Some metals and organic chemicals are more dangerous to aquatic life forms than others. Subtle shifts in the lake's make-up may change the way a toxic acts. For example, the sediments release copper ions into the water when conditions become more acidic than normal.

The plants can take up toxics and pass them to animals that eat the contaminated plants. When these plants and animals die, they decay and release the toxic substances back into the lake. Like people, these organisms also suffer from toxic poisoning.

Health Limits

Specific health regulation limits for toxics in sediments are just now being developed by the U.S. Environmental Protection Agency (USEPA). It is difficult to determine limits because the toxicity of a compound changes with different conditions. For example, one sediment may contain twice the amount of mercury than another. But the sediment with the lower amount could be more harmful if the mercury is more available to plants or other life forms.

Some metals, like mercury, are more apt to travel through the food chain than others, and can therefore pose a health risk to humans. Other metals, like copper, do not threaten human health via the food chain, but they can be very dangerous to the plants and/or animals in the lake.

In 1979 the Illinois Environmental Protection Agency (IEPA) completed a study of the sediments in inland lakes throughout the state, and categorized levels of toxics ranging from "below normal" to "highly elevated". The Health Department has used these categories in its assessment of Lake Barrington.

Sediment samples were taken from four areas in the lake (Figure 3):

Site 1. the deepest spot in the lake;

Site 2. the north bay;

Site 3. just outside the north inlet; and

Site 4. the southern portion of the lake near the beach.

Samples were taken during June and September of 1988, and analyzed for eight heavy metals: arsenic, cadmium, chromium, copper, lead, nickel, mercury and zinc. The same sediments were checked for several organic compounds such as PCB's and DDT.

Two stormwater samples were taken twice during the summer and analyzed for the heavy metals listed above. One sample was taken from the north inlet. The other was a composite, made up of water from the marina boat launch and the two rock-lined inflows near the walking path by the launch.

Metals

According to a past report of Lake Barrington, copper and mercury have been found in the sediments. These records did not state what the concentrations were. The specific date of this information was not stated, but is believed to have been recorded in 1982. In 1989, four metals were found in excess of what is considered normal. These are: cadmium, copper, nickel, and lead (see Appendix D). Even though these were high, there does not appear to be an immediate health hazard to humans. Superficial skin contact with the sediment is not a danger.

Cadmium

Cadmium has been found in almost all lakes the Health Department has sampled. Under certain conditions, cadmium can poison juvenile fish and invertebrates. Fortunately, these conditions do not exist in Lake Barrington. Unfortunately, no matter what the conditions, cadmium slows plant growth. It was found in Lake Barrington at all four sites on both sample dates. It may have entered the lake by any of the routes previously mentioned. This metal accumulates in fish, but usually in organs such as the liver and kidneys rather than the edible parts. It is rare for humans to be poisoned from eating contaminated fish. But because there is that chance, regulatory standards state that fish with over 0.5 milligrams per kilogram (mg/Kg) should not be eaten. The lab did not detect cadmium in the fish from Lake Barrington.

Copper

Copper was found in very high amounts. Copper does not pose a risk for humans eating fish, but it is dangerous to aquatic life. The normal concentration of copper in an Illinois lake sediment according to the Illinois EPA is 99 milligrams per kilogram (mg/Kg). The average concentration found in Lake Barrington was 271.4 mg/Kg. The highest concentration found was 400 mg/Kg in the North bay. In comparison, some industrial sources will produce about 500 mg/Kg of copper residue, and sewage disposal usually has less than or equal to 250 mg/Kg.

The high readings for Lake Barrington can be misleading. The Health Department was not informed that copper sulfate, an algicide, was sprayed in the lake shortly before the sediments and water were sampled. Therefore, the results may not indicate true conditions. Because of this, and the fact that copper has been found in the past, the sediment should be resampled for copper.

Copper is very toxic to invertebrates, such as crayfish and bottom-dwelling insects. Even though these animals are not the most glamorous, they are important in the lake as scavengers or decomposers. Mercury is the only heavy metal more dangerous to fish than copper. Knowing this, the benefits of using copper sulfate must be carefully weighed. An important publication from the Illinois State Water Survey should be read by all who are considering spraying copper sulfate. It is entitled, "Using Copper Sulfate to Control Algae in Water Supply Impoundments".

Nickel

All sample points except one had nickel in elevated levels. Nickel is not as harmful to fish and other aquatic life as the other metals. It also does not accumulate in the food chain. However, in combination with copper, and copper/zinc, nickel can pose a danger to fish. It is not well understood how nickel is taken up by fish. This metal could have reached the lake by stormwater runoff or atmospheric fallout.

Lead

Lead was found just outside the north inlet both times it was sampled. The concentrations fall in IEPA's "elevated" classification. Lead does not normally accumulate through the food chain like other metals or pesticides, but in cases of extreme pollution, can accumulate in the food chain. As with other metals, some forms of lead can be more toxic than others. There is not information that shows which species, which feeding habits, or which age groups are more susceptible than others.

Organic Chemicals

The sediments in Lake Barrington were also tested for organic chemicals such as PCB's and pesticides. Some of these are the chemicals that can be found in Lake Michigan fish. They are a threat to humans because like some metals, these compounds can enter our bodies directly from eating tainted fish. Other forms of life are also at risk. For example, DDE is a breakdown product of DDT, and is the principal culprit for the nation's decline of predatory birds. Mammals such as mink or bears can have reproductive failure or tumors. Both compounds are very persistent in the environment and can cause problems for years to come. The eggs and larvae of some fish can be damaged by DDT and DDE. As a result, in lakes and streams where these compounds are prevalent, fish can have trouble reproducing.

On the second sample date, small amounts of DDT and DDE were found at all sample sites. Note that none of the sample sites had these compounds reported on the first sample date. It is suspected that a laboratory interference may have distorted the results of the second set of samples.

Toxics in Fish

When people raise the concern about toxics in lake systems, their foremost concern for their own health should be with the fish they catch and eat. The fish from Lake Barrington were analyzed for PCB's, dieldrin, and DDE and organic compounds. Two results were reported for each fish: the edible fillet, and the whole body. All fish analyzed were found to be safe for consumption, below the U.S. Food and Drug Administration's (USFDA) health limits for these compounds.

These fish were also analyzed for the same heavy metals that were analyzed in the sediment. Mercury is the most dangerous of all metals for a person to ingest from a contaminated fish. None of the fish in Lake Barrington were found to contain concentrations of metals higher than the USFDA health standards.

Even though none of the fish from the lake were found to contain dangerous levels of toxics, it is important to monitor them about every three to five years to see if these levels have changed. This is an excellent preventative measure.

Stormwater

For both storm events, the sampled stormwater carried only trace or insignificant amounts of all metals to the lake. Most metals were found at concentrations that would be considered safe for drinking water.

CONCLUSIONS

Based on more than 630 measurements collected in the main body of the lake, (3 feet, 7 feet, and 11 feet below the surface), the north bay, and the north inlet from April to September 1989, the following conclusions were reached:

1. The clarity of the water was such that from April through July, an object could be seen to a depth of five feet or deeper. This is good, considering that the recommended guideline on clarity for safety reasons is four feet. The average Secchi disc reading for the season was 7.6 feet. However, during the months of August and September, it was not possible to see below a depth of four feet. This may be due excessive algae.
2. The stormwater flowing into the lake delivered high concentrations of suspended sediments on some occasions. If the sediment load is high enough over time, this can eventually cause shallowness and water clarity problems.
3. The amount of chlorophyll a in the water during the later summer months indicated an excessive amount of algae production. This creates nuisance conditions such as odor, low water clarity, and poor aesthetics and may limit recreational use of the lake.
4. Aquatic plants, or macrophytes, are overabundant throughout the lake. The two predominant plants are water milfoil and curlyleaf pondweed. Although plants are necessary for a healthy lake ecosystem, the heavy amount in Lake Barrington poses nuisance conditions and safety hazards. In addition, after they die, these plants contribute nutrients and other solid matter to the lake. The use of mechanical weed harvester has mitigated the impacts somewhat. Continuation of harvesting and a holistic long-term control program must be initiated.
5. There are high amounts (greater than 0.05 mg/L) of phosphorus in Lake Barrington's water. Concentrations were higher than that found during the summers of 1980 and 1981; however, it is inconclusive if the phosphorus concentration is increasing.

The high phosphorus concentration is one of the principal reasons why the lake is choked with plants. In order to slow the potential trend of increasing phosphorus, inputs from the watershed need to be curtailed. The lake sediments though, did not have high amounts of phosphorus. It appears that at this time of summer growth, most of the phosphorus in the system is in the water and in the plants themselves.

6. Overall, the water did not contain high amounts of nitrogen (above 0.3 ppm), the second most important nutrient for plant growth. This was encouraging. On the other hand, the sediments contained extremely high levels of nitrogen which may be contributing to the overabundant milfoil population (above 7850 ppm).
7. The stormwater flowing to the lake was found to deliver high levels of nutrients (greater than 0.3 mg/L nitrogen and 0.05 mg/L phosphorus) to the lake. These nutrients encourage plant growth, and in excessive amounts would sustain plant stands of nuisance proportions (See conclusion 4).
8. The dissolved oxygen in the lake during the months of April and May was sufficient for fish and other aquatic life. Oxygen was depleted below a depth of nine feet in May, however. During June and July, the lake had little oxygen - there was a depletion below five feet in June, and below three feet in July. Such conditions may stress the fish community. Conditions did not improve in August and September. Oxygen was depleted below six feet and seven feet, respectively.
9. Fecal coliform bacteria at the beach were at satisfactory levels during the summer. However, during and after a rain, stormwater from the north inlet and from the marina area were found to have unsatisfactory levels of these bacteria.
10. High amounts of cadmium, nickel, lead, and very high amounts copper were found in the lake sediments. None of the samples taken on the first date were reported to have any organic compounds. However, the laboratory reported two organic compounds, DDT and DDE, in all samples taken on the second sampling date. This may be due to a laboratory interference. The cadmium, nickel, and lead probably entered the lake through atmospheric deposition. Copper has been added from the frequent copper sulfate applications.

11. The fish were analyzed for various metals and for pesticides/ PCB's. All fish analyzed were found to have concentrations well below the U.S. Food and Drug Administration health standards for these toxics.
12. The fishery in Lake Barrington is in good condition. This is based on a collection that was taken during the summer of 1989 and past records.
13. The watershed is small for a lake this size. It is usually easier to manage stormwater run-off in a small watershed than in a larger one. Nearly 80 percent of the watershed is residential, a land use that can adversely impact the lake in several ways. Some examples are lawn chemicals, oil, gas, debris and garbage.
14. The compiled phosphorus, chlorophyll, and Secchi disc data from Lake Barrington classify the lake as being eutrophic. This means it is a productive lake in terms of plant/algae growth. (See Appendix C).

MANAGEMENT ALTERNATIVES

To preserve and enhance the quality of Lake Barrington, a cooperative and concerted effort must be made by the entire community. If the community does not engage in this unified effort, lake quality may deteriorate. The lake seems to be a major draw for people who consider living in the Lake Barrington Shores community. It is essential to improve the lake and preserve the property values from declining due to poor lake quality.
Management plans to correct lake problems can be complex and expensive. **Now that there have been at least three lake management reports completed with recommendations for this lake (and each agreeing on the state of the lake), enough knowledge has been gained to begin applying this information toward a comprehensive management of the lake.** It is crucial for people to understand that no lake management practice can stand alone as a "quick fix" for the total improvement of any lake. They need to establish realistic goals and management priorities and apply the appropriate practices to begin restoring lake conditions. **THIS TAKES TIME.**

It is also important that the lake not be managed like a swimming pool. Although pleasing aesthetics of a lake are important for many people, it is also important to recognize the lake as a living system. The many aspects of a lake make it impossible for it to exist solely for human enjoyment. The Health Department believes that Lake Barrington has the potential to be a model example for other lake communities if properly cared for. The following recommendations are listed approximately in order of their importance. However, the true priorities must be established by the Lake Barrington community.

Organization

1. A lake management body needs to be formed among the homeowners. This organization could then work closely with those at the James Company who are presently making lake management decisions. This would prepare the homeowners for the future responsibility of maintaining their own lake. Eventually this organization would work to maintain the lake on a permanent basis.

2. Keep a chronological log of all events relating to the lake's management and all data gathered on the lake's condition. Include dates, costs, quantities (e.g., of plants harvested, type and amount of chemicals applied, etc.), maps, and species (e.g., of fish stocked or plants treated). This recommendation has been given in previous reports.

Education

1. Because the lake's health is dependent upon the actions of residents and users, create a plan for ongoing community education. Consider such things as: a.) a feature series in the local newspaper; b.) a regular column in the town's/association's newsletter; c.) interpretive signs at lakefront beaches; d.) workshops; and e.) a brochure mailed to all households within the watershed. Consider youth education as well as adult education. The Lakes Management Unit is happy to share expertise in this area.
2. Because Lake Barrington frequently uses copper sulfate in the lake, the Health Department highly recommends the reading of Using Copper Sulfate to Control Algae in Water Supply Impoundments. This extremely informative eleven page booklet was written by the Illinois State Water Survey in 1989. Even though the title mentions control in impoundments, this information also applies to recreational lakes and ponds. One of the case studies in this manuscript is about Lake Catherine in Lake County. A copy of this booklet is at the back of this report. For more copies, call the Illinois State Water Survey and ask for Miscellaneous Publication 111 (217/333-4747).
3. Every lake manager, interested person, and lakefront property owner in the Lake Barrington area should join the Illinois Lake Management Association (ILMA). This is a statewide, not-for-profit educational service organization. ILMA provides educational services on lake management to its members. A yearly conference and an informative newsletter are geared toward those from both professional and nonprofessional backgrounds and who are interested in lake management. Contact Holly Hudson of the Northeast Illinois Planning Commission at 312/454-0400 for information on ILMA.

Watershed Practices

1. The soils in the watershed need to be analyzed for their nitrogen and phosphorus content in order to form a good lawn care program, and avoid over-fertilizing. The University of Illinois Extension Service can assist in interpretation of results, and development of a proper fertilization plan. There is a fee of about $5.00 for a soil test. Call 708/223-8627.
2. A vegetated buffer strip of unfertilized land next to the shoreline needs to be established. This strip should circle the lake shore, and be at least 20 feet wide. This recommendation has been given before. Some areas have this already, where the walking path has a vegetation strip next to the lake. Any applied fertilizer will move down the lawn and settle on the unfertilized portion. This will prevent the fertilizer from flowing into the lake and contributing to the algae/plant growth. The Soil Conservation Service can provide more information about buffer strips. Call 708/223-1057.
3. Stormwater flow needs to be controlled at the marina launch site and at an outflow pipe about 200 feet west of the launch. These are areas at which stormwater flows directly into the lake, bringing along sediment and nutrients. The pipe west of the launch cannot be seen directly from the walking path - it flows from the adjacent road over the path.
   a. The marina launch is extremely steep and delivers not only sediment and nutrients, but also petroleum by-products to the lake. The solid pavement could be replaced with porous material that would slow or prevent these materials from entering the water.
   b. The pipe needs to be diverted to the rock lined inflows or the water should be slowed by rocks, sod, or grasses.
4. Stormsewer grates and basins within the watershed on Highway 59 catch debris that can add nutrients, sediments, and other materials to the lake. Contact the Village for the present maintenance schedule of these catch basins. If not presently being done, they should be cleaned out regularly.

Macrophyte Control

It is obvious that Lake Barrington has a severe plant problem. Several management alternatives may help alleviate this:

1. Some lakes have had success in managing plants by dredging areas of high plant mass. This removes not only plant roots and seeds, but also essential plant nutrients in the sediments. It is recommended that sediment cores be taken to determine the depth of accumulated sediment and the depth of elevated nutrient concentrations within the sediment. Only the top one to two feet may need removal to achieve root, seed and nutrient removal. If this were done, shoreline plantings with native aquatic plants would help to discourage nuisance plants from reestablishing, and to keep sediments from clouding the water. This needs to be done in conjunction with the present harvesting. There are nurseries that have aquatic plants for these purposes. Call the Health Department or the Illinois Lakes Management Association for information on these nurseries.
2. Harvesting should be continued. In mid to late May, areas ten feet deep and over should be harvested, such as the southern portion. However, **NO BAYS** should be harvested during this month in order not to disturb spawning fish. In mid-June or July, most of the lake may need harvesting again. Harvesting is beneficial to the fishery as a population check - if this practice were to stop, Lake Barrington would soon have stunted fish. Plant growth should be limited to about 25 to 35 percent of the shoreline area for a healthy fishery. Unless there is still a heavy stand of plants, it is not necessary to harvest in late September, because most plants are beginning to die at this time. However, a late season harvesting will facilitate the removal of nutrients and oxygen demanding plant matter.
3. Vegetation mats are large sheets of various materials that act as sediment covers. They are placed on top of the sediments along the shoreline in areas inaccessible to harvesters. They could be used near the beach area, and near the boat launch. The advantages and disadvantages are as follows:

Advantages

1. Use is confined to a specific area.
2. They are out of sight and create no disturbance on shore.
3. They can be installed in areas where harvesters cannot reach.
4. No toxic materials are used.
5. They are easy to install over small areas.

Disadvantages

1. They do not correct the cause of the problem.
2. They are expensive.
3. They are difficult to apply over large areas or obstructions.
4. They may slip on steep grades. If gas impermeable ones are used, they may float to the surface if gases are trapped beneath them.
5. They may be difficult to remove or relocate.
6. They must be removed and cleaned every year.
7. They must be placed on the lake bottom very carefully so as not to tear.
8. Some materials may be degraded by sunlight.

Prices in 1988, not including application fees, ranged from $1,374/acre for common burlap to $8,700/acre for fiberglass PVC (Aquascreen). It must be noted that the burlap is effective, but only for one season, because it can start to decompose.

4. Grass carp (white amur) may be considered for this lake, but only with extreme care. These are non-native fish, and have been known to denude an entire lake of plants. An eradication of plants will cause a lake to become muddy, lose its healthy fishery, and be unable to support needed beneficial plants for fish and other organisms. Lake Barrington has an excellent fishery that would be degraded if grass carp were improperly stocked.

Herbicide Application

The Health Department discourages the indiscriminate use of aquatic herbicides. Man-made chemicals applied over time can be harmful to the environment. Herbicide treatment is only temporary and does not treat the cause of the problem, but only a symptom. Lake Barrington already has excessively high amounts of copper in the sediments. This is probably due to the previous application of copper-based herbicides. It was noted during the review of past management plans that copper was found in high levels.

In many cases, algae blooms develop after the lake recovers from herbicide treatment. In some instances, however, other means of algae control may not be effective. Lake Barrington may have to continue its use of herbicides for algae control. Several factors must to be considered before spraying.

1. The alkalinity in the water needs to be analyzed. Lake water with alkalinity over 40 milligrams per liter (mg/L) as calcium carbonate does not need more than 5.4 pounds of copper sulfate per acre. This is equivalent to 1.0 mg/L of copper sulfate for the top two feet of the lake **surface**, where most algae growth occurs. Lake Barrington is probably in the category of waters with high alkalinity, as are most Illinois lakes.
2. The days before and after spraying any area, the dissolved oxygen in the water needs to be measured. This recommendation has been stated in previous lake management reports about Lake Barrington. Measurements should be taken at the deepest point in the lake, and at every area where spraying would be considered. This measurement should be taken about five feet down at the deep hole, and halfway down to the bottom in other areas. Because the plants will quickly use up oxygen as they decompose, no spraying should be done in areas with under 5.0 mg/L dissolved oxygen. A fish kill would likely be the result.
   a. Health Department staff noticed the dissolved oxygen meter owned by the Lake Barrington staff was in poor condition. The instrument and the probe need to be serviced to see if they can give accurate readings. If not, they should be replaced. In any case, at least three people should know how to correctly use and maintain them.
   b. Because of the expense of this instrument, and in order to get accurate readings, regular maintenance (changing the membrane and solution every two weeks, etc.) needs to be done. If there are questions about instrument use and maintenance, contact the manufacturer or the Health Department's Lakes Management Unit.

3. The Health Department recommends harvesting instead of herbicide applications. A combination of harvesting and herbicide application would be better than the sole use of herbicides. For example, a small area such as the north bay could be harvested with as deep a cutting as possible, then treated with diquat. This way, there would be less biomass, or plant matter to decompose and release nutrients after the plants are killed. Consult with your herbicide applicator and harvesting consultant to determine the possibility of this option. Accurate written records should be kept to see what long term benefits result from combinations of herbicide/ harvesting treatments.
4. If spraying is still considered, only small areas should be treated at a time. This will help protect the fish. This recommendation has been given before in other lake management reports on Lake Barrington.

Monitoring

1. Dissolved oxygen should be measured at the lake's deepest point, and three other areas in the lake. These other areas could be in the north bay, near the inlet on the north side, and in the southern area off the beach. It should be measured not only every two weeks in the summer months, but also once a month from October through March if possible. This could warn of an impending fish kill if the oxygen drops too low. If the lake has a tendency to have dangerous oxygen levels in winter, installation of an aerator may again be reconsidered. If an aerator is installed, residents should be warned that during the winter, the ice may be dangerously thin.
2. Because the sediments have been subjected to large amounts of copper from frequent copper sulfate applications, sediment samples should be analyzed about every five years to see if there are any changes in concentration. Remember that copper is highly toxic to bottom dwelling organisms and fish. The analyses should include arsenic, cadmium, chromium, lead, mercury, nickel, and zinc. The sediments also should be analyzed for pesticides such as DDT. Because DDT

and DDE were found at all sample sites but only on one sample date, subsequent samples should be collected at these same sites. Other samples should be taken at different areas to see if there is a trend. Contact the Lake County Health Department for suggestions about other locations.

3. The fish should be sampled and analyzed for heavy metals such as mercury, and pesticides such as DDT every three to five years. This is a preventative measure for the protection of anglers who eat their catch.
4. The water at the deepest point in the lake and in the north bay should be monitored for nutrients and chlorophyll a to note any changes. This may be done between the months of May and September as often as is financially feasible. Over time, if these levels increase, it is a signal that the ongoing management practices are not being effective and need to be redirected.

The Fishery

The following recommendations have been drafted by the Illinois Department of Conservation, Division of Fisheries and the Lake County Health Department. These can also be found in the text of this report. Some have been suggested in the past.

1. Continue harvesting the lake's plants in a systematic manner. This will provide cruising lanes for the predatory fish in order that they can prey on the panfish as well as open up the lake to more recreational activities. This will prevent the panfish population from becoming overpopulated and stunted. Harvesting also helps control the panfish population by removing the stunted fish with the plants. The reduction of plant cover to 25 to 30 per cent of the lake's surface would be ideal for a healthy fishery.
2. Encourage anglers to keep all the panfish they catch. Disposal bins should be provided at boat launches. No matter what the size, these fish should not be thrown back.
3. Keep largemouth bass populations healthy by setting a fourteen inch size limit and by stocking supplemental fish. Other protective measures that can be used are to decrease the allowed bag limit or to encourage a catch and release program.

4. Initiate a supplemental stocking program of northern pike, muskellunge, or channel catfish. These will provide a more diverse recreational fishery, and will more effectively control the panfish and other forage fish.
5. The carp population is presently under control. However, if the population were to explode, management steps would need to be taken. Holding carp fishing derbies, and seine netting these fish in the shallow areas during spawning would help. Like the panfish, carp should never be thrown back when caught.
6. The dissolved oxygen should be monitored periodically throughout the summer, and in winter if possible. If herbicides or algicides are to be used, measure the dissolved oxygen in the water before and after any treatment. If the oxygen reads below 5 ppm at a depth halfway down to the bottom, it may be unwise to use a herbicide treatment. As plants die, they can rapidly use up oxygen, and cause stress or death for the fish.

Wetlands

Wetlands offer significant benefits to any lake. They preserve shorelines from erosion, filter inflowing stormwater from sediments, nutrients, and other pollutants, and offer spawning grounds for gamefish such as northern pike.

1. The small wetland area on the east side of the lake across from the deepest point (sample site 1) should not be disturbed. Gamefish may use this area for spawning.
2. The small isolated bay on the northeast side just below the north bay should be cleaned out and planted with native wetland species to create a fish sanctuary for spawning. Many native aquatic plants are beautiful in bloom. Contact the Illinois Lakes Management Association for information regarding wetland consultants and nurseries.

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APPENDIX A

SOILS WITHIN THE LAKE BARRINGTON AREA

As the glaciers in Lake County melted and retreated to the north, they left in their wake massive amounts of unconsolidated deposits, consisting primarily of sand, silt, and clay. This material formed the topography that we see today, and became the parent materials of the soils in Lake County.

In the Lake Barrington watershed, the upland soils formed in two types of deposits - glacial till and outwash. The glacial till is made up primarily of a highly compacted and unsorted mix of sand, silt, and clay, along with some pebbles and rocks. The particle composition varies from area to area in the county. Outwash deposits, on the other hand, formed as streams flowed from glacial meltwaters, allowing the mixture to be sorted.

The glacial till soils are found throughout Lake Barrington's watershed. In the western half, they are characterized by being formed from silty deposits and the underlying glacial material of silt-loam, loam, and/or sand. They have slopes ranging from 4 to 30 percent. These soils are moderately well to well drained, and have a seasonally high water table usually 3 feet below the surface in the spring. Soil permeability is moderate for most of the area, but in some places it is moderately slow. The available moisture holding capacity is high for all but the sandier soils where it is only moderate. On the steeper slopes, surface water run-off is rapid, and erosion can be a serious problem.

Glacial till soils found along the remainder of the watershed are characterized by being formed in the silty deposits and the underlying till of silty clay loam texture. They have moderately slow permeability and a high available moisture capacity. Drainage varies from somewhat poorly drained to moderately well drained. The depth to the seasonally high water table for poorly drained soils is between 1 and 3 feet. The seasonally high water table for the moderately drained soils is deeper than 3 feet below ground. The soil slopes range from 2 percent to 25 percent.

Soils in the watershed that formed in outwash plain deposits are found primarily east of the lake. They were developed in two to three feet of silty material. Underlying this layer is stratified silt and sand. These soils range from somewhat poorly drained to well drained. The depth to the sesonally high water table is one to three feet, and greater than three feet, respectively. The permeability is moderate, and the available moisture capacity is high. The slopes for this soil type range from 2 percent to 7 percent. Erosion can be a problem on the steeper portions.

Soils found in the depressional areas within the watershed were formed from the materials left behind from glacial meltwaters. These soils are poorly to very poorly drained, with the seasonally high water table at or near the surface in the spring. The water table usually is within one foot of the surface throughout the year for very poorly drained soils. For those that are poorly drained, the water table is between one and four feet of the surface. The permeability of these soils ranges from moderate to moderately slow, with a high available moisture capacity.

APPENDIX B

WATER QUALITY RESULTS COLLECTED FROM LAKE BARRINGTON

Sampling Date:	April 19, 1989
Wind, Speed & Direction:	2 - 3 mph, NNW
Rain < 24 hrs.:	Yes
Secchi Disc:	13 feet

Location:	pH*	DO@	BOD	NH_3	NO_3	TKN	PO_4	P	TSS	TS	VS	FC**	Chl a***
Station 1	9.3	13.2	1.0	<0.10	< 0.05	0.70	<0.01	0.01	5.0	110.00	30.00	<10.00	2.00
Station 2	9.3	13.1	0.7	<0.10	0.05	1.20	0.01	0.01	2.0	106.00	56.00	<10.00	1.87
Station 3	9.3	13.1	0.9	<0.10	<0.05	---	<0.01	<0.01	2.0	114.00	84.00	<10.00	0.00
Station 4	9.2	12.1	0.9	<0.10	0.08	---	<0.01	0.02	13.0	362.00	184.00	<10.00	1.87
Station 5	9.9	15.4	0.8	<0.10	<0.05	---	<0.01	0.01	8.4	88.00	26.00	<10.00	2.27

Sampling Date:	May 17, 1989
Wind, Speed & Direction:	5 - 8 mph, SSE
Rain < 24 hrs.:	No
Secchi Disc:	13 feet

Location:	pH*	DO@	BOD	NH_3	NO_3	TKN	PO_4	P	TSS	TS	VS	FC**	Chl a***
Station 1	10.2	13.1	<1.0	<0.10	<0.05	---	<0.01	0.02	2.0	202.00	174.00	<10.00	0.53
Station 2	10.1	12.8	<1.0	<0.10	<0.05	---	<0.01	0.02	13.0	133.00	37.00	<10.00	1.07
Station 3	9.4	6.3	1.0	<0.10	<0.05	---	<0.01	0.02	13.0	202.00	140.00	<10.00	2.94
Station 4	10.5	14.5	<1.0	<0.10	<0.05	---	<0.01	0.04	4.2	224.00	148.00	<10.00	1.20
Station 5		NO FLOW - NO SAMPLE COULD BE TAKEN											

Station Descriptions: 1 = Deep Hole, 3 feet, 2 = Deep Hole, 7 feet, 3 = Deep Hole, 11 feet, 4 = north bay, 5 = north inlet
* pH expressed as hydrogen ion concentration; mean expressed as median, standard deviation not applicable
** Fecal Coliform expressed as number of colonies per 100 ml
*** Cholorophyll a expressed as mg/m^3
@ D.O. measurements are from the Winkler Method
Other parameters described as mg/L

APPENDIX B

WATER QUALITY RESULTS COLLECTED FROM LAKE BARRINGTON

Sampling Date:	June 21, 1989
Wind, Speed & Direction:	5 - 8 mph SSW
Rain < 24 hrs.:	No
Secchi Disc:	8' 3"

Location:	pH*	DO@	BOD	NH_3	NO_3	TKN	PO_4	P	TSS	TS	VS	FC**	Chl *a****
Station 1	8.9	7.4	<1.0	<0.10	<0.05	---	0.08	0.11	2.0	292.00	134.00	<10.00	2.94
Station 2	8.8	4.8	1.0	<0.10	<0.05	---	0.08	0.12	2.4	299.00	138.00	10.00	2.54
Station 3	8.4	0.2	7.0	0.16	<0.05	---	0.15	0.21	16.0	330.00	150.00	10.00	11.10
Station 4	8.8	9.6	1.0	<0.10	<0.05	---	0.07	0.10	1.0	330.00	142.00	<10.00	2.27
Station 5		NO FLOW - NO SAMPLE COULD BE TAKEN											

Sampling Date:	July 26, 1989
Wind, Speed & Direction:	3 - 7 mph, S
Rain < 24 hrs.:	Yes
Secchi Disc:	5' ##

Location:	pH*	DO@	BOD	NH_3	NO_3	TKN	PO_4	P	TSS	TS	VS	FC**	Chl *a****
Station 1	8.7	5.80	2.0	0.50	0.07	1.6	0.09	0.17	2.4	266.00	126.00	40.00	6.14
Station 2	8.7	4.77	2.0	0.49	0.06	---	0.10	0.19	2.6	281.00	110.00	40.00	13.40
Station 3	8.5	0.87	1.8	0.85	0.05	---	0.28	0.41	4.0	290.00	112.00	50.00	5.47
Station 4	8.9	6.77	2.4	<0.10	0.00	---	0.30	0.23	2.0	268.00	116.00	<10.00	9.88
Station 5	NO FLOW - NO SAMPLE COULD BE TAKEN												

Station Descriptions: 1 = Deep Hole, 3 feet, 2 = Deep Hole, 7 feet, 3 = Deep Hole, 11 feet, 4 = north bay, 5 = north inlet
* pH expressed as hydrogen ion concentration; mean expressed as median, standard deviation not applicable
** Fecal Coliform expressed as number of colonies per 100 ml
*** Cholorophyll *a* expressed as mg/m^3
@ D.O. measurements are from the Winkler Method
Secchi data from 1989 Volunteer Lakes Management Program
Other parameters described as mg/L

APPENDIX B

WATER QUALITY RESULTS COLLECTED FROM LAKE BARRINGTON

Sampling Date:	August 23, 1989
Wind, Speed & Direction:	5 - 8 mph NW
Rain <24 hrs.:	Yes
Secchi Disc:	3' 7"

Location:	pH*	DO@	BOD	NH_3	NO_3	TKN	PO_4	P	TSS	TS	VS	FC**	Chl *a****
Station 1	9.1	7.77	3.0	<0.1	0.05	1.4	0.06	0.13	6.4	306.00	120.00	20.00	18.20
Station 2	9.0	6.23	2.0	<0.1	0.05	---	0.16	0.22	4.0	300.00	110.00	20.00	14.50
Station 3	8.2	0.20	5.0	1.1	0.05	---	0.33	0.40	6.0	300.00	140.00	40.00	11.60
Station 4	9.3	9.58	3.0	<0.1	<0.05	---	0.05	0.09	6.4	286.00	96.00	<10.00	17.60
Station 5	8.0	5.70	2.0	<0.1	0.38	---	0.01	0.03	70.0	776.00	320.00	>680.00	0.67

Sampling Date:	September 20, 1989
Wind, Speed & Direction:	0 - 3 mph SW
Rain < 24 hrs.:	Yes
Secchi Disc:	3'

Location:	pH*	DO@	BOD	NH_3	NO_3	TKN	PO_4	P	TSS	TS	VS	FC**	Chl *a****
Station 1	9.1	13.70	6.0	0.24	0.06	3.1	0.05	0.17	12.00	304.00	138.00	<10.00	17.90
Station 2	8.6	6.03	3.0	0.11	0.05	---	0.07	0.19	8.80	297.00	123.00	<10.00	16.40
Station 3	8.2	2.41	2.0	0.19	0.05	---	0.10	0.21	12.00	292.00	122.00	<10.00	21.20
Station 4	9.1	5.36	6.0	0.27	0.06	---	0.05	0.24	13.00	296.00	118.00	<10.00	17.40
Station 5	7.9	13.70	3.0	0.12	0.21	---	<0.01	0.08	40.00	642.00	210.00	430.00	4.14

Station Descriptions: 1 = Deep Hole, 3 feet, 2 = Deep Hole, 7 feet, 3 = Deep Hole, 11 feet, 4 = north bay, 5 = north inlet
* pH expressed as hydrogen ion concentration; mean expressed as median, standard deviation not applicable
** Fecal Coliform expressed as number of colonies per 100 ml
*** Cholorophyll *a* expressed as mg/m^3
@ D.O. measurements are from the Winkler Method
Other parameters described as mg/L

APPENDIX B

WATER QUALITY RESULTS COLLECTED FROM LAKE BARRINGTON

RAIN EVENT DATA
Sample Date: June 12, 1989

Location:	ph*	NH_3	NO_3	PO_4	P	TSS	TS	FC**
Marina composite	7.9	<0.1	0.95	0.05	0.15	59.0	368.0	1900.0
north inlet	7.8	<0.1	0.23	<0.01	0.03	36.0	772.0	1900.0

RAIN EVENT DATA
Sample Date: August 4, 1989

Location:	ph*	NH_3	NO_3	PO_4	P	TSS	TS	FC**
Marina composite	7.8	<0.1	2.42	0.11	0.25	21.0	566.0	1800.0
north inlet	7.5	<0.1	2.01	0.01	0.03	12.0	770.0	>2900.0

* pH expressed as hydrogen ion concentration; mean expressed as median, standard deviation not applicable
** Fecal Coliform expressed as number of colonies per 100 ml
Other parameters described as mg/L

APPENDIX B

WATER QUALITY RESULTS COLLECTED FROM LAKE BARRINGTON

SUMMARY STATISTICS FOR ALL IN-LAKE SAMPLES

Location:	pH*	DO@	BOD	NH_3	NO_3	PO_4	P	TSS	TS	VS	FC**	Chl a***
Average	9.00	8.3	2.30	0.21	0.07	0.06	0.13	10.1	185.0	126.0	56.0	7.67
Standard Deviation	0.65	4.6	1.78	0.25	0.07	0.08	0.11	14.3	145.0	58.0	148.0	6.90
Maximum	10.50	15.4	1.00	0.85	0.38	0.01	0.41	70.0	776.0	320.0	680.0	21.20
Minimum	7.90	0.2	7.00	0.10	0.05	0.33	0.01	1.0	88.0	26.0	10.0	0.00

Station Descriptions: 1 = Deep Hole, 3 feet, 2 = Deep Hole, 7 feet, 3 = Deep Hole, 11 feet, 4 = north bay, 5 = north inlet
* pH expressed as hydrogen ion concentration; mean expressed as median, standard deviation not applicable
** Fecal Coliform expressed as number of colonies per 100 ml
*** Cholorophyll _a_ expressed as mg/m^3
@ D.O. measurements are from the Winkler Method
Other parameters described as mg/L

APPENDIX C

TROPHIC STATE INDEX

The Trophic State Index (TSI) is used to categorize the lakes according to how nutrient enriched or how productive they are in terms of plant growth. The basic categories are oligotrophic, mesotrophic, eutrophic and hypereutrophic.

An example of an oligotrophic lake is one that has very little plant or algae growth. The nutrients in these lakes are very limited, and do not offer plants the ability to grow in large stands. They are generally deeper lakes and support a cold water fishery. In the Midwest, oligotrophic lakes are found in northern Wisconsin and Minnesota. Very few are found in Illinois.

A mesotrophic lake is one in which the nutrients are somewhat more available, biological activity is also greater. The water clarity may not be as good as the clarity in an oligotrophic lake. An example of a mesotrophic lake is Cedar Lake in Lake County.

A eutrophic lake is very productive. They are not necessarily poor quality lakes, but they may have noticeable stands of large plants and algae that can be of nuisance proportions. Nutrients are readily available, and the water clarity is between 1.5 feet and 6.5 feet. Most of the lakes in this county are eutrophic, with Lake Barrington being one of them.

A hypereutrophic lake has overgrown plants and/or large algae blooms that create a severe nuisance problem. The lake may look pea soup green. The amount of nutrients in the water is excessive, and the water clarity is under two feet. Nearby Grassy Lake is hypereutrophic.

The trophic state is determined by measuring total phosphorus, chlorophyll a values, and water clarity. The Lakes Management Unit calculated TSI values using Carlson's (1977) Index. This Index assigns lakes with a number between 0 and 100. The higher the TSI number, the higher the trophic state. Lakes with TSI values over 50 are considered nutrient rich and productive, and are classified as eutrophic. Each increase of 10 units represents a doubling of plant/algae biomass.

Carlson's TSI must be used with caution, however. When plants are heavy but algae is not, the plant roots stabilize the sediments. This way, they are not swept up into the water by wind or wave action, and the water is relatively clear. The TSI for the Secchi disc, then, can place the lake in a lower trophic state. If this is the case, a lake manager must take into account that the overabundance of plants still points to a nutrient rich, or eutrophic condition.

Lake Barrington fits this last description. The seasonal TSI of chlorophyll a, 50.6, indicates the lake is just into the eutrophic range (Table 1). The seasonal Secchi disc, 47.9, classifies the lake as mesotrophic. On the other hand, the seasonal total phosphorus TSI, 74.6, classifies Lake Barrington as hypereutrophic. The average of these numbers gives a reading in the eutrophic category. Note that the TSI numbers rise quite dramatically after the month of June. The months from July through September are the months of highest plant growth.

The comparison of TSI values of neighboring lakes can help put the water quality of Lake Barrington into perspective (Table 2). The TSI values of Tower Lake, Honey Lake, and Grassy Lake were all measured in 1988. The seasonal Secchi disc TSI and chlorophyll a TSI for Lake Barrington were lower than all three neighboring lakes. The total phosphorus TSI for Lake Barrington, though, was much higher than the value in Honey Lake and in Tower Lake. Grassy Lake, with its severe algae problem, was the highest.

Table 1. Carlson's Trophic State Index.

Trophitate	TSI	Secchi Disc (in)	Total Phosphorus (mg/L)	Chlorophyll a (mg/L)
Oligotrophic	0 - 40	>145	0 - 0.012	0 - 2.5
Mesotrophic	40 - 50	79 - 145	0.012 - 0.025	2.5 - 7.5
Eutrophic	50 - 70	- 79	0.025 - 0.100	7.5 - 55
Hypereutrophic	> 70	0 - 18	> 0.100	> 55

1989 TSI Calculations for Lake Barrington

Month	TSI Secchi	TSI Total Phosphorus	Total Chlorophyll a
April	40.2	42.4	35.2
May	40.2	53.2	34.2
June	45.8	75.4	45.8
July	53.9	84.1	51.8
August	58.8	78.8	55.4
September	61.4	79.1	57.4
Seasonal Average	47.9	74.6	50.6

Table 2. Comparison of TSI Results of Nearby Lakes*

	Lake Barrington	Tower Lake	Honey Lake	Grassy Lake
TSI Secchi Disc Index	47.9	70.1	50.9	76.6
TSI Total Phosphorus	74.6	63.3	58.9	80.1
TSI Chlorophyll a	50.6	62.1	53.9	82.1

* Seasonal averages

NOTE: Data for Tower, Honey, and Grassy Lakes were all collected during the 1989 sampling season.

APPENDIX D

TOXIC ANALYSES RESULTS FOR LAKE BARRINGTON SEDIMENTS

LAKE BARRINGTON - Deep Hole, Site 1

SAMPLE DATE	June 21, 1989	Sept. 20, 1989	Units
Cadmium	2.78	3.84	mg/Kg
Hex. Chromium	<0.59	2.23	mg/Kg
Copper	129.00	254.00	mg/Kg
Lead	44.70	58.20	mg/Kg
Nickel	22.90	36.2	mg/Kg
Zinc	129.00	123.00	mg/Kg
Arsenic	5.17	5.38	mg/Kg
Mercury	<0.06	<0.07	mg/Kg
Aldrin	<0.20	<0.20	PPB
Alpha BHC	<0.20	<0.20	PPB
Beta BHC	<0.20	<0.20	PPB
Gamma BHC	<0.20	<0.20	PPB
Delta BHC	<0.20	<0.20	PPB
Chlordane	<0.20	<0.20	PPB
4,4'-DDT	<0.20	26.00	PPB
4,4'-DDE	<0.20	0.50	PPB
4,4'-DDD	<0.20	<0.20	PPB
Dieldrin	<0.20	<0.20	PPB
Endosulfan I	<0.20	<0.20	PPB
Endosulfan II	<0.20	<0.20	PPB
Endosulfan Sulfate	<0.20	<0.20	PPB
Endrin	<0.20	<0.20	PPB
Endrin Aldehyde	<0.20	<0.20	PPB
Hecptachlor	<0.20	<0.20	PPB
Heptachlor Epoxide	<0.20	<0.20	PPB
Toxaphene	<0.20	<0.20	PPB
PCB's	<1.00	<1.00	PPM
TOC	94118.00	66923.00	mg/Kg
Total Solids	17%	13%	

APPENDIX D

TOXIC ANALYSES RESULTS FOR LAKE BARRINGTON SEDIMENTS

LAKE BARRINGTON - North Bay, Site 2

SAMPLE DATE	June 21, 1989	Sept. 20, 1989	Units
Cadmium	3.00	3.40	mg/Kg
Hex. Chromium	2.72	3.20	kmg/Kg
Copper	400.00	320.00	mg/Kg
Lead	65.50	39.00	mg/Kg
Nickel	20.00	36.00	mg/Kg
Zinc	118.00	130.00	mg/Kg
Arsenic	7.27	7.50	mg/Kg
Mercury	<0.09	<0.10	mg/Kg
Aldrin	<0.20	<0.20	PPB
Alpha BHC	<0.20	<0.20	PPB
Beta BHC	<0.20	<0.20	PPB
Gamma BHC	<0.20	<0.20	PPB
Delta BHC	<0.20	<0.20	PPB
Chlordane	<0.20	<0.20	PPB
4,4'-DDT	<0.20	13.00	PPB
4,4'-DDE	<2.00	0.50	PPB
4,4'-DDD	<2.00	<2.00	PPB
Dieldrin	<2.00	<2.00	PPB
Endosulfan I	<2.00	<2.00	PPB
Endosulfan II	<0.20	<0.20	PPB
Endosulfan Sulfate	<0.20	<0.20	PPB
Endrin	<2.00	<2.00	PPB
Endrin Aldehyde	<0.20	<0.20	PPB
Heptachlor	<0.20	<0.20	PPB
Heptachlor Epoxide	<0.20	<0.20	PPB
Toxaphene	<0.20	<0.20	PPB
PCB's	<1.00	<1.00	PPM
TOC	127273.00	110000.00	mg/Kg
Total Solids	11%	10%	