# *Bone Lake Management Plan*

## *Phase III: Lake Management Plan*

*Prepared for*
*Bone Lake Management District*

*October 1999*



BARR

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***Prepared for***
***Bone Lake Management District***

***Prepared by***
***Barr Engineering Co.***
***with assistance from***
***Bone Lake Management District***
***Polk County Land Conservation Department***
***Wisconsin Department of Natural Resources***

***October 1999***

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| | |
|---|---|
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# Executive Summary

The study described by this report was initiated by the Bone Lake Management District to provide information to Bone Lake Management District Commissioners, water resource managers, and citizens regarding the management of Bone Lake.

During 1996, the Bone Lake Management Commission completed the first phase of a three-phase project to develop a Lake Management Plan. Phase I was designed to assemble the requisite data to provide an understanding of the interacting physical, chemical, and biological processes controlling the water quality of Bone Lake. The project included taking periodic water samples from Bone Lake, two inflowing streams, and the lake's outlet during the June through September period and sending them to the Wisconsin Department of Hygiene Lab to be analyzed. Additional on lake activities included monitoring of water clarity (Secchi disc) and temperature, dissolved oxygen, and conductivity of the water column at two sites in the lake. On shore activities included monitoring the lake level and precipitation on a daily basis throughout the spring, summer, and fall. A study of the data collected led to the following conclusions (Barr, 1997) :

- Bone Lake exhibited excellent water quality during the early part of the summer.
- The lake's water quality deteriorated throughout the summer.
- Excessive algal blooms during August and September reduced the lake's water transparency to a level considered undesirable for recreational users.
- The lake's water quality problems result from excess phosphorus concentrations in the upper layers of the lake.
- Higher than expected yields of algae from the available phosphorus further exacerbated the lake's water quality problems.
- A management plan for the lake is needed to improve and protect its water quality.

During the summer of 1998, Bone Lake was not sprayed with an algicide to control algal blooms. A water quality monitoring program was completed during late July through mid September to determine the lake's total phosphorus, chlorophyll, and Secchi disc levels. The 1998 results were compared with the results of 1996. Copper sulfate was sprayed on portions of the lake each week during 1996. The 1998 data were generally similar to data collected during 1996 and indicate that spraying the lake with copper sulfate does not result in significant water quality improvement. The 1998 results indicate that the water quality results of 1996 and the water quality model based upon 1996 data are representative of current conditions.

Phase II involved preparation of hydrologic and phosphorus budgets for existing watershed land use conditions. The budgets were used to provide an understanding of the sources of phosphorus to Bone Lake and their effects on the lake's water quality.

A visit to the Bone Lake watershed during the fall of 1998 revealed that various portions of the lake's watershed are made up of depressions which do not directly contribute overland flow to Bone Lake under normal climatic conditions. Approximately 3,411 acres of the 11,977-acre total watershed area is essentially landlocked and does not contribute surface flow to the lake. Therefore, the hydrologic and phosphorus budgets for Bone Lake were revised to exclude contributions of landlocked areas of the watershed. Phosphorus budget results indicate:

- About two thirds of the total phosphorus load to Bone Lake comes from surface runoff.

- Internal load (i.e., recycled phosphorus from the lake's sediments) comprises approximately 14 percent of the lake's annual load.

- The remaining load consists of contributions from septic systems (about 7 percent), and atmospheric deposition (i.e., dry deposition and direct rainfall on the lake surface, which cleans the air of its phosphorus, and contributes 13 percent of the annual load).

The third phase of the project, described in this report, involves the preparation of the Bone Lake Management Plan. The first step in the development of the management plan was the completion of a membership survey to assist with the establishment of a long-term water quality goal for the lake. A survey was sent to 553 property owners on Bone Lake and 252 completed survey forms were received (a 46 percent return rate). Survey results indicated the management goal of greatest importance to the members was improvement of the lake's water quality. The management goal of second greatest importance to the members was protection of the lake's water quality.

The second step in the development of the management plan was the establishment of long-term water quality goals for Bone Lake. In response to the membership survey, two goals were established for Bone Lake:

- The first goal is to achieve an average summer total phosphorus concentration in the lake's mixed surface waters (i.e., upper 6 feet) not to exceed 18 µg/L, the midpoint of the mesotrophic category (i.e., moderate phosphorus concentration, moderate productivity level). Goal achievement would result in 38 percent and 24 percent reductions in average summer total phosphorus concentrations in the north and south basins, respectively.

- The second goal is to protect the lake's water quality from additional degradation.

The third step in the development of the lake's management plan was the completion of water quality modeling scenarios to determine water quality improvements resulting from reduction of the lake's internal load and removal of phosphorus loading from shoreland septic systems. Water quality modeling was also completed to determine impacts from various watershed development scenarios and from the malfunction of all current septic systems. Finally, modeling was completed to determine mitigation of watershed development impacts by BMPs. Modeling results indicated:

- An alum treatment of Bone Lake to remove 90 percent of the current internal load is estimated to result in a summer average total phosphorus concentration of 17 µg/L (i.e., a 39 percent reduction) in the north basin and 15 µg/L (i.e., a 35 percent reduction) in the south basin. The alum treatment will achieve the lake's water quality improvement goal.

- Bone Lake's water quality is highly susceptible to increasing development within the lake's watershed. The annual average total phosphorus concentration in Bone Lake would be expected to increase by approximately 30 percent if an additional 50 percent of the watershed were developed into low density residences (i.e., cottages) and would increase by approximately 65 percent if the entire watershed were developed into low density residences.

- Protection of the water quality of Bone Lake will occur if structural Best Management Practices (BMPs) were instituted for all development scenarios. Structural BMPs were assumed to be detention basins that remove 60 percent of total phosphorus.

- Failure of all of the septic systems around the lakeshore would result in an estimated increase in the annual average total phosphorus concentration of 14 percent at the north basin and 22 percent at the south basin.

- Installation of a sanitary sewer system or holding tanks for all residences would result in less than 4 percent reduction in average summer total phosphorus concentration in the north basin and no change in the average summer total phosphorus concentration of the south basin.

The final step in the development of the lake's management plan was the recommendation of specific management actions to improve and preserve the quality of Bone Lake. The recommended actions include an alum treatment to improve the water quality of Bone Lake by reducing the quantity of phosphorus loaded to the lake by internal loading. To protect the water quality of Bone Lake under future development conditions, Best Management Practices (BMPs) to reduce the quantity of phosphorus in watershed runoff waters reaching the lake are recommended. BMPs include:

- Stormwater ordinance
- Shoreland ordinance
- Septic system ordinance
- Additional watershed BMPs

Details for these recommendations are found in the Bone Lake Management Plan section of this report.

A long-term water quality monitoring program is recommended to determine goal achievement of the Bone Lake Management Plan. Annual Secchi disc monitoring (i.e., the WDNR Self Help Program) and monitoring the mixed surface waters for total phosphorus and chlorophyll one year per every three years is recommended. Sample collection should be at a biweekly to weekly frequency (i.e., similar to the 1996 monitoring program).

Whenever feasible, the Bone Lake Management Commission should apply for additional lake management grant monies or lake protection grant monies to partially fund its projects.

# Bone Lake Management Plan
# Phase III: Lake Management Plan

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# Introduction

Bone Lake in Polk County, Wisconsin, has a reputation as one of the better muskellunge lakes in the state. However, the lake is very fertile and has been experiencing problems with algal blooms and weed beds for more than 20 years. The local people were concerned about the lake and formed the Bone Lake Management District in 1975 under Chapter 33, Wisconsin Statutes. They requested and received technical assistance from the Office of Inland Lake Renewal, who conducted a one-year data collection program during 1977 through 1978. A report, entitled *"Feasibility Study Results, Management Alternatives,"* was issued during 1980 (Wisconsin Department of Natural Resources, 1980). The study concluded that Bone Lake was a eutrophic body of water and ample nutrients were present to support an abundant aquatic "crop" of algae. The study concluded that significant quantities of phosphorus were being supplied to the algae from an inlake recycling mechanism. Alum treatment of the lake was recommended to reduce inlake phosphorus levels. Other management alternatives that were recommended included conducting macrophyte harvesting on selected areas, protecting the watershed and insuring the correction of existing inadequate shoreline disposal systems.

WDNR Fish Management and Water Resources personnel have cooperated with the Bone Lake organization to control the lake's algae and macrophyte problems while protecting the lake's critical areas. Management of the lake's algal blooms has been supported by the WDNR through the issuance of annual algicide permits to allow copper sulfate treatments of Bone Lake each summer. A survey to document aquatic plant "sensitive area" sites on the lake was conducted in 1988 and 1989. Eleven sites on Bone Lake were designated as sensitive areas because they provide valuable spawning, feeding, and nursery areas for fish populations, waterfowl, and other aquatic life (see Appendix A). Specific aquatic management recommendations were made. The WDNR uses the recommendations as a basis for decisions regarding macrophyte control permits (i.e., herbicide treatment or harvesting of macrophytes).

From 1989 through the present, a volunteer from Bone Lake has collected water transparency data through the WDNR "Self-Help" program. The data show a decline in the lake's water transparency throughout the summer as algal blooms increase. The data suggest the lake is eutrophic and that nutrients increase throughout the summer. In recent years, the Bone Lake Management District has been treating the lake with copper sulfate to manage its algal blooms. The lake has generally been treated with algicide weekly throughout each summer.

During 1993, a survey among property owners was completed to define concerns and desired actions to deal with riparian concerns. Many respondents favored a strengthening of the lake district and the development of a long-term management plan for the lake (Bone Lake Management District, 1993). Consequently, the Bone Lake Management District initiated a three-phase project to develop a management plan. The three phases of the project include:

- **Phase I**—Collection of data (Barr, 1997)
- **Phase II**—Preparation of annualized hydrologic and phosphorus budgets for existing watershed land use conditions (Barr, 1997)
- **Phase III**—Preparation of the lake management plan.

This report discusses the methodology, results, and conclusions from Phase III of the Lake Management Plan. The Phase III portion consisted of:

- A water quality monitoring program to determine whether not spraying the lake with an algicide results in water quality changes
- Revision of the hydrologic and phosphorus budgets to exclude landlocked portions of the watershed
- Establishment of long-term water quality goals for Bone Lake;
- An evaluation of water quality modeling to determine whether an alum treatment would achieve the lake's goal for water quality improvement;
- An evaluation of water quality modeling scenarios of Bone Lake and its tributary watershed to predict the effect of new sources of phosphorus following various levels of development;
- An evaluation of water quality modeling scenarios of Bone Lake and its tributary watershed to determine whether BMPs would protect the lake from degradation following various levels of development;
- An evaluation of water quality modeling scenarios of Bone Lake to determine impacts of failed septic systems and the impact of removing septic system inputs of phosphorus to the lake;
- A lake management plan to achieve the long-term water quality goals of Bone Lake;
- A long-term monitoring plan to determine goal achievement.

# Phase I Summary: Water Quality Study of Bone Lake

The 1996 water quality survey of Bone Lake was designed to provide an understanding of the interacting physical, chemical, and biological processes controlling the water quality of Bone Lake. This information was used for model calibration during Phase II of the project. It was also designed to provide baseline water quality information for the lake to help the Bone Lake Management District complete its Lake Management Plan in the Phase III portion of the project. Table 1 presents the physical morphometry of Bone Lake.

**Table 1. Bone Lake Physical Morphometry**

| | |
|---|---|
| Normal Elevation | 1,152.0 feet (MSL) |
| Surface Area @ Normal | 1,677 acres |
| Maximum Depth | 38 feet |
| Volume @ Normal | 36,460 acre-feet |
| Mean Depth (Volume/Surface Area) | 22 feet |
| Total Watershed Area, including non-contributing area | 11,977 acres |
| Watershed Area to Lake Area Ratio | 7:1 |

Bone Lake has two distinct basins, and samples were collected from each of the two basins shown on Figure 1. Water samples were collected from Bone Lake biweekly during June and July and weekly from August through mid-September. Samples were collected from 0-2 meters (i.e., integrated composite samples) and analyzed for various water quality constituents including nutrients (i.e., phosphorus and nitrogen species), and biomass (i.e., chlorophyll analyses), and water quality indicator parameters (pH, and alkalinity). In addition, total dissolved phosphorus samples were collected at approximately 1.5 meter intervals from the 1.5 meter depth to approximately one-half meter above the lake bottom. In addition, measurements of Secchi disc transparency, temperature, dissolved oxygen, and specific conductance were completed during each sample event.

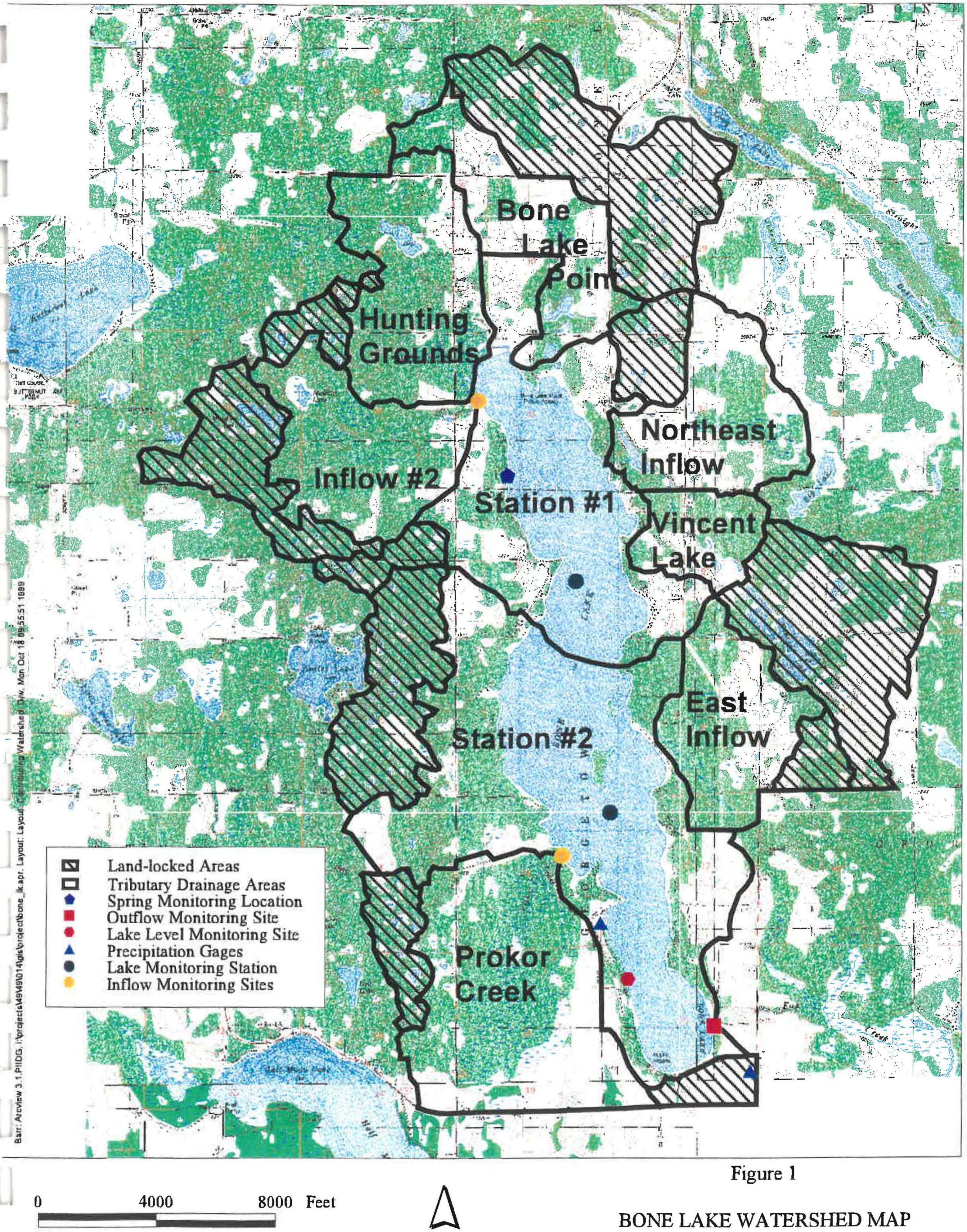



Figure 1

BONE LAKE WATERSHED MAP
BONE LAKE MANAGEMENT PLAN

## 1996 Bone Lake Water Quality

Data collected from Bone Lake during 1996 indicate its water quality is excellent during the spring and early summer period. However, the water quality deteriorated throughout the summer, and was considered poor during the late summer period. Results of each of the water quality monitoring parameters, below, are discussed in the following sections:

- Total Phosphorus
- Chlorophyll *a*
- Secchi Disc Transparency
- Temperature and Dissolved Oxygen

## Total Phosphorus

Total phosphorus is the nutrient limiting algal growth within Bone Lake. As such, it indicates the lake's potential for algal growth, and indicates the lake's level of eutrophication. Total phosphorus data collected from Bone Lake during 1996 indicate the lake would have a designated trophic status of eutrophic. This means the lake is rich in nutrients and has a high productivity. Total phosphorus data collected from Bone Lake were within the mesotrophic (i.e., moderate amount of nutrients category) during the spring and early summer period and the eutrophic (i.e., nutrient rich) category during the late summer period. The lake's two basins exhibited similar phosphorus concentrations during the growing season. The average epilimnetic (i.e., surface waters—upper 6 feet) summer phosphorus concentrations at Stations 1 and 2 were 0.028 mg/L and 0.023 mg/L, respectively.

## Chlorophyll *a*

Chlorophyll *a* is a pigment found within algae. Its measurement indicates the quantity of algae found within a lake, and provides a measure of a lake's level of eutrophication. Chlorophyll *a* data collected from Bone Lake indicate the lake's trophic status ranges from mesotrophic during the late spring period to eutrophic during the summer period. Similar chlorophyll *a* concentrations were observed in the two basins during the late spring and early summer period; however, the north basin (i.e., Station 1) exhibited higher chlorophyll *a* concentrations than the south basin during the late summer period. Summer average epilimnetic (i.e., surface waters—upper 6 feet) chlorophyll *a* concentrations at Stations 1 and 2 were 32.4 and 23.8 µg/L, respectively. The seasonal pattern of chlorophyll *a* concentrations was similar to phosphorus concentrations in the two basins, confirming that the lake's algal growth is directly related to phosphorus levels. The chlorophyll data indicate a relatively high yield of algal biomass resulted from the lake's available phosphorus.

## Secchi Disc

Secchi disc transparency provides a measure of a lake's water clarity. Because increasing eutrophication is associated with decreasing water clarity, Secchi disc measurements can provide an indication of a lake's level of eutrophication. Secchi disc measurements in Bone Lake generally mirrored phosphorus and chlorophyll *a* concentrations. The data show that the lake's water transparency is largely determined by algal abundance and the lake's algal abundance is largely determined by the lake's phosphorus concentration. Based on a study by the Metropolitan Council of the Twin Cities metropolitan area (Osgood, 1989), the 1996 average summer Secchi disc transparencies at Stations 1 and 2 (1.7 and 1.8 meters, respectively) indicate that the lake generally experiences moderate recreational use-impairment.

## Temperature and Dissolved Oxygen

Depth/time relationships or isopleths were used to determine the stratification (mixing) pattern at each Bone Lake sample site (i.e., temperature isopleths) and to assess the loss of oxygen near the lake bottom (i.e., oxygen isopleths). Temperature isopleths indicate Bone Lake was thermally stratified during the spring and summer period. The density difference between the warm surface waters and the cold bottom waters caused the hypolimnion (bottom waters) to be "sealed off" from the atmosphere by the epilimnion (surface waters). The oxygen in the hypolimnion (bottom waters) was not replenished by wind and wave action as occurred in the epilimnetic (surface) waters. Instead it was depleted by decomposition of organic matter. The dissolved oxygen isopleths indicated that extremely low dissolved oxygen concentrations were noted in the hypolimnion (bottom waters) at all sampling locations during the summer period. Oxygen depletions in the bottom waters of Bone Lake result in the release of phosphorus from its lake sediments. This release of phosphorus from the sediments is known as the lake's "internal load." The lake's thermal stratification can "seal off" most of the phosphorus rich bottom waters from the epilimnion (surface waters) until the fall overturn period. However, some of the phosphorus recycled from bottom sediments can diffuse into the epilimnion and contribute to increased algal growth during the late-summer months. Hence, the internal phosphorus load from the lake's bottom waters appears to be at least partially responsible for the increasing epilimnetic phosphorus concentrations during the late-summer period and is likely released into the surface waters during the fall overturn period.

# Phase II Summary: Phosphorus Budget and Lake Water Quality Mass Balance Model

Preparation of the 1996 hydrologic and phosphorus budgets for existing watershed land use conditions was designed to provide an understanding of the sources of phosphorus and how the inputs affect the water quality of Bone Lake. The phosphorus budget prepared during the Phase II study estimated an annual total annual phosphorus load into Bone Lake of approximately 2,067 pounds, based upon the 1995-1996 data. The modeled water quality with this load was an average annual total phosphorus concentration of 0.047 mg/L for the north basin and 0.030 mg/L for the south basin. The modeled water quality was higher than the observed water quality (i.e., an average annual total phosphorus concentration of 0.028 mg/L for the north basin and 0.023 mg/L for the south basin). For this reason, additional adjustments were made to the watershed phosphorus export coefficients during the Phase III project. Also, the lake's water quality model was refined during the Phase III project. The results of the Phase III adjustments are discussed in the Phase III results section.

# Phase III: Methods

The methods used for Phase III of the Lake Management Plan project are discussed in the following sections of this report. Included in the discussion are:

- 1998 Water Quality Monitoring Program
- Revised Hydrologic and Phosphorus Budget Determinations
- Membership Survey
- Water Quality Modeling to Determine Benefits of Reduced Internal Loading
- Water Quality Modeling to Determine Impacts of Septic Tank Malfunction or Removal
- Water Quality Modeling to Determine Impacts of Additional Watershed Development
- Water Quality Modeling to Determine Benefits of Best Management Practices (BMPs)

## 1998 Water Quality Monitoring Program

During the period July 23 through September 10, Bone Lake was monitored weekly by Bone Lake volunteers to determine the lake's water quality. A 0-2 meter (i.e., 0- to 6-feet) composite sample was collected from Stations 1 and 2 on each occasion and analyzed by the Barr Engineering Company Laboratory for total phosphorus and chlorophyll *a*. Secchi disc transparency was measured at each location on each sample occasion.

## Revised Hydrologic and Phosphorus Budget Determinations

A visit to the Bone Lake watershed during the fall of 1998 revealed that various portions of the lake's watershed area are made up of depressions which do not directly contribute overland flow to Bone Lake under normal climatic conditions. Approximately 8,566 acres of the 11,977-acre total watershed area directly contribute overland flow to Bone Lake, while the remaining watershed area is essentially landlocked. Therefore, the hydrologic and phosphorus budgets for Bone Lake were revised to exclude contributions of landlocked areas of the watershed. The revised hydrologic and phosphorus annual loadings were then used to revise the Bone Lake water quality model (i.e., Dillon and Rigler, 1974, modified by Nurnberg, 1984). Table 2 summarizes the watershed revisions (i.e., landlocked and directly contributing subwatershed areas of the Bone Lake watershed).

Table 2. **Bone Lake Subwatershed Areas**

| Subwatershed | Directly Contributing Watershed Areas (acres) | Non-Contributing Watershed Areas (acres) | Total Watershed Area, Including Non-Contributing Area (acres) |
|---|---|---|---|
| Station #1 | 1,485 | 324 | 1,809 |
| Station #2 | 2,367 | 669 | 3,036 |
| Inflow #2 | 690 | 518 | 1,208 |
| Prokor Creek | 1,184 | 101 | 1,285 |
| Hunting Grounds | 777 | 0 | 777 |
| Bone Lake Point | 590 | 930 | 1,520 |
| East Inflow | 568 | 101 | 669 |
| Northeast Inflow | 630 | 0 | 630 |
| Vincent Lake | 275 | 768 | 1,043 |
| Total Watershed Area | 8,566 | 3,411 | 11,977 |

Because of the changes to the directly contributing watershed area shown in Table 2, modifications were made to the watershed phosphorus export coefficients to calibrate the water quality model. The changes reduced the gap between the predicted and observed in-lake phosphorus concentrations noted during Phase II. A description of the methodology for the completion of the phosphorus budget, including revisions follows.

The watershed surface runoff component was estimated using an annual phosphorus export coefficient for each land use type within the direct subwatersheds. An annual phosphorus export coefficient of 0.04 lbs/ac/yr was used for the forested portions of the subwatersheds. This value closely corresponds with that observed by Taylor et al. (1971), Nicholson (1977) and Dillon and Kirchner (1975). The row cropland phosphorus export coefficient of 0.45 lbs/ac/yr, used in this analysis, agrees well with that observed by others (Bradford, 1974; Alberts et al., 1978). The non-row cropland export coefficient of 0.22 lbs/ac/yr, used in this analysis, generally agrees with that observed by Harms et al. (1974). The residential phosphorus export coefficient of 0.27 lbs/ac/yr corresponds with other published data (Much and Kemp, 1978; Mattraw and Sherwood, 1977. Finally, Harms et al. (1974) obtained a phosphorus export coefficient of 0.22 lbs/ac/yr, which corresponds well with the 0.18 lbs/ac/yr used for the pasture/CRP land use within the direct subwatersheds.

Internal loading was estimated for each of the lake basins using the total phosphorus data from the lake's water column. The summer internal load, for each basin, is the product of the fraction of hypolimnetic phosphorus released to the surface waters, the sediment phosphorus release rate, the fraction of the lake basin surface area experiencing anoxia, and the duration of hypolimnetic anoxia. The 1996 dissolved oxygen profiles of each basin were used to estimate the duration of anoxia (D.O. <0.5 mg/L). The fraction of each lake basin's total surface area experiencing anoxia was based on the depths of the observed summer anoxia and the morphometry of each basin. The average sediment total phosphorus release rate of 2.0 mg/m$^2$/day was estimated using the total phosphorus data from the lake's water column. This sediment release rate is lower than the release rates determined from the sediment phosphorus release experiment (approximately 6 mg/m$^2$/day) conducted as part of this study, but agrees well with the observed increase of total phosphorus over the anoxic portion of the hypolimnetic waters of each basin during the summer of 1996. Finally, the fraction of hypolimnetic total phosphorus released to the surface waters was estimated to facilitate the calibration of the lake mass balance model. For the calibrated model, this fraction was 0.20 for each basin. This release fraction agrees with that observed by Einsele (1936).

An atmospheric wet and dry deposition rate of 0.09 lbs/ac/yr, which agrees well with Wright (1976) and Burwell et al. (1975), was applied to the surface area of Bone Lake. The groundwater flow component of the phosphorus budget was determined using the inflow volume from the hydrologic budget and an average groundwater total phosphorus concentration of 0.020 mg/L, based on nearby sampling data collected by the WDNR (1988) and published by the Wisconsin Geological and Natural History Survey (1990). The watershed runoff component from the tributary subwatersheds was estimated using the export coefficients determined from the measured inflow concentrations and estimated runoff from each of the monitored watersheds. The Prokor Creek and Inflow #2 subwatershed total phosphorus export coefficients were 0.026 and 0.108 kg/ha/yr, respectively. The measured Prokor Creek export coefficient is significantly less than published values for other subwatersheds with similar land uses, and may reflect the nutrient removal capacity of the large wetland directly upstream of the outfall.

Phosphorus export rate computations, used in the WILMS model and published by the U.S. EPA for septic systems, were used to estimate an annual load from drain fields (Panuska, 1994). The equation used for Bone Lake estimated the septic system load as follows:

$$\textit{Total Septic System Load (kg/yr)} = Ec_{st} * \textit{Number of capita-years} * (1 - SR)$$

Where:

| | | |
|---|---|---|
| $Ec_{st}$ | = | export coefficient to septic tank systems (0.5 kg/capita/yr) |
| cap.-yrs. | = | # of people occupying a dwelling each year |
| | = | [(# of permanent residents/dwelling) * (# of permanent dwellings)] + [(# of seasonal residents/dwelling) * (x days/yr) * (# of seasonal dwellings)] |
| SR | = | weighted soil retention coefficient (85 for most likely value used in model) |

The Bone Lake property owners survey results were used to determine the number of septic systems within each of the two lake basin areas and the total number of septic systems for both permanent and seasonal residences. The most likely soil retention coefficients of 90 and 40 were chosen for properly and improperly functioning systems, respectively. Ten percent of the septic systems were assumed to be improperly functioning, yielding a weighted soil retention coefficient of 85. Each permanent and seasonal dwelling unit was assumed to have three and five residents, 100 days per year. Finally, the USGS Quad Maps were used in conjunction with the number of septic systems within each township to assign the number of dwellings adjacent to each of the two lake basins of Bone Lake. The ratio of permanent to seasonal residences was kept the same as the total for each basin. The assumptions made regarding the septic system inputs agree well with the estimates made for Balsam Lake in Polk County, Wisconsin (Bursik, 1996).

## Membership Survey

The Bone Lake Board of Commissioners at their October 22, 1998 meeting decided it was important to get input from all property owners in the district on what they wanted for short and long term water quality goals for Bone Lake. The Bone Lake Management District, working cooperatively with Barr Engineering Company and the Polk County Land Conservation Department, developed a survey instrument to survey all property owners in the Bone Lake Management District. In November of 1998 the survey was sent to 553 property owners on Bone Lake. A total of 252 completed survey forms were received (46 percent return rate). A copy of the survey is found in Appendix B.

## Water Quality Modeling to Determine Benefits of Reduced Internal Loading

The Bone Lake water quality model (i.e., Dillon and Rigler, 1974, modified by Nurnberg, 1984), with revised watershed loadings (i.e., excluded landlocked areas of watershed; used revised phosphorus export coefficients) was used to determine the benefits of reduced internal loading to

Bone Lake. The internal load to the lake was reduced by 90 percent and the resultant water quality modeled.

## Water Quality Modeling to Determine Impacts of Septic Tank Malfunction or Removal

The revised Bone Lake water quality model was used to determine the impacts of changes in septic system loading on the water quality of Bone Lake. A modeling scenario was completed in which all current Bone Lake septic systems were assumed to malfunction and the resultant lake water quality was estimated. A second modeling scenario was completed in which all current Bone Lake septic systems were assumed to contribute no phosphorus to the lake (i.e., assumed conversion to holding tanks or sanitary sewer installation) and the resultant lake water quality was estimated.

## Water Quality Modeling to Determine Impacts of Additional Watershed Development

Development of portions of the watershed into cottages represents a potential source of water quality degradation for Bone Lake. Such degradation would be unacceptable to residents who, by responding accordingly to a survey, have expressed a desire to protect the lake's water quality. Consequently, impacts of additional watershed development and resultant water quality impacts to Bone Lake were modeled. Because low density residential development is believed to be the most likely type of development to occur in the Bone Lake watershed, low density development was used for all modeling scenarios. Development scenarios included residential development of an additional 20, 50, 80 and 100 percent of the watershed. The resultant water quality changes to Bone Lake were modeled for each development scenario. Because it is believed that additional residential development of the watershed may result in surface runoff from current landlocked areas, two lake water quality scenarios were modeled for each development scenario. The first scenario assumed all current landlocked areas will remain landlocked under all development scenarios. The second scenario assumed that 100 percent of the watershed contributed surface flow under all modeling scenarios. The two scenarios provide a range of conditions that are expected to occur should additional residential development occur in the watershed.

## Water Quality Modeling to Determine Benefits of BMPs

Water quality modeling was completed to determine whether watershed BMPs can successfully protect Bone Lake from water quality degradation under various watershed development scenarios. Structural BMPs (detention basins) are believed to be the most effective protective measure to prevent water quality degradation of Bone Lake. Consequently, modeling was completed with structural BMPs in place to determine resultant Bone Lake water quality under various development scenarios. Structural BMPs were assumed to be wet detention ponds capable of removing 60 percent of the total phosphorus load entering the ponds. Development scenarios with structural BMPs included residential development of an additional 20, 50, 80, and 100 percent of the watershed. The resultant water quality of Bone Lake was modeled. Because it is believed that additional residential development of the watershed may result in surface runoff from current landlocked areas, two lake water quality scenarios were modeled. The first scenario assumed all current landlocked areas will remain landlocked under all development scenarios. The second scenario assumed that 100 percent of the watershed contributed surface flow under all modeling scenarios. The two scenarios provide a range of conditions that are expected to occur if BMPs are used to mitigate lake water quality impacts of additional residential development in the watershed.

# Phase III: Results and Discussion

The Phase III Results and Discussion section presents the results of the 1998 water quality monitoring program, the revised hydrologic and phosphorus budgets, the revised lake water quality mass balance model, and the results of the membership survey. Finally, results of the following lake water quality modeling scenarios are presented:

- a scenario in which 90 percent of the current internal phosphorus load is removed
- a scenario in which all existing septic systems are assumed to malfunction
- a scenario in which all existing septic systems are assumed to contribute no phosphorus to the lake
- several development scenarios
- the use of Best Management Practices (BMPs) in conjunction with development scenarios

## 1998 Water Quality Monitoring Program

The results of the 1998 monitoring program (See Appendix C) were compared with the results of the 1996 monitoring program (i.e., Phase I). The comparison is presented in Table 3. During 1996, portions of Bone Lake were sprayed weekly with copper sulfate. The lake was not sprayed with copper sulfate during 1998. Even though there were some differences in climatic conditions, temperature, precipitation, and radiant energy during 1996 and 1998, no significant difference in water quality was noted. The data indicate that spraying the lake with copper sulfate does not result in a significant improvement in water quality. The results further indicate that the water quality results of 1996 and the water quality model based upon the 1996 results are representative of current conditions.

**Table 3. Comparison of 1996 and 1998 Bone Lake Water Quality Data, July 23–September 10 Average Values**

| | Station #1 (North) | | | Station #2 (South) | | |
|---|---|---|---|---|---|---|
| Year | Secchi (ft.) | Chlor. *a* (µg/L) | Total P. (µg/L) | Secchi (ft.) | Chlor. *a* (µg/L) | Total P. (µg/L) |
| 1996 | 4.2 | 29.2 | 27 | 4.2 | 25 | 26 |
| 1998 | 3.9 | 22.6 | 26 | 3.9 | 23 | 28 |

## Hydrologic Budget

A visit to the Bone Lake watershed during the fall of 1998 revealed that various portions of the lake's watershed area are made up of depressions which do not directly contribute overland flow to Bone Lake under normal climatic conditions. Approximately 8,566 acres of the 11,977-acre total watershed area directly contribute overland flow to Bone Lake, while the remaining watershed area is essentially landlocked. Therefore, the hydrologic budget was revised. The revised hydrologic budget (i.e., excludes surface runoff contributions from noncontributing landlocked areas) is presented in Table 4. For comparison purposes, the hydrologic budget that assumes the entire watershed, including landlocked areas, contributes flow to the lake is also presented in Table 4.

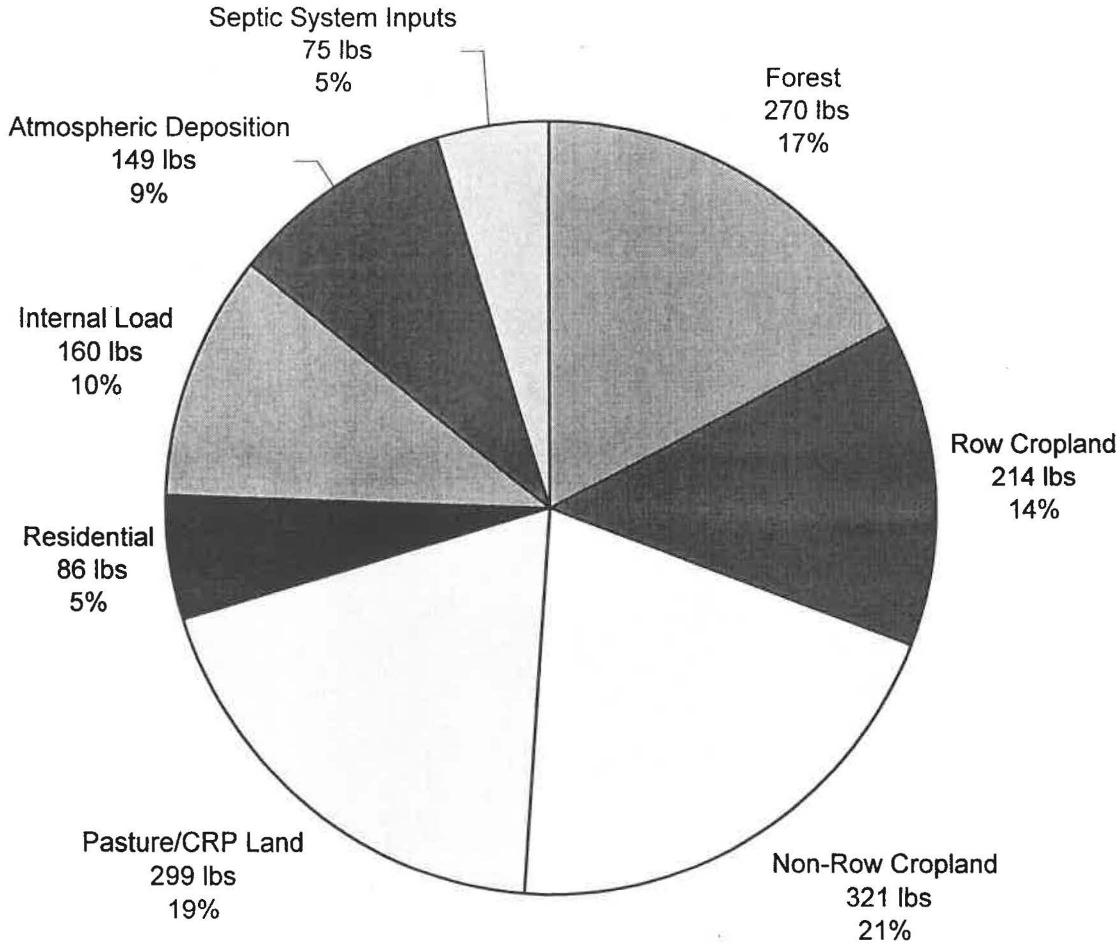
**Table 4. Hydrologic Budget Comparison Between 100% of Watershed Contributing Surface Flow and Exclusion of Landlocked Areas**

| | 100% Watershed Contributes Surface Flow | | Revised to Exclude Landlocked Areas | |
|---|---|---|---|---|
| **Parameter** | **Station 1** | **Station 2** | **Station 1** | **Station 2** |
| Total Drainage Area, including watershed lakes and wetlands (Acres) | 6,987 | 4,990 | 4,447 | 4,119 |
| Annual Runoff Volume (Acre Feet) | 2,212 | 1,385 | 1,330 | 1,081 |
| Residence Time (Years) | 6.55 | 5.22 | 10.42 | 7.42 |

## Phosphorus Budget and Lake Water Quality Mass Balance Model

The phosphorus budget was also revised to exclude portions of the watershed that do not directly contribute overland flow to the lake. Phosphorus budget results are presented in Figures 2 through 7 and in Table 5. Phosphorus budgets presented in Figures 2 through 4 assume landlocked areas do not contribute surface flow to the lake. Figures 2 through 4 present phosphorus budget results for the whole lake, north basin, and south basin, respectively. Phosphorus budgets presented in Figures 5 through 7 assume the entire watershed contributes surface flow to the lake. Figures 5 through 7 present phosphorus budget results for the whole lake, north basin, and south basin, respectively.

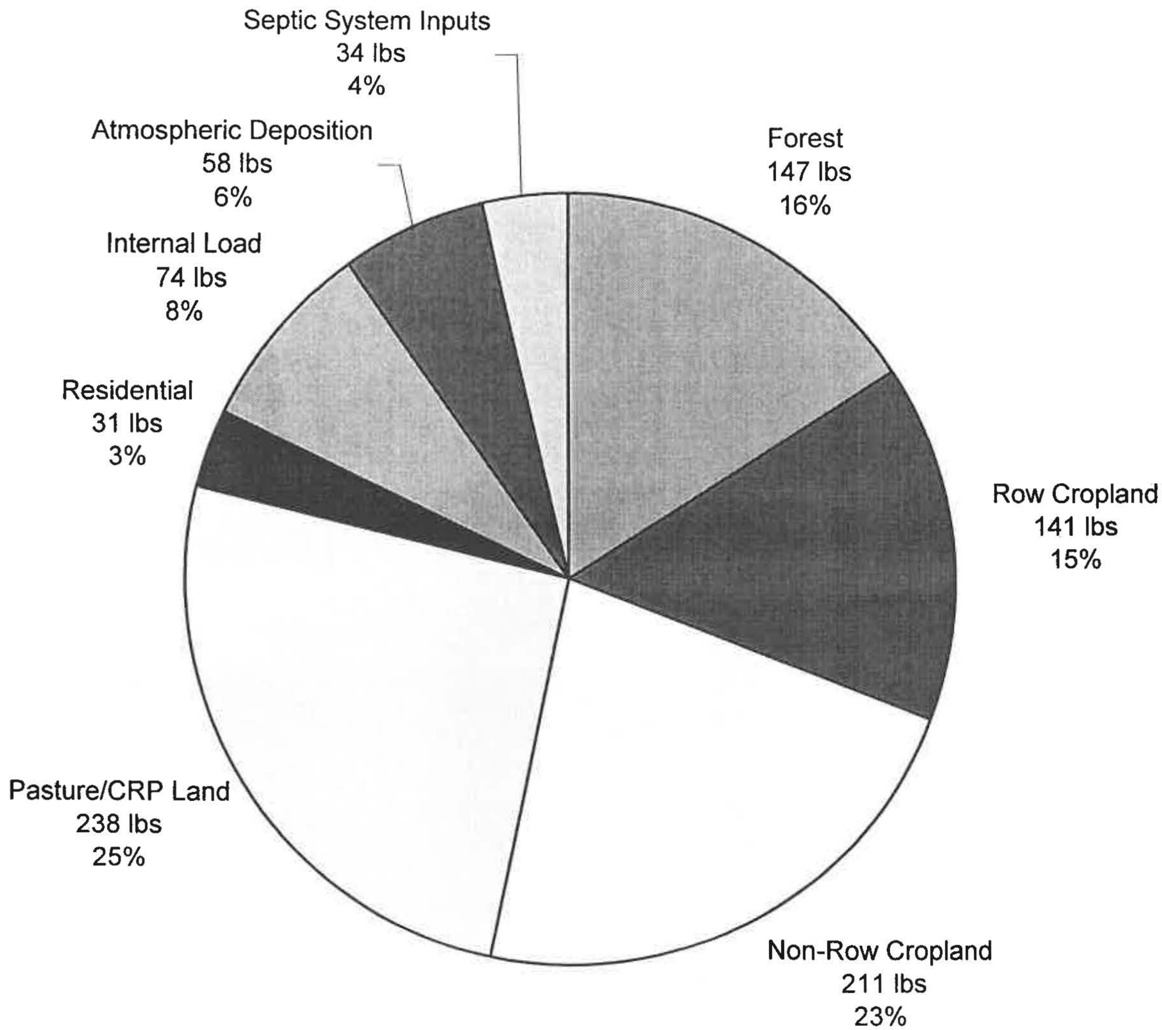
# Bone Lake - Whole Lake
## 1996 Annual Phosphorus Budget




Annual Load = 1,575 lbs.
(Assumes 100 Percent of Watershed Area Contributes Surface Flow)

**Figure 2**

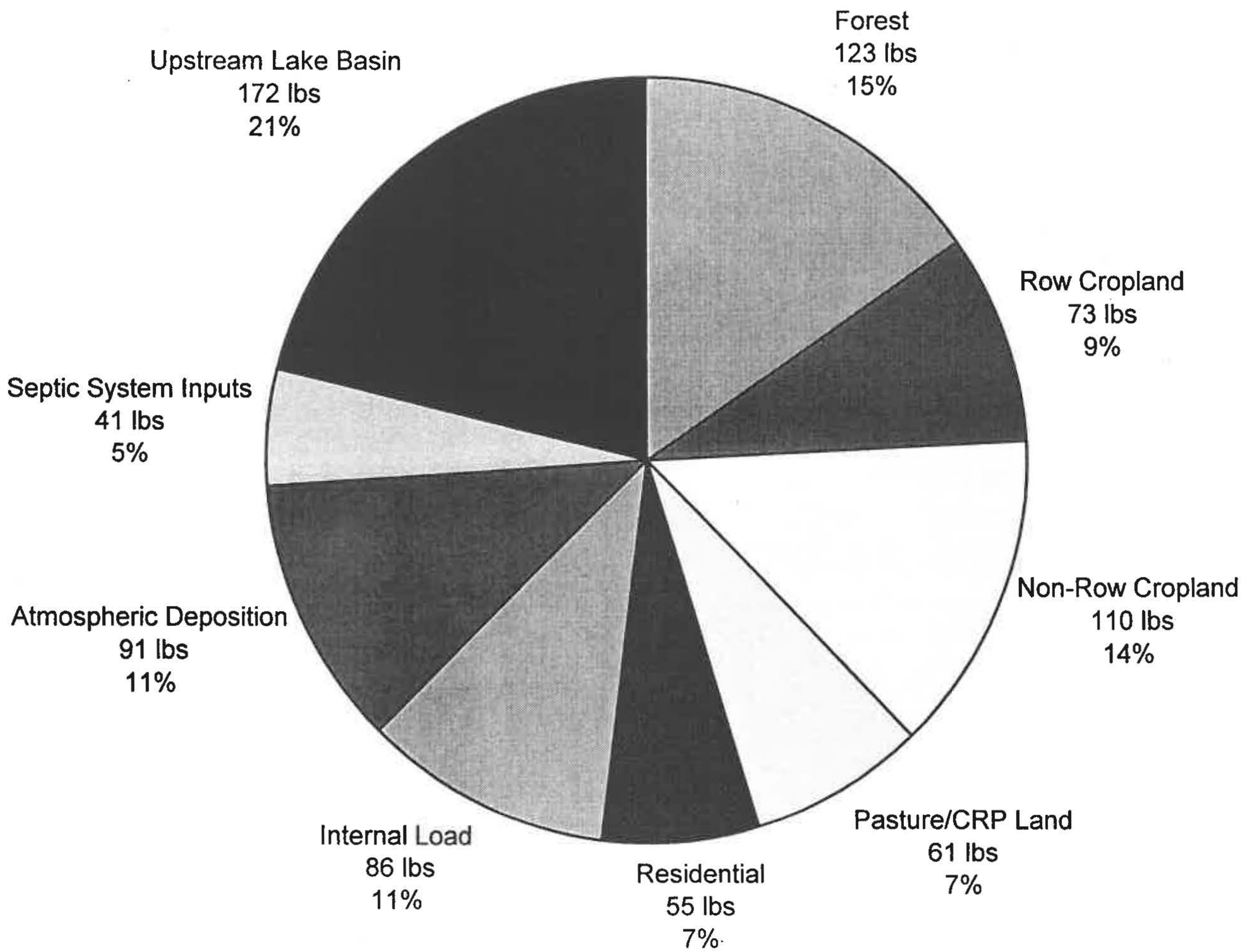
## Bone Lake - Station 1
1996 Annual Phosphorus Budget




Annual Load = 934 lbs.
( Assumes 100 Percent of Watershed Area Contributes Surface Flow)

**Figure 3**

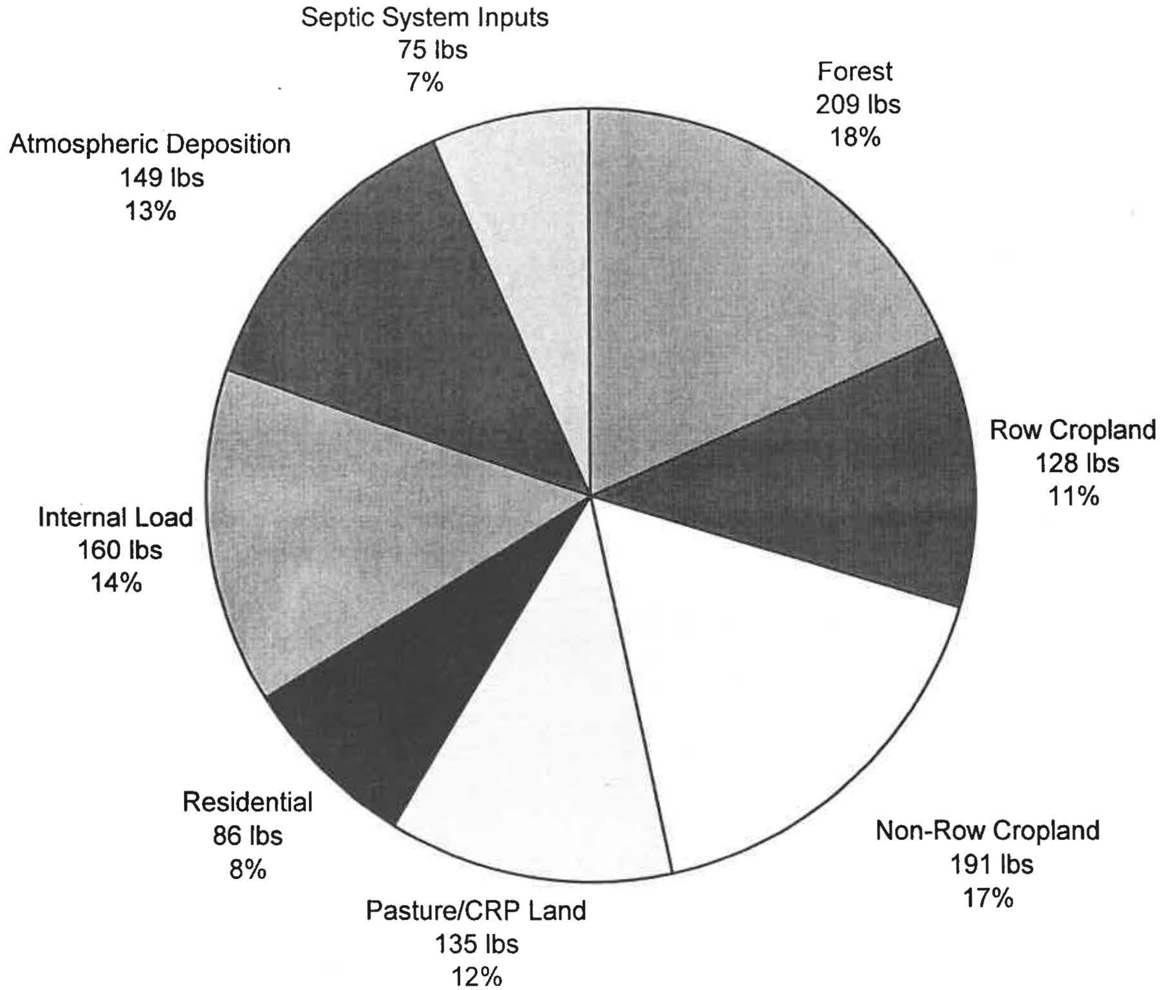
## Bone Lake - Station 2
1996 Annual Phosphorus Budget




Annual Load = 813 lbs.
(Assumes 100 Percent of Watershed Area Contributes Surface Flow)

**Figure 4**

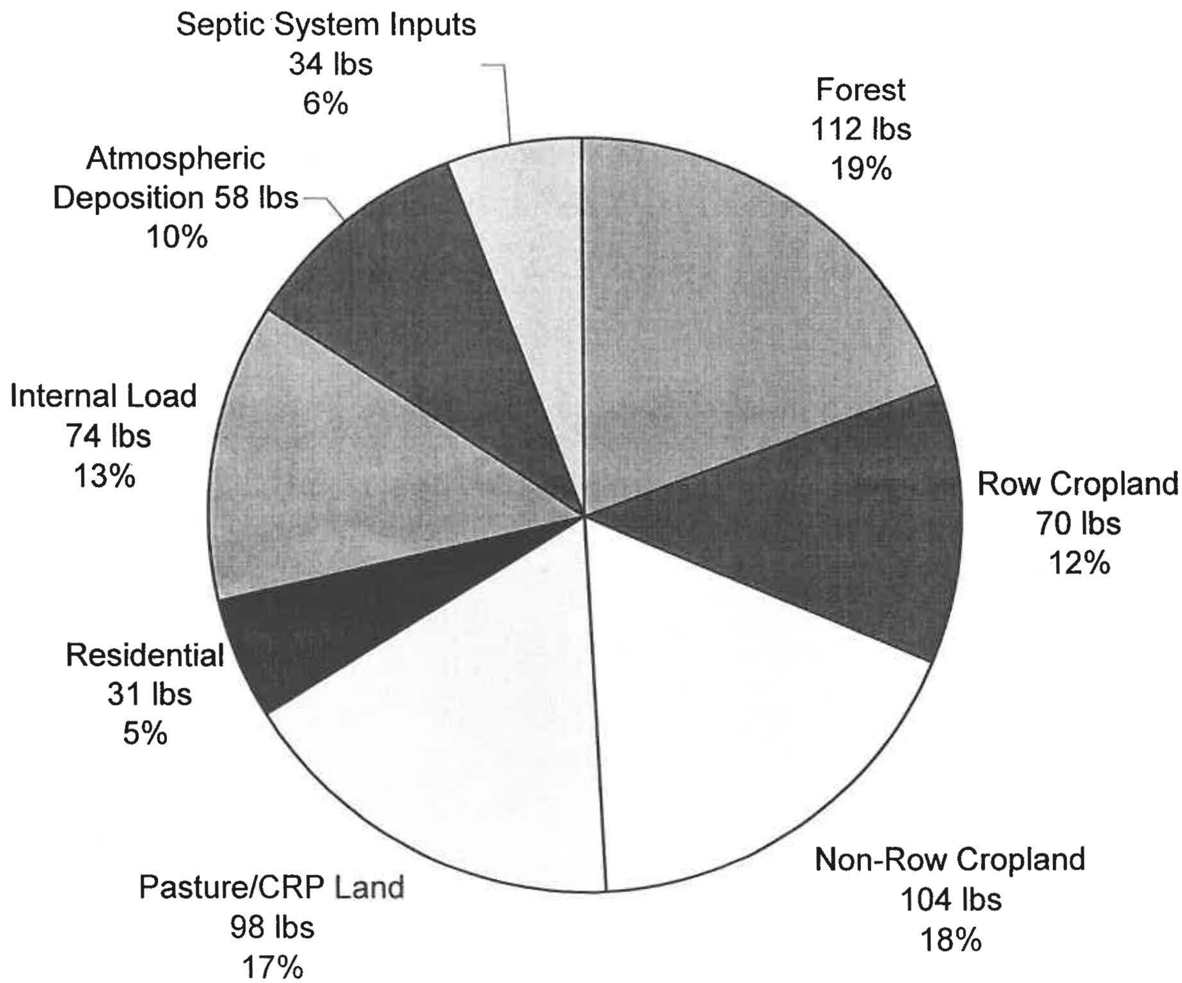
## Bone Lake - Whole Lake
1996 Annual Phosphorus Budget




Annual Load = 1,133 lbs.
(Assumes Land Locked Areas of Watershed Do Not Contribute Surface Flow)

**Figure 5**

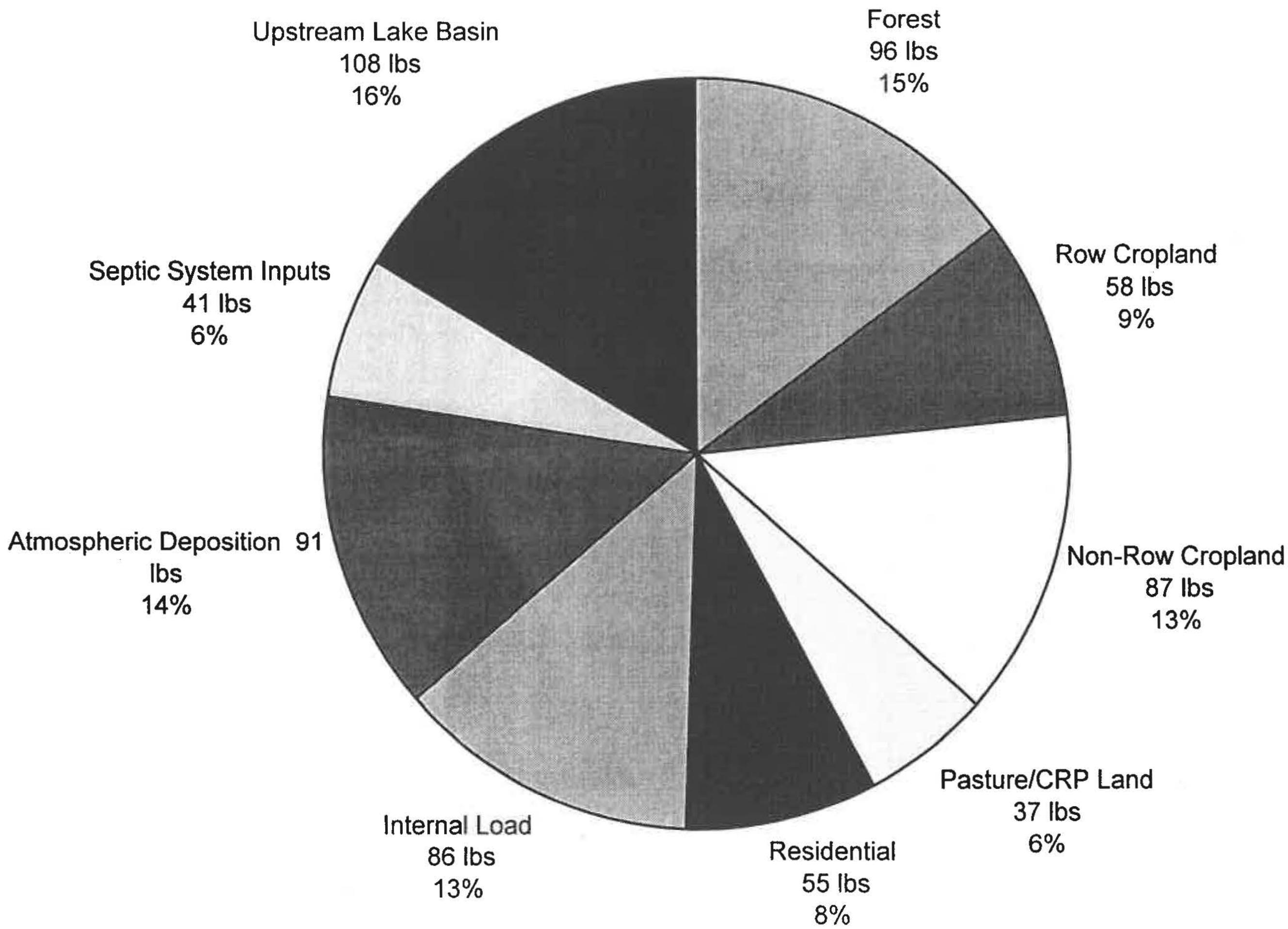
## Bone Lake - Station 1
1996 Annual Phosphorus Budget




Annual Load = 582 lbs.
(Assumes Land Locked Areas of Watershed Do Not Contribute Surface Flow)

**Figure 6**

# Bone Lake - Station 2
1996 Annual Phosphorus Budget




Annual Load = 660 lbs.
(Assumes Land Locked Areas of Watershed Do Not Contribute Surface Flow)

Figure 7

**Table 5. Phosphorus Budget Comparison Between 100% of Watershed Contributing Surface Flow and Exclusion of Landlocked Areas**

| | 100% Watershed Contributes Surface Flow | | Revised to Exclude Landlocked Areas | |
|---|---|---|---|---|
| **Parameter** | **Station 1** | **Station 2** | **Station 1** | **Station 2** |
| Total Drainage Area, including watershed lakes and wetlands (Acres) | 6,987 | 4,990 | 4,447 | 4,119 |
| Total Annual Phosphorus Load (Kg/Year) | 430 | 291 | 264 | 250 |

The resultant water quality of Bone Lake was modeled. Table 6 presents a comparison of the modeled water quality of Bone Lake, assuming landlocked areas do not contribute surface flow. For comparison purposes, the modeled lake water quality, assuming 100 percent of the watershed area contributes surface flow, is presented.

**Table 6. Water Quality Modeling Comparison Between 100% of Watershed Contributing Surface Flow and Exclusion of Landlocked Areas**

| | 100% Watershed Contributes Surface Flow | | Revised to Exclude Landlocked Areas | |
|---|---|---|---|---|
| **Parameter** | **Station 1** | **Station 2** | **Station 1** | **Station 2** |
| Average Annual Total Phosphorus Concentration (µg/L) | 29 | 19 | 33 | 22 |

The modeled average annual total phosphorus concentration under current conditions (i.e., landlocked areas excluded) is somewhat higher than the observed concentration at Station 1 (i.e., observed concentration of 28 µg/L and modeled concentration of 33 µg/L) and very close to the observed concentration at Station 2 (i.e., observed concentration of 23 µg/L and modeled concentration of 22 µg/L).

The lake's average annual concentration of phosphorus was estimated to be higher when landlocked areas were assumed to contribute no surface flow than when the entire watershed was assumed to contribute surface flow. Most of the watershed's landlocked areas are forested and, consequently, surface runoff from these areas is estimated to contain low concentrations of phosphorus. When these forested areas are assumed to contribute surface flow to the lake, the low phosphate runoff waters from the forested areas dilute the higher phosphate runoff waters from other land uses before the composite surface runoff enters the lake. Consequently, the composite surface runoff waters entering the lake are estimated to have a lower phosphorus concentration than the runoff waters from non-forested areas of the watershed. However, exclusion of the landlocked forested areas results in estimated phosphorus concentrations of runoff waters that are higher than concentrations of runoff waters that include landlocked forested areas. Consequently, when these forested areas are assumed to be landlocked, the higher phosphate waters from other land uses enter the lake undiluted and are estimated to have a greater impact on the lake's water quality (i.e., result in higher average total phosphorus concentration of lake water).

## Membership Survey Results

Members of the Bone Lake Management District were surveyed to determine their:

- Perception of lake's current water clarity
- Support of water quality improvement projects
- Water clarity goal for the lake
- Recreational activities under current water quality conditions
- Recreational activities under ideal water quality conditions
- Lake management goals

A total of 553 surveys were mailed and 252 responses were received (i.e., 46 percent return rate). Survey results are presented in Appendix B. The survey results indicated:

- Most respondents perceived the lake's current water clarity as somewhat cloudy (40 percent) or clear (39 percent); a few respondents perceived the lake's water clarity as murky (11 percent) or very cloudy (10 percent).

- Most respondents support projects to improve the lake's water quality (63 percent), assuming a portion of the project cost will be born by property owners, including the respondents.

- Most respondents believe the lake's water clarity goal should be clear (81 percent); a few respondents believe the goal should be somewhat cloudy (11 percent) or crystal clear (8 percent).

- Respondents indicated the primary use of Bone Lake is fishing. Other major uses were motorized boating and swimming.

- Under ideal water quality conditions, the primary use of Bone Lake would be swimming. Other major uses would be fishing and motorized boating.

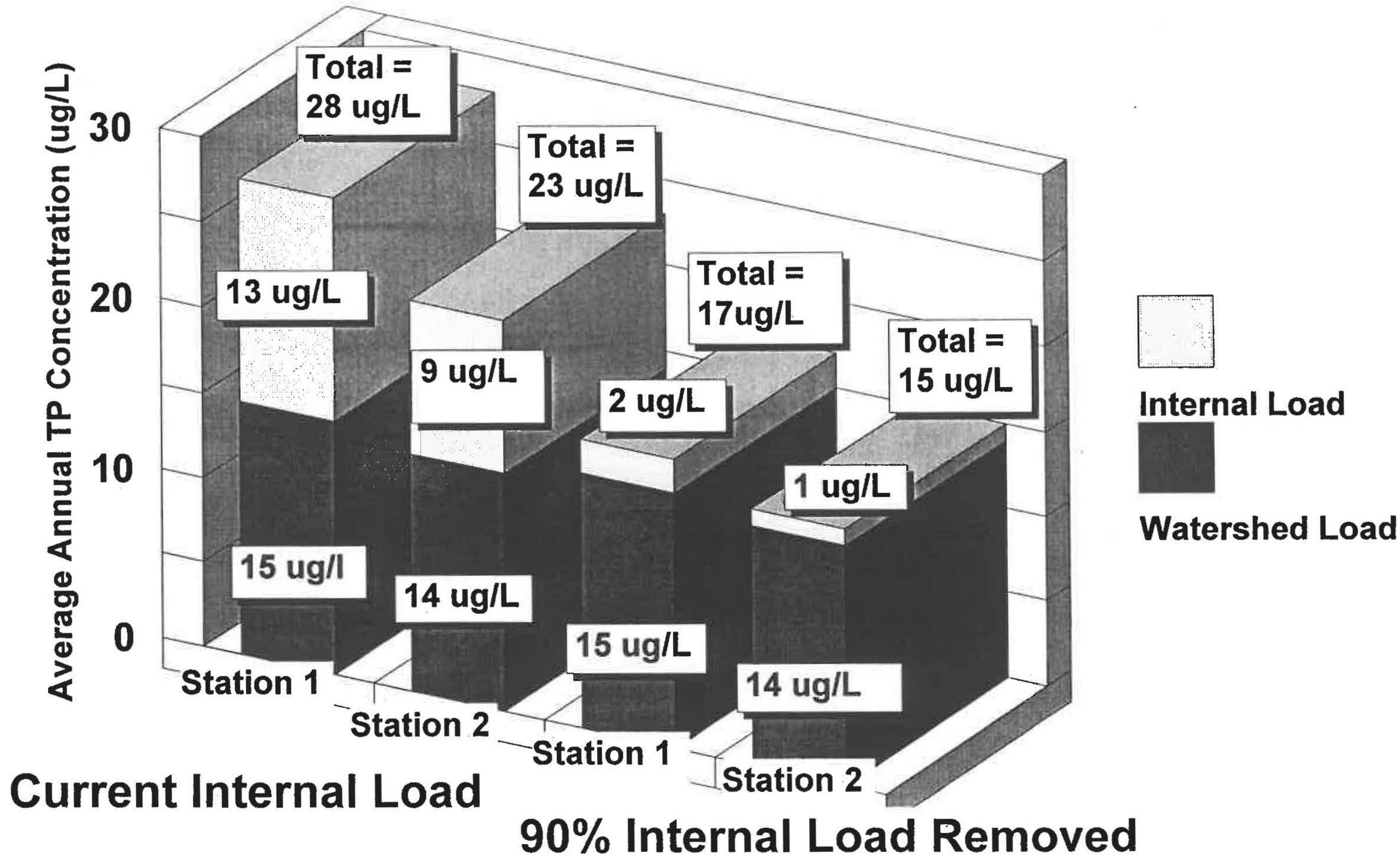
- Respondents indicated improvement of the lake's water quality to be the primary lake management goal. Respondents indicated protection of the lake's water quality to be the second most important lake management goal.

## Lake Water Quality Modeling of Internal Phosphorus Load Reduction

Because a majority of survey respondents indicated a desire for improvement of the lake's water quality, modeling was completed to determine resultant water quality improvements from an alum treatment of the lake. An alum treatment would reduce the lake's internal phosphorus load, the phosphorus re-released from the lake's sediments back into the water. Alum added to the lake would form a floc layer on the bottom of the lake. The floc layer would act as a kind of phosphorus barrier by combining with (and trapping) the phosphorus as it is released from the sediments. This would reduce the amount of internal recycling of phosphorus in the lake and improve the lake's water quality.

Lake water quality modeling was completed to determine the expected water quality changes following a 90 percent removal of the current internal phosphorus load. Modeling results are presented in Figure 8. Average annual phosphorus concentrations would be reduced 39 percent and 36 percent at the north and south basins, respectively, following the internal phosphorus load reduction.

# Bone Lake Average Annual TP Conc. Current Int. Load & 90% Removal




Assumes Current Non Contributing Area Does Not Contribute Surface Flow

Figure 8

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## Lake Water Quality Modeling of Septic System Malfunction/Removal

Lake water quality modeling was completed to estimate impacts of both increased and decreased phosphorus loading from septic systems. The following two scenarios were modeled:

- All current septic systems were assumed to malfunction
- All current septic systems were assumed to contribute no phosphorus to the lake (i.e., removal assumed because of replacement with holding tanks or installation of a sanitary sewer)

Modeling results are presented in Figure 9. Malfunction of all current septic systems is estimated to result in north and south basin increases in the average annual total phosphorus concentrations of 14 percent and 22 percent, respectively. The resultant water quality degradation would further exacerbate the lake's current water quality problems.

Removal of all phosphorus loading from septic systems is estimated to result in a 3 percent decrease in the average annual total phosphorus concentration of the north basin and no change in the average annual total phosphorus concentration of the south basin. The results indicate no appreciable improvement in water quality would result from a sanitary sewer system.

## Lake Water Quality Modeling of Development Scenarios

Bone Lake survey respondents indicated that protection of the lake's water quality was an important water quality management goal. Because future developments within the lake's watershed may result in water quality degradation, lake water quality modeling was completed to estimate impacts of increased development in the watershed. Increased development within the watershed is likely to result in increased surface runoff. Consequently, increased surface runoff may result in surface flow contribution from areas within the watershed that are currently landlocked. A range of surface runoff conditions was estimated for the lake by modeling two conditions:

- Current landlocked areas were assumed to contribute no surface flow to the lake
- The entire watershed was assumed to contribute surface flow to the lake

For each condition (i.e., landlocked or 100 percent of watershed contributing), four development scenarios were modeled to estimate the lake's water quality under 20 percent, 50 percent, 80 percent, and 100 percent increases in watershed development. Modeling results are presented in Figures 10 and 11 and in Table 7.

**Reserved for**

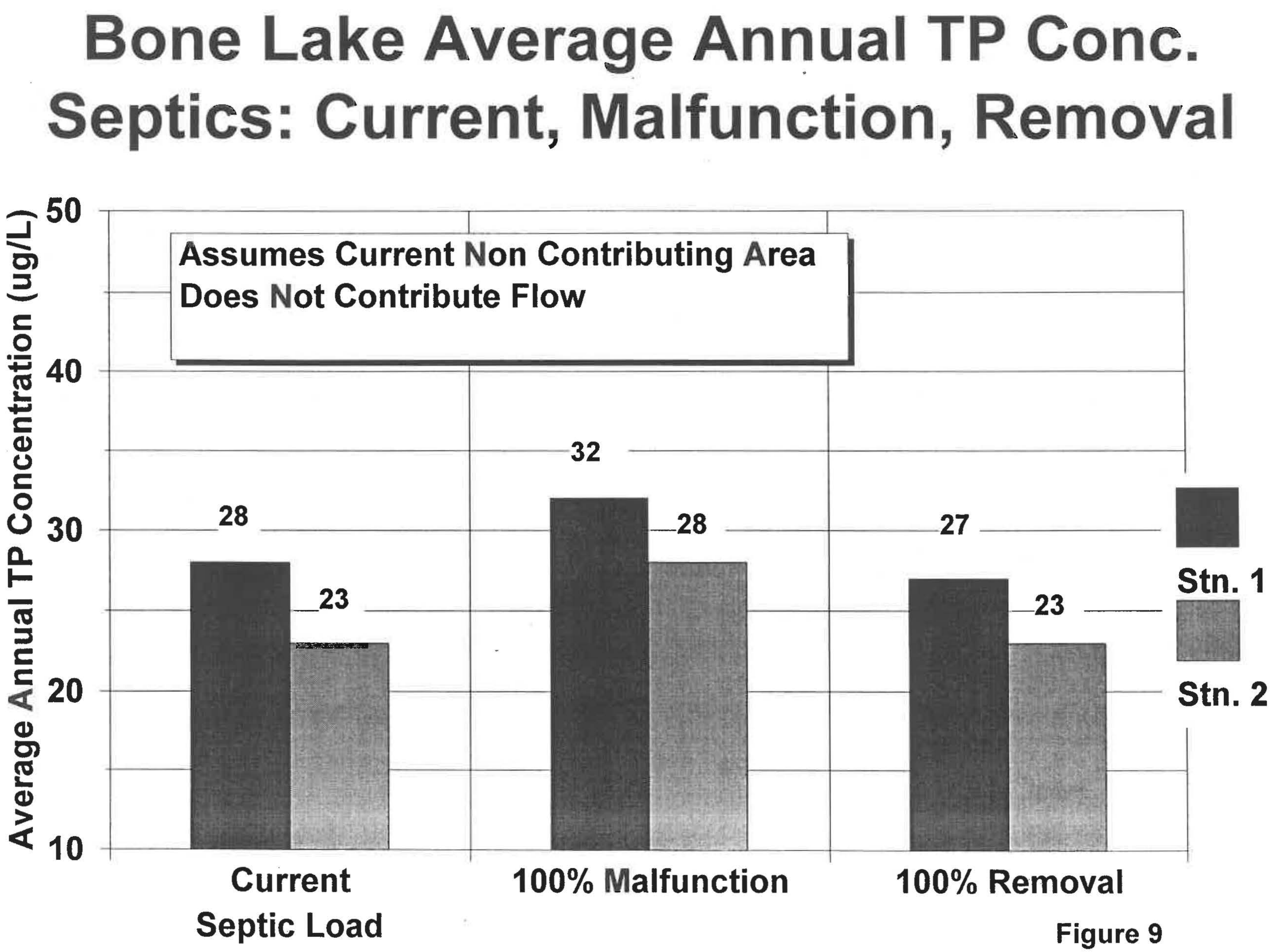


Figure 9

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# Bone Lake Average Annual TP Conc.
# Development Scenarios From 0-100%

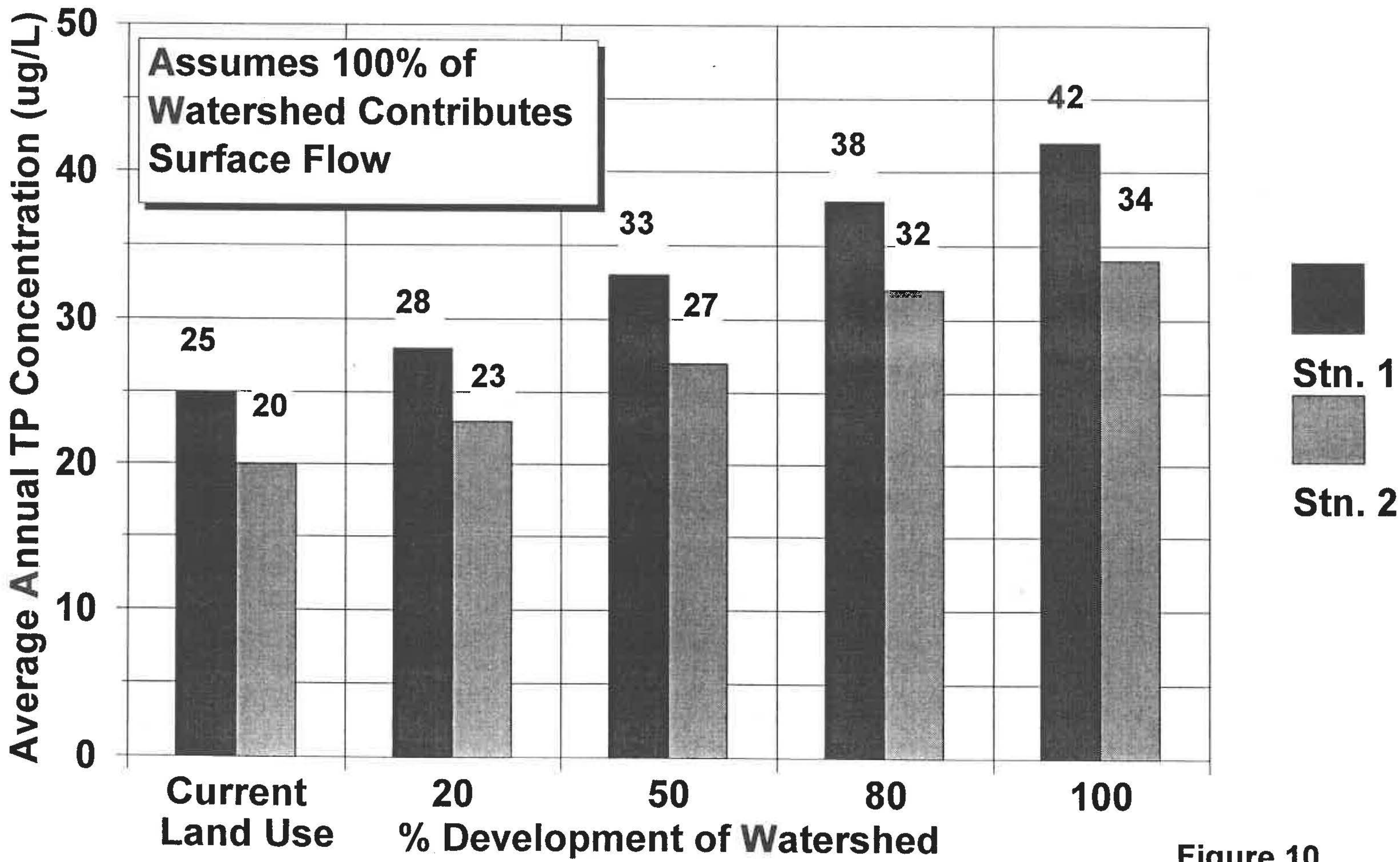


Figure 10

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# Bone Lake Average Annual TP Conc. Development Scenarios From 0-100%

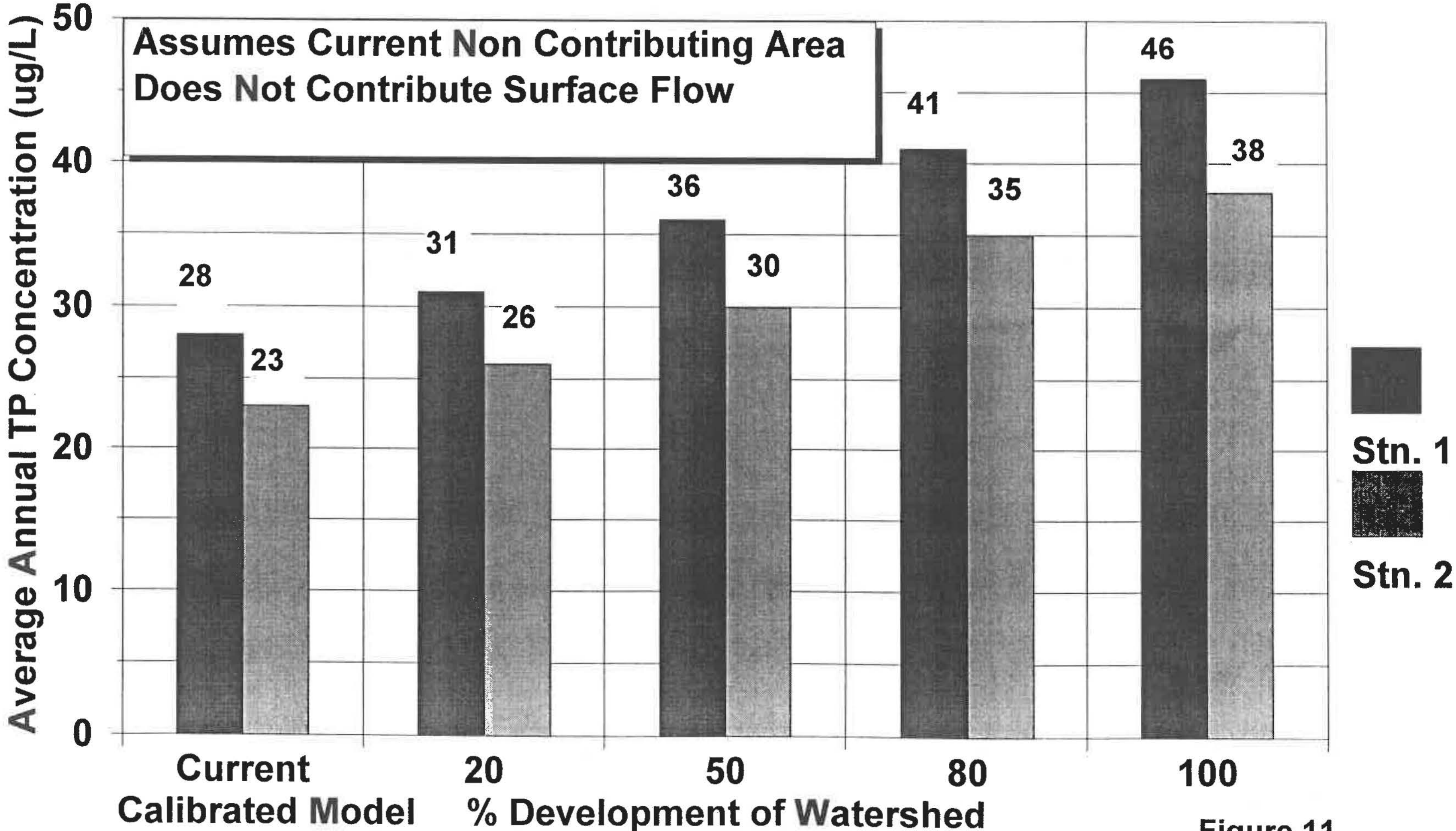


Figure 11



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**Table 7. Percent Increase in Bone Lake Average Annual Total Phosphorus Concentration Under Various Development Scenarios**

| Basin/Condition | Percent Increase in Average Annual Total Phosphorus Concentration Under Various Development Scenarios — % Increase in Watershed Development: 20 | 50 | 80 | 100 |
|---|---|---|---|---|
| **Basin 1:** | | | | |
| Assumes 100% of Watershed Contributes Surface Flow | 10 | 31 | 52 | 66 |
| Assumes Current Landlocked Areas Contribute No Surface Flow | 12 | 30 | 48 | 64 |
| **Basin 2:** | | | | |
| Assumes 100% of Watershed Contributes Surface Flow | 16 | 37 | 58 | 68 |
| Assumes Current Landlocked Areas Contribute No Surface Flow | 14 | 32 | 50 | 64 |

Modeling results indicate Bone Lake's water quality is expected to degrade should increased watershed development occur. The rate of lake water quality degradation is estimated at 0.6 percent increase in average annual total phosphorus concentration per each percent increase in watershed development, assuming current landlocked conditions. Assuming 100 percent of the watershed contributes surface flow, the average rate of lake water quality degradation is estimated at 0.7 percent increase in average annual total phosphorus concentration per each percent increase in watershed development. The north (basin 1) and south (basin 2) basins are estimated to exhibit the same rate of degradation (e.g., each basin is expected to exhibit a 0.6 percent increase in average annual total phosphorus concentration per each percent increase in watershed development, assuming current landlocked conditions).

## Lake Water Quality Modeling of Development Scenarios with BMPs

Because watershed development is expected to result in water quality degradation, water quality modeling was completed to determine whether management practices can successfully protect Bone Lake from water quality degradation under various watershed development scenarios. All of the watershed development scenarios discussed in the previous section "Lake Water Quality Modeling of Development Scenarios" were modeled with structural BMPs in place to determine resultant Bone Lake water quality. As discussed in the methods section, structural BMPs are assumed to be detention basins that remove approximately 60 percent of the phosphorus load. Modeling results are presented in Figures 12 and 13 and in Table 8.

**Table 8. Percent Increase in Bone Lake Average Annual Total Phosphorus Concentration Under Various Development Scenarios with BMPs**

| | Percent Increase in Average Annual Total Phosphorus Concentration Under Various Development Scenarios with BMPs | | | |
|---|---|---|---|---|
| | % Increase in Watershed Development | | | |
| Basin/Condition | 20 | 50 | 80 | 100 |
| **Basin 1:** Assumes 100% of Watershed Contributes Surface Flow | NC | NC | NC | NC |
| Assumes Current Landlocked Areas Contribute No Surface Flow | NC | NC | NC | NC |
| **Basin 2:** Assumes 100% of Watershed Contributes Surface Flow | NC | NC | NC | NC |
| Assumes Current Landlocked Areas Contribute No Surface Flow | NC | NC | NC | NC |

NC = Negligible Change (i.e., <10%).

Modeling results indicate BMPs are expected to effectively mitigate lake water quality degradation resulting from increased watershed development. With BMPs, the rate of lake water quality degradation is estimated to be negligible. BMPs are expected to mitigate more than 90 percent of the water quality degradation resulting from increased development.

# Bone Lake Average Annual TP Conc. Development Scenarios With BMPs

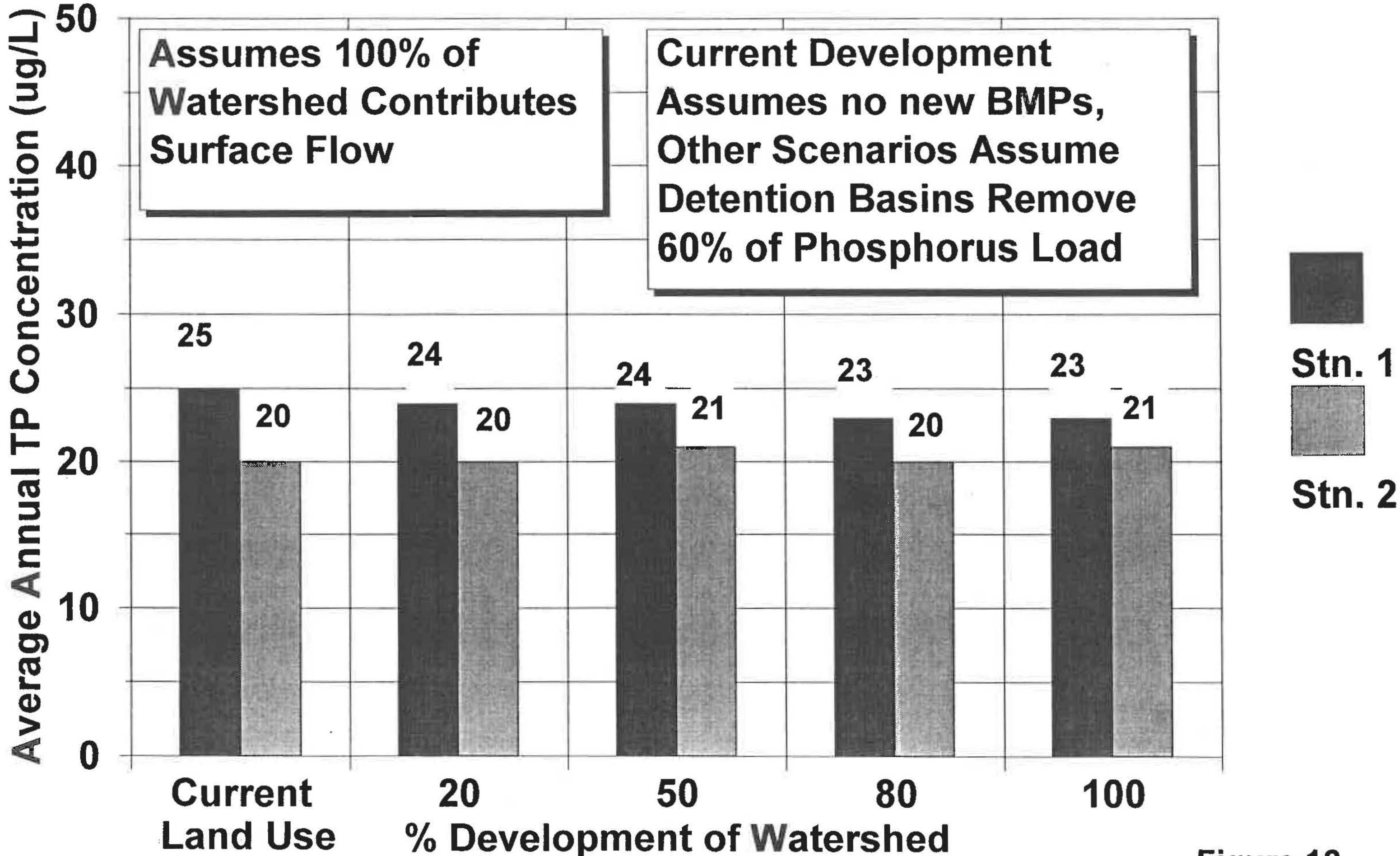


Figure 12

# Bone Lake Annual Average TP Conc.
# Development Scenarios With BMPs

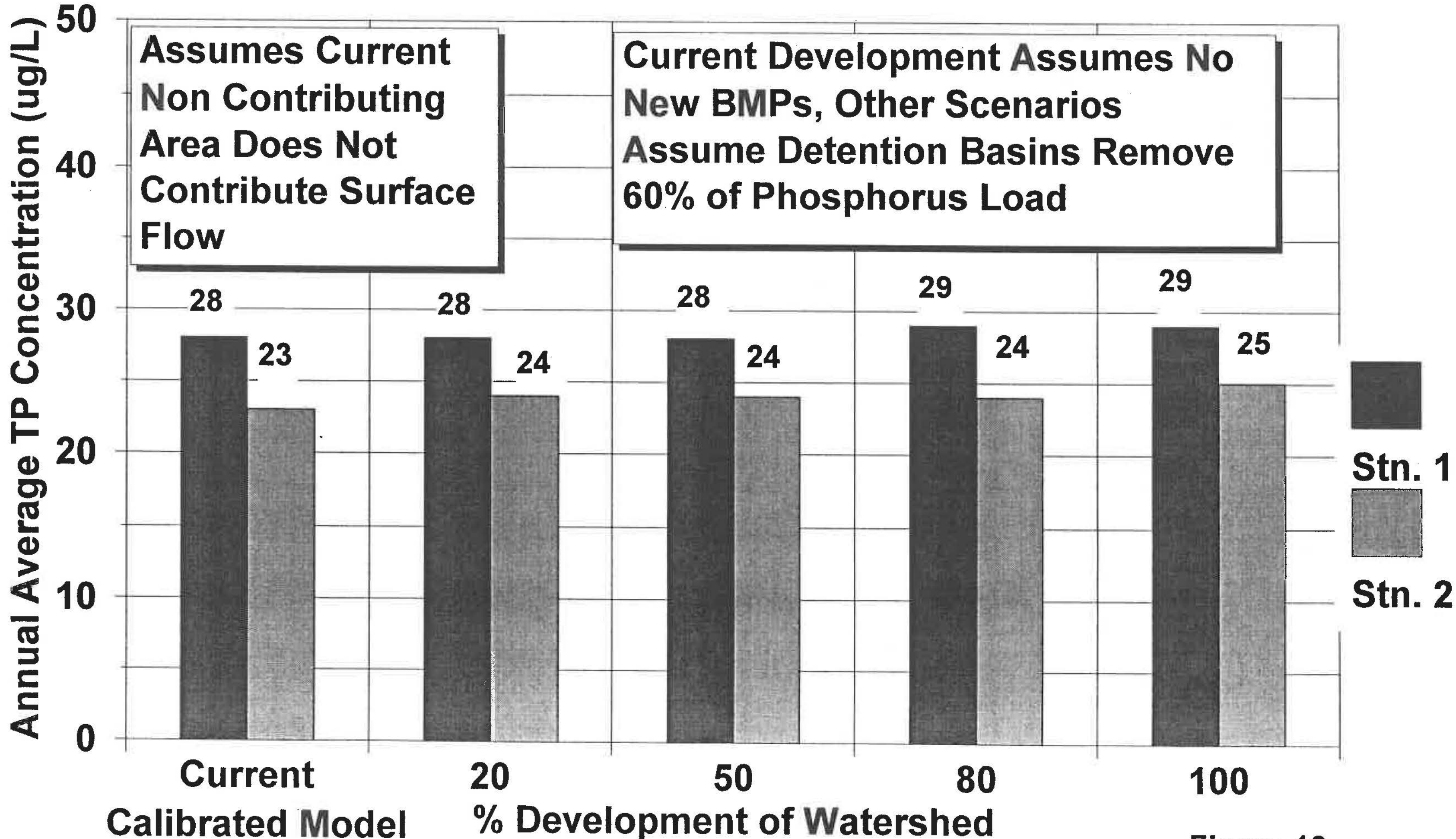


Figure 13



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## Lake Water Quality Modeling of Development Scenarios with BMPs and Internal Load Reduction

Because Bone Lake survey respondents indicated water quality improvement and water quality protection were important water quality management goals, modeling scenarios were completed to evaluate achievement of the two goals concurrently. As discussed previously, reduction of the lake's internal load would result in water quality improvement and use of BMPs would protect the lake from development impacts. Consequently, water quality modeling scenarios were completed to determine whether the lake's improved water quality following internal load reduction would be protected under various watershed development scenarios with BMPs. All of the watershed development scenarios discussed in the previous section "Lake Water Quality Modeling of Development Scenarios with BMPs" were modeled with 90 percent of the internal load removed to determine resultant Bone Lake water quality. Modeling results are presented in Figures 14 and 15. Modeling results indicate BMPs are expected to effectively mitigate lake water quality degradation from increased watershed development. Consequently, the lake's improved water quality following internal phosphorus load reduction would be protected by BMPs under all watershed development scenarios.

# Bone Lake Average Annual TP Conc. Dev. Scenarios W/BMPs & Remove Int. P

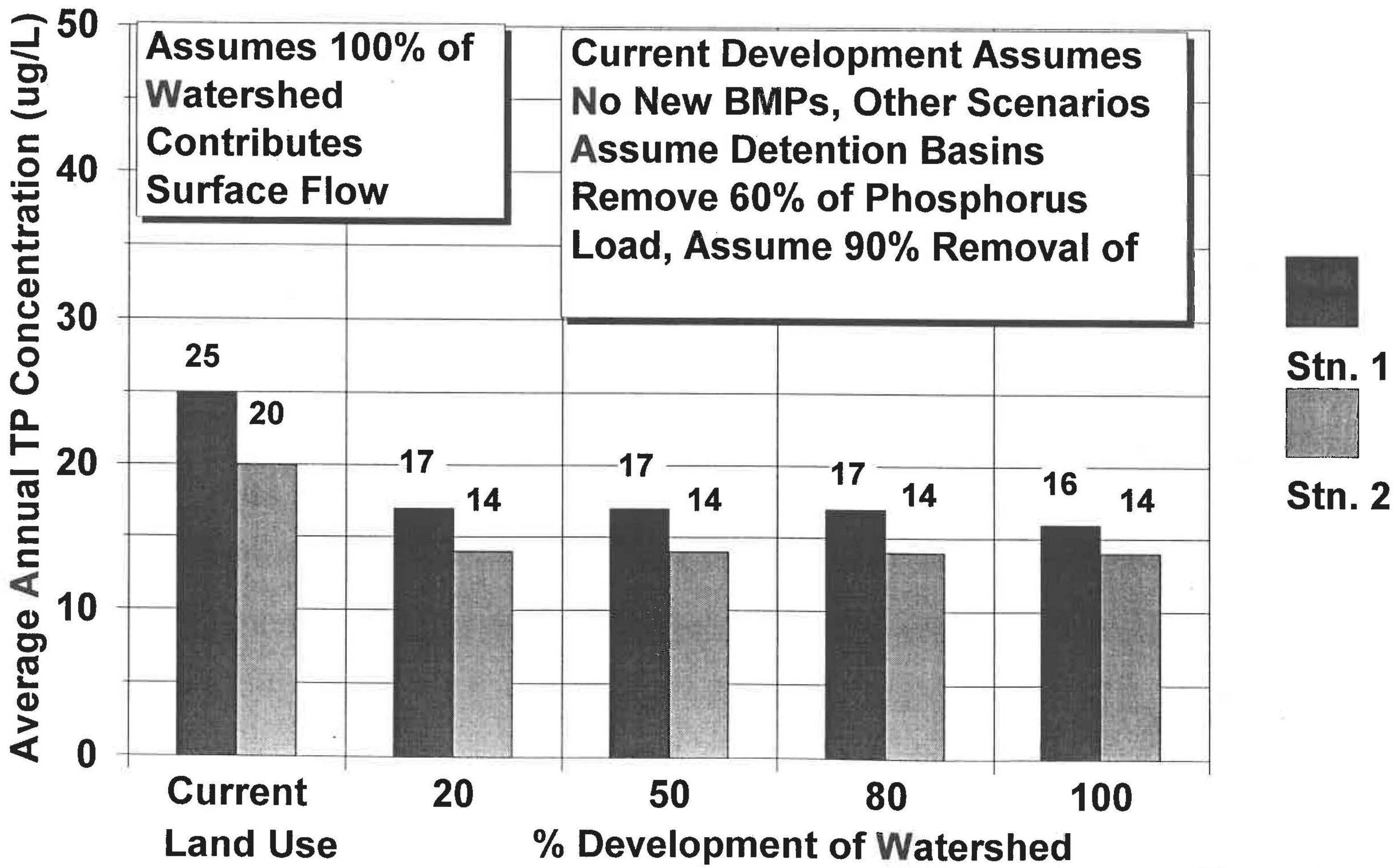


Figure 14

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# Bone Lake Average Annual TP Conc.
# Dev. Scenarios W/BMPs & Remove Int. P

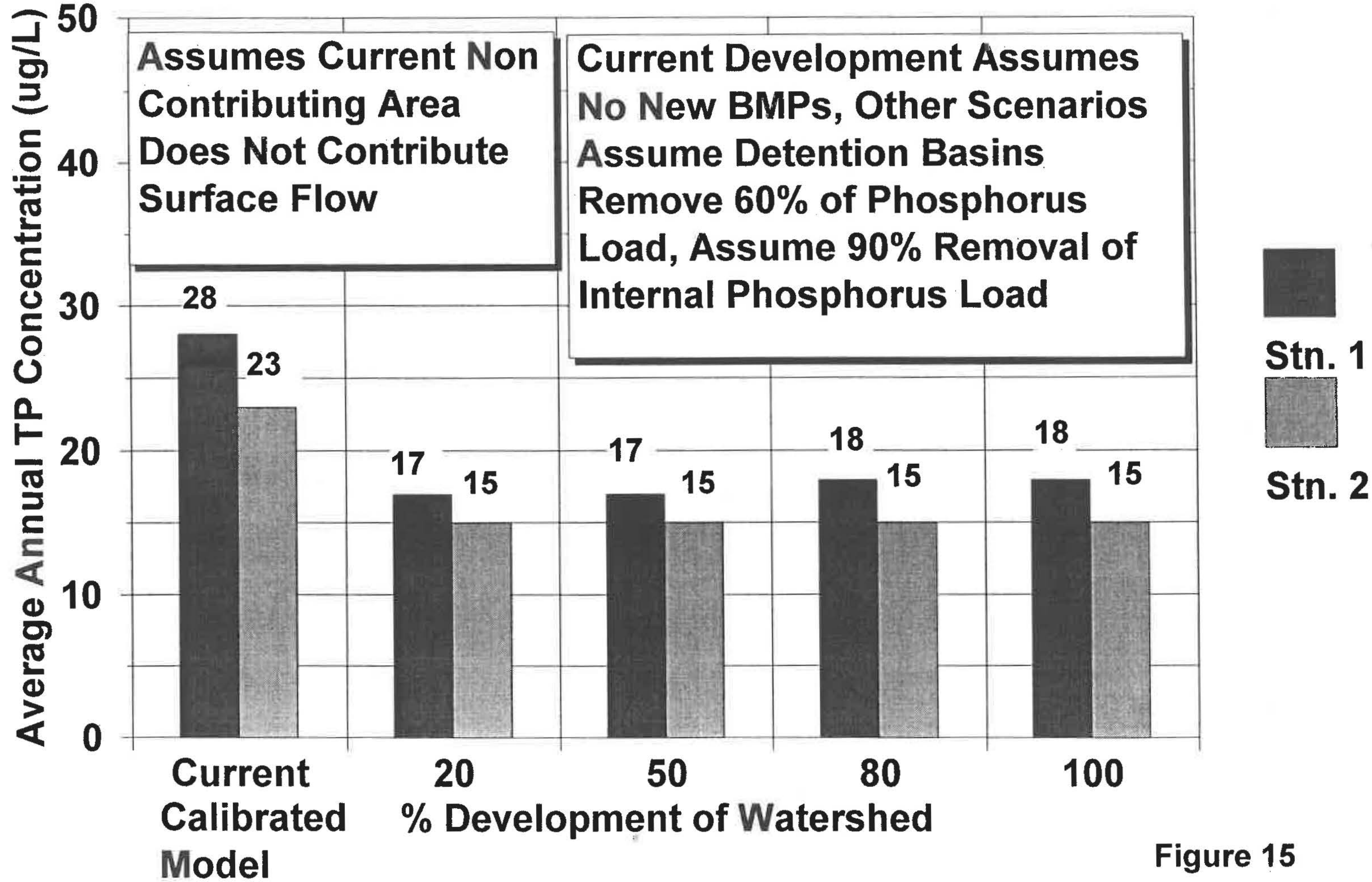


Figure 15



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Prior to the development of a lake management plan, the following questions are answered:

1. What is the water quality of the lake under existing watershed development conditions?
2. What is the long-term water quality goal of the lake?
3. Does the current water quality of the lake achieve its water quality goal?
4. What will be the water quality of the lake if unchecked development is allowed to occur?
5. Will the lake's water quality goal be met if unchecked development is allowed to occur?

If the answer to question five is no, the following question is asked.

6. Can the lake's water quality goal be achieved with the implementation of lake and/or watershed management practices?

If the answer to question six is yes, a lake management plan is completed to outline the management practices which must be implemented to achieve the lake's long-term water quality goal.

The above six questions were answered prior to the development of the Bone Lake Management Plan. The answers are as follows:

1. The current water quality of Bone Lake is within the mesotrophic category during the spring and early summer and the eutrophic category during the late summer period. This means the lake is moderately rich in phosphorus and its water quality is good during the spring and early summer period. However, the lake is rich in nutrients and its water quality is poor during the late summer period. Based on a study by the Metropolitan Council (Osgood, 1989), the 1996 average summer Secchi disc transparencies at Stations 1 and 2 (1.7 and 1.8 meters, respectively) indicate that the lake generally experiences moderate recreational use impairment.

2. Two long-term water quality goals have been selected for Bone Lake. The first lake water quality goal is to improve the lake's water quality. The specific goal selected was an average annual epilimnetic (i.e., upper 6 feet) total phosphorus concentration not to exceed 18 µg/L, the midpoint of the mesotrophic category (i.e., moderate phosphorus concentration, moderate productivity level). Goal achievement would result in 38 percent and 24 percent reductions in

average summer total phosphorus concentrations in the north and south basins, respectively. The second lake water quality goal of is to protect the lake's water quality from additional degradation. The goal includes prevention of degradation under current water quality conditions and prevention of degradation under the improved water quality condition (i.e., average annual epilimnetic total phosphorus concentration of 18 µg/L).

3. The current water quality of Bone Lake does not achieve its long-term goal to achieve an average annual epilimnetic total phosphorus concentration of 18 µg/L. Consequently, water quality improvement must occur to achieve this goal.

4. Unchecked development of the lake's watershed will cause degradation of the lake's water quality. The degree of water quality degradation increases with increasing development. Implementation of structural BMPs during watershed development mitigates the adverse impacts of development. Consequently, BMPs protect the lake's water quality under all development scenarios.

5. The lake's long-term goal will not be met if unchecked development is allowed to occur without the implementation of BMPs..

6. The lake's water quality goals can be achieved with the reduction of the internal phosphorus load and the implementation of BMPs to mitigate watershed development impacts.

The following management plan outlines the management practices which must be implemented to achieve Bone Lake's long-term water quality improvement and preservation goals. The plan improves the water quality of Bone Lake by reducing the lake's internal phosphorus load and protects Bone Lake by requiring structural BMPs to mitigate watershed development impacts. BMPs reduce the quantity of phosphorus loaded to the lake under future development conditions.

The Bone Lake Management Plan addresses the following:

- Alum Treatment of Bone Lake
- Watershed Best Management Practices (BMPs
- Recommended Monitoring

## Alum Treatment of Bone Lake

It is proposed that Bone Lake be treated with the chemical alum to improve its water quality. The alum treatment will provide safe, effective and long-term control of the amount of algae in Bone Lake. Consequently, the treatment will result in cleaner, clearer water and a more pleasurable environment for recreation on and around Bone Lake.

Alum (aluminum sulfate) is a compound derived from aluminum, the earth's most abundant metal. Alum has been used in water purification and wastewater treatment for centuries and in lake restoration for decades.

Alum is used primarily to control the internal loading of phosphorus from the sediments of the lake bottom. Alum reduces the growth of algae by trapping the nutrient phosphorus, the algae's food source, in sediments. Like most other plants, algae require phosphorus to grow and reproduce. Algal growth is directly dependent on the amount of phosphorus available in the water. Without available phosphorus, algae cannot continue to grow and reproduce.

Alum is injected into water several feet below the surface. On contact with water, alum becomes aluminum hydroxide (the principal ingredient in common antacids such as Maalox). This fluffy substance, called floc, settles to the bottom of the lake.

On the way down, it interacts with phosphorus to form an aluminum phosphate compound that is insoluble in water. As a result, phosphorus in the water is trapped as aluminum phosphate and can no longer be used as food by algae. An added bonus occurs as the floc settles downward through the water. It collects other suspended particles in the water, carrying them down to the bottom and leaving the lake noticeably clearer.

On the bottom of the lake, the floc forms a layer that acts as a kind of phosphorus barrier by combining with (and trapping) the phosphorus as it is released from the sediments. This reduces the amount of internal recycling of phosphorus in the lake.

An alum treatment of Bone Lake is estimated to cost approximately $314,000. The cost estimate assumes a total of 445,000 gallons of alum applied to areas of the lake at least 5 feet deep. The recommended application rate is 6.0, 11.9, and 17.9 grams of aluminum per square meter at the 5-10, 10-15, and greater than 15-foot depths, respectively. The recommended liquid alum application rate is 109, 218, and 327 gallons per acre at the 5-10, 10-15, and greater than 15-foot depths, respectively. The surface area of the lake at the three depth intervals is 130, 112, and 1,203 acres at the 5-10, 10-15, and greater than 15-foot depths, respectively. The alum application is assumed to occur over a 14-day period.

Following the treatment, the lake's average annual total phosphorus concentration is expected to be 17 µg/L in the north basin and 15 µg/L in the south basin. The improved water quality achieves the lake's improvement goal of an average annual total phosphorus concentration of 18 µg/L or less. Benefits from the treatment are estimated to last approximately 10 years.

The estimated treatment dose was based upon the lake's phosphorus internal load, determined from sediment phosphorus release experiments completed during the Phase I study. Recent research indicates the effectiveness and longevity of an alum treatment is determined by the extractable phosphorus content of the lake's sediments. Consequently, determination of alum dose from sediment extractable phosphorus data is considered a more precise estimate of dose than estimation of dose from sediment phosphorus release data. To insure that the alum dose selected for Bone Lake effectively accomplishes the lake's water quality improvement goal and lasts approximately 10 years, measurement of the extractable phosphorus content of the lake's sediments is recommended. If this recommendation is implemented, duplicate cores will be collected from the north and south basins (i.e., Stations 1 and 2) and the upper 5 centimeters of each core will be analyzed for extractable phosphorus. A recommended alum dose will then be computed, based upon Rydin, E. and Welch, E. B. (1998).

## Watershed Best Management Practices

Modeling results indicate watershed best management practices are needed to achieve the lake's water quality protection goal. Four watershed management practices are proposed:

- Stormwater ordinance
- Shoreland ordinance
- Septic system ordinance
- Additional watershed best management practices

## Stormwater Ordinance

A Polk County ordinance to regulate development/redevelopment is proposed to mitigate the impacts of watershed development on the lake's water quality. Modeling results indicate such regulation is necessary to achieve the lake's water quality protection goal and that such an ordinance to restrict phosphorus loading from the lake's watershed will protect the lake from degradation under all watershed development conditions. A proposed stormwater ordinance, presented in Appendix D, provides erosion control design standards, has lawn fertilizer regulations, requires submission of a stormwater management plan and performance bond. The proposed ordinance should apply to the entire Bone Lake watershed. A key feature of the ordinance is the requirement to treat all stormwater runoff from all developed/redeveloped sites, except shoreland development. All nonshoreland owners/developers will be required to construct an on site detention basin or contribute money towards the construction of a regional facility. A 60 percent total phosphorus removal efficiency will be required for all on-site and regional detention basins. Treatment of all watershed runoff resulting from watershed development is necessary to achieve the Bone Lake water quality goal under future watershed development conditions. Therefore, it is recommended that Polk County pass the proposed ordinance presented in Appendix D. An additional model ordinance that may be considered is included in the "Wisconsin Construction Site Best Management Practice Handbook" (WDNR, 1994).

## Shoreland Ordinance

A shoreland ordinance to regulate shoreland development/redevelopment is proposed. Because shoreland development is excluded from the requirement to treat runoff in a detention basin, a buffer strip requirement is recommended to treat runoff from shoreland areas. The ordinance will become important as redevelopment of shoreland property occurs with the passage of time.

A buffer strip is a permanently vegetated area (i.e., not mowed grass, however) whose function is to remove pollutants from runoff waters and to slow the flow of runoff waters, thereby encouraging infiltration. Buffer strips remove phosphorus from runoff waters and, therefore, restrict phosphorus loading to lakes from shoreland property. Buffer strips provide a means of mitigating impacts from redevelopment by removing additional pollutants from runoff waters. A national survey of 36 local buffer programs revealed the median width selected for a buffer was 100 feet (Heraty, 1993). Schueler (1995) recommends a minimum base width of at least 10 feet to provide adequate stream protection relative to phosphorus removal. The results of studies of buffer programs indicate a 100-foot-wide buffer strip would provide adequate phosphorus removal to protect the water quality of Bone Lake from shoreland development/redevelopment impacts. It is recommended that Polk County pass an ordinance requiring a 100-foot buffer strip for all new developments and redevelopments on Bone Lake shoreland lots to achieve the lake's long-term water quality protection goal. Effective and attractive buffer strip designs are presented in *Lakescaping for Wildlife and Water Quality* (1999).

## Septic System Ordinance

Modeling results indicate water quality degradation will result from malfunctioning shoreland septic systems. Therefore, the Bone Lake Management District should work with Polk County to establish a septic system ordinance for the Bone Lake watershed. All septic systems must be tested when properties change hands or building permits are issued for development or redevelopment. Systems failing to pass the test must be brought into compliance before sale of property can take place or issuance of a building permit.

## Additional Watershed Best Management Practices (BMPs)

A visit was made to the Bone Lake watershed to evaluate the need for watershed BMPs. The evaluation results indicated BMPs are currently used throughout the Bone Lake watershed. Only three recommendations for BMPs were identified. Figure 16 shows the three locations within the watershed that would benefit from BMP implementation. The locations and recommended BMPs are:

- Erosion problem at one location within the Vincent Lake subwatershed—The Bone Lake Management District should work with an engineer to identify and implement feasible erosion control BMPs.
- Horse farm adjacent to Inflow #2—The Bone Lake Management District should work with the farmer to insure that the animals are not allowed to enter the stream.
- Dairy farm within an area that does not contribute surface flow to the lake— If development occurs within this subwatershed, the Bone Lake Management District should work with an engineer to insure that flow from the dairy farm area does not enter Bone Lake.

In addition, it is recommended that watershed residents refrain from using phosphorus fertilizers unless soil testing indicates the soil is deficient in phosphorus. An education program to discourage the use of phosphorus fertilizers is recommended. Locations where non phosphate fertilizers may be purchased should be communicated to watershed residents.

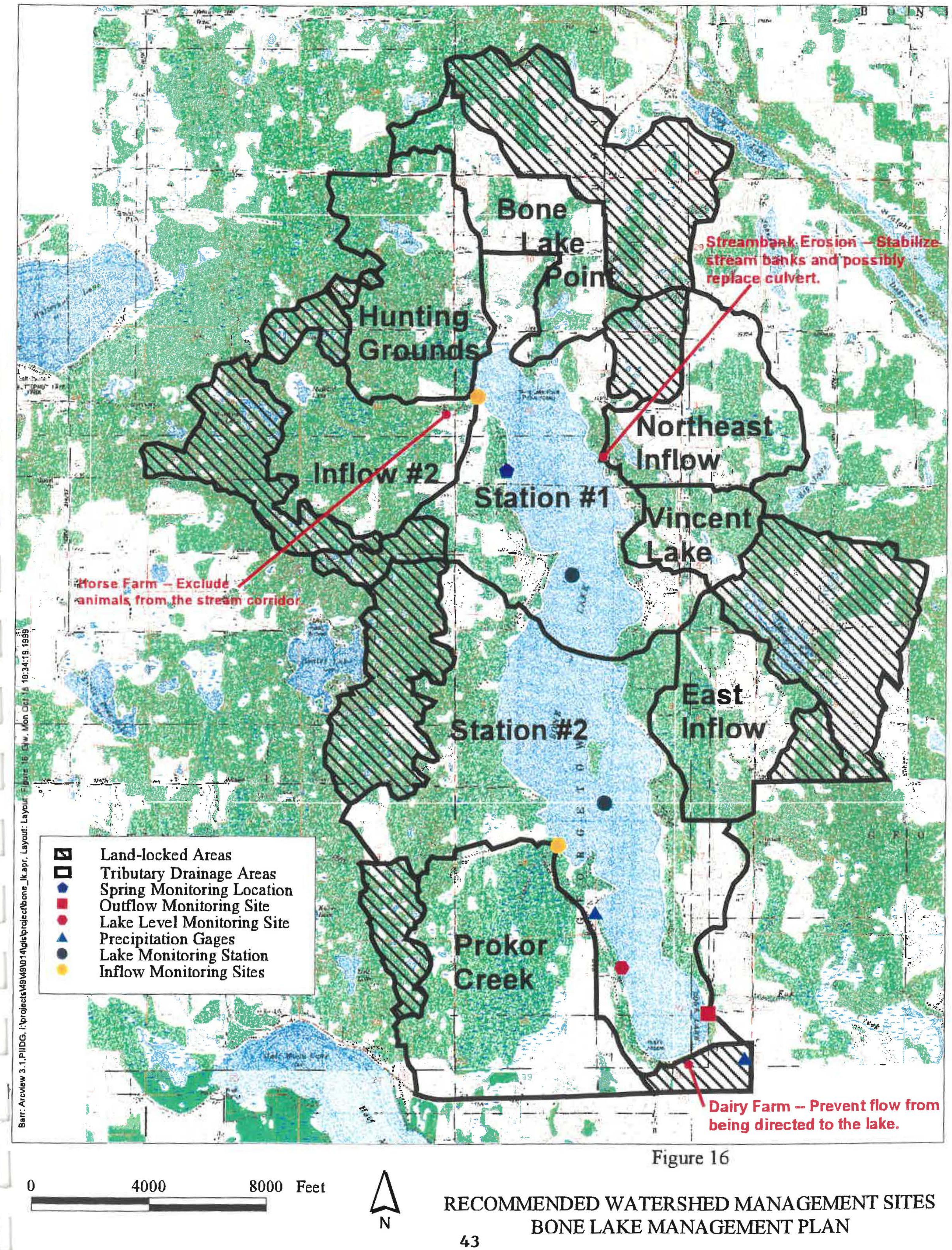


Figure 16

RECOMMENDED WATERSHED MANAGEMENT SITES
BONE LAKE MANAGEMENT PLAN

## Recommended Monitoring

The success or failure of a lake management plan is determined from the plan's ability to achieve the water quality goal of the lake being managed. Therefore, a long-term water quality monitoring program is needed to determine goal achievement of the Bone Lake Management Plan. A lake resident currently monitors the lake's Secchi disc transparency annually as a participant in the WDNR Self Help program. Continued participation is recommended to determine any changes in the lake's water quality that may occur. In addition, monitoring the mixed surface waters (i.e., 0-2 meter composite sample) for total phosphorus and chlorophyll *a* one year per every three years is recommended. A monitoring frequency similar to the 1996 monitoring program is recommended. The data will be used to determine goal achievement.

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# *Appendix A*

## *Aquatic Plant Management-*
## *Sensitive Area Assessment Summary*
## *(WDNR, July 18, 1988 and July 26, 1989)*

WISCONSIN DEPT. OF NATURAL RESOURCES

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## AQUATIC PLANT MANAGEMENT

## SENSITIVE AREA ASSESSMENT SUMMARY

LAKE: BONE — COUNTY: POLK

DATE OF ASSESSMENT: JULY 18, 1988; JULY 26, 1989 — NUMBER OF SENSITIVE AREAS: 11

SITE EVALUATORS: FRANK KOSHERE - WATER QUALITY BIOLOGIST
RICK CORNELIUS - FISH MANAGER
RANDY MCDONOUGH - WILDLIFE TECHNICIAN
LARRY DAMMAN - FISH MANAGER
MARK SUNDEEN - ENVIRONMENTAL SPECIALIST

## BONE LAKE SITE RECOMMENDATION SUMMARY

Site

A.
1. No chemical treatment allowed.
2. No mechanical harvesting allowed.
   a. Minimal hand control allowed around docks.

B.
1. No chemical treatment allowed.
2. No mechanical harvesting allowed.
   a. Minimal hand control allowed around docks.

C.
1. Chemical treatment allowed for 25 foot navigational channels to developed properties.
2. Mechanical control allowed for 25 foot navigational channels to developed properties.

D.
1. No chemical treatment allowed.
2. No mechanical control allowed.

E.
1. No chemical treatment allowed.
2. No mechanical control allowed.

F. 1. No chemical treatment allowed.
2. Mechanical control allowed for a 25 foot navigational channel to developed properties.

G. 1. No chemical treatment allowed.
2. No mechanical control allowed.

H. 1. Chemical treatment of submergents only for the development of a 25 foot navigational channel to developed properties.
2. Mechanical control for the development of a 25 foot navigational channel to developed properties only.

I. 1. Chemical treatment of submergents only.
2. Mechanical control allowed.

J. 1. No chemical treatment allowed.
2. No mechanical control allowed.

K. 1. Chemical treatment of submergents to develop a 25 foot navigational channel to developed properties only.
2. Mechanical control to develop a 25 foot navigational channel to developed properties only.

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### RESOURCE VALUE OF SITE A

This is a bay-like area located on the eastern shore at the north end of Bone Lake. The length of shoreline involved is approximately 1000 feet and extends 150 feet out from shore. The substrate in this area is predominantly sand, gravel, and rubble. The maximum depth at the outer boundary on this site is 7 to 9 feet. The riparian property is in contiguous development, lawns are present, the area is wooded and the south half of the shoreline is rip-rapped.

This area is fairly lacking in emergent vegetation with only arrowhead found in a few locations. Submergent vegetation appears to be a diverse balanced aquatic plant community. Species found here include muskgrass, bushy pondweed, flatstem pondweed, milfoil, coontail, large leaf pondweed, clasping leaf pondweed, whitestem pondweed, wild celery, narrow leaf pondweed, curly leaf pondweed and filimentous algae.

Distribution of these species vary from low density and low-growing forms of most species in the shallow, 0 to 3 feet depth, to abundant populations and larger plants in the 3 to 6 foot depth.

Fish species using the area consist of bluegill, largemouth bass, northern pike, and muskie. Vegetation in the bay provides valuable spawning, feeding, and nursery areas for the fish populations.

Protection of the existing native plants is an important method of helping diminish invasions of exotic species such as purple loosestrife and Eurasian milfoil.

## MANAGEMENT RECOMMENDATIONS FOR SITE A

1. No chemical treatment allowed.
2. No mechanical harvesting allowed.
3. Minimal hand control allowed near dock areas.
4. Efforts should be undertaken to prevent erosion from developments.
5. Strictly enforce shoreland and wetland ordinances.

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LARRY DAMMAN - FISH MANAGER
MARK SUNDEEN - ENVIRONMENTAL SPECIALIST

### RESOURCE VALUE OF SITE B

This site is a bay located along the eastern shore on the northern half of the lake. It may best be identified as the bay along which "E-Z Living Campground" is located. The area is comprised of 1000 feet of shoreline and extends out 150 feet from shore to a depth of 6 feet. The substrate is sand and gravel with pockets of muck.

Emergenct vegetation is found along the northern half of the bay near the shore. Spikerush, bullrush, whitewater lily, and arrowhead are present. Submergent species are very diverse in the area. Wild celery is most dominant, found throughout the site. Bushy pondweed and filimentous algae were found to be abundant. Common species are largeleaf pondweed, clasping leaf pondweed, milfoil, and flatstem pondweed. Coontail and narrow leaf pondweed were also present.

Fish species using the area consist of musky, northern pike, largemouth bass, and panfish. Vegetation in the bay provides valuable spawning, feeding, and nursery areas for the fish populations.

Protection of existing native plants is an important method of helping diminish invasions of exotic species such as purple loosestrife and Eurasian milfoil.

## MANAGEMENT RECOMMENDATIONS FOR SITE B

1. No chemical treatment allowed.
2. No mechanical harvesting allowed.
3. Minimal hand control in high use areas near docks.
4. Efforts should be undertaken to prevent erosion from developments.
5. Strictly enforce shoreland and wetland ordinances.

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LARRY DAMMAN - FISH MANAGER
MARK SUNDEEN - ENVIRONMENTAL SPECIALIST

### RESOURCE VALUE OF SITE C

This site is a small bay situated near the midpoint of the eastern shore. The total shoreline length is approximately 600 feet. The substrate is mostly muck. The riparian property is mostly undeveloped and wooded. There are two cabins at the very northern most part of this area.

The aquatic vegetation found here is very diverse. Emergent species include cattails, burreed, bull rush, yellow water lily, white water lily, and arrowhead. Wild celery and mud plantain are abundant submergent species found throughout the bay. Bushy pondweed, flatstem pondweed, narrow leafed pondweed, clasping pondweed, large leafed pondweed, and filimentous algae are common in this area. Also present is milfoil, coontail, curly leaf pondweed, and clasping leaf pondweed.

Fish species using the site consist of musky, northern pike, large mouth bass, and panfish. Vegetation in the bay provides valuable spawning, feeding, and nursery areas for the fish populations. Northern pike will use the emergent vegetation around the bay for spawning.

Shorebirds, songbirds, and water fowl use this area for feeding, nesting, and rearing young. Muskrat, raccoon, and other furbearers feed and care for young here.

This area contains many high value aquatic plant species. They provide cover and make up a very stable base in the food web of the bay. Also aquatic vegetation helps prevent shoreline erosion and the protection of the existing native plants is an important method of helping diminish invasions of purple loosestrife and Eurasian milfoil.

## MANAGEMENT RECOMMENDATIONS FOR SITE C

1. Chemical control will be allowed in the form of a 25 foot navigational channel to the two existing developed properties. Only water lilies are to be treated to allow navigation.

2. Mechanical control is limited to a 25 foot navigational channel into the two existing developed properties only.

3. Efforts should be undertaken to prevent erosion from developments.

4. Strictly enforce shoreland and wetland ordinances.

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RANDY MCDONOUGH - WILDLIFE TECHNICIAN
LARRY DAMMAN - FISH MANAGER
MARK SUNDEEN - ENVIRONMENTAL SPECIALIST

### RESOURCE VALUE OF SITE D

This site is located along the smaller of two islands found on the lake. The specified area is a small bay at the northeast corner of the island. This site is approximately 400 feet of shoreline and extends outward 100 feet. The wooded island is state owned, so no development has taken place here. The substrate around the entire island consists of gravel and sand with sediment accumulations deposited over the substrate.

White water lily is found along the shore. Coontail is dominant throughout the area. Filimentous algae and bushy pondweed are abundant in the shallow water. Sago pondweed, large leg pondweed, milfoil, and flatstem pondweed are also present in the area nearest the shore.

There are no riparian owners, so there should not be permits issued for any alterations. This area provides wildlife and fisheries habitats.

## MANAGEMENT RECOMMENDATIONS FOR SITE D

1. No chemical treatment allowed.
2. No mechanical treatment allowed.

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MARK SUNDEEN - ENVIRONMENTAL SPECIALIST

### RESOURCE VALUE OF SITE E

This site is a bay found along the northern shore of the larger of two wooded islands found on Bone Lake. The riparian property is privately owned but no shoreline development has taken place anywhere on the island. The bay is approximately 650 feet of shoreline and extends 150 to 200 feet from shore. The substrate is gravel and sand.

The site is lacking in emergent vegetation. Abundant submergents found in the bay are musk grass, large leaf pondweed, and bushy pondweed. Wild celery is commonly found here. Variable pondweed, clasping pondweed, white stem pondweed, curly leaf pondweed, and flatstem pondweed are also present.

Fish species using the area are musky, large mouth bass, and panfish. Vegetation in the bay provides valuable spawning, feeding, and nursery areas for the fish populations. Shorebirds, songbirds, and waterfowl use this area for feeding.

Aquatic vegetation helps prevent shoreline erosion. Protection of the existing native plants is an important method of helping diminish invasions of exotic species such as purple loosestrife and Eurasian milfoil.

## MANAGEMENT RECOMMENDATIONS FOR SITE E

1. No chemical treatment allowed.
2. No mechanical control allowed.
3. Efforts should be undertaken to prevent erosion from developments.
4. Strictly enforce shoreland and wetland ordinances.

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LARRY DAMMAN - FISH MANAGER
MARK SUNDEEN - ENVIRONMENTAL SPECIALIST

### RESOURCE VALUE OF SITE F

This site is a large shallow bay along the eastern shore. The shoreline is completely developed with lawns extending to the water along its entire length. This area is approximately 1100 feet long and extends 100 feet out from shore. The maximum depth of this area is 3 feet. The substrate is made up of gravel and sand.

Emergent vegetation is concentrated near the shoreline. Species present are spike rush, arrowhead, cattails, and bull rush. Yellow and white water lily can be found in spots further from shore. Submerged plants include bushy pondweed, buttercup, and clasping leaf pondweed. All plant species are sparsely distributed throughout this area and most submergents are growing in a low profile form.

Largemouth bass and panfish use this area to feed, spawn, and rear their young. Songbirds and water fowl feed in the bay.

Existing native species of plant in the bay can help prevent shoreline erosion and help diminish invasions of exotic species such as purple loosestrife and Eurasian milfoil.

## MANAGEMENT RECOMMENDATIONS FOR SITE F

1. No chemical treatment allowed.
2. Minimal hand control is allowed in dock areas.
3. Efforts should be undertaken to prevent erosion from developments.
4. Strictly enforce shoreland and wetland ordinances.

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### RESOURCE VALUE OF SITE G

This site is located at the southeast corner of the lake. Fox Creek leaves the lake at the midpoint of this area. The approximate length of this site is 2000 feet and extends to 150 feet from shore. The northern and southern halves of this areas vary greatly. The northern portion is mostly developed with lawn extending to the waters edge. This is the only location with emergent vegetation. The depth varies from 0 to 5 feet in the site boundaries. The southern half of the site is undeveloped and wooded. Most submergents will be in this location. The littoral zone in this area is very narrow with site boundaries having 10 to 20 foot depths.

Plant species would be classified as common or present. No species are found throughout the area and plant populations are considered sparse. Emergent vegetation consists of bull rush only. Submergent species include bushy pondweed, milfoil, wild celery, sago pondweed, flatstem pondweed, clasping pondweed, buttercup, white stem pondweed, large leaf pondweed, muskgrass, and filimentous algae.

Fish species consist of northern pike, musky, largemouth bass, and panfish. The vegetation in the lake provide valuable spawning, feeding, and nursery areas for the fish populations. Heavy use by muskies during the spawning season has been observed here.

Aquatic vegetation helps prevent shoreline erosion. Protection of existing native plants is an important method of helping diminish invasions of non-native species such as purple loosestrife and Eurasian milfoil.

## MANAGEMENT RECOMMENDATIONS FOR SITE G

1. No chemical treatment allowed.
2. No mechanical control allowed.
3. Efforts should be undertaken to prevent erosion from developments.
4. Strictly enforce shoreland and wetland ordinances.

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### RESOURCE VALUE OF SITE H

This site includes a bay and adjacent shoreline along the western shore of the southern portion of Bone Lake. The total shoreline length of this site is approximately 2500 feet extending 150 to 200 feet from shore. The substrate of the site is gravel and sand. Development is found intermittently along the site making up about half of the total shoreline involved.

Emergent species are very diversified and found scattered throughout the area. Species include bullrush, white water lily, bur reed, tall spike rush, pickerel week, cattail, yellow water lily, and arrowhead. Submergent vegetation consists of muskweed, wild celery, milfoil, flatstem pondweed, largeleaf pondweed, clasping pondweed, white stem pondweed, coontail, bushy pondweed, and buttercup. Filimentous algae is found periodically here throughout the year.

Fish species using the area consist of musky, northern pike, large mouth bass, and panfish. The vegetation on this site provides valuable spawn, feeding, and nursery ares for the fish populations.

Shorebirds, songbirds, and waterfowl use this area for feeding and resting during migration. Many of these birds remain, nest, feed, and bear their young here.

Raccoon and muskrat can be found frequenting the edges of this site. Many raise young in the area.

Aquatic vegetation helps prevent shoreline erosion. The protection of the existing native plants is an important method of helping diminish invasions of purple loosestrife and Eurasian milfoil.

## MANAGEMENT RECOMMENDATIONS FOR SITE H

1. Chemical control with conditions:

   a. No treatment of spike rush and bull rush.
   b. Chemical control is limited to a 25 foot navigational channel to developed properties only.

2. Mechanical control with conditions:

   a. Avoid harvest of spike rush and bull rush.
   b. Mechanical harvesting providing a 25 foot navigational channel to developed properties only.

3. Efforts should be undertaken to prevent erosion from developments.

4. Strictly enforce shoreland and wetland ordinances.

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MARK SUNDEEN - ENVIRONMENTAL SPECIALIST

### RESOURCE VALUE OF SITE I

This site is the largest designated in the survey. It is located midway along the length of the lake on the western shore. The total length of this site is approximately one mile and extends 150 feet from shore. The substrate is mostly gravel with areas of rubble, sand, and silt. Most of the shoreline is undeveloped with those dwellings present lacking lawns that extend to the lakeshore. The riparian property is heavily wooded.

The emergent community found here is the most dominant aquatic vegetation. Bullrush and spike rush can be found along the entire length of this site. Submergent vegetation consists of an average mix of all species common to this lake. None of these could be classified as abundant.

Fish species using this site include large mouth bass, musky, northern pike, and panfish. The aquatic vegetation provides valuable spawning, feeding, and nursery areas for the fish populations.

Shorebirds, songbirds, and waterfowl use this area for feeding and nesting during migration. Many remain in the spring and nest and rear their young. Muskrat, raccoon, and other furbearers use this area for cover and food.

The aquatic vegetation helps prevent shoreline erosion. Protection of the existing native plants is an important method of helping diminish invasions of purple loosestrife and Eurasian milfoil.

## MANAGEMENT RECOMMENDATIONS FOR SITE I

1. Chemical treatment with conditions:

    a. No chemical treatment of emergent vegetation.
    b. Chemical treatment of submergent vegetation is allowed.

2. Mechanical control allowed.

3. Efforts should be undertaken to prevent erosion from developments.

4. Strictly enforce shoreland and wetland ordinances.

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LARRY DAMMAN - FISH MANAGER
MARK SUNDEEN - ENVIRONMENTAL SPECIALIST

### RESOURCE VALUE OF SITE J

This site consists of a stand of bullrush which forms a small 150 by 150 foot island. The location is near the north end of the lake and approxiamtely 1000 feet from the western shore. The substrate is rubble and drops off to the 30 foot depth within 100 feet of this stand.

This site is used by musky and largemouth bass as a feeding area. Great Blue Herons feed on this site.

## MANAGEMENT RECOMMENDATIONS FOR SITE J

1. No chemical treatment allowed.

2. No mechanical treatment allowed.

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### RESOURCE VALUE OF SITE K

This site is located at the north end of the lake. The approximate length of this site is 3000 feet and extends out to the 5 foot depth. This site receives drainage from a large area of farm land which forms a bowl surrounding the northern portion of the lake. The substrate is mostly muck over a rubble bottom.

This area has dominant emergent vegetation. Cattails, pickerel weed, bull rush, spike rush, arrowhead, wild rice, and white and yellow water lily are found here in abundant populations. Submergent plants consist of an average mix of all species found on the lake. No submergent species would be classified as dominant.

This site provides feeding, spawning, and nursery ares for the fish populations. Northern pike, largemouth bass, musky, and panfish use this site.

Shorebirds and wading birds feed in this area. Waterfowl use the area for feeding and resting during migration. Some nest and rear their young on this site. Furbearers such as muskrat and raccoon use the area for feeding.

Protection of the existing native plants is an important method of helping diminish invasions of exotic species such as purple loosestrife and Eurasian milfoil.

## MANAGEMENT RECOMMENDATIONS FOR SITE K

1. Chemical treatment with restrictions:

   a. No chemical treatment of emergents.
   b. Chemical treatment of submergents allowing a 25 foot navigational channel to developed properties only.

2. Mechanical control with restrictions:

   a. Mechanical harvesting to form navigational channels, 25 feet wide, to developed sites only.

3. Efforts should be undertaken to prevent erosion from developments.

4. Strictly enforce shoreland and wetland ordinances.

# *Appendix B*

## *1998 Membership Survey*

# Bone Lake Management

Questionnaire

At the Bone Lake Management District Annual Meeting on Saturday Aug 8, 1998 we discussed the results of Phase I and II of our Lake Management Planning process and goals for Phase III of the project. We now need your help to establish these goals for Bone Lake.

1. Please circle the term that best describes the water clarity of Bone Lake during the summer of 1998.

   a. Crystal clear  b. Clear  c. Somewhat cloudy
   d. Very cloudy  e. Murky

Most practices to maintain or improve the water quality of Bone Lake will cost money. We will pursue financial support from the Wis DNR, as well as federal and local funding sources but some of the costs will have to be paid by you as a property owner.

2. Assuming the above do you support projects to: (select one)

   a. primarily maintain the water quality as it exists
   b. Improve the water quality

3. What water clarity should our goal be for Bone Lake.

   a. Crystal clear  b. Clear  c. Somewhat cloudy
   d. Very cloudy  e. Murky

4. There is an assumption that water clarity-water quality limits your recreational activities on Bone Lake.

   What recreational activities do you enjoy at Bone Lake? Please list up to five activities in order of priority (i.e. 1. The activity of highest priority to you and 5 the activity of lowest priority to you)

   **Recreational Activities**

   a. Fishing  b. Observing Wildlife
   c. Swimming  d. Scuba Diving
   e. Appreciate Peace and Tranquility  f. Snorkeling
   g. Enjoying the View  h. Water Skiing
   I. Jet Skiing  j. Motorized Boating
   k. Non-Motorized Canoeing, Rowing  l. Sailing,, Wind Surfing
   m. Other (Please State)

   **Your Bone Lake Recreational Activities Under Current Water Quality Conditions**

   1. ____________________
   2. ____________________
   3. ____________________
   4. ____________________
   5. ____________________

5. What recreational activities would you enjoy at Bone Lake if its water quality was at whatever level you desire? Please list up to five activities in order of priority (i.e., 1 the activity of highest priority to you and 5 the activity of lowest priority to you).

**Your Bone Lake Recreational Activities Under Ideal Water Quality Conditions**

1. ______________________________
2. ______________________________
3. ______________________________
4. ______________________________
5. ______________________________

6. Please rank the following Lake Management Goals in order of importance (i.e., 1 is the management goal that is most important to you and 9 is the management goal that is least important to you).

a. _____ Protect existing water quality of the lake (I.e., prevent water quality from getting worse.
b. _____ Improve the lake's water quality.
c. _____ Protect existing fisheries (I.e., prevent harm to current fisheries.
d. _____ Improve fisheries.
e. _____ Protect existing weed growth (I.e., prevent loss of current weed growth)
f. _____ Increase weed growth
g. _____ Decrease weed growth
h. _____ Protect aesthetics (I.e., prevent a negative change in how the lake looks)
I. _____ Improve aesthetics (I.e., help the lake to look better)

7. How long have you owned property on Bone Lake? ________ years

8. Are you a seasonal or permanent resident of Bone Lake? Circle one (Seasonal, Permanent)

9. What do you like MOST about Bone Lake?

10. What do you like LEAST about Bone Lake?

11. Please list any additional comments you would like to consider.

# Bone Lake Management

Property Owners Survey Results
November 1998

At the Bone Lake Management District Annual Meeting on Saturday Aug 8, 1998 members of the district discussed the results of Phase I and II of our Lake Management Planning process and goals for Phase III of the project.

The board of commisisioners at their October 22, 1998 meeting decided it was important to get imput from all property owners in the district on what they wanted for short and long term water quality goals for Bone Lake. Roger A. Swanson, chair of the Bone Lake Management District, working in cooperation with Meg Ratti of Barr Engineering of Minneapolis and Jeff Timmons County Conservationist for Polk County developed a survey insturment to survey all property owners in the Bone Lake Management District. The results of this survey will be used to establish water quality goals, phosphorus reduction goals and recommendatiions of watershed management practices to accomplish these goals.

In November the survey was sent to 553 property owners on Bone Lake. We received 252 completed survey forms a 46% return rate. Thanks to all who completed and returned the survey.

THE FOLLOWING IS THE COMPILED AND SUMMARIZED RESULTS.

1. Please circle the term that best describes the water clarity of Bone Lake during the summer of 1998.

| a. Crystal clear | b. Clear | c. Somewhat cloudy | d. Very cloudy | e. Murky |
|---|---|---|---|---|
| | 89 = 39% | 92 = 40% | 22 = 10% | 27 = 11% |

**Comments:**
We have pictures of all the scum on the water most of the summer
Green scum late Aug and Sept.
Murky at times
Very good this summer
Clear 1st week of July
Clear early in summer, somewhat cloudy later in summer
Green too often
More consistently clear we've seen in many years
This year was best on the North end. Most years it is very cloudy to murky.

2. Most practices to maintain or improve the water quality of Bone Lake will cost money.
We will pursue financial support from the Wis DNR, as well as federal and local funding sources but some of costs will have to be paid by you as a property owner.
Assuming the above do you support projects to: (select one)

| a. primarily maintain the water quality as it exists | b. Improve the water quality |
|---|---|
| 86 = 37% | 145 = 63% |

**Comments:**
No
Depends on how much the cost is
This lake is public ! All users should pay the cost of improvement

3. What water clarity should our goal be for Bone Lake.

| a. Crystal clear | b. Clear | c. Somewhat cloudy | d. Very cloudy | e. Murky |
|---|---|---|---|---|
| 19 = 8% | 192 = 81% | 25 = 11% | | 1 |

**Comments:**
Let nature decide

6. **Bone Lake Management Goals**

Please rank the following Lake Management Goals in order of importance (i.e., 1 is the management goal that is most important to you and 9 is the management goal that is least important to you).

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | Total |
|---|---|---|---|---|---|---|---|---|---|---|
| Improve Lake's Water Quality | 95 | 65 | 26 | 16 | 16 | 10 | 9 | 4 | 7 | 248 |
| Protect Lake's Water Quality | 72 | 57 | 36 | 21 | 21 | 5 | 1 | 1 | 0 | 214 |
| Decrease Weed Growth | 33 | 32 | 29 | 22 | 16 | 13 | 11 | 16 | 16 | 188 |
| Improve Fisheries | 12 | 17 | 24 | 7 | 27 | 19 | 32 | 6 | 2 | 146 |
| Protect Asthetics | 10 | 23 | 31 | 28 | 32 | 29 | 31 | 9 | 3 | 196 |
| Improve Asthetics | 5 | 15 | 27 | 29 | 28 | 39 | 31 | 16 | 6 | 193 |
| Protect Existing Fisheries | 4 | 18 | 32 | 27 | 17 | 24 | 16 | 4 | 0 | 142 |
| Protect Weed Growth | 2 | 6 | 10 | 18 | 13 | 22 | 25 | 77 | 9 | 182 |
| Increase Weed Growth | 0 | 1 | 2 | 4 | 10 | 9 | 15 | 36 | 125 | 202 |

**Comments:**
Decrease milfoil (4)

7. How long have you owned property on Bone Lake?,

| | | % |
|---|---|---|
| <2 years | 15 | 6 |
| 2-5 years | 48 | 19 |
| 6-10 years | 59 | 23 |
| 11-15 years | 34 | 13 |
| 16-20 years | 16 | 6 |
| >20 years | 86 | 33 |
| | 258 | 100 |

8. Are you a seasonal or permanent resident of Bone Lake? Circle one (Seasonal, Permanent)

| Seasonal | Permanent |
|---|---|
| 208 = 81% | 49 = 19% |

**Comments:**
Both
Plan on retiring there
Spend part of winter there
Permanent last 18 of 39 years
Year-round, out of town
Seasonal now, but grew up on Bone Lake
Soon to be permanent
Had a seasonal for 3 years prior on Bone Lake
Seasonal, we use our lake home every season, including winter

Water clarity, scenery, islands, wildlife, oack of crowded conditions, general demanor
The views of the lake - fishing - swimming
Large beautiful lake, close to where we live in Hudson
Size and diversity, Big lake you can boat, ski, swim and fish
Location, size-large lake, great neighbors, not over crowded
It is still a beautiful lakd with a lot of wildlife.
It's pretty peaceful especially since the jet skiers have to stay farther away.
View, wildlife, swimming, fishing
It is a good all all around lake good fishing, boating and recreation
Riding around the lake on my pontoon
The sense of community and how it supports the lake and its many uses.
The size, scenery & establishments on the lake
water quality
It is not as busy as other lakes
The fishing, the northwoods feel, somewhat remote natural setting
Size, depth, water,people, fishing, recreation
I love the beauty of the lake and the wildlife
The natural beauty and peace
Reasonably quiet (boat trafffic) and still some natural shoreline
This is a great place to relax and enjoy nature
Size and recreational opportunities
Size, water quality, location, depth
The beauty of the lake, both above and below the water
Multiple recreational activities available
It's generally quiet
muskey fishing, boating, swimming
Nice to get away from the cities
People, Peace & Tranquility
Far enough away, yet close to the Twin Cities

10. What do you like **LEAST** about Bone Lake?
High powered boats
Jet Skis (26)
Water quality
Weeds (6)
Algae (3)
Increase in PWC noise
The noise levels from jet skis and high powered boats
I don't like to see the lake sprayed for cosmetic reasons
Swimmers itch. That's my main complaint. We cant have people in the water as the weather gets warm. The itch is awful
The rape and pillage on lake property, owner taxation
Not there enough
Poor fishing
Rocks and shallow lake shore
No walleyes
Its getting too built up around the lake
Deterioration of water quality in mid to late summer
speed boats cutting close from my point and eroding my shorline
conflicts between fishing and recreational users(i.e. skiiing)
fishing within 10' of my dock and shoreline
Excessive boating and related activities
Closeness of neighbors and amount of kids on jetskis that are not courteous
DNR is hard to work with- doesnt use common sense in any improvement to lake lots
The algae was out of control in summer 98Neighboring shared access, boat traffic
Jet skis, high speed boat traffic and weekend congestion reduce the qualities people value
too many muskie in the lake, too much jet ski and speed boat traffic. not enough law
Too much muskie and not enough other fish;jet skis not used properly
enforcement on lake

WEEDS Noise from jet skies
That it is a rocky bottom, cold lake & it gers "green" in the later summer months.
The jet-ski noise and hazard to boating, skiing and swimming
The musky population had destroyed the perch and bass and completely eliminated the walleyes
Personal water craft
Weed growth and water clarity
Decline in water quality, increase in jet ski use
Pan fish are almost non existant
Too much musky - not enough pan fish
mid-july to september poor water clarity and algae growth
The recent years increase in boat raffic and Jet skies
Weeds, fishing tournaments, increased population
Nothing
taxes
Fishing could be improved
Green scum and jet skies
JET SKIES!!!!!
Sherrif
Motorized recreation other than fishing.
Swimmers itch and green water
weeds, algae
Very good lake to be on. I hope they control the building on this lake so it doesn't get over populated
Would prefer fish other than musky, Don't like jet skies! Too loud and dangerous
Green water too often
Take care of itch
small pan fish, blue gills and pearch

11. Please list any additional comments you would like us to consider.

Let us improve our shorelines.
My quality time on the lake has been reduced due to the fishing tournaments and the increasing # of jet skis
I would like to commend the bone lake management district on their work, the questionaire was a great idea
I would like to commend the bone lake management district on their work, the questionaire was a great idea
Stop wasting tax money
Protect the animals as well as the areas surrounding the lake
Ban jet skis from all lakes
Please enforce banning jet skis close to shore and ban use in pm and early am
Don't do anything that would asttract attention and thus more people to bone lake;do not expand public access;no casinos on or close to the lake
Thanks for your efforts
Thank you for caring
More wake control
I appreciate al the time you and your committee spend to better the conditions on bone lake
Every improvement has a cost, be sure to consider the cost/benefit of any improvement considered
I appreciate your concern for the quality of the lake+
Make sure no sewage is going into the lake
I feel that the DNR police are creating "specialty lakes", increasing traffic between lakes and mores.
98 summer water quality was the best in years, why? Ski-doo's suck-too noisy, very uncontrolled, a basic no brain-no effort activity;no obligation from no property owners who use and abuse th lake. Share the fun-share the cost
Would like to see more panfish in lake for chidren's fishing and less muskies
DNR should buy the existing lots on the lake to preserve the natural lake shore
Thanks for doing this
Stock more bass and less muskies
Respect of all users is needed. Jet skiing need to keep a distance and fishing boats should everything else is fine
We've been on the lake since 1967 and are concemed about the loss of weeds. They have changed from a broader leaf weed to a smaller leaf weed. We think the weeds are necessary for good water quality

I would like to see lake shore owners devote a part of their beach front for natural growth to help preserve the environment.

We live in Colorado now, and have a cabin on Bone. Here in Colo, it is a law that when water skiing theat one person in the boat raises a brightly colored flag up when the skier is down in the water. If it is not a law in Wisc believe it should be one!

Clean up all the junk along GG - junk cars, etc

Limit boats on to lake at access

Stop promoting Bone Lake as a prime musky lake. It does nothing for the lake residents.

I,m sorry that more land and the island was not left natural. I would also like more boating regulations inforcec

Good luck

The water quality continues to decrease

Because 1998 lake opening was the earliest on record water quality was worse than normal. If we can keep t water quality as good as previous years, I would be satisfied.

If money is needed, all users of the lake should pay equally - it is a public lake. Several fishing tournaments a held on the lake - here a public facility is used for private profit.

We need a fuel pump on a dock. Individual fillin gof boats with gas spills far more gas than a central location would. Let's have a voluntary moratorium on all lawn chemicals!

Musky size limit too high!

We have only owned our cabin 1/2 year, but would like to see Bone Lake relatively clear & clean for swimmin Hope we can keep it beautiful with kind & considerate property owners respectful to nature & each other so kids can grow up having fun at the lake & also learn about nature & responsibility. Thanks for all you do!

Thank you for all your work and efforts to help make Bone Lake "the best." Can I help in some way to becom more involved in the process. Thanks

How can we as an association regulate the number of watercrafts that put in at public landings and mis-use th lake. Both by fishing and by improper use of their watercraft. Not observing buoy's-speeding, noise, etc.

We have been on the lake for 5 seasons. The first year 1994 the water quality was the worst, 1998 summer v the best water quality. My question is it nautre or lake management the reason for the change. My guy tells ı it probably was nature. Let's make our decisions smart, not hastily.

More patrolling/monitoring of skiiers (jet and water); also possible hour restrictions.

Keep islands undeveloped as possible. Great asset to lake. Ideal: Do not increase popuolation-decrease if possible, of trailers in trailer park.

Less weeds in bay east of north island on east side of lake!

Does the new "jet-ski" regulations apply to other very noisy watercraft such as the "hovercrafttype" used by resident of the big island. This is a real nusiance and should be regulated!

## *Appendix C*

### *1998 Water Quality Monitoring Data*

## BONE LAKE - STATION #1

| Date | Secchi Disc (M) | Sample Depth (M) | Chlor. a (ug/L) | Total P (mg/L) | Date | Secchi Disc (M) | Sample Depth (M) | Chlor. a (ug/L) | Total P (mg/L) |
|---|---|---|---|---|---|---|---|---|---|
| 06/10/96 | 3.0 | 0-2 | 2.36* | 0.013 | | | | | |
| 06/24/96 | 3.0 | 0 | -- | -- | | | | | |
| 07/09/96 | 2.7 | 0-2 | 13.4 | 0.021 | 07/23/98 | 1.5 | 0-2 | 9.6 | 0.027 |
| 07/23/96 | 1.8 | 0-2 | 23.8 | -- | 07/30/98 | 1.2 | 0-2 | 16.5 | 0.019 |
| 08/06/96 | 1.4 | 0-2 | 28.7 | 0.035 | 08/06/98 | 1.2 | 0-2 | 15.6 | 0.025 |
| 08/13/96 | 1.3 | 0-2 | | | 08/13/98 | 1.4 | 0-2 | 20.8 | 0.021 |
| 08/19/96 | 1.4 | 0-2 | 25.3 | 0.016 | 08/20/98 | 1.4 | 0-2 | 27.5 | 0.027 |
| 08/26/96 | 1.3 | 0-2 | 32.0 | | 08/27/98 | 1.4 | 0-2 | 29.8 | 0.027 |
| 09/03/96 | 1.2 | 0 | 28.2 | 0.030 | 09/03/98 | 1.2 | 0-2 | 30.3 | 0.028 |
| 09/10/96 | 1.1 | 0-2 | 37.3 | | 09/10/98 | 1.1 | 0-2 | 30.3 | 0.034 |
| 7/23-9/10 avg. | 1.4 | 0-2 | 29.2 | 0.027 | 7/23-9/10 avg. | 1.3 | 0-2 | 22.6 | 0.026 |
| **8/6-9/10 avg.** | **1.3** | **0-2** | **30.3** | **0.027** | **8/6-9/10 avg.** | **1.3** | **0-2** | **24.2** | **0.027** |

# BONE LAKE - STATION #2

| Date | Secchi Disc (M) | Sample Depth (M) | Chlor. a (ug/L) | Total P (mg/L) | Date | Secchi Disc (M) | Sample Depth (M) | Chlor. a (ug/L) | Total P (mg/L) |
|---|---|---|---|---|---|---|---|---|---|
| 06/10/96 | 3.1 | 0-2 | 2.08* | 0.014 | | | | | |
| 06/24/96 | 3.0 | 0 | -- | -- | | | | | |
| 07/09/96 | 2.7 | 0-2 | 13.4 | 0.021 | 07/23/98 | 1.5 | 0-2 | 10.8 | 0.019 |
| 07/23/96 | 1.8 | 0-2 | 23.8 | -- | 07/30/98 | 1.4 | 0-2 | 15.1 | 0.027 |
| 08/06/96 | 1.4 | 0-2 | 28.7 | 0.035 | 08/06/98 | 1.4 | 0-2 | 16.2 | 0.023 |
| 08/13/96 | 1.3 | 0-2 | -- | -- | 08/13/98 | 1.4 | 0-2 | 18.4 | 0.019 |
| 08/19/96 | 1.4 | 0-2 | 25.3 | 0.016 | 08/20/98 | 1.2 | 0-2 | 24.5 | 0.035 |
| 08/26/96 | 1.3 | 0-2 | 32.0 | -- | 08/27/98 | 1.4 | 0-2 | 28.3 | 0.031 |
| 09/03/96 | 1.2 | 0 | 28.2 | 0.030 | 09/03/98 | 1.2 | 0-2 | 30.8 | 0.030 |
| 09/10/96 | 1.1 | 0-2 | 37.3 | -- | 09/10/98 | 1.1 | 0-2 | 39.7 | 0.039 |
| 7/23-9/10 avg. | 1.4 | 0-2 | 25.0 | 0.014 | 7/23-9/10 avg. | 1.3 | 0-2 | 23.0 | 0.028 |
| **8/6-9/10 avg.** | **1.3** | **0-2** | **25.3** | **0.016** | **8/6-9/10 avg.** | **1.3** | **0-2** | **25.8** | **0.029** |

# *Appendix D*

## *Model Stormwater Management Ordinance*

## 5. SCOPE AND EFFECT

5.1 Applicability. Every applicant for a building permit, subdivision approval, or a permit to allow land disturbing activities must submit a storm water management plan to the [planning department, department of community development, zoning administrator]. No building permit, subdivision approval, or permit to allow land disturbing activities shall be issued until approval of the storm water management plan or a waiver of the approval requirement has been obtained in strict conformance with the provisions of this ordinance. The provisions of section 9 of this ordinance apply to all land, public or private, located within the [City, Town, County] of ___________.

5.2 Exemptions. The provisions of this ordinance do not apply to:

a) Any part of a subdivision if a plat for the subdivision has been approved by the [City Council, County Board, Town Board] on or before the effective date of this ordinance;

b) Any land disturbing activity for which plans have been approved by the watershed management organization within six months prior to the effective date of this ordinance;

c) A lot for which a building permit has been approved on or before the effective date of this ordinance;

d) Installation of fence, sign, telephone, and electric poles and other kinds of posts or poles; or

e) Emergency work to protect life, limb, or property.

5.3 Waiver. The [City Council, Town Board, County Board], upon recommendation of the Planning Commission, may waive any requirement of this ordinance upon making a finding that compliance with the requirement will involve an unnecessary hardship and the waiver of such requirement will not adversely affect the standards and requirements set forth in Section 6. The [City Council, Town Board, County Board] may require as a condition of the waiver, such dedication or construction, or agreement to dedicate or construct as may be necessary to adequately meet said standards and requirements.

## 6. STORM WATER MANAGEMENT PLAN APPROVAL PROCEDURES

6.1 Application. A written application for storm water management plan approval, along with the proposed storm water management plan, shall be filed with the [planning department, department of community development, zoning administrator] and shall include a statement indicating the grounds upon which the approval is requested, that the proposed use is permitted by right or as an exception in the underlying zoning district, and adequate evidence showing that the proposed use will conform to the standards set forth in this ordinance. Prior to applying for approval of a storm water management plan, an applicant may have the storm water management plans reviewed by the appropriate departments of the [city, town, county].

Two sets of clearly legible blue or black lined copies of drawings and required information shall be submitted to the [planning department, department of community development, zoning administrator] and shall be accompanied by a receipt from the ___________ [governmental unit's chief financial officer] evidencing the payment of all required fees for processing and approval as set forth in Section 7.5, and a bond when required by Section 7.4

4) Schedule of anticipated starting and completion date of each land disturbing activity including the installation of construction site erosion control measures needed to meet the requirements of this ordinance; and

5) Provisions for maintenance of the construction site erosion control measures during construction.

c) Plan of final site conditions. A plan of final site conditions on the same scale as the existing site map showing the site changes including:

1) Finished grading shown at contours at the same interval as provided above or as required to clearly indicate the relationship of proposed changes to existing topography and remaining features;

2) A landscape plan, drawn to an appropriate scale, including dimensions and distances and the location, type, size and description of all proposed landscape materials which will be added to the site as part of the development;

3) A drainage plan of the developed site delineating in which direction and at what rate storm water will be conveyed from the site and setting forth the areas of the site where storm water will be allowed to collect;

4) The proposed size, alignment and intended use of any structures to be erected on the site;

5) A clear delineation and tabulation of all areas which shall be paved or surfaced, including a description of the surfacing material to be used; and

6) Any other information pertinent to the particular project which in the opinion of the applicant is necessary for the review of the project.

## 7. PLAN REVIEW PROCEDURE

7.1 Process. Storm water management plans meeting the requirements of Section 6 shall be submitted by the [planning department, department of community development, zoning administrator] to the Planning Commission for review in accordance with the standards of Section 8. The Commission shall recommend approval, recommend approval with conditions, or recommend denial of the storm water management plan. Following Planning Commission action, the storm water management plan shall be submitted to the [City Council, Town Board, County Board] at its next available meeting. [City Council, Town Board, County Board] action on the storm water management plan must be accomplished within 120 days following the date the application for approval is filed with the [planning department, department of community development, zoning administrator].

*[COMMENTARY: The process outlined in Section 7.1 can be modified to be consistent with the regulatory process of the particular local government unit. For example, one local government may have a particular department which reviews land use regulatory matters except the final decision to approve or deny a land use plan or permit which is reserved for the governing body of the local government unit. Another local governmental unit may provide the department which reviews land use regulatory matters with full authority to take final action on the application. Other local governments may use a hybrid process where some permits are acted upon by the appropriate regulatory department while other land use matters are left to the governing body for final approval.]*

7.2 Duration. Approval of a plan submitted under the provisions of this ordinance shall expire

8.4 Tracking. Each site shall have graveled roads, access drives and parking areas of sufficient width and length to prevent sediment from being tracked onto public or private roadways. Any sediment reaching a public or private road shall be removed by street cleaning (not flushing) before the end of each workday.

8.5 Drain inlet protection. All storm drain inlets shall be protected during construction until control measures are in place with a straw bale, silt fence or equivalent barrier meeting accepted design criteria, standards and specifications contained in the MPCA publication "Protecting Water Quality in Urban Areas."

8.6 Site erosion control. The following criteria (a. through d.) apply only to construction activities that result in runoff leaving the site.

a) Channelized runoff from adjacent areas passing through the site shall be diverted around disturbed areas, if practical. Otherwise, the channel shall be protected as described below. Sheetflow runoff from adjacent areas greater than 10,000 square feet in area shall also be diverted around disturbed areas, unless shown to have resultant runoff rates of less than 0.5 $ft.^3/sec.$ across the disturbed area for the one year storm. Diverted runoff shall be conveyed in a manner that will not erode the conveyance and receiving channels.

b) All activities on the site shall be conducted in a logical sequence to minimize the area of bare soil exposed at any one time.

c) Runoff from the entire disturbed area on the site shall be controlled by meeting either subsections 1 and 2 or 1 and 3.

1) All disturbed ground left inactive for fourteen or more days shall be stabilized by seeding or sodding (only available prior to September 15) or by mulching or covering or other equivalent control measure.

2) For sites with more than ten acres disturbed at one time, or if a channel originates in the disturbed area, one or more temporary or permanent sedimentation basins shall be constructed. Each sedimentation basin shall have a surface area of at least one percent of the area draining to the basin and at least three feet of depth and constructed in accordance with accepted design specifications. Sediment shall be removed to maintain a depth of three feet. The basin discharge rate shall also be sufficiently low as to not cause erosion along the discharge channel or the receiving water.

3) For sites with less than ten acres disturbed at one time, silt fences, straw bales, or equivalent control measures shall be placed along all sideslope and downslope sides of the site. If a channel or area of concentrated runoff passes through the site, silt fences shall be placed along the channel edges to reduce sediment reaching the channel. The use of silt fences, straw bales, or equivalent control measures must include a maintenance and inspection schedule.

d) Any soil or dirt storage piles containing more than ten cubic yards of material should not be located with a downslope drainage length of less than 25 feet from the toe of the pile to a roadway or drainage channel. If remaining for more than seven days, they shall be stabilized by mulching, vegetative cover, tarps or other means. Erosion from piles which will be in existence for less than seven days shall be controlled by placing straw bales or silt fence barriers around the pile. In-street utility repair or construction soil or dirt storage piles located closer than 25 feet of a roadway or drainage channel must be covered with tarps or suitable alternative control, if exposed for more than

e) A protective buffer strip of vegetation surrounding the permanent pool at a minimum width of one rod (16.5 feet) *[this width is consistent with the draft rules developed by the Board of Water and Soil Resources under the Wetland Conservation Act of 1991]*;

f) All storm water detention facilities shall have a device to keep oil, grease, and other floatable material from moving downstream as a result of normal operations;

g) Storm water detention facilities for new development must be sufficient to limit peak flows in each subwatershed to those that existed before the development for the 10 year storm event. All calculations and hydrologic models/information used in determining peak flows shall be submitted along with the storm water management plan;

h) All storm water detention facilities must have a forebay to remove coarse-grained particles prior to discharge into a watercourse or storage basin.

8.9 Wetlands.

a) Runoff shall not be discharged directly into wetlands without presettlement of the runoff.

b) A protective buffer strip of natural vegetation at least one rod (16.5 feet) in width shall surround all wetlands. *[This width is consistent with the draft rules developed by the Board of Water and Soil Resources under the Wetland Conservation Act of 1991.]*

c) Wetlands must not be drained or filled, wholly or partially, unless replaced by restoring or creating wetland areas of at least equal public value. Replacement must be guided by the following principles in descending order of priority:

1) Avoiding the direct or indirect impact of the activity that may destroy or diminish the wetland;

2) Minimizing the impact by limiting the degree or magnitude of the wetland activity and its implementation;

3) Rectifying the impact by repairing, rehabilitating, or restoring the affected wetland environment;

4) Reducing or eliminating the impact over time by preservation and maintenance operations during the life of the activity; and

5) Compensating for the impact by replacing or providing substitute wetland resources or environments. *[Compensation, including the replacement ratio and quality of replacement should be consistent with the requirements outlined in the rules which will be adopted by the Board of Water and Soil Resources to implement the Wetland Conservation Act of 1991.]*

8.10 Steep slopes. No land disturbing or development activities shall be allowed on slopes of 18 per cent or more.

8.11 Catch basins. All newly installed and rehabilitated catch basins shall be provided with a sump area for the collection of coarse-grained material. Such basins shall be cleaned when they are half filled with material.

8.12 Drain leaders. All newly constructed and reconstructed buildings will route drain leaders to pervious areas wherein the runoff can be allowed to infiltrate. The flow rate of water exiting deemed committed on each day during or on which a violation occurs or continues.

## 11. OTHER CONTROLS

In the event of any conflict between the provisions of this ordinance and the provisions of an erosion control or shoreland protection ordinance adopted by the [City Council, Town Board, County Board], the more restrictive standard prevails.

## 12. SEVERABILITY

The provisions of this ordinance are severable. If any provision of this ordinance or the application thereof to any person or circumstance is held invalid, such invalidity shall not affect other provisions or applications of this ordinance which can be given effect without the invalid provision or application

## 13. EFFECTIVE DATE

This ordinance shall be effective the _______ day of _________, 199__.