Winlsow Homer: *Boy Fishing*, 1892

Comprehensive Lake Management Plan for Big Bear Lake, Burnett County, Wisconsin

June 2003

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with contributions from Wisconsin Department of Natural Resources
and the Big Bear Lake Association

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Big Bear Lake Management Report

Summary

prepared by Steve McComas, Blue Water Science

Big Bear Lake is a 189 acre lake located in Burnett County, Wisconsin with an average depth of 9 feet and a maximum depth of 17 feet. A comprehensive lake management study was conducted in 2002. The results and recommendations are shown below.

Goals
The goals of this project were:
* to examine existing lake conditions.
* to develop a lake management plan that protects, maintains, and enhances Big Bear Lake water quality.

Geology and Soils
Big Bear Lake is a glacial lake formed during the last retreat of the Superior glacial lobe starting about approximately 16,000 years ago. The sediments deposited by the glacier are primarily sands and subsequently, loamy sand soils have developed.

Watershed Characteristics
The lake's watershed area which is the area that drains to Big Bear is approximately 900 acres in size. Land use is primarily forest and wetlands, with developed land (urban) accounting for only about 5% of the total. The watershed is almost five times larger than the lake area. This is normal for glacial lakes. Web Lake may contribute some water to Big Bear as well.

Dissolved Oxygen and Temperature
Big Bear Lake does not strongly thermally stratify during the summer meaning the lake water is mixed through the summer and the temperature is about the same from top to bottom. Oxygen concentrations are found throughout the water column in summer.

Lake Nutrients
Phosphorus concentrations in Big Bear Lake are low (around 10 parts per billion) which is a desirable feature because low nutrients will keep the algae growth down as well. Maintaining these low lake nutrient levels should be a primary goal for the Big Bear Lake Association.

Aquatic Plants

There are fair stands of emergent vegetation in shallow water near the shoreline which is beneficial as a filter for nutrients and as well as for fish and wildlife habitat. Submerged plant distribution is good covering over 80% of the lake bottom. Low lake soil fertility may also be a factor in limiting nuisance plant growth.

Fish

A fish survey was conducted in the summer of 2002 with the help of lake association volunteers. Northern pike were found to be small and underweight. A surprise was the abundant crappie population. Sunfish numbers were fair and largemouth bass were scarce. There appears to be a lack of forage fish in Big Bear. Overall the fish community is in fair shape although the northern pike and the largemouth bass populations could be improved.

Lake Report Card

- Lake water chemistry results are comparable to and in some cases better than Ecoregion values. This is an outstanding feature of Big Bear Lake. It receives an "A" grade.
- The data base does not go back far enough to examine trends, however Big Bear Lake is in good shape at this time in regard to lake clarity.

What Will Big Bear Lake Look Like in the Future?

- Future lake water quality predictions can be made based on changes that could occur in the watershed. Often water quality in lakes decline as development occurs.
- For Big Bear Lake, the model predicted a future lake concentration of 15 ppb of phosphorus. The actual lake phosphorus level was 12 ppb in 2002. Future lake water quality is expected to remain the same assuming there is only moderate future development.

Recommended Lake Management Projects

The challenge for Big Bear Lake is to maintain the high water quality values currently experienced. Four program areas are recommended for maintaining good water quality conditions.

1. Shoreland Protection and Landscaping Projects

Controls are in place at the county level to guide new shoreland development and redevelopment. Meanwhile vegetative buffers should be maintained along the shoreline.

2. Fish Management Options

The fish management program is based on findings from the 2002 fish survey combined with results of the lake resident survey indicating fishery preferences and perceived problems.

The objective of the fish management program is to improve the quality of the northern pike population while not adversely impacting the panfish.

It appears the main factor contributing to skinny northerns is a lack of forage. Its possible that the surprisingly robust crappie population is probably competing with northerns for forage . . . and winning.

One approach is to concentrate fishing on crappies. Although stocking white suckers as an additional forage species for northern pike was considered, it probably would not be successful in Big Bear Lake.

Lastly, we recommend dissolved oxygen testing in January and February to check the possibility of a potential fish winterkill. At this time there is no indication of winterkill occurring in Big Bear Lake.

3. Aquatic Plant Management

Aquatic plants are the key to maintaining good water quality in Big Bear Lake. Coverage is currently over 80% of the lake bottom, but they do not grow to nuisance conditions. It is recommended aquatic plants should be protected, and if removal is necessary for swimming areas, remove the minimum needed.

4. Future Lake Monitoring Plans

A lake monitoring program is outlined in Table 1. It is designed to be flexible to accommodate the volunteer work force and a fluctuating budget.

Table 1. Big Bear Lake Water Quality Monitoring Program

Category	Level	Alternative	Labor Needed	Cost/Year
A. Dissolved oxygen	1	Check dissolved oxygen in Big Bear Lake every two weeks in January, February, and March depending on winter conditions.	Moderate	$0
	2	Check dissolved oxygen in Big Bear Lake every one to two weeks in December, January, February, and March, depending on winter conditions.	Moderate	$0
B. Water clarity	1	Secchi disc taken at spring and fall turnover.	Low	$0
	2	Secchi disc monitoring once per month May - October.	Low-moderate	$0
	3	Secchi disc monitoring twice per month, May - October.	Moderate	$0
C. Water chemistry	1	Spring and fall turnover samples are collected and sent to UW-Stevens Point. Selected parameters for analysis include: TP and chlorophyll.	Low	$200
	2	Spring and fall turnover samples are collected and sent to UW-Steven Point. Standard package of parameters is analyzed.	Low	$600
	3	Sample for phosphorus and chlorophyll once per month from May - September (surface water only).	Low-moderate	$300
	4	Sample for phosphorus and chlorophyll twice per month from May - October.	Moderate	$600
	5	Sample for phosphorus, chlorophyll, Kjeldahl-N, nitrate-nitrite-N, and ammonia-N once per month (May-October)	Moderate	$960
	6	Sample for phosphorus, chlorophyll, Kjeldahl-N, nitrate-nitrite-N, and ammonia-N twice per month (May-October).	Moderate	$1,920
D. Special samples or surveys	1	Special samples: suspended solids, BOD, chloride, turbidity, sampling bottom water, and other parameters as appropriate. Aquatic plant surveys, etc.	--	$50+

For 2004, a recommended program consists of Level A1 every three years, Level B2 annually, Level C1 annually and an aquatic plant survey (Level D1) every three years.

1. Introduction and Project Setting

Big Bear Lake is located in Burnett County, Wisconsin (Figure 1) and is 189 acres in size. Big Bear Lake characteristics are shown in Table 1.

The objectives of this study were to characterize existing lake conditions and to make recommendations to protect and improve the lake environment where feasible.

Table 1. Lake statistics.

	Big Bear Lake
Size (acres)	189
Mean depth (ft)	9
Maximum depth (ft)	17

Figure 1. Big Bear Lake is located in Burnett County, Wisconsin.

2. Glaciers and Soils

Big Bear Lake was formed approximately 10,000 years ago during the last glacial retreat of the Superior Lobe (Figure 2). The soils deposited by the Superior Lobe glacier were primarily sands and loamy-sands (Figure 3). Beneath these soils, at depths of about 50-350 feet, is Precambrian bedrock that is over one billion years old. The bedrock is referred to as the North American shield.

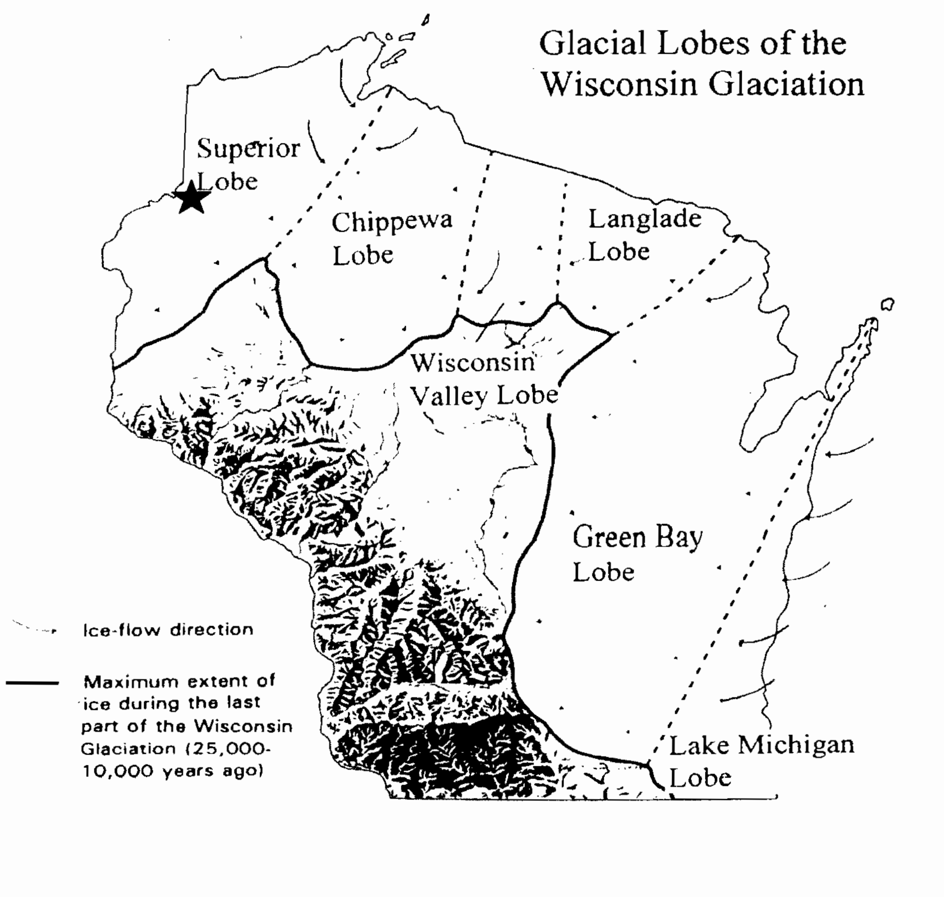

Figure 2. Glacial lobes of the Wisconsin glaciation. Big Bear Lake is located in the Superior lobe.

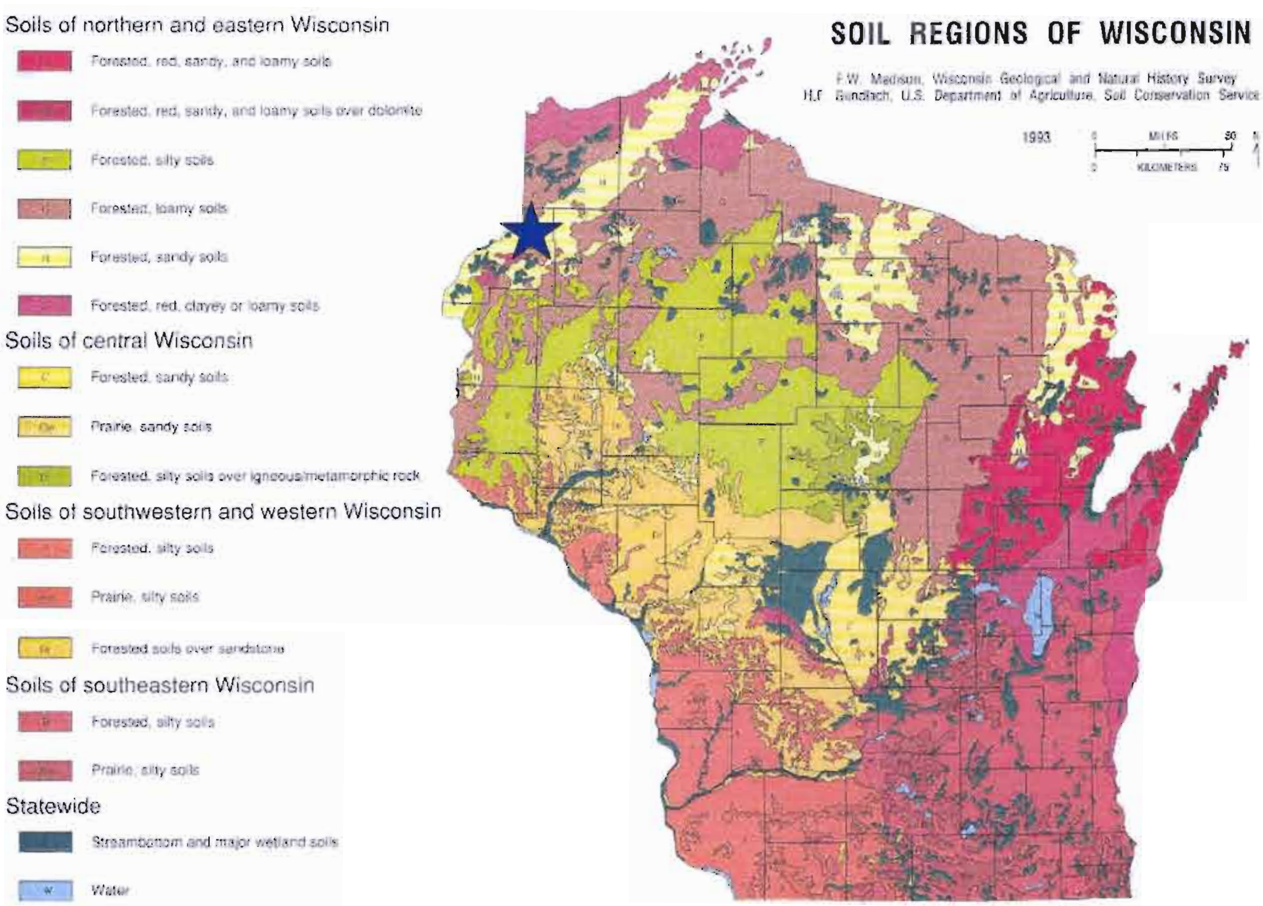

Figure 3. Big Bear Lake is located in a soils group referred to as forested sandy soils.

3. Watershed Features

3.1. Drainage Area to Big Bear Lake

The drainage area, which is the land area that drains to Big Bear Lake, is about 900 acres in size.

The drainage area to Big Bear Lake is displayed in Table 2 and is shown in Figure 4. The size of the watershed that drains to Big Bear is typical for northern Wisconsin glacial lakes.

Table 2. Watershed area for Big Bear Lake (prepared by Blue Water Science).

	Big Bear
Lake Size (ac)	189
Total Contributing Watershed Area (not including lake)(ac)	900

The drainage area to Big Bear Lake is dominated by forests and wetlands. The forests have been clear-cut at least once in the last 150 years, but have grown back and existing conditions are dominated by undeveloped land use. This condition allows the potential for good water quality to run off the land and into the lake, thus sustaining good water quality in the lake as well.

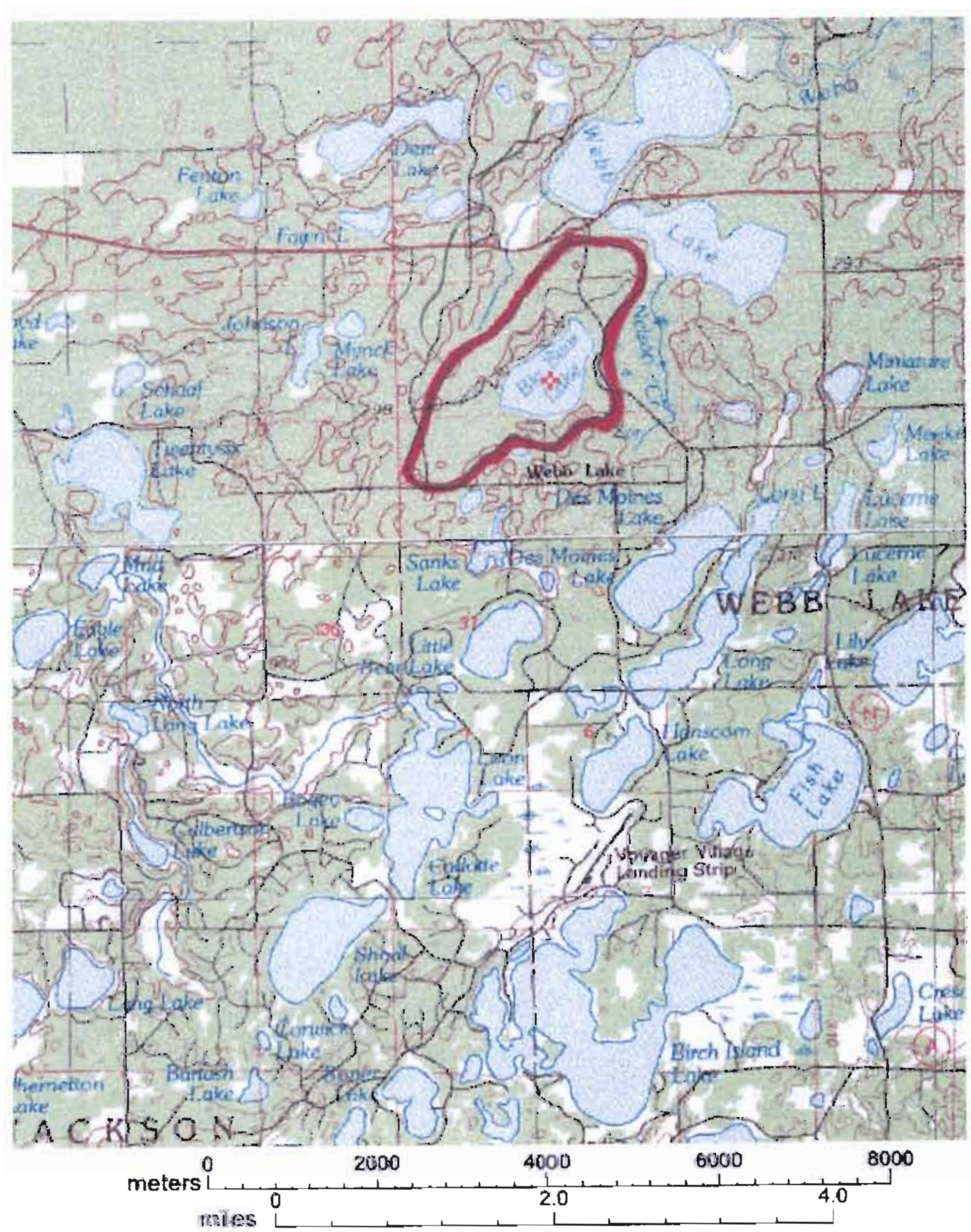

Figure 4. Watershed area for Big Bear Lake.

3.2. Source of Water to Big Bear Lake

Source of water to Big Bear Lake is from several sources that includes groundwater that seeps into the lake from fringe wetlands, from surface runoff, and from rainfall. The amount of water flowing into and out of Big Bear Lake is estimated to be about 1.1 cubic feet per second. Flows were estimated based on runoff amounts listed for Burnett County in the Wisconsin Spreadsheet Lake Model (Table 3).

Table 3. Average annual water flow into Big Bear Lake.

Watershed size (acre)	900
Average yearly runoff for Burnett County (inches)	10.8
Total water inflow (acre-feet)	810

***810 acre-feet would be enough water to fill a 790 foot deep swimming pool the size of a football field. It would also be enough drinking water to supply a town of 10,000 for a year.**

Although this is a lot of water coming into Big Bear Lake, the volume of Big Bear Lake is 1,700 acre-feet. If Big Bear Lake completely dried up, it would take 2 years to fill.

Figure 5. Jeff Henderson, Big Bear Lake, observes inflowing water to Big Bear Lake. The surface inflow is one source of water, but rainfall and groundwater are larger water sources.

3.3. Sources of Nutrients to Big Bear Lake

All lakes receive nutrients from a variety of sources. The challenge is to minimize the amount of phosphorus and nitrogen inputs to Big Bear in order to minimize algae blooms.

Currently, low levels of nutrients enter Big Bear Lake. The dominant nutrient source is rainfall. About 60 pounds of phosphorus per year falls into Big Bear (a little less than ½ pound per lake acre). Nutrients in runoff from the surrounding land contributes about 50 pounds per year.

The long term challenge will be to continue to keep the amount of nutrient inputs to Big Bear low.

Figure 6. An inflowing stream to Big Bear Lake has low nutrient concentrations which is desirable for maintaining low fertility in Big Bear.

3.4. Shoreland Inventory

The shoreland area encompasses three components: the upland fringe, the shoreline, and shallow water area by the shore. A photographic inventory of the Big Bear Lake shoreline was conducted on September 11, 2002. The objectives of the survey were to characterize existing shoreland conditions which will serve as a benchmark for future comparisons.

For each photograph we looked at the shoreline and the upland condition. Our criteria for natural conditions were the presence of 50% native vegetation in the understory and at least 50% natural vegetation along the shoreline in a strip at least 15 feet deep. We evaluated shorelands at the 75% natural level as well.

A summary of the inventory results is shown in Table 4. Based on our subjective criteria over 71% of the parcels in Big Bear Lake shoreland area meet the natural ranking criteria shorelines and upland areas. This is good for a lake in northern Wisconsin. However in the next 10 years there could be pressure to reduce natural conditions. Proactive volunteer native landscaping should maintain existing conditions and improve other parcels.

Table 4. Summary of buffer and upland conditions in the shoreland area of Big Bear Lake. Approximately 87 parcels were examined.

Big Bear Lake	Natural Shoreline Condition		Natural Upland Condition		Undevel. Photo Parcels	Shoreline Structure Present	
	>50%	>75%	>50%	>75%		riprap	wall
TOTALS (no. of photos = 87)	75 (86%)	66 (76%)	82 (71%)	54 (62%)	11 (13%)	7 (8%)	1 (1%)

Examples of shoreland conditions around Big Bear are shown in Figure 7.

A comparison of Big Bear Lake conditions to other lakes in Wisconsin and Minnesota is shown in Figure 8.

**Figure 7. [top] This parcel would rate as having a shoreline with a buffer greater than 50% of the lot width and an understory with greater than 50% natural cover.
[bottom] This parcel would not qualify as having a natural shoreline buffer greater than 50% of the lot width. Also understory in the upland area would be rated as having less than 50% natural cover.**

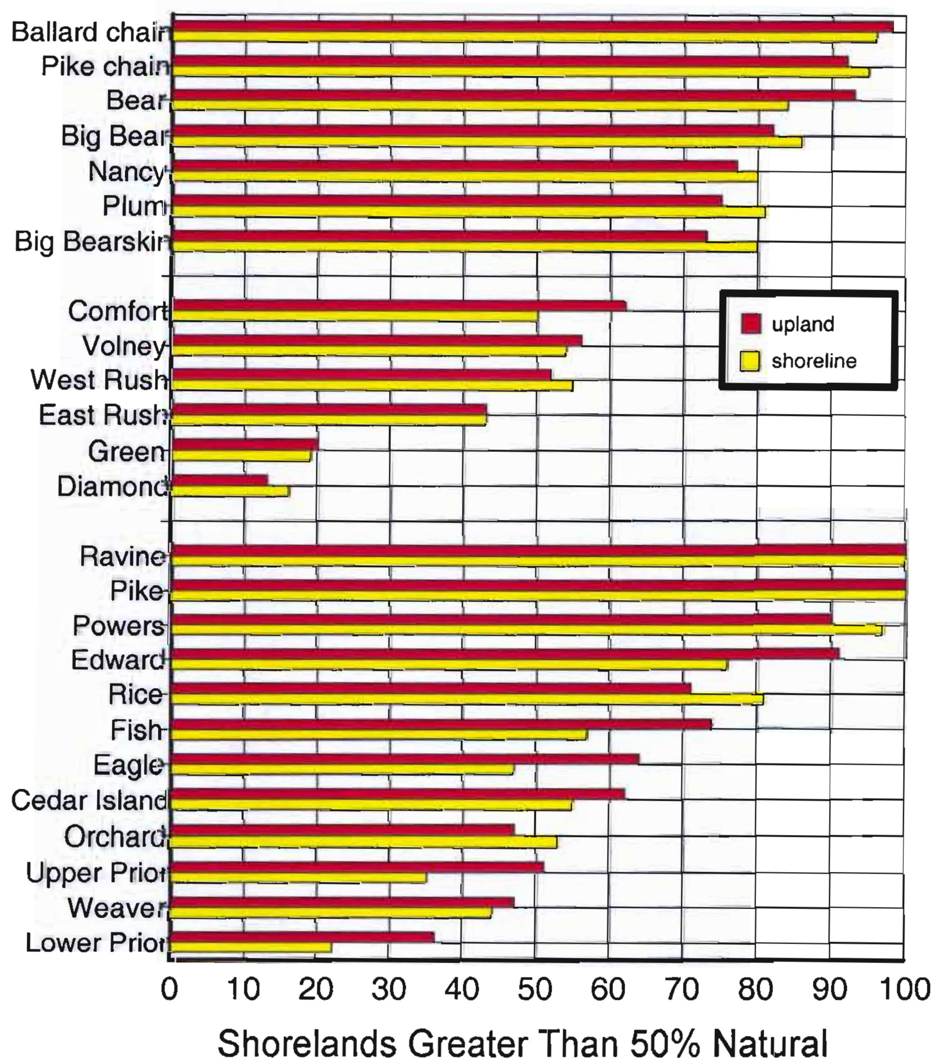

Figure 8. A summary of shoreland inventory results for 25 lakes using an evaluation based on shoreland photographs. For each lake the percentage of shoreline and upland conditions with greater than 50% natural conditions is shown.

3.5. Groundwater and Onsite Wastewater Treatment Systems

Groundwater inflow was evaluated indirectly by measuring lake water conductivity in the shallow nearshore area. The objective was to see if there was any change in conductivity. An increase or decrease in conductivity could indicate the inflow of groundwater. The groundwater could be coming from natural flows or from septic tank drainfields.

Specific conductance or conductivity is a measure of dissolved salts in the water. The unit of measurement is microSiemans/cm^2 or micro umhos/cm^2 . . . both are used. The saltier the water the higher the conductivity. For example oceans have higher conductivity than fresh water. For the conductivity survey on Big Bear Lake we used a YSI (Yellow Springs Instruments) probe attached to the end of an eight-foot pole. The survey used two people. One person held the probe under the surface of the water and recorded the reading off of a conductivity meter while the other person maneuvered the boat around the perimeter of Big Bear Lake.

Results are shown in Figure 10. The background or base conductivity was 63 umhos/cm. Several areas around Big Bear Lake had readings above background. However, because of a lack of homes or because the homes are far removed from the lakeshore, it does not appear that the elevated conductivity is from septic leachate discharges entering Big Bear Lake. Rather, the results suggest that Big Bear Lake may be receiving groundwater inflows that have slightly elevated conductivity concentrations. There is a location by the wetland that has low conductivity. This could be a source of groundwater into Big Bear Lake.

Figure 9. The submerged probe used in the conductivity survey is shown here. The entire nearshore area of Big bear Lake was surveyed.

Wetland on the southwest side of the lake appeared to be an area of groundwater inflow.

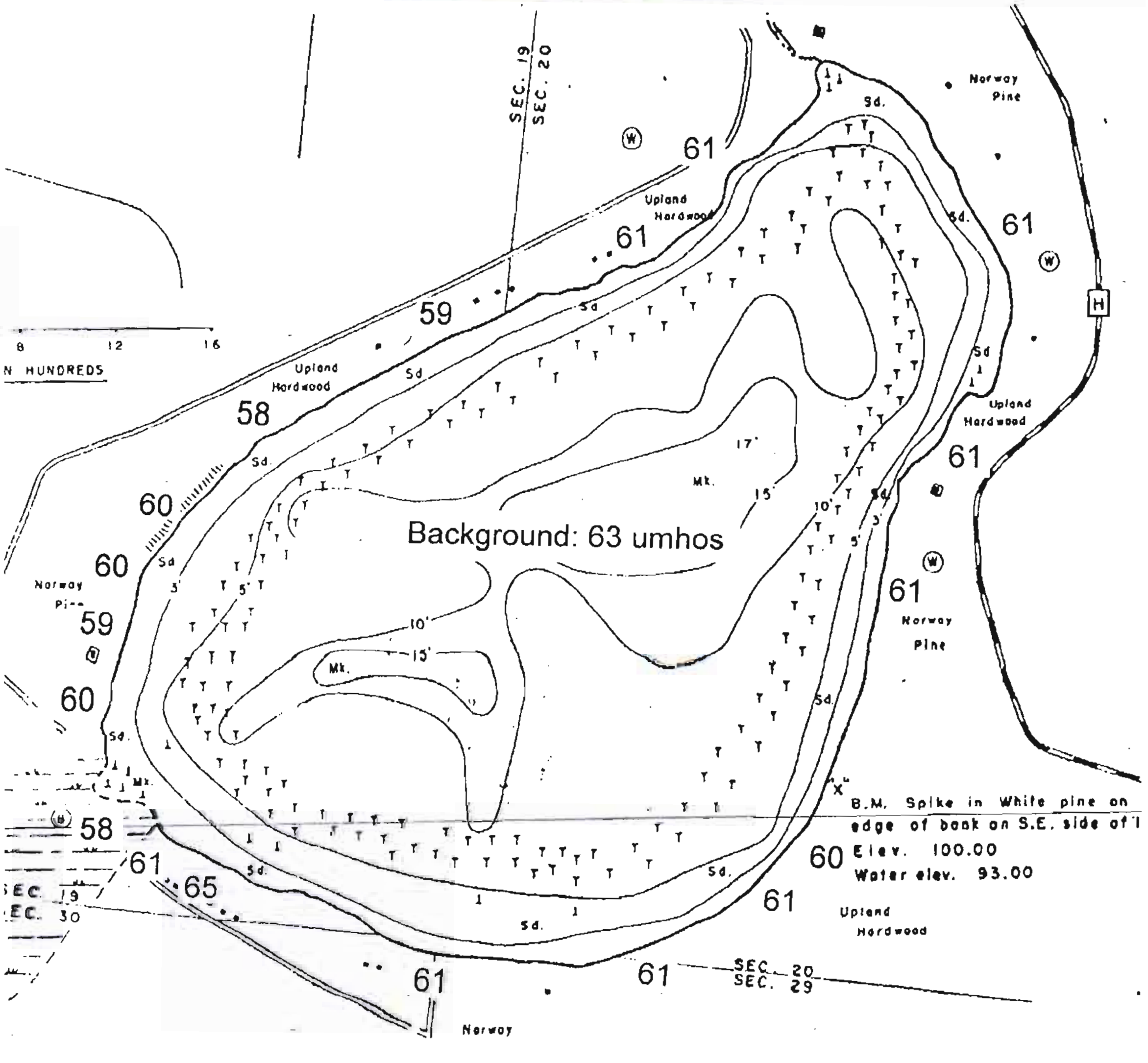

Figure 10. Big Bear Lake conductivity survey results for September 13, 2002.

Onsite Systems Status: Onsite systems appear to be in mostly good condition based on the conductivity survey results, the surrounding soils, and the setback of the cabins and homes. A conventional onsite system is shown in Figure 11. With proper maintenance (such as employing a proper pumping schedule) onsite systems are an excellent wastewater treatment option. The challenge is to maintain systems in good working condition.

Sewage bacteria break up some solids in tank. Heavy solids sink to bottom as sludge. Grease & light particles float to top as scum. Liquid flows from tank through closed pipe and distribution box to perforated pipes in trenches; flows through surrounding crushed rocks or gravel and soil to ground water (underground water). Bacteria & oxygen in soil help purify liquid. Tank sludge & scum are pumped out periodically. Most common onsite system.

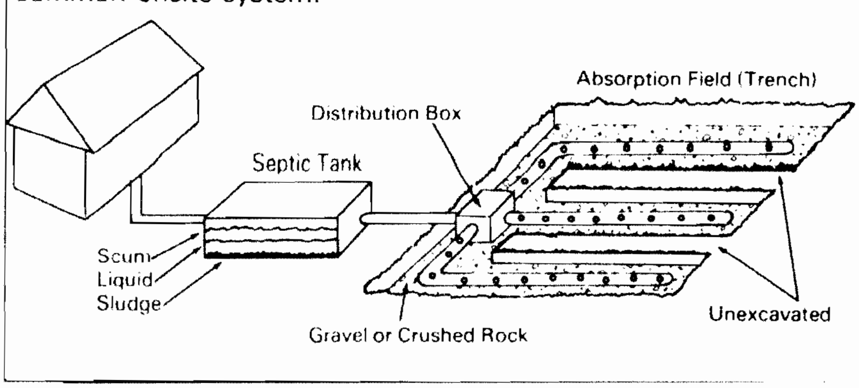

Figure 11. Typical onsite wastewater treatment system found in the Big Bear Lake watershed.

3.6. Big Bear Lake Wildlife Observations

A wide variety of wildlife are present in the Big Bear Lake area. A summary of wildlife observations in 2002 by lake volunteers is shown in Table 5.

Table 5. Summary of observations of wildlife made from the Houck property on Big Bear Lake in 2002. The wildlife was either observed on the property or observed on the lake from the property (submitted by Dean and Carolyn Houck).

Animals Observed

Animal	Time Frame
Black Bear (sub-adult)	May 4^{th}, May 26th
Chipmunk	Spring - Fall
Gray Squirrel	Spring - Fall
Raccoon	Summer
Red Fox	April 7th
Red Squirrel	Spring - Fall
White Tail Deer	All Year
Wolverine	April 7th

Birds Observed

Bird	Time Frame
Bald Eagle	Spring - Fall
Baltimore Oriole	Summer
Belted Kingfisher	April
Black-capped Chickadee	Spring - Fall
BlueJay	Spring - Fall
Canada Goose	Spring - Fall
Common Crow	Spring - Fall
Common Merganser (Duck)	Spring
Downy Woodpecker	Spring – Fall
Golden Eye (Duck)	Spring
Goldfinch	Spring - Fall
Great Blue Heron	Spring - Fall
Gull (type ?)	Spring - Fall
Hairy Woodpecker	Spring
Hooded Merganser (Duck)	Spring
House Finch	Spring
Junco	Spring - Fall
Loon	Spring - Fall
Osprey	Spring - Fall
Pileated Woodpecker	Spring
Red Bellied Woodpecker	Spring
Red Crossbill	Spring
Robin	Spring
Ruby Throated Hummingbird	Spring - Summer
Ruffed Grouse	Spring
Tree Swallow	Summer
White Breasted Nuthatch	Spring - Fall
Wild Turkey (flock of 16)	September 30th
Wood Duck	Spring
Yellow-shafted Flicker	Spring

3.7. Watershed Synopsis

The watershed area that drains to Big Bear Lake is dominated by wilderness areas and is composed primarily of forests and wetlands.

Questions have been raised by lake users about the water quality coming into Big Bear Lake. Results of water testing indicate water coming into Big Bear Lake is typical for the region and is not polluted. Acceptable levels of nutrients are entering Big Bear Lake at the present time (Figure 12).

The challenge will be to maintain the natural attributes of the watershed which will keep watershed nutrient inputs low which will aid in preserving good lake water quality.

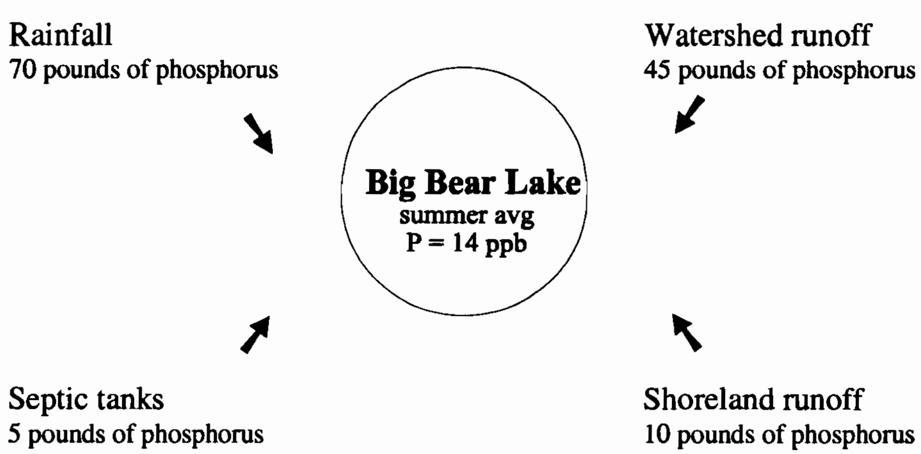

Figure 12. Estimated sources of phosphorus that feed into Big Bear Lake are shown above.

4. Lake Features

4.1. Lake Map and Lake Statistics

Big Bear Lake is approximately 189 acres in size, with a watershed of 900 acres. The average depth of Big Bear Lake is 2.7 meters (9 feet) with a maximum depth of 5.2 meters (17 feet) (Table 6). A lake contour map is shown in Figure 13. Big Bear Lake is located in an area of Wisconsin that is dominated by forests.

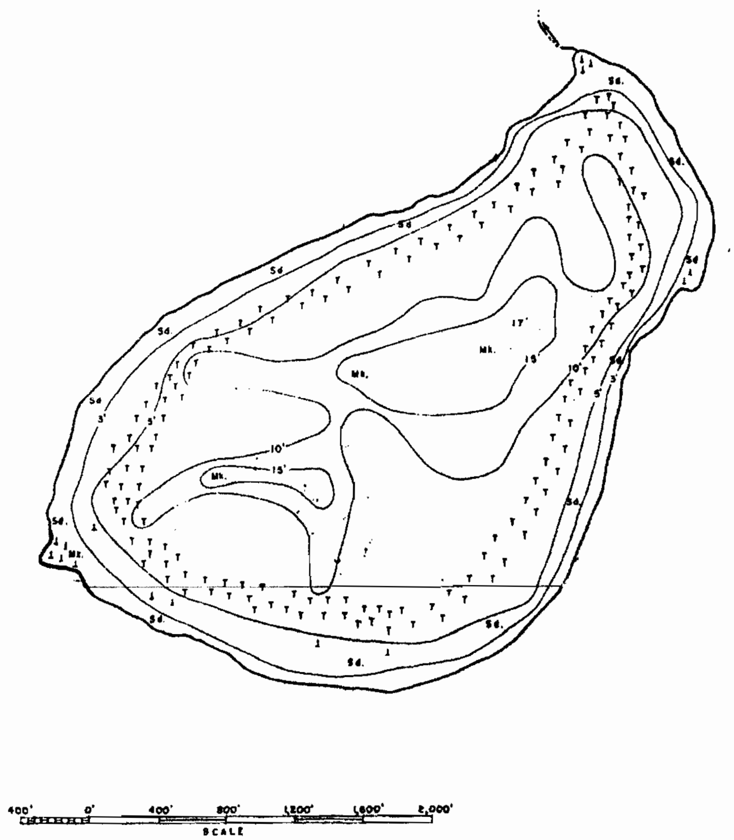

Figure 13. Big bear Lake contour map.

Table 6. Big Bear Lake Characteristics

Area (Lake):	189 acres (76 ha)
Mean depth:	9 feet (2.7 m)
Maximum depth:	17 feet (5.2 m)
Volume:	1,701acre-feet
Watershed area:	900 acres
Watershed: Lake surface ratio	4:1
Accesses (#):	1
Inlets: 1	Outlets: 0

4.2. Dissolved Oxygen and Temperature

The summer dissolved oxygen and temperature profiles in Big Bear Lake in 2002 are shown in Figure 14.

One profile was obtained for the month of September, 2002 is shown in Figure 14. By examining the profiles, one can learn a great deal about the condition of a lake and the habitat that is available for aquatic life.

The September profile showed that the lake was not thermally stratified in 2002. **Thermally stratified** means that the water column of the lake is segregated into different layers of water based on their temperature. Just as hot air rises because it is less dense than cold air, water near the surface that is warmed by the sun is less dense than the cooler water below it and it "floats" forming a layer called the *epilimnion*, or *mixed layer*. The water in the epilimnion is frequently mixed by the wind, so it is usually the same temperature and is saturated with oxygen.

Below this layer of warm, oxygenated surface water is a region called the *metalimnion*, or *thermocline* where water temperatures decrease precipitously with depth. Water in this layer is isolated from gas exchange with the atmosphere. The oxygen content of this layer usually declines with depth in a manner similar to the decrease in water temperature.

Below the thermocline is the layer of cold, dense water called the *hypolimnion*. This layer is completely cut off from exchange with the atmosphere and light levels are very low. So, once the lake stratifies in the summer, oxygen concentrations in the hypolimnion progressively decline due to the decomposition of plant and animal matter and respiration of benthic (bottom-dwelling) organisms.