BIG ROCHE A CRI LAKE
LAKE CLASSIFICATION REPORT

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EXECUTIVE SUMMARY

Background Information about Big Roche a Cri Lake

Big Roche a Cri Lake is located in Adams County in south central Wisconsin and is a 215-acre impoundment (man-made) lake located in the Town of Preston, Adams County, in the Central Sand Plains Area of Wisconsin. This lake is formed by an impoundment of Big Roche a Cri Creek. Big Roche a Cri Creek ultimately empties into the Wisconsin River. The Little Roche a Cri Creek watershed is large, covering 177 square miles and extending into the next county east of Adams. Big Roche a Cri Lake has two public boat ramps, one owned by the county near the dam; the other a rough ramp near Highway 13. There are several Native American archeological and American historical sites located in the Big Roche a Cri Lake watersheds that cannot be further disturbed without permission of the federal government an/or input from the local tribes.

The primary soil type in both the surface and ground watersheds is loamy sand. The second most common soil type in both watersheds is sand. There are also pockets of muck, sand loam, and silt loam, along with gravel pits and landfills.

Loamy sands tend to be well-drained, with water, air and nutrients moving through them at a rapid rate. Runoff, when it occurs, tends to be slow. Loamy sands have little water-holding capacity and low natural fertility, although they usually have more organic matter present than do sandy soils. Both wind and water erosion are potential hazards with loamy sands, as is drought. There are difficulties with waste disposal and vegetation establishment because of slope and seepage.

Land Use in Big Roche a Cri Lake Watersheds

Both the surface and ground watersheds for Big Roche a Cri Lake are fairly large. Big Roche a Cri Lake also receives significant input of materials from the large upper watershed. In both the surface and ground watersheds, the main two land use types are Woodlands and Irrigated Agriculture.

Big Roche a Cri Lake has a total shoreline 6.1 miles (32,208 feet). Much of the lakeshore is in residential use. Many of the areas near the shore are very sandy and steeply sloped. A 2004 shore survey revealed that 64% of Big Roche a Cri Lake's shoreline is vegetated. The rest of the shore is a mix of active erosion, sand, rock and/or other hard structure. Since the survey was done, Big Roche a Cri Lake District was awarded a lake management plan implementation grant that allowed several property owners to install shore protection practices to reduce some of the erosion. It has recently applied for an additional grant to address properties not previously covered.

The 2004 inventory included classifying areas of the Big Roche a Cri Lake shorelines as having “adequate” or “inadequate” buffers. An “adequate” buffer was defined as one having the first 35 feet landward covered by native vegetation. An “inadequate” buffer was anything that didn’t meet the definition of “adequate buffer”, including native vegetation strips less than 35 feet landward. Using these definitions, only 33.6% (10821.89 feet) of Big Roche a Cri Lake’s shoreline had an “adequate buffer” in 2004, leaving 66.4% (21386.11 feet) as “inadequate.” Most of the “inadequate” buffer areas were found with mowed lawns and/or insufficient native vegetation at the shoreline to cover 35 feet landward from the water line.

Adequate buffers on Big Roche a Cri Lake in some places could be easily installed on the inadequate areas by either letting the first 35 feet landward from the water just grow without mowing it, except for a path to the water, or by planting native seedlings sufficient to fill in the first 35 feet or using biologs to protect the shore that are vegetated. Where areas are deeply eroded, shaping, revegetating and protecting the shores will be necessary to prevent further erosion.

<u>Water Testing Results</u>

Between 2004 and 2006, Adams County Land & Water Conservation Department gathered water chemistry and other water quality information on Big Roche a Cri Lake. Overall, Big Roche a Cri Lake was determined to be a mildly eutrophic lake with fair to good water quality and good water clarity.

Measuring the phosphorus in a lake system provides an indication of the nutrient level in a lake. Increased phosphorus in a lake will feed algal blooms and also may cause excess plant growth. The 2004-2006 summer average phosphorus concentration in Big Roche a Cri Lake was 33.91 micrograms/liter. This average is over the 30 micrograms/liter level recommended to avoid nuisance algal blooms. This concentration suggests that Big Roche a Cri Lake is likely to have nuisance algal blooms from excessive phosphorus.

Water clarity is a critical factor for plants. If plants don’t get more than 2% of the surface illumination, they won’t survive. Water clarity is measured with a Secchi disk. Average summer Secchi disk clarity in Big Roche a Cri Lake in 2004-2006 was 7.19 feet. This is good water clarity.

Chlorophyll-a concentration provides a measurement of the amount of algae in a lake’s water. Algae are natural and essential in lakes, but high algal populations can increase water turbidity and reduce light available for plant growth, as well as result in unpleasing odor and appearance. The 2004-200 growing season (June-September) average chlorophyll-a concentration in Big Roche a Cri Lake was 14.15 micrograms/liter, a fairly low algal concentration for an impoundment.

Big Roche a Cri Lake water testing results showed "hard" water with an average of 145 milligrams/liter CaCO3. Hard water lakes tend to produce more fish and aquatic plants than soft water lakes because they are often located in watersheds with soils that load phosphorus into the lake water.

A lake with a neutral or slightly alkaline pH like Big Roche a Cri Lake is a good lake for fish and plant survival. Natural rainfall in Wisconsin averages a pH of 5.6. This means that if the rain falls on a lake without sufficient alkalinity to buffer that acid water coming in by rainfall, the lake's fish cannot reproduce. That is not a problem at Big Roche a Cri Lake, since its surface water alkalinity averages 103.2 milliequivalents/liter. The pH levels from the bottom of the lake to the surface hovered between nearly 7 and 8, alkaline enough to buffer acid rain.

Most of the other water quality testing at Big Roche a Cri Lake showed no areas of concern. The average calcium level in Big Roche a cri Lake's water during the testing period was 33.63 milligrams/liter. The average Magnesium level was 14.94 milligrams/liter. Both of these are low-level readings. Both sodium and potassium levels in Big Roche a Cri Lake are very low: the average sodium level was 2.17 milligrams/liter; the average potassium reading was 2.02 milligrams/liter.

To prevent the formation of hydrogen sulfate gas, levels of 10 milligrams/liter are best. A health advisory kicks in at 30 milligrams/liter. Sulfate levels in Big Roche a Cri Lake are 21.61 milligrams/liter, above the level for formation of hydrogen sulfate, but below the health advisory level. Turbidity reflects water clarity. The term refers to suspended solids in the water column—solids that may include clay, silt, sand, plankton, waste, sewage and other pollutants. Very turbid waters may not only smell and mask bacteria & other pollutants, but also tend to be aesthetically displeasing, thus curtailing recreational uses of the water. Turbidity levels for Big Roche a Cri Lake were at low levels between 2004-2006.

Some water testing results indicated a need to continue monitoring the nutrients to make sure no problems are developing. The presence of a significant amount of chloride over a period of time may indicate that there are negative human impacts on the water quality present from septic system failure, the presence of fertilizer and/or waste, deposition of road-salt, and other nutrients. Chloride levels found in Big Roche a Cri Lake during the testing period averaged 4.43 milligrams/liter, considerably over the natural level of 3 milligrams/liter for this region of Wisconsin. This issue needs to be further investigated to see if the high chloride readings are indicative of some other problem.

Nitrogen levels can affect other aspects of water quality. The sum of water testing results for nitrate, nitrite and ammonium levels of over .3 milligrams/liter in the spring can be used to project the likelihood of an algal bloom in the summer (assuming sufficient phosphorus is also present). Big Roche a Cri Lake's combination spring levels from 2004 to 2006 average 3.23 milligrams/liter, considerably above the .3 milligrams/liter predictive level. This could be a problem because the growth level of Eurasian watermilfoil, the main invasive aquatic plant species in Big Roche a Cri Lake, has been correlated with fertilization of lake sediments by nitrogen-rich runoff.

Phosphorus

Like most lakes in Wisconsin, Big Roche a Cri Lake is a phosphorus-limited lake: of the pollutants that end up in the lake, the one that most affects the overall quality of the lake water is phosphorus. The amount of phosphorus especially affects the frequency and density of aquatic vegetation and the frequency and density of various kinds of algae, as well as water clarity and other water quality aspects.

The total phosphorus (TP) concentration in a lake is considered a good indicator of a lake's nutrient status, since the TP concentration tends to be more stable than other types of phosphorus concentration. For a man-made lake like Big Roche a Cri Lake, a total phosphorus concentration below 30 micrograms/liter tends to result in few nuisance algal blooms. Big Roche a Cri Lake's growing season (June-September) surface average total phosphorus level of 33.91 micrograms/liter is over that limit, suggesting that phosphorus-related nuisance algal blooms may occur.

Land use plays a major role in phosphorus loading. The land uses around Big Roche a Cri Lake that contribute the most phosphorus are irrigated and non-irrigated agriculture. Some phosphorus deposition cannot be controlled by humans. However, some phosphorus (and other nutrient) input can be decreased or increased by changes in human land use patterns. Practices such as shoreland buffer restoration along waterways; infiltrating stormwater runoff from roof tops, driveways and other impervious surfaces; using no phosphorus lawn fertilizers; and reducing phosphorus input to and properly managing septic systems will minimize phosphorus inputs into the lake. Such practices need to be implemented in all of the Big Roche a Cri Creek Watershed in order for a significant impact on phosphorus reduction to occur.

Reducing the amount of input from the surface and ground watersheds results in less nutrient loading into the lake itself. Under the modeling predictions, reducing phosphorus inputs from human-based activities even 10% could improve Big Roche a Cri Lake water quality by up to 10 micrograms and bring the average eplimnetic TP down to 32.1 micrograms/liter. A 25% reduction could save up to 26 micrograms/liter and which would reduce the overall eplimnetic growing season total phosphorus to 26.7 micrograms/liter, under the 30 micrograms/liter recommended to avoid nuisance algal blooms) in total phosphorus levels that algal blooms would be greatly reduced. These predictions make it clear that reducing current phosphorus inputs to the lake are essential to improve, maintain and protect Big Roche a Cri Lake's health for future generations.

Aquatic Plant Community

The aquatic plant community is characterized by below average quality for Wisconsin lakes, good species diversity and impacted by high levels of disturbance. Big Roche-a-Cri Lake is within the 25% of lakes in the state most tolerant of disturbance and furthest from an undisturbed condition. Disturbances include invasions of exotic species, boat traffic, shoreline development, harvesting and past herbicide treatments.

In 2004, *Ceratophyllum demersum* (coontail) was the most frequently occurring aquatic plant species in Big Roche-a-Cri Lake in 2004. *Elodea canadensis* (common watermeal), *Lemna minor* (small duckweed), *Myriophyllum sibiricum* (northern watermilfoil), *Potamogeton zosteriformis* (flat-stemmed pondweed) and *Vallisneria americana* (water celery) were also commonly occurring species.

Vallisneria americana was the species with the highest mean density in Big Roche-a-Cri Lake. Where *Vallisneria americana* occurred, it exhibited a growth form of above average density in Big Roche-a-Cri Lake. *Carex comosa* (bristly sedge), *Elodea canadensis* and *Wolffia columbiana* (common watermeal) also exhibited a growth form of above average density.

Two invasive species—*Myriophyllum spicatum* (European watermilfoil) and *Potamogeton crispus* (Curly-leaf pondweed)—were found in the 2006 aquatic plant survey. The one occurring with the most frequency and density

is Eurasian watermilfoi. For the past several years, the Big Roche a Cri Lake District has been using mechanical harvesting and removal of the harvesting results to manage the aquatic invasives in the lake. It also has management of aquatic plant species and aquatic invasives incorporated into its lake management plan.

Critical Habitat Areas

Wisconsin Rule 107.05(3)(i)(I) defines a "critical habitat areas" as: "areas of aquatic vegetation identified by the department as offering critical or unique fish & wildlife habitat or offering water quality or erosion control benefits to the body of water. Thus, these sites are essential to support the wildlife and fish communities. They also provide mechanisms for protecting water quality within the lake, often containing high-quality plant beds. Finally, critical habitat areas often can provide the peace, serenity and beauty that draw many people to lakes. Five areas on Big Roche a Cri Lake were determined by a team of lake professionals to be appropriate for critical habitat designation.

RC1 is 13 acres of the shallow river inlet, which is largely undisturbed, and contains shallow marsh wetlands and shrub-carr. Sixteen species of aquatic plants were found here: four species were emergent plants; one species was a rooted floating-leaf plant; two species were free-floating species; and eight kinds were submergent species. Emergent vegetation protects the shoreline, as well as providing important food sources and cover for fish and wildlife and fish spawning habitat. Floating-leaf rooted vegetation dampens wave action and provides fish cover and wildlife habitat. A diverse submergent plant community provides cover, food sources, and spawning areas. One invasive aquatic species, Curly-Leaf Pondweed, was found in this area.

RC2 extends along approximately 1500 feet of the northern shoreline of the east basin of the lake and is about 8 acres in size. It includes deep marsh and shrub-carr wetlands. There are some scattered homes in this area, with some leaving the natural vegetation at the shore and some cleaning the natural vegetation out. Nineteen species of aquatic plants were found here: four emergent aquatic species; one floating-leaf rooted plant; two free-floating species; and six submergent species. The invasive Curly-Leaf Pondweed was also found in this area.

RC3 comprises about 1500 feet of shoreline along the north shore, just west of Highway 13. The shore is mostly wooded covered with some shrub growth, herbaceous cover and shoreline development. 13 species of aquatic plants were found at this site: two free-floating aquatic species and eleven submergent species. Wild Celery and Coontail were dominant at this site. The aquatic invasive plants, Curly-Leaf Pondweed and Eurasian Watermilfoil, were both found at this site. RC4 is about 1100 feet of the south shore, just west of Highway 13. It has important shallow water habitat. The shore is mostly wooded cover, with some shrub growth, herbaceous plants and shoreline development. 13 aquatic plant species were found at this site: one emergent plant, one floating-leaf rooted plant, two free-floating aquatic plant species, and nine submergent plan species. The invasive, Eurasian Watermilfoil, was common at this site. Finally, RC5 is about 1900 feet of shore on the south shore of the lake, in the narrows areas. The shoreline is mostly wooded cover with a fair amount of shrub understory and some housing development. Six aquatic plant species were found in this area, all submergent aquatic plant species. The invasive Curly-Leaf Pondweed was present at this site; the invasive Eurasian Watermilfoil was abundant.

Fish/Wildlife/Endangered Resources

WDNR fish stocking records for Big Roche a Cri Lake go back to 1932, when 196 black bass were stocked. Stocking continued through the 1970s. The first recorded fish inventory by the WDNR was in 1957, when bluegills and white sucker were abundant; black crappie were common; and northern pike, largemouth bass, yellow perch, and bullheads were scarce. In the most recent fish inventories in 1998 and 2002, largemouth bass and bluegill were abundant; other fish, including northern pike, yellow perch, black crappie and bullheads, were scarce. In all years, there was heavy fishing pressure on the lake.

As part of the preparation of the 1996 Lake Management Plan, wildlife in the watersheds was evaluated. Abundant were blue-winged teal, deer, fox squirrel, grey squirrel, muskrat, opossum, raccoon, ruffed grouse, and turkey. Common were beaver, Canada goose, cottontail rabbit, coyote, grey fox, mallard, red fox, woodchuck, woodcock, and wood duck. Scarce wildlife included badger, greater prairie chicken, green-winged teal, Hungarian partridge, jack rabbit, pheasant, quail and sharp-tailed grouse.

The Big Roche a Cri watersheds were inventoried in the 1990s by the WDNR Natural Heritage Inventory personnel. Endangered natural communities in the watersheds include: alder thicket; floodplain forest; northern sedge meadow; and stream (hard, fast, cold). Plants of concern were 1-Flowered Broomrape, Slim-Stem Small Reedgrass and Whip Nutrush. The pygmy shrew and greater prairie chicken are also known to inhabit these watersheds. Endangered invertebrates in the area include the Karner Blue butterfly, Persius Dusky Wing butterfly, Sand snaketail dragonfly and a tiger beetle.

Conclusion

Big Roche a Cri Lake is currently an impoundment impacted substantially by its large surface and ground watersheds, as well as significant disturbances. The Big Roche a Cri Lake District will need to regularly review and update its lake management plan in order to address the management issues in a logical, cohesive manner.

RECOMMENDATIONS

Lake Management Plan

The Big Roche a Cri Lake District will need to regularly review and update its lake management plan in order to address the management issues needed. The plan will need to always address the following: aquatic plant management; control/management of invasive species; wildlife and fishery management; watershed management; shoreland protection; critical habitat protection; water quality protection; inventory & management of the larger watershed.

The District has a very active Citizen Lake Advisory Group that has been invaluable in gathering information for the district. It is recommended that it continue.

Watershed Recommendations

With such a large ground watershed and large point nutrient source of the very large upper watershed, results of the modeling certainly suggest that input of nutrients, especially phosphorus, are factors that need to be explored for Big Roche a Cri Lake.

Therefore, it is recommended that both the surface and ground watersheds be inventoried, documenting any of the following: runoff from any livestock operations that may be entering the surface water; soil erosion sites; agricultural producers not complying with nutrient management plans and/or irrigation water management plans. If such sites are documented, steps for dealing with these issues can be incorporated into the lake management plan as needed.

The Big Roche a Cri Lake District might consider approaching the WDNR or conservancy organizations to explore putting the east end of the lake, with its meandering stream and wetlands, into a conservancy or limited development area to assure that those areas won't be changed in a way that would degrade water quality of the lake.

Shoreland Recommendations

All lake residents should practice best management on their lake properties, including keeping septic systems cleaned and in proper condition, eliminating the use of lawn fertilizers, cleaning up pet wastes and not composting near the water.

Aquatic Plant Management Recommendations

1) Reinvolvement of the Lake District in water quality monitoring and invasive species monitoring through the Citizen Volunteer Lake Monitoring Program. The Lake District should also have volunteers actively involved in the Clean Boats, Clean Waters program to assist in preventing the introduction of other invasives into the lake and assist in boater education.

2) Chemical treatments for plant growth are not recommended in Big Roche-a-Cri Lake due to the undesirable side effects of chemical treatments.
   a) The decaying plant material releases nutrients that feed algae growth that further reduce water clarity.
   b) The decaying material also enriches the sediments at the site.
   c) The herbicides are toxic to an important part of a lake food chain, the invertebrates.
   d) Broad-spectrum treatments would open up areas that would be vulnerable to the spread of the exotic species.

3) Restore natural shoreline restoration. Disturbed shoreline covers nearly one-third of the shore and mowed lawn alone covers nearly one-quarter of the shore.
   a) Unmowed native vegetation reduces shoreline erosion and run-off into the lake and filters the run-off that does enter the lake thus reducing nutrient inputs.
   b) Shoreline restoration could be as simple as leaving a band of natural vegetation around the shore by discontinuing mowing.
   c) Restoration could be as ambitious as extensive plantings of attractive native wetland species in the water and native grasses, flowers, shrubs and trees on the near shore area.

4) Fine-tune the harvesting plan. Plan should be designed to remove nutrients, target Eurasian watermilfoil, provide navigation and recreation where appropriate, prevent the spread of species that could become overabundant and improve habitat.
   a) Nutrient reduction. Harvesting removes the nutrients found in the plant tissue and filamentous algae mats. There is evidence that mechanical harvesting may already to be reducing filamentous algae and nutrients. The 0-1.5ft depth zone has the highest density and occurrence of plant growth, but is not practical for mechanical harvesting. Since the density and occurrence of plant growth is nearly as high in the 1.5-5ft depth zone, harvesting the 3-5 ft depth zone would be effective for nutrient removal.
   b) Target Eurasian watermilfoil. The milfoil can be targeted by conducting an early-season harvest and a late-season harvest that cuts only where the milfoil is colonized, cutting the largest and densest milfoil areas first and cutting deep. The 5-10ft depth zone is the zone where Eurasian watermilfoil is most prevalent and will likely be the area targeted most during the milfoil harvest. Mid-summer harvesting would focus on the other goals of the harvesting plan. The early-season cutting should be conducted when mifloil is almost to the surface and cut near the sediment level without disturbing the sediments. This harvesting will stress the milfoil and open up the top canopy to allow light penetration into the water for the native species. The late-season harvesting would be conducted in September when native plants are going dormant. This cutting would focus on cutting the milfoil before it autofragments in the fall. This autofragmentation is a strategy milfoil has evolved to increase its spread. If curly-leaf pondweed increases to a nuisance condition, early spring harvesting for this species could be instituted. Skimming off coontail as the harvester is operating will help control this species that is becoming abundant.
   c) Provide navigation and recreation where appropriate. Cutting channels through the areas that have the densest plant growth and cutting to control Eurasian watermilfoil will also aid navigation of the lake. Harvesting in the depth zone greater than 10 feet to maintain an open area for higher speed boat traffic would also aid navigation.
   d) Prevent the spread of species that could become overabundant. *Vallisneria americana* is one of the few submergent aquatic plants that grow from the base, as grass does. Frequent harvesting in beds of *V. americana* will encourage its growth. Avoid these plant beds when they are not hindering navigation. When *V. americana* is harvested, cut near the sediment, or as deep as the cutter bar extends. The dam end of the lake supports the most *V. americana.* Harvesting the dam end in less than 10 feet should be avoided.

e) Improve habitat. The mid-portion of the lake (area 2) and the 5-10ft depth zone have the greatest colonization of plants and this area could be improved the most with channels (not clear-cutting). Cutting channels in this area provides edge needed for habitat and allows the predator fish to better find prey, supporting a more balanced fishery. These open areas are also used by wildlife. The 0-1.5ft depth zone supports the best species richness and diversity. The only harvesting that should be conducted in this zone are channels next to the docks for land owner access.

5) Cooperate with programs in the watershed to reduce nutrient inputs to the lake. Currently nearly half of the relatively large watershed is in agriculture.

6) Eliminate the use of lawn fertilizers, both organic and inorganic, on properties around the lake.

7) Investigate the possibility of using periodic winter drawdowns to control Eurasian watermilfoil in the shallow zone.

Critical Habitat Recommendations

(1) Maintain current habitat for fish and wildlife.
(2) Maintain snag, cavity and fallen trees along the shore for nesting & habitat.
(3) No alteration of littoral zone unless to improve spawning habitat.
(4) Seasonal protection of spawning habitat.
(5) Maintain any snag/cavity trees for nesting.
(6) Install nest boxes.
(7) Maintain corridor and restore natural shoreline vegetations where cleared to increase wildlife corridor.
(8) Designate critical habitat areas as no-wake lake areas.
(9) Protect emergent vegetation with no removal of emergent vegetation.
(10) No removal of submergent and floating-leaf vegetation. Minimize aquatic plant and shore plant removal to maximum 30' wide viewing/access corridor and navigation purposes. Leave as much vegetation as possible to protect water quality and habitat.
(11) Seasonal control of Eurasian Watermilfoil and other invasives with methods selective for control of exotics.
(12) Use winter drawdown for EWM control no more frequently than every 3 to 5 years, with drawdown occurring before October 1.
(13) Continue mechanical harvesting, thus removing some of the phosphorus from the lake.

(14) Use best management practices.
(15) No use of lawn products, including fertilizers, herbicides & other chemicals.
(16) No bank grading or grading of adjacent land.
(17) No pier placement, boat landings, development or other shoreline disturbance in the shore area of the wetland corridor.
(18) No pier construction or other activity except by permit using a case-by-case evaluation and only using light-penetrating materials.
(19) No installation of pea gravel or sand blankets.
(20) Install bank restoration in highly eroded areas. Otherwise, permit no bank restoration unless the erosion index scores moderate or high. Use bioengineering practices only, but not rock riprap, retaining walls or other hard armoring.
(21) No placement of swimming rafts or other recreational floating devices.
(22) Maintain aquatic vegetation buffer in undisturbed condition for wildlife habitat, fish use and water quality protection.
(23) Post exotic species information at public boat landing.
(24) Permit no dredging except for a single channel for navigation.
(25) Investigate making the far east end of the lake a conservancy or purchasing an easement to maintain its mostly undisturbed state.

LAKE CLASSIFICATION REPORT
FOR BIG ROCHE A CRI LAKE, ADAMS COUNTY

INTRODUCTION

In 2003, The Adams County Land & Water Conservation Department (Adams County LWCD) determined that a significant amount of natural resource data needed to be collected on the lakes with public access in order to provide it and the public with information necessary to manage the lakes in a manner that would preserve or improve water quality and keep it appropriate for public use. In some instances, there was significant historical data about a particular lake; in that instance, the study activities concentrated on combining and updating information. In other instances, there was no information on a lake, so study activities concentrating on gathering data about that lake. Further, it was discovered that information was scattered among various citizens, so often what information was actually available regarding a particular lake was unknown. To assist in updating some information and gathering baseline information, plus centralize the data collected, so the public may access it. The Adams County LWCD received a series of grants from the Wisconsin Department of Natural Resources (WDNR) from the Lake Classification Grant Program.

Objectives of the study were:

- collect physical data on the named lakes to assist in assessing the health of Adams County lake ecosystems and in classifying the water quality of the lakes.
- collect chemical and biological data on the named lakes to assist in assessing the health of Adams County lake ecosystems and in classifying the water quality of the lakes.
- develop a library of lake information that is centrally located and accessible to the public and to City, County, State and Federal agencies.
- make specific recommendations for actions and strategies for the protection, preservation and management of the lakes and their watersheds.
- create a baseline for future lake water quality monitoring.
- Provide technical information for the development of comprehensive lake management plans for each lake
- provide a basis for the water quality component of the Adams County Land and Water Resource Management Plan. Components of the plan will be incorporated into Adams County's "Smart Growth Plan".
- develop and implement educational programs and materials to inform and educate lake area property owners and lake users in Adams County.

METHODS OF DATA COLLECTION

To collect the physical data, the following methods were used:

- delineation & mapping of ground & surface watersheds using topographic maps, ground truthing and computer modeling;
- identification of flow patterns for both the surface & ground watersheds using known flow maps and topographic maps;
- inventory & mapping of current land use with orthographic photos and collected county information;
- inventory & mapping of shoreline erosion and buffers using county parcel maps and visual observation;
- inventory & mapping for historical and cultural sites using information from the local historical society and the Wisconsin Historical Society;
- identification & mapping of critical habitat areas with WDNR and Adams County LWCD staff;
- identification & mapping of endangered or threatened natural resources (including natural communities, plant & animal species) using information from the Natural Heritage Inventory of Wisconsin;
- identification & mapping of wetland areas using WDNR and Natural Resource Conservation Service wetland maps;
- preparation of soil maps for each of the lake watersheds using soil survey data from the Natural Resource Conservation Service.

To collect water quality information, different methods were used:

- for three years, lakes were sampled during late winter, at spring and fall turnover, and several times during the summer for various parameters of water quality, including dissolved oxygen, relevant to fish survival and total phosphorus, related to aquatic plant and algae growth;
- random samples from wells in each lake watershed were taken in two years and tested for several factors;
- aquatic plant surveys were done on all 20 lakes and reports prepared, including identification of exotics, identifying existing aquatic plant community, evaluation of community measures, mapping of plant distribution, and recommendations;
- all lakes were evaluated for critical habitat areas, with reports and recommendations being made to the respective lakes and the WDNR;
- lake water quality modeling was done using data collected, as well as historical data where it was available.

WATER QUALITY COMPUTER MODELING

Wisconsin developed a computer modeling program called WiLMS (Wisconsin Lake Modeling Suite) to assist in determining the amount of phosphorus being loaded annually into a lake, as well as the probable source of that phosphorus. This suite has many models, including Lake Total Phosphorus Prediction, Lake Eutrophic Analysis Procedure, Expanded Trophic Response, Summary Trophic Response, Internal Load Estimator, Prediction & Uncertainty Analysis, and Water & Nutrient Outflow. The models that various types of data inputs: known water chemistry; surface area of lake; mean depth of lake; volume of lake; land use types & acreage. This information is then used in the various models to determine the hydrologic budget, estimated residence time, flushing rate, and other parameters.

Using the data collected over the course of the studies, various models were run under the WiLMS Suite. These water quality models are computer-based mathematical models that simulate lake water quality and watershed runoff conditions. They are meant to be a tool to assist in predicting changes in water quality when watershed management activities are simulated. For example, a model might estimate how much water quality improvement would occur if watershed sources of phosphorus inputs were reduced. However, it should be understood that these models predict only a relative response, not an exact response. Modeling results will be incorporated into topic discussions as appropriate.

DISSEMINATION OF PROJECT DELIVERABLES

The results of this study will be distributed various agencies, organizations and the public as previously described. Based on the classification information, the Adams County Land and Water Conservation Department will identify assistance requests and determine the appropriate future activities, based on the classification determinations. To provide the requested assistance, Adams County Land and Water Conservation Department will incorporate the lake management plans goals, priorities and action items into its Annual Plan of Operations. Goals, priorities and action items may include educational programs, formation of lake districts, further development of lake management plans and implementation of lake management plans.

ADAMS COUNTY INFORMATION

Adams County lies in south central Wisconsin, shaped roughly like the outline of Illinois. Adams County is a small rural county with a full-time population of about 20,000. Between 1980 and 2000, Adams County's population grew by more than 20%, with most of the population increase being located upon the lakes and streams. The population increase has resulted in a greater need for facilitation, technical assistance and education, including information on the lakes and streams.

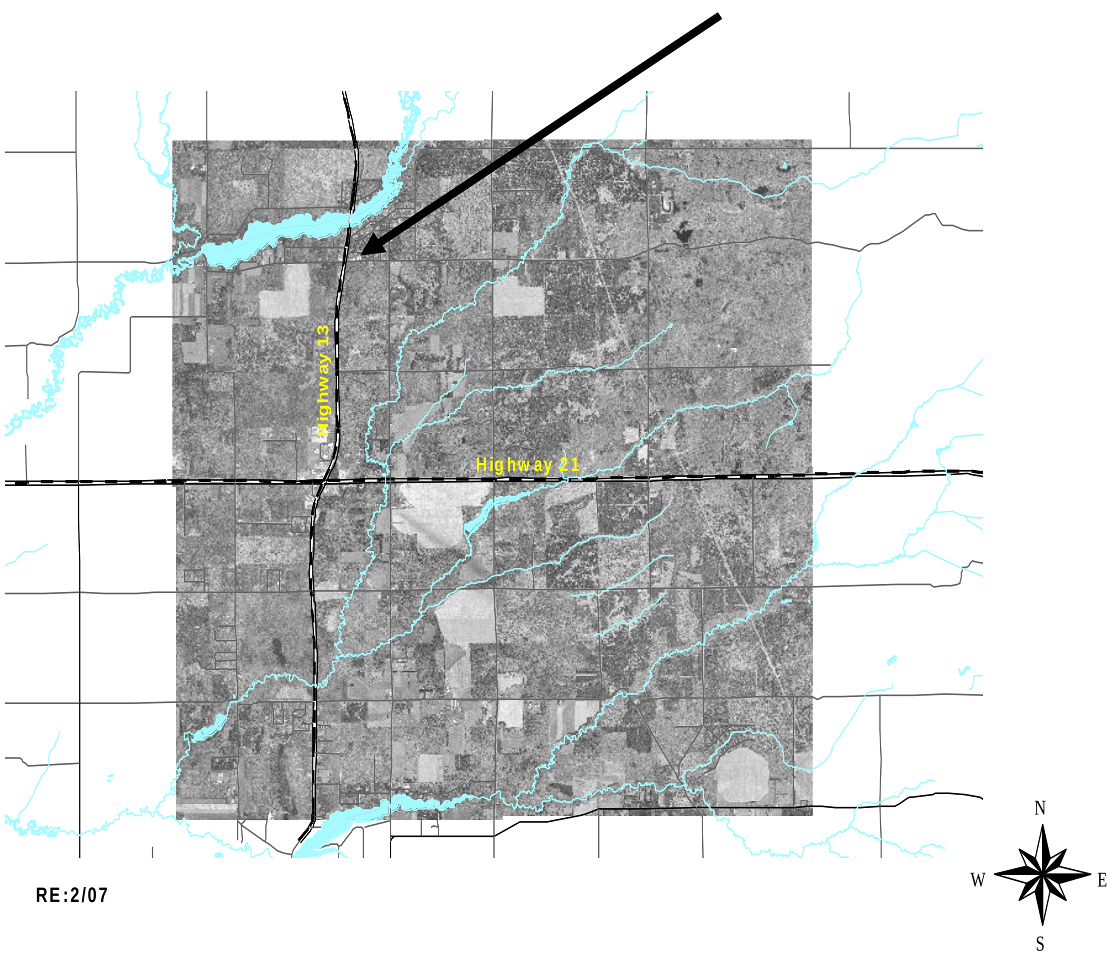
Figure 1: Adams County Location in Wisconsin

BIG ROCHE A CRI LAKE BACKGROUND INFORMATION

Big Roche a Cri Lake is a 205-acre impoundment (man-made lake) located in the Town of Preston, Adams County, in the Central Sand Plains Area of Wisconsin. As an impoundment of Big Roche a Cri Creek, it has both an inlet and outlet. Through Big Roche a Cri Lake moves input of a very large watershed of 177 square miles that extends into the next county east. Downstream of Big Roche a Cri Lake is another impoundment, Arkdale Lake. Big Roche a Cri Creek ultimately empties into the Wisconsin River.

Big Roche a Cri Lake is managed by the Big Roche a Cri Lake District. There is a public boat ramp on the northwest end of the lake owned by the Adams County Park District. There is another public boat ramp on the north side just off Highway 13. The dam is owned by Adams County, but leased to a private individual. It has at times generated electricity

Figure 2: Big Roche a Cri Lake location



The Central Sand Plains, which contain Big Roche a Cri Lake, are found in the Driftless Area of Wisconsin. The area is characterized by varying elevations, with numerous, usually flat-topped ridges & hills sometimes called "mounds." Deposits made by streams from the melting ice sheet cover large areas and usually consist of sand, clay and gravel.

<u>Archeological Sites</u>

There are many Native American archeological and American historical sites in Adams County, with some located in the Big Roche a Cri Lake watersheds. Under the federal act on Native American burials, the burial sites cannot be further disturbed without permission of the federal government and input from the local tribes.

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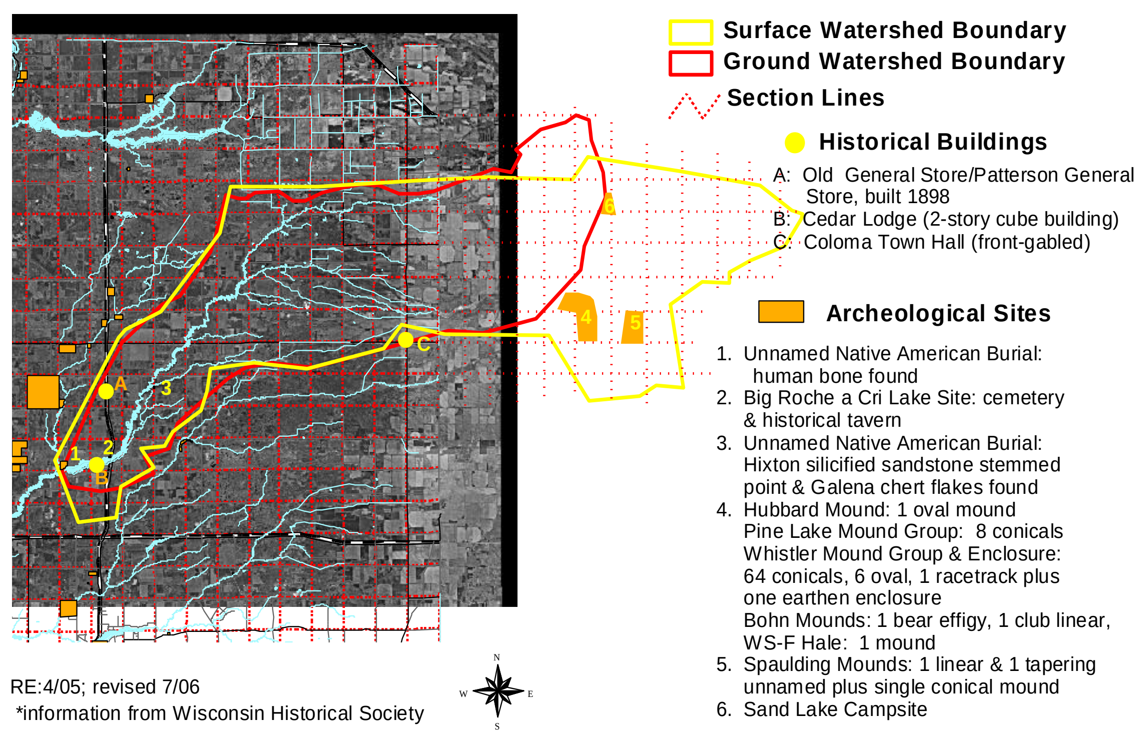
Figure 3: Big Roche a Cri Lake Archeological Sites



Bedrock and Historical Vegetation

Bedrock around Big Roche a Cri Lake is mostly sandstone, both weak and resistant, formed in the Cambrian Period of Geology (542 to 488 millions years ago). Bedrock may be 200 or more feet below the sand/clay/gravel deposits left by melting ice cover.

Original upland vegetation of the area included extensive wetlands of many types (including open bogs, shrub swamps & sedge meadows), as well as prairies, oak forests, savannahs and barrens. Mesic white pine & hemlock forests were found in the northwest portion of the region. Most of the historic wetlands were drained in the 1900s and used for cropping. The current forested areas are mostly oak-dominated, followed by aspen and pines. There are also small portions of maple-basswood forest and lowland hardwoods.

Soils in the Big Roche a Cri Lake Watersheds

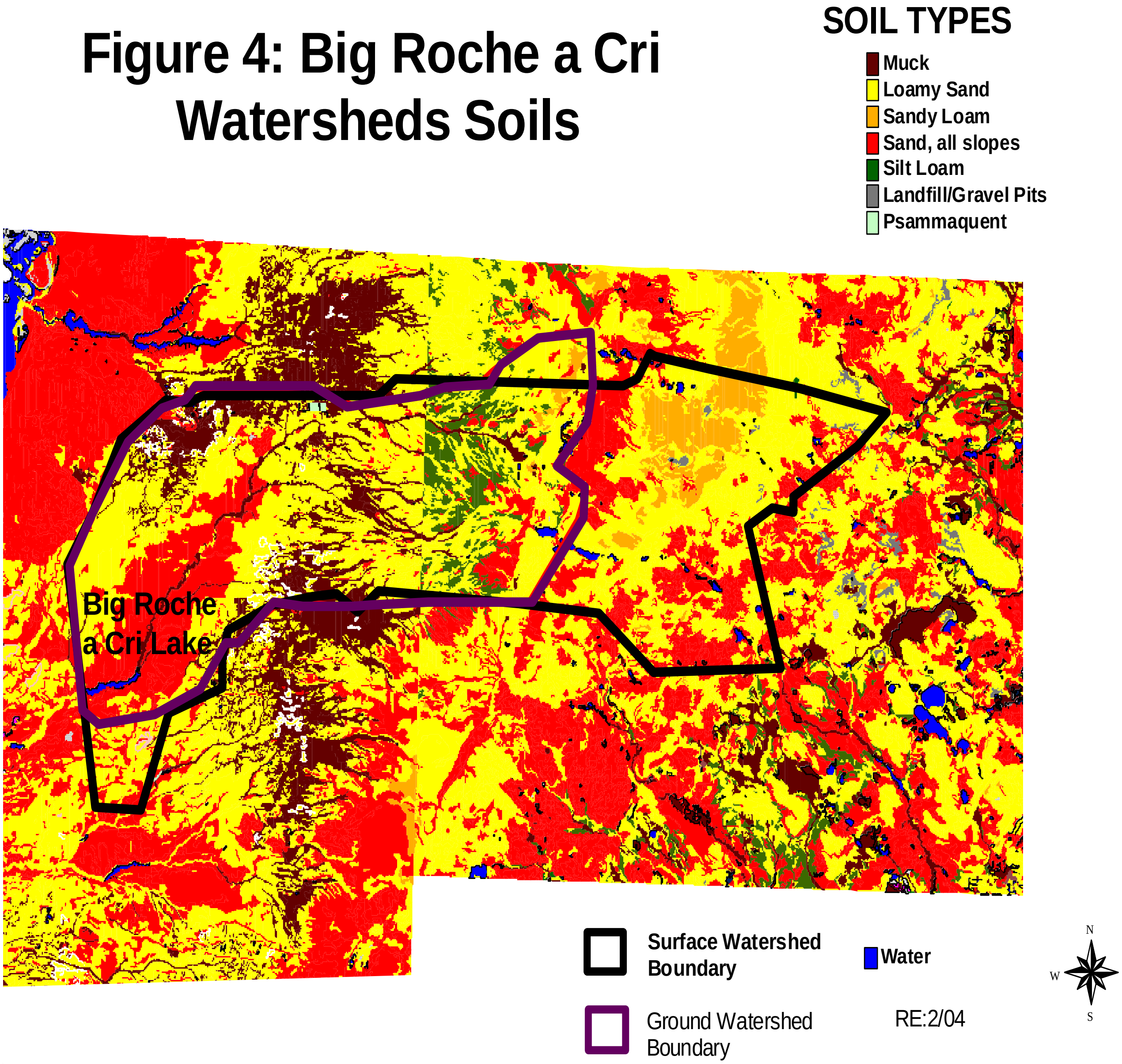
The primary soil type in both the surface and ground watersheds is loamy sand. The second most common soil type in both watersheds is sand. There are also pockets of muck, sand loam, and silt loam, along with gravel pits and landfills.

Loamy sands tend to be well-drained, with water, air and nutrients moving through them at a rapid rate. Runoff, when it occurs, tends to be slow. Loamy sands have little water-holding capacity and low natural fertility, although they usually have more organic matter present than do sandy soils. Both wind and water erosion are potential hazards with loamy sands, as is drought. There are difficulties with waste disposal and vegetation establishment because of slope and seepage.

Sandy soil tends to be excessively drained, no matter what the slope. Water, air and nutrients move through sandy soils at a rapid rate, so that little runoff occurs unless the soil becomes saturated. Although water erosion can be a problem, wind erosion may be more of a hazard with sandy soils, especially since these soils dry out so quickly. There are also draught hazards with sandy soils. Getting vegetation started in sandy soils is often difficult due to the low available water capacity, as well as low natural fertility and organic material. Onsite waste disposal in sandy soils is also a problem because of slope and seepage; mound systems are usually required.

The soil and soil slopes around lakes and streams are very important to water quality. They affect amount of infiltration of surface precipitation into the ground and the amount of contaminants that may reach the groundwater, as well as the amount of surface stormwater runoff. In addition, these two factors affect the amount and content of pollutants and particles (including soil) that may wash into a water body, affecting its water quality, its aquatic plant community and its fishery. Further, soil types and soil slopes help determine the appropriate private sewage system and other engineering practices for a particular site, since they affect absorption, filtration and infiltration of contamination from engineering practices.

Figure 4: Big Roche a Cri Watersheds Soils



PRIOR STUDIES OF BIG ROCHE A CRI LAKE AREA

In 1970-1971, the Soil Conservation Service (now called the Natural Resource Conservation Service) outlined a soil and water conservation plan for the Big Roche a Cri Lake Association (which became a district in 1988). The plan included preventing erosion of the shore by good vegetative cover; monitoring erosion from ongoing new construction; deepening the lake through dredging; and investigating sewage disposal around the lake. The plan also estimated dredging costs at that time for the removal of one foot of the lake bottom around the lake and removal of three feet of the lake bottom around the lake. For the east end of the lake, it estimated that removal of one foot in the 43 acres would cost $13,872, while removal of three feet in that area would cost $41,616. For the middle of the lake to approximately the west end of Chicago Lake, approximately 66 acres, removal of one foot was estimated at $21,291 and removal of three feet was estimated at $63,875.

With a grant from the WDNR, a study was done in the mid-1990s to prepare a lake management plan for Big Roche a Cri Lake District. As part of that study, a survey of residents of the surface watershed was made. 55% of those sent a survey returned it. 99% of the respondents owned lakefront property. 29% were permanent, full-time residents on the lake. Although the average length of time lakefront property had been owned was 12 years, 26% of the respondents had owned their property over 20 years.

The survey revealed that the most popular activities of the respondents were fishing, swimming, boating, water skiing, and ice fishing, in that order. Most people owned more than one boat. Respondents saw the major lake problems as weed growth, water level, algae presence, and lake depth. They felt the lake needed more weed removal and should be dredged to deepen areas filled in by sediment.

The lake management plan report described areas of concern that it felt should be addressed in ongoing management of the lake. These included protection of ecologically vulnerable areas, runoff pollution control, water quality, lake congestion, public access and water level stability.

The report made the following recommendations in 1996:

- Education about shoreline protection
- Restoration of shorelines, especially highly-eroded areas
- Development of methods to abate the sediment and nutrient loading from agriculture and the lake's developed shores

- Development of an aquatic plant management plan that included mechanical harvesting
- Reducing the lake congestion by enforcing ordinances about time, pattern, etc.
- Protection of sensitive areas by limiting boat speed in those areas; initiating an education/information program to discourage human disturbance of those areas; prohibition of dredging in those areas; no placement of dredged materials or herbicides within the lake; marking sensitive areas with buoys and signage to enforce the restrictions
- Preservation of the wetlands through zoning (including Towns of Big Flats, Colburn, Leola and Preston)
- Education about alternative lawn and garden care, use of household chemicals, etc., to minimize the impact of residential shore development
- Development of a program to monitor existing septics and to test private septics, with the lake district taking on sanitary district powers to make testing and repair mandatory
- Regular water quality monitoring
- Regular monitoring and inventory of lake vegetation and aquatic plants
- Regular monitoring of invasives
- Increase of machine harvesting by obtaining a second harvester
- Development of the park area for non-boating public access
- Through a Town of Preston ordinance, limiting high speed boating to deeper areas of the lake.

In 1999-2000, the private firm, Foth & Van Dyke, did a study of the lake. This study included a septic system survey which determined that most septic disposal fields were over 100 feet from the lake shore and more than 10 feet above the lake water level. The report indicated that 550 pounds of phosphorus per year were discharged into the lake from septics. The estimated phosphorus load from the watershed was 826 pounds/year, with about 150 pounds of that ending up in the lake. The report also noted that since groundwater flowed into the lake at the east end of the lake, residential septics at that end were likely to have a higher impact on the lake water phosphorus levels. Groundwater flowed out of the lake at the west end. The report indicated that as groundwater flows away from the lake, septic absorption field effluents might be flowing into wells in the area. At that time, agriculture was 31% of the land use, but produced 56% of the phosphorus load. Residential land use was only 2% of the watershed at that time.

The estimated phosphorus loading was outlined: 68 pounds/year from residential land use; 1265 pounds/year from agriculture; 347 pounds/year from grassland/pasture; 400 pounds/year from woodlands; 172 pounds/year from wetlands, and 657 pounds/year from residential wastewater, for a total of 2909 pounds/year as a phosphorus load.

The study involved various water samples several times in 1999 and early 2000, testing levels of dissolved oxygen, total phosphorus, chlorophyll-a levels, and nitrogen. Water clarity was also tested. The report indicated that Big Roche a Cri was a mesotrophic lake, based on the water sampling done.

The report, which was published in December 2000, made the following recommendations:

- Make sure that the lake management plan is directed toward maintaining and protecting water quality that includes water testing, education, management for lake protection, ordinances about zoning, sanitation and pollution control, extensive mechanical weed harvesting and control of boat practices that cause erosion and/or sediment disturbance
- Limit the amount of phosphorus coming into the lake to the amount being removed by mechanical harvesting
- Evaluate methods of reducing the phosphorus load to the lake
- Evaluate dredging to remove sediment and phosphorus to reduce excessive weed growth
- Install buffer of natural landscaping at the shores
- Limit the amount of impermeable areas around the shore
- Minimize uses of fertilizer
- Leave grass clippings on the land
- Burn no leaves near the shore
- Don’t mow grass very short, but instead leave it fairly long to help filter runoff
- Keep gardens away from the shore
- Compost aquatic weeds for garden use
- Use natural controls for garden pests, rather than pesticides
- Minimize runoff from slopes by diverting the runoff
- Minimize the amount of bare soil and the amount of soil disturbance
- Consider using a cluster septic system and develop an ordinance requiring regular pumping and maintenance
- Avoid having garbage disposal in the residences around the lake
- Discourage pouring any substances onto the ground that contain contaminates
- Continue to mechanical weed harvesting
- Use winter drawdowns to help in weed control
- Develop plans to reduce agricultural runoff and phosphorus loading

CURRENT LAND USE

Both the surface and ground watersheds for Big Roche a Cri Lake are fairly large. Big Roche a Cri Lake also receives significant input of materials from the large upper watershed. In the surface watershed, the main two land use types are Woodlands and Irrigated Agriculture. The same two land uses are the largest land use types in the ground watershed. (See Figures 5, 6a, 6b & 7).

Figure 5: Big Roche a cri Lake Watersheds Land Use in Acres and Percent of Total

	Surface		Ground			Total
Big Roche a Cri						
Agriculture--Non Irrigated	4569.84	9.75%	1673.99	8.27%	6243.83	9.30%
Agriculture--Irrigated	18,088.50	38.59%	6729.19	33.26%	24817.69	36.98%
Government	285.43	0.61%	103.18	0.51%	388.61	0.58%
Grassland/Pasture	808.86	1.73%	505.77	2.50%	1314.63	1.96%
Residential	3113.97	6.64%	2495.54	12.34%	5609.51	8.36%
Water	1820.21	3.88%	821.37	4.06%	2641.58	3.94%
Woodland	18,185.17	38.80%	7901.84	39.06%	26087.01	38.88%
total	46,871.98	100.00%	20,230.88	100.00%	67102.86	100.00%

In a 1996 Lake Management Plan for Big Roche a Cri Lake, it was reported that a land use survey revealed the following: Agriculture (all types) comprised 27.1% of the total watershed (surface + ground); Woodlands & Wetlands covered 71.8% of the watershed; Water comprised 0.5%; Residential covered only 0.6%. As can be seen in the table above, woodland land use has been reduced considerably, almost one-half less, while residential land use is 14 times more than it was in the mid-1990s.

Studies have shown that land use around a lake has a great impact on the water quality of that lake, especially in the amount and content of surface runoff. (James, T., 1992, I-10; Kibler, D.F., ed. 1982. 271) For example, while natural woodland may (on the average) absorb 3.5" out of a 4" rainfall, leaving only .5" as runoff, a residential area with quarter-acre lots may absorb only 2.3" of the 4", leaving 1.7" to run off the land into the lake—the same amount as may be expected to run off from a corn or soybean field. 1.7" of runoff translates into 46,200 gallons per acre ending up in the lake! Percentage of impervious surface, the soil type, vegetation present and slope of the site can all affect runoff volume. (Frankenberger, J, ID-230). The changes in the Big Roche a Cri watershed land use are therefore likely to significantly increase the runoff in volume and content unless protection steps are taken.

Figure 6a: Land Use in Big Roche a Cri Lake Surface Watershed

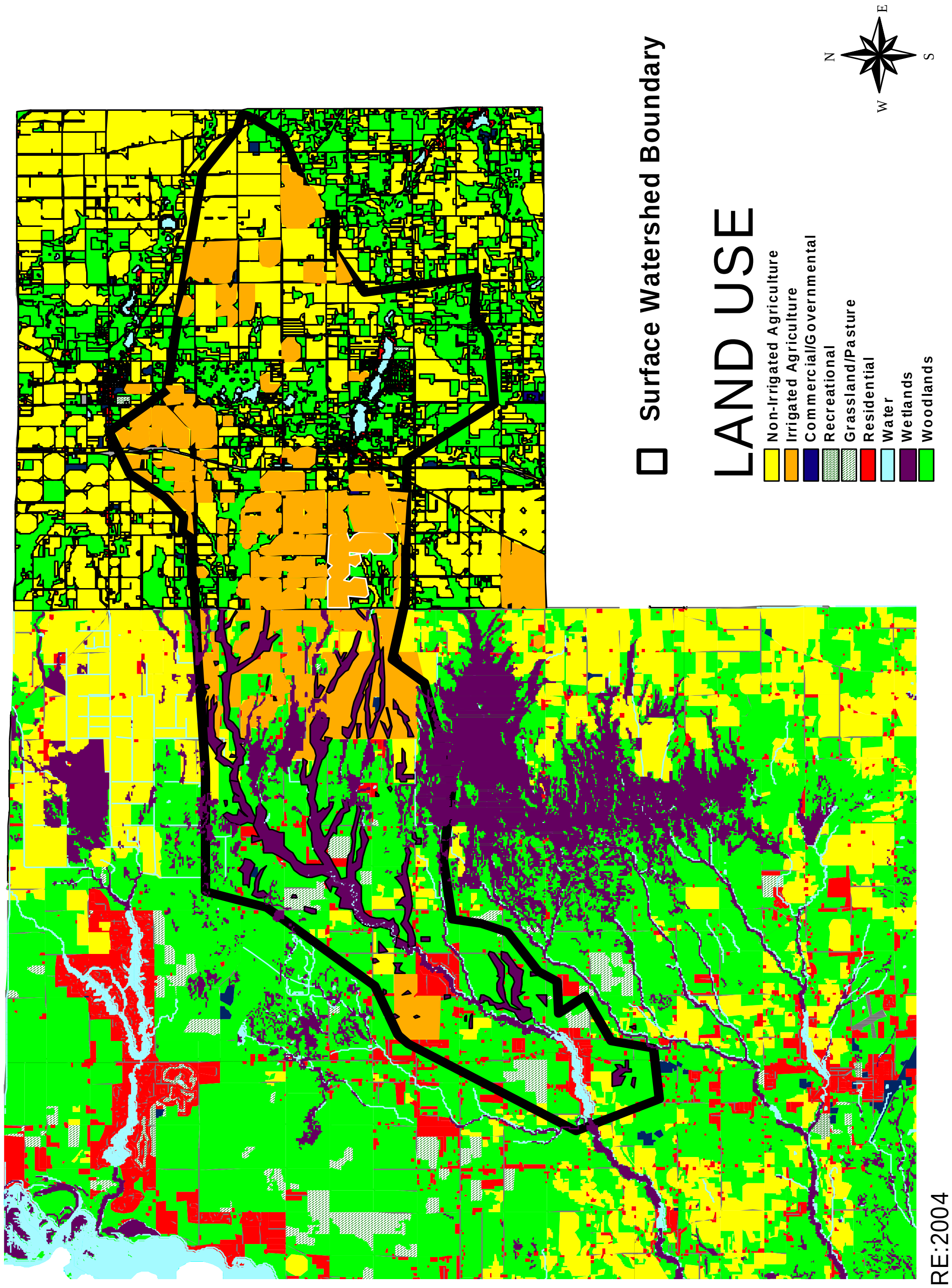
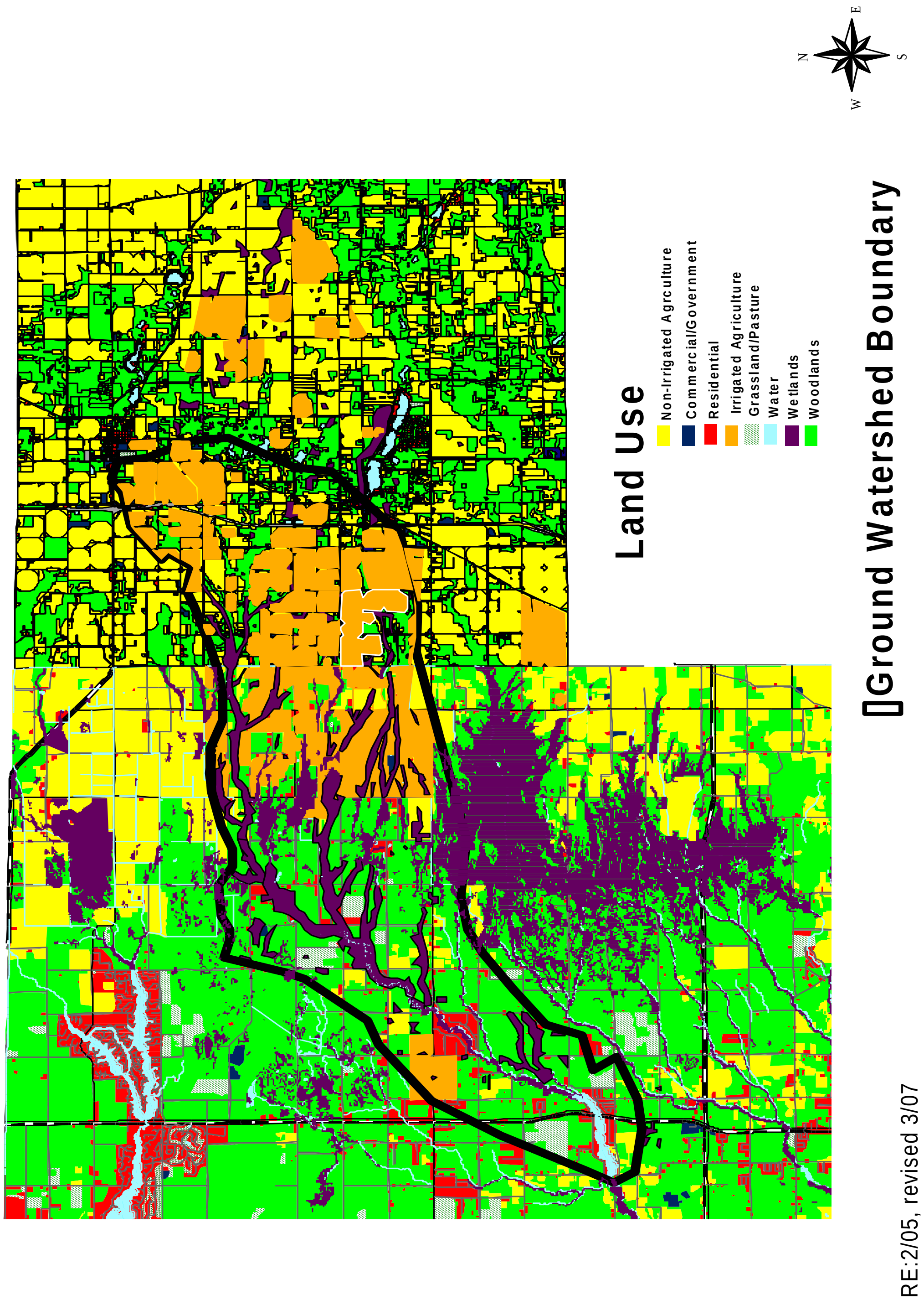
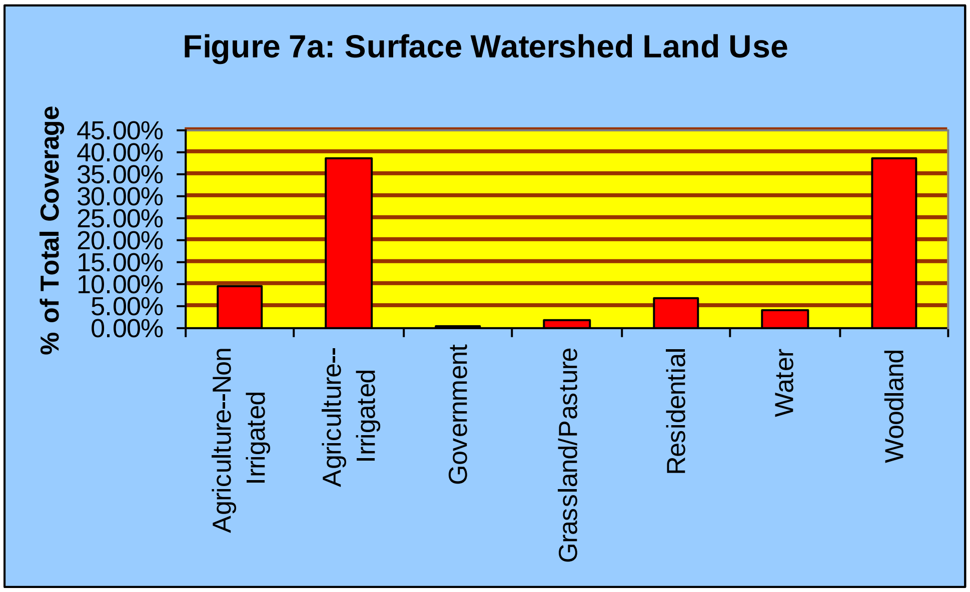
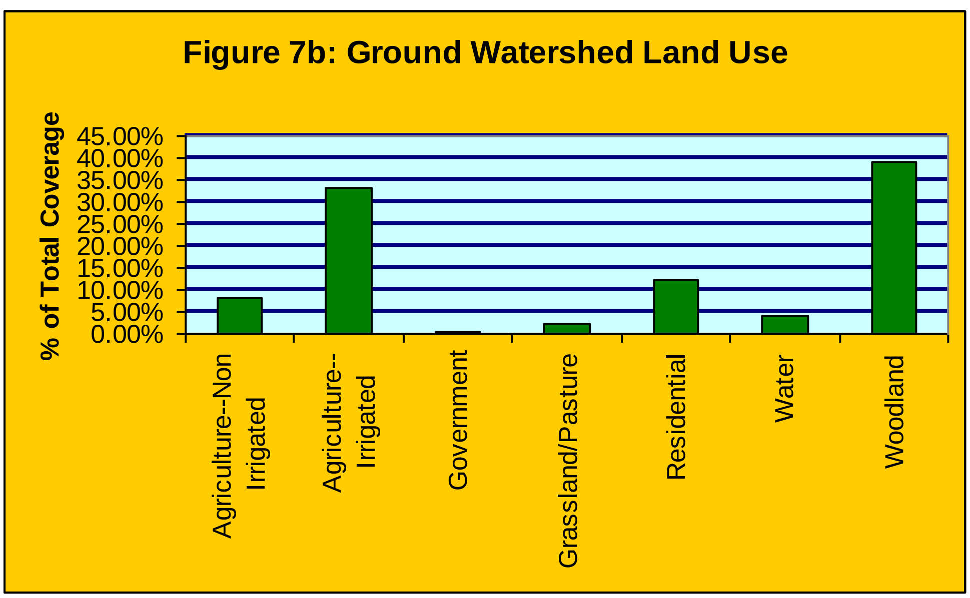


Figure 6b: Land use in Big Roche a Cri Lake Ground Watershed



When water runs over a surface, it picks up whatever loose pollutants—sediment, chemicals, metals, exhaust gas, etc—are present on that surface and takes those items with it into the lake. Increased development around a lake tends to increase the amount of pollutants being carried into the lake, thus negatively affecting water quality. Residential development areas with lots of one-quarter acre or less may deliver as much as 2.5 pounds of phosphorus per year to the lake for each acre of development.





There are two specific kinds of land use—wetlands and shorelands--that are so important to water quality that they will be separately discussed.

WETLANDS

A number of wetlands are located in the Big Roche a Cri Lake surface and ground watersheds, especially before the lake around the stream coming in (Figures 6a & 6b). In the past, wetlands were seen as "wasted land" that only encouraged disease-transmitting insects. Many wetlands were drained and filled in for cropping, pasturing, or even residential development. In the last few decades, however, the importance of wetlands has become evident, even as wetlands continue to decline in acreage.

Wetlands play an important role in maintaining water quality by trapping many pollutants in runoff and flood waters, thus often helping keep clean the water they connect to. They serve as buffers to catch and control what would otherwise be uncontrolled water and pollutants. Wetlands also play an essential role in the aquatic food chain (thus affecting fishery and water recreation), as well as serving as spaces for wildlife habitat, wildlife reproduction and nesting, and wildlife food.

The large areas of wetlands in the Big Roche a Cri Lake watersheds serve as filters and traps that help keep Big Roche a Cri Lake as clean as it is. It is essential to preserve these wetlands for the health of Big Roche a Cri Lake.

Figure 8: Wetland at East End of Big Roche a Cri Lake

SHORELANDS

Big Roche a Cri Lake has a total shoreline 6.1 miles (32,208 feet). Much of the lakeshore is in residential use. Many of the areas near the shore are very sandy and steeply sloped. A 2004 shore survey revealed that 64% of Big Roche a Cri Lake's shoreline is vegetated. The rest of the shore is a mix of active erosion, sand, rock and/or other hard structure. Since the survey was done, Big Roche a Cri Lake District was awarded a lake management plan implementation grant that allowed several property owners to install shore protection practices to reduce some of the erosion. It has recently applied for an additional grant to address properties not previously covered.

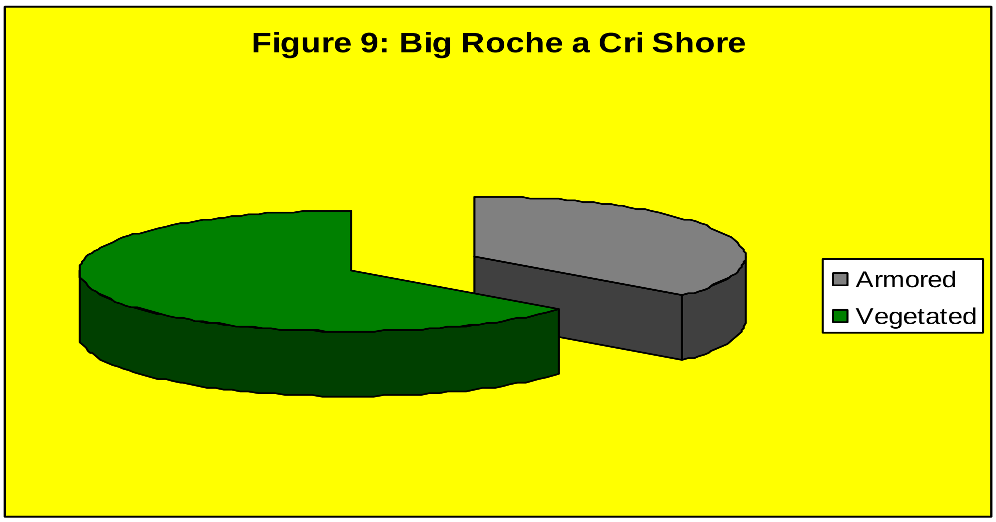
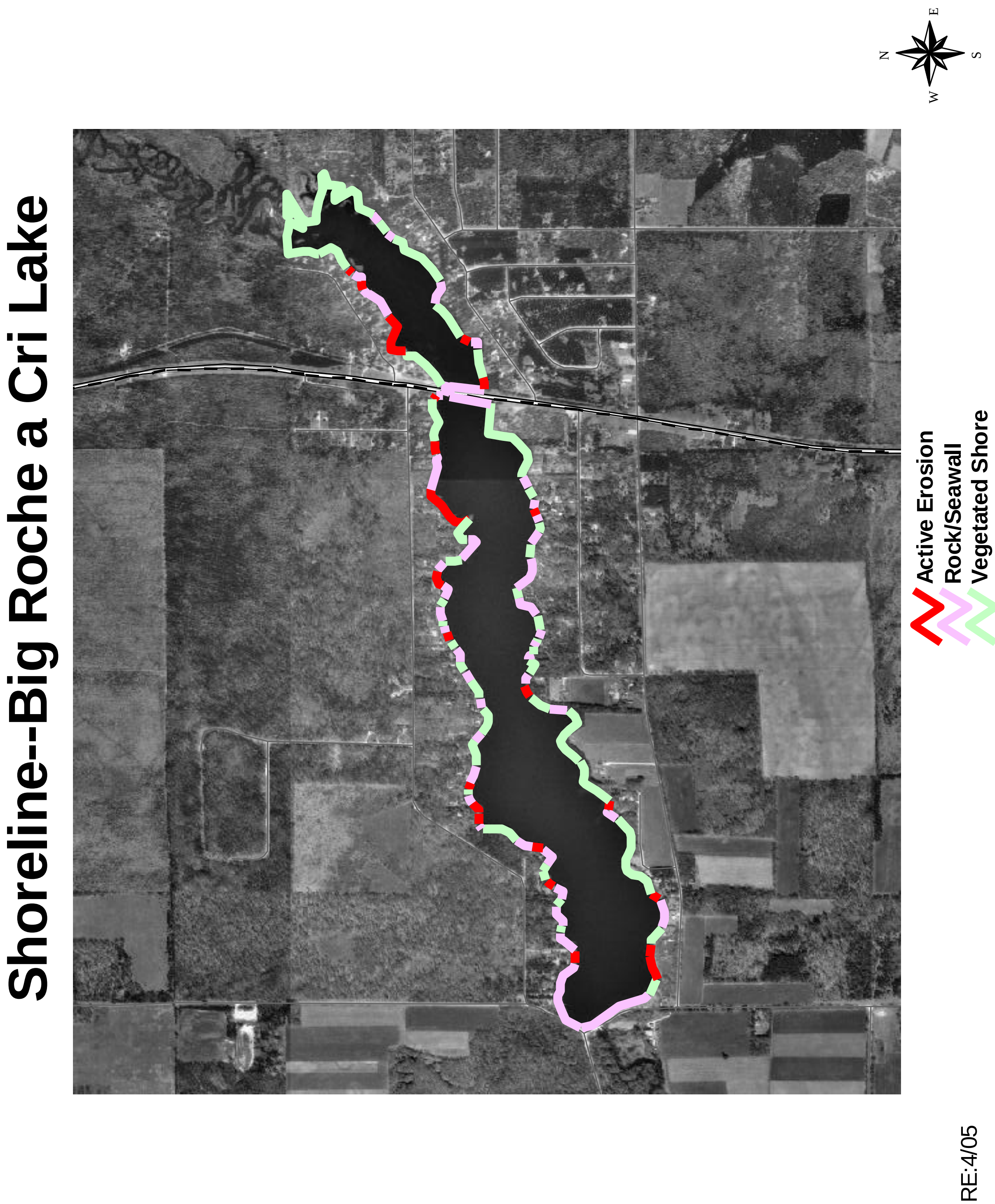


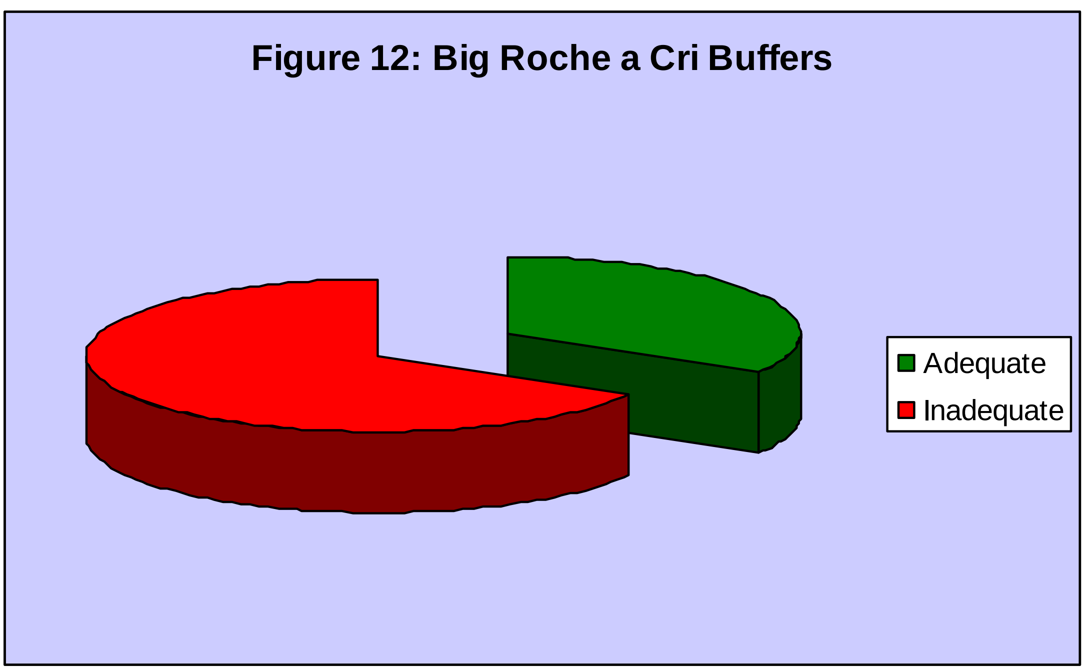
Figure 10: Example of Erosion on Big Roche a Cri Lake

Figure 11: Shoreland Map of Big Roche a Cri Lake (2004)



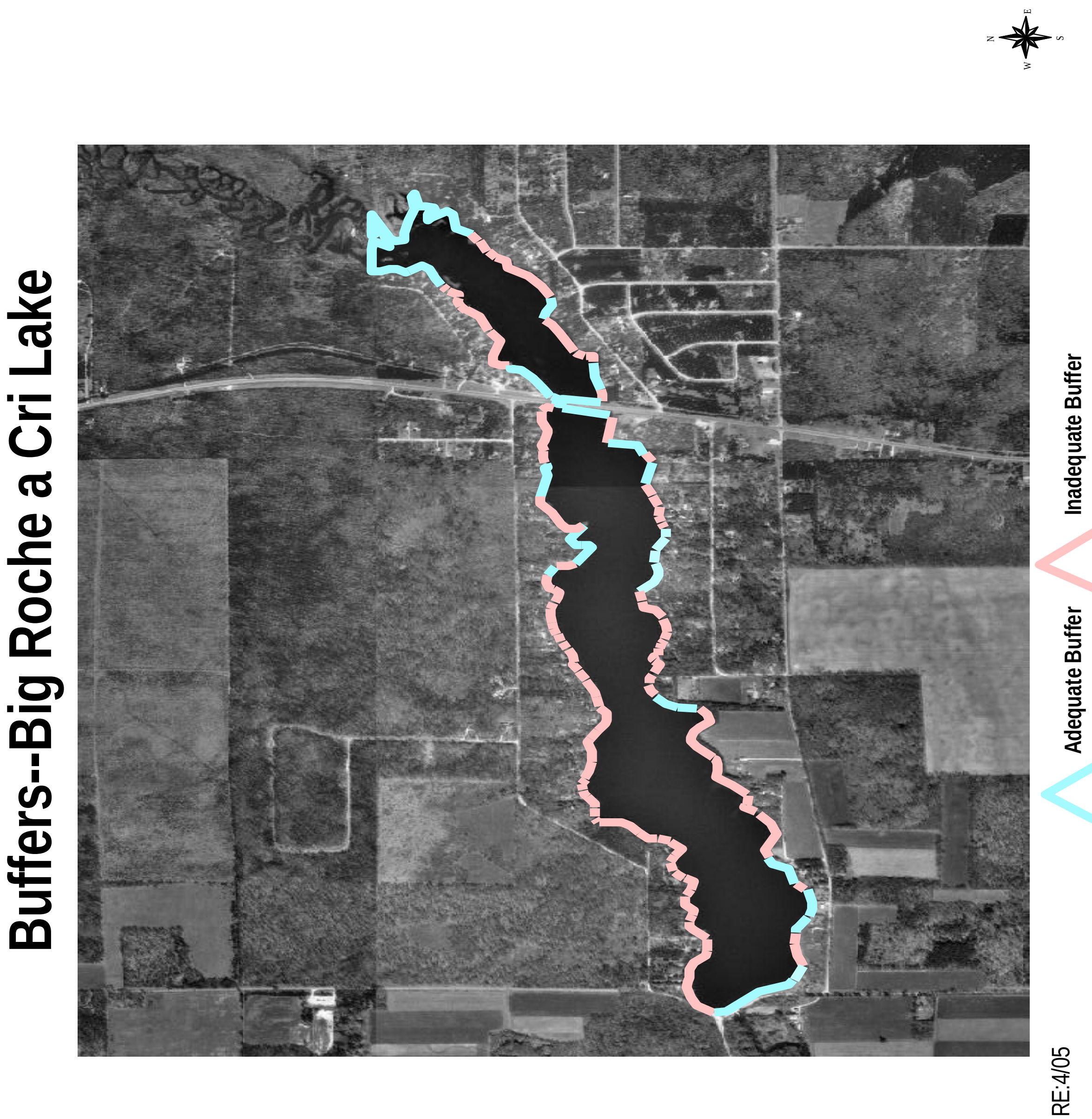
The Adams County Shoreline Ordinance defines 1000' landward from the ordinary high water mark as "shoreland". Under the ordinance, the first 35 feet landward from the water is a "buffer." Shoreland buffers are an important part of lake protection and restoration. These buffers are simply a wide border of native plants, grasses, shrubs and trees that filter and trap soil & similar sediments, fertilizer, grass clippings, stormwater runoff and other potential pollutants, keeping them out of the lake. A 1990 study of Wisconsin shorelines revealed that a buffer of native vegetation traps 5 to 18 times more volume of potential pollutants than does a developed, traditional lawn or hard-armored shore.

The 2004 inventory included classifying areas of the Big Roche a Cri Lake shorelines as having "adequate" or "inadequate" buffers. An "adequate" buffer was defined as one having the first 35 feet landward covered by native vegetation. An "inadequate" buffer was anything that didn't meet the definition of "adequate buffer", including native vegetation strips less than 35 feet landward. Using these definitions, only 33.6% (10821.89 feet) of Big Roche a Cri Lake's shoreline had an "adequate buffer" in 2004, leaving 66.4% (21386.11 feet) as "inadequate." Most of the "inadequate" buffer areas were found with mowed lawns and/or insufficient native vegetation at the shoreline to cover 35 feet landward from the water line.



Vegetated shoreland buffers help stabilize shoreline banks, thus reducing bank erosion. The plant roots give structure to the bank and also increase water infiltration and decrease runoff. A vegetated shore is especially important when shores are steep and soft, as are many of Big Roche a Cri Lake shores. Figure 13 maps the adequate and inadequate buffers on Big Roche a Cri Lake.

Figure 13: Big Roche a Cri Lake Buffer Map (2004)



Lakeside buffers also serve as important habitat. Lake edges usually contain aquatic and wetland plants, grading into drier groundcover, then shrubs and trees as one moves inland towards drier land. Buffers provide habitat for many species of water-dependent wildlife, including furbearers, reptiles, birds and insects. Many wildlife species, including birds, small mammals, fish & turtles breed, nest, forage and/or perch in shore buffer areas. Further, 80% of the endangered and threatened species listed spend part of their life in this near-lake buffer area. (Wagner et al, 2006)

When the natural shoreline is replaced by traditional mowed turf-grass lawns, rock, wooden walls or similar installments, bird and animal life, land-based insects, and aquatic insects that hatch or winter on natural shore are negatively impacted. For example, on many Adams County lakes, the non-native aquatic plant, Eurasian Watermilfoil has invaded. There is a weevil native to Wisconsin that weakens Eurasian Watermilfoil by burrowing into and developing within its stems, but that weevil depends on a native-plant shore to overwinter. If the shore is instead covered by rock, seawall or traditional lawn, these weevils will be unavailable for the lake to use as Eurasian Watermilfoil control.

The filtering process and bank stabilization that buffers provide help improve a lake’s water quality, including water clarity. Studies in Minnesota, Maine and Michigan have shown that waterfront property value increases for every foot the water clarity of a lake increases. (Krysel et al, 2003).

Figure 14: Example of Inadequate Vegetative Buffer

Figure 15: Example of Adequate Buffer

Natural shoreland buffers serve important cultural functions. They enhance the lake's aesthetics. Studies have shown that aesthetics rank high as one of the reasons people visit or live on lakes. Shore buffers can provide visual & audio privacy screens for homeowners from other neighbors and/or lake users.

Adequate buffers on Big Roche a Cri Lake in some places could be easily installed on the inadequate areas by either letting the first 35 feet landward from the water just grow without mowing it, except for a path to the water, or by planting native seedlings sufficient to fill in the first 35 feet or using biologs to protect the shore that are vegetated. Where areas are deeply eroded, shaping, revegetating and protecting the shores will be necessary to prevent further erosion.

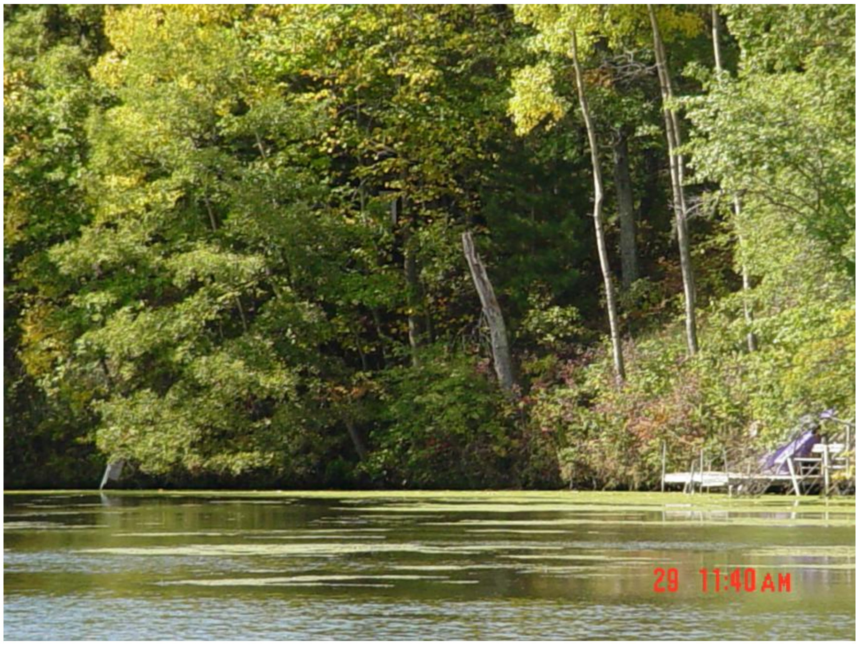


Figure 16: Vegetated Buffer on Big Roche a Cri Lake

WATER QUALITY

Between 2004 and 2006, Adams County Land & Water Conservation Department gathered water chemistry and other water quality information Big Roche a Cri Lake. Part of the information was gained from periodic water sampling done by Adams County LWCD. Historic information about water testing on Big Roche a Cri Lake was also obtained from a Soil & Water Conservation Plan in 1970, from the WDNR in a series of tests in 2002 and 2003, from a lake study done in 1995-1996, and from Self-Help Monitoring records from 1989-2003.

Phosphorus

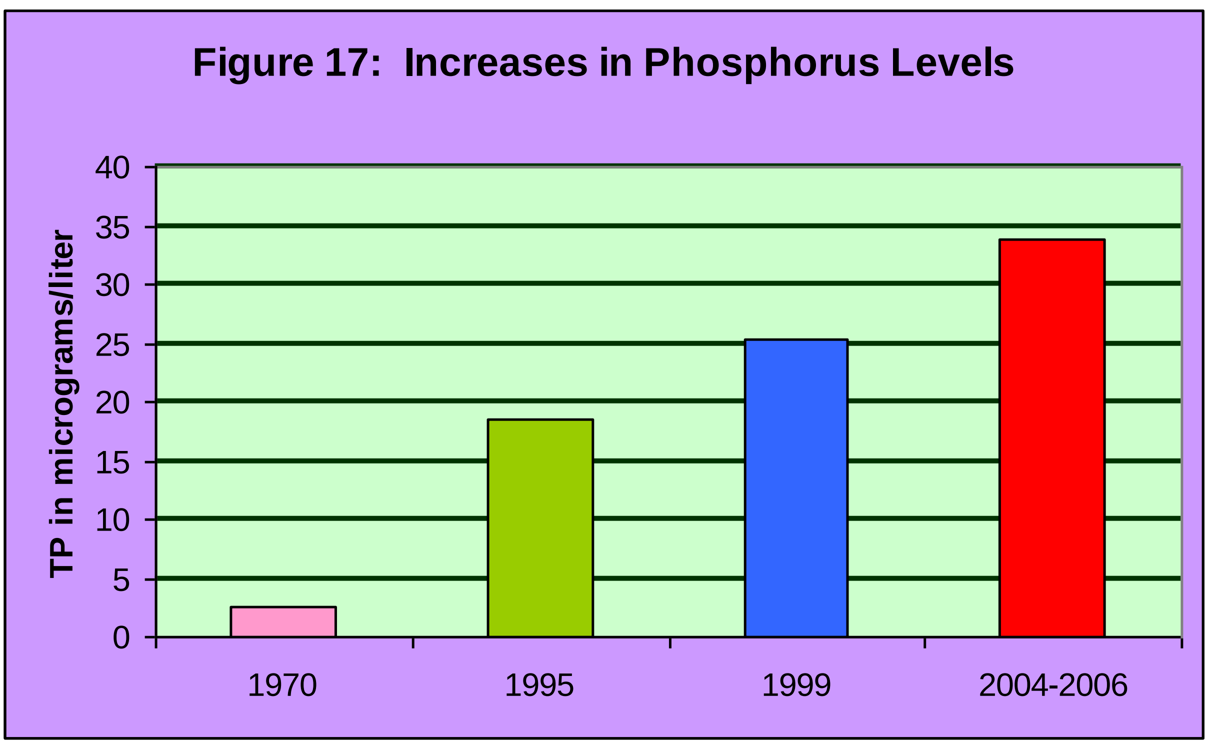
Most lakes in Wisconsin, including Big Roche a Cri Lake, are phosphorus-limited lakes: of the pollutants that end up in the lake, the one that most affects the overall quality of the lake water is phosphorus. The amount of phosphorus especially affects the frequency and density of aquatic vegetation and the frequency and density of various kinds of algae, as well as water clarity and other quality aspects. One pound of phosphorus can produce as much as 500 pounds of algae.

Phosphorus is not an element that occurs in high concentration naturally, so any lake that has significant phosphorus readings must have gotten that phosphorus from outside the lake or from internal loading. Some phosphorus is deposited onto the lake from atmospheric deposition, especially from soil or other particles in the air carrying phosphorus. A lake that includes a flooded wetland area may have a significant amount of phosphorus being released during the flushing of the wetland area. Phosphorus may accumulate in sediments from dying animals, dying aquatic plants and dying algae. If the bottom of the lake becomes anoxic (oxygen-depleted), chemical reactions may cause phosphorus to be released to the water column.

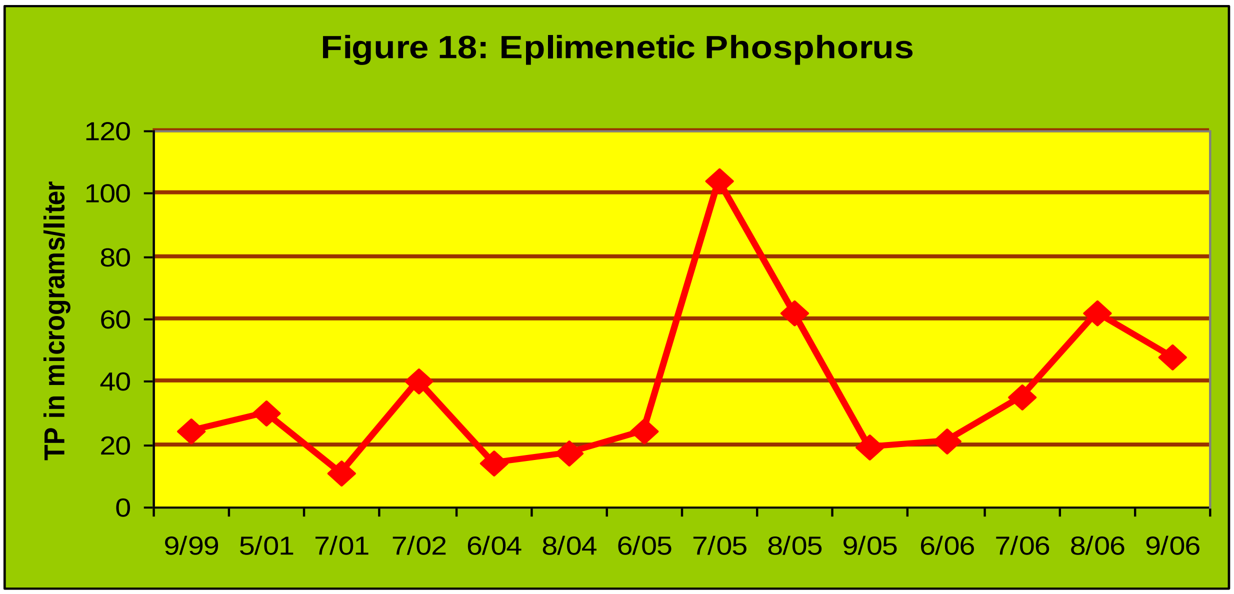
Although there are several forms of phosphorus in water, the total phosphorus (TP) concentration is considered a good indicator of a lake's nutrient status, since the TP concentration tends to be more stable than other types of phosphorus concentration. For an impoundment lake like Big Roche a Cri Lake, a total phosphorus concentration below 30 micrograms/liter tends to prevent nuisance algal blooms. Big Roche a Cri Lake's growing season (June-September) surface average total phosphorus level of 33.91 micrograms/liter is slightly over to the level at which nuisance algal blooms can be expected. And areas of Big Roche a Cri Lake do have nuisance-level algal blooms, especially in the shallower east end.

Since phosphorus is usually the limited factor, measuring the phosphorus in a lake system thus provides an indication of the nutrient level in a lake. Increased phosphorus in a lake will feed algal blooms and also may cause excess plant growth.

The 2004-2006 summer average phosphorus concentration in Big Roche a Cri Lake places Big Roche a Cri Lake in the "fair" water quality section for impoundments, and in the "mesotrophic" level for phosphorus. The total epilimnetic phosphorus levels has been creeping up in Big Roche a Cri Lake. In 1970, the earliest information available, eplimnetic total phosphorus was 2.65 micrograms/liter. By the summer of 1995, the eplimnetic total phosphorus averaged 18.46 micrograms/liter. It crept up to an average of 25.4 micrograms/liter by 1999. And in 2004-2006, it averaged 33.91 micrograms/liter. These levels show that nutrients are accumulating in the lake as time goes on.



As Figure 18 indicates, the growing season total phosphorus levels have varied and often registered above the level recommended to avoid nuisance algal blooms. Except for a spike in July 2005, the eplimnetic total phosphorus levels since August 1999 stayed below the state impoundment average of 65 micrograms/liter, but above the recommended level to avoid nuisance algal blooms. Especially due to the increasing epilimnetic total phosphorus levels, phosphorus should continue to be monitored and steps should be taken to reduce the phosphorus levels in the lake.



Groundwater testing of various wells around Big Roche a Cri Lake was done by Adams County LWCD and included a test one year for total phosphorus levels in the groundwater coming into the lake. The average TP level in the all but one of the wells tested an average of 10.75 micrograms/liter, considerably lower than the lake surface water results. One of the wells tested a very high 136 micrograms/liter and was reported to the landowner as a potential problem. Excepting for this well, even if some of this phosphorus from the other wells enters the lake from groundwater, it is unlikely to contribute significantly to the rising phosphorus levels.

Land use plays a major role in phosphorus loading. A key component of the computer models used is the phosphorus budget, that is, the estimated amount of phosphorus delivered to the lake from each land use type annually. The land uses that contribute the most phosphorus are non-irrigated agriculture and residences. Using the current land use data, as well as phosphorus readings from 2004 through 2006 water sampling, a phosphorus loading prediction model was run for Big Roche a Cri Lake. The current results are shown in Figure 19a.

Figure 19a: Current Phosphorus Loading by Land Use

ESTIMATED CURRENT PHOSPHORUS LOADING		
	% Loading	**Lbs/Acre/Yr**
Irrigated Agriculture	68.2%	3265.45
Non-Irrigated Agriculture	13.8%	660.23
Grassland/Pasture	0.9%	43.72
Residential	3.0%	136.51
Woodlands	4.2%	201.64
Other Water	1.8%	87.44
Ground Watershed	7.6%	364.91
Lake Surface	0.2%	10.71
Septics	0.2%	11.78
Commercial/Government	0.1%	5.35
total	100.0%	4787.74

In a study of the lake done by the firm of Foth & Van Dyke in the late-1990s, phosphorus loading was somewhat different than the current estimates (see figure 19b).

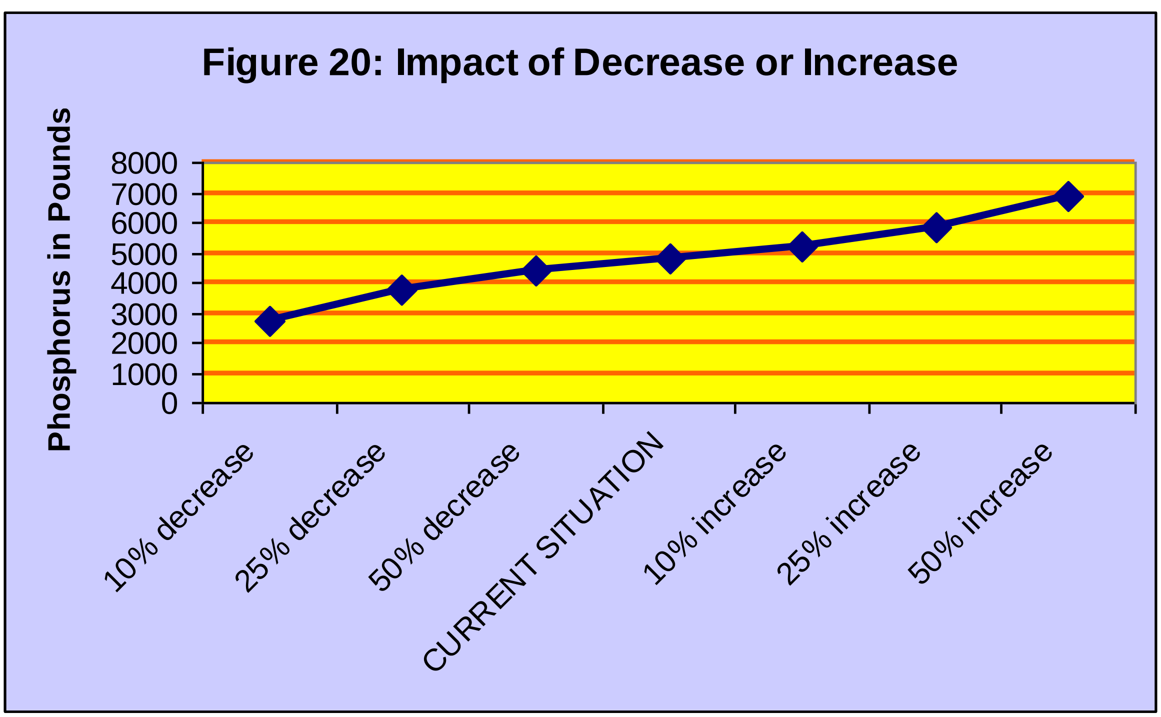
Figure 19b: Phosphorus Loading in late-1990s

	P in lbs/yr	**% Total**
Agriculture	1265	45.02%
Grass/Open	347	12.35%
Residential	68	2.42%
Residential Wastewater	657	19.86%
Wetlands	172	6.12%
Woodlands	400	14.23%
total	2909	100.00%

These figures reveal that are phosphorus loading in the watersheds is now 164.58% more than it was in the mid-1990s. This may be due to the greatly increased residential development, with increased impervious surface, and an increase in irrigated agriculture throughout Adams County in the past ten years.

Currently, the most phosphorus loading is coming from agriculture in the surface watershed and from the ground watershed. Although phosphorus deposits such as that from flooded wetlands or from atmospheric deposition cannot be controlled by humans, phosphorus loads from human activities such as agriculture, residential development and septic systems can be partly controlled by changes in human land use patterns. Practices such as agricultural buffers, nutrient management, shoreland buffer restoration; infiltrating stormwater runoff from roof tops, driveways and other impervious surfaces; using no phosphorus lawn fertilizers; and reducing phosphorus input to and properly managing septic systems will minimize phosphorus inputs into the lake. Circumstances such as increased impervious surface, lawns mowed to water's edge, disturbance of shore areas, improperly-functioning septic systems and removal of native vegetation can greatly increase the volume and content of runoff—and thus increase the volume of phosphorus entering the lake. Many of these practices can also increase the concentration of phosphorus entering the lake, by runoff or other methods of entry.

The models were run using not only the current known phosphorus readings in the lake, but also representing decreases or increases of human-controlled phosphorus input by 10%, 25%, and 50%. Just a 10% reduction of the human-impacted phosphorus would reduce the overall load by 421.17 pounds/acre/year. This figure may not seem like much---until you calculate that one pound of phosphorus can result in up to 500 pounds of algae. A 10% reduction in these three areas could result in up to 210,585 pounds less of algae per acre per year!



Reducing the amount of input from the surface and ground watersheds results in less nutrient loading into the lake itself. Under the modeling predictions, reducing phosphorus inputs from human-based activities even 10% could improve Big Roche a Cri Lake water quality by up to 10 micrograms and bring the average eplimnetic TP down to 32.1 micrograms/liter. A 25% reduction could save up to 26 micrograms/liter and thus reduce the overall eplimnetic growing season total phosphorus to 26.7 micrograms/liter, under the 30 micrograms/liter recommended to avoid nuisance algal blooms) in total phosphorus levels that algal blooms would be greatly reduced. These predictions make it clear that reducing current phosphorus inputs to the lake are essential to improve, maintain and protect Big Roche a Cri Lake's health for future generations.

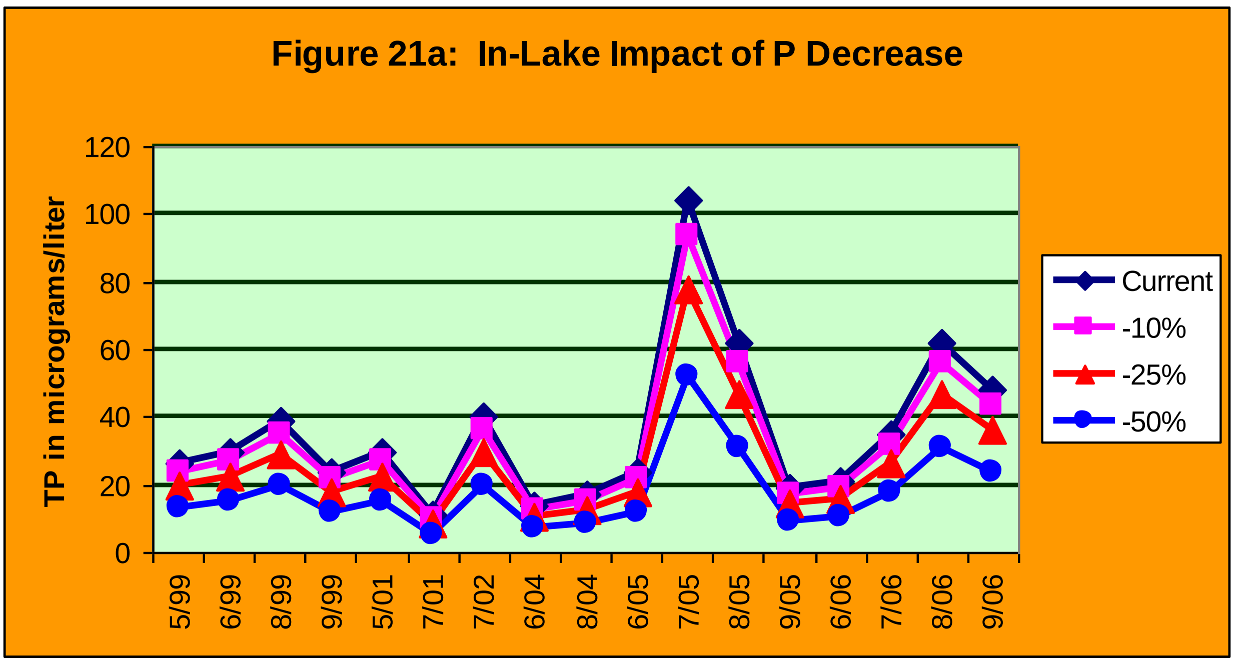
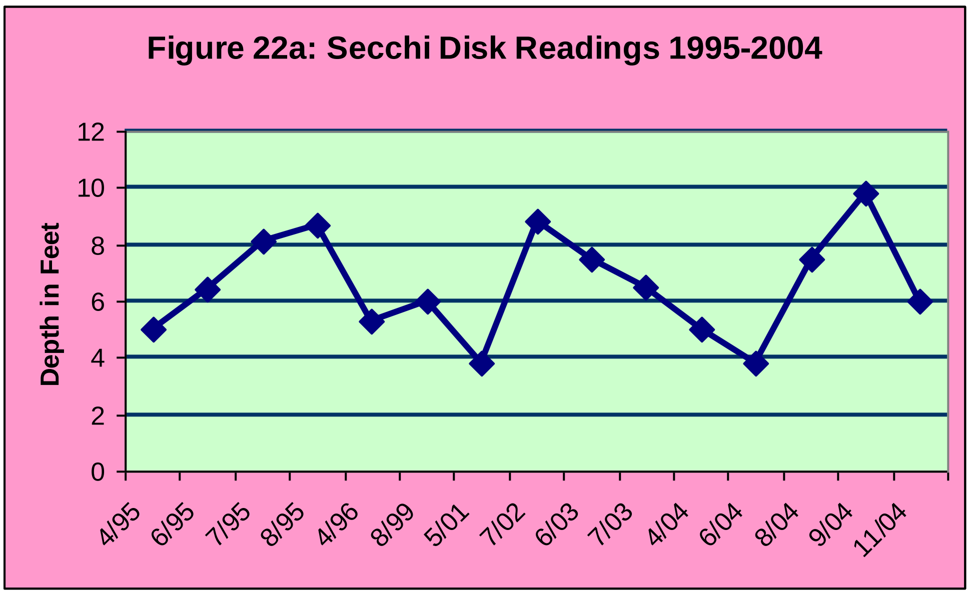
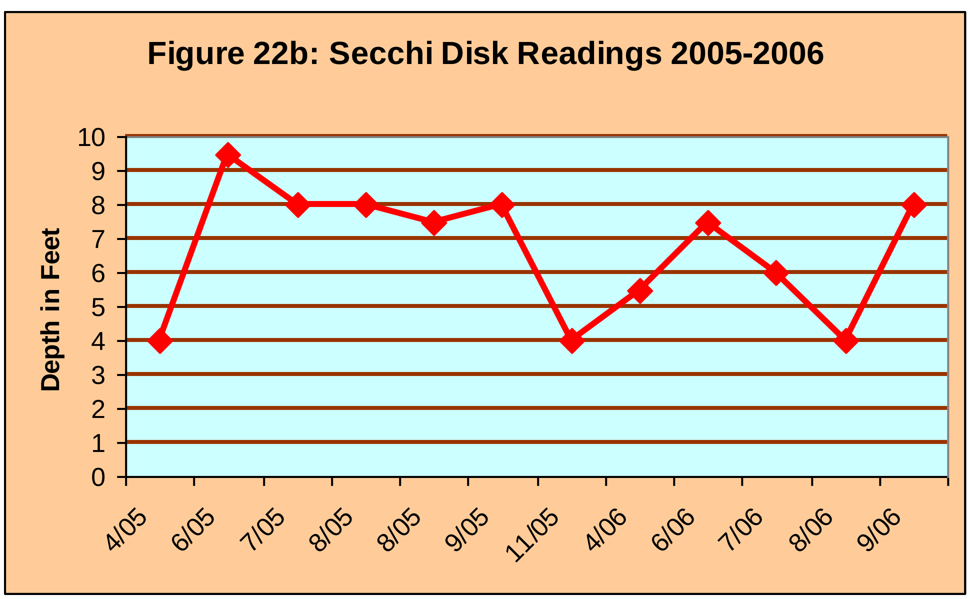


Figure 21b: Photo of a Lake in Algal Bloom

Water Clarity

Water clarity is a critical factor for plants. If plants don't get more than 2% of the surface illumination, they won't survive. Water clarity can be reduced by turbidity (suspended materials such as algae and silt) and dissolved organic chemicals that color or cloud the water. Water clarity is measured with a Secchi disk. Average summer Secchi disk clarity in Big Roche a Cri Lake in 2004-2006 was 7.19 feet. This is good water clarity, putting Big Roche a Cri Lake into the "mesotrophic" category for water clarity.





Big Roche a Cri Lake has a considerable history of Secchi disk readings in a number of years. A look at the average Secchi depth for the growing season in each year since 1989 reveals that except for spikes for unknown reason in 1991 and 1992, the Secchi disk depth readings have remained fairly steady since 1989 (see figure 23). The overall average depth for the fourteen years for which there are records is 7.51 feet.

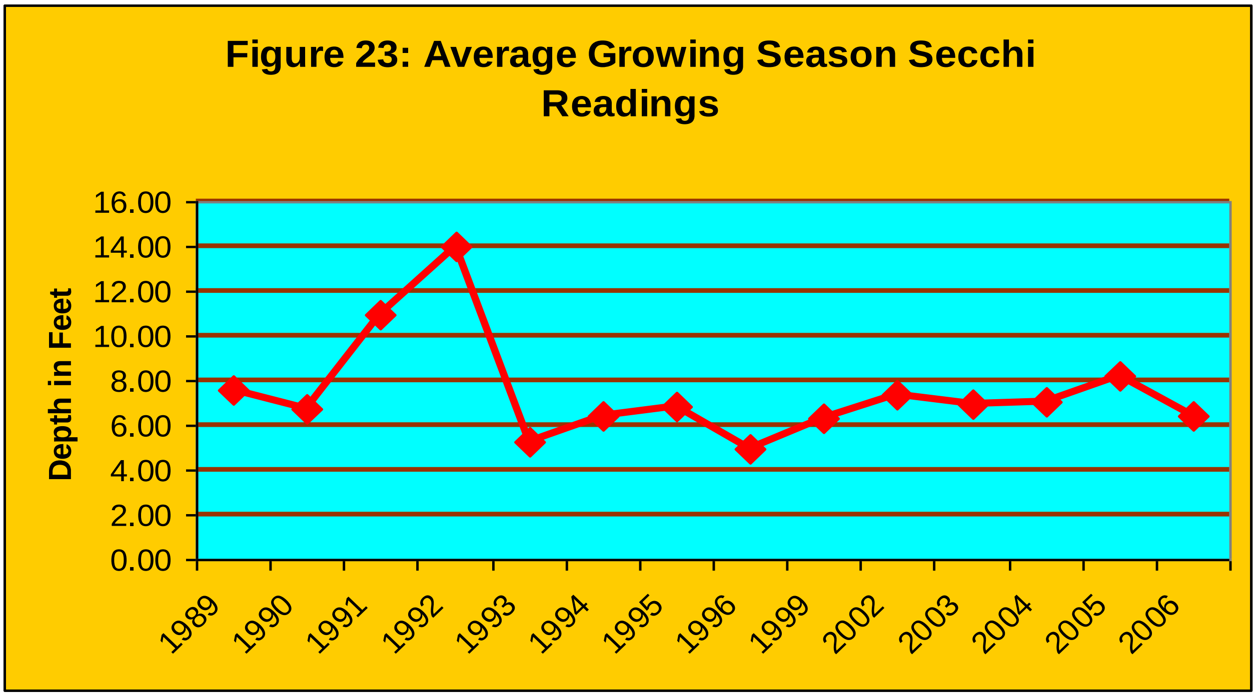
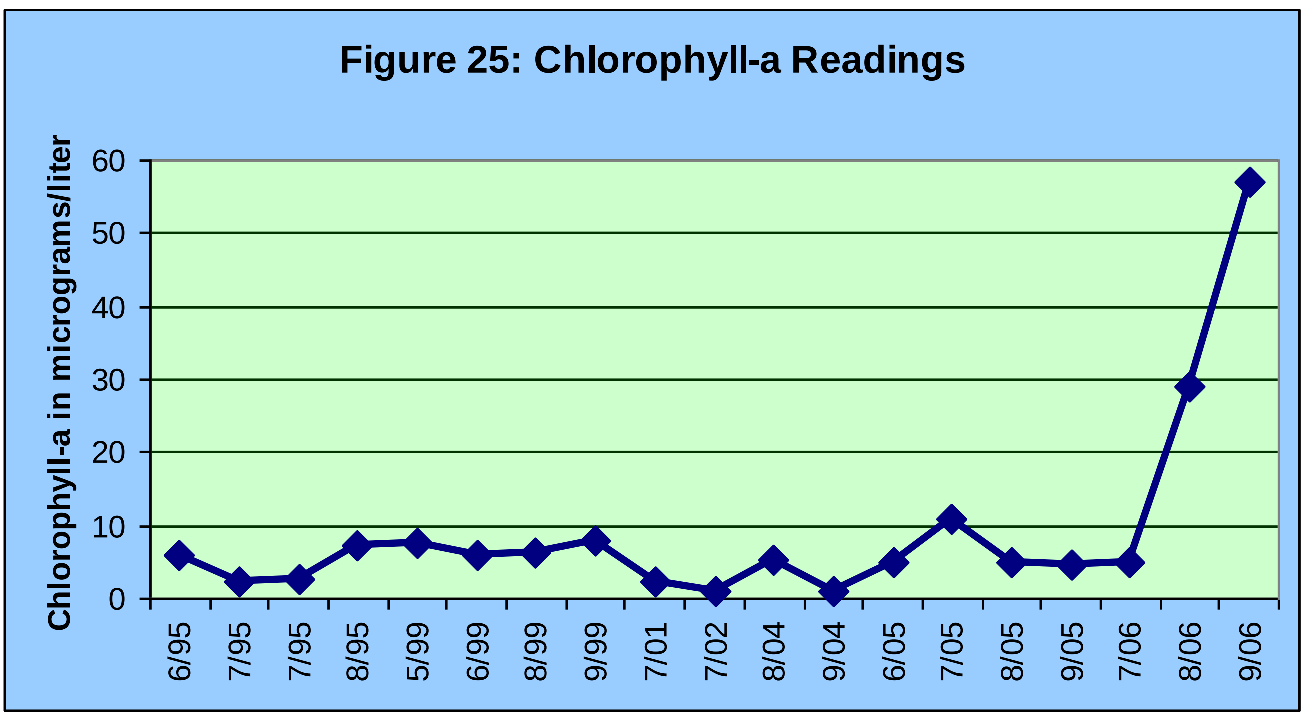


Figure 24: Photo of Testing Water Clarity with Secchi Disk

Chlorophyll a

Chlorophyll-a concentrations provide a measurement of the amount of algae in a lake's water. Algae are natural and essential in lakes, but high algal populations can increase water turbidity and reduce light available for plant growth, as well as result in unpleasing odor and appearance. Studies have shown that the amount of chlorophyll a in lake water depends greatly on the amount of algae present; therefore, chlorophyll-a levels are commonly used as a water quality indicator. The 2004-2006 growing season (June-September) average chlorophyll concentration in Big Roche a Cri Lake was 14.15 micrograms/liter. Such an algae concentration places Big Roche a Cri Lake at the "fair" level for chlorophyll a results.

Chlorophyll-a averages remained fairly steady until 2006, when summer figures were very elevated. However, these readings might have been a factor of the very hot summer of 2006, as plants slowed down photosynthesis due to the much hotter water (Figure 25).



Dissolved Oxygen

Oxygen dissolved in the water is essential to all aerobic aquatic organisms. The oxygen in a lake comes from the atmosphere and from the process of photosynthesis. Aquatic plants and algae consume carbon dioxide and respirate oxygen back into the lake water. The distribution of oxygen within a lake is affected by many factors, including water circulation, water stratification, winds or storms, air temperature; water temperature, nutrient availability, and the density and location of algae and/or aquatic plants. During the summers of 2004, 2005 and 2006, dissolved oxygen levels didn't usually go below levels 5 milligrams/liter, the appropriate level for good fish survival. There was one month—June 2006—during which dissolved oxygen at all depths were 2.2 milligrams/liter or less, for reasons unknown. This kind of reading has not been repeated, nor was it found during the earlier years in which dissolved oxygen profiles were taken (1995, 1996, 2002, and 2003). The charts (Figures 26a, 26b, 26c & 26d) below show the annual (2004-2006) variations in dissolved oxygen levels in milligrams/liter, depth in feet and months of the years.

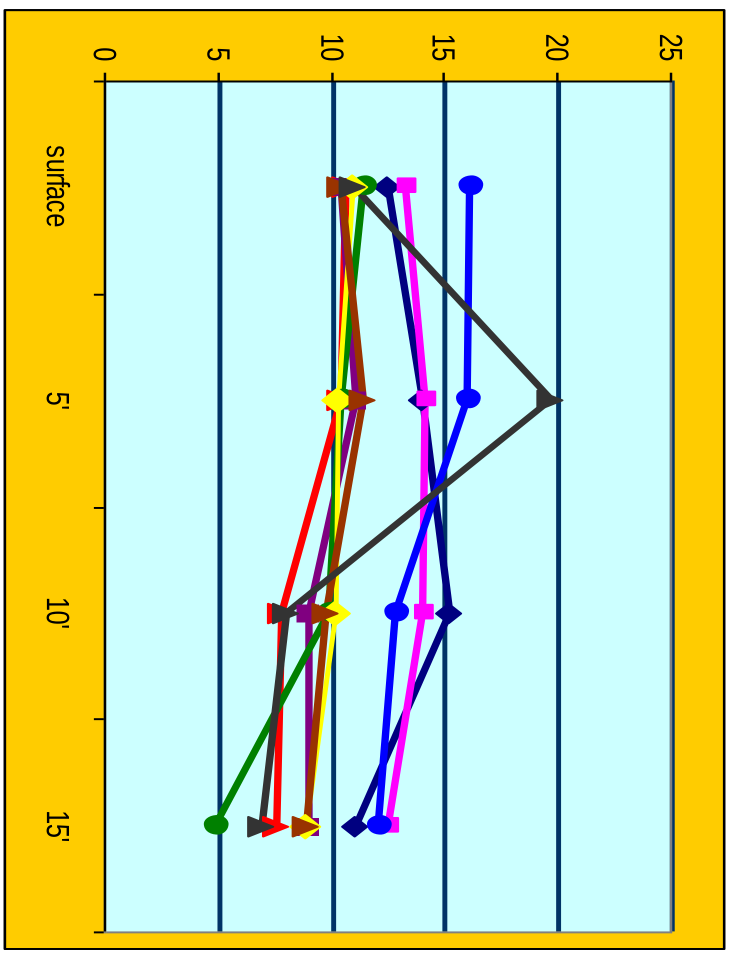


Figure 26a: Dissolved Oxygen Levels 1995-2003 in milligrams/liter

6/95
7/95
7/95
3/96
4/96
7/02
7/02
8/02
6/03

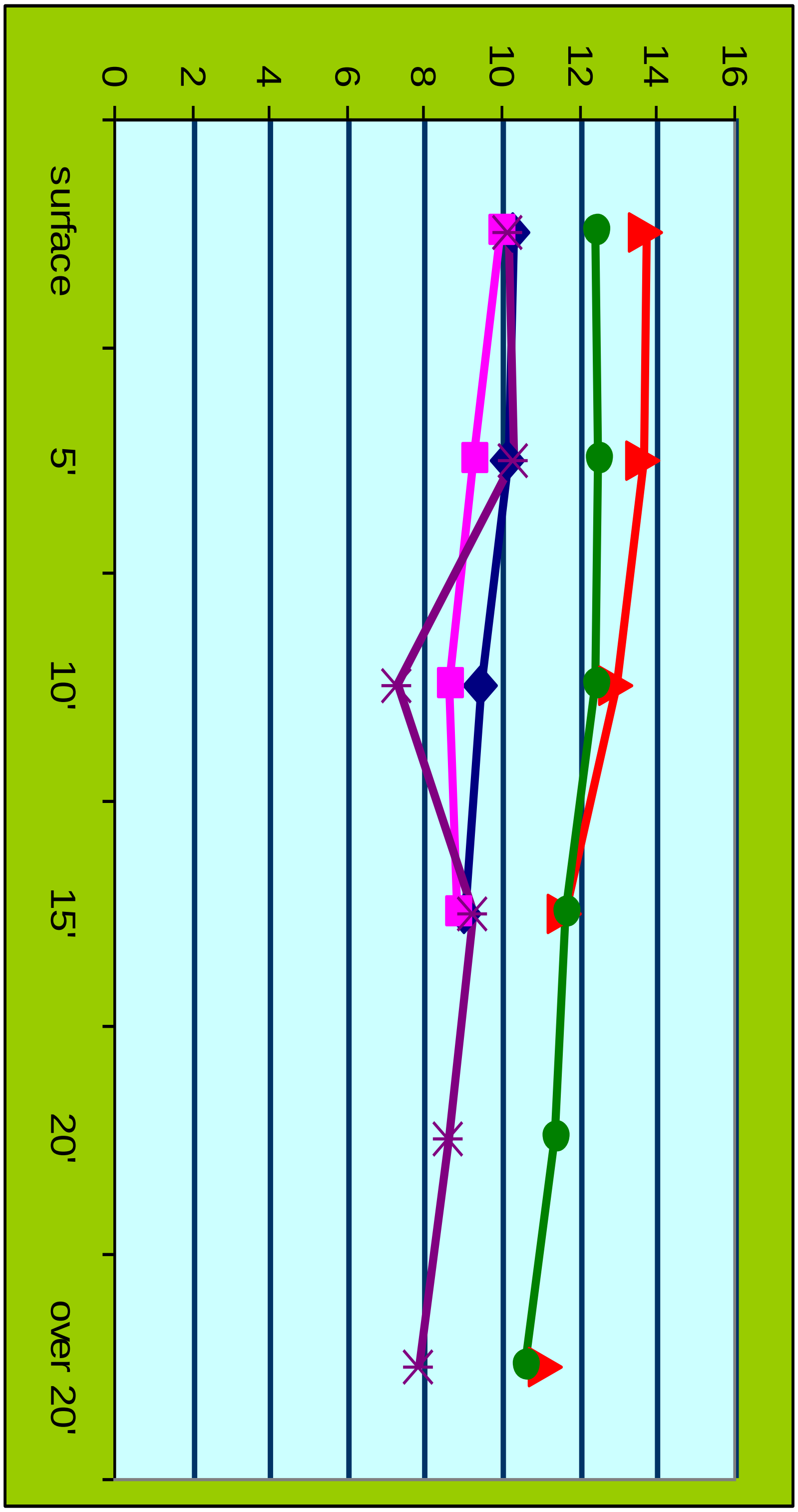


Figure 26b: Dissolved Oxygen Levels During 2004 Water Testing in milligrams/liter

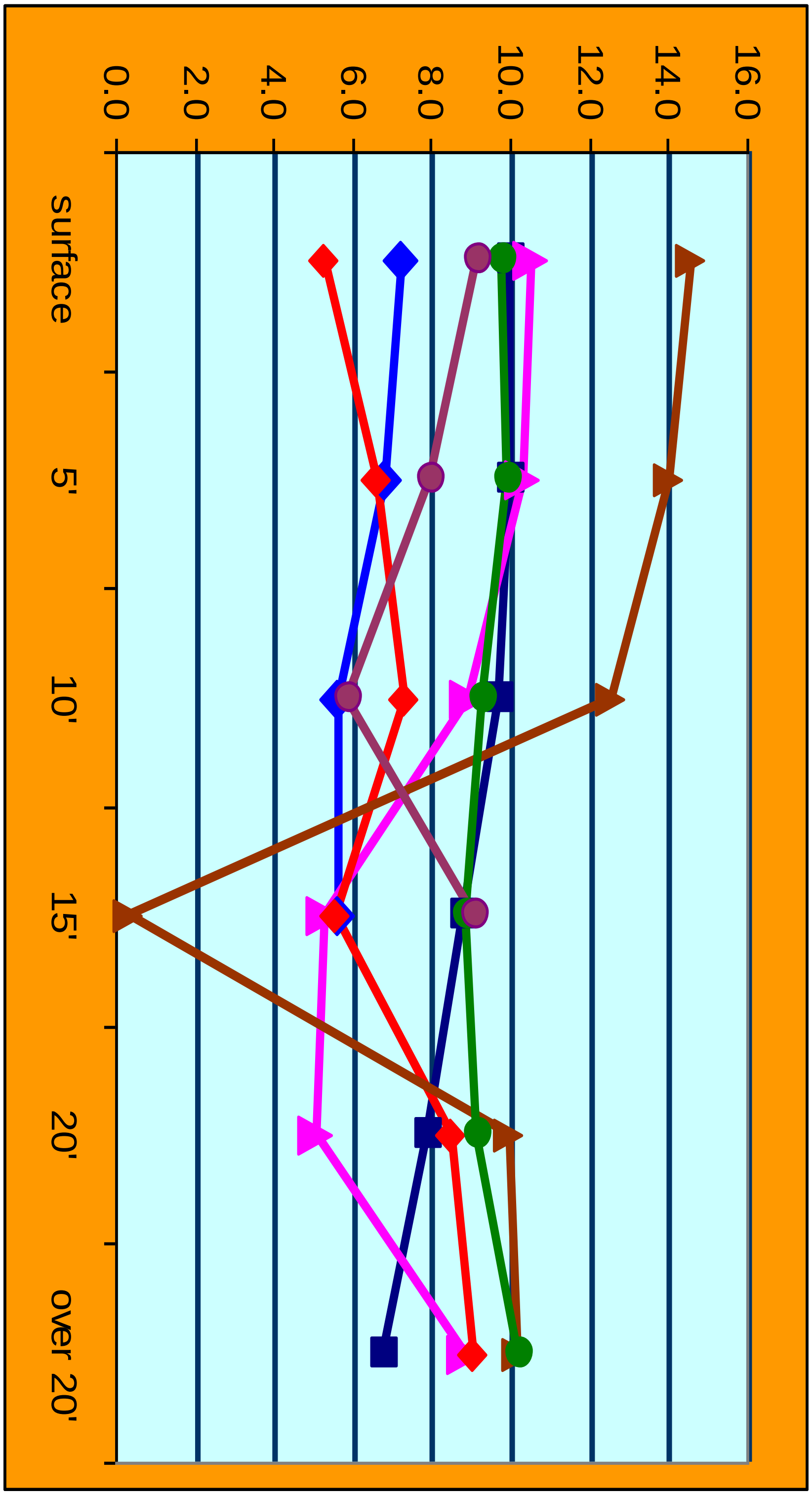
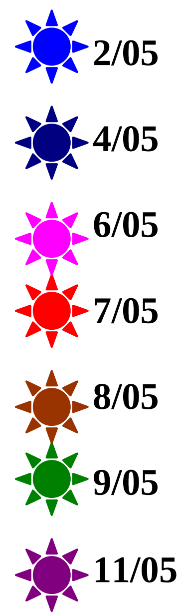


Figure 26c: Dissolved Oxygen Levels During 2005 Water Testing in milligrams/liter



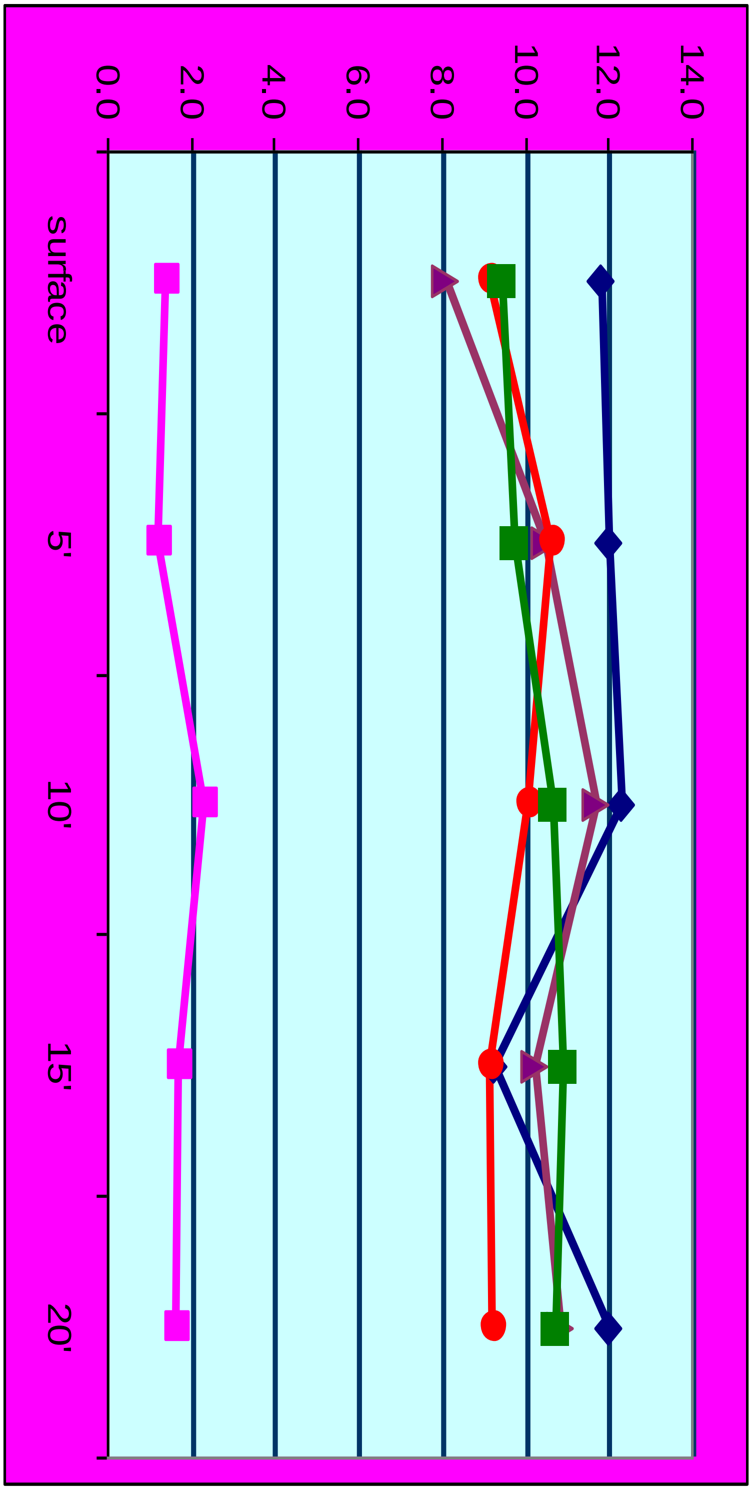
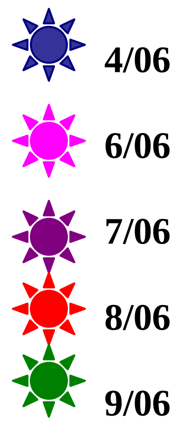


Figure 26d: Dissolved Oxygen Levels During 2006 Water Testing in milligrams/liter



In deeper lakes, when the surface waters have cooled in autumn and water density throughout the water column is the same, the water column mixes vertically, a process known as "fall turnover." Most of Big Roche a Cri Lake is shallow and does not stratify. However, the west end of the lake, where depths exceed 20 feet deep, goes stratify and turns over in the spring or fall.

Further, since flowing stream goes through the lake from east to west through Big Roche a Cri Lake, some open water is common throughout the winter on part of the lake. This probably allows oxygen levels to stay elevated—even the winter, most of the dissolved oxygen readings over the amount needed by fish (over 5 milligrams/liter).

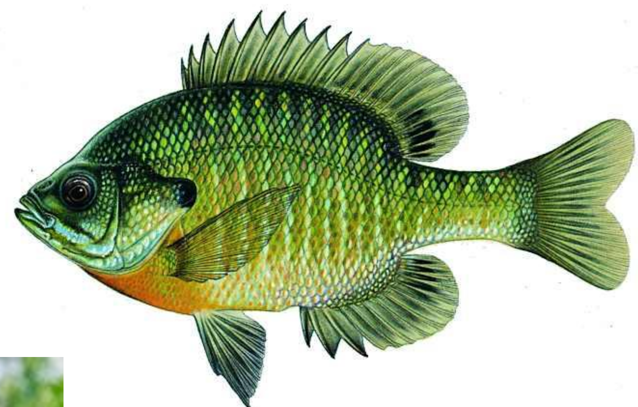


Figure 27a: Most abundant fish in Big Roche a Cri Lake—Bluegill (*Lepomis macrochirus)*

Figure 27b: Common Fish in Big Roche a Cri Lake—Largemouth Bass (*Micropterus salmoides)*

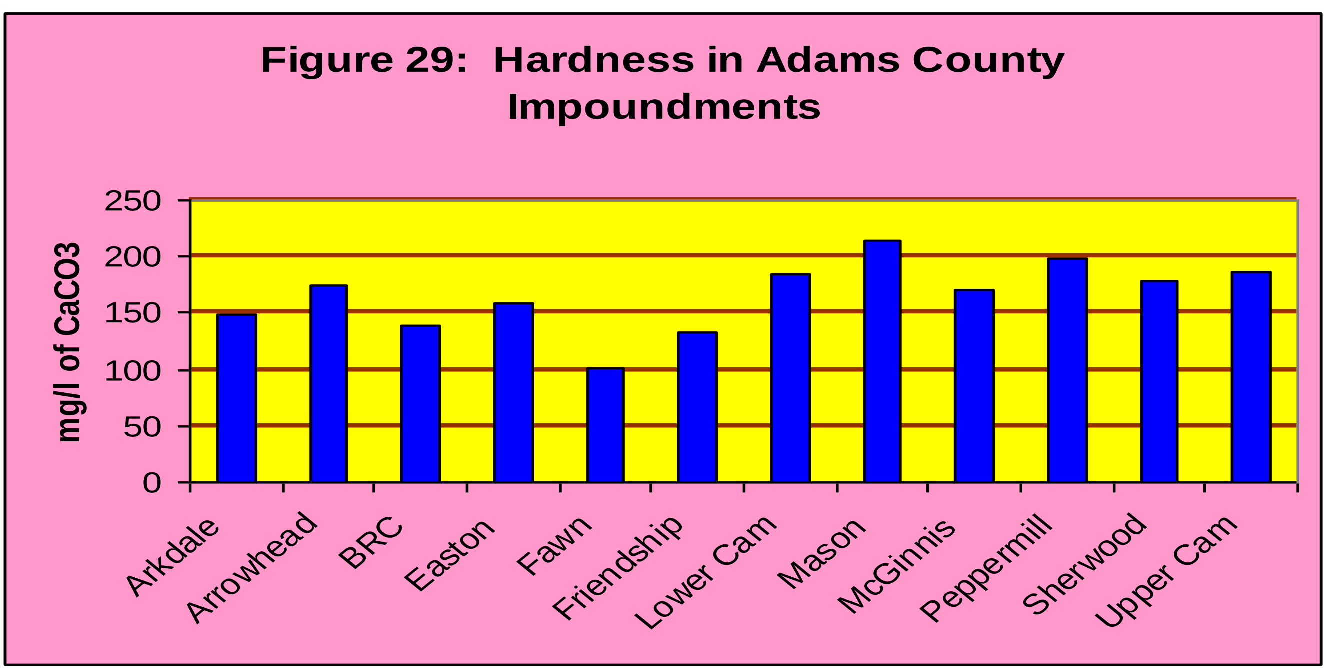
Water Hardness, Alkalinity and pH

Testing done by Adams County LWCD on Big Roche a Cri Lake included annual testing for water alkalinity and water hardness. Hardness and alkalinity levels in a lake are affected by the soil minerals, bedrock type in the watershed, and frequency of contact between lake water & these materials.

Level of Hardness	Milligrams/liter CaCO3
SOFT	0-60
MODERATELY HARD	61-120
HARD	121-180
VERY HARD	>180

Figure 28: Hardness Table

One method of evaluating hardness is to test the water for the amount of calcium carbonate ($CaCO_3$) it contains. The surface water of all of the public access lakes in Adams County have water that is moderately hard to very hard, whether they are impoundments (man-made lakes) or natural lakes. In 2005 and 2006, random samples were also taken of wells around Big Roche a Cri Lake to measure the hardness of the water coming into the lake through groundwater. Hardness in the groundwater ranged from 80 (moderately hard) to 285 (very hard), with an average of 193 milligrams/liter. The hardness in both surface and groundwater is likely due to the underlying bedrock in Adams County, which is mostly sandstone with pockets of dolomite and shale.



As the graph (Figure 29) shows, Big Roche a Cri Lake surface water testing results showed "hard" water (average 145 milligrams/liter CaCO3), less than the overall hardness average impoundments in Adams County of 166 milligrams/liter of Calcium Carbonate. Hard water lakes tend to produce more fish and aquatic plants than soft water lakes because they are often located in watersheds with soils that load phosphorus into the lake water.

Alkalinity is important in a lake to buffer the effects of acidification from the atmosphere. "Acid rain" has long been a problem with lakes that had low alkalinity level and high potential sources of acid deposition.

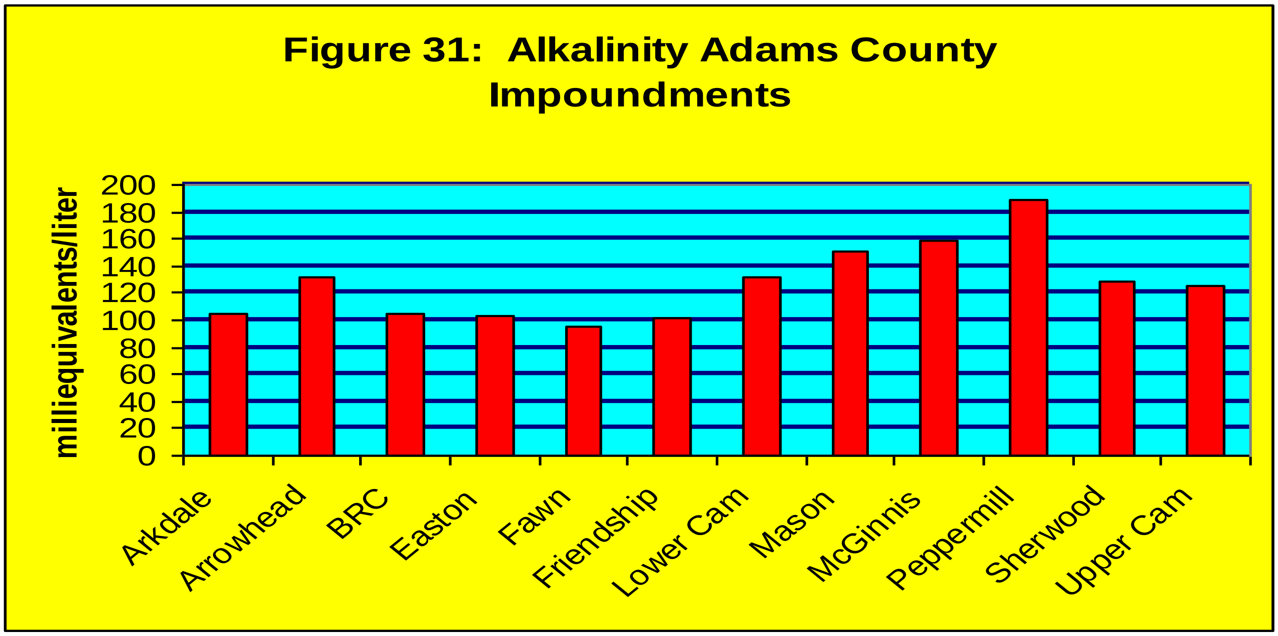
Acid Rain Sensitivity	ueq/l CaCO3
High	0-39
Moderate	49-199
Low	200-499
Not Sensitive	>500

Figure 30: Acid Rain Sensitivity

Well water testing results ranged from 88 milliequavalents/liter to 176 milliequivalents/liter in alkalinity, with an average of 128.67 milliequivalents/liter. This is higher than the surface water average of 103.2 milliequivalents/liter. Big Roche a Cri Lake's potential sensitivity to acid rain is moderate, but luckily for Adams County, the acid deposition rate is very low, probably due to the little industrialization in the county.

Alkalinity also affects the pH level of lake water. The acidity level of a lake's water regulates the solubility of many minerals. A pH level of 7 is neutral. The pH level in Wisconsin lakes ranges from 4.5 in acid bog lakes to 8.4 in hard water, marl lakes.

Some of the minerals that become available under low pH, especially the metals aluminum, zinc and mercury, can inhibit fish reproduction and/or survival. Even what seems like a small variance in pH can have large effects because the pH scale is set up so that every 1.0 unit change increases acidity tenfold, i.e., water with a pH of 7 is 10 times more acid than water with pH of 8. Mercury and aluminum are not only toxic to many kinds of wildlife; they can also be toxic to humans, especially those that eat tainted fish.



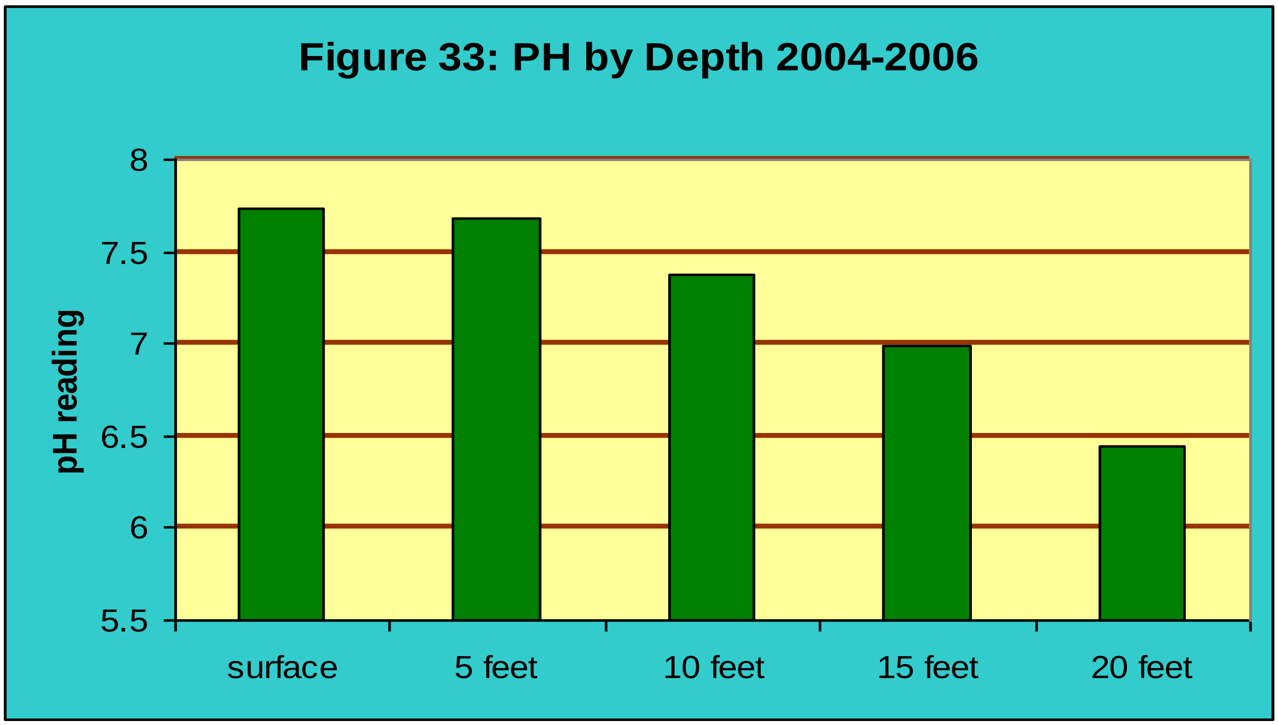
The testing occurring from 2004-2006 also included regular monitoring of the pH at several depths in Big Roche a Cri Lake. As is common in the lakes in Adams County, Big Roche a Cri Lake has pH levels starting at just under neutral (6.45) at 20 feet depth and increasing in alkalinity as the depth gets less, until the surface water pH averages 7.73. A lake's pH level is important for the release of potentially harmful substances and also affects plant growth, fish reproduction and survival. Most plants grow best at pH levels between 5.5 and 8.

More importantly for many lakes, fish reproduction and survival are very sensitive to pH levels. The chart below indicates the effect of pH levels under 6.5 on fish (Figure 32):

Figure 32: Effects of pH Levels on Fish

Water pH	Effects
6.5	walleye spawning inhibited
5.8	lake trout spawning inhibited
5.5	smallmouth bass disappear
5.2	walleye & lake trout disappear
5	spawning inhibited in most fish
4.7	Northern pike, sucker, bullhead, pumpkinseed, sunfish & rock bass disappear
4.5	perch spawning inhibited
3.5	perch disappear
3	toxic to all fish

No pH levels taken in Big Roche a Cri Lake between 2004-2006 fell below the pH level that inhibits walleye reproduction. A lake with a neutral or slightly alkaline pH like Big Roche a Cri Lake is a good lake for fish and plant survival. Natural rainfall in Wisconsin averages a pH of 5.6. This means that if the rain falls on a lake without sufficient alkalinity to buffer that acid water coming in by rainfall, the lake's fish cannot reproduce. That is not a problem at Big Roche a Cri Lake. Big Roche a Cri Lake has a good pH level for fish reproduction and survival.



There is some pH information taken from the data from the WDNR, Self-Help Monitoring, 1996 Lake Management Plan and the Foth/Van Dyke study. Although pH information is given, the data doesn't show a depth profile, just a pH level for the surface water. The figures indicate that surface pH before 2000 was more alkaline than the current pH levels—pH readings were between 8 and 9. Since 2000, the surface level pH has stayed mostly between 7 and 8 on the pH scale, i.e., neutral to slightly acid (see figures 34a & 34b).

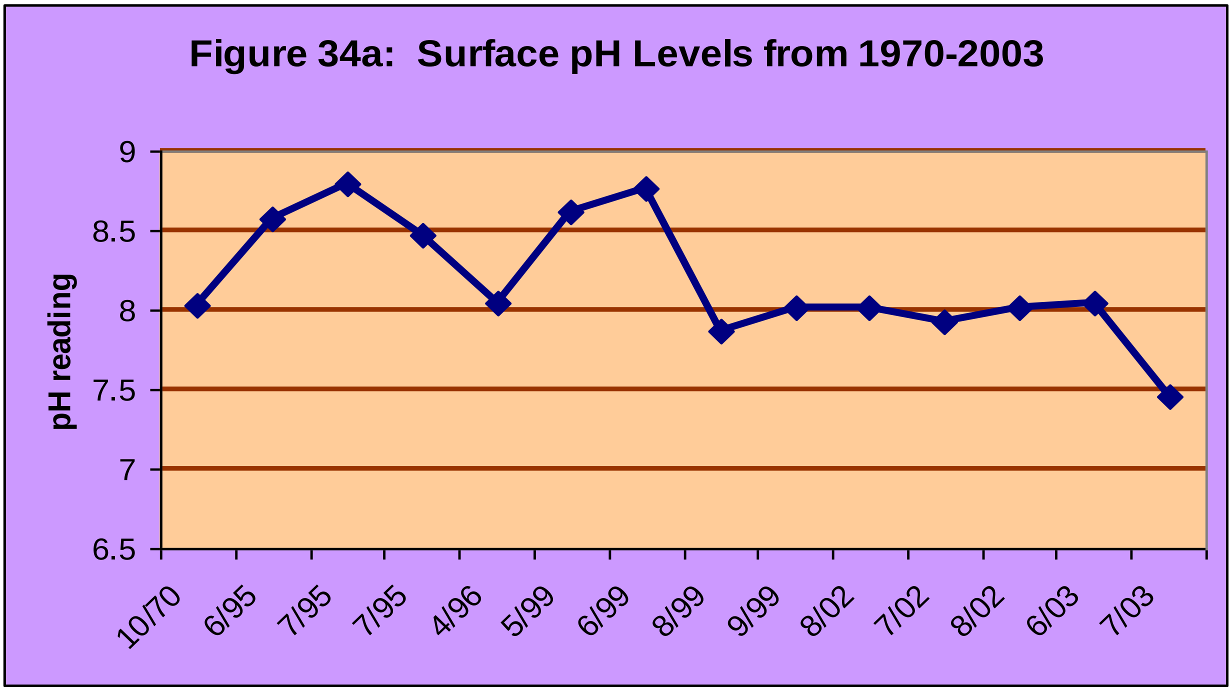


Figure 34a: Surface pH Levels from 1970-2003
pH reading
9
8.5
8
7.5
7
6.5
10/70
6/95
7/95
7/95
4/96
5/99
6/99
8/99
9/99
8/02
7/02
8/02
6/03
7/03

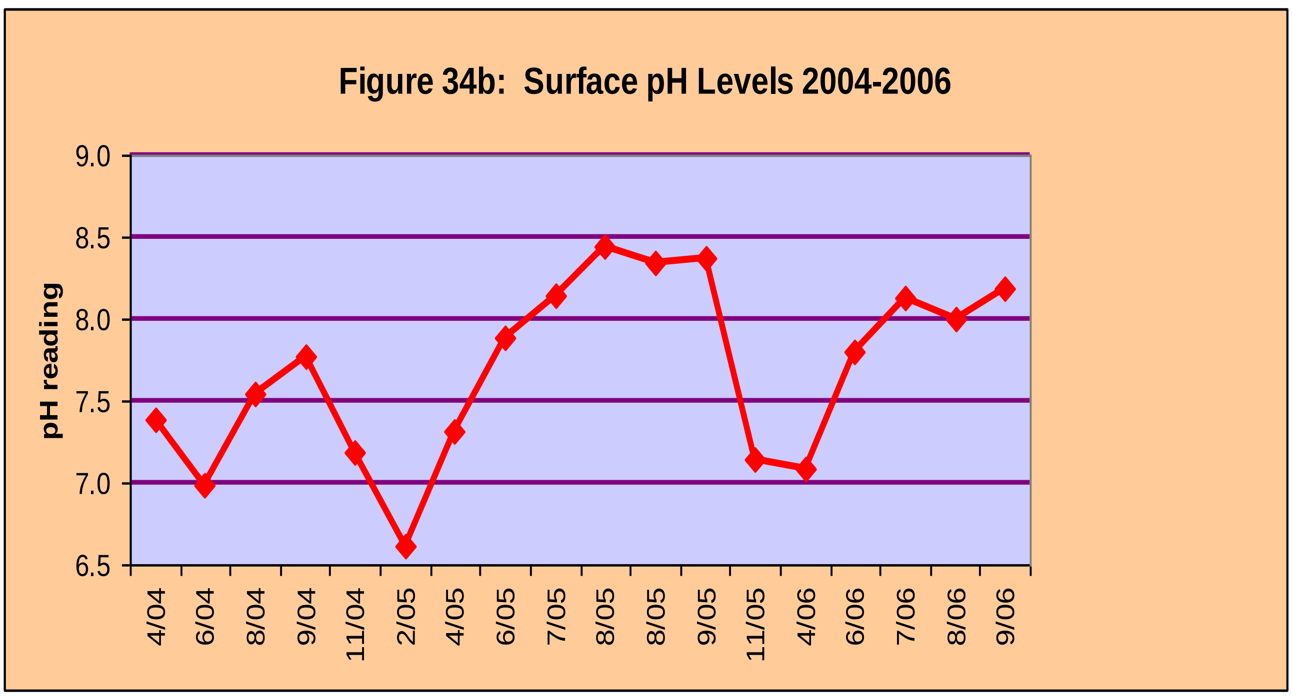


Figure 34b: Surface pH Levels 2004-2006
pH reading
9.0
8.5
8.0
7.5
7.0
6.5
4/04
6/04
8/04
9/04
11/04
2/05
4/05
6/05
7/05
8/05
8/05
9/05
11/05
4/06
6/06
7/06
8/06
9/06

Other Water Quality Testing Results

CHLORIDE: Chloride does not affect plant and algae growth and is not known to be harmful to humans. It isn't common in most Wisconsin soils and rocks, so is usually found only in very low levels in Wisconsin lakes. However, the presence of a significant amount of chloride over a period of time indicates there may be negative human impacts on the water quality present from septic system failure, the presence of fertilizer and/or waste, deposition of road-salt, and other nutrients. An increased chloride level is thus an indication that too many nutrients are entering the lake, although the level has to be evaluated compared to the natural background data for chloride. The average chloride level found in Big Roche a Cri Lake during the testing period was 7.07 milligrams/liter, elevated substantially above the natural level of 3 milligrams/liter for chloride in this area of Wisconsin. Further investigation as to the cause of such elevations needs to be performed.

NITROGEN: Nitrogen is necessary for plant and algae growth. A lake receives nitrogen in various forms, including nitrate, nitrite, organic, and ammonium. In Wisconsin, the amount of nitrogen in a lake's water often corresponds to the local land use. Although some nitrogen will enter a lake through rainfall from the atmosphere, that coming from land use tends to be in higher concentrations in larger amounts, coming from fertilizers, animal and human wastes, decomposing organic matter, and surface runoff. For example, the growth level of the exotic aquatic plant, Eurasian Watermilfoil (*Myriophyllum spicatum*) has been correlated with fertilization of lake sediment by nitrogen-rich spring runoff.

Nitrogen levels can affect other aspects of water quality. The sum of water testing results for nitrate, nitrite and ammonium levels of over .3 milligrams/liter in the spring can be used to project the likelihood of an algal bloom in the summer (assuming sufficient phosphorus is also present). Big Roche a Cri Lake combination spring levels from 2004 to 2006 averaged 3.22 milligrams/liter, far above the .3 milligrams/liter predictive level for nitrogen-related algal blooms. These elevations suggest that some of the algal blooms on Big Roche a Cri Lake may be at least partly nitrogen-related. Big Roche a Cri Lake has had an ongoing problem with fairly large and frequent algal blooms during the growing season.

CALCIUM and MAGNESIUM: Calcium is required by all higher plants and some microscopic lifeforms. Magnesium is needed by chlorophyllic plants and by algae, fungi and bacteria. Both calcium and magnesium are important contributors to the hardness of a lake's waters. Magnesium elevated about 125 milligrams/liter may have a laxative effect on some humans. Otherwise, no health hazards to humans and wildlife are known from calcium and magnesium. The average Calcium level in Big Roche a Cri Lake's water during the testing period was 33.63 milligrams/liter. The average Magnesium level was 13.58 milligrams/liter. Both of these are low-level readings.

SODIUM AND POTASSIUM: These elements occur naturally only in low levels in Wisconsin waters and soils. Their presence may indicate human-caused pollution. Sodium is found with chloride in many road salts and fertilizers and is also found in human and animal waste. Potassium is found in many fertilizers and also found in animal waste. The level of these two is generally not useful as a specific pollution indicator, but increasing levels or one or both of these elements can indicate possible contamination from damaging pollutants. High levels of sodium have also been found to influence the development of a large population of cyanobacteria, some of which can be toxic to animals and humans. Some health professionals have suggested that sodium levels over 20 milligrams/liter may be harmful to heart and kidney patients if ingested. Both sodium and potassium levels in Big Roche a Cri Lake are very low: the average sodium level was 2.17 milligrams/liter; the average potassium reading 2.02 milligrams/liter.

SULFATE: In low-oxygen waters (hypoxic), sulfate can combine with hydrogen and becomes the gas hydrogen sulfate, which smells like rotten eggs and is toxic to most aquatic organisms. Sulfate levels can also affect the metal ions in the lake, especially iron and mercury, by binding them up, thus removing them from the water column. To prevent the formation of hydrogen sulfate, levels of 10 milligrams/liter are best. A health advisory kicks in at 30 milligrams/liter. Big Roche a Cri Lake sulfate levels averaged 21.61 milligrams/liter during the testing period, above the level for hydrogen sulfate formation, but below the health advisory level.

TURBIDITY: Turbidity reflects water clarity. The term refers to suspended solids in the water column—solids that may include clay, silt, sand, plankton, waste, sewage and other pollutants. Turbid water may mask the presence of bacteria or other pollutants because the water looks murky or muddy. In general, turbidity readings of less than 5 NTU are best. Very turbid waters may not only smell, but also tend to be aesthetically displeasing, thus curtailing recreational uses of the water. Turbidity levels for Big Roche a Cri Lake's waters were 2.17 NTU in 1995, 1.9 and 2.3 NTU in 1995, 2.6 in 1996. They remained at low levels during the 2004-2006 testing period: 1.89 NTU in 2004, 2.01 NTU in 2005 and 2.62 NTU in 2006—all below the level of concern.

Figure 35: Examples of Very Turbid Water

HYDROLOGIC BUDGET

According to date in a 1965 WDNR bathymetric (depth) map, Big Roche a Cri Lake has 204.7 surface acres, and the volume of the lake is 1834 acre-feet. At that time, 11% of the lake was less than 3 feet deep. The maximum depth was 20 feet.

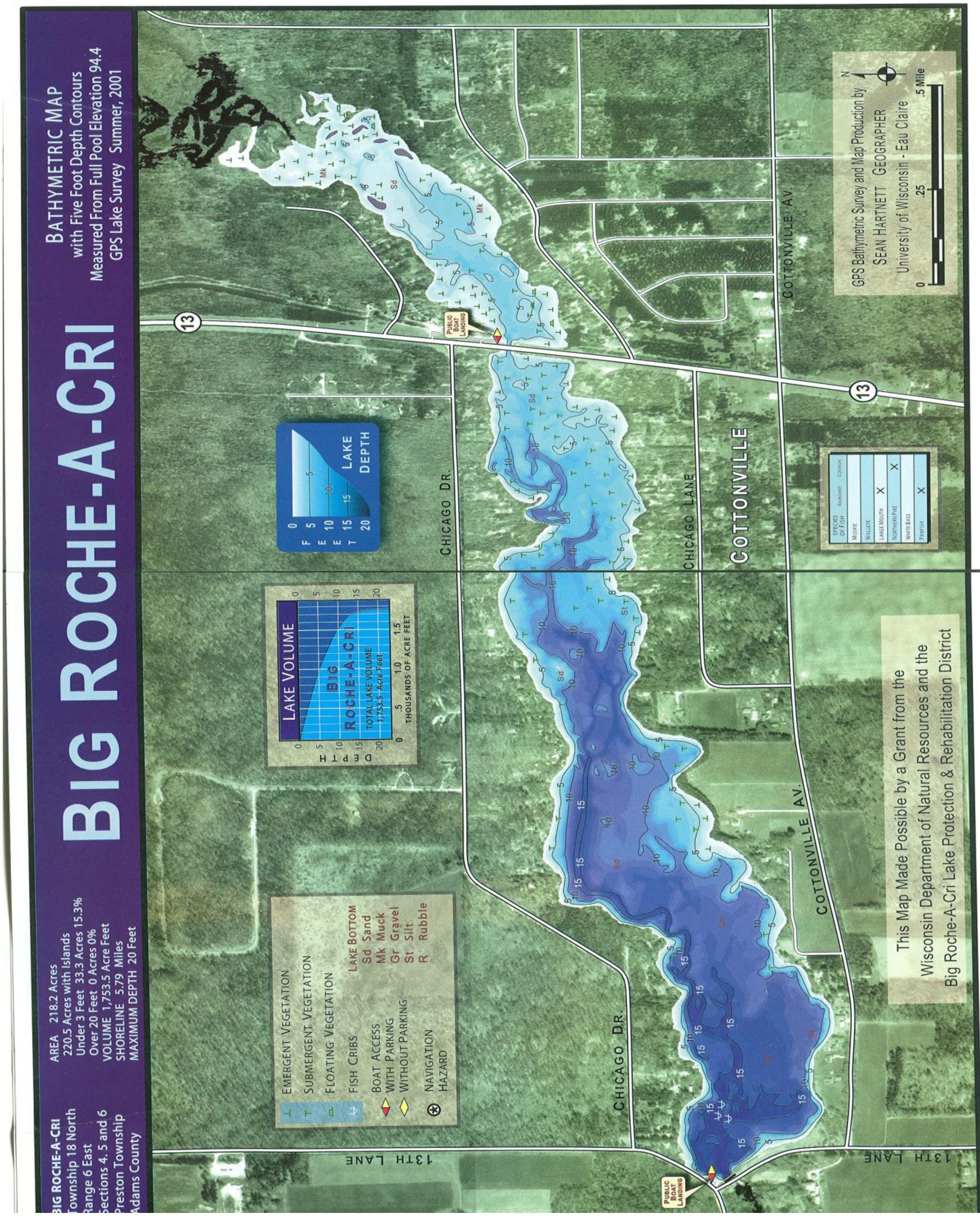
In the summer of 2001, field work for an updated bathymetric map was performed, resulting in another bathymetric map with updated information. That map indicated that the lake was 220.5 at its surface, with 15.3% less than 3 feet deep. Although the surface acres were greater, the volume of the lake was determined to be 1753.5 acre-feet, i.e., 80.5 fewer acre-feet than the 1965 map information. This may be the result of accumulating sediments in the lake coming from the shores and also being carried in by the upstream Big Roche a Cri Creek.

A "hydrologic budget" is an accounting of the inflow to, outflow from and storage in a hydrological unit (such as a lake). "Residence time" is the average length of time particular water stays within a lake before leaving it. This can range from several days to years, depending on the type of lake, amount of rainfall, and other factors. "Flushing rate" is the time it takes a lake's volume to be replaced. "Annual runoff volume", as used in WiLMS, is the total water yield from the drainage area reaching the lake. The "drainage area" is the amount of area (in acres) contributing surface water runoff and nutrients to the lake. The "areal water load" is the total annual flow volume reaching the lake divided by the surface area of the lake. "Hydraulic loading" is the total annual volume of all water sources (including precipitation, non-point sources & point sources) loading into the lake.

Using the data gathered from historical testing and that done by the Adams County LWCD from 2004-2006, the WiLMS model calculated the tributary drainage area for Big Roche a Cri Lake as 59897.9 acres. The average unit runoff for Adams County in the Big Roche a Cri Lake area is 9.4 inches. WiLMS determined the expected annual runoff volume as 46920 acre-feet/year. Anticipated annual hydraulic loading is 46964.1 acre-feet/year. Areal water load is 229.1 feet/year.

In an impoundment lake like Big Roche a Cri Lake, a significant portion of the water and its nutrient load running through it from the impounded creek tend to flush through the lake and continue downstream—in Big Roche a Cri Lake's case, modeling estimates a water residence of 0.04 year. The calculated lake flushing rate is 25.61 1/year. Water and its load flow through Big Roche a Cri Lake fairly quickly.

Figure 36: Big Roche a Cri Bathymetric Map



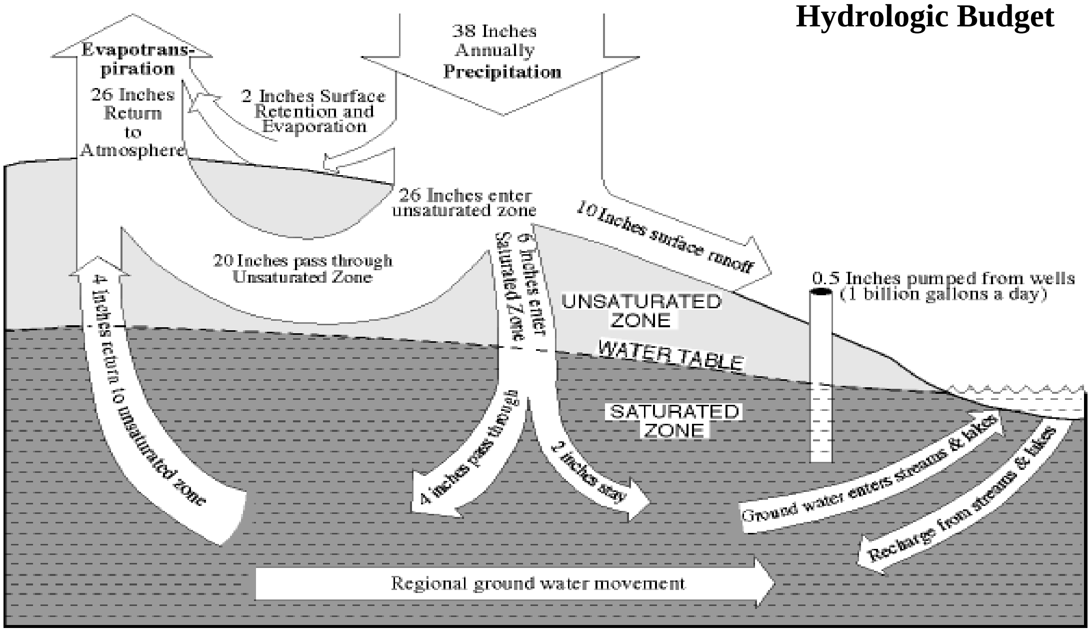


Figure 37: Example of Hydrologic Budget

Figure 38: Area Where Big Roche a Cri enters the Lake on east end of the lake

TROPHIC STATE

The trophic state of a lake is one measure of water quality, basically defining the lake's biological production status (see Figure 39a). **Eutrophic lakes** are very productive, with high nutrient levels, frequent algal blooms and/or abundant aquatic plant growth. **Oligotrophic lakes** are those low in nutrients with limited plant growth and small populations of fish. **Mesotrophic lakes** are those in between, i.e., those which have increased production over oligotrophic lakes, but less than eutrophic lakes; those with more biomass than oligotrophic lakes, but less than eutrophic lakes; often with a more varied fishery than either the eutrophic or oligotrophic lakes. In comparing water quality testing results with the prediction from the computer modeling of this modeling with the actual figures outlined above, the actual Trophic State of Big Roche a Cri Lake is what was predicted from the modeling. Modeling results predicted that the overall TSI for Big Roche a Cri Lake would be **55**. This score places Big Roche a Cri Lake's overall TSI at above average for impoundment lakes in Adams County (52.83).

Figure 39a: Trophic Status Table

Score	TSI Level Description
30-40	**Oligotrophic:** clear, deep water; possible oxygen depletion in lower depths; few aquatic plants or algal blooms; low in nutrients; large game fish usual fishery
40-50	**Mesotrophic:** moderately clear water; mixed fishery, esp. panfish; moderate aquatic plant growth and occasional algal blooms; may have low oxygen levels near bottom in summer
50-60	**Mildly Eutrophic:** decreased water clarity; anoxic near bottom; may have heavy algal bloom and plant growth; high in nutrients; shallow eutrophic lakes may have winterkill of fish; rough fish common
60-70	**Eutrophic:** dominated by blue-green algae; algae scums common; prolific aquatic plant growth; high nutrient levels; rough fish common; susceptible to oxygen depletion and winter fishkill
70-80	**Hypereutrophic:** heavy algal blooms through most of summer; dense aquatic plant growth; poor water clarity; high nutrient levels

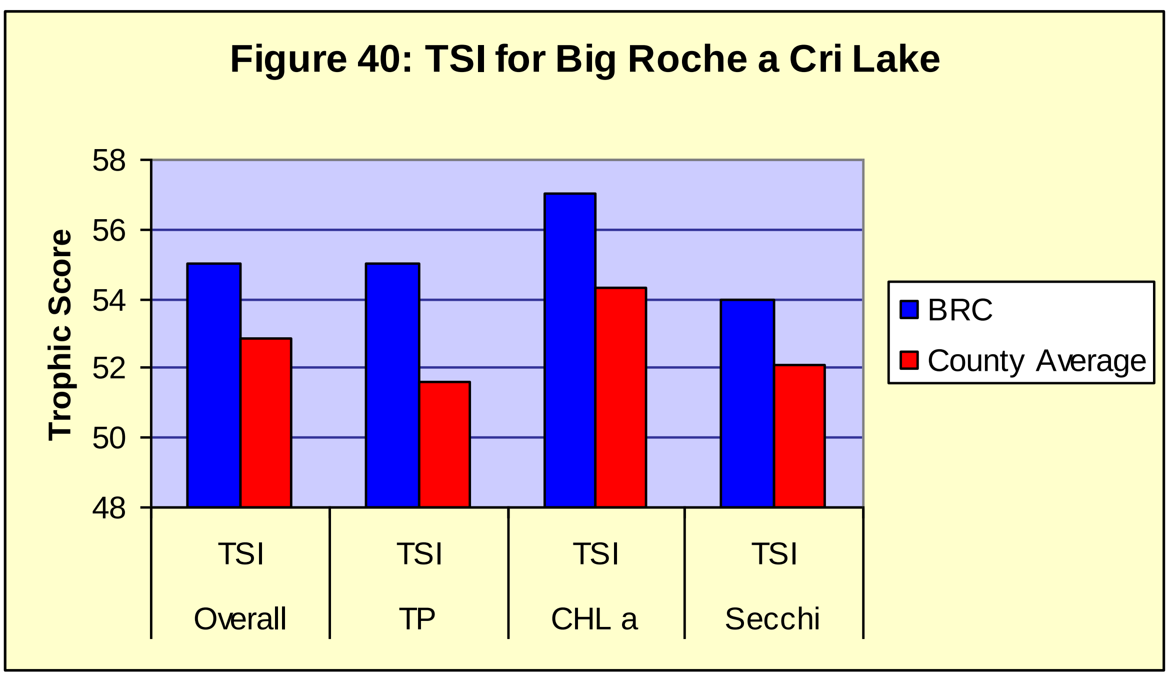
Big Roche a Cri Lake = 55 → 50-60

Phosphorus concentration, chlorophyll-a concentration and water clarity data are collected and combined to determine a trophic state. As discussed earlier, the average growing season epilimnetic total phosphorus for Big Roche a Cri Lake was 33.91 micrograms/liter. The average growing season chlorophyll-a concentration was 14.15 micrograms/liter. Growing season water clarity averaged a depth of 7.19 feet. Figure 39 shows where each of these measurements from Big Roche a Cri Lake fall in trophic level.

Figure 39b: Big Roche a Cri Lake Trophic Status Overview

Trophic State	Quality Index	Phosphorus	Chlorophyll a	Sechhi Disk
		(ug/l)	(ug/l)	(ft)
Oligotrophic	Excellent	<1	<1	>19
	Very Good	1 to 10	1 to 5	8 to 19
Mesotrophic	Good	10 to 30	5 to 10	**6 to 8**
	Fair	**30 to 50**	**10 to 15**	5 to 6
Eutrophic	Poor	50 to 150	15 to 30	3 to 4
BRC Lake		**33.91**	**14.15**	**7.19**

These figures show that Big Roche a Cri Lake has fair to good levels overall for the three parameters often used to described water quality: Secchi disk depths; average TP for the growing season; and chlorophyll a levels. It is normal for all of these values to fluctuate during a growing season. However, they can be affected by human use of the lake, by summer temperature variations, by algae growth & turbidity, and by rain or wind events. Big Roche a Cri Lake is above the county impoundments average for overall TSI levels—which is negative, since with TSI levels, the lower the better.



IN-LAKE HABITAT

Aquatic Plants

A healthy aquatic plant community plays a vital role within the lake community. This is due to the role plants play in improving water quality, providing valuable habitat resources for fish and wildlife, resisting invasions of non-native species and checking excessive growth of the most tolerant species.

In 2004, the first qualitative aquatic plant survey was done on Big Roche a Cri Lake by staff from WDNR and Adams County Land & Water Conservation Department. Quantitative surveys were done on Big Roche a Cri Lake in 1964 and 1996 using methods different than the qualitative survey done in 2004. These surveys were not designed to record all species, but possibly just to characterize the common species. In 1964, a simple species list was made and the dominant species was identified. The 1964 assessment found that curly-leaf pondweed was the dominant species, with sago pondweed, flat-stem pondweed and wild celery also present. In 1996, Big Roche-a-Cri Lake was divided into 3 areas and quantitative assessments of the plant communities were made within each area. The species in each area were characterized as scattered, common, abundant or thick.

The aquatic plant community is characterized by below average quality for Wisconsin lakes, good species diversity and impacted by high levels of disturbance. Big Roche-a-Cri Lake is within the 25% of lakes in the state most tolerant of disturbance and furthest from an undisturbed condition. Disturbances include invasions of exotic species, boat traffic, shoreline development, harvesting and past herbicide treatments.

In 2004, *Ceratophyllum demersum* (coontail) was the most frequently occurring species in Big Roche-a-Cri Lake in 2004. *Elodea canadensis* (common watermeal), *Lemna minor* (small duckweed), *Myriophyllum sibiricum* (northern watermilfoil), *Potamogeton zosteriformis* (flat-stemmed pondweed) and *Vallisneria americana* (water celery) were also commonly occurring species.

Vallisneria americana was the species with the highest mean density in Big Roche-a-Cri Lake. Where *Vallisneria americana* occurred, it exhibited a growth form of above average density in Big Roche-a-Cri Lake. *Carex comosa* (bristly sedge), *Elodea canadensis* and *Wolffia columbiana* (common watermeal) also had growth forms of above average density.

Ceratophyllum demersum was the dominant aquatic plant species in Big Roche-a-Cri Lake. *Vallisneria americana* was sub-dominant. The exotic invasive species, *Myriophyllum spicatum* (Eurasian watermilfoil), was tied with *Elodea canadensis* as the third ranked species within the plant community. *Myriophyllum spicatum* occurred at its highest density and frequency in the 5-10ft depth zone.

Figure 41. Big Roche-a-Cri Lake Aquatic Plant Species, 2004

Scientific Name	Common Name
Emergent Species	
1) *Carex comosa* Boott.	bristly sedge
2) *Cicuta bulbifera* L.	bulb-bearing water hemlock
3) *Impatiens capensis* Meerb.	spotted jewelweed
4) *Rumex* spp.	dock
5) *Salix exigua* Nutt.	sandbar willow
6) *Scirpus validus* Vahl.	softstem bulrush
7) *Typha latifolia* L.	common cattail
Floating-leaf Species	
8) *Lemna minor* L.	small duckweed
9) *Nuphar variegata* Durand.	bull-head pond lily
10) *Spirodela polyrhiza* (L.) Schleiden.	great duckweed
Submergent Species	
11) *Ceratophyllum demersum* L.	coontail
12) *Elodea canadensis* Michx.	common waterweed
13) *Myriophyllum spicatum* L.	Eurasain water milfoil
14) *Najas guadalupensis* (Spreng.) magnus.	common water-nymph
15) *Potamogeton amplifolius* Tuckerman.	large-leaf pondweed
16) *Potamogeton crispus* L.	curly-leaf pondweed
17) *Potamogeton illinoensis* Morong.	Illinois pondweed
18) *Potamogeton natans* L.	floating-leaf pondweed
19) *Potamogeton pectinatus* L.	sago pondweed
20) *Potamogeton pusillus* L.	small pondweed
21) *Potamogeton richardsonii* (Ar. Benn.) Rydb.	clasping-leaf pondweed
22) *Potamogeton zosteriformis* Fern.	flatstem pondweed
23) *Vallisneria americana* L.	water celery
24) *Zosterella dubia* (Jacq.) Small	water stargrass

Aquatic plants occurred throughout Big Roche-a-Cri Lake, at 87% of the sampling sites (85% with rooted vegetation), to a maximum rooting depth of 13 feet at which *Vallisneria americana* occurred. *Ceratophyllum demersum* occurred at 14.5 ft, but is not a truly rooted plant and can float in the water column. This allows *Ceratophyllum demersum* to occur in water deeper than the maximum rooting depth based on water clarity. At the western dam end of the lake, 80% of the sites were vegetated, *Vallisneria americana* was dominant and *Myriophyllum spicatum* (Eurasian watermilfoil) was ranked third in dominance. In the mid-portion of the lake, 96% of the sites were vegetated, *Ceratophyllum demersum* was dominant and *Myriophyllum spicatum* (Eurasian watermilfoil) was ranked third in dominance, tied with *Elodea canadensis*. At the east end of the lake, 94% of the sites were vegetated, with *Elodea canadensis* dominant and *Myriophyllum spicatum* (Eurasian watermilfoil) only scattered.

The dominant species were found throughout the lake, but some abundant and common species were not distributed throughout the lake. *Myriophyllum spicatum* was abundant (41% occurrence) and found mostly west of the Highway 13 bridge. Many common species were found only in the east end of the lake: *Elodea canadensis* (39% occurrence) found only in the east ¾ of the lake; *Lemna minor*, *Potamogeton zosteriformis* and *Spirodela polyrhiza* were found only in the east half of the lake; *Wolffia columbiana* was only found in the east basin, east of the Highway 13 bridge.

The highest total occurrence and total density of plant growth was recorded in the 0-1.5ft depth zone. Total plant occurrence and density declined with increasing depth. The greatest species richness (mean number of species per site) was also found in the 0-1.5 ft. depth zone; the highest percentage of vegetated sites was in the 5-10ft depth zone

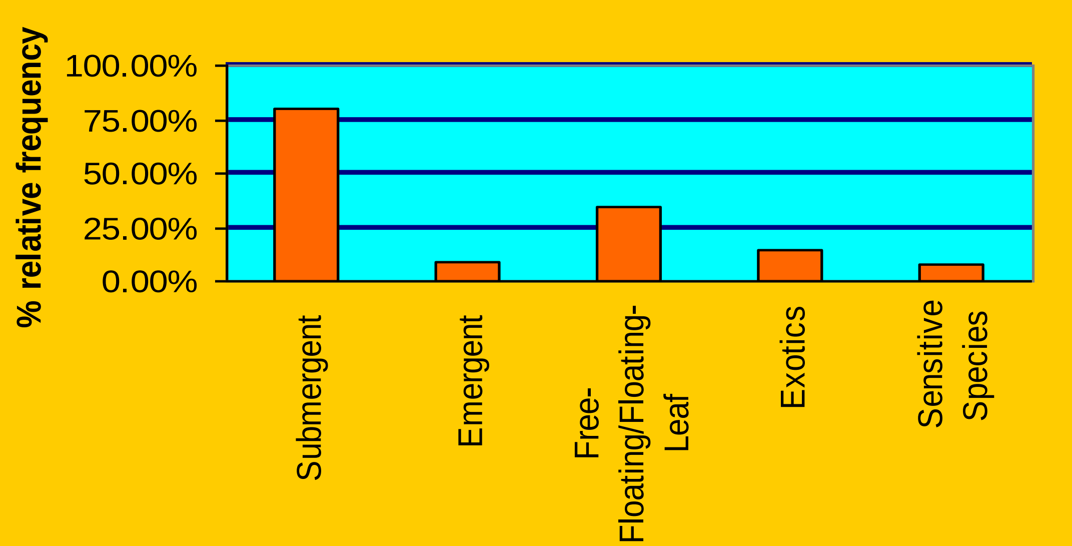
Simpson's Diversity Index was 0.87, indicating good species diversity. A rating of 1.0 would mean that each plant in the lake was a different species (the most diversity achievable). The Aquatic Macrophyte Community Index (AMCI) for Big Roche-a-Cri Lake is 45. This value is below average quality for lakes in Wisconsin and in the lowest quartile of lakes in the North Central Region. The highest value for this index is 70.

The presence of two invasive exotic species (Eurasian watermilfoil and Curly-leaf Pondweed) and the lack of sensitive species are limiting the quality of Big Roche-a-Cri Lake. The Average Coefficient of Conservatism for Big Roche-a-Cri Lake was in the lowest quartile for all Wisconsin lakes and lakes in the North Central Hardwood

Region. This suggests that the aquatic plant community in Big Roche-a-Cri Lake is among the group of lakes in Wisconsin and the North Central Hardwoods Region most tolerant of disturbance. This is likely due to selection by past disturbance.

The Floristic Quality Index of the plant community in Big Roche-a-Cri Lake was below average for Wisconsin lakes and above average for lake in the North Central Hardwood Region. This indicates that the plant community in Big Roche-a-Cri Lake is as close to an undisturbed condition as the average lake in Wisconsin or the North Central Hardwood Region. This suggests that the aquatic plant community in Big Roche-a-Cri has been impacted by an above average amount of disturbance.

Figure 42: Relative Frequency of Plant Types



The dominant sediment in Big Roche-a-Cri Lake was sand, in all depth zones and throughout the lake. No other sediment types were even common, at any depth. Sand may limit plant growth due to its high-density (Barko and Smart 1986); however 85% of the sites with sand sediment were vegetated. The only sediments that were not 100% vegetated were other high-density, hard sediments. Overall, 88.9% of the lake bottom is vegetated, suggesting that even the sand sediments in Big Roche a Cri Lake hold sufficient nutrients to maintain aquatic plant growth. Due to the shallow depth of the lake, sunlight can encourage plant growth at all depths in the lake.

Figure 43a: Distribution of Emergent Plants in BRC Lake 2004

Emergent Plants Found

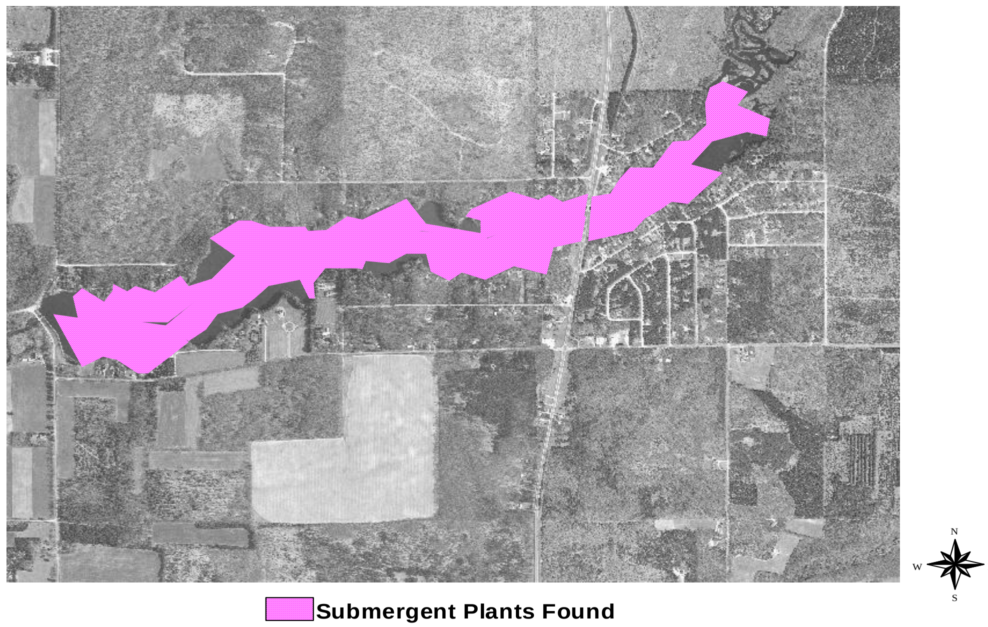
RE:2/07

Figure 43b: Distribution of Free-Floating & Floating-Leaf Plants in BRC Lake in 2004

Free-Floating & Floating-Leaf Plants Found

RE:2/07

Figure 43c: Submergent Aquatic Plants in BRC Lake 2004



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The total number of species and number of species recorded in each area increased between 1964 and 1996 and again between 1996 and 2004. This is likely due to increasingly more rigorous studies. Because of the different methods, direct comparisons can not be made, but some observations can be compared.

The dominant species in Big Roche-a-Cri Lake changed from the exotic invasive *Potamogeton crispus* in 1964 to *Vallisneria americana* in 1996 to *Ceratophyllum demersum* in 2004.

In the area upstream and east of Highway 13 (east third of the lake), eight species were recorded in 1996 and twenty-one species were recorded in 2004. In 1996, *Zosterella dubi* (water stargrass) was characterized as thick and abundant.; *Elodea canadensis* was common to abundant; *Potamogeton zosteriformis* as scattered to abundant; *Nuphar variegate* (white water lily) was found in only one place; and *Ceratophyllum demersum, Myriophyllum sibiricum, Potamogeton crispus, Potoamogeton nodosus* (long-leaf pondweed), and *Potamogeton richardsonii* (clasping-leaf pondweed) were scattered.

However, in 2004, *Zosterella dubiawas* only scattered in this third of the lake. *Ceratophyllum demersum* and *Elodea canadensis* were thick and dense, having increased to the dominant and subdominant species in this area. Three species of free-floating plants--*Lemna minor, Spirodela polyrhiza* (great duckweed), *Wolfia columbiana*—were now abundant in this area. Two species formerly found here--*Myriophyllum sibiricum, Potamogeton nodosus*—were no longer found here.

In the middle third of the lake, west of Highway 13, four species were recorded in 1996 and fifteen in 2004. In 1996, *Vallisneria americana* was thick along the entire shore; *Elodea canadensis* was abundant to thick; *Potamogeton zosteriformis* was scattered to common; and *Ceratophyllum demersum* was only scattered. By 2004, *Ceratophyllum demersum* had become thick and dense and was the dominant species. *Vallisneria americana* had decreased to abundant and was sub-dominant. Three new species in the area were common--*Lemna minor, Wolffia columbiana, Zosterella.* Another new species in this area, the non-native invasive *Myriophyllum spicatum,* was now abundant and dense in this area.

In the western third of the lake, closest to the dam, four species were recorded in 1996 and eleven in 2004. In 1996, *Vallisneria americana* was thick along the entire shore; *Potamogeton zosteriformis* was scattered to common; *Ceratophyllum demersum* and *Elodea canadensis* were scattered. By 2004, *Ceratophyllum demersum* had become abundant and was the sub-dominant species. The exotic invasive species *Myriophyllum spicatum* had been introduced and was now common and dense in this area of the lake.

Overall, the changes found between the earlier aquatic plant surveys and the one in 2004 were significant because they serve as indicators about what is going on in the lake. Species that are tolerant of lower water clarity have increased: *Elodea canadensis* in one area, duckweed species (*Lemna minor, Wolffia columbiana* and *Spriodela polyrhiza)* in two areas, *Ceratophyllum demersum* in all three areas. The Invasive, non-native watermilfoil (*Myriophyllum spicatum)* has been introduced and increased in colonization throughout the west portion of the lake. The introduced invasive milfoil may be out-competing native species: since 1996, the dominant *Vallisneria americana* has decreased in one area; and two native species (*Potamogeton nodosus* and *Myriophyllum sibiricum* (native watermilfoil)) appear to have disappeared from the lake. The dominant species changed from the invasive exotic *Potamogeton crispus* (curly-leaf pondweed) in 1964 to *Vallisneria americana* in 1996. Harvesting early in the season may have controlled the exotic curly-leaf pondweed. This allowed *Vallisneria americana* to become dominant as the water clarity increased due to nutrient removal. Dominance of species changed from *Vallisneria americana* 1996 to *Ceratophyllum demersum* in 2004. The dominance of *Ceratophyllum demersum* may have increased due to declining water quality or due to its ability to compete with the

Eurasian watermilfoil invasion. Since *Ceratophyllum demersum* is not a rooted plant, it floats in the water column just under the surface and is therefore not dependent on light availability to the bottom of the lake or being subjected to competition for rooting space. The increase in disturbance-tolerant species may also indicate declining water clarity: *Elodea canadensis* is tolerant of low light, and the three free-floating species (*Lemna minor*, *Spirodela polyrhiza* and *Wolffia columbiana*) float on the water surface and are not dependent on good water clarity.

There is a long history of chemical use for treating aquatic plant growth and algae in Big Roche-a-Cri Lake, 1959-1987. In some years, up to 10 treatments per year were conducted and up to one-quarter of the lake was treated at a time. Two products that are now banned because of their toxicity had been used for 7 years. Broad-spectrum chemicals were used for 13 years. Two chemicals that do not biodegrade, but build up in the sediment, resulting in toxic sediment were used. Chemicals that are toxic to young fish had been used for 11 years.

Figure 44. Herbicide Applied to Big Roche-a-Cri Lake

	Arsenic Trioxide (lbs.)	Silvex 2,4,5-TP	2,4-D (gal.)	Cutrine (gal.)	Copper Sulfate (lbs.)	Diquat (gal.)	Endothall	Area Treated (acres)	# Treatments
1959	3720							33	2
1960	5220							47	
1962	4500							30	2
1963	1620							12	2
1964	2000							16	2
1965	1200						7.2g. 1200#	6	
1966	2700	35					25.4g.	23	1
1970			20	87	189	30		70	4
1972							25#	0.1	1
1975			14		975	36.4	23.6g. 150#	50	10
1976					450	9.5	12.5g. 550#	14	6
1977			10		550	6	9g. 500#	30	4
1978			10		350	17	1150#	23	3
1983							1200#	5.3	1
1984							1320 #	7	1
1985							1400#	8	1
1986							1400#	12	1
1987							2000#	8	1
Total	20,960	35	44	87	2514	98.9	77.7gal. 10,895#		

The problems with the herbicides that were used included the following:

1) Arsenic is highly toxic. Between 1959 and 1966, more than 10 tons of arsenic was applied to Big Roche-a-Cri Lake. Arsenic is no longer allowed as an aquatic pesticide because it is highly toxic to all species. Since it does not break down, arsenic stays in the sediments, resulting in the necessity to treat lake sediments as hazardous waste.
2) Another toxic compound used in Big Roche-a-Cri was Silvex (2,2,4,5-TP). Silvex is now banned as a possible carcinogen.
3) The broad-spectrum chemicals Diquat and Endothall compounds were used. These compounds killed all plant species and inadvertently opened up areas for the introduction of exotic and invasive species. Almost 100 gal of Diquat compounds were used between 1970 and 1978. Endothall products were applied as 1) 77 gallons of Aquathol between 1967 and 1977 and 2) more than 5 tons of Hydrothol between 1965 and 1987.
4) The Hydrothol formulation of Endthall is more toxic to young fish.
5) Cutrine and CuSO4 are copper products that were used to kill algae and reduce swimmer's itch. Since copper is an element, it does not biodegrade further, building up the sediments. The drawbacks of copper treatments are: (a) the very short effective time; (b) the toxicity of copper to aquatic insects, an important part of the food chain in a lake; (c) the build up of copper in the sediments, resulting in sediments that are toxic to mollusks that are the natural consumers of algae in a lake.

Since 1988, mechanical harvesting has been conducted in Big Roche-a-Cri Lake and has removed more than 30 million pounds of plant material. This removal of vegetation helps with nutrient reduction, although impoundments have continuous nutrient input from the river and watershed. In order to counter the estimated yearly 826-pound phosphorus load to Big Roche-a-Cri, harvesting would have to remove 115-257 tons of plant material a year (based on tissue phosphorus concentrations of aquatic plants in area lakes). Big Roche-a-Cri has been removing an average of 694 tons per year (1260 tons per year since the purchase of a second harvester) and should be able to counteract this yearly phosphorus load. Harvesting has generally started in Mid-May each year, sometimes as late as mid-June, and generally continues until late-September, sometimes as late as early October.

Figure 45: Removal of Aquatic Vegetation by Mechanical Harvesting in Big Roche-a-Cri Lake, 1988 – 2004

	Loads removed	Approx. weight of a load (pounds)	Approx. Weight (tons)
1988	32	~6000	96
1989	250	7800	975
1990	216	6680	722
1991	287	6000	861
1992	210	6000	630
1993	260	6000	780
1994	193	6000	579
1995	125	6048	378
1996	208	6000	626
1997*	332	6000	996
1998	348	6000	1044
1999	358	6000	1074
2000	445	6000	1335
2001	325	6000	975
2002	509	6000	1527
2003	953	6000	2859
2004			963
Total	5051		16,420

* - A second harvester was purchased, now two are operating.

The Big Roche a Cri Lake District also did a winter drawdown during the winter of 2006 to assist in controlling the Eurasian Watermilfoil. They intend to request permission to do so again for the winter of 2009.

Figure 46: Photo of BRC Lake Showing Colony of Free-Floating Plants and Filamentous Algae

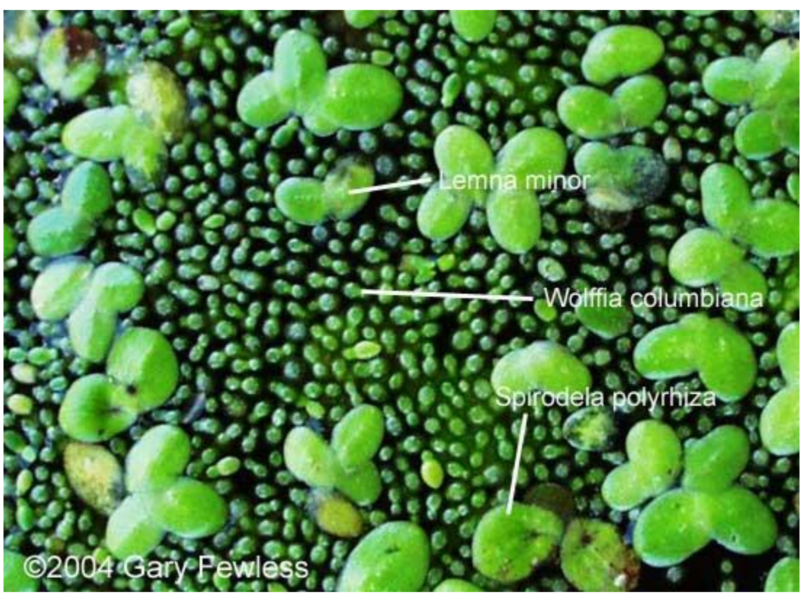
Vallisneria americana
(Wild Celery)

Figure 47: Some Common Native Aquatic Species in BRC Lake

Ceratophyllum demersum
(Coontail)

Lemna minor
***(*Small Duckweed)**

Wolffia columbiana
(Common Watermeal)



Aquatic Plant Management Recommendations

1) Reinvolve the Lake District in water quality monitoring through the Self-Help Volunteer Lake Monitoring Program.

2) Chemical treatments for plant growth are not recommended in Big Roche-a-Cri Lake due to the undesirable side effects of chemical treatments.

a) The decaying plant material releases nutrients that feed algae growth that further reduce water clarity.
b) The decaying material also enriches the sediments at the site.
c) The herbicides are toxic to an important part of a lake food chain, the invertebrates.
d) Broad-spectrum treatments would open up areas that would be vulnerable to the spread of the exotic species.

3) Restore natural shoreline restoration. Disturbed shoreline covers nearly one-third of the shore and mowed lawn alone covers nearly one-quarter of the shore.

a) Unmowed native vegetation reduces shoreline erosion and run-off into the lake and filters the run-off that does enter the lake thus reducing nutrient inputs.
b) Shoreline restoration could be a as simple as leaving a band of natural vegetation around the shore by discontinuing mowing.
c) Restoration could be as ambitious as extensive plantings of attractive native wetland species in the water and native grasses, flowers, shrubs and trees on the near shore area

4) Fine-tune the harvesting plan. Plan should be designed to remove nutrients, target Eurasian watermilfoil, provide navigation and recreation where appropriate, prevent the spread of species that could become overabundant and improve habitat.

a) Nutrient reduction. Harvesting removes the nutrients found in the plant tissue and filamentous algae mats. There is evidence that mechanical harvesting may already be reducing filamentous algae and nutrients. The 0-1.5ft depth zone has the highest density and occurrence of plant growth, but is not practical for mechanical harvesting. Since the density and occurrence of plant growth is nearly as high in the 1.5-5ft depth zone, harvesting the 3-5 ft depth zone would be effective for nutrient removal.
b) Target Eurasian watermilfoil. The milfoil can be targeted by conducting an early-season harvest and a late-season harvest that cuts only where the milfoil is colonized, cutting the largest and densest milfoil areas first and cutting deep. The 5-10ft depth zone is the zone where Eurasian watermilfoil is most prevalent and will likely be the area targeted most during the milfoil harvesting will stress the milfoil and open up the top canopy to allow light

penetration into the water for native species.The late-season harvesting would be conducted in September when native plants are going dormant. This cutting would focus on cutting the milfoil before it autofragments in the fall. This autofragmentation is a strategy milfoil has evolved to increase its spread. If curly-leaf pondweed increases to a nuisance condition, early spring harvesting for this species could be instituted. Skimming off coontail as the harvester is operating will help control this species that is becoming abundant.

c) Provide navigation and recreation where appropriate. Cutting channels through the areas that have the densest plant growth and cutting to control Eurasian watermilfoil will also aid navigation of the lake. Harvesting in the depth zone greater than 10 feet to maintain an open area for higher speed boat traffic would also aid navigation.

d) Prevent the spread of species that could become overabundant. *Vallisneria americana* is one of the few submergent aquatic plants that grow from the base, as grass does. Frequent harvesting in beds of *V. americana* will encourage its growth. Avoid these plant beds when they are not hindering navigation. When *V. americana* is harvested, cut near the sediment, or as deep as the cutter bar extends. The dam end of the lake supports the most *V. americana*. Harvesting the dam end in less than 10 feet should be avoided.

e) Improve habitat. The mid-portion of the lake (area 2) and the 5-10ft depth zone have the greatest colonization of plants and this area could be improved the most with channels (not clear-cutting). Cutting channels in this area provides edge needed for habitat and allows the predator fish to better find prey, supporting a more balanced fishery. These open areas are also used by wildlife. The 0-1.5ft depth zone supports the best species richness and diversity. The only harvesting that should be conducted in this zone are channels next to the docks for land owner access.

6) Cooperate with programs in the watershed to reduce nutrient inputs to the lake. Currently nearly half of the relatively large watershed is in agriculture.

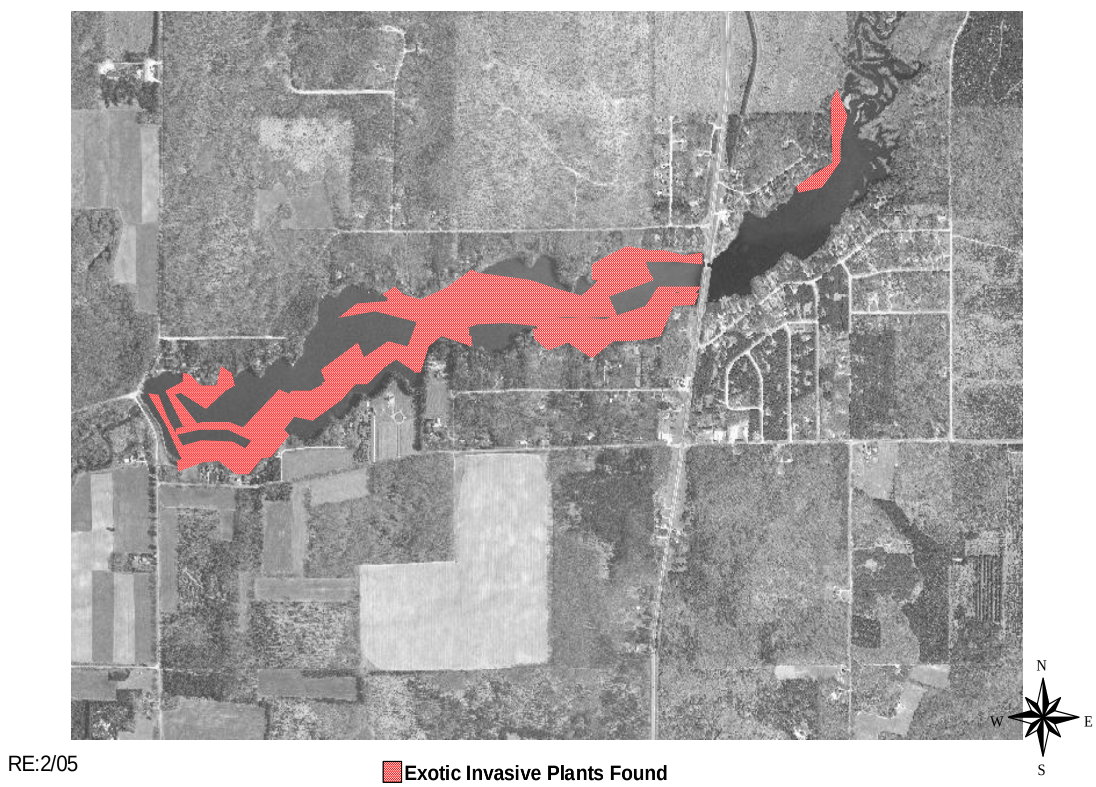
7) Eliminate the use of lawn fertilizers, both organic and inorganic, on properties around the lake.

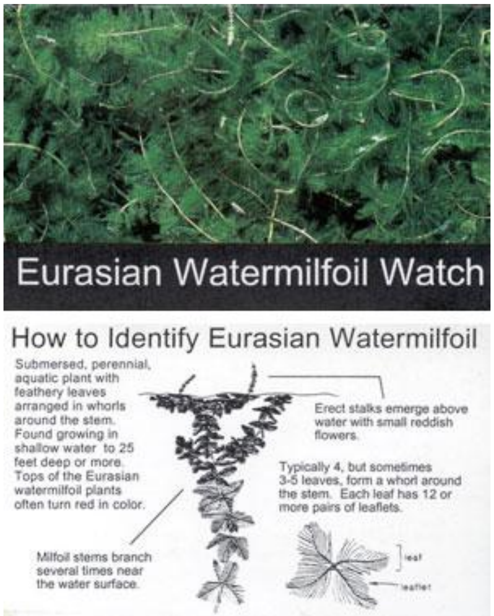
8) Investigate the possibility of using periodic winter drawdowns to control Eurasian watermilfoil in the shallow zone.

Aquatic Invasives

Big Roche a Cri Lake has two known invasive aquatic species: Curly-Leaf Pondweed (submergent) and Eurasian Watermilfoil (submergent). The lake gets a significant amount of transient boat traffic due to its location (right off a main highway) and two public boat ramps. The Big Roche a Cri Lake District has a lake management plan that includes management of aquatic invasives. The lake has been using targeted harvesting for Eurasian Watermilfoil, emphasizing the harvesting of that plant in May and September, while harvesting the summer months for navigation, rather than control of Eurasian Watermilfoil. In 2007, some lake citizens were trained to monitor the aquatic invasives and participate in the Clean Boats, Clean Waters boater education program.

Figure 48: Distribution of Exotic Aquatic Plants in 2004





Myriophyllum spicatum
(Eurasian Watermilfoil)

Figure 49: The Two Invasive Aquatic Plants in BRC Lake

Potamogeton crispus
(Curly-Leaf Pondweed)

Critical Habitat

Designation of critical habitat areas within lakes provides a holistic approach for assessing the ecosystem and for protecting those areas in and near a lake that are important for preserving the qualities of the lake. Wisconsin Rule 107.05(3)(i)(I) defines a "critical habitat areas" as: "areas of aquatic vegetation identified by the department as offering critical or unique fish & wildlife habitat or offering water quality or erosion control benefits to the body of water. Thus, these sites are essential to support the wildlife and fish communities. They also provide mechanisms for protecting water quality within the lake, often containing high-quality plant beds. Finally, critical habitat areas often can provide the peace, serenity and beauty that draw many people to lakes.

Protection of critical habitat areas must include protecting the shore area plant community, often by buffers of native vegetation that absorb or filter nutrient & stormwater runoff, prevent shore erosion, maintain water temperature and provide important native habitat. Buffers can serve not only as habitats themselves, but may also provide corridors for species moving along the shore.

Besides protecting the landward shore areas, preserving the littoral (shallow) zone and its plant communities not only provides essential habitat for fish, wildlife, and the invertebrates that feed on them, but also provides further erosion protection and water quality protection.

Field work for a critical habitat area study was performed on September 26, 2005, on Big Roche a Cri Lake, Adams County. The study team included: Scot Ironside, DNR Fish Biologist; Deborah Konkel, DNR Aquatic Plant Specialist; Buzz Sorge, DNR Lakes Manager; Jim Keir, DNR Wildlife Biologist and Reesa Evans, Adams County Land & Water Conservation Department. Areas were identified visually, with digital photos providing additional information. Input was also gained from Terry Kafka, DNR Water Regulation. Five areas on Big Roche a Cri Lake were determined to be appropriate for critical habitat designation.

RC1 is 13 acres of the shallow river inlet, which is largely undisturbed, and contains shallow marsh wetlands and shrub-carr. Important near-shore terrestrial habitat, shoreline habitat and littoral zone habitat at this site are composed of a mixture of forest growth, shrub cover, herbaceous cover and the aquatic plant species. Sixteen species of aquatic plants were found here: four species were emergent plants; one species was a rooted floating-leaf plant; two species were free-floating species; and eight kinds were submergent species. Emergent vegetation protects the shoreline, as

]well as providing important food sources and cover for fish and wildlife and fish spawning habitat. Floating-leaf rooted vegetation dampens wave action and provides fish cover and wildlife habitat. A diverse submergent plant community provides cover, food sources, and spawning areas.

Wild celery and water stargrass are present here; common waterweed and coontail are abundant. One invasive aquatic species, Curly-Leaf Pondweed, was found in this area. Nesting bald eagles were reported in this area as recently as 2002. A threatened species, Bog bluegrass (*Poa paludigena*), was present in the wetlands that make up much of RC1. Just upstream of this area, in Big Roche a Cri Creek, a fish species of special concern, Pirate Perch (*Aphredonderus sayanus)*, was found.

Figure 50: Some Areas in RC1

RC2 extends along approximately 1500 feet of the northern shoreline of the east basin of the lake and is about 8 acres in size. It includes deep marsh and shrub-carr wetlands. Shoreline habitat includes woodland cover, with an understory of shrub and herbaceous vegetation. There are some scattered homes in this area, with some leaving the natural vegetation at the shore and some cleaning the natural vegetation out.

Nineteen species of aquatic plants were found here: four emergent aquatic species; one floating-leaf rooted plant; two free-floating species; and six submergent species. Water stargrass is present, and wild celery is common at this site. Both coontail and common waterweed are abundant here. The invasive Curly-Leaf Pondweed was also found in this area. The important habitat features at this site are the emergent vegetation, floating-leaf vegetation, shoreline shrubs, snag trees, perch trees and fallen logs in the water.

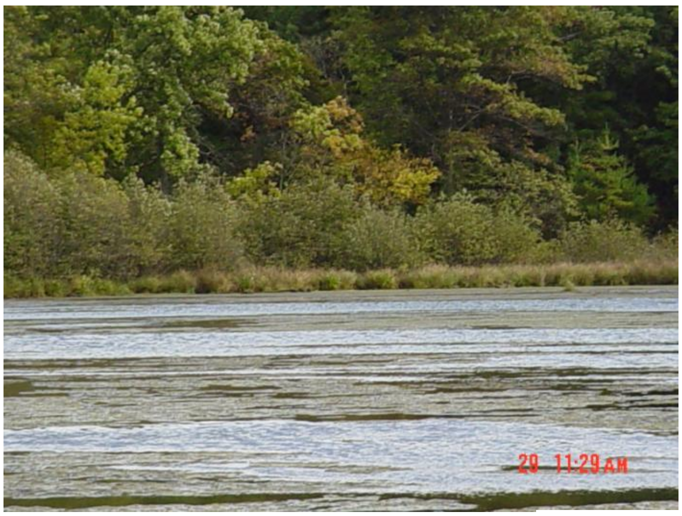


Figure 51: Parts of RC2

About 1500 feet of shoreline along the north shore, just west of Highway 13, comprises RC3. It includes important shallow water habitat. The shore is mostly wooded covered with some shrub growth, herbaceous cover and shoreline development. 13 species of aquatic plants were found at this site: two free-floating aquatic species and eleven submergent species. Wild Celery and Coontail were dominant at this site. The aquatic invasive plants, Curly-Leaf Pondweed and Eurasian Watermilfoil, were both found at this site. Significant submergent vegetation at this site provides habitat for a number of fish species.

Figure 52: Vegetated Shore in RC3

Figure 53: Area of Severe Erosion in RC3

RC4 is about 1100 feet of the south shore, just west of Highway 13. It has important shallow water habitat. The shore is mostly wooded cover, with some shrub growth, herbaceous plants and shoreline development. There are some fallen trees in the water that provide important habitat for fish cover and wildlife resting areas. 13 aquatic plant species were found at this site: one emergent plant, one floating-leaf rooted plant, two free-floating aquatic plant species, and nine submergent plan species. Coontail is dominant at this site. Wild celery is abundant, common waterweed is common here, and both water stargrass and bushy pondweed are present. The invasive, Eurasian Watermilfoil, was common at this site.

Large woody cover from stumps and fallen trees in the water, emergent vegetation, floating-leaf vegetation and submergent vegetation at this site provide important fish habitat for a diverse fish population.

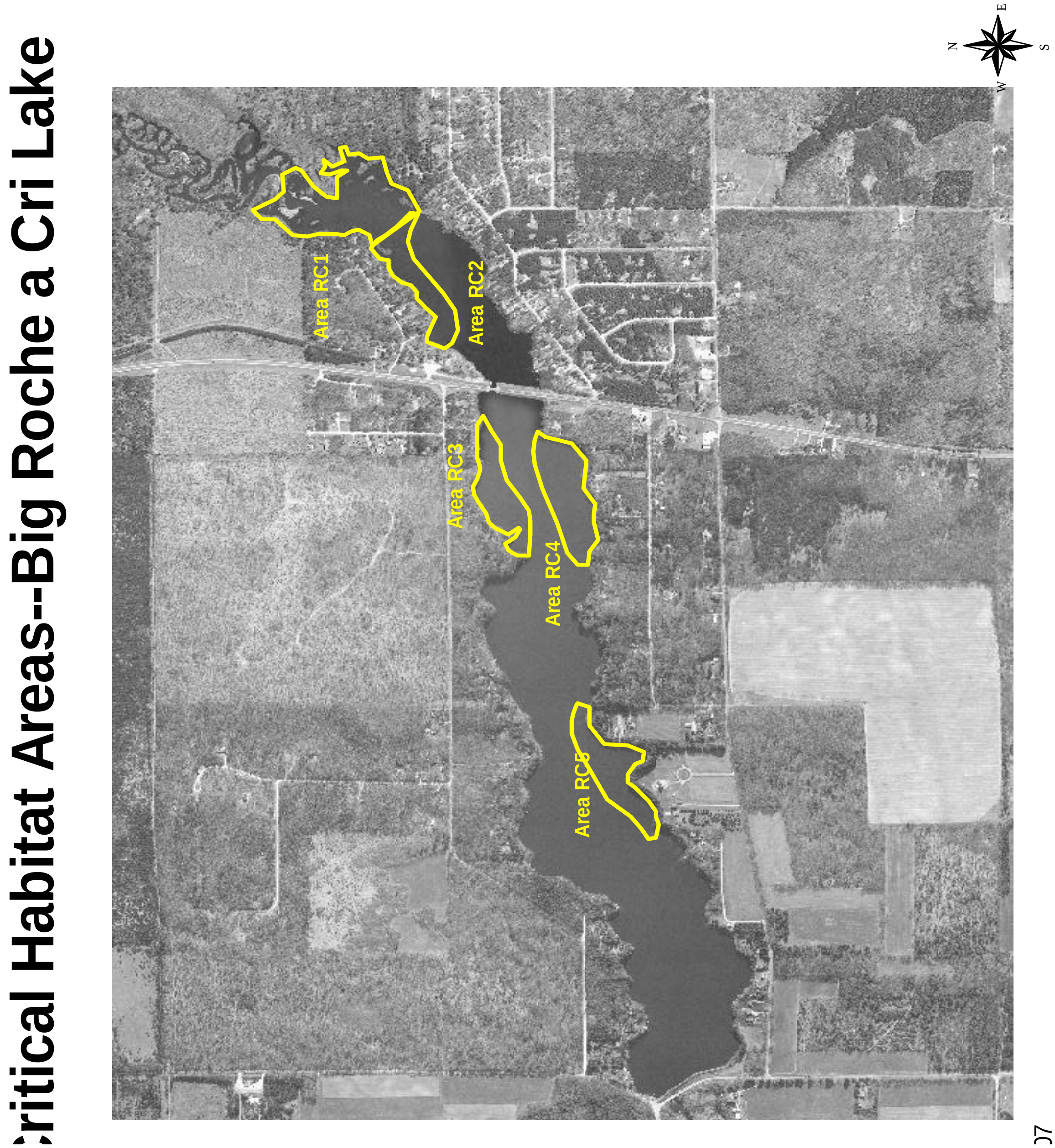
Figure 54: Natural Shore in RC4

Figure 55: Developed Shore in RC4

Finally, RC5 is about 1900 feet of shore on the south shore of the lake, in the narrows areas. It has important near-shore terrestrial habitat and shallow water habitat. The shoreline is mostly wooded cover with a fair amount of shrub understory and some housing development. Six aquatic plant species were found in this area, all submergent aquatic plant species. Wild celery and coontail dominate, and common waterweed is common. The invasive Curly-Leaf Pondweed was present at this site; the invasive Eurasian Watermilfoil was abundant.

Figure 56:
Sections of RC5

Figure 57: Critical Habitat Areas on Big Roche a Cri Lake



Critical Habitat Recommendations

(1) Maintain current habitat for fish and wildlife.
(2) Maintain snag, cavity and fallen trees along the shore for nesting & habitat.
(3) No alteration of littoral zone unless to improve spawning habitat.
(4) Seasonal protection of spawning habitat.
(5) Maintain any snag/cavity trees for nesting.
(6) Install nest boxes.
(7) Maintain corridor and restore natural shoreline vegetations where cleared to increase wildlife corridor.
(8) Designate critical habitat areas as no-wake lake areas.
(9) Protect emergent vegetation with no removal of emergent vegetation.
(10) No removal of submergent and floating-leaf vegetation. Minimize aquatic plant and shore plant removal to maximum 30' wide viewing/access corridor and navigation purposes. Leave as much vegetation as possible to protect water quality and habitat.
(11) Seasonal control of Eurasian Watermilfoil and other invasives with methods selective for control of exotics.
(12) Use winter drawdown for EWM control no more frequently than every 3 to 5 years, with drawdown occurring before October 1.
(13) Continue mechanical harvesting, thus removing some of the phosphorus from the lake.
(14) Use best management practices.
(15) No use of lawn products, including fertilizers, herbicides & other chemicals.
(16) No bank grading or grading of adjacent land.
(17) No pier placement, boat landings, development or other shoreline disturbance in the shore area of the wetland corridor.
(18) No pier construction or other activity except by permit using a case-by-case evaluation and only using light-penetrating materials.
(19) No installation of pea gravel or sand blankets.
(20) Install bank restoration in highly eroded areas. Otherwise, permit no bank restoration unless the erosion index scores moderate or high. Use bioengineering practices only, but not rock riprap, retaining walls or other hard armoring.
(21) No placement of swimming rafts or other recreational floating devices.
(22) Maintain aquatic vegetation buffer in undisturbed condition for wildlife habitat, fish use and water quality protection.
(23) Post exotic species information at public boat landing.
(24) Permit no dredging except for a single channel for navigation.
(25) Investigate making the far east end of the lake a conservancy or purchasing an easement to maintain its mostly undisturbed state.

FISHERY/WILDLIFE/ENDANGERED RESOURCES

WDNR fish stocking records for Big Roche a Cri Lake go back to 1932, when 196 black bass were stocked. Stocking continued through the 1970s. Fish types stocked in those years also included perch, smallmouth bass, bullheads, largemouth bass, and northern pike. The first recorded fish inventory by the WDNR was in 1957, when bluegills and white sucker were abundant; black crappie were common; and northern pike, largemouth bass, yellow perch, and bullheads were scarce. In the most recent fish inventories in 1998 and 2002, largemouth bass and bluegill were abundant; other fish, including northern pike, yellow perch, black crappie and bullheads, were scarce. In all years, there was heavy fishing pressure on the lake.

As part of the preparation of the 1996 Lake Management Plan, wildlife in the watersheds was evaluated. Abundant were blue-winged teal, deer, fox squirrel, grey squirrel, muskrat, opossum, raccoon, ruffed grouse, and turkey. Common were beaver, Canada goose, cottontail rabbit, coyote, grey fox, mallard, red fox, woodchuck, woodcock, and wood duck. Scarce wildlife included badger, greater prairie chicken, green-winged teal, Hungarian partridge, jack rabbit, pheasant, quail and sharp-tailed grouse.

Muskrat and mink are also known to use Big Roche a Cri Lake shores for cover, reproduction and feeding. Seen during the field survey were various types of waterfowl, songbirds, and turkey. Frogs and salamanders are known, using the lake shores for shelter/cover, nesting and feeding. Turtles and snakes also use this area for cover or shelter in this area, as well as nested and fed in this area.

The Big Roche a Cri watersheds were inventoried in the 1990s by the WDNR Natural Heritage Inventory personnel. Endangered natural communities in the watersheds include: alder thicket; floodplain forest; northern sedge meadow; and stream (hard, fast, cold). Plants of concern were 1-Flowered Broomrape, Slim-Stem Small Reedgrass and Whip Nutrush. The pygmy shrew and greater prairie chicken are also known to inhabit these watersheds. Endangered invertebrates in the area include the Karner Blue butterfly, Persius Dusky Wing butterfly, Sand snaketail dragonfly and a tiger beetle.

Scleria triglomerata
(Whip Nutrush)

Orobanche uniflora
(1-Flowered Broomrape)

Figure 58: Photos of some of the species of concern in Big Roche a Cri Lake Watersheds

***Tympanuchus cupdio* (Greater Prairie Chicken)**

*information courtesy of Wisconsin Department of Natural Resources

Lycaeides Melissa samuelis
(Karner Blue Butterfly)

Erynnis persius
(**Persius Dusky Wing)**

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Figure 59: Shore of Big Roche a Cri Lake