California Regional Water Quality Control Board
Santa Ana Region

August 26, 2005

ITEM: **12**

SUBJECT: **Public Workshop: Proposed Basin Plan Amendment – Incorporation of Total Maximum Daily Loads (TMDLs) for Sediment for Big Bear Lake and Rathbun Creek**

California Regional Water Quality Control Board
Santa Ana Region

Staff Report on the Sediment Total Maximum Daily Loads for Big Bear Lake and Rathbun Creek

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EXECUTIVE SUMMARY

Described within this document are the proposed Total Maximum Daily Loads (TMDLs) for sedimentation for Big Bear Lake and Rathbun Creek. Section 303(d) of the Clean Water Act (CWA) requires States to identify waters that do not or are not expected to meet water quality standards (beneficial uses, water quality objectives and the state's antidegradation policy) with technology-based controls. The States are then required to develop a TMDL for each of the constituents listed on the 303(d) list. The TMDL establishes the maximum load of a pollutant that can enter the listed water body without violating water quality standards. A TMDL is defined as the sum of individual wasteload allocations for point sources, load allocations for nonpoint sources including natural background, and a margin of safety. Seasonal variations and critical conditions must also be addressed. The Regional Board placed Big Bear Lake and Rathbun (Rathbone) Creek on the 303(d) list in 1994 due to sedimentation/siltation. The listings were based on historic information summarized in Section 2.2. Sedimentation due to erosion within the watershed or to organic matter deposition in the lake affects the lake's designated beneficial uses. Excessive sediment deposition in Big Bear Lake has resulted in a decrease in lake capacity, which directly affects municipal, habitat and recreational beneficial uses. It has also contributed to the eutrophic condition of the lake by reducing depths and increasing light and substrate available for macrophyte colonization and growth. Sediments also contribute nutrients that are the direct cause of eutrophication. Phosphorus sorbs to soil particles and is transported to surface waters via eroded sediments. Inorganic nitrogen is transported in surface water runoff in both dissolved and particulate forms. Sedimentation of nutrients also occurs with deposition of organic matter, including animal wastes and decaying plant matter. The eutrophication problem in the lake is being addressed in separate nutrient TMDLs. However, because of the relationship between sedimentation/siltation and nutrient inputs, the sediment TMDLs proposed herein are linked to the nutrient TMDLs. By reducing sediment loading to the lake in response to the proposed TMDLs, nutrient loads should be reduced as well. The nutrient TMDLs call for reductions in in-lake organic matter (macrophytes and algae). Presumably, these reductions will also result in decreases in sedimentation.

Summarized within this document is information used by the California Regional Water Quality Control Board, Santa Ana Region (Regional Board) to develop the proposed TMDLs for sedimentation/siltation for Big Bear Lake and Rathbun Creek. The components of the Big Bear Lake and Ratbhun Creek sedimentation/siltation TMDLs include:

1. Problem Statement. This section reviews the historic information used to include Big Bear Lake and Rathbun Creek on the 303(d) list, and evaluates data collected since the listing. Narrative water quality objectives for solids, suspended and settleable, are not currently being met because sedimentation/siltation has decreased the lake's capacity and has contributed to excessive plant growth in shallow areas, impacting the lake's recreation and freshwater habitats. Rathbun Creek is a main contributor of sediment to the lake and has been modified, which has led to erosion problems within the creek itself.

2. Numeric Targets. The proposed numeric targets for Big Bear Lake and Rathbun Creek include mass-based loads. The recommended numeric target for sediment for Big Bear Lake was calculated using sediment yields from forest north and forest south land uses and multiplying these yields by the total area of north facing slopes and south facing slopes for the entire watershed area to obtain a total sediment load. This total sediment load is that which would be expected absent anthropogenic activities in the watershed, assuming that the sediment load from forest land uses represents natural background conditions. In this watershed, this assumption may

not represent actual conditions. The numeric target for sediment for Rathbun Creek was calculated using the same methodology, except that the sediment yields were multiplied by the Rathbun Creek subwatershed area. In addition to mass-based loads, other numeric and/or narrative indicators for Big Bear Lake and Rathbun Creek are proposed (Tables 3-1 and 3-2). For Big Bear Lake, these include a 5% increase in lake capacity within 10 years. For Rathbun Creek, targets based on turbidity and benthic macroinvertebrates are also identified.

3. Source Analysis. This section quantitatively evaluates all sources of sediment to Big Bear Lake and Rathbun Creek. The sources are subdivided into nonpoint and point sources, as an average over a 14-year period (1990 to 2003) (Tables 4-2, 4-3 and 4-4). External inputs from various land uses were simulated using the Hydrological Simulation Program Fortran (HSPF) model and are summarized for 1990-2003. For Big Bear Lake and Rathbun Creek, external nonpoint source inputs are from forest and resort land uses (Tables 4-3 and 4-4); external point source inputs are from high density urban and residential runoff subject to NPDES permits (Tables 4-3 and 4-4).

4. Linkage Analysis and TMDLs. The linkage analysis for Big Bear Lake and Rathbun Creek discusses the relationship between watershed loads and effects on beneficial uses. The loading capacities (TMDLs) for sediment for Big Bear Lake and Rathbun Creek are shown in Tables 5-1 and 5-2.

5. TMDL Allocations. The only point sources in the watershed are urban runoff (residential and high density urban land uses) subject to NPDES permits. Proposed wasteload allocations for the Big Bear Lake and Rathbun Creek sediment TMDLs are shown in Tables 6-1 and 6-2. Load allocations for sediment are proposed for nonpoint source categories (forest and resort) after application of Best Management Practices (Tables 6-1 and 6-2). The proposed WLAs and LAs are expressed as 10-yr running averages.

6. Seasonal Variation and Critical Conditions. There are inherent seasonal (and annual variations) in the delivery of sediment. To address this variability, annual average sediment loads from each significant source were simulated for a 14-year period (1990-2003), which incorporates all types of seasonal/hydrological conditions. These results are the basis of the proposed targets, TMDLs, WLAs and LAs. In addition, the numeric sediment targets, TMDLs, WLAs and LAs are proposed as 10-year running averages to take annual variability into account. The proposed lake capacity target requires improvement in lake capacity over time, despite seasonal, climatic or other variations in sediment loading.

Consideration of critical conditions ensures that even under the worst water quality conditions, water quality standards can still be met through loads established in the TMDLs. Critical conditions for sediment include events, such as storms, that result in the erosion and transport of sediment and immediate adverse impacts on beneficial uses (e.g., removal or covering of spawning substrate). Reasonably feasible control measures must be implemented to address such inputs. Compliance with the proposed numeric targets, TMDLs WLAs and LAs will require the implementation of such measures. However, the adverse effects of erosion/sedimentation continue to be felt over the long-term, unless the sediment is removed. The effects of the loss of lake capacity in Big Bear Lake are most pronounced during the spring and summer of dry years, when the level of the lake declines and water levels are shallower. Recreational use of the lake is typically at its peak during these months and this is also the period of macrophyte growth. The sediment TMDLs for Big Bear Lake and Rathbun Creek address the dry period critical conditions by specifying alternative numeric targets, including a lake capacity target for Big Bear Lake and benthic macroinvertebrate metrics for Rathbun Creek. In addition, the proposed implementation

plan includes a requirement for the development of a lake management plan that is to identify an overall sediment control and management strategy designed to restore and protect beneficial uses, including during the critical dry periods.

7. Margin of Safety. The TMDLs contain an explicit margin of safety of 10%. An explicit MOS was used to account for uncertainties in the calculated total sediment load and assumptions made about the delivery of sediment to the sedimentation basins in Rathbun Creek.

8. Implementation Plan. This section describes the actions, regulatory tools and other measures necessary to achieve the wasteload and load allocations as specified in the TMDLs. Implementation of the proposed Big Bear Lake and Rathbun Creek TMDLs are the responsibility of the United States Forest Service (USFS), the Big Bear Mountain Resorts, the City of Big Bear Lake, the California Department of Transportation (Caltrans), the County of San Bernardino and the San Bernardino County Flood Control District (SBCFCD). The Big Bear Municipal Water District must be a cooperating partner working with the local stakeholders to implement the Big Bear Lake sediment TMDL, given the District's significant responsibilities for management of the lake. Attainment of the final numeric targets is projected to occur within 15 years of final approval of the TMDLs (i.e., no later than 2020).

9. Monitoring Plan. In order to evaluate the effectiveness of actions and programs implemented pursuant to the TMDLs, continuation of the existing watershed and lake water quality monitoring programs (with some modifications), as well as some additional monitoring elements, is a part of the recommended implementation plan. Because the proposed TMDLs are phased, follow-up monitoring and evaluation is essential to validate and revise the TMDLs as necessary.

1.0 INTRODUCTION

The proposed TMDLs for sedimentation/siltation for Big Bear Lake and Rathbun Creek are described in this document. Big Bear Lake and Rathbun Creek were placed on the 303(d) list in 1994 for sedimentation/siltation. The following paragraphs provide an introduction to the history of Big Bear Lake.

Big Bear Lake is a man-made reservoir created by the construction of Bear Valley Dam in 1883-84. The lake is located in the San Bernardino Mountains in San Bernardino County, approximately 100 miles northeast of Los Angeles and 40 miles northeast of the City of San Bernardino. It is the dominant feature of Big Bear Valley and its eastern area covers what was once a large flat meadow (Leidy 2003, 6-11).

Frank E. Brown constructed the first dam in 1883-84 as a single arch dam across Bear Creek, a tributary of the Santa Ana River. During 1912, a 20-foot higher, multiple arch dam was completed downstream of the existing dam (Leidy 2003, 12-16). These dams were constructed to store water for downstream irrigation uses in the Redlands/San Bernardino area.

In 1964, the Big Bear Municipal Water District (BBMWD) was created in an effort to develop programs and projects to stabilize the lake's water level. BBMWD is directed by a five-member elected Board of Directors. BBMWD's primary responsibility is the day-to-day management of Big Bear Lake, including the management of water releases, Bear Valley dam, recreation, and fisheries and wildlife. In January 1977, BBMWD acquired the title to the dam, the lake bottom, and the surface recreation rights of Big Bear Lake, for a purchase price of $4,700,000. Bear Valley Mutual Water Company (Mutual), which manages the distribution of lake water to downstream irrigation users, retained the water rights to Big Bear Lake (BBMWD 2002). Mutual provides Big Bear Lake water as a source of domestic supply for users within its service area. BBMWD must provide Mutual with 65,000 acre-feet (af) of water in any rolling ten-year period. When Mutual needs water above this amount, BBMWD has several options. BBMWD can release water from the lake, or provide water from another source (i.e., groundwater or State Water Project)(BBMWD 2002).

Big Bear Lake has a storage capacity of 73,320 acre-feet (af) and a water surface area of 2,971 acres at the elevation of the top of the dam (6743.2 feet). The lake is full at a gage height reading of 72.33 feet (Big Bear Watermaster 2001, 6). In order to maintain recreational and wildlife uses of the lake, especially at the east end and other shallow areas, BBMWD implements a Lake Stabilization Program designed to stabilize Big Bear Lake within 15 feet of the dam elevation (i.e., in the range of 6728.2-6743.2 feet) over the long-term (BBMWD 2002). Recreational uses of the lake are severely impacted if the lake level falls more than 15 feet (i.e., lake elevation of 6728.2 feet). Water levels have been measured continuously since July 1998 with the installation of a continuous lake level recorder by the BBMWD (Big Bear Watermaster 2001, 5). During most years, the lake level fluctuates no more than 3-5 feet, but during drought conditions, when little surface runoff from the surrounding watershed enters Big Bear Lake, the lake levels can fluctuate up to 15 feet. High evaporation levels, due to high wind and low humidity conditions, can remove up to 48 inches per year from the lake surface. This number varies seasonally, depending on temperature, lake level (and thus surface area), and other factors. Evaporation is calculated monthly, using precipitation, temperature and other data and is reported in BBMWD's annual Watermaster reports. Lake inflow is calculated monthly by the following formula: Inflow = Evaporation + Releases + Spills + Leakage + Net Withdrawals - Change in Storage. Inflow is calculated rather than measured (BBMWD 2002). Average annual inflow to Big Bear Lake

approximates 17,300 af and adjusted evaporation approximates 11,300 af based on Watermaster data from 1977-2001 (Table 1-1).

The State Water Resources Control Board adopted Order WR No. 95-4 to assure adequate flows downstream of the dam to protect fisheries in Bear Creek. Order WR No. 95-4 requires minimum outflows of 0.3 cfs at Station B (300 feet below Bear Valley Dam) and 1.2 cfs at Station A (West Cub Creek confluence with Bear Creek) (BBMWD 2002). Big Bear Lake is also utilized as a source of water for snow making operations. Snow Summit and Bear Mountain ski resorts can acquire a total of 1000 af of lake water per year (BBMWD 2002).

Table 1-1. Big Bear Lake statistics

Lake Elevation	6743.2 feet
Lake length	7 miles
Average lake width	½ mile
Shoreline	22 miles
Max depth at dam	72.33 feet
Max lake capacity	73,320 acre-feet
Big Bear Valley Length	12.5 miles
Average inflow	17,300 af/year
Average outflow at dam[1]	5,510 af/year
Average evaporation rate[2]	11,300 af/year
Average lake capacity	58,500 af/year
Average detention time of water (avg lake capacity/avg outflow at dam)	11 years

Source: BBMWD 2002; BBMWD 2004a
[1]Outflow includes dam releases, spills, leakage and withdrawals
[2]Evaporation is calculated with the Blaney Criddle formula using the estimated evaporation rate and the average surface area of the lake during the month (Big Bear Watermaster 2001, 6).

1.1 Big Bear Lake Watershed

The Big Bear Lake watershed is approximately 37 square miles and is drained by more than 10 streams (Figure 1-1). Local stream runoff and precipitation on the lake are the water supply inputs to Big Bear Lake. Big Bear Lake drains to Bear Creek, which is tributary to the Santa Ana River. Twelve percent of Big Bear Lake's drainage basin consists of the lake itself.

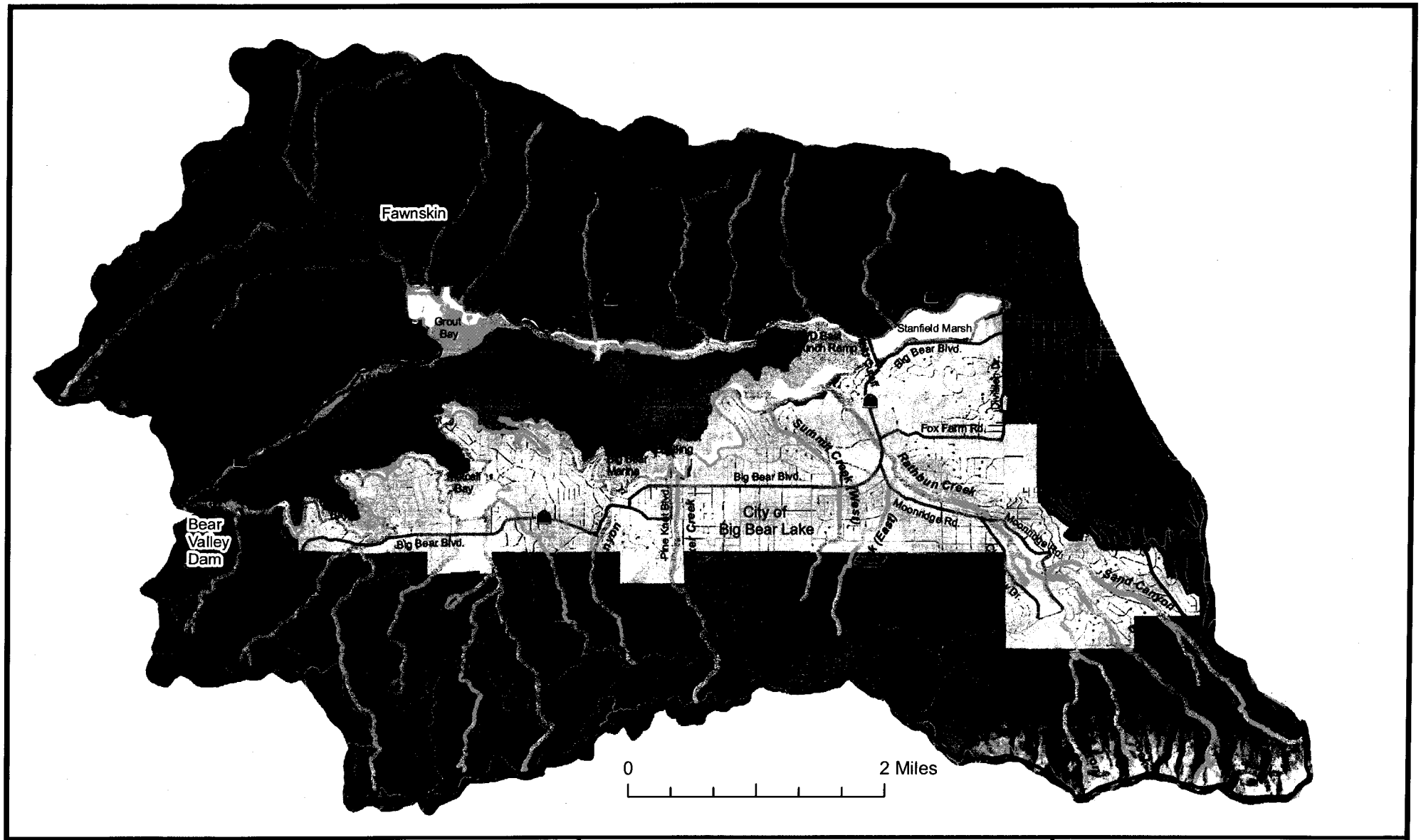
The mountain peaks surrounding the Big Bear Basin rise to approximately 7,800-8,600 feet along the southern rim of the lake. Some prominent peaks include Butler Peak (8,537 feet) to the west, Bertha Peak (8,198 feet) to the north, and Snow Summit (8,470 feet) to the south. The watershed is dominated by yellow pine and white fir; junipers and pinyon pine are found on the drier slopes. The lower reaches of most of the Big Bear Lake tributaries, particularly those in the eastern area, are underlain with older and younger alluvium. The western portion and the upper eastern portions of the lake are dominated by undifferentiated basement complex rocks, which are mostly impervious.

The underlying groundwater basin is used for domestic water supply of the Big Bear Valley and is mined in three ways: wells drilled into alluvial deposits, bedrock slant wells, and springs. During the 1970s, the Big Bear Lake watershed was divided into seven hydrographic subareas which were "based essentially on drainage boundaries, to facilitate the description of the region and for the tabulation of pertinent data according to a geographic locale"(Neste, Brudin, and Stone Inc. 1973, 3-12). These hydrographic subareas are termed Village, Rathbone, Division, North Shore, Grout Creek, Mill Creek, and Gray's Landing (Neste, Brudin, and Stone Inc. 1973, 3-14) (Figure 1-2). The City of Big Bear Lake Department of Water and Power (DWP), established in 1989, obtains its water from local groundwater and provides domestic water service to the city and areas outside the city limits. The Division, Village and Rathbone (Rathbun) subareas provide groundwater used by the city (City of Big Bear Lake 1999, ER-31).

(A) Rathbun (Rathbone) Creek Subwatershed. The Rathbun Creek subwatershed is located in the Moonridge area south of Big Bear Lake. The subwatershed drains approximately 4090 acres of land (6.4 square miles), 30% within the City of Big Bear Lake and the remainder within the San Bernardino National Forest (Figure 1-3). There are four major drainages included in the Rathbun Creek subwatershed: Rathbun Creek, Deer Canyon, Sand Canyon, and Bow Canyon. Rathbun Creek is 3.5 miles long. The Rathbun Creek subwatershed is characterized by steep fluvial/V-shaped erosional and mildly sloping alluvial valley bottom types with elevations from 6700 to 8900 feet above sea level (USDA 1995, 1). Bear Mountain ski area is located in the upper reaches of Rathbun Creek, Deer Canyon and several unnamed drainages, while Snow Summit ski area is located within the headwaters of Summit Creek, which drains into the Rathbun Creek watershed. Most of the drainage area has been substantially altered by human activities. The paragraphs below describe the condition of Rathbun Creek from the confluence of Sand Canyon Channel to the mouth.

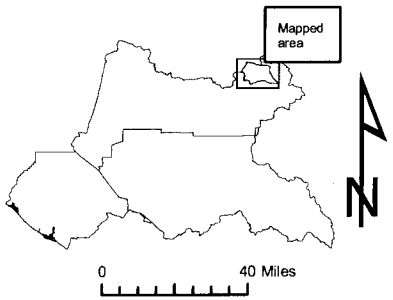
Sand Canyon Channel

Sand Canyon Channel merges with Rathbun Creek at Moonridge Road. This channel is an ephemeral stream dominated by snowmelt runoff. Soils in the area are coarse textured. The channel gradient is approximately 6 percent and is devoid of riparian vegetation. The channel is partially maintained by the San Bernardino County Flood Control District (SBCFCD) (USDA 1995, 3).



Water Boards

Data Sources:
Tributaries (modified by RWQCB 8),
Elevation - San Bernardino County, 2004
Watershed boundary - Hydmet, Inc., 2003
Lake bathymetry - ReMetrix, Inc., 2000
Section 303(d) listed water bodies - SWRCB, 2004
Major roads - San Bernardino County, 2004
City of Big Bear Lake boundary -
City of Big Bear Lake, 2002



Map Features

- Clean Water Act Section 303(d) listed bodies of water
- Major roads
- Big Bear Lake Tributaries
- City of Big Bear Lake boundary
- Big Bear Lake watershed boundary
- Streets

Big Bear Lake Bathymetry

DEPTH

- 69 - 51 feet
- 50 - 36 feet
- 35 - 21 feet
- 20 - 9 feet
- 8 - 1 feet

Figure 1-1. Big Bear Lake Watershed

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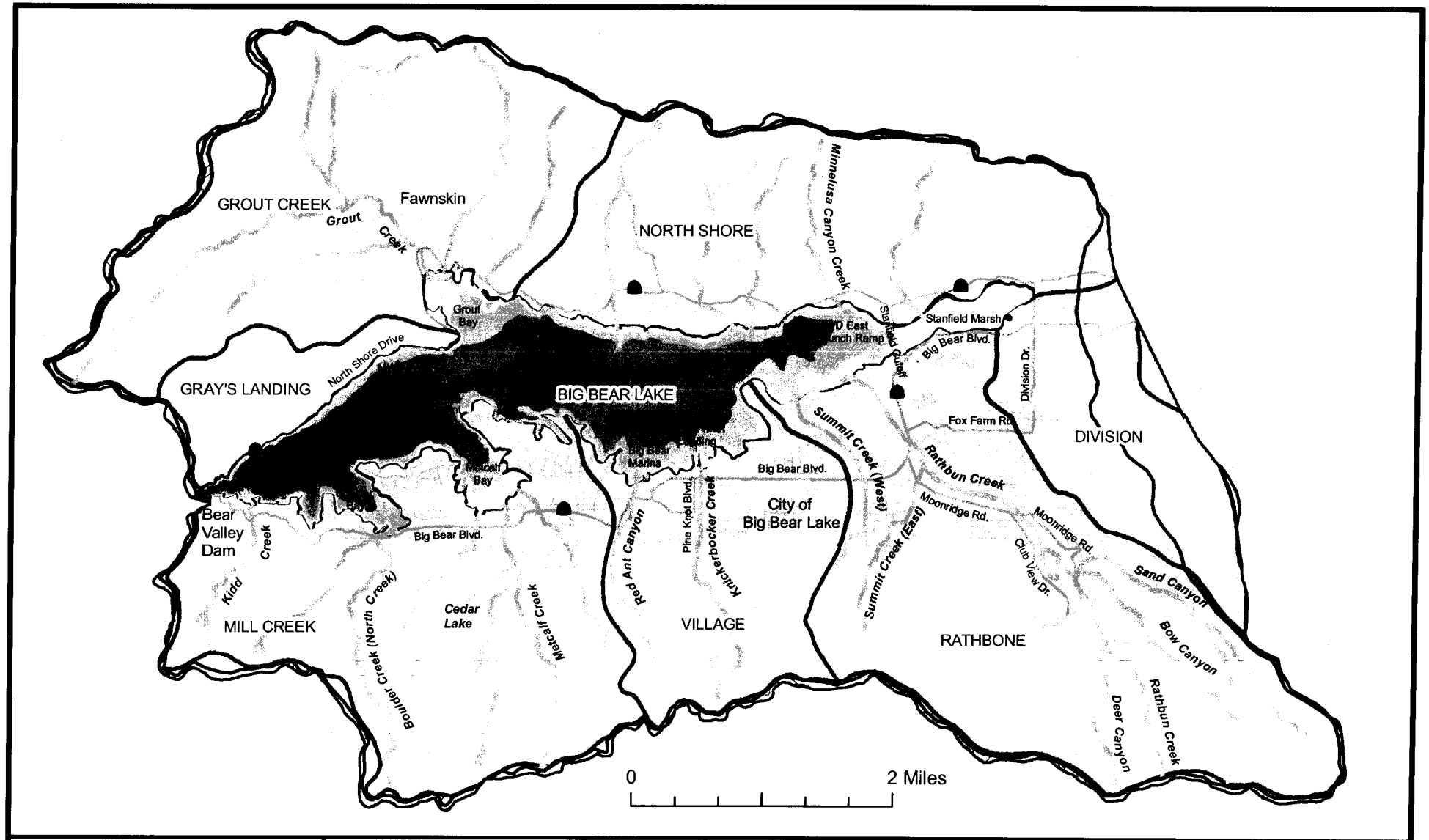
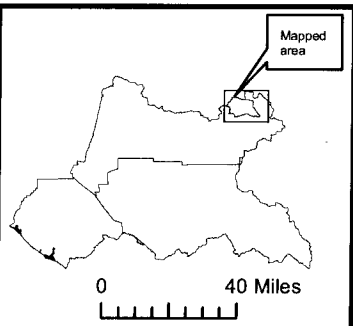
Map Contact: Heather Boyd, CA Regional Water Quality Control Board, Santa Ana Region, June 2005



Water Boards

Data Sources:
Tributaries (modified by RWQCB 8) - San Bernardino County, 2004
Watershed boundary - Hydmet, Inc., 2003
Lake bathymetry - ReMetrix, Inc., 2000
Major roads - San Bernardino County, 2004
City of Big Bear Lake boundary, Hydrographic subareas - City of Big Bear Lake, 2002



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Map Features

- Hydrographic subareas
- City of Big Bear Lake boundary
- Big Bear Lake watershed boundary
- Major roads
- Streets

Figure 1-2. Hydrographic subareas

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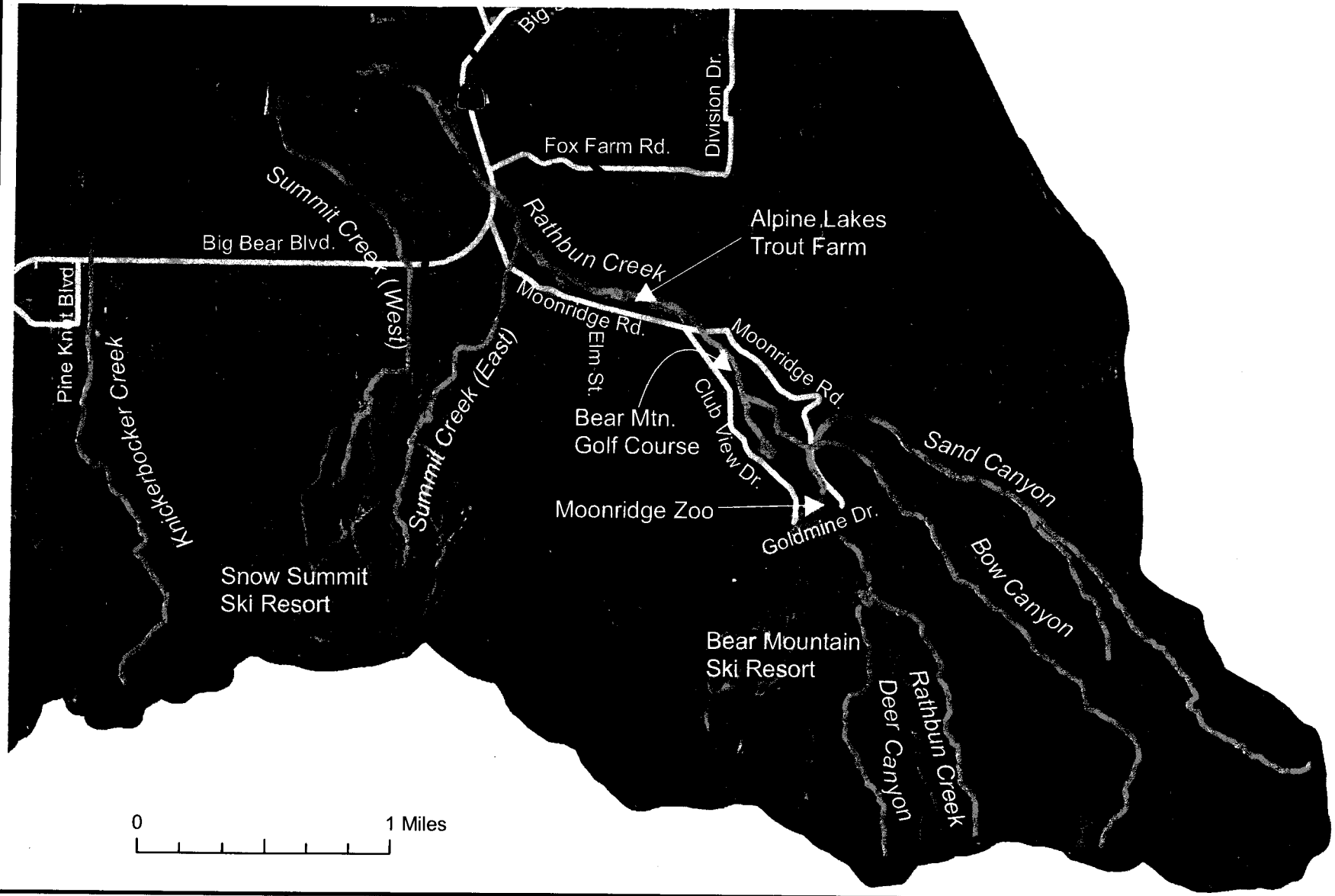
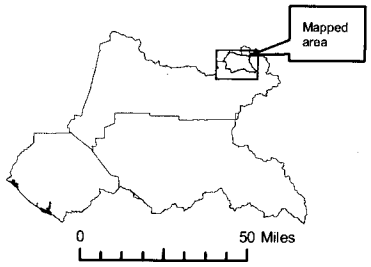
Map contact: Heather Boyd, CA Regional Water Quality Control Board, Santa Ana Region, June 2005



Water Boards

Data Sources:
Tributaries (modified by RWQCB 8), aerial imagery, major roads -
San Bernardino County, 2004
Watershed boundary - Hydmet, Inc., 2003



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Map Features

- Rathbun Creek Subwatershed boundary
- Big Bear Lake Tributaries
- Major roads
- Streets

Figure 1-3. Rathbun Creek Subwatershed

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Map contact: Heather Boyd, CA Regional Water Quality Control Board, Santa Ana Region, June 2005

Sand Canyon Channel has been widened to 40 feet with 2:1 side slopes for flood protection for the nearby homes. The channel is unlined alluvial sediment consisting of fine to coarse-grained sands and gravels with interbedded silt (Black and Veatch 1990, 7). This channel is experiencing streambed erosion and bank sloughing (USDA, 1995, p.3). Modifications to Sand Canyon Channel, consisting of armoring the banks about 600 feet upstream of Moonridge Road, were completed in 1997 with funds from a Clean Water Act Section 319(h) grant. In addition, supported by a Clean Water Act Section 319(h) grant awarded in 1999, the culvert at Teton Drive was replaced and the banks along the north and south sides of Teton Drive were armored. This project, located upstream of the first 319(h) project, was completed in 2002.

Rathbun Creek: Goldmine Road to Moonridge Road (Golf Course)

Historically, Rathbun Creek meandered, with flows from Sand and Bow Canyons joining the creek near the center of the valley. The upper portion of the creek was rerouted along the east side of the valley to allow for the golf course. This adjustment straightened the creek and in the process caused the creek to become entrenched (USDA 1995, 5). The 43-acre golf course was formerly a meadow (City of Big Bear Lake 1999, OPR-3). The Moonridge Zoo (2.7 acres) is located at the intersection of Moonridge and Goldmine Roads (City of Big Bear Lake 1999, OPR-3). Flow from the watershed area above Lassen Drive is directed into a culvert that outlets immediately below and to the west of the zoo. The lower portion of the creek, below the golf course to Moonridge Road, is a naturally meandering channel with a floodplain width between 30-50 feet. Horse grazing occurs below the golf course. Grazing has impaired the growth of riparian vegetation and contributes animal waste, high in nitrogen, which is discharged into the creek through surface runoff and leaching (USDA 1995, 5).

Rathbun Creek – Moonridge Road to the Trout Pond

A commercial trout pond (1 acre in size) is located within Rathbun Creek (City of Big Bear Lake 1999, OPR-3). Concrete check dams between Moonridge Road and Elm Road that serve as sediment traps are also effective as grade control structures. Below Elm Road there is a diversion that serves to divert moderate flows around the trout pond, while allowing low and high flows to continue flowing in the natural channel. Between Moonridge Road and the diversion downstream of Elm Road, the creek is straightened and channelized and consists of coarse loamy soils with an average channel slope of 2 percent (USDA 1995, 6-7).

Rathbun Creek – Trout Pond to State Highway 18

From the trout pond to Big Bear Boulevard (State Highway 18), the entire reach of Rathbun Creek is vegetated with tall shrub willows. After the installation of a 9x12 foot double box culvert under State Highway 18, a headcut developed in the upper section of this reach. Summit Creek drains the eastern edge of the Snow Summit Ski area. Runoff enters a trapezoidal concrete channel and flows through the residential area between the ski area and Moonridge Road. The creek (shown in Figure 1-3 as Summit Creek East) joins Rathbun Creek behind the Big Bear Inn through a 5x8 foot box culvert (USDA 1995, 8). A bank stabilization project was completed below the box culvert near the confluence of Summit and Rathbun Creeks in 1999. The banks were stabilized with rock and filter fabric (BBMWD 2002).

Rathbun Creek – State Highway 18 to Big Bear Lake

From State Highway 18 to Big Bear Lake, Rathbun Creek was historically a natural, meandering stream channel. The SBCFCD straightened and channelized the creek into an earth graded channel. Because of this channelization, sediment is not deposited throughout the floodplain but remains in creek flow and is deposited into the lake (USDA 1995, 9).

Bear Mountain Parking Areas

Two gravel overflow parking lots operated by Bear Mountain ski resort border Rathbun Creek. One parking lot covers approximately 20 acres and is bordered by Moonridge Road, Elm Road, and Rathbun Creek. The second parking lot is located upstream of the Trout Pond between Rathbun Creek and the diversion channel. This parking lot is approximately 5 acres in size. Plowed snow enters the creek. In addition, rain, ice melt, and snowmelt transport untreated sediment and pollutants into Rathbun Creek (USDA 1995, 16).

Climate. Precipitation varies greatly in the Big Bear area due to a rainshadow effect. The west end of the lake, near the dam, typically receives an average of 30-35 inches per year while at the east end of the lake, the average is less than 20 inches (Figure 1-4). The Big Bear Lake Dam weather station, established in 1883, has been monitoring precipitation continuously starting with the first precipitation records from the 1883-84 season. Information on other daily and hourly precipitation records in the San Bernardino Mountains is found in the modeling report (BBMWD, Hydmet, Inc. and AquAeTer, Inc. 2003).

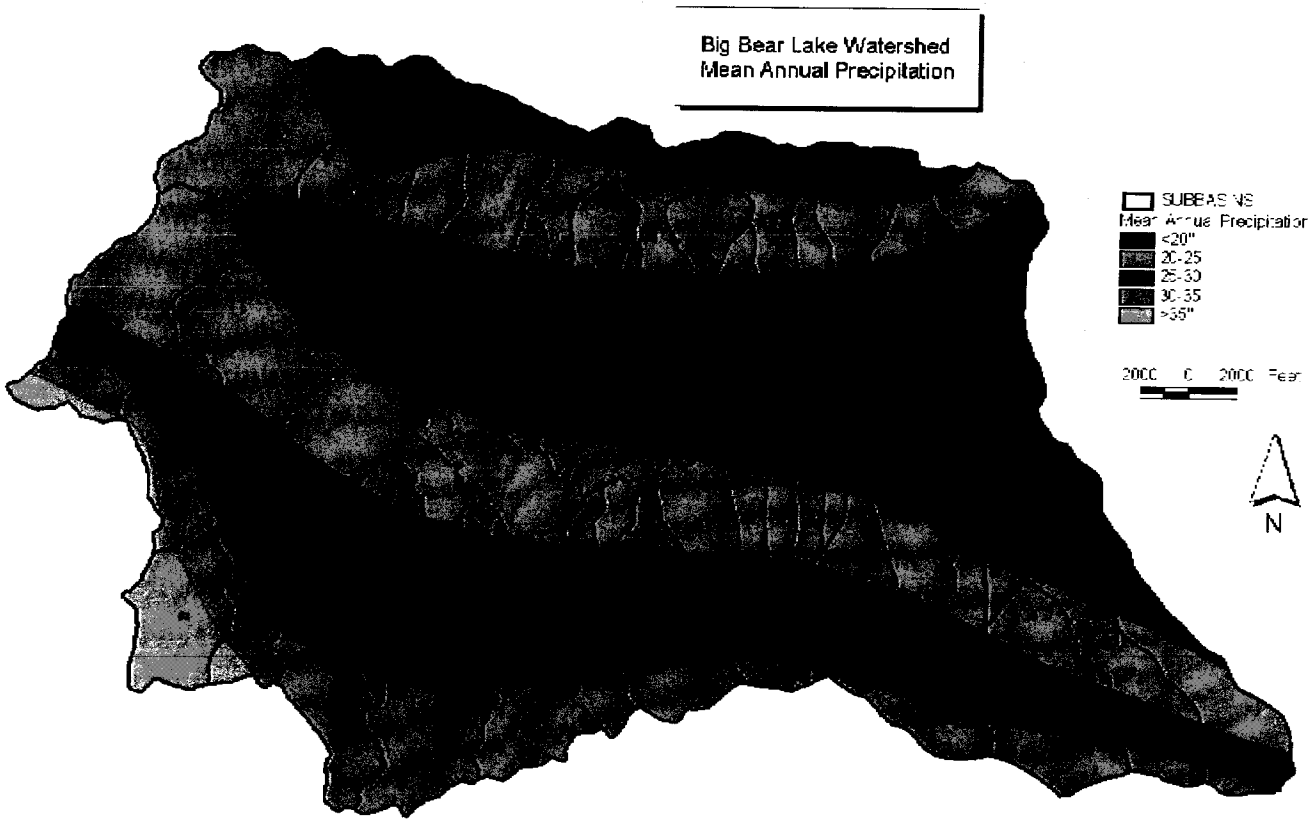


Figure 1-4: Mean annual precipitation for the Big Bear Lake watershed (source: BBMWD, Hydmet, Inc., and AquAeTer, Inc. 2003)

Figure 1-5 shows annual precipitation amounts, in inches per calendar year, measured at Bear Valley Dam. These annual numbers do not include snowfall, which does occur at this elevation. Most precipitation occurs from December through March, as indicated by monthly precipitation averages. Over a period of 56 years, the wettest year observed was in 1969 (Figure 1-5). Since the inception of the TMDL Task Force's[1] monitoring program (2001), recorded precipitation levels have been low. Consequently, lake levels, which are dependent upon surface runoff and direct precipitation, have also been extremely low (Figure 1-6).

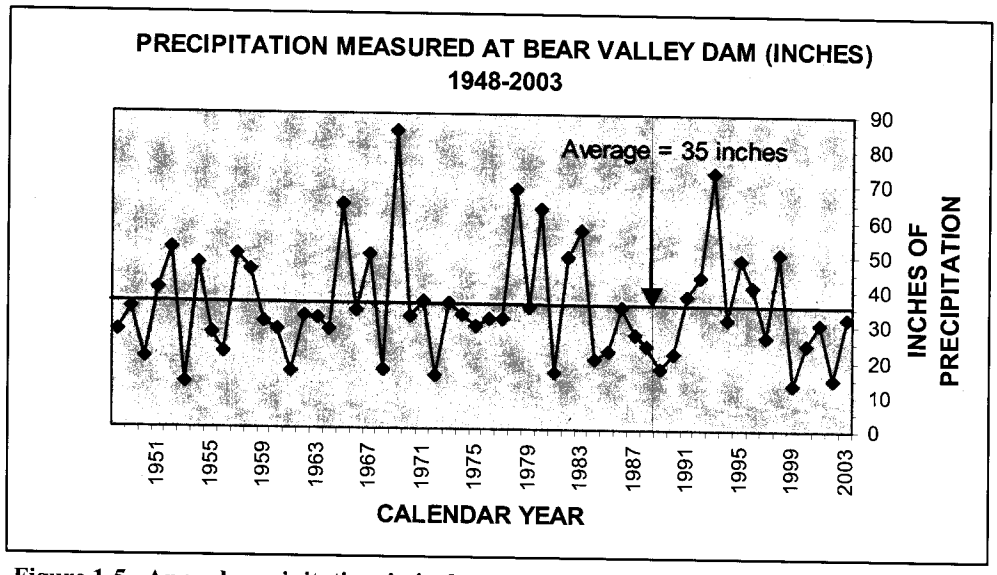


Figure 1-5. Annual precipitation, in inches, measured at Bear Valley Dam (Source: BBMWD 2004b)

[1] The TMDL Task Force was created by the Big Bear Municipal Water District in 2000. It consists of a number of local agencies and private interest groups including: the City of Big Bear Lake; San Bernardino County Flood Control District (SBCFCD); Big Bear Area Regional Wastewater Agency (BBARWA); Regional Board staff; Caltrans; Big Bear Mountain Resorts; the USFS; and others. BBMWD, acting on behalf of the Big Bear TMDL Task Force, has hired Tim Moore of Risk Sciences, Inc., as a consultant to develop and execute the appropriate studies to support TMDL development and to secure funding sources for the needed studies. The Task Force budget was created by a partnership of the BBMWD, the City of Big Bear Lake, SBCFCD, and BBARWA.

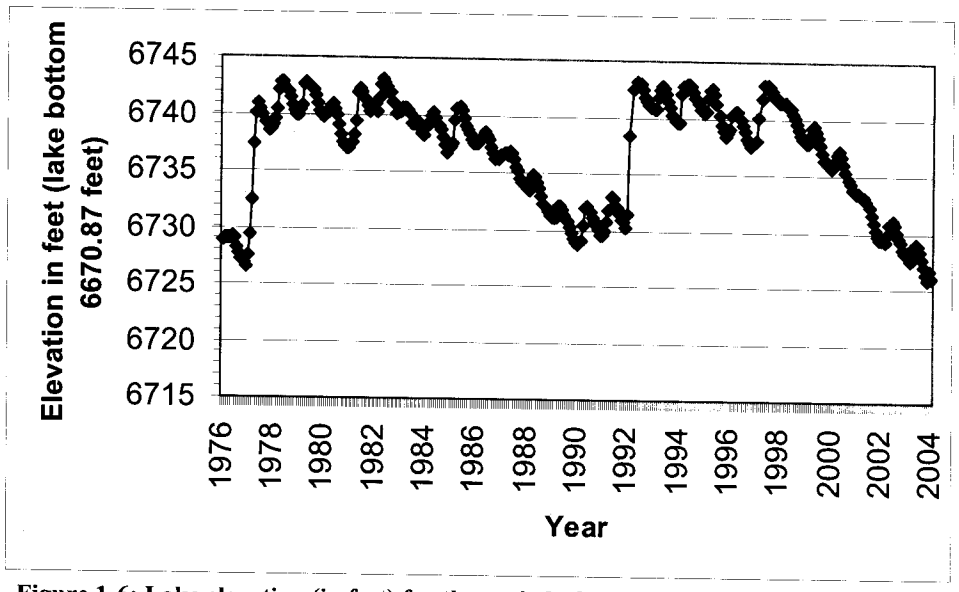


Figure 1-6: Lake elevation (in feet) for the period of record 1977- 2004 (full pool at 6743.2 feet) (Source: BBMWD 2004a)

Wastewater. Big Bear Area Regional Wastewater Agency (BBARWA), a joint powers authority created in 1974, provides interceptor service, secondary treatment and disposal by reclamation of all collected municipal wastewater in the Big Bear Valley (Engineering Resources of Southern California 1998, 1). The agency is located in Big Bear City and all the treated wastewater is disposed of in Lucerne Valley (Engineering Resources of Southern California 1998, 2). The sewerage system was installed in response to a prohibition on the use of subsurface disposal systems adopted by the Regional Board in 1973; there are limited exemptions to the prohibition, largely applicable to developments on large parcels outside existing sewer service area boundaries.

Land Use. The USFS is the largest landowner in the Big Bear area. The two ski resorts, Bear Mountain and Snow Summit, operate under special use permits from the USFS. Bear Mountain ski resort has 748 total permit acres; of that total, 198 acres are developed with 34 trails. The remaining acreage (550 acres) is undeveloped land that includes Deer, Goldmine and Bow Canyons (Bear Mountain Resort 2003). Snow Summit ski resort, built in 1952, is 620 acres in size, with 230 skiable acres (City of Big Bear Lake 1999, ER-24, OPR-6). Snow Summit is also used for mountain biking during the summer. A third abandoned ski resort, Snow Forest, is located to the southwest of Knickerbocker Creek. The San Bernardino Recreation Club and the Big Bear Lake Park District opened this area to skiing and tobogganing in 1939 (City of Big Bear Lake 1999, ER-24). This site is a contributor of sediment and potentially nutrients to Big Bear Lake.

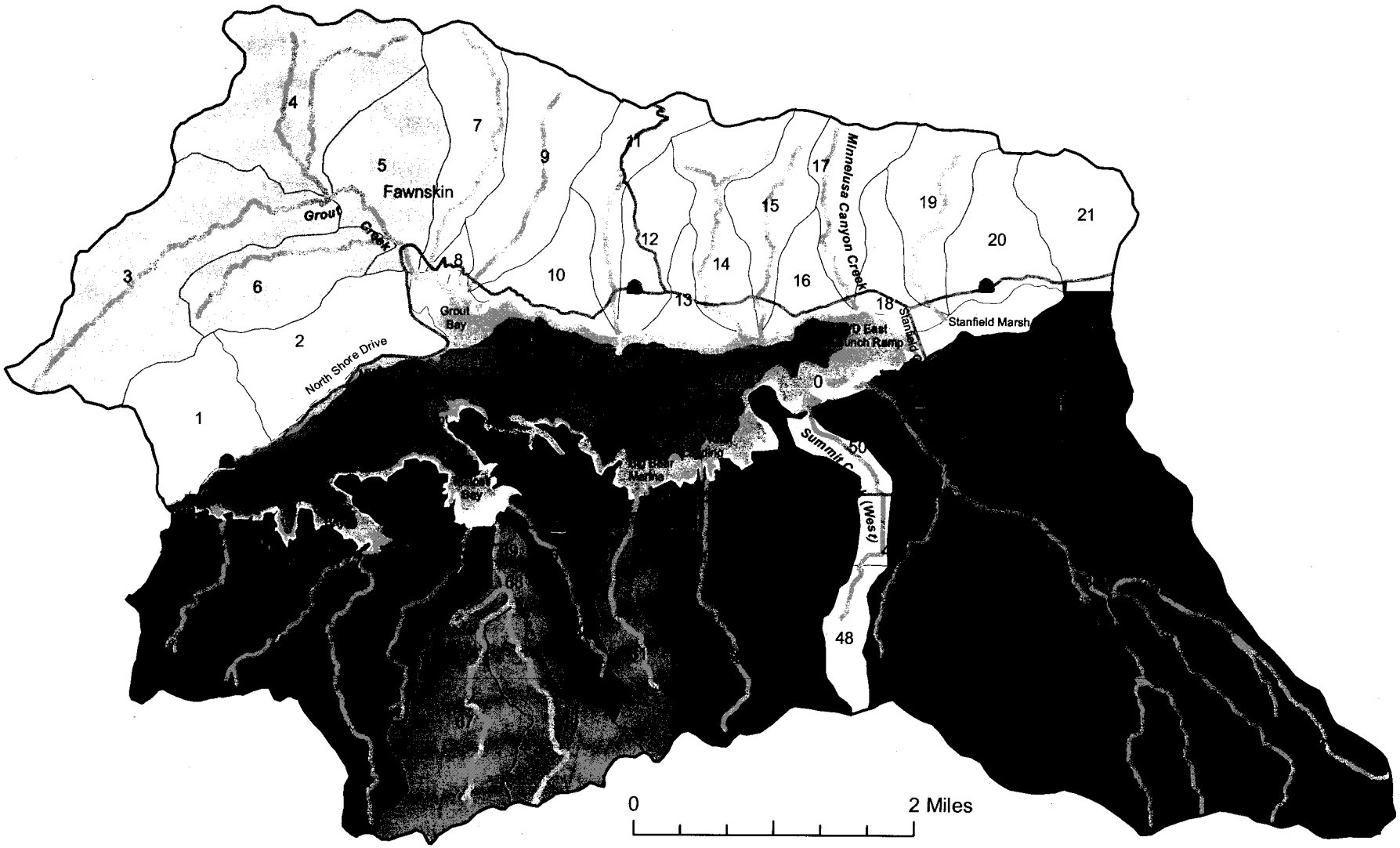
The only incorporated city in the Big Bear Lake watershed is the City of Big Bear Lake, which was incorporated in 1980. The permanent population of the City of Big Bear Lake in 1980 was 4,923 and 6,049 in 1998. Of a total of 9,019 dwelling units in the City as of January 1, 1998, only 26% were permanently occupied. An estimated 50,000 or more people visit the City of Big Bear Lake on a peak holiday weekend and the U.S. Forest Service estimates 5 million people visit Big Bear Valley each year (City of Big Bear Lake 1999, LU-4, LU-6).

A total of 4,466 acres are currently in the City of Big Bear Lake's planning area and are designated for a variety of land uses, including residential, commercial, and industrial. The southern boundary of the City of Big Bear Lake's sphere of influence follows the USFS' boundary (City of Big Bear Lake 1999, LU-3) (see Figure 1-1).

For modeling purposes, the Big Bear Lake watershed was delineated using the watershed boundaries from CalWater v. 2.2 and incorporated the Hydrologic Subarea Boundary (HSA) of Bear Valley (801.71). Further refinement of the watershed boundary was obtained using the USGS 7.5 Minute Quadrangle sheets (Fawnskin, Moonridge, Big Bear Lake, and Big Bear City). The watershed was then further divided into 83 subbasins (Figure 1-7) to permit the greatest flexibility in simulating watershed processes. The subbasins were delineated based on topographic features, stream reaches, and the storm water system Geographical Information System (GIS) files supplied by the City of Big Bear Lake. The Rathbun Creek subwatershed consists of subbasins 31-46 as shown in Figure 1-7.

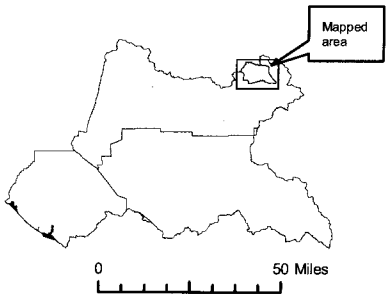
Utilizing GIS analysis, the areas of various types of land use within the watershed were determined (Table 1-2, Figure 1-8). These land uses were also used for the Hydrological Simulation Program Fortran (HSPF) model development (see Section 4.0). Land use layers were derived from the City of Big Bear Lake's current (2002) zoning map and 1996 aerial photos from the USGS. The following ratios were used to determine the percentage of impervious/pervious area for each land use: forest north (0.5%, 99.5%); forest south (0.5%, 99.5%); resort (5%, 95%); residential (15%, 85%); and high density urban (50%, 50%)[2]. The majority of land use area in the Big Bear Lake watershed is still pervious. The predominant land use in the watershed is forest (62.7%). The resort land use designation includes the ski resorts, parks and golf courses. The historic ski resort, Snow Forest, near Knickerbocker Creek, was also included in the resort land use category. High density urban includes commercial, industrial and multiple family land uses (BBMWD, Hydmet, Inc., and AquAeTer, Inc. 2003).

[2] The nomenclature "Forest North" and "Forest South" refer to the topographic aspect, not to whether the forest is located to the north or south of the lake. Distinctions in topographic aspects were important to the HSPF modeling effort because of the effect of snow accumulation and snowmelt on water resources. North facing slopes accumulate more snow and melt slower than do south facing slopes.



Water Boards

Data Sources:
Tributaries (modified by RWQCB 8) - San Bernardino County, 2004
Watershed boundary, subbasins - Hydmet, Inc., 2003
Lake bathymetry - ReMetrix, Inc., 2000
Major roads - San Bernardino County, 2004



N

Map Features

Subbasins
- Local North
- Grout Creek
- Minnelusa Canyon
- Local South
- Division Creek
- Rathbun Creek
- Summit Creek (West)
- Knickerbocker Creek
- Red Ant Canyon
- Metcalf Creek
- Boulder (North) Creek

Big Bear Lake Tributaries

Big Bear Lake Bathymetry

DEPTH
- 69 - 51 feet
- 50 - 36 feet
- 35 - 21 feet
- 20 - 9 feet
- 8 - 1 feet

Big Bear Lake watershed boundary

Major roads

Figure 1-7.
Big Bear Lake subbasins

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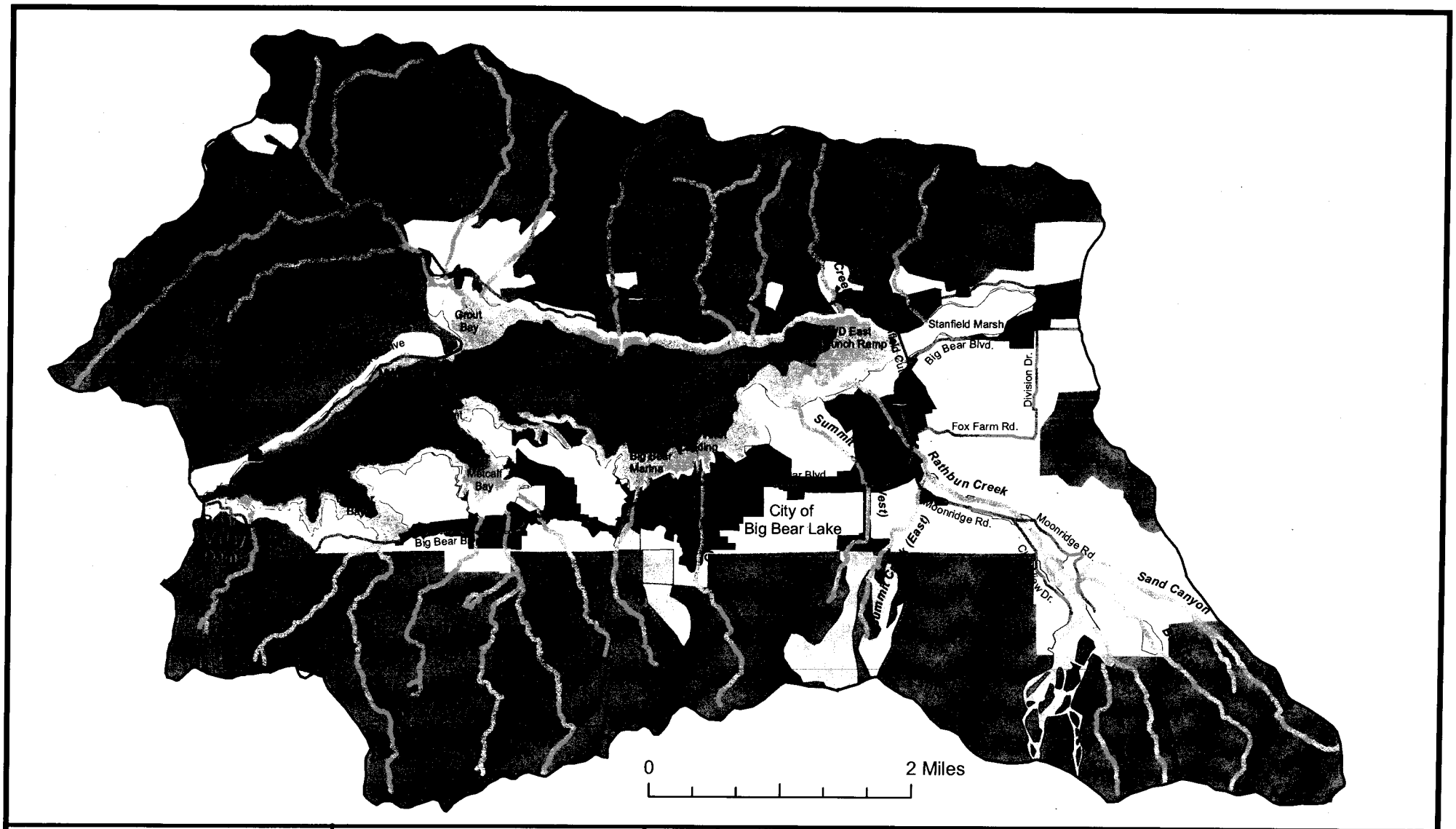
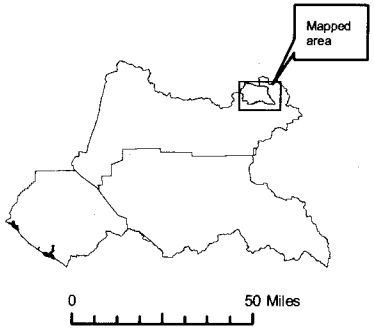
Map contact: Heather Boyd, CA Regional Water Quality Control Board, Santa Ana Region, June 2005



Water Boards

Data Sources:
Tributaries (modified by RWQCB 8) - San Bernardino County, 2004
Watershed boundary, Land use - Hydmet, Inc., 2003
Lake bathymetry - ReMetrix, Inc., 2000
Major roads - San Bernardino County, 2004
City of Big Bear Lake boundary - City of Big Bear Lake, 2002



N

Map Features

Big Bear Lake Tributaries

Big Bear Lake Bathymetry

DEPTH

- 69 - 51 feet
- 50 - 36 feet
- 35 - 21 feet
- 20 - 9 feet
- 8 - 1 feet

Big Bear Lake watershed boundary

Major roads

Land Use

- Commercial Resort
- Forest
- High Density Urban
- Residential
- Water

Figure 1-8.
Land Use within the Big Bear Lake watershed

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Map contact: Heather Boyd, CA Regional Water Quality Control Board, Santa Ana Region, June 2005

Table 1-2. Impervious and Pervious land use distribution in the Big Bear Lake watershed

	AREA (acres)			
Major Land Use Type	**Impervious**	**Pervious**	**Total**	**Percentage of Watershed (%)**
Forest North	38	7,595	7,633	32.9
Forest South	35	6,876	6,911	29.8
Resort	35	669	704	3.0
Residential	580	3,287	3,867	16.7
High Density Urban	644	644	1,288	5.5
Big Bear Lake	-	-	2,808	12.1
Total Watershed	1,332	19,071	23,211	100

Note: Forest North and Forest South refer to the aspect, not to whether the forest is located to the north or south of the lake.
Source: Modified from Hydmet, Inc. 2004

Shown in Table 1-3, are the pervious and impervious land use distributions for Rathbun Creek. The percentages of impervious/pervious land use identified for the watershed as a whole were also used for this subwatershed. The predominant land use in the Rathbun Creek subwatershed is forest.

Table 1-3. Impervious and pervious land use distribution in the Rathbun Creek subwatershed

	AREA (acres)			
Major Land Use Type	**Impervious**	**Pervious**	**Total**	**Percentage of Subwatershed (%)**
Rathbun Creek				
Forest North	10	1,991	2,001	49
Forest South	2	434	436	11
Resort	9	417	426	10
Residential	151	856	1,007	25
High Density Urban	110	110	220	5
Total subwatershed	282	3,808	4,090	100

Note: Forest North and Forest South refer to the aspect, not to whether the area is located to the north or south of the lake
Source: Modified from Hydmet, Inc. 2004

Geology. The San Bernardino Mountains are part of the Transverse Range Geomorphic Province of California. The geology of the Big Bear Lake watershed is composed principally of three distinct rock groups: carboniferous and pre-carboniferous sedimentary rocks; volcanic and metamorphic rocks; and Cenozoic sedimentary deposits (Owen and Associates 1977, III-33) (Figure 1-9).

These geologic formations can be divided into two categories: water-bearing and non-water bearing. The Quarternary unconsolidated deposits (e.g., Recent Alluvium (Qa), Older Alluvium (Qoa) and Older Alluvial Fan Deposits (Oof)) are considered water-bearing and comprise the largest percentage of the groundwater reservoir in the Big Bear Lake watershed. The recent alluvium is primarily present in stream bottoms and flood plains at lower elevations. This alluvium consists of gravel and sand and is from other rock units in the tributary drainage basin. The Paleozoic Furnace limestone has a higher water yielding potential than the other basement complex rocks due to the solution channels within the limestone bodies (Crandall and Associates 1978, 2-4).

The non-bearing rock formations may contain limited amounts of water in fractures or joints, but do not absorb, transmit, or yield water readily. These types of rock formations consist of igneous and metamorphic rocks that range in composition from quartz monzonite to quartz diorite, biotite diorite gneiss and quartzite (Crandall and Associates 1978, 4).

The physical condition of the crystalline, nonwater-bearing rocks ranges from completely crushed rock to massive, moderately jointed rock. Deep weathering is evident in some areas, and in some of the creek bottoms, the rock outcrops are intact and more massive (Crandall and Associates 1978, 5).

In the Big Bear Lake watershed, production of sediment includes weathering processes and transport likely includes mass wasting and watershed erosion. These processes will be evaluated in greater detail during 2005 and 2006 as part of a Proposition 13 grant.

Weathering processes. The primary source of sediment delivered to rivers in California occurs by chemical physical weathering of minerals and breakdown of parent material (Mount 1995, 102). Weathering rates are controlled by temperature, the quantity of water and its movement, acidity and the properties of minerals (Leopold, Wolman and Miller 1995, 116).

Mass wasting processes. Because of the steep slopes within the Big Bear Lake watershed, mass wasting processes are likely a dominant form of erosion. Mass wasting is the movement of soil, rock and organic debris downslope by gravity and consists of landslides, rockfalls, debris avalanches, debris flows, slumps, soil creeps, and others (Beschta 1996, 123).

Watershed erosion. Watershed erosion includes both surface and channel erosional processes. Surface erosional processes consist of rainsplash, sheetwash, and gully and rill erosion. Channel erosional processes include both streambed and streambank erosion.

Rainsplash erosion occurs when raindrops hit the surface and dislodge and transport soil particles downhill. Rainfall intensity, slope steepness, amount of vegetative cover, and the resistance of the soil to erosion all factor into the amount of erosion that occurs due to rain. Construction sites, road cuts and recently burned areas are locations that are affected by this type of erosion (Mount 1995, 106-107).

Overland flow occurs only when the infiltration capacity of the land surface is exceeded and the depression storage is filled. This flow is also called Horton overland flow, or sheetwash, and causes the highest rates of hillslope erosion. Factors that are important in controlling the amount of sediment transported by overland flow are the type and amount of vegetative cover, BMPs implemented to control erosion, steepness of the slope, resistance of the soil to erosion, and the distance that flow travels across a slope (Mount 1995, 107-108). Changes in land use, such as conversion of forested areas to urban areas, can alter flow regimes and surface runoff patterns. As an area becomes more impervious, changes in the hydrograph result in an increase of discharge over a shorter time period because the runoff has a reduced ability to infiltrate the soil and has less natural resistance to flow. This alters overland runoff, causing erosion and the transport of sediment, especially the finer-material such as silts and clays, and increasing channel erosion (Guy 1970).

The last type of erosion is from formation of rills and gullies. Rills are tiny incisions or channels formed by concentrating flows on uneven surfaces. Gullies are formed by rills that continue to incise with each significant overland flow event, and are one or more feet deep. Rills and gullies usually contribute only a minor amount of sediment to the overall sediment budget, except in the case of rivers that are adjacent to construction sites and road cuts that are particularly susceptible to rill and gully erosion and can then be important to the overall sediment budget (Mount 1995, 108).

Stream channels continuously adjust in response to one or more changes in eight variables (channel width, depth, slope, discharge, velocity, hydraulic roughness, sediment load and sediment size) in order to attain equilibrium (Leopold, Wolman and Miller 1995, 268). Fine sediment particles are suspended in the water column and usually move down the channel with the flow. Coarser-grained particles usually only move short-distances or roll and bounce along the stream bottom. Rill and gully flow carry the finer-material as well as any coarser material that is eroded from the banks and bed of the channel. Due to these differences in the transportation of differently-sized sediment particles within streams, variations in sediment concentration at a given cross-section are expected (Guy 1970).

Soils. A soil survey of the San Bernardino National Forest Area was prepared from fieldwork conducted in 1974-1979 (Cohn and Retelas n.d., ii). This survey is an Order 3 survey, meaning that every delineation of each different map unit was not verified in the field and the exact location of each soil type was not delineated. Instead, a number of soil map units were identified, each of which consists of a group of soils with similar landforms, parent rock material, and similar geographic areas and is named after the major soils or miscellaneous areas occurring in the unit (Cohn and Retelas n.d., 8). Field verification of the survey is needed prior to any type of project planning. Other soils data available in GIS format include the STATSGO[3] data used in the watershed model (see Section 4.0- Source Assessment,) and newer SSURGO[4] data for the San Bernardino National Forest Area.

Six soil map units are identified in the Big Bear Lake watershed, including (30%) Morical, very deep-Hecker families complex; (30%) Pacifico-Wapi families complex; (19%) Pacifico-Preston families complex; (8%) Merkel-Switchback families complex; (13%) Lithic Xerorthents, calcareous-Lizzant family association; and (0.4%) Morical-Wind River families complex[5] (Figure 1-10). These units are found on moderate (2-30%) to steep (30-50%) slopes. The soils are generally somewhat excessively drained to well drained. The matrix of these soils is sandy loam and loamy sand. Soil families are made up of soils that have similar profiles[6]. Each soil map unit consists of a description of soil features such as slope gradient, slope stability, maximum erosion hazard, soil depth, and permeability, which aids in the determination of which soils are suitable for specific uses (Cohn and Retelas n.d., 8,17-21). Shown in Table 1-4 are some selected properties of soil units found in the Big Bear Lake watershed.

[3] STATSGO is the State Soil Geographic data base with data at a scale of 1:250,000, prepared by the U.S. Department of Agriculture's (USDA) Natural Resources Conservation Service (NRCS).
[4] SSURGO is the Soil Survey Geographic data base with data at a scale of 1:24,000, also prepared by the NRCS.
[5] Note that the percentages were obtained from GIS analysis of the soils map. The percentages are based on land area only and do not include the lake itself. More discrete classes of soils are available; however, this analysis used the soils map and associated information that was prepared for the HSPF modeling effort (see Section 4.0). In the future, a more detailed soils map can be prepared.
[6] A soil profile is the vertical arrangement of layers of soil (i.e., soil horizons) down to the bedrock.

Table 1-4. Selected properties of soil map units found in the Big Bear Lake watershed

Soil Map Unit Name	Soil Map Unit Symbol	Depth (in.)	Slope %	Hydrologic Soil Group	Erosion Hazard
Morical, very deep-Hecker complex	BoD	36 to 60	2 to 15	B	Moderate
Pacifico-Wapi complex	DaE	10 to 20	15 to 30	C	High
Pacifico-Preston complex	DdDE	15 to 28	2 to 30	C-B	Moderate
Merkel-Switchback complex	FbE	18 to 30	15 to 30	B	Moderate
Lithic Xerorthents, calcareous rock outcrop, Lizzant complex	FrF	24 to 46	30 to 50	C-B	High
Morical-Wind River complex	MbF	20 to 50	30 to 50	B	High

Source: Cohn and Retelas n.d., 28,37,42,57,62,76
Hydrologic soil groups are used to estimate runoff from precipitation. Soils that aren't protected by vegetation are assigned to one of four groups, increasing in runoff potential from A to D. A =low runoff potential; B = moderately low runoff potential; C = moderately high runoff potential; D = high runoff potential. Maximum erosion hazard appraises relative risk of accelerated sheet and rill erosion; the system does not rate gully erosion, dry ravel[7], wind erosion, or mass wasting. Erosion hazard assessment is based on little or no vegetative cover and on the long-term average occurrence of 2-year, 6-hour storm events. Erosion hazards are greater when storm frequency, intensity and/or duration exceed long-term average occurrence. Very high and high erosion hazard: accelerated erosion will occur in most years. Moderate erosion hazard: accelerated erosion likely to occur in most years.

The most likely areas for high erosion potential based on soils and slope steepness are indicated in Figure 1-11.

[7] Unconsolidated material consisting of rock fragments, finer grained earth material, and organic matter deposited on and at the base of steep slopes by direct gravitational action (Cohn and Retelas n.d., 152).

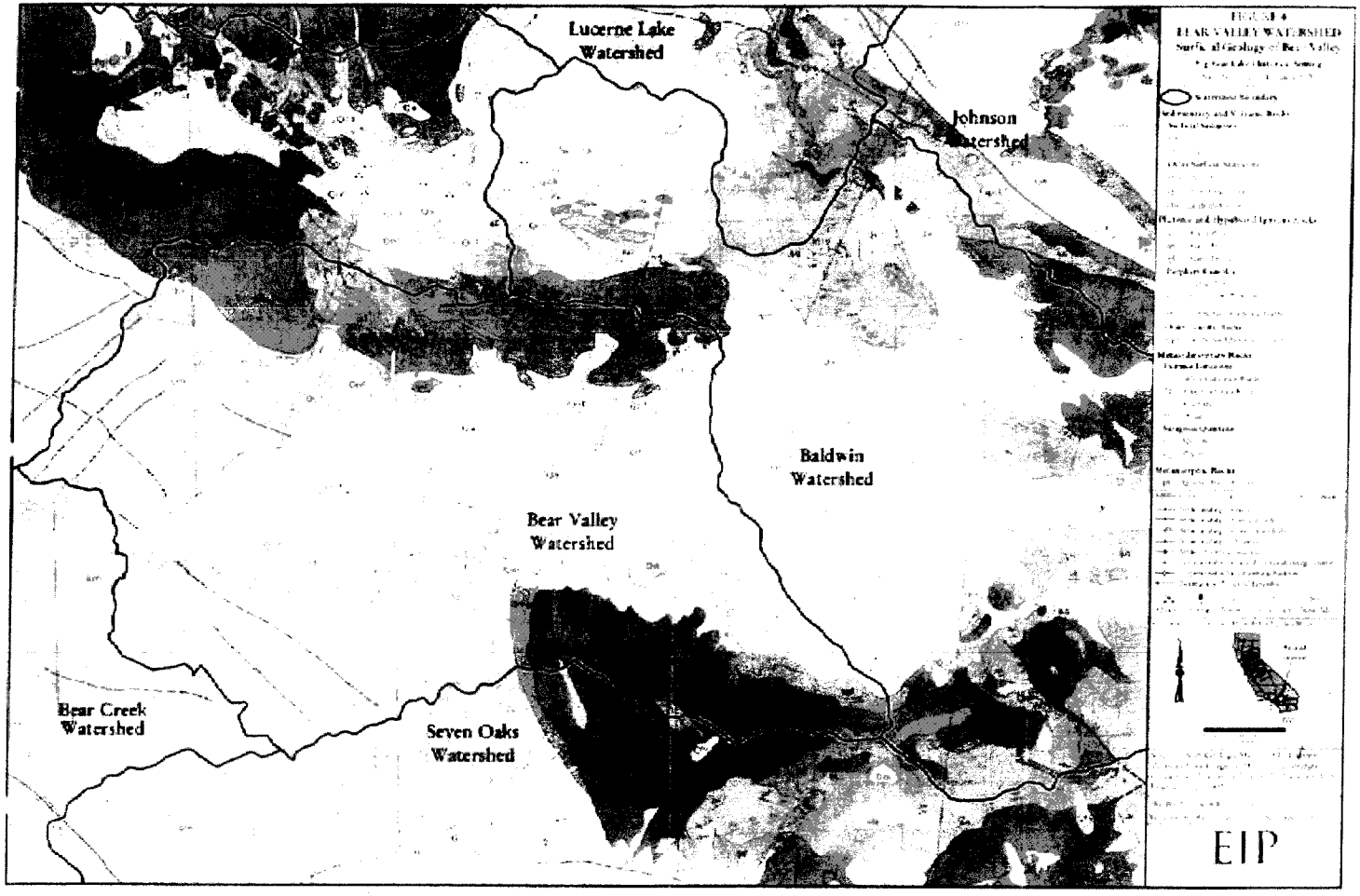


FIGURE 1-9. SURFICIAL GEOLOGY OF THE BIG BEAR LAKE WATERSHED (Source: Leidy 2003)

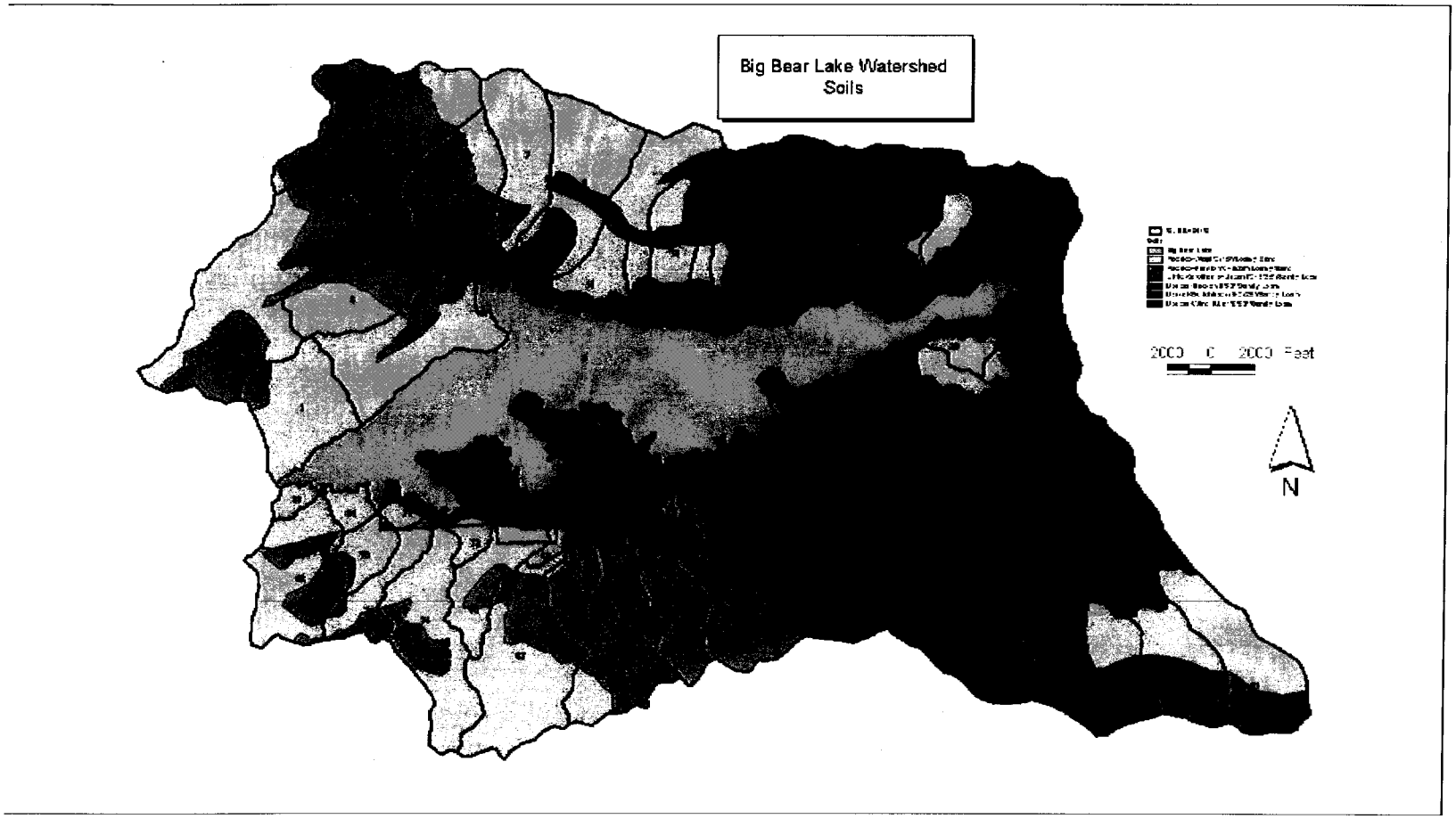
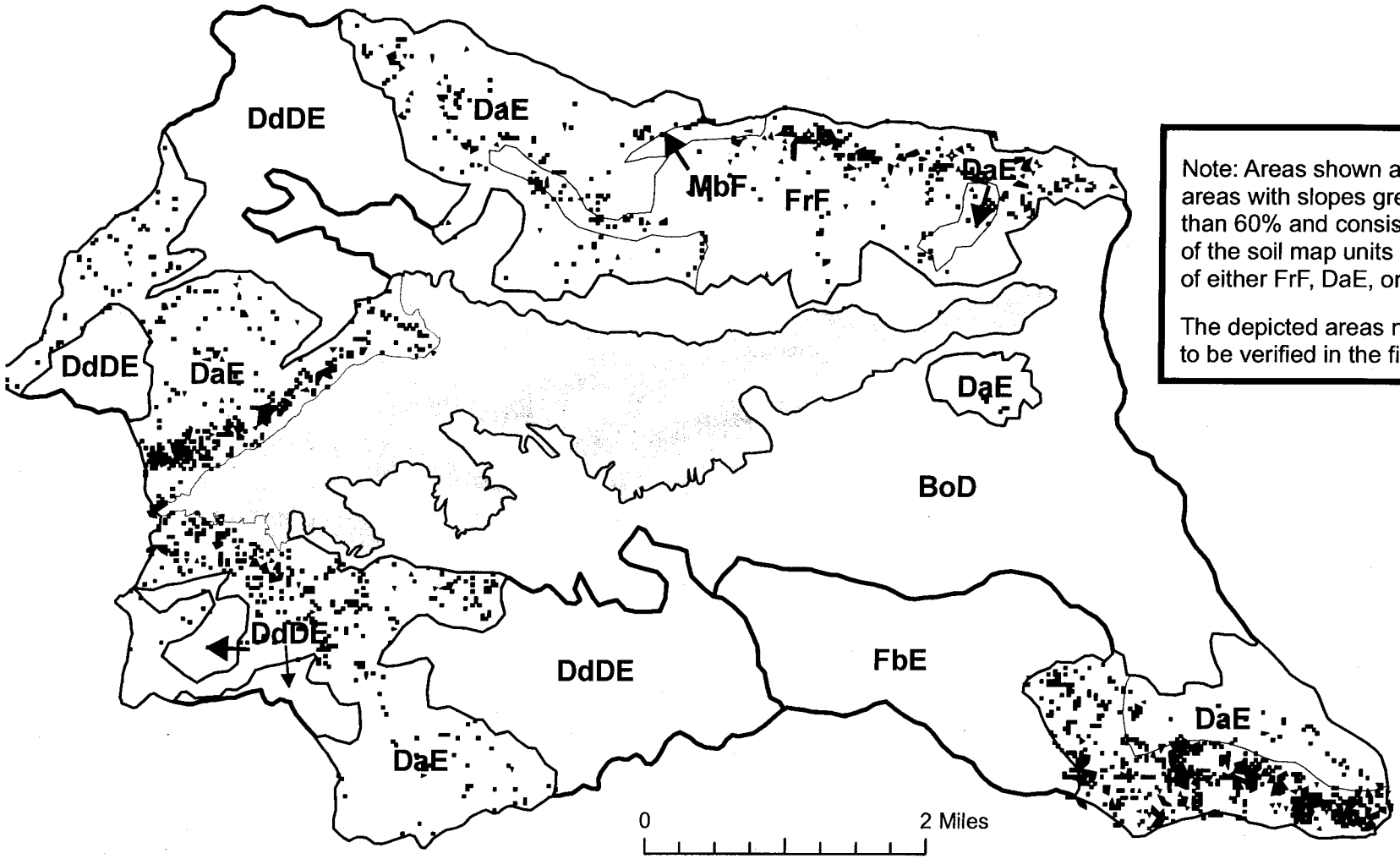


FIGURE 1-10. SOILS MAP OF THE BIG BEAR LAKE WATERSHED (Source: Hydmet, Inc. 2003)

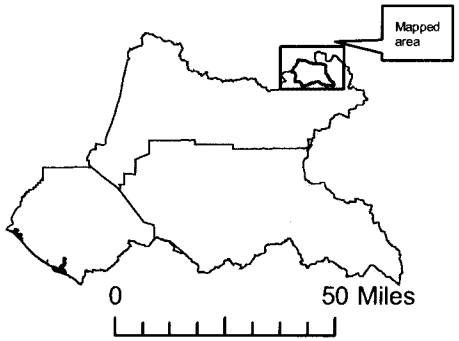


Note: Areas shown are those areas with slopes greater than 60% and consisting of the soil map units of either FrF, DaE, or MbF.

The depicted areas need to be verified in the field.

Water Boards

Data Sources:
Soil data: Hydmet, Inc., 2003
TIN used to calculate slope:
San Bernardino County, 2004



N

Map Features

Slopes > 60%

Soil map unit

Figure 1-11.
Areas within the Big Bear Lake watershed most susceptible to erosion

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Map contact: Heather Boyd, CA Regional Water Quality Control Board, Santa Ana Region, July 2005

Fish and Wildlife. There are two fisheries in Big Bear Lake, a warm water fishery consisting of centrarchids (largemouth bass, bluegill and pumpkinseed) and channel catfish, and a cold water fishery, with frequent stocking of rainbow trout. In addition, there are large populations of carp present in the lake. The three centrarchids, members of the Sunfish family (Family taxon Centrarchidae), spawn at different water temperatures. The largemouth bass spawns in the early spring when water temperatures are at 14-16° C, the bluegill spawns when water temperatures are at about 18-21° C, and the pumpkinseed spawns when water temperatures are at about 20° C. These fish have different dietary and habitat preferences as well. The pumpkinseed prefer damselfly naiads and gastropods and prefer the dense macrophyte beds. The bluegill's diet consists of zooplankton, damselfly naiads, and chironomids and they prefer the fringe of the weed beds. The largemouth bass' diet consists of chironomids, crayfish and fish. The bass also prefer the fringe of the weed beds but select larger prey than the bluegill (Siegfried et al. 1978, 49-50). Half-pound Rainbow trout from the Mojave Fish Hatchery are stocked in Big Bear Lake twice a month from April to November, with a 36,000 lb allotment per calendar year. One hundred fifty thousand subcatchables are also stocked per year. These smaller, 6-inch rainbow trout are an Eagle Lake trout strain (Uplinger 2000). According to the Big Bear Municipal Water District (2002), there are 9 species of fish in the lake (Largemouth bass, smallmouth bass, silver salmon, bluegill, pumpkinseed, crappie, catfish, carp and rainbow trout). Because of these habitat and dietary differences, it is important that the aquatic plant community in the lake consist of a variety of species and that no one species forms a monoculture, as Eurasian watermilfoil has essentially done in Big Bear Lake. A diverse aquatic plant community is necessary to support the diversity of fish and other wildlife species. The development of a monoculture threatens the diversity of the biota.

Rare/Threatened/Endangered Species. Bald eagles winter at Big Bear Lake and adjacent Baldwin Lake. In 1998, there were approximately 15 to 28 bald eagles. The eagles perch in trees within wooded areas along the southern lakeshore, around Metcalf Bay and Eagle Point, and along the eastern shore of the lake. They also forage on fish within Big Bear Lake. Any outdoor activity that could disturb the eagles should be restricted from December 1 through April 1 (City of Big Bear Lake 1999, ER-5, ER-6).

2.0 PROBLEM STATEMENT

The process of sedimentation is the detachment, transport, and deposition of inorganic particles by water (Beschta 1996, 124). Although sediment is a necessary part of the watershed, excessive sediment can impair beneficial uses such as recreation, aquatic life habitat, and drinking water supply (USEPA 1999b). The transport of sediment particles in the water column and deposition of excessive sediments on lake and creek bottoms can reduce growth and survival rates of bottom-dwelling organisms, clog fish gills, and affect fish food sources and the ability of organisms to hide from prey. Changes in water temperature can also result, in turn affecting aquatic biota. Transport and build up of excess sediment can also change the habitat from more complex to less complex, leading to reduced biotic diversity (USEPA 1999b). Researchers have found reduced numbers and diversity of macroinvertebrates with turbidity values of 7-23 NTUs[8]. This reduction is most likely due to reduced periphyton[9] biomass resulting from light attenuation caused by the increase in turbidity (USEPA 2000, 33). Build up of excess sediment in certain areas can result in boat navigational hazards and limit water contact recreation activities.

While the term sediment refers to inorganic soil particles, organic particulate matter can also be a significant part of the total solids suspended in the water column, contributing to increased turbidity and reduced water clarity and light penetration, and to excessive sedimentation on lake and creek bottoms. Biological organisms contribute wastes that may settle on the lake bottom; dead and decaying organic matter also settles to the bottom. Organic particulate matter is also transported from the watershed with soil particles, particularly in streams draining forested watersheds or streams with high densities of riparian vegetation (Beschta 1996, 124).

Big Bear Lake and Rathbun Creek were placed on the Clean Water Act Section 303(d) list for sedimentation/siltation[10]. Excessive erosion and sediment transport in Rathbun Creek and the build-up of sediment in Big Bear Lake adversely affect the warm and cold freshwater habitat, recreational and municipal beneficial uses of these water bodies.

As described in Section 1.1, Rathbun Creek has been hydromodified and this has led to problems with stream channel stability. Bank erosion and stream bottom down cutting are significant problems in the creek that lead to sediment transport to the lake. Watershed sources also contribute sediment that is transported to the creek and thence Big Bear Lake. Aquatic habitat in Rathbun Creek is adversely affected by both the production and transport of sediment.

Over time, the capacity of Big Bear Lake has decreased due to erosion and transport of sediment from the watershed[11]. It is likely that watershed disturbances (e.g., conversion of forest land to ski resorts, urbanization, and road building) and changes in watershed hydrology led to increased erosion and transport of sediment to the lake. A recent hypothesis is that the changing lake levels contribute to the sedimentation problem in Big Bear Lake (Kirby 2005). Excessive sediment build up in Big Bear Lake, particularly at the mouths of the tributary creeks, has limited or restricted recreational access. Shallow areas at the mouths of the creeks and elsewhere in the lake allow for greater light penetration to the bottom, usually resulting in an increase in macrophyte biomass. In these shallow, littoral areas of Big Bear Lake, aquatic macrophytes are

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[8] Turbidity values are reported in NTUs. Turbidity is a measurement of how clear the water is - higher amount of total suspended solids, the higher the measured turbidity.
[9] Periphyton are organisms that grow on underwater surfaces.
[10] Siltation is the deposition of soil particles on lake or stream bottoms.
[11] Initial capacity (1912) of 85, 400 af. In 1977, storage capacity was 72,500 af (BBMWD 2002).

overabundant, especially the noxious aquatic plant, Eurasian watermilfoil[12]. Excessive macrophyte growth and the dominance of certain species severely impact the beneficial uses of the lake, including water contact recreation (REC1), non-contact water recreation (REC2), warm (WARM) and cold (COLD) freshwater habitat, wildlife habitat (WILD) and municipal and domestic supply (MUN)[13].

Sedimentation also contributes to the eutrophication problem in the lake since nutrients are sorbed to soil particles. Via sedimentation, nutrients are deposited on the lake bottom and may then become resuspended in the water column and available for plant growth (see also Big Bear Lake Nutrient TMDLs staff report, June 1, 2005).

Runoff from the watershed results in the addition of nitrogen and phosphorus to surface waters. Inorganic nitrogen is transported in surface water runoff in both dissolved and particulate forms. Phosphorus is transported to surface waters via eroded sediments. Phosphorus can become biologically unavailable as it sorbs to particles and the bottom substrate of lakes and reservoirs. However, as the bottom layer of a lake or reservoir becomes anoxic, phosphorus can desorb from sediments and recycle back into the water column. Also, bottom dwellers such as carp can disturb the bottom layer, causing phosphorus to be released from the sediments back into the water column. Algae, including both microscopic and attached forms, and bacteria, take up soluble reactive phosphorus (SRP), mainly as orthophosphate, and convert it to organic phosphorus. These algae and bacteria are in turn consumed by zooplankton, which excrete some of the organic phosphorus as SRP. Plants and animals then take in the SRP and the cycle begins again (USEPA 1999a, 2-4).

Phosphorus is deposited in lake bottom sediments via five different pathways: sedimentation of phosphorus minerals transported from the surrounding watershed; adsorption or precipitation of phosphorus with inorganic compounds; allochthonous[14] organic matter sedimentation of phosphorus; autochthonous[15] organic matter sedimentation of phosphorus; and, algal and macrophyte uptake of phosphorus from the water column and subsequent deposition to the sediments as detritus (Wetzel 2001, 245-246).

Because of the relationship between sediment and nutrient inputs to Big Bear Lake, the sediment TMDL for Big Bear Lake is linked to the nutrient TMDLs (see the Big Bear Lake Nutrient TMDLs staff report, June 1, 2005). By reducing sediment loads to the lake, nutrient loads are expected to be reduced as well. The Big Bear Lake nutrient TMDLs contain an in-depth discussion of eutrophication, nitrogen and phosphorus cycles, macrophytes and algae. This discussion is not repeated in this report (see the Big Bear Lake Nutrient TMDLs staff report, June 1, 2005).

The following sections (Sections 2.1-2.2) outline the applicable water quality standards and evaluate the data that were used to place Big Bear Lake and Rathbun Creek on the 1994 303(d) list for sedimentation/siltation. The specific justification used to place these waterbodies on the 303(d) list was not documented. The primary reasons for including Big Bear Lake and Rathbun

[12] Note that Eurasian watermilfoil was until recently the most dominant plant in Big Bear Lake. During 2002 and 2003, an aquatic herbicide was applied to Big Bear Lake, which resulted in the almost complete eradication of this noxious aquatic plant. Other plants may become nuisances if allowed to grow within recreational areas or become overabundant, reducing the diversity of plant species.
[13] Please refer to the Big Bear Lake Nutrient TMDLs staff report, June 1, 2005 for a description of macrophytes and the associated impacts on beneficial uses in Big Bear Lake.
[14] Organic matter created within the watershed and imported to the water body (Wetzel 2001, 49)
[15] Organic matter created within the water body (Wetzel 2001, 49)

Creek on the 303(d) list for sediment were (1) staff's best professional judgment that sediments provided a source of nutrients to the lake; (2) that Rathbun Creek was the largest contributor of sediment; and, (3) that the east end of the lake was becoming shallow, affecting recreational opportunities. Additional data that were collected after Big Bear Lake was placed on the 1994 303(d) list are also evaluated against the standards. Finally, a new set of data was collected beginning in 2001 as part of the TMDL Task Force monitoring. These data are also evaluated against the applicable water quality standards.

2.1 Applicable Water Quality Standards

The beneficial uses of Big Bear Lake as identified in the 1995 Water Quality Control Plan for the Santa Ana River Basin (Basin Plan) are as follows:

- Municipal and Domestic Supply **(MUN)**
- Agricultural Supply **(AGR)**
- Groundwater Recharge **(GWR)**
- Water Contact Recreation **(REC1)**
- Non-contact Water Recreation **(REC2)**
- Warm Freshwater Habitat **(WARM)**
- Cold Freshwater Habitat **(COLD)**
- Wildlife Habitat **(WILD)**
- Rare, Threatened or Endangered Species **(RARE)**

The beneficial uses of Rathbun Creek as identified in the Basin Plan are as follows:

- Municipal and Domestic Supply **(MUN)**
- Groundwater Recharge **(GWR)**
- Water Contact Recreation **(REC1)**
- Non-contact Water Recreation **(REC2)**
- Cold Freshwater Habitat **(COLD)**
- Wildlife Habitat **(WILD)**

The following Basin Plan narrative and numeric water quality objectives for inland surface waters pertain to sedimentation/siltation impairment:

> Solids, Suspended and Settleable: "Inland surface waters shall not contain suspended or settleable solids in amounts which cause a nuisance or adversely affect beneficial uses as a result of controllable water quality factors."
>
> Turbidity: "Increases in turbidity which result from controllable water quality factors shall comply with the following:

Natural Turbidity	Maximum Increase
0-50 NTU	20%
50-100 NTU	10 NTU
Greater than 100 NTU	10%

All inland surface waters of the region shall be free of changes in turbidity which adversely affect beneficial uses."

No site-specific numeric sediment objectives have been established for Big Bear Lake or its tributaries.

2.2 Assessment of Existing Conditions Relative to Numeric and Narrative Water Quality Objectives

This section describes the conditions in the Big Bear Lake watershed that resulted in the inclusion of Big Bear Lake and Rathbun Creek on the 1994 303(d) list due to sedimentation/siltation. As stated previously, these listings resulted from the judgments that sediments were a likely contributor of nutrients, that Rathbun Creek was the largest contributor of sediment and that the east end of the lake was becoming shallow, in turn affecting recreation. Limited secchi disk transparency data were available for the 303(d) listing assessment (Table 2-1); no turbidity or total suspended solids (TSS) data were collected as part of the assessment, nor were any turbidity or TSS data available. Additional sediment data that were evaluated as part of the development of this TMDL report and problem statement were the data collected from 1994-2000 by the San Bernardino County Flood Control District (SBCFCD) (Table 2-2), data collected from 1997-2000 by the BBMWD (Table 2-3), data collected by the RWQCB in 1998 (Table 2-4), and data collected from 2001-2003 by the TMDL Task Force (Tables 2-5 and 2-6). Data collected included total suspended solids (TSS) measurements and secchi depth measurements. The Basin Plan does not specify objectives for secchi disk transparency[16], nor are there any numeric objectives for total suspended solids (TSS), only a narrative objective. In addition, there are no identified reference creeks or lakes within this watershed or similar watersheds with TSS measurements that could be used as a guide in determining impairment for Big Bear Lake and Rathbun Creek. Therefore, it is difficult to determine from these data the concentration at which TSS impacts beneficial uses in Big Bear Lake and in Rathbun Creek. Only with the identification and selection of a reference condition for lakes and creeks similar to the Big Bear Lake watershed and collection of this type of data over the long-term and under various hydrological periods can beneficial use impacts be tied with certainty to TSS measurements.

Big Bear Lake Data

Secchi disk transparency. The data used to place Big Bear Lake on the 1994 303(d) list due to sedimentation/siltation were collected as part of a Clean Water Act Section 314 grant (Clean Lakes Study) titled, "Investigation of Toxics and Nutrients in Big Bear Lake." (Courtier and Smythe 1994). The data were collected between April 1992 and April 1993 (Table 2-1).

Transparency is affected by algae and nonalgal turbidity[17]. Transparencies are greatest at the dam (Site #1), the deeper end of the lake, and gradually decrease from west to east (Site #4). The east end is shallower than the west end and is therefore more susceptible to sediment resuspension. The east end also contains a greater density of macrophytes. As macrophytes decay, organic matter is deposited on the lake bottom and can be resuspended. In addition, the prevailing wind is usually from the west. Due to these prevailing wind patterns, any matter on the lake tends to collect at the east end. Seasonal variations in secchi disk transparencies were also observed. The

[16] Secchi depth is a measure of the water's clarity. High readings mean greater clarity.
[17] Includes color and inorganic suspended solids.

deepest secchi values were seen in May and the shallowest values were generally observed in August. The shallow secchi depth readings probably correlate to increases in algal biomass during late summer, which can result in a reduction of water clarity. There were also differences in secchi values between 1992 and 1993; that is, secchi depths were greater in 1993 than in 1992. The improvement in water clarity can be attributed to the increase in lake levels in 1993. Lake levels were approximately 12 feet below full pool in 1992, whereas in 1993, lake levels were nearly at full pool due to significant amounts of precipitation received in the earlier part of the year (Figures 1-5 and 1-6).

Table 2-1. Secchi disk transparencies (feet) for Big Bear Lake (RWQCB: April 1992-April 1993)

	Near Dam Site No. 1	Metcalf Bay Site No. 2	Pine Knot Landing Site No. 3	East End Site No. 4
Average	6	8	6	4
Median	5	7	5	4
Number of samples	5	4	4	5
Max	11	10	10	6

Data collected in Big Bear Lake by the BBMWD from 1997-2000 were also evaluated (Table 2-2). Spatial and temporal differences were again observed in secchi disk transparencies. The west end station (Station 1) recorded deeper secchi disk measurements than did the east end station (Station 5). The deepest secchi disk measurements were recorded in June through July and the shallowest transparencies in late summer and early fall. These results are consistent with the data collected in 1992-1993, as discussed above.

Table 2-2. Secchi disk transparencies (feet) for Big Bear Lake (BBMWD:1997-2000)

	Site #1	Site #2	Site #3	Site #4	Site #5
Average	10	11	11	11	9
Median	10	11	10	10	9
Number of samples	114	110	112	111	112
Max	21	21	21	21	19

BBMWD's Sites #1 and #5 are equivalent to RWQCB's Sites #1 and #4. BBMWD's Sites #3 and # 4 are comparable to RWQCB's Sites # 2 and # 3; however, the RWQCB's sites are closer to the shoreline, while the BBMWD's sites are located in open water.

TMDL Monitoring Program

Starting in June 2001, a program of monthly sediment monitoring at four main lake stations and seven tributary stations was initiated as part of the Total Maximum Daily Load (TMDL) development process and is presently ongoing. Originally, ten lake stations were monitored but after February 2002, only **four** main lake stations (Dam, Gilner Point, Mid Lake Middle, and Stanfield Middle; hereinafter referred to as MWDL1, MWDL2, MWDL6, and MWDL9, respectively) were monitored due to limited funds (Figure 2-1). For this report, data from June 2001 through December 2003 are included in the analysis for these four main TMDL stations and data from June 2001 through February 2002 for the other six lake stations (Table 2-3). At all ten

stations, a photic zone[18] composite water column sample and a discrete bottom water column sample[19] were analyzed for total suspended solids and volatile suspended solids (VSS). The VSS method is used to determine the relative proportion of the organic fraction within the total suspended solids concentration. This determination is important in this forest-dominated watershed, which would be expected to have a greater percentage of organic litter compared to other land uses. Secchi disk transparency was also recorded at each of the lake stations and is reported in Table 2-4.

Spatial as well as temporal differences in secchi disk transparencies were observed. Greater secchi disk transparencies were recorded at the deeper west end of the lake (MWDL1 and MWDL2) than at the bays and the east end of the lake (MWDL8, MWDL9 and MWDL10). The shallowest secchi disk transparencies were generally observed in late August and the beginning of September, while the greatest secchi disk transparencies were observed during the winter and early spring months. Other researchers (Irwin and Lemons 1974, 23) report similar findings, and the results are consistent with the 1992-93 RWQCB and 1997-2000 BBMWD studies. During the late summer, macrophytes start to decay and algal blooms occur. Both of these processes contribute significant amounts of detritus to the water column and contribute to the lowering of water clarity.

Because secchi disk transparency is affected by algae and/or nonalgal turbidity, it would be useful to determine which has the greater impact on turbidity. Even though turbidity was not measured, Walker (1996, 4-15) provides an equation to calculate nonalgal turbidity from secchi disk transparency and chlorophyll *a* measurements. The purpose of this equation is to determine whether turbidity is caused by algal response to nutrients or by allochthonous particulates. The equation is as follows:

$$(1/\text{secchi}) - (0.025 \times \text{chl } a) = \text{nonalgal turbidity}$$

secchi in meters; chlorophyll *a* in mg/m^3
Results <0.4: allochthonous particulates unimportant;high algal response to nutrients
Results >1 allochthonous particulates possibly important; low algal response to nutrients

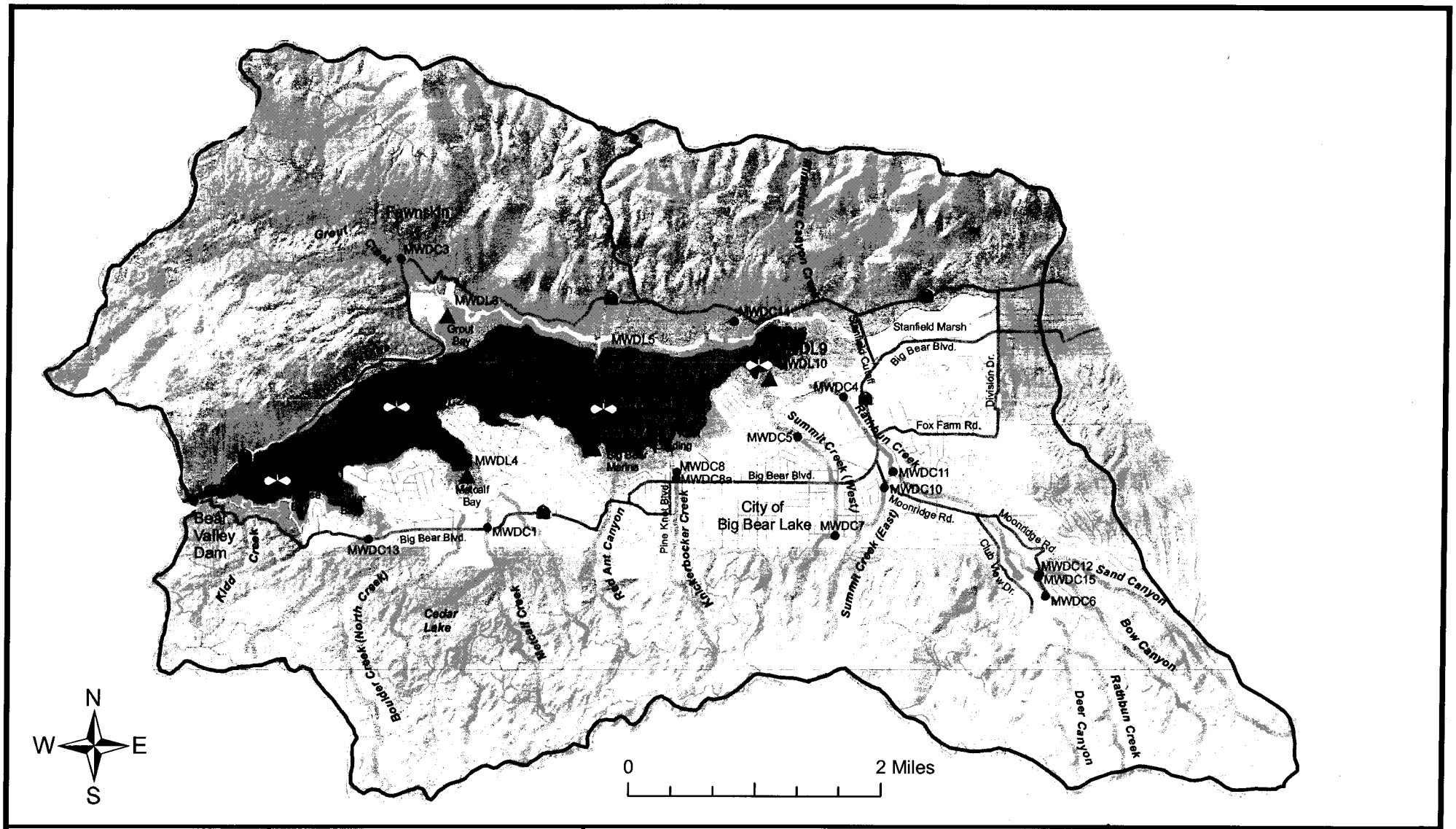
For each paired chlorophyll *a* and secchi disk transparency measurement, nonalgal turbidity was calculated and then an average nonalgal turbidity value was calculated for each main TMDL lake station (MWDL1, MWDL2, MWDL6, and MWDL9). Yearly and seasonal averages were calculated (Table 2-4). TMDL lake stations MWDL1, MWDL2 and MWDL6 all had the same nonalgal turbidity average value of 0.2, while station MWDL9 at the east end near Stanfield Marsh had an average nonalgal turbidity value of 0.3. In all instances, these numbers were less than 0.4, implying that the turbidity seen in the lake water column was caused by algae and not allochthonous particulates. There were temporal differences as well: at lake station MWDL9, a spring and winter average value of 0.5 was recorded, which is the highest for any station. It appears that this number might be related to snowmelt runoff and storm events, although no numbers were greater than 1.

[18] Photic zone is the zone to which light can penetrate the water column; for monitoring purposes, the photic zone was calculated as two times the secchi depth.
[19] The discrete bottom sample was collected approximately 0.5 meters above the lake bottom surface using a pump.

The USEPA developed a set of parameters (i.e., total P, chlorophyll *a*, secchi disk depth, and hypolimnetic oxygen percent of saturation) in the mid 1970s to characterize a lake's trophic status. A secchi disk depth of >4 meters (~13 feet) is representative of oligotrophic lakes, a secchi disk depth of <2 meters (~7 feet) characterizes eutrophic lakes, and mesotrophic lakes fall in between these numbers (Novotny and Olem 1994, 784). As shown in Table 2-3, the average secchi disk depth readings for all the Big Bear Lake stations are characteristic of a eutrophic lake. This confirms the findings of eutrophic status based on the other parameters (see Big Bear Lake Nutrient TMDLs staff report, June 1, 2005).

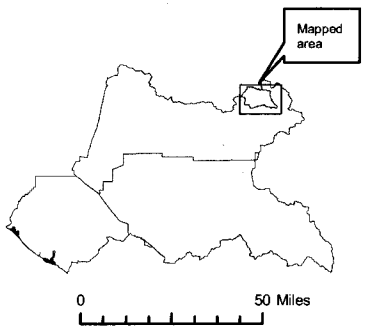
Spatial differences were observed in both TSS and VSS concentrations, with higher values seen in the bays and in the east end (MWDL9) (Figures 2-2 and 2-3). In addition, TSS and VSS concentrations in bottom water column samples were generally higher than the photic zone composite concentrations during most sampling events. TSS concentrations were most likely greater at the bottom and in the shallower waters of the bays and east end due to sediment resuspension. Temporal differences were observed in TSS and VSS concentrations for both the photic and bottom water column samples, although the differences in concentrations in the bottom water column samples were more extreme than those in the photic zone, especially for MWDL6 (Mid Lake) and MWDL9 (east end) probably caused by the increase in detritus from decaying macrophytes. Concentrations increased slightly during early spring (March) likely corresponding to snowmelt and runoff while during late summer/early fall concentrations increased significantly corresponding to increased phytoplankton biomass and detritus from decaying macrophytes.

Differences in the relative contribution of organic sources (VSS) to total suspended solids concentrations were observed between photic zone and bottom discrete samples. Ratios of VSS to TSS between MWDL1 and MWDL9 for both photic zone and bottom discrete concentrations were compared and for both stations, the photic zone samples contributed a greater percentage of organic sources (measured as VSS) than did the bottom discrete samples. This difference is likely due to the presence of phytoplankton within the photic zone. On average, the total suspended load consisted of 50% organic particulates (measured as VSS) for MWDL1 and 44% for MWDL9.



Water Boards

Data Sources:
Tributaries (modified by RWQCB 8), Elevation - San Bernardino County, 2004
Watershed boundary - Hydmet, Inc., 2003
Lake bathymetry - ReMetrix, Inc., 2000
Monitoring Stations -RWQCB, 2002
Major roads - San Bernardino County, 2004
City of Big Bear Lake boundary - City of Big Bear Lake, 2002



Map Features

- Main TMDL Lake Monitoring Stations
- Other TMDL Lake Monitoring Stations
- Big Bear Lake Tributary Monitoring Stations
- Big Bear Lake watershed boundary
- Big Bear Lake Tributaries
- City of Big Bear Lake boundary
- Major roads
- Streets

Big Bear Lake Bathymetry

DEPTH

- 69 - 51 feet
- 50 - 36 feet
- 35 - 21 feet
- 20 - 9 feet
- 8 - 1 feet

Figure 2-1.
Big Bear Lake and
Tributary Monitoring Stations

D:GISDATA/BBL/BBL_3_sed.mxd

Map contact: Heather Boyd, CA Regional Water Quality Control Board, Santa Ana Region, June 2005

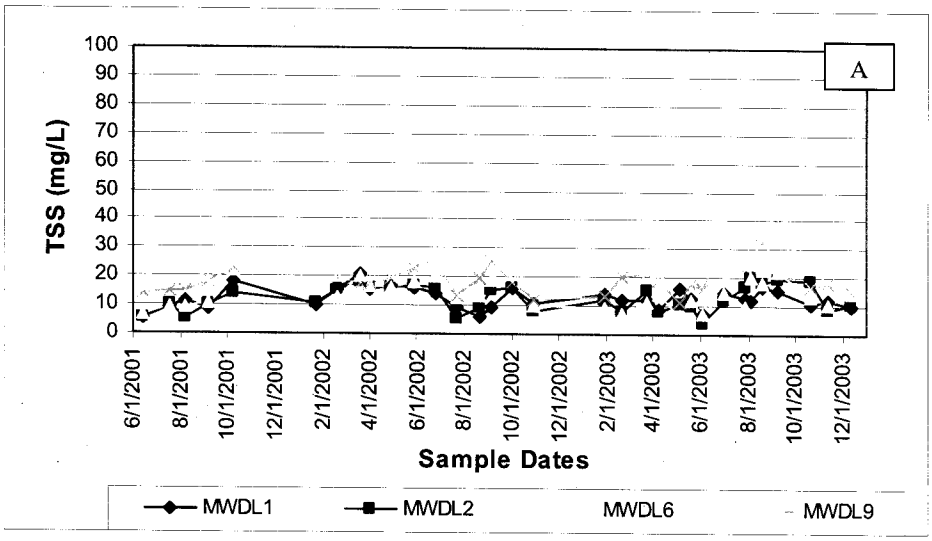
Table 2-3. Water Quality Data Summary for Big Bear Lake (June 2001-December 2003)

	Dam	Gilner Point	Mid Lake Middle	Stanfield Middle	Grout Bay	Metcalf Bay	Mid Lake North	Mid Lake South	Stanfield North	Stanfield South
Parameter Analyzed	MWDL1	MWDL2	MWDL6	MWDL9	MWDL3	MWDL4	MWDL5	MWDL7	MWDL8	MWDL10
Secchi Disk Transparency(feet)										
Average	7.5	7.0	5.9	3.7	2.5	4.7	5.3	5.4	3.5	4.5
Median	7.0	7.0	5.0	3.3	2.7	5.0	5.0	5.0	3.3	4.0
# of samples	43	43	42	42	8	8	8	8	8	8
Max	14.0	13.1	13.1	8.0	3.2	7.0	6.2	9.5	4.6	8.2
TSS (mg/L)										
Average	15.7	14.9	19.4	23.5	30.8	25.2	14.7	12.7	30.9	17.5
Median	13.8	13.0	15.2	19.4	29.6	21.6	14.8	12.2	16.9	15.8
# of samples	64	65	63	62	8	8	12	7	12	7
# of non-detects	0	0	0	0	0	0	0	0	0	0
Max	84.0	60.0	92.0	71.8	59.8	68.2	22.6	25.8	138.0	23.8
VSS (mg/L)										
Average	7.2*	7.0*	8.2*	9.9	13.4	10.4	6.8	6.6	9.9	8.6
Median	7.0*	6.7*	7.4*	8.4	13.1	10.5	6.5	6.0	7.9	8.6
# of samples	63	64	62	61	8	8	12	7	12	7
# of non-detects	2	3	2	0	0	0	0	0	0	0
Max	25.0	16.3	23.5	23.5	18.3	19.8	10.4	11.6	30.0	11.0

Note: Main TMDL stations 1, 2, 6, and 9 were sampled from June 2001-December 2003. Other stations were sampled from June 2001- February 2002.
*Estimated using both the robust probability plotting method and by the (parametric) maximum likelihood method adjusted for bias (Helsel and Cohn 1988)
TSS= total suspended solids
VSS=volatile suspended solids

Table 2-4. Nonalgal turbidity for Big Bear Lake (June 2001-Dec. 2003)

	# of samples	MWDL1	MWDL2	MWDL6	MWDL9
Overall Average	30	**0.2**	**0.2**	**0.2**	**0.3**
2001 average	5	0.2	0.2	0.1	0.2
2002 Average	12	0.2	0.2	0.2	0.3
2003 Average	13	0.2	0.2	0.2	0.3
Spring (March-May) Average	7	0.2	0.2	0.3	0.5
Summer (June-August) Average	11	0.2	0.2	0.2	0.1
Fall (September –November)Average	8	0.2	0.2	0.2	0.3
Winter (December –February)Average	4	0.0	0.0	0.1	0.5



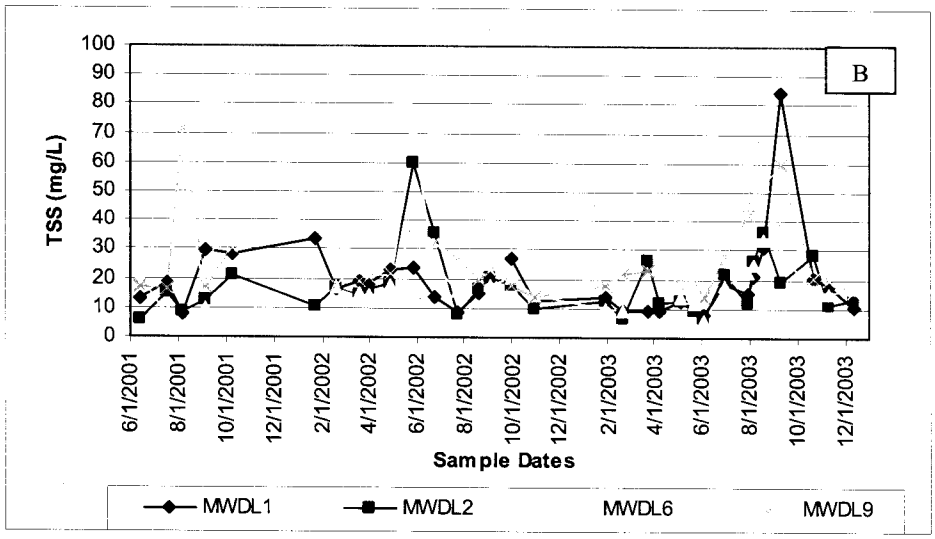
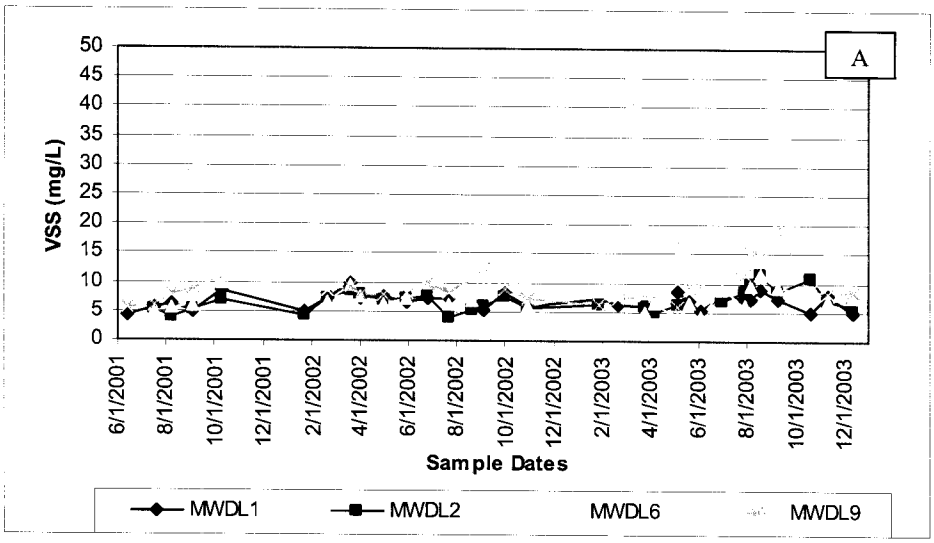


Figure 2-2. TOTAL SUSPENDED SOLIDS concentrations in the four main Big Bear Lake TMDL stations (A) photic composite and (B) bottom discrete.



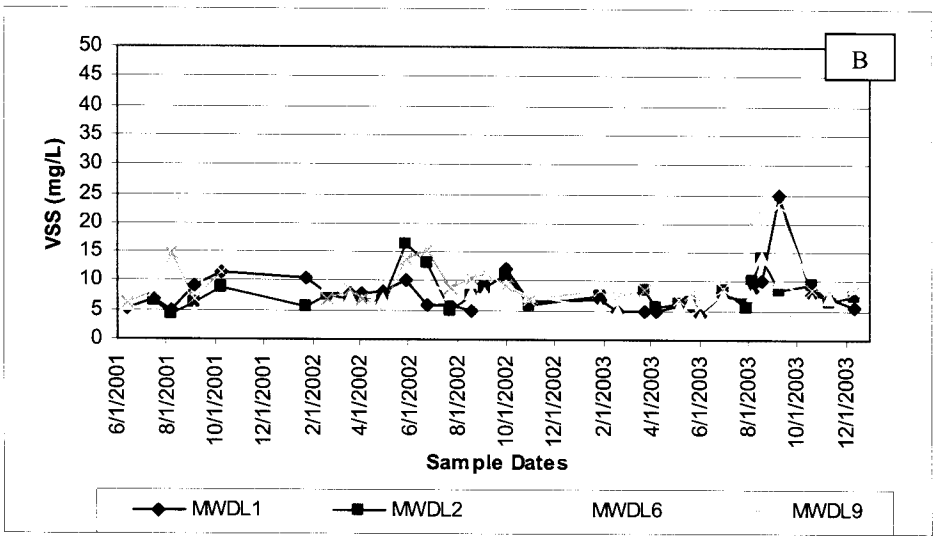


Figure 2-3. VOLATILE SUSPENDED SOLIDS concentrations in the four main Big Bear Lake TMDL stations (A) photic composite and (B) bottom discrete.

Rathbun Creek Data

Total Suspended Solids. As part of their National Pollutant Discharge Elimination System (NPDES) Stormwater Permit, SBCFCD monitored total suspended sediment (TSS) concentrations at two locations within Rathbun Creek: Rathbun Creek at Sandalwood Dr. (the mouth of Rathbun Creek) (Site #6), and Rathbun Creek at Bear Mountain Golf Course (downstream of the confluence with Sand Canyon Creek) (Site #7) from 1994 through 2000 (see Figure 1-3). First flush (sample collected during the first 30 minutes of the storm) and main program (sample collected the first two hours of the storm including the first flush) samples were collected. These "program" samples were collected as time-weighted composite samples (composited for discrete, equal-time intervals) (San Bernardino County Flood Control District 1998, 3-1, 3-3). The results are shown in Table 2-5. Maximum values for both the first flush and main program samples were recorded at Site #6, which is located near the mouth of Rathbun Creek. This makes sense as the bottom of the watershed is expected to receive sediment from the surrounding watershed and from the creek itself. However, Site #7 contributed a large amount of sediment during the first flush events. For both first flush and main program samples, the highest TSS values were obtained during the months of December and January. Note that there are no flow data available that correspond with these TSS data.

Table 2-5. Total suspended solids concentrations (mg/L) for Rathbun Creek (SBCFCD: 1994-2000)

	First Flush		Main Program	
	Rathbun Creek at Sandalwood Dr. Site #6	Rathbun Creek at Bear Mountain Golf Course Site #7	Rathbun Creek at Sandalwood Dr. Site #6	Rathbun Creek at Bear Mountain Golf Course Site #7
Average	275	245	358	224
Median	170	119	160	130
Number of samples	23	22	22	21
Max	2370	1820	2950	960

During March and April of 1998, Regional Board staff collected samples at several locations within Rathbun Creek (see Figure 1-3)[20]. One of the constituents measured was total suspended solids (TSS). The results are shown in Table 2-6. The values vary both spatially and temporally. The highest values were seen immediately below Bear Mountain, while lower values were seen farther down the creek. These data are different from those reported by the SBCFCD, which showed higher TSS concentrations at the mouth (Table 2-5). Differences could be attributed to different sampling methodologies, different flow events and to the unreliability of the TSS method in measuring suspended sediment concentration (Gray and Glysson, 2001). There are no flow data associated with these data.

[20] According to the Bear Valley Dam precipitation records, there was no rain during the sample collection dates (i.e., March 4, 1998 and April 28, 1998). For the March sampling date, precipitation had last occurred on Feb. 24, 1998 and for the April sampling date, precipitation had last occurred on April 15, 1998.

Table 2-6. Total suspended solids concentration (mg/L) for Rathbun Creek (RWQCB: March-April 1998)

	Below Bear Mtn.	Below Zoo	Below Parking Lot	At mouth
Average	129	22	34	11
Median	129	42	34	11
Number of samples	2	1	2	2
# of non-detects	0	1	0	0
Max	150	42	58	12

½ the detection limit used to calculate summary statistics for non-detects

TMDL Monitoring Program

Starting in June 2001, a program of monthly sediment monitoring at seven tributary stations was initiated as part of the nutrient and sediment TMDL development process and is presently ongoing (Figure 2-1). For this report, data from June 2001 through February 2003 are included in the analysis for these seven main tributary stations. Collected tributary data were sparse because little or no flows occurred in several of the creeks for much of the year. The installation of compound weirs and automatic samplers with bubble flow meters aided in the collection of storm event samples from a few tributaries. Samples were analyzed for TSS and VSS. Spatial differences were observed in TSS and VSS concentrations, with the highest values observed during storm events at sampling site MWDC4 (Mouth of Rathbun Creek)(Tables 2-7 and 2-8). The data might support temporal differences in TSS and VSS concentrations as well, but because not all tributaries were sampled during each event due to lack of flow, no conclusions to this effect can be made at this time. Ratios of VSS to TSS were evaluated and the contribution of organic sources (measured as VSS) varied with no apparent pattern.

Table 2-7. Total suspended solids concentration for Big Bear Lake tributaries (June 2001- February 2003)

	Sampling Station						
Parameter Analyzed	Metcalf Creek (MWDC1)	Bear Creek Outlet [(a)] (MWDC2)	Grout Creek (MWDC3)	Mouth Rathbun Creek (MWDC4)	SummitCR at Swan (MWDC5)	BMZoo on RC (MWDC6)	SummitPK West (MWDC7)
TSS (mg/L)-Grab sample							
Average	9.8	11.4		871.5	65.8	62.4	63.6
Median	9.4	9.5		871.5	14.4	64.1	63.6
# of samples	8	4		2	5	4	2
# of non-detects	0	0		0	0	0	0
Max	17.0	19.6		914.0	234.0	71.8	74.2
TSS (mg/L)-First flush sample							
Average	478.8		1,766.0	529	564.2		473.0
Median	20.6		1,766.0	472.5	564.2		473.0
# of samples	3		1	4	2		1
# of non-detects	0		0	0	0		0
Max	1,409.0		1,766.0	1,155.0	670.3		473.0
TSS (mg/L)-Flow composite sample							
Average	608.4		709.0	345.7	248.0		
Median	34.6		709.0	273.8	248.0		
# of samples	3		1	4	1		
# of non-detects	0		0	0	0		
Max	1,781.0		709.0	825.0	248.0		

Note: (a) represents lake water releases at the dam

Table 2-8. Volatile suspended solids concentration for Big Bear Lake tributaries (June 2001- February 2003)

	Sampling Station						
Parameter Analyzed	Metcalf Creek (MWDC1)	Bear Creek Outlet [(a)] (MWDC2)	Grout Creek (MWDC3)	Mouth Rathbun Creek (MWDC4)	SummitCR at Swan (MWDC5)	BMZoo on RC (MWDC6)	SummitPK West (MWDC7)
VSS (mg/L)-Grab sample							
Average	4.1*	4.5*		144.0	17.6	14.4	15.0
Median	4.6*	4.0*		144.0	7.2	14.5	15.0
# of samples	8	4		2	5	4	2
# of non-detects	2	1		0	0	0	0
Max	6.2	8.6		157.0	58.0	15.2	18.2
VSS (mg/L)-First flush sample							
Average	52.5		152.0	77	91.9		113.5
Median	6.6		152.0	73.0	91.9		113.5
# of samples	2		1	4	2		1
# of non-detects	1		0	0	0		0
Max	146.0		152.0	157.0	94.7		113.5
VSS (mg/L)-Flow composite sample							
Average	65.3		85.0	63.9	55.0		
Median	13.0		85.0	57.8	55.0		
# of samples	3		1	4	1		
# of non-detects	0		0	0	0		
Max	179.0		85.0	133.0	55.0		

Notes: (a) represents lake water releases at the dam
*Estimated using both the robust probability plotting method and by the (parametric) maximum likelihood method adjusted for bias (Helsel and Cohn 1988)
MWDC1 First flush, not enough data points to use Helsel and Cohn (1988) method, used ½ the detection limit to calculate average and median.

3.0 NUMERIC TARGETS

As stated by Novotny and Olem (1994, 243), "...it is unrealistic to expect or require complete control or elimination of sediment loads to receiving waters. Such "wall-to-wall control measures would be technically and economically impossible." The authors then state that "...it is feasible to control or manage excessive sediment loadings that have resulted from man's land use activities that would be detrimental to the quality of the receiving bodies of water and to the aquatic and terrestrial habitat." Pursuant to federal TMDL requirements, quantifiable and measurable numeric targets that will ensure compliance with water quality standards (including beneficial uses and water quality objectives) must be established in a TMDL (USEPA 1999b).

The TMDLs and numeric targets for Big Bear Lake and Rathbun Creek must be structured to guarantee protection of the MUN, COLD, WARM, WILD, REC1, and REC2 beneficial uses and attainment of the sediment-related water quality objectives specified in the Basin Plan (see Section 2.1). In addition, the TMDL and numeric targets for Big Bear Lake must also ensure protection of Bear Creek, downstream of the lake.

Numeric targets that are proposed for Big Bear Lake include those related directly to sedimentation/siltation, as well as those that provide a means to track the overall improvement in the health of the lake and the watershed. The proposed numeric targets for Big Bear Lake represent desired conditions of lake capacity that would result in improvement in aquatic habitat and recreational beneficial uses. Similarly, the proposed numeric targets for Rathbun Creek are related directly to sedimentation/siltation and include indicators of the overall improvement in stream health.

To establish the numeric targets, Regional Board staff first considered use of established narrative and numeric sediment objectives. As discussed in Section 2.1, the Basin Plan specifies narrative and numeric water quality objectives for suspended solids and turbidity, respectively, for Big Bear Lake and Rathbun Creek. Turbidity could be used as a numeric target, but it appears that for the most part, turbidity in Big Bear Lake is due to algae and not inorganic particulates (see nonalgal turbidity discussion, page 36). For this reason, it was determined that turbidity would not be an adequate or appropriate numeric target in assessing sedimentation/siltation for Big Bear Lake. However, a turbidity numeric target for Rathbun Creek appears to be reasonable because about 75% of the TSS concentration is attributed to inorganic sources. Because the suspended solids water quality objective is a narrative one, it is necessary to identify some numeric expression of compliance, which serves as the requisite numeric target. Comparison of TSS data from reference streams or watersheds to data from the listed body of water is often utilized. However, in this case, there are no TSS data from reference streams or watersheds in the Santa Ana Region similar to the Big Bear Lake watershed that could be used for comparison to impaired conditions. Creeks such as Boulder, Metcalf and Grout could serve as potential reference creeks for the watershed, however, a detailed reference creek survey is a prerequisite. As part of the implementation plan, future monitoring in this watershed is proposed and the relationship between TSS concentrations and reference conditions might be quantified.

Regional Board staff evaluated other alternatives to select both water quality indicators and target values. A regression analysis could be developed for turbidity and TSS. Using the regression equation, the TSS value could be predicted from a known turbidity value. This approach is often used and results in better relationships than those between suspended sediment concentration and discharge (Thomas 1985). However, paired datasets of turbidity and suspended sediment concentration are needed and these data were not available for this TMDL. In addition, as

discussed above, turbidity does not appear to be a useful indicator for the Big Bear Lake sedimentation/siltation problem.

The USEPA protocol for developing sediment TMDLs acknowledges that erosion is a natural process and that it is difficult to separate sediment produced from natural conditions from sediment produced from disturbed conditions (USEPA 1999b). In addition, sediment production rates vary considerably from year to year. The protocol also mentions that relating sediment mass loading levels to beneficial use impacts or source contributions is difficult because sediment yields vary at different spatial and temporal scales and therefore quantifying "average" conditions is difficult. The USEPA protocol mentions other alternative approaches to mass loads in expressing sediment TMDLs, such as expressing numeric targets related to substrate or channel condition, aquatic biological conditions, or hillslope indicators. USEPA (1999b) encourages using multiple numeric targets and a "weight of evidence" approach, meaning that indicators would be evaluated as a whole and if one target was not met, it would not necessarily imply that the TMDL is not working.

For Big Bear Lake in particular, consideration of such an alternative TMDL approach is appropriate. In part this is because of the lack of relevant data on which to base suitable numeric targets. The more important reason pertains to the nature of the lake itself. As described in Section 1.0, the lake is artificial, having been created by the construction of the dam in 1883-84. As discussed in the next Section (Source Assessment), most of the sediment entering the lake appears to come from natural sources in the watershed and results from erosion and sediment transport during storm events[21]. Consistent with the principles of ecological succession, without human intervention, the lake would naturally fill-in over time and be restored as a meadow habitat. The reality, however, is that Big Bear Lake is an ecological and recreational resource of statewide significance, and its continued existence is necessary to support the local economy, as well as these beneficial uses. Accordingly, it is appropriate to define numeric targets and TMDLs that recognize the unique nature of the lake, the largely natural sources of sediment loading, and the need for active and coordinated management of the lake to assure that beneficial uses are protected. With respect to sediment, management of the lake can be expressed in terms of improvement of lake capacity, tied to specific and coordinated plans to manage aquatic plant nuisance growth and to create and enhance fisheries and other wildlife habitat.

While, as noted, much of the sediment loading to the lake results from natural sources during wet weather, human-induced activities have likely contributed to the erosion problem (see Section 4.0, Source Assessment). For example, sediment loads might be increasing in lower parts of tributaries due to the degradation and scour caused by increased flood flows resulting from urbanization (Humphrey 2003a; Humphrey 2003b). It is appropriate to require the implementation of BMPs to reduce such sediment loading to the maximum extent practicable. Accordingly, a sediment load numeric target is also proposed for the Big Bear Lake TMDL. This numeric target was developed based on the HSPF model results (see Section 4.0).

[21] A draft report prepared by Dr. Matthew Kirby titled "Determination of sedimentation rate and sedimentation processes at Big Bear Lake: Using a paleo-perspective to understand modern sedimentary systems" discusses the dominant sedimentation processes (Kirby 2005). In this document, the author hypothesizes that as lake levels decrease for prolonged periods, sedimentation actually increases and is more important to the overall sedimentation rate than local runoff during storms and snowmelt. This statement is in direct conflict with information reported in the report prepared by BBMWD, Hydmet, Inc., and AquAeTer, Inc. 2003. More studies are needed to fully identify the dominant process or processes responsible for the majority of the sediment loads to Big Bear Lake.

Similarly, a proposed numeric target for Rathbun Creek is directly related to the biological health of the creek and the desired environmental conditions. A sediment load target is based on the HSPF model results, and the second proposed target is based on the Basin Plan objectives for turbidity.

It is recognized that much more data are needed to refine the proposed numeric targets and to consider the application of other targets, such as hillslope indicators. The proposed TMDLs are phased to allow for such data collection and refinement, and the proposed Implementation Plan (Section 9.0) includes specific, pertinent monitoring requirements.

The following sections describe the proposed numeric targets in greater detail.

3.1 Big Bear Lake Sediment Numeric Targets

Proposed numeric targets for Big Bear Lake are shown in Table 3-1. Total sediment load is proposed as a numeric target. Additional investigation of the water quality measures needed to achieve the total sediment load target is likely to be necessary. Thus, a schedule for compliance no later than 2020 is proposed. The other proposed numeric target is for a 5% improvement in lake capacity to be achieved no later than ten years from the effective date of the TMDL. Related to this target is a requirement in the proposed implementation plan for the development and implementation of an approved lake management plan and in 3 years to reevaluate the numeric target (see Section 9.0, Implementation Plan). This plan would integrate sediment management with biological and recreational resource management to assure the protection of beneficial uses. It also needs to integrate plans developed and implemented to address eutrophication in the lake (see Big Bear Lake Nutrient TMDL staff report, June 1, 2005). It is expected that the lake management plan will, in part, define optimal future lake capacity conditions and the control measures needed to achieve them. The plan must necessarily take a watershed view and address control and management of sediment inputs from Rathbun Creek and other tributaries. Restoration/protection of the beneficial uses of the tributaries to the lake, as well as Bear Creek, downstream from the lake, must also be addressed. Approved numeric targets and TMDLs for both Big Bear Lake and Rathbun Creek will be revised as appropriate to reflect the approved lake management plan and the desired environmental conditions identified therein.

Derivation of the Big Bear Lake proposed targets is discussed below.

3.1.1 Sediment Load

Numeric Target

The proposed target for sediment is 12,000 tons sediment per year and is based on the sediment load from forested lands that would be expected under natural conditions (i.e, no anthropogenic activities that would affect erosion and sedimentation). The Big Bear Lake watershed is comprised of 11,690 acres of north facing slopes and 8,899 acres of south facing slopes. The sum of the area of these two aspects is 20,589 acres, excluding the lake area[22]. To calculate an average natural background load, the sediment loading rates for both the north and south forest

[22] Note that there is a discrepancy between this total land area and the watershed area as shown in Table 1-2. This is due to slight differences in the GIS layers that were provided as part of the HSPF watershed model.

land uses (0.36 tons/acre/yr and 0.86 tons/acre/year, respectively, were multiplied by the acres of north and south facing slope areas in the watershed. These loading rates assume that all lands with the forested areas are not impacted by human activities. The result of the calculation is 11,862 tons/year of sediment delivered by forested land for the entire watershed area. This figure was rounded to 12,000 (two significant figures)[23]. This numeric target assumes that erosion/sedimentation caused by anthropogenic activities can and will be controlled to the maximum extent practicable. Where it is infeasible to achieve the wasteload and/or load allocations based on this target (see Section 6.0), in-lake sediment removal/control programs can be implemented such that the net effect is compliance with the allocations and numeric target.

Board staff recognizes the limitations in using sediment loads as a numeric target, i.e., variability of sediment production rates from year to year, and difficulties in relating sediment mass loadings to beneficial use impacts. To address these limitations and take into account the inherent variability in sediment loading, the numeric target is proposed as a 10-year running average[24]. In addition, as stated previously, the proposed TMDLs are based on a phased approach, which means that as new data are collected and analyzed, the numeric targets, allocations and TMDLs themselves will be reviewed and revised, if necessary.

The monitoring programs proposed as part of the implementation plan for this TMDL will aid in the development of a comprehensive sediment budget for this watershed (see Section 10.0). Because it is impractical to monitor all inputs to the lake, compliance with the target value will be determined from flow, suspended sediment and bedload concentration data collected at five key tributaries (Rathbun Creek, Minnelusa Canyon Creek, Knickerbocker Creek, Boulder Creek and Grout Creek). If these creeks and/or methodology are not suitable for this determination, alternatives can be provided. These data will be used to extrapolate loads from the remainder of the watershed to determine the total sediment loads to the lake.

[23] It is recognized that there are roads, campgrounds, mountain bike trails, fire reduction programs and programs to remove dead trees (resulting from bark beetle infestation and drought conditions in the watershed), and that these facilities/ activities likely affect erosion and sedimentation in the watershed and lake. No data are currently available on the extent of these facilities/activities and their sediment-related effects.

[24] Staff believes that use of a 10-year running average is a reasonable approach. It allows adequate time for collecting new data on sources of sediment and sediment yields, along with implementing, monitoring and assessing BMPs. The data collected are to be used in a new modeling effort. During this time, the 10-year running average approach can be reevaluated with respect to the newly collected data and the new model scenarios.

Table 3-1. Proposed numeric targets and indicators for the Big Bear Lake sediment TMDL

Indicator	Target Value[c]	Reference
Total Sediment Load [a]	Annual average of 12,000 tons/year as a 10-yr running average; to be attained no later than 2020	HSPF modeling (BBMWD, Hydmet, Inc., and AquAeTer, Inc. 2003; Hydmet 2004)
Lake capacity[b]	A 5% improvement in lake capacity in 10 years[d]	NA

[a] source targets related to load allocations/waste load allocations (see Section 5.0)
[b] monitoring target that will not be used for load allocations/waste load allocations
[c] compliance with the targets to be achieved as soon as possible, but no later than the date specified
[d] see also Section 9.0, Implementation Plan

3.1.2 Lake capacity

According to BBMWD (2002), the lake capacity in 1912 was 137,105,000 cubic yards, or 85,000 af. In 1977, the lake was resurveyed and the lake capacity had decreased to 116,942,500 cubic yards, or 72,500 af, a 15% decline over the 65-year period. The difference between these two volumes is 20,162,500 cubic yards, or roughly 20 million cubic yards. With stakeholder input, it was determined that it was not feasible to remove this amount of sediment from the lake. As discussed in Sections 3.0 and 3.1, an alternative approach to management of the lake and protection of beneficial uses is recommended. The proposed numeric target is for a 5% improvement in lake capacity to be achieved as soon as possible but no later than 10 years from the effective date of the TMDL. It is expected that this numeric target will be revisited and likely revised and quantified once a lake management plan required by the proposed implementation plan is developed and approved. As stated previously, it is expected that this plan will include specific goals for lake capacity, coupled with management strategies intended to protect biological and recreational beneficial uses.

Because the lake is also on the Clean Water Act Section 303(d) list for nutrients, and bottom sediments contribute a significant portion of the nutrients through recycling, a costly, but effective, method of improving lake capacity would be dredging. Dredging would address not only the adverse beneficial use impacts caused by sedimentation and the creation of shallow areas in the lake but also would result in the removal of nutrients from the lake bottom that are currently recycled back into the water column. By deepening some shallow areas, resuspension of bottom sediments might be decreased, improving secchi disk transparency, lowering water column concentrations of nutrients, and improving aquatic habitat and recreational beneficial uses. Selective dredging strategies are likely to be an important element of the lake management plan required by the proposed implementation plan.

Numeric Target

The proposed numeric target is specified as a 5% improvement in lake capacity, to be achieved as soon as possible but no later than 10 years from the effective date of the TMDL. This target can be met through implementation of BMPs in the watershed and removal of sediment by selective dredging in areas with maximum sediment accumulation in accordance with the lake management

plan[25]. For example, selective dredging of areas in which marinas and boat docks are located would protect recreational uses and hinder macrophyte growth (due to the greater depths). Reduced macrophyte growth would also reduce the need to harvest weeds or apply aquatic herbicides to these areas.

3.2 Rathbun Creek Sediment Numeric Targets

Proposed numeric targets for Rathbun Creek are shown in Table 3-2. Additional investigation of the water quality measures needed to achieve the numeric targets is likely to be necessary. Thus, a schedule for compliance no later than 2020 is proposed.
An average annual sediment load is proposed for Rathbun Creek as the primary numeric target. Indicators and targets for parameters other than the annual sediment load are also proposed in order to track improvements in the instream health of the creek. These additional indicators include turbidity and benthic macroinvertebrates. Board staff recognizes the limitations of using sediment loads as a numeric target, as discussed above for Big Bear Lake; however, the proposed target is expressed as a 10-year running average to mitigate the effects of spatial and temporal variability in sediment delivery rates. Moreover, the proposed TMDL is based on a phased approach, which means that as new data are collected and analyzed, load allocations and numeric targets will be reviewed and revised, if necessary.

Derivation of the Rathbun Creek proposed targets is discussed below.

3.2.1 Sediment Load

Numeric Target

The proposed target for sediment is 1900 tons sediment per year, measured at the mouth of Rathbun Creek (this figure is rounded to two significant figures). This proposed target was determined using the same approach as for Big Bear Lake. The Rathbun Creek watershed is comprised of 3154 acres of north facing slopes and 940 acres of south facing slopes. The sum of the area of these two aspects is 4094 acres[26]. To calculate an average natural background load, the sediment yields for both the north and south forest land uses (0.36 tons/acre/yr and 0.86 tons/acre/year, respectively) were multiplied by the acres of north and south facing slope areas in the watershed. This results in 1944 tons/year of sediment delivered by forested land for the entire watershed area. As for Big Bear Lake, these sediment yields assume that no anthropogenic activities in the watershed that affect erosion/sedimentation. This proposed numeric target is expressed as a 10-yr running average to minimize the effects of spatial and temporal differences in sediment delivery. Compliance with the target value will be based on measurements of flow, suspended sediment and bedload concentrations collected at the mouth of Rathbun Creek.

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[25] Until the lake management plan is developed and approved, selection of appropriate dredging sites can be conducted in accordance with a beneficial uses map that is to be prepared as part of a Clean Water Act Section 401 water quality standards certification for the pilot dredging project at the east end of Big Bear Lake. This project is part of a Proposition 13 grant project. The beneficial uses map will designate areas of the lake with specific beneficial uses to aid in the selection of areas for improvement and enhancement of fisheries habitat and recreational access.
[26] Note that there is a discrepancy between this total land area and the watershed area as shown in Table 1-3. This is due to slight differences in the GIS layers that were provided as part of the HSPF watershed model.

3.2.2 Turbidity

Turbidity is a measure of light scattered due to particulates in water. Turbidity is affected by both inorganic and organic particulates. Although turbidity has not been monitored in Rathbun Creek, the ratios of VSS to TSS were evaluated. VSS is a measure of the organic fraction of TSS. For Rathbun Creek, the average contribution of organic sources was nearly 25%, meaning that 75% of the suspended solids are from inorganic sources. Turbidity thus appears to be a good indicator of impairment of beneficial uses caused by suspended sediment. Researchers have found reduced numbers and diversity of macroinvertebrates with turbidity values of 7-23 NTUs. This reduction is most likely due to reduced periphyton biomass resulting from light attenuation caused by the increase in turbidity (USEPA 2000, 33).

Numeric Target

The proposed numeric targets are the same as the Basin Plan objectives for turbidity.

"Increases in turbidity which result from controllable water quality factors shall comply with the following:

Natural Turbidity	Maximum Increase
0-50 NTU	20%
50-100 NTU	10 NTU
Greater than 100 NTU	10%

All inland surface waters of the region shall be free of changes in turbidity which adversely affect beneficial uses."

This indicator should be measured during storm flows, snowmelt and baseflow to measure the variability in turbidity values. In addition, measurement of levels upstream and downstream of management activities would enable the comparison of changes in turbidity levels due to those activities.

3.2.3 Benthic Macroinvertebrate Metrics

As noted above, benthic macroinvertebrate populations are affected by turbidity and serve as good indicators of changes in water quality. This indicator will be evaluated using the California Department of Fish and Game's Stream Bioassessment Protocol (Ode, Rehn and May 2004). Sites within Rathbun Creek can then be compared to the SoCal IBI[27] and the predictive O/E[28] models being generated for the US Forest Service to evaluate watershed health. Together with physical and chemical parameters, biological assessment provides a third measure of overall stream health.

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[27] The SoCal IBI is a macroinvertebrate-based assessment of biological integrity and is suitable for assessing biological integrity in wadeable streams and rivers for all of coastal California, from Monterey County to the Mexican border and inland to the borders of the Central Valley and the Mojave and Colorado deserts (Ode, Rehn, and May 2004).

[28] O/E is the ratio of observed to expected taxa (O/E). Values less than 1 indicate loss of taxa and biological impairment (Hawkins n.d.). This method of assessing the biological condition of streams is used primarily by the USFS.

Evaluations similar to the California Stream Bioassessment Protocol took place in October 2002 in Rathbun Creek, as well as in Big Bear Lake. However, at the time of the assessment there was no flow in the creek and the assessment was necessarily limited.

Numeric Target

Improving trends in the eight metrics specified for the SoCal IBI. These eight metrics are: Percent Collector-Gatherer + Collector-Filterer Individuals, Percent non-insect taxa, percent tolerant taxa, Coleoptera richness, predator richness, scraper richness, average tolerance value and EPT richness. Each metric is scored on a 0-10 scale, therefore, the SoCal IBI has a scoring range of 0-80, where 0 =very poor and 80 = very good.

Table 3-2. Proposed numeric targets and indicators for the Rathbun Creek sediment TMDL

Indicator	Target Value[c]	Reference
Total Sediment Load [a]	Annual average of 1900 tons/year as a 10-yr running average; to be attained no later than 2020	HSPF modeling (BBMWD, Hydmet, Inc., and AquAeTer, Inc. 2003; Hydmet 2004)
Turbidity[b]	Increases in turbidity which result from controllable water quality factors shall comply with the following: Natural Turbidity — Maximum Increase 0-50 NTU — 20% 50-100 NTU — 10 NTU Greater than 100 NTU — 10% To be attained no later than 2020	SARWQCB 1995
Benthic Macroinvertebrate Metrics[b]	Improving trends in 8 metrics as specified for the SoCal IBI[d]; to be attained no later than 2020	Ode, Rehn, and May 2004

[a] source targets related to load allocations/waste load allocations (see Section 5.0)
[b] monitoring targets that will not be used for load allocations/waste load allocations
[c] compliance with the targets to be achieved as soon as possible, but no later than the date specified
[d] SoCal IBI consists of 8 metrics (Percent Collector-Gatherer + Collector-Filterer Individuals, Percent non-insect taxa, percent tolerant taxa, Coleoptera richness, predator richness, scraper richness, average tolerance value and EPT richness). Each metric is scored on a 0-10 scale, therefore, the SoCal IBI has a scoring range of 0-80, where 0 =very poor and 80 = very good.

4.0 SOURCE ASSESSMENT

Current sources of sediment loading to Big Bear Lake and its tributaries were evaluated using computer modeling (i.e., HSPF watershed model) and direct load measurements. The HSPF model is used for the simulation of hydrology and water quality in watersheds, including sediment transport and movement of contaminants. The HSPF pervious sediment transport method was used to simulate sediment loads for the Big Bear Lake watershed from the pervious areas of the four land uses (forest, resort, residential, and high density urban)[29]. This sediment transport method addresses sediment produced by land surface erosion for pervious land segments only. To calculate the net sediment yield for a watershed, a sediment budget could be prepared that consists of the sum of sediment from overland flow and gully erosion, sediment from mass movements, and sediment from bank erosion, minus the sediment accumulated in major river channels. In most instances, the sediment yield from each of these processes is not known and is difficult to measure (Mount 1995, 118). These processes were not individually quantified for the Big Bear Lake watershed; instead a gross sediment load by land use was obtained from the watershed model. A more detailed source assessment will be carried out in 2005 and 2006 as part of a Proposition 13 grant. At that time, both hillslope and instream erosional processes and rates and potential control measures will be examined in greater detail (Reid and Dunne 1996, 5).

For more detailed information on the watershed modeling and external sediment source assessment, please refer to the nutrient budget report (BBMWD, Hydmet, Inc., and AquAeTer, Inc. 2003) and to the updated model runs (Hydmet, Inc. 2004), as well as information sent by Humphrey (2003). Note that all of the following graphs and tables for the flow and HSPF loads were created by Regional Board staff using data supplied by Hydmet, Inc (2004). The source assessment discussion below describes the sources of sediment and summarizes the sediment load estimates.

External nonpoint sources are grouped into general land use categories (forest and resort); point sources include urban runoff from high density urban and residential land use. The urban runoff category represents land uses that are within the City of Big Bear Lake and the County of San Bernardino. The urban discharges from these areas are regulated under NPDES permits issued to the San Bernardino County Flood Control District, the City of Big Bear Lake (as co-permittees) and Caltrans.

The major categories of sources that were evaluated in the Big Bear Lake watershed were:

- runoff from forest and resort land uses
- runoff from residential and high density urban land uses (hereafter described generically as urban runoff)

The HSPF model simulated streamflow, total suspended sediment and nutrients. The hydrologic component of the model used was calibrated to the monthly Big Bear Lake inflow by three independent procedures. These procedures included preparation of a lake water balance, conduct of a Plunge Creek regression and conduct of a Santa Ana River regression. Note that Plunge Creek, although in an adjacent watershed, has hydrology similar to the Big Bear Lake watershed and that the Santa Ana River gaging station located downstream of Big Bear Lake was used to calibrate the outflow at Big Bear Lake. These procedures had to be used to simulate flows since there are currently no gaging stations in the Big Bear Lake watershed and, again, there are few

[29] Refer to Section 1.1, p. 19 for a description of the land uses.

flow data available for the watershed. The water quality component of the model simulated total nitrogen, total phosphorus, total kjeldahl nitrogen (TKN), nitrate, nitrite, orthophosphate and ammonia, while the sediment component of the model simulated total suspended sediment. One of the limitations of the simulations with the HSPF model is that the hydrologic events that were sampled for calibration purposes were of low intensity and consisted of rainfall/snowmelt in dry years that could not be extrapolated to average precipitation or wet years. As a result, fits between the simulated and observed flows for calibration purposes were within 10% for annual runoff and 20% for monthly runoff. These results were considered sufficient due to the fact that there were few local tributary inflow data, and the only recorded precipitation data records were near the lakeshore, with no records of higher elevation precipitation or snow cover.

HSPF model calibrations for external sediment loads based on Big Bear Lake watershed data were not performed since the existing observed data were not adequate for this purpose (BBMWD, Hydmet, Inc., and AquAeTer, Inc. 2003)[30]. However, the model was calibrated by using the accumulated sediment load in the Rathbun Creek sediment basins and dividing by ten years (i.e., the period of record for the sediment basins) (Table 4-1). This number was then multiplied by the ratio of the entire area of the Big Bear Lake watershed to that of the Rathbun Creek watershed and adjusted for the perceived higher sedimentation rates from Rathbun Creek compared to other tributary watersheds. The estimate was 10,000 to 20,000 tons of sediment per year. The HSPF model was set up with parameters in the sediment detachment and removal equations to produce an average annual load of 10,000 tons. Wet year HSPF sediment concentrations (e.g., 1993) were comparable to flood events monitored in Lake Tahoe and to the flood event methods used by the U.S. Army Corps of Engineers Los Angeles District for Southern California (Humphrey 2003a; Humphrey 2003b).

As part of the phased TMDL approach, additional sediment water quality and flow data collected during higher intensity rainfall and snowmelt and data collected from a high elevation weather station (proposed for installation) will be used to calibrate the water quality and sediment components of the HSPF watershed model.

[30] Weirs and flow meters installed in 2002 at key locations within the watershed were used to sample stormwater and record flows. However, much more flow and load data needs to be collected before there will be an accurate understanding of the duration, magnitude and type of flow (e.g., baseflow, storm events or snowmelt) that delivers sediment to the lake.

Table 4-1. Sediment detention basins within the Rathbun Creek subwatershed

Name	Location	Approximate Size lxwxd (in feet)	Approximate Capacity (cubic yards)	Clean out method/frequency	Material Disposal	Impacts
Station A	500 feet south of Big Bear Lake in Rathbun Creek	400x40x15	2500	Dragline/once every 2 years	Moved from basin and set to the west of the basin and allowed to dry for 1 year. Silt fence surrounds the material while drying. Then used by a contractor for topsoil.	Willows are trimmed back for access.
Station B	25 feet south of Elm Street, next to Bear Mtn.'s lower parking lot, in Rathbun Creek in lower Moonridge. There is a concrete check dam.	35x35x2	--	Backhoe or excavator/once a year in the fall after creek stops flowing	Removed from site and loaded on trucks and hauled off-site	Willows are trimmed back for access
Station C	Located between Station B and Station D south of Elm Street and north of Moonridge Road	30x20	--	Backhoe or excavator	Removed from site and loaded on trucks and hauled off-site	Willows are trimmed back for access
Station D	1000 feet north of Moonridge Road, next to Bear Mtn.'s lower paking lot in Rathbun Creek in lower Moonridge. It has a concrete check dam.	45x30x2	--	Backhoe or excavator	Removed from site and loaded on trucks and hauled off-site	Minimal vegetation disturbance
BBMWD 1	Lake bottom at the mouth of Rathbun Creek	--	9000	Backhoe or excavator/2-3 years	--	--
BBMWD 2	Rathbun Creek near the trout farm	--	500	--	--	--

Note: Data obtained from 401 Waiver issued by SARWQCB on 3/25/1998 and by personal communication with Gene Martin, BBMWD's Lake Manager (2003).
-- = data not provided
For a 10-year period (1993-2003), approximately 10,000 cubic yards of sediment were removed at the mouth of Rathbun Creek (Martin 2003).

Fourteen water years, 1990-2003, are simulated by the model. ***The proposed TMDLs are based on the average of all loads from the period of record of 1990 to 2003. This period incorporates loads from wet, dry, and average hydrological periods.***

The Watershed Database Management (WDM) file consists of all the meteorological time series data used for the hydrology simulation of the HSPF model and was assembled for the time period of October 1948 to December 2002 (54 years). HSPF accesses WDM files for both input and output time series data. The WDM file was extended through December 2003 for the WASP modeling effort conducted by Tetra Tech in 2004[31]. Because hourly precipitation data were not available or published for any location in the San Bernardino Mountains before October 1948, model simulations prior to 1948 were not possible (BBMWD, Hydmet, Inc., and AquAeTer, Inc. 2003).

The GIS data assembled and used to characterize the Big Bear Lake watershed consisted of subbasins, mean annual precipitation, elevation/aspect, land use, and soils. The datasets contained the following attributes: 1) four land uses (forest, resort, residential, and high density urban); 2) two elevation zones (>7,500 ft and <7,500 ft); 3) two aspects (land oriented facing north or facing south); 4) four precipitation zones (15-20", 20-25", 25-30", and 30-35"); and 5) two dominant soil types (low and high water holding capacity). By combining the GIS datasets, a total of 128 types of pervious surfaces (PERLND in the HSPF model) were obtained. Ultimately, only 30 pervious land use types were used to define all the possible combinations of the variables. The other combination types simply were not present or had areas that were less than 10 acres. Eight impervious land use types were used in the Big Bear Lake watershed model (BBMWD, Hydmet, Inc., and AquAeTer, Inc. 2003).

The surface area of the lake was estimated at approximately 2,282 acres. Based on the bathymetry provided by ReMetrix in 2001, the surface area of the lake at full pool (i.e., at a lake elevation of 6,743.2 ft.) was determined to be 2,808 acres, with a corresponding volume of 72,696 af (compare to Table 1-1) (BBMWD, Hydmet, Inc., and AquAeTer, Inc. 2003). The lake has lost storage capacity since the original gage height-lake capacity chart was created in 1977. These updated values, based on the newest bathymetry obtained in 2000, were used in the HSPF model.

Hydrology of the Big Bear Lake Watershed

The summary of HSPF simulated inflows for the period of record 1990 to 2003 around the average total flow shows that 1993 was the wettest year during this period (Figure 4-1). In fact, out of the entire 14-year period, there were only 3 years with flow above the average total flow of 14,032 AF (1993, 1995 and 1998). The majority of the years are below the average total flow. Low-flow conditions typically occur from July through October, with the minimum monthly average simulated flow of 34.7 AF recorded during August (Figure 4-2).

[31] Discussed in the Big Bear Lake Nutrient TMDLs staff report, June 1, 2005.

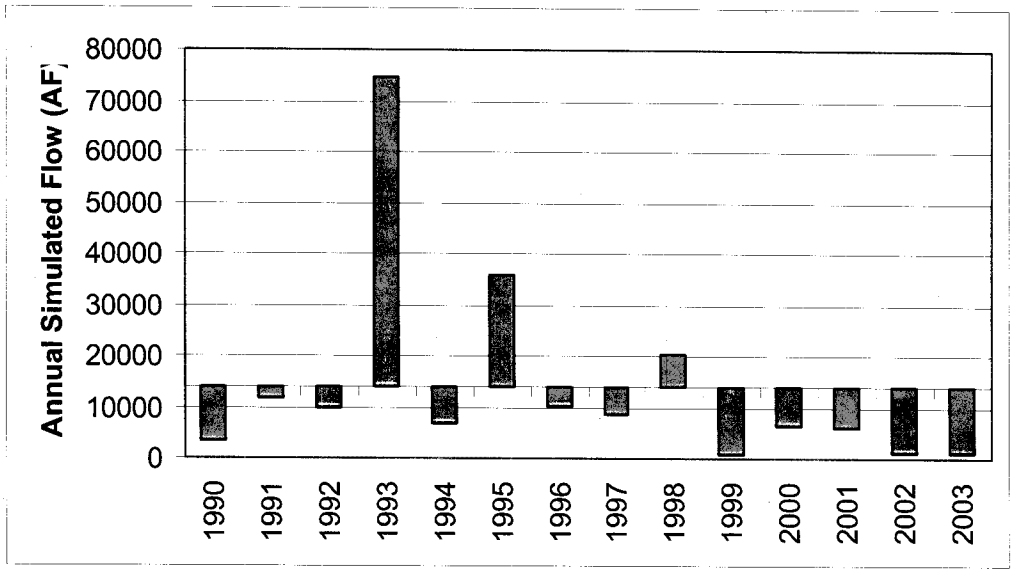

Figure 4-1: Variation of annual total flow (AF) from HSPF model land uses around average total flow (AF) for the period of record 1990-2003 (CY)

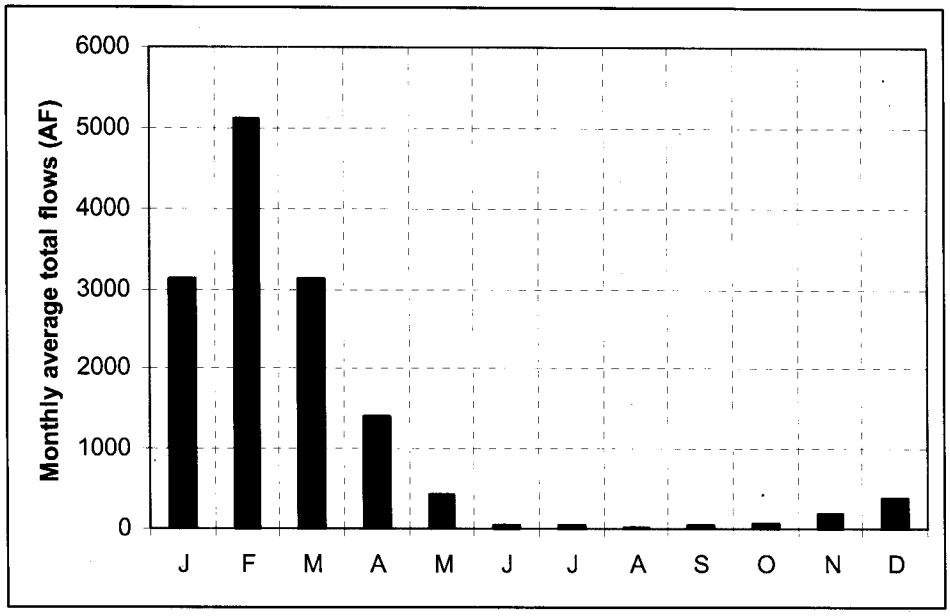

Figure 4-2: Monthly trends of average total flow (AF) for Big Bear Lake, 1990-2003 (CY)

Hydrology of the Rathbun Creek subwatershed

Shown in Figures 4-3 and 4-4 are the total annual simulated flows and average monthly simulated flows in AF for Rathbun Creek. The wettest year for the 14-year period of record (1990-2003) was 1993. The majority of the flows occur during the winter, with February contributing the greatest flows (Figure 4-4). For the past few years, runoff due to precipitation and snowmelt have been the lowest in years. Rathbun Creek has only been sampled on a few occasions due to lack of flow. Rathbun Creek comprises approximately 18% of the total Big Bear Lake watershed area, with an average flow of roughly 2600 AF for the 14-year period.

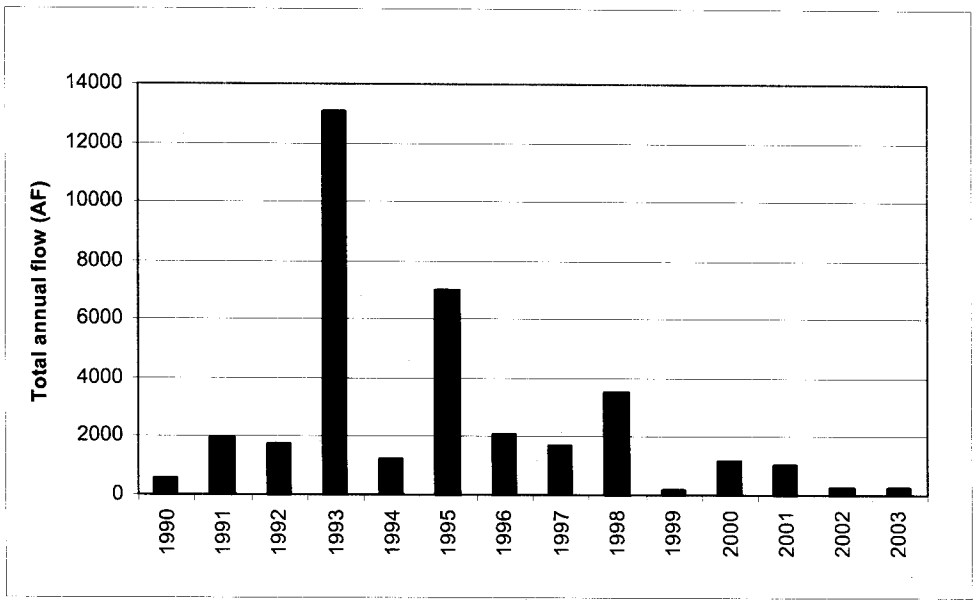

Figure 4-3: Total annual simulated flow from HSPF land uses for Rathbun Creek 1990-2003 (CY))

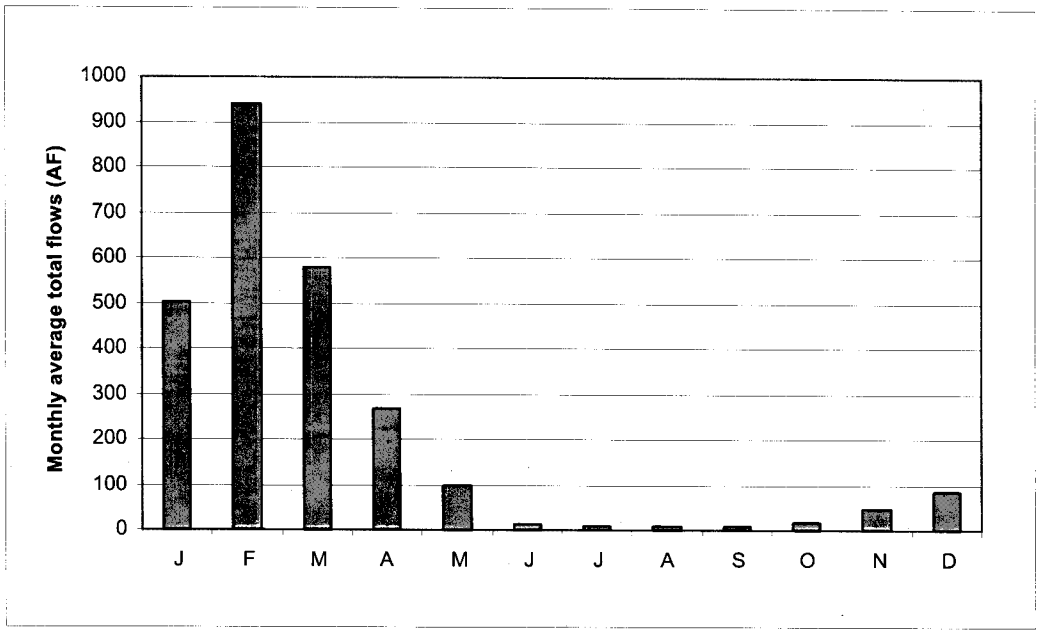

Figure 4-4: Monthly trends of average total flow for Rathbun Creek, 1990-2003 (CY)

4.1 Loads from Forest, Resort and Urban land uses

Big Bear Lake

Sediment produced by land surface erosion for pervious land segments was simulated by the SEDMNT module section in HSPF. Subroutine SOSED2 was used to simulate the washoff of detached sediment and the scouring of the soil matrix. The washoff process involves the detachment of sediment from the soil matrix, the attachment of sediment to the soil matrix, and the transport of this sediment (Bicknell et al. 2001, 88). Rainfall splash causes the detachment of sediment. Overland flow transports the detached sediment. Attachment of sediment to the soil matrix only occurs on days without rainfall (Bicknell et al. 2001, 88). Sediment loads were obtained for the Big Bear Lake watershed from the four land uses (forest, resort, residential, and high density urban), each of which has pervious and impervious areas. To reiterate, the following ratios were used to determine the percentage of impervious/pervious area for each land use: forest north (0.5%, 99.5%); forest south (0.5%, 99.5%); resort (5%, 95%); residential (15%, 85%); and high density urban (50%, 50%). The model set-up used the default value of 1.0 for the Supporting Management Practice Factor (SMPF), which is used to simulate the reduction in erosion achieved by use of erosion control practices. The default value of 1.0 assumes that there is no erosion control implemented on the various land uses. Whether or not this represents actual conditions in the watershed will be evaluated as part of the source assessment that is part of a Proposition 13 grant.

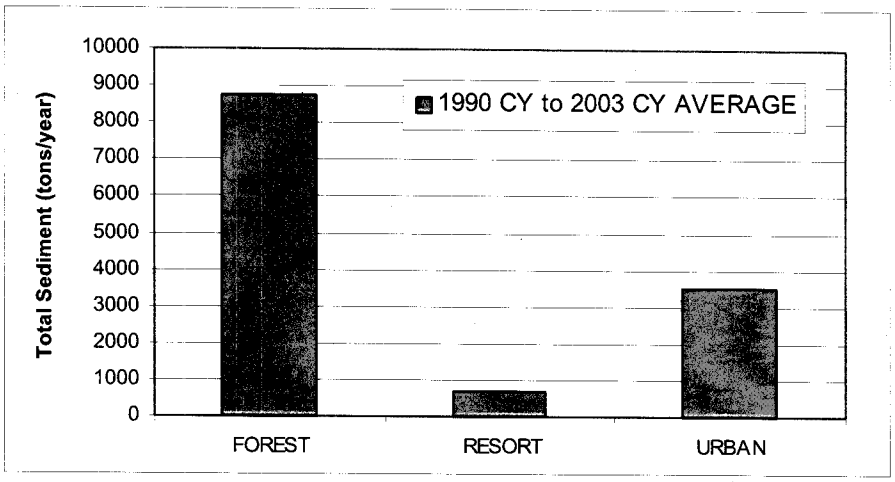

Figure 4-5: Average annual simulated sediment loads from land uses for 14 years (1990-2003)

Annual total sediment loads to Big Bear Lake simulated by the HSPF model for 1990 to 2003 are shown in Table 4-2. The largest sediment load, 64,882 tons, for the last 14 years (1990-2003) was calculated for 1993, which also corresponded to the wettest year and the greatest external inflows. Total sediment loads for the last 5 years (1999-2003) averaged 4,096 tons per year (Table 4-2). The annual average load during the 14-year period, 1990-2003, is more than 3 times the annual average load for the period of record from 1999-2003. The difference in the annual average load for these two time spans is attributed to the wet hydrological conditions that occurred in 1993, 1995, and 1998, although a recent study conducted by Kirby (2005) suggests that changing lake levels and not major storm events, such as those that occurred in 1993, contributes the majority of sediment to the lake (see footnote 21 on page 48). Runoff from forest areas contributed 68% of the total average sediment load for the 14 period (1990-2003), while runoff from resort areas contributed 5% and urban areas contributed 27%. These loads are depicted in Figure 4-5 and tabulated and summarized in Table 4-3.

Note that sediment loads from impervious areas of the four land uses are not included in the total pervious sediment loads. The total sediment loads summarized in Table 4-2 include only the fraction from pervious land uses, although dry atmospheric deposits, street deposition, and organic litter would be expected to build up on the impervious land surfaces. Rainfall would allow these sources to wash off into the receiving bodies of water due to the reduced ability of water to infiltrate into the ground. The volume of runoff from the various land surfaces drives the sediment loads from impervious land surfaces.

Table 4-2 HSPF simulated annual sediment loads to Big Bear Lake (CY)

CALENDAR YEAR	PRECIPITATION AT BIG BEAR LAKE DAM (IN)+	TOTAL ANNNUAL INFLOW (AF)	TOTAL SEDIMENT (TONS)
1990	22	3271	8294
1991	38	11665	7674
1992	44	9677	13496
1993	74	74610	64882
1994	32	6852	8736
1995	49	35880	23624
1996	41	10262	9525
1997	27	8742	9323
1998	50	20246	15210
1999	13	852	1741
2000	25	6254	4220
2001	31	5906	10519
2002	15	1104	2619
2003	32	1130	1379
1999-2003 AVERAGE	**23**	**3049**	**4096**
1990-2003 AVERAGE	**35**	**14032**	**12946***
MAX	74	74610	64882
MIN	13	852	1379

+Annual rainfall data are from January 1 through December 31 (*Data Source: Big Bear Municipal Water District 2004b*)
*12945.9 rounded up to 12946

Table 4-3. Total annual simulated sediment loads to Big Bear Lake from HSPF model land uses for the 14-year period, 1990-2003 (CY)

	TOTAL SEDIMENT LOADS FROM LAND USES (TONS/YEAR)			
CALENDAR YEAR	FOREST	RESORT	URBAN	TOTAL
1990	5815	449	2030	8294
1991	4962	454	2258	7674
1992	9469	720	3307	13496
1993	42985	3286	18611	64882
1994	6078	476	2181	8736
1995	15508	1091	7025	23624
1996	6688	496	2342	9525
1997	6871	459	1993	9323
1998	9914	835	4462	15210
1999	1215	113	413	1741
2000	2902	241	1076	4220
2001	7168	647	2704	10519
2002	1751	151	717	2619
2003	970	75	335	1379
1990-2003 AVERAGE	**8735.2**	**678.2**	**3532.5**	**12945.9**
% OF TOTAL AVERAGE	**68**	**5**	**27**	
MAX	42985	3286	18611	
MIN	970	75	335	
1999-2003 AVERAGE	2801	246	1049	4096
% OF TOTAL AVERAGE	68	6	26	

Rathbun Creek

Shown in Table 4-4 are the calculated external sediment loads for the period of record (1990 to 2003) for the Rathbun Creek subwatershed. Sediment loads to this tributary were not actually simulated due to the lack of monitoring data for model calibration. Instead, a ratio of subwatershed area to the total Big Bear Lake watershed area was determined for each pervious/impervious land use that occurred in the tributary watershed (see Tables 1-2 and 1-3). This percentage was then multiplied by the total sediment loads to Big Bear Lake for each land use to obtain the total sediment load for the different land uses for Rathbun Creek.

For the 14-year period 1990-2003, runoff from forest areas contributed 47% of the total average sediment load, runoff from resort areas contributed 18%, and runoff from urban areas contributed 35%. The largest sediment load, 10,908 tons, for the last 14 years (1990-2003) was calculated for 1993, which also corresponded to the wettest year and the greatest external inflows. Total sediment loads for the last 5 years (1999-2003) averaged 739 tons per year. The annual average load during the 14-year period, 1990-2003, is more than three times the annual average load for the period of record from 1999-2003. The difference in the annual average load for these two time spans is attributed to wet hydrological conditions that occurred in 1993, 1995, and 1998 (also see discussion on pages 48 and 60).

Sediment yields for the different land uses for Rathbun Creek were calculated in tons/acre/year. These yields were 0.36 for forest north, 0.86 for forest south, 0.96 for resort, 0.60 for residential, and 0.95 for high density urban.

Sediment Load by Tributary Area

In addition, the sediment yields for other tributary watersheds within the Big Bear Lake watershed were evaluated by staff (Figure 4-6). Using GIS, the percentages of each type of soil, land use, aspect and elevation were summarized for individual tributaries (Table 4-5). Based on the information in Table 4-5 and the sediment yields in Figure 4-6, some inferences about sediment yields in similar tributaries can be made. For instance, Grout Creek and Metcalf Creek have a similar composition of soils and land use and the sediment yields for Grout Creek and Metcalf Creek are also similar (0.6 tons/acre/year and 0.5 tons/acre/year, respectively). Similarly, Knickerbocker and Red Ant Creeks have a comparable composition of soils and have the same sediment yield of 0.6 tons/acre/year. Minnelusa Canyon Creek has the highest sediment yield of all the tributaries examined (0.8 tons/acre/year) and is comprised almost completely of the Lithic Xerothents-Lizzant (FrF) soil units. As shown in Figure 1-11, the areas in which the highest erosion potential exists are those areas in which the slopes are steepest and are comprised of the DaE, FrF or MbF soil units. From this, it would appear that Boulder Creek and Minnelusa Canyon Creek are within the high erosion category. Grout Creek and Metcalf Creek have similar percentages of DaE, while Rathbun Creek's combined percentage of the DaE and FrF soil units consists of a little more than a third of the total. Although Rathbun Creek was placed on the 303(d) list for sedimentation, it appears based on this evidence that other creeks (i.e., Minnelusa Canyon Creek, Grout Creek) might contribute greater sediment loads to Big Bear Lake than Rathbun Creek. To verify the simulated sediment load from Minnelusa Canyon Creek and other creeks, the creeks should be field checked and monitored as part of the watershed-wide monitoring proposed for this TMDL (see Attachment A).

Table 4-4. Total annual simulated sediment loads to the Rathbun Creek subwatershed from HSPF model land uses for the 14 year period, 1990-2003 (CY)

	TOTAL SEDIMENT LOADS FROM LAND USES (TONS/YEAR)			
CALENDAR YEAR	FOREST	RESORT	URBAN	TOTAL
1990	728	272	503	1503
1991	515	275	542	1333
1992	1321	436	818	2576
1993	4838	1991	4078	10908
1994	772	289	539	1600
1995	2290	661	1508	4459
1996	916	300	566	1783
1997	1068	278	485	1831
1998	1312	506	1023	2841
1999	109	69	103	280
2000	445	146	247	838
2001	839	392	674	1905
2002	162	92	176	430
2003	115	45	82	243
1990-2003 AVERAGE	**1102.3**	**410.9**	**810.3**	**2323.5**
% OF TOTAL AVERAGE	**47**	**18**	**35**	
MAX	4838	1991	4078	10908
MIN	109	45	82	243
1999-2003 AVERAGE	334	149	256	739
% OF TOTAL AVERAGE	45	20	35	

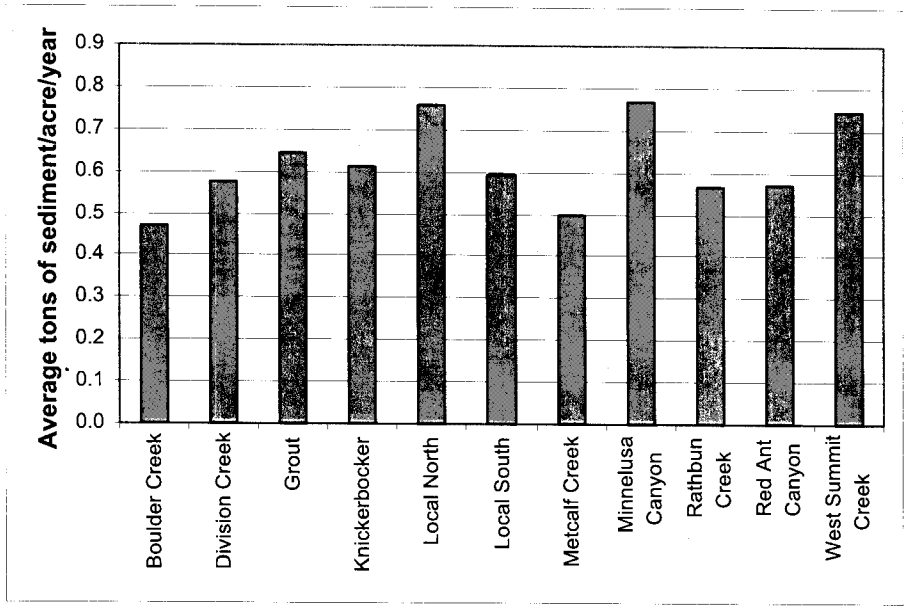

Figure 4-6. Estimated average sediment yield for selected tributaries within the Big Bear Lake watershed

Table 4-5. Relative percentages of soil family, mean annual precipitation, land use type and aspect/elevation for selected Big Bear Lake tributaries

	Soil Family					Mean Annual Precipitation					Land Use Type				Aspect/elevation			
Tributary Name	DdDE	DaE	BoD	FbE	FrF	<20"	20-25"	25-30"	30-35"	>35"	Forest	Resort	Residential	High Density Urban	South <7400	South >7400	North <7400	North >7400
Boulder Creek	23	77	0.3					31	69		100				5	16	17	61
Division Creek		3	97			100					36		61	3	23		77	
Grout Creek	58	33	9			17	61	15	5	3	96		3.6	0.5	38	19	24	19
Knickerbocker Creek	74		18	8			13	60	28		67	11	6	15	6	13	38	42
Metcalf Creek	49	47	4				1	40	59		96		2	2	5	19	28	48
Minnelusa Canyon Creek			3		97	10	42	47			90		10		41	45	8	7
Rathbun Creek		15	36	27	21	24	32	32	13		60	10	25	5	13	10	35	42
Red Ant Creek	69		31				14	63	23		79	9	2	9	10	10	45	35
Summit Creek			55	45		30	25	40	5		19	30	32	19	4	2	64	30

Notes: Soil family descriptions: DdDE = Pacifico-Preston; DaE = Pacifico-Wapi; BoD = Morical-Hecker; FbE = Merkel-Switchback; FrF = Lithic Xerothents-Lizzant

5.0 LINKAGE ANALYSIS AND TMDLs (LOAD CAPACITY)

As stated by the USEPA (1999b), the linkage analysis is an essential component of the development of a TMDL. A link needs to be established between predicted sediment loads and the numeric target(s) chosen to measure the attainment of beneficial uses. This linkage allows the assimilative capacity for sediment loading to be determined for the impaired body of water.

The relationship or link between the selected numeric target(s) and the predicted sediment loads can be determined using a combination of monitoring data, analytical tools (including models), and best professional judgment (USEPA 1999b). Ideally, a long-term monitoring data set with different flow regimes and sediment loads would be available for the body of water in order to determine the load capacity under various hydrological regimes. Once the load capacity is determined, the amount of sediment loading reduction needed to meet the selected numeric target(s)/TMDL is quantified.

Big Bear Lake

As discussed in Section 3 – Numeric Targets, the USEPA has acknowledged the difficulties in establishing TMDLs for sediment. Spatial, temporal and climatic variability in sediment yields makes it difficult to define "average" sediment mass loads that can be related to beneficial use impacts or to specific source contributions. As reflected in the Source Assessment Section (Section 4), it is also difficult to differentiate between erosion and sedimentation that occurs naturally and that resulting from disturbed areas, particularly where, as here, data are extremely limited. The USEPA has identified sediment TMDL approaches other than mass loading, and the proposed numeric targets reflect this flexibility.

The proposed TMDL for Big Bear Lake (Table 5-1) is the same as the proposed sediment load numeric target. The intent is to assure that anthropogenic sources are controlled to the maximum extent practicable, and wasteload and load allocations are proposed accordingly (see Section 6.0). An extended compliance schedule (as soon as possible but no later than 2020) is proposed to allow the development and implementation of appropriate control or sediment trading[32] measures, and, perhaps more importantly, to allow the collection of much-needed, relevant data to enable accurate assessment of source contributions and their effects on the lake. The numeric target and TMDL will be reviewed and revised as necessary based on additional data collection required by the proposed implementation plan (Section 9).

The other numeric target proposed for Big Bear Lake is a 5% increase in lake capacity, to be achieved no later than ten years from the effective date of the TMDL. This target is not used as the basis for establishing allocations. It is intended to provide more evident and direct control over the loss of lake capacity due to sedimentation and resultant impairment of the municipal, biological and recreational beneficial uses of the lake. As discussed in Section 3, this target is tied to a requirement in the proposed implementation plan for the development and implementation of a lake management plan that would integrate sediment control and management with programs to restore and protect the beneficial uses of the lake, including those related to the lake's biological and recreational resources. The lake is man-made, and its continued existence relies on the efforts of stakeholders to maintain and protect it. The identification and implementation of an appropriate lake management plan by the stakeholders is

[32] Where compliance with the proposed wasteload or load allocations is infeasible, implementation of measures (e.g., in-lake dredging) to mitigate excess sediment contributions can be implemented.

the sensible and practical approach to assure that the water quality problems affecting the lake (including nutrients as well as sediment) are addressed in coordinated fashion, and that beneficial uses are restored and protected.

This lake capacity target reflects the difficulty in predicting the linkage between erosion in the watershed (due to hillslope processes, channel erosion, etc.) and in-lake conditions because although erosional processes occur in the watershed, sediment might not be transported immediately to stream channels and thence the lake. As already noted, seasonal and annual variations in the delivery of sediment to stream channels also exist. In the case of Big Bear Lake, the long-term sediment load to the lake is more important than a detailed analysis of in-stream storage and transport. Comparison of the calculated load resulting from natural background sources and the estimated loads from all sources in the watershed for 1990-2003 (Table 4-2) indicates that the majority of the sediment entering Big Bear Lake arises from natural sources. The proposed lake capacity target takes these circumstances into account and requires stakeholders to implement a coordinated program that is expected to include both source control measures and in-lake remediation activities.

The proposed TMDL shown in Table 5-1 uses an "inferred linkage" based on comparison of loads from natural background (e.g., forest land uses) with existing loads from the watershed. The assumption is made that some loading reduction in the watershed combined with sediment removal in the lake will result in the attainment and maintenance of beneficial uses. Reducing sediment loads to natural background conditions may still result in unacceptable sediment loads to the lake, but it is not feasible to reduce sediment loads to the lake completely since erosion is a natural process. The proposed TMDL target, 12,000 tons of sediment per year, expressed as a 10-year running average, reflects the assumption that BMPs will be effective when fully implemented (and assuming a 10% margin of safety-see Section 8.0).

BMPs are in place in the ski areas (e.g., culverting, over side drains, cross ditching, mulching, grass growing and irrigation, protective matting, silt collection basins and debris rakes, flow channels and runoff filtering) (Klouzer 2004). The effectiveness of each of these BMPs is not known at this time. Future monitoring will allow for better quantification of the total effectiveness of implemented BMPs and the sediment load that these BMPs already control. Load allocations can be adjusted based on this new information. The USFS is responsible for controlling NPS runoff from their lands. The USFS has signed a Management Agency Agreement (MAA) with the SWRCB to manage NPS pollution from their lands and has a manual for implementing BMPs and assessing their effectiveness on USFS lands (USDA 2000). No information was received on BMPs implemented by the USFS. As monitoring is conducted in the future, this information can also be quantified. The City and County both implement BMPs in accordance with the MS4 permit. Again, with future monitoring, the effectiveness of each BMP can be elucidated and wasteload allocations can be adjusted based on this information.

Rathbun Creek

Many of the difficulties in identifying the specific linkage between sediment loading, numeric targets and beneficial use impacts for Big Bear Lake, discussed above, pertain also to Rathbun Creek, e.g., lack of data, spatial and temporal variability in erosion and sediment transport. However, in the case of Rathbun Creek, the use of the proposed benthic macroinvertebrate target can aid in the determination of acceptable sediment loads. Using both the IBI and the O/E model will allow a direct linkage to be made between levels of sediment loading and ecosystem health. Currently, the only comparison that can be made is to the benthic macroinvertebrate study conducted in 2002, when conditions were representative of a degraded system. Future survey

results will be compared to the year 2002, and changes in the macroinvertebrate community can be detailed and related to sediment data.

As with the Big Bear Lake TMDL, the Rathbun Creek TMDL also relies on an "inferred linkage" based on comparison of loads from natural background (forest land uses) with existing loads from the watershed. An assumption is that the reduction in sediment loading from the watershed to natural background loads will achieve an improvement in benthic macroinvertebrate community health and beneficial uses will be attained and maintained. The proposed TMDL target, 1900 tons of sediment per year, expressed as a 10-year running average, reflects the assumption that BMPs will be effective when fully implemented (and assuming a 10% margin of safety –see Section 8.0).

As discussed above for Big Bear Lake, additional studies are needed to evaluate the effectiveness of the BMPs implemented by various stakeholders.

5.1 Proposed TMDLs

Tables 5-1 and 5-2 summarize the proposed sediment TMDLs for Big Bear Lake and Rathbun Creek necessary to achieve the final numeric targets. Included are the proposed allowable loads from all external sources. The TMDL, WLAs and LAs are based on the average of sediment loads from the 14-year period, 1990-2003, and are consistent with the proposed numeric targets discussed in Section 3. Existing sediment loads are also based on the average of sediment loads from this 14-year period (Table 4-3). This 14-year period incorporates loads from wet, average, and dry hydrological periods. The proposed TMDLs are based on a 10-year running average, to account for the inherent seasonal and annual variations in sediment loads. The allowable loads for each source are compared to the existing average load for each source to determine the reductions that will be required to meet the recommended numeric targets.

Table 5-1. Sediment TMDL to achieve the sediment numeric target (12,000 tons/year expressed as a 10-yr running average) for Big Bear Lake (to be met as soon as possible, but no later than 2020) (all numbers in tons/year)

	Sediment	Existing Sediment Load	% Reduction
External loading	12,000	12,946	7
TMDL	**12,000**	12,946	7

Table 5-2. Sediment TMDL to achieve the sediment numeric target (1900 tons/year expressed as a 10-yr running average) for Rathbun Creek (to be met as soon as possible, but no later than 2020) (all numbers in tons/yr)

	Sediment	Existing Sediment Load	% Reduction
External loading	1900	2324	18
TMDL	**1900**	2324	18

The next section describes the allocation of these proposed TMDLs to different sources.

6.0 TMDL ALLOCATIONS

As discussed in Section 4.0, sediment inputs to Big Bear Lake come from both point source and nonpoint source discharges. The TMDLs must account for both types of inputs, as well as a margin of safety. This is expressed as follows:

$$TMDL = \Sigma WLA + \Sigma LA + MOS$$

where:

WLA = wasteload allocations for point source discharges
LA = load allocations for nonpoint source discharges
MOS = Margin of Safety

An explicit MOS of 10% of the TMDLs is proposed for each of the TMDLs (see Section 8.0).

Point source discharges of sediments to Big Bear Lake include urban storm and non-stormwater runoff (MS4 permitted dischargers and Caltrans).

Nonpoint source discharges of sediments include forest and resort runoff.

The proposed allocations are not affected by future growth in the watershed because the watershed is already close to its build-out capacity.

The allocations for the all the land use based sources are considered together as follows:

Urban WLA + Forest LA + Resort LA = TMDL – MOS

Proposed WLAs and LAs to achieve the TMDLs for Big Bear Lake and Rathbun Creek are shown in Tables 6-1 and 6-2, respectively. The percent reduction in sediment load from each source that would be required to comply with the allocation is also shown.

Table 6-1. Proposed TMDL, wasteload and load allocations for Big Bear Lake (to be achieved as soon as possible, but no later than 2020)*

		Sediment load allocation (tons/yr)	Existing sediment load (tons/yr)	Reduction (%)
TMDL		**12,000**	**12,946**	**7**
WLA		**3100**	3532	12
	Urban	3100	3532	**12**
LA		**7700**	9413	18
	Forest	7100	8735	**19**
	Resort	600	678	**12**
MOS		**1200**		

*Specified as a 10-yr running average based on a calendar year (January 1- December 31)

Table 6-2. Proposed TMDL, wasteload and load allocations for Rathbun Creek (to be achieved as soon as possible, but no later than 2020)*

		Sediment load allocation (tons/yr)	Existing Sediment load (tons/yr)	Reduction (%)
TMDL		**1900**	**2,324**	**18**
WLA		**650**	810	20
	Urban	650	810	**20**
LA		**1060**	1513	30
	Forest	730	1102	**34**
	Resort	330	411	**20**
MOS		**190**		

*Specified as a 10-yr running average based on a WY

The following describes the approach used to determine the LAs and WLAs for each of these sediment sources.

First, staff utilized the HSPF model results from Hydmet, Inc. (2004) to determine current sediment loading from each source (Tables 4-3 and 4-4). Staff then determined the reductions required from all sources in order to meet the proposed TMDLs (Tables 5-1 and 5-2). The requisite reductions were then allocated among the sources, based, in part, on consideration of information concerning present BMP implementation. The ski resorts and the City of Big Bear Lake each submitted letters that contained a description of BMPs that they have implemented in the watershed to control sediment loads from their jurisdictions; however, there was no information provided as to the effectiveness of these BMPs (Klouzer 2004; Perry 2004). No information was received on BMPs implemented by the USFS. A report produced by RBF Consulting for the Orange County Stormwater Program in 2003 summarized BMP effectiveness and provided maintenance and cost estimates for a variety of BMPs implemented by different agencies. This report was reviewed to determine reasonable and feasible percent load reductions for sediment (i.e., TSS) (RBF 2003). An average percent removal efficiency of 70% for TSS was thought to be acceptable based on the reported removal efficiencies. In light of this information, reductions of up to 34% are proposed to meet these TMDLs and are considered reasonable. Given that the city/ski resorts have implemented some BMPs, for the Big Bear Lake TMDL, lower reduction percentages were assumed for urban and resort (12% each) than for forest (19%). These percentages were applied to the HSPF simulated existing sediment loads to calculate the sediment load allocations for each source. Similarly, lower sediment reduction percentages were assumed for urban and resort for the Rathbun Creek TMDL (20% each), than for forest (34%). Again, these percentages were applied to the simulated existing loads from each source to calculate their respective allocations. The USFS is the largest landowner in the watershed and thereby the largest contributor of sediment. Reduction of this load is thus particularly important.

Since they are based on HSPF results for the period 1990-2003, the proposed TMDLs, WLAs and LAs take into consideration the cumulative effect of the watershed hydrological conditions during wet, average and dry years. The allocations shown in Tables 6-1 and 6-2 are proposed to apply as 10-yr running averages to account for variations in hydrological conditions. The 10-year running average means that at the end of 10 years after the TMDLs take effect, an average will be calculated using the first ten years of annual averages. Thereafter, the ten year running average will be calculated annually, using the annual averages of that year and the preceding nine years. Loads from each source over the calendar year (CY) (January 1-December 31) for the 10-yr

running average shall not exceed the allocations specified in Tables 6-1 and 6-2. Staff proposes that the allocations be achieved as soon as possible, but no later than 2020. The proposed implementation plan includes the requirement for the collection of additional data to provide interim evaluations of the effectiveness of the BMPs implemented, and to enable the calibration of the watershed model for sediment under all hydrologic conditions.

In the event of catastrophic events, such as a wildfire or massive landslide, the USFS should implement BMPs, as outlined in the USFS' BMP manual for Southern California (USDA 2000) in a timely and aggressive fashion so as to prevent or at least minimize resultant erosion and sedimentation. The MAA between the SWRCB and the USFS calls for the USFS to implement BMPs to the extent feasible. With respect to meeting the proposed sediment load allocations and TMDLs, staff recognizes that in the event of fires, mass wasting or other natural uncontrollable phenomena, the TMDLs and sediment load allocations are likely not to be met. In these instances, the proposed capacity target for Big Bear Lake and the benthic macroinvertebrate target for Rathbun Creek will be the drivers for control and remediation actions to protect beneficial uses.

7.0 SEASONAL VARIATION AND CRITICAL CONDITIONS

TMDLs must include consideration of seasonal factors. The difficulties in establishing TMDLs for sediment because of seasonal/climatic variability in loading have already been noted (Section 3). In Big Bear Lake and Rathbun Creek, external loading of sediment is greatest during the winter and spring months due to rainfall and snowmelt. To address this variability, annual average sediment loads from each significant source were simulated with the HSPF model for a 14-year period (1990-2003), which incorporates all types of seasonal/hydrological conditions. These results are the basis of the proposed targets, TMDLs, WLAs and LAs. In addition, the numeric sediment targets, TMDLs, WLAs and LAs are proposed as 10-year running averages to take annual variability into account. The proposed lake capacity target requires improvement in lake capacity over time, despite seasonal, climatic or other variations in sediment loading.

TMDLs must also include consideration of critical conditions to ensure that even under the worst water quality conditions, water quality standards can still be met through implementation of the TMDL. Erosion and sediment deposition can exert both immediate and long-term adverse impacts on beneficial uses. To the extent that erosion and sedimentation in Big Bear Lake and Rathun Creek are associated with storm or other events that result in the removal or covering of spawning substrate for fish or other organisms, there may be immediate adverse effects on aquatic biota during these conditions. Reasonably feasible control measures must be implemented to address such inputs. Compliance with the proposed numeric targets, TMDLs WLAs and LAs will require the implementation of such measures. However, the adverse effects of erosion/sedimentation and the loss of lake capacity may continue to be observed over the long-term, unless the sediment is removed. As described in Section 2, these include adverse effects on recreational, wildlife and municipal uses through habitat and substrate changes, reduced depths, etc. Sediment deposition in the lake increases the extent of shallower areas, contributing to the growth of nuisance macrophytes that in turn exert their own set of adverse impacts on recreational and wildlife uses (see also the Big Bear Lake Nutrient TMDLs staff report). These effects of the loss of lake capacity due to sediment loading and deposition in Big Bear Lake are most pronounced during the spring and summer of dry years, when the level of the lake declines and water levels are shallower. Recreational use of the lake is typically at its peak during these months and this is also the period of macrophyte growth. Similarly, the longer-term effects of changes in substrate in Rathbun Creek due to erosion and sediment deposition are likely to be

more pronounced during dry periods, when flows in the creek are low, and repopulation of the benthic macroinvertebrate community may be problematic. The proposed TMDLs account for the dry period critical conditions by specifying alternative numeric targets, including a lake capacity target for Big Bear Lake and benthic macroinvertebrate metrics for Rathbun Creek. In addition, the proposed implementation plan includes a requirement for the development of a lake management plan that is to identify an overall sediment control and management strategy designed to restore and protect beneficial uses, including during the critical dry periods.

8.0 MARGIN OF SAFETY

TMDLs must include an explicit or implicit margin of safety (MOS) to account for uncertainty in determining the relationship between pollutant loads and impacts on water quality standards. An explicit MOS can be provided by reserving (not allocating) part of the TMDL and therefore requiring greater load reductions from existing and/or future sources. An implicit MOS can be provided by conservative assumptions in the TMDL analysis. The assumptions that account for the MOS should be adequately identified.

Sources of uncertainty in the Big Bear Lake sediment TMDL development analysis include: 1) the lack of watershed specific data on sediment loading from surface runoff to allow calibration of the water quality component of the watershed model; 2) the lack of discharge measurements from the tributaries; 3) the inherent seasonal and annual variability in delivery of sediment; 3) the lack of data to verify assumptions made about the efficiency of potential BMPs; 4) the absence of a high elevation weather station for use in calibrating the watershed model; 5) the lack of both bedload and suspended sediment concentration data; 6) the lack of information regarding rates, types and locations of erosion in the watershed; 7) the lack of suspended sediment concentration data taken over the hydrograph; 8) the assumption that the Rathbun Creek sedimentation basins are representative of sediment loading within the watershed and that the quantified amount reflected all of the sediment loads from the tributary; and, 9) the lack of knowledge of delivery of sediment from baseflow, storm event and snowmelt runoff. In addition, the lake and tributary water column monitoring were carried out during drought years; data for other hydrologic conditions are lacking.

Because of these uncertainties, staff recommends use of an explicit margin of safety. A MOS of 10% is thought to be adequate to represent the uncertainty in sediment loads. As new data are collected under various hydrologic conditions, data gaps will be filled, an uncertainty analysis can be conducted and the MOS and TMDLs can be adjusted as appropriate.

9.0 MONITORING PROGRAM RECOMMENDATIONS

Federal regulations require the State to identify measures needed to implement TMDLs in the state water quality management plan (Basin Plan) (40 CFR 130.6). California law requires that Basin Plans have a program of implementation to achieve water quality objectives. The implementation program must include a description of actions necessary to achieve the objectives, a time schedule for these actions, and a description of the surveillance and monitoring activities to determine compliance with the objectives. Staff proposes that the Big Bear Lake and Rathbun Creek sediment TMDLs be adopted as phased TMDLs. Further, given the lack of data with regard to beneficial use impacts to Rathbun Creek from sediment, the proposed implementation plan includes a requirement to address this creek. The TMDL's phased implementation framework provides time to conduct further monitoring and assessment,

including refining the existing watershed model. The results of these studies may provide the analytical basis for modifying the TMDL, WLAs, LAs and/or other elements of the TMDLs.

The proposed Basin Plan amendment, shown in Attachment A, includes an implementation plan and monitoring program designed to implement the TMDLs and evaluate their effectiveness. TMDLs are not standards and do not establish new criteria; they are a mechanism to attain existing standards. An implementation plan ensures that the TMDLs achieve this purpose. Implementation is expected to result in compliance with the proposed sediment numeric targets, TMDLs and allocations for Big Bear Lake and Rathbun Creek and thereby ensure protection of the beneficial uses of these water bodies. The proposed implementation plan includes requirements directed at both point and nonpoint sources. Implementation of the Big Bear Lake and Rathbun Creek sediment TMDLs is the responsibility of the dischargers of sediment including the U.S. Forest Service, Big Bear Mountain Resorts, the City of Big Bear Lake, Caltrans, County of San Bernardino, and the San Bernardino County Flood Control District. The Big Bear Municipal Water District must be a cooperating partner working with the local stakeholders to implement the Big Bear Lake sediment TMDL, given the District's significant responsibilities for management of the lake (Section 1.0).

Regional Board staff will coordinate implementation of the TMDLs with the Board's permitting, enforcement and stormwater sections of the Board. In addition, implementation will be coordinated with the following:

- The State Board's Nonpoint Source Implementation and Enforcement Policy (NPS Policy)
- The Big Bear Lake TMDL Workgroup coordinated by the Big Bear Municipal Water District (BBMWD)
- The U.S. Forest Service, San Bernardino National Forest (Big Bear Lake Ranger Station) and the existing MAA between the SWRCB and the Forest Service regarding control of nonpoint source pollution from forest activities within California
- The U.S. Army Corps of Engineers and their Feasibility Study within the Big Bear Lake watershed
- The U.S. Fish and Wildlife Service
- California Department of Fish and Game

9.1 Implementation Actions by the Regional Board

In order to implement the TMDLs, WLAs and LAs, Board staff proposes that the Regional Board undertake the following actions. Proposed dates for implementation of these actions are specified in the proposed Basin Plan amendment (Attachment A).

1. Establish New Waste Discharge Requirements or Conditional Waivers of WDRs
    a. Review the State Board's new NPS policy and act accordingly with respect to nonpoint sources. This could include drafting new WDRs or conditional waivers of WDRs for the Big Bear Mountain Resorts and ensuring that the MAA and its provisions between the USFS and SWRCB are being met through new WDRs or conditional waivers of WDRs.

2. Revise Existing Waste Discharge Requirements

   The Regional Board shall review and revise, as necessary, the following existing NPDES permit to incorporate the appropriate WLAs, compliance schedules and monitoring program requirements.
   Waste Discharge Requirements for the San Bernardino County Flood Control District, the County of San Bernardino and the City of Big Bear Lake, Areawide Urban Runoff, NPDES No. CAS 618036 (Regional Board Order No. R8-2002-0012).

3. Review/Revise Sediment Related Water Quality Objectives for Big Bear Lake and Rathbun Creek

   The Regional Board shall review, and revise as necessary, the numeric water quality objectives for turbidity and the narrative objectives for suspended solids for Big Bear Lake and Rathbun Creek. The Regional Board shall also examine the appropriateness of establishing biocriteria for Big Bear Lake and Rathbun Creek.

4. Review collected data on beneficial use impairment due to sediment in Rathbun Creek.

5. Utilize new monitoring data and model simulations for revising the sediment TMDL.

9.2 Implementation Actions by Other Agencies/Entities

In order to ensure that effective sediment control and management programs are developed and implemented to achieve the numeric targets, TMDLs, WLAs and LAs, staff proposes that the following requirements for the appropriate responsible entity (-ies), as identified in Section 9.0, be incorporated into the Implementation Plan. Proposed dates for implementation of these actions are specified in the proposed Basin Plan amendment (Attachment A).

- Development and implementation of an approved Big Bear Lake management plan. The intent is to develop a coordinated, long-term program for management of the lake and the water quality problems affecting it so as to assure the restoration and protection of the lake's beneficial uses. The management plan is to identify sediment control and management strategies, including dredging or other remedial actions. The plan must include a methodology for measuring changes in the capacity of the lake to enable determination of compliance with the proposed lake capacity numeric target. The plan is to be coordinated and integrated with other control and management strategies designed to address other TMDL requirements, e.g., nutrient reductions and control of macrophyte growth and species composition. It must also integrate the beneficial use survey information required to be developed pursuant to the Regional Board's March 3, 2005, Clean Water Act Section 401 Water Quality Standards Certification for the Big Bear Municipal Water District's Big Bear Lake Nutrient/Sediment Remediation Project.

- Development and implementation by the responsible parties of an approved plan to address erosion, sedimentation and channel stability problems in Rathbun Creek.

- Development of an IBI for Rathbun Creek by the responsible parties based on benthic macroinvertebrates and physical habitat data. Both the Fish and Game's California

Stream Bioassessment Protocol and the USFS' O/E models can be used to assess improvement in ecosystem health (see Section 3.2.3).

The tasks identified above for Rathbun Creek may be incorporated in the lake management plan for Big Bear Lake. Indeed, in order to provide comprehensive and coordinated management of sediment and other water quality problems in Big Bear Lake, it is expected to be necessary to identify in that plan strategies that apply to all the lake's tributary waters (see also Task 10.3).

10.0 MONITORING PROGRAM RECOMMENDATIONS

Section 13242 of the California Water Code specifies that Basin Plan implementation plans must contain a description of the monitoring and surveillance to be undertaken to determine compliance with water quality objectives. Several monitoring requirements are proposed as part of the proposed Big Bear Lake and Rathbun Creek sediment TMDLs (Attachment A) in order to evaluate the effectiveness of actions and programs implemented pursuant to the TMDLs. In addition, since the Big Bear Lake and Rathbun Creek TMDLs are phased TMDLs, follow-up monitoring and evaluation is essential to validate and revise the TMDLs as necessary.

10.1 Big Bear Lake In-lake Monitoring Program

The Big Bear Municipal Water District and various stakeholders in the watershed, along with Regional Board staff, implemented a Big Bear Lake in-lake monitoring program in 2001. This program, which is currently ongoing, consists of the collection of water quality data along with depth profile measurements at stations in Big Bear Lake on a year-round basis. The purpose of this program is to evaluate changes in lake water quality due to nutrient and sediment input or other environmental factors. This monitoring program has been funded by stakeholders as well as by grants.

Staff proposes in the Basin Plan amendment that watershed stakeholders continue the in-lake monitoring program to assess the response of the lake to the sediment loadings and to determine if the load reductions and other management strategies that may be implemented result in the achievement of numeric targets (as proposed in Section 3.0). The lake monitoring program for nutrients specified in Task 4.2 of the nutrient TMDLs can suffice as the lake monitoring program for sediment.

10.2 Watershed-wide Sediment Water Quality Monitoring Program

A watershed-wide sediment monitoring program was implemented in 2001 by the Big Bear Municipal Water District and various stakeholders in the watershed along with Regional Board staff and is currently ongoing. The purpose of this monitoring program has been to collect data needed to develop the nutrient and sediment TMDLs, as well as other TMDLs. The monitoring program consists of the collection of stream flow and water quality data in the Big Bear Lake watershed. Because there are no USGS stream gages in this watershed, this program is key to developing accurate loading estimates from the watershed and accurate inflow measurements. This watershed-wide monitoring program has been instrumental in the development of the proposed sediment TMDLs and is critical to the implementation plan.

The proposed Basin Plan amendment specifies that the responsible parties continue to implement this watershed-wide sediment monitoring program and focus on collecting sediment yield data from specific land use sources, e.g., open space/forest lands, urban runoff as well as determine and quantify the loads from major erosional processes (e.g., mass wasting estimates, rill erosion, etc.). In addition, suspended sediment and bedload samples should be collected across stream cross-sections. The locally-built weirs and ISCO stormwater samplers, or other flow measuring and sampling devices, should also be continually operated and maintained, and water quality samples should be collected from all stations to quantify sediment loads from various sources in the watershed. In addition, a high elevation weather station should be installed and maintained in order to obtain the necessary data for calibration of the present watershed model. The data generated will not only be used to evaluate TMDL compliance, but will also be used to calibrate/update the current watershed model and refine the TMDLs.

10.3 Special studies

Finally, staff believes that there is a need to conduct special, sediment-related studies in the watershed. These studies should be undertaken jointly by the responsible parties as identified in Section 9.0.

- Unified Stream assessment: Perform an assessment of the major tributaries in the watershed to locate and evaluate problems pertaining to sediment and erosion and restoration opportunities within the stream corridor using an established stream assessment protocol (see Task 3.1 in Attachment A).

- Establish a reference reach: Development of a reference reach in the Big Bear Lake watershed will help to determine natural background sediment loads, measure changes in the channel stability of Rathbun Creek and determine appropriate biocriteria for assessing sediment-related impacts to the aquatic biota (see Task 3.1 in Attachment A).

- Model update/development: Update/revision of the watershed sediment model developed by Hydmet, Inc. (2004) will be needed in the future as additional data are generated. An updated watershed model could be used to determine BMP effectiveness and to determine TMDL, WLA and LA compliance. The model could also be used as a tool to evaluate potential pollutant trading options. A lake model will likely be needed to evaluate the effects of sediment on the health of the lake ecosystem. A new lake model will be used for future refinement of the proposed TMDLs, WLAs, LAs and numeric targets.

11.0 ECONOMIC CONSIDERATIONS

Regional Water Boards are required to adopt TMDLs as basin plan amendments. There are three statutory triggers for consideration of economics in basin planning. These triggers are:

- Adoption of an agricultural water quality control program (Water Code Section 13141). The Regional Board must estimate costs and identify potential financing sources in the Basin Plan before implementing any agricultural water quality control plan.
- Adoption of water quality objectives (Water Code Section 13241). The Regional Board is required to consider a number of factors, including economics, when establishing or revising water quality objectives in the Basin Plan.
- Adoption of a treatment requirement or performance standard. The Regional Board must comply with the California Environmental Quality Act (CEQA) when amending the Basin Plan. CEQA requires that the Board consider the environmental effects of reasonably foreseeable methods of compliance with Basin Plan amendments that establish performance standards or treatment requirements, such as TMDLs. The costs of the methods of compliance must be considered in this analysis.

It should be noted that in each of these three cases, there is no statutory requirement for a formal cost-benefit analysis.

There are no agricultural operations in this watershed, therefore the first statutory trigger does not apply. The adoption of these TMDLs does not constitute the adoption of new or revised water quality objectives, so the second statutory trigger does not apply here. However, compliance with these TMDLs will likely necessitate changes in programs (including educational programs and BMPs) designed to reduce sediment inputs from urban stormwater or other sources, as well as the implementation of remedial activities such as dredging. The proposed TMDLs also require monitoring and other investigations. The costs of these activities must be considered.

The proposed TMDLs include requirements for the development and implementation of a lake management plan, for the development of an IBI for Rathbun Creek and for both routine monitoring and special investigations. The following provides available cost information. It is expected that this information will be supplemented by the responsible parties for consideration by the Regional Board. Again, the proposed TMDLs are phased and include extended compliance schedules. In part, this is to allow for review and refinement of the TMDLs, and the strategies required to implement them, based on new information. As the TMDLs are reviewed and refined in future, and as potential management strategies are identified and developed through the tasks required in the proposed implementation plan, a more accurate assessment of the costs and methods of funding can be made. If and when the TMDLs are revised through the basin planning process, consideration of the economic ramifications will again be a requisite component of the Regional Board's deliberations.

The development of a recommended lake management plan is expected to require approximately $250,000 - $500,000. Board staff is in the process of evaluating/identifying potential grant sources of funding to support this work. A local match may be required. The costs of implementation of the plan will depend on the strategies identified. Again, grants may be

obtained to support implementation of one or more tasks, and Board staff will support such funding requests through the requisite approval process.

Ongoing watershed and lake monitoring will be required to assess the effectiveness of lake and watershed improvement strategies and in determining compliance with the TMDL numeric targets. Funding for these monitoring programs will largely be provided through 2006 through two Proposition 13 Phase III grants awarded to the Big Bear Municipal Water District and the East Valley Resource Conservation District. These grants are also expected to support some of the studies identified in Section 10, which are scheduled to begin in 2005 and 2006.

Table 11-1 shows some of the ongoing costs associated with the TMDLs. Table 11-2 shows costs associated with dredging.

Table 11-1. Cost estimates for TMDL monitoring

Medium	Study type	Cost per sample $
Sediment	Sediment traps	3000
Water	Tributaries	100
Sediment	Bedload, suspended sediment concentration and grain size analysis	150
Sediment	Analyze sediment cores for determination of sedimentation rate and geochemical analyses (cost does not include drilling for the cores)	30,000 for study

Table 11-2. Estimated costs of lake management options for Big Bear Lake

LAKE MANAGEMENT TECHNIQUE	TREATMENT ASSUMPTIONS	COST RANGE PER ACRE TREATED ($)
Dredging	Average sediment depth = 2ft	15,000 to 50,000
	Average sediment depth = 5ft	25,000 to 80,000

Source: Modified from a table provided as a task deliverable for a Proposition 13 grant (Contract # 02-069-258-0 with the BBMWD).

BMPs such as street sweeping, sediment catchment basins, and cleaning out drainage culverts are already being implemented throughout the watershed. Information provided by the BBMWD, the City of Big Bear Lake and Big Bear Mountain Resorts is summarized below in Table 11-3 (Hamilton 2004; Klouzer 2004; Perry 2004). In addition to the BMPs listed, the City of Big Bear Lake and presumably the County of San Bernardino and the San Bernardino County Flood Control District, implement measures in accordance with the NPDES requirements, such as monitoring erosion control measures on construction sites, BMP training sessions, etc. Note that

as shown in Table 11-3, cost information of BMP implementation only includes that which was provided to staff.

By the end of 2007, the amount of money spent in the Big Bear Lake watershed for developing and implementing the Big Bear Lake TMDLs, including both the nutrient and sediment TMDLs, will have reached well over $4 million (Table 11-4). This amount includes grants funded by Proposition 13, Section 319(h) of the Clean Water Act and TMDL funds provided by the State Board. Not included in this amount is the TMDL Task force budget of $90,000 per year or the other funds contributed by the BBMWD, as well as the $100,000 the U.S. Army Corps of Engineers spent on their reconnaissance study and the money now being spent as part of their feasibility study.

Table 11-3. BMPs in place within the Big Bear Lake watershed

Agency	BMP	Capital Cost	O and M Cost	Date Completed
BBMWD	Sediment catchment basins of Rathbun Creek between Elm St. and Moonridge Rd.[1]			1980s
BBMWD	3,000 cubic yard catchment basin at the mouth of Rathbun Creek		$37,912 cleaned out in 1998	Early 1990s
BBMWD	9,000 cubic yard catchment basin on lake bottom at the mouth of Rathbun Creek	$9,000		2000
BBMWD	Stabilized channel banks of Sand Canyon Channel in the area of Sheephorn Road[2]	$32,200*		October 1997
BBMWD	Replaced two storm culverts and a portion of Teton Road and bank stabilization work in the Sand Canyon Channel[2]	$185,000**		April 2002
BBMWD	Bank stabilization project below the box culvert near the confluence of Summit and Rathbun Creeks.[3]	$15,500		2000
BBMWD	Shoreline erosion control[4]			Ongoing
City of BBL	Street sweeper[5]	$141,236.30		Purchased 1999
City of BBL	Sweep 658 curb miles of roadway-removal of 1,000 cubic yards of debris and snow cinders		Contracted out by City	Ongoing
City of BBL	Testing and disposal of cinders and debris in accordance with State and Federal regulations		$20,000 annually	Ongoing
City of BBL	Dept. of Public Works inspects and cleans as necessary, 135 drainage culverts annually		2003-160 hours hydro-vactoring 80 culverts	Ongoing
Big Bear Mountain Resorts	Soil protection measures, cross ditching, overside drains, culverts, silt collection dams and basins, runoff filtering, temporary measures			Ongoing

[1]The basins are cleaned out annually by Bear Mountain ski resort.
[2]The San Bernardino County Flood Control District, the City of Big Bear Lake, the BBMWD and the East Valley Resource Conservation District were involved in two 319(h) projects pertaining to channel erosion control in the Sand Canyon channel.
*Overall cost of project was $278,771, the BBMWD's share was $32,200.
**Overall cost of project was $377,849, the BBMWD's share was approximately $185,000.
[3]Culvert was cleaned out by Snow Summit ski area –prior to project, culvert capacity was reduced by more than 50%.
[4]The BBMWD has prepared a pamphlet explaining methods of shoreline erosion control.
[5]The City of BBL utilizes the street sweeper to sweep the four-lane portion of Big Bear Blvd. (approx. 2.5 lineal miles) a minimum of 26 times per year.

Table 11-4. Sources and amounts of funding for the Big Bear Lake Watershed

Funding Source	Project	Deliverables	Amount	Recipient
State TMDL funds	Nutrient monitoring	Watershed and lake nutrient monitoring from June 01-Oct.02	$40,000	BBMWD
State TMDL funds	Nutrient Budget	HSPF model WASP model Sediment core-flux analyses and sediment characterization Watershed and lake nutrient monitoring ISCO samplers Plant tissue analyses	$77,000	BBMWD
Prop. 13	Pilot-scale remediation	Lake wide fish survey Lake wide macroinvertebrate study Biological surveys (zooplankton, phytoplankton) Access database of all monitoring data Trial alum project in Papoose Bay Big Bear Lake Atlas website	$200,000	BBMWD
Federal 319(h) funds	Nutrient and plant remediation	Sonar application Pre-and post- treatment aquatic macrophyte surveys	$120,000	BBMWD
Prop. 13	High resolution aerial mapping	Low and high altitude aerial photography GIS coverages (DTM, contours, utility, parcels)	$490,000	SBC
Prop. 13	Large-scale alum application	Lake wide alum application Water quality monitoring prior to, during and after project Sediment core-flux data	$500,000	BBMWD
Prop. 13	Lake and Tributary monitoring support	Continued water quality monitoring-2005 Phytoplankton and zooplankton analyses Preliminary macrophyte index	$80,000	BBMWD
Prop. 13	BMP implementation	BMP implementation in Snow Forest area NPS education	$250,208	EVRCD
Federal 106(g) funds	WASP model	WASP model Updated HSPF model runs	$50,000	RWQCB8
Prop. 13	Lake dredging and study	Continued water quality monitoring Studies needed for TMDL implementation High elevation weather station Monumented cross-sections Dredging of east end Update to Access database Model plan	$2,300,000	BBMWD

12.0 CALIFORNIA ENVIRONMENTAL QUALITY ACT (CEQA)

The Secretary of Resources has certified the Basin Planning process as "functionally equivalent to" the preparation of an Environmental Impact Report (EIR) or a Negative Declaration pursuant to the California Environmental Quality Act (CEQA). However, in lieu of these documents, the Regional Board is required to prepare the following: the Basin Plan amendment; an Environmental Checklist that identifies potentially significant adverse environmental impacts of the Basin Plan amendment; and, a staff report that describes the proposed amendment, reasonable alternatives, and mitigation measures to minimize any significant adverse environmental impacts identified in the CEQA checklist. The Basin Plan amendment, Environmental Checklist, and staff report together are functionally equivalent to an EIR or Negative Declaration.

The draft Environmental Checklist (Attachment B to this report) concludes that there would be no potentially significant impacts on the environment caused by adoption of this Basin Plan amendment. Therefore, no mitigation measures are required.

This staff report will be followed by another report that includes comments received on the proposed amendment, staff responses to those comments, and a discussion of any changes made to the proposed amendment as the result of the comments or further deliberation by the Board, and/or Board staff. This follow-up report would address any additional CEQA considerations, including economics, that might arise as the result of any changes to the proposed amendment.

Consideration of Alternatives

1. No Project Alternative

The "No Project" alternative would be no action by the Regional Board to adopt a TMDL with implementation measures and a monitoring program. This alternative would not meet the purpose of the proposed action, which is to correct ongoing violations of the Basin Plan narrative objectives regarding suspended solids and adverse impacts to beneficial uses. This alternative would result in continuing water quality standards violations and threats to public health and safety and the local economy. This alternative would not comply with the requirements of the Clean Water Act.

2. Alternatives

The Regional Board could consider TMDLs based on alternative numeric targets, such as more restrictive numeric targets; however, the proposed numeric targets are based on the best scientific information now available concerning sediment and its impact to Big Bear Lake and Rathbun Creek. The proposed targets provide the best assurance that the narrative water quality objective for suspended solids will be achieved and that the beneficial uses of both water bodies will be protected.

The Board could also consider an alternative TMDL implementation strategy that is based on a different compliance schedule approach. Adoption of a longer schedule would prolong non-attainment of the water quality standards. The proposed compliance schedule approach reflects the timing of implementation of projects that have been carried out and that are proposed for Big Bear Lake. These projects are expected to result in improvements in lake water quality. The proposed compliance schedule also considers the need for additional studies to fill data gaps, particularly the collection of data during wet hydrological conditions, and to address uncertainties in the TMDL calculations. The proposed compliance schedules are therefore considered reasonable.

3. Proposed Alternative
Staff believes that the recommended TMDLs reflect a reasoned and reasonable approach to the improvement of beneficial uses of Big Bear Lake and Rathbun Creek. The proposed implementation schedule also provides a realistic time frame in which to complete the tasks required by the TMDL.

13.0 PUBLIC PARTICIPATION

Federal TMDL regulations require public participation to provide the public an opportunity to review and comment on the TMDLs. A number of opportunities for public participation are afforded throughout the entire TMDL Basin Plan Amendment process and through the CEQA review process.

- Basin Plan amendments require advanced public notice and a public hearing (CWC § 13244).
- CEQA requires circulation of a Notice of Filing to the public and interested public agencies.
- Public workshops are held by the Regional Board to consider evidence and testimony related to the proposed TMDLs.
- Regional Board staff must prepare written responses to comments that are received at least 15 days before the Board's public hearing. For those late comments for which written responses are infeasible and for oral comments at the Board meeting, staff must respond orally at the public hearing.
- Draft TMDLs, Basin Plan Amendments, Public Notices, Notice of Filing, CEQA documentation are made available on the Regional Board's website.
- After Regional Board adoption of the Basin Plan Amendment, the SWRCB and the USEPA conduct their review and approval processes, which afford more opportunities for public participation.
- Documentation of all public participation, including copies of hearing notices, press releases, written public comments and written responses, and tapes or minutes of hearing testimony will be included in the administrative record of the Basin Plan amendments.

In June 2000, Regional Board staff convened a TMDL workgroup to assist staff in the development of the Big Bear Lake and Rathbun Creek sediment TMDLs. Soon thereafter the Big Bear Municipal Water District hired Tim Moore of Risk Sciences as the TMDL facilitator. The BBMWD created the Big Bear Lake TMDL Task Force, which includes representatives from the Big Bear Municipal Water District, San Bernardino County Flood Control District, City of Big Bear Lake, the Big Bear Area Regional Wastewater Authority, Caltrans, the Big Bear City Community Services District and the Big Bear Mountain Resorts, and just recently, the USFS. The BBMWD also created a TMDL fund to pay for studies in the watershed with contributions by the BBMWD, the City of Big Bear Lake, the San Bernardino County Flood Control District and the Big Bear Area Regional Wastewater Authority. The Big Bear Municipal Water District has been instrumental in assisting Regional Board staff in the development of the proposed sediment TMDLs by compiling existing data, designing, coordinating and implementing the watershed and in-lake monitoring programs, and reviewing the results of studies conducted in the watershed. The District has also secured a number of grant funds, including a Clean Water Act Section 319(h) grant that was used to eradicate the Eurasian watermilfoil, a noxious aquatic plant, from Big Bear Lake and several Proposition 13 grants (see Table 11-4). The Proposition 13 funds have supported a macroinvertebrate study, a pilot alum project along with a full-scale alum

project, lake and tributary monitoring, to name just a few items. In addition, the County of San Bernardino along with the City of Big Bear Lake was awarded a Proposition 13 grant to obtain aerial photos of the entire Big Bear Lake watershed for implementation of their stormwater program and for other projects within the watershed. The East Valley Resource Conservation District was also awarded a Proposition 13 grant to work with the USFS in reducing sediment and nutrient loads from an abandoned ski area in the watershed. As previously indicated, by the end of 2007, more than 4 million dollars will have been spent by the state and EPA to develop and implement TMDLs within this watershed (Table 11-4).

14.0 STAFF RECOMMENDATION

Direct staff to prepare a Basin Plan amendment and related documentation to incorporate the TMDLs for sediment for Big Bear Lake and Rathbun Creek that are shown in Attachment A for consideration at a future public hearing.

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Attachment A

Resolution No. R8-2005-0097

ATTACHMENT TO RESOLUTION NO. R8 2005–0097

Draft

(NOTE: The following language is proposed to be inserted into Chapter 5 of the Basin Plan. If these amendments are approved, corresponding changes will be made to the Table of Contents, the List of Tables, page numbers, and page headers in the plan. Due to the two-column page layout of the Basin Plan, the location of tables in relation to text may change during final formatting of the amendments. For formatting purposes, the maps may be redrawn for inclusion in the Basin Plan, and the final layout may differ from that of the draft.)

Chapter 5 - Implementation Plan

2. Big Bear Lake and Rathbun Creek Sediment Total Maximum Daily Loads (TMDLs)

Erosion and sedimentation in Big Bear Lake and its watershed has resulted in both direct and indirect adverse impacts on water quality and beneficial uses. These problems led to the placement of the lake and Rathbun Creek, the principal tributary of relevant concern, on the Clean Water Act Section 303(d) list of impaired waters due to sediment in 1994. Sedimentation in Big Bear Lake, particularly at the mouths of tributary creeks such as Rathbun Creek, has resulted in shallower depths and a decrease in lake capacity. In certain areas, the shallow depths hinder or even preclude recreational use, and they provide additional habitat that is suitable for colonization by macrophytes, including Eurasian watermilfoil, (*Myriophyllum spicatum*). Excessive growth of this noxious aquatic plant also impairs recreational use of the lake and results in reduced habitat diversity for plants and wildlife (see the Big Bear Lake Nutrient TMDLs). The nutrients transported with sediment contribute to the eutrophication problem in the lake. Nutrients are deposited on the lake bottom by sedimentation and are then resuspended in the water column where they are available for biological uptake. The deposition of excessive nutrients leads to increased macrophyte and algae production and adverse effects on aquatic habitat and recreation. The Big Bear Lake Nutrient TMDLs shows the nutrient TMDLs that were developed to address the eutrophication problem. Given the interrelationship between sediment and nutrients, the sediment TMDLs and implementation actions identified below were developed in coordination with the development of the nutrient TMDLs.

Rathbun Creek has been hydromodified, which has led to problems with channel stability. Bank erosion and stream bottom down cutting are significant problems in the creek, resulting in significant adverse effects on instream habitat and beneficial uses and leading to sediment transport to the lake. Watershed sources also contribute sediment that is transported to the creek and thence Big Bear Lake. Both recreation and aquatic life habitat beneficial uses of Rathbun Creek are affected by the production and transport of sediment, as well as by the nature and scope of the hydromodifications themselves.

A TMDL staff report prepared by Regional Board staff describes the sediment related problems in Big Bear Lake and Rathbun Creek in greater detail and discusses the technical basis for the TMDLs that follow [Ref. # 1].

1. A. Numeric Targets

Table 5-9a-j and Table 5-9a-k show the numeric targets for Big Bear Lake and Rathbun Creek, respectively. In addition to total sediment load, targets that are more direct indicators of impairment are specified to assess and track water quality and beneficial use improvements. For Big Bear Lake, this indicator target is a 5% increase in lake capacity. For Rathbun Creek, targets include turbidity concentrations and benthic macroinvertebrate metrics.

Table 5-9a-j
Big Bear Lake Sediment TMDL Numeric Targets[a]

Indicator	Target Value
Total Sediment Load	Annual average of 12,000 tons/year as a 10-yr rolling average; to be attained no later than 2020*
Lake Capacity	At least a 5% increase in lake capacity by [*10 years from effective date of BPA*][b]

[a] Compliance with the targets to be achieved as soon as possible, but no later than the date specified
[b] see also Task 5
*Compliance to be determined from data and information collected pursuant to Task 3.1.
[Note: BPA => Basin Plan Amendment]

Table 5-9a-k
Rathbun Creek Lake Sediment TMDL Numeric Targets[a]

Indicator	Target Value[c]
Total Sediment Load	Annual average of 1900 tons/year as a 10-yr running average; to be attained no later than 2020
Turbidity	Increases in turbidity which result from controllable water quality factors shall comply with the following: Natural Turbidity — Maximum Increase 0-50 NTU — 20% 50-100 NTU — 10 NTU Greater than 100 NTU — 10% to be attained no later than 2020
Benthic Macroinvertebrate Metrics	Improving trends in 8 metrics as specified for the SoCal IBI[b]; to be attained no later than 2020

[a] Compliance with the targets to be achieved as soon as possible, but no later than the date specified
[b] SoCal IBI= Southern California Index of Biological Indicators. The SoCal IBI consists of 8 metrics (Percent Collector-Gatherer + Collector-Filterer Individuals, Percent non-insect taxa, percent tolerant taxa, Coleoptera richness, predator richness, scraper richness, average tolerance value and EPT richness). Each metric is scored on a 0-10 scale, therefore, the SoCal IBI has a scoring range of 0-80, where 0 =very poor and 80 = very good. The SoCal IBI assessment is to be performed at least once every 2 years and scores from each metric are to be compared to the previous score. An improving trend is defined as an increase in the total score from the last assessment.

2. B. Sediment TMDLs, WLAs and LAs and Compliance Dates

TMDLs, and the WLAs and LAs necessary to achieve them, are established for both Big Bear Lake and Rathbun Creek for total sediment load. The total sediment TMDLs for Big Bear Lake and Rathbun Creek and the corresponding WLAs for point source discharges and LAs for nonpoint source discharges are shown in Table 5-9a-l.

WLAs are specified for the only point sources in the watershed – urban runoff (e.g., residential and high density urban and highway runoff) subject to NPDES permits. Load allocations for total sediment load are specified for the nonpoint sources -- forest and resort (ski areas) land uses. The WLAs and LAs are expressed as a 10-year running average to account for varied hydrologic conditions.

Table 5-9a-l

Big Bear Lake and Rathbun Creek
Total Sediment TMDLs and Wasteload and Load Allocations

	Big Bear Lake Final Total Sediment Allocation (tons/yr)[b]	**Rathbun Creek Final Total Sediment Allocation (tons/yr)[b]**
TMDL	**12,000**	**1,900**
WLA	**3,100**	**650**
Urban	3,100	650
LA	**7,700**	**1,060**
Forest	7,100	730
Resort	600	330
Margin of Safety	**1,200**	**190**

[a] Compliance with allocations to be achieved as soon as possible, but no later than December 31, 2020.

[b] Specified as a 10-yr running average based on a calendar year

2.C. Margin of Safety

As shown in Table 5-9a-l, the Big Bear Lake and Rathbun Creek sediment TMDLs contain an explicit 10% margin of safety to account for uncertainty associated with the sediment watershed model and the lack of site-specific sediment data for the watershed.

2. D. Seasonal Variations/Critical Conditions

The sediment TMDLs for Big Bear Lake and Rathbun Creek address seasonal variations through the development of allocations based on average loads from 1990 to 2003. This time frame incorporates wet, dry and average hydrological conditions, and thus accounts for seasonal (and annual) variations.

Erosion and sediment deposition exert both immediate and long-term adverse impacts on beneficial uses. Critical conditions that result in the more immediate effects include the relatively infrequent, high intensity storms that occur largely in the winter months but may also take the form of intense summer thundershowers. These events can result in significant erosion and the transport and deposition of sediment, removing or covering up spawning habitat for aquatic species and causing sediment plumes that make the water aesthetically unpleasing for recreational activities. Over the long-term, shallower depths resulting from sediment deposition can hinder or preclude recreational activities and modify aquatic life habitat and community structure. Shallower depths in certain areas of Big Bear Lake provide additional habitat suitable for colonization by nuisance aquatic macrophytes, which in turn adversely affect recreational and wildlife beneficial uses. The long-term effects of sediment deposition are most pronounced during the spring and summer of dry years, when the level of the lake declines and water levels are typically shallower. Recreational use is generally at its peak, and this is the period of macrophyte growth. To address this range of critical conditions, the TMDL implementation plan requires the development and implementation of an approved lake management plan that must be coordinated with the identification of strategies designed to address channel stability and erosion/sedimentation problems in Rathbun Creek. Management strategies to restore and protect beneficial uses in the lake and Rathbun Creek (as well as other tributaries) must be identified, taking into account the need to address these critical conditions.

2. E. TMDL Implementation

Table 5-9a-m outlines the tasks and schedules to implement the TMDLs. Each of these tasks is described below. To the extent feasible, the implementation tasks are to be coordinated with the implementation tasks specified in the Big Bear Lake Nutrient TMDLs. Other TMDLs are expected to be developed for the Big Bear Lake watershed. Where it is appropriate to do so, these TMDLs will identify the need to coordinate implementation with the sediment (and nutrient) TMDLs.

1.2 Waste Discharge Requirements (WDRs) or Conditional Waiver of WDRs to the Big Bear Mountain Resorts to incorporate the sediment load allocations and monitoring and reporting requirements for ski areas.

Other sediment discharges will be addressed and permitted as appropriate.

Task 2: Review and/or Revise Existing Waste Discharge Requirements

Waste Discharge Requirements (WDRs) have been issued by the Regional Board to regulate discharges of various types of wastes in the Big Bear Lake watershed. On or before (**6 months from the effective date of this Basin Plan amendment**), and consistent with the schedule specified in the Big Bear Lake Nutrient TMDLs, these WDRs shall be reviewed and revised as necessary to incorporate sediment wasteload allocations and TMDL monitoring requirements.

2.1 Waste Discharge Requirements for the San Bernardino County Flood Control and Transportation District, the County of San Bernardino and the Incorporated Cities of San Bernardino County within the Santa Ana Region, Areawide Urban Runoff, NPDES No. CAS 618036 (Regional Board Order No. R8-2002-0012). The current Order has provisions to address TMDL issues. In light of these provisions, revision of the Order may not be necessary to address TMDL requirements.

2.2 State of California Department of Transportation (Caltrans) Stormwater Permit
Provision E.1 of Order No. 99-06-DWQ requires Caltrans to maintain and implement a Storm Water Management Plan (SWMP). Annual updates of the SWMP needed to maintain an effective program are required to be submitted to the State Water Resources Control Board.

Provision E.2 of Order No. 99-06-DWQ requires Caltrans to submit a Regional Workplan by April 1 of each year for the Executive Officer's approval. As part of the annual update of the SWMP and Regional Workplan, Caltrans shall submit plans and schedules for conducting the monitoring and reporting requirements specified in Task 3 and the special studies required in Tasks 4, 5 and 6.

Task 3: Sediment Water Quality Monitoring Program

3.1 Watershed-wide Sediment Monitoring Plan (s)

No later than (**3 months from effective date of this Basin Plan amendment** *), and consistent with the schedule specified in the Big Bear Lake Nutrient TMDLs, the US Forest Service, the State of California Department of Transportation (Caltrans), the County of San Bernardino, San Bernardino County Flood Control District, the City of Big Bear Lake and Big Bear Mountain Resorts shall, as a group, submit to the Regional Board for approval a proposed watershed-wide sediment monitoring plan that will provide data necessary to review and update the Big Bear Lake and Rathbun Creek sediment TMDLs, and to determine specific sources of sediment to Big Bear Lake and Rathbun Creek. Data to be collected and analyzed shall address, at a minimum, determination of compliance with the Big Bear Lake sediment TMDL, including numeric targets, WLAs and LAs and with the Rathbun Creek sediment TMDL, including numeric targets, WLAs and LAs. The proposed sampling plan shall also include plans, protocols, sampling locations, and a schedule for conducting benthic macroinvertebrate analyses according to the DFG's Stream Bioassessment Procedure [Ref. #2]. The plan shall include a proposal for establishing a stream reference reach for tributaries to Big Bear Lake.

The proposed plan shall be coordinated with the Big Bear Lake Nutrient TMDLs Monitoring Program, and at a minimum, shall include the consideration of the collection of samples at the stations specified in

Table 5-9a-n and shown in Figure 5-9, at the frequency specified in Table 5-9a-o. If one or more of these monitoring stations are not included, rationale shall be provided and proposed alternative monitoring locations shall be identified in the proposed monitoring plan. Consistent with requirements of the Big Bear Lake Nutrient TMDLs (Task 3), flow measurements shall be taken each time water quality samples are obtained.

The proposed plan shall also include protocols and a schedule for conducting Unified Stream Assessments, using an established stream assessment protocol, of the major tributaries in the watershed to locate and evaluate problems pertaining to sediment and erosion and to identify restoration opportunities within the stream corridors.

At a minimum, samples shall be analyzed for the following constituents:

- Suspended sediment concentration
- Grain size
- Total nitrogen in sediment
- Turbidity
- Bedload concentration
- Total phosphorus in sediment

The proposed monitoring plan shall be implemented upon Regional Board approval at a duly noticed public meeting. An annual report summarizing the data collected for the year and evaluating compliance with the WLAs/LAs shall be submitted by February 15 of each year.

In lieu of this coordinated monitoring plan, one or more of the parties identified above may submit a proposed individual or group monitoring plan for Regional Board approval. Any such individual or group monitoring plan is due no later than (*3 *months from effective date of this Basin Plan amendment**) and shall be implemented upon Regional Board approval at a duly noticed public meeting. An annual report of data collected pursuant to approved individual/group plan(s) shall be submitted by February 15 of each year. The report shall summarize the data and evaluate compliance with the WLAs/LAs.

Table 5-9a-n

Big Bear Lake Watershed – Sediment TMDL
Minimum Required Sampling Station Locations

Station Number	**Station Description**
MWDC3	Grout Creek at Hwy 38
MWDC4	Rathbun Creek at Sandalwood Ave.
MWDC8a	Knickerbocker Creek at Hwy 18
MWDC13	Boulder Creek at Hwy 18
MWDC20	Minnelusa Creek at Hwy 38

At a minimum, samples shall be analyzed at the frequencies specified in Table 5-9a-o:

Table 5-9a-o

Big Bear Lake Watershed – Sediment TMDL
Sampling Frequency

Flow type	**Months monitoring is required**	**Frequency**
Snowmelt	January 1 – May 31[1]	Varied -See note 1 below
Storm events	January 1 – December 31	5 storms per year[2]

[1] Samples to be collected daily for the first three days of the snowmelt period. If ambient air temperatures remain above freezing after three days have passed, snowmelt sampling will then be performed once a week for the following three weeks or until the snowmelt period ceases. Snowmelt cessation will be determined by one of the following: a) ambient air temperatures drop below freezing during most of the day; or b) a storm/rain precipitation event occurs after the snowmelt event was initiated. Beginning March 15th of each year, snowmelt flows will most likely be continuous since ambient air temperatures will usually remain above freezing. From March 15th through May 31 of each year, snowmelt sampling events will be conducted daily for the first two days of a snowmelt event and then once a week thereafter until the spring runoff period has ended or the tributary station location shows no signs of daily flows for one week. Flow status will be evaluated in the afternoon, when ambient air temperatures are highest and flow potential is greatest.

[2] Three storm events to be sampled during October – March; two storm events to be sampled during April – September. For each storm event, eight samples across the hydrograph are to be collected.

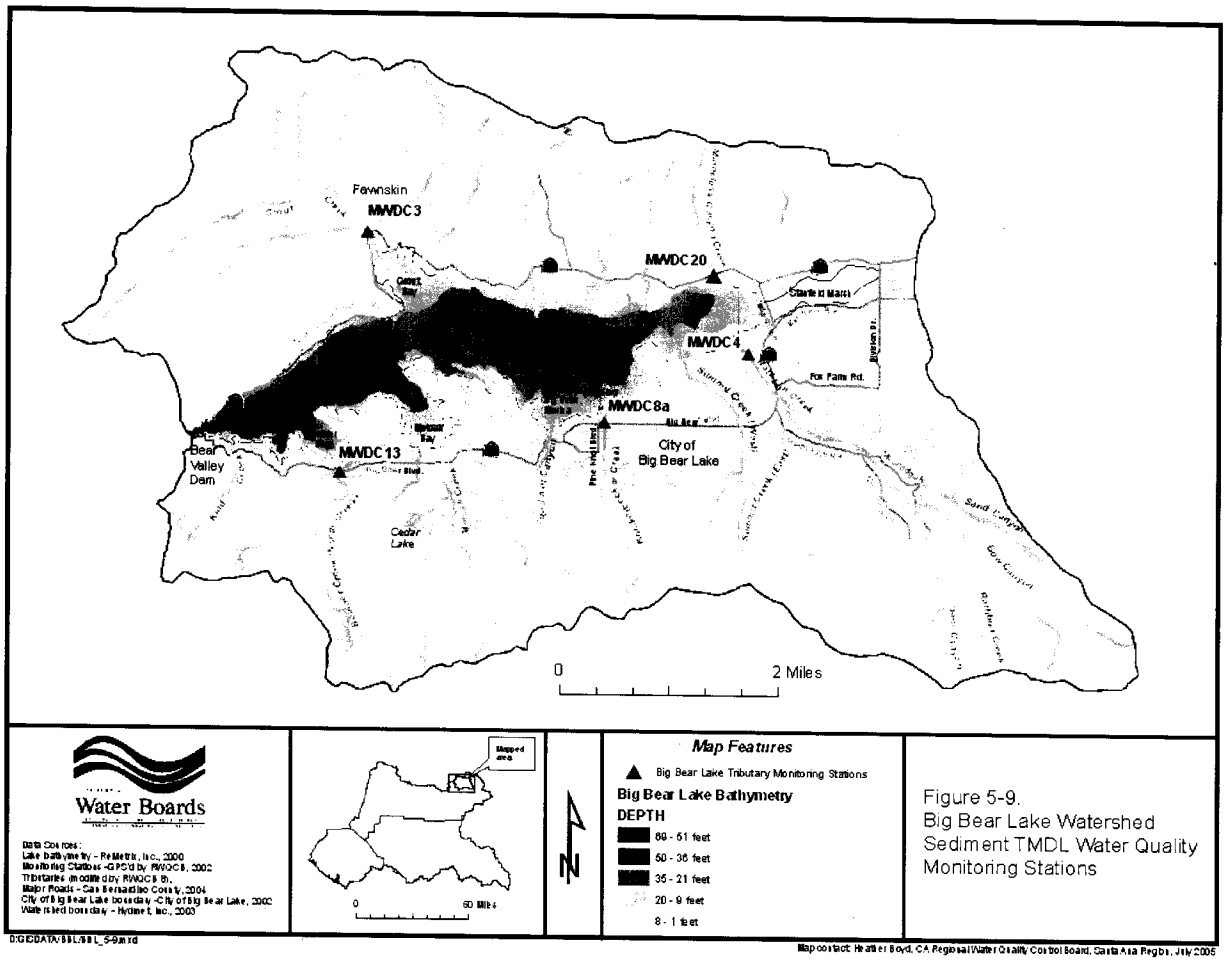

Figure 5-9 – Big Bear Lake Watershed Sediment TMDL Water Quality Stations

3.2 Big Bear Lake: In-Lake Monitoring Program

Task 4.2 of the Big Bear Lake Nutrient TMDLs includes requirements for the development and implementation of an in-lake monitoring program by the following responsible parties; the US Forest Service, the State of California Department of Transportation (Caltrans), the County of San Bernardino, San Bernardino County Flood Control District, the City of Big Bear Lake and Big Bear Mountain Resorts. Implementation of the Nutrient TMDL monitoring program will suffice to provide data on sediment related conditions in Big Bear Lake. In addition, determination of compliance with the Big Bear Lake - Lake Capacity numeric target specified in Table 5-9a-j, will be achieved via implementation of the Big Bear Lake Management Plan (Task 5, below).

Task 4: Update of Watershed and In-Lake Sediment Models

No later than (**6 months from effective date of this Basin Plan amendment* *), and consistent with the schedule specified in the Big Bear Lake Nutrient TMDLs, the US Forest Service, the State of California Department of Transportation (Caltrans), the County of San Bernardino, San Bernardino County Flood Control District, the City of Big Bear Lake, and Big Bear Mountain Resorts, shall, as a group, submit to the Regional Board for approval a proposed plan and schedule for updating the existing Big Bear Lake watershed sediment model and preparing a Big Bear Lake in-lake sediment model. The proposed plan shall be coordinated with the Big Bear Lake nutrient TMDLs watershed and in-lake model plan (Nutrient TMDL Task 6). The plan and schedule must take into consideration additional data and information that are or will be generated from the respective TMDL monitoring programs (Task 3, above).

The plan for updating the watershed and in-lake models shall be implemented upon Regional Board approval at a duly noticed public meeting.

In lieu of this coordinated plan, one or more of the parties identified above may submit a proposed individual or group Watershed and In-lake Sediment Model Update Plan for approval by the Regional Board. Any such individual or group Plan is due no later than (**6 months from effective date of this Basin Plan amendment**)* and shall be implemented upon Regional Board approval at a duly noticed public meeting.

Task 5: Big Bear Lake – Lake Management Plan

No later than (**3 years from effective date of this Basin Plan amendment* *), the US Forest Service, the State of California Department of Transportation (Caltrans), the County of San Bernardino, San Bernardino County Flood Control District, the City of Big Bear Lake, and Big Bear Mountain Resorts, shall, as a group, submit to the Regional Board for approval a proposed Big Bear Lake Management Plan. The purpose of the Plan is to identify a coordinated and comprehensive strategy for management of the lake to address restoration and protection of the lake's beneficial uses. At a minimum, the plan shall address the following:

- The plan shall be based on identified goals for lake capacity that are consistent with the lake capacity numeric target, as well as goals for biological resources and recreational opportunities.
- The plan must include a methodology for measuring changes in the capacity of the lake to enable determination of compliance with the proposed lake capacity numeric target.
- The proposed plan shall identify recommended short and long-term strategies for control and management of sediment inputs to the lake and sediment in the lake, including dredging.
- The plan shall integrate management plans and control measures designed to assure compliance with approved nutrient TMDLs for Big Bear Lake and its tributaries.
- The plan shall also integrate the beneficial use survey information required to be developed pursuant to the Regional Board's March 3, 2005, Clean Water Act Section 401 Water Quality Standards Certification for Big Bear Lake Nutrient/Sediment Remediation Project, City of Big Bear Lake, County of San Bernardino, California. The purpose of the beneficial use survey is to correlate beneficial uses of the lake with lake bottom contours. The survey will be conducted over the entire lake. The survey will determine the location and the quality of beneficial uses of the lake and the contours of the lake bottom where these uses occur. The survey will be used in regulating future lake dredge projects to maximize the quality of the lake's beneficial uses.
- The submittal shall also contain a proposed sediment monitoring program to evaluate the effectiveness of any strategies implemented.

The Big Bear Lake Management Plan shall be implemented upon Regional Board approval at a duly noticed public meeting. Once approved, the plan shall be reviewed and revised as necessary at least once every three

years. The review and revision shall take into account assessments of the efficacy of control/management strategies implemented and relevant requirements of new or revised TMDLs for Big Bear Lake and its watershed.

In lieu of this coordinated plan, one or more of the parties identified above may submit an individual or group Big Bear Lake –Lake Management Plan for approval by the Regional Board. Any such individual or group Plan is due no later than (*3 *years from effective date of this Basin Plan amendment**) and shall be implemented upon Regional Board approval at a duly noticed public meeting.

Task 6: Big Bear Lake –Sedimentation Processes Plan

No later than (*6 months *from effective date of this Basin Plan amendment* *), the US Forest Service, the State of California Department of Transportation (Caltrans), the County of San Bernardino, San Bernardino County Flood Control District, the City of Big Bear Lake, and Big Bear Mountain Resorts, shall, as a group, submit to the Regional Board for approval a proposed plan and schedule for development of a Big Bear Lake Sedimentation Processes Plan for the determination of the dominant sedimentation processes in Big Bear Lake.

At a minimum, the proposed plan shall include the placement of sediment traps at the mouths of Rathbun, Knickerbocker, Grout, Boulder and Minnelusa Creeks to determine the rate of influx of sediment to Big Bear Lake, as specified in Table 5-9a-n and shown in Figure 5-9, at the specified frequency indicated in Table 5-9a-o. If one or more of these sites are not included, rationale shall be provided and proposed alternate sites shall be identified in the proposed plan. In addition, the proposed plan shall include the collection of sediment cores, geochemical analyses and a seismic reflection survey to enable the determination of pre-dam and post-dam sediment, sediment unit thickness, and depositional processes. The location and schedule for the collection and analysis of the sediment cores shall be identified by the responsible parties mentioned above. These analyses will aid in the determination of the major processes affecting lake sedimentation as well as the lake sedimentation rate.

In lieu of this coordinated plan, one or more of the parties identified above may submit a proposed individual or group Big Bear Lake – Sedimentation Processes Plan proposal for approval by the Regional Board. Any such individual or group Plan is due no later than (*6 *months from effective date of this Basin Plan amendment**) and shall be implemented upon Regional Board approval at a duly noticed public meeting.

Task 7: Review and Revision of Water Quality Objectives

By December 31, 2012, the Regional Board shall review and revise as necessary the numeric water quality objectives for turbidity and the narrative objectives for suspended solids for Big Bear Lake and Rathbun Creek. The Regional Board shall also examine the appropriateness of establishing biocriteria for Big Bear Lake and Rathbun Creek. Given budgetary constraints, completion of this task is likely to require substantive contributions from interested parties.

Task 8: Review/Revision of the Big Bear Lake Sediment TMDL (TMDL "Re-opener")

The basis for the TMDLs and implementation schedule will be re-evaluated at least once every three years[1] to determine the need for modifying the allocations, numeric targets and TMDLs. Regional Board staff will continue to review all data and information generated pursuant to the TMDL requirements on an ongoing basis. Based on results generated through the monitoring programs, special studies and/or modeling analyses, changes to the TMDLs may be warranted. Such changes will be considered through the Basin Plan Amendment process.

The Regional Board is committed to the review of these TMDLs every three years, or more frequently if warranted by these or other studies.

References

1. California Regional Water Quality Control Board, Santa Ana Region. Staff Report on the Sediment Total Maximum Daily Loads for Big Bear Lake, July, 2005.

2. California Department of Fish and Game. California stream bioassessment procedure: Protocol brief for biological and physical/habitat assessment in wadeable streams, December, 2003.

[1] The three-year schedule is tied to the 3 year triennial review schedule.

ATTACHMENT B
ENVIRONMENTAL CHECKLIST

I. BACKGROUND

1. **Project title:** *Basin Plan amendment to incorporate Sediment TMDLs for Big Bear Lake and Rathbun Creek in the Big Bear Lake Watershed*

2. **Lead agency name and address:** *California Regional Water Quality Control Board, Santa Ana Region, 3737 Main Street, Suite 500, Riverside, CA 92501-3348*

3. **Contact person and phone number:** *Hope Smythe (951) 782- 4493*

4. **Project location:** *Big Bear Lake Watershed, San Bernardino County (all portions of the City of Big Bear Lake)*

5. **Project sponsor's name and address:** *California Regional Water Quality Control Board, Santa Ana Region, 3737 Main Street, Suite 500, Riverside, CA 92501-3348*

6. **General plan designation:** *Not applicable*

7. **Zoning:** *Not applicable*

8. **Description of project:** *Adoption of a Basin Plan amendment to incorporate Sediment TMDLs for Big Bear Lake and Rathbun. The TMDLs establish wasteload allocations and load allocations for allowable sedimentt inputs by all identified sources that discharge to Big Bear Lake and Rathbun Creek. The intent is to achieve numeric, water quality targets that will protect the beneficial uses of the lake. The Basin Plan amendment includes an implementation plan that details the actions required by the Regional Board and other responsible parties for implementing the TMDLs.*

9. **Surrounding land uses and setting:** *Not applicable*

10. **Other public agencies whose approval is required:** *The Basin Plan amendment must be approved by the State Water Resources Control Board, the Office of Administrative Law, and the U.S. Environmental Protection Agency before it becomes effective.*

ENVIRONMENTAL FACTORS POTENTIALLY AFFECTED:
The environmental factors checked below would be potentially affected by this project, involving at least one impact that is a "Potentially Significant Impact" as indicated by the checklist on the following pages.

☐ Aesthetics	☐ Agricultural Resources	☐ Air Quality
☐ Biological Resources	☐ Cultural Resources	☐ Geology/Soils
☐ Hazards & Hazardous Materials	☐ Hydrology / Water Quality	☐ Land Use / Planning
☐ Mineral Resources	☐ Noise	☐ Population / Housing
☐ Public Services	☐ Recreation	☐ Transportation / Traffic
☐ Utilities / Service Systems	☐ Mandatory Findings of Significance	

II. DETERMINATION

On the basis of this initial evaluation:

X I find that the proposed project COULD NOT have a significant effect on the environment.

____ I find that the proposed project MAY have a significant effect on the environment. However, there are feasible alternatives and/or mitigation measures available that will substantially lessen any adverse impact. These alternatives are discussed in the attached written report.

____ I find that the proposed project MAY have a significant effect on the environment. There are no feasible alternatives and/or feasible mitigation measures available that would substantially lessen any significant adverse impact. See the attached written report for a discussion of this determination.

Signature _____ Date _____

Hope Smythe
Senior Environmental Specialist

III. ENVIRONMENTAL IMPACTS

CEQA Checklist

Question	Potentially Significant Impact	Less Than Significant With Mitigation Incorporation	Less Than Significant Impact	No Impact
I. AESTHETICS - Would the project:				
a) Have a substantial adverse effect on a scenic vista?			X	
b) Substantially damage scenic resources, including, but not limited to, trees, rock outcroppings, and historic buildings within a state scenic highway?				X
c) Substantially degrade the existing visual character or quality of the site and its surroundings?				X
d) Create a new source of substantial light or glare that would adversely affect day or nighttime views in the area?				X
II. AGRICULTURE RESOURCES: In determining whether impacts to agricultural resources are significant environmental effects, lead agencies may refer to the California Agricultural Land Evaluation and Site Assessment Model (1997) prepared by the California Dept. of Conservation as an optional model to use in assessing impacts on agriculture and farmland. Would the project:				
a) Convert Prime Farmland, Unique Farmland, or Farmland of Statewide Importance (Farmland), as shown on the maps prepared pursuant to the Farmland Mapping and Monitoring Program of the California Resources Agency, to non-agricultural use?				X
b) Conflict with existing zoning for agricultural use, or a Williamson Act contract?				X
c) Involve other changes in the existing environment that, due to their location or nature, could result in conversion of Farmland, to non-agricultural use?				X
III. AIR QUALITY - Where available, the significance criteria established by the applicable air quality management or air pollution control district may be relied upon to make the following determinations. Would the project:				
a) Conflict with or obstruct implementation of the applicable air quality plan?				X
b) Violate any air quality standard or contribute substantially to an existing or projected air quality violation?				X
c) 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				X

CEQA Checklist

Question	Potentially Significant Impact	Less Than Significant With Mitigation Incorporation	Less Than Significant Impact	No Impact
air quality standard (including releasing emissions which exceed quantitative thresholds for ozone precursors)?				
d) Expose sensitive receptors to substantial pollutant concentrations?				X
e) Create objectionable odors affecting a substantial number of people?				X
IV. BIOLOGICAL RESOURCES - Would the project:				
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 California Department of Fish and Game or U.S. Fish and Wildlife Service?			X	
b) Have a substantial adverse effect on any riparian habitat or other sensitive natural community identified in local or regional plans, policies, and regulations, or by the California Department of Fish and Game or US Fish and Wildlife Service?			X	
c) Have a substantial adverse effect on federally protected wetlands as defined by Section 404 of the Clean Water Act (including, but not limited to, marsh, vernal pool, coastal, etc.) through direct removal, filling, hydrological interruption, or other means?				X
d) Interfere substantially with the movement of any native resident or migratory fish or wildlife species or with established native resident or migratory wildlife corridors, or impede the use of native wildlife nursery sites?			X	
e) Conflict with any local policies or ordinances protecting biological resources, such as a tree preservation policy or ordinance?				X
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?				X
V. CULTURAL RESOURCES - Would the project:				
a) Cause a substantial adverse change in the significance of a historical resource as defined in ¤15064.5?				X
b) Cause a substantial adverse change in the significance of an archaeological resource pursuant to ¤15064.5?				X
c) Directly or indirectly destroy a unique paleontological resource or site or unique geologic feature?				X

CEQA Checklist

Question	Potentially Significant Impact	Less Than Significant With Mitigation Incorporation	Less Than Significant Impact	No Impact
d) Disturb any human remains, including those interred outside of formal cemeteries?				X
VI. GEOLOGY AND SOILS - Would the project:				
a) Expose people or structures to potential substantial adverse effects, including the risk of loss, injury, or death involving:				X
i) Rupture of a known earthquake fault, as delineated on 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 and Geology Special Publication 42.				X
ii) Strong seismic ground shaking?				X
iii) Seismic-related ground failure, including liquefaction?				X
iv) Landslides?				X
b) Result in substantial soil erosion or the loss of topsoil?				X
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-site or off-site landslide, lateral spreading, subsidence, liquefaction or collapse?				X
d) Be located on expansive soil, as defined in Table 18-1-B of the Uniform Building Code (1994), creating substantial risks to life or property?				X
e) Have soils incapable of adequately supporting the use of septic tanks or alternative waste water disposal systems where sewers are not available for the disposal of waste water?				X
VII. HAZARDS AND HAZARDOUS MATERIALS - Would the project:				
a) Create a significant hazard to the public or the environment through the routine transport, use, or disposal of hazardous materials?				X
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?				X
c) Emit hazardous emissions or handle hazardous or acutely hazardous materials, substances, or waste within one-quarter mile of an existing or proposed school?				X

CEQA Checklist

Question	Potentially Significant Impact	Less Than Significant With Mitigation Incorporation	Less Than Significant Impact	No Impact
d) Be located on a site which is included on a list of hazardous materials sites compiled pursuant to Government Code Section 65962.5 and, as a result, would it create a significant hazard to the public or the environment?				X
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 result in a safety hazard for people residing or working in the project area?				X
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?				X
g) Impair implementation of or physically interfere with an adopted emergency response plan or emergency evacuation plan?				X
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?				X
VIII. HYDROLOGY AND WATER QUALITY - Would the project:				
a) Violate any water quality standards or waste discharge requirements?				X
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)?				X
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 that would result in substantial erosion or siltation on-site or off-site?				X
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-site or off-site?				X
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?				X
f) Otherwise substantially degrade water quality?				X
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?				X

CEQA Checklist

Question	Potentially Significant Impact	Less Than Significant With Mitigation Incorporation	Less Than Significant Impact	No Impact
h) Place within a 100-year flood hazard area structures that would impede or redirect flood flows?				X
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?				X
j) Inundation by seiche, tsunami, or mudflow?				X
IX. LAND USE AND PLANNING - Would the project:				
a) Physically divide an established community?				X
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?				X
c) Conflict with any applicable habitat conservation plan or natural community conservation plan?				X
X. MINERAL RESOURCES - Would the project:				
a) Result in the loss of availability of a known mineral resource that would be of value to the region and the residents of the state?				X
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?				X
XI. NOISE - Would the project result in:				
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?				X
b) Exposure of persons to or generation of excessive groundborne vibration or groundborne noise levels?				X
c) A substantial permanent increase in ambient noise levels in the project vicinity above levels existing without the project?				X
d) A substantial temporary or periodic increase in ambient noise levels in the project vicinity above levels existing without the project?			X	
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				X

CEQA Checklist

Question	Potentially Significant Impact	Less Than Significant With Mitigation Incorporation	Less Than Significant Impact	No Impact
residing 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 or working in the project area to excessive noise levels?				X
XII. POPULATION AND HOUSING - Would the project:				
a) Induce substantial population growth in an area, either directly (for example, by proposing new homes and businesses) or indirectly (for example, through extension of roads or other infrastructure)?				X
b) Displace substantial numbers of existing housing, necessitating the construction of replacement housing elsewhere?				X
c) Displace substantial numbers of people, necessitating the construction of replacement housing elsewhere?				X
XIII. PUBLIC SERVICES				
a) Would the project result in substantial adverse physical impacts associated with the provision of new or physically altered governmental facilities, need for new or physically altered governmental facilities, the construction of which could cause significant environmental impacts, in order to maintain acceptable service ratios, response times or other performance objectives for any of the public services: Fire protection? Police protection? Schools? Parks? Other public facilities?				X
XIV. RECREATION - Would the project:				
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?				X
b) Does the project include recreational facilities or require the construction or expansion of recreational facilities that might have an adverse physical effect on the environment?				X
XV. TRANSPORTATION/TRAFFIC - Would the project:				
a) Cause an increase in traffic that is substantial in relation to the existing traffic load and capacity of the street system (i.e., result in a substantial increase in either the number of vehicle trips, the volume to capacity ratio on roads, or congestion at intersections)?			X	

CEQA Checklist

Question	Potentially Significant Impact	Less Than Significant With Mitigation Incorporation	Less Than Significant Impact	No Impact
b) Exceed, either individually or cumulatively, a level of service standard established by the county congestion management agency for designated roads or highways?				X
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?				X
d) Substantially increase hazards due to a design feature (e.g., sharp curves or dangerous intersections) or incompatible uses (e.g., farm equipment)?				X
e) Result in inadequate emergency access?				X
f) Result in inadequate parking capacity?				X
g) Conflict with adopted policies, plans, or programs supporting alternative transportation (e.g., bus turnouts, bicycle racks)?				X
XVI. UTILITIES AND SERVICE SYSTEMS – Would the project:				
a) Exceed wastewater treatment requirements of the applicable Regional Water Quality Control Board?				X
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 effects?				X
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 effects?			X	
d) Have sufficient water supplies available to serve the project from existing entitlements and resources, or are new or expanded entitlements needed?				X
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?				X
f) Be served by a landfill with sufficient permitted capacity to accommodate the project's solid waste disposal needs?				X
g) Comply with federal, state, and local statutes and regulations related to solid waste?				X
XVII. MANDATORY FINDINGS OF SIGNIFICANCE -				

CEQA Checklist

Question	Potentially Significant Impact	Less Than Significant With Mitigation Incorporation	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?				X
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)?				X
c) Does the project have environmental effects that will cause substantial adverse effects on human beings, either directly or indirectly?				X

Attachment - Environmental Checklist

Discussion of Environmental Impacts

Explanation of Environmental Checklist "Less than significant" Answers

Note: Adoption of the Basin Plan amendment to incorporate Sediment TMDLs for Big Bear Lake and Rathbun Creek will not have any direct adverse impact on the environment. Implementation of actions necessary to achieve the TMDLs may affect the environment, as described below. However, the intent of TMDL implementation is to restore and protect the water quality of the lake and the creek and their beneficial uses. Any potential adverse environmental effects associated with TMDL implementation will be subject to project-specific CEQA analysis and certification to assure appropriate avoidance/minimization and mitigation.

I. Aesthetics (a)

The proposed TMDLs call for reductions in sediment loads to the lake and creek, which may include the implementation of BMPs that could be aesthetically unpleasing.

IV. Biological Resources (a), (b), (d)

The proposed TMDLs call for actions to reduce sediment loading to the lake and creek, which may include sediment removal. The Big Bear Lake watershed is host to many sensitive species including the Federally-threatened Bald Eagle. Such actions have the potential to affect the biota, including sensitive species. Any such actions are likely to be temporary and in the long-term, would result in the enhancement of the Big Bear Lake and Rathbun Creek aquatic habitat utilized by sensitive species.

XI. Noise (d)

Implementation of actions necessary to implement the proposed TMDLs may result in increases in noise levels. However, these effects are expected to be limited in scope and duration and are not considered significant. Again, proposed implementation actions would be subject to specific CEQA analysis and certification.

XV. Transportation/Traffic (a)

Implementation of actions necessary to implement the proposed TMDLs, such as removal and disposal of dredge materials, may result in increases in traffic on the two main highways that serve Big Bear Lake. However, these effects are expected to be limited in scope and duration and are not considered significant. Again, proposed implementation actions would be subject to specific CEQA analysis and certification.

XVI. Utilities and Service Systems (c)

The proposed TMDLs call for reductions in sediment contributions to the lake and creek from external sources. To achieve these reductions, modifications to the storm drainage system may be necessary. Any such projects associated with storm drainage systems modifications would be subject to further, case-specific environmental review and certification.