Bear Lake

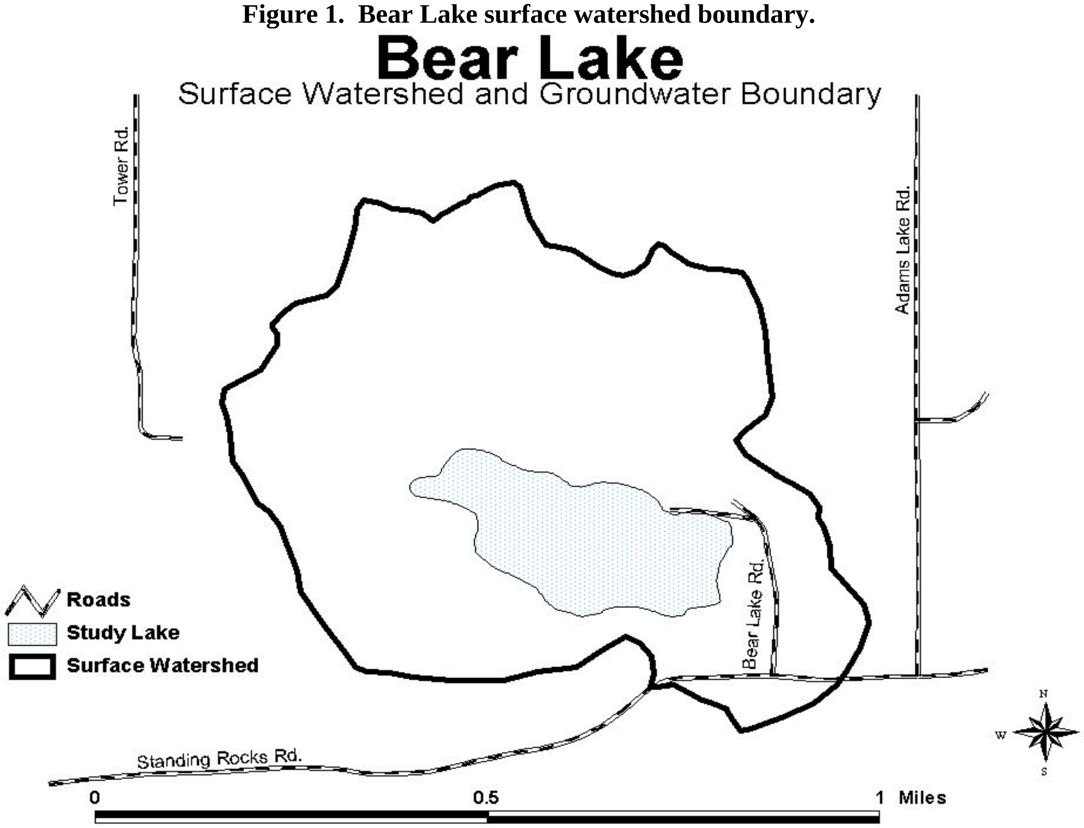
Introduction

Bear Lake is a 28.7 acre **seepage lake** located in rolling hills near the glacial moraine six miles southwest of Amherst in the Town of Stockton. Data from the 1970s and 1980s indicate that Bear Lake was a moderately hard lake, but **hardness** measured in the lake water in the 2000s reveal a significant drop in total **hardness** with the lake now categorized as a **soft water** lake. The shoreline length is 1 mile. **Littoral** bottom materials are mostly muck and sand. Maximum lake depth is 30 feet and estimated **retention time** is 1 year. Much of the shoreline of Bear Lake is undeveloped with steep slopes on the north and south shores. Largemouth bass and panfish are the most common fish species present.

Land Use and Watershed

Bear Lake's surface **watershed** is 253 acres and is mostly comprised of forested land (Figure 1). Non-irrigated cropland has increased slightly since 1948, but remains a secondary land use at 15% of the **watershed** (Figure 1). Sometime between 1968 and 1990 approximately 75 acres of forest was cut and a corresponding increase in shrub/wetland land resulted. By 2002 a pine plantation was established and the number of forested acres returned to their pre-1968 levels of slightly more than 120 acres. Residential use has increased and although the pressure remains relatively low, residences are now larger and tend to have more mowed lawn and impervious surface. Standing Rocks Park is on the southwest side of the lake providing some land preservation within the county park system (Figure 2).

Figure 1. Bear Lake surface watershed boundary.



*For terms in bold, see glossary pp 19-24

Figure 2. Land use in the Bear Lake surface watershed 2002.

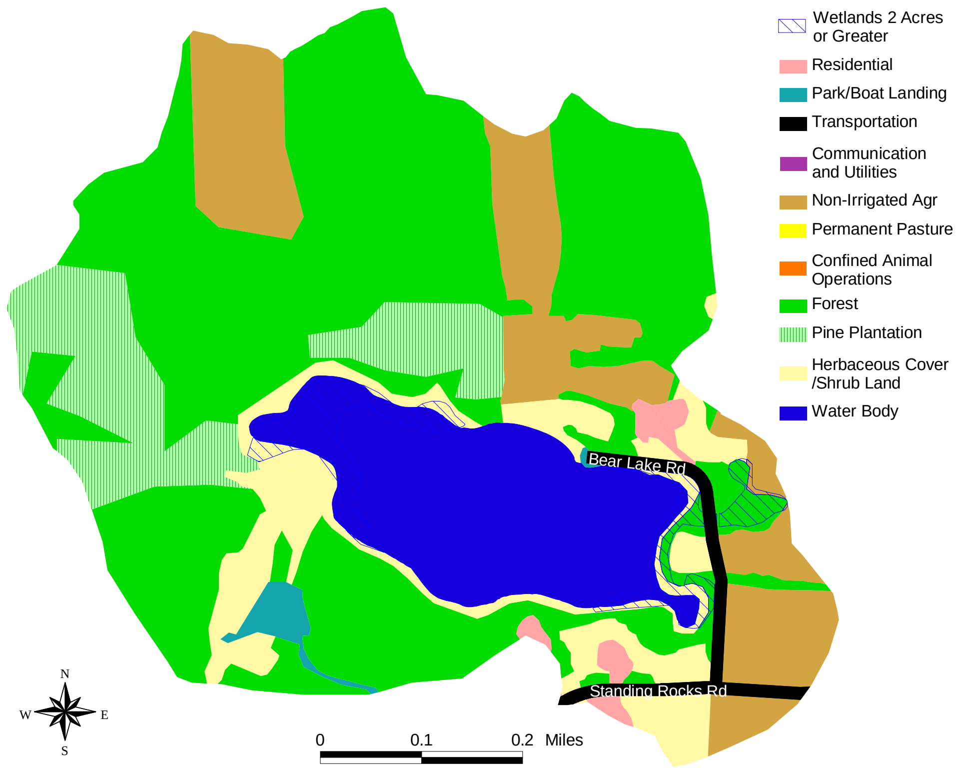
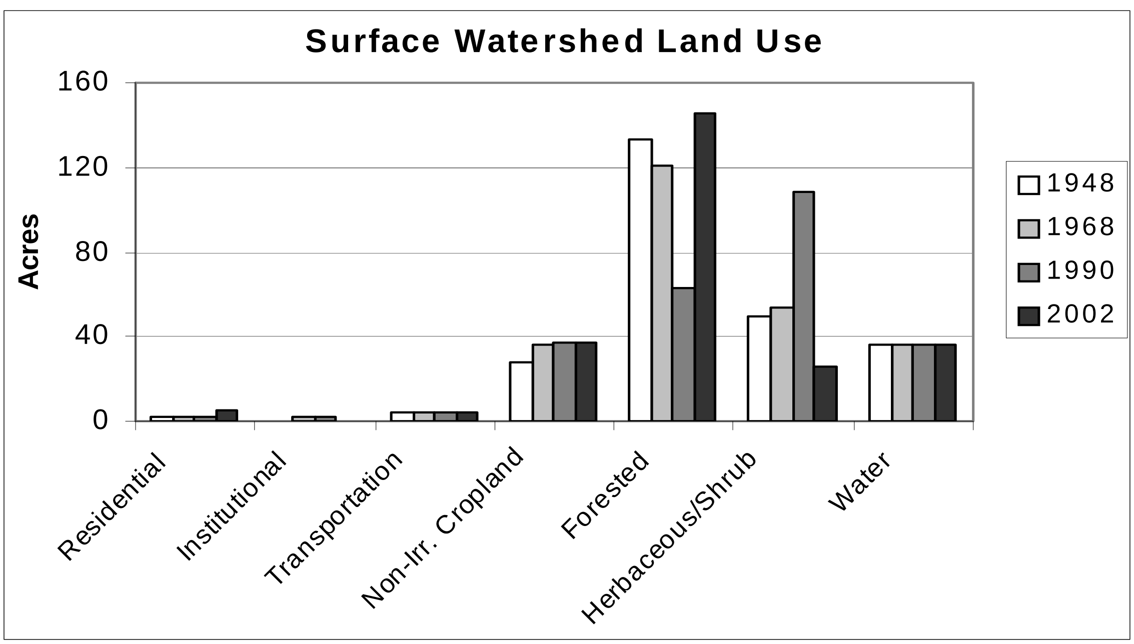


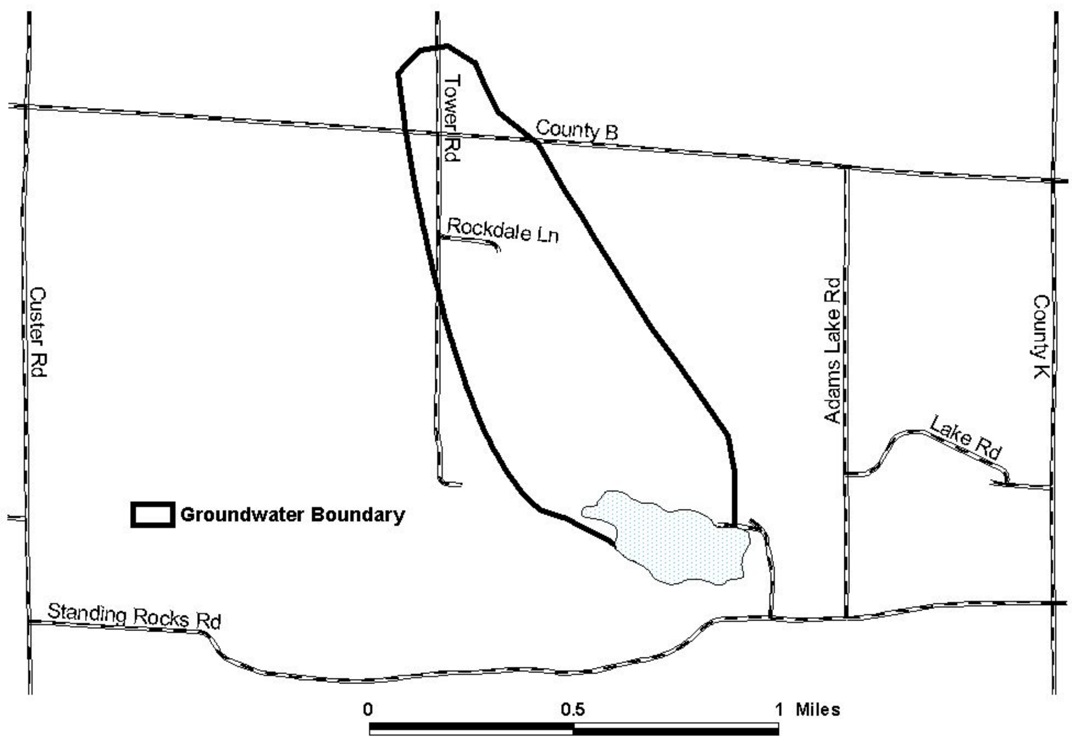
Figure 3. Land use in the Bear Lake surface watershed 1948-2002.



*For terms in bold, see glossary pp 19-24

The **groundwater watershed** for Bear Lake extends to the northwest of the lake and includes considerably more non-irrigated agricultural land than found in the surface **watershed** (Figure 4). Between 1968 and 2002 non-irrigated agriculture decreased by nearly 40 acres but currently it still accounts for 30% of the land use. The forested areas account for 39% of the land use. After 1968 pasture was present in the **groundwater watershed**, increasing to nearly 30 acres by 2002 (Figure 5 and Figure 6). The number of confined animal operations increased slightly between 1948 and 1968 but has since remained the same, however the number of animals may have changed. We were not able to locate accurate records of animal numbers. The number of residences has remained fairly constant over time. Based on age, there are no records of potentially failing septic systems or former landfill sites in the Bear Lake surface or **groundwater watersheds.**

Figure 4. Bear Lake groundwater watershed boundary.



*For terms in bold, see glossary pp 19-24

Figure 5. Land use in the Bear Lake groundwater watershed 2002.

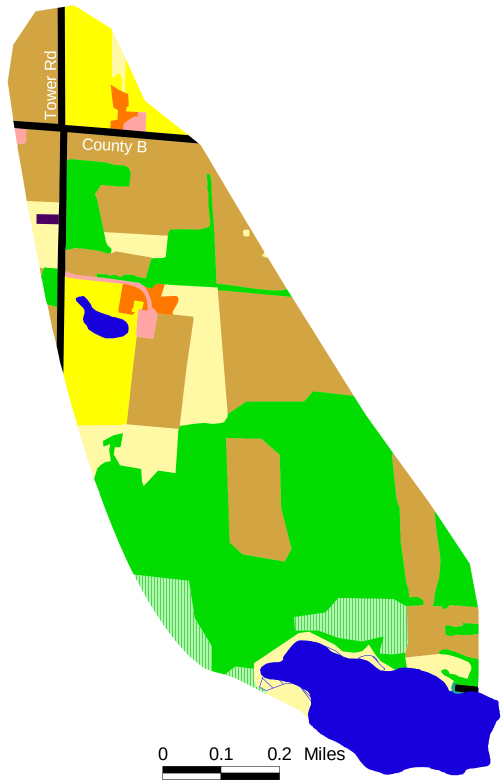
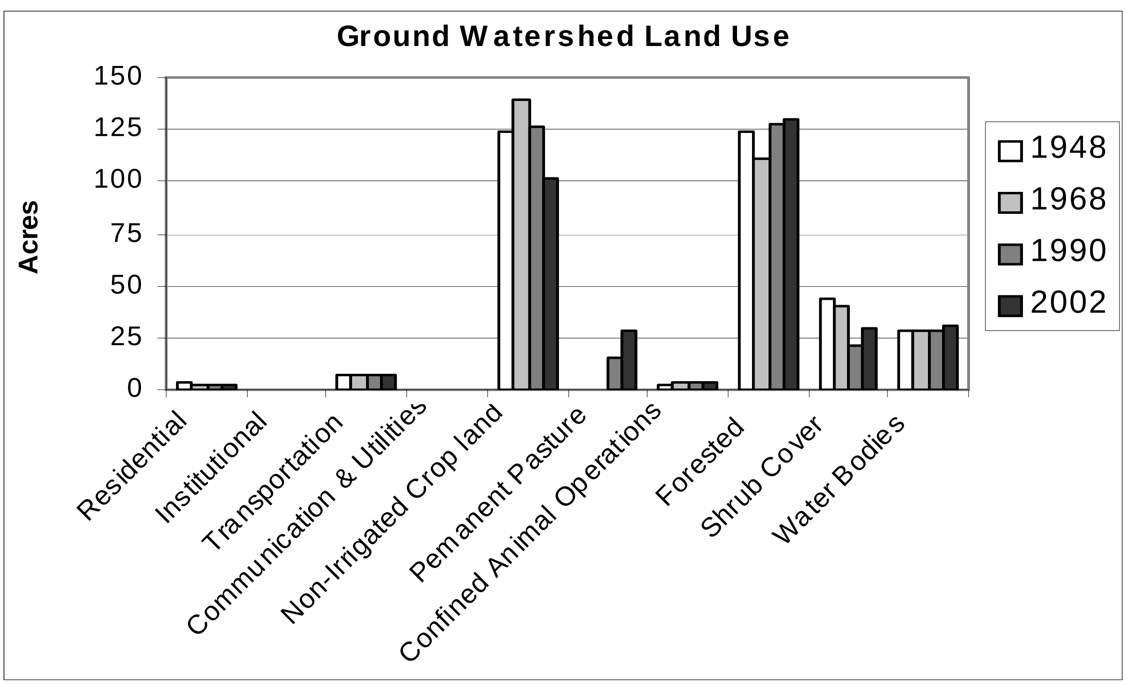


Figure 6. Land use in the Bear Lake groundwater watershed 1948-2002.

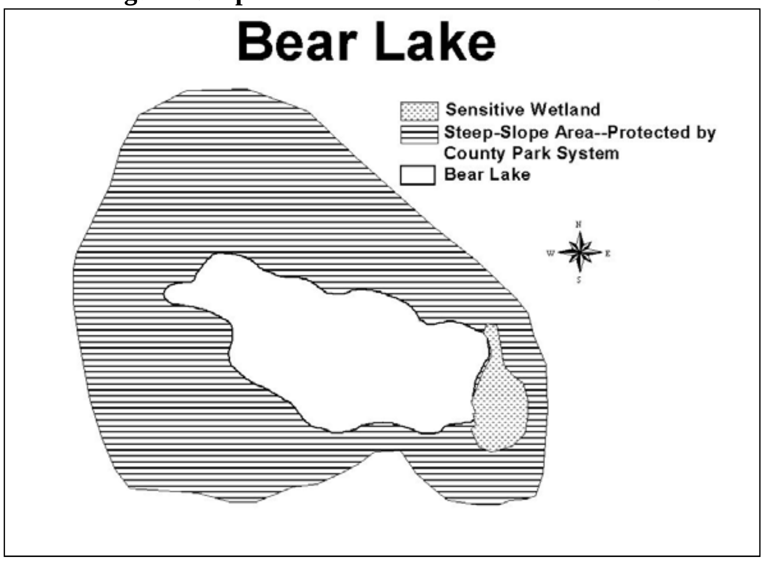


*For terms in bold, see glossary pp 19-24

Upland Sensitive Areas

A survey of upland sensitive areas was conducted to note areas immediately around the lakeshore that are particularly valuable or sensitive to disruption. Near Bear Lake the survey notes the wetland at the east end of the lake and the steep slopes along the shore that are particularly prone to **erosion** if they become denuded of vegetation (Figure 7). Although there are a few homes around the Bear Lake, development has been kept to a minimum in large part due to Standing Rocks County Park.

Figure 7. Upland sensitive areas near Bear Lake.



Birds

Lakeshore development can negatively or positively affect habitat quality of birds depending on the ecological requirements of each species. Development can play a important role in providing resources unavailable to certain species in a more natural environment, yet eliminate other species' needs altogether, especially at the most extreme levels of development.

Of the 28 most common species, eastern phoebe (*Sayornus phoebe*), American goldfinch (*Carduelis tristis*), American robin (*Turdus migratorius*), mourning dove (*Zenaida macroura*), and downy woodpecker (*Picoides pubescens*) showed the greatest tendency to be found in developed areas. These species may be taking advantage of different resources available in the urban environment, such as birdfeeders (as in the case of the American goldfinch and downy woodpecker), open foraging areas (American robin and mourning dove), or nest sites (eastern phoebe).

At undeveloped sites, least flycatcher (*Empidonax minimus*), great crested flycatcher (*Myiarchus crinitus*), red-eyed vireo (*Vireo olivaceus*), black-capped chickadee (*Poecile atricapillus*), blue jay (*Cyaanocitta cristata*), red-bellied woodpecker (*Melanerpes carolinus*), eastern wood-pewee (*Contopus virens*), indigo bunting (*Passerina cyanea*), and common yellowthroat (*Geothylypis trichas*) were the most common. A majority of these species are insectivores and are likely to feed in more forested environments.

*For terms in bold, see glossary pp 19-24

Table 1. Bird species identified near Bear lake.

Common Name	Number Observed	Food	Foraging	Nest Type	Nest Location
Red-winged Blackbird	27	insects	ground gleaner	cup	reed
American Crow	1	omnivore	ground gleaner	cup	deciduous
American Goldfinch	6	seeds	foliage gleaner	cup	shrub
American Robin	2	insects	ground gleaner	cup	deciduous
Blue Jay	1	omnivore	ground gleaner	cup	coniferous
Blue-winged Warbler	1	insects	foliage gleaner	cup	ground
Brown-headed Cowbird	1	insects	ground gleaner	parasite	deciduous
Catbird	3	insects	ground gleaner	cup	shrub
Chipping Sparrow	1	insects	ground gleaner	cup	coniferous
Eastern Phoebe	2	insects	bark gleaner	cavity	snag
Northern Cardinal	2	insects	ground gleaner	cup	shrub
Red-eyed Vireo	1	insects	hover gleaner	cup	shrub
Rose-breased Grosbeak	1	insects	foliage gleaner	cup	deciduous
Song Sparrow	2	insects	ground gleaner	cup	ground
Total	**51**				

Shoreline Vegetation, Reptiles, and Amphibians

Amphibians (frogs and toads) were included in this survey because with their permeable skin and biphasic lifecycle (meaning that the young live in water while adults can survive on land) they are considered excellent indicators of overall ecosystem health. Furthermore, both turtles and amphibians utilize both aquatic and terrestrial habitats and especially the shoreline interface between these two habitats, and thus are of particular relevance.

Large sections of continuous natural shoreline on lakes are ideal habitats for many frog species. Natural areas with large amounts of submergent, emergent, and floating-leaf vegetation provide protection and a place for attachment of eggs during the breeding season. The upland areas surrounding these lakes also provide important habitat as many frog species migrate to lakes and other bodies of water in the spring or fall to breed and spend the summer months foraging in the uplands. Several species also use the surrounding uplands for overwintering. The turtle species found associated with lakes are predominantly aquatic, usually departing from the water only to deposit eggs in a nest. Nests are usually on south facing slopes above the shoreline where there is open vegetation and sandy soil. The newly hatched young then find their way to the water. Thus, both turtles and amphibian are intimately associated with lakes and the associated habitats of a **watershed**.

Only one turtle species was observed during the survey Bear Lake, the painted turtle (*Chrysemys picta*). Amphibians observed included five frog species [spring peeper (*Pseudacris crucifer*), American toad (*Bufo americanus*), gray treefrog (*Hyla versicolor*), chorus frog (*Pseudacris triseriata*), and green frog (*Rana clamitans*)]. The primary amphibian habitat is located on the east and west sides of the lake (primary habitat is identified in red in Figure 8). Some of the key features of this habitat include protected areas of marsh with large amounts of submergent, emergent, and floating-leaf vegetation.

*For terms in bold, see glossary pp 19-24

The good news is that large amounts of natural habitat are available because, although houses are present on the lake, shoreline development has been kept to a minimum. The bad news is that there is a small amount of recreational use on the lake which may negatively affect amphibian populations.

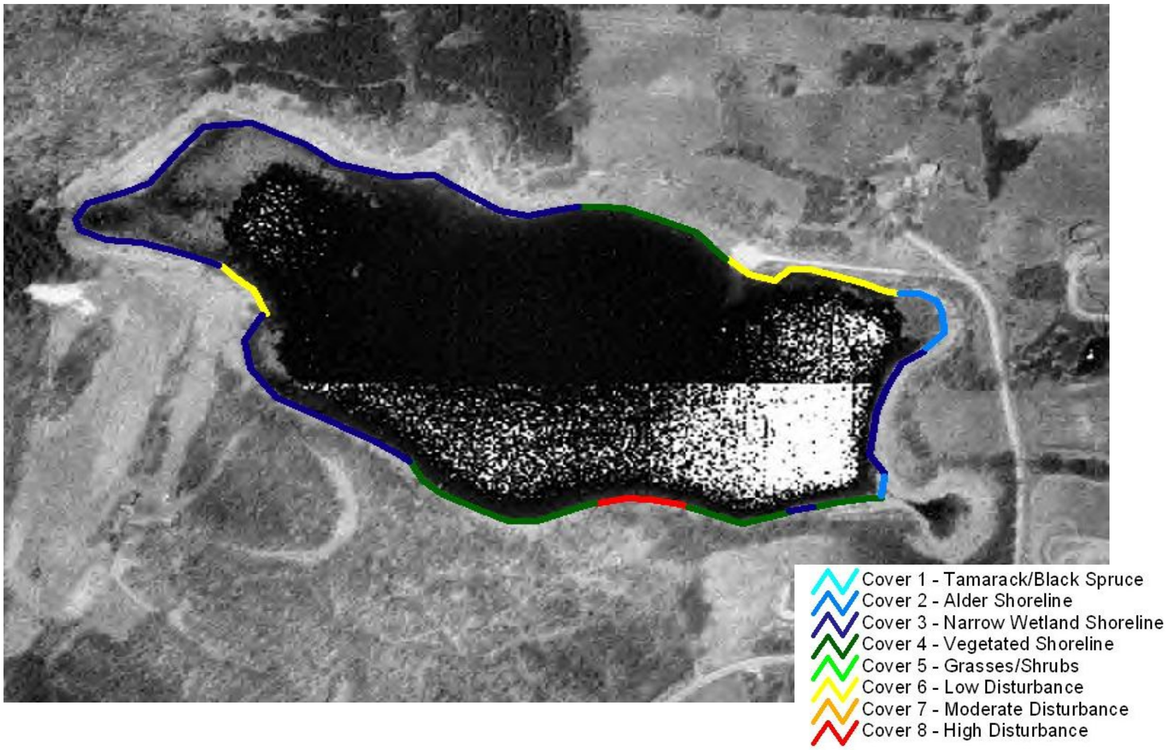
Figure 8. Regions of primary amphibian habitat around Bear Lake.

Approximately 50% of the shoreline around Bear Lake is comprised of narrow wetland shore which is represented by dark blue in Figure 9. The next most common component of Bear Lake's shoreline vegetation, which is represented by dark green, is vegetated shoreline. This category is characterized as being densely vegetated by tall grasses or dense shrubs adjacent to the water without a rocky component. The grasses and shrubs category is the next most prevalent, occupying roughly 8% of the total shoreline. This is represented by light green and is comprised of grasses and shrubs that are not as dense as the previous category and may have a rocky component. The remaining category is represented by sky blue which is defined as wetland areas comprised predominantly of tag alder (*Alnus incana*).

Around Bear Lake, 8% of the lake was disturbed, with 3.8% of the lake's shoreline vegetation considered to be low level disturbance and 4.2% is highly disturbed development. An area that exhibits low vegetation disturbance is defined as a location where there is an unaltered shore zone except for pier access. An area that exhibits high vegetation disturbance is defined as a beach, **rip rap**, sea wall or where the shore is mowed to the water line.

*For terms in bold, see glossary pp 19-24

Figure 9. Categories of shoreline vegetation and disturbance around Bear Lake.



Aquatic Plants

There were 85 species of **vascular plants** found in Bear Lake or rooted in wet or water logged soil on the shore and in the small adjacent wetlands. This is well above average when compared to the other Portage County lakes. The average **coefficient of conservatism (c-value)** of these 85 species is 5.0 which is also above average. The **floristic qualtity index** is 45.6 which is again, above average when compared to the other Portage County lakes.

The aquatic and wetland flora of Bear Lake is remarkably large and diverse, including several relatively rare species, although no threatened or endangered have been found. The submersed vegetation is rather dense, but not extreme. Dominant submersed plants include common water-milfoil (*Myriophyllum sibiricum*), several pondweeds (*Potamogeton* spp.), Canadian waterweed (*Elodea canadensis*), bush-pondweed (*Najas flexilis*), and coontail (*Ceratophyllum demersum*). Free-floating carnivorous bladderworts (*Utricularia* spp.) are unusually common. The shoreline includes dense concentrations of shallow water submersed plants and emergents such as water-marigold (*Megalodonta beckii*), spikerushes (*Eleocharis* spp.), and three-way sedge (*Dulichium arundinaceum*). Water levels have fluctuated greatly over the years, with plants which can adapt to being submersed or rooted on moist soil, such as needle spikerush (*Eleocharis acicularis*), amphibious smartweed (*Polygonum amphibium*), and brown-fruited rush (*Juncus pelocarpus*), thriving regardless whether water is exceptionally high or exceptionally low. The richest areas for wetland plants are on the north shore near the boat landing, and in small areas on the east and west end of the lake. Several typical bog species were found here in the late 1960's and early 1970's; most of these species have not been seen in recent years.

*For terms in bold, see glossary pp 19-24

As of 2003 invasive alien species were not abundant in or around the lake; reed canary-grass (*Phalaris arundinacea*) is spreading in wetland areas, but not yet dominant. However, one plant of Eurasian water-milfoil (*Myriophyllum spicatum*) was found floating in the lake in 2003, and removed. A follow up survey did not show any established beds of Eurasian water-milfoil and suggested that this plant may have been brought into the lake by a boat, trailer, or other piece of equipment (Thorstenson, 2003). Bear Lake needs to be monitored carefully and routinely to prevent the establishment of Eurasian water-milfoil.

The Fishery

Bear Lake supports a warm water fish community. A total of 14 species of fish have been reported in Bear Lake since 1960 (Table 2). Ten species of fish were collected from Bear Lake in 2002-2003 compared to nine from historical records. Taxa not previously reported from this lake include yellow bullhead (*Ictalurus natalis*), blackchin shiner (*Notropis heterodon*), central mudminnow (*Umbra limi*), and the bluegill/pumpkinseed hybrid (*Lepomis gibbosus x Lepomis macrochirus*). Species lost from the lake or not detected include pumpkinseed (*Lepomis gibbosus*), green sunfish (*Lepomis cyanellus*), and white sucker (*Catostomus commersoni*). The most abundant species in Bear Lake as in other Portage County lakes is the bluegill (*Lepomis macrochirus*). There are no official records of stocking Bear Lake, but it would be unusual if this public access lake had not received state propagated fish at some time.

A 1962 WDNR report indicated an excellent bluegill and crappie (*Pomoxis* spp.) sport fishery present in the lake with largemouth bass (*Micropterus salmoides*) and northern pike (*Esox lucius*) present. A WDNR survey performed in 1985 again substantiated the excellent bluegill and black crappie (*Pomoxis nigromaculatus*) population. The report also noted that Bear Lake had the largest pumpkinseed fishery seen in any central Wisconsin Lake with individuals up to 9.5 inches (possible state record at the time). In the 2002-2003 survey more sizable largemouth bass were caught in Bear Lake than in any of the other lakes sampled, but the notable population of pumpkinseed sunfish had disappeared, apparently lost though hybridization with bluegill. Populations of pumpkinseed sunfish appear to have significantly decreased or have been lost to hybridization in a number of Portage County lakes. These species commonly hybridize in some lakes and in others remain isolated. Hybridization between sunfish (*Lepomis* spp.) in some lakes has been attributed to overcrowding, limited spawning habitat or environmental disturbance. The average size of these hybrids and bluegill was small indicating overcrowding and possible stunting, a typical condition in most of the lakes sampled. Black crappie appear to be less abundant and smaller in size than in the past, but anglers reportedly still specifically fish the lake for crappie. The warmouth sunfish (*Lepomis gulosus)* is near the northern extent of its range in Wisconsin and continues to be found in Bear Lake. It is uncommon to rare throughout its range in Wisconsin, but appears to have become well established in a number of the small lakes in Portage County that lie near the headwaters of tributaries to the Wolf River. It is reported to prefer densely vegetated areas and has a greater tolerance to low dissolved oxygen than other species of sunfish which may account for its continued presence in Bear Lake.

Newly reported species in this lake such as the yellow bullhead and central mudminnow are common residents of central Wisconsin lakes and streams. The blackchin shiner is a glacial relict of lakes and streams in Wisconsin. It is rare or endangered throughout much of its range in the U.S. and has been extirpated in some states. It was once much more abundant throughout

*For terms in bold, see glossary pp 19-24

Wisconsin but has been eliminated from most streams because of increased **turbidity**. Its distribution is mostly restricted to small relatively undisturbed glacial lakes. Because Bear Lake does not have an inlet or outlet it is possible a small undetected population of this species has existed here in relative isolation since glaciation. Although it is not classified as a rare fish in Wisconsin, a potentially isolated population such as this is possibly unique and should be given consideration for protection.

Table 2. Species occurrence in Bear Lake in the 2002/2003 study and historical WDNR records.

Bluegill	2003, 2002, 1985, 1968, 1962, 1960
Bluegill/Pumkinseed hybrid	2003, 2002
Pumpkinseed	1985, 1968
Green Sunfish	1962
Warmouth	2002, 1985
Largemouth Bass	2003, 2002, 1968, 1962, 1960
Black Crappie	2003, 1985, 1968, 1962, 1960
Yellow Perch	2002, 1985, 1968, 1962
Northern Pike	2003, 2002, 1985, 1968
Yellow Bullhead	2003
Bullhead sp.	1962
White Sucker	1962
Blackchin Shiner	2003
Central Mudminnow	2002

Bottom Substrate, Vegetative Structure, and Critical Habitat

Bottom substrate in **littoral** areas is mostly muck and sand with one small area of gravel and another with widely scattered boulders (Figure 10). The small area of sand and gravel noted along the southeast shore is unique and should be protected from disturbance. Although largemouth bass and sunfish species commonly nest on sand, gravel or mixed sand and gravel is the preferred substrate for nest building. The sandy shoreline habitat is more extensive, but still limited and is probably critical for sustaining reproduction in the blackchin shiner. Increased **turbidity** from disturbance of the lake bed or from runoff within the **watershed** will also adversely affect this species.

Bear Lake has extensive beds of emergent and floating aquatic vegetation (Figure 11). The emergent sedges and rush in shallow water less than one foot in depth along all but the northern shore are the preferred spawning habitat for northern pike. Limitations to the northern pike population in this lake may be more related to fishing pressure than to lack of suitable spawning habitat. The deep water edge provided by the water lilies and pondweed along the north shore provide excellent habitat for largemouth bass, and northern pike to ambush prey. However, the percentage of the lake with extensive vegetative cover is large and may contribute to overpopulation of small bluegill. There was no woody cover noted in this lake. Downed trees in **littoral** areas represent the most permanent and often only year-round cover for fish. As in many **seepage lakes** water levels fluctuate widely and in 2002-2003 water levels were low with water receding far beyond where falling trees could reach water. Fish populations in this lake would benefit from the addition of woody cover below the lowest reported water levels where it would

*For terms in bold, see glossary pp 19-24

remain continuously submerged. Minimally, trees that fall on the shoreline during low water periods should be left in place and not removed so they will provide cover during high water periods.

Figure 10. Littoral bottom map of Bear lake 6/21/03.

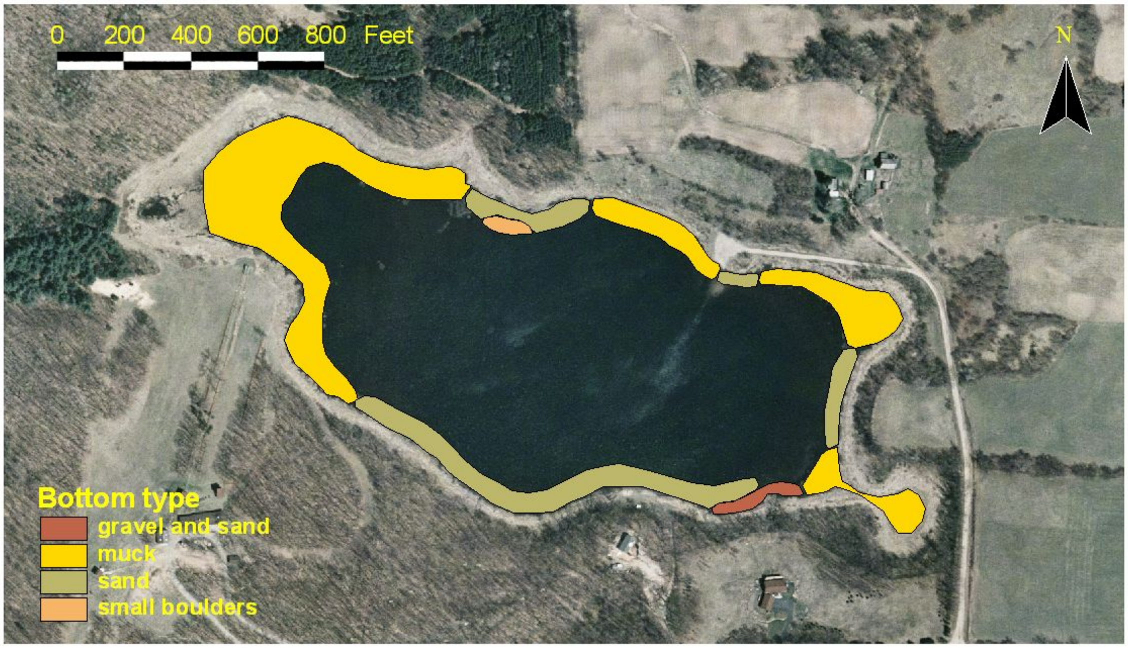
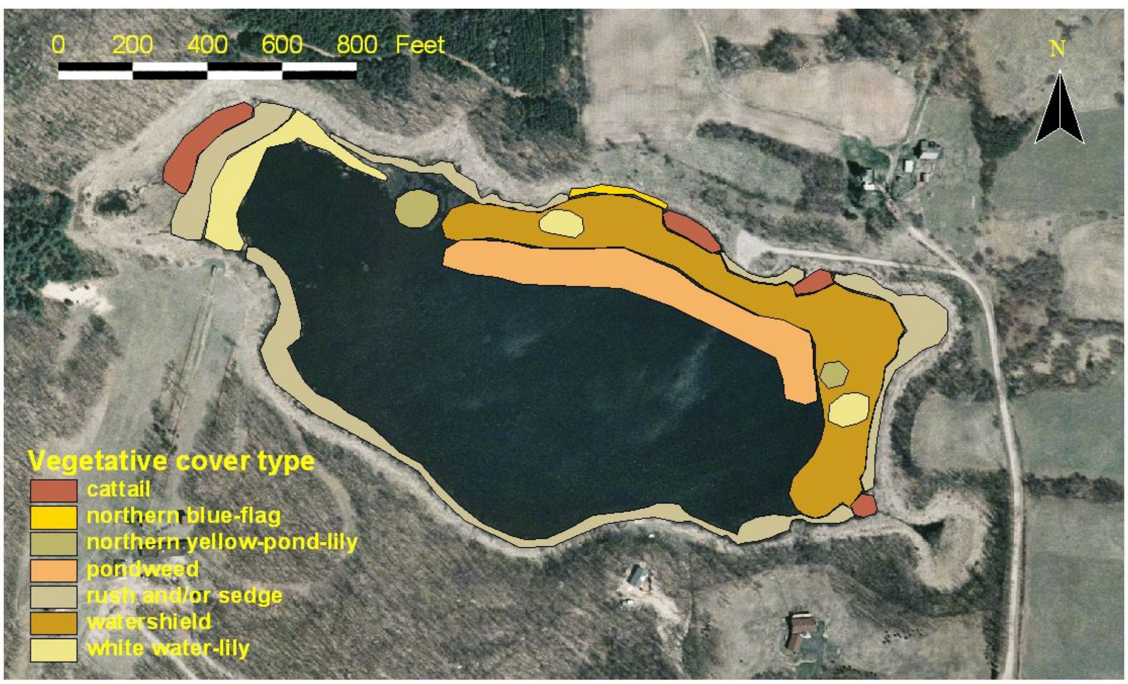


Figure 11. Aquatic vegetative cover map of Bear Lake 6/21/03.



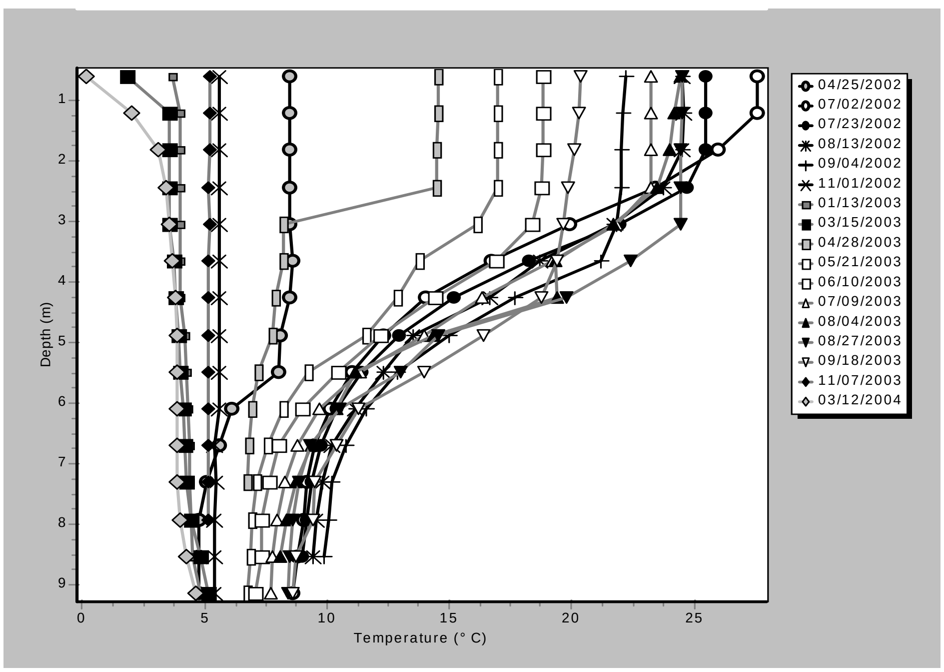
*For terms in bold, see glossary pp 19-24

Current Water Quality Conditions

Each of the water chemistry constituents discussed play a complex role in water quality. A more detailed interpretation can be found at the beginning of this report and should be consulted for a more complete understanding of each lake. Assessment of water quality conditions includes a number of characteristics including temperature, dissolved oxygen, water **clarity**, water chemistry, **chlorophyll *a***, and **algae** communities.

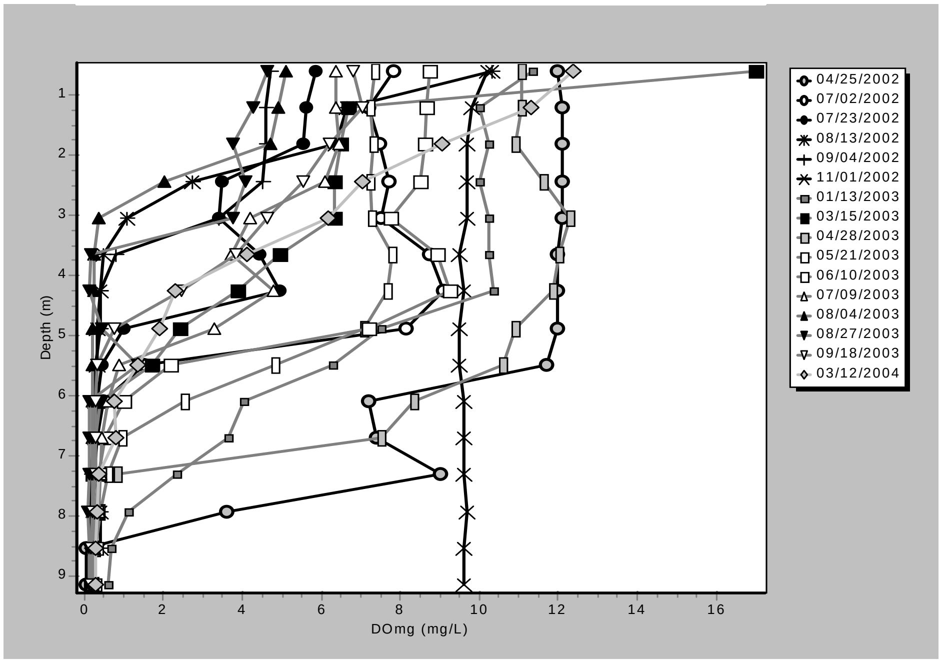
Temperature and dissolved oxygen were measured from top to bottom of the lake at the time of sample acquisition. Based on the temperature profiles, Bear Lake exhibits normal seasonal **stratification** and mixing. The thermocline in Bear Lake tends to begin at approximately fourteen feet and the lake appears to lack oxygen in the lower depths both during the summer and the winter (Figure 12 and Figure 13). During some parts of the year only the upper six feet of water contain dissolved oxygen concentrations greater than 5 **mg/l**. Accumulated material from aquatic plants and biota decompose at the lake's bottom and through this process utilize oxygen, therefore, it is important to limit the amount of nutrients entering Bear Lake from **groundwater** and runoff to prevent increasing the oxygen demand in the lake.

Figure 12. Profile of temperature in Bear Lake 2002-2004.



*For terms in bold, see glossary pp 19-24

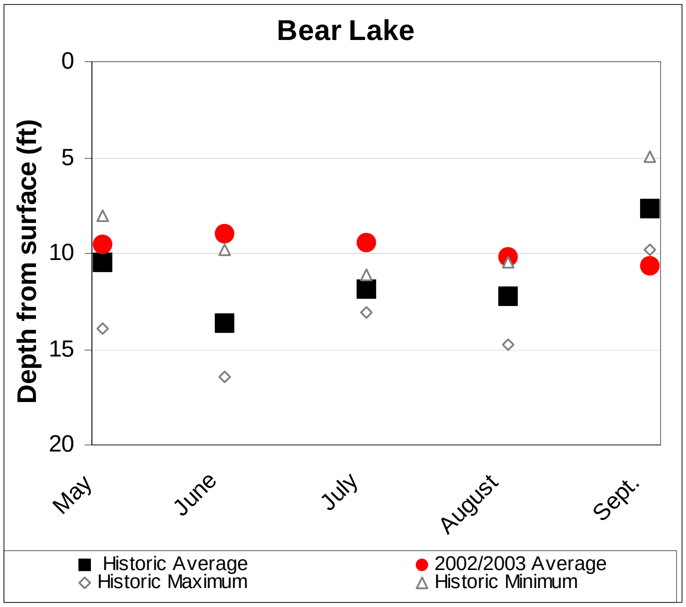
Figure 13. Profile of dissolved oxygen in Bear Lake 2002-2004.



Water **clarity** is a measure of the depth that light can penetrate into the water. It is an aesthetic measure and is also related to the depth that **rooted aquatic plants** can grow. Water **clarity** is affected by water **color** and suspended materials in the water (**turbidity)**. **Turbidity** consists of **suspended solids**, such as suspended sediments and **algae** (**chlorophyll *a***). In Bear Lake samples the **color** and **turbidity** measured low, but the **chlorophyll *a*** was elevated (Table 3). Water **clarity** in Bear Lake is considered average; the average Secchi disc depth readings for **seepage lakes** in Portage County are 9 to 10 feet. Compared with historic measurements, the water **clarity** is quite reduced. It is normal for water **clarity** to fluctuate throughout the warm months and was best in the month of June and worst in September (Figure 14).

*For terms in bold, see glossary pp 19-24

Figure 14. Monthly average water clarity measurements in BearLake 2002-2003 and historic average, maximum and minimums.



Nutrients (**phosphorus** and **nitrogen**) are used by **algae** and aquatic plants to grow (similar to houseplants and crops). **Phosphorus** as total and reactive forms were below levels of concern throughout the year. Current **hardness**, **alkalinity**, pH, and conductivity measures are about half of what they were historically. Historic **hardness** and **alkalinity** concentrations were near 100 **mg/l**, but more recent **hardness** concentrations are quite low (less than 45 **mg/l**), now categorizing it as a soft-water lake. **Soft water** lakes are more sensitive to inputs of **phosphorus** so future additions of **phosphorus** will likely accelerate **algae** and aquatic plant growth. This type of major shift is not common. Reasons for the decline in calcium and magnesium **hardness** have not been determined.

Chloride levels, and to a lesser degree **sodium** and **potassium** levels, are commonly used as an indicator of how strongly a lake is being impacted by human activity. These concentrations were all low (Table 4). **Atrazine** was found in low concentrations in the lake water (0.12 and 0.08 µg/L), however some toxicity studies have indicated that **endocrine** disruption can occur in frogs at these levels. The presence of **atrazine** indicates that other agri-chemicals may also be entering Bear Lake.

Table 3. Seasonal averages of water chemistry in Bear Lake 2002-2004.

Bear Lake	TP (ug/L)	RP (ug/L)	TN (mg/L)	NO2+NO3 (mg/L)	NH4 (mg/L)	Alkalinity (mg/L)	Total Hardness (mg/L)	Calcium Hardness (mg/L)	Color (CU)	Turbidity (NTU)	Chlorophyll a (ppm)
Spring Averages	22.3	17.3	0.90	0.07	0.09	45.5	47.5	24.0	21	2.3	0.0
Summer Averages	19.7	4.8	0.99	0.02	0.02	45.5	41.5	20.7	29	2.4	7.2
Fall Averages	22.5	6.5		0.02	0.07	43.5	43.5	24.0	36	1.6	
Winter Averages	18.0	6.0		0.16	0.18						
2002-2004 Averages	20.4	8.2	0.95	0.06	0.08	44.8	44.2	22.9	29	2.1	6.5

TP=total **phosphorus**; RP=reactive or soluble **phosphorus**; TN=total **nitrogen**; NO2+NO3=**nitrite** and **nitrate nitrogen**; NH4=**ammonia nitrogen**

*For terms in bold, see glossary pp 19-24

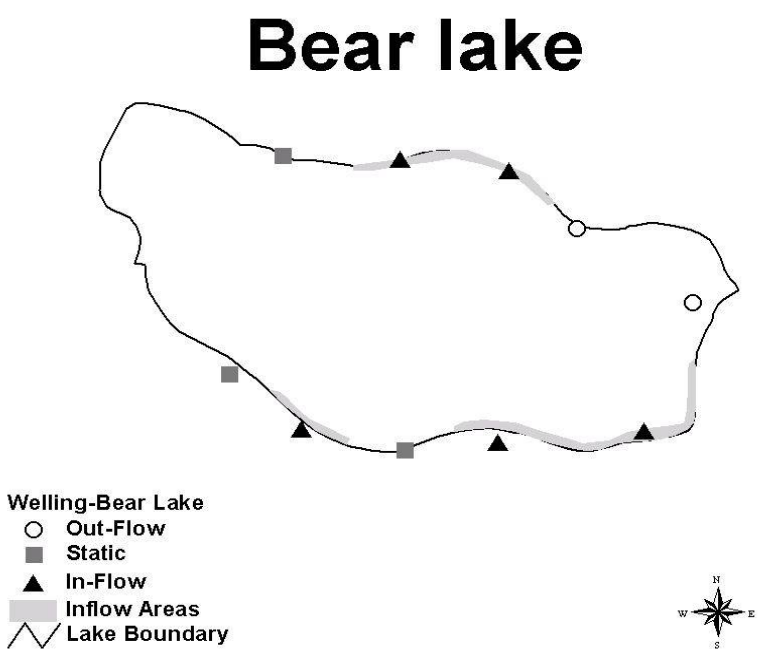
Table 4. 2002-2004 Bear Lake water chemistry averages and reference values.

Bear Lake	Low	Medium	High	Reference Values	Low	Medium	High
Sulfate	1.12			*Sulfate*	<10	10-20	>20
Chloride	0.57			*Chloride*	<3	3-10	>10
Potassium	0.80			*Potassium**	<2.16	2.16-4.30	>4.30
Sodium	0.63			*Sodium**	<2.28	2.28-5.09	>5.09

**Ranges of low, medium, high defined by taking the median values from the lake study and dividing into thirds.*

The **groundwater** entering lakes originates in the entire **groundwater watershed**. Mini-wells were used to estimate where **groundwater** is entering and leaving Bear Lake. In addition, observations of open water during late winter were made by residents to enhance the results from the mini-wells. Installation of mini-wells in July 2003 showed ground water entering the lake on both the north and south sides (Figure 15). The ground water contours and the colder temperature of the inflowing water indicates that ground water is primarily entering on the north side of the lake, however the steep slope of the southern shore results in local **groundwater** also entering on the south side of the lake. **Groundwater** exits the lake at the east end. Field conductivity measurements from all inflowing **groundwater** sites showed low values as did the water quality lab analysis conducted on two samples, indicating that **groundwater** does not appear to be transmitting elevated nutrients to Bear Lake at this time.

Figure 15. Locations in Bear Lake showing groundwater inflow/no flow/outflow from mini-piezometer measurements and winter observations.



Algal Community

The algal community in Bear Lake (Table 5) was dominated by green **algae** (Chlorophyta) and **blue-green algae** (Cyanobacteria). In the 2100+ cells counted during this period there were 8

*For terms in bold, see glossary pp 19-24

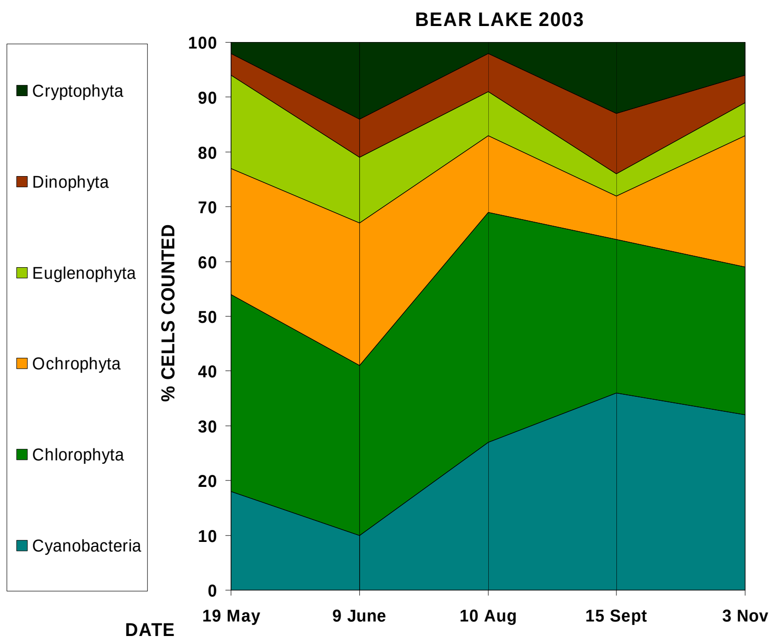
genera of Cyanobacteria, 17 genera of Chlorophyta, 11 genera of Ochrophyta (including 9 diatom genera), 4 genera of Euglenophyta, 3 general of Dinophyta, and 1 genus of Cryptophyta identified. The green **algae** represented between 27-42% (mean = 33%) of all cells counted and the **blue-green algae** represented between 10-36% (25%) of all cells counted (Table 5). The green **algae** were the dominant group in May, June, and August while the **blue-green algae** were the dominant group in September and November (Figure 16). The ochrophytes (Ochrophyta), mostly **diatoms**, were the third most abundant phylum, by cells counted, representing between 8-26% (mean = 19%). This group was also the second most abundant group in the May and June samples.

Table 5. Algal phyla and mean seasonal composition in Bear Lake from May to November 2003.

BEAR LAKE

PHYLUM	% CELLS COUNTED BY PHYLUM AND DATE					**MEAN**
	19 May	9 June	10 Aug	15 Sept	3 Nov	
Cyanobacteria	18	10	27	36	32	25
Chlorophyta	36	31	42	28	27	33
Ochrophyta	23	26	14	8	24	19
Euglenophyta	17	12	8	4	6	9
Dinophyta	4	7	7	11	5	7
Cryptophyta	2	14	2	13	6	7

Figure 16. Algal community composition by date in Bear Lake from May to November 2003 (total phylum cells counted divided by total cells counted).



The green algal genera *Scenedesmus*, *Ankistrodesmus*, and *Selenastrum* dominated the three early sample periods (Figure 17). These very small phytoplankters have high intrinsic growth rates and can numerically dominate a sample without contributing overwhelming amounts of

*For terms in bold, see glossary pp 19-24

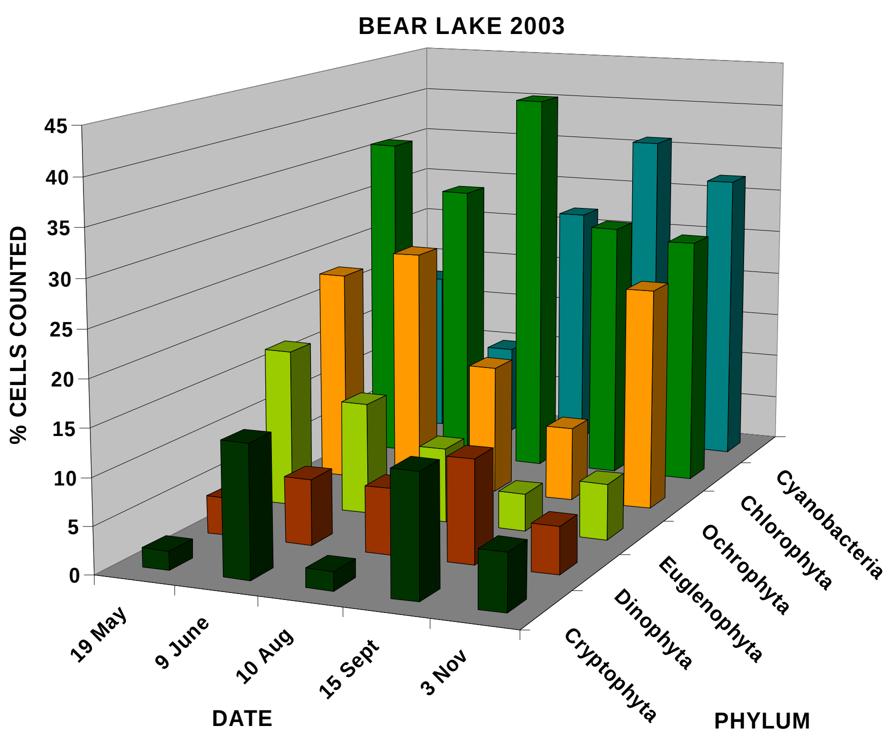
biomass. The colonial blue-green algal genus *Coelosphaerium* dominated the late season samples. Blue-greens generally start slow and develop large populations over the course of the growing season. The size of the ending populations often depends on starting inoculum and nutrient dynamics in the **watershed** and lake. Several genera of **diatoms** (*Asterionella*, *Melosira*, *Fragilaria*) were common and often the second most abundant taxa. Overall, these seven genera were in the top three dominants in 12 of 15 cases (Table 6).

The algal community, when considered relative to the **chlorophyll**, **phosphorus**, and **nitrogen** values for Bear Lake, indicates a **mesotrophic** lake. The 44 genera identified during the sample period are all relatively common and the shifting dynamics of the algal community during the growing season are typical of a mildly **mesotrophic** lake like Bear Lake. There was good water **clarity** during the early season dominance by the green and ochrophyte **algae** (through June). When the **blue-green algae** began to dominate the water **clarity** dropped.

Table 6. Most common algal genera by date in Bear Lake from May to November 2003.

DATE	TOP THREE TAXA (MOST ABUNDANT, LEFT TO RIGHT)		
19 May	*Selenastrum*	*Fragilaria*	*Asterionella*
9 June	*Ankistrodesmus*	*Melosira*	*Euglena 1*
10 August	*Scenedesmus*	*Coelosphaerium*	*Wornichinia*
15 September	*Coelosphaerium*	*Ankistrodesmus*	*Chroomonas*
3 November	*Coelosphaerium*	*Asterionella*	*Scenedesmus*

Figure 17. **Algal community composition by phylum in Bear Lake from May to November 2003**.



*For terms in bold, see glossary pp 19-24

Bear Lake Study Highlights

- Fish populations in this lake would benefit from the addition of woody cover below the lowest reported water levels where it would remain continuously submerged. Minimally, trees that fall on the shoreline during low water periods should be left in place and not removed so they will provide cover during high water periods.
- The blackchin shiner is a glacial relict of lakes and streams in Wisconsin. It is rare or endangered throughout much of its range in the U.S. and has been extirpated in some states. It was once much more abundant throughout Wisconsin but has been eliminated from most streams because of increased **turbidity**. Its distribution is mostly restricted to small relatively undisturbed glacial lakes. Because Bear Lake does not have an inlet or outlet it is possible a small undetected population of this species has existed here in relative isolation since glaciation. Although it is not classified as a rare fish in Wisconsin, a potentially isolated population such as this is possibly unique and should be given consideration for protection.
- Some upland areas around Bear Lake are steep and susceptible to shoreland **erosion**.
- There are several areas of primary amphibian habitat and vegetated shoreland that provides habitat and helps to improve water quality.
- There were 85 species of **vascular plants** found in Bear Lake or rooted in wet or water logged soil on the shore and in the small adjacent wetlands. This is well above average when compared to the other Portage County lakes. The average **coefficient of conservatism (c-value)** of these 85 species is 5.0 which is also above average. The **floristic qualtity index** is 45.6 which, again, is above average when compared to the other Portage County lakes.
- The aquatic and wetland flora of Bear Lake is remarkably large and diverse, including several relatively rare species, although no threatened or endangered have been found. The richest areas for wetland plants are on the north shore near the boat landing, and in small areas on the east and west end of the lake.
- As of 2003 invasive alien species were not abundant in or around the lake; reed canary-grass is spreading in wetland areas, but not yet dominant. However, one plant of Eurasian water-milfoil was found floating in the lake in 2003, and removed. A follow up survey did not show any established beds of Eurasian water-milfoil and suggested that this plant may have been brought into the lake by a boat,
- This once moderately hard-water Bear Lake is now characterized as a **soft water** lake. This is a major shift and does not occur frequently. Sources of calcium and magnesium (**hardness**) to Bear Lake have either reduced significantly, or the ratio of **groundwater** to runoff has decreased significantly resulting in a much lower concentration of **hardness** and **alkalinity** and a shift in pH. This change makes Bear Lake far more susceptible to additional inputs of **phosphorus** and may alter the lake's ecosystem.
- During some parts of the year only the upper six feet of water contain dissolved oxygen concentrations greater than 5 **mg/l**. Accumulated material from aquatic plants and biota decompose at the lake's bottom and through this process utilize oxygen, therefore, it is important to limit the amount of nutrients entering Bear Lake from **groundwater** and runoff to prevent this situation from further decline.

*For terms in bold, see glossary pp 19-24

- Water **clarity** in Bear Lake is considered average; the average Secchi disc depth readings for **seepage lakes** in Portage County are 9 to 10 feet. Compared with historic measurements, the water **clarity** is quite reduced.
- The algal community, when considered relative to the **chlorophyll**, **phosphorus**, and **nitrogen** values for Bear Lake, indicates a **mesotrophic** lake. The 44 genera identified are all relatively common and the shifting dynamics of the algal community during the growing season are typical of a mildly **mesotrophic** lake like Bear Lake. There was good water **clarity** during the early season dominance by the green and ochrophyte **algae** (through June). When the **blue-green algae** began to dominate the water **clarity** dropped.

Glossary

Algae:

One-celled (phytoplankton) or multicellular plants either suspended in water (plankton) or attached to rocks and other substrates (periphyton). Their abundance, as measured by the amount of chlorophyll a (green pigment) in an open water sample, is commonly used to classify the trophic status of a lake. Numerous species occur. Algae are an essential part of the lake ecosystem and provide the food base for most lake organisms, including fish. Phytoplankton populations vary widely from day to day, as life cycles are short.

Alkalinity:

A measure of the amount of carbonates, bicarbonates, and hydroxide present in water. Low alkalinity is the main indicator of susceptibility to acid rain. Increasing alkalinity is often related to increased algae productivity. Expressed as milligrams per liter (mg/L) of calcium carbonate (CaCO3), or as microequivalents per liter (ueq/l). 20 ueq/l = 1 mg/L of $CaCO_3$.

Ammonia, Ammonium:

A form of nitrogen found in organic materials and many fertilizers. It is the first form of nitrogen released when organic matter decays. It can be used by most aquatic plants and is therefore an important nutrient. It converts rapidly to nitrate (NO_3) if oxygen is present. The conversion rate is related to water temperature. Ammonia is toxic to fish at relatively low concentrations in pH-neutral or alkaline water. Under acid conditions, non-toxic ammonium ions (NH_4^+) form, but at high pH values the toxic ammonium hydroxide (NH_4OH) occurs. The water quality standard for fish and aquatic life is 0.02 mg/L of NH_4OH. At a pH of 7 and a temperature of 68^o F (20^o C), the ratio of ammonium ions to ammonium hydroxide is 250:1; at pH 8, the ratio is 26:1.

Atrazine:

The nation’s most widely used weedkiller for both grassy and broadleaf weeds.

Blue-Green Algae:

Algae that are often associated with problem blooms in lakes. Some produce chemicals toxic to other organisms, including humans. They often form floating scum as they die. Many can fix nitrogen (N_2) from the air to provide their own nutrient.

Chloride (Cl-):

Chlorine in the chloride ion (Cl^-) form has very different properties from chlorine gas (Cl_2), which is used for disinfecting. The chloride ion (Cl^-) in lake water is commonly considered an indicator of human activity. Agricultural chemicals, human and animal wastes, and road salt are the major sources of chloride in lake water.

Chlorophyll *a*:

Green pigment present in all plant life and necessary for photosynthesis. The amount present in lake water depends on the amount of algae and is therefore used as a common indicator of water quality.

*For terms in bold, see glossary pp 19-24

Clarity:

see "Secchi disc."

Coefficient of Conservatism (c-value):

Indicates on a scale of 0 to 10 the degree to which a species can tolerate disturbance to a native plant community; a species with a c value of 10 is found only in relatively undisturbed areas of native plant community, whereas a species with a c value of 0 never grows in undisturbed areas of native plant communities. Plants with low numbers tend to occur in a wide range of more-or-less disturbed plant communities. Alien species are also assigned a c value of 0. The c values are used in this report in calculating the Floristic Quality Index for each lake.

Color:

Measured in color units that relate to a standard. A yellow-brown natural color is associated with lakes or rivers receiving wetland drainage. The average color value for Wisconsin lakes is 39 units, with the color of state lakes ranging from zero to 320 units. Color also affects light penetration and therefore the depth at which plants can grow.

Concentration Units:

Express the amount of a chemical dissolved in water. The most common ways chemical data is expressed is in milligrams per liter (mg/L) and micrograms per liter (ug/L). One milligram per liter is equal to one part per million (ppm). To convert micrograms per liter (ug/L) to milligrams per liter (mg/L), divide by 1000 (e.g. 30 ug/l = 0.03 mg/L). To convert milligrams per liter (mg/L) to micrograms per liter (ug/L), multiply by 1000 (e.g. 0.5 mg/L = 500 ug/L). Microequivalents per liter (ueq/L) is also sometimes used, especially for alkalinity; it is calculated by dividing the weight of the compound by 1000 and then dividing that number into the mg/L.

Diatoms:

A major group of eukaryotic algae, which are one of the most common types of phytoplankton. Diatom communities are a popular tool for monitoring environmental conditions, past and present, and are commonly used in studies of water quality; often the brown stuff attached to rock surfaces.

Drainage Basin:

The total land area that drains toward the lake.

Drainage Lakes:

Lakes fed primarily by streams and with outlets into streams or rivers. They are more subject to surface runoff problems but generally have shorter retention times than seepage lakes. Watershed protection is usually needed to manage lake water quality.

Endocrine:

An integrated system of small organs that involve the release of extracellular signaling molecules known as hormones. The endocrine system is instrumental in regulating metabolism, growth, development and puberty, tissue function, and also plays a part in determining mood.

Erosion:

The lowering of the land surface by weathering, corrosion, and transportation, under the influence of gravity, wind, and running water.

Eutrophic:

Eutrophic lakes are high in nutrients and support a large biomass (all the plants and animals living in a lake). They are usually either weedy or subject to frequent algae blooms, or both. Eutrophic lakes often support large fish populations, but are also susceptible to oxygen depletion. Small, shallow, eutrophic lakes are especially vulnerable to winterkill which can reduce the number and variety of fish. Rough fish are commonly found in eutrophic lakes.

*For terms in bold, see glossary pp 19-24

Eutrophication:

The process by which lakes and streams are enriched by nutrients, and the resulting increase in plants and algae. The extent to which this process has occurred is reflected in a lake's trophic classification: oligotrophic (nutrient poor), mesotrophic (moderately productive), and eutrophic (very productive and fertile).

Fen:

A fen is a type of wetland fed by surface and/or groundwater. Fens are characterized by their water chemistry, which is neutral or alkaline, unlike bogs, which are generally acid.

Floristic Quality Index (FQI):

The FQI is a standardized method for evaluating natural plant communities by multiplying the average coefficient of conservatism (c-value) for all species by the square root of the total number of species found at that lake; an additional point is added to the index for each state-listed special concern species, two points added for a threatened species, and three points added for an endangered species. A higher floristic quality index, such as FQI=60, indicates a higher floristic quality and biological integrity and a lower level of disturbance impacts. A lower floristic quality index, such as FQI=20, indicates a lower floristic quality and biological integrity and a higher level of disturbance impacts.

Groundwater:

Water found below the land surface in pore spaces between soil particles or in cracks in rock. It moves slowly from higher to lower areas on the landscape and may provide water to a lake.

Groundwater Drainage Lake:

Often referred to a spring-fed lake, has large amounts of groundwater as its source, and a surface outlet. Areas of high groundwater inflow may be visible as springs or sand boils. Groundwater drainage lakes often have intermediate retention times with water quality dependent on groundwater quality.

Hardness, Hard Water:

The quantity of multivalent cations (cations with more than one +), primarily calcium (Ca++) and magnesium (Mg++) in the water expressed as milligrams per liter of $CaCO_3$. Amount of hardness relates to the presence of soluble minerals, especially limestone, in the lake watershed. Moderately hard water has 61-120 mg/L $CaCO_3$, hard water has 121-180 mg/L $CaCO_3$, and very hard water has more than180 mg/L $CaCO_3$.

Impoundment:

Manmade lake or reservoir usually characterized by stream inflow and always by a stream outlet. Because of nutrient and soil loss from upstream land use practices, impoundments ordinarily have higher nutrient concentrations and faster sedimentation rates than natural lakes. Their retention times are relatively short.

Littoral:

The shallow water zone near the shoreline that is home to most aquatic plants.

Macrophytes:

see "Rooted aquatic plants."

Macrophytic Algae:

Algae that resemble true plants in that they appear to have stems and leaves, and are attached to the bottom.

*For terms in bold, see glossary pp 19-24

Marl:

White to gray accumulation on lake bottoms caused by precipitation of calcium carbonate ($CaCO_3$) in hard water lakes. Marl may contain many snail and clam shells, which are also calcium carbonate. While it gradually fills in lakes, marl also precipitates phosphorus, resulting in low algae populations and good water clarity. In the past, marl was recovered and used to lime agricultural fields.

Mesotrophic:

Mesotrophic lakes lie between the oligotrophic and eutrophic trophic stages. In late summer, they lose oxygen at depth, limiting cold water fish and causing phosphorus release from sediments.

mg/L:

see "Concentration units"

Nitrate (NO_3^-):

An inorganic form of nitrogen important for plant growth. Nitrogen is in this stable form when oxygen is present. Nitrate often contaminates groundwater when water originates from manure pits, fertilized fields, lawns or septic systems. High levels of nitrate-nitrogen (over 10 mg/L) are dangerous to infants and expectant mothers. A concentration of nitrate-nitrogen (NO_3-N) plus ammonium-nitrogen (NH_4-N) of 0.3 mg/L in spring will support summer algae blooms if enough phosphorus is present.

Nitrite (NO_2^-):

A form of nitrogen that rapidly converts to nitrate (NO_3^-) and is usually included in the NO_3^- analysis.

Nitrogen:

A chemical element that is an essential plant nutrient and may occur in the form of nitrate, nitrite, ammonium, or organic nitrogen in lakes.

Oligotrophic:

A trophic state in which lakes are generally clear, deep and free of weeds or large algae blooms. Though beautiful, they are low in nutrients and do not support large fish populations. However, oligotrophic lakes often develop a food chain capable of sustaining a very desirable fishery of large game fish.

Phosphorus:

Key nutrient influencing plant growth in more than 80% of Wisconsin lakes. Soluble reactive phosphorus is the amount of phosphorus in solution that is available to plants. Total phosphorus includes the amount of phosphorus in solution (reactive) and in particulate form.

Photosynthesis:

The process by which green plants convert carbon dioxide (CO_2) dissolved in water to sugar and oxygen using sunlight for energy. Photosynthesis is essential in producing a lake's food base, and is an important source of oxygen for many lakes.

Potassium:

A chemical element that is an essential plant nutrient and may enter lakes from runoff of agricultural fertilizers and animal wastes.

Retention Time: (Turnover Rate or Flushing Rate)

The average length of time water resides in a lake, ranging from several days in small impoundments to many years in large seepage lakes. Retention time is important in determining the impact of nutrient inputs. Long retention times result in recycling and greater nutrient retention in most lakes. Calculate retention time by dividing the volume of water passing through the lake per year by the lake volume.

*For terms in bold, see glossary pp 19-24

Rip Rap (Rip-Rap):

Hard rock, commonly granite or concrete rubble recycled from construction sites, used inland on lakes, rivers, coastlines, and other waterways to prevent bank erosion. Generally rip rap is not considered good management in lakes, due to its inability to provide adequate habitat, and is no longer commonly used.

Rooted Aquatic Plants: (Macrophytes)

Refers to higher (multi-celled) plants growing in or near water. Macrophytes are beneficial to lakes because they produce oxygen and provide substrate for fish habitat and aquatic insects. Overabundance of such plants, especially problem species, is related to shallow water depth and high nutrient levels.

Secchi Disc (Secchi Disk):

An 8-inch diameter plate with alternating quadrants painted black and white that is used to measure water clarity (light penetration). The disc is lowered into water until it disappears from view. It is then raised until just visible. An average of the two depths, taken from the shaded side of the boat, is recorded as the Secchi disc reading. For best results, the readings should be taken on sunny, calm days.

Sedimentation:

Accumulated organic and inorganic matter on the lake bottom. Sediment includes decaying algae and weeds, marl, and soil and organic matter eroded from the lake's watershed.

Seepage Lakes:

Lakes without a significant inlet or outlet, fed by rainfall and groundwater. Seepage lakes lose water through evaporation and groundwater moving on a down gradient. Lakes with little groundwater inflow tend to be naturally acidic and most susceptible to the effects of acid rain. Seepage lakes often have long retention times, and lake levels fluctuate with local groundwater levels. Water quality is affected by groundwater quality and the use of land on the shoreline.

Sodium:

A chemical element that may enter lakes from runoff of road salt, fertilizers, and human and animal wastes.

Soft Water:

Water with less than 60 mg/L CaCO3 (see Hard water).

Stratification, Stratified:

The layering of water due to differences in density. Water's greatest density occurs at $39^{o}F$ ($4^{o}C$). As water warms during the summer, it remains near the surface while colder water remains near the bottom. Wind mixing determines the thickness of the warm surface water layer (epilimnion), which usually extends to a depth of about 20 ft. The narrow transition zone between the epilimnion and cold bottom water (hypolimnion) is called the metalimnion or thermocline.

Sulfate (SO_4^{--}):

The most common form of sulfur in natural waters. The amounts relate primarily to soil minerals in the watershed. Sulfate (SO_4^{--}) can be reduced to sulfide (S^{--}) and hydrogen sulfide (H_2S) under low or zero oxygen conditions. Hydrogen sulfide smells like rotten eggs and harms fish. Sulfate input from acid rain is a major indicator of sulfur dioxide (SO_2) air pollution. Sulfate concentration is used as a chemical fingerprint to distinguish acid lakes acidified by acid rain from those acidified by organic acids from bogs.

Substrate:

The material found at the bottom of a lake, such as silt, mud, sand, clay, marl, gravel, etc.

Suspended Solids:

A measure of the particulate matter in a water sample, expressed in milligrams per liter. When measured on inflowing streams, it can be used to estimate the sedimentation rate of lakes or impoundments.

*For terms in bold, see glossary pp 19-24

Turbidity:

The "cloudiness" or "murkiness" of water, caused by total suspended solids.

Vascular Plants:

Vascular plants are those plants that have tissues for conducting water, minerals, and food through the plant. Vascular plants include the ferns, clubmosses, flowering plants, and conifers.

Watershed:

The total land area that drains either surface water or groundwater toward a lake.