Lake Wapogasset and Bear Trap Lake Comprehensive Lake Management Plan

February 2010

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Introduction

This comprehensive lake management plan is intended to establish strategic direction for priority issues for Lake Wapogasset and Bear Trap Lake. The Lake Wapogasset and Bear Trap Lake Sanitary District (the Sanitary District) initiated the project. Representatives from both the Sanitary District and Lake Wapogasset/Bear Trap Improvement Association (Lake Association) made up the Comprehensive Plan Advisory Committee. The project was funded by a lake planning grant to the Sanitary District from the Wisconsin Department of Natural Resources. The Sanitary District provided the majority of the cash match for the 75% state-funded project. Funds from the Lake Association and volunteer hours provided the remaining match.

Plan Scope

This comprehensive lake management plan presents information about the lakes historical water quality, fisheries, and the management efforts available and used to date. It presents new information gathered as part of this planning process including watershed mapping and characterization, estimates of pollutant loading, and lake water quality response modeling.

The Comprehensive Plan Advisory Committee identified four priority issues of concern: water quality, aquatic invasive species, fisheries, and environmental impacts of management. The management actions focus on these priority issues. Additional issues were identified by the committee and are listed in the plan. They are not, however, given priority for implementation because existing Lake Association or Sanitary District activities adequately address them, they are covered by the Aquatic Plant Management Plan, or they are handled by other agencies or organizations.

Plan Vision

Wapogasset and Bear Trap Lakes and shoreland areas will be recognized as highly desired living environments and valued natural assets for water based sports, recreation, appreciation of wildlife and natural beauty, and general human enjoyment. The Sanitary District and Lake Association will work cooperatively to better understand and manage the lakes to mitigate degradation of our water resource. We will:

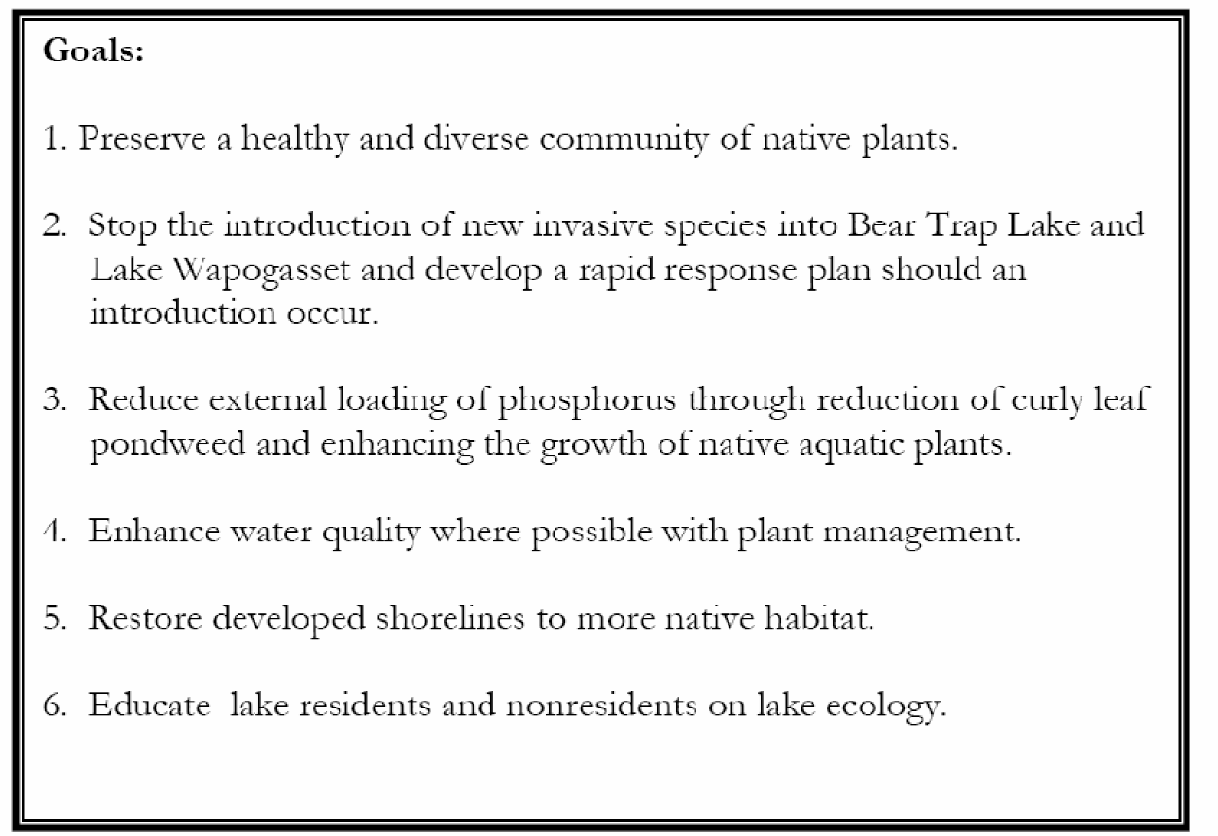
1. *Work together to enhance the overall health and water quality of the lakes given existing constraints of a large watershed, high residential density, potential for extensive watercraft traffic, and significant phosphorus loading from lake sediments.*
2. *Conduct lake management activities in a manner that will limit unintended environmental impacts (Do good – Do no harm).*
3. *Foster understanding by lake residents and users as to the ever evolving nature of lake management, the complexity of issues, the status of projects and activities, the costs and benefits of remedial actions, and the opportunity and techniques to reduce or prevent any negative consequences of lake use and lakeside living.*
4. *Seek the support and partnership of lake area residents, visitors to the lakes, the towns of Lincoln and Garfield, Polk County, Wisconsin Department of Natural Resources, Federal Environmental Protection Agency, Wisconsin Association of Lakes, University of Wisconsin Extension, private foundations, and other potential partners.*

Lake Management Goals

The following goals will guide management efforts for Wapogasset and Bear Trap Lakes.

1. Improve[2] Lake Wapogasset and Bear Trap Lake water quality.
2. Implement Aquatic Plant Management plan goals.
3. Prevent introduction of invasive aquatic organisms and limit the impacts of those introduced to the lakes.
4. Protect and improve the Lake Wapogasset and Bear Trap Lake fishery.

An aquatic plant management plan was prepared for the lakes in 2008-09. Draft aquatic plant management goals are shown below.



Goals:

1. Preserve a healthy and diverse community of native plants.
2. Stop the introduction of new invasive species into Bear Trap Lake and Lake Wapogasset and develop a rapid response plan should an introduction occur.
3. Reduce external loading of phosphorus through reduction of curly leaf pondweed and enhancing the growth of native aquatic plants.
4. Enhance water quality where possible with plant management.
5. Restore developed shorelines to more native habitat.
6. Educate lake residents and nonresidents on lake ecology.

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[2] We will further analyze modeling information and intended actions to assess whether improvement is a realistic goal as management actions are implemented and evaluated.

Lake Wapogasset and Bear Trap Lake Sanitary District

The Sanitary District was first created in 1926. In the early decades, the Sanitary District was engaged in various projects including clearing the channel between Wapogasset and Bear Trap, dredging a channel under the entrance road to Wallace Island (which later became the YMCA camp), and lake improvement projects. The Sanitary District used copper sulfate to control algae on the lake in past decades.[3]

The formal Sanitary District was created by an order of the Town of Lincoln board in April 1941. In the 1940's the Sanitary District's main function was weed control, and membership was optional.[4] The Sanitary District's current main function is the operation of a sanitary sewer system and wastewater treatment plant. The sanitary sewer system was created in 2 phases. The first phase, completed in the fall of 1975, resulted in construction of the aeration ponds, 3 lift stations, and service for about 140 properties. Phase 2, completed in 1978, served an additional 300 properties and the 2 camps.

The Sanitary District operates under an ordinance that is reviewed bi-annually by the commissioners. The ordinance was last revised in 2001. The management, operation, and control of the sewer system for the Lake Wapogasset and Bear Trap Sanitary District are vested in the Commissioners of the District. The majority of the ordinance addresses the operation of the sewer system. The ordinance also includes a section assigning significant fines for transporting boats, trailers, or equipment from a lake contaminated with Eurasian water milfoil to Lake Waposgasset or Bear Trap Lake without proper cleaning to remove all plant fragments. In addition, the Sanitary District has an "Ordinance Regulating Use of Fertilizer."

The Sanitary District took an active role in financing the alum treatment for the lakes. It continued active involvement in lake management by sponsoring the development of an aquatic plant management plan in 2008 and 09, and this comprehensive lake management plan in 2009. The Sanitary District provides information through its web site wapobear.com.

Lake Wapogasset/Bear Trap Improvement Association

The Lake Association formed in 1911. The object of the association was to "foster local interest and pride in the lake, local and popular interest in its attractions, and to enhance its beauty and usefulness as far as possible." [5] In the 1960's the Lake Association expanded to include Bear Trap Lake, and the scope of the association was broadened to include social functions.

The primary purpose of the Lake Association is "to protect and promote the improvement of Lakes Wapogasset and Bear Trap and their surroundings for the current and future benefit of recreational users, the general public, riparian and adjacent watershed landowners and residents. Also, to provide a forum for public expression on lake and watershed issues, to enhance water quality, fishery, recreational use, social activities, public safety and related education/communications." [6]

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[3] From wapobear.com

[4] From *The Lake Scene Reminiscing* column. July 1984.

[5] From lakewapogasset.com/history. Excerpt from the Amery Free Press - August 24, 1911 issue.

[6] *By-Laws of the Lake Wapogasset and Bear Trap Improvement Association, Inc.* Adopted August 13, 2005.

The Lake Association's first project was to acquire the dam site near the outlet of Lake Wapogasset in order to maintain an appropriate and consistent water level in the lakes. Lake Association leaders also created the Sanitary District. Current efforts of the Lake Association include property owner education, fish stocking, carp removal, boat patrol, water quality studies, dam maintenance, self-help water testing and monitoring, slow no-wake buoys, neighborhood watch and crime prevention, and Clean Boats, Clean Waters inspections. In the past, the Lake Association was involved in chemical treatments, channel dredging, and weed harvesting. The Lake Association provides information through the website lakewapogasset.com and the Lake Scene newsletter both produced by lake resident and realtor Kathy Mortensen.

Needs Assessment

Concerns of Lake Residents

Concerns of lake residents were gathered in a variety of ways. These included a public opinion survey, participation of the Comprehensive Plan Advisory Committee, a public meeting, and public draft plan review.

Public Opinion Survey

A lake property owner survey was distributed in April 2009. As of May 25, 2009, 350 out of approximately 650 surveys were completed and returned, a return rate of 54%. The results of the survey are discussed below and are found in Appendix A. Popular lake activities are summarized in Figure 1 below.

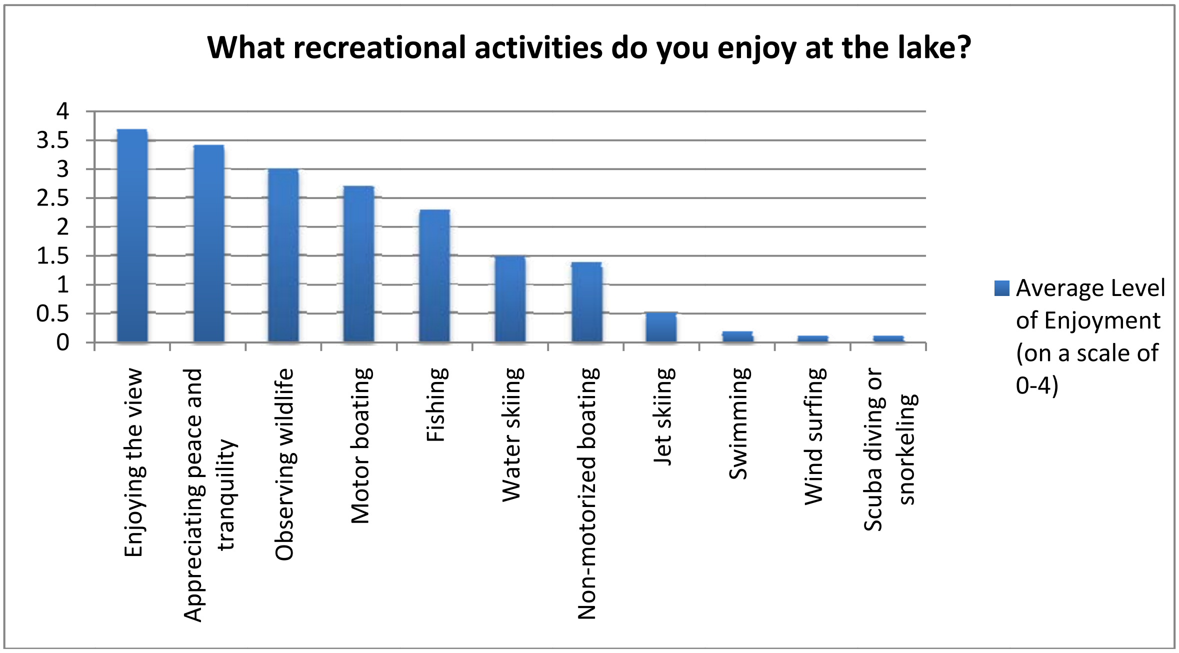

Figure 1. Recreational Activity Survey Questions Response

Additional survey results indicate a range of concerns and priorities from lake residents. The top concerns identified in the survey are protecting the lake environment, potentially toxic algae blooms, water clarity at the end of an owner's dock, and maintaining the investment value of properties. In terms of negative impacts on use and enjoyment of the lake, invasive aquatic plant growth and algae growth were the top two, and native aquatic plant growth ranked third.

Comprehensive Plan Advisory Committee

The Comprehensive Plan Advisory Committee met six times beginning in June 2009 to identify lake management concerns, learn more about priority lake issues, and to develop lake management goals, objectives, and actions.

The Comprehensive Plan Advisory Committee priority concerns are reflected in the goals and objectives in this plan. The committee considered the survey results and identified the following concerns or issues in priority order.

- Water quality/clarity
- Aquatic plants
- Invasive species
- Environmental impacts of management actions
- Fisheries

The committee listed additional concerns for the lakes that are of lower priority. In some cases they are of lower priority because they are already adequately addressed. Additional concerns are listed below in categories that describe how they might be currently addressed.

Navigation (channel dredging and marking)
Litter in or on the lake
Shoreline stabilization (erosion control)
Need for volunteers

Lake Association functions
Water level management (dam control and maintenance)
Self help water testing and monitoring
Regulation of watercraft traffic/boat patrol
Buoys
Neighborhood watch and crime prevention
Clean Boats, Clean Waters boat inspections

Sanitary District functions
Sanitary waste management and sewage treatment
Aquatic plant management

Generally covered by other organizations/entities
Fire and police protection
Public roads and utilities (road maintenance and snow removal)
Lack of a restaurant on lakes
Open space retention
Inadequate enforcement of regulations

Public Review

Public concerns and comments regarding lake management were solicited at a special meeting at the YMCA Camp on September 12, 2009. The draft plan was made available for public comment on the web site: lakewapogasset.com beginning November 13, 2009 with comments accepted through December 5, 2009. The Sanitary District Commissioners approved the Lake Wapogasset and Bear Trap Lake Comprehensive Lake Management Plan at their board meeting January 5, 2010. The Lake Wapogasset / Bear Trap Lake Improvement Association approved the plan February 6, 2010.

Population Dynamics

Lake Wapogasset and Bear Trap Lake are located in central Polk County, Wisconsin in the Towns of Garfield and Lincoln. Both of these towns have experienced significant population growth in the past few decades, as shown in Figure 2.

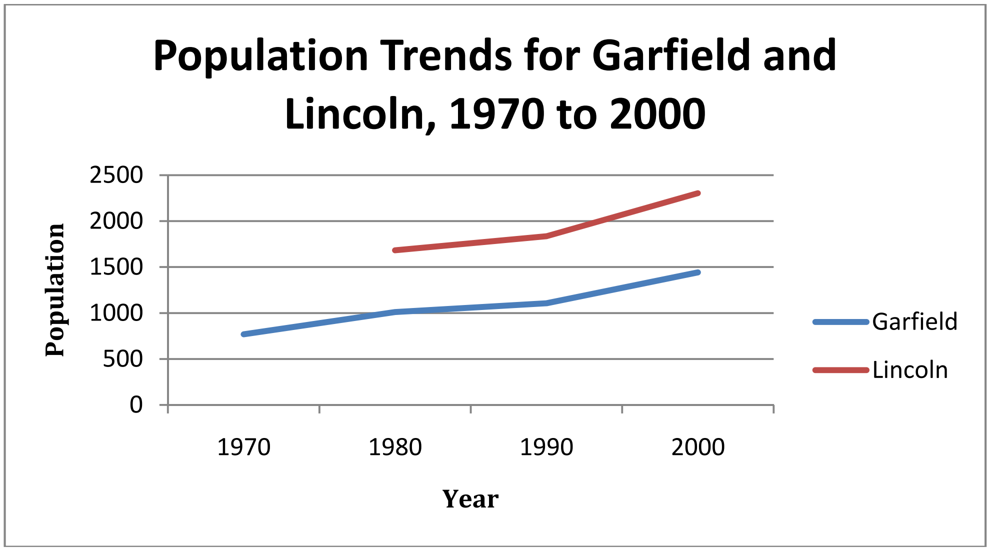

Figure 2. Garfield and Lincoln Population Trends

Lakes Wapogasset and Bear Trap are part of the Balsam Branch watershed, which includes land in the Towns of Eureka, Milltown, Georgetown, St. Croix Falls, Balsam Lake, Apple River, Alden, and Black Brook. This area of Polk County has experienced steady population growth since 1970. As illustrated in Figure 3, the populations of the Towns of Garfield, Lincoln, Alden, Apple River, Balsam Lake, and Georgetown have increased between 101 to 150 percent during this time period. For the remaining towns in the watershed—Eureka, Milltown, St. Croix Falls, and Black Brook—the population increase has been between 51 and 100 percent.

Estimates of expected growth within the next 15 years are similarly significant. Based on the comprehensive plans from the two towns, the population of the Town of Garfield will likely increase by 47 percent from 2000 to 2025, and the Town of Lincoln population will increase by

84 percent. These values are higher than the expected average growth for all of Polk County during this time period, which is estimated to be 37 percent.

Population records include only permanent residents and do not reflect increases in residential development for seasonal housing. Most seasonal housing is concentrated around waterfront. Lake Wapogasset and Bear Trap Lake have about 650 residences, and of these residences, about 67 percent are occupied only seasonally.[7]

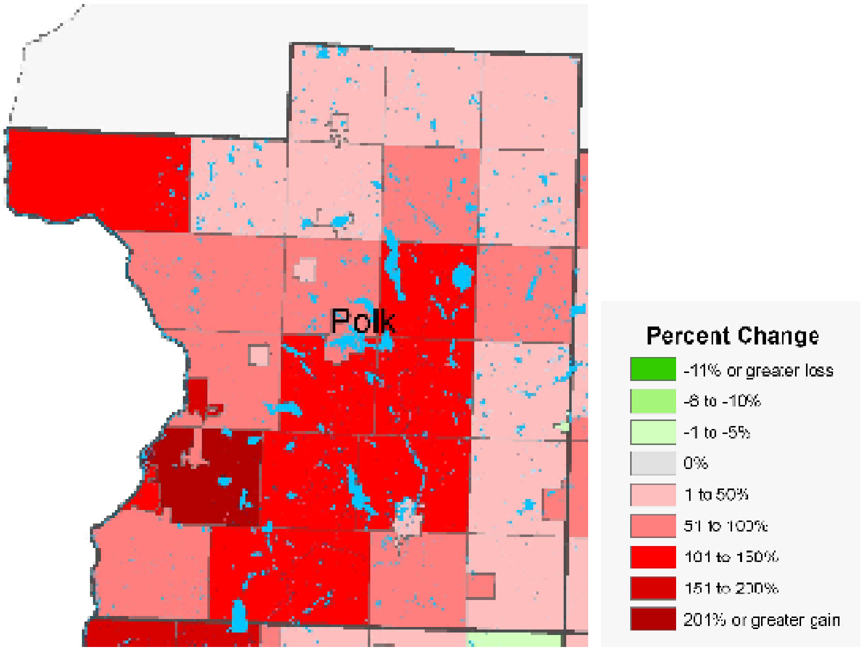

Figure 3. Population Change by Municipality 1970 to 2008

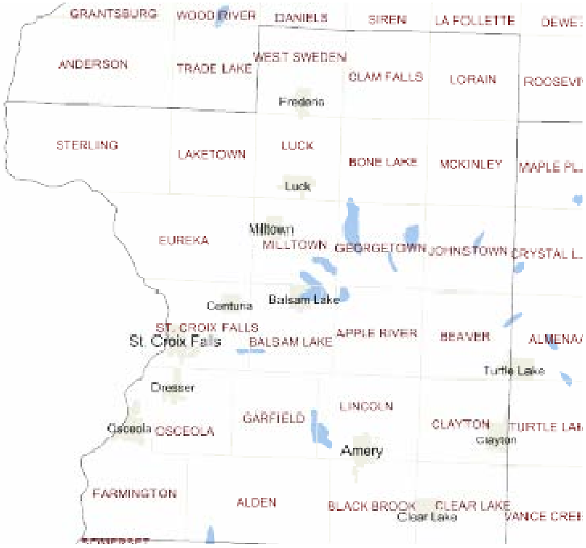

Figure 4. Polk County Towns

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[7] Based upon public opinion survey results.

Lakes Overview

Lakes Wapogasset and Bear Trap are located in Polk County, Wisconsin. Lake Wapogasset is a 1,189-acre lake with a maximum depth of 32 feet (WBIC 2618000). It is located in the Town of Garfield and the Town of Lincoln (T33N, R 17W, S13, 14, 23, 24, 25, and 26). Bear Trap Lake is 247 acres and has a maximum depth of 25 feet (WBIC 2618100). It is located in the Town of Lincoln (T33N, R16, 17W, S25, 30, 31, and 36). Both Lake Wapogasset and Bear Trap Lake are drainage lakes. Friday Creek and the Balsam Branch flow into Lake Wapogasset while the Wapogasset Branch flows out of the lake and eventually reaches the Apple River. A map of both lakes is included as Figure 5. Figures 6 and 7 include lake depth contours.

Historic and Current Lakes Use

In 1911 when the Lake Association was formed, Lake Wapogasset was called Sucker Lake. The name was changed to Lake Wapogasset in 1912 when the Lake Association made this recommendation to the United States Geographic Board.

A dam was built with logs and planks at the outlet of Lake Wapogasset in 1878. It was constructed to control water levels downstream to allow the passage of logs. Because the dam resulted in large fluctuations of water level, the executive committee of the Lake Association recommended money be raised for a concrete dam in the summer of 1912. The shore owners approved the dam unanimously and pledged not to cut down trees on the shore. A control dam approximately 10 feet wide was built with removable planks at a cost of $1,000 dollars. Later, the Lake Association constructed a concrete spillway sixty feet long with an elevation of seventy-two feet. The Public Service Commission ruled the lake level must be maintained one inch above the spillway.[8]

The Town of Garfield has owned a park on Lake Wapogasset since 1926. For many years, the park served as a recreational and meeting area. There was a concession stand with boats for rent, a swimming beach, and groups and families picnicked there. In June 1942, a tornado destroyed the buildings, boats, and trees, and the park was used little in following years.

The Town of Garfield Park was expanded and boat access improved in 2007. This new, heavily used park provides:

- 24 hour boat launch (fee to launch)
- Children's playground
- Handicap accessible fishing piers
- Picnic shelters
- Picnic tables
- Restrooms
- Walking trail[9]

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[8] From *The Lake Scene* Reminiscing column. July 1984.

[9] From www.townofgarfield.com

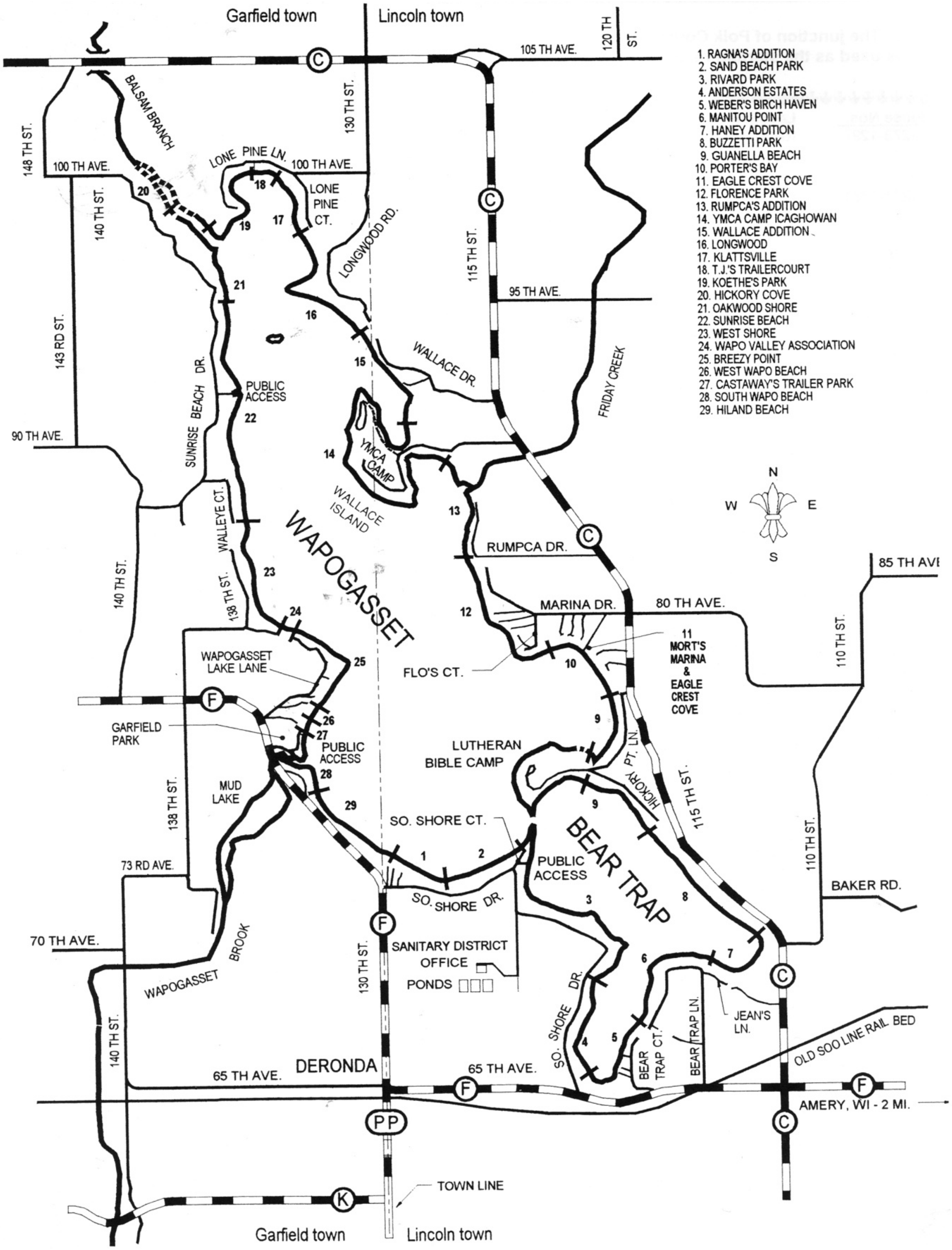

Figure 5. Lake Wapogasset and Bear Trap Lake Map

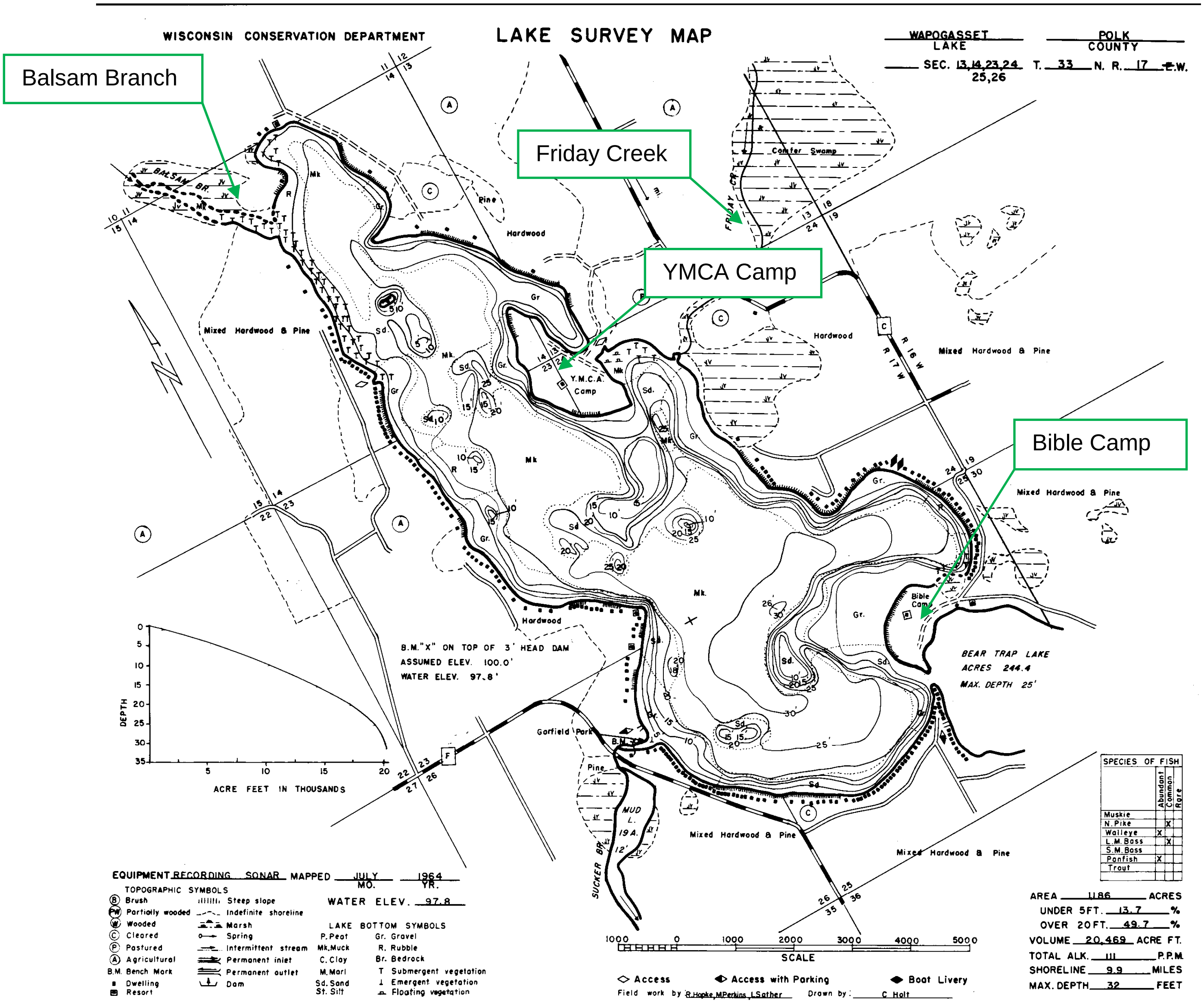

Figure 6. Lake Wapogasset Map with Lake Depth

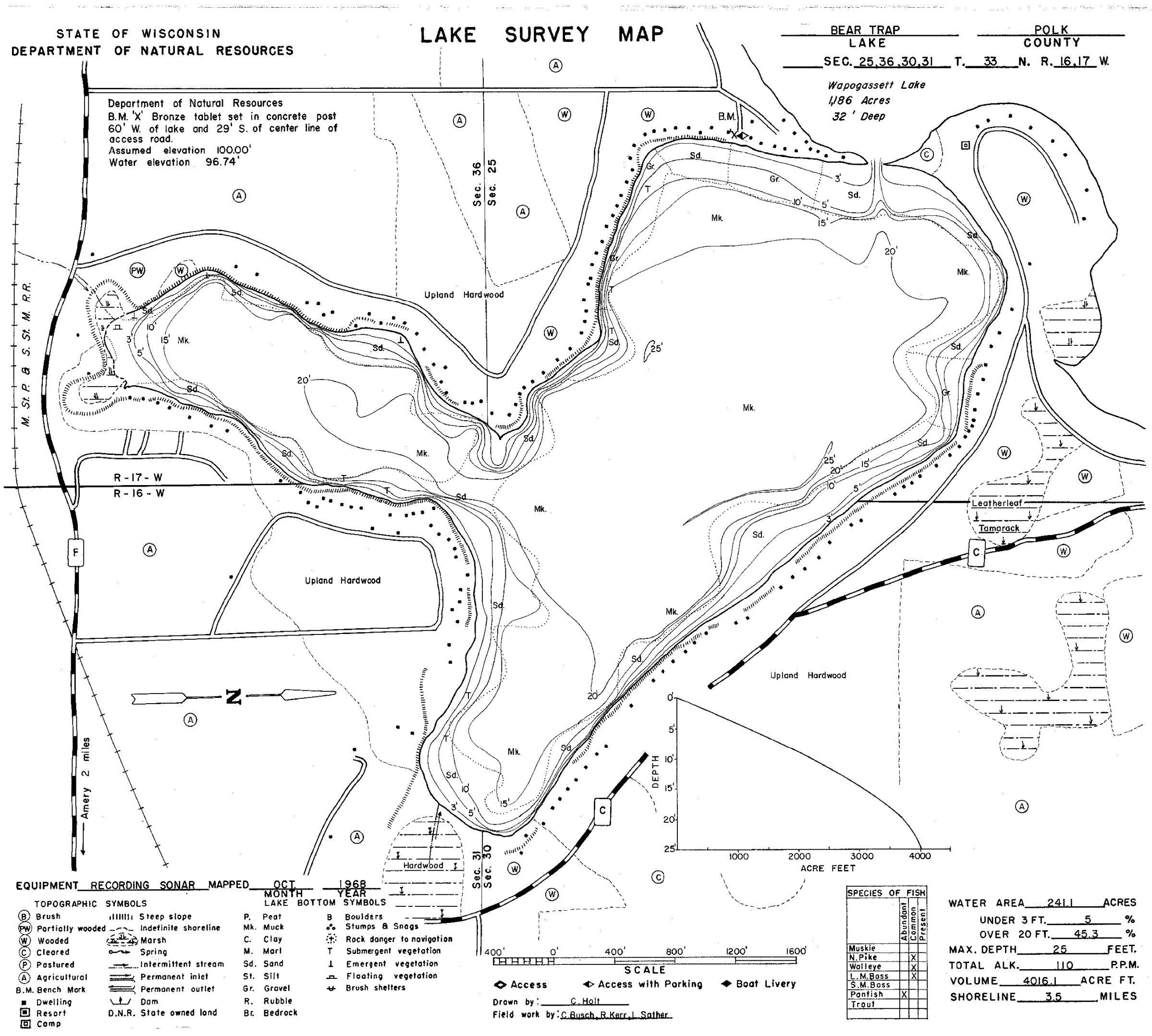

Figure 7. Bear Trap Lake Map with Lake Depth

Water quality concerns are not new to the lakes. Reports from the 1920s and 30s indicate that thick films of algae “scum” and periodic fish kills were present on Lake Wapogasset at that time. [10]

Two camps now bring thousands of visitors to the lakes each year. Lake Wapogasset Lutheran Bible Camp is on the shores of both lakes. YMCA Camp Icaghowan includes 120 acres on Lake Wapogasset.

Fishing tournaments are held occasionally on the lakes. In 2009, there were six tournaments registered with the Wisconsin Department of Natural Resources. All but one targeted small and largemouth bass. The single non-bass tournament was a carp shoot sponsored by the Lake Association on June 6, 2009.

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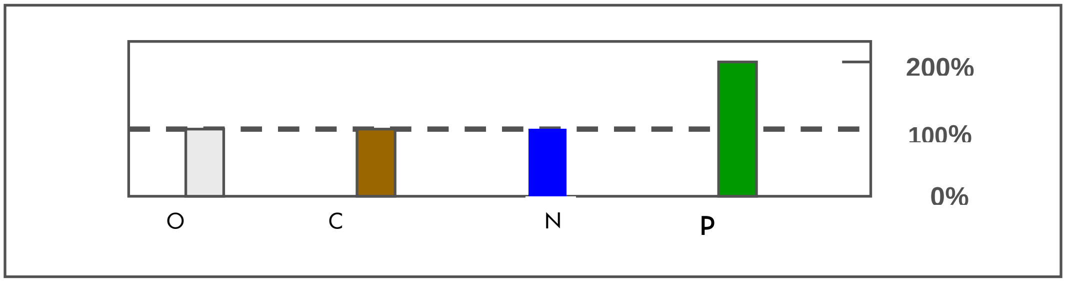
[10] From www.wapobear.com

Basic Limnology – Understanding Lake Information

To help understand the water quality study results in this plan, a basic introduction of limnology - the study of lakes - follows.

Importance of Phosphorus

The two nutrients of greatest interest in lakes are nitrogen and phosphorus. Both are required for plant and algae growth, but phosphorus is the most common limiting nutrient in lakes. "Limiting" means that of all nutrients available, phosphorus will be the first to run out and therefore limit plant growth. Therefore, increasing phosphorus can result in increases in plant and algae growth. Because algae absorb phosphorus directly from the water column, they will often respond most dramatically to increases in phosphorus availability.



This graph shows the resultant algae growth by adding 0.05 micrograms per liter (ppb) of each nutrient in an unproductive (low nutrient) lake[10]. As can be observed in the graph, raising the phosphorus by 0.05 micrograms per liter can double the algae growth while there is no increase with addition of the other nutrients. In a lake setting, increasing phosphorus content by l pound can result in 500 pounds of algae growth.

Aquatic plants will also respond to increases in phosphorus, but many are rooted and absorb the phosphorus from the sediment. As a result, they may not reflect increases in phosphorus concentrations in the water as quickly (except for plants such as coontail which doesn't need to root).

Forms of Phosphorus

Phosphorus usually exists in the form of phosphate (PO_4^{-3}). Phosphate can exist in various forms: organic, inorganic, soluble, and insoluble. The first important form is referred to as soluble reactive phosphorus (SRP) - a common form of phosphorus in fertilizers. This form is dissolved readily in the water and is immediately available for plant and algae growth.

The second important form is total phosphorus (TP). This is the measurement of all forms of phosphorus in the water. Total phosphorus is important because it reflects the

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[10] From *Water on the Web*. University of Minnesota. 2008.

amount of phosphorus potentially available for plant and algae growth. Phosphorus has a propensity to bind to sediments. If an increased amount of sediment is introduced in a lake, the TP will most likely rise as well. Phosphorus can also be contained in the tissue of microorganisms and algae. This, too, would be reflected in TP. A high TP value does not necessarily indicate immediate algae growth since some or much of the total phosphorus may not be in the usable, SRP form.

If a large amount of the TP in runoff to the lake is SRP, it is mostly likely coming from sources such as sewage, fertilizers, and manure. If the TP has very little SRP in it, then most of the phosphorus is in other forms such as those tied to sediment or present in plant tissue. Phosphorus in an unusable form must be converted by biological or chemical reactions before it is available as SRP.

Sources of Phosphorus

Phosphorus can come from many sources. Any tissue or waste from living or once living organisms can be a source of phosphorus. Therefore, any human or animal waste (from septic systems and manure) contains phosphorus. Any leaves or grass clippings can also contain phosphorus. Decomposition of dead plants and animals releases phosphorus.

As mentioned earlier, phosphates tend to bind to sediment. Whether water carrying sediment runs directly from the land into the water, or is carried in streams to the lake, it is a source of phosphorus. High levels of erosion can create significant phosphorus loads.

Phosphorus is also concentrated in raindrops. Raindrops pick up dust and other particulate matter in the air and deposit the phosphorus into the lake as precipitation. In many lakes, this can be a significant source of phosphorus, especially in more pristine lakes that receive little phosphorus from other sources.

As precipitation hits the land around the lake (the watershed), some of the rain will infiltrate into the soil and some will run-off. As the water runs off of the land, it can pick up sediments, dead and living matter, and dissolved forms of phosphorus. When this water reaches the lake, it brings the phosphorus with it. The amount of rain, the soil types, the topography, and the degree of vegetative cover will affect the concentration of phosphorus carried in runoff water. When the land is covered with forest, the soil is more stable. The raindrops dissipate and infiltrate into the soil, and therefore, the runoff volume and phosphorus content will be low. On the contrary, a row crop field such as a cornfield will not dissipate the raindrops, and the exposed soil will be much less stable. This results in increased erosion and runoff volume and therefore, higher phosphorus concentration and higher phosphorus loads into the lake.

Another source of phosphorus in a lake is the release from the lake bottom sediments. As decomposers break down the dead organic matter in the lake bottom sediment, phosphorus is released. Much of the sediment in lakes will bind phosphorus just as on land. The major contributor to this binding is iron. When iron is in high enough oxygen conditions, it has a +3 charge and therefore binds the phosphate (which has a -3 charge) forming an insoluble floc particle and remaining in the sediment. When the oxygen content decreases, the iron is reduced to a +2 charge, becomes soluble, and tends to release the phosphate ions. As a result, the sediment can release very large amounts of phosphorus into the water column. Phosphorus release occurs at a threshold of low dissolved oxygen – referred to as anoxia - of 1 mg/l or less. The length of time the sediment is anoxic and the size of the area that goes anoxic determines the amount of phosphorus released. Release of phosphorus from lake bottom sediment is one component of the lake's internal load.

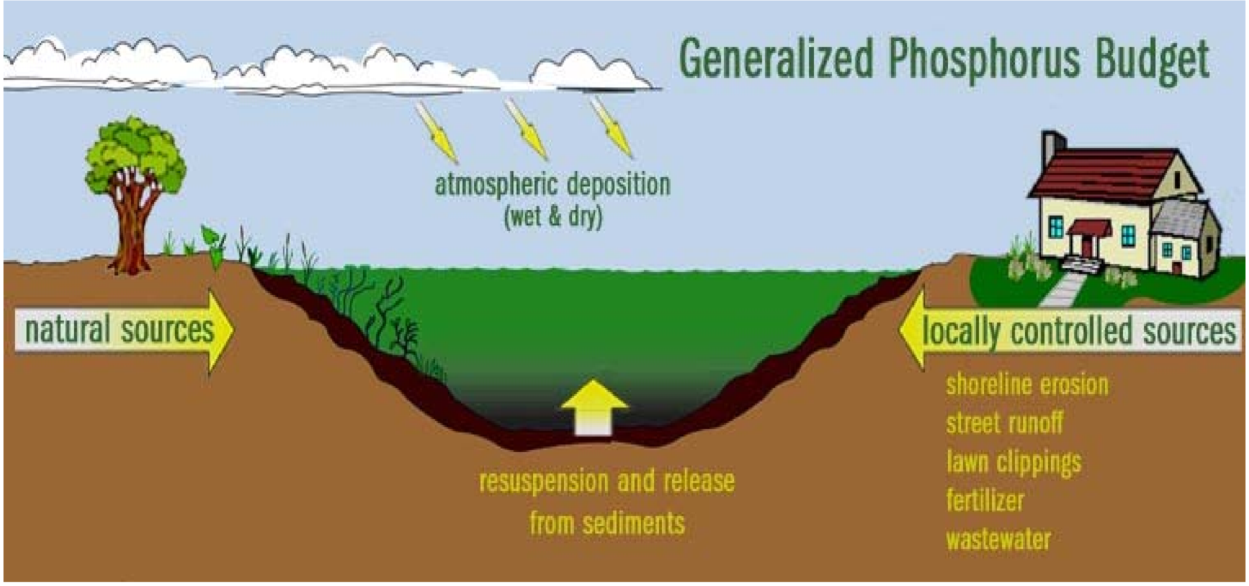
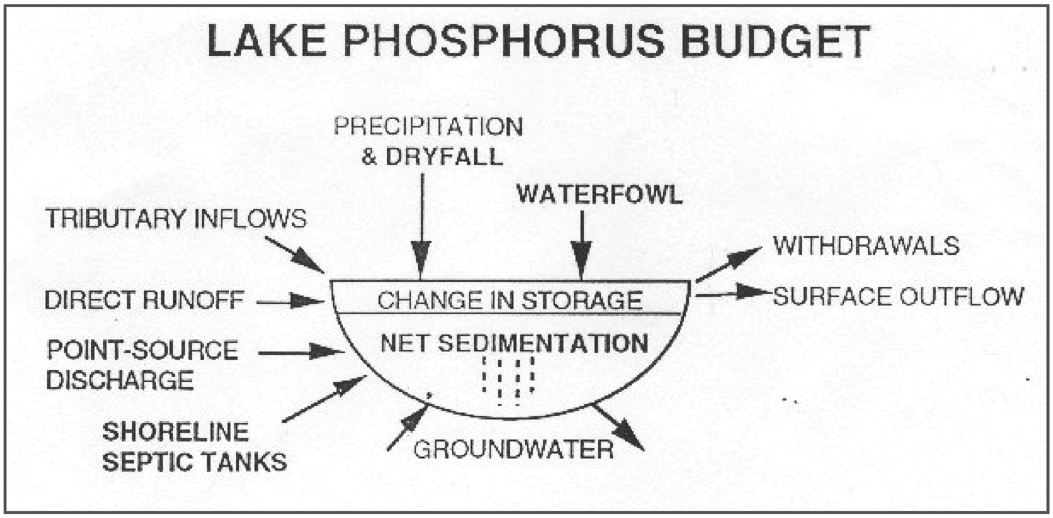


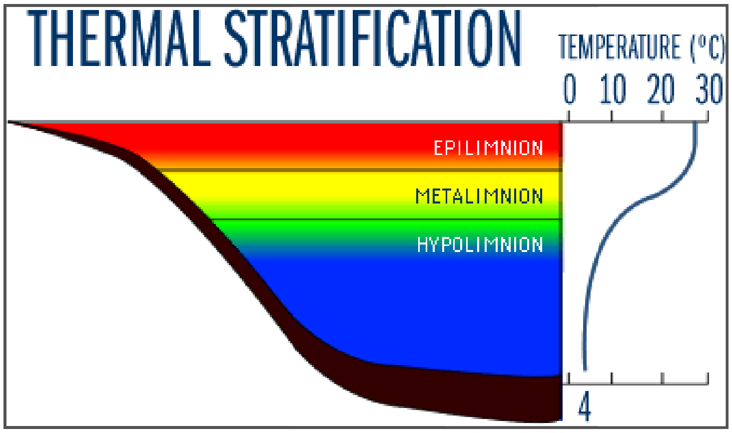
Figure obtained from "Water on the Web" (www.waterontheweb.org) an educational website at the University of Minnesota.

A summary of the phosphorus sources and losses are outlined in the diagram below.[11]



In many cases, a lake will stratify during the summer months. When a lake stratifies, the colder water stays on the bottom (hypolimnion) of the lake while the warmer water remains on the surface (epilimnion). Since this is a very stable situation, the lake water does not mix. The phosphorus released from the bottom sediment (where low oxygen levels occur) remains in the hypolimnion until the lake turns over in the fall. If a lake does not completely stratify but becomes anoxic in portions of the lake, the lake may mix prior to the fall turnover, injecting the phosphorus into the water column where it is available for uptake by algae.

Photosynthesis and wave action are major contributors of oxygen to a lake. When a lake stratifies, however, there is no opportunity for oxygen to get to the bottom of the deep portions of the lake. On the bottom, microorganisms will use and deplete the oxygen during respiration. If the lake doesn't mix and has no photosynthesis, the lake will tend to reach anoxic conditions. The rate of stratification and the rate of respiration (from breaking down organic matter) will determine how early in the summer the lake will go into anoxia on the bottom.



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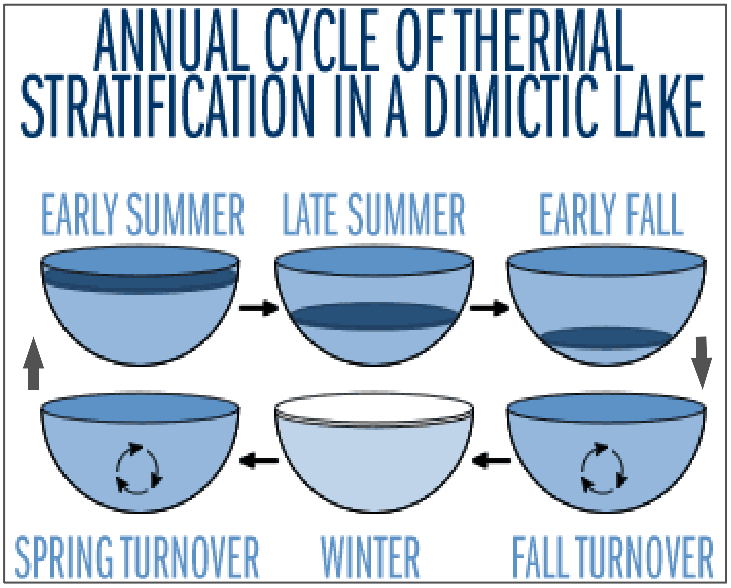
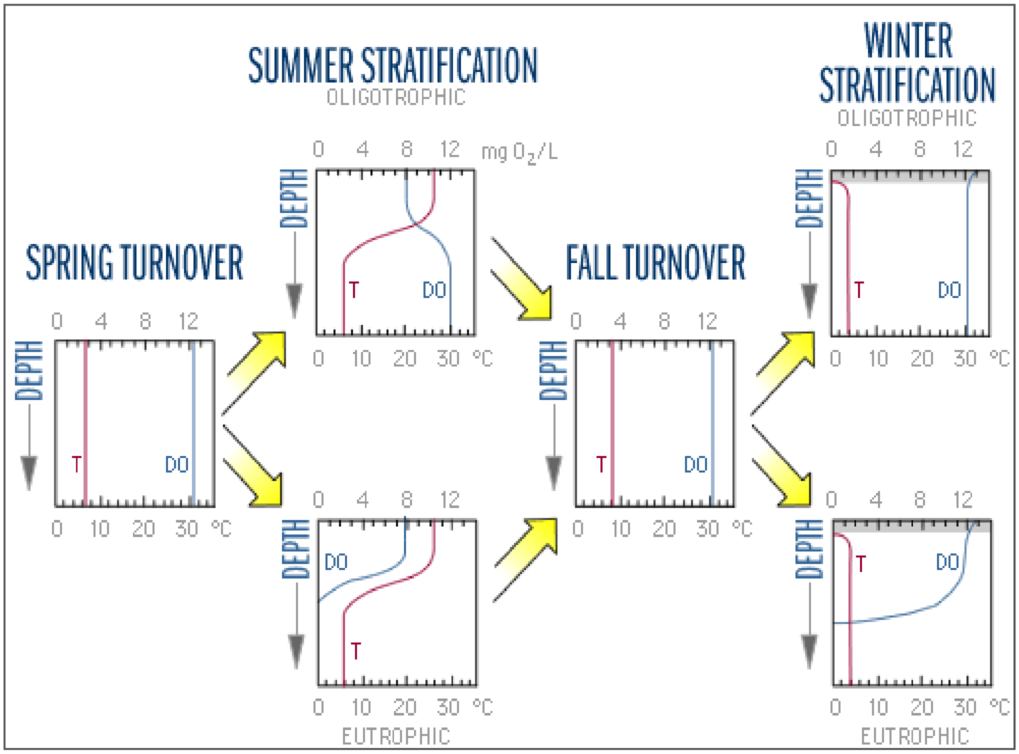
[11] From *Water on the Web*. University of Minnesota. 2008.

As the water cools in the fall, that water becomes denser and sinks, mixing the lake. This process is called fall turnover. When the lake freezes, the ice floats. In the spring when the ice melts, the cold water sinks, again mixing the lake (spring turnover). If anoxic conditions occurred during the summer months, a phosphorus load will usually be released in the water column during fall turnover.



The figure on the following page includes idealized versions of temperature and oxygen profiles (each measured at increasing depth intervals). During turnover periods in spring and fall the temperature and dissolved oxygen will be consistent from top to bottom. During stratification in the summer the temperature will decline immensely at the thermocline (the depth where temperature gets significantly colder). In productive lakes (nutrient-rich or eutrophic lakes) the bottom will be at or near anoxia, and in less productive lakes the dissolved oxygen will still be quite high. In the winter, productive lakes will tend to have anoxia again while less productive lakes will have oxygen on the bottom throughout the winter.



Lakes Wapogasset and Bear Trap appear to be partially stratified lakes. Wapogasset tends to stratify in the southern deep hole but not in the north deep area. The Balsam Branch inflow may cause some mixing. Bear Trap stratifies some years and not others. While the lack of complete stratification limits the release of phosphorus from sediments, phosphorus may be released from sediments when low oxygen levels exist. The phosphorus may be brought to the surface during the summer months instead of in the fall. Lake Wapogasset may be more likely to mix throughout the summer because of its long shape and orientation in line with prevailing winds.

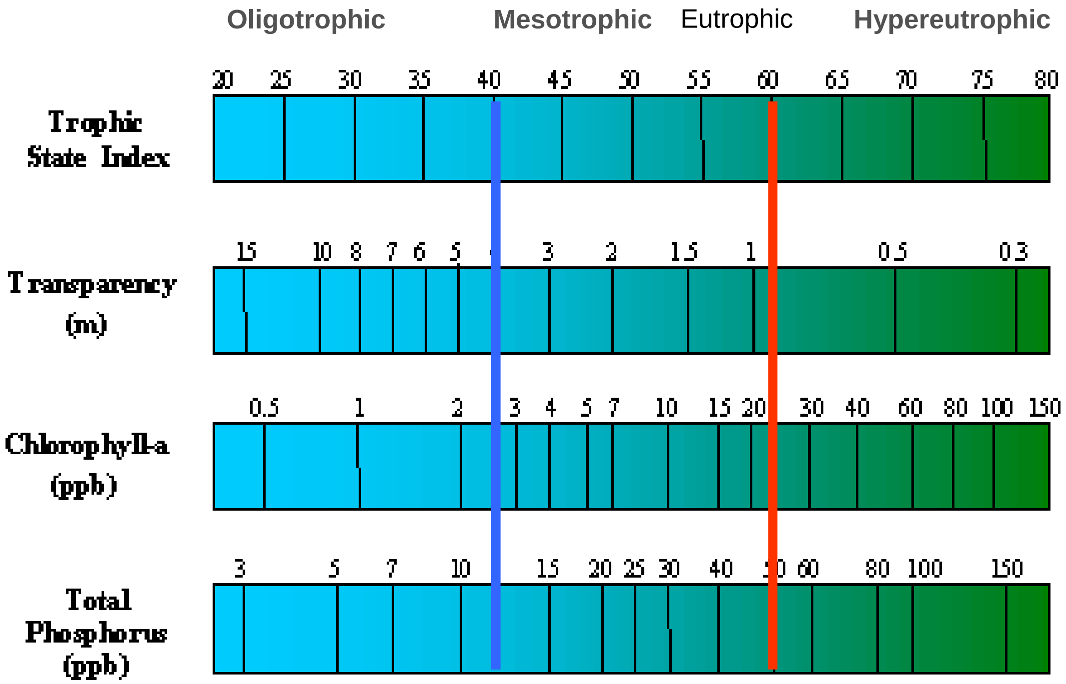
Trophic State

Trophic state describes the productivity of a lake. The least productive lakes are oligotrophic. The most productive lakes are referred to as eutrophic. Those in the middle are called mesotrophic. The more nutrients available in a lake, the more productive the lake will be. If a watershed with little runoff and phosphorus loading surrounds a lake, the water will tend to have low phosphorus levels. This will result in limited plant and algae growth, causing it to be classified as an oligotrophic lake.

Trophic state can be measured and the lake given a trophic state value (the Carlson Trophic State Index). This value can be based upon three measurements: total phosphorus, Secchi depth, and chlorophyll a. If the phosphorus is high, the algae will grow more, resulting in high chlorophyll a and reduced water clarity. Water clarity is measured by the Secchi disk reading. If there is limited phosphorus, the water will have little algae growth, and therefore low chlorophyll a readings and high Secchi depths.

This table shows the Carlson Trophic State value in the left column and the characteristics of each lake type in the right column.

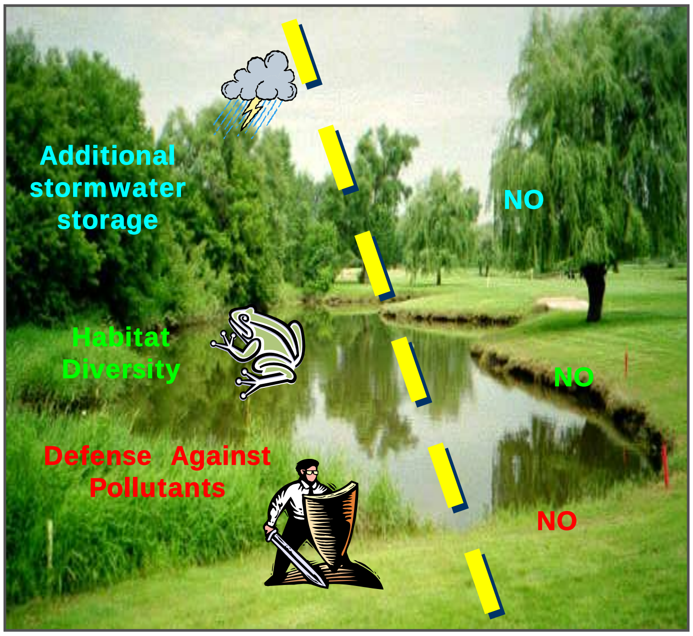
<40	Oligotrophic; clear water; high hypolimnetic O_2 year-round but possible anoxia in the deeper hypolimnion part of year
40-50	Mesotrophic; moderately clear water; possible hypolimnetic anoxia in summer and/or under ice. Fully supportive of all swimmable /aesthetic uses; possible cold-water fishery
50-60	Mildly eutrophic; decreased secchi; anoxic hypolimnion; possible macrophyte “problems”; warm-water fishery; supportive of all swimmable /aesthetic uses but “threatened”
60-70	Blue-green algal dominance with scums possible; extensive macrophyte problems; not supportive of all beneficial uses
>70	Heavy blooms and scums in summer likely; dense “weed” beds; hypereutrophic; possible fish kills; fewer plant beds due to high algae; not supportive of many beneficial uses



Management of Phosphorus

Some sources of phosphorus can be managed very effectively, while other sources can't be managed. Atmospheric deposition is not manageable since it is carried from other locations and deposited via rain. However, when sources of phosphorus are from the watershed, various management options are available. Any practice that can reduce runoff and retain the water or infiltrate the water into the soil is very beneficial. Because phosphorus is tied to sediment, phosphorus loading can be reduced by preventing water with sediment and dissolved phosphorus from making its way into the lake. If the water is infiltrated, it will return to the water table, and the soil it filters through will remove the phosphorus. Land cover with significant vegetation will slow the runoff of water and help reduce phosphorus loading.

For these reasons, restoring areas that contain exposed soil, have vegetation with very shallow root structure, or are prone to erosion and the release of sediment can significantly reduce phosphorus loading. Many agricultural and lawn care practices involve fertilizing with soluble phosphorus. As a result, these areas can greatly increase phosphorus loading. However, if the water runoff can be reduced by planting buffers of taller vegetation or changing agricultural practices to grow crops such as grasses, the phosphorus can be retained and not reach the lake as readily.



Impervious surfaces are those that do not allow water to soak in and result in increased runoff. Roads, driveways, roofs, sidewalks and parking lots are all examples of impervious surfaces. Large amounts of sediment, and therefore phosphorus, are carried to the lake when significant impervious surfaces are present. If that water can be slowed, or better yet, infiltrated into the soil, the loading can be significantly reduced.

In this photo, a sediment plume is very evident. Notice the degree of development and the large amount of impervious surfaces.

Septic system malfunctioning can also cause loading of phosphorus. A typical septic system relies on the soil's ability to retain the nutrients from human waste by infiltrating the water in a drain field. If the system is not functioning properly and lacks the infiltration and ultimate phosphorus removal, the nutrients can reach the lake. Holding tanks that don't leak and are routinely pumped can reduce failure and therefore phosphorus inputs. The sanitary sewer system around the lakes eliminates the possibility of septic system failures.

Management of internal loading is also a possibility, but it can be very difficult and expensive. Alum (aluminum sulfate) was added to control internal phosphorus loading in Lake Wapogasset and Bear Trap Lake. Alum contains an aluminum ion that behaves like iron to bind phosphate ions. However, unlike the iron ion, aluminum can bind phosphates in anoxic conditions.

Aeration is another tool that is sometimes used to reduce internal loading. Aeration is used to mix the lake and reduce anoxic conditions. As described previously, oxygen allows iron to remain bound in an insoluble form with phosphate. Both alum treatment and aeration can be very expensive. However, the internal loading is a very significant portion of the entire phosphorus load for project lakes, so these management methods should be considered.

Water Quality Information

Trophic State

Lake Wapogasset and Bear Trap Lake are eutrophic lakes with relatively clear water in early summer that deteriorates with frequent algae blooms in mid to late summer. Phosphorus concentrations control the level of water clarity in Lakes Wapogasset and Bear Trap because increased phosphorus levels increase algae growth. Lake sediments release phosphorus when the lake water temperatures stratify in the summer and oxygen levels decrease at the lake bottom. The lake may periodically mix with high summer winds (or perhaps water circulation from the introduction of cold water from the Balsam Branch River) so that phosphorus-rich bottom waters are brought to the surface and increase algae growth. In addition to internal loading of phosphorus, phosphorus input to the lakes comes from the watershed, direct rainfall, and groundwater.

Previous Lake Studies

The Wapogasset/Bear Trap Lake Improvement Association has requested and/or funded a variety of studies to increase understanding of the water quality and plant community of the lakes. Summaries of previous studies are included in Appendix B.

Lake Self-Help Monitoring Results[12]

Secchi depths are the most commonly collected self-help lake monitoring data reported. Secchi depths measure water clarity. The Secchi depth reported is the depth at which the black and white Secchi disk is no longer visible when it is lowered into the water. Greater Secchi depths occur with greater water clarity. Lake resident volunteers have collected Secchi disc self-help monitoring data since 1973 (although not every year). Results of average July and August Secchi depth readings for the Lakes Wapogasset and Bear Trap are shown in Figures 8 and 10 below. Figures 9 and 11 illustrate all sample test results using TSI (trophic state index) rankings.

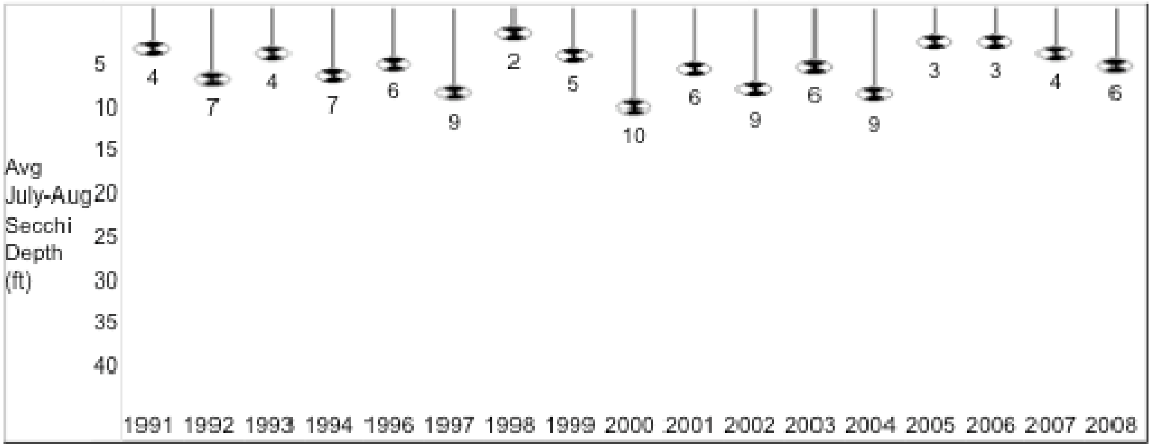


Figure 8. Wapogasset SE End Deep Hole Summer Secchi Depth Averages

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[12] Wisconsin Department of Natural Resources Self Help Monitoring results.

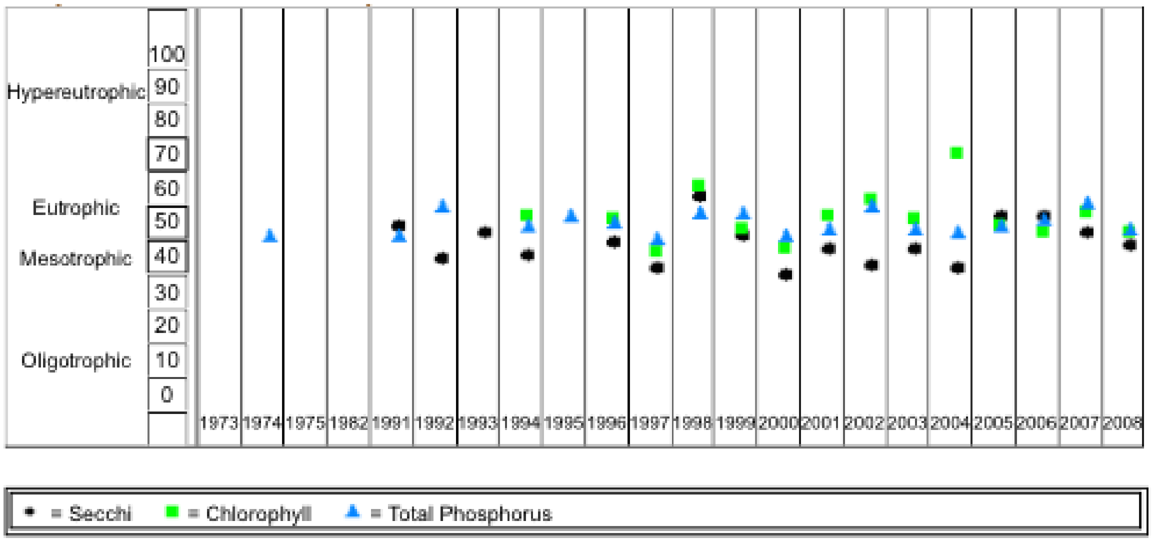

Figure 9. Wapogasset SE End Deep Hole Trophic State Index

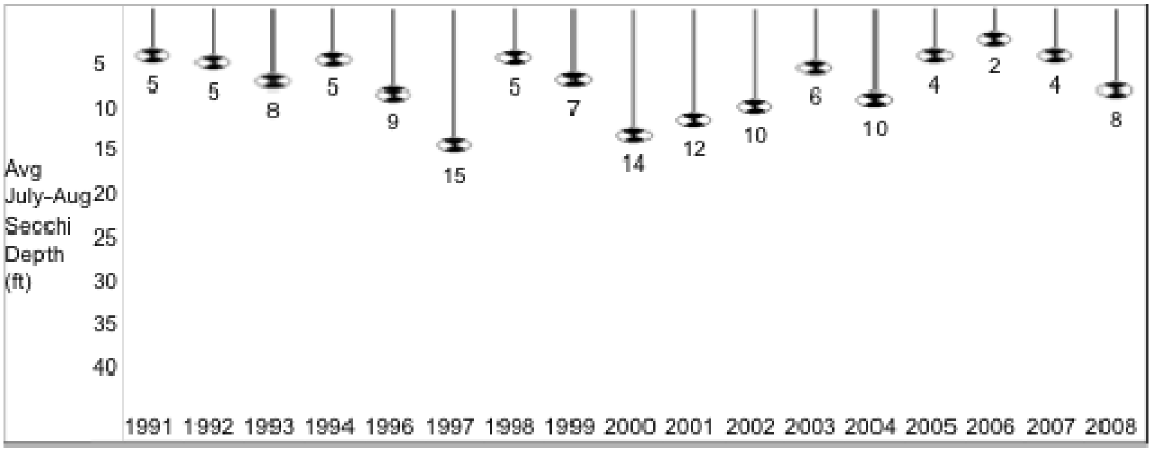

Figure 10. Bear Trap Deep Hole Summer Secchi Depth Averages

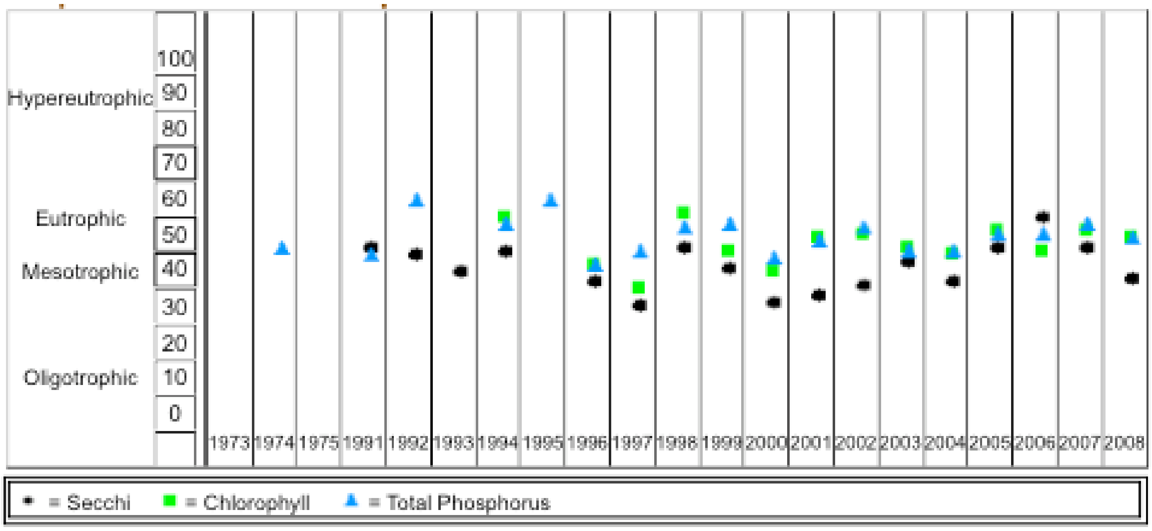

Figure 11. Bear Trap Deep Hole Trophic State Index

Lake Nutrient Analysis

Phosphorus loading in Lake Wapogasset and Bear Trap Lake is the result of both internal (within the lake) and external (not within the lake) sources. As illustrated in Figure 12 below, internal loading contributes approximately 924 kg, or 30 percent of Lake Wapogasset's annual phosphorus budget. External loading is responsible for the remaining 70 percent, or about 2,145 kg per year. Figure 13 illustrates Bear Trap Lake's internal and external contributions of phosphorus. The breakdown is similar to that of Lake Wapogasset with 72% of the phosphorus from external sources and 28% from internal sources.[13]

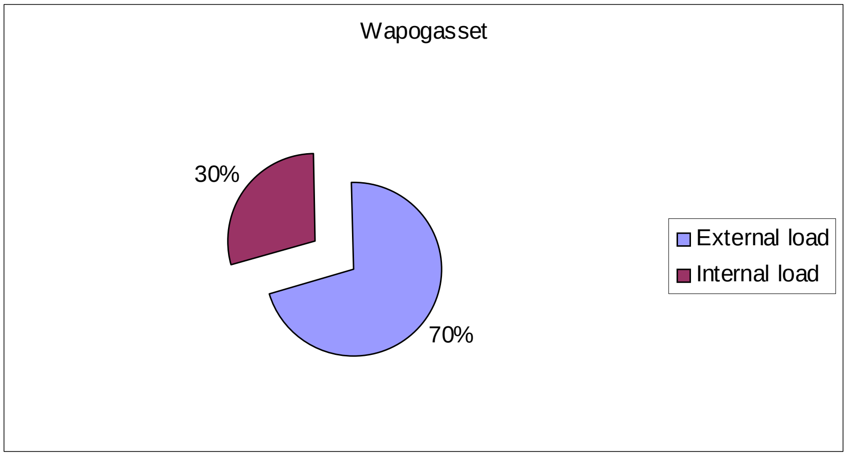

Figure 12. Lake Wapogasset Phosphorus Budget

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[13] Dick Osgood. 2007. Updated with information from Schieffer, Steve. 2009 lake modeling.

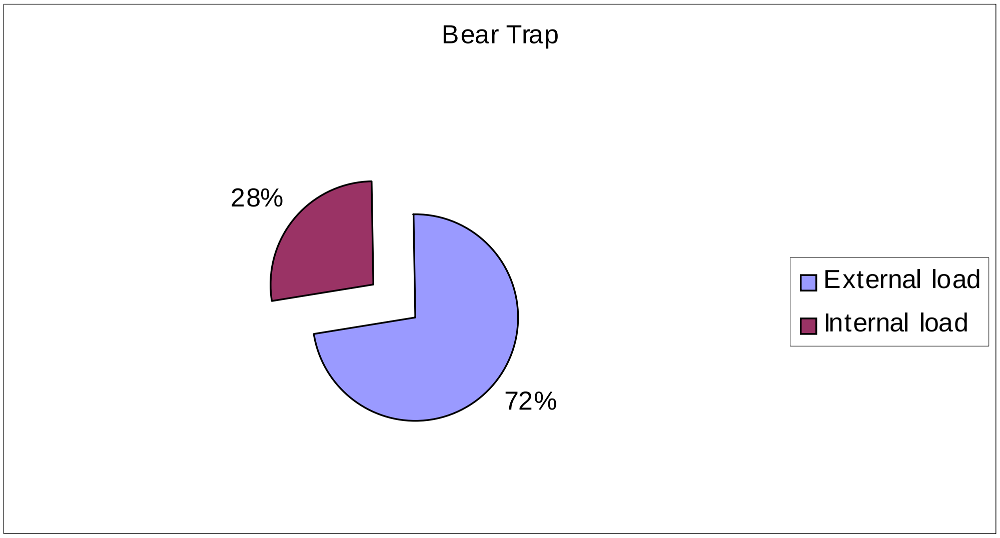


Figure 13. Bear Trap Lake Phosphorus Budget

External Loading

The external loading of Lake Wapogasset and Bear Trap Lake comes from three main sources: tributaries, the watershed, and precipitation. Each source is examined in more detail in the following discussion. The discussion is based upon an analysis of the external loading completed in 2006 and updated for this management plan. The 2006 report is included as Appendix C.

Tributaries

Lake Wapogasset has two tributaries—Balsam Branch and Friday Creek. Steve Schieffer has measured loading from Lake Wapogasset tributaries since 2006. Data logger measurements of stage taken every hour during the sample period (April 22 through October 9, 2006) were used to calculate tributary flow. Water samples were collected once per month and following four storm events. During this period, eleven samples were analyzed for total phosphorus, dissolved reactive phosphorus, total suspended solids, and total volatile suspended solids.

Similar measurements were taken in 2007. The estimated water, phosphorus, and total suspended solids contributions from each of the tributaries in 2007 are listed in Table 1 below. Friday Creek contributes 3 percent of the water flow from tributaries to the lake and 8 percent of the total phosphorus load. The Balsam Branch contributes 97 percent of the water flow and 92 percent of the phosphorus load to the lake. It is important to note that although the total quantity of phosphorus load from the Balsam Branch is the largest single source, the actual concentrations of phosphorus are quite low.

Table 1. Tributary Loading to Lake Wapogasset

Tributary	Water budget (acre-feet)	TP Load (kg/yr)	TSS loading (kg/yr)
Balsam Branch	15,818	1,477.1	121,654
Friday Creek	498	130.1	68,765

Previous studies also analyzed tributary inflow. Stream samples were gathered from both tributaries in 1993 as part of a land use and water quality study. Dissolved oxygen, temperature, and water flow were measured. The Balsam Branch flow was an average twenty times greater than that of Friday Creek. Phosphorus and nitrogen concentrations were higher in Friday Creek than in the Balsam Branch. However, because of the greater flow, phosphorus loading in Balsam Branch was greater. The total annual phosphorus loading—for the months of May through September only—was estimated to be 670 pounds for the Balsam Branch and 167 pounds annually for Friday Creek.

Watershed

The Lake Wapogasset and Bear Trap Lake watershed is part of the Balsam Branch watershed in the St. Croix River Basin. The watershed is illustrated in Figure 14 on the following page. It is divided into subwatersheds that drain directly into project lakes. These subwatersheds are labeled A – J and named for purposes of discussion.

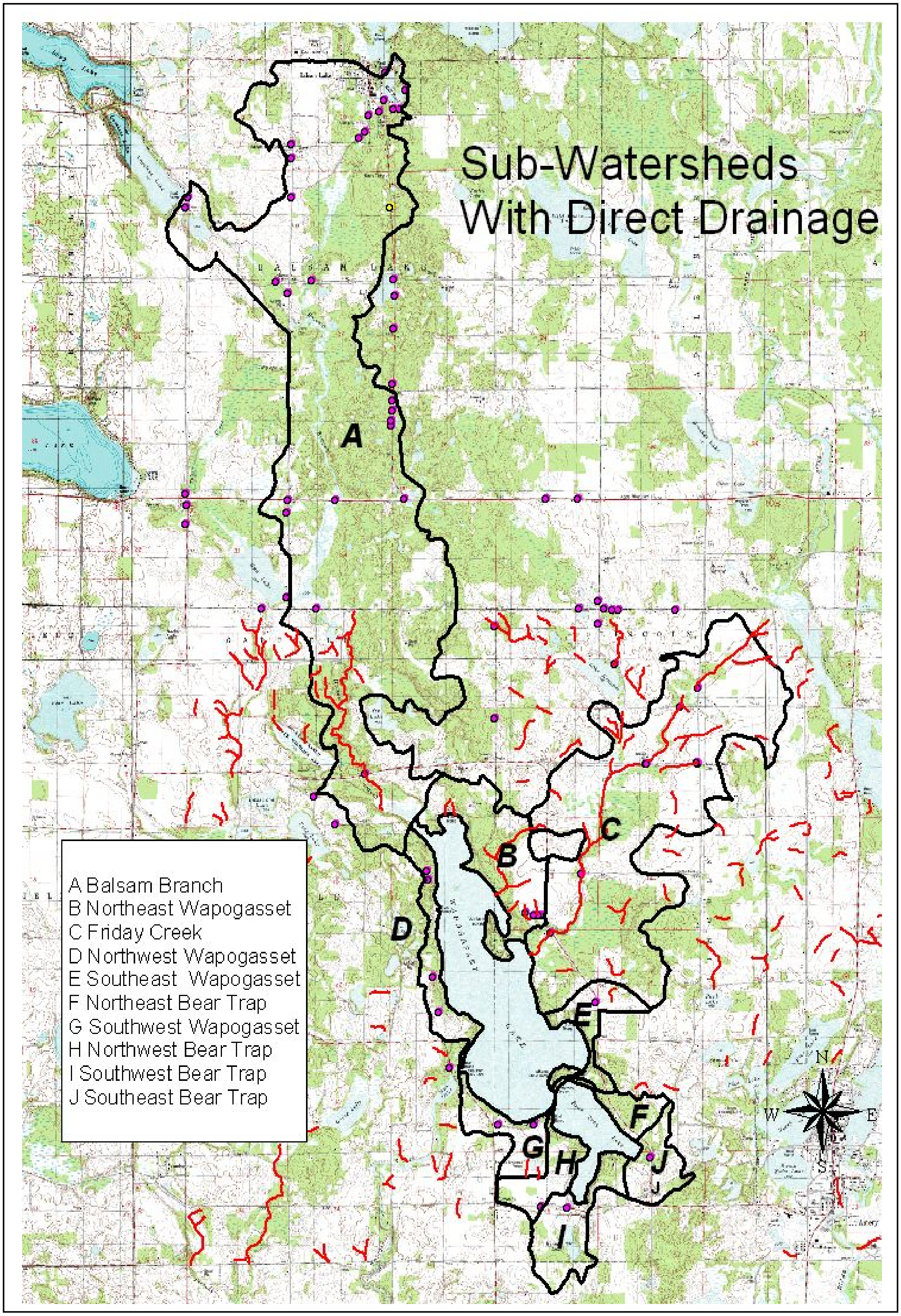
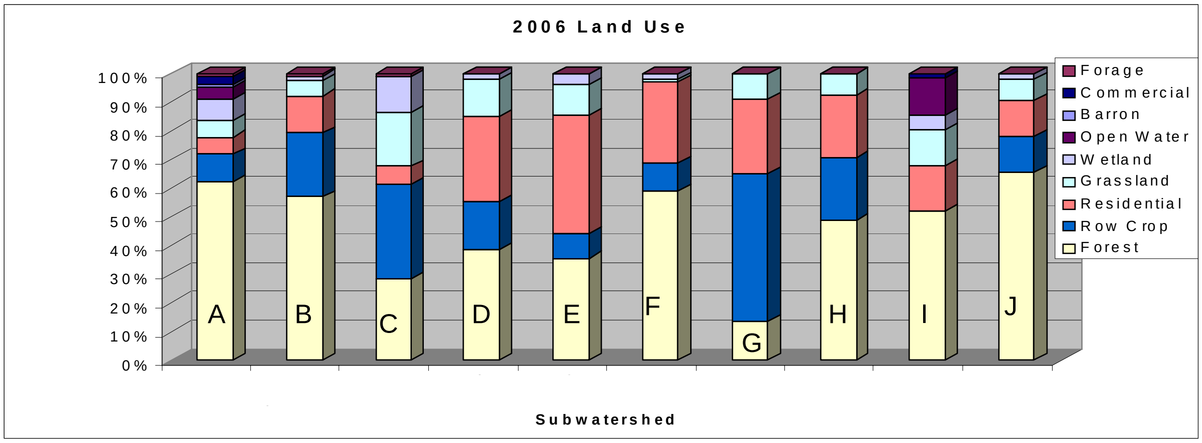


Figure 14. Subwatersheds and Drainage Patterns

Watershed Land Use[14]

The land use from the previous external loading study (in Appendix C) was updated for this comprehensive plan. Land use information was updated using 2006 digital ortho aerial photos. The resulting breakdown of land use for each subwatershed is included in Figure 15 below. The watershed map of land use is included as Figure 16. Land uses are important to understanding nutrient loading because they influence the amount of runoff generated and the nutrients carried to the lake. The breakdown of land use in the combined subwatersheds that drain to each lake is further illustrated in Figures 17 and 18. Lake Wapogasset's subwatersheds (not including those of Friday Creek and the Balsam Branch) are about 50% forested, 10% grassland, 8.5% residential, 8% wetland, and 18% row crop. Bear Trap Lake subwatersheds are about 55.5% forested, 8.5% grassland, 18.3% residential, 3% wetland, and 10% row crop. Of these land uses, residential and row crop contribute the most nutrients to the lakes.

From 1999 to 2006, the watershed land use changed significantly. As local farms switched from dairy to cash grain, forage crops were replaced by row crops, which increased ten percent in two years. As a result, more bare soil is exposed and erosion increases. Acreage in the Conservation Reserve Program (CRP) has also decreased, while residential areas have increased by six percent. The maturation of red pines resulted in change of some grassland to forested land.



A	Balsam Branch
B	NE Wapogasset
C	Friday Creek
D	NW Wapogasset
E	SE Wapogasset
F	NE Bear Trap
G	SW Wapogasset
H	NW Bear Trap
I	SW Bear Trap
J	SE Bear Trap

Figure 15. Subwatershed Land Use

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[14] Dave Peterson, Polk County Land and Water Resources Department, completed this analysis.

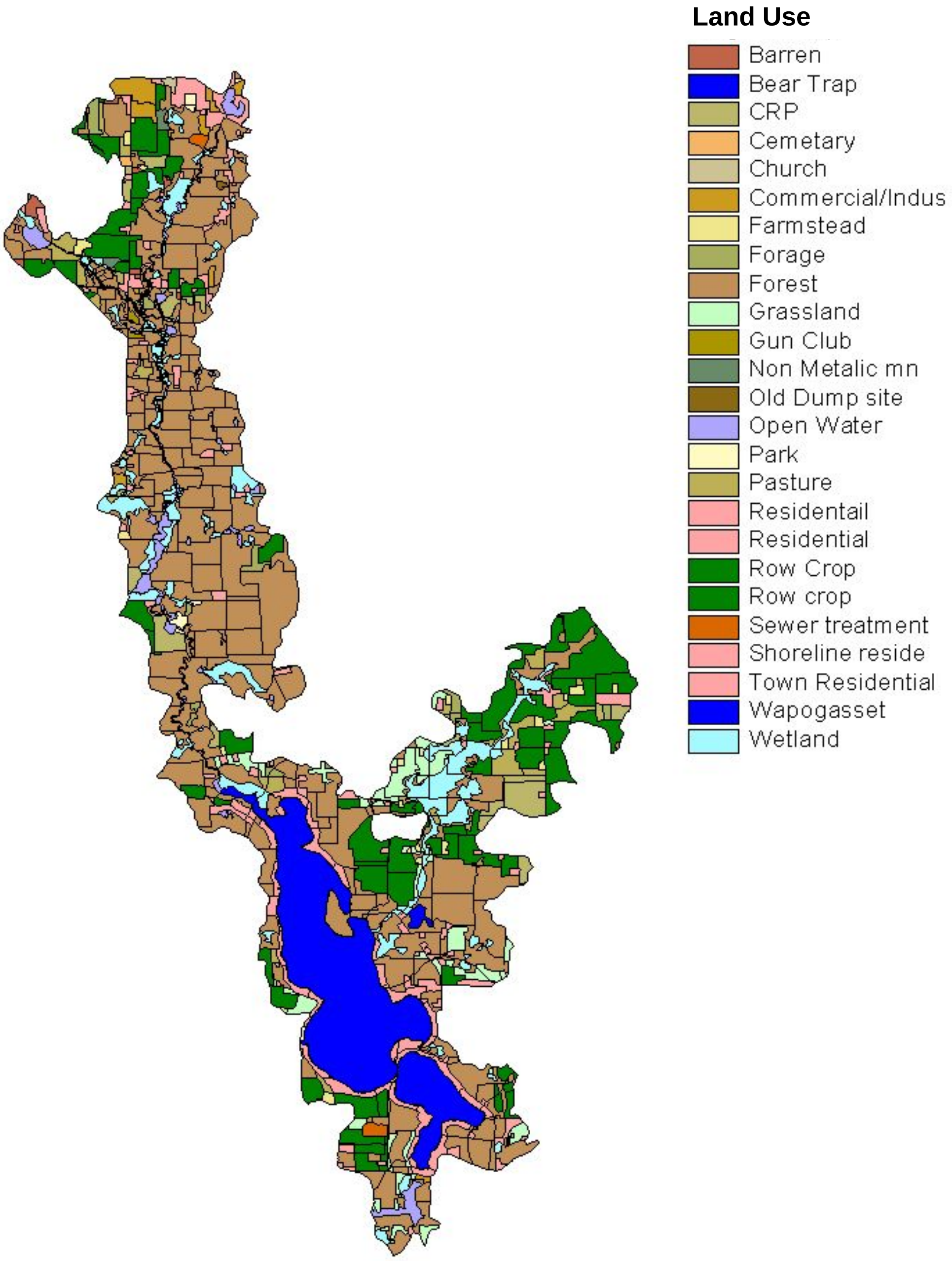

Figure 16. Land Use within the Watershed

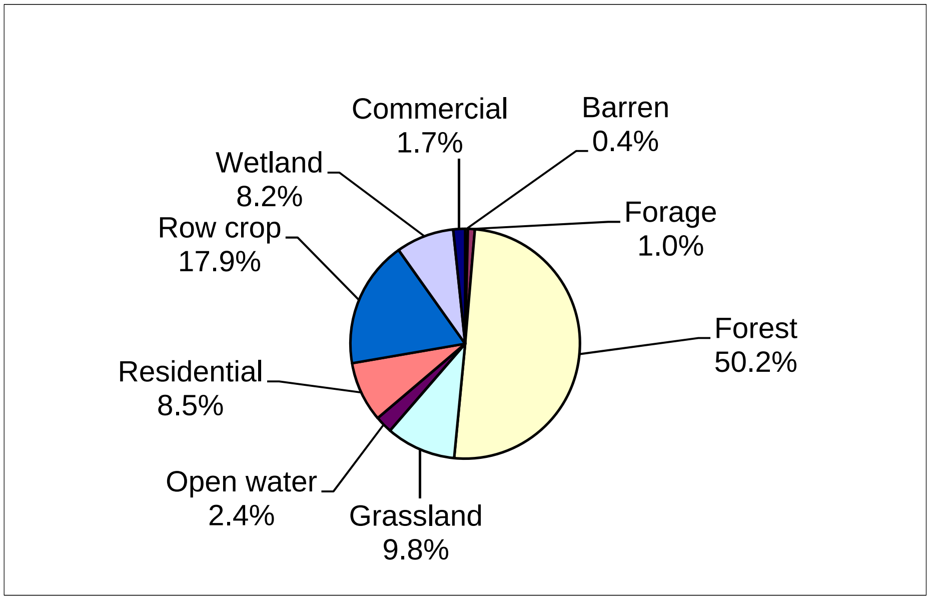

Figure 17. Lake Wapogasset Land Use Cover

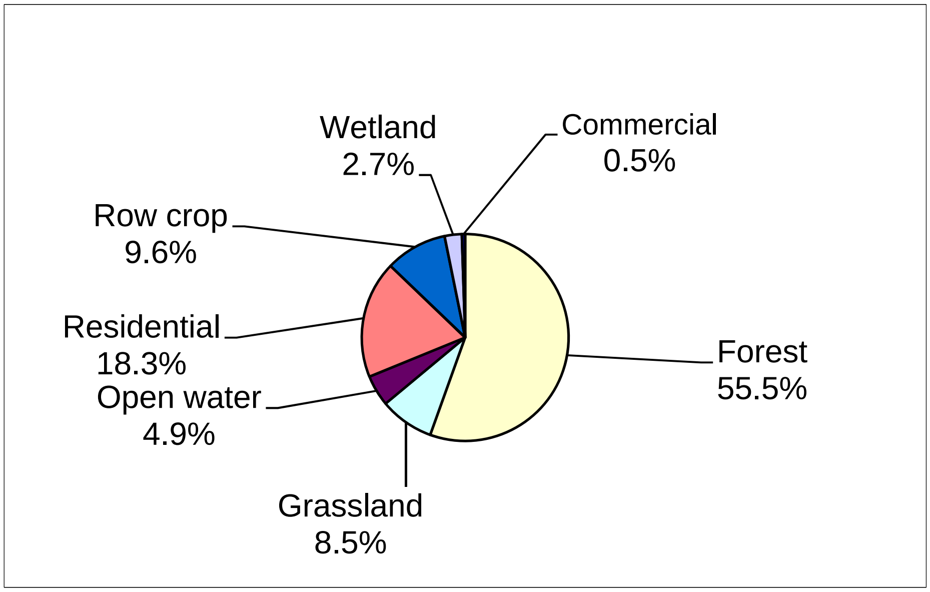

Figure 18. Bear Trap Lake Land Use Cover

Phosphorus Loading from Subwatersheds

Land use information was used to estimate nutrient loading from the subwatersheds using BathTub, a lake water quality model from the United States Army Corps of Engineers. The results confirm that land for residential and row crop land uses result in the highest phosphorus loads from the watershed. For Lake Wapogasset, row crops contribute 56% and residential land contributes 21% of the external load. For Bear Trap, row crops contribute 44.5% and residential land contributes 32% of the external load. These estimates do not include land that flows to the tributaries Balsam Branch and Friday Creek.

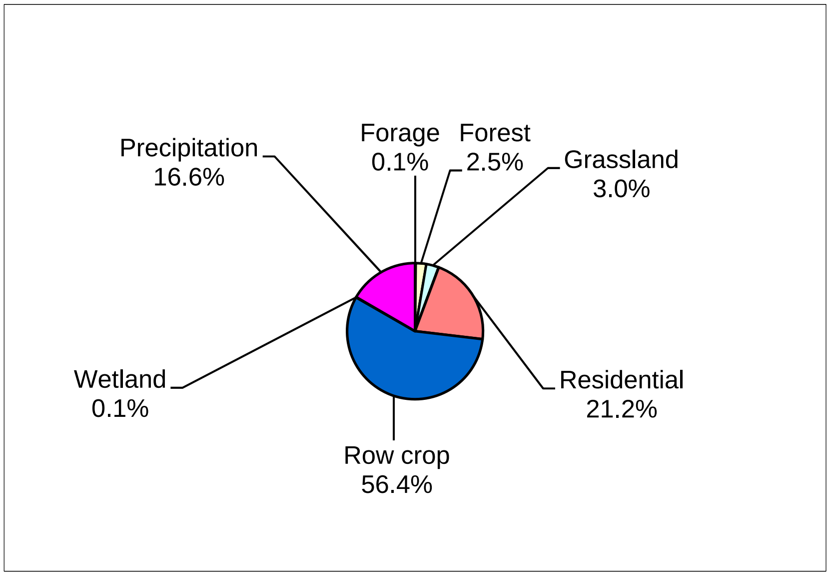

Figure 19. Lake Wapogasset Phosphorus Load by Land Use

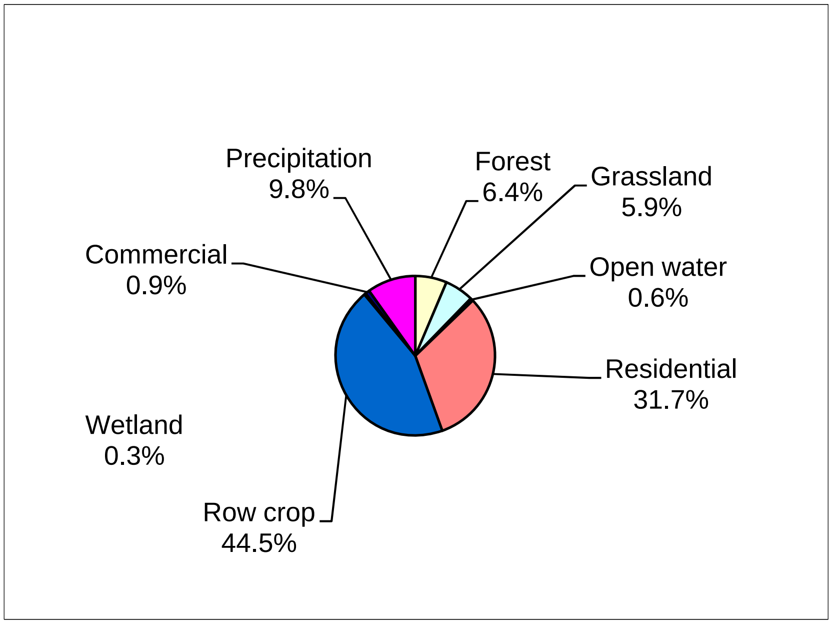

Figure 20. Bear Trap Lake Phosphorus Load by Land Use

Phosphorus loading can also be compared between subwatersheds as in Figures 21 and 22 below. The phosphorus loading is reported in kilograms per acre in the figures below. The loading from tributaries is also included for purposes of comparison. The highest phosphorus load per acre comes from the southwest Wapogasset subwatershed. For Bear Trap Lake, the highest subwatershed load per acre comes from the northwest watershed. Both of these are highlighted in 23.

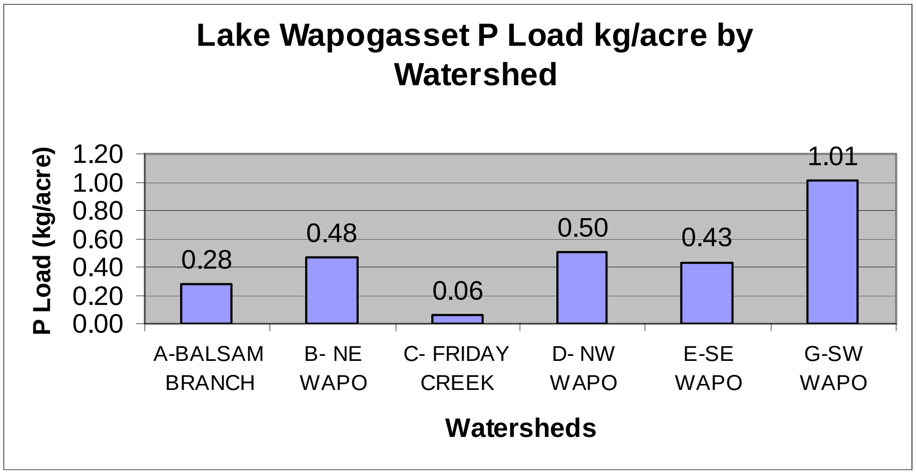

Figure 21. Lake Wapogasset Phosphorus Loading in kg/acre by Subwatershed

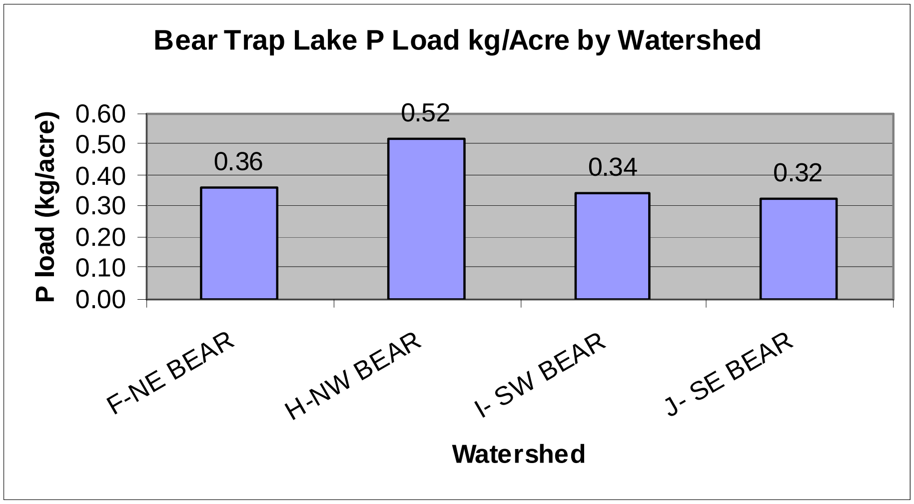

Figure 22. Bear Trap Lake Phosphorus Loading in kg/acre by Subwatershed

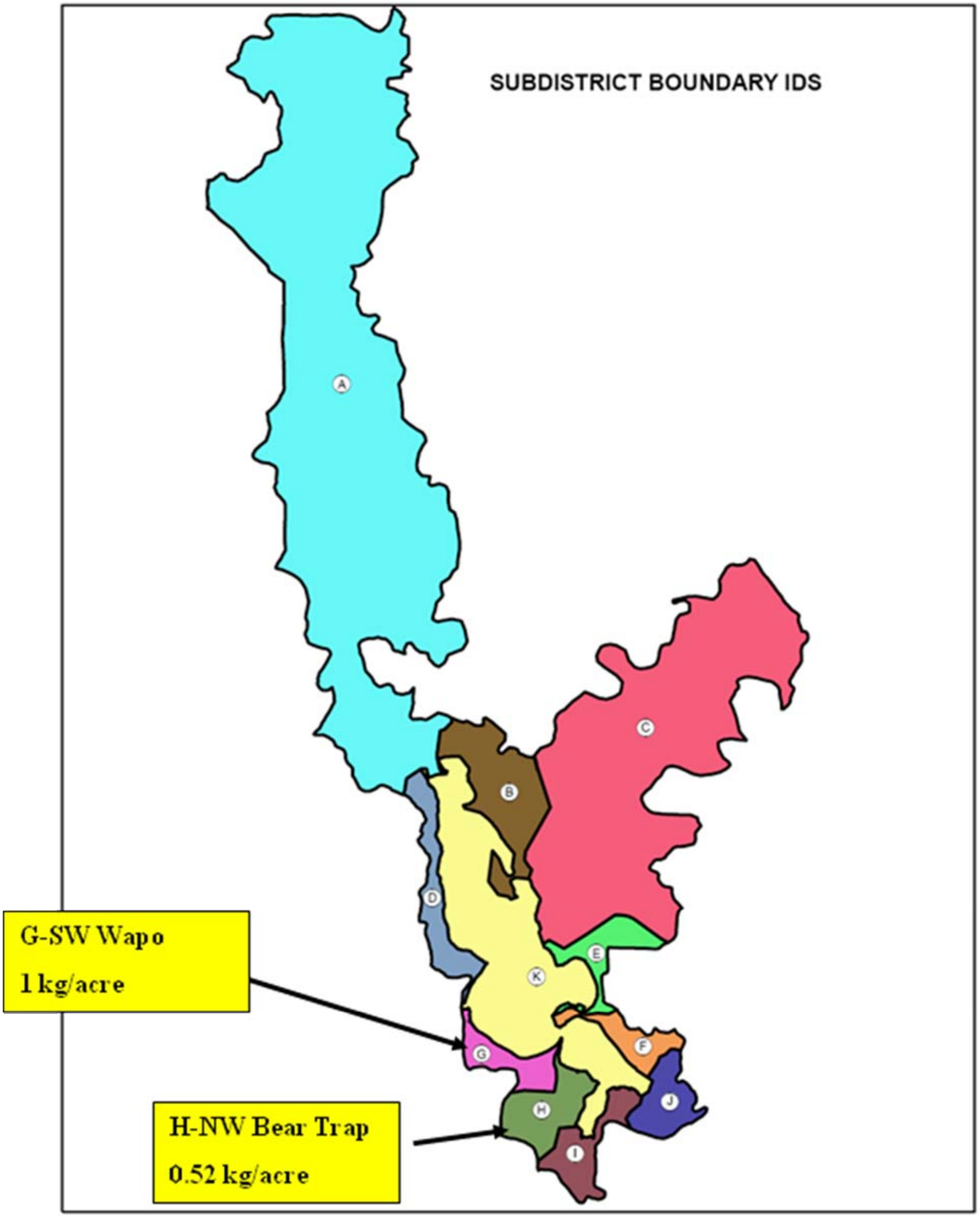

Figure 23. Priority Subwatersheds

Internal Loading

Additional sources of phosphorus come from within the lake. Two of these in-lake sources are 1) the release of phosphorus from bottom sediments and 2) the release of phosphorus from plant growth and subsequent decay. Algae may also bring sediment phosphorus to the surface as part of its life cycle.

Lake Sediments

Internal loading from lake sediments was not analyzed for this plan. However, previous studies have examined internal loading of phosphorus to the lakes in detail. The most recent review of internal loading by Dick Osgood calculated annual loading of phosphorus from lake sediments to be 924 kg/year for Lake Wapogasset and 132 kg/year for Bear Trap Lake.[15] These estimates were based on extensive analysis of lake sediment phosphorus release by Barr Engineering. Phosphorus release from lake sediments was calculated by measuring the amount of mobile phosphorus in lake sediments in several locations and understanding where the lake stratifies and creates anoxic conditions where phosphorus can be released.[16] Barr also relied upon measurements taken by Lake Association volunteers at deep holes in the lakes. Volunteers measured oxygen and temperature and collected water samples to test total phosphorus at various depths. These measurements indicate when and where stratification occurs and provide another measure of the amount of phosphorus released from the sediments during stratification. For Lake Wapogasset, it is assumed that the lake stratifies at depths 25 feet and greater, and for Bear Trap Lake at depths 20 feet and greater. [17]

Earlier estimates of phosphorus load from lake sediments yielded slightly different results with 1,058 kg estimated for Lake Wapogasset and 242 kg of phosphorus estimated for Bear Trap Lake. The internal sediment load was calculated using total phosphorus concentrations present and various depths and the water volume at each depth (Barr 1996).

Curly Leaf Pondweed Dieback

The dieback of the non-native plant, curly leaf pondweed (*Potamageton crispus*) has the potential to increase lake phosphorus levels and therefore algae growth during the growing season. Curly leaf pondweed grows in the fall and winter with accelerated growth in early spring before native plants begin to grow. The plant forms reproductive structures called turions then dies back in early July. Because curly leaf pondweed tends to have high phosphorus amounts in plant tissues, there is the potential for significant in-lake phosphorus increases from curly leaf pondweed (CLP). Lake Wapogasset and Bear Trap Lake have around 100 acres of rather high density CLP. Dieback from CLP could

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[15] Osgood Consulting. Wapogasset – *Bear Trap Lake & Watershed Analysis with Alum Dose Recommendations.* March 2007.

[16] Phosphorus internal loading calculation based on Nurnberg (1988): Log RR = 0.8 + 0.76 log (P); RR = sediment P release rate (mg/m2/d), and P is the surface sediment P concentration mg/g.

[17] Barr Engineering. *Evaluation of Distribution of Mobile Phosphorus.* . January 2006.

contribute between 634 and 1051 kg of phosphorus based on phosphorus levels of CLP found in the literature.[18]

An activity from the aquatic plant management plan is to analyze tissue samples of the CLP for phosphorus content and record density of CLP growth in each bed. If beds have high enough density of CLP to create a significant impact on phosphorus load, they will be treated with herbicide early in the growing season.

Blue Green Algae

Phosphorus Migration Due to Algae

There are several species of algae present in the lakes that may have the ability to transport phosphorus from the lake bottom sediments to the surface of the lake. This includes *Gloeotrichia* species that were present in abundance in the lakes in June 2009. *Gloeotrichia* germinates in lake bottom sediments where it has the ability to absorb and store large amounts of phosphorus. There it develops into a colony, forms a gelatin type sheath, produces gas and floats to surface. Once at the surface, the colony can release large amounts of phosphorus. Research on some lakes estimate it accounts for 67% of internal load.[19]

Blue Green Algae Toxicity

Blue green algae (or cyanobacteria) are also of concern because algae blooms can produce neural and liver toxins that may be harmful to human and animal health. Algae blooms can occur at any time during the growing season, but are most common in late summer. Blooms can look like foam, scum, or mats that float on the surface of the water, but some blooms are present as a thick “pea-soup” without a scum layer. The scum layer can be blue, bright green, brown, or red. Human and animal exposure may result in breathing problems, ear and eye irritation, vomiting or skin rashes. Pets, livestock or wildlife such as birds and fish can also be sensitive to blue green algae toxin exposure. Individuals with suspected exposure should seek medical attention.[20]

Cyanobacterial toxins are classified as neurotoxings and hepatotoxins. Neurotoxins are produced by *Anabaena* and *Oscillatoria* species. Symptoms of exposure include muscle cramps, twitching, paralysis, cardiac or respiratory failure, and death in animals. Hepatotoxins are produced by *Microcystis* and *Cylidrospermopsis* species.[21] *Gloeotrichia* species produce toxins that can cause skin irritation and liver damage.[22]

Blue green algae have been commonly found in the Lake Wapogasset and Bear Trap. They were found in 1972 by the Environmental Protection Agency (EPA), in 1986 by the

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[18] Ecological Integrity Services. *Lake Wapogasset and Bear Trap Lake APMP*. Draft August 2009.

[19] King and Laliberte. *Analysis of the effects of Gloeotrichia echinulata*. May 2005.

[20] Wisconsin Department of Health and Family Services http://www.dhs.wisconsin.gov/eh/bluegreenalgae. May 2009.

[21] Wisconsin Department of Health and Family Services. Division of Public Health. *Cyanobacteria and Human Health*. June 2004.

[22] King and Laliberte. May 2005.

Wisconsin Department of Natural Resources (WDNR), in 1998 by Barr Engineering, and in 2005 by the Polk County Health Department.

The EPA found *Microcystis* in June and *Anabaena sp*. in June and August of 1972. In 1986 the WDNR found positive results in one sample where *Microcystis*, *Anabaena*, and *Aphanizomenon* were present, and marginally positive results in two samples where *Gleotrichia*, *Microcystis*, and *Anabaena* were found. Barr Engineering, in their 1998 study, found *Anabaena* (the predominant species on Wapogasset) and *Ajshanizomenon* (the predominant species on Bear Trap) as well as *Microcystis* to be present. The Polk County Health Department declared a health advisory on August 30, 2005 after finding the following species in Lake Wapogasset: *Anabaena sp., Aphanizomenon sp., Microcystis sp.*, and *Planktothrix sp.* There are established World Health Organization guidelines for actions at various cell densities of cyanobacteria reported in Table 2 below.

Table 2. Summary Table of WHO Guidelines for Cyanobacteria Levels in Water

Risk Category	**Cell Density (cells/mL)**	**Action Recommended**
Low	20,000 – 100,000	None
Moderate	>100,000	Advisory and Possible Closure
High	Visible Scum Layer	Closure

Lakes Wapogasset and Bear Trap Fishery

The Wisconsin Lakes Book indicates that walleye, largemouth bass, and panfish are common in both Lake Wapogasset and Bear Trap Lake. Muskellunge and northern pike are also present.

Table 3. Fish Species of Lakes Wapogasset and Bear Trap

Common Name	**Scientific Name**	**Abundance in Lake Wapogasset**	**Abundance in Bear Trap Lake**
Walleye	*Stizostedion vitreum*	Common	Common
Northern pike	*Esox lucius*	Present	Present
Largemouth bass	*Micropterus salmoides*	Common	Common
Panfish	*various*	Common	Common
Muskellunge	*Esox masquinongy*	Present	Present

Both Lake Wapogasset and Bear Trap Lake have abundant, diverse fish populations. In a population survey conducted in 2008, it was reported that the following fish are present in the two lakes[23]:

Walleye
Northern Pike
Muskellunge
Largemouth Bass
Smallmouth bass
White bass
Bluegill
Black crappie
Pumpkinseed
Yellow perch
Green sunfish
Warmouth
White sucker
Common carp
Redhorse
Bullheads

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[23] Heath Benike. Wisconsin DNR Fisheries Biologist. *Draft Report on 2008 Fish Survey*. February 2008.

The fish management of these two lakes has included extensive stocking of walleye fry and small fingerlings. The walleye stocking program dates back to 1938. The most recent stocking occurred in 2008 when DNR stocked 41,746 (in Wapogasset) and 8,423 (in Bear Trap) walleyes averaging 1.5" in length. In the management recommendations of this fish survey the importance of maintaining an adult walleye population between 1-2 fish/acre through increased walleye stocking (70 fish/acre) was discussed for Lake Wapogasset. It appears that walleye are an integral part of the overall fish management of Wapogasset and Bear Trap Lakes.

In 2005, a low-level muskellunge stocking program was initiated in Lake Wapogasset when 711 fish were stocked. In 2007 another 395 muskellunge were stocked. These fish averaged about 12 inches long. Stocking was initiated to maintain the low-density fishable population that has been present over the past several decades. Historically, muskellunge emigrated from upstream, which reduced the need for stocking. The report recommended that muskellunge stocking continue at a rate of 0.5 fish/acre on alternating years. It is also suggested that the lakes be upgraded to a Class B, 3 muskellunge classification. A Class B fishery is an intermediate class that provides good fishing, but not as good as Class A, prime waters. Reproductive category 3 means there is not natural reproduction, so stocking is necessary to maintain the population. This ranking reflects the DNR priority on muskellunge in the overall fish management of the two lakes.

The most abundant managed game fish in Lake Wapogasset and Bear Trap Lakes is largemouth bass at 8.7 fish per acre. The DNR fish biologist reported that this population is too dense, and may lead to a stunted largemouth bass population. The management report suggested that largemouth bass and smallmouth bass populations be monitored. It appears that the largemouth bass population is increasing and a high density, sub-optimal size population should not be allowed to develop.

When considering fish in lake and watershed management in the lakes, the following should be considered[24]:

1. Although it appears the natural walleye reproduction is minimal, it may be occurring. Walleye spawn on clean gravel beds. Sedimentation can render these areas useless as spawning beds. Walleye spawning beds designated as sensitive areas are shown in Figure 24. It is important to keep sedimentation to these areas to a minimum. Native shorelines, restoration of developed shorelines, and stormwater retention and treatment projects can reduce sedimentation.

2. Muskellunge reproduce in the spring at water temperatures in the mid-50's F. They also spawn amongst aquatic vegetation and/or woody debris. As a result, the loss of early plant growth such as curly leaf pondweed (CLP) could affect the limited muskellunge reproduction. In addition, muskellunge may

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[24] From *Draft Aquatic Plant Management Plan*. August 2009.

use CLP for cover and forage areas early in the spring. As a result, early season treatment of CLP needs to be timed with the muskellunge considered. This would include delaying the treatment after musky spawning. It is also important to target the CLP so native plants can replace the CLP, limiting the potential habitat reduction.

3. Black crappie spawn when the water temperature is the same as that recommended for CLP treatment. This treatment would need to be timed accordingly, either prior to or after crappie spawning.

4. Northern pike rely on aquatic plants for spawning. However they spawn when water temperatures are in the 40's F, so treatment of herbicides in the mid 50's F should not coincide with the northern pike spawning activity.

Fish Management for Water Quality

Grazing zooplankton can sometimes control the amount of algae in a lake. Large zooplankton such as *Daphnia* can filter significant amounts of algae, bacteria, and organic matter as they graze. Fish populations influence the amount of large herbivorous zooplankton. The fry of nearly every fish species and adult bluegill, pumpkinseed, perch and others will graze on zooplankton. Lakes dominated by adult species such as largemouth bass, walleye, and northern pike are likely to have abundant large-bodied zooplankton because these fish eat zooplankton predators. Controlling the density of stunted panfish is recommended as a means to improve both the sport fishery and water clarity. Zooplankton populations can be lower in eutrophic lakes because anoxic areas eliminate their daytime refuges from predators. Copper sulfate and pesticides can also kill zooplankton. [25]

The DNR fisheries biologist believes that biomanipulation of the fish population to control algae is not appropriate for the lakes. Shifting the balance of fish communities would not be supported by the Department of Natural Resources.[26]

Removing bottom feeding carp is another biomanipulation method that might improve water clarity. Bottom feeding releases significant amounts of nutrients to the water column as these fish feed and digest plant material. Harvesting carp has increased water clarity in some cases.[27] It is difficult to quantify carp populations and subsequently reduce their density. Quantifying carp requires a mark and recapture population estimate. This was attempted with no success on Lake Wapogasset several years ago. Carp could be removed via angling, bow fishing, or contract fishing. However, because carp can enter the lakes both via the Balsam Branch and the Wapogasset Branch, removing carp entirely would not be feasible. The DNR suggests removal of carp by encouraging angler and bow fisher harvest.[28]

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[25] *Managing Lakes and Reservoirs*. North American Lake Management Society. 2001.
[26] Email communication. Heath Benike. August 2009.
[27] NALMS. 2001.
[28] Benike. 2009.

Table 4. Spawning Temperatures and Substrate Needs

Fish species[29]	**Spawning Temp in ^{o}F**	**Spawning substrates**
Black crappie	Upper 50's to lower 60's	Build nests in 1-6 feet on hard bottom
Bluegill, Largemouth bass and Pumpkin seed	Mid 60's to lower 70's	Build nests in less than 3 feet on hard bottom
Muskellunge[30]	Mid 50's to near 60.	Broadcast eggs over organic sediment, woody debris and submerged vegetation.
Northern Pike	Upper 30's to mid 40's soon after ice-out	Broadcast eggs onto vegetation (eggs attach)
Smallmouth Bass	Usually between 62 and 64 but recorded as low as 53	Nests in circular, clean gravel
Walleye	Low 40's to 50 degrees.	Gravel/rocky shoals with moving or windswept water 1-6 feet deep
Yellow perch	Mid 40's to lower 50's	Broadcast eggs in submergent vegetation or large woody debris

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[29] Information from Heath Benike. Wisconsin DNR Fisheries Biologist. 2006

[30] Information from: Rust, Ashely J., James Diana, Terry L. Margenau, and Clayton J. Edwards. *Lake Characteristics Influencing Spawning Success of Muskellunge in Northern Wisconsin Lakes*. *North American Journal of Fisheries Management*. 2002. p834.

Sensitive Habitats and Species

A sensitive area survey was conducted on Lake Wapogasset in 1989. There were seven locations around the Lake Wapogasset and two locations on Bear Trap Lake that were recorded as "sensitive areas" based upon their importance as habitat in the lake ecosystem. Figure 24 illustrates and Table 5 describes the areas in terms of location, importance and protection. Note that areas B, C, D, and G are noted as walleye spawning beds.

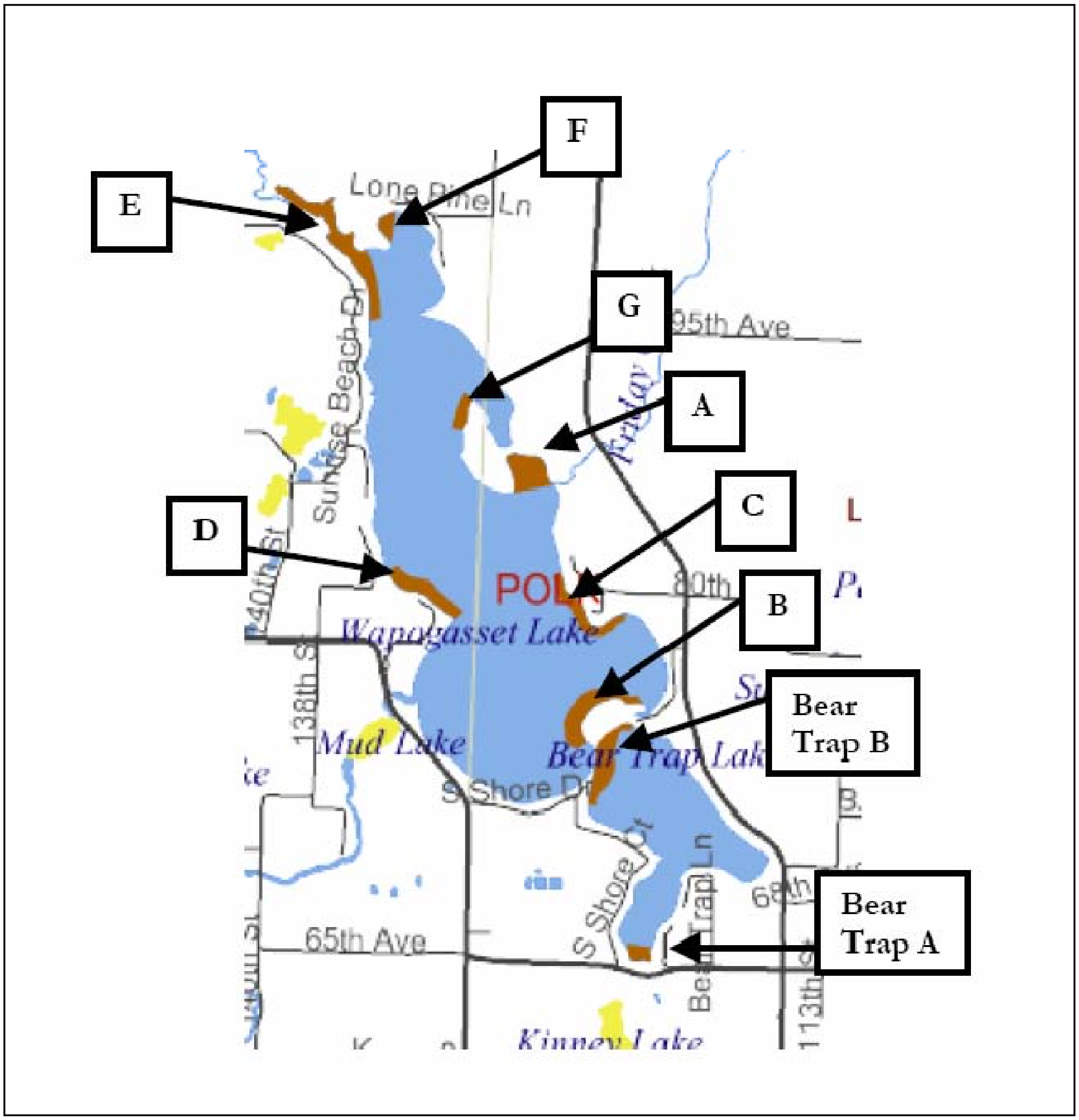

Figure 24. Assumed Sensitive Area Locations (based on description in Table 5)

Table 5. Sensitive Area Descriptions

Sensitive Area	Location/description	Importance	Protection
LAKE WAPOGASSET			
A	3000 feet of shoreline extending from Friday Creek to YMCA Camp	Habitat for centrachid and esocid species of fish; important wildlife habitat	Chemical and mechanical treatments should not be allowed.
B	2000 feet of shoreline out 200 feet on East shore of Wapogasset	Rock and gravel bottom with no silt that provides walleye spawning.	No dredging, structures or deposits should occur.
C	1500 feet of shoreline out 200 feet near bible camp.	Rock and gravel bottom with no silt that provides walleye spawning.	No dredging, structures or deposits should occur.
D	2000 feet of shoreline out 200 feet on western shore of Wapogasset	Rock and gravel bottom with no silt that provides walleye spawning.	No dredging, structures or deposits should occur.
E	Entrance of Balsam Branch into Wapogasset and surrounding wetlands/approx. 3500 feet of shoreline.	Habitat for centrachid and esocid species of fish for spawning and nursing; important wildlife habitat; wild rice in the area	Chemical and mechanical treatments should not be allowed.
F	A small bay on north end of Wapogasset/approx. 800 feet of shoreline	Habitat for centrachid and esocid species of fish for spawning and nursing; important wildlife habitat	Chemical and mechanical treatments should not be allowed.
G	Located along YMCA camp out 200 feet covering approx. 900 feet of shoreline.	Rock and gravel bottom with no silt that provides walleye spawning	No dredging, structures or deposits should occur.
BEAR TRAP LAKE			
A	Southern Bay near HWY F. Includes approximately 550 feet of shoreline and extends up to 100 feet up the shore.	Habitat for centrachid and esocid species of fish for spawning and nursing; important wildlife habitat	Chemical treatments and mechanical harvesting should be limited to navigation channels.
B	NW shoreline including the narrows from the public boat launch to the Bible Camp.	Habitat for centrachid and esocid species of fish for spawning and nursing; important wildlife habitat	Chemical treatments and mechanical harvesting should be limited to 80 feet from shore.

Rare and Endangered Species

Lakes Wapogasset and Bear Trap are in the Town of Garfield (T33N, R17W) and the Town of Lincoln (T33N, R16W). Rare species are noted in this area. However, records of species present are not available to the public, so there is no indication of what species are actually present or if they are located within or surrounding Lakes Wapogasset or Bear Trap. No state or federally listed threatened, endangered, rare or special concern plant species were found in any lake plant surveys.

Scientific Name	**Common Name**	**State Status**[31]	**T33N R16W**	**T33N R17W**
Haliaeetus Leucocephalus	Bald eagle	SC/FL	YES	YES
Fundulus Diaphanus	Banded killifish	SC/N	YES	YES
Cypripedium parviflorum var. m	Northern yellow lady's-slipper	SC		YES

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[31] THR = Threatened, END = endangered, SC/FL = Special Concern (federally protected as endangered or threatened), SC/N = Special Concern (no laws regulating use, possessions, or harvesting), and SC/H = Special Concern (take regulated by establishment of open closed seasons).

Wildlife

The wildlife around Lake Wapogasset and Bear Trap Lake is very plentiful. Animals ranging from the abundant whitetail deer (*Odocoileus virginianus)* to the majestic bald eagle (*Haliaeetus leucocephalus*) can be found in the area.

Some of the common species present in the area are: wild turkeys, ring-neck pheasants, grouse, woodcock, mallards, wood ducks, geese, coyotes, fox, black bear, raccoon, beavers, otters, fishers, mink, muskrats, various song birds, snakes, frogs, and turtles to name a few.

One reason for the wildlife diversity around the lakes and their watersheds is the habitat diversity. This geographic area contains various types of wetlands, open grasslands, upland and lowland woodlands, and agricultural areas - key habitats to the wildlife in the area.[32]

Aquatic Invasive Species

Non-native aquatic invasive species (AIS) threaten Wisconsin lakes. Because AIS plant species are addressed in the Aquatic Plant Management Plan, the discussion here is limited to animal species. The following were identified to create the greatest potential threat to project lakes: rainbow smelt, spiny water flea, zebra mussels, rusty crayfish, and the Chinese mystery snail. [33]

Rainbow Smelt *(Osmerus mordax)*

Rainbow smelt are a small (7 to 9 inch long) forage fish that originally invaded the Great Lakes and are now spreading to inland lakes of Wisconsin. Smelt have been present in Wisconsin waters of the Great Lakes for over 70 years, and were first discovered in 1928 in Little Sturgeon Bay in Door County. Through the intentional or accidental efforts of private individuals, smelt began to spread to Wisconsin's inland waters in the 1980's.

Rainbow smelt feed on young walleye and perch and therefore reduce successful walleye reproduction. There are lakes nearby where rainbow smelt are present, and Wapogasset and Bear Trap are vulnerable to smelt introduction.

Rainbow smelt has come to represent an important component of the recreational and commercial fishery. In 2004, commercial trawlers in Wisconsin harvested 155,000 pounds of rainbow smelt from Lake Michigan and Green Bay; the peak harvest in recent years was 1,800,000 pounds (1990). Recreational anglers gather along streams with seines to harvest the fish during their spring spawning runs, cooking them up for the popular "smelt fry."

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[32] Provided by Eric Mark, DNR Wildlife Biologist, Balsam Lake. January 5, 2006.

[33] Information provided by Jeremy Williamson, Polk County Land and Water Resources Department in a presentation to the committee, 9/08/09 and from http://dnr.wi.gov/invasives.

Current control techniques can't eliminate rainbow smelt from lake communities without harming the rest of the lake population. Thus, it is most important to educate water users and to always follow the Clean Boats, Clean Waters protocol for preventing the spread of aquatic invasive species.

Spiny Water Flea (*Bythotrephes cederstroemi)*

Spiny water flea is native to Eurasia and arrived in ship ballast water from Europe in the 1980s. Only about ¼ to ½ inches in length, individual waterfleas may go unnoticed. However, they tend to gather in masses on fishing lines and downrigger cables, so anglers may be the first to discover a new infestation.

Spiny waterfleas are predators - they eat smaller zooplankton (planktonic animals), including Daphnia. This puts them in direct competition with juvenile fish for food. Young fish have trouble eating these water fleas due to their long, spiny tails. Fishing, boating, and other water recreational equipment can transport spiny water fleas and their eggs to new water bodies. Their resting eggs can survive long after the adults are dead, even under extreme environmental conditions. Care must be taken not to transport water between water bodies and to remove all water fleas and eggs from equipment.

Spiny water fleas were found in the Gile Flowage (Iron County) in 2003 and Stormy Lake (Vilas County) in 2007. These are the only inland Wisconsin lakes known to contain invasive water fleas. Unfortunately, at this time no effective strategy is available to control the spiny water fleas once they are introduced to lakes. Lake Waposgasset and Bear Trap are not identified by the DNR as likely locations for spiny water flea establishment because the waters tend to be turbid, and spiny water flea are visual predators.[34]

Zebra Mussels (*Dreissena polymorpha*)

The zebra mussel is a tiny (1/8-inch to 2-inch) bottom-dwelling clam native to Europe and Asia. Zebra mussels were introduced into the Great Lakes in 1985 or 1986, and have been spreading throughout them since that time. They were most likely brought to North America as larvae in ballast water of ships that traveled from fresh-water Eurasian ports to the Great Lakes. Zebra mussels look like small clams with a yellowish or brownish D-shaped shell, usually with alternating dark- and light-colored stripes. They can be up to two inches long, but most are under an inch. Zebra mussels usually grow in clusters containing numerous individuals.


Ohio Sea Grant

Zebra mussels were first found in Wisconsin waters of Lake Michigan in 1990. They are now found in a number of inland Wisconsin waters. Zebra mussels are the only freshwater mollusks that can firmly attach themselves to solid objects. They are generally found in shallow (6-30 feet deep), algae-rich water.

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[34] Jeremy Williamson. Personal communication 11/09/09.

Zebra mussels feed by drawing water into their bodies and filtering out most of the suspended microscopic plants, animals, and debris for food. This process can lead to increased water clarity and a depleted food supply for fish and other aquatic organisms. The higher light penetration fosters growth of rooted aquatic plants which, although creating more habitat for small fish, may inhibit the larger, predatory fish from finding their food. This thicker plant growth can also interfere with boaters, anglers, and swimmers. Zebra mussel infestations may also promote the growth of blue-green algae, since zebra mussels avoid consuming this type of algae but not others.

Once zebra mussels are established in a water body, very little can be done to control them. It is therefore crucial to take all possible measures to prevent their introduction in the first place. Be sure to follow the Clean Boats, Clean Waters procedure in preventing the spread of aquatic hitchhikers. In addition to these measures, boaters can take specific precautions in protecting their motors from zebra mussels.

No selective method has been developed that succeeds in controlling zebra mussels in the wild without also harming other aquatic organisms. To a certain extent, ducks and fish will eat small zebra mussels, but not to the point of effectively controlling their populations. As of yet, no practical and effective controls are known, again emphasizing the need for research and prevention.

Rusty Crayfish *(Orconectes rusticus)*

Rusty crayfish tend to occupy small productive lakes with modified shorelines. Rusty crayfish are native to streams in the Ohio River Basin states of Ohio, Kentucky, Illinois, Indiana, and Tennessee. They were likely introduced to Wisconsin waters by anglers who used them as live bait. They are still sold as bait and by biological supply companies. It is illegal to possess both live crayfish and angling equipment simultaneously on any inland Wisconsin water (except the Mississippi River). It is also illegal to release crayfish into a water of the state without a permit. A fishing license is required to harvest crayfish.

Rusty crayfish eat small fish, insects, and fish eggs. They also eat aquatic vegetation, damaging underwater habitat that is important for fish spawning, cover, and food. They are aggressive and displace native crayfish.

Chinese Mystery Snail

Chinese mystery snails are remarkably widespread in northern Wisconsin, and have been reported in Wapogasset and Bear Trap Lakes. The snails are associated with nutrient-rich lakes, close to a population center that have high shoreline housing density. Their ecological impacts are subtle and unclear. They are reported to eat phytoplankton and zooplankton and compete with native snails for food and space. These snails are sold as food in Asian markets. The snails can serve as vectors for parasites. These snails can definitely be a nuisance along shorelines. More research is needed to determine whether the snails are a serious management concern. There are no known controls that do not adversely affect native species.

Shoreland Habitat Assessment

Lake Association volunteers began a shoreland habitat assessment in the fall of 2009 and will complete the assessment in the spring of 2010 as part of this project. The purpose of the assessment is to assess shoreline and buffer zone composition, to identify habitat characteristics around the lake, and to assess the potential for runoff from waterfront lots.

The assessment will examine the characteristics of the immediate shoreline at ordinary high water mark and the shoreland buffer zone. The ordinary high water mark is the level water reaches during periods of high water.[35] The shoreland buffer zone begins at the ordinary high water mark and extends 35 feet inland. Shoreline characteristics will be recorded in feet and shoreland buffer characteristics in square feet.

Results will be available in a separate report in 2010. The results will help to guide the educational and technical assistance program for waterfront residents.

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[35] In 1914, the Wisconsin Supreme Court defined the OHWM as "the point on the bank or shore up to which the presence and action of the water is so continuous as to leave a distinct mark either by erosion, destruction of terrestrial vegetation or other easily recognized characteristic."

Lake Management

Lake Management Activities

A range of management activities are available to address water quality and habitat concerns. Categories for consideration include the following:

- Education/Incentives
- Conservation Practices
- Land Preservation
- Enforcement/Land Use Planning
- Lake Studies/Evaluation
- In-Lake Management

Education/Incentives

Providing education and information to lake residents and visitors is an important component of any lake management program. There is an abundance of printed and web information to help explain lake ecology and management methods. Incentives such as payments, tax credits, and recognition can also encourage adoption of desired lake management behaviors.

Information can be distributed using a variety of methods including

- Packets of information for new homeowners
- Notebooks with pertinent information
- Brochures
- Web sites
- Newsletters
- Newspapers
- Workshops and training sessions

Distributing information can certainly increase knowledge. A key consideration is that sometimes people have the knowledge of lake concerns, but still don't make desired behavioral changes. It is important to identify the barriers to behavioral change and to design programs that overcome these barriers.

Conservation Practices

Conservation practices, frequently called best management practices, are installed to reduce pollutants. For lake management, conservation practices tend to focus on reducing erosion, slowing water flow, and encouraging infiltration. Many times these practices use native vegetation to accomplish pollutant reduction objectives. For the most effective installation of conservation practices, the most likely participants where significant sources of pollution can be addressed should be targeted.

Installation of conservation practices is likely to require some form of technical assistance. For simple practices, this might be in the form of a guidebook. Many practices will require on-site visits with designs prepared by technicians. More complicated practices may require designs by professional engineers.

Large-scale practices and multiple small-scale practices are likely to require significant funding for design and installation. Some lake organizations provide direct financial and technical assistance. It is more common for lake organizations to work together with a county and/or another nonprofit organization. DNR Lake Protection Grants are available for both small and large-scale practices with comprehensive lake management plan approval.

Conservation practices for Lake Wapogasset and Bear Trap Lake are likely to focus on reducing runoff and pollutant loading from waterfront property and/or reducing erosion and runoff from agricultural crop fields.

Waterfront Runoff Practices

Waterfront runoff practices include rock pits or trenches, rain gardens, and shoreline buffers. It may be appropriate for Lake Wapogasset and Bear Trap Lake to consider offering design assistance and cost sharing for these practices. Nearby Deer Lake, Balsam Lake, Pipe Lakes, and Burnett County offer programs and education materials to encourage waterfront runoff practices. These programs could be used as examples.

Agricultural Best Management Practices

Large-scale best management practices are likely to be more expensive and must be targeted carefully by understanding the significance of the pollutant source. Best management practices might involve conversion of a crop field to a more permanent vegetative cover, restoring wetlands, constructing sediment basins, or implementing nutrient management plans.

A nutrient management plan consists of a conservation plan to insure that crop rotations and tillage methods are within the range of tolerable soil loss (T). The plans help to manage the amount, source, placement, form, and timing of the application of nutrients and soil amendments. All nutrient sources, including soil reserves, commercial fertilizer, manure, organic byproducts, legume crops, and crop residues are accounted for and properly utilized. These criteria are intended to minimize nutrient entry into surface water, groundwater, and atmospheric resources while maintaining and improving the physical, chemical, and biological condition of the soil.

Land Preservation

Land preservation involves purchasing land or putting land in conservation easements to preserve natural areas or to ensure that conservation practices will remain in place. There are several nearby examples of land preservation purchases and easements. To ensure that conservation practices remain in place, the Deer Lake Conservancy has easements or owns land where the practices are installed. The Half Moon Lake Conservancy accepted donation of forty acres of natural area along Harder Creek, the largest tributary flowing into the lake. The Balsam Lake District purchased twelve acres on the north side of the lake to preserve and prevent development of an important wildlife area.

Enforcement / Planning

Lake Association involvement in enforcement of state and local regulations and planning activities can help to protect lakes. Lake Association members can report potential violations of regulations and ordinances to assist with appropriate enforcement. However, it is important to note that the Lake Association cannot establish or enforce laws (except for boating laws under certain circumstances). Involvement in planning activities can help to ensure that land uses that protect the lake are in place in the watershed. Plans might be developed at the town, county, or state level.

In-Lake Management

There are several options for in-lake management. Aeration, dredging, and alum treatment are just a few. As past management efforts on Lake Wapogasset and Bear Trap Lake have shown, these techniques generally require in-depth study, detailed permits, and significant funding.

Alum Treatment

Alum (aluminum sulfate) works by preventing the release of phosphorus from lake sediments under anoxic conditions. It also removes phosphorus from the water column as it settles to the bottom. Lake Wapogasset and Bear Trap Lake were selected as good candidates for alum treatment following studies in the early 1990s because high amounts of phosphorus are released from lake sediments and the external load had been reduced with the Balsam Branch Priority Watershed project. Barr Engineering predicted that Lake Wapogasset phosphorus concentration would decrease from 63 to 37 ppm at fall turnover and Bear Trap Lake phosphorus concentration would decrease from 60 to 24 ppm with their recommended alum application.[36] Department of Natural Resources staff reviewed Barr recommendations, and predicted even better results.

An alum application, paid for by contributions from lake residents and a DNR Lake Protection Grant, occurred in October 1999. The treatment used 744,000 gallons of alum applied at a rate of 40 g/m^2 at depths 15 feet and greater and 16 g/m^2 in shallow areas. Figure 25 below reports actual phosphorus concentration approximately at fall turnover prior to and following the alum treatment. Figure 26 illustrates mid-summer (late June to late August) average phosphorus concentrations. Fall turnover phosphorus was at the levels predicted for the alum application for only one season following treatment. Summer phosphorus concentrations were also low in 2000, and have steadily increased since that time. Although it is tempting to blame the failure of the alum treatment on the rupture of the dam on the Balsam Branch at D. D. Kennedy in April of 2001, a follow-up study has shown that to not be the case. A study by Barr Engineering in 2004 found that dam sediments covered alum only near the mouth of the Balsam Branch River where the lake doesn't stratify. That same study does suggest that increased summer algae growth probably was caused by the dam rupture. The inflow of the Balsam Branch River causing mixing of the lake may also make an alum treatment less successful, according to Barr.

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[36] Barr Engineering. *Wisconsin Lake Planning Grant Final Report*. June 1996.

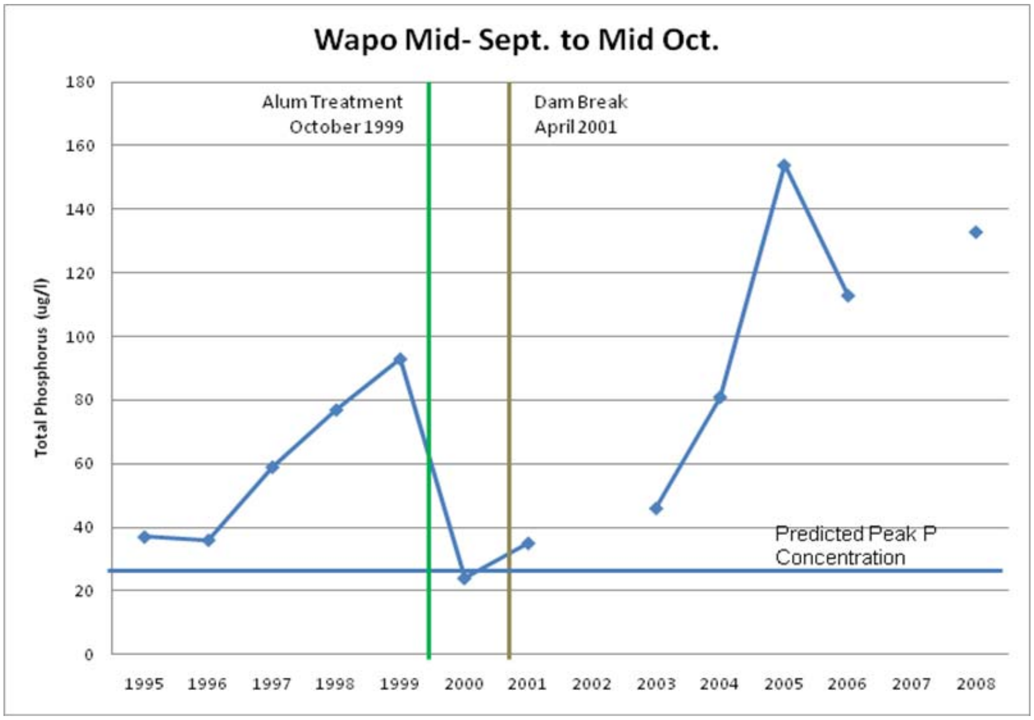
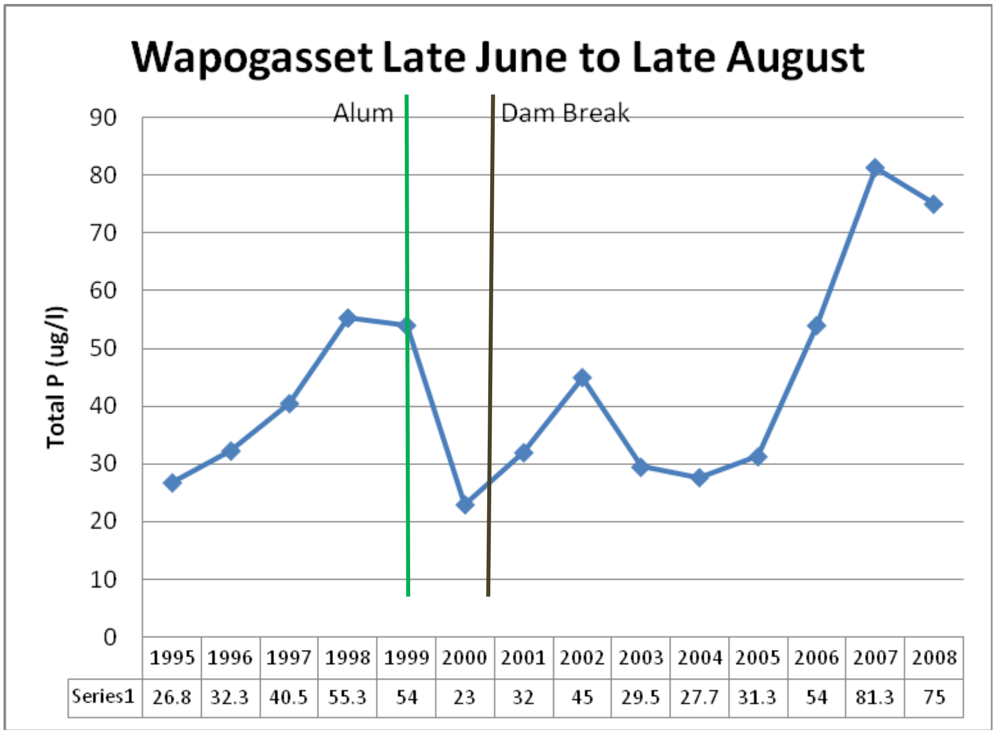


Figure 25. Fall Overturn Phosphorus Prior to and Following Alum



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Series1	26.8	32.3	40.5	55.3	54	23	32	45	29.5	27.7	31.3	54	81.3	75

Figure 26. Summer Phosphorus Prior to and Following Alum

Paul Garrison of the DNR evaluated lake sediments to determine the reasons why the alum treatment didn't work. He discussed the following possible and/or partial explanations in his report: a large reservoir of highly mobile phosphorus in lake sediments, a low ratio of Aluminum (Al) to Iron (Fe), and low calcium levels. A ratio of Al:Fe greater than 1 is desired for effective alum treatment. If there is less aluminum present, phosphorus will bind to iron from which it readily releases. Al:Fe ratios in Wapogasset were .22 pretreatment and .30 post treatment. For Bear Trap, they were .18 pretreatment and .27 post treatment. Phosphorus can also bind preferentially to calcium over iron, but the lakes are low in calcium.

The DNR released another update on the alum treatment in 2002. The report analyzed lake bottom sediments, and found that the alum was not all retained. Where present, it was surprisingly deep—up to 22 cm in Wapogasset and 8 cm in Bear Trap. The conclusion was that Wapogasset was not a good candidate for alum treatment, but that Bear Trap was better suited.

Later in 2002, the Army Corps of Engineers analyzed sediment cores and conducted sequential alum additions to sediment samples in the lab to determine the application rates that would be necessary for effective treatment of the lakes. Current proposed alum applications by Barr Engineering, DNR, and Osgood Consulting rely upon these estimates of mobile phosphorus to calculate an appropriate application rate of alum. The recommended current dosage is 87 g/m^2 (Barr 2006) to 200 g/m^2 (Garrison). This dosage is to be applied at depths greater than 25 feet (264 acres) in Lake Wapogasset; and greater than 20 feet (75 acres) in Bear Trap (Barr). This amounts to 1,000,000 gallons for Lake Wapogasset and 190,000 gallons for Bear Trap Lake (Garrison). Barr recommended less alum in 2006 - 586,000 gallons for Wapogasset and 120,000 gallons for Bear Trap. Osgood provides a range of recommendations consistent with those reported above.

Sediment Removal

Another potential in-lake management measure is to remove nutrient rich sediments from deep areas of the lake. Barr Engineering evaluated dredging the top 14 cm of nutrient rich sediments in the deepest portions of the lake in 2006. Based on the areas and depth of sediment removal in the Barr report and cost ranges from other sources, Osgood estimated the cost of dredging to be $5 to $17 million. Lake Wapogasset sediments were analyzed by Genesis Fluid Solutions in 2006 to see how effectively their systems could dewater lake sediments.

Aeration

Aeration was a tentative recommendation in the Barr Engineering report back in 1996. An aeration system was installed in Cedar Lake in 1991. The system included a blower that discharged air and a manifold system to distribute air into the water column near the center of the lake. The purpose of the aeration system was to prevent the lake from strongly stratifying, so that less wind would be needed to mix the lake. The blower was turned on before stratification began in late May and operated continuously until early September. The system successfully reduced phosphorus release from lake sediments by decreasing the period of anoxia on the lake. Measured phosphorus release from lake sediments decreased by 70 percent with operation of the aeration system during the first two years of operation.[37]

Lake Studies/Evaluation

The water quality study completed in preparation for this plan is one example of a lake study. It is common for studies to identify further work that is needed to better understand the lake. It is important to understand why data is being collected before taking the time and spending the money to do it. Recommendations for evaluation for specific purposes are included in the implementation plan.

Choosing Management Options

To choose from the many management options that are available, it is important to do the following:

- Set clear goals and objectives
- Understand potential results
- Prioritize activities
- Consider social and political feasibility
- Investigate funding possibilities
- Seek available assistance

The goals, objectives, and action items in the implementation plan seek to incorporate the above considerations.

Public Survey Results

Selected public survey results can assist in choosing management options. The survey results can also help to guide the development of a program for preventing runoff from residences. Figure 27 demonstrates that many residents were familiar with rain gardens (53%) and rain barrels (56%), but fewer were familiar with water diversions (40%), infiltration pits/trenches (41%), or native plantings (41%).

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[37] *Cedar Lake, Polk County. Destratification Report*. Paul Garrison, Bureau of Science Services. April 2002 and *Managing Lakes and Reservoirs*. NALMS 2001.

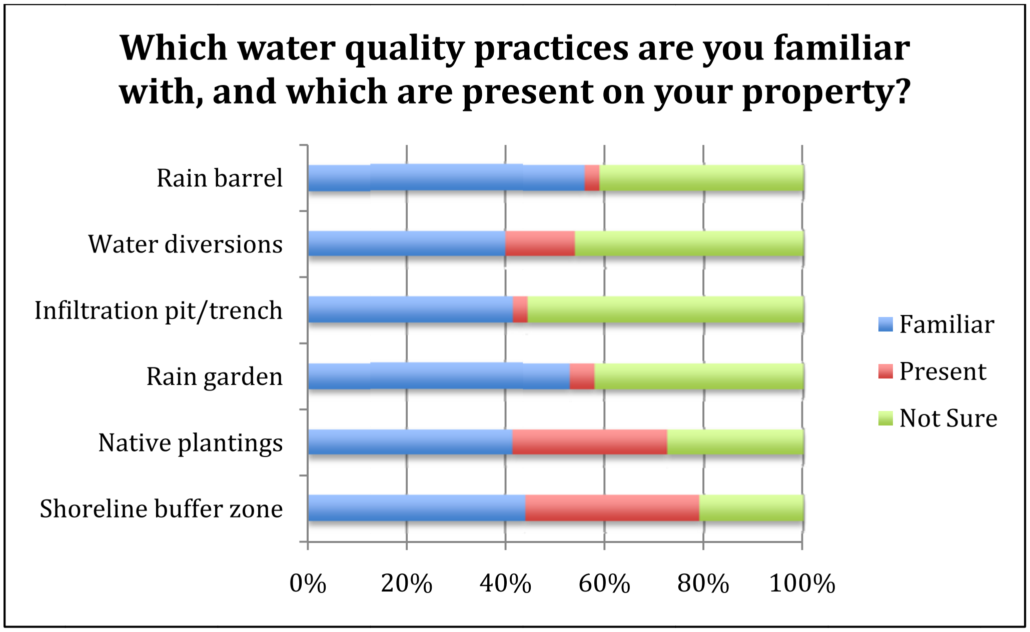

Figure 27. Familiarity With and Presence of Water Quality Practices

There is also little awareness of the negative impact of runoff from residential property or the effectiveness of shoreline buffer zones in survey results as shown in Figure 28 below. The numbers on figure bars are in percentage of total response.

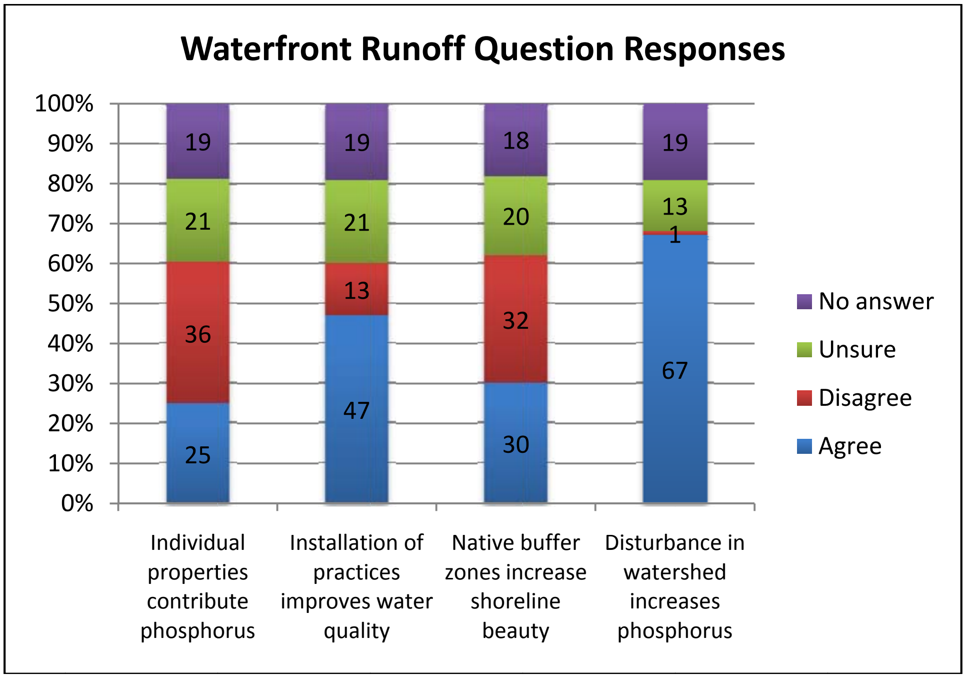

Figure 28. Selected Survey Responses Related to Waterfront Runoff Practices

The survey can further help understanding of the potential motivation for installation of waterfront practices. Improving lake water quality—in general and around individuals' docks—is the biggest reported motivator for project installation.

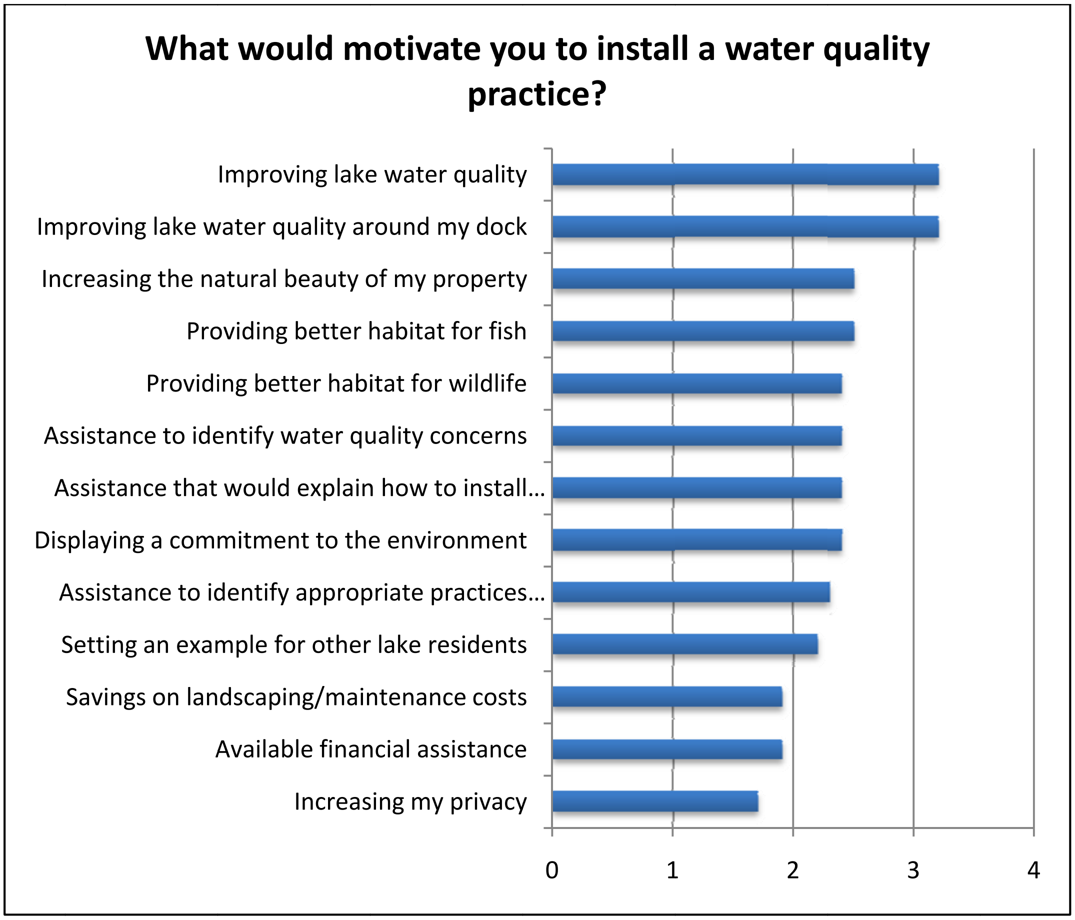

Figure 29. Motivation for Waterfront Practice Installation

Related Plans, Regulations, and Ordinances

As described previously, knowledge of and involvement in the development and implementation of local plans and ordinances can assist the Sanitary District and Lake Association in achieving the goals of this comprehensive lake management plan.

Polk County Land and Water Management Plan

The land and water management plan guided the activities of the Polk County Land and Water Resources Department from 2005 to 2009. The department partnered with local, state, and federal agencies and organizations to conserve soil and water resources, reduce soil erosion, prevent nonpoint source pollution, and enhance water quality. Activities included technical assistance with enforcement, technical and financial assistance, and education. Local plans and ordinances are described in the document. The land and water management plan includes an implementation strategy for state agricultural performance standards. Farmers are required to meet these standards when the county offers cost sharing. The plan is currently under revision.

WI Agricultural Performance Standards (NR 151)

For farmers who grow agricultural crops

- Meet “T” on cropped fields
- Starting in 2005 for high priority areas such as impaired or exceptional waters, and 2008 for all other areas, follow a nutrient management plan designed to limit entry of nutrients into waters of the state

For farmers who raise, feed, or house livestock

- No direct runoff from feedlots or stored manure into state waters
- No unlimited livestock access to waters of the state where high concentrations of animals prevent the maintenance of adequate or self sustaining sod cover
- Starting in 2005 for high priority areas, and 2008 for all other areas, follow a nutrient management plan when applying or contracting to apply manure to limit entry of nutrients into waters of the state

For farmers who have or plan to build a manure storage structure

- Maintain a structure to prevent overflow, leakage, and structural failure
- Repair or upgrade a failing or leaking structure that poses an imminent health threat or violates groundwater standards
- Close a structure according to accepted standards
- Meet technical standards for a newly constructed or substantially-altered structure

For farmers with land in a water quality management area (defined as 300 feet from a stream, or 1,000 feet from a lake or areas susceptible to groundwater contamination)

- Do not stack manure in unconfined piles
- Divert clean water away from feedlots, manure storage areas, and barnyards located within this area

Comprehensive Land Use Planning

The Polk County Comprehensive Land Use Plan was adopted in 2002. The plan includes an analysis of population, economy, housing, transportation, recreation, and land use trends. It also reports the physical features of Polk County. The purpose of the land use plan is to provide general guidance to achieve the desired future development of the county and direction for development decisions. The lakes classification outlines restriction on development according to lake features. Planning areas are recommended in the plan. Plan information is available online at http://co.polk.wi.us/landinfo/.

Smart growth is a state mandated planning requirement to guide land use decisions and facilitate communication between municipalities. Wisconsin's Comprehensive Planning Law (Statute 66.1001, Wis. Stats.) was passed as part of the 1999 Budget Act. The law requires that if a local government engages in zoning, subdivision regulations, or official mapping, those local land use regulations must be consistent with that unit of local government's comprehensive plan beginning on January 1, 2010. The law defines a comprehensive plan as having at least the following nine elements:

- Issues and opportunities
- Housing
- Transportation
- Utilities and community facilities
- Agricultural, natural, and cultural resources
- Economic development
- Intergovernmental cooperation
- Land use
- Implementation

Polk County was awarded a 2007 Comprehensive Planning Grant from the Wisconsin Department of Administration. This multi-jurisdictional grant is being used by the participating municipalities to establish local comprehensive plans as well as amendments to the county's 2003 Land Use Plan. Polk County's comprehensive plan is currently under revision. Both Garfield and Lincoln have drafts of their Smart Growth plans available online.

Polk County Comprehensive Land Use Ordinance

The Polk County Comprehensive Land Use Ordinance, more commonly known as the Zoning Ordinance, was last updated effective June 1, 2007. The Towns of Lincoln and Garfield have adopted the county zoning ordinance. Land use regulations in the zoning ordinance include building height requirements, lot sizes, permitted uses, and setbacks among other provisions.

Shoreland Protection Zoning Ordinance

Polk County passed an update of the Shoreland Ordinance in 2002 and again in 2008. The updates put in place standards for impervious surfaces, a phosphorus fertilizer ban for shoreland property, and lakes classification and setback standards. The shoreland protection ordinance applies to all land within 1,000 feet of a lake and 300 feet of a river or stream in Polk County. The ordinance is available online at http://www.polkshore.com.

Subdivision Ordinance

The subdivision ordinance, adopted in 1996 and updated in 2005, requires a recorded certified survey map for any parcel less than 19 acres. The ordinance requires most new plats to incorporate storm water management practices with no net increase in runoff from development. The ordinance is available online at http://co.polk.wi.us/landinfo/PDFs/subdivisionordinance.pdf.

Animal Waste

The Polk County Manure and Water Quality Management Ordinance was revised in January 2000. A policy manual established minimum standards and specifications for animal waste storage facilities, feedlots, degraded pastures, and active livestock operations greater than 300 animal units for livestock producers regulated by the ordinances. The Land and Water Resource Department's objective was to have countywide compliance with the ordinance by 2006. The ordinance is available online at http://www.co.polk.wi.us/landwater/MANUR21A.htm.

Storm Water and Erosion Control

The ordinance, passed in December 2005, establishes planning and permitting requirements for erosion control on disturbed sites greater than 3,000 square feet, where more than 400 cubic yards of material is cut or filled, or where channels are used for 300 feet more of utility installation (with some exceptions). Storm water plans and implementation of best management practices are required for subdivisions, survey plats, and roads where more than ½ acre of impervious surface will result. The Polk County Land and Water Resources Department administers the ordinance. The ordinance is a local mechanism to implement the Wisconsin Non-agricultural Runoff Performance Standards found in NR 151.

WI Non-Agricultural Performance Standards (NR 151)

Construction Sites >1 acre – must control 80% of sediment load from sites

Storm water management plans (>1 acre)
- Total Suspended Solids
- Peak Discharge Rate
- Infiltration
- Buffers around water

Developed urban areas (>1000 persons/square mile)
- Public education
- Yard waste management
- Nutrient management
- Reduction of suspended solids

Boating Regulations

The Department of Natural Resources regulates boating in the state of Wisconsin.[38] Wisconsin conservation wardens enforce boating regulations. A few highlights of boating regulations are found below.

- ✓ Personal watercrafts (PWCs) may not operate from sunset to sunrise.
- ✓ PWC operators must be at least 12 years old.
- ✓ There are 100-foot restrictions between boats or PWCs and water skiers, towropes, and boats towing skiers.
- ✓ It is unlawful to operate within 100 feet of any dock, raft, pier, or buoyed restricted area at a speed in excess of "slow-no-wake." *Note: slow-no-wake areas will be expanded to include all areas within 100 feet of shore with passage of WI Act 31 in July 2009. This will take effect early in 2010.*
- ✓ Boats have specific lighting requirements after dark.
- ✓ Speed must be reasonable and prudent under existing conditions to avoid colliding with any object or person.

A town or village may delegate the authority to adopt lake use regulations to a lake district. These may include regulation of boating equipment, use, or operation; aircraft; and travel on ice-bound lakes.[39] Local ordinances may now extend the slow-no-wake zone to within 200 feet of shore with passage of WI Act 31.

Dredging Regulations (Sec 30.20 Wis. Stats.)[40]

A general permit or an individual permit is required to dredge material from the bed of a navigable waterway. Local zoning permits and U.S. Army Corps of Engineers permits may also be required.

Involvement in Planning and Zoning

The Lake Association has historically been involved in activities such as the development of the Balsam Branch Priority Watershed plan, revisions to the Polk County Shoreland Land Use ordinance, and updates to the Polk County Land and Water Resource Management Plan. This involvement is important because county and state policy can certainly affect lake management activities.

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[38] Boating regulations may be found online at www.dnr.wi.us/org/es/enforcement/docs/boating regs.pdf.

[39] Chapter 33. Wisconsin State Statutes.

[40] Information from http://dnr.wi.gov.org/water/fhp/waterway/dredging.

Water Quality Model Results[41]

The water quality model (WILMS) was used to predict the impacts of changes in external and internal phosphorus loading. The actual 2006 in-lake total phosphorus growing season mean (GSM) was 59 ppb for Lake Wapogasset which is consistent with model predictions. For Bear Trap, the predicted phosphorus average was 58 ppb, while 45 ppb was observed. Additional predictions are indicated below and illustrated in Figures 30 and 31. Approximately 30 ppb phosphorus is recognized as the eutrophic threshold.

Model predictions (Schieffer):
- Predicted current values (GSM P): Wapogasset = 59 ppb; Bear Trap = 58 ppb
- Reduce residential by 40%: Wapogasset = 57 ppb; Bear Trap = 54 ppb
- Reduce row crop by 40%: Wapogasset = 56 ppb; Bear Trap = 55 ppb
- Reduce residential and row crop: Wapogasset = 53 ppb; Bear Trap = 51 ppb
- Reduce all internal load (WILMS): Wapogasset = 33 ppb; Bear Trap = 40 ppb

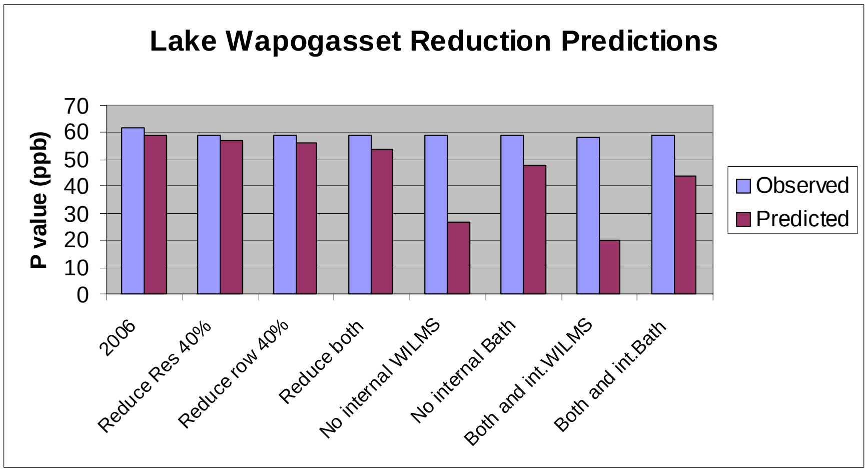

Figure 30. Lake Wapogasset Phosphorus Reduction Predictions

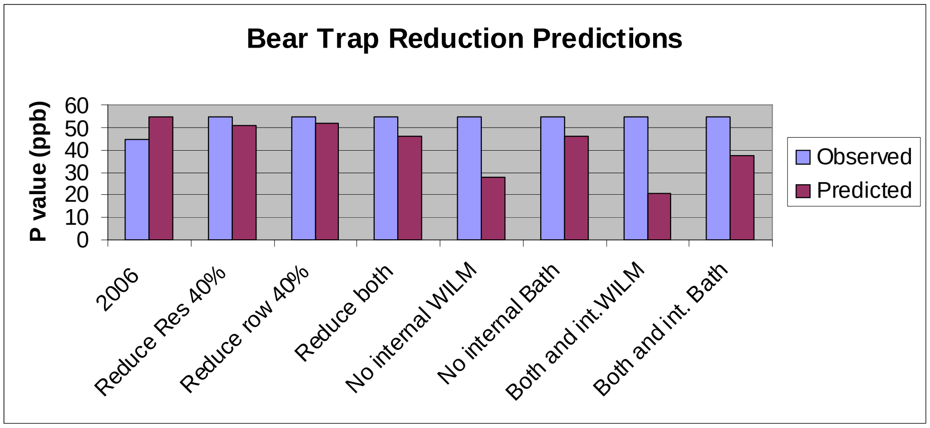

Figure 31. Bear Trap Lake Phosphorus Reduction Predictions

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[41] Information from Steve Schieffer, Ecological Integrity Services.

Advisory Committee Recommendations

The advisory subcommittee examined consultant and advisor recommendations and analyzed available information to make recommendations regarding ways to improve the water quality of the lakes. Potential management activities and their impacts were considered in the development of the recommendations that follow. Management recommendations as modified by the advisory committee are included below.

Water Quality Recommendations

A two-pronged approach is recommended for improving water quality in the lakes. Reducing external load is important for improving localized lake characteristics, and for maintaining effectiveness of internal load management. However, it is recognized that significant water clarity improvement will not occur without reducing the phosphorus load from lake sediments – the internal load. It is valid to assume that a high reduction in internal loading will cause the biggest, quickest change. It would NOT be prudent to ignore the external loading because reducing the external load will increase the longevity of internal load reductions.

The focus for external load reductions is to get the biggest reductions for the amount invested in projects. For internal load reductions, the strategy is to further investigate and pursue the most promising methods.

External Load

The highest loading subwatersheds identified in the land use and lake modeling will be the focus for external load reductions. These subwatersheds have a loading rate of 0.5 kg/acre or more and include:

Bear Trap (NW Bear)
Wapogasset (SW Wapo then NW Wapo and NE Wapo)

Within these subwatersheds, work will focus on reducing phosphorus loading from row crops and residential areas. The Polk County Land and Water Resources Department has already initiated contacts with landowners in the watershed to begin these efforts. Further work will need to be a cooperative effort between the county and the Sanitary District and/or Lake Association. These efforts would likely include:

Promote and possibly subsidize nutrient management planning
Purchase portions of fields (direct drainage area, >12% slope, non-buffered)
Establish permanent cover on purchased fields
Installation of stormwater diversion, retention, and treatment practices

Options are available to convert crop fields to more permanent cover, thereby reducing runoff to the lake. Purchasing a crop field and/or portions of fields can allow conversion to permanent vegetative cover. The USDA Conservation Reserve Program (CRP) makes payments to agricultural producers to temporarily take cropland out of production. The

Sanitary District might also provide monetary incentives to encourage a change in cropping practices to leave more residue on the field and reduce erosion. Fertilizer applications that meet but do not exceed crop needs could also be beneficial to lake water quality. Nutrient management planning and associated conservation practices can lead to these desired changes.

Nutrient Management Planning

Changes in tillage practices can reduce phosphorus loading by 30-90 percent, depending upon the current and final practice. As the cropland becomes a cash grain operation with more years of row crops (corn-soybean rotations), high residue management and no-till are needed to reduce soil erosion to a tolerable amount (commonly referred to as “T”). Any buffering between the field and the lake or retention of runoff water will reduce the load that actually reaches the lake.

Stormwater Management

Reducing phosphorus loading from residential areas will involve identifying areas of channelized runoff from priority subwatersheds. Neighborhood stormwater projects will look for opportunities to re-route and infiltrate stormwater. If infiltration is not possible, stormwater treatment and methods to reduce erosion will be initiated.

To proceed with stormwater projects in priority areas:

1) analyze priority subwatersheds in more detail to identify priority parcels or areas with the greatest potential for phosphorus and/or sediment loading reduction;
2) identify potential water quality practices; and
3) identify and contact owners to assess interest.

Waterfront Runoff Reduction

Promotion of individual practices to reduce runoff from all waterfront lots is also recommended. This promotion should include general education and design and planning assistance. The main recommendation for residential land is to install conservation practices to reduce runoff from waterfront lots. These practices include rain gardens and rock trenches to infiltrate water and shoreland buffer zones to slow runoff and improve habitat around the lake. Installing rain gardens and shoreland buffer zones can result in a 50-90+% reduction in phosphorus runoff from residential lands.

Internal Load

The method chosen for reduction of internal load should be the most likely to be effective and cost efficient. External funding sources may influence cost effectiveness. Department of Natural Resources staff involvement should be sought to prioritize direction for internal load reduction.

The most promising methods for reducing internal load include:

- Alum
- Aeration
- Reducing curly leaf pondweed populations (depending upon plant phosphorus content and bed density)
- Better understanding blue-green algae growth and circulation in the lakes.

Fisheries Recommendations

Education:
Continue sponsorship of carp shoot (Lake Association)

Do not pursue carp population monitoring. Carp are difficult to count. They are also extremely difficult to manage in lake systems with both an inflow and outflow. See fisheries section of this plan for more information.

Consider means to increase walleye populations

Stock larger fingerling walleye (pay for this)

Prevent sediment loading to walleye spawning beds (identified as sensitive areas) using methods including upland management practices.

Aquatic Invasive Species Recommendations

Continue and expand the Clean Boats / Clean Waters Program at landings on Wapogasset and Bear Trap Lakes (from APMP)

Monitor for the introduction of (non-plant) AIS that are most likely to be introduced into the lakes: zebra mussels, rainbow smelt, rusty crayfish (already present), spiny water flea, Chinese mystery snail.

Request that Polk County monitor Wapogasset and Bear Trap Lakes for zebra mussels and spiny water flea.
DNR has responded that because other lakes are more likely for introduction of these species, Wapogasset and Bear Trap are unlikely candidates for monitoring[42]*. This recommendation was revised to request that Polk County conduct the monitoring.*

Train volunteers to identify and monitor for AIS - Polk County Water Quality Specialist (Jeremy Williamson)

Follow a rapid response plan if AIS are identified in the lakes (from APMP)

Education:
Lake residents are provided with information regarding AIS identification.
Lake residents should collect potential invasive species and provide to Polk County AIS specialist or DNR for identification.

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[42] Personal communication via email. Pamela Toshner. 11/04/09.

Monitoring/Establishing Baseline

Paleolimnological Sediment Cores

Sediment cores are used to reconstruct the history of a lake. A core that is sampled deeply enough can capture a record of ecological change over decades. The information collected includes sediment accumulation rates, in-lake nutrient levels over time, and some blue-green algae presence/absence.

The committee recommends considering standard sediment cores as a medium to low priority. The value of this monitoring effort should be compared to the value of installation of practices to reduce the phosphorus load to the lake. The cost of a standard core that would provide a progression of phosphorus concentrations, sedimentation rates, sediment type over time, and blue-green algae presence/absence, would be approximately $10,000 per core. A more detailed, expensive analysis could reconstruct feeding groups of invertebrate species over time.

One core may be adequate for scientific reasons, but there is concern that the lakes be treated equally. The sediment core would help to clarify water quality impacts to the lakes and identify reasonable lake management objectives and communicate both to lake residents.

Implementation Plan

Plan Timeframe

This plan covers a ten year time frame. As new knowledge is acquired and events unfold, it will be updated as appropriate. Plan review and revision will be scheduled for completion by January 1, 2010.

Implementation Plan Updates

An implementation plan is found in the following section. The implementation plan or work plan details how action steps will be carried out over the next three year period. This implementation plan will be updated cooperatively by the sanitary district and the lake association each year to keep actions up-to-date.

Goals

1. Improve[43] Lake Wapogasset and Bear Trap Lake water quality.
2. Implement Aquatic Plant Management Plan Goals.
3. Prevent introduction of invasive aquatic organisms and limit the impacts of those introduced to the lakes.
4. Protect and improve the Lake Wapogasset and Bear Trap Lake fishery.

An aquatic plant management plan was prepared for the lakes in 2008-09. Aquatic plant management goals are shown below.

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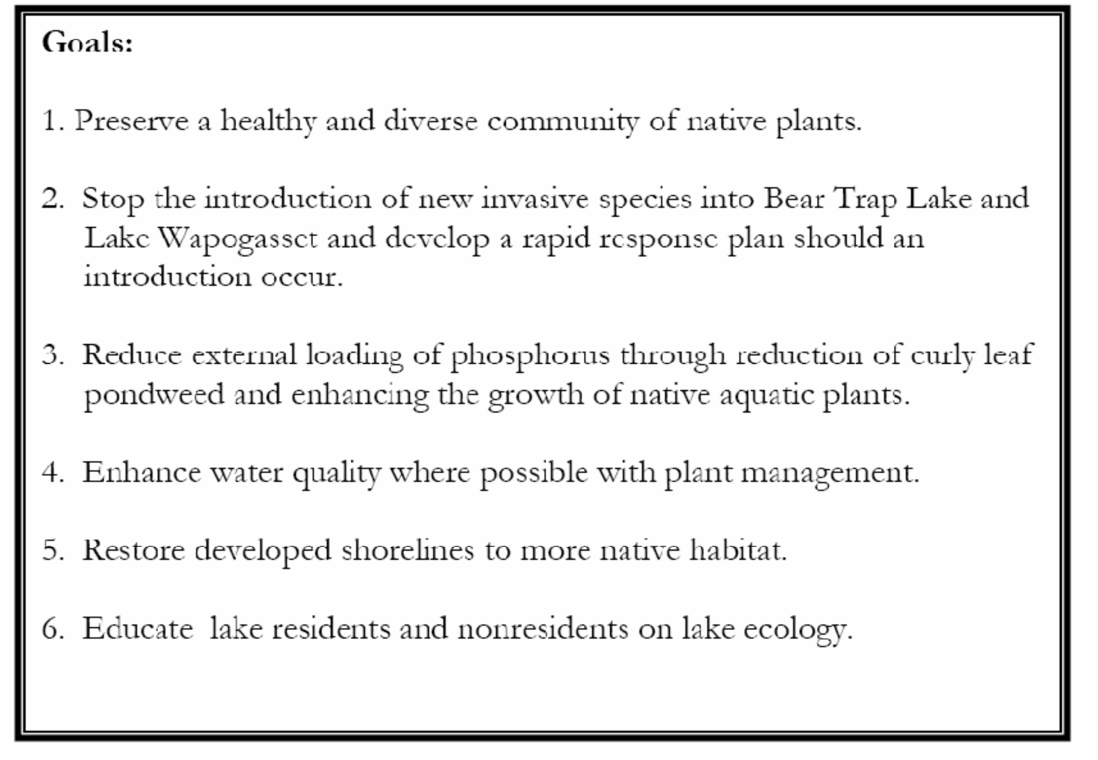
[43] We will further analyze modeling information and intended actions to assess whether improvement is a realistic goal as plan is implemented.



Goals:

1. Preserve a healthy and diverse community of native plants.
2. Stop the introduction of new invasive species into Bear Trap Lake and Lake Wapogasset and develop a rapid response plan should an introduction occur.
3. Reduce external loading of phosphorus through reduction of curly leaf pondweed and enhancing the growth of native aquatic plants.
4. Enhance water quality where possible with plant management.
5. Restore developed shorelines to more native habitat.
6. Educate lake residents and nonresidents on lake ecology.

Educational Strategies/Methods

Education is an important means of achieving each of the plan goals. The following strategies are currently used by the sanitary district and lake association.

Existing Methods

Sanitary District Web Site
Kathy Mortensen's web site
Lake Scene newsletter (delivered by trustees 7X/year)
Lake Association Annual Meeting
Lake Association Trustee Meetings
Letters to residents
    Annual December letter from Sanitary District
    December and spring letter from Lake Association
Special letters and mailings
Signs at boat landings
Clean Boats, Clean Waters
Social events
Use PCALR documents

Methods to Consider

Newsletter sponsored by sanitary district and/or lake association
Web-based plan questionnaires/surveys
Email list serve
Cable channel programming
DVDs
Lake Fair (with Polk County LWRD)
Appoint county board representative to boards
Amery Free Press lakes column

Goal1. Improve[44] Lake Wapogasset and Bear Trap Lake water quality.

Objectives

Achieve an in-lake average summer phosphorus concentration of 25-35 ppb.

Reduce watershed phosphorus (P) loading by 20% or more.

- Reduce P loading from urban sources by lowering runoff from 25% of residential lots by 50%.
- Reduce P loading from cropland sources by reducing loading by 25%.
- Reduce tributary loading of phosphorus by 10%.

Better understand the potential for nutrient reduction in the lakes.

Evaluate and implement alternatives to reduce internal loading.

- Alum
- Aeration
- Reducing curly leaf pondweed populations (depending upon plant phosphorus content and bed density)
- Better understanding blue-green algae growth and circulation in the lakes.

Actions

Crop Fields

1. Investigate options for reducing nutrient loading in priority subwatersheds. (high priority)[45]
    a. analyze priority subwatersheds in more detail to identify priority parcels or areas with the greatest potential for phosphorus and/or sediment loading reduction;
    b. identify potential water quality practices; and
    c. identify and contact owners to assess interest.

2. Encourage implementation of practices that reduce runoff and erosion from cropland.
    a. Use existing federal, state and local programs to encourage implementation (high priority)

    b. Use local lake funds to supplement existing programs above. (medium priority)

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[44] We will further analyze modeling information and intended actions to assess whether improvement is a realistic goal.

Reducing runoff and erosion from cropland generally involves changing the crop that is planted, modifying tillage methods, or converting cropland to permanent vegetative cover. Federal, state, and local incentives may be available to encourage these changes. These incentive programs may be supported with funds from lake organizations.

3. Consider purchasing a portion(s) of a crop field(s) that contributes significant nutrients to the lake. (medium high priority)

Neighborhood Stormwater

4. Investigate and implement options for reducing nutrient loading in priority subwatersheds. (medium high priority)
    a. analyze priority subwatersheds in more detail to identify priority parcels or areas with the greatest potential for phosphorus and/or sediment loading reduction;
    b. identify potential water quality practices; and
    c. identify and contact owners to assess interest.
    d. Provide cost sharing and technical assistance to install practices such as stormwater wetlands, infiltration areas, and diversions. (high priority)

Waterfront Runoff

5. Provide on-site technical assistance to property owners to encourage implementation of practices that reduce runoff from waterfront property. *Technical assistance must be no-strings attached and non-regulatory.* (medium priority)

6. Provide education for lake residents. (high priority)
Target education based upon an understanding of the barriers to implementing practices.

Waterfront Education Strategy

Audience
Lake residents
Residents within one mile of lake
Farming community
Town boards
Landscapers

Messages
Impacts of waterfront runoff to lake water quality.
How waterfront runoff practices protect water quality.
Native vegetation is critical for wildlife habitat.
Acknowledge human use of shoreland area.
If you fertilize your lawn, use zero phosphorus fertilizer – it's the law
Do not blow grass and leaves into the lake
Burning leaves is illegal and creates nuisances for your lake neighbors
Easy steps for a clean lake

Methods
Newsletters
Web sites
Workshops
Annual meeting
How-to guides
Local lake fair (Garfield Park)

Information Gathering/Evaluation

7. Assess phosphorus loading from curly leaf pondweed. (high priority)
   Note: study methods are outlined in the aquatic plant management plan.

8. Investigate aeration as a method to reduce internal loading. (medium high priority)
   a. Co-sponsor a forum regarding lake aeration in cooperation with DNR, Bone Lake, and Cedar Lake.

9. Further investigate alum application as a method to reduce internal loading and algae blooms. (medium high priority)
   a. Complete topographical mapping of lake bottom to determine most productive treatment areas (Barr recommendation)

10. Assess the importance of blue green algae species on phosphorus circulation and internal loading in the lakes. (high priority)
    a. Use results of Cedar Lake DNR water quality study.

11. Consider full sediment cores that assess diatoms to estimate phosphorus levels, skeletal remains of specific blue-green algae, and sediment characteristics and accumulation rates over time. The value of this monitoring effort should be compared to the value of installation of practices that reduce the phosphorus load to the lake. (medium-low priority)

12. Implement chosen method(s) to reduce internal loading. (priority to be determined)

13. Continue and expand the Citizen’s Lake Monitoring Network (CLMN) activities. Enhance data base and the scope of analysis. (high priority)

Goal 2. Implement goals of the Aquatic Plant Management Plan.

See aquatic plant management plan.

Goal 3. Prevent introduction of invasive aquatic organisms and limit the impacts of those introduced to the lakes.

Note: Since the aquatic plant management plan addresses invasive plants, this goal addresses invasive macroinvertebrates and other animals.

Objectives

A. Keep invasive organisms out of the lakes: priorities including but not limited to zebra mussels, rainbow smelt, and spiny water flea.

B. Identify and respond rapidly to introduced invasive fauna.

C. Limit the impacts of invasive organisms already introduced to the lakes: currently rusty crayfish and Chinese mystery snail.

Actions

1. Continue and expand the Clean Boats / Clean Waters Program at landings on Wapogasset and Bear Trap Lakes (high priority)

2. Monitor for the introduction of (non-plant) AIS that are most likely to be introduced into the lakes: (high priority)

    a. Request that Polk County LWRD monitor Wapogasset and Bear Trap Lakes for zebra mussels and spiny water flea.

    b. Train volunteers to identify and monitor for AIS - Polk County Water Quality Specialist (Jeremy Williamson).

3. Follow a rapid response plan if AIS are identified in the lakes (high priority)

4. Implement educational programs to prevent AIS introduction and limit their impacts. (high priority)

Aquatic Invasive Species Educational Strategy

Audience
Lake residents
Lake users
DNR

Messages
Identification information and pictures
Lake residents should collect potential invasive species and provide to Polk County AIS specialist or DNR for identification.
Problems and potential impacts of AIS
How AIS are transported
How to prevent/avoid infestations

Methods
Clean Boats, Clean Waters monitoring and education
Signs
Bait stickers
DNR boating and fishing regulations

Goal 4. Protect and improve the Lake Wapogasset and Bear Trap Lake fishery.

Objectives

A. Maintain desirable levels of game fish in the lakes.
B. Remove carp from the lakes.

Actions

1. Prevent sediment loading to walleye spawning beds (identified as sensitive areas) using methods including upland management practices. (medium-high priority)
2. Promote fishing and bow-hunting of carp by sponsoring an annual tournament with bounties for carp harvest. (medium priority)
3. Consider supporting stocking of game fish (e.g., walleye) based on DNR recommendations (low priority).

Plan Implementation and Review

Implementation of plan activities is outlined in the work plan in Appendix D. The work plan lists a schedule for each activity, the lead organization, partners, potential funding sources, and other relevant comments. Overall plan implementation will be guided by a steering committee appointed by the Sanitary District and Lake Association boards. A subcommittee chair will be appointed for each designated focus area. Sanitary District staff may aid in plan coordination and committee support. Individual activities may be carried out by staff, volunteers, or consultants.

Public education and outreach will be extremely important to the success of this comprehensive lake management plan. A general education strategy for plan implementation is outlined below.

Plan Implementation Educational Strategy

<u>Audience</u>
Lake residents
Towns of Garfield and Lincoln
County representatives
Department of Natural Resources
General public

<u>Messages</u>
How does plan impact individuals who live around the lake?
How do individual actions affect the lake?
Understanding water quality goals – set up realistic expectations. Our work may impact future generations more than current.
Explain vision, goals, objectives, activities, and timing.
Plan is dynamic, it will evolve as it is implemented

<u>Methods</u>
Announce draft plan availability – email trustees, Amery Free Press
Hold public meeting December 5, 2009
Plan summary
August reports of plan progress
December letters

Plan Review and Updates

The work plan will be reviewed annually by the steering committee and the boards of the Sanitary District and Lake Association. Changes to the work plan can be expected as more detailed implementation is planned and knowledge is gained. Plan amendments may be necessary when significant deviation from plan goals and objectives is desired. These amendments will be reviewed by the public and approved by the respective board of the Sanitary District and Lake Association. Final plan amendments will be forwarded to the Department of Natural Resources for review.

Funding Plan Implementation

The work plan in Appendix D describes potential funding sources for plan implementation. The main sources of implementation funds are Sanitary District revenues, Lake Association fees, and Department of Natural Resources grants. The DNR Lake Management Grant Program has two major types of grants: planning and lake protection grants. Lake planning grants are available at two scales – large scale up to $10,000 and small scale up to $3,000. These applications are accepted twice each year on February 1 and August 1. DNR lake protection grants for plan implementation have a maximum grant amount of $200,000. These grants are due each year by May 1. Plan activities will be eligible for lake protection grant funds following approval by the DNR.

The Department of Natural Resources also manages Targeted Runoff Management (TRM) Grants for urban and agricultural practices as described in the state runoff rule: NR151. Cities, villages, towns, counties, regional planning commissions, tribal governments, and special purpose districts such as lake, sewerage, and sanitary districts are eligible to apply for TRM grants.

<u>DNR Lake Planning Grants</u>

Large scale – up to $10,000
Small scale – up to $3,000

Applications due February 1 and August 1
These grant applications could proceed without final plan approval.

<u>DNR Lake Protection Grants</u>

Up to $200,000
Requires DNR approval of tasks in the comprehensive plan (allow 60 days)

Applications due May 1

<u>DNR Targeted Runoff Management</u>

Up to $150,000 for each <u>specific project</u>.
Ranking is split between urban and agricultural practices

Application due April 15th of each year

Appendix A. Public Opinion Survey Results

Lake Wapogasset and Bear Trap Lake Property Owner Survey Results

Results compiled 5/25/09
350 surveys returned / approximately 650 sent out = 54% return

1. On which lake do you own property? **(Check one.)**

233	**67%**	a. Lake Wapogasset
99	**28%**	b.Bear Trap Lake
4	**1%**	c. My property is on both Wapo and Bear Trap.
14	**4%**	d. My property is not on the shore of either lake.

If you checked "d", please return the blank survey with a note letting us know you've moved.

2. Is your Lake Wapogasset or Bear Trap Lake property your permanent residence? **(Circle one)**
Yes 100 (29%) No 235 (67%)
If your answer is yes, skip to question 4 below.

3. Which of the following best describes how often you stayed at your lake property last year? **(Check one.)**

26	**7%**	a. For most of the year, such as for more than three months at a time
16	**5%**	b. For a single season, such as three months during the summer
71	**20%**	c. Mostly during the weekends in the summer, for vacations, and on holidays
51	**15%**	d. Mostly on weekends during the summer
39	**11%**	e. Mostly on weekends throughout the year
6	**2%**	f. Mostly on vacations and holidays

4. How much do you enjoy the following recreational activities at Lake Wapogasset and/or Bear Trap Lake? **(Circle appropriate response for each item.)**

		Not at all	A little	Some	Quite a bit	A great deal
All rated on a scale of 0-4		0	1	2	3	4

(Number of responses in parens, second number = average response)

Appreciating peace and tranquility	(328)	3.4
Enjoying the view	(334)	3.7
Fishing	(331)	2.3
Jet skiing	(323)	0.5
Motor boating	(332)	2.7
Non-motorized boating	(326)	1.4
Observing wildlife	(328)	3.0
Wind surfing	(323)	0.1
Scuba diving or snorkeling	(324)	0.1
Swimming	(328)	0.2
Water skiing	(323)	1.5
visit Mort's Marina	(8)	1.3
wish we had a restaurant	(1)	3.0

cruising	(1)	2
sailing	(5)	3.6
wake boarding/tubing	(14)	2.4
pontoon	(2)	4 .0
relaxing by water	(2)	3.5
snowmobile	(1)	3.0
entertain friends & family	(5)	3.6
biking	(1)	1.0
cross country skiing	(1)	4.0
ice skating	(1)	4.0
having 2 camps on our lakes	(1)	4.0
campfires	(1)	4.0
bird/wildlife watching	(1)	4.0

5. To what extent is each of the following a problem for you regarding owning waterfront property on Wapo or Bear Trap? **(Circle appropriate level of problem for each item.)**

Level of Problem

None Small Medium Large

All responses rated on a scale of 0 – 3		0 1 2 3
(Number of responses in parens)		
Lack of water clarity in the middle of the lake	(317)	1.9
Lack of water clarity at the end of my dock	(328)	2.5
Excessive invasive aquatic plant growth in the lake	(321)	2.4
Excessive native aquatic plant growth in the lake	(326)	2.3
Potentially toxic algae blooms	(319)	2.6
Maintaining the investment value of my property	(325)	2.5
Protecting the lake environment	(324)	2.6
Other (list) noise level	(8)	2.6
Other (list) boating violation -no boat patrol	(4)	2.3
Other (list) rude boaters	(1)	3.0
Other (list) dealing with zoning	(1)	3.0
Other (list) taxes	(6)	2.8
Other (list) carp	(3)	2.7
Other (list) can't swim due to algae	(1)	3.0
Other (list) Balsam Branch Bay	(1)	3.0
Other (list) curly leaf pond weed	(1)	3.0(+)
Other (list)rock hazard	(1)	3.0
Other (list) life & fire rescue depts.	(1)	3.0
Other (list) channel silting	(1)	3.0
Other (list) Swimmer's Itch	(4)	3.0
Other (list) farm fertilizer	(1)	3.0

6. Please indicate how much each of the following **negatively** impacts your use of the lakes. **(Circle appropriate level of negative impact for each lake.)**

	Level of Negative Impact									
	Lake Wapogasset					**Bear Trap Lake**				
	Not at all	A little	Some	Quite a bit	A great deal	Not at all	A little	Some	Quite a bit	A great deal
All responses on a scale of	0	1	2	3	4	0	1	2	3	4
Number of responses in (parens)										
Algae growth	(274)			3.1		(167)			3.0	
Small fish size	(270)	1.5				(169)	1.4			
Not enough fish	(268)	1.6				(169)	1.6			
Lake level too high	(269) 0.3					(168)0.3				
Lake level too low	(269) 0.9					(172) 0.8				
Native aquatic plant growth	(273)		2.5			(167)		2.4		
Invasive aquatic plant growth	(271)			3.2		(164)			3.0	
Loss of wildlife habitat	(267)		2.0			(160)	1.7			
Boat congestion	(276)	1.5				(171)	1.7			
Noise	(275)	1.6				(170)	1.6			
Loss of natural scenery	(272)	1.6				(169)	1.4			
No boat patrol/speeders	(2)				4.0					
Rude boaters	(2)			3.0						
People mowing too close to water(1)					4.0					
Carp	(1)		2.0			(1)		2.0		
Bay Depth	(1)				4.0					
Restaurant/Club	(3)		2.7							
Over Developed	(1)				4.0					
Channel Silting	(1)				4.0					
Extreme algae growth	(1)				4.0					
Trailer parks	(1)				4.0					
Other (list)jet ski						(4)	1.5			

7. Please describe how much each of the following water quality changes would benefit you.

(Circle appropriate response for each lake and item.)

	Degree of Benefit									
	Lake Wapogasset					**Bear Trap Lake**				
	Not at all	A little	Somewhat	Quite a bit	A great deal	Not at all	A little	Somewhat	Quite a bit	A great deal
All responses on a scale of	0	1	2	3	4	0	1	2	3	4
Number of response in (parens)										
Algae blooms that begin later in the summer	(273)			3.0		(170)			2.9	
Algae blooms that are **not** potentially toxic	(269)			3.0		(165)			2.9	
Increased water clarity in May	(270)		2.2			(169)		2.0		
Increased water clarity in June	(275)			2.8		(169)		2.6		
Increased water clarity in July	(279)			3.3		(172)			3.1	
Increased water in August	(276)			3.5		(172)			3.3	
Increased water clarity in September	(272)			3.0		(171)			2.9	

8. Below is a list of activities intended to improve our lakes. Please tell us if you think each activity should be pursued by the Sanitary District and/or Lake Association. **(Circle a response for each item.)**

	Definitely no	Probably no	Unsure	Probably yes	Definitely yes
All responses on a scale of 0-4	0	1	2	3	4

Number of responses in (parens)

Spray native aquatic plants	(316)	2.4
Harvest native aquatic plants	(314)	2.5
Spray invasive aquatic plants	(391)	2.6
Harvest invasive aquatic plants	(312)	3.1
Educate residents about lake issues	(320)	3.3
Prevent nutrient runoff from farms	(324)	3.5
Prevent runoff from residences	(322)	3.3
Stock fish	(322)	3.1
Be involved in local planning and zoning	(315)	2.7
Pay residents to install water quality practices	(315)	1.7
Monitor lake water quality	(316)	3.7
Monitor for aquatic invasive species	(323)	3.7
Prevent aquatic invasive species introduction	(321)	3.7
Protect sensitive habitat areas	(318)	3.2
Improve boat landings	(316)	2.0
Increase boating regulation enforcement	(319)	2.3
Acquire property to protect the lakes	(315)	2.0
Expand “slow no-wake” zones	(321)	1.9
Repeat an alum treatment on Lake Wapogasset	(314)	2.3
Repeat an alum treatment on Bear Trap Lake	(321)	2.0
Study phosphorus release from lake sediments	(315)	3.1
Monitor boat landings to check boats	(2)	2.0
Harvest carp	(3)	3.7
Sediment	(2)	4.0
Continued Improvement	(1)	3.0
Shoreline buffers	(1)	4.0

Note that alum treatments are not likely to be funded by state grants again in the near future.

QUESTIONS RELATED TO AQUATIC PLANT MANAGEMENT FOLLOW

9. How would you describe the <u>overall level of aquatic plants</u> in the lakes? **(Circle for each lake.)**

Lake Wapogasset				**Bear Trap Lake**			
Not sure	Too few	Right amount	Too many	Not sure	Too few	Right amount	Too many
0	1	2	3	0	1	2	3
(298 responses)			2.6	(241 responses)		2.3	

10. During the past few years how much, if at all, have aquatic plants limited participation for you or your family in the following activities?
(Circle the appropriate response for each item.)

	Lake Wapogasset?					**Bear Trap Lake**				
	Not at all	A little	Somewhat	Quite a bit	A great deal	Not at all	A little	Somewhat	Quite a bit	A great deal
Rated from 0 - 4	0	1	2	3	4	0	1	2	3	4
(Number of responses in (parens)										
Swimming	(288)		2.5			(188)		2.2		
Fishing	(282)		1.8			(186)	1.7			
Boating	(287)		2.1			(189)		2.0		
Enjoying the view	(287)	1.6				(187)	1.3			

11. Curly leaf pondweed is an aquatic invasive plant that is found in many lakes in Wisconsin.
Do you believe that you can identify this plant? **(Circle one.)**

Definitely No	88 (25%)
Maybe No	28 (8%)
Not sure	72 (21%)
Maybe Yes	75 (21%)
Definitely Yes	66 (19%)
No Answer	21 (6%)

12. Curly leaf pondweed has been found in both Lake Wapogasset and Bear Trap Lake. The <u>potential</u> impacts of this invasive plant include overtaking native plants, impeding navigation in early summer, and increasing phosphorus levels in the water when the plant dies in early June. Would you like to see a reduction of curly leaf pondweed in the lakes? **(Circle for each lake.)**

Lake Wapogasset		**Bear Trap**
Definitely No	6 (2%)	4 (1%)
Maybe No	1 (0%)	0 (0%)
Not Sure	12 (3%)	16 (5%)
Maybe Yes	36 (10%)	33 (9%)
Definitely Yes	248 (71%)	192 (55%)
No Answer	47 (13%)	105 (30)

QUESTIONS RELATED TO WATER QUALITY LANDSCAPING PRACTICES FOLLOW

13. The following are landscaping practices used to improve lake water quality. Please tell us which practices you are familiar with and which ones are already present on your Lake Wapo or Bear Trap property. If needed, please refer to the definitions on the back of the letter. **(Write an "F" if you are familiar with the practice but it is not present or a "P" if the practice is present on your property. If you are not familiar with the practice, leave the line blank.)**

	Familiar	Present	No Answer
Shoreline buffer zone	153 (44%)	122 (35%)	75 (21%)
Native plantings	145 (41%)	109 (31%	96 (27%)
Rain garden	184 (53%)	18 (5%)	148 (42%
Infiltration pit or trench	145 (41%)	11 (3%)	194 (55%)
Water diversions	141 (40%)	48 (14%	161 (46%)
Rain barrel	196 (56%)	10 (3%)	144 (41%)
Dispose firepit ash away from channel		1	
Shoreline rock		3	

25 (7%) Check this line if you are not familiar with any of the landscaping practices listed above.

14. How interested do you think you might be in installing a water quality practice on your property on Lake Wapogasset or Bear Trap Lake? **(Circle one)**

Not at all interested	21 (6%)
Not very interested	26 (7%)
Unsure	119 (34%)
Fairly interested	89 (25%)
Very interested	57 (16%)
No answer	38 (11%)

15. To identify the best actions to protect Lake Wapogasett and Bear Trap Lake, we need to understand the reasons why you might consider installing a water quality practice. To what degree might each of the following motivate you to do so? If you have already installed a practice, please indicate the degree to which each of the following motivated you to install it.
(Circle appropriate response for each line.)

Rated from 0 – 4 **(Number of responses in parens)**	Not at all 0	A little 1	Somewhat 2	Quite a bit 3	A great deal 4
Improving lake water quality	(285)			3.2	
Improving water quality around my dock	(286)			3.2	
Setting an example for other lake residents	(271)		2.2		
Savings on landscaping/maintenance costs	(271)		1.9		
Increasing the natural beauty of my property	(271)			2.5	
Providing better habitat for fish	(278)			2.5	
Providing better habitat for wildlife	(273)			2.4	
Increasing my privacy	(271)		1.7		
Available financial assistance	(267)		1.9		
Assistance to identify water quality concerns	(269)			2.4	
Assistance to identify appropriate practices to install	(269)			2.3	
Assistance that would explain how to install practices	(268)			2.4	
Displaying a commitment to the environment	(268)			2.4	
Other (list) Lk. Assoc. Example	(1)				4.0
Other (list) Tax Benefit	(1)				4.0
Other (list) Only if all install	(1)				4.0
Other (list) Inc. lot value	(1)				4.0

16. If you are not interested in installing a water quality practice, please indicate why.
(Check all that apply.) NUMBER OF CHECKS ARE LISTED

35 (10%) My property doesn't impact the lake.
45 (13%) I don't believe the practices will make a difference.
20 (6%) I don't have the time.
57 (16%) I don't want to spend the money.
32 (9%) I don't know how to install the practices.
11 (3%) My neighbors might not like it.
22 (6%) It might get in my way.
1 rent trailer lot
1 doesn't look good
1 1st priority Balsam Branch water

17. The following statements address factors that can affect the health the lakes. Please tell us whether you agree or disagree or are unsure for each of the following statements.
    (A = agree, D = disagree, U = unsure)

Water that runs off from my property adds more phosphorus to the lake than before my property was developed (with buildings, drive, turf grass, etc.)
Agree = 86 (25%) Disagree = 126 (36%) Unsure = 73 (21%) No Answer = 65 (19%)

Having one or more of the water quality landscaping practices listed in question 13 on my property would (or does) help improve the water quality of the lake.
Agree = 165 (47%) Disagree = 45 (13%) Unsure = 72 (21%) No Answer = 68 (19%)

Having native vegetation (a buffer zone) along my shoreline would (or does) enhance the beauty of the property.
Agree = 106 (30%) Disagree = 111 (32%) Unsure = 70 (20%) No Answer = 63 (18%)

Land disturbances such as road construction, agriculture, and stream bank erosion in the lake watershed can increase the amount of phosphorus in the lakes.
Agree = 234 (67%) Disagree = 3 (1%) Unsure = 47 (13%) No Answer = 66 (19%)

In the space below, please include any other comments you may have regarding the lakes, or the activities of the sanitary district or lake association.

Appendix B. Summaries of Previous Water Quality Studies

Lake Wapogasset and Bear Trap Lake Studies

General

Wapogasset and Bear Trap Lake. Discussion of what we have learned and where we go from here. Presentation. January 15, 2007.

Report on 1998 Lake Monitoring Activities. Wisconsin Lake Management Planning Grant LPL-519 (Wapogasset and Bear Trap Lakes Polk County, Wisconsin). Prepared for Wapogasset and Bear Trap Lakes Association. December 1998.
The study included the following:

- an aquatic macrophyte (plant) survey
- lake sediment quality monitoring
- late summer phytoplankton (algae) sampling.

Lake Use and Water Quality Study: Lake Planning Grant Report. May 1993.
U.S. Environmental Protection Agency National Eutrophication Survey. Report on Wapogasset Lake. Polk County WI. 1972.

> Estimates external loading to Lake Wapogasset and loss of nutrients through outflow. Lake and tributary water quality data were gathered. Phytoplankton were quantified by genera.

External Loading

External Phosphorus/Water Budget 2006. Lake Wapogasset/Bear Trap Lake Saintary District. Schieffer, Steve. Harmony Environmental.

Nonpoint Source Control Plan for the Balsam Branch Priority Watershed Project. Department of Natural Resources. April 1995.

Alum Application and Effectiveness

Wappogasset - Bear Trap Lake & Watershed Analysis with Alum Dose Recommendations. Dick Osgood. March 2007.

Evaluation and Distribution of Mobile Phosphorus in Lake Wapogasset and Bear Trap Lake Sediments. Calculation of Alum Doses, and Sediment Removal Volumes for Dredging. Barr Engineering. January 2006.

Investigation of Alum in Lake Wapogasset and Bear Trap Lake. Barr Engineering. December 2004.

Dredging

Genesis Laboratory Test Report. Genesis Fluid Solutions for Barr Engineering. April 2006.
Lake Wapogasset sediments were analyzed to see how well their systems will dewater lake sediments.

Aquatic Plant Management

Wisconsin Lake Planning Grant Final Report: Lake Wapogasset and Bear Trap Lake Polk County, Wisconsin. June 1996. (also sediment metals monitoring and blue-green algae).

Blue Green Algae

High Concentrations of Blue-Green Algae Detected in Lake Wapogasset. Polk County Health Department. September 2005.
Polk County issued a health advisory based on 8/30/05 tests which found
Anabaena sp. 1 at 6,000 natural units/ml
Anabaena sp. 2 at 300 natural units/ml
Aphanizomenon sp. 1,5000 natural units/ml
Microcystis sp. At 200 natural units/ml
Planktothrix sp. At 200 natural units/ml

1998 Barr Engineering report found *Anabaena (*predominate species on Wapo), *Ajshanizomenon* (predominate species on Bear Trap) and *Microcystis* present on September 9, 1998.

Report of Algae Tested for Toxins in Wisconsin Lakes and Streams in the Summer of 1986. Vennie and Wedephol. WDNR.
Toxins found in Wapogasset:
Sample 111 - Marginally positive results with *Gloeotrichia, Microcystis* present
Sample 143(142 on another list) – Marginally positive with *Anabaena and Microcystis* present
Sample 186 – Positive with *Microcystis, Anabaena,* and *Aphanizomenon* present
Additional samples (#s not identified found positive or

1972 EPA Report also found *Anabena* sp. In June and August 1972. *Microcystis* in June 1972.

Alum Application Review of Information

Wisconsin Lake Planning Grant Final Report. Lake Wapogasset and Bear Trap Lake Polk County, Wisconsin. Prepared for the Lake Wapogasset and Bear Trap Improvement Association. Barr Engineering Company. June 1996.

The purpose of the report was threefold:

1) Estimate the amount of phosphorus released from the sediments;
2) Examine water quality parameters to estimate the effects of sediment phosphorus on lake water quality; and
3) Determine cost and effectiveness of an alum treatment to control sediment phosphorus release.

An executive summary provides the main conclusions of the report. A non-technical summary is also included.

The main conclusions of the report are as follows:
The lakes stratified from June through September, although stratification was weak and phosphorus released from the bottom sediments entered the upper layers of the water column occasionally (in July).

Figure 9 on page 42 illustrates the total calculated water and phosphorus budget.

The total external phosphorus load was estimated to be 1,718 kg including 282 kg from the atmosphere for Lake Wapogasset and 135 kg including 60 pounds from the atmosphere for Bear Trap Lake. Watershed loads were estimated using export coefficients (amount of phosphorus released per acre) for various land uses. See Table 10 on page 36.

The internal load from lake sediments to the epilimnion was estimated to be 1,058 kg of phosphorus for Lake Wapogasset (38% of the total load) and 242 kg of phosphorus for Bear Trap Lake (64% of the total load). [The internal sediment load was calculated using total phosphorus concentrations present at various depths and the water volume at each depth.]

A significant decrease in phosphorus levels and resulting increase in lake water clarity was predicted with recommended alum application. For Lake Wapogasset: from 63 to 37 micrograms per liter at fall turnover. For Bear Trap Lake: from 60 to 24 micrograms per liter at fall turnover.

Barr recommended an alum application of dose of 278,363 gallons for Lake Wapogasset and 67,465 gallons for Bear Trap at a rate of $1 per gallon.

One item to note is that Barr Engineering recommended considering an aeration system as used by Cedar Lake in southern Polk County. (Paul Garrison with DNR in Madison was used as a reference.)

Evaluation of Alum Treatment as a Management Alternative for Wapogasset and Bear Trap Lakes. Roesler, Craig. WDNR. April 1997.

> Roesler reviews the Barr report Barr 1996 report and offers critique and alternative means to estimate the significance of internal loading. His conclusion is that internal loading is even more significant than indicated in the Barr report and that an alum treatment is a viewed favorably. With an 80% reduction of internal load, a peak surface phosphorus concentration of 31 ug/l is predicted for Wapo and 24 ug/l for Bear Trap.

ALUM APPLICATION OCCURRED IN October 1999

BALSAM BRANCH DAM FAILURE AT DD KENNEDY OCCURRED IN April 2001

An Evaluation of the Alum Treatment of Wapogassett and Bear Trap Lakes, Polk Co. Paul Garrison. WDNR. November 2001.

> Garrison reviews available data to assess why the alum treatment was not successful. The loading rates in Wapo and Bear Trap are very high when compared with study lakes in Western Washington. There may be a large reservoir of highly mobile P in Wapo Bear Trap sediments.
>
> Ratio of Aluminum (Al) to Iron (Fe) is important to release of P in sediments – alum will be more effective if Al:Fe ratio is greater than 1. (Under anoxic conditions, iron readily releases P while aluminum does not. If there is not enough aluminum present, phosphorus will remain bound to iron rather than phosphorus.) The Al:Fe ratios for Wapo are .22 pretreatment and .30 post treatment. For Bear Trap - .18 pretreatment and .27 post treatment.
>
> Another factor discussed is the low level of calcium in Wapo and Bear Trap. With this low calcium, phosphorus is complexed with iron instead of calcium. When complexed with iron, the phosphorus releases much more readily. Estimating alum application rates by measuring the amount of mobile inorganic sediment P in the top 4 cm of the lake is recommended.

Further Update on Wapogasset and Bear Trap Lakes. Paul Garrison (author assumed). WDNR. 2002.

> Wapo and Bear Trap sediments were analyzed to assess where Al from alum treatment ended up. It seems that not all aluminum was retained in the lake sediments. Where it was present, it was surprisingly deep.

In Wapogasset the added alum appears to reach 22 cm with a peak at 10-12 cm. This is much deeper than expected. The depth is attributed to large lake size and soft sediments. The conclusion is that Wapo is not a good candidate for alum.

In Bear Trap, the added alum is in the upper 8 cm of the lake sediments. The conclusion is that Bear Trap is a better candidate for alum.

Furthest Update on Wapogasset and Bear Trap Lakes. Paul Garrison (author assumed). WDNR. May. 2002.

The Army Corps of Engineers analyzed 2 sediment cores from Wapo and 1 from Bear Trap. The added alum to determine how much alum would be needed to reduce the release of phosphorus from the sediments. The analysis indicates that the application rate should be 200 g/m^2 rather than the 40 g/m^2 applied in 1999. [For comparison, 744,000 gallons of alum were applied in 1999 and recent Barr and Osgood recommendations total approximately 667,000 gallons.] The 200 g/m^2 application rate may still not be enough in Wapo because the alum sank so deep with the previous application. In Bear Trap, where the alum did not sink as deeply, there is a greater chance for success with this increase application rate.
[alum application rate based upon sequential addition of alum to lake sediments in lab]

Investigation of Alum in Lake Wapogasset and Bear Trap Lake. Barr Engineering. December 2004.

The study analyzed sediment characteristics in ten locations in Lake Wapogasset and Bear Trap Lake. The purpose of the study was to assess the impact of the 2001 rupture of the Balsam Branch dam at D.D. Kennedy on the effectiveness of the 1999 alum treatment.

Barr concludes that the dam rupture did cause a spike in algae levels in 2001 and 2002. However, they also conclude that dam sediments covered the alum application only near the mouth of the Balsam Branch River and did not and will not affect alum levels and effectiveness throughout the two lakes.

The study further finds that there are high levels of mobile phosphorus in the deepest portions of Lake Wapogasset and Bear Trap Lake. Consideration of a repeat alum treatment only in the deepest portions of the lakes is recommended. A further recommendation is to monitor the water in the Balsam Branch River to assess the significance of this source of phosphorus in the lakes.

Alum application recommendations:
1270 gal/acre
Wapo: 25 feet and greater = 343,000
Bear Trap: 20 feet and greater = 152,000

Evaluation of the Distribution of Mobile Phosphorus in Lake Wapogasset and Bear Trap Lake Sediments, Calculation of Alum Doses, and Sediment Removal Volumes for Dredging. Barr Engineering. January 2006.

Sediment sampling was used to identify areas with high rates of sediment phosphorus release under anaerobic conditions. In Lake Wapogasset, the area 25 feet and deeper was identified. In Bear Trap Lake, the area 20 feet and deeper was identified. If alum were to be reapplied in these areas at $1 per gallon, the treatment area in Lake Wapogasset would be 264 acres at a cost of $586,000. The treatment area in Bear Trap Lake would be 75 acres at a cost of $120,000.

Dredging the top 14 cm of sediment is another option presented for removal of mobile phosphorus in the deepest portions of the two lakes (the same areas targeted for the alum application). This would require removal of 255,229 cubic yards (187,000 tons) of sediment. There is no cost analysis or discussion of sediment removal techniques in the report.

[Alum application rate is based upon mobile p concentrations at depths of 20 feet and greater (Bear Trap) and 25 feet and greater (Wapo).]

Wappogasset - Bear Trap Lake & Watershed Analysis with Alum Dose Recommendations. Osgood Consulting. March 2007.

- Provides a second opinion regarding Barr 2006 alum dose recommendations
- Analyzes potential benefits of additional alum application
- Evaluates additional lake management options

Phosphorus sediment loading rates are reviewed and reported for
Wapogasset: 924 kg/year and Bear Trap 132 kg/year

Estimates presented for 2006 external phosphorus loading are
Wapogasset: 2145 kg/year and Bear Trap 391 kg/year

Osgood recommends an alum treatment dose that substantially agrees with Barr’s 2006 application recommendations. It appears that these recommendations address the mobile P in 0-4 cm depth of sediment. They would be applied at depths of 20 feet and greater.
Wapogasset: 512,000 to 1,024,000 gallons
Bear Trap: 97,000 to 194,000 gallons

Additional alum is added to the recommendation to account for alum consumed in the water column as it is applied. This increases the minimum recommended application rates to:
Wapogasset: 560,000 gallons
Bear Trap: 107,000 gallons

If this alum application reduces sediment internal loading by 80 percent (predicted), the lakes' total phosphorus concentration is predicted to decrease from 58-62 ppb to 23-25 ppb.

Excessive curly leaf pondweed growth, loading from tributaries, and disturbance by carp will not be addressed with the alum application.

Dredging as an alternative to alum application is estimated to cost $5 to $7 million.

The annual cost of algaecides is estimated to be $75,000 to $225,000 and this option is not recommended. [Note that a previous study identified high levels of copper in sediments. The most common algaecide is copper sulfate. cc]

[Method to calculate alum dose = mobile P method (Rydin and Welch 1999)
Method to calculate internal phosphorus loading rates = Nurnberg (1988) Log RR = 0.8 + 0.76 log (P) RR = sediment P release rate (mg/m2/d) and P is the surface sediment P concentration (mg/g)]

External Loading

External Phosphorus/Water Budget 2006. Lake Wapogasset/Bear Trap Lake Saintary District. Schieffer, Steve. Harmony Environmental.

The two main tributaries to Lake Wapogasset were studied. Data logger measurements of stage every hour during the sample period (April 22 through October 9, 2006) were used to calculate tributary flow. During this period, eleven samples were collected and analyzed for total phosphorus, dissolved reactive phosphorus, total suspended solids, and total volatile suspended solids. Samples were collected once per month and following four storm events.

Analysis of groundwater flow from sewage treatment ponds included in this report.

Lake Use and Water Quality Study. Lake Planning Grant Final Report. Lake Wapogasset/Bear Trap Improvement Association. May 1993.

Stream samples from Balsam Branch and Friday Creek measured dissolved oxygen, temperature, and water flow. The Balsam Branch flow was an average twenty times greater than that of Friday Creek. Phosphorus and nitrogen concentrations are higher in Friday Creek than in the Balsam Branch. However, because of the greater flow, phosphorus loading in Balsam Branch was greater. **The total annual phosphorus loading was estimated to be 670 pounds annually for the Balsam Branch and 167 pounds annually for Friday Creek. This included only the months of May through September.** The study did not estimate loading of phosphorus released from the sediments.

Appendix C. 2006 Lake Nutrient Analysis

External Phosphorus/Water Budget

2006

Bear Trap Lake/Lake Wapogasset

Sponsored by:

Lake Wapogasset/Bear Trap Lake Sanitary District

Prepared by:

Harmony Environmental

Table of Contents

Tables and figures

Introduction

Historically the nutrient loading in Lake Wapogasset and Bear Trap Lake has been analyzed several years ago. However, in only one occasion have the tributaries been actually measured with field data and not simply modeled. In that case, the data was rather sporadic and special mention was made about the need for better data[1]. In addition, in 1995 a nutrient budget analysis was completed for determining dosing for an alum treatment. The nutrient budget was largely based on modeling. A subsequent alum treatment then failed in less than two years. As a result, an updated nutrient budget is being conducted to help in the evaluation of future management practices. This nutrient budget involves field data from the tributaries and modeling the watershed using updated and corrected land use information.

The nutrient budget in this analysis is external loads only. The internal loading has been studied a great deal and it did not appear necessary to have that redundancy. The most recent internal loading data uses extensive sediment data and should be very representative of the actual internal loading.

Methods

Tributaries

The two main tributaries into Lake Wapogasset are the Balsam Branch, which flows from Balsam Lake into Lake Wapogasset in the north end of the lake, and Friday Creek. Friday Creek flows in from the east side of the lake near the YMCA camp. It originates from a wetland area served largely by groundwater.

A data logger that measures the level (stage) of the water every hour was installed in both tributaries. On seven different dates and during four storm events the flow was measured to correlate to the stage. The stage meters were placed in an area where the cross section of the stream was well defined. This allowed for a more accurate cross section measurement, which allows accurate flow calculations. The flow was then compared to the stage on a graph. A regression was completed on the graph to correlate the stage to flow, thereby allowing a calculation of flow each hour of each day during the sampling period. The sampling period ran from April 22, 2006 until October 9, 2006.

During the sampling period, seven samples (approximately one per month) were collected. The total phosphorus, dissolved reactive, total suspended solids (TSS), and total volatile suspended solids (TVSS) were analyzed. In addition, four storm event samples were taken with each sample analyzed for the same chemical analysis. The sample concentrations were averaged for TSS and TVSS to determine the sedimentation load. The total phosphorus values vs daily flow averages were graphed. A regression analysis was then conducted to determine daily loads. It has been found in stream analysis a regression analysis of daily load

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[1] This is how the data was referred to in the study. *Lake Wapogasset and BearTrap Lake Nutient and Water Budget Anlysis.* 1993. Prepared by Lake Wapogasset/Bear Trap Lake Association.

vs flow gives a good reflection of true nutrient loads. It usually tends to underestimate the loads when evaluated, depending on the number and intensity of storm events.[2]

Figure 1. Sample locations.

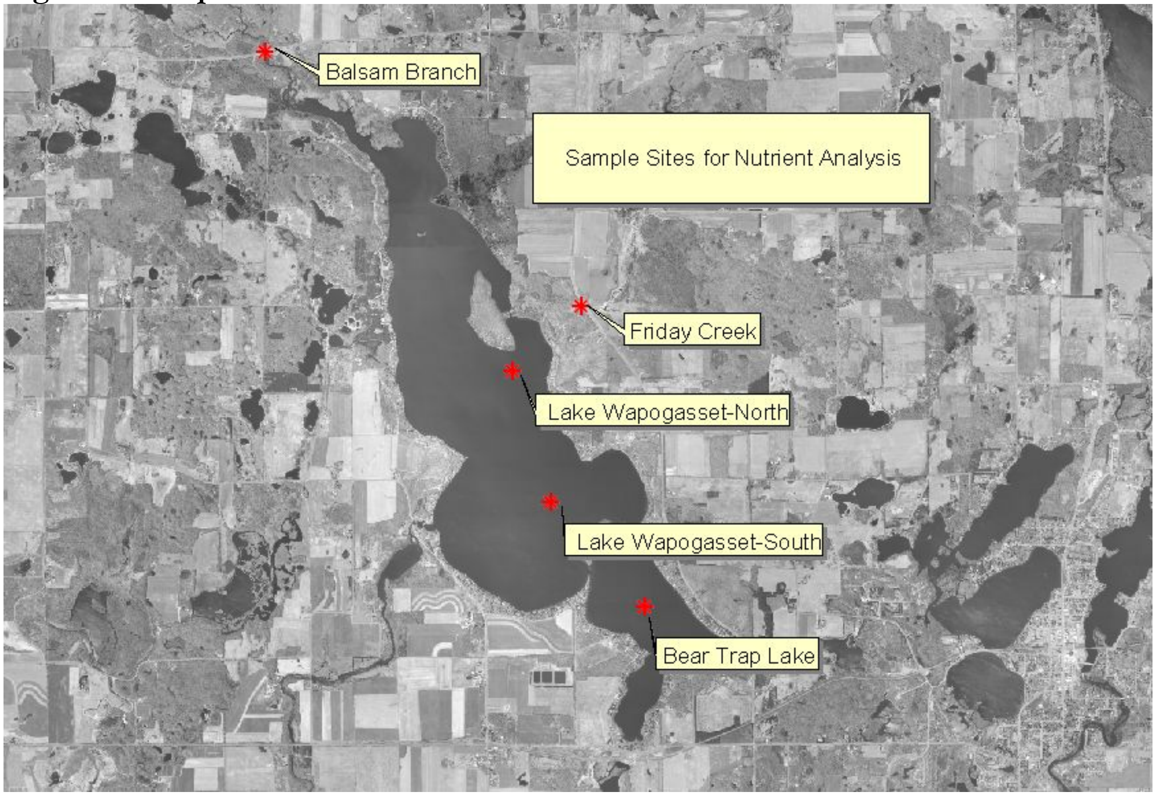
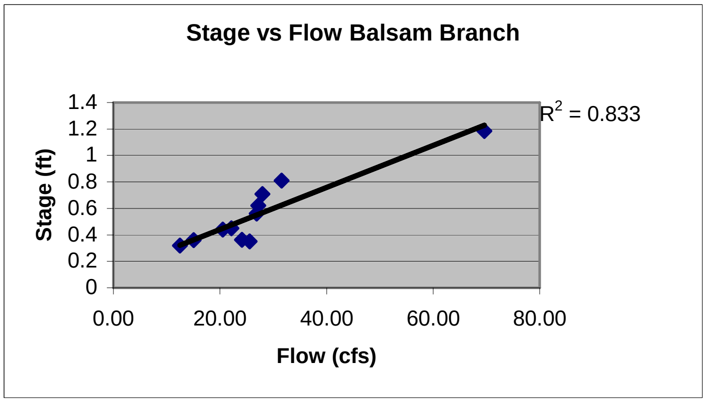


Figure 2. Graph of stage vs flow regression for Balsam Branch



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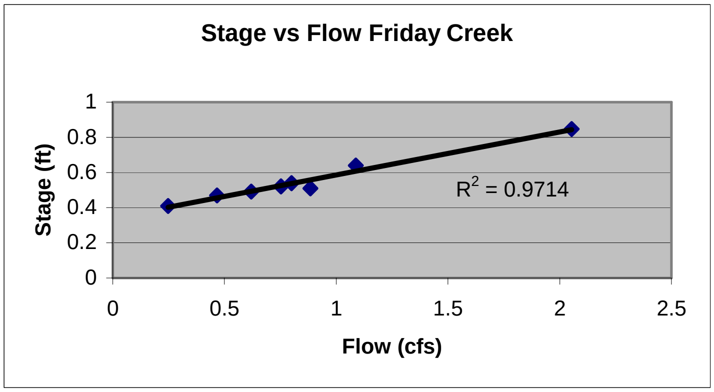
[2] Leith, Katherine McArthur, 1998. *Estimating Tributary Phosphorus Loads Using Flow Weighted Composite Storm Sampling.* Master of Science Thesis. Virginia Polytechnical Institute and State University.

Figure 3. Graph of stage vs flow regression for Friday Creek



Modeling watershed

To determine the external load from the remaining portions of the watershed, the model United States Army Corp of Engineers model BathTub was used. The most recent land use files were provided by Polk County Land and Water Conservation Department and utilized for the model. Some key areas of concern were then updated through ground truth methods and analysis from the air. As a result some agricultural areas and near lake residential land uses were corrected. In addition, the riparian zone of the lakes was analyzed for residential development, with these areas being implemented into the model. The entire watershed was divided into sub-watersheds to aid in watershed evaluation.

The outflow at Lake Wapogasset was monitored for flow and total phosphorus. There were monthly lake samples collected and analyzed for total phosphorus and dissolved reactive phosphorus to calibrate the model.

Precipitation and evaporation data was collected from the nearest weather station to Amery, Wisconsin for use in the water budget portion of the model.

Sewage treatment ponds[3]

In 1995, Barr Engineering completed a nutrient analysis. In their report, it was stated that a Barr Engineering groundwater hydro geologist examined both the WDNR (Wisconsin Department of Natural Resources) monitoring well data and the USGS 7.5 minute topographic quadrangle map of the area. He concluded that localized groundwater levels flow caused by seepage from the treatment ponds might skew the groundwater levels measured in the monitoring wells. Also, the surface topography in the vicinity of the treatment ponds definitely slopes towards Bear Trap Lake. Since shallow groundwater flow almost always mimics surface water flow, he concluded that groundwater flow most likely proceeds from the ponds towards Bear Trap Lake. Therefore, it was assumed that the seepage from the Wapogasset/Bear Trap sanitary system treatment ponds does flow towards Bear Trap Lake. It was estimated, based on sewage inflow values, that the annual phosphorus load from these ponds was 20.7 kg/year. It was stated that evaluation of this

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[3] Information on speculated seepage pond loads from Barr Engineering. *Wisconsin Lake Planning Grant Final Report. Lake Wapogasset and Bear Trap Lake, Polk, County, Wisconsin*. June 1996.

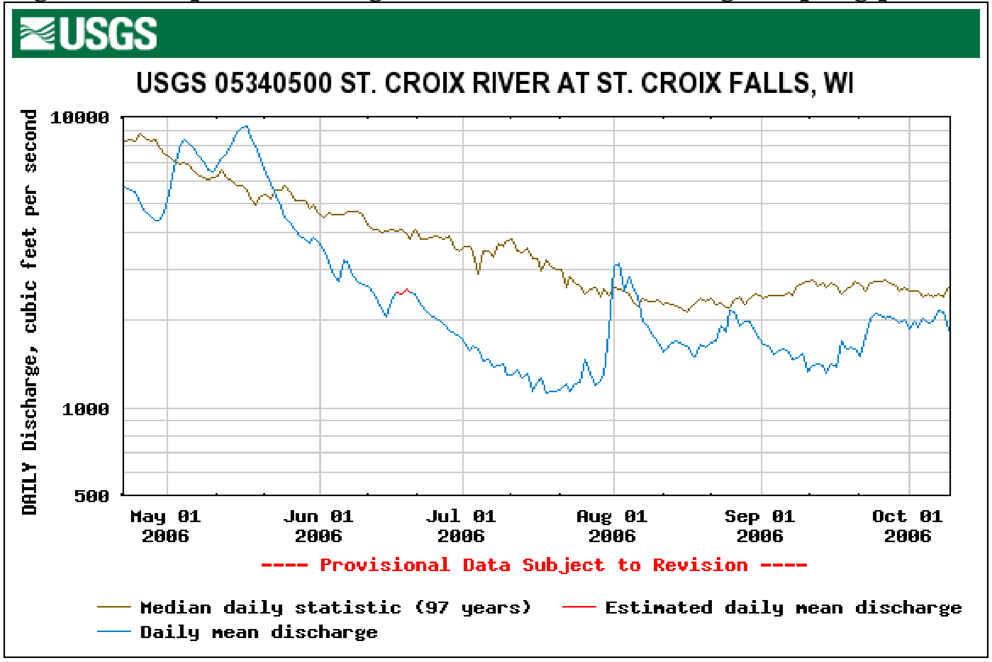
flow is difficult and the well data was inconclusive. Adding more test wells was also recommended.

To investigate this issue, the data on well elevations, water analysis and groundwater flow into the lake were evaluated. The concentration of chloride was the focus of the water analysis, since chloride are not normally high in groundwater and don't bind to sediments. This allows chloride to be a good indicator of sewage water flow into the water table. The chloride values from the past two years were evaluated. In addition, a total phosphorus analysis was completed from water samples at each well in August 2006. To evaluate groundwater flow into the lake, mini-piezometers were inserted into the lakebed at 18-inch depths, to a depth of 4 feet. The water was pumped until it was estimated groundwater was obtained. The pump was released and the level of the water was observed. If the level was above the lake level, a positive flow (into lake) was recorded. If the level fell slightly below the lake surface, a negative flow (out of lake) was recorded.

Summer of 2006 exceptions

The summer of 2006 was extremely dry. For this reason, the validity of the data could be reduced. The precipitation total for the period April through September was approximately 28 % below an average year. There has been no previous base flow data taken for the tributaries being analyzed, but one can use the real time data of the nearest river (St. Croix River) to compare what the flow might be in drought conditions. The graph below demonstrates the flow of the St. Croix River as collected at a gauge station in St. Croix Falls, Wisconsin. This graph indicates that the average discharge during the sampling period was approximately 23% lower than the 93-year average for the St. Croix River at this gauging station.

Figure 4. Graph of discharge at St. Croix River during sampling period.



Results

Tributaries

As mentioned in the methods, the daily flow was weighted for phosphorus load. The daily load vs. flow was graphed and a regression analysis was conducted. In Balsam Branch the daily load vs. flow was used to give a strong correlation. In Friday Creek, the best correlation came from graphing the log of daily load vs. log of flow.

Figure 5. Regression of daily load vs flow of Balsam Branch.

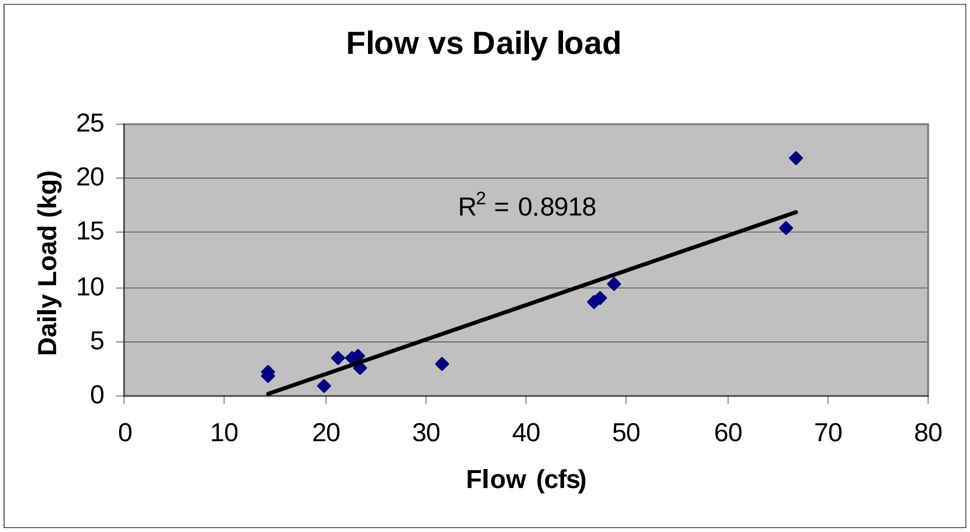
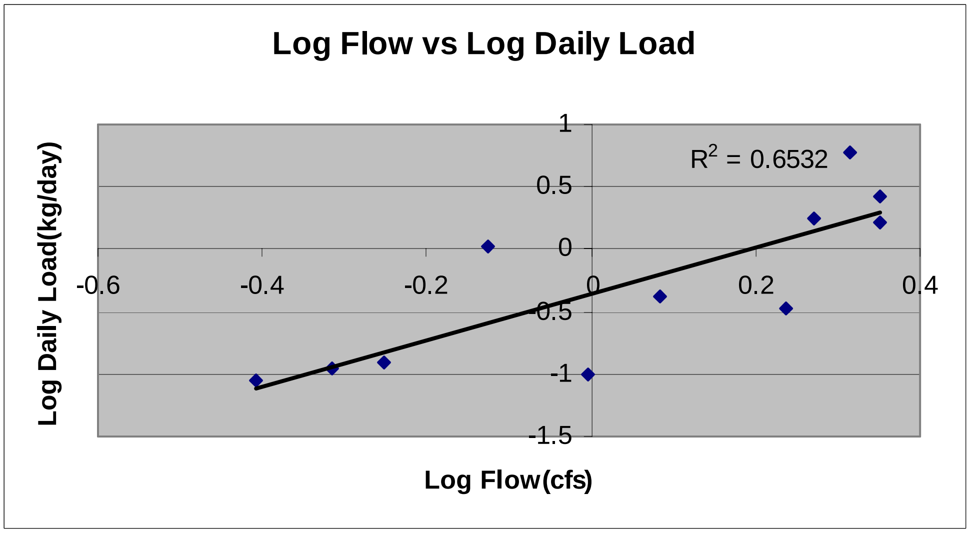


Figure 6. Regression of log of daily load vs log of flow of Friday Creek.



Due to the limited number of storm events, the largest portion of the data collected reflects base flow. This should allow for a more precise measurement of nutrient loads. Balsam Branch data reflects this with a very high correlation. However, Friday Creek seemed to respond more variably to the few rain events. In one rain event the flow was not very high and the nutrient concentration was very high, reflecting first flush increases. On another storm event, the flow was high, but the nutrient concentration was lower than might be expected, possibly reflecting the lack of first flush concentrations. Considering all of this, the correlation is relatively good allowing for the prediction of loads in none sample flow periods.

In the case of Total Suspended Solids (TSS), the daily averages and the average loads were used to calculate the total load during the sampling period.
The results of all calculated loads are in table 1.

Table 1. Averages for water quality analysis (includes base flow and storm events).

Test	Balsam Branch	Friday Creek
Mean Total Phosphorus	0.066 mg/L	0.292 mg/L
Mean Ortho Phosphate	0.061 mg/L	0.226 mg/L
Mean TSS	6.18 mg/L	111.73 mg/L
Mean TVSS	2.0 mg/L	45.36 mg/L

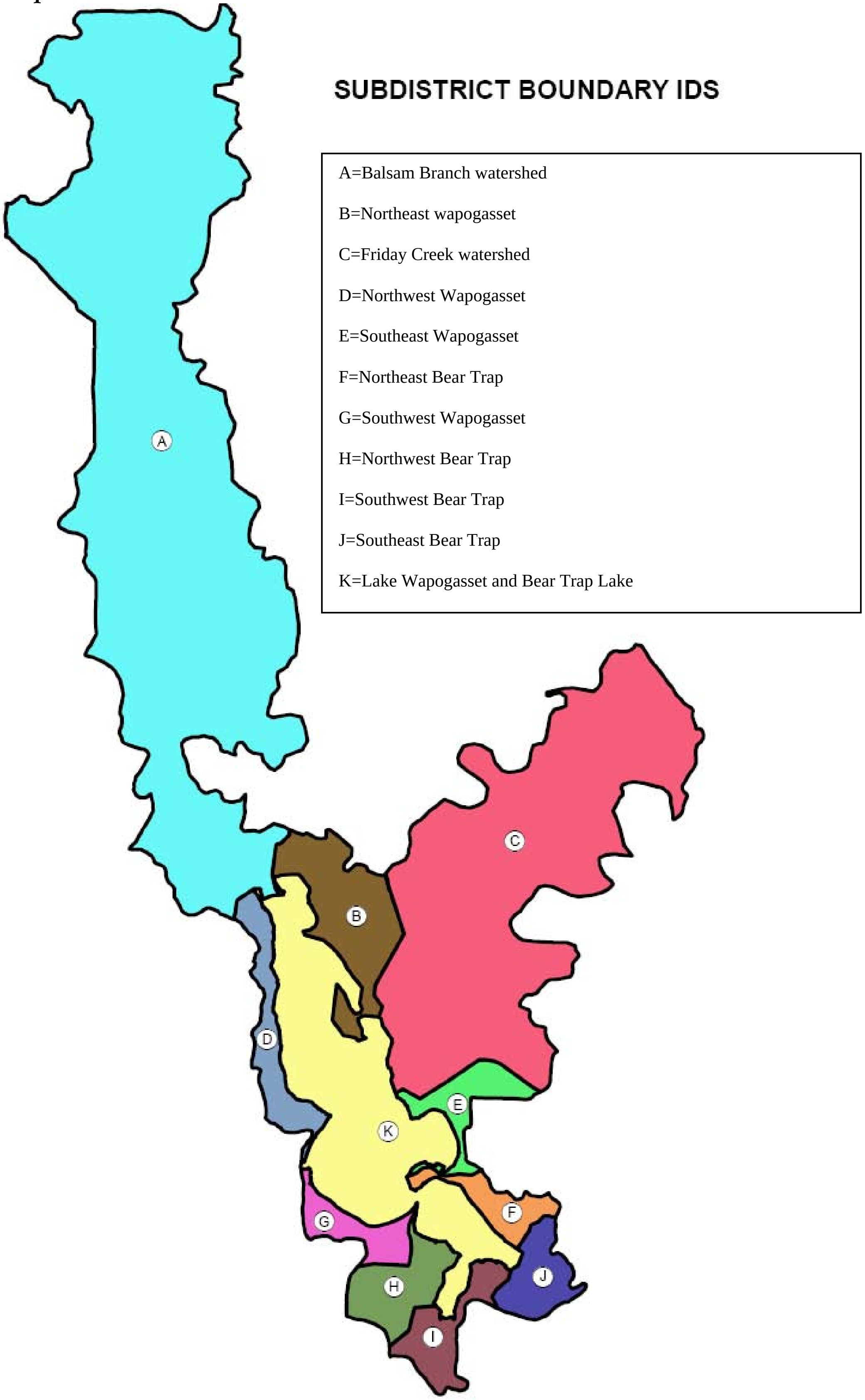
Table 2. Calculated loads and flows.

Stream	Inflow in hm3 April-Oct	Total P load April-Oct	TSS load April-Oct.	Peak flow	Low flow	Mean flow
Balsam Branch	10.77	729.4 kg	66 586 kg	69.95 cfs	10.2 cfs	25.39 cfs
Friday Creek	0.34	76.6 kg	37 821 kg	3.17 cfs	0.205 cfs	0.68 cfs

Remaining watershed

The remaining watershed was modeled to determine water and nutrient inputs. The most recent land use data was incorporated. In addition the watershed was divided into sub watersheds.

Figure 7. Map of sub watersheds.



SUBDISTRICT BOUNDARY IDS

A=Balsam Branch watershed

B=Northeast wapogasset

C=Friday Creek watershed

D=Northwest Wapogasset

E=Southeast Wapogasset

F=Northeast Bear Trap

G=Southwest Wapogasset

H=Northwest Bear Trap

I=Southwest Bear Trap

J=Southeast Bear Trap

K=Lake Wapogasset and Bear Trap Lake

Table 3. Land use area for various sub watersheds. Values are in km^2.

Name	Barren	Forage	Forest	Grassland	Open water	Residential	Row crop	Wetland
A - Balsam Branch	0.2	0.68	11.44	4.46	0.44	0.02	0.92	3.56
B - NE wapo	0	0.35	1.11	0.20	0	0.18	0.07	0
C - Friday Creek	0	2.59	2.11	2.29	0.02	0.03	1.68	2.03
D - NW wapo	0	0.15	0.39	0.05	0.01	0.30	0.11	0.04
E - SE wapo	0	0.09	0.23	0.30	0.01	0.16	0.01	0.01
F - NE Bear	0	0.02	0.37	0.04	0	0.14	0.04	0.02
G - SW wapo	0	0.11	0.14	0.11	0	0.19	0.14	0
H - NW bear	0	0.05	0.19	0.41	0.02	0.12	0.26	0
I - SW bear	0	0.02	0.33	0.25	0.09	0.13	0.01	0.07
J - SE Bear	0	0.05	0.32	0.29	0	0.01	0.1	0.04
Percent of Total Land cover	0.5	10.19	41.25	20.83	1.46	3.17	8.28	14.31

Table 4. The following represent the export coefficients used to determine loading from land use.

Land use name	Runoff mean (m/yr)	Total P (ppb)
Barren	0.44	1000
Forage	0.092	300
Forest	0.0473	100
Grassland	0.092	300
Open water	0.8077	450
Residential	0.1838	300
Row crop	0.44	1000
Wetland	0.10	100

Precipitation coefficient	0.56 kg/hectare/yr

Table 5. Precipitation data

Global variables	Mean
Averaging Period (yrs)	1
Precipitation (m)	0.8077
Evaporation (m)	1.3077
Storage Increase (m)	-0.5

Table 6. Lake Wapogasset Outflow Data.

Lake Wapogasset Outflow	Amount
Mean Daily Discharge April-Oct	0.52 hm^3/day
Mean Total Phosphorus	0.043 mg/L
Total Discharge April-Oct	11.77 hm^3
Total Phosphorus discharge	506.14 kg

Table 7. Lake Wapogasset and Bear Trap Total Phosphorus Data (in mg/L)

Lake Location	6/13/2006	6/14/2006	7/12/2006	8/21/2006	8/28/2006	9/25/2006
Wapo North Hole	0.081		0.037	0.1		0.096
Wapo South Hole	0.018	0.016	0.026	0.073	0.083	0.11
Bear Trap	0.015	0.016	0.023	0.077	0.104	0.06

Table 8. Nutrient and water budget loads

Lake Wapogasset

Wapogasset sub-watershed	Annual load	Inflow (hm3/yr)	Mean daily load	Max daily load	Min daily load	Mean daily flow
A (Balsam Branch)	1477.1 kg/y	23.31	4.04 kg/day	16.96 kg/day	0.11 kg/day	26.10 cuffs
B (NE Wapo)	66.9 kg/y	0.17				
C (Friday Creek)	130.1 kg/y	0.68	0.36 kg/day	2.47 kg/day	0.04 kg/day	0.8075 cfs
D (NW Wapo)	85.4 kg/y	0.15				
E (SE Wapo)	33.1 kg/y	0.09				
F (SW Wapo)	85.4 kg/y	0.12				
Precipitation	267.21 kg/y	3.85				
Total external load	2145.21 kg/y	28.37				

Bear Trap Lake

Bear Trap Sub-watershed	Annual load	Inflow (hm3/yr)
F (NE Bear Trap)	28.9 kg/y	0.07
H (NW Bear Trap)	141.9 kg/y	0.20
I (SW Bear Trap)	54.0 kg/y	0.15
J (SE Bear Trap)	55.8 kg/y	0.10
Precipitation	56.48 kg/y	0.82
Total external load	337.08 kg/y	1.33

Figure 8. Pie Graph of external water budget for Lake Wapogasset.

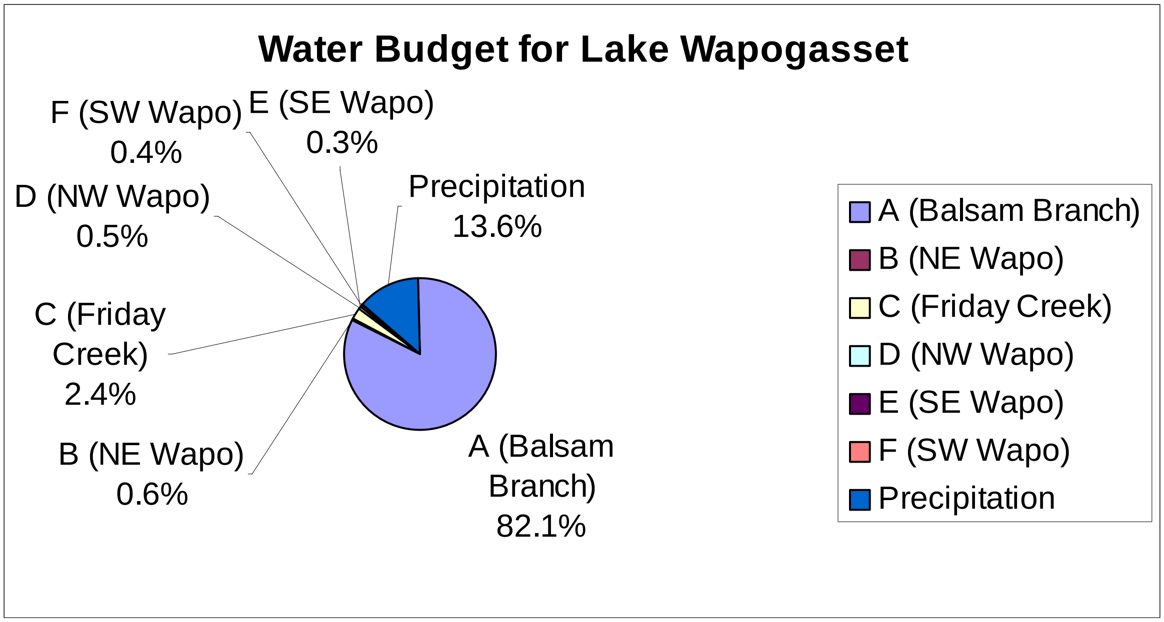


Figure 9. Pie graph of external water budget for Bear Trap Lake

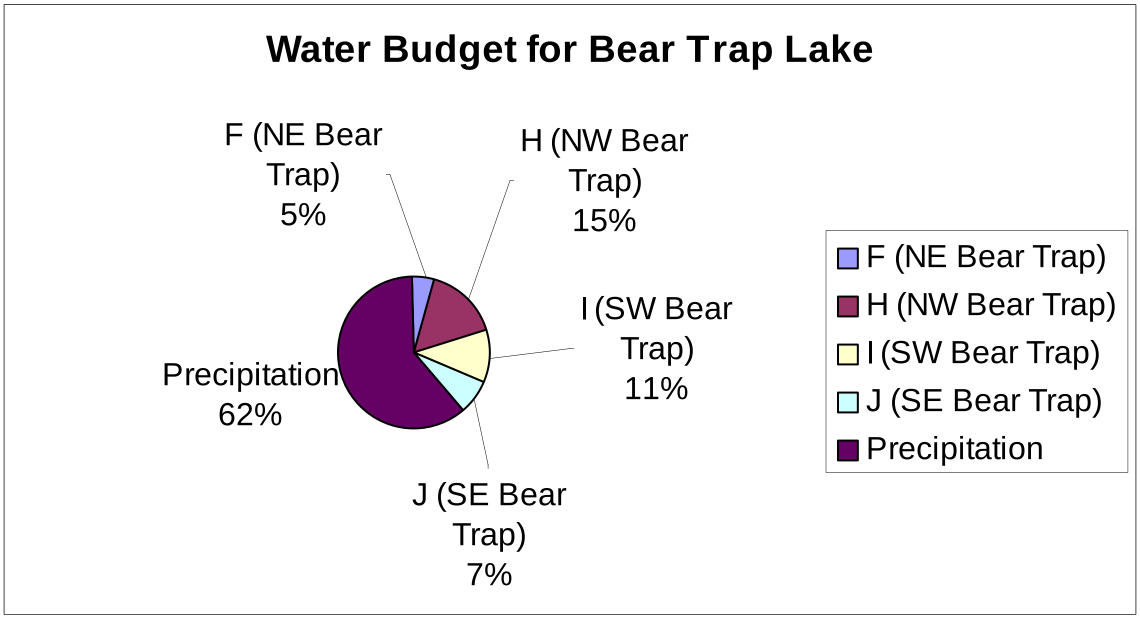


Figure 10. Phosphorus budgets for Lake Wapogasset and Bear Trap Lake.

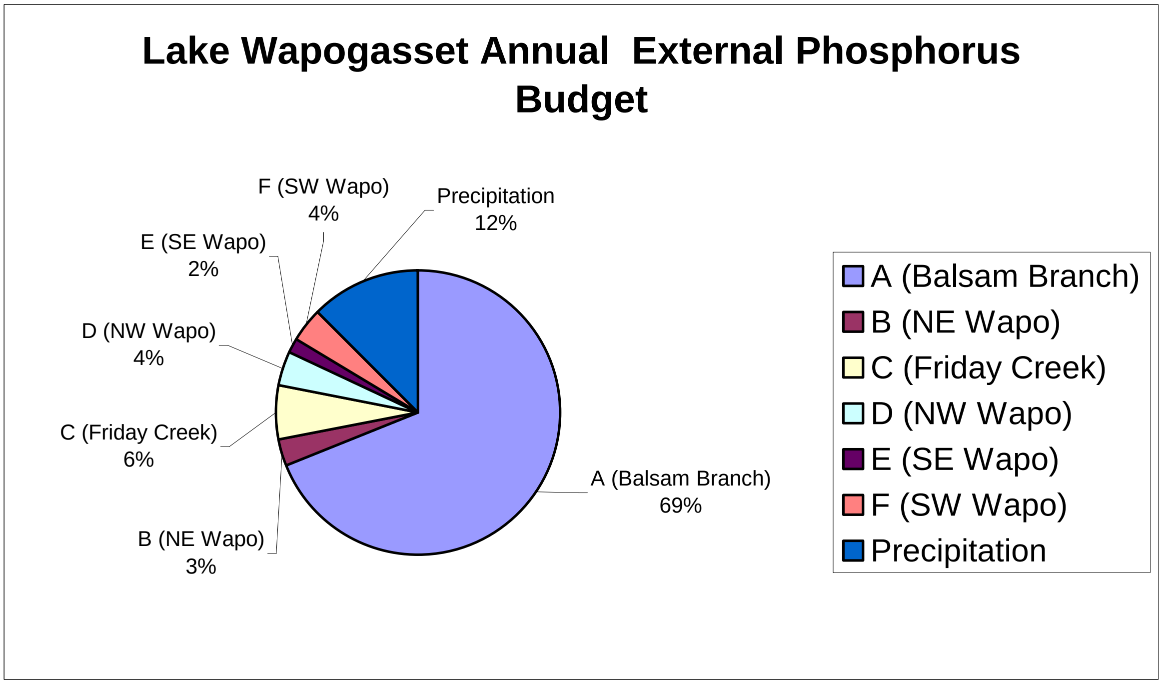
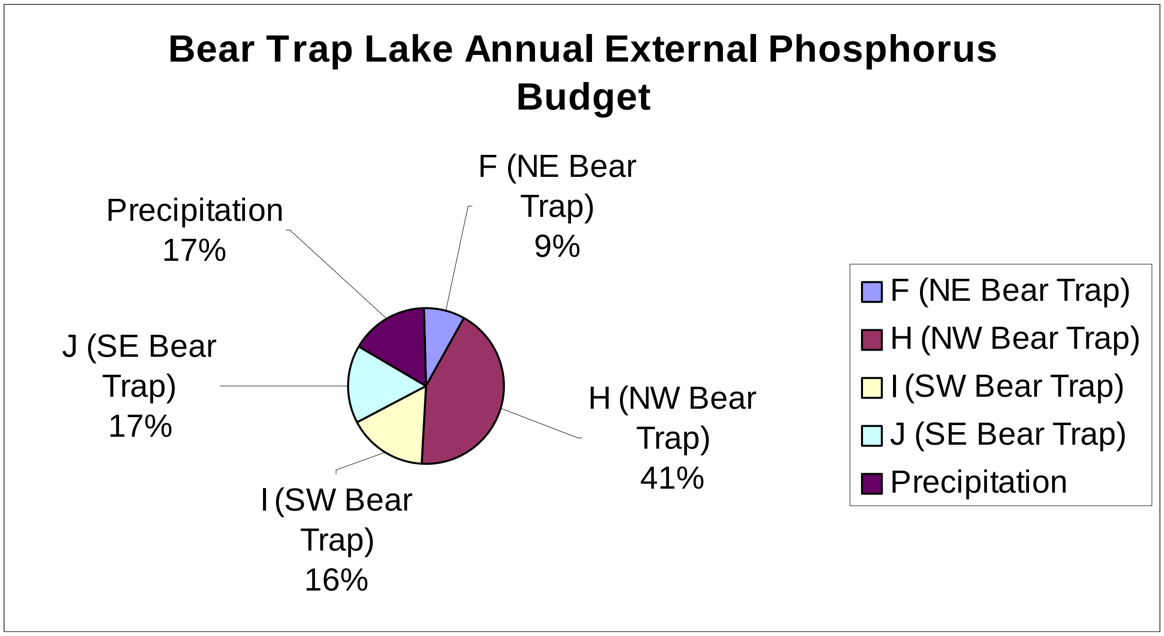


Figure 11. External phosphorus budget Bear Trap Lake



Sewage treatment ponds

The following is a graphic that shows the well locations, water elevation, average chloride concentration for one-year water analysis, and the phosphorus concentration in the last water analysis.

Figure 12. Map and data for sewage treatment pond monitoring wells.

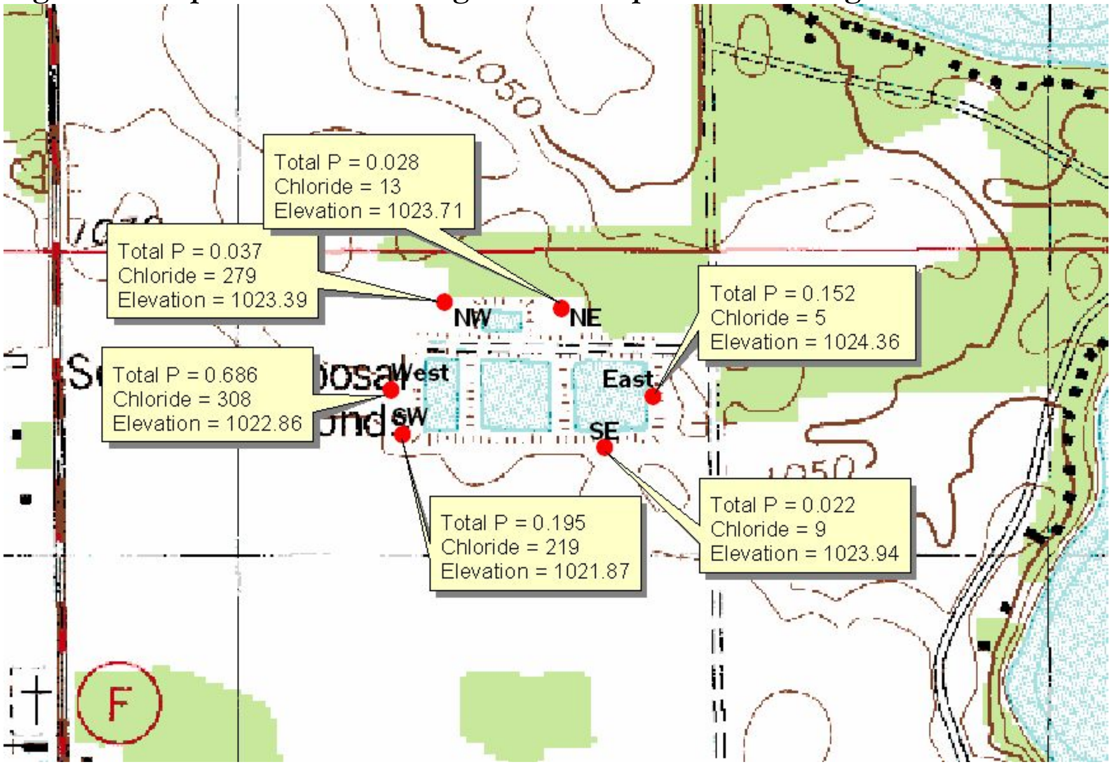
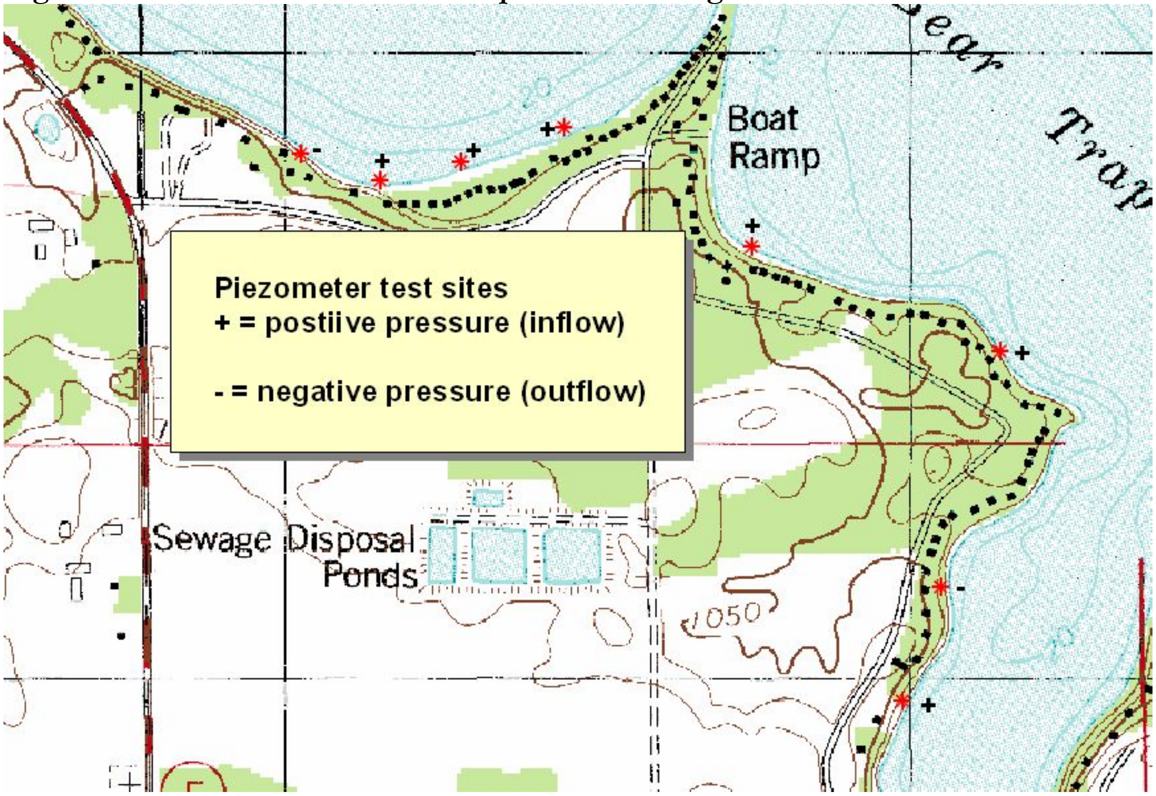


Figure 13. Piezometer test sites with pressure reading.



Discussion of results

External loading

The largest percentage of phosphorus into Lake Wapogasset is the Balsam Branch. This tributary accounts for about 69% of the external phosphorus load annually. The summer of 2006 was extremely dry; therefore the flow was most likely lower than an average year. As a result, the increased flow would increase the phosphorus load. In addition, Friday Creek loads Lake Wapogasset with only 6% of the total phosphorus. This could change immensely with an average year of precipitation. In comparing the two tributaries, Balsam Branch has a rather low phosphorus concentration during base flow. It did increase significantly during rain events, but was still not extremely high. However, its flow is extensive and provides a high flow, low concentration scenario. As a result, the phosphorus load is higher. In some cases, the concentration of phosphorus in Balsam Branch is actually lower than the lake phosphorus concentration. During rain events in mid to late summer, high volumes of water could help contribute to mixing the lake, allowing the release of high phosphorus concentration hypolimnetic water.

One must be careful when looking at the overall load this tributary contributes. During rain events, the large flow could cause sediment release near the outflow (which has accumulated) and cause mixing in the lake, thereby contributing more beyond the phosphorus contained in the tributary water itself.

Friday Creek has very low flow by comparison to Balsam Branch. The phosphorus concentration is higher at base flow, and increases dramatically even with relatively minor rain events. This stream also had less loading based on field data than the model predicted based on land cover. This may be due to the fact that there are many wetlands in the Friday Creek watershed immediately adjacent to the creek. These wetlands appeared to be mostly dry throughout most of the sampling period. During rain events, the runoff may have been absorbed by the wetlands, never reaching the stream. It is for this reason that the drought year may reduce the significance of Friday Creek in the nutrient load and this should be considered when evaluating the load from Friday Creek in the future.

In terms of sediment contributions, Balsam Branch and Friday Creek differ significantly. The total suspended solids (TSS) mean is much lower for Balsam Branch than for Friday Creek (6 mg/L and 111 mg/L). As a result, the total suspended solids flowing toward the lake is higher in Balsam Branch due to much higher flow, but when comparing flows, Friday Creek has a much higher load. In both cases, the stream flow decreases immensely before reaching the lake, which can allow for settling of the solids. This is evident when observing the outlets of both tributaries, with extensive sediment buildup at both locations. The total volatile suspended solids (TVSS) value is used to help determine the amount of the suspended solids that may be organic as opposed to inorganic. In Balsam Branch, the mean TVSS is about one third of the mean TSS with the value being low (6 mg/L and 2 mg/L) and is rather insignificant. In Friday Creek, the mean TVSS is a little less than half of the TSS (111 mg/L and 45 mg/L). This indicates that a large portion of the suspended solids could be organic in nature as opposed to inorganic sediments.

When comparing the total phosphorus values to the dissolved-reactive phosphorus values, some interesting points could be made. Because total phosphorus includes dissolved-reactive phosphorus, one can calculate the percentage of total phosphorus that is dissolved-reactive. In Balsam Branch, the mean dissolved-reactive phosphorus was 92.4 % of the mean total phosphorus. This indicates that most all of the phosphorus in Balsam Branch is dissolved and available for absorption by plant material (algae and macrophytes). In Friday Creek, the mean dissolved-reactive phosphorus was 77% of the mean total phosphorus. Again, the majority of the phosphorus is dissolved and available for absorption, although much lower than Balsam Branch. This would be consistent with the TSS values, since Balsam Branch has such little TSS and Friday Creek has much higher TSS values. This would represent more phosphorus potentially tied up in sediments in the tributary water in Friday Creek.

The remaining watershed contributes to the water and phosphorus budgets. In Lake Wapogasset, this impact is much less than the tributaries. Balsam Branch and Friday Creek, according to the field data, accounts for about 75% of the external phosphorus budget during the sampling period. With precipitation accounting for 12% of the phosphorus, the remaining watershed contributed about 13% of the total external phosphorus load. The total mass contributed from the remaining watershed was rather evenly distributed between the various sub watersheds in Lake Wapogasset.

For Bear Trap Lake, there are no major tributaries. A small stream was identified in the southeastern portion of the lake, which locals refer to as Bear Trap Creek. One phosphorus sample was analyzed and it was much lower than the concentration of Bear Trap Lake (0.086

mg/L vs. 0.104 mg/L). This result does not indicate an insignificant contribution. However, in evaluation of the watershed of this stream, it is mostly wetlands and the model does not suggest any significant impact beyond what the model predicts. The flow of the stream is unknown and further evaluation may be warranted to verify the model.

The direct watershed of Bear Trap Lake is therefore the major contributor of the external phosphorus with 83% of the external load (17% from precipitation). Comparing the sub-watersheds, the northwest Bear Trap sub watershed contributes 41%. This may be due to the extensive row cropland use, which has one of the highest export coefficients of any land cover type. The phosphorus loading of this sub watershed is much greater than any other sub watershed. Southeast Bear Trap watershed (J), is the next highest with 17%, followed by southwest Bear Trap (I) at 16%.

Upon evaluation of the data for the sewage treatment test wells, as well as the groundwater flow by the engineer in this project, it is inconclusive if the seepage ponds are contributing phosphorus. The well elevations indicate groundwater movement to the southwest, away from the lake. Also, the chloride data supports this conclusion. However, the East well had a very high phosphorus value, which could indicate possible water flow in that direction. Whether it reaches the lake is unknown. There was positive groundwater pressure at all lake/water table interface locations except for two. This does not necessarily mean that the groundwater below the seepage ponds is flowing into the lake. There is a break in the topography between the ponds and the lake, which could account for the positive flow into the lake and yet flow away from the lake at the pond locations. The overall conclusion is that it doesn't appear the seepage ponds are leeching into the lake, but this is not certain. If the load is occurring as Barr Engineering predicted (20 kg/yr) in 1995, it is less than the precipitation and rather small in comparison to the whole phosphorus load. However, considering the rationalization for a sewage treatment facility, this issue should be resolved through increased monitoring.

Internal loading

The internal loading was not analyzed in this study. This loading has been analyzed extensively before and after the alum treatment. Based on the data collected, it is significant in both lakes. Also, there are two deep holes in Lake Wapogasset. One of the two deep holes does not appear to stratify based on data collected previously. This makes for an unstable water column potentially allowing mixing of the hypolimnion with the epilimnion prior to fall turnover. The southern most portion of Lake Wapogasset does appear to stratify, limiting hypolimnetic phosphorus loading to overturn events (mainly fall). In Bear Trap Lake, the lake does seem to stratify earlier, but appears to lose stratification in late summer, which could allow mixing prior to fall turnover. The potential phosphorus load internally in both lakes is extensive.

In 1995, the internal loading of Lake Wapogasset and Bear Trap Lake were determined from a model by Barr Engineering. The results indicated an internal load for Lake Wapogasset of 1058 kg/yr, and for Bear Trap Lake an internal load of 242 kg/yr.[4] in 2004, more extensive

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[4] Amount taken directly from Barr Engineering. *Wisconsin Lake Planning Grant Final Report. Lake Wapogasset and Bear Trap Lake, Polk County, Wisconsin*. June 1996.

data was collected through sediment core sampling. In this study, release rates and area of sediments with those release rates were determined. Taking into consideration the length of anoxic conditions, the calculated internal loads were approximately 792 kg/y and 122 kg/y in Lake Wapogasset and Bear Trap Lake respectively.[5] In either lake, the amount is significant.

Recommendations

Since the sampling season of 2006 was very dry, it is recommended that another year of tributary monitoring be carried out. This would allow for data collected over a longer period of time, giving a better reflection of the contributions each tributary makes to Lake Wapogasset. Furthermore, the spring melt was missed in this sample period and can have a big impact on the load calculations.

The sewage treatment ponds do not appear to be contributing phosphorus. In addition, if they are, it makes up a very small percentage of the total load. The data is rather inconclusive so it is not certain if the sewage pond load is occurring. Since the Sanitary District oversees the operation of the sewage treatment facility, and this was installed to reduce nutrient loading from private systems, it would be prudent to study this issue further.

The most valid method to determine if this load is occurring would be to install more monitoring wells between the lake and the sewage treatment ponds. This can be very costly. Therefore, we recommend first testing shallows wells that are already present on properties adjacent to the lake. This could give more insight into the possible loading from the seepage ponds. If this data should indicate such a load, further study could be included, possibly more monitoring wells.

Bear Trap Lake appears to have all of its phosphorus coming in internally and from the direct runoff of the watershed. The management practices available for controlling internal loading are being reviewed, which is important. Potential land purchases and/or conservation easements should be explored to try and implement best management practices on some key properties that have potentially large nutrient loads into Bear Trap Lake. As an example, changing a parcel from row crop to native grassland could reduce phosphorus loading by approximately 80% per acre. This could be a very large reduction in kilograms of phosphorus reaching Bear Trap Lake. Furthermore, reducing residential influence through buffer installations and infiltration devices could reduce runoff enough to make a difference in nutrient loading from these areas.

Reducing Lake Wapogasset external loading is more complicated since most of the phosphorus is coming from Balsam Branch. During the past several years, the Balsam Branch has had many best management practices implemented as a priority watershed. This has most definitely reduced the phosphorus concentrations in Balsam Branch, reflected by low average total phosphorus values. However, this stream has a large flow and will always contribute a large load as a result. Better management along Friday Creek would help reduce its loading, but it is a relatively small percentage of the total load.

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[5] Amount calculated from release rate data from Barr Engineering. *Investigation of Alum in Lake Wapogasset and Bear Trap Lake*. December 2004.

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Appendix D. Implementation Plan or Work Plan 2010-2012

The implementation plan begins on the following page. The strengths of each organization were considered in identifying the lead agency for each activity. While a lead organization is identified for each activity, a steering committee with representatives from both organizations will guide overall implementation as described in the recommended implementation strategy below.

The implementation plan estimates time and dollars needed to implement activities in 2010. Time and cost estimates for 2011 and 2012 will be developed in 2010 as plan implementation is underway.

Strengths of each Organization

<u>Sanitary District</u>
Ability to raise $
Facilities (office/meeting space)
Has existing staff – can hire staff
Can manage and sponsor grants
Existing website
Reputation of getting things done

<u>Lake Association</u>
Volunteers
Fund-raising ability
Individuals with expertise
Newsletter (7X/year) (contribute and distribute)
Website (contribute to Kathy Mortensen's site)

Recommended Implementation Strategy

- Establish a Comprehensive Lake Management Plan Steering Committee consisting of Sanitary District and Lake Association representatives
- Appoint project manager/subcommittee chair for each focus area
- Individual activities may be carried out cooperatively or by SD or LA
- Consider sanitary district staff to aid in plan coordination and committee support
- Continue to use consultants on specific projects

Goal. Improve Lake Wapogasset and Bear Trap Lake water quality.

Action Items[1]	Cost 2010	2011	2012	Lead (SD or LA)	Resources/ Partners	Funding Sources	Notes
Crop Fields							
1a. Analyze priority subwatersheds and parcels (H)	40 hours (VOL)	Yes	Yes	SD	LWRD		Board chairs as major contact
1b. Identify potential water quality practices (H)	10 hours (VOL)	Yes	Yes	SD	LWRD NRCS		Additional projects may be identified in subsequent years.
1c. Identify and contact landowners (H)	10 hours (VOL)	Yes	Yes	SD/LA	LWRD		Volunteer contact may change with each project/landowner.
2a. Design and install practices using available funds (H)	$3,000 (design)	Yes	Yes	SD	LWRD	NRCS DATCP Lake planning grant for design	Identified costs are for engineering/design.
2b. Install practices with local lake funds or grants (M)		$? Consider if funds not available for installation	$? Consider if funds not available for installation	SD	LWRD	Lake protection grant TRM grant	Implementation budgets to be determined. Lake protection grant due May 1 of preceding year.
3. Consider purchasing portions of crop fields (M)	$1,000 (survey)	$? If project identified	$? If project identified	SD	LWRD	Lake protection grant	Implementation budgets to be determined.

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[1] See implementation plan section beginning on page 62 for action item detail. SD = Lake Wapogasset Bear Trap Sanitary District. LWRD = Land and Water Resources Department. DNR = Wisconsin Department of Natural Resources. NRCS = Natural Resource Conservation Service. DATCP = Department of Agriculture, Trade &Consumer Protection. TRM = Targeted Runoff Management.

Goal. Improve Lake Wapogasset and Bear Trap Lake water quality.							
Action Items[1]	**Cost 2010**	**2011**	**2012**	**Lead** (SD or LA)	**Resources/ Partners**	**Funding Sources**	**Notes**
Neighborhood Stormwater							
4a. Analyze subwatersheds (MH)	40 hours (VOL)	Yes	Yes	LA	LWRD Consultant?		Use 2000 aerial survey, ground-truthing, and shoreland habitat assessment.
4b. Identify water quality practices (MH)	10 hours (VOL)	Yes	Yes	LA	LWRD DNR Consultant?		
4c. Identify and contact landowners to assess interest (MH)	10 hours (VOL)	Yes	Yes	LA	LWRD Consultant?		
4d. Provide cost sharing and technical assistance to design and install practices (H)		$3,000 (design)	$?	SD	LWRD DNR Consultant?	Lake Protection Grant TRM grant	Will likely need to develop local funding sources through lake funds or grants.
Waterfront Runoff							
5. Develop and implement waterfront runoff technical assistance program (M) Complete shoreland habitat assessment	30 hours (VOL) 40 hours (VOL)	$?	$?	LA	LWRD DNR Landscapers Consultant?	Lake protection grant	Request assistance from LWRD in cooperation with local landscapers. Expand if demand is high.
6. Develop and implement educational program (H)	50 hours (VOL) Materials $500	Yes	Yes	LA	LWRD UWEX DNR	Lake protection or small scale planning grant	Use educational materials from other sources.

Goal. Improve Lake Wapogasset and Bear Trap Lake water quality.							
Action Items[1]	**Cost 2010**	**2011**	**2012**	**Lead** (SD or LA)	**Resources/ Partners**	**Funding Sources**	**Notes**
Evaluation/Studies							
Assess phosphorus from curly leaf pondweed – plant tissue testing and consultant analysis (H)	Yes			SD	Sanitary District Board DNR Consultant	Planning grant or AIS grant (2/01/10)	CLP study included in APM plan.
Investigate aeration as a method to reduce internal loading (MH)	Yes	$? Carry out study as needed		SD	Committee Consultant DNR	Planning grant (8/01/10)	Request proposals and information. Obtain reference from Cedar Lake District and/or DNR.
Further investigate alum application as a method to reduce internal loading (MH)		$? Yes		SD/LA	Consultant DNR	Planning grant	Osgood and Pilgrim (Barr) have worked on this previously.
Assess importance of blue green algae species on phosphorus circulation and internal loading in the lakes (H)	Yes (Preliminary sampling and study design)	$? Carry out study		SD/LA	Consultant LWRD DNR	Planning grant (8/01/09)	Cedar Lake DNR study may have useful information.
Complete sediment cores to obtain historical record of phosphorus levels, sedimentation, and blue green algae (ML)			Consider		Consultant DNR	Planning grant	

Goal. Prevent introduction of invasive aquatic organisms and limit the impacts of those introduced to the lakes.

Action Items[2]	**Cost 2010**	**Cost 2011**	**Cost 2012**	**Lead** SD or LA	**Resources/ Partners**	**Funding Sources**	**Notes**
1. Continue and expand the Clean Boats/Clean Waters Program (H)	300 hours (VOL)	Yes	Yes	LA	LWRD DNR	AIS grant	
2a. Request Polk LWRD monitor for zebra mussels and spiny water flea. (MH)	5 hours (VOL)	Yes	Yes	LA	LWRD DNR		
2b. Train volunteers to identify and monitor for AIS (MH)	100 hours (VOL)	Yes	Yes	LA	LWRD DNR		LA AIS Monitoring Committee
3. Develop and follow a rapid response plan if AIS are identified in lakes (H)	40 hours (VOL)	If needed	If needed	LA	Consultant LWRD DNR		
4. Implement AIS education program (H)	40 hours (VOL)			LA			

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[2] See implementation plan section beginning on page 62 for action item detail. SD = Lake Wapogasset Bear Trap Sanitary District. LWRD = Land and Water Resources Department. DNR = Wisconsin Department of Natural Resources. NRCS = Natural Resource Conservation Service. DATCP = Department of Agriculture, Trade &Consumer Protection. TRM = Targeted Runoff Management. UWEX = University of Wisconsin Extension.

Goal. Protect and improve the Lake Wapogasset and Bear Trap Lake fishery.

Action Items[3]	**Cost 2010**	**Cost 2011**	**Cost 2012**	**Lead** SD or LA	**Resources/ Partners**	**Funding Sources**	**Notes**
1. Prevent sediment loading to walleye spawning beds (MH)	40 hours (VOL)	Yes	Yes	SD/LA	DNR		This activity ties in with water quality activities 1 – 4.
2. Sponsor annual carp shoot (M)	$1,000	Yes	Yes	LA	DNR		
3. Support fish stocking (L)			$?		DNR Tribes	Local	What species and how much support needs to be determined.

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[3] See implementation plan section beginning on page 62 for action item detail. SD = Lake Wapogasset Bear Trap Sanitary District. LWRD = Land and Water Resources Department. NRCS = Natural Resource Conservation Service. DATCP = Department of Agriculture, Trade &Consumer Protection. TRM = Targeted Runoff Management.

Action Items[4]	**Cost 2010**	**2011**	**2012**	**Lead** SD or LA	**Resources / Partners**	**Funding Sources**	**Notes**
Lake resident education (Applies to all goals)						Small scale grants Lake protection grants	
Develop list of topics for newsletter and web sites	30 hours (VOL)	Yes	Yes	SD/LA Steering Committee	LWCD UWEX		
Develop email list	10 hours (VOL)			SD/LA			
Host demonstration tour	$50			LA			Install project June 2010.
Host lake fair		Yes		LA	LWCD DNR Towns		
December and spring letters	$850	Yes	Yes	SD/LA			
Send board members and volunteers to conferences	$2,500	Yes	Yes	LA			

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[4] See implementation plan section beginning on page 62 for action item detail. SD = Lake Wapogasset Bear Trap Sanitary District. LWRD = Land and Water Resources Department. DNR = Wisconsin Department of Natural Resources. NRCS = Natural Resource Conservation Service. DATCP = Department of Agriculture, Trade &Consumer Protection. TRM = Targeted Runoff Management. UWEX = University of Wisconsin Extension.

Appendix E. Glossary

Aeration — To add air (oxygen) to the water supply. Generally used in lake management to reduce the release of phosphorus from lake sediments or to prevent fish kills.

Algae — Small aquatic plants without roots that contain chlorophyll and occur as single cells or multi-celled colonies. Algae form the base of the food chain in aquatic environments.

Algal bloom — Heavy growth of algae in and on a body of water resulting from high nutrient concentrations.

Alluvium — Clay, silt, sand, gravel, or similar detrital material deposited by running water.

Alkalinity — The acid combining capacity of a (carbonate) solution, also describes its buffering capacity.

Animal waste management — A group of practices including barnyard runoff management, nutrient management, and manure storage facilities designed to minimize the negative effects of animal manure on surface and groundwater resources.

Aquatic plant survey — A systematic mapping of types and location of aquatic plants in a water body, usually conducted in a boat. Survey information is presented on an aquatic plant map.

Aquifer — A water-bearing stratum of permeable rock, sand, or gravel.

BMP's (Best Management Practices) — Practices or methods used to prevent or reduce amounts of nutrients, sediments, chemicals or other pollutants from entering water bodies from human activities. BMP's have been developed for agricultural, silvicultural, construction, and urban activities.

Bathymetric map — A map showing depth contours in a water body. Bottom contours are usually presented as lines of equal depth, in meters or feet.

Benchmark — A mark of reference indicating elevation or water level.

Benthal — Bottom area of the lake

Biocontrol — Management using biological organisms, such as fish, insects or micro-organisms like fungus.

Biomass — The total organic matter present

Bottom barriers — Synthetic or natural fiber sheets of material used to cover and kill plants growing on the bottom of a water body; also called sediment covers.

Buffer strips - Strips of grass, shrubs, trees, and other vegetation between disturbed areas and a stream, lake, or wetland.

Cluster development - Grouping homes on part of a property while maintaining a large amount of open space on the remaining land.

Chlorophyll — The green pigments of plants.

Conservation easement — A legal document that restricts the use of land to farming, open space, or wildlife habitat. A landowner may sell or donate an easement to a government agency or a private land trust.

Consumers — Organisms that nourish themselves on particulate organic matter.

Contact herbicide — An herbicide that causes localized injury or death to plant tissues it contacts. Contact herbicides do not kill the entire plant.

Cost effective — A level of treatment or management with the greatest incremental benefit for the money spent.

Decomposers — Organisms, mostly bacteria or fungi, that break down complex organic material into its inorganic constituents.

Detritus — Settleable material suspended in the water. Organic detritus comes from the decomposition of the broken down remains of organisms. Inorganic detritus comes from settleable mineral materials.

Dissolved oxygen — A measure of the amount of oxygen gas dissolved in water and available for use by microorganisms and fish.

Drainage basin — The area drained by, or contributing to, a stream, lake, or other water body (see watershed).

Drawdown — Decreasing the level of standing water in a water body to expose bottom sediments and rooted plants. Water level drawdown can be accomplished by physically releasing a volume of water through a controlled outlet structure or by preventing recharge of a system from a primary external source.

Dredging — Physical methods of digging into the bottom of a water body to remove sediment, plants, or other material. Dredging can be performed using mechanical or hydraulic equipment.

Ecology — Scientific study of relationships between organisms and their surroundings (environment).

Ecosystems — The interacting system of a biological community and its nonliving surroundings.

Emergent plants — Aquatic plants that are rooted or anchored in the sediment around shorelines, but have stems and leaves extending well above the water surface. Cattails and bulrushes are examples of emergent plants.

Endothall — The active chemical ingredient of the aquatic contact herbicide Aquathol®.

Environmental Protection Agency — The federal agency responsible for enforcing federal environmental regulations. The Environmental Protection Agency delegates some of its responsibilities for water, air, and solid waste pollution control to state agencies.

Epilimnion — The uppermost, warm, well-mixed layer of a lake.

Eradication — Complete removal of a specific organism from a specified location, usually refers to a noxious, invasive species. Under most circumstances, eradication of a population is very difficult to achieve.

Erosion — The wearing away of the land surface by wind or water.

Eutrophic — Refers to a nutrient-rich lake. Large amounts of algae and weeds characterize a eutrophic lake (see also "Oligotrophic" and "Mesotrophic").

Eutrophication — The process of nutrient enrichment of a lake leading to increased production of aquatic organisms. Eutrophication can be accelerated by human activity such as agriculture and improper waste disposal.

Exotic — Refers to species of plants or animals that are not native to a particular region into which they have moved or invaded. Eurasian watermilfoil is an exotic plant invader.

Fecal coliform — A group of bacteria used to indicate the presence of other bacteria that cause disease. The number of coliform is particularly important when water is used for drinking and swimming.

Floating-leafed plant — Plants with oval or circular leaves floating on the water surface, but are rooted or attached to sediments by long, flexible stems. Waterlilies are examples of rooted floating-leafed plants.

Fluridone — The active chemical ingredient of the systemic aquatic herbicide SONAR®.

Flushing rate — Term describing rate of water volume replacement of a water body, usually expressed as basin volume per unit time needed to replace the water body volume with inflowing water. The inverse of the flushing rate is the (hydraulic) detention time. A lake with a flushing rate of one lake volume per year has a detention time of one year.

Food chain — A sequence of organisms where each uses the next as a food source.

Freely-floating plants — Plants that float on or under the water surface, unattached by roots to the bottom. Some have small root systems that simply hang beneath the plant. Water hyacinth and tiny duckweed are examples of freely-floating plants.

Glyphosate — The active chemical ingredient of the systemic herbicide RODEO®.

Ground-truthing —Close or on-the-ground observation used to test the validity of observations made at a distance as in aerial or satellite photography

Groundwater — Water which fills internal passageways of porous geologic formations (aquifers) underground. Groundwater flows in response to gravity and pressure, and is often used as the source of water for communities and industries.

Habitat — The place or type of site where a plant or animal naturally lives and grows.

Herbicide — A chemical used to suppress the growth of or to kill plants.

Habitat — The physical place where an organism lives.

Hydraulic detention time — The period of detention of water in a basin. The inverse of detention time is flushing rate. A lake with a detention time of one year has a flushing rate of one lake volume per year.

Hypolimnion — The cold, deepest layer of a lake that is removed from surface influences.

Integrated aquatic plant management — Management using a combination of plant control methods to maximize beneficial uses, minimize environmental impacts and optimize overall costs.

Limiting nutrient — Essential nutrient needed for growth of a plant organism which is the most scarce in the environment. Oftentimes, in freshwater systems, either phosphorus or nitrogen is the limiting nutrient for plant growth.

Limnology — The study of inland waters.

Littoral zone — The region of a body of water extending from shoreline outward to the greatest depth occupied by rooted aquatic plants.

Loam — A soil consisting of varying proportions of sand, clay, and silt. Generally well-suited for agriculture.

Loess — A loamy soil deposited by wind.

Macrophyte — Large, rooted or floating aquatic plants that may bear flowers and seeds. Some plants, like duckweed and coontail, are free-floating and are not attached to the bottom. Occasionally, filamentous algae like *Nitella* sp. can form large, extensive populations and be an important member of the aquatic macrophyte community.

Mesotrophic — Refers to a moderately fertile nutrient level of a lake between the oligotrophic and eutrophic levels. (See also "Eutrophic" and "Oligotrohpic.")

Milligrams per liter (mg/l) — A measure of the concentration of substance in water. For most pollution measurements this is the equivalent of "parts per million" (ppm).

Mitigation — The effort to lessen the damages from a particular project through modifying a project, providing alternatives, compensating for losses, or replacing lost values.

Morphology — Study of shape, configuration, or form.

Navigable waters — A water body with a bed and a bank that can float a watercraft at any point in the year.

Natural beauty — (as defined by Bone Lake Comprehensive Lake Management Plan Advisory Committee) Wildlife, plants, trees, clear water, quiet solitude, and a variety of scenery, views of the lake. Where development occurs, it is preferable to have minimal views of buildings.

Niche — The position or role of an organism within its community and ecosystem.

Nitrogen — A chemical constituent (nutrient) essential for life. Nitrogen is a primary nutrient necessary for plant growth.

Nonpoint source pollution (NSP) — Pollution whose sources cannot be traced to a single point such as a municipal or industrial wastewater treatment plant discharge pipe. Nonpoint sources include eroding farmland and construction sites, urban streets, and barnyards. Pollutants from these sources reach water bodies in runoff. They can best be controlled by proper land management.

Non-target species — A species not intentionally targeted for control by a pesticide or herbicide.

Nutrient — Any chemical element, ion, or compound required by an organism for the continuation of growth, reproduction, and other life processes.

Nutrient management plan — A guidance document that provides fertilizer and manure spreading recommendations for crop fields based upon soil test results and crop needs. Plans are sometimes referred to as NRCS 590 plans for the Natural Resources Conservation Service Standard that guides their preparation.

Oligotrophic — Refers to an unproductive and nutrient-poor lake. Such lakes typically have very clear water. (See also "Eutrophic" and "Mesotrophic.")

Ordinary high water mark — The point on the bank or shore up to which the water leaves a distinct mark on the shore or bank from its presence, wave action, or flow. The mark may be indicated by erosion, destruction of or change in vegetation, or another easily recognizable characteristic.

Oxidation — A chemical process that can occur with the uptake of oxygen.

pH — The negative logarithm of hydrogen ion activity. pH values range from 1-10 (low pH values are acidic and high pH levels are alkaline).

Peat — Soil material formed by partial decomposition of plant material.

Pesticide — Any chemical agent used to control specific organisms, such as insecticides, herbicides, fungicides, etc.

Phosphorus — A chemical constituent (nutrient) essential for life. Phosphorus is a primary nutrient necessary for plant growth. When phosphorus reaches lakes in excess amounts, it can lead to over-fertile conditions and algae blooms.

Photosynthesis — Production of organic matter (carbohydrate) from inorganic carbon and water in the presence of light.

Phytoplankton — Free floating microscopic plants (algae).

Point (pollutant) source — A source of pollutants or contaminants that discharges through a pipe or culvert. Point sources, such as an industrial or sewage outfall, are usually readily identified.

Pollution — The presence of materials or energy whose nature, location, or quantity produces undesired environmental effects. Pollutants can be chemicals, disease-producing organisms, silt, toxic metals, and oxygen-demanding materials, to name a few.

Primary production — The rate of formation of organic matter or sugars in plant cells from light, water, and carbon dioxide. Algae are primary producers.

Problem statement — A written description of important uses of a water body that are being affected by the presence of problem aquatic plants.

Producers — Organisms able to build up their body substance from inorganic materials.

Productivity — A measure of the amount of living matter which is supported by an environment over a specific period of time. Often described in terms of algae production for a lake.

Public awareness/outreach — Programs designed to share technical information and data on a particular topic, usually associated with activities on or around a water body.

Recruitment — The process of adding new individuals to a population.

Residence time — The average length of time that water or a chemical constituent remains in a lake.

Riparian — Belonging or relating to the bank of a lake, river, or stream.

Riprap — Broken rock, cobbles, or boulders placed on the bank of a stream to protect it against erosion.

Rotovation — A mechanical control method of tilling lake or river sediments to physically dislodge rooted plants. Also known as bottom tillage or derooting.

Runoff — Water from rain, snowmelt, or irrigation that flows over the ground surface and returns to streams and lakes. Runoff can collect pollutants from air or land and carry them to receiving waters.

Secchi depth — A measure of transparency of water (the ability of light to penetrate water) obtained by lowering a secchi disc into the water until it is no longer visible. Measured in units of meters or feet.

Secchi disc — A 20-cm (8-inch) diameter disc painted white and black in alternating quadrants. It is used to measure light transparency in lakes.

Sediment — Soil particles suspended in and carried by water as a result of erosion.

Sensitive areas — Plant communities and other elements that provide important fish and wildlife habitat as designated by the Wisconsin Department of Natural Resources.

Septic system — Sewage treatment and disposal for homes not connected to sewer lines usually with a tank and drain field. Solids settle to the bottom of the tank. Liquid percolates through the drain field.

Standing crop — The biomass present in a body of water at a particular time.

Storm sewers — A system of sewers that collect and transport rain and snow runoff. In areas that have separated sewers, such stormwater is not mixed with sanitary sewage.

Stratification — Horizontal layering of water in a lake caused by temperature-related differences in density. A thermally stratified lake is generally divided into the epilimnion (uppermost, warm, mixed layer), metalimnion (middle layer of rapid change in temperature and density) and hypolimnion (lowest, cool, least mixed layer).

Submersed plants — An aquatic plant that grows with all or most of its stems and leaves below the water surface. Submersed plants usually grow rooted in the bottom and have thin, flexible stems supported by the water. Common submersed plants are milfoil and pondweeds.

Susceptibility — The sensitivity or level of injury demonstrated by a plant to effects of an herbicide.

Suspended solids (SS) — Small particles of solid pollutants suspended in water.

Systemic herbicide — An herbicide in which the active chemicals are absorbed and translocated within the entire plant system, including roots. Depending on the active ingredient, systemic herbicides affect certain biochemical reactions in the plant and can cause plant death. SONAR® and RODEO® are systemic herbicides.

Thermal stratification — Horizontal layering of water in a lake caused by temperature-related differences in density. A thermally stratified lake is generally divided into the epilimnion (uppermost, warm, mixed layer), metalimnion (middle layer of rapid change in temperature and density), and hypolimnion (lowest, cool, least mixed layer).

Thermocline — Zone (horizontal layer) in a water body in which there is a rapid rate of temperature decrease with depth. Also called the metalimnion, it lies below the epilimnion.

Tolerable soil loss — The tolerable soil loss rate, commonly referred to as “T,” is the maximum average annual rate of soil erosion for each soil type that will permit a high level of crop productivity to be sustained economically and indefinitely (ATCP 50.01(16)).

Topographic map — A map showing elevation of the landscape in contours of equal height (elevation) above sea level. This map can be used to identify boundaries of a watershed.

Total maximum daily loads — The maximum amount of a pollutant that can be discharged into a stream without causing a violation of water quality standards.

Transect lines — Straight lines extending across an area to be surveyed.

Tributaries — Rivers, streams, or other channels that flow into a water body.

Trophic state — The level of growth or productivity of a lake as measured by phosphorus content, algae abundance, and depth of light penetration. Lakes are classified as oligotrophic (low productivity, "good" water quality), mesotrophic (moderate productivity), or eutrophic (high productivity; "poor" water quality).

Turbid — Lack of water clarity. Turbidity is closely related to the amount of suspended materials in water.

Uniform dwelling code — A statewide building code specifying requirements for electrical, heating, ventilation, fire, structural, plumbing, construction site erosion, and other construction related practices.

University of Wisconsin Extension (UWEX) — A special outreach and education branch of the state university system.

Vascular plant— A vascular plant possesses specialized cells that conduct fluids and nutrients throughout the plant. The xylem conducts water and the phloem transports food.

Variance — Governmental permission for a delay or exception in the application of a given law, ordinance, or regulation. Also, see water quality standard variance.

Waste — Unwanted materials left over from manufacturing processes; refuse from places of human or animal habitation.

Water body usage map — A map of a water body showing important human use areas or zones (such as swimming, boating, fishing) and habitat areas for fish, wildlife, and waterfowl.

Water quality criteria — A measure of the physical, chemical, or biological characteristics of a water body necessary to protect and maintain different water uses (fish and aquatic life, swimming, etc.).

Water quality management area (WQMA) — The area within 1,000 feet from the ordinary high water mark of navigable waters that consists of a lake, pond or flowage; the area within 300 feet from the ordinary high water mark of navigable waters that consist of a river or stream; and a site that is susceptible to groundwater contamination, or that has the potential to be a direct conduit for contamination to reach groundwater. (NR 151.015(24))

Watershed — The entire surface landscape that contributes water to a lake or river.

Watershed management — The management of the natural resources of a drainage basin for the production and protection of water supplies and water-based resources.

Wetland — Areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support a variety of vegetative or aquatic life.

Wetland vegetation requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally include swamps, marshes, bogs, and similar areas.

Wisconsin administrative code — The set of rules written and used by state agencies to implement state statutes. Administrative codes are subject to public hearing and have the force of law.

Zooplankton — Microscopic animal plankton in water (Gr. *zoion* animal). *Daphnia* sp. or water fleas are freshwater zooplankton.

Glossary sources: Washington State Department of Ecology; Maribeth Gibbons Jr.; Wisconsin priority watershed planning guidance.

Appendix F. Additional References

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Appendix G. Important Contacts

Ecological Integrity Services	
Steve Schieffer, Owner	715.554.1168
Harmony Environmental	
Cheryl Clemens, Owner	715.268.9992
Polk County Land and Water Resources Department	715.485.8699
Jeremy Williamson, Water Quality Specialist	
Dave Peterson, Conservation Planner	
Lake Wapogasset & Bear Trap Lake Sanitary District	715.268.7761

Web Sites

Lake Improvement Association: http://lakewapogasset.com

Lake Wapogasset Bear Trap Lake Sanitary District: http://wapobear.com

Polk County Land and Water Resources Dept.: www.co.polk.wi.us/landwater/

WAL / Wisconsin Association of Lakes: www.wisconsinlakes.org/

Wisconsin DNR: www.dnr.state.wi.us/ http://www.communityhotline.com