

Adopted Amendments to the *Water Quality Control Plan for the Lahontan  
Region*  
Concerning

**Total Maximum Daily Load and  
Implementation Plan for Indian Creek  
Reservoir, Alpine County, California**

**California Regional Water Quality Control Board  
Lahontan Region  
2501 Lake Tahoe Blvd  
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July 2002

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*The following language is proposed to be inserted into Chapter 4, Section 4.13 of the Basin Plan. If the amendments are approved, corresponding changes will be made to the "Record of Amendments" page, the Table of Contents, the List of Tables, page numbers, and page headers in the plan. Due to the Basin Plan's two-column page layout, the location of tables in relation to text may change during final formatting of the amendments. The map will be redrawn for inclusion in the Basin Plan, and the final layout may differ from that of the draft.*

## **Indian Creek Reservoir, Alpine County**

**Introduction.** Indian Creek Reservoir was constructed in 1969-70 on an ephemeral tributary of Indian Creek, a tributary of the East Fork Carson River. The location of the reservoir within the Carson River watershed is shown in Figure 3-7 of this Basin Plan. The reservoir was designed to store tertiary wastewater effluent exported from the Lake Tahoe watershed for later use in pasture irrigation and to support a trout fishery. The U.S. Bureau of Land Management (USBLM) operates a campground and day use facilities at the reservoir. The reservoir became eutrophic during the 1970s and was placed on the Section 303(d) list for eutrophication in the 1980s. It no longer receives wastewater, and its level is maintained with water diverted from the West Fork Carson River and Indian Creek.

The subwatershed affected by this TMDL is shown in Figure 4.13-ICR-1. It includes the lands that contribute surface runoff directly to the reservoir and the lands tributary to upper Indian Creek and to Snowshoe Thompson Ditch #1 downstream of the diversion point from the West Fork Carson River. Water entering the ditch at the diversion point is considered "background" quality for purposes of the TMDL. The TMDL implementation program does not include controls for nonpoint sources in the West Fork Carson River watershed above the diversion point. Nonpoint source problems in that watershed will be addressed through other Regional Board programs (e.g., the nonpoint source, stormwater, and Watershed Management Initiative programs).

The purpose of this TMDL is to ensure the attainment of all water quality standards for Indian Creek Reservoir that are affected by eutrophication, including beneficial uses for aquatic life and recreation. Attainment will be interpreted in terms of a change from eutrophic to mesotrophic conditions and maintenance of mesotrophic conditions over time. A Regional Board staff report (California Regional Water Quality Control Board, Lahontan Region, 2001), and a 2002 supplement to that report, provide the technical information supporting the regulatory elements of this TMDL.

**Problem Statement:** The South Tahoe Public Utility District (STPUD) discontinued wastewater disposal to Indian Creek Reservoir in 1989 and acquired water rights to maintain a minimum reservoir level to support recreational uses. Monitoring showed decreases in the concentrations of most wastewater-related constituents after wastewater disposal ceased. Concentrations of total phosphorus decreased but remained at levels which the scientific literature indicates will maintain eutrophic conditions, apparently due to internal loading from the sediment. The reservoir has continued to show symptoms of

eutrophication including blooms of blue-green algae, low transparency, and depletion of dissolved oxygen in the hypolimnion.

**Numeric Targets and Indicators.** Total phosphorus was selected as the quantitative focus of the TMDL because frequent violations of the water quality objective for this constituent have occurred even after the cessation of wastewater disposal and because of the important role of phosphorus as a factor in the eutrophication of many north temperate lakes. Other parameters are also potentially important in control of eutrophication, and a variety of other indicators and targets have been selected for monitoring and periodic evaluation.

The primary numeric target for the Indian Creek Reservoir TMDL is an annual mean concentration in the water column of 0.02 mg/L total phosphorus. A scientific literature review, summarized in the staff report, indicates that this target represents the threshold between mesotrophic and eutrophic conditions. Mesotrophic conditions should adequately protect aquatic life and recreational uses of the reservoir. Based on the literature review and modeling of tributary water quality, the target can feasibly be attained if phosphorus loading from the sediment is significantly reduced. Phosphorus loading can be reduced by methods such as increased flushing, removal of phosphorus-rich sediment, or chemical treatment to prevent phosphorus release to the water column.

The current water quality objective for total phosphorus (0.04 mg/L expressed as a mean of monthly means) was based the water quality achievable when the reservoir was receiving tertiary wastewater effluent, rather than on criteria for protection of beneficial uses. An interim total phosphorus target based on this objective is proposed, and is projected for attainment by 2013. The Regional Board recognizes that potential reservoir management measures (oxygenation of the hypolimnion or significantly increased dilution and flushing) may lead to attainment and maintenance of mesotrophic conditions at an ambient total phosphorus concentration higher than the long term target. If monitoring demonstrates that beneficial uses are supported at a higher phosphorus concentration, the Board may consider revising that target. Targets and indicators for the TMDL are summarized in Table 4.13-ICR-1.

**Source Analysis.** Indian Creek Reservoir does not receive phosphorus loading from any natural tributary streams. (The ephemeral stream reach dammed during construction of the reservoir was completely inundated.) Phosphorus enters the reservoir in water diverted from the West Fork Carson River and Indian Creek, in precipitation and direct surface runoff, and by internal loading from the sediment. Internal loading is the most important source of phosphorus. The estimated "existing" loads are based on modeling of tributary inputs using water quality and flow data for 1999. Literature sources were used to estimate precipitation and runoff inputs and internal phosphorus loading rates. Numbers are rounded to the nearest pound. The "tributary inflow" source represents combined diversions from the West Fork Carson River and Indian Creek. All sources are considered to be nonpoint. Estimated loads from all sources are summarized in Table 4.13-ICR-2.

**Table 4.13-ICR-1. Numeric Targets and Indicators for Indian Creek Reservoir TMDL**

<b>Indicator<sup>1</sup></b>	<b>Target Value</b>	<b>Reference</b>
Total P concentration	(Interim <sup>2</sup> ) No greater than 0.04 mg/L, annual mean	Current water quality objective (mean of monthly means); see Basin Plan Table 3-14
Total P concentration	(Long term <sup>2</sup> ) No greater than 0.02 mg/L, annual mean	USEPA, 1988, 1999.
Dissolved oxygen concentration	(Interim <sup>2</sup> ) 30 Day Mean 6.5 mg/L; 7 Day Mean Minimum 5.0 mg/L; 1 Day Minimum 4.0 mg/L	Regionwide water quality objective for waters designated for COLD use; see Basin Plan Table 3-6
Dissolved oxygen concentration	(Long term <sup>2</sup> ) Shall not be depressed by more than 10 percent, below 80 percent saturation, or below 7.0 mg/L at any time, whichever is more restrictive.	Water quality objective for surface waters of Indian Creek watershed; see Basin Plan Chapter 3
Secchi depth	Summer mean no less than 2 meters	USEPA, 1988. 1999
Chlorophyll a	Summer mean no greater than 10 ug/L	USEPA, 1988,1999
Carlson Trophic Status Index	Composite index no greater than 45 units	USEPA 1988, 1999

<sup>1</sup> These indicators will be measured for at least one depth profile sampling station in Indian Creek Reservoir. The Carlson Trophic Status Index will be computed from other parameters as explained in the technical staff report.

<sup>2</sup> Interim targets are expected to be attained by 2013. Long term targets are expected to be attained by 2024. See the Implementation Plan below.

**Table 4.13-ICR-2. Estimated Existing Phosphorus Loads to Indian Creek Reservoir from External and Internal Sources (rounded to the nearest pound)**

Source	Load (pounds per year) and % of total
<b><i>EXTERNAL SOURCES</i></b>	
Precipitation	3
Direct surface runoff	68
Tributary inflow	43
Minor sources <sup>1</sup>	0
<b><i>A. Total External Load (lb/yr)</i></b>	114 [24%]
<b><i>INTERNAL SOURCES</i></b>	
Total anoxic load (by literature formula from Welch and Cooke, 1999, for 120 day stratification period)	204
Total oxic load (by subtraction)	150
<b><i>B. Total Internal Load (lb/yr)</i></b>	354 [76%]
<b><i>C. Loss in Reservoir outflow (lb/yr)</i></b>	137
<b><i>TOTAL LOAD (A + B)</i></b>	468
<b><i>NET WATER COLUMN LOAD (A + B – C)</i></b>	331

<sup>1</sup>Loading and losses from the minor sources and sinks discussed in the staff report are considered *de minimis*.

**Loading Capacity.** Assuming a uniform phosphorus concentration throughout the water column and a reservoir volume of 1515 acre feet (at the minimum staff gage level maintained under an agreement between STPUD and Alpine County), the maximum amount of phosphorus that can be present in the water column if a concentration of 0.02 mg/L total phosphorus is to be maintained is 82 lb/yr.

**Load Allocations.** There are no point sources of phosphorus loading to Indian Creek Reservoir; thus, the wasteload allocation is zero. Load allocations for external and internal nonpoint sources of phosphorus are summarized in Table 4.13-ICR-3. The load allocations for external sources assume no reduction in phosphorus loading from precipitation, a 75% reduction in loading from surface runoff and tributary inflow, and an 87 % reduction in internal loading. No load allocations are being established for indicators other than total phosphorus.

**Loading capacity linkage analysis.** The loading capacity and the associated numeric target for phosphorus are based on a strong quantitative framework, developed through a large set of empirical scientific data, that allows for the prediction of algal biomass and other associated water quality parameters from nutrient loading and water column

nutrient concentrations (USEPA, 1999). The proposed phosphorus concentration target corresponds to a literature threshold between mesotrophic and eutrophic conditions. The literature review summarized in the staff report indicates that the proposed numeric target and the associated loading capacity, if attained, will be adequate to protect designated aquatic life and recreational uses of Indian Creek Reservoir, the beneficial uses most likely to be impaired by eutrophication, and to ensure compliance with applicable narrative water quality objectives.

**Table 4.13-ICR-3. Load Allocations for Indian Creek Reservoir**

<b>Source</b>	<b>Load Allocation (lb/yr)</b>
<b><i>EXTERNAL</i></b>	
Precipitation	3
Direct Surface Runoff <sup>1</sup>	17
Tributary Inflow <sup>1</sup>	32
<b><i>Total external allocation</i></b>	<b>52</b>
<b><i>INTERNAL</i></b>	
<b><i>Total internal allocation</i></b>	<b>46</b>
<b><i>OUTFLOW</i></b>	<b>18</b>
<b><i>Total Load Allocation</i></b>	<b>98</b>
<b><i>Net Load Allocation<sup>2</sup></i></b>	<b>80</b>

<sup>1</sup>Allocations for these parameters are interpreted as 10 year rolling averages to account for seasonal and annual variability.

<sup>2</sup>This allocation is to the water column, with the assumption that an additional 18 lb/yr of internally derived phosphorus will leave the reservoir in the outflow.

**Margin of safety.** The Indian Creek Reservoir TMDL provides an implicit margin of safety by:

1. Interpreting compliance with standards (including beneficial use support and progress from eutrophic to mesotrophic conditions) through multiple targets and indicators.
2. Incorporating conservative assumptions in the source analysis and development of load allocations. Assumptions that provide a margin of safety include:
  - Development of the TMDL for total phosphorus rather than for orthophosphate or "soluble reactive phosphorus," which are the forms of phosphorus most readily available to plants. The analysis assumes that all P in the system, including sediment P, will eventually be recycled and made biologically available.
  - The "worst case" assumption that all phosphorus released from the sediment during summer stratification is made available for algal growth in the hypolimnion during the summer.

**Seasonal and interannual factors and critical conditions.** The TMDL for Indian Creek Reservoir accounts for seasonal and annual variations in external and internal phosphorus loading and associated impacts on beneficial uses in several ways:

- The load allocations for surface runoff and tributary inflow are set as a 10 year rolling averages to account for seasonal and annual variations in runoff, tributary flows, and phosphorus concentrations.
- The most critical conditions for attainment of aquatic life and recreational uses in Indian Creek Reservoir occur during summer stratification, when the greatest release of phosphorus from the sediment occurs and warm temperatures promote algal blooms and depletion of oxygen in the hypolimnion. Attainment of the loading capacity will require significant reduction of internal phosphorus loading through methods such as removal of phosphorus rich sediment or chemical treatment to lower phosphorus release from the sediment, or else a significant increase in the level of dilution and flushing with fresh water. Summer stratification of the reservoir may continue to occur, but reduced phosphorus loading will reduce the risk of oxygen depletion in the hypolimnion.

**Implementation Plan.** Implementation of the TMDL is the responsibility of the STPUD (for control of internal phosphorus loading) and of the U.S. Bureau of Land Management, Alpine County, STPUD, and other land owners and land managers in the watershed (for control of external sources). The implementation program does not specify the means of compliance with the TMDL, but rather establishes a process for identification and implementation of controls for external and internal sources of phosphorus loading to Indian Creek Reservoir. (The Regional Board is prohibited by Section 13360 of the California Water Code from specifying the manner of compliance with its orders.) The implementation program will involve an adaptive management approach.

Implementation will be done in coordination with the Regional Board's ongoing watershed management planning and nonpoint source control efforts. The California State Water Resources Control Board's 2000 *Plan for California's Nonpoint Source Pollution Control Program* (California Nonpoint Source Plan) and the 1995 *California Rangeland Water Quality Management Plan* will be used as appropriate in the implementation process.

The implementation process will include the following:

#### **1. For control of all sources:**

Within 4 months after final approval of the TMDL, Regional Board staff will convene a stakeholder group for ongoing communication about TMDL issues. The group should include, but will not be limited to, representatives of STPUD, the USBLM, the U.S. Forest Service and Alpine County, and other public and private landowners in the subwatershed affected by the TMDL (Figure 4.13-ICR-1). Participation should also be invited from the U.S. Natural Resource Conservation Service, the Alpine Resource

Conservation District, the Alpine County Watershed Group, and downstream stakeholders in California and Nevada, including the Nevada Division of Environmental Protection, the Upper Carson River Coordinated Resource Management Plan group and the Carson Water Subconservancy District.

## **2. For control of internal loading:**

- Immediately after final approval of the TMDL, Regional Board staff will request a report from the STPUD on the method(s) it intends to use to reduce internal loading of phosphorus to Indian Creek Reservoir from the sediment and to optimize reservoir management for protection and enhancement of aquatic life and recreational uses.
- By 15 months after final approval of the TMDL, STPUD will investigate the feasibility of controls for internal phosphorus loading to Indian Creek Reservoir and the feasibility of other management measures to protect and enhance beneficial uses and will submit a plan for approval by the Regional Board. Depending upon the nature of the proposed action, the Regional Board may provide direction to staff for implementation, issue waste discharge requirements and/or a formal monitoring program for activities to control internal phosphorus loading, or take other appropriate action.
- By 2013, STPUD will fully implement controls for internal phosphorus loading.

## **3. For control of external loading:**

- By 1 year after final approval of the TMDL, Regional Board staff and stakeholders will identify specific sites within the watershed contributing direct surface runoff to Indian Creek Reservoir that need Best Management Practices (BMPs) for phosphorus control.
- By 1 year after final approval of the TMDL, Regional Board staff and stakeholders will identify specific sites needing BMPs for phosphorus control on public and private lands within the watershed tributary to the irrigation ditch that provides inflow to Indian Creek Reservoir from Indian Creek and the West Fork Carson River. Problem assessment and planning for BMP implementation on non-federal rangelands will follow the implementation procedures in the *California Rangeland Water Quality Management Plan*.
- By 3 years after final approval of the TMDL, depending on progress toward BMP implementation under the 1995 *California Rangeland Water Quality Management Plan* and the 2000 California Nonpoint Source Plan, staff will consider the need for regulatory action to ensure implementation of BMPs to control external sources of phosphorus loading to Indian Creek Reservoir.
- By 2013, BMPs will be fully implemented for nonpoint sources of phosphorus loading to Indian Creek Reservoir within the subwatershed affected by the TMDL.

The California Nonpoint Source Plan requires implementation of management measures for all nonpoint source problems statewide by 2013.

Attainment of the interim total phosphorus and dissolved oxygen targets is projected to occur by 2013. Attainment of the long term total phosphorus and dissolved oxygen targets, other TMDL targets and the narrative water quality objectives related to protection of beneficial uses is projected to occur by 2024.

Potential implementation measures include BMPs to control external sources of phosphorus loading and in-lake measures to increase flushing of phosphorus from the reservoir, remove phosphorus-rich sediment or inactivate the internal phosphorus release process. Agricultural BMPs potentially relevant to control of external phosphorus loading to Indian Creek Reservoir include: range and pasture management, proper livestock to land ratios, irrigation management, livestock waste management, fences (livestock exclusion), retention/detention ponds, constructed wetlands, streambank stabilization, sediment ponds; and riparian buffers (USEPA, 1999). The STPUD (2002) has proposed conversion of the irrigation ditch tributary to Indian Creek Reservoir to an underground pipeline; this could eliminate some or all of the need for agricultural BMPs in that area. Additional potentially relevant nonpoint source management measures include: education outreach; runoff control for existing development; road, highway and bridge runoff systems; marina and recreational boating management measures (including shoreline stabilization); instream habitat restoration; and vegetated treatment systems.

Further study will be necessary to identify the best and most cost effective in-lake phosphorus control method(s) for Indian Creek Reservoir. The STPUD is considering the acquisition of additional water for flushing phosphorus from the reservoir through purchase and changes in the place and time of use of water rights. Based on the literature review summarized in the staff report, both phosphorus inactivation (by one of several chemical methods) and phosphorus removal (by dredging or bulldozing) appear to have the potential for rapid attainment of the numeric target. Other potential control methods include hypolimnetic withdrawal, hypolimnetic oxygenation, biomanipulation, and treatment systems involving harvest of periphyton to remove nutrients.

The BMPs and lake restoration measures summarized in the staff report and supplement are technically feasible and have been shown to be effective in reducing phosphorus loading and/or abating eutrophic conditions. The Regional Board recommends that, in addition to any in-lake treatment measure(s), STPUD should use the full amount of its existing water rights, under the constraints imposed by the Alpine Decree, in a manner that will maximize fresh water inflow into Indian Creek Reservoir.

**Monitoring.** The proposed TMDL monitoring plan involves continuation of current monitoring by the STPUD of Indian Creek Reservoir and its tributary inflow. (Not all of the parameters sampled are necessary for determining compliance with TMDL load allocations.) Regional Board staff recognize that sampling parameters, stations and frequencies may need to be changed over time as a result of an adaptive management approach to implementation. Consequently, the Basin Plan does not specify sampling

parameters, locations and frequencies of sampling and analytical protocols. The Regional Board's Executive Officer may adopt a formal monitoring program for Indian Creek Reservoir and its tributary inflow pursuant to the California Water Code, and changes in this program may be made over time without the necessity for further Basin Plan amendments.

The TMDL monitoring program is expected to involve:

- monitoring of tributary inflow and water quality (including P concentration)
- monitoring of Indian Creek Reservoir including gage height, water quality, and algal cell/colony counts
- monthly depth-profile measurements in Indian Creek Reservoir including dissolved oxygen and temperature
- monthly measurements of total phosphorus concentrations at several depths including the hypolimnion
- monthly measurement of chlorophyll a at the near-surface depth
- monthly measurements of Secchi depth in Indian Creek Reservoir during the stratification period, and
- periodic inspections of BMPs, once they have been installed.

The phosphorus concentration and inflow amounts of precipitation and surface runoff to the reservoir will not be measured directly. The success of BMPs to reduce phosphorus runoff to Indian Creek Reservoir will be assessed through measurements of reservoir quality. If implementation results in increased outflow from the reservoir, monitoring of the outflow channel and Indian Creek may be necessary to document impacts on downstream water quality and beneficial uses.

**Schedule for review and revision of the TMDL.** Regional Board staff will continue to review monitoring reports on an ongoing basis and will periodically discuss them with STPUD and other stakeholders. The review process will use all indicators and targets to evaluate progress from eutrophic to mesotrophic conditions. Comprehensive reviews of monitoring data and progress toward implementation and attainment of targets will be conducted at five year intervals following final approval of the TMDL. Because some of the targets and load allocations are expressed as ten year rolling averages to account for seasonal and annual variability, the first decision point on the need for revision of the TMDL will not occur until after the comprehensive review held in the tenth year.

**References:**

*A. The following references cited in the plan amendment language are incorporated by reference. These references will be added to the Basin Plan's bibliography, with the footnote: "Incorporated by reference into the Basin Plan". Copies of these references or of the cited pages will be included in the administrative record of the Basin Plan amendments. The record will be maintained at the Regional Board's South Lake Tahoe office.*

U.S. Environmental Protection Agency, 1988. *The Lake and Reservoir Restoration Guidance Manual*, First Edition. EPA 440/5-88-002, February 1988, pp. 4-12 to 4-15.

U.S. Environmental Protection Agency, 1999. *Protocol for Developing Nutrient TMDLs, First Edition*. EPA 841-B-99-007, November 1999.

Welch, E.B. and G.D. Cooke, 1999. Effectiveness and Longevity of Phosphorus Inactivation with Alum. *Lake and Reservoir Management* 15(1): 5-27.

*B. The following references will be added to the Basin Plan's bibliography. Citation in the amendment language above is not meant to imply incorporation by reference.*

California Regional Water Quality Control Board, Lahontan Region, 2001. *Technical Staff Report: Total Maximum Daily Load and Implementation Plan, Indian Creek Reservoir, Alpine County, California*.

California Regional Water Quality Control Board, Lahontan Region, 2002. *Supplement to 2001 Technical Staff Report: Total Maximum Daily Load and Implementation Plan, Indian Creek Reservoir, Alpine County, California*.

California State Water Resources Control Board, 1995. *California Rangeland Water Quality Management Plan*.

California State Water Resources Control Board, 2000. *Plan for California's Nonpoint Source Pollution Control Program*.

South Tahoe Public Utility District, 2002. *Draft Environmental Impact Report, Recycled Water Facilities Master Plan*.