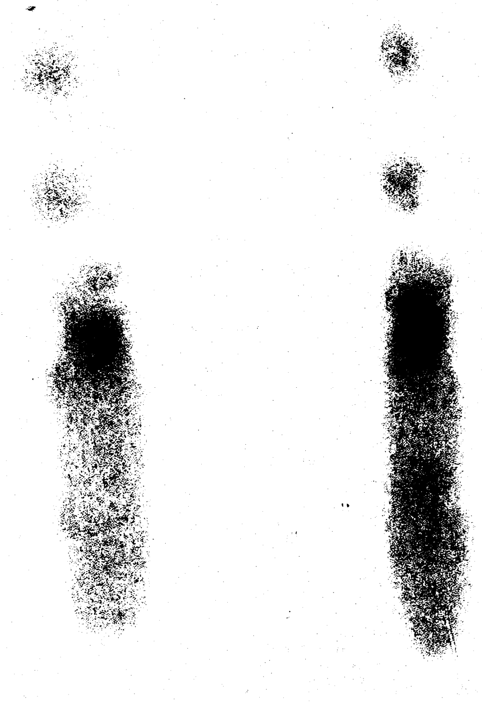

THE UNIVERSITY OF MICHIGAN
Biological Station

Environmental Features of Walloon Lake and its Watershed (Emmet and Charlevoix Counties, Michigan) With Special Reference to Nutrient Management

Technical Report No. 6

by

Project CLEAR STAFF

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Douglas Lake

PREFACE

The University of Michigan Biological Station was established in 1909 at Douglas Lake near Pellston, Michigan, as a teaching and research facility. It occupies a 10,000-acre tract of semi-wilderness in northern lower Michigan, surrounded by a remarkable variety of upland and lowland deciduous and coniferous forests, meadows, marshes, bogs, dunes, lakes and streams. The three upper Great Lakes - Michigan, Huron and Superior - are nearby. As the largest and one of the most distinguished inland biological stations in the world, it serves as an intellectual meeting place for biologists and students from the United States and around the world.

The Biological Station is well-equipped for investigations of the diverse natural environments around it. In addition to the modern, winterized Lakeside Laboratory, which was funded by the National Science Foundation, the Station has 140 buildings, including laboratories, classrooms, and living quarters for up to 300 people. Special facilities include a library, study collections of plants and animals, a large fleet of boats, and a full array of modern laboratory and field equipment. The Station offers tranquility and harmony with nature - it is a place where plants and animals can be studied as they live.

Dr. David M. Gates, Director of the Station since 1971, and Mark W. Paddock, Assistant to the Director, have promoted new and exciting fields of research, including problem-oriented research to help cope with emerging environmental problems.

The Station is currently undertaking specific investigations in northern lower Michigan to provide information about the land, the water, and the people in the area. Results will be made available to community leaders for use in long-term land-use planning. In addition, many research projects are underway, geared toward a better understanding of the structure and function of both aquatic and terrestrial ecosystems.

This publication is one of a series of reports that are issued periodically to disseminate information on research generated at the Biological Station. This series provides accounts of work in progress, or completed, which are either too detailed for acceptance by professional journals or predominately of local interest. For further information concerning other publications in this series or information on the Biological Station in general, address inquiries to: The University of Michigan Biological Station, Pellston, Michigan 49769 (Phone 616-539-8406).

ENVIRONMENTAL FEATURES OF WALLOON LAKE AND ITS WATERSHED (EMMET AND CHARLEVOIX COUNTIES, MICHIGAN)

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July, 1978

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[1]THIS INVESTIGATION WAS SUPPORTED BY A GRANT FROM THE WALLOON LAKE ASSOCIATION

FORWARD

This report is an environmental assessment of the Walloon Lake watershed and was prepared by students in Project CLEAR (Community Lakes Environmental Awareness Research) at the University of Michigan Biological Station, Pellston, Michigan. It includes information from aquatic, terrestrial, and social research conducted at The Biological Station since 1972, and also information from nutrient enrichment and lake management studies conducted specifically for the Walloon Lake watershed by Project CLEAR during summer, 1977.

In this environmental assessment, the present water quality of the lake and each of its basins was evaluated. The sources and extent of nutrient input were estimated to determine how susceptible each basin might be to adverse impact from human development.

Since seepage from septic systems has been a commonly cited source of detrimental nutrient input to the lake, analyses of shoreline soils were conducted to determine soil suitability for effective domestic wastewater treatment. Overlay maps, which display potential nutrient loading problem areas, were prepared and correlated with soil type and population density information to pinpoint potential nutrient loading areas.

The report also draws conclusions for future management of Walloon Lake to retain its present high water quality.

This report is technical in content and has not been written for a general, non-scientific audience. It will be most valuable for natural resource management officials and those with a background in science, particularly limnology. However, the management section contains information pertinent to lake property owners, and has therefore been written as non-technically as possible. Readers who encounter unfamiliar terminology in this report can find definitions and background information in Inland Lake Protection for Northern Michigan (1975) and The Walloon Lake Profile (1976), available from The Walloon Lake Association or The University of Michigan Biological Station.

Table of Contents

List of Tables

List of Figures

SUMMARY and CONCLUSIONS

To provide an overview of the condition of Walloon Lake, the results of the study are summarized here. Points included in the summary are discussed in further detail in the remainder of the report.

*** The overall water quality of Walloon Lake is very good. The prospects for maintaining this level of quality are enhanced by the small watershed and by the marl in the water which buffers pollutants (phosphorus). However, the relatively long water residence time hampers the lake's natural ability to cleanse itself.

*** Phosphorus has been identified as the limiting nutrient in the lake. Phosphorus and nitrogen inputs to the lake must be minimized to maintain high water quality.

*** The North Arm Basin has lower water quality than the other basins in Walloon Lake.

*** The North Arm basin is more susceptible to eutrophication than the other basins in Walloon Lake because of its smaller volume and longer water residence time.

*** Areas have been identified where shoreline soils do not adequately remove nutrients from septic system effluent. These areas constitute an appreciable source of pollution to Walloon Lake.

INTRODUCTION

Walloon Lake is a large and picturesque inland lake in northern Michigan. Its deep basins with their emerald green waters surrounded by rolling hills are recognized as a resource of regional value and significance.

Since the turn of the century, the lake has attracted development. Within the last 20 years, the development rate has greatly increased from 370 dwelling units (Michigan Department of Natural Resources, 1957) to 695 dwelling units. (Walloon Lake Association, 1976).

This high development rate for the Walloon Lake area is expected to continue. It is estimated that the three Charlevoix County townships bordering Walloon Lake will have a 69% increase in population by 1990 (Charlevoix County Planning Department, 1974). Resort Township in Emmet County, bordering the north shore of the lake and the outskirts of Petoskey, had a growth rate of over 40% between 1971 and 1973 (Marans et al., 1976). Suburban sprawl toward the lake from Petoskey is already occurring and further growth of this kind is anticipated.

As well as an increase in population, a change is occurring in the nature of development around the Walloon Lake shoreline. Traditionally predominated by seasonal residences, the Walloon Lake area is becoming the year round home of a growing number of people. Since growth is inevitable, the challenge facing the Walloon community is how to channel this growth and its corresponding development to minimize impact on the environmental quality of the lake.

DESCRIPTION OF STUDY AREA

Walloon Lake lies in Emmet and Charlevoix Counties (T34N, R6W) in the northwest portion of northern lower Michigan. The lake has a relatively small watershed (22,650 A; 9,170 ha) compared to lake surface area (4,270 A; 1,728 ha). The watershed is primarily agricultural land and forest. Development is most concentrated near the lakeshore (Fig. 1, Table 1). Politically, the lake and its watershed are located in Bay, Evangeline, and Melrose townships of Charlevoix County; and Bear Creek and Resort Townships of Emmet County (Appendix I).

Walloon Lake existed in pre-glacial times as a river valley which was re-shaped and deepened by glacial activity. Gently rolling ground moraine deposits left by the glacier on the northern extremities of the lake give way to the steep end moraines that rise 200 ft (61 m) or more above the shore. Glacial deposits range from less than 50 ft (15 m) to greater than 150 ft (46 m) in thickness over Devonian Age shales and limestones. The majority of soil types near the shore are sandy, reflecting the nature of the deposits from which they developed. Water-logged, mucky soils occur in two adjacent wetland areas (Fig. 1).

Walloon Lake is the 26th largest lake in Michigan. It is also one of the deepest lakes, with mean and maximum depths of 28.9 ft (8.8 m) and 100 ft (30.5 m), respectively (Table 2). The shoreline is irregular, with long, narrow embayments known locally as "arms". The shoreline development factor (i.e. the ratio of shoreline length to lake surface area) of Walloon Lake is the highest (3.0) of all Emmet County lakes (see The Biological Station's Lakeland Report No. 3, 1975).

The lake includes four distinct depressions or basins (Fig. 2). Three of these basins (called the Foot, Main Basin, and West Arm) are deep (80, 81, and 100 ft or 24.4 m, 27.1 m, and 30.5 m, respectively) and the fourth (North Arm) is shallower (52 ft or 15.8 m). The three deep basins are interconnected along the main axis of the lake, but the North Arm is separated from the others by a narrow, shallow sill (Fig. 2). Walloon Lake is primarily fed by groundwater and only has a few small inlet creeks. The lake empties into Lake Michigan through Bear River.

Table 1. Description of the Land Cover Types in the Walloon Lake Watershed (depicted in Figure 1).*

Forest Land

Broad-leaved Forest (generally deciduous)

Typical species in the region are oak, maple, beech birch, aspen, and cottonwood.

Coniferous Forest

Includes all forested areas in which predominant species are those with needle foliage.

Agricultural Land

Cropland, Rotation and Permanent Pasture

Orchards, Bush-Fruits, Berries

Rangeland

Rangeland supports early stages of plant succession by plant communities characterized by grasses or shrubs.

Open Land

Open land is land used for outdoor, cultural, public assembly and recreational purposes. Examples would be parkland, ski areas and cemeteries.

Wetlands

Wetlands are those areas where the water table is at, near or above the land surface for a significant part of most years. Examples of wetlands include marshes, wooded swamps, and floating vegetation situated on the shallow margins of bays, lakes, rivers, ponds, and streams. Shallow water areas with submerged aquatic vegetation are classed as "Water" and are not included in the "Wetland" category.

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* This information was obtained from working paper #8, Land Use Inventory, May, 1977 from Northwest Michigan Regional Planning Development Commission, Traverse City, MI.

Urban and Built-Up Land

Residential

Residential development along shorelines is linear and sometimes extends back only one residential parcel from the shoreline to the first road.

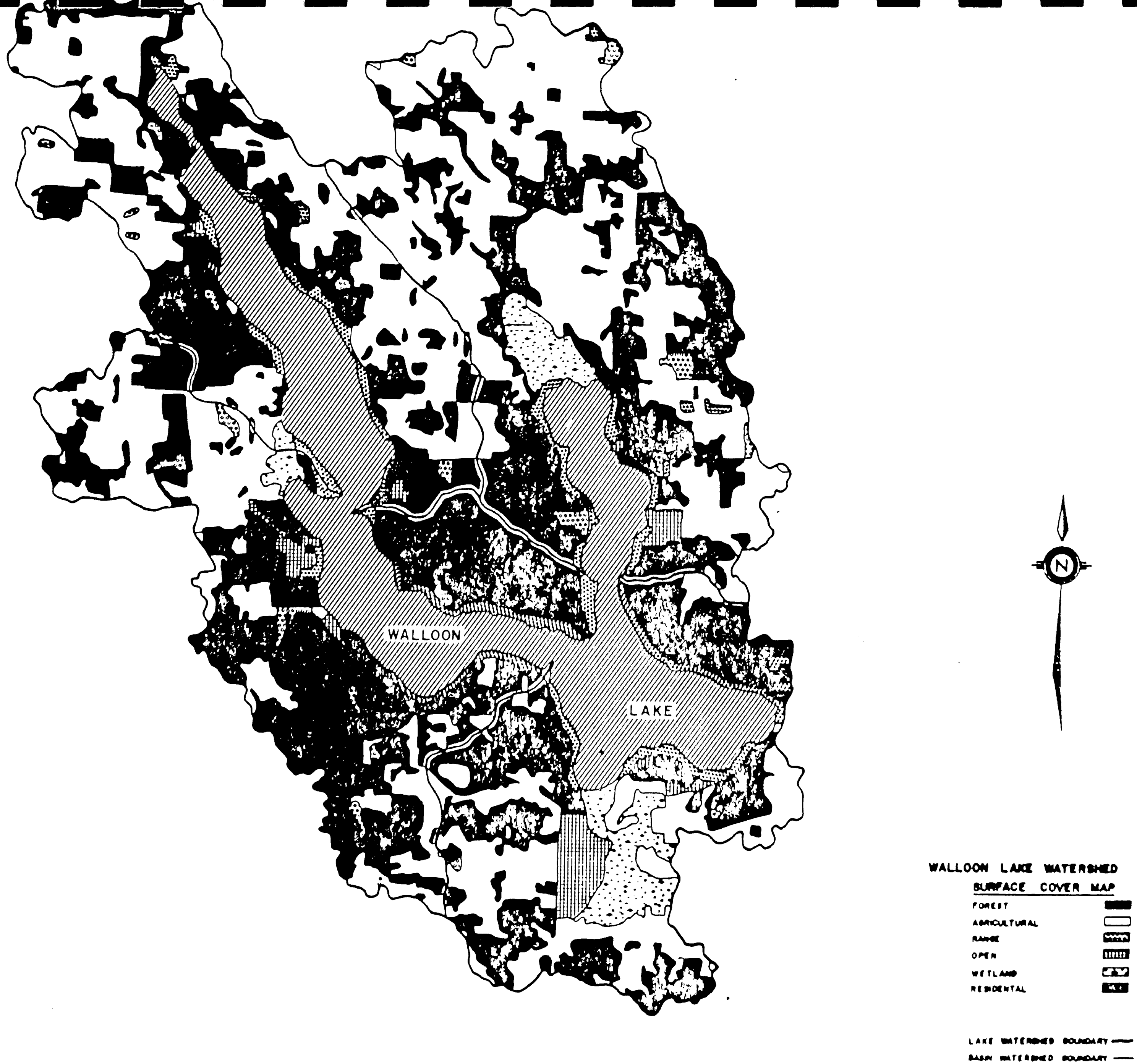


Fig. 1. Land Cover Map of the Walloon Lake Watershed and Basin Drainage Areas. A description of the land categories is presented in Table 1.

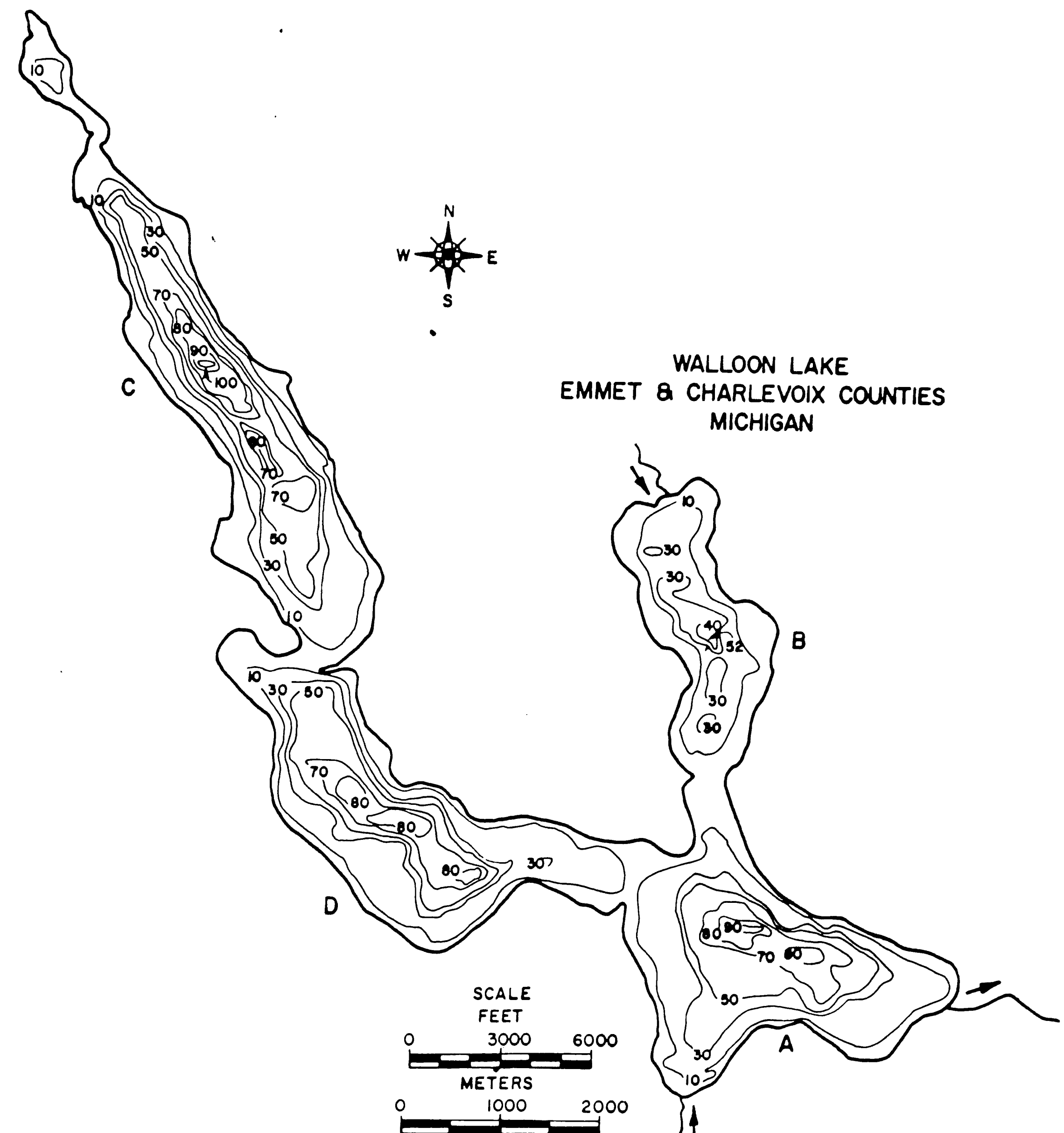


Fig. 2. Depth Contour (morphometric) Map of Walloon Lake. Depth contours are in feet. Distinct basins are indicated by the follow letters. A=Foot; B=North Arm; C=West Arm; D=Main Basin.

Table 2. Morphometric Characteristics of Walloon Lake. Definitions are according to Hutchinson (1975). Data from Gannon and Paddock (1974).

	Units	
	Metric	English
Maximum Depth	30.5 m	100.0 ft
Mean Depth	8.8 m	28.9 ft
Lake Volume	154.5×10^6 m^3	$5{,}444.9 \times 10^6$ ft^3
Maximum Length	10.1 km	6.3 mi
Maximum Width	4.0 km	2.5 mi
Mean Width	1.7 km	1.1 mi
Shoreline Length	44.2 km	27.5 mi
Lake Surface Area	1728.0 ha	4,270.0 A
Watershed Area	9170.0 ha	22,659 A
Shoreline Development Factor	3.0	
Watershed Area/Lake Surface Area Ratio	5.3	

METHODS

Surface Water Sampling

Water chemical samples were obtained from the lake surface at central stations in the Foot, West, and North Arm Basins, at the mouths of three inflowing creeks during summer, 1977 (Fig. 3). Samples were collected from the head of Bear River during this period. Samples from each station were placed in pre-washed 500 ml polyethylene bottles, stored in a cooler for transport to the Biological Station, and immediately frozen. Lake and stream samples were analyzed on a Technicon Autoanalyzer II for nitrate-nitrogen, ammonia-nitrogen, total phosphorus, and chloride ions using standard methods (EPA, 1974).

Discharge measurements were obtained in each stream with a Pygmy current meter at the same time water samples were collected. Flushing rate was determined by dividing the volume of Walloon Lake by the estimated yearly outflow of the Bear River (Appendix II). Surface area, volume, and watershed area of each sub-basin were obtained with a Gelman Planimeter. Retention coefficients were derived from estimates of hydraulic outflow (Larson and Mercier, 1976).

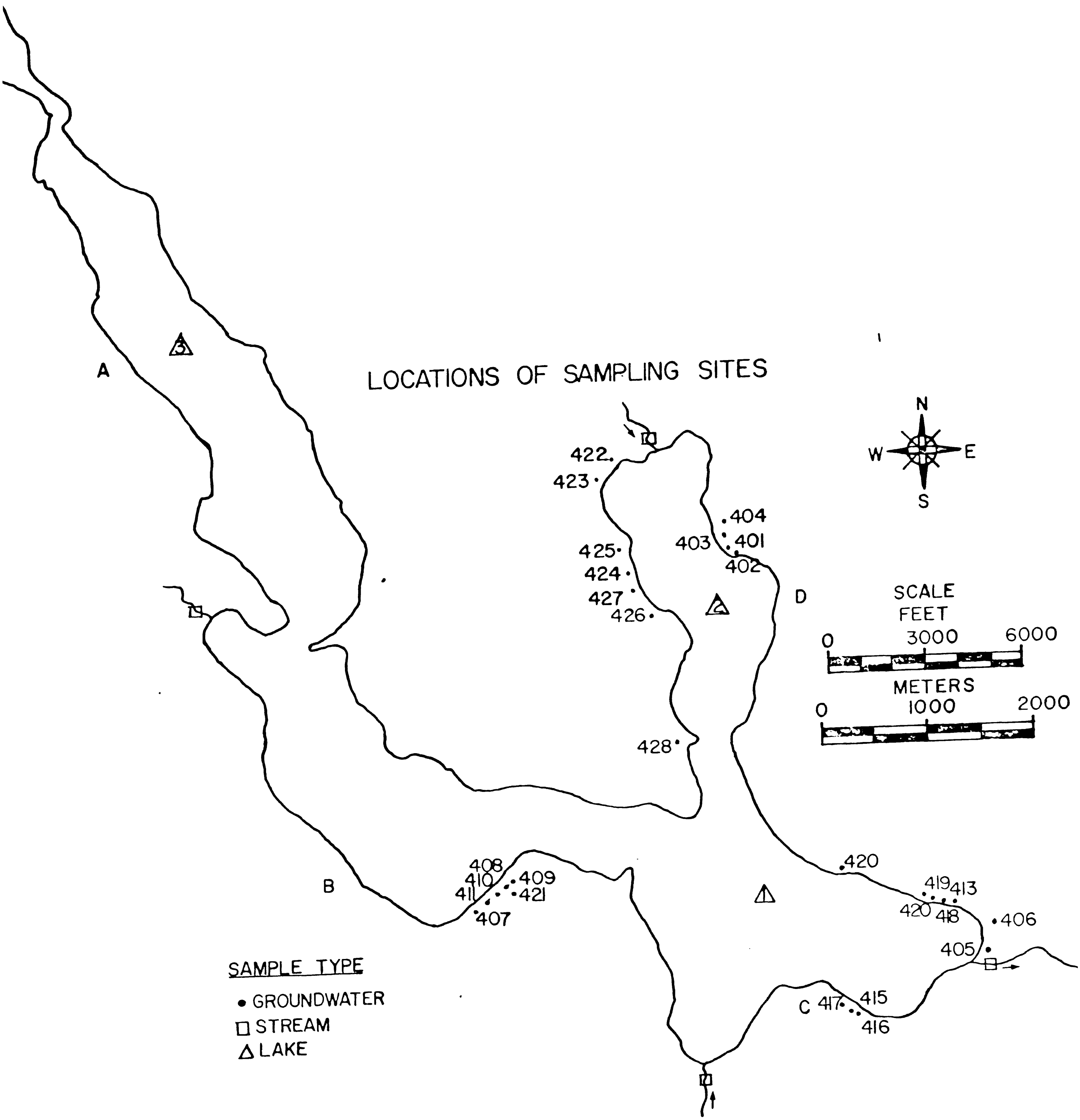


Fig. 3. Location of Sampling Stations for Water Chemistry, summer, 1977. Basins are indicated by letter as on Figure 2.

Nutrient Budget

Inputs of nitrogen (N) and phosphorus (P) were estimated from a CLEAR household survey, and from data previously collected by the Biological Station from fall, 1972 through spring, 1975 (Gannon and Paddock, 1974; Gannon, unpublished data). Because of the difficulties involved in measuring and quantifying nutrient inputs from shallow and deep groundwater, our limited data on nutrients in shallow groundwater was not used for the analysis. Information on nutrient contributions from various land uses (Brezonik, 1973) was considered more representative, and therefore was used in this investigation.

The area for each land-use/land cover in the Walloon Lake watershed (Fig. 1; Table 3) was determined using a Gelman Planimeter. Forest and wetland categories were combined and treated as forest land. Likewise, range and open land were combined and treated as range land so that nutrient loading estimations from Brezonik (1973) could be used in this investigation (Table 4). Calculations were made for the entire watershed and for the drainage areas of the individual basins.

Data on amount of phosphorus (P) and nitrogen (N) entering the lake from precipitation and dryfall were obtained from Gannon and Paddock (1974). Total loadings from these nutrient sources of 2.5 mg/m^2/yr for total phosphorus and 10.6 mg/m^2/yr for total nitrogen (5.3 mg organic nitrogen, 5.3 mg inorganic nitrogen) were used in nutrient budget calculations.

A survey to determine household nutrient output was distributed to 385 lakeshore residents by the Walloon Lake Association and by Project CLEAR (Appendix IV).

Table 3. Areas of Land-Use/Cover in the Walloon Lake Watershed (km^2).

Basin	Forest	Agriculture	Urban	Range
West	10.60	8.03	1.00	0.40
Main	13.31	8.47	1.45	0.48
North	12.30	15.90	0.90	0.60
Foot	8.40	6.90	1.40	0.17
Total	44.6	39.32	4.73	1.65
% of Water-shed	49.3	43.5	5.2	2.0

Table 4. Phosphorus Loading Values ($mg/m^2/yr$) for Various Land-use/Covers. Chosen from Brezonik, (1973).

Land-Use	Phosphorus	Nitrogen
Forest	13	440
Agriculture	26	980
Residential	110	880
Range	18	850

Average nutrient loading to each septic system was calculated to be 1.2 kg P and 10.8 kg N per household per year. Based on an average occupancy of two people per year (Appendix IV) the average human waste contribution was 1.0 kg P per household per year and 10.8 kg N per household per year.

Loading values of 2 g P per dishwasher load and 6 g P per laundry load were estimated from available detergents found in stores in the Walloon Lake vicinity. Automatic dishwasher use was estimated at one time per day and washing machine use at 0.67 times per day when the house is occupied. Loading from these sources to the septic tank was calculated to be 0.2 kg P per household per year.

By comparing the drainage class of each lakeshore soil (Alfred et al., 1973; Alfred and Hyde, 1974) with its phosphorus adsorbing capacity (Schneider and Erickson, 1972) the percent of phosphorus from septic systems that reaches the lake was estimated (Table 5) (Gannon and Paddock, 1974). The percent of nitrogen in lakeshore septic systems that reaches the lake was estimated from the drainage class of each soil (Table 6).

Location of lakeshore residences was determined by visual observation by boat on August 8, 1977. From the number of residences on each soil type and the percentage of septic system nutrients that reach the lake from each soil type, the actual loading of N and P to the lake from lakeside septic systems was calculated.

Table 5. Estimated Nitrogen Contributions from Septic Systems in Varying Soil Conditions (Gannon and Paddock, 1974).

Drainage Class	Percent of N from each system that reaches the lake
Well drained	85
Somewhat poorly drained	65
Poorly drained	50

Table 6. Estimated Phosphorus Contributions from Septic Systems in Varying Soil Conditions (Gannon and Paddock, 1974).

Drainage class	P-adsorbing capacity	Percent of P from each septic system that reaches the lake
Good	high, very high	25
Good	medium	45
Good	low, very low	65
Poor	high, very high	35
Poor	medium	55
Poor	low, very low	75

Although critically important to wastewater treatment efficiency, factors such as groundwater flow patterns, slope of land, age of system, distance from a lakeshore, and septic tank maintenance habits were not considered in the nutrient budget analysis. However, several of these characteristics are considered on the soil suitability maps. Estimates of nutrient loading from lakeside lawn fertilization were not included in the nutrient budget because of insufficient information.

Groundwater Sampling

Shallow groundwater samples were collected and analyzed in order to determine sites of nutrient loading from lawn fertilization and septic systems. Stations were chosen based on soils data (Alfred, et al., 1973; Alfred and Hyde, 1974), personal communication with lakeshore residents, and information from the household survey (Fig. 3).

At each sampling site, wells were driven to the water table with a No. 60 mesh, 2 ft. long, sand point attached to 2.5 ft. sections of galvanized pipe. Groundwater was pumped with a pitcher pump until clear. The samples were then stored in pre-washed 500 ml polyethylene bottles and treated in the same manner as lake and stream samples.

Two sites were sampled at each station; one above the septic field (upgrade) as a control (i.e. uncontaminated with wastewater), and the other nearer the lakeshore from the drain-field (downgrade) and presumably in the area of wastewater seepage. Groundwater samples were analyzed in the same manner as lake and stream samples.

Soil Parameter Overlays

Overlay maps for slope, permeability, depth to seasonally high groundwater, and phosphorus retention capacity were prepared, based on development capability criteria established by the U.S. Soil Conservation Service (1966), Schneider and Erickson (1973), and Gannon and Paddock (1974). The classification and distribution of soil types in the watershed of Walloon Lake were obtained from Alfred et al. (1973) and Alfred and Hyde (1974).

Locations of lakeshore dwelling units in the study area were acquired from a visual survey by boat on August 8, 1977.

Phosphorus retention capacities of each soil type were derived from both the phosphorus adsorption capacity (Schneider and Erickson, 1972) and drainage class (Alfred et al., 1973; Alfred and Hyde, 1974) based on the assumptions of Gannon and Paddock (1974). Phosphorus adsorption data were unavailable for the Blue Lake soil series in the study area. The phosphorus adsorption for Blue Lake loamy sand around Walloon Lake was estimated as "low" by Forrest (personal communication).

The following characteristics of slope, depth to seasonal high groundwater, and permeability are depicted for each respective soil property (Alfred et al., 1973; Alfred and Hyde, 1974):

Slope (Percent)	Depth to Seasonal High Groundwater (feet)	Phosphorus Retention (% Removed by the soil)	Permeability (inches/hour)
Acceptable 0-2	> 6	Good 75-65	Acceptable 2.0-20.0
Unacceptable > 12	2-6	Moderate 65-35	Unacceptable < 2.0
	< 2	Poor 35	

Permeability values represent the lowest rate that occurs in the upper 5-6 feet of soil.

Each variable is depicted on a separate transparency that overlays a base map showing the location of the total lakeshore dwelling units around Walloon Lake. Increasing degrees of shading are employed to indicate greater restrictions imposed by each variable on development and on-site wastewater disposal. When all four transparencies are viewed together, greatest restrictions for wastewater disposal are indicated by the darkest areas. Those soils exhibiting high groundwater and rapid permeability may be more limited in their capacity to treat wastewater than these overlays actually depict (Appendix I).

TROPHIC (WATER QUALITY) STATUS

In order to wisely manage a water resource, citizens and government officials must be aware of Walloon Lake's present water quality and its ability to withstand human impact.

Limnologists, scientists who specialize in the ecology of freshwaters, classify water quality condition by its trophic (productive) state. Lakes are divided into three categories: oligotrophic, mesotrophic, and eutrophic. Oligotrophic lakes are low in nutrient content, have high water clarity, sparse plant growth (both weeds and algae), and other attributes most recreationalists view as "good" water quality. Conversely, eutrophic lakes are high in nutrient quality and plant growth and have reduced water clarity. Water bodies exhibiting intermediate characteristics are known as mesotrophic lakes.

Physicochemical Characteristics

To clearly understand Walloon Lake's aquatic ecosystem and trophic state, it is necessary to first examine several chemical features of the lake's water.

The water quality of a lake may be determined by the availability of nutrients in the water. Waters where the concentration of nitrogen is greater than 15 times the concentration of phosphorus are generally considered to be phosphorus limited (Vollenweider, 1968).

Walloon Lake has ratios of nitrogen (nitrite,nitrate and ammonia) to phosphorus (total phosphorus) ranging from 20:1 to 28:1 in the three basins sampled and is therefore a phosphorus limited lake. This means that the trophic (productive) status of Walloon's water will vary depending on the amount of phosphorus available. If phosphorus concentrations increase, the lake could become more productive with corresponding water quality decline.

Walloon Lake, however, has the lowest phosphorus concentrations of the 39 lakes in Emmet and Cheboygan counties sampled by The University of Michigan Biological Station (Gannon and Paddock, 1974). One reason for the low phosphorus concentrations that the lake contains hard water (alkalinity 120 mg/ℓ) (Gannon and Paddock, 1974) and exhibits marl deposition. Marl is precipitated calcium carbonate ($CaCO_3$) or lime, which forms in the presence of high amounts of calcium (Ca) and carbonate (HCO_3^-). It is a natural substance which generally is characteristic of lakes with good water quality.

The presence of fine, suspended particles of marl in the water imparts the aesthetically pleasing emerald green color to Walloon Lake waters. Marl also causes a greyish-white coating on rocks, weeds, and bottom sediments.

Phosphorus ions in the water column become adsorbed on marl particles, settle into the bottom sediments, and become unavailable to stimulate algae and weed growth. As long as dissolved oxygen does not become depleted in bottom waters, precipitation of phosphorus with marl is an important mechanism in maintaining high water quality in Walloon Lake. Under anaerobic conditions, however, phosphorus is released from the sediments to the water column and may again support algae growth.

Although Walloon Lake's water clarity is relatively good, marl does decrease its transparency. Therefore, Secchi disc measurements are less useful for trophic state assessment of Walloon Lake than they are in softer waters.

Along with low concentrations of phosphorus, a review of physicochemical data collected by the Biological Station during recent years indicates that the overall water quality condition of Walloon Lake is good. The lake is considered to be oligotrophic based on several methods of rating trophic conditions (Tierney et al., 1975; Carlson, 1977) (Fig. 4). Recent research on biological indicators of trophic conditions indicates similarities between Walloon Lake and the oligotrophic lakes of Colorado (Cairns, personal communication).

Inter-Basin Comparison

Comparison of the water quality of the four basins of Walloon Lake reveals noteworthy differences in trophic status. While the Foot, Main, and West basins have many of the features normally attributed to oligotrophic lakes, the North Arm basin appears more productive and shows signs of a mesotrophic condition.

The slower flushing rate is a major factor that has resulted in lesser water quality in the North Arm basin. The North Arm is separated from the Foot basin (Fig. 2) by triangular-shaped sand spits which indicate that its waters are not readily mixed with the Foot (Scott, 1921) or directed immediately toward the Bear River outlet. In contrast, prevailing north and west winds push the waters of the West, Main, and Foot basins toward the lake's major outlet. Consequently, nutrients and other contaminants that

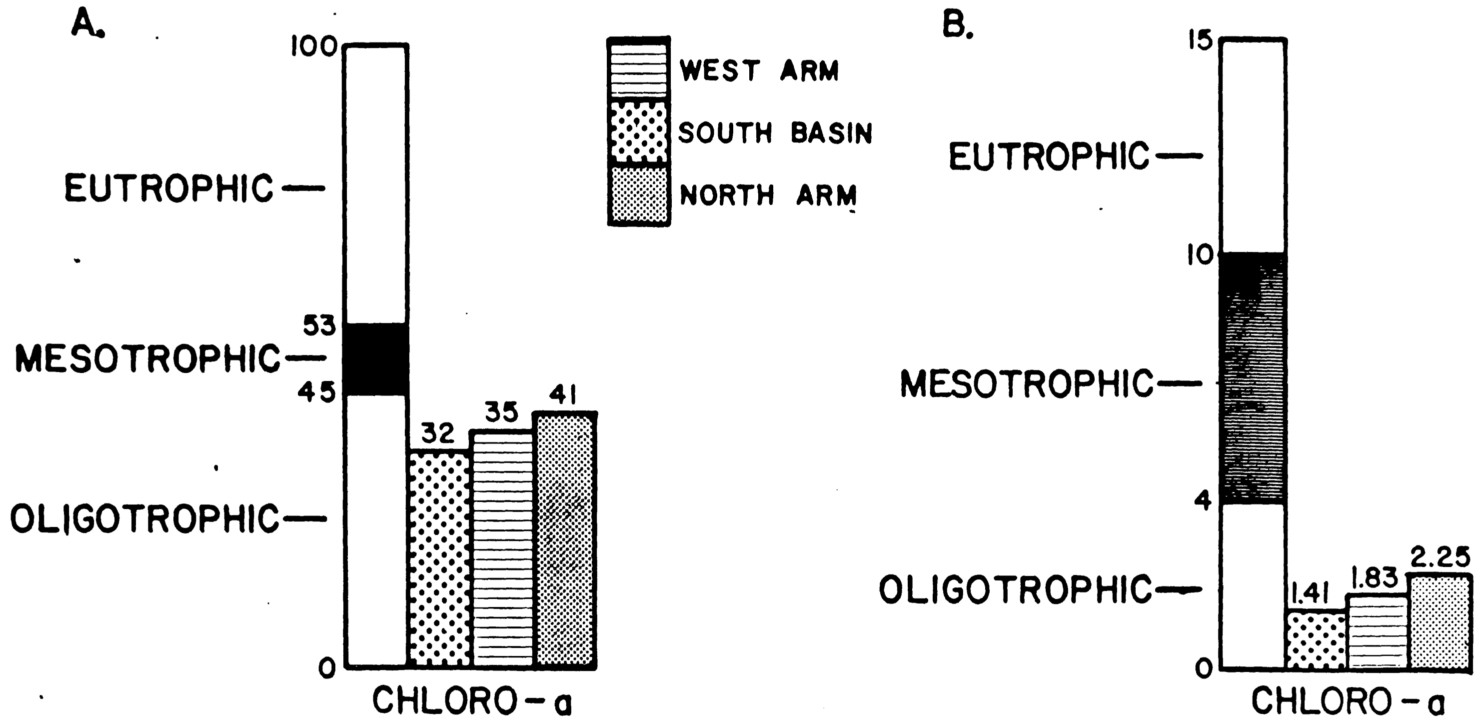


Fig. 4. Trophic Status of Walloon Lake Based on Two Rating Systems Using Epilimnetic Chlorophyll *a* Concentrations. A) Trophic State Index (Carlson, 1977). B) Michigan Self Help (Tierney et.al. 1975).

enter Walloon Lake have a longer period of influence in the North Arm than the other basins.

Morphometric differences between the North Arm and the other basins have also influenced its water quality. The average depth of the North Arm basin is only 5.4 m (52 ft.). This shallowness, coupled with a thermocline that begins 7 m (23.4 ft.) below the surface, creates a small hypolimnion which is susceptible to oxygen depletion. Summer hypolimnetic dissolved oxygen levels as low as 0.1 mg/l were measured in 1974 (Gannon, unpublished data).

The morphometric characteristics of the other basins (Table 7) are typical of oligotrophic lakes. The Foot, West, and Main basins have mean depths of 8.65 m (28.4 ft.), 10.1 m (33.1 ft.), and 9.5 m (31.2 ft.) respectively. The basins thermally stratify during the summer with thermoclines beginning from 9 to 10 m (27.3 to 32.8 ft.) below the surface, leaving approximately half of the water volume below the epilimnion. The hypolimnia are therefore large and maintain cold oxygenated water throughout the summer. Summer hypolimnetic temperatures are between 9 and 13°C in the deep basins. Oxygen distribution with depth is clinograde during the summer; dissolved oxygen concentrations as high as 7.5 mg/l are found in the upper portions of the hypolimnia of the Foot and West Arm basins.

Inter-basin water quality differences are again evident when nutrient concentration data is examined. North Arm water samples show higher concentrations of total phosphorus than the Foot and West Arms (Fig. 5). Using a classification method based on spring phosphorus concentrations, mean water depth, and flushing rate (Dillon and Rigler, 1975), the North Arm is mesotrophic and the West and Foot Basins are oligotrophic (Fig. 6).

Table 7. Morphometric Characteristics of the Basins of Walloon Lake in Emmet and Charlevoix Counties, Michigan

	North Arm		Foot		Main		West Arm	
Shoreline Length miles (km)	4.65	(7.50)	6.26	(10.10)	6.88	(11.10)	7.69	(12.40)
Surface Area sq.mi (sq.km)	1.34	(3.48)	1.90	(4.95)	1.83	(4.76)	1.76	(4.57)
Maximum Depth ft. (m)	52.00	(15.85)	94.00	(28.65)	85.00	(25.90)	100.00	(30.48)
Mean Depth ft. (m)	17.70	(5.42)	28.37	(8.65)	31.16	(9.50)	33.13	(10.10)
Water Volume x 10^6 cu.ft. (cu.m)	669.28	(18.96)	1456.48	(41.26)	1589.90	(45.04)	1640.74	(46.48)
Watershed Area sq.mi. (sq.km)	11.56	(30.00)	6.67	(17.30)	9.34	(24.20)	7.75	(20.10)
Ratio Watershed Area ÷ Water Volume	1.5		0.419		0.537		0.432	
Water Retention Time (yr)			4.07		4.07		4.07	
Flushing Rate hydraulic (yr)			0.245		0.245		0.245	

Fig. 5

INTERBASIN COMPARISON OF SELECTED PHYSICAL AND CHEMICAL FEATURES OF WALLOON LAKE

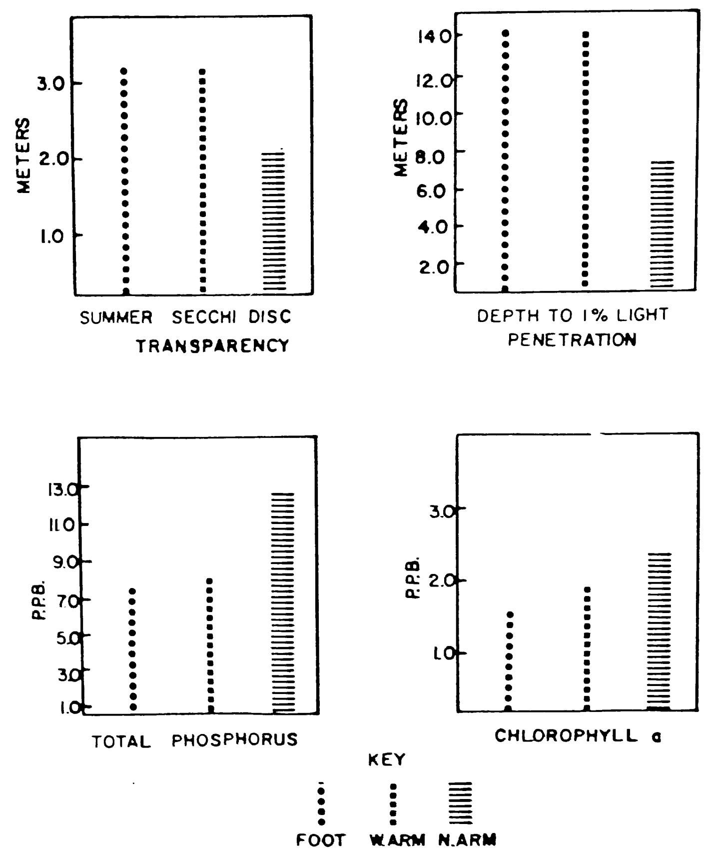
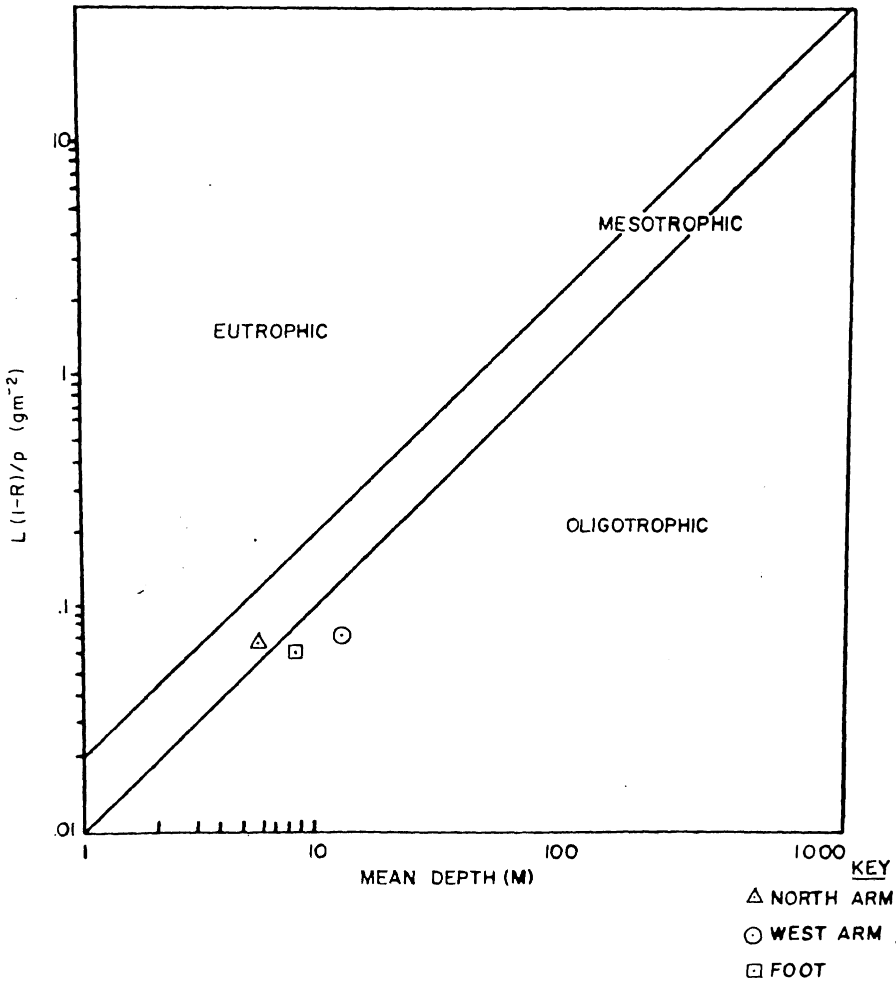


Fig. 6

PRESENT TROPHIC STATE OF WEST ARM, NORTH ARM, AND THE FOOT (DILLON & RIGLER, 1975)



Since phosphorus is the limiting nutrient in Walloon Lake, the higher levels of phosphorus in the North Arm suggest the potential for greater aquatic productivity, or a more mesotrophic condition. Chlorophyll *a* data confirms that a larger standing crop of algae exists in the North Arm than in either the Foot or West basins. Chlorophyll *a* measured 2.3 µg/L in the North Arm; 1.4 µg/L in the Foot; and 1.8 µg/L in the West Arm (Fig. 5).

LandSat Satellite images visually display the differences in chlorophyll *a* concentrations between the North Arm and the rest of the lake (Rogers, 1977). In color maps generated by computer processing of LandSat data, the Foot, West Arm, and Main basins appear white, while the North Arm appears as a mixture of white and yellow. White is indicative of marl turbidity in the water; yellow coloration indicates moderate algal turbidity.

The greater turbidity of the North Arm is also apparent in field measurements. Light penetration of 1% occurs at 7 meters in the North Arm as compared to 14 meters in both the Foot and the West Arm. Secchi disc readings, another measurement of water turbidity, average 2 meters in the North Arm and 3 meters in both the Foot and West Arm (Fig. 5).

Biological organisms can be used as indicators of water quality in addition to physicochemical measurements. The North Arm again distinguishes itself from the other basins by supporting some organisms indicative of more mesotrophic conditions. Two rotifer species (microscopic aquatic animals) indicative of lakes with hypolimnetic oxygen depletion, <u>Kellicottia bostoniensis</u> and <u>Conchilus hippocrepis</u>, have been found in the North Arm. These rotifer species are absent from samples taken in the West and Foot basins which have higher bottom summer dissolved oxygen concentrations (Stemberger, personal communication). Notholca michiganensis, a rotifer typically indicative of oligotrophy (Stemberger, personal communication), has been found in the winter and late fall in the Foot and West basins, but never in the North Arm.

North Arm residents have noticed increased algal and aquatic plant growth in recent decades. In contrast, biological samples suggest that no appreciable change in water quality of the West basin of Walloon Lake has occurred in the last twenty years. Pontoporeia affinis, a deep water crustacean found in oligotrophic lakes, appeared in samples collected in the West Arm of Walloon Lake in both 1955 and 1975 (Gannon et al., 1977). Salvelinus namaycush (lake trout) frequents cold, oxygenated oligotrophic waters, and continues to thrive in the west basin of Walloon Lake (DNR, unpublished data).

The isolated nature of the North Arm, coupled with its larger watershed and shallow basin morphometry (See Fig. 1 and 2) are undoubtedly important factors causing water quality differences between it and the other basins. Management schemes for the North Arm must take into consideration its limiting features.

Nutrient Contributions

In the past, morphological characteristics largely determined the trophic status of lakes. Increasing development has, in more recent times, accelerated the rate of lake aging by adding nutrients and silt to lakes.

Natural sources of nutrient input to the lake include inflowing streams, groundwater inflow, precipitation, dryfall, and land run-off. Cultural sources are septic system drainage (household discharges including human sewage and laundry wastewater), run-off and seepage from urbanized land (including lawn and garden fertilizers) and agricultural run-off. Although the natural sources cannot be controlled, input from cultural sources may be reduced and degradation prevented.

All sources that contribute nutrients to a lake influence the quantity of algae and weeds in the lake waters. A nutrient budget study of Walloon Lake was conducted to inventory the quantity and sources of nutrients entering the lake.

Walloon Lake is a seepage lake, fed primarily by groundwater. Most of the hydrologic inputs to the lake pass through the soil and receive at least some degree of purification before reaching the lake.

Lakeside nutrient sources have the greatest potential to impact lake water quality. These inputs are not diluted or purified as much as nutrient inputs that originate in the upper reaches of the watershed. Septic systems and urban runoff from lakeshore development constitutes 29% of all the phosphorus input to Walloon Lake (Table 8). Lakeside septic systems were calculated to account for 13% of the phosphorus input to the lake (Table 8), approximately 25% of which originated from detergents. Septic system loading figures are related to each soil's ability to treat wastewater and the amount of development on each soil type. Current

Table 8a. Sources and Quantities of Phosphorus Loading to Walloon Lake (kg/yr)

Basin	Forest	Agriculture	Residential	Range	Prec. & Dryfall	Septic Systems	Total
West	138.49	209.04	110.55	7.23	159.9	78.69	703.90
Main	173.03	220.22	159.72	8.70	166.6	123.24	851.51
North	159.90	413.40	99.00	10.80	128.8	82.59	887.49
Foot	110.20	179.92	152.24	3.10	173.2	142.81	761.47
Total	581.62	1022.58	521.51	29.83	621.5	427.33	3204.37
%	18	32	16	1	19	13	100

Table 8b. Sources and Quantities of Nitrogen Loading to Walloon Lake (kg/yr)

Basin	Forest	Agriculture	Residential	Range	Prec. & Dryfall	Septic Systems	Total
West	4,687	7,879	882	341	3,930	1,308	19,027
Main	5,856	8,301	1,277	411	4,093	1,584	21,522
North	5,412	15,582	792	516	2,992	892	26,186
Foot	3,729	6,781	1,218	147	4,257	2,032	18,164
Total	19,684	38,543	4,171	1,409	15,272	5,816	84,895
%	23.2	45.4	4.9	4.6	18.0	6.9	100

health regulations and building codes, if properly enforced, will sharply limit the number of new septic systems on the lakeshore. However, if septic systems are allowed in poor soils (see Appendix I), nutrient loading from this source could become more significant.

The backlands of the watershed are primarily forested or agricultural and contribute an estimated 51% of the phosphorus and 69% of the nitrogen input to Walloon Lake (Table 8). Further development of these areas would increase the nutrient loading from the backlands; residential areas contribute five to ten times the amount of phosphorus that comes from lands under forest cover or agricultural use (Table 4) (Brezonik, 1973). As residential developments continue to grow, they will play an even more prominent role in the nutrient budget of the lake. Nutrient budget information, when coupled with a simple hydrological model, shows that the North Arm is more susceptible to accelerated eutrophication than are the other basins (Dillon and Rigler, 1975). The differential equation generated by the model was used to predict the spring phosphorus concentration in a lake or basin using information on nutrient loading (L), mean depth ($\bar{Z}$), retention coefficient (R), and flushing rate (P) (Table 9).

Using the flushing rate of 0.3 yr (water retention time 4.1 yrs) based on the yearly outflow at the Bear River, the model predicts that the three deep basins are oligotrophic (Fig. 7). The predictive model agrees with measurements of spring phosphorus concentrations in the North Arm if the flushing rate is less than 0.15 yr (6.6 yr water retention time) for that basin.

Table 9. Characteristics used to Predict Phosphorus Concentrations in the Basins of Walloon Lake.

Basin	Flushing Rate/yr (P)	Retention Coefficient (R)	Mean Depth (Meters) $\bar{Z}$	Phosphorus loading rate ($g/m^2/yr$)	Predicted Spring (P) (mg/m^3) $\frac{L\,(1-R)}{Pzm}$	Measured Spring (P) 1974, 1977 (mg/m^3)
West	.245	.65	10.1	.035	5.0	7.4
Main	.245	.65	9.5	.035	5.2	
North	(.150)** .245*	(.70)** .65*	5.4	.0295	(10.9)** 7.8*	12.45
Foot	.245	.65	8.65	.045	7.4	7.0
Walloon Lake	.245	.65	8.8	.035	5.7	

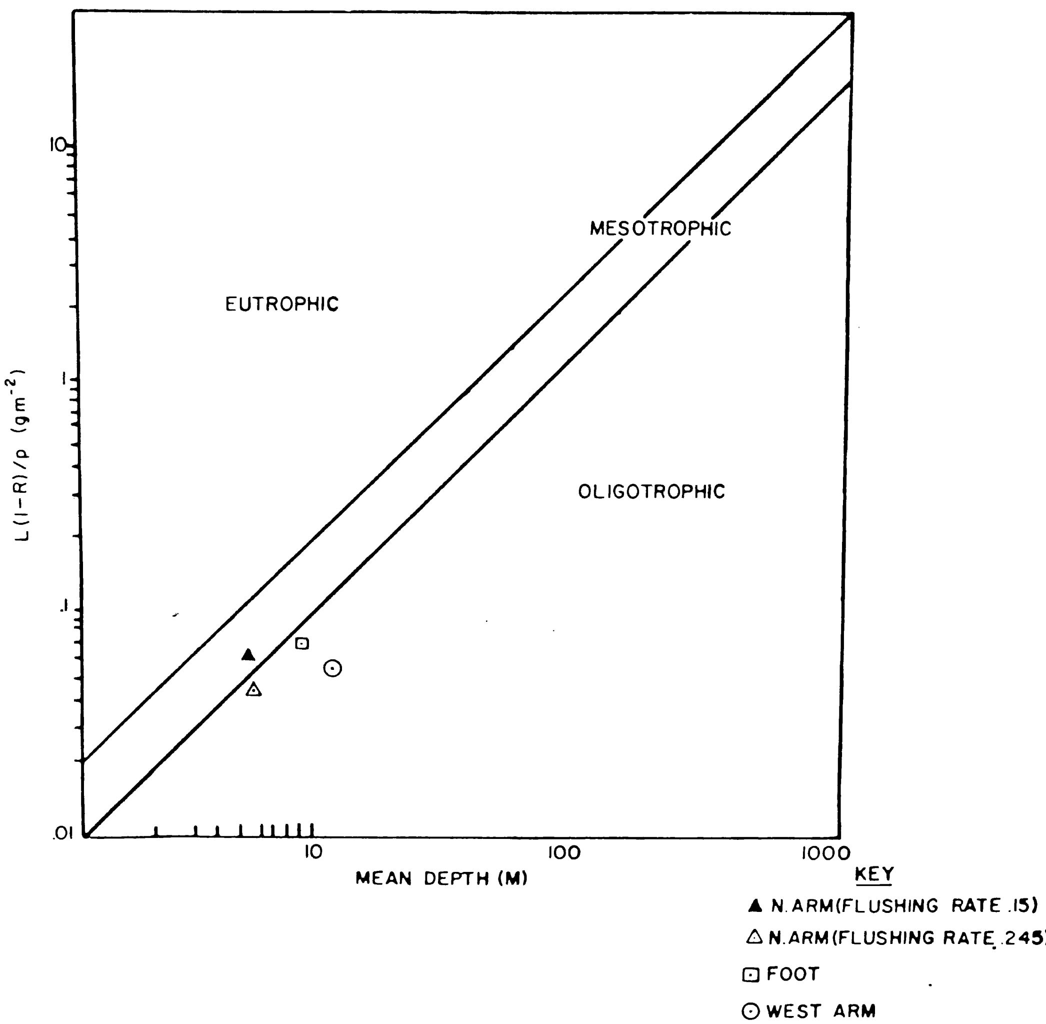
*Based on the outflow from the Bear River, 1976-1977.

**Concentrations as in Dillon (1975).

With a slower flushing rate and shallower basin, the model shows why deterioration in water quality has been noted in the North Basin more than the rest of the lake in recent years.

Fig. 7

PREDICTED TROPHIC STATUS OF WEST ARM NORTH ARM, AND THE FOOT (DILLON & RIGLER, 1975)



SOIL SUITABILITY FOR SEPTIC TREATMENT

The performance of lakeshore septic systems around Walloon Lake is discussed in this section. Areas that may be potential sources of nutrient contamination to the lake are indicated. In some instances wastewater treatment options have been suggested for consideration by public health officials and engineers. Further investigations of the problem areas should be completed before corrective actions are undertaken.[1]

A number of factors were evaluated in this analysis including soil characteristics, the location of dwelling units, and shallow groundwater chemistry data (Appendix II).

It is suggested that this study be used in conjunction with the Emmet County Soil Survey, (Alfred *et. al.*, 1973), the Charlevoix County Soil Survey (Alfred and Hyde, 1974), and the maps which depict the suitability of lakeshore soils for on-site wastewater disposal (Appendix I).

North Arm

General Soils are moderately well-suited to well-suited for septic treatment in areas other than the northern portion of the basin where organic soils exist. The average phosphorus loading per dwelling unit is 0.6 kg/yr.

Problem areas Thirty-eight homes along the northeast shore of the basin are built on Linwood muck. These soils are severely limited in their ability to purify septic wastes

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[1]No construction, repair or alteration of any sewage disposal facility shall begin until the owner or his authorized representative has made application to the Health Officer and has received a construction permit (Michigan District Health Department No. 3, 1970).

(Alfred, Hyde, and Larson, 1973). The estimated phosphorus loading from these homes is 35 kg/yr (0.92 kg/yr per dwelling unit). This comprises 41% of the input from septic systems for the entire basin.

Alternative wastewater treatment methods systems for these homes should be explored. Three homes within the area along Jones Landing have installed systems in which the drainfields are placed in a mound of soil two to six feet high (mound systems) located 45.7 m (150 ft.) or more from the lake. Soils which are suitable for land disposal (Emmet sandy loams), located adjacent to the muck soil, may make cluster sewage treatment a feasible alternative.

Homes on the north and northwest shore on Killarney Shores and Indian Garden Road are built on Carbondale muck which has severe restrictions for septic systems (Alfred, et. al., 1973). Groundwater samples with high concentrations of phosphorus indicate phosphorus loading to the lake from this area. Mound systems should be considered to upgrade existing systems. Au Gres and Emmet soils 400 m (1312 ft.) from the lake provide a potential disposal site for cluster treatment.

Development along the west shore is concentrated on Kalkaska sand. Although this soil is well suited for disposal (Alfred, et. al, 1973), our survey indicates that approximately 50% of the systems are within 30.5 m (100 ft.) of the lake and constitute potential sources of nutrient loading to the lake. Moving drainfields further from the lake would reduce contamination from septic wastes by providing more complete effluent treatment.

Foot

General The Foot has more lakeside residences than the other basins. The estimated phosphorus loading of 142.81 kg/yr (0.69 kg/yr per dwelling unit) in the Foot exceeds that of the other basins (Table 8). Steep slopes and wetland areas are the major constraints for septic treatment around this basin.

Problem areas Steep slopes along the northwest shore of the Foot present difficulties for drainfield installation and wastewater treatment. Serial loading between trenches would aid in achieving an even distribution of effluent in a sloping drainfield, maximizing the purification potential of the soil (Warshall, 1976).

North of Walloon Lake Village dense development occurs on Leelanau-Rubicon loamy sands. The low phosphorus adsorption capacity of this soil series indicates that phosphorus loading to the lake from this area may be high (Schneider and Erickson 1972).

The commerical strip in Walloon Lake Village is built on Carbondale muck. This soil is poorly suited for septic treatment (Alfred, and Hyde, 1974). The majority of the establishments pump wastewater across M-75 and away from the lake. Surface topographic features indicate that groundwater may be moving away from the lake in this area, and contaminants may flow towards the Bear River.

Dwellings are concentrated for 2 km (12 mi.) along the south shore of the basin westward from Hamilton Court. Soil types exhibit a high degree of variability in this area. High groundwater is a problem in several of these soils. Mound systems could be used to remedy problem areas. On-site inspection is required to locate specific problem soils.

Main Basin

General Most of the homes around the Main Basin are located on well-drained soils which have good capacity to assimilate septic wastes. However, the Leelanau soils on the north shore have a low phosphorus adsorption capacity, and may be unsatisfactory for purifying wastes from dense developments. Immediate attention should be given to homes located on poor soils in Wildwood Harbor. Average phosphorus loading per dwelling unit is 0.65 kg/yr.

Problem areas Twenty homes in Wildwood Harbor are built on Au Gres sands and Cathro Muck. These soils are considered severely limited in their ability to treat septic effluent (Alfred and Hyde, 1974). Low permeability and high groundwater present problems to several systems. Mound systems or cluster treatment alternatives should be considered. Blue Lake loamy sand within 300 m (984 ft.) of the lake should be considered as a site for cluster sewage treatment.

The 58 septic systems located on Leelanau loamy sands on the north shore of the Main Basin contribute 37% of the phosphorus loading from septic systems in that basin (0.79 kg/yr per dwelling unit). Increasing densities in the area could significantly raise this contribution. To maximize the phosphorus adsorption capacity of the soil, oversized drainfields could be used or year-round residences could consider installing alternating drainfields.

West Basin

General Estimated phosphorus loading is lowest in the West Basin (78.0 kg/yr, 0.65 kg/yr per dwelling unit). Soils are moderately to well-suited around most of the basin. Most homes are located on Emmet, Leelanau-Rubicon and Au Gres soils. Four hundred meters (1312 ft.) of Cathro muck at the northern tip is poorly suited for septic treatment (Alfred, Hyde, and Larson, 1973), and is the only wetland area on the basin.

Problem areas Our survey indicates that 45% of the drain-fields on the east shore are within 100 feet of the lake. Pumping septic effluent farther from the lake should considerably upgrade treatment of wastewater by soils.

MANAGEMENT OPTIONS

The results of this report clearly indicate that lake water quality is directly related to the type and intensity of land-use practices throughout Walloon Lake's watershed. Therefore, the way land is used upslope from the lake is as important to water quality planning and management as is the land directly adjacent to the lake.

Political boundaries around the lake (i.e. township and county divisions) do not coincide with natural watershed boundaries. Fortunately, lake associations can be an effective "common denominator" for coordination of lake planning and management programs on a watershed level. A lake association can act as a communication link between unassociated government units within the lake's watershed and also maintain contact with other factors that will determine general lake management policy.

In the future, management of lake communities may become more formalized. Until then, however, lake associations must be the forerunners of lake management programs for water quality protection.

A wide range of suggestions are offered in this section. If preventative actions (which require little outlay of capital and energy) are taken now, residents may avoid more costly corrective measures in the future. It is necessary, however, to keep in mind that although Walloon is one of the most thoroughly studied lakes in northern Michigan, it is impossible to precisely predict how long it will remain in its present condition and exactly how much impact it can withstand without experiencing a decline in water quality.

Hopefully, these suggestions can serve as a catalyst in the search for effective ways to maintain and improve Walloon Lake's water quality. They include wastewater treatment alternatives, septic system maintenance programs, and other pertinent management ideas.

Wastewater Treatment Alternatives

Septic systems can effectively prevent contamination of lake or surrounding ground water if:

a) they are located on suitable soils

b) they are set back from the lakeshore

c) they are properly maintained

However, a malfunctioning septic system has the potential to act as an open faucet, letting wastewater directly into a lake.

Many lakeside septic systems were built before the present sanitary requirements and codes were established. These septic systems may be in unsuitable soils, have too small a drainfield, or may be located on the water's edge.

A variety of corrective measures can be used to minimize the impact of household wastewater on Walloon Lake. The lake association can work with local and regional officials and county sanitarians to promote wastewater treatment alternatives described in this report. Additional information can be found in the Biological Station's Lakeland Report No. 14.

Septic System Maintenance Programs

Failing systems are often the result of poor maintenance and improper care. Regular inspection and up-keep of all of the lakeside septic tanks and drainfields would insure that existing treatment methods are working as effectively as possible.

A program could be created through the lake association to insure that all septic systems are properly maintained and checked on a regular basis. Septic system servicers have indicated that very reasonable rates could be obtained if they could check and clean a large number of systems at their convenience in one area.

New Design Standards for Lakeside Septic Systems

Present public health codes insure that new septic systems meet certain minimum health standards. However, treatment levels that effectively safeguard public health may not adequately limit the nutrients that cause adverse changes in water quality. It is possible that in problem areas more stringent standards would be indicated that require new lakeside septic systems to be even more efficient than existing Public Health Codes dictate. For example, mounds, dosing chambers, alternating drainfields, and innovative trench designs can increase a septic system's ability to treat waste effluent.

Minimum lot size regulations

Regulations concerned with minimum lot size can be tailored to accomodate the varying capacities of lakeshore soils to remove nutrients from septic system effluent. Minimum lot size should be greater in soils that are poorly suited for on-site waste disposal (Appendix I).

Upgrading existing treatment

Homeowners residing on soils that have limited capacities to remove nutrients can construct mounds (septic systems in which the drainfields are placed in a mound of soil two to six feet high) or pump the septic effluent to more suitable soils for wastewater treatment. On soils with low phosphorus adsorption capacity, drainfield size should be increased to enhance removal of phosphorus from the effluent (Appendix I).

Cluster Treatment

Septic system failure is often not limited to a single home. More often, a cluster of homes (5-200) built about the same time and located on the same unsuitable soils may all have inadequate waste disposal conditions. Treatment alternatives do exist to handle cluster problems of this nature without the expense of regional collection (sewer) treatment.

Group management of wastes can offer advantages beyond the scope of the disposal options for a single lot owner. For example, effluent from several homes can be pumped to small community drainfields located on suitable soils away from the lakeshore. Before such options can be implemented, public health standards and legal obligations for ownership and maintenance must be explored.

Alternative On-site Wastewater Treatments

In existing developments where local soils are unsuitable for septic treatment, waterless toilets such as composting toilets may be considered. This would eliminate most of the groundwater contamination from malfunctioning septic systems. Before any corrective actions of this nature are taken, however, local health officials should be consulted.

Watershed Management

The streams and groundwater which feed a lake carry nutrients and sediments that can degrade water quality. What they contribute is directly influenced by the way land is used throughout the watershed of the lake. Watershed input can be minimized through land-use management practices such as:

Development Review Process

Existing county and state regulations, if adequately enforced, can work to help environmental preservation. Lake associations can have considerable input to development plans for lakeshores. The Walloon Lake Association should continue its review of shoreline developments.

Wetlands Protection

The wetlands of Walloon Lake (Fig. 1) filter nutrients from water as it drains from the land, before it enters the lake. This filtering function is especially important as development in the watershed increases. Protection of the wetlands in the North Arm is particularly vital, since their proximity to the Petoskey area makes them desirable property for residential and commercial development.

The Walloon Lake Association can promote wetland management around the lake. For further information on the importance, identification and management of wetlands, refer to the Biological Station's Lakeland Reports No. 10 and 11.

Wetlands Acquisition

Owners of wetlands may donate such lands to public agencies or land conservancies thus insuring protection of the land from development.

Federal sources may provide up to 50% matching funds for wetland acquisition. Information is available from The Northwest Michigan Resource Conservation & Development Program, Keith Martel, Coordinator, 10850 Traverse Highway, Traverse City, MI 49684.

Wetlands Zoning Ordinances

Township or counties can include provisions in their zoning codes to protect wetland areas. Several Michigan townships have already taken this step to protect their water quality. Contact Max Putters, Emmet County Planner, for further information.

Tax Relief to Wetland Owners

Local units of government can reduce the property tax burden of wetlands by classifying these regions as open space eligible for special tax treatment under state legislation (P.A. 116 of 1974). If owners of the wetlands choose to enter into an agreement with the state not to develop such land, the taxes paid will not reflect its previous development potential and the property owner's tax will be lowered, diminishing the financial pressure to develop. Local zoning ordinances can provide a similar tax break by reducing the tax rate on property classified as wetlands. Contact the Emmet County Extension Service for further information on P.A. 116.

State and Federal Review Responsibilities

Most modifications of wetlands -- dredging, filling, creating obstructions -- require a permit from the State DNR or the U. S. Army Corps of Engineers (Appendix III).

Control of Agricultural Run-off

It is difficult to predict the extent of agricultural impact on the lake's water quality. However, sound farming practices should be followed to minimize soil erosion and agricultural run-off to the lake. Strip cropping, grassed waterways, and no-plow tilling all limit run-off from reaching the lake. Buffer zones should be maintained between agricultural lands and the lake.

Lakeshore Management

The actions of every lakeshore property owner influence the water quality of the lake. The lake association and the townships can work together to mitigate existing and potential problems in the following ways:

<u>Lakeshore Planning Districts</u>

Townships and counties can designate lakeshore areas as separate planning and management districts to carry out the following management measures:

<u>Density Regulations</u>

Density regulations on lakeshore development can require minimum lot size for single dwellings on the lakeshore, as well as regulate proliferation of multiple housing units.

<u>Lakeside Greenbelts</u>

Townships or counties can enact ordinances requiring a strip of vegetation (greenbelt) between new developments and the water's edge (See <u>Lakeland Report</u> No. 12).

<u>Surface Pollution Curtailment</u>

Great discretion should be used in the application of fertilizers, pesticides and herbicides.

Lake Resident Education

The lake association can support environmental education programs to instruct lake residents in environmentally sound lakeshore property practices.

Lake Water Quality Monitoring

Continued monitoring of Walloon Lake is highly recommended. The lake and its watershed is a very dynamic system and only by periodic re-evaluation will adverse changes be detected in time to correct them.

Annual Monitoring

Annual monitoring through the Michigan Department of Natural Resources Self-Help Program should be continued. In addition, summer oxygen concentrations in the bottom waters of the basins should be sampled annually.

Nutrient Budget

In light of the projected growth rates for the watershed, a re-evaluation of the nutrient budget should be undertaken every five years, starting in 1982.

[illegible]

We gratefully acknowledge [illegible] assistance and [illegible] for [illegible] paring the manuscript [illegible] drafted the figures and J. Pritker [illegible] The manuscript was typed [illegible]

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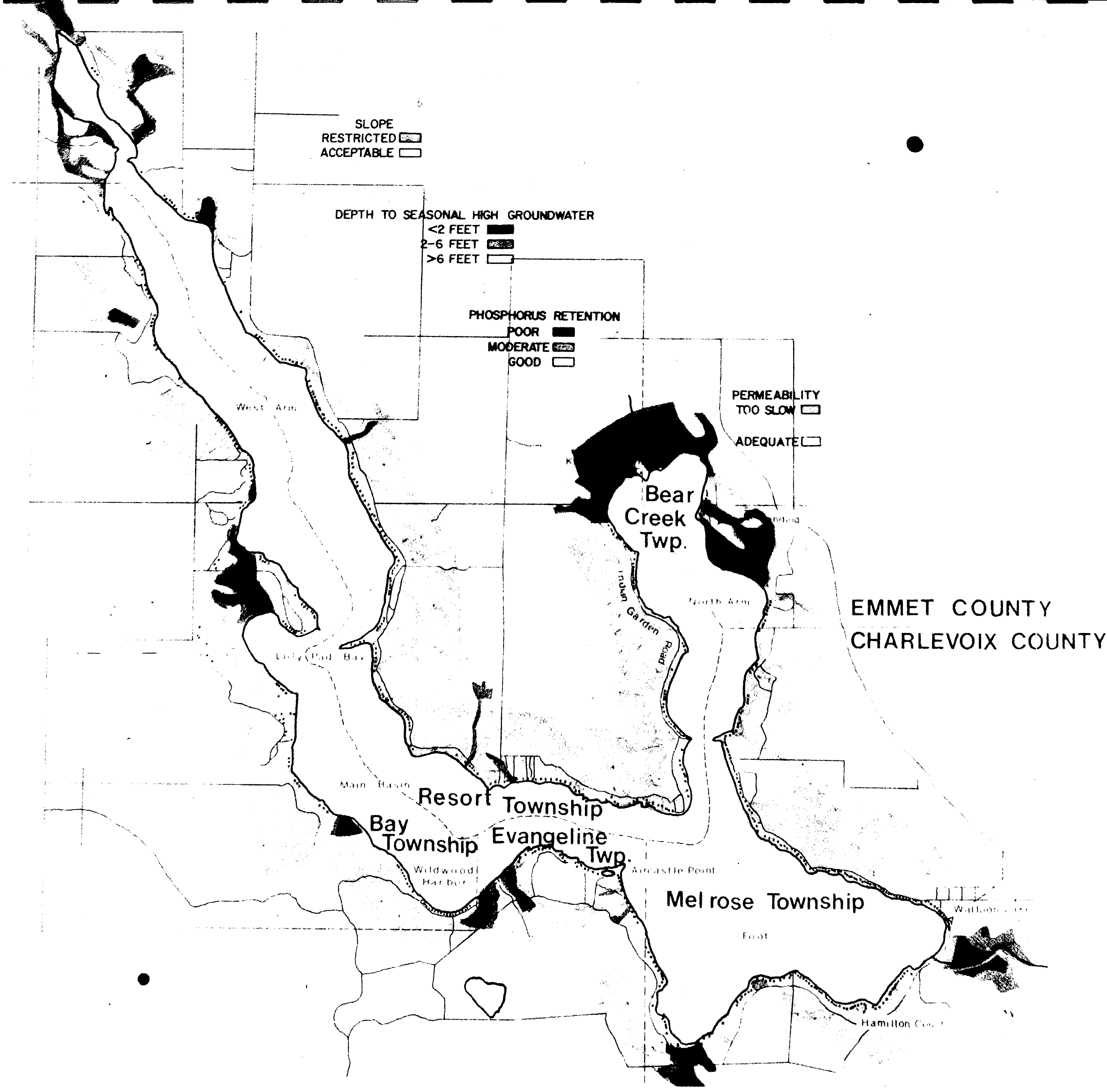
APPENDIX I

The Suitability of Soils for Onsite Wastewater Disposal



SLOPE
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2-6 FEET
>6 FEET
PHOSPHORUS RETENTION
POOR
MODERATE
GOOD
PERMEABILITY
TOO SLOW
ADEQUATE
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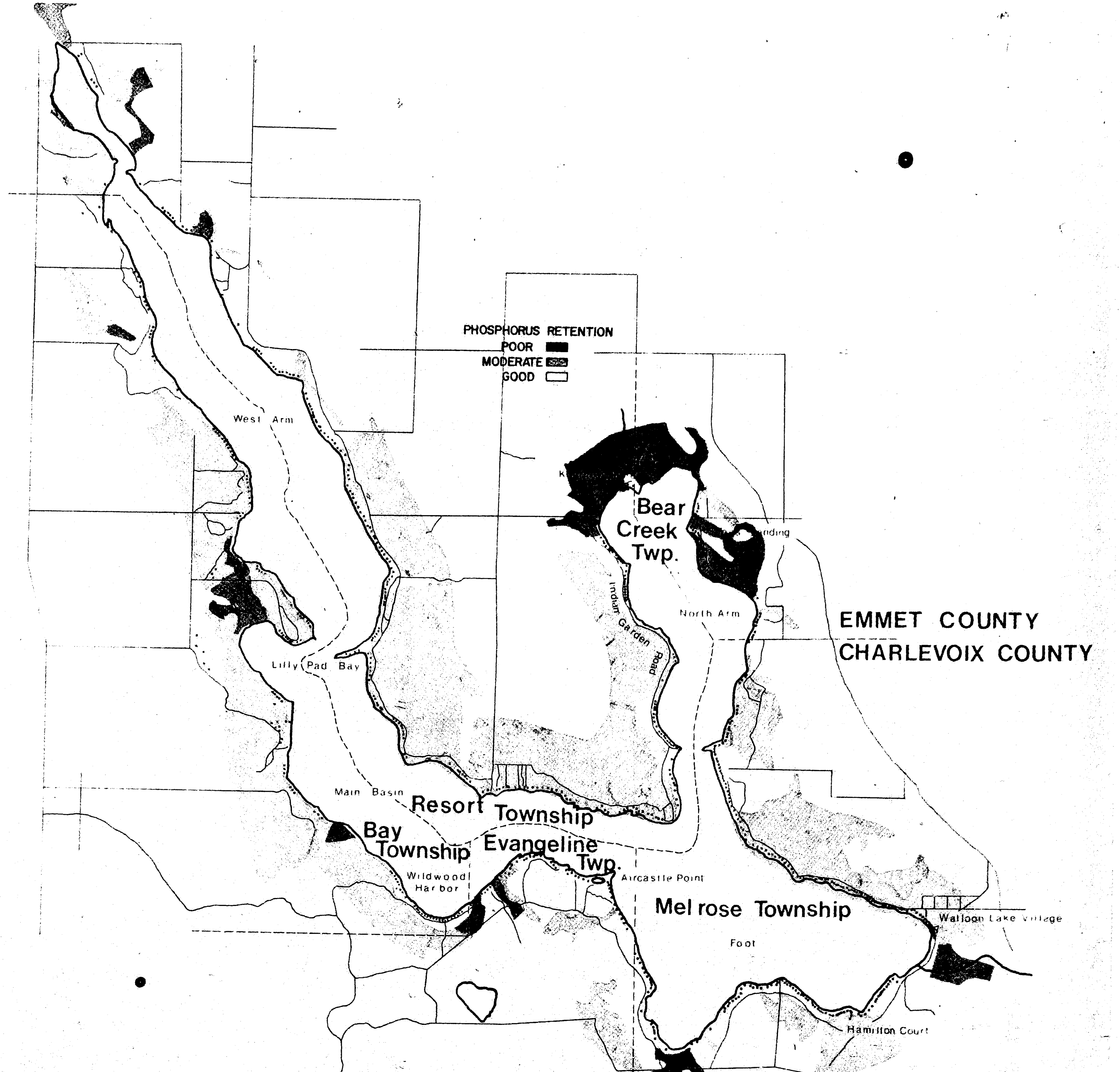
Bear Creek Twp.
Indian Garden Road
North Arm
EMMET COUNTY
CHARLEVOIX COUNTY
Lilly Pad Bay
Main Basin
Resort Township
Bay Township
Evangeline Twp.
Wildwood Harbor
Ancastle Point
Melrose Township
Foot
Hamilton


PHOSPHORUS RETENTION
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Wildwood Harbor
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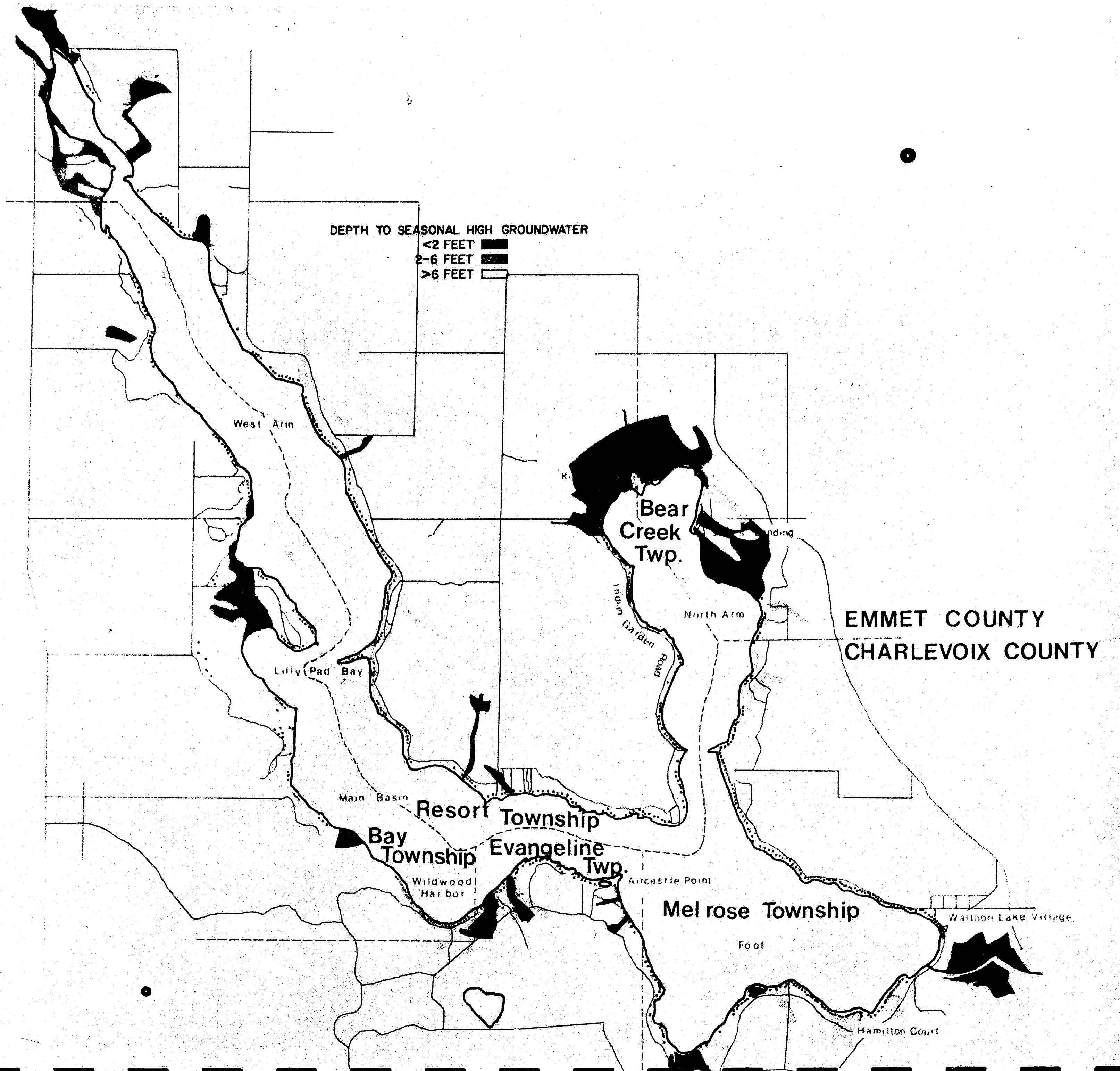
Melrose Township
Foot
Walloon Lake Village
Hamilton Court



DEPTH TO SEASONAL HIGH GROUNDWATER
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2-6 FEET
>6 FEET
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Lilly Pad Bay
Main Basin
Resort Township
Bay Township
Evangeline Twp.
Wildwood Harbor
Bear Creek Twp.
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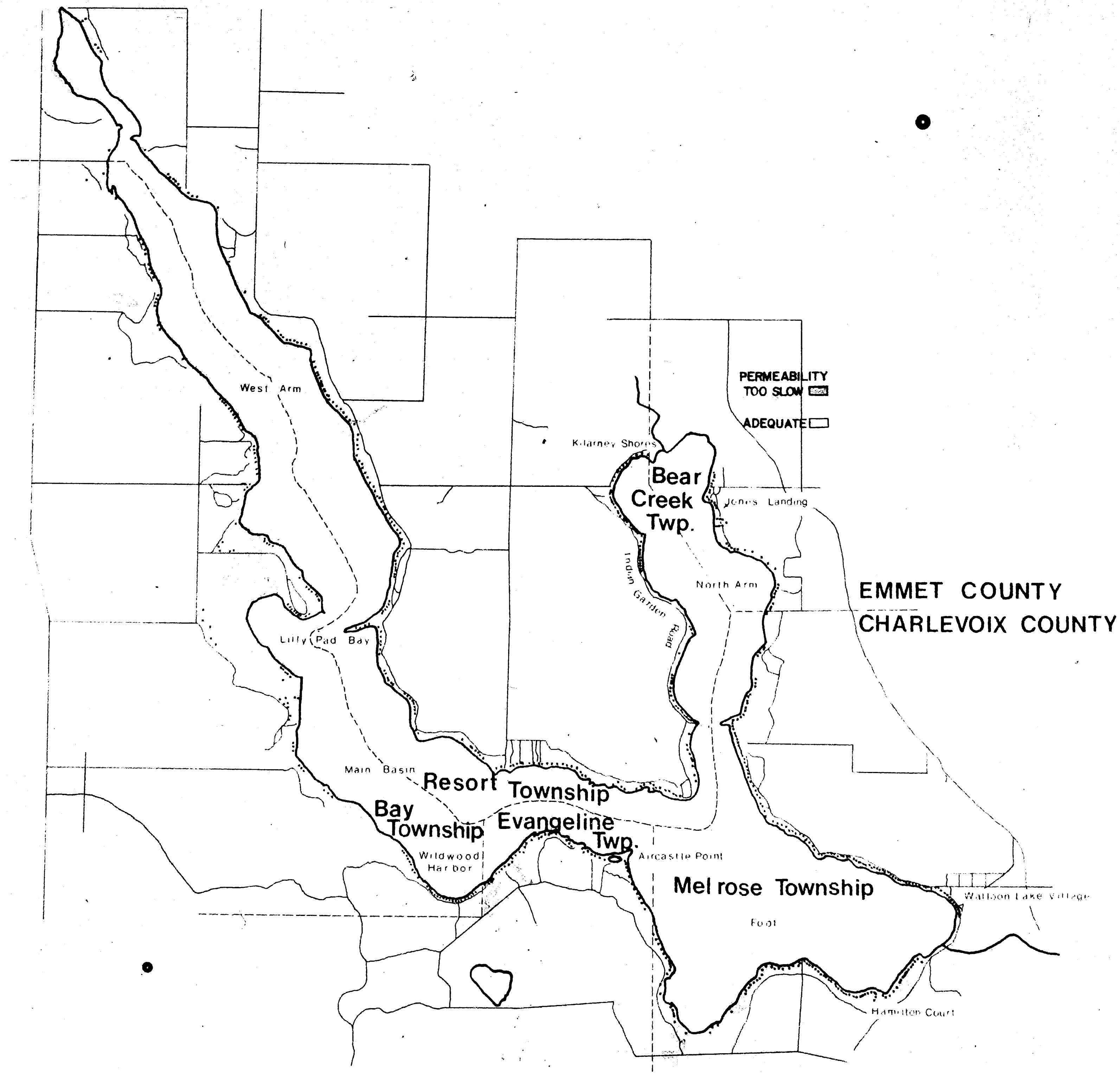
Mel rose Township
Foot
Walloon Lake Village
Hamilton Court


PERMEABILITY
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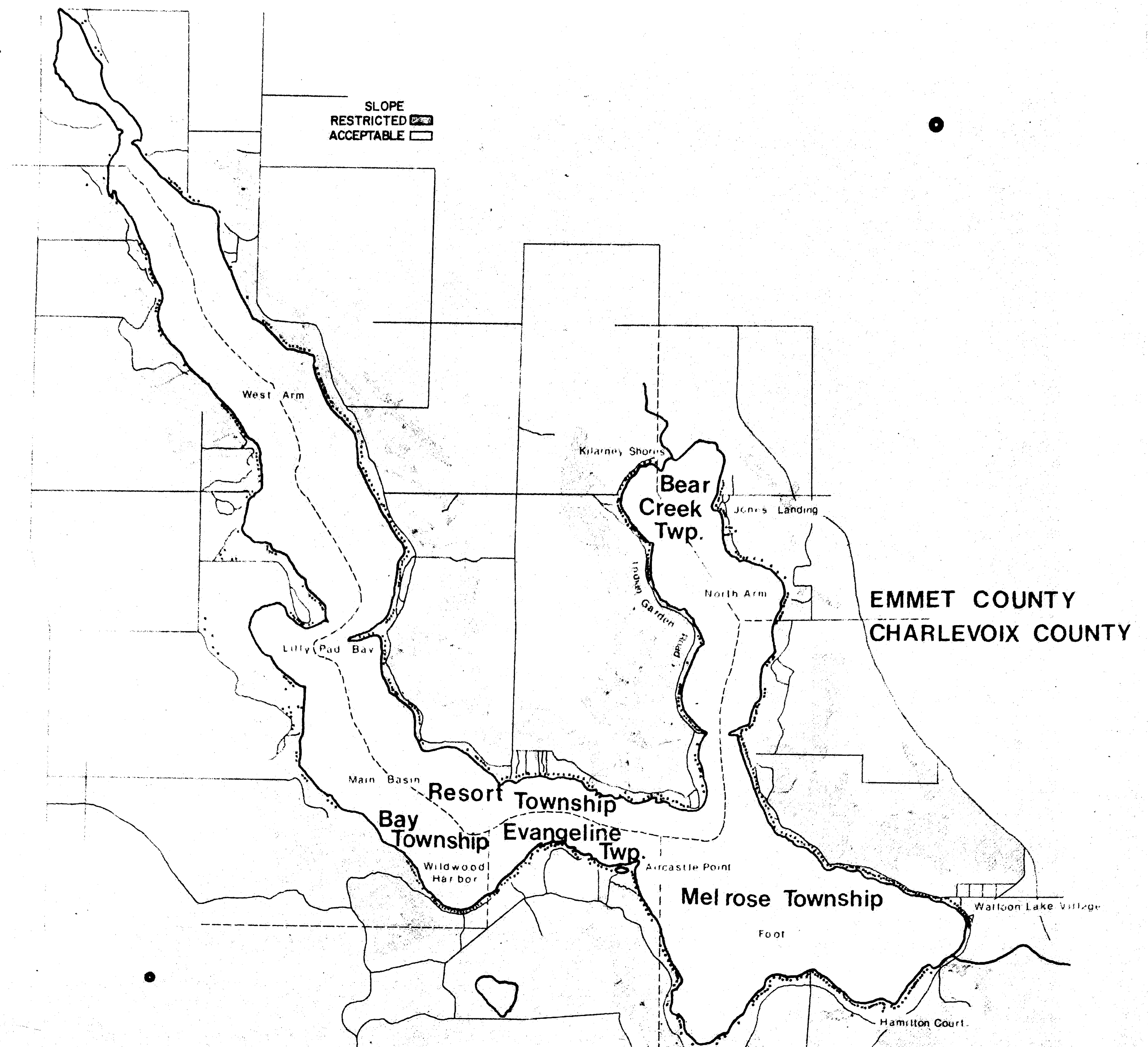
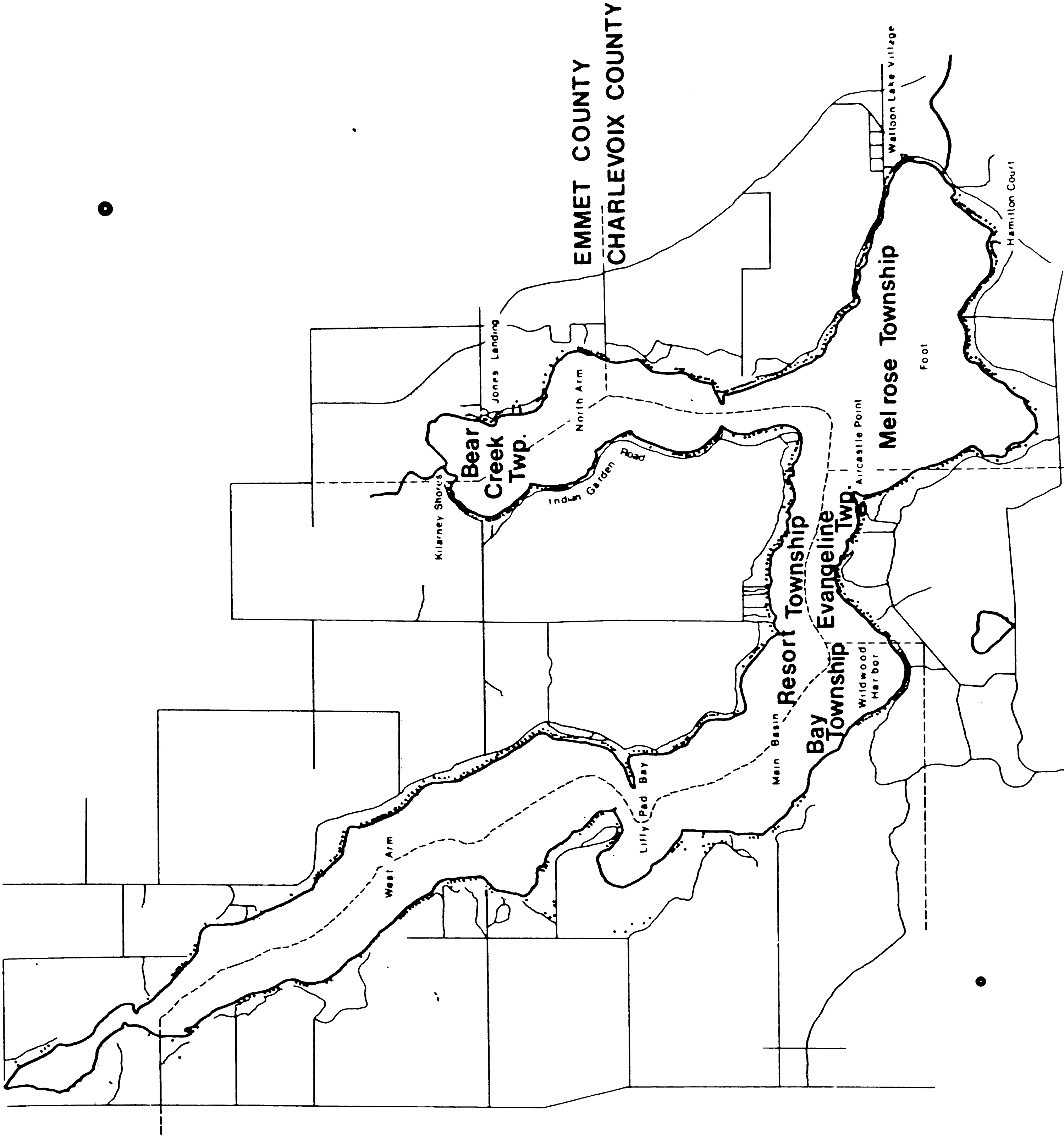
Foot
Hamilton Court


SLOPE
RESTRICTED
ACCEPTABLE
West Arm
Lilly Pad Bay
Main Basin
Resort Township
Bay Township
Evangeline Twp.
Wildwood Harbor
Kilarney Shores
Bear Creek Twp.
Jones Landing
North Arm
Indian Garden Road
EMMET COUNTY
CHARLEVOIX COUNTY
Melrose Township
Foot
Walloon Lake Village
Hamilton Court



EMMET COUNTY
CHARLEVOIX COUNTY
Walloon Lake Village
Hamilton Court
Melrose Township
Foot
Aircastle Point
Jones Landing
North Arm
Bear Creek Twp.
Indian Garden Road
Killarney Shores
Resort Township
Evangeline Twp.
Wildwood Harbor
Bay Township
Main Basin
Lilly Pad Bay
West Arm

APPENDIX II

Selected Data on the Soils and
Water of Walloon Lake and its Watershed

A. Surface Water Nutrient Chemistry

1977

B. Results of Groundwater Sampling

1977

C. Flow Rates of the Bear River

1976 - 1977

D. Nutrient Inputs from the Septic
Systems of Walloon Lake

A.

Surface Water
Nutrient Chemistry
Summer, 1977

	Date	T.P. (ppb)	NO_3-N (ppb)	NH_3-N (ppb)	Cl (ppm)	Chl *a* (ppb)
Bear Creek	4-17	1.00	100.0	38.0	2.80	-
	5-5	7.20	76.0	19.0	3.90	-
	6-10	6.00	20.0	10.0	2.50	-
	7-7	9.00	7.50	12.0	3.80	-
	7-30	7.80	3.00	6.0	3.30	-
South Arm Creek	7-7	32.00	13.0	16.0	3.10	-
	7-30	21.00	42.0	27.0	4.20	-
North Arm Creek	5-5	6.60	N.D.	8.6	3.40	-
	7-7	43.00	43.0	153.0	12.00	-
Skornia Creek	7-7	27.00	40.0	17.0	3.60	-
West Basin (Center)	6-27	5.00	40.0	10.0	3.50	1.51
	7-30	6.00	16.0	6.0	3.00	2.12
North Basin (Center)	6-27	6.00	5.0	10.0	3.50	2.39
	7-30	7.80	4.50	18.0	3.60	2.40
Central Basin (Center)	6-27	7.50	15.0	10.0	3.50	2.53

B. Groundwater Sampling Results

Sample Number	Total Phosphorous (PPB)	NO_3-Nitrogen (PPB)	NH_3-Nitrogen (PPB)	Chlorides (PPM)
401	171	0	2744	8.5
402	459	0	1904	20
403	162	18	238	9.5
404	81	0	3864	7.5
405	54	0	50	4.3
406	45	0	966	7.5
407	173	180	1050	15
408	25	0	30	0.9
409	63	0	108	1.6
410	65	0	23	1.2
411	470	3	1113	19
412	No sample	No sample	No sample	No sample
413	122	36	258	11.3
414	116	0	48	15
415	165	3	6	15
416	230	63	0	8.1
417	278	108	0	7.1
418	25	258	5775	24
419	24	1082	57	47
420	111	153	6	7.5
421	43	0	17	1.7
422	2184	0	6300	29
423	254	3	2142	24
424	99	0	71	34
425	147	0	1638	119
426	129	0	2730	137
427	97	0	0	32
428	360	0	6510	102

C. Flow rates of the Bear River 1976-1977.

	cfs	cms
March 14, 1976	54.0	1.5
April 17, 1977	69.58	1.97
June 10, 1977	14.43	0.408
July 7, 1977	13.72	0.388
October 14, 1977	36.90	1.025
Average Estimated Outflow	42.2	1.2

D. Nutrient Inputs from the Septic Systems of Walloon Lake. (P=phosphorus; N=nitrogen).

West Arm Soil Type	Time to P Saturation in Soils (yrs)	% P Reaching the Lake	% N Reaching the Lake	#Homes/ Soil Type	Estimated N Reaching the Lake (kg/yr)	Estimated P Reaching the Lake (kg/yr)
Emmet-Leelanau complex En	19	25	85	11	101.0	3.3
Emmet soils Es	19	25	85	37	339.7	11.1
Emmet sandy loam Em	19	25	85	7	64.3	2.1
Leelanau-Rubicon loamy sand Lr	12	65	85	10	91.8	7.8
Leelanau loamy sand Ld	12	65	85	25	229.5	19.5
Kalkaska sand Ka	>20	25	85	2	18.4	0.6
Linwood muck Ls	<10	75	50	1	5.4	0.9
Roscommon sand Rc	12	75	50	3	16.2	2.7
Carbondale muck Ca	<10	75	50	1	5.4	0.9
Au Gres loamy sand (gravelly) Av	12	65	85	23	211.1	17.9
East Lake loamy sand Ea	19	35	65	2	14.0	0.8
Total for Basin				122	1308.0	78.7

D. - continued

North Arm Soil Type		Time to P Saturation in Soils (yrs)	% P Reaching the Lake	% N Reaching the Lake	#Homes/ Soil Type	Estimated N Reaching the Lake (kg/yr)	Estimated P Reaching the Lake (kg/yr)
Emmet-Leelanau complex	En	19	25	85	3	27.5	0.9
Emmet soils	Es	19	25	85	11	101.0	3.3
Emmet sandy loam	Em	19	25	85	5	45.9	1.5
Leelanau loamy sand	Ld	12	65	85	4	36.7	3.1
Iosco loamy sand	Il	15	50	65	10	70.2	6.0
Charlevoix sandy loam	Ch	15	50	65	8	56.2	4.8
Linwood muck	Ln	<10	75	50	38	205.2	34.2
East Lake loamy sand	Ea	19	25	85	16	146.9	4.8
Carbondale muck	Ca	<10	75	50	10	54.0	9.0
Kalkaska sand	Ka	>20	25	85	23	211.1	6.9
Made land	Ma	too variable to assess			9		
Total for Basin					137	892.0	82.6

D. - continued

Main Soil Type	Time to P Saturation in Soils (yrs)	% P Reaching the Lake	% N Reaching the Lake	#Homes/ Soil Type	Estimated N Reaching the Lake (kg/yr)	Estimated P Reaching the Lake (kg/yr)
Leelanau loamy sand Ld	12	65	85	58	532.0	45.2
Leelanau-Rubicon loamy sand Lr	12	65	85	23	211.1	17.9
Blue Lake loamy sand BlB	12	65	85	2	18.4	1.6
Emmet-Leelanau complex En	19	25	85	42	385.6	12.6
Au Gres loamy sand Av	19	30	65	27	189.5	9.7
East Lake loamy sand Ea	>20	25	85	9	82.6	2.7
Ensley sandy loam Ey	15	55	50	2	10.8	1.3
Mancelona loamy sand McB	15	45	85	9	82.6	4.9
Cathro muck Cc	<10	75	50	4	21.6	2.4
Otisco loamy sand OtB	12	70	65	7	49.1	5.9
Deer Park duneland DD	>20	25	85	4	36.7	1.2
Total for Basin				187	1584.0	123.2

D. continued

Foot Soil Type		Time to P Saturation in Soils (yrs)	% P Reaching the Lake	% N Reaching the Lake	#Homes/ Soil Type	Estimated N Reaching the Lake (kg/yr)	Estimated P Reaching the Lake (kg/yr)
Emmet-Leelanau complex	En	19	25	85	67	615.1	20.1
Emmet-Onaway sandy loam	Eo	19	25	85	9	76.5	2.7
Leelanau-Rubicon loamy sand	Lr	12	65	85	87	798.5	67.9
Au Gres sand	Av	19	35	65	8	56.1	3.4
Gladwin loamy sand	Gl	15	50	65	16	112.3	9.6
Charlevoix-Mackinac loam	Cm	15	55	65	1	7.0	0.6
Detour cobbly loam	De	15	55	50	4	21.6	2.6
Deer Park duneland	DD	>20	25	85	1	9.2	0.3
Carbondale muck	Ca	<10	75	50	1	5.4	0.9
Roscommon sand	Rc	15	75	50	2	10.8	1.8
Angelica-Ensley loam	An	19	35	50	2	10.8	0.8
East Lake loamy sand	Ea	19	25	85	1	9.2	0.3
Made land	Ma	too variable to assess			7		
Total for Basin					206	2032.0	142.8

APPENDIX III

Resource Agencies for Lake Management

RESOURCE AGENCIES FOR LAKE MANAGEMENT

I. Township Level

The township governmental units are those which are closest and most readily available to the residents of the watershed. They hold powers which are important for the protection and regulation of land and water resources such as the ability to plan, zone and tax. Where on-site wastewater treatment systems aren't working effectively, the township has the responsibility to seek out other means of waste disposal for the citizens within their jurisdiction. Application for federal funding to finance sewage treatment is made by the township.

Bay, Evangeline, and Melrose Townships in Charlevoix County have enacted Township zoning ordinances. Resort and Bear Creek follow the Emmet County zoning code. Copies of the ordinances may be obtained from the county or township offices.

Charlevoix County

Bay Township: Supervisor - Carl Skornia

Evangeline Township: Supervisor - Joe Eaton

Melrose Township: Supervisor - Harry Griffith

Emmet County

Resort Township: Supervisor - Wilfred Sterzik

Bear Creek Township: Supervisor - Rex Gibbard

II. County Level

A. County Planner and County Planning Commission

Specific information on county planning activities and advice on planning that can be carried out on a township level can be obtained from the county planner. The county planner is concerned with future growth and development within the county and serves as advisor to township governments on matters of planning and zoning. Final policy decisions on planning and development are made by an appointed planning commission made up of county citizens.

Emmet County Planning Office
City-County Bldg.
Petoskey, MI 49770
(616) 347-7780

Charlevoix County Planning Dept.
New City Bldg.
Charlevoix, MI 49720
(616) 547-4292

B. Local Enforcing Agency - Soil Erosion & Sedimentation Control Act

The Soil Erosion and Sedimentation Control Act requires that certain land use activities involving earth changes within 500 feet of a stream or a lake be approved by certified officials. The county level enforcing agencies for such activities around Walloon are:

Emmet County Community Development Department
200 Division
Petoskey, MI 49770
(616) 347-5330

Charlevoix County Department of Building Code Inspection
203 Antrim
Charlevoix, MI 49720
(616) 547-4419

III. Regional and Special Purpose Organizations

A. District Health Department #3

The District Health Department is responsible for inspection of septic tank/drainfield construction and issuance of permits for installation of such systems. They also review water supply and sewage disposal plans of new developments.

The Health Department is aware and interested in new septic system designs and can provide advice on watewater treatment methods for lakeshore areas.

Health Department District #3
203 Antrim
Charlevoix, MI 49720

Emmet County Health Dept.
(Branch Office, District #3)
453 Lake
Petoskey, MI 49770

B. The Northwest Regional Planning and Development Commission

The Northwest Regional Planning and Development Commission is the agency authorized by the Environmental Protection Agency to conduct planning programs related to water quality protection. The commission has prepared a CLEAN WATER plan for a ten-county area in Northwest Michigan which includes suggestions for lake management. Copies of the plan and information on technical and policy-related aspects of lake management can be obtained from the commission.

Northwest Regional Planning
and Development Commission
2334 Aero Park Court
Traverse City, MI 49684
(616) 946-5922

C. Soil Conservation Districts (SCD's)

Soil Conservation District Officers provide technical assistance on request to property owners, and farmers on soil conservation and soil improvement practices. They can assist in solving erosion problems and offer advice on property management. The Soil Conservation District Officers for Emmet and Charlevoix Counties may be contacted through U.S. Soil Conservation Service Personnel in Boyne City.

D. Soil Conservation Service (SCS)

The SCS also provides advice on soil and land management practices to prevent soil erosion and destruction of valuable land and water resources. The SCS is part of the U.S. Department of Agriculture and has district offices throughout Michigan. SCS assistance is available to local citizens, resource managers, planners, and Soil Conservation District Officers.

U.S. Soil Conservationist
29 North Park
Boyne City, MI 49712
582-7341

IV. State Level

A. District Fisheries Habitat Biologist

The District Fisheries Habitat Biology surveys fish locations, initiates stocking programs, and supervises several lake protection programs of the Michigan DNR and the Federal government. Responsibilities of the Fisheries Biologist includes issuing permits required for herbicide application, reviewing dredge and fill permit requests, and conducting the field inspections required for dredge and fill operations.

District #5 Fisheries Habitat Biologist
6984 M-68
Indian River, MI 49749
(616) 238-9313

B. The Division of Land Resource Programs

The Land Resource Division administers state land use legislation including: the Farmlands and Open Space Preservation Act, the Wilderness and Natural Areas Act, the Natural Rivers Act, the Natural Beauty Roads Act, the Shorelands Protection Act, the Soil Erosion and Sedimentation Control Act, and the Endangered Species program. For information on the programs, contact:

Land Resource Programs
Stevens T. Mason Bldg.
Lansing, MI 48926
(517) 373-3328

C. Water Quality Division

The DNR Water Quality Division administers the wastewater treatment construction grant program (Section 201 of the Federal Clean Water Act). Their responsibilities include surveillance of local wastewater collection and treatment systems, review and approval of wastewater treatment plans, and distribution of federal funds to local units of government. Contact them for information on how to apply for federal grants for wastewater treatment.

Water Quality Division
Michigan Department of Natural Resources
Stevens T. Mason Bldg.
Lansing, MI 48926
(517) 373-1947

V. Federal Level

Public Law 92-500, the Clean Water Act of 1972, provides the framework for water quality protection in the United States. The Environmental Protection Agency is responsible for administering the act. The EPA sets environmental regulations and policy guidelines concerning water management and supports research on many aspects of environmental protection. EPA information is passed to regional EPA offices across the country for dissemination to state government, state regional EPA agencies, and local governments. The regional EPA office for Michigan is:

Region V
U.S. Environmental Protection Agency
Office of Public Affairs
230 South Dearborn
Chicago, IL 60604

Questions on Federal programs and policies may also be channeled through the 208 planners working with the Northwest Regional Planning and Development Commission, Traverse City.

APPENDIX IV

CLEAR Social Survey

CLEAR SOCIAL SURVEY

A household survey was conducted to refine estimates of nutrient loading to Walloon Lake. Results are summarized in the following table.

Methods of Distribution

The surveys were distributed by mail to the 350 members of the Walloon Lake Association. Approximately 35 surveys were distributed personally in areas chosen for groundwater sampling.

Results and Discussion

A total of 142 surveys were returned to Project C.L.E.A.R. Since the majority of surveys went to members of the Walloon Lake Association this survey may not represent an accurate sample of lakeshore residents. It was expected that the sample obtained through the Association would be comprised of a larger percentage of seasonal residents. However, results approach those found in an earlier social survey (Marans et. al. 1977). The C.L.E.A.R. survey showed 81 percent of the sample to be seasonal residents. Marans et. al. (1977) found 76 percent of the residents of Walloon Lake to be seasonal residents.

Data used in Nutrient Budget Estimates

From the 142 responses received from the CLEAR household survey (Appendix IV), it was determined that the average occupancy was two people per year (i.e., 4 people for 6 months or 2 people for 12 months, sixty-nine percent of the surveys returned reported that the houses had automatic dishwashers, and 22% used phosphate enriched laundry detergent in their washing machines.

The survey did not locate predominant regions of year-round residents. The results to indicate however that the ratio of seasonal residents to year-round residents is constant on all areas of the lakeshore.

RESULTS OF WASTEWATER SURVEY

*Question #3

Types of households:

Seasonal	114	81%
Year-round	28	19%
Total	142	100%

*Question #3,4,5

Average number of occupants per year (# of occupants x # of months occupied)

Two people/year

*Question #7

Household appliances:

	With	%	Without	%	Total
Clothes washing machine	108	76	34	24	142
Dishwashing machine	98	68	44	32	142
Water softening system	41	29	101	71	142
Sink garbage disposal	41	29	101	71	142

*Question #8

Use of phosphate free detergent:

Yes	31	22%
No	111	78%
Total	142	100%

*Question #9

Lawn fertilization:

Never	92	65%
1/yr	6	3
1/yr	21	15
1-2/yr	17	12
2/yr	5	4
3/yr	1	1
Total	142	100%

WASTEWATER MANAGEMENT QUESTIONAIRE

This questionaire was developed by project CLEAR, a group of students from the University of Michigan Biological Station. The information you provide, coupled with the scientific data the University has collected, will help to formulate long range plans for preservation of your lake.

1. Address (number and street) ______________________________

2. Name of Owner ______________________________

   Name of Occupant, if not same ______________________________

3. When do you normally live in this house (check one):

   __________ All Year

   __________ Part of Year from __________ to __________

   __________ Weekends

   __________ Other (explain) ______________________________

4. How many people normally live in this house when it is occupied?

   ____

5. Does the number of occupants usually increase at any time of the year?

   Yes __________

   No __________

   If you answered yes, at what time (for example, "mid-June" or "every weekend from June to September")

   ____

   And for how long (for example, "for two weeks" or "for the entire weekend") ______________________________

   At this time, approximately how many occupy the house? (Give average figure) ______________________________

6. Is this home winterized? Yes________ No________

If not, do you have plans to winterize it soon? ________

7. Does this house have any of the following? If so, how many?

a.________ Clothes washing machine ________

b.________ Dishwashing machine ________

c.________ Water softening system ________

d.________ Sink garbage disposal ________

8. Do you use phosphate free laundry detergent?

Yes________ No________

9. Is there a lawn? Yes________ No________

Are there shrubs, bushes, or other vegetation between the grass and the beach or waterfront?

Yes________ No________

Does the lawn extend to the water's edge?

Yes________ No________

How often is it fertilized? Never________

One or two times a year ________

More than twice a year ________

10. If this house has septic tanks:

a. Do you know the approximate dimensions or volume of the tank (or tanks)? ________

b. How old is the tank (or tanks)? ________

c. When was the last time it was emptied? ________

d. How often is it emptied? ________

e. Do you know approximately how far the system (especially the drainage field) is from the lake? ________