutant load reductions, including tracking and modeling these pollutant loads with the models developed under the TMDL process. TRPA also recommended changing its WQ-2 threshold to be consistent with the transparency standard as stated in the Basin Plan. Specifically, TRPA proposes to use the annual average Secchi depth of 29.7 meters as its updated threshold standard for deep water transparency.

TRPA based this proposed threshold change on the recommendations of the Water Quality Technical Working Group. This technical group, convened in late 2004 through 2007 as part of a larger Tahoe basin Pathway process, consisted of a committee of scientists and Lake Tahoe agency representatives who reviewed certain TRPA thresholds and recommended changes to improve consistency among the TRPA thresholds, Basin Plan, NDEP regulations, and the USFS Forest Plan. In addition to reviewing the water quality standards and thresholds, the Water Quality Technical Working Group developed a desired condition statement for Lake Tahoe clarity, so all stakeholders, including regulators, project implementers, and the public at large, could align individual plans to the same goal:

> ***Lake Tahoe Clarity Desired Condition****: Restore, then maintain the waters of Lake Tahoe for the purposes of human enjoyment and preservation of its ecological status as one of the few large, deepwater, ultraoligotrophic lakes in the world with unique transparency, color and clarity.*

Regional Board and NDEP staff will continue working with TRPA to ensure that updates to TRPA's Regional Plan do not conflict with the requirements under this TMDL.

6 Numeric Target

The purpose of the Lake Tahoe TMDL is to develop a plan for restoring Lake Tahoe's historic transparency and clarity. The Water Board, Nevada Division of Environmental Protection (NDEP), and the Tahoe Regional Planning Agency (TRPA) identified the visual aesthetics of Lake Tahoe's clarity as a beneficial use affording Lake Tahoe a high level of protection. Each of the three entities adopted its own water quality objectives to protect Lake Tahoe's aesthetic beneficial use, but not all the objectives are the same. This TMDL evaluated the California and Nevada water quality objectives and selected the most appropriate and protective numeric target for the lake's deep water transparency and clarity.

The Lake Tahoe TMDL focuses solely on the deep water transparency and does not address shallow, nearshore conditions of the lake. The numeric target is defined as 29.7 meters average annual Secchi depth.

6.1 Transparency and Clarity Objectives

The Water Board has both transparency and clarity water quality objectives, while NDEP relies solely on a clarity objective. To determine the most appropriate numeric target (clarity or transparency), the relationship between transparency and clarity objectives was evaluated.

6.1.1 Transparency (Secchi Depth) vs. Clarity (VEC) Objectives

Transparency of Lake Tahoe's deep water is measured by lowering a 25 centimeter diameter Secchi disk into the water until the disk cannot be seen from directly above. The Water Board transparency standard states:

> *For Lake Tahoe, the Secchi disk transparency shall not be decreased below the levels recorded in 1967-1971, based on a statistical comparison of seasonal and annual mean values. The "1967-71 levels" are reported in the annual summary reports of the "California-Nevada-Federal Joint Water Quality Investigation of Lake Tahoe" published by the California Department of Water Resources.*

The State Water Resources Control Board adopted a Statement of Policy with respect to Maintaining High Quality of Waters in California in 1968 (Resolution No. 68-16). The 1967-1971 period of record was selected to set a baseline average Secchi depth condition and a restoration target that corresponded to this resolution adoption date.

Deep water *clarity* is measured as the vertical extinction coefficient (VEC) of light in the water column. The VEC is a measurement of the fraction of light held back per meter of water from particle absorption and scattering (Goldman and Horne 1983). The Water Board and NDEP both have the same clarity objective for deep water in Lake Tahoe:

The vertical extinction coefficient must be less than 0.08 per meter when measured at any depth below the first meter.

The relationship between VEC and Secchi depth readings in Lake Tahoe was examined for the periods 1967-2002 (Swift 2004). Between the years 1967-1971, the period upon which transparency objectives are based, Secchi depths were in the range of 28.5-32.5 meters and, in general, corresponded to VEC values between approximately 0.045-0.065 per meter. During 1967-1971, a VEC of ≥ 0.08 per meter was measured only three times in close to 100 observations. From 1972 to 2002, VEC in the deep water has varied from about 0.04 to 0.11 per meter, with annual values of approximately 0.06 per meter between 1968 and 1976 and annual values of 0.08-0.09 per meter during the period 1997-2002 (Swift 2004). At no time between 1967 and 2002 did a VEC of 0.08 per meter correspond to a Secchi depth of 30 meters. A more appropriate value for VEC that reflects actual conditions between 1967-1971 would be on the order of 0.05-0.06 per meter. These observations show that the California water quality objective for average annual transparency (i.e. Secchi depth) is more representative of lake conditions from 1967-1971 than the California and Nevada clarity objective (VEC).

6.1.2 TRPA Transparency Objective

The Tahoe Regional Planning Agency (TRPA) objective for deep water transparency is a winter Secchi depth of 33.4 meters. The TRPA objective uses a winter average Secchi depth objective because measured light transmission is at its maximum during this season (Jassby et al. 1999). The TRPA winter objective does not reflect the entire year, so it is not representative of lake conditions from 1967-1971, or of the transparency during the other three seasons, particularly during the spring months when snowmelt results in the greatest pollutant loads being delivered to the lake. Summer is typically when most people experience the visual quality of Lake Tahoe’s deep water transparency. Consequently, the annual average Secchi depth is representative of lake conditions from 1967-1971 and accounts for seasonal variability.

6.2 Historic Transparency Data

The Water Board’s transparency references a Secchi depth dataset reported in the *California-Nevada-Federal Joint Water Quality Investigation of Lake Tahoe* (Department of Water Resources 1973). The University of California, Davis Tahoe Research Group (TRG) also measured Secchi depth during the same time period. These two datasets were collected during the reference period from 1967-1971 using different sample sites and different sized Secchi disks.

The California Department of Water Resources (DWR) used a 20 centimeter diameter, black and white quadrant, Secchi disk and measured deep water transparency at two stations generally along the California-Nevada state line for a total of 55 measurements.

The DWR data show an average annual Secchi depth of approximately 25.5 meters. The DWR stopped collecting Secchi depth measurements at Lake Tahoe in 1974.

The TRG used a 25 centimeter diameter, all white Secchi disk and measured deep water transparency at a standardized index station for a total of 119 measurements between 1967 and 1971. The TRG data (UC Davis - TERC unpublished data) shows an average annual Secchi depth of 29.7 meters. UC Davis researchers continue to collect Secchi measurements at established monitoring points, providing more than 40 years of continuous transparency monitoring data.

The Lake Clarity Model and Lake Tahoe Watershed model analyses in this TMDL relied on the long term TRG Secchi depth data set. Because the UC Davis transparency data have been collected over a longer period and at a greater frequency than the DWR effort, the transparency objective and numeric target is based on the TRG data (UC Davis – TERC unpublished data). The Secchi depth measurements that were used to calculate the value of 29.7 meters were collected during each month with 29 ± 3 (mean ± standard deviation) individual measurements per year. Over the entire period of record Secchi depth continues to be measured within each month (year-round) at a frequency of 32 ± 4 (mean ± standard deviation) times per year.

6.3 Clarity Challenge

The Lake Tahoe TMDL program has set an interim transparency goal called the Clarity Challenge. The Clarity Challenge represents a reasonable, yet ambitious goal for the 20-year planning horizon, which also lines up with updates to the 20-year TRPA Regional Plan and the US Forest Service-Lake Tahoe Basin Management Unit Forest Plan.

The Clarity Challenge establishes basin-wide fine sediment particle and nutrient load reductions adequate to achieve 23.5 to 24 meter Secchi depth measurements. As such, the Clarity Challenge establishes load reduction targets to be achieved within the first 15 years of implementation to allow for five years of Secchi depth trend analysis with the 20-year plan horizon.

Meeting the Clarity Challenge will mark a clear turning point from the decline in transparency and will represent a significant achievement in environmental restoration.

7 Source Analysis

This chapter summarizes the research and modeling work that generated the pollutant load estimates. Subsections describe research, monitoring, and modeling efforts for each source followed by discussions of relative confidence and methods used to convert sediment mass load estimates to number of fine sediment particles. This chapter highlights the complete information documented in the Lake Tahoe TMDL Technical Report (Lahontan and NDEP 2010).

7.1 Introduction

Data collected over the past 40 years within the Lake Tahoe Basin was used to estimate nitrogen, phosphorus, and fine sediment particle loading to the lake from five primary pollutant loading sources: upland runoff, atmospheric deposition, stream channel erosion, and shoreline erosion. As of 1968, all of Lake Tahoe's treated sewage effluent was pumped out of the basin; a management practice that continues to this day. Consequently, this source is not relevant with respect to this TMDL. Fine inorganic particles have a significant impact on Lake Tahoe's clarity (e.g. Jassby et al. 1999, Perez-Losada 2001, Swift 2004, and Swift et al. 2006). The Lake Clarity Model was developed with this understanding. For the source analysis, fine sediment is defined as material with a diameter of less than 63 micrometers (µm) in size. The Lake Clarity Model requires that these particles be divided into the seven size categories of 0.5 – 1µm, 1 – 2 µm, 2 – 4 µm, 4 – 8 µm, 8 – 16 µm, 16 – 32 µm, and 32 – 64 µm for input to the model (Perez-Losada 2001, Sahoo et al. 2007).

Existing knowledge, ongoing monitoring efforts by the Lake Tahoe Interagency Monitoring Program, and studies conducted specifically for the Lake Tahoe TMDL Program all helped increase the confidence in the pollutant loading estimates for the five pollutant sources and were used to convert fine sediment load estimates to fine sediment particle numbers. Pollutant loading estimates from the major source categories are summarized in Table 7-1 and Figure 7-1, Figure 7-2, and Figure 7-3. Of the particles less than 63 micrometers in diameter, it is the particles smaller than 16 micrometers in diameter that have the most impact on lake clarity. The number of particles less than 16 micrometers in diameter are reported in Table 7-1 and Figure 7-3.

Table 7-1. Pollutant Loading Estimates.

Source Category		Total Nitrogen (metric tons/year)	Total Phosphorus (metric tons/year)	Number of Fine Sediment Particles (x10^{18})
Upland	Urban	63	18	348
	Non-Urban	62	12	41
Atmospheric Deposition	(wet + dry)	218	7	75
Stream Channel Erosion		2	<1	17
Groundwater		50	7	0
Shoreline Erosion		2	2	1
TOTAL		397	46	481

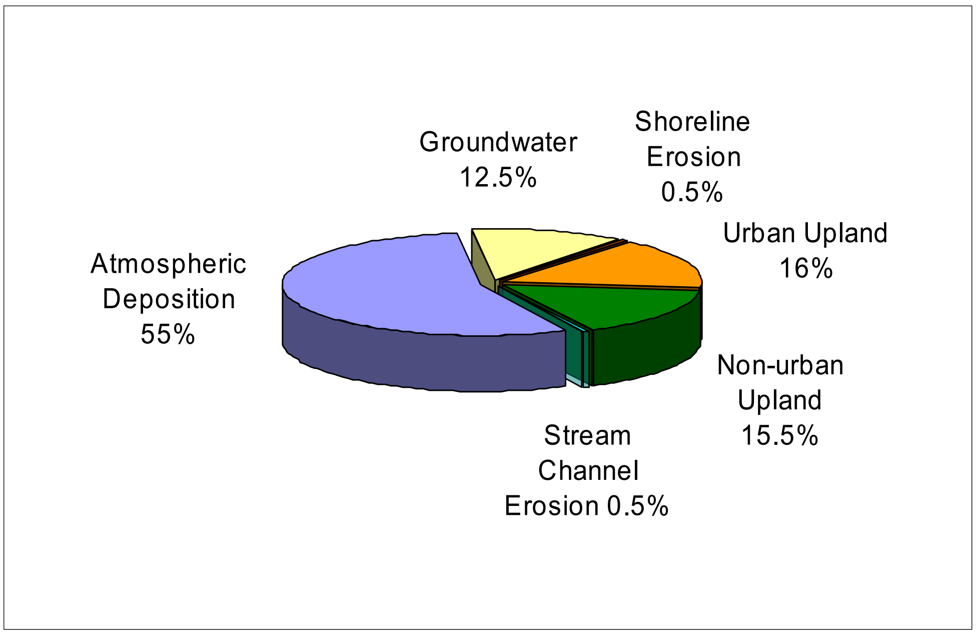

Figure 7-1. Percent Total Nitrogen Contribution per Source Category.

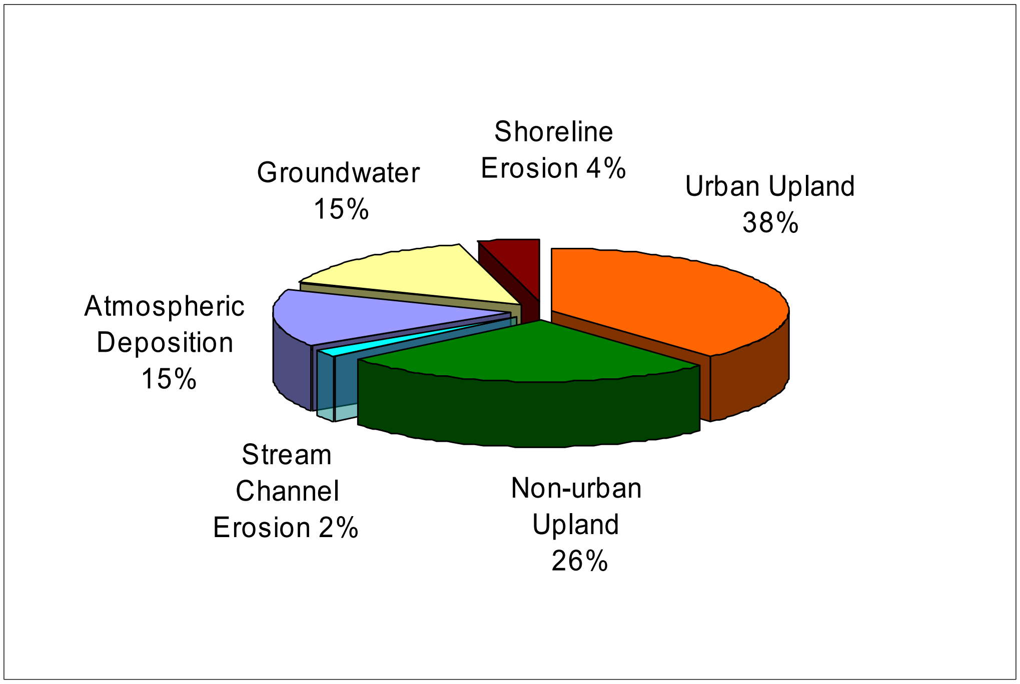

Figure 7-2. Percent Total Phosphorus Contribution per Source Category.

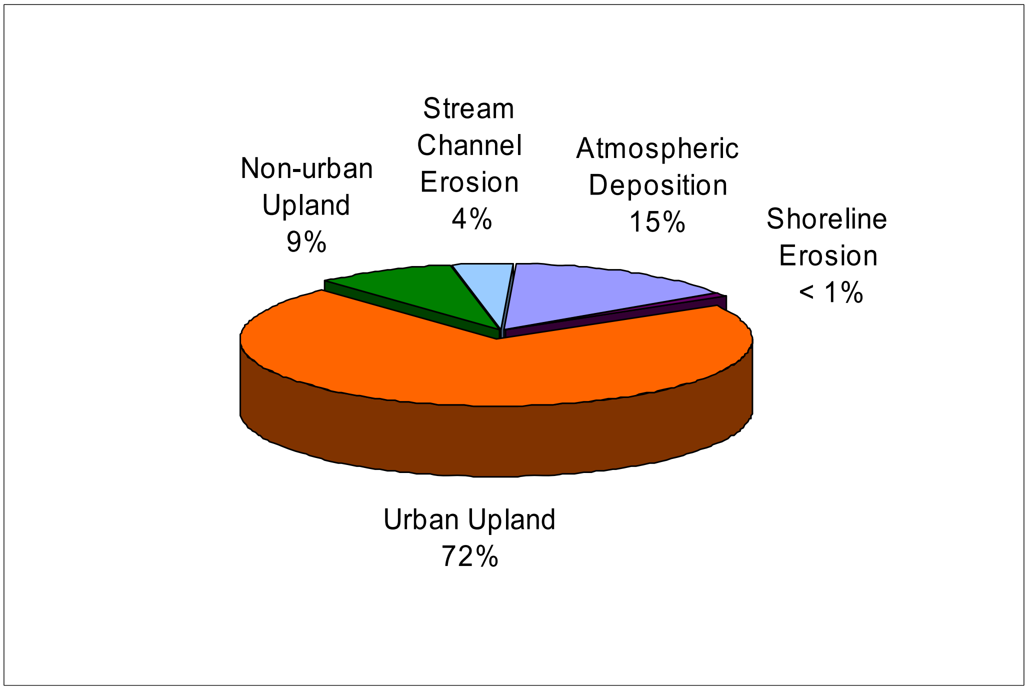

Figure 7-3. Percent Fine Sediment Particle (< 16 micrometer) Contribution per Source Category.

7.2 Groundwater

Groundwater flow contributes phosphorus and nitrogen to the lake at the aquifer-lake interface. To incorporate nutrient loading from groundwater into the Lake Clarity Model, existing data were re-evaluated. Note that fine sediment is not believed to be transported via groundwater and will not be discussed further in this section (S. Tyler 2003 personal communication, G. Fogg 2003 personal communication).

Thodal (1997) published the first basin-wide evaluation of groundwater quality and quantity from 1990-1992. His study provides a detailed evaluation of hydraulic gradient, hydraulic conductivity, and recharge-precipitation relationships. Thodal estimated total annual groundwater contributions based on these assessments. According to Thodal's study, the estimated annual groundwater contribution of nitrogen and phosphorus to the lake is 54 and 3.6 metric tons, respectively.

The United States Army Corps of Engineers (USACE) completed the *Lake Tahoe Basin Framework Study Groundwater Evaluation* (USACE 2003) as an independent assessment of Thodal's (1997) analysis. There were two notable differences between the Groundwater Evaluation approach (USACE 2003) and Thodal's work: (1) the USACE divided the Basin into six regions and six sub-regions based on jurisdictional boundaries and major aquifer limits; and (2) the USACE provided estimates of background nutrient contributions to Lake Tahoe.

The USACE (2003) study assumed no water was added to or taken from the system and the aquifers are homogenous. Nutrient concentrations were selected by one of three approaches. The first was an average concentration method that uses average measured phosphorus or nitrogen in each region. The second method evaluated downgradient nutrient concentrations to calculate the amount of phosphorus and nitrogen expected to reach the lake by proximity. The last approach was a land-use weighted concentration method that considered different development patterns within the identified groundwater regions.

Using these methods, the USACE developed regional/sub-regional groundwater discharge and nutrient loading estimates throughout the basin for the six delineated sub-regions. By combining the annual loads for the regions, the USACE generated an overall annual loading estimate for nitrogen and phosphorus for the entire Lake Tahoe basin that is very similar to Thodal's (1997) load estimate. USACE (2003) estimates are 50 metric tons of nitrogen annually and 6.8 metric tons of phosphorus annually.

7.3 Shoreline Erosion

Wave action and lake level fluctuation cause erosion of the Lake Tahoe shoreline as evidenced by the changing shape of the lake's shore over time. The Desert Research Institute (DRI) performed research to determine sediment and nutrient loading from shoreline erosion. *Historic Shoreline Change at Lake Tahoe from 1938 to 1994:*

Implications Sediment and Nutrient Delivery (Adams and Minor 2001) used aerial photographs to estimate the volume of material eroded by wave action from 1938-1994 to be 429,350 metric tons, or 7,150 metric tons per year. These maps and photographs were acquired from the Tahoe Regional Planning Agency (TRPA), United States Forest Service Lake Tahoe Basin Management Unit (LTBMU), and the United States Geological Survey (USGS). Sediment grab samples were collected from multiple shoreline locations to analyze the nutrient content of the eroded shorezone material.

The supplementary report *Shorezone Erosion at Lake Tahoe: Historical Aspects, Processes, and Stochastic Modeling* (Adams 2004) assessed the particle size distribution of collected shoreline sediment samples. The report estimates that of the total material annually eroded at the shoreline, an average annual load of 550 metric tons per year is silt and clay sized sediment (< 63 μm). The Water Board and NDEP staff used the information from Adams (2004) and converted the 550 metric tons of silt and clay to a total load of 1.08×10^{18} particles per year distributed into the seven size classes required for input to the Lake Clarity Model.

Based on the nutrient sampling data in Adams (2004), approximately 117 metric tons of phosphorus and 110 metric tons of nitrogen have been introduced into the lake because of shoreline erosion over the last 60 years. These volumes equate to approximately two metric tons of phosphorus per year and 1.8 metric tons of nitrogen per year. Shoreline erosion is therefore the smallest source of pollutants impacting Lake Tahoe's clarity and transparency.

7.4 Stream Channel Erosion

The first estimates of stream channel erosion were conducted by the USDA-National Sedimentation Laboratory for the *Lake Tahoe Basin Framework Study: Sediment Loadings and Channel Erosion* (Simon et al. 2003). This research combined detailed geomorphic and numerical modeling investigations of several representative watersheds with field measurements from approximately 300 sites in the Tahoe basin. To better quantify the contributions of fine sediment from stream channel erosion in all 63 tributary stream systems, the USDA-National Sedimentation Laboratory completed additional work contained in *Estimates of Fine Sediment Loading to Lake Tahoe from Channel and Watershed Sources* (Simon 2006). This study provides valuable information on the average annual fine sediment loadings in metric tons per year from streambank erosion and the relative contribution of each of the Basin's 63 streams. Fine sediment in this study is defined as sediment less than 63 μm in diameter. The USDS-National Sedimentation Laboratory work also provides the average annual fine sediment particle (< 16 μm) loading estimates in number of particles per year.

In support of the TMDL development, the magnitude and extent of channel erosion was determined using five methods (Simon et al. 2003, Simon 2006): (1) comparison of historical cross-section surveys; (2) reconnaissance surveys of stream channel stability; (3) rapid geomorphic assessments; (4) numerical modeling; and (5) basin-wide evaluations. For streams with no historical monitoring information, the USDA-National

Sedimentation Laboratory researchers used empirical relationships to extrapolate how much fine sediment was contributed from channel erosion.

Using past data with new information and the above-described methodologies, stream channel erosion was numerically simulated or extrapolated to determine sediment, nitrogen, and phosphorus loadings into Lake Tahoe. Based on this work, the fine sediment (< 63 μm) load was estimated at 3,800 metric tons per year from stream channels. Phosphorous loading was estimated to be 0.6 metric tons per year and nitrogen loading at 2 metric tons per year.

Rabidoux (2005) developed regression equations to establish a relationship between fine sediment particle numbers and streamflow based on the data collected during 2002-2003. Rabidoux used a linear model, the Rating Curve Method, for estimating particle flux based on streamflow for each of the seven particle size classes used in the Lake Tahoe Clarity Model. Rabidoux applied the Bradu-Mundlak Estimator to the linear regression models to correct for statistical bias and to determine the final load flux estimations (Cohn et al. 1989).

Tetra Tech (2007) calibrated the Lake Tahoe Watershed Model parameters using measured data from the 10 LTIMP streams. The calibrated Lake Tahoe Watershed Model established flow estimates for the remaining streams that are not monitored as part of LTIMP. These streams were grouped to the LTIMP stream with the most similar geography and land use. Rating curves from the LTIMP streams were assigned to the modeled stream flows in their group to determine sediment flux for each tributary. Rabidoux's initial sediment load calculations included fine sediment particles (< 16 μm) from a mixture of sources, including stream channel erosion and upland runoff. When divided from the upland contributions to in-stream particle loads, the loading values for particles < 63 μm from stream channel erosion was estimated to be 27 percent of total stream particle load as calculated by the Rabidoux (2005) regression equations and modeled flow. The number of fine sediment particles less than 16 micrometers that is from stream channel erosion is 1.67×10^{19} particles per year.

7.5 Upland Source

Uplands, both urban and non-urban (forested) uplands, account for sediment and nutrient inputs from various land uses within the 63 watersheds and intervening zones (where surface water enters the lake directly). Upland sources include products of anthropogenic influences within the urbanized environment and products of natural surface erosion from undeveloped areas.

The Lake Tahoe TMDL Program contracted Tetra Tech, Inc. to develop the Lake Tahoe Watershed Model to estimate sediment and nutrient loads from the upland sources. Once calibrated, the model provided a tool to predict flows and quantify loads from the upland tributaries and to simulate changes in load expected from land use changes resulting from simulated basin-wide pollutant reduction strategies. The Loading Simulation Program C++ (LSPC) (http://www.epa.gov/athens/wwqtsc/html/lspc.html) was selected to develop the Lake Tahoe Watershed Model. LSPC is a USEPA approved model developed to facilitate large scale, data intensive watershed modeling applications. The model was calibrated using 11 years (1994-2004) of hydrology and water quality data. The calibrations compared simulated and observed values of interest in a hierarchical process that began with hydrology and proceeded to water quality. The hydrology and water quality data were collected as part of the Lake Tahoe Interagency Monitoring Program (LTIMP), which regularly gathers field data from 10 select streams that together account for half of all stream flow to the lake.

The Lake Tahoe Watershed Model requires a physical basis for representing the variability in hydrology and pollutant loading throughout the Basin, which are both related to land-use and geology. The model relies on six land-use categories: water body, single-family residence (SFR), multi-family residence (MFR), commercial/institutional/communications/utilities (CICU), transportation, and vegetation. Vegetation is further sub-divided into unimpacted, turf, recreational, ski areas, burned, and harvested. Unimpacted areas are further divided into 5 categories based on erosion potential to the lake. For further details of land-use descriptions and categories, refer to Section 4.3.4 of the Lake Tahoe TMDL Technical Report.

A two-year study by UC Davis measured particles and size distribution at the most downstream stations in the 10 LTIMP streams (Rabidoux 2005). The Lake Tahoe TMDL stormwater monitoring study, jointly conducted by UC Davis and the Desert Research Institute gathered data from stormwater runoff in the Tahoe basin (Heyvaert et al. 2007). Loads (number of fine sediment particles) from upland sources are expressed on the basis of urban and non-urban sources. The initial approach to distinguish fine sediment loading originating in urban land-uses from loading originating in non-urban land-uses included Rabidoux's streamflow-particle regression equations used with percent flow estimates from the urban landscape. These results were compared to data from the Lake Tahoe TMDL Stormwater Monitoring Study. The Lake Tahoe TMDL Stormwater Monitoring Study provided data for particle concentration for monitored storm events from 9 sites around Lake Tahoe, concurrently with Rabidoux's regression models.

Particle concentration in urban runoff is up to two orders of magnitude greater than in streams (Lahontan and NDEP 2010). Because of this inequity, the specific streamflow-particle relationships developed for the LTIMP streamflow were not considered to be appropriate for describing urban runoff without an adjustment factor. Additionally, intervening zones typically have a high percentage of urban land-use, preventing accurate predictions of intervening zone particle concentration based solely on Rabidoux's streamflow particle regression models. A multiplication factor was applied to the regression models to correct for the differences between streamflow and urban runoff particle characteristics. Loading from intervening zones was calculated using the urban loading correction factor. Refer to Section 5.1.2 of the Technical Report for detail of the equation application.

Based on the continuous simulations provided by the Lake Tahoe Watershed Model, Tetra Tech, Inc. estimated average annual fine sediment particle loads for urban and non-urban upland sources are 4,430 and 4,670 metric tons, respectively. Annually, total nitrogen and total phosphorus loads for the urban uplands were estimated to be 63 and 18 metric tons, while the non-urban upland contributes 62 metric tons of total nitrogen and 12 metric tons of total phosphorus. Total urban uplands fine sediment particle contribution to the lake is 3.48×10^{20} particles per year. Total contribution from non-urban uplands sources is 4.11×10^{19} particles per year.

A detailed description of the watershed model development process and its results can be found in *Hydrologic Modeling and Sediment and Nutrient Loading Estimation for the Lake Tahoe Total Maximum Daily Load Project* (Tetra Tech 2007) and is documented in the Lake Tahoe TMDL Technical Report (Lahontan and NDEP 2010).

7.6 Atmospheric Deposition

Atmospheric deposition refers to the deposition of pollutants that land directly on the lake surface. This can occur as dry deposition or as part of a precipitation event (wet deposition). Because the surface area of the lake is 501 km^2 in comparison to its drainage area of 812 km^2, airborne input of nutrients and fine sediment particles to Lake Tahoe's surface is significant.

The California Air Resources Board (CARB) conducted the *Lake Tahoe Atmospheric Deposition Study* (LTADS) to estimate the contribution of dry atmospheric deposition to Lake Tahoe. These estimates were paired with long term monitoring data collected by UC Davis - TERC to provide detailed pollutant loading numbers to use for lake clarity modeling purposes.

Gertler et al. (2006) and CARB (2006) found that airborne pollutants are generated mostly from within the Lake Tahoe basin and come from motor vehicles, wood burning, and road dust. Motor vehicles, including cars, buses, trucks, boats, and airplanes are primary sources of atmospheric nitrogen. Swift et al. (2006) determined that inorganic particles are the dominant factor in clarity loss since those particles contribute greater than 55 to 60 percent of the clarity loss while organic particles contribute up to 25 percent of the clarity loss.

CARB (2006) and UC Davis - TERC used two different methods to measure dry atmospheric deposition to Lake Tahoe. The LTADS (CARB 2006) monitored nutrient and sediment concentrations in ambient air and used a pollutant deposition model to estimate atmospheric deposition to the surface of Lake Tahoe. UC Davis - TERC deployed wet, dry, and bulk (wet and dry) collectors on the lake surface to empirically estimate atmospheric deposition.

Wet deposition data used in the CARB analysis comes largely from the Ward Valley Lake Level (WVLL) station where approximately 30 - 40 precipitation events are measured during a typical year. A data record of nearly 25 years is available for nitrate, ammonium, and soluble reactive phosphorus (SRP) at the WVLL station. Historic data from Incline Village, Glenbrook, Meyers, Tahoe Vista, and Bijou were used for comparison with findings at WVLL. Comparisons show that phosphorus, nitrogen, and particulate matter concentrations associated with precipitation were similar at all sites. It was concluded that that the WVLL wet deposition concentration data were representative of near-shore locations and that this data could be used for basin-wide deposition estimates.

Wet and dry, whole-lake pollutant loading estimates for atmospheric deposition directly to the surface of Lake Tahoe were derived from both the UC Davis and LTADS studies. Dry deposition of particulate matter is estimated at 586 metric tons per year and wet at 163 metric tons per year for a total of approximately 749 metric tons per year. Atmospheric deposition of total nitrogen was approximately 218 metric tons per year and estimates for total phosphorus range between 6 - 8 metric tons. Because the Lake Clarity Model uses particle count rather than particle mass to estimate clarity changes, the CARB data was converted into number of fine sediment particles. CARB collected particle mass data in three size classes; $PM_{2.5}$, PM_8, and PM_{20}. The smallest of the size classes was further divided in two to account for composition differences associated with particle size in the $PM_{2.5}$ size class. The full set of seven-size classes required for input to the Lake Clarity Model was interpolated and extrapolated from these four-size measured classes. Refer to Section 5.1.4 of the Technical Report for equations used and assumptions made for this conversion. The total fine sediment particle contribution from atmospheric deposition is 7.4×10^{19} particles (< 16 µm) per year.

8 Linkage of Pollutant Loading to In-Lake Effects and Load Capacity Analysis

8.1 Background

The Lake Tahoe TMDL program developed the Lake Clarity Model to link pollutant loading from all sources (watershed and atmospheric deposition) to in-lake effects and specifically Secchi depth. The Lake Tahoe TMDL Technical Report (2010) contains detailed information on the linkage and load capacity analysis. This chapter summarizes much of the information found in the Technical Report. The reader is referred to the Technical Report for more in-depth analysis of pollutant sources and associated load capacity.

Three main objectives guided the Lake Clarity Model effort:

1. Develop a calibrated and validated model to simulate Secchi depth using the available input data.
2. Determine the levels of load reduction needed to meet the TMDL target(s).
3. Examine the effects of pollutant load reduction on Secchi depth using the Lake Clarity Model to guide the development of a science-based recommended pollutant load reduction strategy.

The Lake Clarity Model is a complex system that includes interacting sub-models for hydrodynamics, plankton ecology, water quality, particle dynamics, and lake optical properties with data input values for fine sediment particle and nutrient loads from atmospheric deposition, tributaries and intervening zones, shoreline erosion, and groundwater (nutrients only) (Figure 8-1).

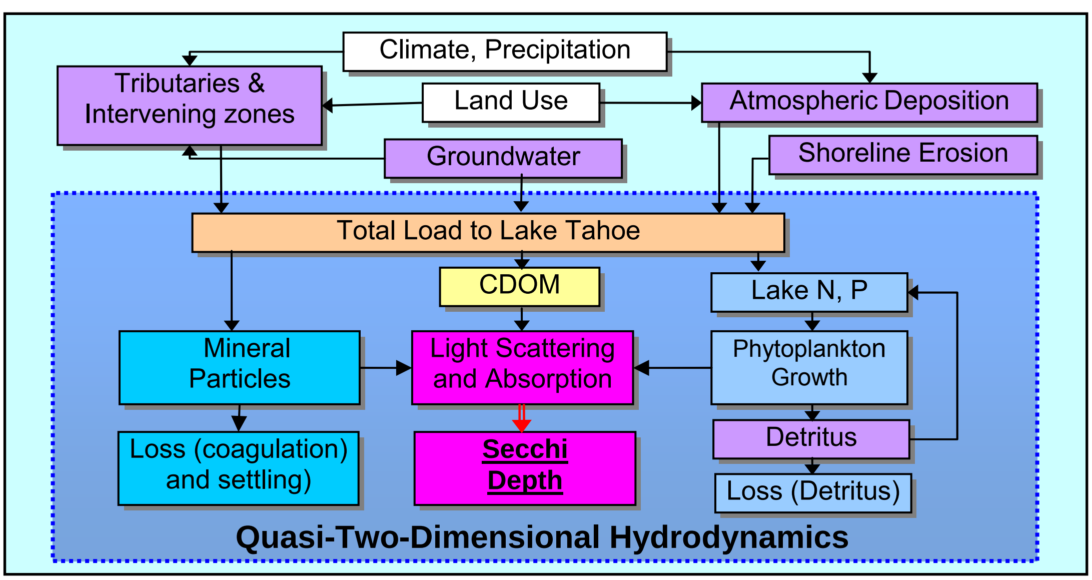

Figure 8-1. Conceptual Lake Clarity Model.

8.2 Lake Clarity Model Development & Operation

The Lake Clarity Model is the first lake water quality model designed and used for estimating Secchi depth in Lake Tahoe. Model development began in 1997 with a National Science Foundation Water and Watersheds program grant to UC Davis. The model was further refined as part of the Lake Tahoe TMDL program. The model accounts for a number of variables, including algal concentration, suspended inorganic sediment concentration, particle size distribution, and colored dissolved organic matter (CDOM) in predicting Secchi depth.

The hydrodynamic component of the model is based on the original Dynamic Reservoir Model (DYRESM) of Imberger and Patterson (1981). Lindenschmidt and Hamblin (1997) reported that DYRESM has already tested its widespread applicability to a range of lake sizes and types. Hamilton and Schladow (1997) combined the ecological sub-model and water quality sub-model that described the numerical description of phytoplankton production, nutrient cycling, the oxygen budget, and particle dynamics with the DYRESM model and demonstrated its wider applicability. The model has further been modified by Fleenor (2001) and completely adapted for use at Lake Tahoe (Perez-Losada 2001). An optical sub-model (Swift 2004, Swift et al. 2006) was developed based on fine sediment particle research at Lake Tahoe, and incorporated to estimate Secchi depth. The model was further refined during 2005-2007 as part of the Lake Tahoe TMDL science effort (Sahoo et al. 2007, 2009).

8.2.1 Data Inputs

Input data to the Lake Clarity Model includes daily weather information, daily stream inflow, lake outflow, pollutant loading estimates from each major source, lake physical data, initial water column conditions, physical model parameters, water quality boundary conditions, and water quality parameters. The Lake Clarity Model also required the in-lake profile data for the simulation starting date. Additional information for selected input parameters is highlighted below.

<u>Meteorology</u> – Meteorological activity drives the lake's internal heating, cooling, mixing, and circulation processes which in turn affect nutrient cycling, food-web characteristics, and other important features of Lake Tahoe's limnology. Required daily meteorological values for the Lake Clarity Model include solar short wave radiation, incoming long wave radiation (or a surrogate such as fraction of cloud cover), air temperature, vapor pressure (or relative humidity), wind speed and precipitation. Hourly recorded data from 1994 and 2004, collected at the meteorological station near Tahoe City, were either averaged or integrated as necessary to obtain daily values.

<u>In-Lake Water Quality</u> – As part of the ongoing Lake Tahoe Interagency Monitoring Program, UC Davis - TERC regularly collects numerous lake water samples at different depths. UC Davis - TERC researchers take samples at two lake stations: 1) the mid-lake (deep water) station at the 460-meter water depth and 2) the index station near the

west shore at the 150-meter water depth. Parameters measured for the Lake Clarity Model include temperature, Secchi depth, photosynthetically active radiation, fine particles (seven different size classes), nitrate, ammonia, total Kjeldahl-N, total dissolved-P, total hydrolyzable-P, total-P, chlorophyll, and phytoplankton and zooplankton primary productivity.

8.2.2 Calibration and Validation

Model calibration and validation is necessary to adjust the model parameters to align predicted values with measured values. The calibration and validation also reduces uncertainty associated with input data measurement error and mathematical representation of the complex physical, chemical, and biological processes. Using the calibrated input values, the model is validated using an independent data set.

The Lake Clarity Model has approximately 50 unique model parameters among all the sub-models, but not all values or parameters were taken through a single, calibration and validation process. The hydrodynamic sub-model has been shown to not require calibration and has been successfully applied to a large number of lakes and reservoirs (e.g. Schladow and Hamilton 1997; Lindenschmidt and Hamblin 1997). Therefore, default values were used for the hydrodynamic inputs. Because there are not sufficient local zooplankton data to completely calibrate the zooplankton model parameters, values were taken from the literature. Only the water quality and ecological sub-models were needed to be calibrated as part of the Lake Tahoe TMDL development.

The optical sub-model parameters were developed by Swift et al. (2006) using measured lake profile data, laboratory results, and established literature values. UC Davis researchers validated these optical model parameters by comparing the actual measured Secchi depths with model predictions. In total, 157 field measurements were made in the five-year period (2000 to 2004). Annual average values summarized in Table 8-1 shows simulated and measured annual Secchi depths.

Table 8-1. Comparison of annual average Secchi depths (Sahoo et al. 2009).

Year	Measured Secchi Depth (m)	Simulated Secchi Depth (m)	Difference (m)	Difference (%)
2000	20.5	23.8	-3.3	-16.1
2001	22.6	23.1	-0.5	-2.2
2002	23.8	23.9	-0.1	-0.4
2003	21.6	23.3	-1.7	-7.8
2004	22.4	23.9	-1.5	-6.7

There is a three-year measured data set (2000-2002) from Lake Tahoe for water temperature, chlorophyll, nitrate, ammonia, biologically available phosphorus and particle size distribution and concentration. Lake Clarity Model results show that simulated temperatures closely match measured temperature records including the onset and degradation of thermal stratification and mixing. The modeled chlorophyll *a* concentrations also match well with the field measurements. The Lake Clarity Model was able to reproduce the characteristic deep chlorophyll maximum during the summer at 30-60 meters. The Lake Clarity Model was also able to simulate the documented decline of nitrate in the surface waters in the summer caused by algal uptake along with the build up of nitrate in deeper waters driven by mineralization of dead organic matter and nitrification. The measured biologically available phosphorus in the water column was found within the narrow range of < 1 to 3 micrograms per liter (µg/L) and the Lake Clarity Model simulated range was nearly identical at < 1 to < 2 µg/L.

8.3 Load Capacity Determination

The load capacity is defined as the maximum pollutant loading allowable to achieve a defined standard. In addition to the water quality standard (29.7 meters annual average Secchi depth), the Lake Tahoe TMDL program has established an interim target of reaching approximately 24 meters of Secchi depth within the first twenty year implementation period.

Following model development, parameterization, calibration/validation and an initial sensitivity analysis, the Lake Tahoe TMDL program used the Lake Clarity Model to establish the relationship between annual average pollutant load reduction and the resulting average annual Secchi depth. This section briefly reviews Lake Clarity Modeling efforts to estimate how the Secchi depth may respond to a variety of loading scenarios. This information provides the framework for establishing Lake Tahoe's pollutant load capacity.

8.3.1 Transparency Response to Baseline Loading

The baseline simulation in the analysis below (Figure 8-2) represents the predicted future Secchi depths assuming the lake continues to receive similar fine sediment particle and nutrient loads as it has in the past 10 years (i.e. period of the source analysis). Because measured loading estimates included the effect of Best Management Practices in place as of water year 2004, those measures are included in the baseline condition. Figure 8-2 shows the projected trend for Secchi depth if no changes are made in current pollutant control efforts. Although the modeled trend flattens slightly, Lake Clarity Model predictions suggest that Lake Tahoe will continue to lose transparency if additional load reduction measures are not taken.

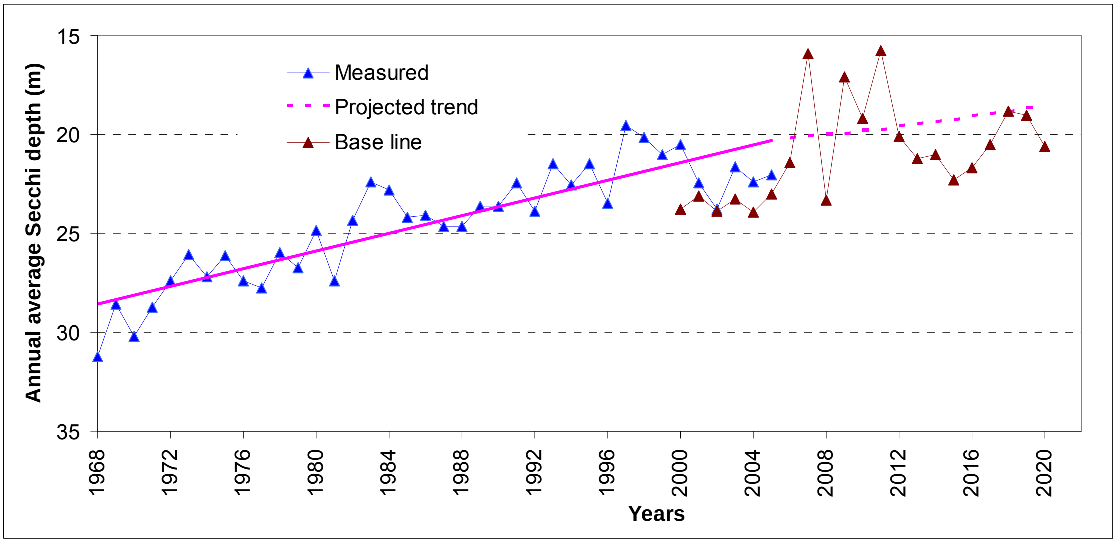

Figure 8-2. Measured and modeled Secchi depths for 2000-2020. The close agreement during the period between 2000-2005 between field data and modeled output highlight utility of the Lake Clarity Model (Sahoo et al. 2009).

8.3.2 Transparency Response to Pollutant Load Reduction

Lake Clarity Model simulations suggest that is it possible to achieve Secchi depths to meet both the interim Clarity Challenge target and the transparency standard, provided necessary load reductions are achieved.

In this section, example model runs are presented to demonstrate the utility of the Lake Clarity Model to evaluate transparency response to reduction of nutrient and fine sediment particle loads. These model runs generated an initial range for the magnitude of pollutant reduction required to achieve the Secchi depth targets. The presented results are a few examples of all Lake Clarity Model runs performed as part of the TMDL analysis from conceptual pollutant reduction scenarios.

To begin the process, the Lake Clarity Model simulated transparency response to an initial set of load reduction options. Four load reduction scenarios (zero percent reduction, 25 percent reduction, 50 percent reduction, and 75 percent reduction) were applied to nutrients and fine sediment particles individually and in combination. The percent reductions were converted to absolute loads (metric tons or number of fine sediment particles) based on the basin-wide nutrient and fine sediment particle budgets. The Lake Clarity Model was run for a 10-year simulated period to account for a sufficient range of precipitation levels.

These results suggested that reaching the 29.7 meter Secchi depth annual average standard requires a significant level of pollutant reduction (greater than 50 percent). Consistent with the in-lake field studies reported by Swift (2004) and Swift et al. (2006), the Lake Clarity Model demonstrates the greater importance of reducing fine sediment loading as compared to nutrient loading. This insight was a key consideration used to formulate the recommended implementation strategy. At the higher levels of load reduction the model results show a synergistic effect from removing nutrient and fine sediment.

The Lake Clarity Model results also suggest there is little difference between nitrogen and phosphorus reduction when considering Secchi depth improvement. While algal growth bioassay experiments show that phosphorus alone is more likely to stimulate phytoplankton growth, versus solely nitrogen, the combination of nitrogen and phosphorus additions results in significant increases in algal biomass at virtually all times of the year (Hackley et al. 2007).

Table 8-2. Modeled average Secchi depth for the years 2011–2020 for different load reduction scenarios. The 0 percent reduction assumes no additional water quality BMP/restoration efforts beyond the level accomplished during the period 1994-2004. The number within the parentheses represents the standard deviation over the estimated annual average Secchi depths (Sahoo et al. 2009).

Reduction (%)	Average Secchi Depth (meters) for the Years 2011–2020				
	Nutrient (N) Reduction	Nutrient (P) Reduction	Nutrient (N+P) Reduction (m)	Fine Sediment Reduction	Nutrient (N+P) and Fine Sediment Reduction
0	20.1 (2.1)	20.1 (2.1)	20.1 (2.1)	20.1 (2.1)	20.1 (2.1)
25	20.4 (2.1)	20.5 (1.8)	21.3 (2.2)	23.2 (2.5)	23.2 (2.2)
50	21.0 (2.3)	21.6 (2.1)	21.4 (2.4)	26.2 (2.3)	27.0 (2.2)
75	22.0 (2.5)	21.8 (2.4)	21.7 (2.3)	28.6 (2.6)	35.3 (2.8)

8.3.3 Lake Clarity Model Helps Quantify Specific Load Reduction Approach

The Lake Clarity Model was used to evaluate needed load reductions to achieve both interim and ultimate transparency goals. To achieve the load reductions needed to meet the Clarity Challenge, the TMDL Pollutant Reduction Opportunity analysis evaluated on-the-ground options for reducing pollutant loads from the various sources. Source-specific load reduction opportunities were evaluated in collaboration with stakeholders to determine achievability and feasibility of the various pollutant load reduction opportunities. These source-specific load reductions from the primary pollutant sources were input to the Lake Clarity Model to show transparency response.

Table 8-3 lists the fine sediment particle and nutrient load reductions needed to achieve both the Clarity Challenge and transparency standard based on the load reduction opportunity analysis. The Pollutant Reduction Opportunity Report (Lahontan and NDEP 2008a) contains detailed information from the evaluation process.

Table 8-3. Basin-wide pollutant reductions needed to meet Clarity Challenge and transparency standard.

Pollutant	Interim Secchi Depth 24.0 meters “Clarity Challenge”	Target Secchi Depth 29.7 meters Transparency Standard
Fine Sediment Particles (< 16 µm)	32 %	65 %
Phosphorus	14 %	35 %
Nitrogen	4 %	10 %

9 Load Reduction Analysis and Recommended Implementation Strategy

After estimating annual loads from the major pollutant sources, the Water Board and the Nevada Division of Environmental Protection (NDEP) identified and quantified pollutant load reduction opportunities, evaluated the relative costs and water quality benefits from implementing various load reduction actions, and used the resulting findings to develop a comprehensive implementation approach for meeting required pollutant load reductions.

The Water Board and NDEP conducted the Pollutant Reduction Opportunity project (Lahontan and NDEP 2008a) to assess the cost and expected fine sediment, nitrogen, and phosphorus load reductions from implementing known, quantifiable pollutant control measures for the major pollutant sources. Through the Integrated Water Quality Management Strategy effort (Lahontan and NDEP 2008b), the Water Board and NDEP crafted three different integrated implementation strategies based on feasible, cost effective options identified by the Pollutant Reduction Opportunity project. The Water Board and NDEP then refined the integrated strategies into a single implementation approach through an iterative process involving stakeholder feedback regarding the political, social, and economic implications of the proposed strategies. The resulting Recommended Water Quality Management Strategy (“Recommended Strategy”) provides the basis for the load reduction allocation schedule of fine sediment particles and nutrients to Lake Tahoe for the first fifteen year TMDL implementation phase (Lahontan and NDEP 2008b).

The Recommended Strategy provides the basis for both the Lake Tahoe TMDL pollutant load allocation and implementation plans. The allocation plan specifies the load reduction schedule for each of the four major source categories so the numeric target is achieved. The Implementation Plan is a package of representative actions to achieve the load reductions necessary to meet the required load reductions.

9.1 Source Category Load Reductions

The first 15 years of TMDL implementation will reduce fine sediment particle loads to Lake Tahoe by an estimated 32 percent relative to the basin-wide Lake Tahoe TMDL baseline pollutant budget. Total nitrogen and total phosphorus load reductions over the same period are expected to be four percent and 17 percent, respectively. Table 9-1 shows how the basin-wide fine sediment particle, total nitrogen, and total phosphorus load reductions are distributed among the four primary pollutant source categories.

Table 9-1. Source load reductions expected from implementing the Recommended Strategy. Reductions are expressed as an estimated percent of the basin-wide fine sediment particle load from these four sources (not including groundwater and shoreline erosion).

Pollutant Source	To Meet the Clarity Challenge		
	Fine Sediment Particle Load Reduction	Total Nitrogen Load Reduction	Total Phosphorus Load Reduction
Forest upland	1%	0%	0%
Stream channel erosion	2%	0%	0%
Atmospheric deposition	5%	0.5%	7%
Urban uplands	24%	3.5%	10%
Basin-wide Total	**32%**	**4%**	**17%**

After the first fifteen years, ongoing implementation measures and additional load reduction actions will be needed to further reduce fine sediment particle and nutrient loads to meet the transparency standard.

9.1.1 Urban Runoff

Urban runoff produces the majority of fine sediment and phosphorus loading and provides the greatest estimated potential for pollutant control. Therefore, responsible parties (local municipalities and state highway departments) are expected to prioritize advanced operations and maintenance practices and innovative technologies that will reduce fine sediment particle and associated nutrient loads from the urban runoff source category. As noted in Table 9-1, implementing the Recommended Strategy is expected to reduce the basin wide fine sediment particle load by approximately 24 percent. To achieve the clarity standard, the fine sediment particle load carried by urban stormwater runoff must be reduced by roughly 70 percent.

The Recommended Strategy assumes that pollutant controls will be applied differently based on configuration of impervious coverage and slope. Areas of concentrated impervious coverage, such as commercial land uses with extensive streets, parking areas, and rooftops, may require intensive application of advanced pollutant control measures, while land uses with dispersed impervious coverage will likely need less advanced treatments. Enhanced operations and maintenance of roadways and associated pollutant controls are important elements in the Recommended Strategy to reduce pollutants from urban runoff discharges. Additional information about the mix of pollutant controls included in each treatment tier and the process for deriving load estimates is in the

Integrated Water Quality Management Strategy Final Report (Lahontan and NDEP 2008b).

9.1.2 Atmospheric Deposition

Although atmospheric deposition is a smaller source of fine sediment particles (roughly fifteen percent of the basin-wide load), atmospheric deposition contributes approximately 55 percent of basin-wide nitrogen and 15 percent of basin-wide phosphorus directly to the lake. The TMDL Implementation Plan includes cost-effective treatments to control dust from sources such as unpaved parking areas, construction sites, dirt roads, traction abrasives on paved surfaces, and organic soot from residential wood burning. Water Board and NDEP staff expect these control measures will reduce the basin-wide sediment particle load by approximately five percent and the phosphorus load by about seven percent.

Nitrogen emissions from mobile sources (i.e., vehicles) will be controlled through continuation of the air quality control programs enforced by the Tahoe Regional Planning Agency, including implementation of the updated Lake Tahoe Regional Transportation Plan (TRPA 2008).

9.1.3 Stream Channel Erosion and Stream Restoration

Stream channel erosion contributes roughly 3.5 percent of the basin-wide fine sediment particle load to Lake Tahoe. As shown in Table 9-1, implementing the Recommended Strategy is projected to significantly reduce this contribution (by more than half) in the first 15 years.

The TMDL Implementation Plan emphasizes restoration activities on the three tributaries that input the most fine sediment particles to Lake Tahoe. Together, these three streams are responsible for 96 percent of the stream channel erosion fine sediment particle load reaching the lake:

- Upper Truckee River (60%)
- Blackwood Creek (23%)
- Ward Creek (13%)

Several resource management agencies in the Lake Tahoe basin, including the United States Forest Service Lake Tahoe Basin Management Unit, the California Tahoe Conservancy, and the California Department of Parks and Recreation, have planned stream restoration projects on these three major tributaries.

Restoration activities on the Upper Truckee River, Blackwood Creek, and Ward Creek are estimated to reduce the basin-wide fine sediment particle loads by roughly two percent within the first 15 years. Given that stream channel erosion contributes almost four percent to the basin-wide load, the two percent reduction equates to reducing the stream channel erosion contribution by more than half. To achieve the clarity standard, the fine sediment particle load coming from stream channel erosion must be reduced by nearly 90 percent.

The broader ecosystem and habitat benefits of stream restoration are expected to be significant. A combination of full channel restoration and bank stabilization measures will provide multiple environmental benefits, including rehabilitation of floodplains, riparian corridors and meadows, fisheries enhancement, and wildlife habitat restoration.

9.1.4 Forest Upland

Federal, state, and some of the larger local land management agencies have active, well-defined, multi-objective forest restoration programs with established and secure funding. The Recommended Strategy focuses forest management efforts on small disturbed areas (e.g. unpaved roads, campgrounds and ski runs) where relatively high sediment particle yields and easy access make pollutant controls cost-effective. Land management activities within the forest uplands are anticipated to reduce the basin-wide fine sediment particle load by approximately one percent, which equates to a 12 percent reduction from the forest upland source in the first 15 years. To meet the clarity standard, a 20 percent reduction in fine sediment particle loading is needed from the forest upland source within the estimated 65-year full implementation timeframe.

The Forest Upland load reduction analysis determined that maintenance activities (including fuel reduction projects) in the forest uplands have the potential to reduce or avoid increases in fine sediment and nutrient loads (Lahontan and NDEP 2008a).

10 Load Allocations

The TMDL process requires an allocation of allowable pollutant loads to identified pollutant sources. Water Board and NDEP staff determined the distribution of allowable pollutant loads to sources by applying Recommended Strategy load reductions to the Lake Clarity Model. Building on the comprehensive Pollutant Reduction Opportunity analysis (Lahontan and NDEP 2008a), and the Integrated Water Quality Management Strategy effort (Lahontan and NDEP 2008b) the TMDL Implementation Plan outlines a justified, reasonable approach for achieving needed fine sediment particle, nitrogen, and phosphorus load reductions.

10.1 Attainment Timeframe

The Water Board and NDEP have set timeframes for achieving the interim Clarity Challenge target based on the Recommended Strategy and for achieving the deep water transparency standard. The following sections describe these timeframes and the established milestones that will be used to assess load reduction progress.

10.1.1 Clarity Challenge

The Recommended Strategy, as described by the Integrated Water Quality Management Strategy Project Report (Lahontan and NDEP 2008b), demonstrates that fine sediment particle, nitrogen, and phosphorus load reductions needed to meet the Clarity Challenge can be accomplished within the first fifteen years of TMDL implementation. The Recommended Strategy load reduction estimates extend for five years beyond the Clarity Challenge target, providing pollutant load reduction targets for the first twenty years of TMDL implementation.

10.1.2 Deep Water Transparency Standard

Using the Lake Clarity model and the distribution of expected load reductions from the four major pollutant sources described by the Recommended Strategy, Water Board and NDEP staff have identified the magnitude of load reductions needed to meet the deep water transparency standard. Based on the best professional judgment of Water Board and NDEP staff, reducing fine sediment, nitrogen, and phosphorus loads to meet the deep water transparency standard will take approximately 65 years. This estimate assumes that load reduction rates following the first twenty years will decline as load reduction opportunities become scarcer.

10.1.3 Load Reduction Milestones

The Water Board and NDEP have established five year load reduction milestones to help define regulatory compliance points and assess progress at meeting overall load reduction goals upon TMDL adoption. Meeting each milestone is expected to cost approximately $500 million for the first three milestones (years 5, 10, and 15).

Developed using the Integrated Water Quality Management Strategy analysis (Lahontan and NDEP 2008b), the first three milestones reflect an expected evolution of implementation efforts, particularly for the urban uplands pollutant source. The first five-year (year 5) milestone assumes modest load reductions as implementing agencies focus on employing current best practices and maintaining existing infrastructure. Though the first milestone will be five years from TMDL adoption, load reduction actions since the end of calendar year 2004 can be applied toward meeting the first milestone. (The source load analysis was completed with water quality data through the end of 2004). The reductions expected at the second (year 10) milestone are based on the expected implementation of new and innovative technologies, while the third (year 15) milestone reflects accelerated and more widespread implementation of these advanced pollutant controls.

To determine milestone values between the first 15 year implementation phase and the ultimate goal of meeting the deep water transparency standard, Water Board and NDEP staff assumed load reduction percentages would progress in a roughly linear manner. A rough linear progression between the third (year 15) milestone and the final year 65 target was used to establish load reduction milestones for years 20, 25, 30, 35, 40, 45, 50, 55, and 60. The Water Board and NDEP will work within the adaptive management framework following TMDL adoption to evaluate the appropriateness of the established milestones and, if necessary, make adjustments to reflect new information.

10.2 Load Allocation Tables

The following tables show the necessary load reductions for each of the four major pollutant source categories. Table 10-1 thru Table 10-3 describe the 2004 baseline loads for each source, including the source's percent contribution to the basin wide load and the needed percent reductions from that baseline load for each of the established five-year milestones.

Fine sediment particle values are presented in scientific notation. The capital "E" is an abbreviation for "times ten raised to the power." For instance, that total baseline fine sediment particle load is presented as "4.8E+20", which is an abbreviation for "4.8×10^{20}", or 480 quintillion fine sediment particles.

Note that because of the relatively small fine sediment, Total Nitrogen, and Total Phosphorus load contributions from groundwater and shoreline erosion, these sources are not included in the allocation tables, thus the sums of the allocated source loads are slightly different than the baseline load values presented in previous chapters.

Table 10-1. Fine Sediment Particle Load Allocations by Pollutant Source Category.

	Baseline Load		Milestone Load Reductions												Standard Attainment
	Basin-Wide Load (Particles/yr)	% of Basin-Wide Load	5 yrs	10 yrs	15 yrs	20 yrs	25 yrs	30 yrs	35 yrs	40 yrs	45 yrs	50 yrs	55 yrs	60 yrs	65 yrs
Forest Upland	4.1E+19	9%	6%	9%	12%	12%	13%	14%	15%	16%	17%	18%	19%	20%	20%
Urban Upland	3.5E+20	72%	10%	21%	34%	38%	41%	45%	48%	52%	55%	59%	62%	66%	71%
Atmosphere	7.5E+19	16%	8%	15%	30%	32%	35%	37%	40%	42%	45%	47%	50%	52%	55%
Stream Channel	1.7E+19	3%	13%	26%	53%	56%	60%	63%	67%	70%	74%	77%	81%	85%	89%
Basin Wide Total	4.8E+20	100%	10%	19%	32%	35%	38%	42%	44%	47%	51%	55%	58%	61%	65%

Table 10-2. Total Nitrogen Load Allocations by Pollutant Source Category.

Nitrogen	Baseline Load		Milestone Load Reductions												Standard Attainment
	Basin-Wide Nitrogen Load (MT/yr)	% of Basin-Wide Load	5 yrs	10 yrs	15 yrs	20 yrs	25 yrs	30 yrs	35 yrs	40 yrs	45 yrs	50 yrs	55 yrs	60 yrs	65 yrs
Forest Upland	62	18%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Urban Upland	63	18%	8%	14%	19%	22%	25%	28%	31%	34%	37%	40%	43%	46%	50%
Atmosphere	218	63%	0%	0%	1%	1%	1%	1%	1%	1%	1%	1%	2%	2%	2%
Stream Channel	2	1%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Basin Wide Total	345	100%	2%	3%	4%	5%	6%	6%	7%	7%	8%	8%	9%	9%	10%

Table 10-3. Total Phosphorus Load Allocations by Pollutant Source Category.

Phosphorus	Baseline Load		Milestone Load Reductions												Standard Attainment
	Basin-Wide Phosphorus Load (MT/yr)	% of Basin-Wide Load	5 yrs	10 yrs	15 yrs	20 yrs	25 yrs	30 yrs	35 yrs	40 yrs	45 yrs	50 yrs	55 yrs	60 yrs	65 yrs
Forest Upland	12	32%	1%	1%	1%	2%	1%	1%	2%	2%	2%	2%	2%	3%	3%
Urban Upland	18	47%	7%	14%	21%	23%	26%	28%	31%	33%	36%	38%	41%	44%	46%
Atmosphere	7	18%	9%	17%	33%	36%	39%	42%	45%	48%	51%	53%	56%	58%	61%
Stream Channel	1	3%	8%	15%	30%	32%	34%	36%	38%	40%	42%	44%	46%	48%	51%
Basin Wide Total	38	100%	5%	10%	17%	19%	22%	24%	26%	28%	30%	32%	33%	34%	35%

10.3 Jurisdiction-Specific Waste Load Allocations for Urban Runoff

To be consistent with the scale of the Lake Tahoe TMDL source and load reduction analyses, all pollutant loads are allocated at a basin-wide scale for each of the four major pollutant sources. Waste load allocations for urban stormwater dischargers (including El Dorado, Placer, Douglas, and Washoe Counties, the City of South Lake Tahoe, and the California and Nevada Departments of Transportation), however, must be specified at a jurisdiction level so that the Water Board and NDEP can incorporate load reduction requirements into relevant regulatory measures.

To translate basin-wide urban runoff load allocations into jurisdiction-specific load allocations for municipalities and state highway departments, the Water Board and NDEP will require those agencies to conduct a jurisdiction-scale baseline load analysis as the first step in the implementation process. For each five year milestone, individual urban stormwater jurisdiction load reduction requirements will be calculated by multiplying the urban uplands basin-wide load reduction percentage by the jurisdiction's individual baseline load.

To ensure comparability between the basin-wide baseline load estimates and the jurisdiction-scale baseline load estimates for urban runoff, urban stormwater dischargers must use a set of standardized baseline condition values that are consistent with those used to estimate basin wide pollutant loads. For example, traction abrasive application rates, street and BMP maintenance practices, and typical residential BMP compliance rates should reflect baseline conditions. More specific guidance, including references to approved modeling tools and a detailed review and approval process, will be included in California NPDES Stormwater Permits for El Dorado and Placer Counties, the City of South Lake Tahoe and the California Department of Transportation, as well as the Nevada Memoranda of Implementation between NDEP and Douglas and Washoe Counties, and the Nevada Departments of Transportation.

10.4 Expressing Allocations as Daily Loads

The Water Board and NDEP considered two different approaches to expressing allowable pollutant load allocations as daily loads. The results for a *flow range* daily load analysis and *seasonal* daily load analysis for fine sediment particles, total nitrogen, and total phosphorus are available in the *Integrated Water Quality Management Strategy Project Report* (Lahontan and NDEP 2008b).

Although the Water Board and NDEP staffs have completed the daily load analysis as required by the USEPA, the daily load values are not well suited to the variability associated with natural systems. Urban runoff, the primary source of pollutants affecting Lake Tahoe's transparency, is highly variable in both flow volume and pollutant concentration. The other major pollutant sources, including atmospheric deposition, stream channel erosion, and forest upland runoff, are similarly variable and not well suited to daily analysis and tracking.

The *average annual* load expression remains a more useful and appropriate management tool for the Lake Tahoe basin, and that the most meaningful measure of Lake Tahoe’s transparency is generated by averaging the seasonal Secchi depth data. The transparency target is an average annual standard. The modeling tools used to predict load reduction opportunity effectiveness, as well as the lake’s response, are driven by average annual conditions. An emphasis on average annual fine sediment particle and nutrient loads also levels the hydrologic variability driven by seasonal and inter-annual differences in precipitation amount and type. Finally, average annual estimates provide a more consistent regulatory metric to assess whether implementation partners are meeting established load reduction goals.

11 Lake Tahoe TMDL Implementation Plan

The Lake Tahoe TMDL Implementation Plan summarizes representative actions that the various resource management agencies must take to reduce fine sediment particle, phosphorus, and nitrogen loads to Lake Tahoe and meet established load reduction milestones, including the Clarity Challenge and the deep water transparency standard.

Using the Pollutant Reduction Opportunity analysis and the Integrated Water Quality Management Strategy stakeholder process, the Water Board and NDEP crafted a number of alternative implementation strategies to meet the Clarity Challenge. These strategies combined selected pollutant controls from each of the four primary sources of fine sediment particles and nutrients. Each of the identified strategies demonstrated the magnitude of possible load reduction opportunities from each pollutant source and established justifiable load reduction milestones from a suite of quantifiable activities.

The Recommended Strategy, summarized in Chapter 9, provides the framework for the magnitude of expected load reductions from the four major pollutant sources and describes reasonably foreseeable load reduction activities that responsible parties may choose to undertake. Although the Water Board and NDEP evaluated specific load reduction actions to determine the most reasonable load reduction distribution, the Recommended Strategy does not translate to recommendations for project-scale application and implementing agencies are not required to implement the specific controls contained within the analysis. Rather, the Recommended Strategy demonstrated that the pollutant load reductions for the first 15 years of implementation are achievable but does not establish a prescription for implementing agencies to follow in meeting load reduction requirements.

Following an overview of the responsible parties describing the regulatory and implementation agencies and their respective roles in implementing this bi-state TMDL, the Implementation Plan is organized by major pollutant source. Subsequent sections on each of the four source categories list reasonably foreseeable actions that will achieve the Clarity Challenge goals, and associated performance assessment measures. The final section briefly describes the adaptive management process.

11.1 Regulatory Agencies

The Water Board and NDEP are the two state regulatory agencies who will oversee implementation of this TMDL. These two agencies may enact policy and regulations based on the TMDL analysis and key scientific findings of the TMDL. Each agency will use its regulatory authority to ensure that the performance objectives specified in this TMDL are achieved.

The Water Board and NDEP will each conduct the following tasks to ensure progressive implementation towards meeting the Clarity Challenge and the numeric target:

- Administer and apply the Lake Clarity Crediting Program to each of its urban stormwater programs, NPDES permits in California and Memoranda of Implementation in Nevada.

- Develop policies and procedures to consistently track and report load reduction actions with respect to the forest uplands, atmospheric deposition, and stream channel erosion source categories.

- Recommend, require, and support current and future monitoring and research programs to reduce uncertainties associated with the analyses, develop innovative load reduction options, and assess effectiveness of actions and lake transparency response.

- Develop and implement the TMDL Management System that will enable incorporation of new information and key findings to potentially update policies and assess and refine implementation strategies and actions, as needed.

- Work with implementation agencies to overcome barriers associated with implementation.

The TRPA will play a crucial role in TMDL implementation because the TRPA has the ability to incentivize TMDL implementation. As the agency responsible for zoning and permitting a wide variety of land uses and construction projects throughout the basin, TRPA has the ability to release or restrict building allocations, additional building height, and commercial floor area. TRPA is currently in the process of updating its Regional Plan. NDEP and the Water Board are actively working with TRPA to ensure consistency with the TMDL and the incorporation of the best possible incentive and regulatory packages.

11.2 Implementation Agencies

11.2.1 Federal

United States Forest Service

The United States Forest Service Lake Tahoe Basin Management Unit (an agency of the U.S. Department of Agriculture) manages roughly 80 percent of the land in the Lake Tahoe basin. The land is administered by the Lake Tahoe Basin Management Unit (LTBMU), a special unit that oversees federally owned forest lands within the Lake Tahoe basin. Although the bulk of LTBMU land is undeveloped forested upland (including undeveloped urban lots), the LTBMU manages a variety of recreational facilities within the urbanized landscape such as trailheads, parking lots, and campgrounds. The LTBMU's land management activities impact each of the four major pollutant source categories.

The LTBMU Land and Resource Management Plan (Forest Plan) guides management direction. The current plan, adopted in 1988, is under revision to update portions related to ecosystem restoration, recreation management, land-use, and adaptive management. The Forest Plan update effort has been an integral part of the interagency Pathway planning process and the updated plan will include desired future conditions assessments, related goals and objectives for a 10-50 year planning horizon, and management and monitoring approaches.

Other Federal Agencies

There are a number of other federal agencies that provide critical support through the Lake Tahoe Federal Interagency Partnership. This Partnership was established in 1997 with strong local, State, Administration and Congressional support. It includes the US Army Corps of Engineers, the USDA Natural Resources Conservation Service, US Geological Survey, US Environmental Protection Agency, US Fish & Wildlife Service, US Bureau of Reclamation, and US Department of Transportation. The Partnership supports TMDL implementation through direct funding of TMDL research and regional, local, and state government water quality improvement projects.

11.2.2 California

California Tahoe Conservancy

The California Tahoe Conservancy (CTC) is an independent State agency within the Natural Resources Agency of the State of California. It was established in its present form by State law in 1984 (Chapter 1239, Statutes of 1984). Its jurisdiction extends only to the California side of the Lake Tahoe Basin. The CTC is not a regulatory agency. It was established to develop and implement programs through acquisitions and site improvements to improve water quality in Lake Tahoe, preserve the scenic beauty and recreational opportunities of the region, provide public access, preserve wildlife habitat areas, and manage and restore lands to protect the natural environment.

CTC erosion control and stream environment zone restoration programs play a critical role in TMDL program funding and implementation. Through the Lake Tahoe license plate program and bond funds authorized by Propositions 40 and 50 (and potentially other funding sources), the CTC provides essential program funding for local government erosion control projects, stream restoration efforts, and land conservation programs. The CTC owns numerous urban lots and several larger parcels and implements land management plans that will further assist in meeting Lake Tahoe TMDL load reduction goals by restoring historically disturbed areas, preventing new disturbance, providing opportunities for urban stormwater treatment, and leading Upper Truckee River and Ward Creek stream restoration efforts.

California Departments of Parks and Recreation

The California Department of Parks and Recreation is a department of the State of California Natural Resources Agency. In the Lake Tahoe basin, the Sierra District manages nine park units covering over 8,600 acres. The Sierra District Resource

Program actively protects, preserves, and manages many aspects of park resources, including forests and fuels, watershed restoration, sensitive species, invasive species, and cultural features to provide high quality recreation opportunities. The program is also actively working to address stream bank and bed erosion problems on portions of the Upper Truckee River that flow through a golf course managed by the Department.

The Department also manages a number of campgrounds, trailheads, historic sites, and other lands that require best management practices to control runoff from impervious surfaces.

California Department of Transportation
The California Department of Transportation (Caltrans), a department of the State of California Business, Transportation, and Housing Agency, is responsible for operating and maintaining the state highway system within the state of California. Caltrans' mission is to improve mobility across the state and its strategic goals include preserving and enhancing California's resources and assets. Caltrans operates 68 miles of roadways within the Tahoe basin that range in elevation from 6,250 to over 7,200 feet. The majority of the roadways are two lanes, and Caltrans performs snow management operations along all the roadways during the winter including the application of traction abrasives and deicers. Caltrans has developed a Storm Water Management Program to comply with statewide NPDES stormwater permitting requirements.

Before July 1999, stormwater discharges from Caltrans' stormwater systems were regulated by individual permits issued by the Regional Water Boards. On July 15, 1999, the State Water Resources Control Board issued a statewide permit (Order No. 99-06-DWQ, NPDES Permit No. CAS000003) which regulated all stormwater discharges from Caltrans owned stormwater systems, maintenance facilities and construction activities.

Future permit revisions or individual orders issued by the Water Board will require Caltrans to prepare and implement a Load Reduction Plan for the Lake Tahoe basin to achieve pollutant load reductions required by this TMDL.

11.2.3 Nevada

Nevada Tahoe Resource Team Agencies
The Nevada Tahoe Resource Team is an interagency team coordinated by the Division of State Lands and is dedicated to preserving and enhancing the natural environment in the Lake Tahoe basin. The Nevada Tahoe Resource Team is an interagency team coordinated by the Division of State Lands and dedicated to preserving and enhancing the natural environment in the Lake Tahoe basin. In addition to Division of State Lands staff, the team is made up of representatives from the Nevada Division of Forestry, the Division of State Parks, and the Department of Wildlife.

The Nevada Tahoe Resource Team is responsible for implementing Nevada's share of the Environmental Improvement Program. As such, the Team coordinates and implements a wide range of projects designed to improve water quality, control erosion, restore natural watercourses, improve forest health and wildlife habitat, and provide recreational opportunities.

The Division of State Lands administers two grant programs: the Water Quality and Erosion Control Grant and the Nevada Lake Tahoe License Plate Grant, in addition to the Excess Coverage Mitigation Program and the Urban Lot Management Program. The Division is also responsible for permitting activities affecting the bed of the Lake below elevation 6223'.

Nevada Department of Transportation

The Nevada Department of Transportation (NDOT) operates and maintains the Nevada state highway system. NDEP regulates stormwater discharges from NDOT facilities under a statewide NPDES Permit (NV0023329). The permit requires NDOT to address and limit the discharge of pollutants to the maximum extent practicable. NDOT has developed a Storm Water Management Program to comply with the permit requirements and address storm water pollution related to highway planning, design, construction, and maintenance activities throughout the state. The permit also contains language requiring compliance with any established TMDLs. Therefore, with NDEP and USEPA approval of this TMDL NDOT will be responsible to retrofit jurisdictional roadways within the Lake Tahoe basin to reduce fine sediment particle and nutrient loads consistent with TMDL waste load allocations to be specified in the Memorandum of Agreement.

11.2.4 Local

California Local Government Agencies

There are three municipal jurisdictions on the California side of the Lake Tahoe basin: one incorporated city, the City of South Lake Tahoe and El Dorado and Placer counties. Under the municipal stormwater NPDES permit (CAG616002), these three local government entities are responsible for the quality of stormwater runoff from within their jurisdictional boundaries (excepting federal and state owned lands). Federal NPDES storm water regulations require each jurisdiction to develop and implement comprehensive Storm Water Management Plans that address urban runoff problems from commercial, industrial, residential, and construction sources along with addressing runoff municipally owned facilities (roadways, maintenance yards, etc.). The municipal NPDES program also requires the municipalities to provide education and outreach to a variety of audiences to inform the public about the importance of stormwater management.

Nevada Local Government Agencies

Three jurisdictions – Washoe County, Douglas County, and Carson City Rural Area – comprise the Nevada side of Lake Tahoe. While the portions of Washoe and Douglas Counties that lie within the Lake Tahoe basin are predominantly developed, the portion of Carson City Rural Area is undeveloped forest land. Incline Village, located in Washoe County, is the largest urban area on the Nevada side of the Lake Tahoe basin but does not meet the population density thresholds for mandatory Municipal Stormwater NPDES permitting. Washoe County has assumed responsibility for planning, implementation and maintenance of water quality and erosion control projects located within its jurisdiction. In Douglas County, water quality improvement project and storm water program planning, implementation and maintenance has historically been shared between the county and the numerous General Improvement Districts within it.

11.3 Implementation Actions by Source Category

11.3.1 Urban Uplands

The majority of the basin-wide pollutant load discharges, and the most cost effective and efficient load reduction opportunities, are associated with urban runoff. The Pollutant Load Reduction Opportunity (Lahontan and NDEP 2008a) and the Integrated Water Quality Management Strategy (Lahontan and NDEP 2008b) analyses demonstrated that continued application of existing stormwater management practices would be insufficient to meet needed fine sediment particle, nitrogen, and phosphorus load reductions. Enhanced operations and maintenance coupled with more intensive application of treatment measures with a demonstrated ability to reduce fine sediment particle loads will be needed to achieve TMDL requirements.

Implementation Actions to Meet the Clarity Challenge and Achieve the TMDL

The following is a representative list of practices and treatment options that responsible parties might use to meet the Clarity Challenge load reductions by year 15, and achieve the TMDL in 65 years. Many of these practices are already in use by responsible parties, and an enhanced level of effort may contribute to reduced sediment and nutrient discharges to Lake Tahoe. In the future, technological advances may add other actions to this list. This list is not intended to be exclusive; implementing agencies may select other actions to achieve required load reductions.

- Stabilize and re-vegetate road shoulders
- Vacuum-sweep streets (in heavily sanded areas)
- Upgrade/enhance fertilizer / turf management practices to reduce nutrient application
- Remove impervious coverage (increase infiltration)
- Redirect runoff for additional treatment
- Install and maintain infiltration trenches
- Install and maintain prefabricated infiltration systems
- Install and maintain detention basins
- Install and maintain sand filters
- Apply advanced deicing strategies (to reduce or eliminate abrasive application)

- Upgrade/increase/enhance infrastructure operation and maintenance
- Control retail fertilizer sales within the Basin
- Recommend landscaping practices that reduce nutrient mobilization
- Install and maintain wet basins / infiltration basins
- Install and maintain constructed wetlands
- Install and maintain media filters in stormwater vaults
- Pump stormwater to more suitable treatment locations

Performance and Compliance Assessment and Reporting

Urban municipalities and the state highway departments will be required to participate in the Lake Clarity Crediting Program, which provides a system of tools and methods to help urban jurisdictions estimate pollutant loads at a jurisdiction and project scale, link projects, programs, and operations and maintenance activities to estimated load reductions, and track compliance with one-year targets and five-year milestones. By defining a consistent water quality credit, this program provides dischargers with the flexibility to achieve needed load reductions using a blend of treatment approaches and cooperative efforts that span jurisdictional boundaries. The Water Board and NDEP will use the Lake Clarity Crediting Program to track compliance with stormwater regulatory measures.

Following approval of the Lake Tahoe TMDL, the Water Board and NDEP will apply the load allocation milestones (expressed as a percent reduction from baseline) to establish five-year load reduction requirements for NPDES permits (California municipalities and state highway departments) and Memoranda of Implementation (Nevada municipalities and state highway departments). To translate basin-wide percent reduction requirements for the urban source into numeric load values and associated enforceable Lake Clarity Crediting Program requirements, each municipal jurisdiction and state highway department must develop a jurisdiction-scale baseline load estimate using consistent methods.

The Water Board and NDEP will establish annual Lake Clarity Credit targets for each jurisdiction to track ongoing progress. Urban stormwater dischargers shall use either the Pollutant Load Reduction Model (Northwest Hydraulic Consultants et al. 2009) (or an equivalent method approved by the Water Board and NDEP, along with baseline condition information described in the *Lake Clarity Crediting Program Handbook* (Lahontan and NDEP 2009) to estimate pollutant loading from representative catchment and extrapolate those results to generate jurisdiction-wide baseline load estimates for fine sediment particles, total nitrogen, and total phosphorus. The Water Board and NDEP will then apply the percent reduction milestones shown in Table 10-1 thru Table 10-3 to each jurisdiction’s established baseline to determine the number of Lake Clarity Credits required for each five-year permit term.

The Water Board and NDEP will require Lake Tahoe municipal jurisdictions, including both State highway departments, to prepare, submit, and implement stormwater management plans (or equivalent) that describe how load reduction requirements will be met. To ensure implementing partners continue to achieve load reductions needed to meet the Clarity Challenge and other milestones, the Water Board and NDEP will monitor load reduction progress by reviewing annual stormwater program reports and, if necessary, will take enforcement action against any jurisdiction that fails to meet established Lake Clarity Credit requirements. Table 11-1 summarizes the TMDL requirements for the Urban Upland jurisdictions.

Table 11-1. Lake Tahoe TMDL Implementation/Reporting Schedule – Urban Uplands

Action	Schedule	Responsible Party
Submit Storm Water Management Plans or equivalent to Water Board and NDEP describing how 5-year load reduction requirements will be met	No later than two years after TMDL approval* and every five years following	El Dorado County Placer County Douglas County Washoe County California Department of Transportation Nevada Department of Transportation City of South Lake Tahoe
Submit jurisdiction-specific 2004 baseline load estimates for fine sediment particles, phosphorus, and nitrogen to the Water Board and NDEP for review/approval**	No later than two years after TMDL approval*	
Reduce and maintain pollutant loads of fine sediment particles, total phosphorus, and total nitrogen as specified in Table 10-1, Table 10-2, and Table 10-3	Achieve the percent reduction specified no later than each respective 5-year milestone following TMDL approval*	

*TMDL approval is the date the USEPA approves the Lake Tahoe TMDL.
**The baseline load estimates must be done using either the Pollutant Load Reduction Methodology, or an equivalent method that uses a continuous hydrologic simulation process and other similar input values.

11.3.2 Forest Uplands

The Pollutant Reduction Opportunity analysis (Lahontan and NDEP 2008a) identified types of disturbed areas in forest lands (e.g., unpaved roads, campgrounds, ski runs) where relatively high sediment particle yields and easy maintenance access provide cost-effective pollutant control opportunities. The implementation approach for forest uplands focuses most efforts on these easy-access, high pollutant-yielding disturbed areas.

Pollutant controls for this source can be categorized by land-use and by actions taken on various land-uses, in two categories. Standard BMP treatments are planned by federal and state land management agencies for roads, trails, campgrounds, and fuels reduction projects under their jurisdiction. More advanced treatments designed to achieve better hydrologic function and complete restoration activities to mimic natural conditions are also recommended to reduce pollutant loads.

Implementation Actions to Meet the Clarity Challenge and Achieve the TMDL

The following is a representative list of practices and treatment options that responsible parties may use to meet the Clarity Challenge load reductions by year 15, and achieve the TMDL in 65 years. Many of these practices are already in use by responsible parties, and an enhanced level of effort may contribute to reduce sediment and nutrients to Lake Tahoe. In the future, technological advances may add other actions to this list. This list is not intended to be exclusive; implementing agencies may select other actions to achieve required load reductions.

- Install and maintain (annually) full unpaved roadway BMPs (e.g. waterbars, armored swales, drainage stabilization, and stormwater treatment infrastructure)
- Revegetate and stabilize ski runs
- Implement forest treatments with low pressure and other innovative ground-based equipment and standard BMPs
- Capture and retain sediment from unpaved roadways
- Install and maintain advanced BMP measures to increase infiltration and reduce runoff from landings, ski runs, trails and paved and unpaved roads in forested areas
- Decommission and re-contour unauthorized or historic roads and trails by tilling, adding organic soil amendments, mulching, and revegetation
- Fully restore legacy roads and trails to return to native forest conditions with natural hydrologic function

Performance and Compliance Measures, Assessment, and Reporting

The forest upland load reductions described by the Recommended Strategy will be accomplished through continued implementation of forest management programs, policies, restoration activities, and vegetation management approaches. The United States Forest Service Lake Tahoe Basin Management Unit (LTBMU), Nevada Division of State Parks, California Department of Parks and Recreation, and the California Tahoe Conservancy (CTC) are the primary public forested land management agencies responsible for maintaining and expanding existing land management activities as needed to reduce pollutant loads from forested lands to meet the Clarity Challenge and other load reduction goals.

The Water Board and NDEP have worked with the LTBMU to include references to applicable TMDL implementation elements in the updated Land and Resource Management Plan. The Water Board and NDEP expect the revised Forest Plan to commit to ongoing maintenance of LTBMU unpaved roadways and trails; regular inspections and maintenance of trailhead and parking lot best management practices;

continued efforts to identify and restore landscape disturbances; and responsible implementation of vegetation management actions with appropriate BMPs. Similarly, the California Department of Parks and Recreation, the CTC, and the Nevada Division of State Parks have programs and policies in place to implement projects and activities to reduce pollutant loads.

The Water Board and NDEP will track forest implementation partner activities to determine whether expected load reduction actions are being taken and are remaining consistent with the Recommended Strategy and the TMDL Implementation Plan. If forest management agencies continue to complete projects and activities consistent with the Pollutant Reduction Opportunity Analysis (Lahontan and NDEP 2008a), the Recommended Strategy (Lahontan and NDEP 2008b) and this TMDL, then the Water Board and NDEP expect forest upland load reduction requirements will be met.

If the LTBMU, CTC, and the California Department of Parks and Recreation fail to continue to implement needed load reductions, the Water Board maintains the authority to issue Waste Discharge Requirements or Time Schedule Orders, as needed, to be certain appropriate programs, policies, and activities continue as anticipated to reduce pollutant loading to Lake Tahoe. The NDEP has the authority to enter into Memoranda of Agreement with forest management partners on the Nevada side of the Lake Tahoe basin to explicitly define TMDL expectations on undeveloped lands in Nevada to meet Lake Tahoe TMDL pollutant load reductions should those agencies fail to implement expected load reduction actions.

11.3.3 Atmospheric Deposition

Roughly 15 percent of the basin-wide fine sediment particle load is transported and deposited on the lake surface through atmospheric deposition. The Recommended Strategy and this implementation plan focus on stationary sources of fine sediment particles within the atmospheric source category because these sources provide the bulk of the load reaching Lake Tahoe from the air, primarily as road dust. Dust sources, such as paved and unpaved roads, disturbed vacant parcels, and construction sites are responsible for more than 88 percent of atmospheric fine sediment particle emissions in the Lake Tahoe Basin (Lahontan and NDEP 2008a).

Mobile sources (such as automobiles, buses, and boats) predominantly produce nitrogen, not fine sediment particles or phosphorus. Stationary source controls for fine sediment particles and associated phosphorus are also three orders of magnitude less expensive per unit removed than mobile sources according to the *Pollutant Reduction Opportunity Report* (Lahontan and NDEP 2008a).

This TMDL relies on the Tahoe Regional Planning Agency’s (TRPA) air quality and transportation plans to continue managing the load of nitrogen to the atmosphere from the mobile sources; this continued management is expected to reduce the basin-wide nitrogen load by at least one percent within 15 years. A two percent reduction in nitrogen load from the atmosphere is needed to attain the transparency standard.

Because TRPA's Regional Plan does not project beyond twenty years of implementation, subsequent TRPA Regional Plan updates are anticipated to include an atmospheric nitrogen emission reduction strategy that meets the TMDL transparency standard attainment needs.

Implementation Actions to Meet the Clarity Challenge and Achieve the TMDL

Cost-effective treatments to reduce road dust include enhanced operations and maintenance of non-mobile dust sources including paved and unpaved roadways, parking lots, and construction sites as well as revegetation and/or stabilization of disturbed vacant land. TRPA programs for reducing emissions from residential wood burning are also expected to provide some particle reduction from this source.

The following is a representative list of practices and treatment options that responsible parties may use so the Forest Upland source could meet the basin-wide load reduction necessary to achieve the Clarity Challenge by year 20, and achieve the TMDL in 65 years. Many of these practices are already in use by responsible parties, and an enhanced level of effort may contribute to reduced sediment and nutrient discharges to Lake Tahoe. In the future, technological advances may add other actions to this list. This list is not intended to be exclusive; implementing agencies may select other actions to achieve required load reductions.

- Regularly vacuum sweep streets
- Pave or apply gravel to unpaved roads
- Limit speed on unpaved roads
- Require adequate soil moisture or other dust suppression techniques during earth moving operations
- Reduce residential wood burning emissions
- Reduce Vehicle Miles Traveled (VMT) through incentives/disincentives

Performance and Compliance Measures, Assessment, and Reporting

Since the majority of the atmospheric fine sediment particle load is generated by urban roadways, much of the required atmospheric load reductions and interim load allocations will be met by implementing measures to control the sources of stormwater pollutants from urban roadways under the urban upland source category. Similarly, TMDL implementation actions taken to control runoff issues from unpaved roadways (see the Forest Uplands section above) will also reduce dust from these areas. Urban and forest stormwater dischargers cannot, however, "take credit" or otherwise account for these reductions as progress at reducing pollutant loads from the urban and forest pollutant sources.

11.3.4 Stream Channel Erosion

Multi-objective stream channel restoration programs in the Lake Tahoe basin are well established. Because these programs achieve a number of environmental benefits in addition to water quality improvements, implementation efforts for this source category are based on current plans and approaches. The loading and load reduction analysis focused only on fine sediment particles (and associated nutrients) released from stream bank and bed erosion. Load reduction estimates did not consider the other potential ecological benefits available from stream or wetland restoration. The Water Board and NDEP anticipate that restoring floodplain connectivity and improving natural geomorphic function will provide additional fine sediment particle and nutrient load reductions. When research and monitoring are able to quantify these expected benefits, the load reductions will be accounted for through the adaptive management process.

Implementation Approach

TMDL stream channel erosion reduction estimates were developed based on ongoing implementation and planned restoration activities in the top three fine sediment particle producing streams in the basin, which are responsible for 96 percent of the fine sediment particle load in this source category (Lahontan and NDEP 2008a). These streams, in order of load production, are:

1. Upper Truckee River
2. Blackwood Creek
3. Ward Creek

Implementation and funding agencies have well-developed restoration plans for each of these three streams and are in various phases of planning and/or construction to implement restoration actions. Detailed, multi-agency planning for five different reaches of the Upper Truckee River was initiated in 2002. The California Tahoe Conservancy (CTC) has completed a project at the mouth of the river to remove fill placed during development of the Tahoe Keys (Lower West Side Upper Truckee River Project) and is evaluating alternatives for restoring the Upper Truckee Marsh. The CTC is also actively planning Upper Truckee restoration at the Sunset Stables property. The City of South Lake Tahoe constructed channel improvements adjacent to the Lake Tahoe Airport in 2008 and are completing the restoration effort in 2010. The California Department of Parks and Recreation is working to address stream bank erosion by restoring portions of the Upper Truckee River that flow through the Lake Tahoe Golf Course. Finally, the Tahoe Resource Conservation District is working with private property owners to construct stream channel improvements downstream of the Lake Tahoe Airport.

The Lake Tahoe Basin Management Unit (LTBMU) has taken the lead in planning and constructing restoration projects on Blackwood Creek. Three projects have been constructed on Blackwood Creek within the past five years, including removal of fish passage barriers, Barker Pass culvert removal and bridge construction; and floodplain rehabilitation. The LTBMU has additional plans for further channel and floodplain work to address channel instability from historic gravel mining and grazing disturbances. The CTC is also planning work on Blackwood Creek to treat channel incision at the Highway 89 crossing.

The CTC has prepared a comprehensive Watershed Assessment report (Hydro Science and River Run Consulting 2007) to evaluate both opportunities and constraints on restoration within the Ward Creek watershed. This report provides the framework for watershed and stream restoration activities to address, where appropriate, in-channel erosion and geomorphic instability within Ward Creek.

Many restoration projects are also planned for streams and riparian areas that are not within the subwatersheds of the three major streams listed above (e.g Rosewood Creek in Incline Village, Nevada, and Angora Creek in South Lake Tahoe, California). These restoration projects are expected to provide some load reduction benefit (though it cannot be quantified at this time) and will have significant benefits to other resources such as wildlife, vegetation, and fisheries.

Implementation Actions to Meet the Clarity Challenge and Achieve the TMDL

Implementation efforts for this source category are based on current plans and approaches. The loading and load reduction analysis focused only on fine sediment particles (and associated nutrients) released from stream bank and bed erosion.

The following is a representative list of stream channel restoration, rehabilitation, and bank protection measures that responsible parties may take.

Actions suitable for areas where restoration is unconstrained by existing development:

- Lower stream channel banks and reduce angle to accommodate more frequent over-bank flow and reduce bank erosion/slumping
- Increase channel length and sinuosity (over time will decrease channel bed slope) by constructing new channel segments
- Restore riparian vegetation
- Remove infrastructure (e.g., bridges) that fragments floodplains or restricts channel flow

The Water Board and NDEP expect needed load reductions and interim load allocations for the stream channel erosion source will be met when all the restoration projects and activities are completed for the three major tributaries. These restoration projects are anticipated to be completed within 15 years from the adoption of the TMDL.

11.4 Watershed Approach to TMDL Implementation

In highly complex or priority watersheds tributary to Lake Tahoe, it may be appropriate for resource management agencies to undertake a more focused, watershed approach to TMDL implementation. Watershed planning based on the analytical framework of the TMDL can help direct cost-effective implementation of necessary load reductions while providing other ecosystem services. The approach is described in U.S. EPA's *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* (US EPA 2008), which explains that EPA's Clean Water Act Section 319 grant funding is being directed towards implementing watershed plans consistent with TMDLs.

Watershed plans identify and prioritize load reduction opportunities and measures, and are especially helpful in situations where such strategies involve several interacting land and/or resource managers. Substantial work toward implementing the watershed approach is already occurring within the basin; examples include California Tahoe Conservancy's Ward Creek Watershed Assessment and the Upper Truckee River Watershed Advisory Group currently led by the U.S. Forest Service. The Natural Resource Conservation Service's Areawide Conservation Planning program supports private landowner and community coordination and participation in the Environmental Improvement Program and other projects at the watershed scale.

11.5 Beyond the Clarity Challenge

After 10 years of Lake Tahoe TMDL implementation, the Water Board and NDEP will conduct a thorough evaluation of load reduction progress and, if necessary, adjust the implementation plan to continue load reduction efforts. This evaluation will include an assessment of the implementation strategy and a review of available load reduction estimation and tracking tools. At that time, Water Board and NDEP staff will seek to incorporate any new and relevant data and use that information to adjust, if necessary, future load reduction milestone requirements. Both the Water Board and NDEP are committed to a detailed planning exercise to adjust implementation policy as needed to ensure ongoing progress to meet Lake Tahoe's transparency standard of 97.4 feet.

Implementing the Lake Tahoe TMDL to achieve the transparency standard is estimated to take approximately 65 years. The Recommended Strategy established five-year load reduction milestones for the initial fifteen year implementation phase but did not formulate nor assess implementation plans beyond year 15. During the first 15 year implementation period, the Water Board, NDEP, and other stakeholders will annually assess relevant research and monitoring findings and may adjust annual load reduction targets and/or the TMDL implementation approach as needed.

Following the first fifteen year implementation period, the Water Board and NDEP will evaluate the status and trend of the lake transparency relative to the load reductions achieved. This information will help guide the Water Board and NDEP in determining if the five-year load reduction milestones need adjustment to ensure load reductions progress occurs at an appropriate pace to achieve the final transparency standard by year 65.

The Water Board and NDEP may consider reopening the TMDL if additional detail is needed for the implementation plan, including five-year load reduction milestones. The Water Board and NDEP, in partnership with implementation, funding, and regulatory stakeholders, anticipate conducting this adaptive management process as needed to ensure the transparency standard will be met by year 65.

12 Adaptive Management

The United States Environmental Protection Agency (USEPA) has sponsored a project to develop the Lake Tahoe TMDL Management System (Management System). The US Bureau of Land Management approved funding for the project on November 1, 2009, under the Southern Nevada Public Land Management Act of 1998 (Public Law 105-263). This project will create the tools, templates, and standard operating procedures, then will will beta-test the Management System for one-year to make refinements.

The Water Board and the Nevada Division of Environmental Protection (NDEP) will use the Management System for managing, tracking, integrating and evaluating new information generated from TMDL implementation actions, effectiveness monitoring, research efforts, and other factors such as climate change and wildfires. The Water Board and NDEP anticipate using the Management System to help inform the decision whether load allocations and the implementation plan need to be adjusted for years 20 through year 65 to achieve the numeric target.

This chapter summarizes the development and components of the Management System, describes a number of potential environmental factors that might influence TMDL progress, and discusses how the TMDL implementation may adapt to these challenges.

12.1 Lake Tahoe TMDL Management System

The Management System will define structure, operations, and tools for a continual improvement cycle and an adaptive management process. The continual improvement focuses on tracking and evaluating program implementation and regulatory compliance while the adaptive management element outlines a process for reducing uncertainty within load estimation tools and other assumptions driving source category load allocations.

The Management System will enable the project implementers, project funders, research scientists, and other interested stakeholders to interact with the Water Board and NDEP in a structured and transparent process for 1) continual improvement of regulations and programs related to TMDL load allocations, and 2) active adaptive management. The Management System project includes four key aspects for human interaction: (1) developing relationships between agencies, implementers, and stakeholders to work together to accomplish a common goal, (2) defining the tasks and processes to enable all parties to work together, (3) defining how others will participate and provide input through a transparent and predictable set of processes, and (4) developing tools and templates to facilitate communication, and reporting.

The Management System is based on an adaptive management framework to (1) link load reduction effectiveness with project implementation monitoring to improve project design and to assess if actual environmental improvement is occurring as expected; (2) establish guidance and operational protocols for how new information will be incorporated into project designs and TMDL program implementation; (3) establish prioritized TMDL research needs to fill data gaps and reduce uncertainties; and (4) implement a process for updating and establishing pollutant load reduction credits/estimates and tracking projects within the TMDL implementation timeline. This project will create a linked series of tools, standard procedures, and feedback loops that will allow for operation of the TMDL into the future, building on projects currently under development.

The Management System diagram (Figure 12-1) depicts the primary components, framework, and procedural steps and once fully developed, will create the protocol and process to link the individual components or boxes. The "Plan" component of the diagram is the starting point with the goal (both the Clarity Challenge and the transparency standard), a conceptual model to identify linkages between variables and the goal, TMDL load allocations, and associated regulatory programs to achieve the goal. These components are the backbone of the TMDL and this Management System, and they drive the implementation actions that will be evaluated for effectiveness.

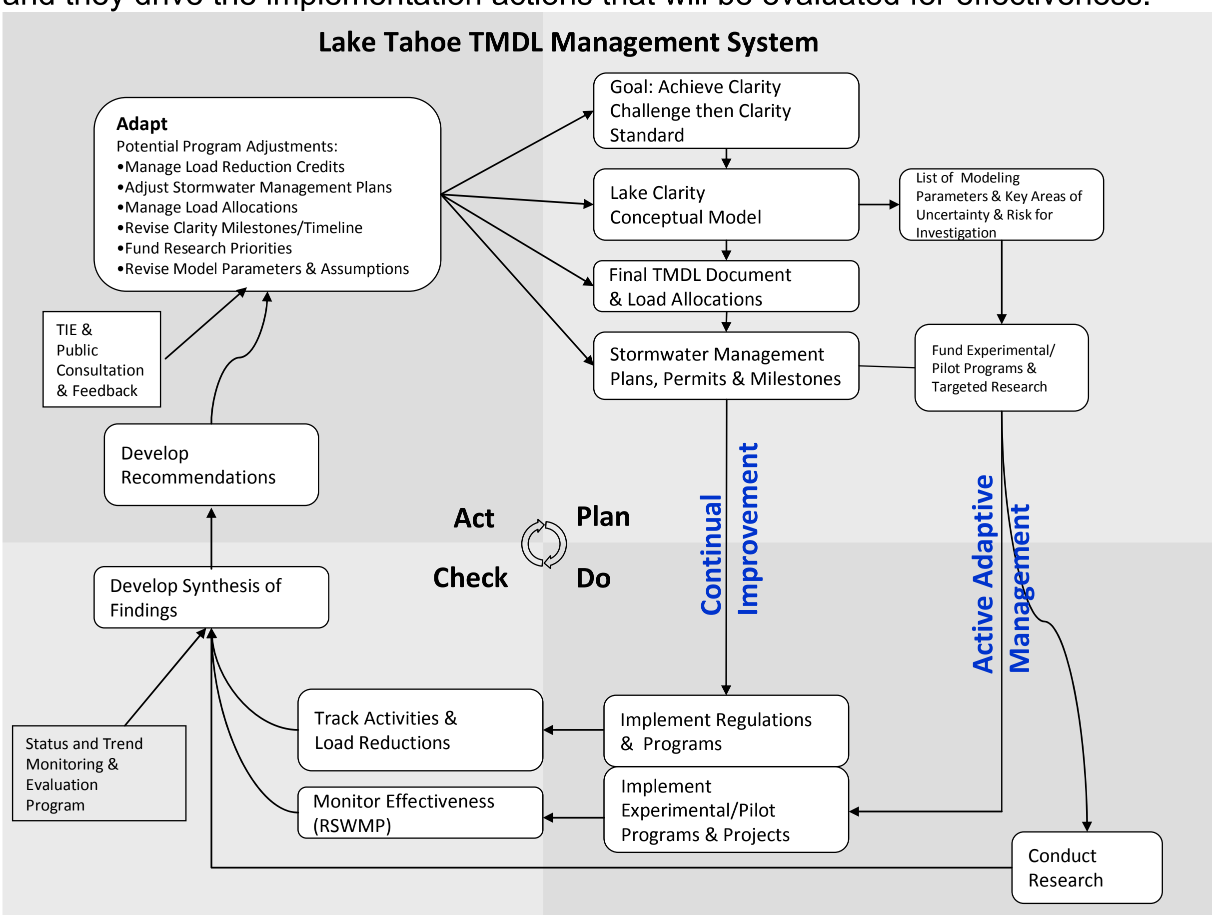

Figure 12-1. Lake Tahoe TMDL Management System diagram illustrating the continual improvement and active adaptive management cycles (adapted from Sokulsky and Beierle 2007).

The “Do” component of the diagram in Figure 12-1 comprises TMDL implementation and associated pilot projects along with research. The “Check” component is needed to verify the effectiveness of various actions at reducing fine sediment particle and nutrient loads as well as track progress at meeting established milestones. A Synthesis of Findings report will allow all entities within the basin to benefit from the findings of research and monitoring data, which will be available for public review and input, and will guide the recommendations for future investigations.

The “Act” component is where management decisions are based on the recommendations that stem from the Synthesis of Findings report. The feedback loop then continues to another annual adaptive management cycle to continue building on past efforts.

This framework provides for adaptive management cycles to occur at various time scales. For instance, the same framework provides for (1) annual review of implementation progress and research priorities, (2) five-year assessments of overall load reduction accomplishments and monitoring results, and (3) fifteen year implementation planning efforts to evaluate the need for load allocation adjustments and to establish new five-year milestones for future implementation periods.

The following sub-sections elaborate on selected components of the Management System.

Conceptual Model

The conceptual model is the visual linkage for how fine sediment particle and nutrient control actions for the different source categories will reduce pollutant loading to Lake Tahoe and will affect (or improve) transparency (see Appendix A for Lake Clarity Conceptual Model). The conceptual model clearly describes the current understanding of cause and effect linkages. The conceptual model documents and links: 1) the relationships between the goal and the associated indicator and target, as well as other points in the system that can be measured to understand the system; 2) the relationship between management actions and the goal; 3) areas of uncertainty within the understanding of the system, and 4) the different pollutant sources to the lake clarity response with various transport mechanisms. The conceptual model also identifies the most important drivers and actions related to lake transparency.

Research Needs

The adaptive management system will have a process to incorporate and manage TMDL research needs and will guide future funding priorities for specific areas of investigation. The process will allow the load reduction estimation models to be updated as needed with the latest research results regarding model input parameters, incorporate new load reduction opportunities from innovative practices, and adjust policies if necessary. The incorporation of key research findings will help reduce areas of uncertainties and adjust policies when appropriate. Future research will focus on key areas of uncertainty related to TMDL development, modeling parameters, assumptions, and potential implications from climate change or other factors.

Experimental Pilot Projects

The Water Board and NDEP will facilitate targeted research and support funding recommendations for experimental and pilot projects that evaluate and quantify benefits from innovative practices. Implementers and water quality managers will work collaboratively to implement the Recommended Strategy, which calls for advanced, alternative and innovative practices to meet the required load reductions. These actions are often expensive and planning must be informed by up to date and scientifically sound information. Important findings from research and data collection will be incorporated in the Synthesis of Findings report.

Track activities and Load Reductions

The Water Board and NDEP have developed the Lake Clarity Crediting Program to support the Lake Tahoe TMDL. The Lake Clarity Crediting Program specifies the process and protocols enabling the urban jurisdictions to link projects, programs, and operations and maintenance activities to estimated pollutant load reductions. By defining a consistent water quality credit, the Lake Clarity Crediting Program provides flexibility for the urban jurisdictions to plan and implement actions to achieve required load reductions using a blend of operations and maintenance practices, capital improvement projects, and restoration efforts. The Water Board and NDEP will use the Lake Clarity Crediting Program to track compliance with stormwater regulatory measures.

An Accounting and Tracking Tool has been created to track Lake Clarity Credits and associated estimates of fine sediment particle, phosphorus and nitrogen load reductions. The Tool is a database that will allow with Water Board and NDEP to easily collect, store, and manage load reduction and credit value data. In the future, the Water Board and NDEP plan to expand the database to an online system that can integrate other stormwater tracking information.

In addition to tracking load reductions and Lake Clarity Credits associated with urban actions, the Accounting and Tracking Tool includes data fields for fine sediment particle, phosphorus, and nitrogen load reductions from forest upland, stream channel erosion, and atmospheric deposition sources. However, methods to quantify the load reductions from these three sources (forest upland, stream channel erosion, and atmospheric deposition) have not been developed. Once developed, the data can be input to allow for tracking and reporting on load reduction progress.

The Management System will provide the framework to track pollutant load reductions from all source categories and report them to the public via a web portal and an annual reporting document. The Management System will also establish the venue for creating standardized protocols for estimating load reductions from the atmospheric deposition, forest upland and stream channel source categories.

Monitor Effectiveness

The TMDL Monitoring Program is a critical part of evaluating project and BMP effectiveness, project load reductions, and overall status and trends within certain sub-watersheds and the basin as a whole.

The Regional Stormwater Monitoring Program, currently under development, will be focused on characterization and effectiveness monitoring of urban stormwater runoff throughout the Tahoe basin. This monitoring program will focus on three scales; individual BMP effectiveness, project scale, and catchment/index station scale monitoring. The monitoring information will be used to calibrate and validate load reduction estimation tools within the adaptive management process.

The Lake Tahoe Interagency Monitoring Program (LTIMP) is composed of two components: the stream network monitoring and lake monitoring (in and on Lake Tahoe). The LTIMP stream monitoring will be used to evaluate watershed scale status and trends and to evaluate load reductions from actions taken in the forest uplands and stream channels. The LTIMP lake monitoring will be used to track annual average Secchi disk depth and evaluate lake response to TMDL implementation. The lake monitoring will evaluate long term status and trends for Secchi depth amongst many other parameters, including atmospheric deposition sampling. New information generated from these monitoring programs will help to assess progress in meeting load reduction goals for the forest upland, stream channel, and atmospheric source categories.

Synthesis of Findings Report

Water Board and NDEP staff will work collaboratively with researchers to generate an annual Synthesis of Findings report that summarizes the load reduction accomplishments from the previous year and provides an integrated understanding of load reductions achieved, opportunities for innovation and efficiency, changes in Lake Tahoe's transparency, and new research findings. The synthesis will assemble and analyze new data and information to inform policy recommendations. The report will provide a mechanism to communicate with the public on progress towards meeting load allocation targets, promote ongoing load reduction activities, and document implementation achievements to support additional funding.

In addition to the annual Synthesis of Findings report, Water Board and NDEP staff will prepare a five-year milestone evaluation report to assess whether required load reduction actions from the major pollutant source categories are being accomplished. This evaluation report will provide important information to help guide future prioritization of the most effective projects. This report will include status and trends information, and will be useful in informing potential program adjustments.

Develop Recommendations

The recommendations for management decisions will be based on the Synthesis of Findings Report which incorporates information from both the continual improvement and the adaptive management processes. The report will recommend management and executive decisions to adjust TMDL related programs, policies, or timelines as necessary. This step will involve implementer, stakeholder, and public consultation.

Adapt

As TMDL implementation progresses and new information and recommendations arise, the Water Board and NDEP will adaptively manage the TMDL program to make needed program and policy adjustments. Potential adaptations may include: revising load reduction milestone requirements, adjusting implementation strategies, and selecting areas for additional adaptive management investigations.

The advantage of an effective management system is the ability to incorporate the unforeseen into future policy adaptations. An unforeseen circumstance may be a refinement, such as a more precise calculation of the number of fine sediment particles removed by a particular type of control measure, or something more complex and global, such as climate change.

Lake Tahoe is vulnerable to a number of large scale events that may impact the effectiveness of the Lake Tahoe TMDL Implementation Plan.

The Management System will be designed to allow regulators and implementers the ability to adapt not only to advances in pollutant reduction accounting, but to large scale changes in the Lake Tahoe watershed condition. Climate change and catastrophic events are two large scale issues that the Water Board and NDEP will address through the Management System.

12.2 Climate Change

Climate change has the potential to affect pollutant generation and transport processes. This section examines possible climate change trends reported in peer reviewed articles and presents a climate change scenario developed for the Lake Tahoe Watershed Model. This TMDL does not assign pollutant load or waste load allocations to address potential effects of climate change. Since the impacts of climate change on pollutant loading are uncertain and cannot be conclusively determined at this time, the climate change effects will be addressed through the continual improvement and active adaptive management processes of the Management System. Potential measures for adapting to significant climate change effects may include adjustments in the Lake Clarity Crediting Program or adjustments to the implementation strategy to emphasize or de-emphasize different approaches to water quality improvement projects. The information in this section is included to describe the type of watershed changes that may necessitate program adjustments.

Climate Change Impacts on Precipitation, Temperature, and Pollutant Loading

Mountain settings such as Lake Tahoe are especially susceptible to climate change because of the large percentage of precipitation that falls as snow. Temperature recordings in Tahoe City over the last century have shown a rise in the average temperature, so much so that the average nighttime temperature has risen to the melting point. This corresponds with a decrease in the number of days with an average temperature below freezing.

An increase in winter temperature will lower the percentage of precipitation that falls as snow, shrinking the snowpack and changing the temporal patterns of runoff. A shift in peak snowmelt increases the length of summer drought with consequences for ecosystem and wildfire management (Stewart et al. 2004). At Lake Tahoe, this can already be seen in the timing of peak snowmelt in the Upper Truckee River watershed. In the past 50 years the average date of peak snowmelt has shifted earlier by almost three weeks. Furthermore, Howat and Tulaczyk (2005) predict that the Tahoe region will experience an increase in snowpack above 7500 feet, while below this elevation the dominant phase of precipitation will be rain. This differs from the historical condition where the dominant precipitation phase within all elevations of the Tahoe basin is snow.

While the ecosystem impacts from changes in snowmelt timing are themselves cause for concern, it is the greater erosion impact of rainfall that will likely lead to increased pollutant pressures on the lake clarity and transparency standards. A shortening of winter and an earlier spring snowmelt will lead to a drier, more erodible soil structure. As the precipitation regime shifts towards a higher rain to snow ratio, combined with an expected increase in rainfall intensity, the basin will experience greater rates of erosion (Bates et al. 2008, UC Davis - TERC 2008). Future raindrop erosion will not be limited to the summer and fall seasons. As the snowline climbs, raindrop erosion may occur even in winter storm events. Down-slope transport of eroded material would increase the pollutant loading to Lake Tahoe. Potential management adjustments to address this change could include increased flow capacity requirements to treat runoff or increased maintenance of existing treatment measures.

Climate Change Impacts on Lake Processes

The impacts of climate change on achieving Lake Tahoe's water quality objectives are not limited to effects on pollutant loading from the surrounding watershed. Evidence of climate change is already present in the actual lake waters (Melack et al. 1997, Coats et al. 2006, UC Davis - TERC 2008). Future impacts have the potential to alter lake dynamics with consequences for lake transparency and clarity (Sahoo and Schladow 2008).

Seasonal variation is an inherent driver of Tahoe's current lake processes. The mean annual temperature of Lake Tahoe is rising at the rate of 0.015 degrees Celsius (0.027 ºF) per year (Coats et al. 2006) (Figure 12-2). As temperatures continue to increase, the lake will likely experience increased thermal stability (Bates et al. 2008, Sahoo and Schladow 2008).

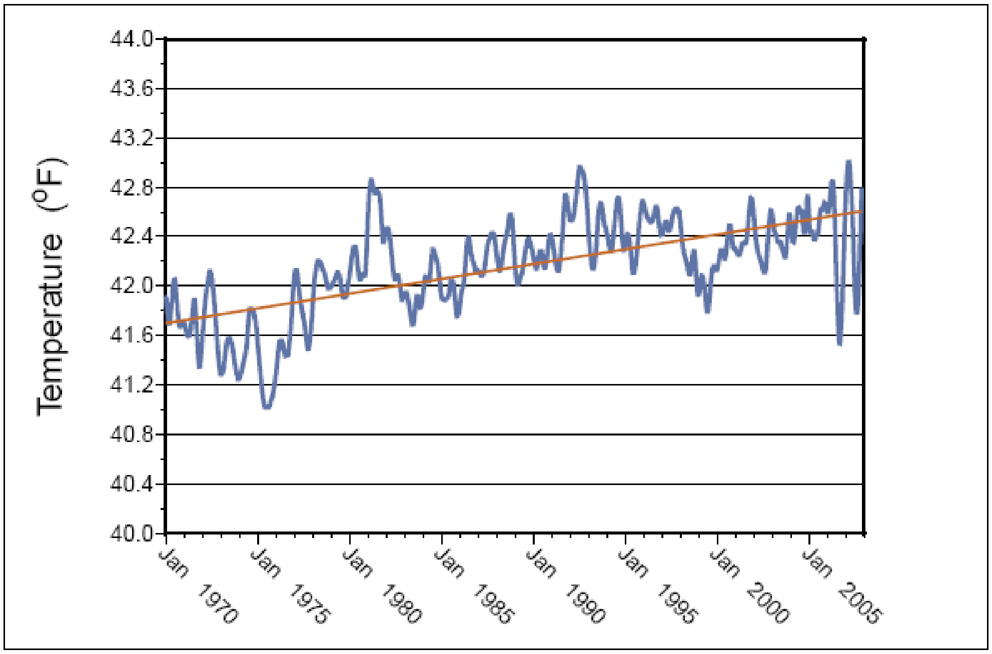

Figure 12-2. Volume-averaged water temperature for Lake Tahoe (UC Davis - TERC 2008).

Lake Tahoe historically undergoes deep mixing of the water column on average once every four years (Coats et al. 2006, Schladow et al. 2008). The depth of the mixing is dependent on thermal stability in the water column as well as the power of winter storm events with sufficient wind to promote mixing. Deep mixing is responsible for oxygenating the entire water column, and results in deep nutrient rich waters being brought to the surface. As the lake temperature rises with climate change, the lake will experience an increase in stability as waters become resistant to the mixing influence of wind and warmer surface waters resist sinking (Coats and Redmond 2008). Since 1982, Lake Tahoe has exhibited evidence to resistance to lake mixing and increased stability of stratification (Winder et al. 2008).

Increased thermal stability and lake stratification will likely reduce the maximum depth of lake mixing. Sahoo and Schladow (2008) modeled lake dynamics under a “business as usual” approach to world carbon emissions where there is no market or regulatory based efforts to reduce carbon emissions. They applied the National Oceanic and Atmospheric Administration's prediction of climate change under a “business as usual” scenario, labeled A2 by the Intergovernmental Panel on Climate Change, to the Lake Clarity Model. Sahoo and Schladow's modeling efforts, which include A2's air temperature changes and a 10 percent progressive increase in longwave radiation, predict that Lake Tahoe would cease mixing to the bottom within a period of approximately 20 years. The predicted maximum depth of mixing was on the order of 250 meters, or about half of Lake Tahoe's maximum depth.

The impacts on lake transparency may be twofold. One side effect of increased stratification is an increased residence time of fine particles in the top most stratified layer of the lake (Coats 2008, Sahoo and Schladow 2008). The other impact of increased thermal stratification is a direct consequence of reduced mixing. Such altered dynamics could result in reduced deep water oxygen concentrations. In an oxygen poor environment, soluble reactive phosphorous may be released from deep lake sediments (Schladow et al. 2008, Bates et al. 2008). When the lake experiences a deep mixing event, perhaps every twenty years, the nutrient rich upwelling may cause a significant algal bloom that could further impair Tahoe's aesthetic beneficial use.

It is acknowledged that the actual ramifications of climate change to Lake Tahoe transparency are not fully known at this time. However, the purpose of this section, as stated above was to describe the type of lake changes that might create program adjustment needs in the future. The data and analyses and climate change modeling fully support the contention that impacts could be significant. The TMDL Management System will enable the Lake Tahoe community to be 'out front' and consider and plan for any impacts associated with future climate change.

Lake Tahoe Watershed Model Climate Change Analysis

Tetra Tech, Inc. conducted an exploratory scenario examining potential impacts associated with climate change (Tetra Tech 2007). The scenario did not use a customized global climate model, but applied best modeled literature values of changes in precipitation and temperature to the watershed model as projected out to 2050. Running the watershed model with these climatic changes gives an estimate of potential pollutant loading changes to Lake Tahoe.

Based on the predictions of Dettinger (2005) and Cayan et al. (2006), 11 climate change scenarios and a baseline scenario were applied to the Lake Tahoe Watershed Model and projected to 2050. Of 11 scenarios, the Central Projection was developed from the Dettinger and Cayan estimates. Ten other scenarios were developed by applying variations of one standard deviation from the Central Projection's -10 percent precipitation change and +2ºC temperature changes. Scenario temperature ranges were from +0ºC to +4ºC above baseline in one degree increments. Precipitation values differing in magnitude from baseline are -25 percent, -10 percent, +0 percent, +15 percent. The baseline temperature and precipitation values used to generate the fine sediment particle and nutrient load estimates were also used for the climate change impact analysis. Results of the Central Projection, which includes an overall 10 percent decrease in precipitation, indicate a 61 percent decrease in basin-wide snowpack. These results agree with the snowline elevation changes predicted by other independent research (Howat and Tulaczyk 2005).

Though the modeled scenarios provide insight into the potential magnitude of precipitation events associated with the mid-century climate impacts, the scenarios do not account for adjustments in event frequency. Greater event frequency may saturate soils more frequently, decrease evapo-transpiration from increased cloud cover, and increase rain on snow events. Conversely, decreased precipitation frequency coupled with an increase in temperature would result in drought conditions, increased evapo-transpiration rates, and lowered stream flows.

Climate Change Impacts on Wildfire

Climate change may have significant implications for future catastrophic wildfire risks. The shift in snowmelt timing and the rise in temperature will result in earlier, longer, and hotter summers. A rise in temperature is expected to increase evapo-transpiration, lowering the water table and drying out soils. Dry conditions could weaken vegetation, leaving trees susceptible to expiration by water deficit or disease. Increased vegetation mortality would lead to increased fuel loading and, coupled with the fuel drying potential of higher temperatures, increased fire susceptibility.

The heightened fire condition would likely result in an increase in both fire frequency and fire intensity. Fires may become more frequent because it would be easier for the fuels to catch fire. Intensity could increase with the change in availability and condition of the fuel supply. While both of these probabilities provide concern for human health and property, fires also threaten the lake with the potential for greater rates of pollutant loading from bare soils eroding and smoke depositing fine sediment particles and nutrients into the lake.

12.3 Catastrophic Events

The Lake Tahoe watershed is vulnerable to a number of potential catastrophic events that may impact the ability to achieve Lake Tahoe's deep water transparency objective. The foremost of these possibilities is wildfire. In addition to the potential impacts of wildfire, Lake Tahoe is vulnerable to tributary flooding, seismic activity, and associated watershed impacts.

Wildfire

Wildfire has the potential to affect loading of the target pollutants to Lake Tahoe. The 2002 Gondola and 2007 Angora fires highlighted the need to address wildfire when discussing basin-wide resource management. While wildfire has the potential to impact Lake Tahoe's water quality, wildfires are also sporadic and unpredictable in frequency, area burned, and intensity.

Wildfire has the potential to contribute to Tahoe's pollutant loading both directly, through smoke deposition, and indirectly through increased particle erosion and down-slope nutrient leaching. Erosion is associated almost exclusively with precipitation and melt events, either through raindrop erosion or overland flow contributing to rill erosion (Robichaud 2000). Erosion potential after a burn is variable and depends on the site characteristics, the burn intensity, speed of vegetation recovery, and, most importantly, precipitation (Robichaud 2000). Remedial efforts, such as hydromulching, tilling, chipping, mastication, and water bar installation, can affect the erosion rates and soil loss of burned areas. Additionally, post-fire soil hydrophobicity can promote overland flow and associated increases in erosion (Robichaud 1996, referenced in Robichaud 2000). Finally, fires can cause nutrient volatilization and nutrient leaching from soils and other burned organic matter. Leached nutrients are available for down slope transport to the lake. Leaching levels can vary with soil type, vegetation, and fire intensity (Murphy et al. 2006).

Case Study: The Gondola Fire and Eagle Rock Creek

In July 2002, a fire burned in the southeastern part of the Tahoe basin, entirely within an undeveloped area. This fire, called the Gondola Fire, burned 673 acres including the Eagle Rock Creek watershed (Allander 2004).

The Lake Tahoe TMDL modeling analysis included pollutant loading from the 2002 Gondola Fire. The Lake Tahoe Watershed Model used tributary monitoring data from 1994-2004, and the Lake Clarity Model was calibrated and validated with Lake Tahoe monitoring data from 2002-2004. Because Eagle Rock Creek flows through the Gondola Fire burn area and into Edgewood Creek, any localized increase in pollutant load water transported by Eagle Rock Creek from the fire was recorded as part of the water quality samples collected from Edgewood Creek. Total nitrogen and suspended sediment concentration data from Edgewood Creek did not show any changes that may be attributed to the Gondola Fire, but total phosphorus concentration approximately doubled immediately after the fire and appeared to return to typical levels after about two years.

Allander (2004) showed post-fire increases in nutrients and sediment into Eagle Rock Creek, but sediment particle size was not analyzed. Several severe thunderstorms occurred a few days after the fire and before some erosion control measures could be implemented. A follow up study by Allander (2006) concluded that nitrogen and phosphorus concentrations in Eagle Rock Creek water quality samples post-fire were about double the pre-fire concentrations but returned to pre-fire levels by about 2006. Eagle Rock Creek monitoring data is consistent with studies examined in Robichaud (2000) which show a post-fire peak in nutrient and sediment loading, followed by attenuation, and conifer watersheds that burn at moderate to high severity can take seven to 14 years for sediment yields to return to normal.

Angora Fire

The Water Board, NDEP, CTC, and USFS LTBMU supported a monitoring project to assess the water quality impact of the 2007 Angora Fire. During the fire, atmospheric deposition of nutrients was two to seven percent higher than normal summer loading rates, but only accounted for approximately one percent of the annual load from all sources (Reuter et al. 2008). The following two years (Water Year 2008 and 2009) were both characterized by below normal precipitation, with low flow, no strong summer thunderstorms, and few significant runoff events. Average annual concentration of nitrate during these two post-fire years increased approximately 8.5 times higher; this is commonly reported in the literature. Total Kjeldahl nitrogen and total nitrogen concentrations were 1.6 - 2.0 times higher after the fire, total phosphorus increased 1.9 times, total suspended solids increased 2.0 times, and turbidity was 3.9 times higher (Reuter et al. 2010). Only nitrate declined between Water Year 2008 and Water Year 2009. The large increase in nitrate upstream was not observed downstream near the Upper Truckee River confluence. Levels of nitrogen were moderate during the large, May 2009 rain event. Phosphorus, total suspended solids and turbidity showed elevated spikes but similar to other peaks for these constituents. An analysis of long-term LTIMP monitoring data for annual flow and load in the Upper Truckee River (15 years), only total phosphorus was higher than expected in 2008 (Oliver et al. 2010). With just two years of data available, it is difficult to attribute this solely to the Angora Fire.

In summary there was no evidence of massive sediment or nutrient inputs from the burned urban area into Angora Creek (Heyvaert et al. 2010). However, there was evidence to suggest that urban runoff (from within the burn area) was contributing to slightly elevated concentrations in the lower Angora Creek site. It appears that the Angora restoration and Washoe Meadows areas provided a level of stormwater treatment to the runoff from the surrounding catchment. Post-fire sediment and nutrient concentrations in the Angora urban runoff and in Angora Creek itself after the fire were generally much better than observed at other urban sites around the Tahoe basin.

Ongoing monitoring of Angora Creek and the Upper Truckee River is needed to evaluate the longer-term (3-10 year) impacts of the 2007 Angora Fire. The monitoring results from these two dry years (WY 2008 and WY 2009) should not be taken as representative of conditions that will be seen after any major wildfire in the Tahoe basin. For example, this is different from initial observations following the Gondola Fire when higher loads were measured - likely due to post-fire storm conditions. Additionally, the location of the Washoe Meadows, between the burn area and the confluence to the Upper Truckee acts to reduce downstream pollutant load. Loading to the lake is likely to be considerably different if such a natural buffer was not present.

Flooding

A significant rain-on-snow event occurred in January 1997 and many areas of the Tahoe basin were flooded. Since the Lake Tahoe Watershed and Lake Clarity Models included input data from 1994-2004, the “New Years 1997” flood event was recorded in the loading analysis.

With the advent of climate change it is possible that future flood events may increase in magnitude, which may impact the ability to achieve load reduction targets. Even if the magnitude of storms does not increase, a substantial elevation increase of the snowline and an increase in rainstorm intensity will likely increase the flood frequency. The Water Board and NDEP will assess the impact of flood events through annual monitoring and the Management System.

Earthquakes and Subsequent Wave Erosion

Located on the border of the Sierra Nevada and the Carson mountain ranges, Lake Tahoe is an active seismologic area (Gardner et al. 2000). The lake is home to two major fault zones. The West Shore-Dollar Point fault zone runs north-south on the western side of the lake, and the North Tahoe- Incline fault strikes northeast, traveling along Tahoe's greatest depths to Incline Village (Ichinose et al. 2000). A third fault, the Genoa fault zone, lies just east of the Tahoe basin.

The Lake Tahoe region periodically experiences small earthquakes. While these tremors are a reminder of the seismic nature of the region's setting, quakes of the size that could impact the goals of this TMDL are rare. The geologic record shows that large earthquakes (Richter Magnitude 7+) in Tahoe have historically occurred every 3000 years (NSF Press Release 2005). Given the rarity of these events, it is highly unlikely that an event of that significance would occur during the project timeframe. However, should such an event occur the Water Board and NDEP will assess the resulting impacts in relation to load reduction milestones and make adjustments as appropriate.

13 Monitoring Program

Integrated and coordinated monitoring is needed by agency managers and decision-makers to determine how the Lake Tahoe TMDL implementation effort is resulting in improved water quality. In collaboration with watershed stakeholders, the Water Board and NDEP have prepared a monitoring program framework to meet this need. The team expects to further develop monitoring program components within the first few years following TMDL adoption by USEPA, and full monitoring program operation is expected to follow. Once fully developed, the monitoring program will assess progress of TMDL implementation and provide a basis for reviewing, evaluating, and revising TMDL elements and associated implementation actions. The monitoring program will cover the pollutant sources and will monitor the in-lake responses to the reduced pollutant loading. The source monitoring will focus on the largest pollutant source, urban uplands, but will also address the other pollutant sources: atmospheric deposition, stream channel erosion, and forested uplands.

13.1 Monitoring needs and conceptual model

The monitoring program will be developed to answer the Lake Tahoe TMDL Core Questions for TMDL implementation and operation:

1. *Are the expected reductions of each pollutant to Lake Tahoe being achieved?*

   Estimating and tracking fine sediment particle and nutrient load reductions from the four major pollutant sources (urban uplands, forest uplands, stream channel erosion, and atmospheric deposition) will help answer this question.

2. *Is the transparency of Lake Tahoe improving in response to actions to reduce pollutants?*

   The Lake Tahoe TMDL monitoring program includes ongoing Secchi depth and other in-lake water quality measurements to assess the lake's response to watershed management actions.

3. *Can innovation and new information improve the strategy to reduce pollutants?*

   The proposed program will evaluate implementation measure effectiveness with an emphasis on assessing the ability of new and innovative technologies/approaches for reducing fine sediment particle loads and nutrients.

Although several parts of the Lake Tahoe TMDL monitoring program have been developed, the entire program has not been fully implemented. Some elements, such as in-lake monitoring, have been operating for many years, while other parts are currently being developed.

In late 2007, TRPA and agency partners with consultant involvement formed a working group to develop a Lake Tahoe Status and Trend Monitoring and Evaluation Program (M & E Program) for select resource area desired conditions in the Lake Tahoe basin. The group includes representatives from the Tahoe Regional Planning Agency (TRPA), NDEP, Water Board, USFS Lake Tahoe Basin Management Unit (LTBMU), and the Tahoe Science Consortium. The working group agreed to a charter that includes a consensus vision for the program:

> *Lake Tahoe agencies will work collaboratively with the scientific community and other partners to develop and operate a cost-effective, integrated status and trend monitoring and evaluation program for the Lake Tahoe basin. The M & E Program will reliably and systematically monitor, evaluate and report on the status and trends of the basin's environmental and socioeconomic conditions in a timely manner. Information provided through this effort will be used to improve agency decision-making and general understanding of Tahoe basin conditions.*

The M & E Program includes a series of conceptual models developed to link program actions to environmental indicators and expect to complete detailed indicator frameworks and associated monitoring and evaluation action plans by late 2009 for each conceptual model. A Lake Tahoe Clarity Conceptual Model has been developed through the M & E Program for the Lake Tahoe Clarity Desired Condition (Appendix A). The conceptual model and associated indicator framework will be used to guide monitoring of the most important drivers that affect the status of the system. For the transparency objective, Secchi depth measurements will be used to evaluate progress since Secchi depth integrates the impact of the three key pollutants of concern (fine sediment particles, phosphorus, and nitrogen), however other parameters such as dissolved oxygen saturation and primary productivity will also be monitored and tracked.

13.2 Definition of Generalized Monitoring Categories

The Lake Tahoe Watershed Assessment provides a definition of monitoring that encompasses three different forms (Murphy and Knopp 2000 [Ch. 7]). All three forms of monitoring can provide information of relevance to the management and operation of the Lake Tahoe TMDL implementation.

- *Implementation monitoring:* Considered to be the monitoring of management actions in relation to intended project plans. The purpose of implementation monitoring is to document that projects comply with regulatory conditions and meet mitigation obligations as specified in the construction plans and permit (e.g. was the project built as designed).

- *Effectiveness monitoring:* The monitoring of the effectiveness of management practices and actions in achieving desired conditions or trends. Within this TMDL, effectiveness monitoring can occur on a variety of scales, (e.g. a single BMP, multiple BMPs that form a water quality improvement project,

- *Status and trends monitoring*: Broadly defined as the monitoring of the status and trends of water quality conditions and controlling factors. This is the principal type of monitoring used to gather the data that can inform us about long-term changes in water quality conditions relative to established water quality standards and/or goals. Status and trends monitoring is directly linked to effectiveness monitoring in that it evaluates water quality improvement over time at each of the spatial scales listed above (e.g. single and multiple BMPs, watershed, whole-basin).

Typically, TMDL monitoring focuses on the specific parameters related to water quality impairment. In the case of the Lake Tahoe TMDL these include Secchi depth in the lake and the amount of nitrogen, phosphorus and fine sediment particles entering the lake from the various major sources.

13.3 Source Load Reduction Monitoring

The following sections describe the various efforts underway to develop the monitoring components for each of the four pollutant source categories.

13.3.1 Urban Uplands

In 2007 the Tahoe Science Consortium began planning a Lake Tahoe Regional Stormwater Monitoring Program (RSWMP) to better understand local urban runoff conditions, evaluate the impact of erosion control and stormwater treatment efforts, and coordinate and consolidate an urban stormwater monitoring work. Agency and Tahoe Science Consortium representatives formed the RSWMP Core Working Group to develop a conceptual framework and craft a phased program implementation approach. The Core Working Group consists of eighteen individuals representing various interests, including regulatory agencies, funding groups, science community, and local and state implementing agencies at Lake Tahoe.

The RSWMP has been organized in three phases. The first phase, completed in 2008, focused on collaboratively framing the elements of a comprehensive stormwater monitoring program. The framework includes relevant agency, implementer and science considerations, an outline of the required elements for a monitoring program, the design for structural (administrative) elements, and goals and objectives for a sustainable program. This phase produced a technical document that provides guidance for the development of the detailed RSWMP technical and organizational plan (Heyvaert et al. 2008).

The second phase of RSWMP builds on the conceptual framework by designing a specific monitoring program for the Tahoe basin to meet regulatory, implementing, and funding agency needs. Phase Two components include: a quality assurance project plan; specific monitoring goals and data quality objectives; monitoring design specifications; detailed sampling and analysis plan; stormwater database development, data management and analysis details; organizational structure of RSWMP; operational costs; funding arrangements; agency roles and responsibilities; and internal and external peer-review processes. The USFS LTBMU agreed to fund the second phase. The work began in 2009 and will be completed in 2010.

During the second phase, a list of priority analytic constituents and physical variables will be created to guide monitoring plan development. The past TMDL Stormwater Monitoring Study (Heyvaert et. al 2007) collected data on the following constituents: total nitrogen, total Kjeldahl nitrogen, nitrate, un-ionized ammonia, total phosphorus, total dissolved phosphorus, soluble reactive phosphorus, total suspended solids (or suspended solids concentration), particle size distribution, turbidity, pH and electrical conductivity. This preliminary list will be evaluated in forming the monitoring plan, and in some cases, data on additional constituents may be needed. In some cases, surrogate variables may substitute for more costly analysis (i.e. using turbidity in place for particle size distribution) depending on additional research to verify preliminary relationships.

A generalized list of consolidated monitoring goals were developed to meet the needs of all interested parties in the Tahoe basin as expressed by the agency, implementer and science representatives in the RSWMP Core Working Group.

- *Pollutant Reduction:* Quantify progress in pollutant reduction and restoration efforts. Includes status and trends monitoring and the watershed/basin scales of effectiveness monitoring.

- *BMP Design, Operation and Maintenance:* Develop information for improvements in BMP design, operation, and maintenance. Includes implementation monitoring and the BMP/project scales of effectiveness monitoring.

- *Pollutant Source Identification:* Identify and quantify specific sources of urban stormwater pollutants needed to update and refine the event mean concentrations (or characteristic runoff concentrations) for stormwater quality used in a number of the management tools.

The last RSWMP phase will be the funding and implementation of the actual stormwater monitoring program. This phase includes selecting monitoring sites and equipment, providing staff to conduct the monitoring, and developing the detailed processes and protocols for reporting monitoring results. Since the RSWMP will largely provide information for the local municipal jurisdictions and state transportation agencies to meet regulatory or other monitoring needs, it is anticipated that local funding will be needed. The Water Board and NDEP will specify RSWMP participation or implementation of an equivalent monitoring program within NPDES municipal stormwater permits and Memoranda of Agreement.

13.3.2 Groundwater

As part of the Lake Tahoe Interagency Monitoring Program (LTIMP), the United States Geological Survey (USGS) (Carson City, NV) conducted groundwater water quality monitoring. Funding for this monitoring is no longer available; however, the USGS performs groundwater monitoring over limited periods of time in conjunction with specific projects in the Tahoe basin. For example, the Bijou Groundwater Project (2005-2007) characterized processes that influence nutrient transport from detention basins to shallow aquifers, estimated mass of nutrients transported by shallow ground water, and identified locations where nutrient-enriched ground water seeps into Lake Tahoe (http://nevada.usgs.gov/water/projects/bijougw.htm). Additionally, water suppliers, such as the South Tahoe Public Utility District and other Tahoe water supply agencies, monitor groundwater wells (under federal and/or state requirements) and submit detailed reports to the Water Board and NDEP.

There are no immediate plans to develop a monitoring program for evaluating groundwater load reductions related to the TMDL implementation. The fine sediment particles of primary concern for Lake Tahoe transparency are not transported to the lake through groundwater flow, and infiltration of pollutants into the shallow aquifer from BMPs may be included in project monitoring. Given the limited effect of this source on lake transparency there is no reason at this time to perform or require additional groundwater monitoring for the TMDL.

13.3.3 Atmospheric Deposition

UC Davis scientists regularly measure atmospheric deposition of nitrogen (nitrate, ammonium and total Kjeldahl nitrogen) and phosphorus (soluble reactive phosphorus, total dissolved phosphorus and total phosphorus). However, fine sediment particle deposition (< 16 μm) monitoring is not part of this monitoring program. Since atmospheric deposition is a significant source of pollutant loading to Lake Tahoe and atmospheric load reductions are a component of the implementation plan, the need for a structured monitoring program exists.

The present atmospheric monitoring program includes sample collection at three primary stations: the lower Ward Lake Level station (on-land) and two stations located on the lake – the deep water (mid-lake) Buoy station located on the northern middle portion of the lake and the Northwest Lake station located between the deep water Buoy station and Tahoe City (see UC Davis - TERC 2008 for sampling location map). Monitoring at these stations can provide lakewide estimates of total particle loading from atmospheric deposition. Additionally, the California Air Resources Board conducts monitoring of PM_{10} in South Lake Tahoe. Analysis of particles < 16 μm should be added to the TMDL monitoring program along with new techniques/methods (standard operating protocols) for collection and analysis.

The monitoring for atmospheric deposition is expected to continue and several research studies, focused on fine sediment particles, are anticipated to be completed by 2011. The results from these studies should help fill important knowledge and data gaps in fine sediment particle deposition on Lake Tahoe, including better estimates of loading from atmospheric deposition.

To assess project effectiveness for reduction of fine sediment particles by individual atmospheric source, targeted air quality control monitoring should be conducted in association with selected project implementation. For example, Gertler et al. (2006) employed a sophisticated series of measurement methods (an instrumented vehicle to measure road dust resuspension and flux towers equipped with ambient monitors for $PM_{2.5}$ and PM_{10}) to assess the effectiveness of street sweeping for controlling road dust re-entrainment along a section of Nevada Highway 28 in the Tahoe basin. Such studies will help determine whether resource management actions are effectively reducing pollutant loads transported and deposited through the air. The existing and ongoing UC Davis atmospheric deposition monitoring is needed to assess basin-wide loading along with future directed monitoring focusing on actions to determine load reductions within the atmospheric source category.

The TRPA Regional Plan (1986) contains regulations in Chapter 91 of the TRPA Code of Ordinances for the purpose of attaining and maintaining applicable state and federal air quality standards and TRPA environmental thresholds. Specifically, Chapter 91 contains emission standards related to new stationary sources for particulate matter less than 10 micrometers in diameter (PM_{10}), nitrous oxides, and other constituents. Nitrous oxides and PM_{10} are the two emission substances that are related to the pollutants identified in this TMDL. This information will be collected from TRPA on an annual basis.

13.3.4 Forest Uplands

The forest uplands comprise over 80 percent of the total upland land area in the Tahoe basin. Land management agencies such as the USFS LTBMU, California Tahoe Conservancy (CTC), Nevada Division of State Lands, California State Parks, and many local municipal jurisdictions are responsible for managing the forested uplands. Entities that manage the majority of the forested uplands have multi-objective restoration programs that are planned or currently on-going.

The LTIMP stream monitoring network will play a key role in evaluating load reduction from these land-uses, while management practice effectiveness will be assessed on a project basis. The LTIMP stream monitoring provides a long term dataset (since 1978) that the Water Board and NDEP will use to evaluate the integrated effect of forest upland watershed management improvements over time. The ten tributaries that are monitored through LTIMP will allow for status and trends analysis to evaluate if long term reductions are being seen. The LTIMP program is scheduled to undergo a revision over the next few years and any revision should include the TMDL need for non-urban uplands monitoring and additional particle size distribution analysis.

Another matter that arises with regard to forest uplands is that there are significant efforts underway in the Tahoe basin for forest management and fire and fuel management. Monitoring will need to occur to ensure these forest management actions are evaluated at either the project and/or sub-basin level to determine if the measures are not increasing pollutant loading (fine sediment and nutrients). Research is planned through Southern Nevada Public Lands Management Act funding for evaluating the potential effects from various fuel reduction practices. The Water Board and NDEP will work with groups such as the USFS LTBMU to develop these monitoring plans.

Responsible parties should document and report annually to the Water Board and NDEP on 1) previous year activities to reduce pollutant loads and 2) plans for next year load reduction activities. The activities include, but are not limited to; fuel reduction projects, BMPs on unpaved roads and trails, ski area revegetation, routine BMP maintenance, and road decommissioning.

13.3.5 Stream Channel Erosion

The USFS LTBMU, CTC, and other responsible stakeholders have prepared detailed stream restoration plans to address stream channel erosion problems on the three largest contributing tributaries (Ward Creek, Blackwood Creek, and the Upper Truckee River). Similar to the forest upland monitoring approach, the relative impact of restoration activities will be evaluated on a project basis.

Responsible agencies are encouraged to use permanent survey markers and monitor changes in stream cross-sections in relation to erosion or aggregation of sediment for stream reaches of interest. Responsible parties should document and report annually to the Water Board and NDEP on 1) progress from past year on restoration and rehabilitation projects on stream channels, and 2) restoration plans for the following year.

Research projects funded through SNPLMA are currently focusing on the benefits of natural floodplains in reducing fine sediment particles and nutrients. It is anticipated that specific research projects will be completed in 2011 and there will be valuable information and consistent protocols useful for quantifying the load reductions from certain streams under specified flow conditions. Over time the largest contributing tributaries will have a stream channel evaluation which will include analysis of long term stream monitoring offering a more comprehensive assessment of how channel restoration efforts integrate with watershed actions to improve water quality.

13.4 Tributary and Lake Response Monitoring

13.4.1 Lake Monitoring

Lake Tahoe is home to one of the longest limnological monitoring programs in the United States. In 1959, Professor Charles R. Goldman (University of California, Davis) began a program of water quality and aquatic ecology studies at Lake Tahoe that is still active, 50 years later (e.g. Goldman 1974, Byron and Goldman 1988, Jassby et al. 1995, UC Davis - TERC 2008). UC Davis has maintained this monitoring program on a continuous basis since mid-1967 (i.e. 40 years). Funds are currently provided for lake monitoring by the Tahoe Regional Planning Agency (TRPA), UC Davis, and the Water Board; with other state and federal agencies contributing over its long history.

Lake sampling is done routinely at two permanent stations (Figure 13-1). At the Index Station (location of the Lake Tahoe Profile or LTP), samples are collected between 0 - 105 meters in the water column at 13 discrete depths. This station is the basis of the > 40 year continuous data set and monitoring is done on a schedule of 25-30 times per year. Data from the Index Station has been instrumental in the establishment of the water quality standards and thresholds for Lake Tahoe and constitutes the scientific evidence upon which many land-use decisions have been made over the years. The deep water Station has been operational since 1980 and has been valuable for comparison with the Index Station. At this location, samples are taken down a vertical profile to the bottom of the lake (0 - 450 meters) at 11 discrete depths on the order of once per month. Sampling along the complete vertical depth profile allows for the analysis of whole-lake changes.

The current list of parameters at the Index and deep water Stations (combined) includes: nitrate, ammonium, total Kjeldahl nitrogen, total nitrogen, total reactive phosphorus, dissolved phosphorus, total hydrolysable phosphorus, total phosphorus, dissolved inorganic carbon, chlorophyll *a*, fluorescence, primary productivity (^{14}C), Secchi depth, light transmission, temperature, and dissolved oxygen. In addition, the lake monitoring program also includes phytoplankton and zooplankton taxonomy and enumeration, algal growth bioassays (using natural populations), and periphyton (attached) algae. Much of this monitoring is summarized in a report entitled, *Tahoe: State of the Lake Report* published by UC Davis (UC Davis - TERC 2008). Lake monitoring is critically important in assessing whether watershed management actions are having the desired impact on Lake Tahoe’s transparency.

13.4.2 Tributary Monitoring

Stream water quality monitoring and suspended sediment load calculations are regularly done as part of the Lake Tahoe Interagency Monitoring Program (LTIMP). LTIMP is a cooperative program including both state and federal partners and is operationally managed by the USGS, UC Davis - TERC, and the TRPA. LTIMP was formed in 1978 and one of its primary objectives is to monitor discharge, nutrient load, and sediment loads from representative streams that flow into Lake Tahoe.

LTIMP currently monitors the following streams: Trout Creek, Upper Truckee River, General Creek, Blackwood Creek, Ward Creek, Third Creek, Incline Creek, Glenbrook Creek, Logan House Creek and Edgewood Creek (Figure 13-1) (Rowe et al. 2002). The program has monitored these tributaries since 1988 and these streams are also part of the USGS national water quality monitoring program.

Cumulative flow from these monitored streams comprises about 50 percent of the total discharge from all tributaries. Each stream is monitored on 30 - 40 dates each year and sampling is largely based on hydrologic events. Nitrogen and phosphorus loading calculations are performed using the LTIMP flow and nutrient concentration database. A list of parameters measured either permanently or intermittently since 1988 (depending on funding availability) includes nitrate, ammonium, total Kjeldahl nitrogen, dissolved Kjeldahl nitrogen, soluble reactive phosphorus, total dissolved phosphorus, total phosphorus, biologically available iron, suspended sediments, fine sediment particle (< 16 μm) distribution, dissolved oxygen, pH and specific conductance. This data is stored on the USGS website at http://wdr.water.usgs.gov/.

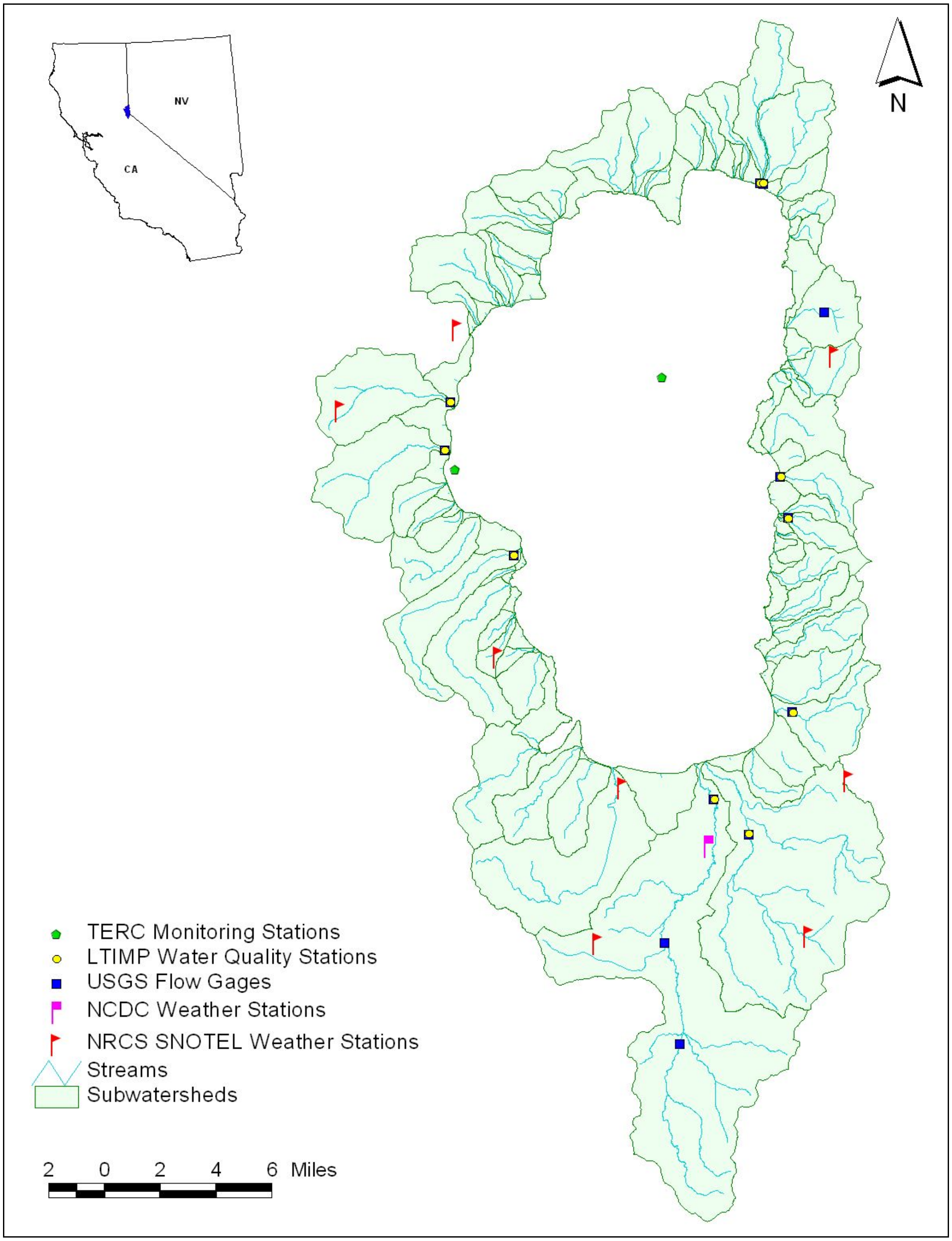

Figure 13-1. Sampling locations for LTIMP Stream and Lake (TERC) sites (Tetra Tech unpublished). The Index Station is the TERC Monitoring Station that is near the west shore, it is located 2km from the shore and is positioned over deep water (greater than 100 meters deep).

LTIMP tributary monitoring data provides a continuous long term dataset that can be used to evaluate water quality trends. The Lake Tahoe TMDL program anticipates the

LTIMP water quality results will continue to be used as a comprehensive measure that integrates load reduction actions across all of the major pollutant sources.

14 Margin of Safety

14.1 Introduction: MOS and its Relation to Uncertainty

The Margin of Safety (MOS), in combination with the Waste Load Allocation and Load Allocation, constitutes the TMDL. Waste Load and Load Allocations are based on the best existing monitoring data and scientific analysis. A MOS must be included in a TMDL to account for "any lack of knowledge concerning the relationship between effluent limits and water quality" (40 CFR section 130.7(c)(1)).

The MOS can be included as an explicit numeric addition to the loading allocation, or it can be included implicitly by incorporating conservative assumptions into the TMDL analysis. The Lake Tahoe TMDL incorporates the MOS implicitly.

A MOS is included in a TMDL to account for uncertainties inherent to the TMDL development process. Uncertainty is an expression commonly used to evaluate the confidence associated with sets of data, approaches for data analysis, and resulting interpretations. Determining uncertainty is notably difficult in studies of complex ecosystems when data are extrapolated to larger scales or when project specific data does not exist and best professional judgment, based on findings from other systems, must be employed. The scientific literature is replete with studies that characterize a specific aspect of an environmental characteristic or environmental process. Fully integrated investigations are much less common and much more difficult.

Within this TMDL, uncertainty was addressed using three independent approaches:

1. A comprehensive science program and science-based analysis was developed to enhance monitoring, fill key knowledge gaps and develop pollutant loading and lake response modeling tools specifically for Lake Tahoe.

2. Use of conservative, implicit assumptions, when justified, in the loading and lake response analyses.

3. Development of an Integrated Water Quality Management System based within an adaptive management framework that will allow the TMDL partners to evaluate scientific uncertainty, success of implementation projects and lake response on a regular schedule into the future and make the necessary adjustments.

14.2 Comprehensive Science Analysis

14.2.1 Science and the MOS

The intent of the comprehensive science plan was to reduce uncertainty throughout the TMDL process. Maximizing the knowledge concerning the relationship between pollutant source loading and water transparency helped limit the dependence of this TMDL on the MOS.

14.2.2 Rich History of Scientific Participation

Water quality management at Lake Tahoe benefited from an extensive science program that began in the late 1950s and which continues to grow. The Lake Tahoe Watershed Assessment (Reuter and Miller 2000) highlighted that hundreds of scientific papers and reports have been written on many aspects of Lake Tahoe, its watershed and its water quality since studies first began nearly 50 years ago. Many of these publications have been peer reviewed journal articles and technical reports while others include graduate student theses and dissertations. This has provided a unique, site-based literature to help guide scientific decision-making. In fact, almost all previous lake water quality management decisions have been based on scientific findings. Funding for science has even become a greater priority for federal and state agencies and local governments since 2000 (e.g. Environmental Improvement Plan, Southern Nevada Public Management Act, etc.). Lake Tahoe is a highly studied location and it is unlikely that this relationship between science and policy will diminish over time.

In addition to this extensive archive of available basic and applied research knowledge, a number of well-established monitoring programs exist at Lake Tahoe. These include long-term monitoring of lake clarity and transparency, water quality and biology; stream flow and pollutant loading (nutrients and sediment); and atmospheric deposition of pollutants. The Lake Tahoe Interagency Monitoring Program (LTIMP) has been collecting monitoring data for over 25 years and includes a wide range of precipitation and hydrologic conditions; i.e. it is a representative data set. As noted elsewhere in this document, the LTIMP has served as an important cornerstone for direct estimates of pollutant loading and model calibration and validation.

14.2.3 Filling Key Knowledge Gaps

Despite a historically rich science-based understanding of the ecological processes concerning the lake, the Lake Tahoe TMDL program began by identifying areas that required further investigation in order to improve our confidence. In some cases a limited amount of previous data had been collected. Therefore the associated level of uncertainty was considered too high. Further investigations included but were not limited to, (a) the Lake Tahoe Atmospheric Deposition Study (LTADS), conducted by the California Air Resources Board, (b) a detailed evaluation of stream channel erosion as a source of sediment to the lake, (c) characterization of biologically available phosphorus, (d) a detailed urban stormwater quality characterization effort, and (e) a thorough evaluation, including modeling of sources, transport, and fate of fine sediment particles. In this regard, the Lake Tahoe TMDL was able to limit the use of data from outside the Lake Tahoe basin and focus on the in-basin studies.

Development of modeling tools based on comprehensive science was considered fundamental to the application of the TMDL. Lake Tahoe and its watersheds were considered unique enough (depth, trophic status, elevation, hydraulic residence time, etc.) that specific loading and lake response models were needed to further reduce uncertainty. As a result, the Loading Simulation Program C++ (LSPC) watershed model was used to create the Lake Tahoe Watershed Model for simulating land-use based nutrient and sediment loading on a basin-wide scale. LSPC has been peer reviewed by the USEPA and it is part of its national TMDL modeling toolbox. The Lake Clarity Model was created specifically for the Tahoe TMDL Program by the University of California, Tahoe Environmental Research Center. While there is still some degree of uncertainty associated with these key models, the overall uncertainty of the TMDL would be much larger if these models were not specifically developed for this project.

14.2.4 Scientific Reliability

When science is used to guide policy, resource agencies and decision-makers must be provided with a sense of how confident researchers are with their findings.

As part of the Lake Tahoe TMDL program a number of practices were applied to ensure that the collection and interpretation of information was conducted in a scientifically acceptable manner. These include:

- Establishment of a diverse team of project scientists with national and international recognition and credentials enhances the caliber of the best professional judgment used in the Lake Tahoe TMDL.

- Use of data sets subject to high levels of quality control. The Lake Tahoe Interagency Monitoring Program (LTIMP) long-term data set on lake clarity and transparency and related limnological characteristics, stream hydrology, nutrient and sediment concentrations/loading, and atmospheric deposition was used for model calibration and validation. This data covers a wide variety of conditions given its long-term nature. The water chemistry is subject to the US Geological Survey's national quality assurance/quality control protocols.

- Availability of hundreds of scientific documents on Lake Tahoe and its watershed. Many have undergone peer review when published in scientific journals. This information was critical for establishing the conceptual model for the Lake Tahoe TMDL and many of the journal articles were used directly to inform modeling and interpretive efforts.

- Models were carefully calibrated and validated using Tahoe-specific data. Modeled results and new field measurement results were continually compared to this accepted body of knowledge.

- Peer reviews have been completed for 101 of the 221 references cited in this report and in the Tahoe TMDL Technical Report. The peer-reviewed references are specifically denoted in the references cited sections. For example, LSPC has been previously peer-reviewed by the USEPA. CARB's LTADS report has been peer reviewed by air quality researchers from the University of California system, and in 2004, Dr. Steven Chapra (Professor and Berger Chair, Civil Engineering, Tufts University, MA) was contracted to provide a critical review that helped guide Lake Clarity Model development. Similarly, the USACE groundwater report was put out for comment following Corps protocol. Comments were received from a number of Tahoe basin agencies, stakeholders, and university researchers. Similarly, the National Sedimentation Laboratory report on stream loadings and stream channel erosion, also funded by the USACE, was subject to a similar comment process.

- A significant part of the peer review process has been the publication of research papers in scientific journals concerning new science conducted as part of the TMDL. These are noted throughout the document.

- A number of Master's Theses and Ph.D. Dissertations have come out of the TMDL science projects, e.g. lake optical model, stream particle characterization, stormwater pollutant characterization, in-lake particle sedimentation processes, biologically available phosphorus. All these were reviewed by a scientific committee at the student's institution prior to being accepted in partial fulfillment of their degree requirements.

- Finally, there are sufficient publications on Tahoe to take a "weight of evidence" approach to reduce uncertainty and increase confidence in the results. Most often, the TMDL results compared favorably with the conclusions of others.

14.3 Conservative Implicit Assumptions

In the context of the Lake Tahoe TMDL, a conservative (protective) assumption is one in which analysis would err towards a higher pollutant loading rate. An underestimate in loading will result in a slightly lower allocation. A conservative estimate would therefore provide a margin of safety to buffer lack of precision in the data or the analysis.

The Tahoe TMDL includes conservative assumptions in two areas of its development. First, conservative assumptions were made in the Lake Tahoe Watershed Model and Lake Clarity Model and pollutant load allocations. Second, conservative assumptions are used to inform pollutant reduction opportunities and the TMDL implementation strategy. Both of these assumptions contributed to the use of an implicit MOS selected for this TMDL.

14.3.1 Lake Tahoe Watershed Model

The Lake Tahoe Watershed Model, constructed using the USEPA approved LSPC modeling program, modified for specificity of the Lake Tahoe TMDL, simulates total sediment and nutrient loading based on land-use characteristics, geology, meteorology and other factors. The Watershed Model includes the following conservative assumptions in the development of the TMDL.

- A 20 percent margin of safety was added to land-use Event Mean Concentration estimates. (Lahontan and NDEP 2010).
- The Lake Tahoe Watershed Model does not account for pollutant reduction as runoff flows overland from the developed and undeveloped intervening zones directly to the lake. This transport loss in the intervening zones requires hydrology modeling and estimates of urban losses that were too fine-scaled for the existing Lake Tahoe Watershed Model. However, estimates of this 'transport loss' were accounted for by the Lake Tahoe Watershed Model in the urban subwatershed areas.
- Estimates of nutrient runoff from fertilizer application on lawns do not account for infiltration loss of nitrogen and phosphorus. Had the estimates included infiltration, less nitrogen and phosphorus would be modeled to runoff from the vegetated turf land-use (Tetra Tech 2007).

14.3.2 Pollutant Reduction Analysis and Implementation Strategy

The success of the Tahoe TMDL is predicated on the ability of implementing agencies to reduce the target pollutants. While assessing these opportunities, the Source Category Groups made a number of conservative assumptions that influenced the analysis of source reduction potential. The assumptions listed in Table 14-1 are taken from the *Pollutant Reduction Opportunity Report* (Lahontan and NDEP 2008a). Because of the magnitude of the urban source and associated load reduction opportunities, the list focuses on conservative assumptions made by the Urban Uplands and Groundwater Source Category Group.

Table 14-1. Conservative assumptions included in analysis of the Urban Uplands and Groundwater Source Category Group of the Pollutant Reduction Opportunity Report (Lahontan and NDEP 2008a).

Source Category Group	Assumption	Margin of Safety Contribution
Urban Uplands and Groundwater (UGSCG)	Hydrologic Source Controls (HSCs) create pollutant load reductions in surface water through reduction in volumes of runoff. To simplify the analysis and facilitate representation in the Watershed Model, HSCs do not alter concentrations in surface storm water runoff and *do not reduce pollutant source generation downstream.* (p.97, emphasis added)	HSCs reduce runoff. This reduces down-slope erosion. The Watershed Model does not account for the reduced erosion from HSC application. Consequently, fine sediment and nutrient loads immediately downstream of HSCs will be over estimated and contribute to the implicit MOS.
UGSCG	Bypassed flows are assumed to	As simulated in the

	enter surface waters (Lake Tahoe) at influent concentrations. (p.82)	Lake Tahoe Watershed Model, flows that bypass a stormwater treatment (SWT) do not attenuate and are not subject to transfer loss en route to the lake.
UGSCG	HSCs are flow-based pollutant control options that are designated to infiltrate urban storm water, thereby reducing flow volumes delivered downstream. HSCs are assumed to provide negligible water quality improvements to infiltrated waters. (p.112)	The Urban Infiltration Box Model used to evaluate the impacts of pollutant control options on groundwater does not model any water quality benefit to infiltrating water from the infiltration process.

14.4 Future Growth

Development in the Lake Tahoe basin is regulated by the Tahoe Regional Planning Agency, the five bordering counties, and the City of South Lake Tahoe. Due to the strict regulatory environment that governs development on vacant and built parcels, recent building trends have focused on redevelopment of existing sites. To examine the potential pollutant impact of complete, allowable development in the Lake Tahoe basin, the TMDL used the Tahoe Land-Use Change Model (Land-Use Model) developed by the US Geological Survey (Halsing 2006).

For each undeveloped parcel, two possibilities exist. One option is that the parcel is restricted from being developed through purchase of a conservation easement, purchase of the development rights, or purchase of the property. Four agencies (TRPA, USFS, NVDSL, and CTC) have programs to permanently restrict lots from being developed. The second option is that the lot is developed when the owner receives a development allocation. Development allocations are divided among the jurisdictions. To establish the worst case scenario for build-out as it relates to pollutant loads, the Land-Use Model preferentially assigns each parcel to be either conserved or developed in a way that results in a scenario that is the most harmful to Lake Tahoe. For example, if the model is presented with two parcels, one of which must be chosen for development and the other for conservation, the model will assign development status to the parcel that has greater potential to contribute pollutants to the lake (Halsing 2006). When the Land-Use Model accounted for development or conservation of all of the undeveloped parcels, this build-out scenario was input into the Watershed Model for analysis of pollutant transport to the lake. The Watershed Model simulation resulted in estimated fine particle sediment load up to about two percent greater than the total load modeled for 2004 conditions (Tetra Tech unpublished).

Actual future development in the Tahoe basin is unlikely to proceed pursuant to the idealized worst case scenario modeled. However, since it was designed to test the worst case scenario, the analysis represents a conservative estimate. Results of the Lake Tahoe Watershed Model for this conservative build-out scenario indicated that the number of fine sediment particles loaded to Lake Tahoe would increase by up to a maximum of two percent. This compares to the 32 percent reduction in fine sediment particles needed to meet the Clarity Challenge. Given the uncertainty involved in the land-use change and watershed models, an increase up to two percent of the total fine sediment particle load is considered within the range of uncertainty in the modeling analysis and, therefore, is not considered a significant increase.

14.4.1 Future Growth Mitigation

The Lake Tahoe TMDL does not specify a pollutant allocation for future growth. The Tahoe basin is subject to strict building regulations designed to address water quality impacts. Also, land-use regulations in the Lake Tahoe basin limit the area that can be built while requiring implementation of applicable measures to prevent pollutant loading. The following presents an evaluation of the potential future growth and there is a low probability that the maximum potential build-out would ever be reached because of successful on-going conservation programs.

As of 2008, a total of 4,841 parcels in the Tahoe basin were undeveloped and may become eligible in the future for being developed (Nielsen 2008 personal communication). Assuming that the 4,841 undeveloped lots have an average size of 0.25 acres and that each lot will be developed, these parcels would comprise 1210 total acres of additional developed land. Coverage on the highest capability land is limited to 30 percent (TRPA 1987, Section 20.3.A). This means that a maximum of 373 acres would be made impervious. At build out, active conservation efforts, such as the CTC urban lot program and the Forest Service Burton-Santini acquisition program, are expected to prevent a number of the lots in question from being developed by converting the private lots to public open space. Retiring these lots from development potential reduces the potential total new coverage.

The TRPA Code of Ordinances requires that all development projects capture and either treat or infiltrate the stormwater runoff. Redevelopment on previously developed parcels, as a condition of permit approval, requires BMP retrofits on the entire parcel, including the areas outside of the construction zone (TRPA 1987, 25.2.B).

The regulatory structure within the Tahoe basin includes code and policy mechanisms to prevent potential degradation of parcels. To comply with existing regulations, any additional parcel development is not permitted to negatively impact water quality. The Lahontan Basin Plan, in Chapter 5.4, includes limitations on coverage based on the assessed capability of the land. These limitations are designed to protect Tahoe's stream environment zones and other sensitive soils, and are mirrored in the TRPA Code of Ordinances and Water Quality Management Plan (208 Plan).

The potential for future growth in the Tahoe basin remains limited. Management of future growth will be informed by monitoring and continuing study to adapt to changes in the lake's response to pollutant controls. This type of adaptive management allows for a change to a more restrictive management strategy, such as increasing performance requirements for implementers, should the lake be impacted to a greater extent than estimated by the TMDL analysis.

15 Public Participation

15.1 Introduction

The Water Board and NDEP recognize public participation is a vital component for the success of the Lake Tahoe TMDL. For this reason, the Lake Tahoe TMDL program embarked on a robust public participation effort as part of developing the science supporting the TMDL load estimates (Phase One) and during the process to identify load reduction opportunities and craft an implementation plan (Phase Two). This chapter summarizes the efforts for Phase One and highlights selected public participation actions for Phase Two. Additional detail for Phase Two public participation process can be found in the *Integrated Water Quality Management Strategy Report* (Lahontan and NDEP, 2008b).

15.2 Phase One Public Outreach & Education – TMDL Technical Report

Phase One, development of the TMDL Technical Report, primarily involved scientific research and modeling efforts. Consequently, the goals for outreach to the public/stakeholders focused on disseminating the information in specific parts:

- Provide initial awareness about the bi-state Lake Tahoe TMDL effort through press releases, kick-off meetings, and quarterly electronic newsletters.
- Inform public/stakeholders about Tahoe TMDL components and process and identify the TMDL as a science-based restoration planning tool.
- Educate and provide a conceptual framework for how this TMDL program will be built on historic knowledge and supplemented with recent scientific research.
- Update the public and stakeholders about program progress.

Water Board and NDEP staff understand that stakeholder participation is critical to building a program that will be embraced and supported by agencies, policy makers, engaged stakeholders and the public. Two primary mechanisms accomplished the Phase One outreach and education efforts: 1) stakeholder and public education and 2) agency coordination. Water used a variety of methods to educate stakeholders and the general public on the status of the TMDL development: quarterly newsletters, targeted stakeholder meetings and presentations, as well as a symposium dedicated to describing the TMDL science plan and the models fashioned for this effort.

TMDL Newsletters

Between the Fall of 2002 and Fall 2006, the Water Board and NDEP staff produced ten newsletters, distributed approximately quarterly to stakeholders and made available on the Lahontan and NDEP websites. Newsletters provided information and updates for an array of scientific projects conducted to support TMDL development.

Public Forums

The Water Board and NDEP staff gave six informational presentations to the public and targeted stakeholder groups from May 2002 through early 2007. These were aimed at providing stakeholders with a background on the TMDL process in general and the Lake Tahoe TMDL in particular, the plan and justification for the science being developed to support the TMDL, and the program timeline. Two public outreach meetings were held in May and June of 2002 in conjunction with the Pathway process – one on the south shore and one on the north shore. In addition, four informational presentations and status updates were provided to the Pathway Forum between 2003 and 2007. These meetings were open to the public and featured an informational slide presentation and a question and answer session,

Targeted Stakeholder Presentations

The Water Board and NDEP staff gave more than 20 presentations to various stakeholder groups from December 2002 through December 2006. The groups included the TRPA Governing Board, Water Board, California Tahoe Conservancy, City of South Lake Tahoe City Council, Contractors Association of Tahoe Truckee, Tahoe Douglas Chamber of Commerce, local homeowners associations, and other non-governmental organizations. These presentations served to keep key stakeholder groups and agency partners abreast of program developments and request feedback on program direction.

Lake Tahoe TMDL Symposium

The Water Board and NDEP staff held a public Lake Tahoe TMDL Symposium in December 2004 in South Lake Tahoe. The 2004 Symposium featured 25 individual speakers giving presentations on research, early implementation, and regulatory changes. The Symposium also included an extensive questions and answer session.

TMDL Technical Report

Phase One TMDL efforts were summarized in a draft report and made available for public review and comment. Comments were considered in updating the Technical Report and in writing the Final TMDL Document.

Agency Coordination

Phase One TMDL development also involved intensive coordination with local, regional, state and federal agencies. Central to this effort was the formation of the TMDL Development Team (D-Team) which included representatives from the USFS Lake Tahoe Basin Management Unit, TRPA, California Tahoe Conservancy, Nevada Division of State Lands, California Department of Parks and Recreation, along with a host of other agencies that were invited to participate. The D-Team primary goal was to agree on assumptions and input to the Lake Tahoe Watershed Model using the best available information and most palatable methods and approach. A secondary benefit of the group was to achieve buy-in by the participatory agencies, since the D-Team served as an informational forum whereby the operation of the model and the rationale for using a particular approach was explained in detail. The Pathway Water Quality Technical Working Group, a subgroup of leading scientific experts in Lake Tahoe water quality issues, performed additional coordination with stakeholder agencies. In particular, the Working Group reviewed existing basin water quality standards and agreed on a TMDL Lake Tahoe transparency numeric target of 29.7 meters of annual average Secchi depth as appropriate.

Draft Lake Tahoe TMDL Technical Report

The Phase One effort culminated in the release of the Draft TMDL Technical Report in September 2007. Public comment has been solicited and accepted through the release of this Draft Final TMDL document. Comments received were considered in this document.

15.3 Phase Two Stakeholder Participation Series

Public participation during Phase One focused on outreach and education to promote awareness and understanding of the TMDL science plan and process. In contrast, Phase Two presented an opportunity for stakeholders and agency partners to take a more active role in the TMDL development process. Because many stakeholders possess a thorough understanding of the social, political, and economic issues of the Lake Tahoe watershed, the Lake Tahoe TMDL program recognized stakeholder input as a key element in developing pollutant load allocations and the associated implementation plan. By encouraging stakeholders to participate and provide feedback throughout the Phase Two development process, the Final TMDL represents a restoration plan that was developed through an intensive public participation process.

The Phase Two public participation effort relied on an interactive, iterative stakeholder feedback process. The process was launched in the fall of 2007 with the release of the *draft Pollutant Reduction Opportunities Report* (Lahontan and NDEP 2008a), which along with the *September 2007 Draft TMDL Technical Report* provided the technical basis to develop various implementation strategies. The stakeholder participation continued through the spring of 2008 to gather input on a proposed integrated implementation strategy and associated pollutant load allocation approach. While the two-part process is summarized below, please refer to the *Pollutant Reduction Opportunity Report* and the *Integrated Water Quality Management Strategy Project Report* (Lahontan and NDEP 2008b) for more detailed information.

Implementation Plan Development

The conceptual strategy and approaches that were to be used in the Pollutant Reduction Opportunity analysis required technical scrutiny by practitioners in the Basin and a general level of agreement of baseline assumptions and methods. Therefore, a series of Focus Teams were created to provide feedback on identified reduction opportunities and load reduction analysis approaches. These groups included local agency and resource professionals who were tasked with gaining a technical understanding of the analytical approach, reviewing the analysis findings and providing interim and final comments. Focus Team feedback was either used to refine the analysis approaches or was documented as potential future work to improve the analysis. Focus Team input was also used to help craft the integrated implementation scenarios. While the Focus Team evaluated the proposed load reduction opportunities from a technical perspective, the Pathway Forum evaluated both reduction opportunities and integrated implementation alternatives from an economic and policy perspective.

Part of the Pathway planning process included creating a Forum of diverse stakeholders to recommend mutually beneficial resource management options to Pathway agency decision-makers. Forum discussions promoted “enlightened self-interest” as participants worked to understand different perspectives and incorporate the interests of all in developing recommendations. Forum Members were volunteers that put tremendous effort into making sure the citizen's voice were heard. Members shared information gained from these discussions to their respective constituencies through various venues.

A series of four Pathway Forum meetings highlighting TMDL implementation strategies featured an iterative process of receiving stakeholder feedback and refinement of proposed strategies. Meetings were open to the public and Focus Team members were invited to attend and participate. This series of meetings culminated in a consensus endorsement for the Recommended Strategy, which focuses on reducing basin-wide fine sediment particle loading to Lake Tahoe and provides the basis for the Lake Tahoe TMDL pollutant load allocation distribution and for the TMDL implementation plan to achieve the Clarity Challenge.

Allocation Development

A second element of the Phase Two public/stakeholder participation series was conducted to guide load and waste load allocation development. Similar to the Forum meetings, a series of TMDL Implementer Meetings were held throughout the fall of 2007 and winter 2008. Local entities responsible for carrying out the TMDL implementation plan, as well as project funding agencies, were invited to learn about the different allocation options being considered and provide feedback on presented proposals. The resulting discussions helped the Water Board and NDEP staffs refine the preferred allocation approach. The primary purpose of these meetings was to further develop allocation options based on feedback provided by the implementation entities, but the meetings also provided a venue to discuss and understand what the allocations will mean to the various entities in terms of implementation expectations and/or requirements. Presentation material and meeting notes can be found in the *Integrated Water Quality Management Strategy Project Report* (Lahontan and NDEP 2008b).

15.4 Phase Three – Implementation and Adaptive Management

After working with the public/stakeholders on the Phase One and Phase Two portions of the TMDL project, the Water Board and NDEP staffs shifted focus to outreach efforts for the implementation and adaptive management phase. Prior to adoption of this TMDL, the team engaged consultants to develop specific programs and processes to aid regulators and implementers in the TMDL implementation. These tools include the Lake Clarity Crediting Program, a Pollutant Load Accounting and Tracking Tool, the Pollutant Load Reduction Model, and two separate urban Rapid Assessment Methodologies to help municipal jurisdictions estimate the pollutant load reduction from proposed and completed projects, consistently account for estimated load reductions, and track TMDL progress.

Additionally, NDEP staff held meetings in the fall 2008 with Nevada implementation agencies to discuss what regulatory approach that NDEP should pursue upon approval of the TMDL. The Nevada portion of the Lake Tahoe basin does not meet the population and density requirements to mandate issuance of stormwater permits for the Nevada-side municipal jurisdictions under the National Pollutant Discharge Elimination System (NPDES) Phase Two Stormwater Rule (Rule). This Rule subjects municipalities to permit requirements for the control and prevention of stormwater pollution. However, the TMDL analysis provides the evidence to support issuance of a stormwater permit. The meeting featured a discussion of the benefits and drawbacks of both the agreement-type and permit approaches for implementation. Attendees acknowledged that the flexibility offered by the Memorandum of Agreement (MOA) approach provided the greatest likelihood for successful implementation within Nevada Lake Tahoe. From summer of 2009 through spring of 2010, NDEP has met and coordinated with TMDL implementation partners to lay out a process and submit grant applications for the development of Stormwater Load Reduction Plans that specify the strategies and actions each of the Nevada Tahoe urban stormwater jurisdictions will accomplish to meet required load reductions.

The Water Board and NDEP staffs presented information on how the tools can aid TMDL implementation to public stakeholders in late 2008 through 2010. Water Board and NDEP staffs expect to use these tools to follow TMDL implementation and to adaptively manage the implementation plans based on new monitoring data and scientific research. The Water Board and NDEP staffs are committed to give informative and interactive presentations as requested and needed through the adoption and full implementation of the Lake Tahoe TMDL.

16 Regulatory Analysis

16.1 Overview

Set forth below are the required analyses of the Water Quality Control Plan for Lahontan Region (Basin Plan) amendment under the California Environmental Quality Act (CEQA), including economic considerations related to water quality program costs; and clarification of regulatory authorities germane to this project.

16.2 Analysis required by the California Environmental Quality Act

The California Regional Water Quality Control Board, Lahontan Region, (Water Board) is the Lead Agency responsible for evaluating potential environmental impacts of the proposed Basin Plan amendment. Under the provisions of California Public Resources Code section 21080.5, the state's Secretary for Resources has certified the regulatory programs of state agencies as exempt from the requirements of preparing environmental impact reports and related documents, if the Secretary finds that the program meets the criteria specified in that section of the code. The Basin Planning process of the Water Boards is certified as such a program as described and listed in CEQA Guidelines section15251 (g). In accordance with the Guidelines the TMDL documentation comprises the required Substitute Environmental Documentation.

16.3 Background

Project Title: LAKE TAHOE TOTAL MAXIMUM DAILY LOAD BASIN PLAN AMENDMENT

Contact Person: Douglas F. Smith

The Project is adoption by the Water Board of an amendment to the Basin Plan establishing Total Maximum Daily Loads for fine sediment particles, total nitrogen, and total phosphorus in Lake Tahoe ("the TMDL"), and an implementation plan to achieve the TMDL.

16.4 Project Description

16.4.1 Environmental Setting

Lake Tahoe straddles the California-Nevada border at 6229 ft. elevation in the Sierra Nevada Mountain Range (see map, Figure 16-1). Surrounding mountains rise to 10,881 ft. The lake's surface area of 191 square miles, and 71 miles of shoreline are in both states. The lake is unusually deep—1,645 ft. maximum depth, and 1,000 ft. average depth. The lake has always been known for its water's extraordinary transparency.

The 506 square mile[2] Lake Tahoe watershed encompasses portions of Placer and El Dorado counties on the California side, and Douglas, Washoe, and Carson City counties in Nevada. Land-uses in the Tahoe Basin include forestry, winter and summer recreation, commercial, and residential.

U.S. EPA and the state of California have designated Lake Tahoe an Outstanding National Resource Water[3]. Under Nevada pollution control regulations, the portion of the lake in Nevada has a designated beneficial use as a "water of extraordinary ecological and/or aesthetic value." State and federal anti-degradation policies require implementation of all reasonable, cost-effective best management practices for nonpoint source pollution control. Aesthetic enjoyment of lake clarity is a beneficial use of the lake.

16.4.2 Purpose and objectives of the Basin Plan Amendment Project

Forty years ago, boaters and swimmers could see nearly 100 feet down into Lake Tahoe's clear blue depths. But the lake has lost about 30 feet of its famed transparency since scientists first monitored the transparency in the late 1960s. Scientists now know that fine sediments, entering the lake from a variety of sources principally including stormwater runoff from urbanized areas around the lakeshore, decrease transparency by scattering light as particles slowly settle through the water. Nitrogen and phosphorus stimulate algae growth, which in turn absorbs light, reducing the depth that light can penetrate into the lake.

Due to this loss of transparency, both California and Nevada list Lake Tahoe as impaired by fine sediment (particles less than 16 micrometers in diameter), nitrogen, and phosphorus. "Listing," or inclusion on the U.S. Environmental Protection Agency's Clean Water Act section 303(d) list of impaired water bodies, requires development and

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[2] http://www.cabnr.unr.edu/saito/intmod/docs/ex2bckgrnd.pdf

[3] See http://www.tiims.org/getdoc/afde4e43-cbd7-4dfb-9f79-0a23122a29c1/Outstanding-National-Resource-Water.aspx?Item=Outstanding%20National%20Resource%20Water

implementation of an action plan to restore water quality. The Lake Tahoe Total Maximum Daily Load, or TMDL, a joint effort between California and Nevada, is that plan.

The “project” under review is the Regulatory Analysis which includes the TMDL and the adoption of an amendment to the Basin Plan for the California side of the Tahoe basin. The amendment incorporates the TMDL and its associated implementation plan, designed to achieve 77 to 80 feet of Lake transparency within the first 20 years of implementation; and full restoration to 97 feet of transparency over a period of about 65 years. It establishes the framework for future permits issued by the Water Board to the California Department of Transportation (Caltrans) and local jurisdictions. Upon adoption by the Water Board and approval by the California State Water Resources Control Board, the State Office of Administrative Law, and the U.S. Environmental Protection Agency, the TMDL will take effect.

In addition to establishing reduction requirements for fine sediments, nitrogen, and phosphorus pollutant loads to the Lake; and an implementation plan to achieve the reduced loads, the amendment

- Shifts the storm water management focus in the Lake Tahoe Basin from numeric, concentration-based *effluent limits* for stormwater discharges to an emphasis on mass-based *allocations* of average annual pollutant loads to four land use sources (urban uplands, forested uplands, stream channel erosion, and atmospheric deposition).
- Includes updates and revisions to related sections of the Basin Plan, specifically: 1) emphasizing that fine sediment particles (particles less than 16 micrometers in diameter and mostly from the urban source) are the dominant stressor to Lake transparency, 2) describing how nutrients (total phosphorus and total nitrogen) remain important factors but contribute less to transparency loss than do the fine sediment particles, and 3) concluding that fine sediment particles are the main source of total phosphorus.

16.4.3 TMDL Implementation Plan

The implementation plan allocates pollutant loads to the four source categories for the first 15 years, focusing on reducing stormwater runoff from roads and urbanized areas of the Lake Tahoe Basin; and on reducing the fine sediment pollutant load that causes most of the loss of lake transparency. Urban stormwater runoff accounts for more than 70 percent of fine sediment particles that enter the lake.

Traditional stormwater treatment methods, however, are generally not designed to remove particles of sediment as small as those that impair Lake Tahoe’s transparency. The TMDL implementation plan emphasizes intensive roadway operations and maintenance practices, and advanced stormwater treatment technologies including street sweeping, runoff collection and conveyance, stormwater treatment, and facilities maintenance practices.

While many of these measures are already common practices of the California Department of Transportation (Caltrans) and local municipalities, implementation of the TMDL may require broader, more comprehensive application of these approaches and technologies, and more vigilant monitoring and enforcement of permit compliance.

Specific implementation actions, which may be selected by responsible parties as they develop strategies for achieving the TMDL, include the following:

Urban Uplands

- Stabilize and re-vegetate road shoulders
- Vacuum-sweep streets (in heavily sanded areas)
- Upgrade fertilizer / turf management practices to reduce nutrient application
- Require education for turf managers
- Control retail fertilizer sales within the Basin
- Recommend landscaping practices that reduce nutrient mobilization
- Remove impervious coverage (increase infiltration)
- Install and maintain infiltration trenches
- Install and maintain prefabricated infiltration systems
- Install and maintain detention basins
- Install and maintain stormwater vaults
- Install and maintain wet basins / infiltration basins
- Install and maintain constructed wetlands
- Install and maintain media filters in stormwater vaults
- Apply advanced deicing strategies

Responsible parties for this category of implementation actions include El Dorado and Placer counties, the California Department of Transportation, and the City of South Lake Tahoe.

Forest uplands

- Install and maintain (annually) unpaved roadway BMPs (e.g. waterbars, armored ditches, rut stabilization)
- Hydroseed and apply tackifier to ski runs
- Implement forest treatments and standard BMPs with hand and ground-based equipment

- Capture and retain sediment from unpaved roadways
- Mulch ski runs and revegetate with seedlings
- Install and maintain advanced BMP measures to increase infiltration and reduce runoff on landings, trails and roads in forested areas
- Eliminate unmaintained roads and trails to restore native forest conditions with natural hydrologic function

Responsible parties include U.S. Forest Service Lake Tahoe Basin Management Unit (LTBMU), California Department of Parks and Recreation, and California Tahoe Conservancy.

Atmospheric Deposition

- Vacuum sweep streets
- Pave dirt roads at access points
- Limit speed on unpaved roads
- Apply gravel to or pave unpaved roads
- Require adequate soil moisture or other dust suppression techniques during earth moving operations
- Reduce emissions from residential wood burning
- Reduce the total number of vehicle trips

Since the majority of the atmospheric fine sediment particle load is generated by paved and unpaved roadways, the required atmospheric load reductions and interim load allocations will be met by implementing measures to control stormwater pollutants from urban and unpaved roadways. Responsible parties include El Dorado and Placer counties, the California Department of Transportation, the City of South Lake Tahoe, LTBMU, California Department of Parks and Recreation, and California Tahoe Conservancy under the urban upland source category. The Tahoe Regional Planning Agency (TRPA) is responsible for regulating air emissions in the Basin.

Stream Channel Erosion

- Lower stream channel banks and reduce angle to accommodate more frequent over-bank flow and reduce bank erosion/slumping
- Increase channel length and sinuosity by constructing new channel segments
- Restore riparian vegetation by planting and encouraging growth of native species
- Remove infrastructure (e.g., bridges) that fragments floodplains or restricts channel flow and replace, where necessary, in
- Install riprap or other armoring on channel banks

- Install grade controls

Restoration projects are underway on Blackwood Creek, Ward Creek, and the Upper Truckee River, which are the three most significant sediment-producing streams in the Lake Tahoe basin. Completion of these projects is expected to show the load reductions are being achieved from this source category to achieve.

Implementation schedule

Implementing this TMDL to achieve the transparency standard is estimated to take about 65 years. This TMDL establishes five-year load reduction milestones for the 65-year implementation plan. From years 15 through 65, the Water Board and the Nevada Division of Environmental Protection (NDEP) will annually assess relevant research and monitoring findings and may adjust annual load reduction targets and/or the TMDL implementation approach as needed to achieve the final target at year 65. In the absence of a successful adaptive management process to adjust the load reduction targets, five-year milestones will be used as load reduction allocation requirements.

The Water Board and NDEP may reopen the TMDL to adjust the implementation schedule to ensure the transparency standard will be achieved by year 65. The Water Board and NDEP, in partnership with implementation, funding, and regulatory stakeholders, may repeat this adaptive management process as needed to establish new implementation phases until the transparency standard has been met.

Use of the Basin Plan amendment by regulatory agencies

The Water Board will oversee TMDL implementation primarily through regulation of urban stormwater runoff via waste discharge requirements, National Pollutant Discharge Elimination System (NPDES) permits, and rural lands pollutant source control measures associated with permits issued by the USDA Forest Service, the U.S. Fish and Wildlife Service, and the state Department of Fish and Game.

The following jurisdictions receive NPDES permits from the Water Board or State Water Board:

- Caltrans
- El Dorado County
- Placer County
- City of South Lake Tahoe

The TRPA is responsible for zoning and permitting a wide variety of land uses and construction projects throughout the Basin. NDEP and the Water Board are working together with TRPA and the Forest Service to update the TRPA Regional Plan and the Forest Plan for consistency with the Basin Plan amendment and this TMDL.

16.4.4 Requirements for Environmental Review and Consultation

Federal requirements

Under 40 CFR Part 25, programs under the Clean Water Act, the Safe Drinking Water Act, and the Resource Conservation and Recovery Act; and projects of the State Water Board and Water Board implementing the Clean Water Act have the following notification and consultation requirements:

§ 25.3 Policy and objectives

(a) EPA, State, interstate, and substate agencies…shall provide for, encourage, and assist the participation of the public. The term, "the public" in the broadest sense means the people as a whole, the general populace. There are a number of identifiable "segments of the public" which may have a particular interest in a given program or decision. Interested and affected segments of the public may be affected directly by a decision, either beneficially or adversely; they may be affected indirectly; or they may have some other concern about the decision. In addition to private citizens, the public may include, among others, representatives of consumer, environmental, and minority associations; trade, industrial, agricultural, and labor organizations; public health, scientific, and professional societies; civic associations; public officials; and governmental and educational associations.

§ 25.4 Information, notification, and consultation responsibilities

(b) Information and assistance requirements.

(1) Providing information to the public is a necessary prerequisite to meaningful, active public involvement. Agencies shall design informational activities to encourage and facilitate the public's participation in all significant decisions …particularly where alternative courses of action are proposed.

(2) Each agency shall provide the public with continuing policy, program, and technical information and assistance beginning at the earliest practicable time. Informational materials shall highlight significant issues that will be the subject of decision-making. Whenever possible, consistent with applicable statutory requirements, the social, economic, and environmental consequences of proposed decisions shall be clearly stated in such material. Each agency shall identify segments of the public likely to be affected by agency decisions and should consider targeting informational materials toward them (in addition to the materials directed toward the general public). Lengthy documents and complex technical materials that relate to significant decisions should be summarized for public and media uses.

(3) Each agency shall provide one or more central collections of reports, studies, plans, and other documents relating to controversial issues or significant decisions in a convenient location or locations, for example, in public libraries.

(4) Each agency shall develop and maintain a list of persons and organizations who have expressed an interest in or may, by the nature of their purposes, activities or members, be affected by or have an interest in any covered activity. Generally, this list will be most useful where subdivided by area of interest or geographic area. Whenever possible, the list should include representatives of the several categories of interests listed under §25.3(a). Those on the list, or relevant portions if the list is subdivided, shall receive timely and periodic notification of the availability of materials under §25.4(b)(2).

(c) Public notification. Each agency shall notify interested and affected parties, including appropriate portions of the list required by paragraph (b)(5) of this section, and the media in advance of times at which major decisions not covered by notice requirements for public meetings or public hearings are being considered. Generally, notices should include the timetable in which a decision will be reached, the issues under consideration, any alternative courses of action or tentative determinations which the agency has made, a brief listing of the applicable laws or regulations, the location where relevant documents may be reviewed or obtained, identification of any associated public participation opportunities such as workshops or meetings, the name of an individual to contact for additional information, and any other appropriate information. All advance notifications under this paragraph must be provided far enough in advance of agency action to permit time for public response; generally this should not be less than 30 days.

(d) Public consultation. For the purposes of this part, “public consultation” means an exchange of views between governmental agencies and interested or affected persons and organizations in order to meet the objectives set forth in §25.3…. Other less formal consultation mechanisms may include but are not limited to review groups, ad hoc committees, task forces, workshops, seminars and informal personal communications with individuals and groups. Public consultation must be preceded by timely distribution of information and must occur sufficiently in advance of decision-making to allow the agency to assimilate public views into agency action. EPA, State, interstate, and substate agencies shall provide for early and continuing public consultation in any significant action covered by this part. Merely conferring with the public after an agency decision does not meet this requirement. In addition to holding hearings and meetings as specifically required in this chapter, a hearing or meeting shall be held if EPA, the State, interstate, or substate agency determines that there is significant public interest or that a hearing or meeting would be useful.

State of California Requirements

The California Environmental Quality Act (CEQA) suggests that early in the process of developing an environmental impact report or substitute environmental documentation (SED), a lead agency "consult directly with any person or organization it believes will be concerned with the environmental effects of the project." The term for such early public consultation is "scoping" (CEQA Guidelines section15083). To satisfy CEQA's recommendation to engage the public and interested parties in early consultation about the scope of the environmental analysis, a scoping meeting was held in Kings Beach, CA on July 15, 2008 and another held in South Lake Tahoe on July 17, 2008. A supplemental scoping meeting was held in South Lake Tahoe on August 12, 2009 to further describe the proposed basin plan amendment.

When the SED is complete in draft, CEQA Guidelines section15086 and the California Code of Regulations section 3775, et seq. for implementation of CEQA (California Code of Regulations, title 23, section 3778) require that this specifically includes consultation with public agencies. The consultation is to be with public agencies that have jurisdiction with respect to the project or that exercise authority over resources that may be affected by the project; specifically consultation with responsible agencies, trustee agencies, "any other state, federal, and local agencies which have jurisdiction by law with respect to the project or which exercise authority over resources which may be affected by the project"; any city or county bordering on an affected city or county; and Caltrans (CEQA Guidelines section15086). Further, the Water Boards' CEQA regulations require that when the draft SED is complete, the Board post a Notice of Filing on its website and commence a written comment period of at least 45 days, unless the Board reduces it to 30 days under "exceptional circumstances." The Board may refuse to consider any written comment received after the end of the noticed comment period (California Code of Regulations, title 23, section 3779(b)).

Newspaper notice: Basin plan amendments require notice by newspaper publication in a newspaper of general circulation within the affected county at least 45 days ahead of the hearing. Newspaper publication shall be at least once. Notice must be posted on the internet.

Additional publication requirements, required under the Bagley-Keene Open Meeting Act (Gov. Code §11125), are met by distributing Water Board agendas to city clerks and newspapers.

Response to Comments: The State and Water Boards' CEQA regulations require that the Board prepare written responses to significant environmental issues raised in written comments submitted during the noticed comment period, as well as in oral comments received at a public hearing held before the close of the comment period. At its discretion, the Board may respond orally or in writing to comments received after the comment period. Copies of written responses must be made available for public review prior to Board adoption of the SED. Written responses to comments from public agencies must be provided to those agencies at least 10 days prior to adoption of the SED.

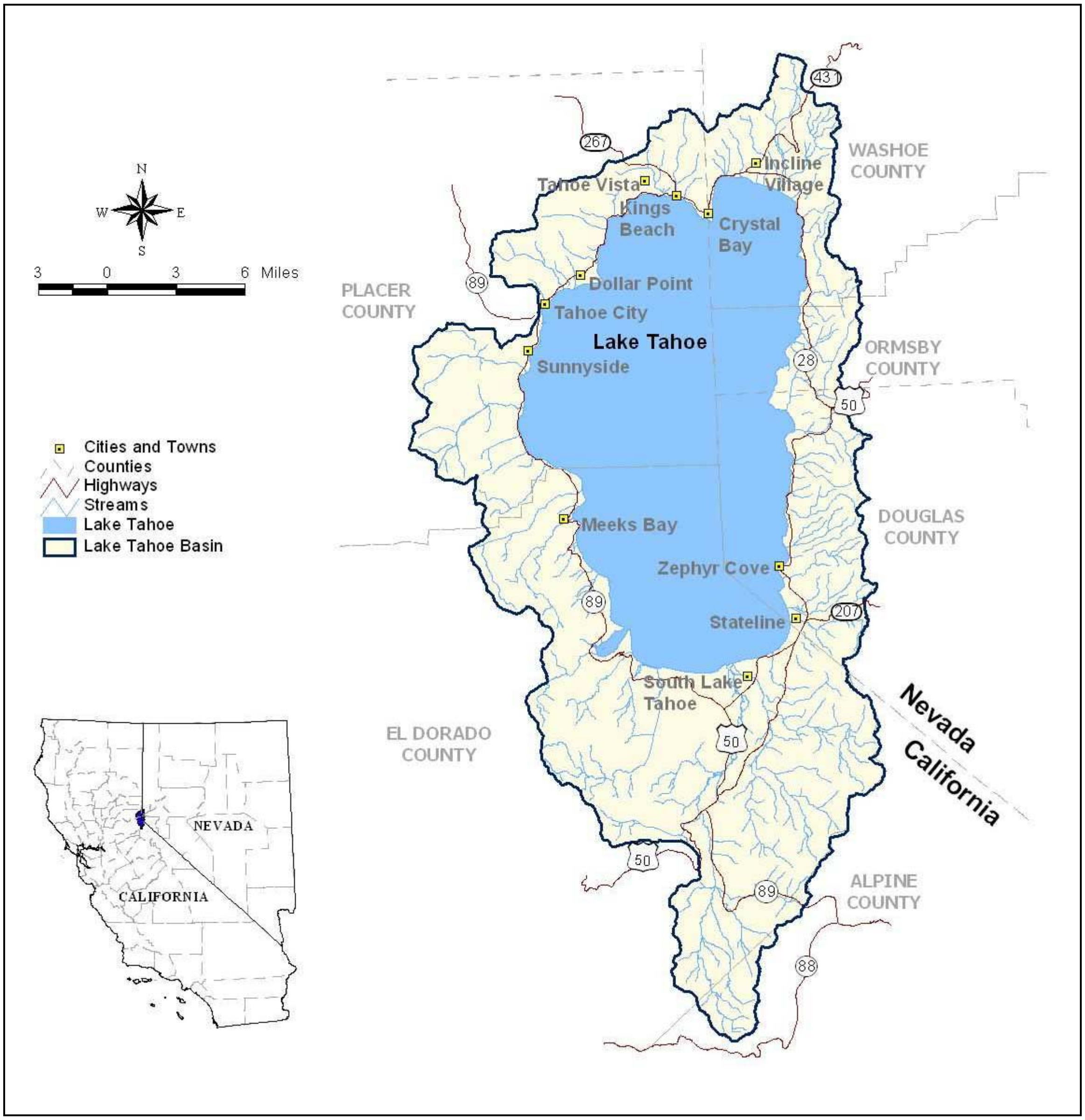

Figure 16-1. Lake Tahoe Watershed Location (Tetra Tech 2007)

16.5 Regulatory Framework

Agencies with permit review or approval authority over the implementation of reasonably foreseeable means of compliance include:

16.5.1 Federal regulatory agencies

National Oceanic Atmospheric Administration/National Marine Fisheries Service (NOAA/NMFS)

With the U.S. Fish and Wildlife Service (USFWS), conducts Endangered Species Act Section 7 consultation for effects to migratory and endangered fish species; enforces the Magnuson-Stevens Fishery Conservation and Management Act, under which it regulates projects that may have a significant effect on such species within the Tahoe basin.

U.S. Fish and Wildlife Service

With NOAA/NMFS, USFWS conducts Endangered Species Act Section 7 consultation for possible effects to listed federal species. The Services enforces the Endangered Species Act, the Migratory Bird Treaty Act, and the Bald and Golden Eagle Protection Act. Endangered, threatened, or candidate species in the Tahoe Basin include the Sierra red fox, mountain beaver, grizzly bear, bald eagle, peregrine falcon; osprey, goshawk, spotted owl, Lahontan cutthroat trout, and the Tahoe yellow cress.

16.5.2 California Regulatory Agencies

State Water Resources Control Board and Lahontan Regional Water Quality Control Board

The primary responsibility for water quality protection in California rests with the State Water Board and the nine Water Boards. The Water Board covering the Tahoe basin has jurisdiction that extends from the Oregon border to the northern Mojave Desert and includes all of California east of the Sierra Nevada Crest, including the California side of the Lake Tahoe basin. The Basin Plan is the Water Board's master planning document for water quality protection, providing the framework for permitting.

The State and Water Boards share responsibility for regulating stormwater discharges. The State Water Resources Control Board issues statewide National Pollutant Discharge Elimination System (NPDES) permits for the California Department of Transportation (Caltrans) for construction that disturbs more than one acre (Construction General Permit Order 2009-0009-DWQ; and for small municipal separate storm sewer systems (MS4s) under a General Permit for the Discharge of Storm Water from Small MS4s (WQ Order No. 2003-0005-DWQ).

The Water Board regulates stormwater discharges from the City of South Lake Tahoe and Placer and El Dorado counties under a single regional NPDES permit (Order R6T-2005-0026) to protect water quality at Lake Tahoe. The permit requires the three municipalities to develop and implement comprehensive Storm Water Management Plans, which provide the framework for local government storm water programs.

The NPDES municipal stormwater permit has a five-year update cycle. Following adoption of the TMDL, the Water Board will incorporate the TMDL's waste load allocations and associated milestone requirements into the permit, and require the co-permittees to amend their Storm Water Management Plans to (1) define baseline fine sediment, nitrogen, and phosphorus pollutant loads from each responsible jurisdiction; and (2) describe actions that will be taken annually to accomplish required 5-year pollutant load reductions. The statewide NPDES permit regulating discharges from the California Department of Transportation will also be amended to include similar planning and waste load allocation requirements.

The Water Board regulates other stormwater discharges in the Basin, including surface discharges from timber harvesting and grazing activities, through waste discharge requirements and waivers of waste discharge requirements for individual dischargers. Waste discharge requirements issued to a number of large commercial property owners require implementation of best management practices to address stormwater discharges.

California Department of Fish and Game

The Department issues permits for incidental takes of state listed species under Sections 2081(b) and (c) of the California Endangered Species Act, if specific criteria are met, and Section 2081 consultation for effects to listed species.

If the Department determines that an activity may substantially adversely affect fish and wildlife resources, the applicant must prepare a Stream Alteration Agreement that includes reasonable conditions necessary to protect those resources. Compliance with CEQA is also required.

16.5.3 Nevada Regulatory Agencies

When approved by the U.S. Environmental Protection Agency, the TMDL for Lake Tahoe will be a bi-state TMDL, effective in both California and Nevada. In Nevada, it will be implemented through regulatory action by the Nevada Division of Environmental Protection (NDEP).

Nevada Division of Environmental Protection

Following approval of the Lake Tahoe TMDL, the Nevada Division of Environmental Protection (NDEP) will regulate urban runoff on the Nevada side of the Basin through Memoranda of Agreement with Douglas and Washoe Counties and the Nevada Department of Transportation. The Memoranda will include requirements to estimate baseline pollutant loads, load allocations, and load reduction milestone and tracking requirements similar to those expected for the California municipal NPDES permits. The NPDES permit regulating discharges from the Nevada Department of Transportation will be amended to reference and specify compliance with the Memorandum, including applicable waste load allocations.

In the Lake Tahoe Basin, NDEP supports the Tahoe Regional Planning Agency's (TRPA's) approach to nonpoint source implementation, as expressed in TRPA's Regional Plan (see below).

16.5.4 Tahoe Regional Planning Agency

The Tahoe Regional Planning Agency (TRPA) was created by an act of Congress in 1969 as a bi-state planning agency with regulatory powers. TRPA is required by the Tahoe Regional Planning Compact (Public Law 96-551, 94 STAT. 3233-3253) to regulate activities within the Lake Tahoe basin that have the potential to substantially affect natural resources. Specifically, TRPA is empowered by the compact to "establish environmental threshold carrying capacities and to adopt and enforce a regional plan and implementing ordinances which will achieve and maintain such capacities."

TRPA has primary regulatory authority for air quality in the Lake Tahoe basin. It has implemented regulatory programs to reduce airborne pollutants discharged from wood burning stoves and reduce dust from active construction sites.

The TRPA Regional Plan, initially approved in 1987, guides all land-use decisions in the basin, providing the basis for TRPA's ordinances and environmental codes. The Regional Plan includes a Code of Ordinances; Transportation and Air Quality Plan; Goals and Policies; Water Quality Management Plan; Plan Area Statements; and the Scenic Quality Improvement Plan; it also addresses monitoring and capital improvements. The Regional Plan provides threshold standards and indicators for nine categories: water quality, air quality, noise, recreation, soil conservation, wildlife habitat, vegetation preservation, scenic quality, and fisheries. The thresholds, adopted in 1982, contain specific indicators and standards that are used to track, evaluate, and report the status of each category over time.

16.5.5 Local Municipal Regulatory Agencies

Placer and El Dorado counties and the City of South Lake Tahoe have ordinances that require conformance with TRPA requirements and CEQA review.

- In Placer County and in the City of South Lake Tahoe, all grading projects in the Basin require a letter of approval from TRPA, and must undergo project-level CEQA analysis, unless categorically exempt. Exempt projects are subject to technical review by the Engineering and Surveying Division. Additional requirements apply between October 15 and May 1.
- Tahoe Basin grading projects in El Dorado County must also conform to TRPA's rules and regulations, and comply with the county's Grading, Erosion, and Sediment Control Ordinance, Chapter 15.14 of the County Code unless specifically exempted. Grading work in the Basin is prohibited between October 15 and May 1 unless exempted. The Director of the Development Services Department may waive permit requirements for very small projects (3 cubic yards

16.6 Environmental Checklist and Analysis

Under the Water Boards' certified regulatory program for basin planning, the Regional Board must satisfy the requirements of California Code of Regulations, title 23, section 3777(a), which requires a written report that includes a description of the proposed activity, an alternatives analysis, and an identification of mitigation measures to minimize any significant adverse impacts. Section 3777(a) also requires the Water Board to complete an environmental checklist as part of its substitute environmental documents.

Additionally, the Board must comply with Public Resources Code section 21159 when adopting performance standards such as those in the proposed Basin Plan amendment. Section 21159 requires the environmental analysis to include: (1) the reasonably foreseeable environmental impacts of the method of compliance; (2) the reasonably foreseeable mitigation measures; and (3) the reasonably foreseeable alternative means of compliance with a rule or regulation. The analysis must take into account a reasonable range of environmental, economic, and technical factors, population and geographic areas, and specific sites. Section 21159 further states that the Regional Board is not required to engage in speculation or conjecture or to conduct a project-level environmental analysis.

While the Water Board will not directly undertake any actions that could physically change the environment, adoption of the proposed Basin Plan amendment will result in future actions by landowners, municipalities, and other agencies. Some compliance actions may result in physical changes to the environment. The environmental impacts of such changes are evaluated below, to the extent that they are reasonably foreseeable. Changes that are speculative in nature are difficult to analyze and, under CEQA, do not require environmental review.

The following sections contain the environmental checklist and analysis for the proposed Basin Plan amendment, and include the required analyses mentioned above. The explanation following the checklist provides details concerning the environmental impact assessment.

16.6.1 Environmental Impacts

The environmental factors checked below could be potentially affected by this project. See the checklist on the following pages for more details.

☐ Aesthetics	☐ Agriculture and Forestry Resources	☐ Air Quality
☐ Biological Resources	☐ Cultural Resources	☐ Geology/Soils

☐	Greenhouse Gas Emissions	☐	Hazards & Hazardous Materials	☐	Hydrology/Water Quality
☐	Land Use/Planning	☐	Mineral Resources	☐	Noise
☐	Population/Housing	☐	Public Services	☐	Recreation
☐	Transportation/Traffic	☐	Utilities/Service Systems	☐	Energy and Mineral Resources

1. AESTHETICS. Would the project:

Issues	Potentially Significant Impact	Less Than Significant With Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Have a substantial adverse effect on a scenic vista?	☐	☐	☐	☑
b) Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway?	☐	☐	☐	☑
c) Substantially degrade the existing visual character or quality of the site and its surroundings?	☐	☐	☐	☑
d) Create a new source of substantial light or glare that would adversely affect day or nighttime views in the area?	☐	☐	☐	☑

a-d) Scenic quality is a Tahoe Regional Planning Agency (TRPA) Threshold program area, and the 1987 Regional Plan (TRPA 1986) includes three numerical scenic threshold standards that are used to maintain scenic quality in the Tahoe basin. These standards are based on scenic units or use areas and apply to travel route ratings, scenic-quality ratings, and scenic quality of visual resources as seen from major public recreation areas and designated bicycle trails. The TRPA Code of Ordinances, Chapter 30 (Design Standards) requires that all projects and activities do not degrade the scenic quality thresholds.

2. AGRICULTURAL AND FOREST RESOURCES. Would the project:

Issues	Potentially Significant Impact	Less Than Significant With Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping & Monitoring Program of the California Resources Agency, to non-agricultural uses?	☐	☐	☐	☑
b) Conflict with existing zoning for agricultural use, or a Williamson Act contract?	☐	☐	☐	☑
c) Conflict with existing zoning for, or cause rezoning of, forest land (as defined in Public Resources Code section 12220(g)) or timberland (as defined by Public Resources Code section 4526)?	☐	☐	☐	☑
d) Result in the loss of forest land or conversion of forest land to non-forest use?	☐	☐	☐	☑

e) Involve other changes in the existing environment which, due to their location or nature, could result in conversion of Farmland, to non-agricultural use or conversion of forest land to non-forest use?	☐	☐	☐	☑

a, b) Based on land use policies in the TRPA Code of Ordinances (Chapter 18 - Permissible Uses) and the TRPA Plan Area Statements), there are no lands in the Lake Tahoe basin designated for agricultural uses. Therefore adoption of the Basin Plan amendment will not: a) reduce the fertility of soils in areas designated as Prime, Unique, or Farmland of Statewide Importance; b) conflict with existing zoning or a Williamson Act contract.

c-e) Forest lands in the Tahoe basin are managed by many agencies, including but not limited to the LTBMU, California State Parks, Nevada Division of State Lands, and the California Tahoe Conservancy. Implementing projects and activities as a result of the Basin Plan amendment are not expected to reduce the amount of forest land nor convert forest land to non-forest uses because it is expected that there will be projects that convert urban land uses to forest land. There will be no loss of or conversion of forest land to non-forest use.

Many urban parcels have been permanently converted to open space, prohibited from being developed, and therefore converted from urban land uses to forest land. According to information obtained from the LTBMU's website, www.fs.fed.us/r5/ltbmu, Congress passed Public Law 96-586, defined as the Santini-Burton Act, on December 23, 1980. In passing the Act, Congress declared that the environmental quality of the Lake Tahoe Basin was jeopardized by over-development of sensitive lands and that the unique character of the Lake Tahoe Basin is of national significance deserving further protection. Properties eligible for purchase under the Act are wetlands, stream environment zones, and steep and fragile lands. The first acquisition of land under the Act was recorded in October 1982. As of 2009, over 3,500 parcels (or Urban Lots) totaling 13,000 acres and valued at $105 million have been acquired under the authority of the Santini-Burton Act. Some recent significant acquisitions include more than a half-mile of lakefront and acreage at Secret Harbor; approximately 300 feet of beachfront on the south shore; and several large acreage parcels adjacent to existing National Forest System lands in the Kingsbury area.

2. AIR QUALITY. Would the project:

Issues	Potentially Significant Impact	Less Than Significant With Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Conflict with or obstruct implementation of the applicable air quality plan?	☐	☐	☐	☑
b) Violate any air quality standard or contribute substantially to an existing or projected air quality violation?	☐	☐	☑	☐

c) Expose sensitive receptors to substantial pollutant concentrations?	☐	☐	☐	☑
d) Result in a cumulatively considerable net increase of any criteria pollutant for which the project region is non-attainment under an applicable federal or state ambient air quality standard (including releasing emissions that exceed quantitative thresholds for ozone precursors)?	☐	☐	☐	☑
e) Create objectionable odors affecting a substantial number of people?	☐	☐	☐	☑

a) Adoption of the Basin Plan amendment will not conflict with the air quality plan for the Tahoe basin. On July 9, 1984, the state of California designated TRPA as the Regional Transportation Planning Agency for the California portion of the Tahoe region. The air quality plan for the Tahoe basin is contained across several components in the TRPA Regional Plan (TRPA 1986), including the TRPA Regional Transportation Plan and specific TRPA Ordinances. The TRPA adopted a Regional Transportation Plan on August 27, 2008, to reduce, to the extent feasible, air pollution that is caused by motor vehicles. TRPA Code of Ordinances, Chapter 91 (Air Quality Control) contains specific emission standards for stationary and mobile sources so the Tahoe basin air quality attains and maintains applicable state and federal air quality standards and TRPA thresholds.

According to the TRPA Threshold Evaluation Report (May 2006), the US Congress designated TRPA the Metropolitan Planning Organization for the Lake Tahoe region on January 1, 1999. The designation brought new federal planning responsibilities and requirements under 23 USC 134(b)(6) and Code of Federal Regulations 450.322, which includes the adoption of a long range transportation plan consistent with Section 172 of the Federal Clean Air Act as amended August 1977 (42 USC 1857 et seq.), the California Clean Air Act (chapter 15568, statutes of 1988), and the California State Government Code, section 65080(b).

b) Implementation of projects or actions as a result of the adopted Basin Plan amendment is not expected to violate an existing air quality standard nor contribute to an existing or potential air quality violation. The implementation will likely use heavy equipment, such as bulldozers, backhoes, graders, loaders, hauling trucks, street sweepers, and vactors trucks, which are typically powered with combustion engines. Construction activities are not expected to significantly increase as a result of this Basin Plan amendment, but maintenance actions will likely increase. Street sweepers and vactor trucks will likely be used more frequently, but the vehicle exhaust is not expected to significantly increase as compared to current levels of emissions from all vehicles in the Tahoe basin. The TRPA Regional Plan (1986) contains regulations in Chapter 91 of the TRPA Code of Ordinances for the purpose of attaining and maintaining applicable state and federal air quality standards and TRPA environmental thresholds. Specifically, Chapter 91 contains emission standards related to new stationary sources for particulate matter less than 10 micrometers in diameter (PM_{10}), nitrous oxides, and other constituents.

Fine particulate matter (PM_{10}) is the pollutant of greatest concern with respect to construction. PM_{10} emissions can result from a variety of construction activities, including excavation, grading, demolition, vehicle travel on paved and unpaved surfaces, and vehicle and equipment exhaust. Given the limited duration (i.e. typically during the summer construction season) and scale of reasonably foreseeable construction activities to comply with the Basin Plan amendment, PM_{10} standards, however, would not be violated. Additionally, if specific construction projects were proposed to comply with requirements derived from the proposed Basin Plan amendment, such projects would have to comply with TRPA requirements with respect to the operation of portable equipment. The TRPA has identified readily available measures to control construction-related air quality emissions that are routinely employed at most construction sites. These measures include watering active construction areas; covering trucks hauling soil; and applying water or applying soil stabilizers on unpaved areas. Therefore, in consideration of all of the foregoing, the Basin Plan amendment would not result in violations of any air quality standard or contribute substantially to any air quality violation, and its temporary construction-related air quality impacts would be less-than-significant.

c) Projects and activities implemented as a result of the Basin Plan amendment are not expected to expose sensitive receptors to substantial pollutant concentrations. Projects to be constructed will likely include stormwater improvements, stream restoration, and revegetation and erosion control measures, while typical actions include regular maintenance of stormwater facilities and cleaning paved roadways. The TRPA Regional Plan (1986) requires that these types of actions and projects implement dust control and appropriate best management practices which will not expose sensitive receptors to substantial pollutant concentrations.

d) Implementation of projects and activities as a result of the Basin Plan amendment are not expected to result in a cumulatively considerable net increase of any criteria pollutant for which the Tahoe region is not in attainment under an applicable federal or state ambient air quality standard. The TRPA 2006 Threshold Evaluation Report (TRPA 2007) identifies that the Lake Tahoe basin air quality is not in attainment with four specific standards: 1) carbon monoxide,2) ozone, 3) PM10, and 4) vehicle miles traveled. Although the report identifies non-attainment, the report also identifies existing programs that are expected to improve the air quality so each emission standard is achieved. The report also discloses that vehicle miles traveled in the Tahoe region has been decreasing over the past few years and are not expected to increase to levels seen in 1987 (when the TRPA Regional Plan was adopted).

e) Projects and activities implemented as a result of the Basin Plan amendment are not expected to release potentially objectionable odors. Expected projects, such as construction of erosion control projects, stream restoration, and urban stormwater improvements in the Tahoe region have not involved nor produced odors that may be considered objectionable to a substantial number of people.

3. BIOLOGICAL RESOURCES. Would the project:

Issues	Potentially Significant Impact	Less Than Significant With Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Have a substantial adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in local or regional plans, policies, or regulations, or by the DFG or USFWS?	☐	☐	☐	☑
b) Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, regulations or by the DFG or USFWS?	☐	☐	☐	☑
c) Have a substantial adverse effect on federally-protected wetlands as defined by Section 404 of the federal Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, *etc.*) through direct removal, filling, hydrological interruption or other means?	☐	☐	☐	☑
d) Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory corridors, or impede the use of native wildlife nursery sites?	☐	☐	☐	☑
e) Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?	☐	☐	☐	☑
f) Conflict with the provisions of an adopted Habitat Conservation Plan, Natural Community Conservation Plan, or other approved local, regional, or state habitat conservation plan?	☐	☐	☐	☑

a) Reasonably foreseeable compliance actions, such as erosion control projects, hillslope erosion protection projects, stream restoration, and revegetation of disturbed areas, will not have an adverse effect, either directly or through habitat modifications, on any species identified as a candidate, sensitive, or special status species in the TRPA Regional Plan. These types of projects and activities will improve the natural habitats by increasing the native vegetation, improving the natural water flow and enhancing and protecting the habitats of special status species, such as Tahoe Yellow Cress, Goshawks and Ospreys, and old growth forest stands. The TRPA Code of Ordinances contains regulations that protect state and federal candidate, sensitive, and special species. These regulations are in TRPA Code Chapters 50-54 (Shorezone protection standards) and Chapter 75 (Sensitive and Uncommon Plant Protection and Fire Hazard Reduction).

b) Reasonably foreseeable compliance actions, such as stream restoration projects, will not have a substantial adverse effect on any riparian habitat or other sensitive natural community. These projects improve the natural habitat of the riparian vegetation by increasing the connectivity of the floodplain and overbanking effects from the stream flows and by restoring the natural hydrologic function of the riparian area.

c) Reasonably foreseeable compliance actions, such as stream restoration, revegetation of disturbed areas, and installation of stormwater outflow devices, will not have a substantial adverse effect on federally-protected wetlands. These projects typically involve removal of fill from wetlands to improve riparian habitat.

d) Reasonably foreseeable compliance actions, such as stream restoration, revegetation of disturbed areas, and installation of stormwater outflow devices, will not interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory corridors, or impede the use of native wildlife nursery sites. These projects typically involve removal of fill from stream courses, replacement of culverts or pipes with arched or bottom-less culverts to improve fish passage, and planting of native vegetation to improve natural habitats.

e, f) Reasonably foreseeable compliance actions, such as erosion control projects, hillslope erosion protection projects, stream restoration, stormwater improvement projects, and revegetation of disturbed areas will not conflict with any local policies or ordinances protecting biological resources and habitat conservation plans. These types of projects must comply with the TRPA Code of Ordinances, which contains regulations that protect biological resources in Chapter 78 (Wildlife Resources), Chapter 79 (Fish Resources), and Chapter 74 (Vegetation Protection and Management).

4. CULTURAL RESOURCES. Would the project:

Issues	Potentially Significant Impact	Less Than Significant With Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Cause a substantial adverse change in the significance of a historical resource as defined in §15064.5?	☐	☐	☐	☑
b) Cause a substantial adverse change in the significance of an archaeological resource as defined in §15064.5?	☐	☐	☐	☑

c) Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?	☐	☐	☑	☐
d) Disturb any human remains, including those interred outside of formal cemeteries?	☐	☐	☑	☐

a-c) Projects and activities implemented as a result of the Basin Plan amendment are not expected to cause a substantial adverse change in the significance of an historic or archaelogical resource, nor destroy a unique paleontological resource or site or unique geologic feature. Reasonably foreseeable compliance projects, such as erosion control projects, hillslope erosion protection projects, stream restoration, stormwater improvement projects, and revegetation of disturbed areas, typically are constructed in areas of disturbed ground and do not involve construction of above-ground structures or destruction of an identified historic resource. Also, all projects proposing grading in excess of seven cubic yards must comply with TRPA Code of Ordinances, Chapter 29 (Historic Resource Protection), which prohibits actions from significantly altering an historic resource..

If, during the review and/or approval of specific implementation projects, it is found these resources or features may be present, the lead agency is required to assess whether the project will have an adverse impact on these resources within the project area, and if so, to mitigate that effect. If areas are identified where potential impacts cannot be mitigated to a level of insignificance, then these project areas may need to be avoided. Specific project proponents should contact the California Historic Resources Information Center through the State Office of Historic Preservation for information on whether the project area has been surveyed for cultural resources, or if the potential exists for cultural resources to be present. The Native American Heritage Commission should be contacted for a Sacred Lands File search. Lead agencies should include in their mitigation plans provisions for identification and evaluation of accidentally discovered archeological resources, per California Code of Regulations, title 14, section 15064.5(f).

If a specific implementation project affects state-owned historical resources, as described in Public Resources Code section 5024, and the lead agency is a state agency, the lead agency shall consult with the State Historic Preservation Officer as provided in Public Resources Code section 5024.5. Consultation should be coordinated in a timely fashion with the preparation of environmental documents.

d) Pursuant to California Code of Regulations, title 14, section 15064.5(d), when an initial study identifies the existence of, or the probable likelihood, of Native American human remains within the project, a lead agency shall work with the appropriate Native Americans as identified by the Native American Heritage Commission as provided in Public Resources Code section 5097.98, The applicant may develop an agreement for treating or disposing of, with appropriate dignity, the human remains and any items associated with Native American burials with the appropriate Native Americans as identified by the Native American Heritage Commission.

5. GEOLOGY and SOILS. Would the project:

Issues	Potentially Significant Impact	Less Than Significant With Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:	☐	☐	☐	☑
i) Rupture of a known earthquake fault, as delineated in the most recent Alquist-Priolo Earthquake Fault Zoning Map issued by the State Geologist for the area or based on other substantial evidence of a known fault? Refer to Division of Mines & Geology Special Publication 42.	☐	☐	☐	☑
ii) Strong seismic ground shaking?	☐	☐	☐	☑
iii)Seismic-related ground failure, including liquefaction?	☐	☐	☐	☑
iv) Landslides?	☐	☐	☐	☑
b) Result in substantial soil erosion or the loss of topsoil?	☐	☐	☐	☑
c) Be located on a geologic unit or soil that is unstable, or that would become unstable as a result of the project, and potentially result in on- or off-site landslide, lateral spreading, subsidence, liquefaction, or collapse?	☐	☐	☐	☑
d) Be located on expansive soils, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?	☐	☐	☐	☑
e) Have soils incapable of adequately supporting the use of septic tanks or alternate wastewater disposal systems where sewers are not available for the disposal of wastewater?	☐	☐	☐	☑

a) The Tahoe basin does not contain any faults delineated on the Alquist-Priolo Earthquake Fault Zoning Maps. Projects and activities implemented as a result of the Basin Plan amendment are not expected to expose people or structures to potential substantial adverse effects involving ground rupture from earthquakes, seismic ground shaking or ground failure, or landslides. Reasonably foreseeable compliance projects, such as erosion control projects, hillslope erosion protection projects, stream restoration, stormwater improvement projects, and revegetation of disturbed areas, do not involve construction of structures so there is little to no risk of exposing people to earthquake hazards. Also, all projects and activities must comply with TRPA Code of Ordinances Chapter 28 (Natural Hazard Standards), which sets forth requirements to protect public health and safety from natural hazards such as potential unstable ground and avalanche zones.

b) Specific projects involving earthmoving or construction activities to comply with requirements derived from the proposed Basin Plan amendment are reasonably foreseeable. Such activities must comply with TRPA Code of Ordinances Chapter 64 (Grading Standards) to prevent discharge of earthen material from the construction site. These specific compliance projects would be subject to the review and approval of the Regional Board and the TRPA, which require implementation of routine and standard erosion control best management practices and proper construction site management. In addition, construction projects over one acre in size would require a general construction National Pollutant Discharge Elimination System permit and implementation of a stormwater pollution prevention plan to control pollutant runoff such as sediment. Therefore, the Basin Plan amendment would not result in substantial soil erosion, and its impacts would be less than significant.

c-d) Local agencies proposing construction as a result of the Basin Plan amendment would be required to obtain all applicable permits to ensure that they do not locate structures on unsuitable soil, including expansive soil. Reasonably foreseeable projects are likely to include construction of stormwater detention and retention basins, stormwater conveyance and infiltration facilities, hillslope stabilization and protection, and stormwater facility upgrade and routine maintenance. TRPA Code of Ordinances Chapter 25 (Best Management Practices) and Chapter 64 (Grading Standards) require construction to be designed to minimize any potential for landslides, lateral spreading, subsidence, liquefaction, or collapse. Therefore, the Basin Plan amendment would not create safety or property risks due to unstable or expansive soils.

e) The Basin Plan amendment would not require wastewater disposal systems. California Water Code section 13950 prohibits land disposal of domestic wastewater within the Lake Tahoe basin and requires export of sewage from the basin. Therefore, affected soils need not be capable of supporting the use of septic tanks or alternative wastewater disposal systems.

6. GREENHOUSE GAS EMISSIONS -- Would the project:

Issues	Potentially Significant Impact	Less Than Significant With Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Generate greenhouse gas emissions, either directly or indirectly, that may have a significant impact on the environment?	☐	☐	☐	☑
b) Conflict with any applicable plan, policy or regulation of an agency adopted for the purpose of reducing the emissions of greenhouse gases?	☐	☐	☐	☑

a) Projects and activities implemented as a result of the Basin Plan amendment are not expected to generate greenhouse gas emissions, either directly or indirectly, that may have a significant impact on the environment. Reasonably foreseeable compliance projects, such as erosion control projects, hillslope erosion protection projects, stream restoration, stormwater improvement projects, and revegetation of disturbed areas, were evaluated qualitatively and determined to not generate additional greenhouse gases. Rather, these types of projects reduce greenhouse gases. These types of projects typically involve planting of native vegetation during restoring and revegetating disturbed areas, removing hard coverage and restoring with native vegetation, protecting hillslope erosion with planted vegetation, and constructing vegetated areas to treat stormwater runoff, all of which improve carbon sequestration with the added or enhanced native vegetation. Street sweepers and vactor trucks will likely be used more frequently to clean fine sediment from roads and from stromwater collection and treatment facilities, but the vehicle exhaust is not expected to significantly increase as compared to current levels of emissions from all vehicles in the Tahoe basin. The increased maintenance will be removing sediment, which is likely to result in some indirect increased carbon sequestration. Stormwater would have less sediment, as compared to runoff from streets and facilities that were not swept clean and vegetated areas receiving the runoff would be less likely to be covered with sediment, thereby allowing greater vegetative function because the vegetation would not be buried.

b) The Basin Plan amendment will not conflict with the TRPA's Lake Tahoe Regional Transportation Plan which includes six policies that indirectly focus on reducing emissions of greenhouse gases. These TRPA policies are goal statements, including items such as encouraging pedestrian transit oriented development, requiring design of pedestrian/bicycle friendly communities, and using intelligent transportation systems to increase use of alternative modes of transportation. Also, staff from TRPA, the Water Board, NDEP, US Forest Service, the California Tahoe Conservancy, and the Tahoe Transportation District is collaborating on a project to develop an organizational and operational framework for addressing climate change in the Tahoe basin action plan

7. HAZARDS and HAZARDOUS MATERIALS. Would the project:

Issues	Potentially Significant Impact	Less Than Significant With Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?	☐	☐	☐	☑
b) Create a significant hazard to the public or the environment through reasonably foreseeable upset and accident conditions involving the release of hazardous materials into the environment?	☐	☐	☐	☑

c) Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within ¼ mile of an existing or proposed school?	☐	☐	☐	☑
d) Be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code §65962.5 and, as a result, would it create a significant hazard to the public or to the environment?	☐	☐	☐	☑
e) For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or a public use airport, would the project result in a safety hazard for people residing or working in the project area?	☐	☐	☐	☑
f) For a project within the vicinity of a private airstrip, would the project result in a safety hazard for people residing or working in the project area?	☐	☐	☐	☑
g) Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?	☐	☐	☐	☑
h) Expose people or structures to a significant risk of loss, injury, or death involving wildland fires, including where wildlands are adjacent to urbanized areas or where residences are intermixed with wildlands?	☐	☐	☐	☑

a-d) Projects and activities implemented as a result of the Basin Plan amendment are not expected to involve hazardous material, either directly or indirectly, that may have a significant impact on the environment. Reasonably foreseeable compliance projects, such as erosion control projects, hillslope erosion protection projects, stream restoration, stormwater improvement projects, revegetation of disturbed areas, street sweeping, and routine maintenance of stormwater facilities, do not typically involve use of hazardous materials. However, TRPA Code of Ordinances (Chapters 64 & 65) requires implementation of best management practices during construction that will eliminate hazards to the public and the environment from transport, use, or disposal of hazardous materials. These practices include proper disposal and transport of contaminated soils. Proper handling in accordance with relevant laws and regulations will minimize hazards to the public or the environment, and the potential for accidents or upsets.

e-f) The Lake Tahoe Airport, owned and operated by the City of South Lake Tahoe, is located within the southern portion of the Lake Tahoe basin, within the area covered by the Basin Plan amendment. The City of South Lake Tahoe operates the Lake Tahoe Airport under an airport master plan (completed in cooperation with the Federal Aviation Administration, TRPA, and other interested parties in 1992). Projects or activities related (either directly or indirectly) to this Basin Plan amendment will not conflict with safety plan elements in the master plan. Therefore, no safety hazards as a result of the Basin Plan amendment are expected to occur.

g) Hazardous waste management activities resulting from the Basin Plan amendment would not interfere with any emergency response plans or emergency evacuation plans. Many agencies operating within the Lake Tahoe basin have emergency response plans or emergency evacuation plans and this Basin Plan amendment would not interfere with any parts of those plans. There are several agencies with emergency-type plans, such as spill response and hazardous material management: El Dorado County Environmental Management Department, California Department of Transportation, Nevada Department of Transportation, Health Departments of Placer County, Douglas County, Washoe County, US Forest Service, California Department of Fish and Game, US Coast Guard, US Department of Fish and Wildlife, local fire departments, California and Nevada Highway Patrols, and local police and sheriff departments.

h) The Basin Plan amendment would not affect the potential for wildland fires.

8. HYDROLOGY and WATER QUALITY. Would the project:

Issues	Potentially Significant Impact	Less Than Significant With Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Violate any water quality standards or waste discharge requirements?	☐	☐	☐	☑
b) Substantially deplete groundwater supplies or interfere substantially with groundwater recharge such that there would be a net deficit in aquifer volume or a lowering of the local groundwater table level (*e.g.*, the production rate of pre-existing nearby wells would drop to a level which would not support existing land uses or planned uses for which permits have been granted)?	☐	☐	☐	☑
c) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, in a manner which would result in substantial erosion or siltation on- or off-site?	☐	☐	☑	☐
d) Substantially alter the existing drainage pattern of the site or area, including through the alteration of the course of a stream or river, or substantially increase the rate or amount of surface runoff in a manner which would result in flooding on- or off-site?	☐	☐	☑	☐
e) Create or contribute runoff water which would exceed the capacity of existing or planned stormwater drainage systems or provide substantial additional sources of polluted runoff?	☐	☐	☑	☐
f) Otherwise substantially degrade water quality?	☐	☐	☐	☑
g) Place housing within a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map?	☐	☐	☐	☑

h) Place within a 100-year flood hazard area structures which would impede or redirect flood flows?	☐	☐	☑	☐
i) Expose people or structures to a significant risk of loss, injury, or death involving flooding, including flooding as a result of the failure of a levee or dam?	☐	☐	☐	☑
j) Inundation by seiche, tsunami, or mudflow?	☐	☐	☐	☑

a) The project amends the Basin Plan, which includes applicable water quality standards. Therefore, it will not violate standards or waste discharge requirements.

b) The Basin Plan amendment will not decrease groundwater supplies or interfere with groundwater recharge. Channel habitat enhancement projects to control channel incision, and/or the construction of facilities such as retention or detention basins, infiltration basins, or vegetated swales could result in increases in groundwater recharge.

c) Specific projects involving earthmoving or construction activities to comply with requirements derived from the proposed Basin Plan amendment are reasonably foreseeable. Such projects would typically be constructed in areas of existing development or dense, urban areas where the natural drainage has been previously altered. These types of project could affect existing drainage patterns. However, to meet proposed Basin Plan amendment allocations, each project would be designed to reduce overall soil erosion, not increase it. These types of reasonably foreseeable compliance projects also require implementation of routine and standard erosion control best management practices and proper construction site management to ensure there are no significant impacts from the temporary construction activity.

d) The Basin Plan amendment could: a) involve earthmoving that could affect existing drainage patterns; b) contribute to enhancement of baseflow during the dry season; and/or c) contribute to increases in the amount of riparian vegetation and/or large woody debris in stream channels to enhance habitat conditions. These actions should reduce flooding hazards. Reasonably foreseeable compliance actions, such as erosion control projects, stormwater facility construction, revegetation of disturbed areas, and street sweeping activities would not substantially increase impervious surfaces but is expected to remove coverage in many cases. These types of projects reduce fine sediment particle, nitrogen, and phosphorus loading from identified sources. Projects to achieve needed load reductions will, in effect, reduce flooding, and are expected to be environmentally beneficial.

e) The Basin Plan amendment will require urban stormwater dischargers to reduce fine sediment particle, nitrogen, and phosphorus loading from stormwater discharges. Reasonably foreseeable compliance activities are, by design, intended to decrease peak runoff rates from urban land uses to reduce fine sediment particle, nitrogen, and phosphorus input to surface waters. Therefore, the Basin Plan amendment would not increase the rate or amount of runoff, exceed the capacity of storm water drainage systems, or degrade water quality, and the impact is less than significant.

f) The purpose of the Basin Plan amendment is to reduce fine sediment particle, nitrogen, and phosphorus loading from identified sources to attain an overall load reduction for achieving a water quality standard. Projects and actions to achieve needed load reductions will be completed so the water quality standard (deep lake transparency) can be achieved. Reasonably foreseeable compliance actions include stormwater improvement projects, erosion control projects, hillslope erosion protection projects, stream restoration, revegetation of disturbed areas, and routine maintenance of stormwater treatment facilities and cleaning of paved roadways. These expected projects and actions will be conducted in compliance with required best management practices as part of an individual waste discharge permit (such as an NPDES stormwater construction permit, or a TRPA grading permit under TRPA Grading Ordinances in TRPA's Regional Plan) or other regulatory mechanism of acceptance. Such projects will be implemented for the specific purpose of improving water quality.

g-j) Projects and activities implemented as a result of the Basin Plan amendment are not expected to place housing within a 100-year flood hazard area as mapped on a federal Flood Hazard Boundary or Flood Insurance Rate Map or other flood hazard delineation map. All projects and activities must comply with TRPA Code of Ordinances Chapter 28 (Natural Hazard Standards), which sets forth requirements to protect public health and safety from natural hazards such as 100-year floodplains and other potentially unstable areas.

9. LAND USE AND PLANNING. Would the project:

Issues	Potentially Significant Impact	Less Than Significant With Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Physically divide an established community?	☐	☐	☐	☑
b) Conflict with any applicable land use plan, policy, or regulation of an agency with jurisdiction over the project (including, but not limited to, the general plan, specific plan, local coastal program, or zoning ordinance) adopted for the purpose of avoiding or mitigating an environmental effect?	☐	☐	☐	☑

Issues	Potentially Significant Impact	Less Than Significant With Mitigation Incorporated	Less Than Significant Impact	No Impact
c) Conflict with any applicable habitat conservation plan or natural community conservation plan?	☐	☐	☐	☑

a) Projects and activities implemented as a result of the Basin Plan amendment are not expected to physically divide an established community. Reasonably foreseeable projects such as stream restoration, erosion control, hillslope stabilization, stormwater control and treatment, and revegetation, are typically constructed at the ground surface or directly below ground surface. These project types normally do not contain walls or buildings that may divide an established community.

b-c) The Basin Plan amendment would not conflict with any land use plan, policy, or regulation, and would not conflict with any habitat conservation plan or natural community conservation plan. Specifically, these plans and programs include the TRPA Regional Plan, LTBMU Forest Plan, California Tahoe Conservancy programs, California State Parks programs, and California State Lands programs. The TRPA Regional Plan (1986) contains several land-use policy and planning documents, none of which conflicts with the Basin Plan amendment, including: Plan Area Statements (similar to zoning ordinances), Land-Use Ordinances, Code of Ordinances, Goals and Policies, and Community Plans.

10. MINERAL RESOURCES. Would the project:

Issues	Potentially Significant Impact	Less Than Significant With Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Result in the loss of availability of a known mineral resource that would be of future value to the region and the residents of the State?	☐	☐	☐	☑
b) Result in the loss of availability of a locally-important mineral resource recovery site delineated on a local general plan, specific plan, or other land use plan?	☐	☐	☐	☑

a-b) Projects and activities implemented as a result of the Basin Plan amendment are not expected to impact mineral resources in the Lake Tahoe region. The TRPA Regional Plan (1986) sets forth the ordinances and policies that regulate land-use in the Lake Tahoe Region. The TRPA Regional Plan does not identify any potential mineral resources in the Lake Tahoe region; mining is not an allowed or permissible use under TRPA Code of Ordinances, Chapter 18 (Permissible Uses).

11. NOISE. Would the project result in:

Issues	Potentially Significant Impact	Less Than Significant With Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Exposure of persons to, or generation of, noise levels in excess of standards established in the local general plan or noise ordinance, or applicable standards of other agencies?	☐	☐	☐	☑
b) Exposure of persons to, or generation of, excessive groundborne vibration or groundborne noise levels?	☐	☐	☐	☑
c) A substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project?	☐	☐	☐	☑
d) A substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project?	☐	☐	☐	☑
e) For a project located within an airport land use plan or, where such a plan has not been adopted, within two miles of a public airport or public use airport, would the project expose people residing in or working in the project area to excessive noise levels?	☐	☐	☐	☑
f) For a project within the vicinity of a private airstrip, would the project expose people residing in or working in the project area to excessive noise levels?	☐	☐	☐	☑

a) Earthmoving and construction could temporarily generate noise. Future projects that local agencies propose to comply with requirements derived from the Basin Plan amendment would not result in exposure of persons to, or generation of, noise levels in excess of standard in TRPA Code of Ordinances Chapter 23 (Noise Limitations).

b) To comply with requirements derived from the Basin Plan amendment, specific projects involving earthmoving or construction, which could result in temporary ground-borne vibration or noise, are reasonably foreseeable. The TRPA Code of Ordinances Chapter 23 (Noise Limitations) establishes limits on outdoor noise; regulates allowable levels of noise; and specifies a mechanism for enforcement.. Construction projects implemented as a result of the Basin Plan amendment would be required to comply with these local ordinances to keep noise levels to less-than-significant levels.

c) The Basin Plan amendment would not cause any permanent increase in ambient noise levels. The TRPA Code of Ordinances, Chapter 23, sets forth the requirements for projects and activities to comply with single noise event standards and to ensure that community noise equivalent levels are not exceeded. The expected projects and activities to be implemented as a result of the Basin Plan amendment will likely occur during the summer building season and will not continue throughout the calendar year, so there would not be a permanent increase in noise levels. Also, all equipment used during the construction process must comply with the TRPA single event noise standards.

d) To comply with requirements derived from the Basin Plan amendment, specific projects involving earthmoving or construction, which could result in temporary noise impacts, are reasonably foreseeable. Noise-generating operations would, however, have to comply with local noise ordinances to keep levels to less-than-significant levels.

e-f) The Basin Plan amendment would not cause any permanent increase in ambient noise levels, including aircraft noise. Therefore, it would not expose people living within an area subject to an airport land use plan or in the vicinity of a private airstrip to excessive noise.

12. POPULATION AND HOUSING. Would the project:

Issues	Potentially Significant Impact	Less Than Significant With Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Induce substantial population growth in an area either directly (*e.g.*, by proposing new homes and businesses) or indirectly (*e.g.*, through extension of roads or other infrastructure)?	☐	☐	☐	☑
b) Displace substantial numbers of existing housing, necessitating the construction of replacement housing elsewhere?	☐	☐	☐	☑
c) Displace substantial numbers of people, necessitating the construction of replacement housing elsewhere?	☐	☐	☐	☑

a-c) Projects and activities implemented as a result of the Basin Plan amendment are not expected to induce substantial population growth in the Tahoe basin. Reasonably foreseeable compliance actions, such as erosion control projects, revegetation of disturbed areas, stream restoration, street sweeping, and routine maintenance of stormwater facilities, does not typically involve housing either directly or indirectly. It is unlikely, but possible that load reduction projects may involve the removal of existing housing from sensitive lands and relocating housing structures (and inhabitants) to appropriate lands within the Tahoe basin. However, such relocation and replacement projects would be done as part of a project to improve stormwater treatment.

13. PUBLIC SERVICES. Would the project result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service rations, response times or other performance objectives for any of the public services:

Issues	Potentially Significant Impact	Less Than Significant With Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Fire protection?	☐	☐	☐	☑
b) Police protection?	☐	☐	☐	☑
c) Schools?	☐	☐	☐	☑
d) Parks?	☐	☐	☐	☑
e) Other public facilities?	☐	☐	☐	☑

a-e) Reasonably foreseeable construction projects, such as stream restoration, erosion control, stormwater treatment, hillslope protection and stabilization, and revegetation of disturbed areas are intended to improve water quality and will not conflict with the objectives of public services. Projects and activities implemented as a result of the Basin Plan amendment are not expected to result in substantial adverse impacts associated with the provision of new or physically altered government facilities.

14. RECREATION. Would the project:

Issues	Potentially Significant Impact	Less Than Significant With Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Increase the use of existing neighborhood and regional parks or other recreational facilities such that substantial physical deterioration of the facility would occur or be accelerated?	☐	☐	☐	☑
b) Include recreational facilities or require the construction or expansion of recreational facilities that might have an adverse physical effect on the environment?	☐	☐	☐	☑

a-b) The reasonably foreseeable projects and activities implemented as a result of the Basin Plan amendment are not expected to increase the use of existing neighborhood and regional parks or other recreational facilities. The typical expected projects, such as erosion control projects, stream restoration, revegetation, street sweeping, and stormwater facility maintenance, are stormwater improvements and are not related to increasing the use of parks..

15. TRANSPORTATION / TRAFFIC. Would the project:

Issues	Potentially Significant Impact	Less Than Significant With Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Exceed the capacity of the existing circulation system, based on an applicable measure of effectiveness (as designated in a general plan policy, ordinance, etc.), taking into account all relevant components of the circulation system, including but not limited to intersections, streets, highways and freeways, pedestrian and bicycle paths, and mass transit?	☐	☐	☐	☑
b) Conflict with an applicable congestion management program, including, but not limited to level of service standards and travel demand measures, or other standards established by the county congestion management agency for designated roads or highways?	☐	☐	☐	☑
c) Result in a change in air traffic patterns, including either an increase in traffic levels or a change in location that results in substantial safety risks?	☐	☐	☐	☑
d) Substantially increase hazards due to a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?	☐	☐	☐	☑
e) Result in inadequate emergency access?	☐	☐	☐	☑
f) Conflict with adopted policies, plans, or programs supporting alternative transportation (e.g., bus turnouts, bicycle racks)?	☐	☐	☐	☑

a,b,f) Projects and activities implemented as a result of the Basin Plan amendment are not expected to cause an exceedance of the capacity of the existing transportation/traffic circulation system. Adoption of the Basin Plan amendment will not conflict with the congestion management plans, which are part of the transportation plan for the Tahoe basin. Reasonably foreseeable projects, such as erosion control projects, stream restoration, revegetation of disturbed areas, street sweeping, and stormwater facility maintenance, are not expected to increase the capacity of the transportation system. However, it is expected that some roads, specifically some unpaved roads, may be taken out service (decommissioned) and those areas restored to natural conditions.

On July 9, 1984, the state of California designated TRPA as the Regional Transportation Planning Agency for the California portion of the Tahoe region. According to the TRPA Threshold Evaluation Report (May 2006), the US Congress designated TRPA the Metropolitan Planning Organization for the Lake Tahoe region on January 1, 1999. The designation brought new federal planning responsibilities and requirements under 23 USC 134(b)(6) and Code of Federal Regulations 450.322, which includes the adoption of a long range transportation plan consistent with Section 172 of the Federal Clean Air Act as amended August 1977 (42 USC 1857 et seq.), the California Clean Air Act (chapter 15568, statutes of 1988), and the California State Government Code, section 65080(b).

c) The Basin Plan amendment is not expected to increase air traffic levels and will not result in substantial safety risks. The Lake Tahoe Airport, owned and operated by the City of South Lake Tahoe, is located within the southern portion of the Lake Tahoe basin, within the area covered by the Basin Plan amendment. The City of South Lake Tahoe operates the Lake Tahoe Airport under an airport master plan (completed in cooperation with the Federal Aviation Administration, TRPA, and other interested parties in 1992). Projects or activities related (either directly or indirectly) to this Basin Plan amendment will not have any impact on the air space over the Lake Tahoe basin or on the operations of the Lake Tahoe Airport.

d) Projects and activities implemented as a result of the Basin Plan amendment are not expected to impact the hazards nor involve changes in design features related to the design feature of roads, such as sharp curves or blind intersections. Reasonably foreseeable compliance actions are likely to be erosion control projects, stream restoration, revegetation of disturbed areas, street sweeping, and maintenance of stormwater facilities, do not involve design of roadways or related hazards.

e) Projects and activities implemented as a result of the Basin Plan amendment are not expected to involve alterations to emergency access.

16. UTILITIES AND SERVICE SYSTEMS. Would the project:

Issues	Potentially Significant Impact	Less Than Significant With Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board?	☐	☐	☐	☑
b) Require or result in the construction of new water or wastewater treatment facilities or expansion of existing facilities, the construction of which could cause significant environmental impacts?	☐	☐	☐	☑
c) Require or result in the construction of new storm water drainage facilities or expansion of existing facilities, the construction of which could cause significant environmental impacts?	☐	☐	☑	☐
d) Have sufficient water supplies available to serve the project from existing entitlements and resources, or are new or expanded entitlements needed?	☐	☐	☐	☑
e) Result in a determination by the wastewater treatment provider that serves or may serve the project that it has adequate capacity to serve the project's projected demand in addition to the provider's existing commitments?	☐	☐	☐	☑
f) Be served by a landfill with sufficient permitted capacity to accommodate the project's solid waste disposal needs?	☐	☐	☐	☑

g) Comply with federal, state, and local statutes and regulations related to solid waste?	☐	☐	☐	☑

a-b) Implementation of the Basin Plan amendment is related to stormwater pollution control, and will have no impact on existing wastewater requirements of the Regional Board,

c) Projects and activities that are implemented as a result of the Basin Plan amendment may result in construction of new stormwater drainage facilities or the expansion of existing facilities. However, each construction proposal, which must conform to TRPA grading ordinances, shall be reviewed separately on its own merits. Because a separate environmental review process must occur for each proposal, this Basin Plan amendment will not directly or indirectly cause a significant environmental impact.

d-e) Projects and activities implemented as a result of the Basin Plan amendment are not expected to require additional water supplies or wastewater treatment capacity. Reasonably foreseeable projects may include stream restoration, erosion control, stormwater collection and treatment, hillslope stabilization and protection, revegetation of disturbed areas, routine maintenance of stormwater facilities, and cleaning of paved roadways. Projects that involve revegetation may require temporary water supply to irrigate and establish vegetation, but such watering is expected to be necessary only during the first or second growing season and may last a few months at most. This temporary watering is not expected to impact the water supply services.

f-g) Projects and activities implemented as a result of the Basin Plan amendment may generate solid waste. The TRPA Regional Plan and the Water Board Basin Plan prohibit discharge of solid waste to lands within the Tahoe region. All solid waste is exported to locations outside of the Tahoe basin...

17. MANDATORY FINDINGS OF SIGNIFICANCE.

Issues	Potentially Significant Impact	Less Than Significant With Mitigation Incorporated	Less Than Significant Impact	No Impact
a) Does the project have the potential to degrade the quality of the environment, substantially reduce the habitat of a fish or wildlife species, cause a fish or wildlife population to drop below self-sustaining levels, threaten to eliminate a plant or animal community, reduce the number or restrict the range of a rare or endangered plant or animal or eliminate important examples of the major periods of California history or prehistory?	☐	☐	☑	☐

b) Does the project have impacts that are individually limited, but cumulatively considerable? ("Cumulatively considerable" means that the incremental effects of a project are considerable when viewed in connection with the effects of past projects, the effects of other current projects, and the effects of probable future projects)	☐	☐	☑	☐
c) Does the project have environmental effects that will cause substantial adverse effects on human beings, either directly or indirectly?	☐	☐	☐	☑

a) When taken as a whole, reasonably foreseeable projects and activities implemented as a result of the Basin Plan amendment are not expected to substantially degrade the quality of the environment. These types of projects, such as erosion control projects, stream restoration, revegetation of disturbed areas, street sweeping, and stormwater facility maintenance will benefit water quality and the environment as a whole by reducing fine sediment particle, nitrogen, and phosphorus loading to Lake Tahoe.

b) Reasonably foreseeable projects or activities implemented as a result of the Basin Plan amendment are not expected to have cumulatively considerable impacts, even when applied to past projects that may have had an effect on the environment. These types of reasonably foreseeable compliance projects, such as as erosion control projects, stream restoration, revegetation of disturbed areas, street sweeping, and stormwater facility maintenance will benefit water quality and the environment as a whole by reducing fine sediment particle, nitrogen, and phosphorus loading to Lake Tahoe.

c) The Basin Plan amendment would not cause any substantial adverse effects to human beings, either directly or indirectly. Reasonably foreseeable compliance actions, such as erosion control projects, revegetation of disturbed areas, stream restoration, street sweeping, and routine stormwater facility maintenance, do not typically cause substantial adverse effects on human beings.

16.7 Alternatives Considered

a) Alternative 1: No Action/No Basin Plan amendment (No Project).

b) Alternative 2: 20 years to Clarity Challenge, 65 years to restore transparency.

c) Alternative 3: 40 years to Clarity Challenge, 65 years to restore transparency.

In defining and presenting reasonable alternatives to the proposed Basin Plan amendment, we discuss how each alternative could affect foreseeable environmental outcomes, and the extent to which each alternative would achieve the project objectives. A discussion of the preferred alternative, the Proposed Basin Plan amendment, is provided at the end of the alternatives discussion. In addition, we briefly discuss three alternative regulatory approaches, which we considered and rejected.

To be considered under the requirements of the CEQA, alternatives must “feasibly attain most of the basic objectives of the project but…avoid or substantially lessen any of the significant effects of the project” (CEQA Guidelines §15126.6(a)). Similarly, in §15126.6(b) the Guidelines interpret Public Resources Code §21002.1 as follows: “the discussion of alternatives shall focus on alternatives to the project…which are capable of avoiding or substantially lessening any significant effects of the project, even if these alternatives would impede to some degree the attainment of the project objectives, or would be more costly.”

The project’s main objectives are to reach the Clarity Challenge by implementation year 20 and within 65 years, achieve the goal of 97.4-foot Secchi depth transparency in Lake Tahoe’s deep water.

16.7.1 Alternative 1: No Action/No Basin Plan amendment (No Project)

CEQA requires the Lead Agency to evaluate “the no-project alternative.” Under this scenario the Regional Board would not amend the Basin Plan to adopt the proposed fine sediment particle, total nitrogen, or total phosphorus TMDL targets or allocations. Some new implementation activities might be initiated under existing Regional Board authority. For example, the Regional Board could issue waste discharge requirements or NPDES stormwater permits in the absence of a TMDL project, but in the absence of a TMDL, these permitting actions cannot specify a load reduction target. Permits can require a discharger or responsible party to reduce pollutant loads without specifying a load reduction percentage. Consequently, this alternative would not enable the Regional Board to determine if adequate progress is being made in reducing loads. It would not be possible to link implementation progress with a transparency response in the deep water of Lake Tahoe because the transparency response is based on a basin-wide load and discharge-specific sampling cannot add up to the basin-wide load. Individual discharge points cannot be correlated to a basin-wide load because the loads comes from a variety of sources (atmosphere, stream channel erosion, forest, and urban) and the precipitation varies throughout the year and by location within the Tahoe basin.

Under the no-project alternative the Basin Plan would retain its current focus on nutrient loads to Lake Tahoe as the cause of the transparency decline, and on reducing those loads. There would be no acknowledgement in the Water Board’s master planning document our current understanding of sediment as the primary source of phosphorus to the Lake, or of the role that fine sediment particles (less than 16 micrometers in diameter) plays in affecting deep water transparency.

Existing concentration-based numeric effluent limits for stormwater runoff would be retained as the primary compliance objective. Those limits, which apply to all stormwater runoff at all times, do not account for storm event variability and do not recognize any correlation between pollutant loads into the Lake and transparency. Implementers would likely continue to construct stormwater improvement projects under this alternative, but the Regional Board could not require them to design for, or achieve, specific load reductions from such projects.

Because Lake Tahoe is listed as impaired by its loss of transparency, under the no-project alternative the U.S. Environmental Protection Agency would be required to impose a total maximum daily load for fine sediment, nitrogen, and phosphorus in the Basin. The Regional Board would then be required to develop an implementation plan to achieve the TMDL. TMDL implementation would likely be delayed for an unknown period of time. Negative impacts associated with this alternative are greater than with the proposed project because implementation actions would be delayed while fine sediment particle discharges continue.

16.7.2 Alternative 2: 20 years to Clarity Challenge, 65 years to restore transparency.

This alternative is the proposed project, which includes adoption of the proposed Basin Plan amendments. These amendments attain project objectives and the transparency standard by year 65. Under this alternative, the Regional Board will set load reduction requirements for each of the four main source categories (urban, forest, atmosphere, and stream channel erosion) every five years until the target is attained at 65 years. The first three load reduction percentages (years 5, 10, 15) are set to achieve the Clarity Challenge at year-20. The Clarity Challenge is defined as 77 to 80 feet of deep water transparency.

The schedule of load reductions for the first 15 years is based on a comprehensive evaluation, documented in the Pollutant Reduction Opportunity Report (Lahontan and NDEP 2008a) and the Integrated Water Quality Management Strategy Project Report (Lahontan and NDEP 2008b). Load reduction requirements for each five years after year 15, from year 15 through year 65, are established based on the assumption that achieving additional load reduction every year will become increasingly difficult; therefore the rate of load reduction is calculated to slow over time.

The Water Board and NDEP, in cooperation with TRPA, the LTBMU, and numerous other stakeholders, have developed the first 15-year load reduction schedule to achieve the Clarity Challenge. Assuming the level of funding for implementing water quality improvement projects in the Tahoe Basin continues at levels similar to spending over the past 20 years, the Water Board expects that the 20-year Clarity Challenge can reasonably be achieved.

The Water Board and NDEP anticipate using the Lake Clarity Crediting Program to plan and track progress in attaining urban load reduction requirements. The Crediting Program includes tools (e.g. the Pollutant Load Reduction Model, Rapid Assessment Methodologies, and the Accounting and Tracking Tool) that urban jurisdictions can use to plan, implement, and quantify local annual load reduction progress. The Crediting Program may be used for the other three source categories as well, following development of quantifiable methodologies appropriate for projects and activities related to those source categories.

16.7.3 Alternative 3: 40 years to Clarity Challenge, 65 years to restore transparency

Except for a load reduction schedule that is different from the schedule under Alternative 2, this alternative includes the same Basin Plan amendments as proposed in the Project. Under this alternative, twice as much time would be allowed to achieve Clarity Challenge transparency as compared to the schedule under Alternative 2.

This alternative is estimated to cost implementing parties more to reach the Clarity Challenge, as compared to Alternative 2. Assuming that costs to achieve load reductions will increase over time because of inflation, the overall (cumulative) cost of achieving the target transparency is expected to be much higher in this alternative than under Alternative 2.

The Lake Clarity Crediting Program and its related tools are expected to be fully viable under this Alternative. However, this alternative expects to meet the Clarity Challenge at 40 years, which does not meet the project objective of achieving the Clarity Challenge in 20 years.

16.8 Selection of the Preferred Alternative (Alternative 2)

Alternative 1 (No Project) does not contain plans to reduce fine sediment loads for achieving the transparency standard and continues to rely on concentration-based numeric effluent limits for stormwater, and reduction of nutrients to the Lake, to restore transparency. Alternative 1 provides no correlation between project implementation and transparency response and flexibility to project implementers in reducing annual pollutant loads.

Both Alternatives 2 & 3 would result in attainment of the Clarity Challenge and transparency standard. As such, they both meet all the project objectives. However, Alternative 3 would result in Clarity Challenge attainment timeframe that is 20 years protracted from Alternative 2. As stated above, a protracted timeline for attainment is expected to increase overall expenditures to achieve the goal. Moreover, the 20 year Clarity Challenge was developed in conjunction with stakeholder input, and both in consideration of previous expenditures for water quality improvements implemented through the Environmental Improvement Program and consistency with the 20 year planning horizon to which the TRPA, a critical partner in TMDL implementation, is subject. For these reasons, Alternative 2 was selected as the preferred alternative

16.9 Alternative Regulatory Approaches, Considered and Rejected

16.9.1 Undertake a Use Attainability Analysis Instead of a TMDL

Fine sediment particles, nitrogen, and phosphorus loads into Lake Tahoe have reduced deep water transparency. Transparency is an aesthetic characteristic of the deep water column, which is related to the non-contact beneficial use of the lake.

As allowed by 40 CFR 131.10(g)(1-6), the Water Board may undertake a “use attainability analysis,” (i.e., remove a beneficial use from the Basin Plan), rather than a TMDL, in certain types of situations, including:

(1) Naturally occurring pollutant concentrations prevent the attainment of the use (g)(1)

(2) Human caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place (g)(3)

(3) Dams, diversions or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or to operate such modification in a way that would result in the attainment of the use (g)(4)

A Use Attainability Analysis is not applicable at this time because the above three conditions do not apply, as described, below:

(1) Fine sediment particles are not “naturally occurring pollutants”, because stormwater runoff from unaltered the forest lands does not contain many fine sediment particles, as compared to the stormwater runoff from urban lands

(2) Association of fine sediment particles with urban land uses tells us the causes of this pollution are indeed human-caused, and technology exists to reduce the pollutant load from those human activity sources.

(3) There are no dams, diversions or other types of hydrologic modifications contributing to sediment or nutrient pollutant loads into Lake Tahoe.

16.9.2 Set Site Specific Objectives for Fine Sediment Particles, Total Nitrogen, and Total Phosphorus in the Lake Tahoe watershed

An action to set a site-specific objective modifies a regional water quality objective to address a local condition or conditions. Such an objective must be set at a level that will protect all beneficial uses in the watershed or waterbody. The Basin Plan contains Lake Tahoe watershed objectives for suspended sediment concentration, total nitrogen, and total phosphorus, which apply to the lake itself and all the tributaries. These objectives, however, are concentration-based. With concentration-based objectives, it would not be possible to link implementation progress with a transparency response in the deep water of Lake Tahoe because the transparency response is based on a basin-wide load. Discharge-specific sampling cannot add up to the basin-wide load. Individual discharge points cannot be correlated to a basin-wide load because the loads comes from a variety of sources (atmosphere, stream channel erosion, forest, and urban) and the precipitation varies throughout the year and by location within the Tahoe basin.

Site specific objectives do not account for the variability of storm events, and they have no relation or correlation with the annual transparency standard that the TMDL addresses. The proposed TMDL establishes new objectives based on annual pollutant load.

16.10 California Health & Safety Code section 57004: Peer Review

In conformance with requirements in California's Health and Safety Code section 57004, the Water Board submitted the draft Lake Tahoe TMDL report along with the draft Lake Tahoe TMDL Technical report, the Pollutant Reduction Opportunity report, the Integrated Water Quality Management Strategy report, a summary of the proposed Basin Plan amendments, and copies of all the electronic document references related to the Lake Tahoe TMDL that we have in our files, for peer review of the scientific basis of the TMDL. The peer reviewers were Prof. Patrick L. Brezonik, Department of Civil Engineering, University of Minnesota; Prof. Menachem Elimelech, Department of Chemical Engineering, Yale University; Prof. Thomas M. Holsen, Department of Civil and Environmental Engineering, Clarkson University; Prof. William M. Lewis, Jr., Center for Limnology, University of Colorado at Boulder; and Prof. John Melack, Bren School of Environmental Science and Management, University of California at Santa Barbara.

The peer reviewers' responses confirmed that the scientific portion of the proposed water quality objectives are based on sound scientific knowledge, methods, and practices, and thus satisfy California Health and Safety Code section 57004. The five peer reviewers did provide any statements indicating that the science does not support the basis of the TMDL. The following are excerpts of summary statements from each of the five peer reviews supporting this conclusion:

Professor Brezonik:

> Overall, my conclusion is that the work was performed carefully with considerable amount of oversight and review. State of the art techniques were employed in data collection and analysis and in the various modeling efforts. The reputations of the leading participants are sound, and many of the individuals, firms and institutions involved are well known internationally and highly respected in their fields. The study has involved considerable public input and stakeholder involvement, and much attention has been paid to developing a long-term strategy for the

implementation plan that appropriately involves a sophisticated adaptive management strategy.

The watershed and in-lake modeling efforts used current modeling techniques and are impressive in their attention to detail. Although I describe some technical issues and concerns about the methods and results of these modeling efforts later in this review, I want to emphasize here that I recognize the huge amount of work that went into these components of the TMDL study and believe they constitute a "state-of-the science" effort.

Professor Holsen:

The Draft Lake Tahoe Total Maximum Daily Load (June 2009) is a well-written document that explains, synthesizes and summarizes an extremely large and complex group of studies. Leading up to this report separate, extensive investigations of many aspects of the Lake Tahoe ecosystem with regards to water clarity were carried out. Portions of this prior work have undergone extensive peer-review (for example the Lake Tahoe Atmospheric Deposition Study). Clearly there are still many unanswered questions however, taken as a whole, I believe the scientific portion of t*he proposed rule is based upon sound, state-of-the-art, scientific and technical knowledge, methods, and practices.*

Professor Lewis

Overall, the TMDL and its supporting documentation is a very impressive body of work. It is rare that such a strong fundamental scientific basis is combined with a detailed analysis of source control, prediction of outcomes, and allocation of resources.

Professor Elimelech

The Lake Tahoe TMDL report is well presented. It clearly states the problem and objectives, provides the necessary background, presents the methodology used to arrive at the plan to attain the TMDL Clarity Challenge, and outlines the implementation steps that need to be taken. The Final Report also refers to the relevant reports and documents when needed. Overall, I find the report to be technically sound and of high quality.

Professor Melack

The process of developing the Lake Tahoe TMDL and the product is scientifically sound and credible. By building on a long period of research with many peer-reviewed publications and by conducting focused studies to augment and synthesize prior information, the TMDL is well supported. Modeling plays a significant part in the determination of the TMDL and is based on established approaches; the models are examined with appropriate sensitivity analyses.

Each of the five reviewers raised some questions and concerns about specific components in the draft TMDL. Consequently, Water Board and NDEP staff made some changes and clarifications in the draft text to clarify technical points and elucidate procedural steps in the TMDL. However, the questions and clarifications from the peer reviewers did not raise concern about the soundness of the scientific basis supporting the TMDL. Appendix B in this report contains all peer review comments and our responses to the significant comments and questions raised by the reviewers.

16.11 Economic Considerations

16.11.1 Introduction

The California Environmental Quality Act requires that whenever one of California's nine Regional Water Quality Control Boards, such as the Lahontan Regional Water Quality Control Board (Water Board), adopts a rule that requires the installation of pollution control equipment or establishes a performance standard or treatment requirement, it must conduct an environmental analysis for reasonably foreseeable methods of compliance (Public Resources Code §21159 [a][1]). This analysis must take into account a reasonable range of factors, including economics. The proposed *Lake Tahoe Total Maximum Daily Load Basin Plan Amendment* includes performance standards (i.e., load allocations), and therefore requires the consideration of economic factors.

In amending the Basin Plan, the Water Board must analyze the reasonably foreseeable methods of compliance with proposed performance standards and treatment requirements (Pub. Resources Code §21000 et seq.). This analysis must include economic factors, but does not require cost-benefit analysis.

Additionally, in accordance with the Porter-Cologne Water Quality Control Act, it is the policy of the state to protect the quality of all waters of the state. Waters of the state include "any surface water or groundwater, including saline waters, within the boundaries of the state" (CWC §13050). The Porter-Cologne Act, the Legislature declares that all values of the water should be considered:

> The Legislature further finds and declares that activities and factors which may affect the quality of the waters of the state shall be regulated to attain the highest water quality which is reasonable, considering all demands being made and to be made on those waters and the total values involved, beneficial and detrimental, economic and social, tangible and intangible" (CWC §13000).

The Porter-Cologne Act directs regulatory agencies to pursue the highest water quality that is reasonable, and *one* of the factors used to determine what is reasonable is economics. It is clear, though, that economic factors cannot be used to justify a result that would be inconsistent with the federal Clean Water Act or the Porter-Cologne Act. The Water Board is obligated to restore and protect water quality and beneficial uses.

16.11.2 Cost Estimates

The Water Board and NDEP staff worked with regional and local experts to estimate the cost of implementing various pollutant control measures on a basin-wide scale associated with adoption of the proposed Basin Plan amendment. The cost estimates did not consider specific projects at specific sites, but looked at general types of projects that are reasonable foreseeable. The cost estimate values for these reasonably foreseeable compliance actions were aggregated to generate a total cost estimate for implementing actions to achieve the Clarity Challenge within the first fifteen-year phase of the Lake Tahoe TMDL. These cost estimates reflect both capital and annual operations and maintenance costs, including planning, design, acquisition, and replacement cost when the useful life of a given control measure is less than 20 years. Additional detail regarding estimated implementation costs can be found in the *Lake Tahoe TMDL Pollutant Reduction Opportunity Report* (Lahontan and NDEP 2008a).

Implementing actions to achieve the Clarity Challenge target within the first fifteen years are estimated to involve a capital investment of approximately $1.5 billion. All values are in 2007/2008-equivalent dollars. The majority of costs, $1.3 billion, are for urban runoff pollutant controls. Pollutant controls for other sources estimated are $120 million, $48 million and $40 million for forest runoff, atmospheric deposition, and stream channel erosion pollutant controls, respectively. The relatively high investment in urban runoff controls is reflective of the importance of this source category in reducing fine sediment particle loads. Both types of costs are important because state and federal funding has historically been available for capital investments, while local jurisdictions have been responsible for operations and maintenance costs.

For purposes of this analysis, average annual operations and maintenance costs include all requirements to maintain effectiveness of the pollutant controls for the expected life of the project. The annual cost of operating and maintaining recommended pollutant controls for all sources is roughly $11 million. These costs are estimated for urban runoff controls and forested runoff controls at $6.0 million and $4.5 million, respectively. Atmospheric controls are estimated to cost approximately $500.000 annually, while stream channel controls are estimated to have minimal costs for the life of the project. The

The Water Board and NDEP staff estimated the cost of achieving the Clarity Challenge targets over the first 15-year implementation phase. This cost averages $100 million per year ($1.5 billion over 15 years). Assuming that costs will rise from inflation over time, then the overall cost for 65 years of TMDL implementation to achieve the transparency standard is estimated to be in excess of at $6.5 billion.

These estimates provide only an approximation and do not take into account details of budgeting or project-level planning. While the Water Board and NDEP collected the best available cost information for the various control actions, there is broad variability in actual implementation costs and implementing agencies may select alternative pollutant control measures that were not considered during the TMDL cost analysis.

16.11.3 California Sources of Funding

Potential sources of funding include monies from both private and public sources. Public financing includes, but is not limited to, grants as described below; single-purpose appropriations from federal, state, and/or local legislative bodies; and bond indebtedness and loans from government institutions. Several potential sources of public financing through grant and funding programs are administered in part or in whole by the Regional Board and the State Water Board. These programs generally vary over time depending upon federal and state budgets and ballot propositions approved by voters. Regional and State Water Board grant and funding programs that are pertinent to the proposed *Lake Tahoe Total Maximum Daily Load Basin Plan Amendment*, and are currently available at the time of this writing or will be available in the near future are summarized and described below.

Consolidated Watershed Nonpoint Source Grant Program (Proposition 40)

The Consolidated Watershed Nonpoint Source (NPS) grant program is funded by Proposition 40, the California Clean Water, Clean Air, Safe Neighborhood Parks, and Coastal Protection Act of 2002. This program has not yet solicited grant proposals, but may fund nonpoint source, coast non-point source, urban storm water, and watershed management projects.

Nonpoint Source Pollution Control Program (Proposition 40)

The Non-point Source Pollution Control Program provides funding for projects that protect the beneficial uses of water throughout the state through the control of nonpoint source pollution. Up to $19 million may be available to local public agencies and non-profit organizations.

Integrated Regional Watershed Management Grant Program (Proposition 40)

The Integrated Regional Watershed Management grant program funds projects for development of local watershed management plans and for implementation of watershed protection and water management projects. This grant program provides about $47.5 million statewide for competitive grants to non-profit organizations and public agencies.

Integrated Regional Water Management (IRWM) Grant Program (Proposition 50)

The IRWM Grant Program is a joint program between the Department of Water Resources (DWR) and the State Water Board which provides funding for projects to protect communities from drought, protect and improve water quality, and reduce dependence on imported water. Funding may be available for both IRWM Planning and Implementation Grants.

Authority: Public Resources Code Sections 21083, 21084, 21084.1, and 21087.

Reference: Public Resources Code Sections 21080(c), 21080.1, 21080.3, 21082.1, 21083, 21083.1 through 21083.3, 21083.6 through 21083.9, 21084.1, 21093, 21094, 21151; *Sundstrom v. County of Mendocino*, 202 Cal. App. 3d 296 (1988); *Leonoff v. Monterey Board of Supervisors,* 222 Cal. App. 3d 1337 (1990).

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18 Appendix A – Lake Clarity Conceptual Model and Indicator Framework

Tahoe Monitoring & Evaluation Program

Title: Lake Tahoe Clarity Conceptual Model & Indicator Framework Briefing

Version 0.81

Date: April 15, 2010

Contact Person: Shane Romsos, M&E Program Manager, TRPA (*phone:* 775.589.5201, *email:* sromsos@trpa.org); Jeremy Sokulsky, Environmental Incentives, LLC (530-541-2980, jsokulsky@enviroincentives.com)

The Lake Tahoe Monitoring and Evaluation Program (M&E Program) is developing conceptual models (CMs) and indicator frameworks (IFs) that will be used to 1) define the current understanding of the most important drivers that affect the status of desired conditions (DCs), 2) assist in the selection and interpretation of meaningful indicators to track DC-related system status, and 3) identify the most influential actions for achieving DCs. The CM included in this briefing is based on the scientific understanding and policy context at the time that it was developed or its most recent update. The CM is expected to be adapted over time with improved scientific understanding, innovations in management actions, and changes in policy context.

This briefing includes: (1) a text description of the Lake Tahoe Clarity DC, objectives and primary chains of cause and effect, (2) the legend of symbols used in the CM, (3) the Lake Tahoe Clarity CM diagram, and (4) the Lake Tahoe Clarity IF diagram. Please contact the person(s) listed above to receive more detailed information related to this CM and IF, including a complete narrative description and tables describing each factor and indicator in the CM and IF.

Lake Tahoe Clarity Desired Condition & Objectives

Lake Tahoe Clarity Desired Condition

Restore, and then maintain, the waters of Lake Tahoe for the purposes of human enjoyment and preservation of its ecological status as one of the few large, deepwater, ultraoligotrophic lakes in the world with unique transparency, color and clarity.

This DC statement is taken directly from the results of the Pathway process and is a proposed TRPA Goal statement. The following two objectives were defined from this DC.

Deep Water Clarity Objective

Restore and maintain deep water clarity at levels measured for the period 1967-1971, which is an annual average Secchi depth of 29.7 meters.

The Clarity Challenge milestone has been defined related to this objective, which seeks a 32% fine sediment particle reduction within 15 years of the adoption of the TMDL. This load reduction is estimated to result in a Secchi depth of approximately 24 meters. The TMDL will define additional milestones both before and after the Clarity Challenge that will ultimately lead to the final Deep Water Clarity objective.

Trophic Status Objective

Preserve Lake Tahoe's ecological status as one of the few large, deepwater, ultraoligotrophic lakes in the world with an appropriate diversity of plants and animals in deep-water and nearshore environments.

To further define this objective, a Trophic Status Index must be developed, and benchmark and target values must be defined. Indicators of deep water trophic status must be integrated to develop a trophic status index that is sensitive to the variability in different nearshore environments as well as the difference between the nearshore and deep water conditions.

Nearshore Aesthetic Objective

Improve nearshore aesthetic quality such that water transparency and the biomass of benthic algae are deemed acceptable at localized areas of significance.

The following steps must be taken to further define this objective:

- Current indicators and standards for nearshore transparency must be updated
- Benthic algae indicators and standards for acceptable levels at localized areas of significance must be defined and adopted

Primary Chains of Cause and Effect

Deep water clarity, trophic status and nearshore aesthetic are affected by fine sediment particles and algae abundance. The Lake Tahoe Clarity CM diagram (Figure 18-1) uses bolded box outlines and linkage arrows to show dominant chains of cause and effect for deep water clarity and nearshore aesthetic.

Deep Water Clarity

Deep water clarity integrates the effects of pollutant loading from throughout the Lake Tahoe Basin. It is primarily driven by the number of fine inorganic particles in the water column. Surface water flows loaded with fine sediment from urban stormwater transport over 70% of the total load of fine sediment to the lake. Sources of urban fine sediment particles include the application of road abrasives, degradation of the road surface and tires, and erosion from road shoulders and unpaved soft coverage areas. Impervious surfaces contribute to increases in stormwater runoff, increases in stream peak flows, erosion and pollutant transport. Management actions that can be implemented in urban areas to prevent and/or reduce fine sediment particle loads include reducing road abrasives application, increasing street sweeping effectiveness, reducing impervious surface coverage, and treating stormwater.

Trophic Status

Trophic status is largely determined by the presence of biologically available nutrients that result in plant growth, which in turn influences dissolved oxygen levels and the diversity and type of biota able to survive in the lake. Lake mixing and circulation, both potentially changing with climate change, have the potential to significantly alter biological availability of nutrients.

Nearshore Aesthetic

Nearshore aesthetic is an inherently localized issue; different locations will have different expected levels of transparency and benthic algae abundance based on local conditions such as nutrient availability, light and temperature. Nutrient-laden urban stormwater and groundwater seepage to nearshore areas can cause localized algae blooms and affect both transparency and the abundance of benthic algae. The same management actions described to control fine sediment particles and improve deep water clarity are assumed to have a similar benefit in reducing nutrient loading to nearshore areas. In addition, restricting fertilizer usage and maintaining sewage infrastructure are nutrient controls that prevent increases of nutrients in groundwater.

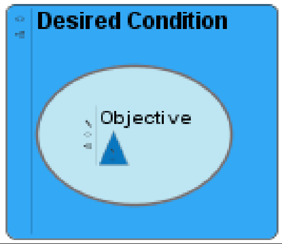
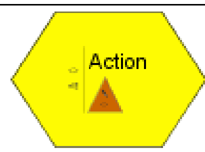
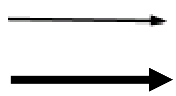
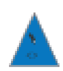
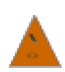
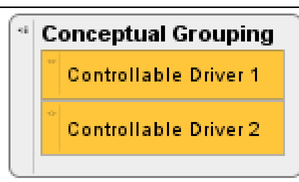
Nearshore aesthetic is an inherently localized issue, different locations will have different expected levels of transparency and benthic algae abundance based on localized conditions. Both attached and floating algae abundance are limited by the availability of biologically available nutrients. Nutrient-laden urban stormwater and groundwater seepage to nearshore areas can cause localized algae blooms and affect both transparency and the abundance of benthic algae. The same management actions described to control fine sediment particles and improve deep water clarity are assumed to have a similar benefit in reducing nutrient loading to nearshore areas. In addition, restricting fertilizer usage and maintaining sewage infrastructure are nutrient controls that prevent increases of nutrients in groundwater.

Other Factors

This Basic Lake Tahoe Clarity CM assumes that current policies and practices related to forest land management practices will be maintained. If BMPs on dirt roads and those related to fuels management projects are not maintained, the current low level of fine sediment particle input from forest uplands, 9%, could greatly increase and become a significant source.

Atmospheric deposition of fine sediment particles and nutrients, particularly nitrogen, are potentially significant. Atmospheric deposition and the related load reduction potential from this source are the area of greatest uncertainty within the TMDL analysis. Therefore, this is an active and important area for research.

Table 18-1: The symbols in this table should be used to create the CM diagram.

Name of Symbol	Visual Appearance	Description
Desired Condition Box		Represents the desired condition of a resource, and contains the more refined and specific objectives
Objective Oval		Objectives represent specific qualities of the desired condition
Driver Boxes		Controllable drivers affect the desired condition and are able to be influenced by human actions within the Tahoe Basin **Controllable drivers that are also desired conditions are shown in blue in the diagram*
		Non-controllable drivers are conditions or processes that affect the desired condition and are not controllable by human actions within the Tahoe Basin
Action Hexagon		Represent activities that humans can undertake to work toward achieving a desired condition
Linkage Arrow		Indicates a linkage between two factors. Bold lines can be added to accentuate the connection between factors that link to create a dominant chain of cause and effect.
Metrics	Status Indicator Triangle 	Represents a measure of system condition
	Driver Measure Triangle 	Represents a measurable quantity that describes the presence and magnitude of a driver
	Performance Measure Triangle 	Represents a measure of human action taken to achieve a objective
Conceptual Grouping Box		Represents a grouping of similar drivers, actions or metrics
Research Priority Diamond		Indicates a driver or action that has a high research priority (ranking of 4 or 5) as determined in the CM Table

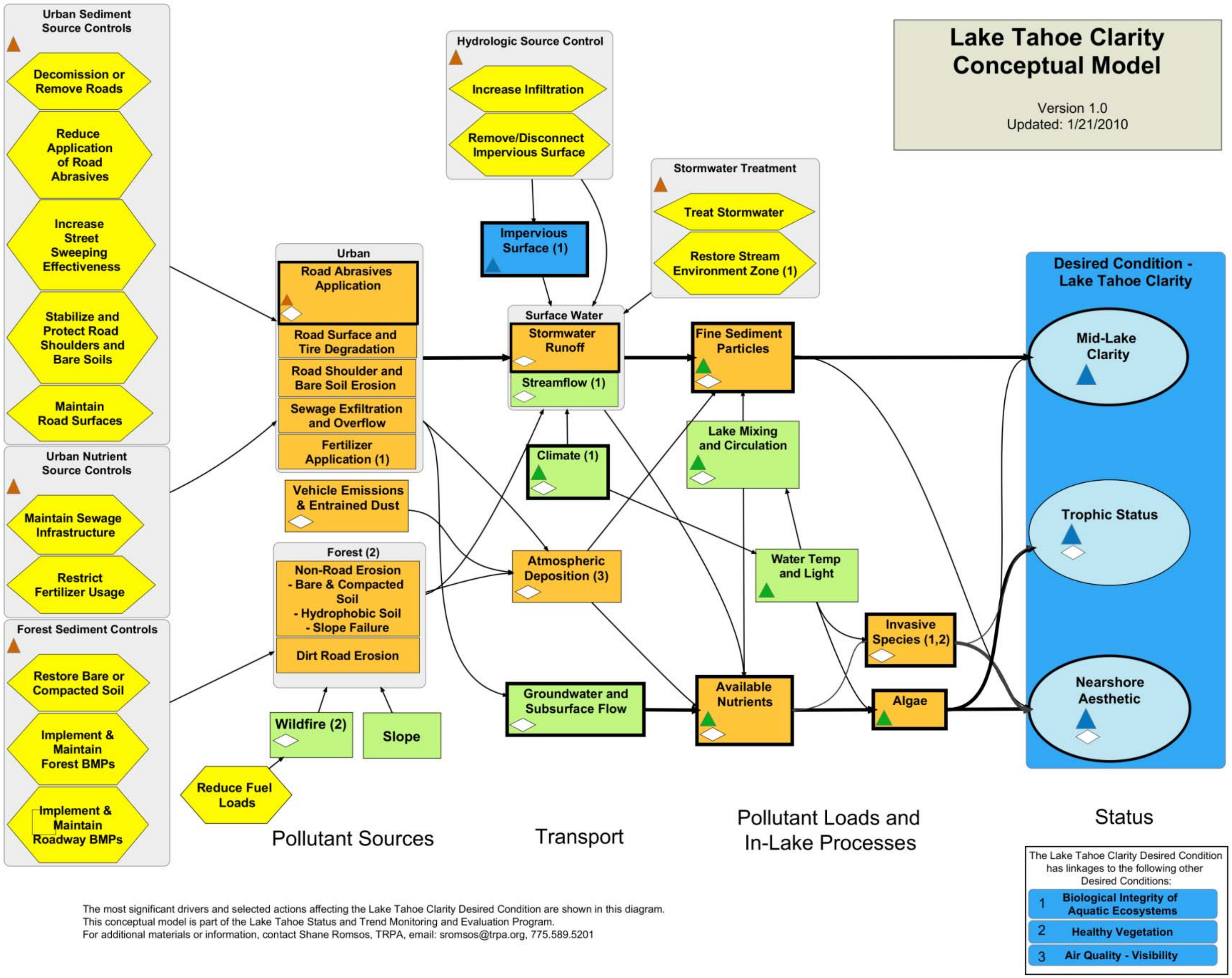


Figure 18-1. Lake Tahoe Clarity Conceptual Model Diagram.

Indicator Framework

An indicator framework (IF) describes the multiple numeric measures that are depicted in the CM and how they are synthesized to assess the overarching status of the system. An IF structures numeric information describing the percent-to-target progress of indicator values so that they can be categorized, aggregated and effectively reported to key audiences. The Lake Tahoe Clarity IF shows how water quality field measurements are analyzed to summary indicators, higher-level status aggregations and the DC. Figure 18-2 is the proposed IF for the Lake Tahoe Clarity DC.

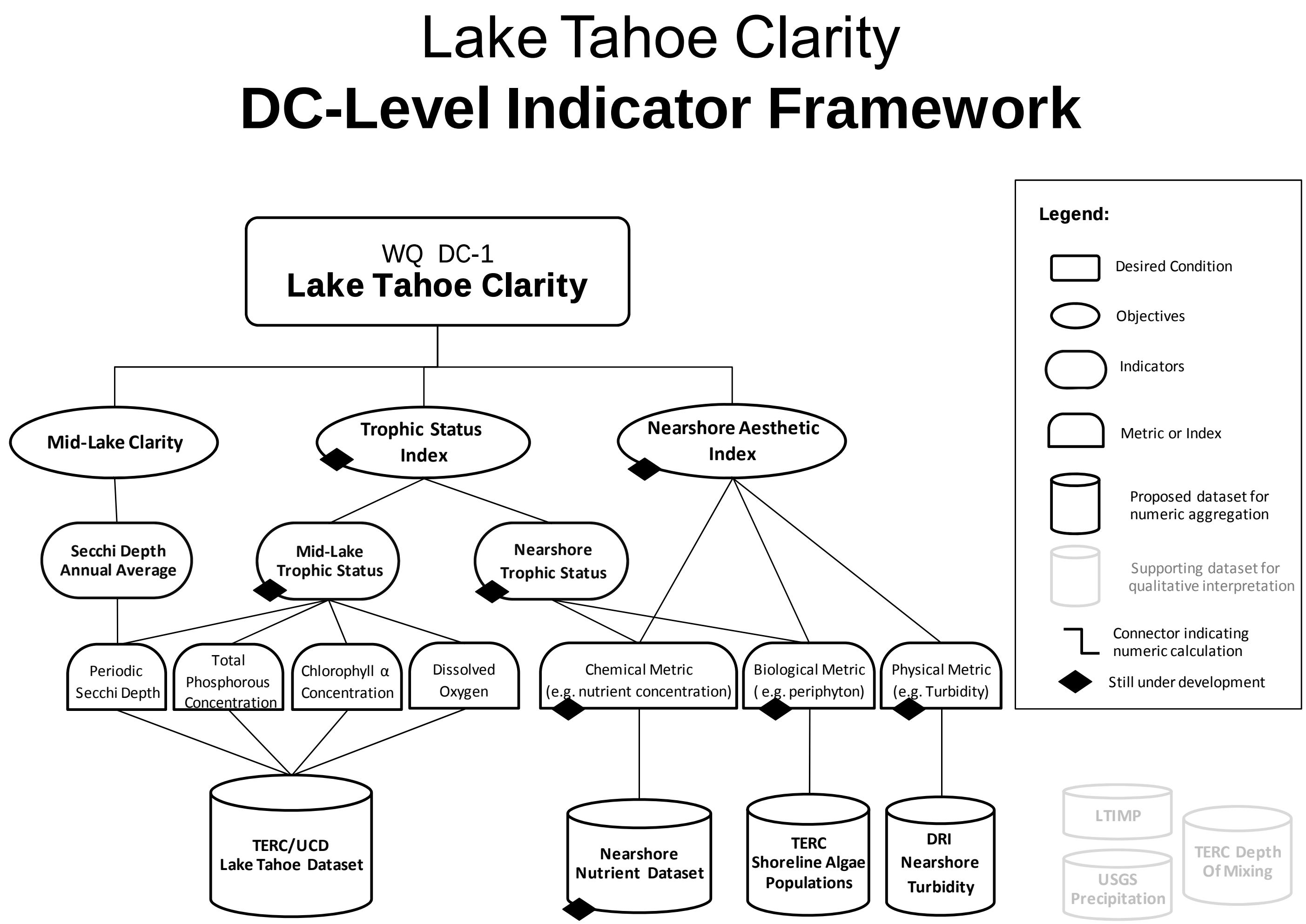


Figure 18-2. Lake Tahoe Clarity Indicator Framework Diagram.

19 Appendix B – Responses to Peer Reviews