United States
Environmental Protection
Agency

Region V
230 South Dearborn
Chicago, Illinois 60604

July, 1979

Water Division

EPA

Environmental Impact Statement

Draft Appendices

Alternative Waste Treatment Systems For Rural Lake Projects

Case Study Number 3
Springvale-Bear Creek Sewage Disposal Authority
Emmet County, Michigan

VOLUME II APPENDICES

DRAFT ENVIRONMENTAL IMPACT STATEMENT

ALTERNATIVE WASTEWATER TREATMENT SYSTEMS FOR RURAL LAKE PROJECTS

CASE STUDY No. 3: SPRINGVALE-BEAR CREEK SEWAGE DISPOSAL AUTHORITY

EMMET COUNTY, MICHIGAN

Prepared by the

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION V, CHICAGO, ILLINOIS

AND

WAPORA, INCORPORATED

WASHINGTON, D.C.

Approved by:

John McGuire
Regional Administrator
U.S. Environmental Protection Agency

July, 1979

APPENDIX

APPENDIX A

SOILS

SOIL FACTORS THAT AFFECT ON-SITE WASTEWATER DISPOSAL

Evaluation of soil for on-site wastewater disposal requires an understanding of the various components of wastewater and their interaction with soil. Wastewater treatment involves: removing suspended solids; reducing bacteria and viruses to an acceptable level; reducing or removing undesirable chemicals; and disposal of the treated water. For soils to be able to treat wastewater properly they must have certain characteristics. How well a septic system works depends largely on the rate at which effluent moves into and through the soil, that is, on soil permeability. But several other soil characteristics may also affect performance. Groundwater level, depth of the soil, underlying material, slope and proximity to streams or lakes are among the other characteristics that need to be considered when determining the location and size of an on-site wastewater disposal system.

Soil permeability - Soil permeability is that quality of the soil that enables water and air to move through it. It is influenced by the amount of gravel, sand, silt and clay in the soil, the kind of clay, and other factors. Water moves faster through sandy and gravelly soils than through clayey soils.

Some clays expand very little when wet; other kinds are very plastic and expand so much when wet that the pores of the soil swell shut. This slows water movement and reduces the capacity of the soil to absorb septic tank effluent.

Groundwater level - In some soils the groundwater level is but a few feet, perhaps only one foot, below the surface the year around. In other soils the groundwater level is high only in winter and early in spring. In still others the water level is high during periods of prolonged rainfall. A sewage absorption field will not function properly under any of these conditions.

If the groundwater level rises to the subsurface tile or pipe, the saturated soil cannot absorb effluent. The effluent remains near the surface or rises to the surface, and the absorption field becomes a foul-smelling, unhealthful bog.

Depth to rock, sand or gravel - At least 4 feet of soil material between the bottom of the trenches or seepage bed and any rock formations is necessary for absorption, filtration, and purification of septic tank effluent. In areas where the water supply comes from wells and the underlying rock is limestone, more than 4 feet of soil may be needed to prevent unfiltered effluent from seeping through the cracks and crevices that are common in limestone.

Different kinds of soil - In some places the soil changes within a distance of a few feet. The presence of different kinds of soil in an absorption field is not significant if the different soils have about the same absorption capacity, but it may be significant if the soils differ greatly. Where this is so, serial distribution of effluent is recommended so that each kind of soil can absorb and filter effluent according to its capability.

Slope - Slopes of less than 15% do not usually create serious problems in either construction or maintenance of an absorption field provided the soils are otherwise satisfactory.

On sloping soils the trenches must be dug on the contour so that the effluent flows slowly through the tile or pipe and disperses properly over the absorption field. Serial distribution is advised for a trench system on sloping ground.

On steeper slopes, trench absorption fields are more difficult to lay out and construct, and seepage beds are not practical. Furthermore, controlling the downhill flow of the effluent may be a serious problem. Improperly filtered effluent may reach the surface at the base of the slope, and wet, contaminated seepage spots may result.

If there is a layer of dense clay, rock or other impervious material near the surface of a steep slope and especially if the soil above the clay or rock is sandy, the effluent will flow above the impervious layer to the surface and run unfiltered down the slope.

Proximity to streams or other water bodies - Local regulations generally do not allow absorption fields within at least 50 feet of a stream, open ditch, lake, or other watercourse into which unfiltered effluent could escape.

The floodplain of a stream should not be used for an absorption field. Occasional flooding will impair the efficiency of the absorption field; frequent flooding will destroy its effectiveness.

Soil maps show the location of streams, open ditches, lakes and ponds, and of alluvial soils that are subject to flooding. Soil surveys usually give the probability of flooding for alluvial soils.

Soil conditions required for proper on-site wastewater disposal are summarized in the Appendix A-3.

Source: Bender, William H. 1971. Soils and Septic Tanks. Agriculture Information Bulletin 349, SCS, USDA.

COMPARISON OF SITE CHARACTERISTICS FOR LAND TREATMENT PROCESSES

Characteristics	Principal processes: Slow rate	Principal processes: Rapid infiltration	Principal processes: Overland flow	Other processes: Wetlands	Other processes: Subsurface
Slope	Less than 20% on cultivated land; less than 40% on noncultivated land	Not critical; excessive slopes require much earthwork	Finish slopes 2 to 8%	Usually less than 5%	Not critical
Soil permeability	Moderately slow to moderately rapid	Rapid (sands, loamy sands)	Slow (clays, silts, and soils with impermeable barriers)	Slow to moderate	Slow to rapid
Depth to groundwater	2 to 3 ft (minimum)	10 ft (lesser depths are acceptable where underdrainage is provided)	Not critical	Not critical	Not critical
Climatic restrictions	Storage often needed for cold weather and precipitation	None (possibly modify operation in cold weather)	Storage often needed for cold weather	Storage may be needed for cold weather	None

1 ft = 0.305 m

Technology Transfer Program. 1977. Process Design Manual for Land Treatment of Municipal Wasteworks. EPA.

APPENDIX B

WATER QUALITY

MICHIGAN SURFACE WATER CLASSIFICATIONS

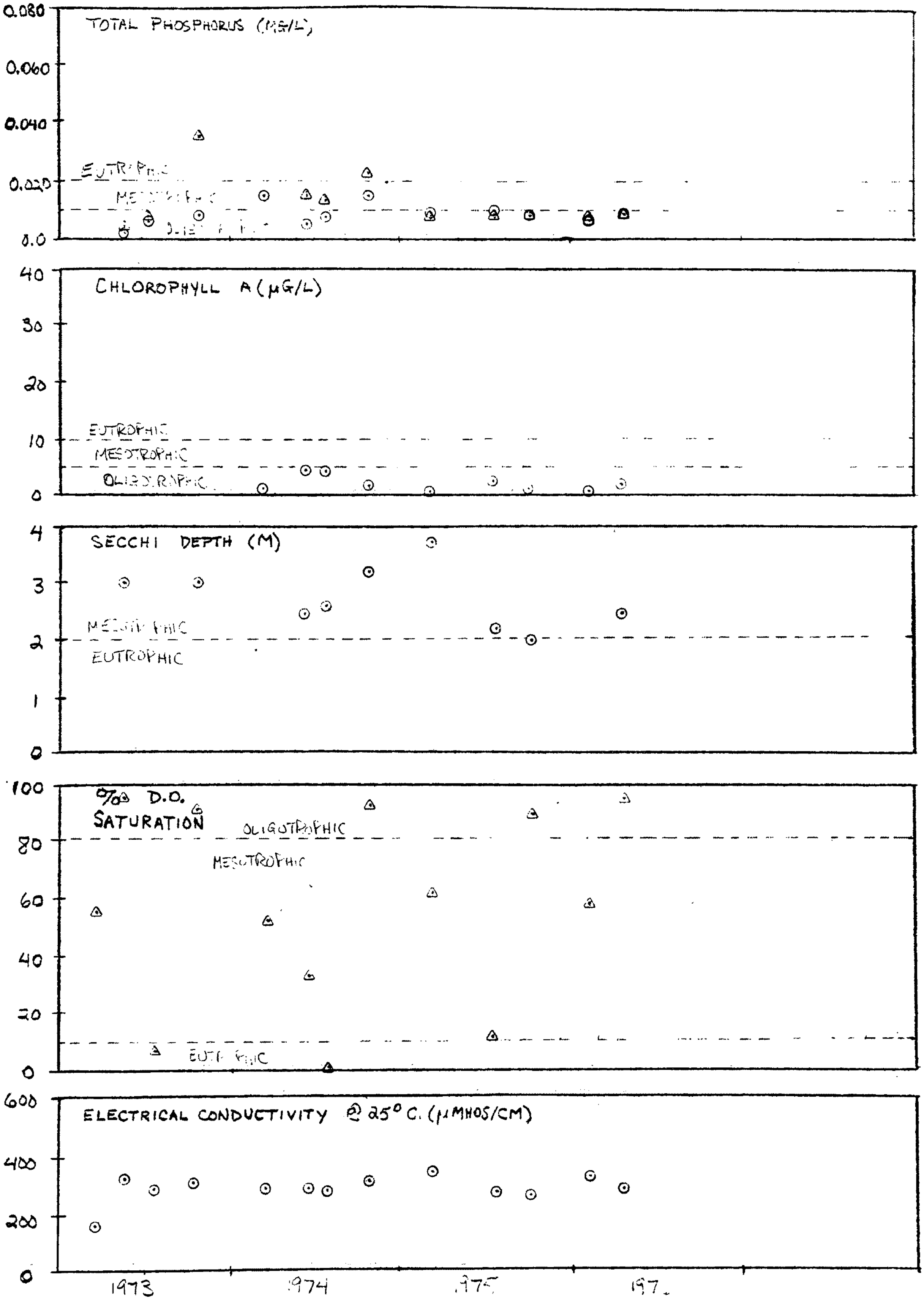
Michigan has established State water quality standards to protect public health and to preserve quality of the several bodies of water for their designated uses. Pertinent Michigan surface water classifications follow.

Classification	Use
A-I	Public and Municipal Water Supply
A-II	Industrial Water Supply
B-I	Total Body Contact Recreation
B-II	Partial Body Contact Recreation
C-I	Coldwater Fish (trout, salmon, etc.)
C-II	Warmwater Fish (bass, pike, etc.)
D	Agriculture
E	Navigation

MICHIGAN STATE WATER QUALITY STANDARDS

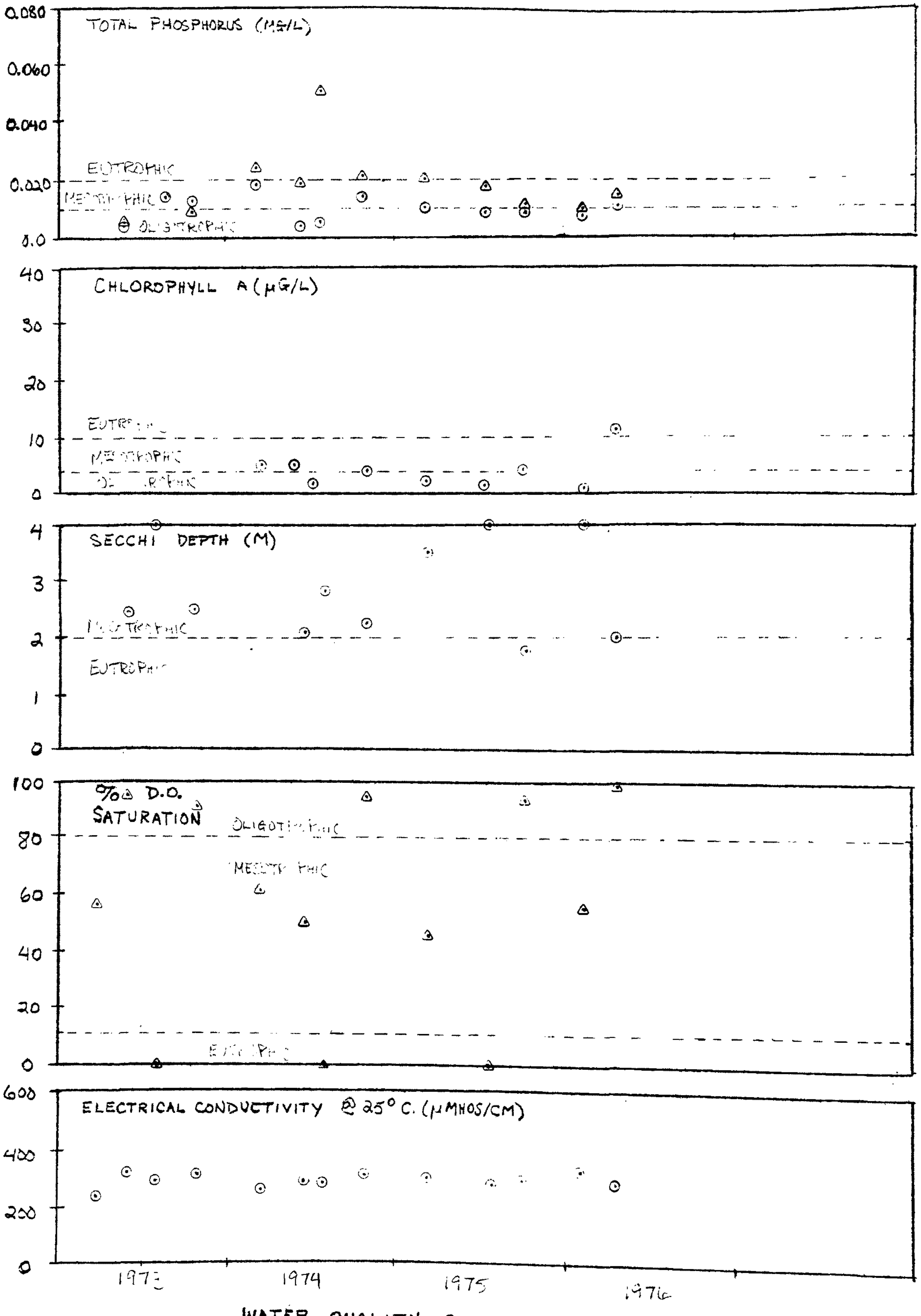
Surface Water Classifications	A-I	A-II	B-I	B-II	C-I	C-II	D	E
Suspended solids	No unnatural turbidity, color, oil films, floating solids or deposits in quantities which are or may become injurious to any designated use							
Dissolved solids	Shall not exceed concentrations which are or may become injurious to any designated use.							
chlorides	≤ 125 mg/l							
pH	6.5 - 8.8							
Plant nutrients	Nutrients shall be limited to the extent necessary to prevent stimulations of growth of aquatic plants, fungi or bacteria which are or may become injurious to the designated use. Phosphorus from point sources shall be controlled by utilizing best practicable waste treatment technology. Goal is 1 mg/l of P							
Fecal coliform	≤ 1000/100 ml		200/100 ml	≤ 1000/100 ml				
DO	5 mg/l but not less than 4 mg/l		6 mg/l		5 mg/l but not less than 4 mg/l			
Temperature	Temperature standards are dependent on location and type of surface water and also the designated use of the surface water.							

State of Michigan Water Quality Requirements, Part 4, undated.



WATER QUALITY PARAMETERS (PICKEREL LAKE)

LEGEND: ⊙ SURFACE
△ BOTTOM



WATER QUALITY PARAMETERS (CROOKED LAKE)

LEGEND: ⊙ SURFACE
△ BOTTOM

APPENDIX
B-4

THE UNIVERSITY OF MICHIGAN
Biological Station

Limnological Features of Crooked and Pickerel Lakes, Emmet County, Michigan

Part I: Water Quality and Nutrient Budget

by

JOHN E. GANNON and DANIEL J. MAZUR

Part II: The Suitability of Soils for On-Site Wastewater Disposal

by

ARTHUR GOLD and JOHN E. GANNON

Technical Report No. 8

Douglas Lake

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 are 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. 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).

LIMNOLOGICAL FEATURES

of

CROOKED AND PICKEREL LAKES
EMMET COUNTY, MICHIGAN

PART I: WATER QUALITY AND NUTRIENT BUDGET[1]

by

John E. Gannon[2]

and

Daniel J. Mazur[3]

TECHNICAL REPORT NO. 8
BIOLOGICAL STATION
THE UNIVERSITY OF MICHIGAN
PELLSTON, MICHIGAN 49769

April 1979

---

1 This report is based on research funded by the National Science Foundation (Grant No. AEN72-03483). Preparation of the report was supported by the Environmental Protection Agency as a sub-contract to a prime contract (EPA-No. 08-01-4612) to WAPORA, Inc.

2 Present address: State University Research Center, Oswego, New York 13126

3 Present address: Missouri Department of Natural Resources, Jefferson City, Missouri 65101

CONTENTS

FIGURES

Number		Page

TABLES

INTRODUCTION

The University of Michigan Biological Station has been studying 40 inland lakes in Cheboygan and Emmet Counties, Michigan, since 1972. This research effort has been designed to provide ecological and sociological information pertinent to management of these lakes and their watersheds for the enhancement of long-term environmental quality. Preliminary results of these investigations are available in Gannon and Paddock (1974). Specific information on geology, hydrology and groundwater quality was presented in Richardson (1978). Sociological data on evaluations, behaviors, and expectations of residents of the study area were reported by Marans and Wellman (1977). Instances of utilization of information generated in this project for water quality and wastewater management purposes has been documented by Pelz (1977) and Pelz and Gannon (1978). Furthermore, information written especially for lake-oriented visitors and residents has been prepared in the Biological Station's Lakeland Report Series, Lake Profile Series, and other publications (Say et al., 1975; Foster, 1976; O'Neil, 1977).

Crooked and Pickerel Lakes have been investigated since the beginning of this problem-oriented research effort. The objective of this report is to provide a summary of salient limnological features of these two water bodies. Special emphasis will be given to the current water quality and trophic status of Crooked and Pickerel Lakes and to an estimate of nutrient (phosphorus and nitrogen) sources to these lakes. Complimentary information on suitability of lakeshore soils for on-site wastewater disposal is included as Part II of this report (Gold and Gannon, 1979).

DESCRIPTION OF STUDY AREA

Crooked and Pickerel Lakes are located near Little Traverse Bay of Lake Michigan in northwestern lower Michigan (Fig. 1). They lie in Emmet County (T35N, R4W) and are bounded by four townships (Bear Creek, Little Traverse, Littlefield, and Springvale). Typical of most lakes in this region, they were formed by melted ice blocks that were left by the retreating glacier over 10,000 years ago. These lakes are the beginning of the Inland Water Route, a series of interconnecting lakes and rivers that eventually empty into Lake Huron through the Cheboygan River.

Crooked and Pickerel Lakes have played an important role in the human history of northern lower Michigan. Although native people were primarily oriented towards the shorelines of Lakes Michigan and Huron, the Inland Water Route was used for passage from Lake Michigan to Lake Huron by canoe, thus avoiding the more hazardous journey around Waugoshance Point and through the Straits of Mackinac. The Inland Water Route

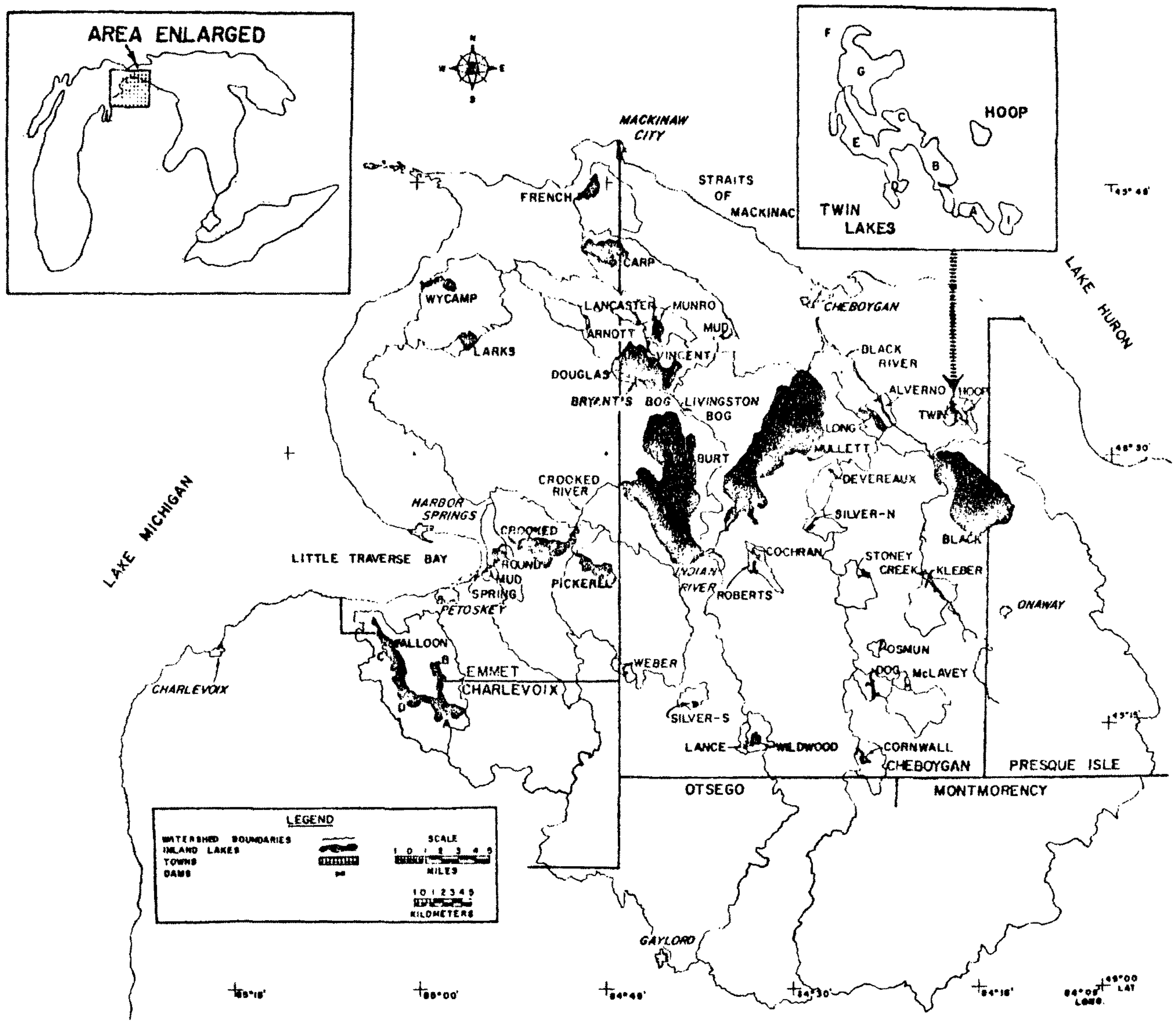


Fig. 1. Location of Crooked and Pickerel Lakes in northwestern lower Michigan in relation to other major inland lakes of the Cheboygan River watershed.

was also used extensively for transportation by European voyagers and settlers. During the logging era around the turn of the century, millions of board feet of white pine and other timber were floated down the Inland Water Route to sawmills; two of these mills were located on Crooked Lake at Oden and Conway.

At the same time, the railroad was built in this area and provided an overland transportation link to the south. Tourism flourished as vacationers came to Crooked and Pickerel Lakes by rail and stayed in resort hotels on the lakeshores. Commercial steamers carried vacationers from Crooked and Pickerel Lakes to Mullett Lake through the Inland Water Route. Crooked and Pickerel Lakes have continued to be popular for water-oriented recreation to the present day. To facilitate recreational boating activities, the Crooked River has been periodically dredged to a depth of 5 ft. since 1956. Water levels in Crooked and Pickerel Lakes were stabilized by construction of a lock and weir on the Crooked River at Alanson in 1964.

Crooked Lake was the only inland water body in northern lower Michigan with a railroad traversing a considerable distance of its shoreline. This allowed for earlier resort devel opment on Crooked Lake than on other lakes of the region. In addition to resort hotels, cottages were built near the railway along the north shore, especially at Conway and Oden. The north shore of Crooked Lake was extensively dotted with seasonal dwellings in the early decades of this century while the south shore of the lake and all of Pickerel Lake's shores remained essentially undeveloped. Building of cottages and homes along all shorelines increased especially after World War II.

Since the north shore of Crooked Lake was first to be developed, it also was the first area to experience pollution problems. Contamination of nearshore water with human sewage was discovered along the north shore, especially near Oden, in the late 1960's and early 1970's. To alleviate this problem, a sanitary sewer was constructed to divert human sewage away from the north shore and into the Harbor Springs sewage lagoon and spray irrigation wastewater treatment system. Although the sewer was completed in Fall of 1975, most lakeshore residences were not hooked up to the sewer system until 1976. Lakeshore dwellings on the remainder of Crooked Lake's shoreline and all of Pickerel Lake continue to be serviced by conventional septic systems.

Human sewage was not the only source of pollution to Crooked Lake. A state fish hatchery has existed on the lake near Oden since 1920. The small stream emanating from the fish hatchery was the major source of ammonia-nitrogen and total phosphorus to Crooked Lake in 1975 (Gannon and Mazur, 1976). Further information on the fish hatchery and nutrient loading to Crooked Lake is presented in this report.

METHODS

Watershed Characteristics

Immediate watershed area is defined here as the area bounded by the highest elevation which continually surrounds a given lake without including other lakes. Total watershed area is the immediate watershed of a given lake plus the immediate watersheds of all other lakes that subsequently drain into the given lake. The watershed areas for Crooked and Pickerel Lakes were traced from U. S. Geological Survey quadrangle maps (1:62, 500 scale) onto a blank piece of paper and cut out with a pair of scissors. The area was determined by passing the piece of paper delineating the watershed area through a Hayashi Denko Automatic Area Meter, Model AAMS. Land-use types and their areal coverage were determined from LANDSAT satellite data (Rogers, 1977).

Limnological Characteristics

Morphometric features of Crooked and Pickerel Lakes were determined from hydrographic maps compiled by the Institute for Fisheries Research, Michigan Department of Natural Resources. The methods employed basically followed Welch (1948) and are discussed in Gannon and Paddock (1974).

Physiochemical data were obtained on a quarterly basis from Fall, 1972 through Winter, 1975 from a central deep station in both lakes (Figs. 2 and 3). Temperature profiles were recorded at one meter intervals, using a Whitney resistance thermometer. Light transparency was measured with a standard Secchi disc. Light penetration measurements were obtained with a submarine photometer fitted with Weston cells during Summer and Winter. Percent light transmission was calculated from the photometer readings. Apparent color of the water was estimated with a Hach colorimeter (pt-co units).

Water samples were obtained from three to five depth intervals, depending upon temperature profile characteristics, with a three-liter capacity Kemmerer bottle. Dissolved oxygen was determined titriometrically with the azide modification of the Winkler method (APHA, 1971). Alkalinity was measured titriometrically with an indicator solution of bromocresol-green and methyl-red (APHA, 1971). Specific conductance was determined on an Industrial Instruments Model RC-16B2 conductivity bridge and pH was measured potentiometrically on either a Beckman Model N or Model H-5 pH meter. All of the above variables were analyzed within 18 hours of collection.

Samples for remaining variables were filtered and frozen for later analysis. These samples were quick-thawed in a water bath to room temperature and chemical analyses were completed by the following methods. Calcium, magnesium, sodium, and potassium

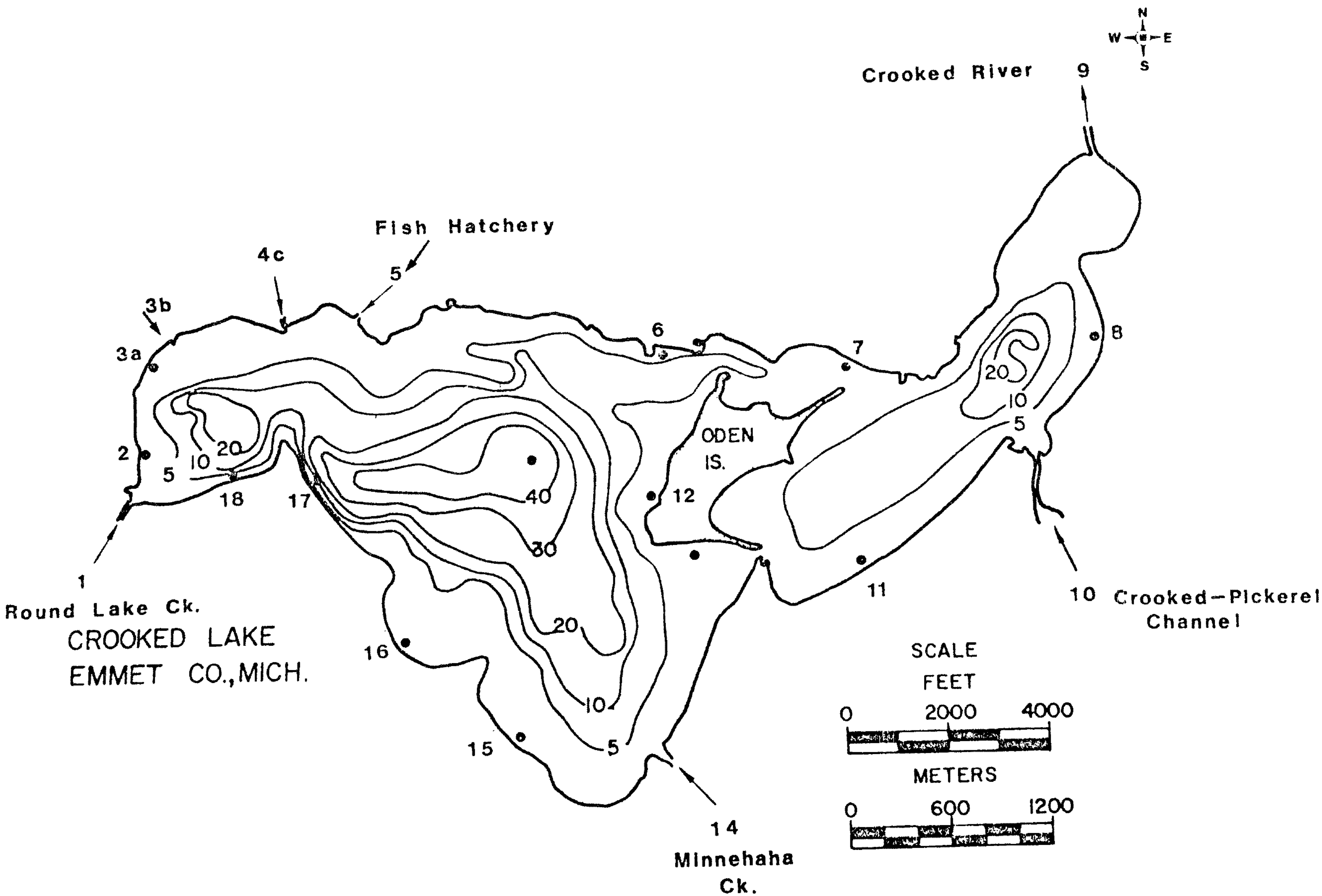


Fig. 2 Depth contour (morphometric) map of Crooked Lake, showing location of sampling stations. Depth contours are in feet.

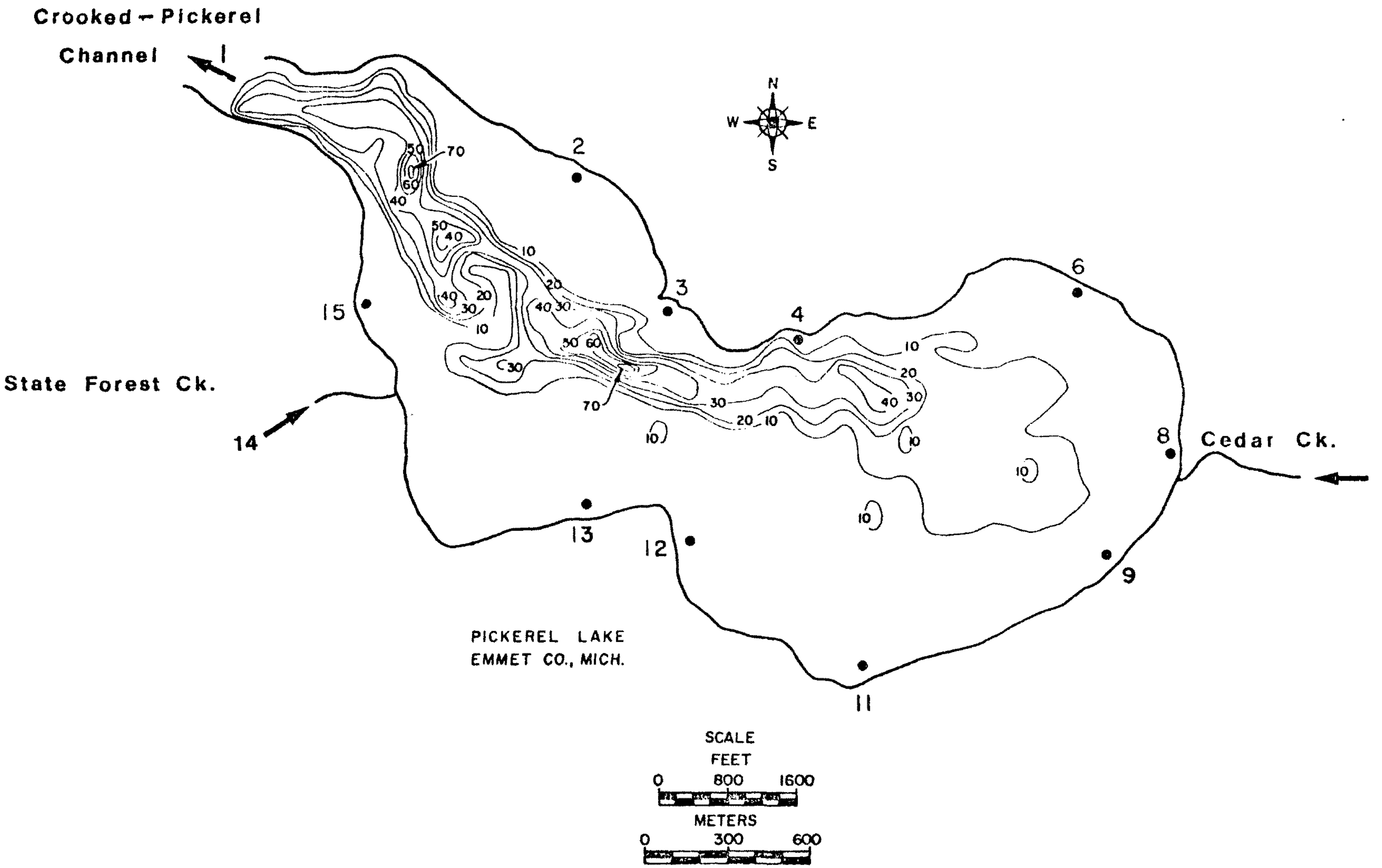


Fig. 3 Depth contour (morphometric) map of Pickerel Lake, showing location of sampling stations. Depth contours are in feet.

were determined on a Perkin-Elmer Model 305 atomic absorption spectrophotometer (EPA, 1974 a). Total phosphorus, soluble-reactive phosphorus, nitrate-nitrogen, ammonia-nitrogen, and silica were determined colorimetrically on a Beckman DB-GT spectrophotometer. Total phosphorus and soluble-reactive phosphorus were measured using a hybrid method of Gales et al. (1966) for digestion and Schmid and Ämbuhl (1965) for neutralization and color development. Nitrate-nitrogen and ammonia-nitrogen were determined by the methods of Müller and Widemann (1955) and Solórazano (1969), respectively. Silica was measured using the heteropole blue method (APHA,1971). Chloride was determined on the Beckman Model H-5 pH meter fitted with a salt bridge and chloride electrode (APHA,1971).

In the Fall of 1974, the Biological Station's chemistry laboratory was automated. A Technicon Autoanalyzer II was used to analyze September, 1974 and all 1975 samples colorimetrically (Technicon, 1972-73). Following the quick-thaw procedure, chemical measurements were performed by the following methods. Ammonia-nitrogen and nitrate-nitrogen* analyses were performed immediately. Simultaneously, sample aliquots for soluble and total phosphorus were poured into test tubes and placed in a gravity drying oven for several days until the sample evaported. Then the samples were digested with persulfate (Mentzel and Corwin, 1965), refrigerated overnight and

---

* Nitrate-nitrogen analysis also includes nitrite-nitrogen.

analyzed the next day. Silica (reported as Si) and chloride analyses were performed on thawed samples that sat at room temperature for one day. Phosphorus, ammonia-nitrogen and silica measurements were determined by automated methods (Technicon Industrial Methods 155-7W, 154-71W, and 186-72W), similar to the manual methods previously used. Nitrate-nitrogen was analyzed by a copper-cadmium reduction method (Technicon Industrial Method 158-7W). Chloride was measured with a mercuric thiocyanate and ferric ammonium sulfate automated method (EPA, 1974a).

Collection of plankton samples was made on each survey date from the central station in both lakes. A cylinder-cone plankton net with No. 20 (76 μm) nylon mesh, 0.25-m diameter, was towed from near bottom to the surface. Samples were examined qualitatively for species composition and relative abundance.

An Ekman grab (15 x 15 cm) was used to collect bottom samples at the central station in both lakes only in Summer, 1973. Samples were sieved with a No. 30 mesh screen and the invertebrates were identified and enumerated in the laboratory.

Nutrient Loading Determinations

Sources and quantities of phosphorus and nitrogen to Crooked and Pickerel Lakes were estimated from data collected from Summer, 1975 through Spring, 1976. Nutrient chemistry and other limnological data*, using previously described methods, were obtained at the central station and selected near-shore stations in both lakes (Figs. 2 and 3). Inshore stations were located at the mouths of inflowing streams, at the heads of outflows, and near concentrations of human development along the shoreline. Streams were monitored for discharge using Price and pygmy current meters and total phosphorus and inorganic nitrogen samples were obtained on a quarterly basis during the study period. An estimate of total nitrogen was obtained by doubling the inorganic nitrogen values since average inorganic and organic fractions were nearly equal in other nearby waters (EPA, 1975; Tierney et al., 1976).

Data were obtained on total phosphorus and inorganic nitrogen contributions from precipitation. Organic nitrogen was considered to be negligible. Precipitation records were from the nearby Pellston Airport. Chemical analyses were performed on precipitation samples collected at 10 sites in Cheboygan and Emmet counties. Total loading from precipitation of 2.5 $kg/km^2/yr.$ total phosphorus and 10.6 $kg/km^2/yr.$ total nitrogen was determined from these analyses.

---

* In addition to limnological data, inshore stations were sampled for coliform bacteria in Summer, 1975. Samples were collected in 100-ml glass containers supplied by a county sanitarian and promptly sent to the Bureau of Laboratories of the Michigan Department of Health for analyses. Although data on both total and fecal coliform bacteria were obtained, only fecal coliform results are reported here.

A recent study by Omernik (1976), who determined phosphorus and nitrogen export values from various land covers, appears to contain data most pertinent to the watersheds of Crooked and Pickerel Lakes. Watershed land cover data (Table 1) and nutrient export values from the north and northeastern forest and forage region of the United States (Table A-1) were employed. Omernik's (1976) "mostly agriculture" category was chosen instead of his "agriculture" category since our "agriculture/grassland" grouping contains both active and fallow farmland.

Nichols and Richardson (in Gannon and Paddock, 1974) made some preliminary calculations on nutrient loading from septic systems to lakes in Cheboygan and Emmet Counties, including Crooked and Pickerel Lakes. Assumptions on numbers of dwelling units, length of occupancy, and household use of phosphate-enriched detergents were too high. Furthermore, assumptions on nutrient movements from septic systems to the lakes were not based on local soils data. Their nutrient loadings from septic systems appear to be over-estimations. Consequently, considerable effort was focused on refining estimates of nutrient loading from septic systems in this investigation.

Loading of phosphorus and nitrogen to Crooked and Pickerel Lakes was calculated using information on household size, length of occupancy, household usage of septic systems, number of dwelling units on each soil type, and the percentage of nutrients that reach the lake from each soil type from lakeside septic systems. It was estimated from the 1970 U. S. census that the average household size in Emmet County was 3.25 persons per dwelling unit. The number of households within 300 ft. (92m) of the shoreline was obtained from the Emmet County Equalization Department and year-round and seasonal occupancy was estimated during Winter (Gold and Gannon, 1978). From a household survey conducted on nearby Walloon Lake (Project CLEAR, 1978), it was estimated that loading of phosphorus to septic systems from dishwater and laundry wastewater was 0.83 kg/household/yr. Dishwashing and laundry habits on Crooked and Pickerel Lakes were assumed to be the same as on Walloon Lake.

Estimations of 0.5 kg/person/yr phosphorus and 5.4 kg/person/yr nitrogen (Vollenweider, 1968) were used as the human waste contribution to the septic system. Including the phosphorus contribution from detergents, total loadings to the septic system of 2.46 kg/household/yr. phosphorus and 17.55 kg/household/yr nitrogen were estimated. The number and type of residences on specific soil types was used to calculate the amounts of phosphorus and nitrogen reaching the lakes. The type of residence was weighted (i.e., 1.0 for year-round occupancy, 0.5 for possible year-round occupancy and 0.25 for seasonal occupancy) and multiplied by the number of residences on each soil type. The soils were identified and transcribed from the Emmet County Soil Survey onto the home location map. From soil characteristics such as natural drainage, depth to seasonal high groundwater (Alfred et al., 1973), and phosphorus adsorption capacity (Schneider and Erickson, 1972), estimations were made on percentage of phosphorus and nitrogen that would reach the lakes through each soil type from septic systems. Then septic systems nutrient loading was calculated from the number and type of residence on each soil type, the total nutrient input per household per year, and percentage of nutrients reaching the lake (Tables A-2 through A-4).

RESULTS AND DISCUSSION

Water quality: Some basic considerations

Although inland lakes are individualistic and exhibit their own unique characteristics, scientists recognize a relatively simple system of grouping and classifying lakes into water quality types. Oligotrophic lakes are nutrient poor and are low in plant and animal productivity. Eutrophic lakes are high in nutrient content which stimulates high production of plants and animals. Lakes exhibiting intermediate characteristics are termed mesotrophic.

Lake residents normally equate good water quality with oligotrophic lakes. These water bodies exhibit clear waters, low turbidity from algae, low amounts of weed growths, and firm bottom sediments. Eutrophic lakes are normally considered poor in water quality with turbid waters high in algal content, high amounts of undesirable weeds, and mucky bottom sediments. Since eutrophic lakes are more productive, they often contain higher quantities of fish than oligotrophic lakes. Consequently, fishermen may consider water quality in eutrophic lakes as good. However, in extreme eutrophic conditions, desirable fish species such as walleye, yellow perch, northern pike, and bass are replaced by less desirable species such as carp, suckers, and bullheads. In most situations, water quality in a water body has been determined by its geological origins and natural features within its watershed. It is the challenge of the riparian community to understand the current water quality status of their lake and to minimize adverse changes in quality as they use and develop the lake and its watershed.

Ideally, current water quality data should be compared with historical records in order to establish any trends in water quality changes. Unfortunately, historical water quality information on Crooked and Pickerel Lakes is extremely scanty. Temperature, alkalinity, dissolved oxygen and pH measurements were occasionally collected by the Fish Division of the Michigan Department of Natural Resources during the past several decades. An examination of these records did not reveal any changes in water quality in Crooked or Pickerel Lakes beyond normal yearly variation. Consequently, current water quality status of these lakes must be determined by interpreting recent physicochemical and biological data and by applying some simple trophic state models that have been developed in recent years.

Watershed Characteristics

The watershed areas of Crooked and Pickerel Lakes are relatively large, encompassing parts of three counties (Fig. 4), and consist primarily of second growth deciduous and mixed (deciduous and coniferous) forests (Table 1). Agriculture and grassland comprises a larger fraction of land-use in Crooked Lake's watershed than in Pickerel Lake's drainage basin (Table 1). However, most agricultural activity occurs in upland areas away from the shore of both lakes. Marshy and swampy wetlands are an important feature and lie primarily near the north shore of Crooked Lake and along the south and east shores of Pickerel Lake.

Pickerel Lake's watershed is large in comparison to its lake surface area (Table 1). The lake is fed mostly by groundwater seepage since its inflowing streams are small. The outflow of Pickerel Lake is to Crooked Lake through the Crooked-Pickerel Channel, although reverse flow can sometimes occur depending on wind and current conditions.

Crooked Lake's immediate watershed (11,190 ha) is smaller than Pickerel Lake's drainage basin (13,660 ha). However, Spring, Mud, Round and Pickerel Lakes all flow into Crooked

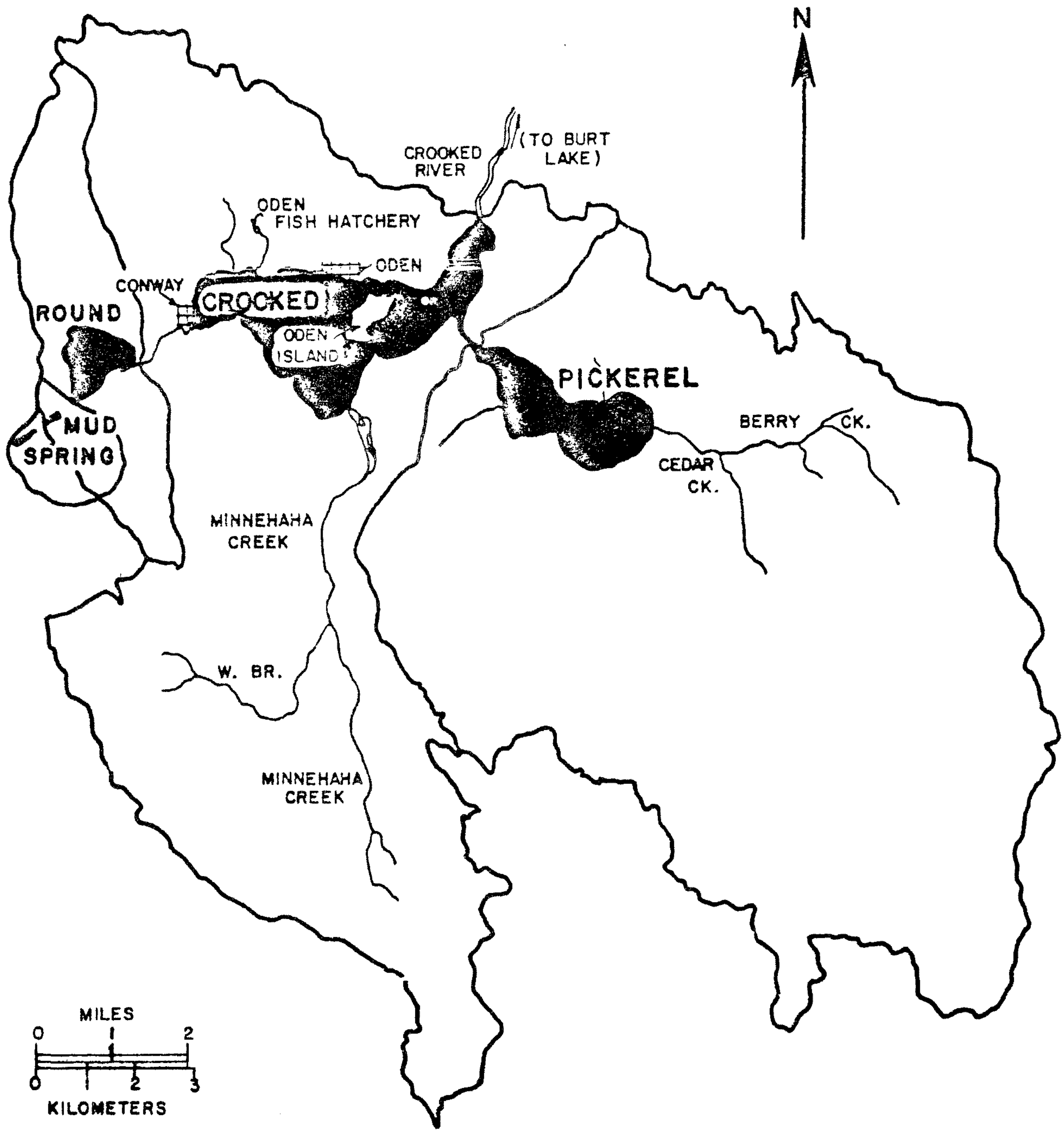


Fig. 4 The watershed bounderies of Crooked and Pickerel Lakes. Since Spring, Mud, Round and Pickerel Lakes all drain into Crooked Lake, the total watershed area of Crooked Lake includes the drainage basins of these neighboring lakes.

TABLE 1. LAND-USE TYPES IN THE CROOKED AND PICKEREL LAKE WATERSHEDS BASED ON LANDSAT DATA (ROGERS, 1977).

Land-Use Type	CROOKED LAKE Acres	CROOKED LAKE km^2	CROOKED LAKE %	PICKEREL LAKE Acres	PICKEREL LAKE km^2	PICKEREL LAKE %
Coniferous Forest *	1,025.3	4.1	3.5	2,985.0	11.9	8.9
Deciduous Forest	7,579.9	30.3	26.0	13,406.0	53.6	39.9
Mixed Forest	4,347.4	17.4	15.0	6,724.6	26.9	20.0
Sparce Forest **	8,045.1	32.2	27.7	6,698.0	26.8	19.9
TOTAL FOREST	20,997.7	84.0	72.2	29,813.6	119.2	88.7
Agriculture/Grassland ***	5,468.1	21.9	18.8	2,880.7	11.5	8.6
Urban/Bare Ground	236.4	1.0	0.9	73.2	0.3	0.2
Uncategorized	330.7	1.3	1.1	160.9	0.6	0.4
TOTAL LAND	27,032.9	108.2	93.0	32,928.4	131.6	97.9
Water	2,060.7	8.2	7.0	951.0	2.8	2.1
GRAND TOTAL †	29,093.6	116.4	100.0	33,879.4	134.4	100.0

* Includes both upland and swamp forests.

** Includes shrubby uplands and wetlands.

*** Includes grassy uplands and marshy wetlands.

† Totals from LANDSAT data differ slightly from those determined with an area meter (see Table 2).

Lake. Consequently, Crooked Lake's total watershed is much larger (25,170 ha), encompassing its immediate watershed and the drainage areas of these neighboring lakes (Fig. 4). Although groundwater seepage is undoubtedly a significant source of Crooked Lake water, inflows from Minnehaha Creek and other streams are important contributors. The Crooked River is the only surface outlet for Crooked Lake.

Information is not available on the numbers of people living in the watersheds of Crooked and Pickerel Lakes. The region is predominantly rural and sparcely populated. Over 1,800 year-round residents were reported in adjacent Littlefield and Springvale townships* in 1970. The number of people living on or near the lakeshores is of particular interest for water quality considerations. About 400 dwelling units are located within 90 m of the Crooked Lake shoreline. Most of these dwellings are located on the north shore and are currently serviced by the wastewater sewer line. Only 112 dwelling units are located on Crooked Lake's south shore and on Oden Island. Pickerel Lake is more sparcely populated, with 134 dwelling units reported on or near its shoreline (Gold and Gannon, 1979).

---

* These townships comprise the largest land area in the watersheds of the two lakes.

Limnological Characteristics

Morphometry

Crooked Lake is about twice as large in surface area as Pickerel Lake. Crooked Lake is aptly named since its shoreline is so irregular. Its shoreline development factor is two times higher than Pickerel Lake and its shoreline is three times longer than Pickerel Lake (Table 2). Consequently, the potential for over-development is considerably greater on Crooked Lake than on Pickerel Lake. Both lakes are moderately deep with maximum depths over 18 m. The average depth of Pickerel Lake (3.9 m) is slightly greater than Crooked Lake (3.0 m). Both lakes contain large expanses of shallow areas suitable for development of weed beds that provide favorable habitat for fishes (Fig. 2, Fig. 3, Table 2).

The current water quality is generally good in both Crooked and Pickerel Lakes and the quantity of water flowing in and out of them is at least partially responsible. Water residence time is the amount of time water remains in the lake's basin before being completely replaced by inflowing water. Calculations of water residence times for these lakes is somewhat complicated by the hydrology of the Crooked-Pickerel Channel, since currents alternately flow in and out of the channel. However, the net flow is from Pickerel to Crooked Lake. Furthermore, because of the geographical locations of the channel and Oden Island, it appears that water from the channel is dis-

TABLE 2. MORPHOMETRIC FEATURES OF CROOKED AND PICKEREL LAKES, EMMET COUNTY, MICHIGAN. DEFINITIONS ARE ACCORDING TO HUTCHINSON (1957).

Variable *	CROOKED LAKE Metric	CROOKED LAKE English	PICKEREL LAKE Metric	PICKEREL LAKE English
Z_m	18.6 m	61.0 ft.	21.3 m	69.8 ft.
$\bar{\bar{Z}}$	3.0 m	9.8 ft.	3.9 m	12.8 ft.
1	5.58 km	3.5 mi	4.09 km	2.5 mi.
b_x	3.09 km	1.9 mi	1.69 km	1.0 mi
$\bar{b}$	1.69 km	1.1 mi	1.09 km	0.7 mi
L	29.63 km	18.4 mi	10.57 km	6.6 mi
A_o	959.59 ha	2,371 acres	427.06 ha	1,055 acres
A_d	111.9 x 10^2ha	27,649 acres	136.6 x 10^2ha	33,750 acres
V	29,534.7 x $10^3 m^3$	1,040 x $10^6 ft^3$	17,176.8 x $10^3 m^3$	605 x $10^6 ft^3$
D_1	2.7		1.4	
D_v	0.5		0.5	
A_d/A_o	11.7		32.0	

* Abbreviations: Z_m, maximum depth; $\bar{Z}$, mean depth; 1, maximum length; b_x, maximum width; $\bar{b}$, mean width; L, shoreline length; A_o, lake surface area; A_d, watershed area; V, volume; D_1, shoreline development factor; D_v, volume development factor; A_d/A_o, ratio of watershed area to lake surface area.

charged primarily through Crooked River and does not significantly mix with Crooked Lake water west of the island. Water from the Crooked-Pickerel Channel comprises about 39% of the flow of the Crooked River, while the remaining 61% represents the outflowing waters of Crooked Lake. The water residence times for Crooked and Pickerel Lakes have been estimated as 4.2 and 4.7 months, respectively. Although these lakes contain a relatively large volume of water, they both have comparatively short water residence times and can flush out pollution inputs rather quickly. In contrast, nearby Walloon Lake has a water residence time of 3.2 years and, therefore, is more sensitive to pollution than Crooked and Pickerel Lakes.

Physicochemistry: Off-shore conditions

Crooked and Pickerel Lakes are basically similar in most physicochemical characteristics. Both lakes thermally stratify during Summer. A uniformly warm layer, the epilimnion, generally extends from the surface to about 8 m. A zone of rapid temperature change, called the thermocline, occurs from 8 m to 13 m. The deepest portion of the lake from 13 m to the bottom is uniformly cold and is known as the hypolimnion. Wind generated currents are primarily confined to the epilmnion during Summer. Two complete circulation periods occur in Spring and Fall when the lake is mixed from top to bottom. Slight inverse stratification occurs during Winter under ice cover when temperatures are slightly warmer near bottom than they are near the surface. The onset and duration of ice cover varies from year to year, depending on meteorological conditions. Generally, ice cover remains from mid-December to early April. Ice disappears from Crooked Lake in Spring earlier than most other lakes of the region, presumably because of groundwater seepage especially along the north shore.

Crooked and Pickerel Lakes contain clear, unstained waters that allow for excellent light penetration. Transparency, as measured by the Secchi disc, was only slightly greater in Pickerel Lake than in Crooked Lake (Table 3). Both lakes contain hard water with high concentrations of alkalinity, specific conductance, and ionic constituents, especially calcium and magnesium. The waters are alkaline with pH generally above 8.0 throughout the photic zone. The inorganic nutrients, phosphorus and nitrogen, average slightly higher in Crooked Lake than in Pickerel Lake. In contrast, silica concentrations are slightly higher in Pickerel Lake (Tables 3 and 4).

Phosphorus is considered to be the limiting nutrient for plant growth in both Crooked and Pickerel Lakes because soluble and total phosphorus concentrations are extremely low relative to nitrogen. The low amount of phosphorus in the water is at least partially controlled by chemical interactions between the water and bottom sediments. Both lakes contain abundant

TABLE 3. COLOR, LIGHT, AND DISSOLVED OXYGEN (D.O.) CHARACTERISTICS OF CROOKED AND PICKEREL LAKES, EMMET COUNTY, MICHIGAN. DATA FROM CENTRAL DEEP STATIONS.

Lake	Color (pt-co)	Secchi Disc Yearly Range(m)	1% T* Summer(m)	Near Bottom D.O. Summer (mg/l)	Near Bottom D.O. Winter (mg/l)
Crooked Lake	10	2.0-5.0	8.8	0	7.3
Pickerel Lake	20	2.5-6.0	8.5	0.1	6.8

* Depth of light penetration to 1% of surface illumination

TABLE 4. CHEMICAL AND CHLOROPHYLL *a* FEATURES OF CROOKED AND PICKEREL LAKES AT DEEP CENTRAL STATIONS DURING SUMMER AND WINTER.*

Variable	CROOKED LAKE Summer	CROOKED LAKE Winter	PICKEREL LAKE Summer	PICKEREL LAKE Winter
T.A. (mg/l)	141.0	158.6	136.4	163.8
Sp. Cond. (μmhos/cm)	289.5	314.9	285.0	326.1
pH	8.4	8.1	8.4	8.0
S-PO_4 (μg/l)	4.0	7.0	5.9	4.0
T-PO_4 (μg/l)	11.9	11.3	9.8	18.3
NO_3-N (μg/l)	44.2	356.5	62.1	320.0
NH_3-N (μg/l)	20.1	40.3	18.0	44.3
SiO_2 (μg/l)	2,578.8	3,475.8	2,665.3	3,686.8
CI (mg/l)	12.5**	2.5	10.9**	3.7
Ca (mg/l)	38.7	42.2	38.4	48.9
Mg (mg/l)	13.9	12.7	13.4	13.1
K (mg/l)	0.8	0.8	0.7	0.9
Na (mg/l)	2.1	2.2	2.2	2.5
Chl. *a* (μg/l)	3.3**	2.0	2.8**	0.7

* Data are means for the euphotic zone (> 1% light transmittance) in Summer, 1973 and 1974 and Winter, 1974 and 1975 except where otherwise indicated. T.A. is total alkalinity as $CaCO_3$ and Sp. Cond. is specific conductance corrected to 25C

calcium and inorganic carbon, a situation conducive for marl deposition. Marl is precipitated calcium carbonate ($CaCO_3$) or lime, and forms the characteristic grayish-white, clay-like bottom sediments and coatings on rock and other firm substrates. Phosphorus ions in the water column adsorb on marl particles, settle into the bottom sediments and become unavailable to stimulate algae and weed growths.

As long as dissolved oxygen content remains high, co-precipitation of phosphorus with marl is an important mechanism in maintaining high water quality in Crooked and Pickerel Lakes. However, under anaerobic conditions, phosphorus is released from the sediments and becomes available for plant growth. Currently, anaerobic conditions are confined to the near bottom waters of the deepest portions of Crooked and Pickerel Lakes during the Summer stratification period. During the Summers of 1973 and 1974, the bottom 4 m of Crooked Lake and the bottom 2 m of Pickerel Lake contained less than 1% saturation of dissolved oxygen. Consequently, dissolved oxygen depletion in the hypolimnion is slightly greater in Crooked Lake than in Pickerel Lake.

Chemistry and bacteria: Near-shore conditions

Nutrient chemistry and coliform bacteria tests were conducted on near-shore areas and at mouths of inflowing streams of Crooked and Pickerel Lakes in order to locate any "hot spots" of human wastewater contamination.

The highest concentrations of total phosphorus occurred in the stream emanating from the Oden Fish Hatchery on Crooked Lake during all seasons. Phosphorus below the fish hatchery was 15 times higher than at the Crooked Lake central station during summer (Fig. 5). High concentrations in comparison with the central station were also observed near the village of Oden and off Oden Island's west side. Phosphorus values below a small, private fish pond (Station No. 4c) did not differ significantly from central station values.

The streams below both the State and private fish culture facilities were consistently high in inorganic nitrogen during all seasons. Values at these respective locations were 19 and 25 times higher than at the central station in summer (Fig. 6). Other comparatively high inorganic nitrogen concentrations were noted near the villages of Conway and Ponshewaing and at the mouth of Minnehaha Creek (Fig. 6).

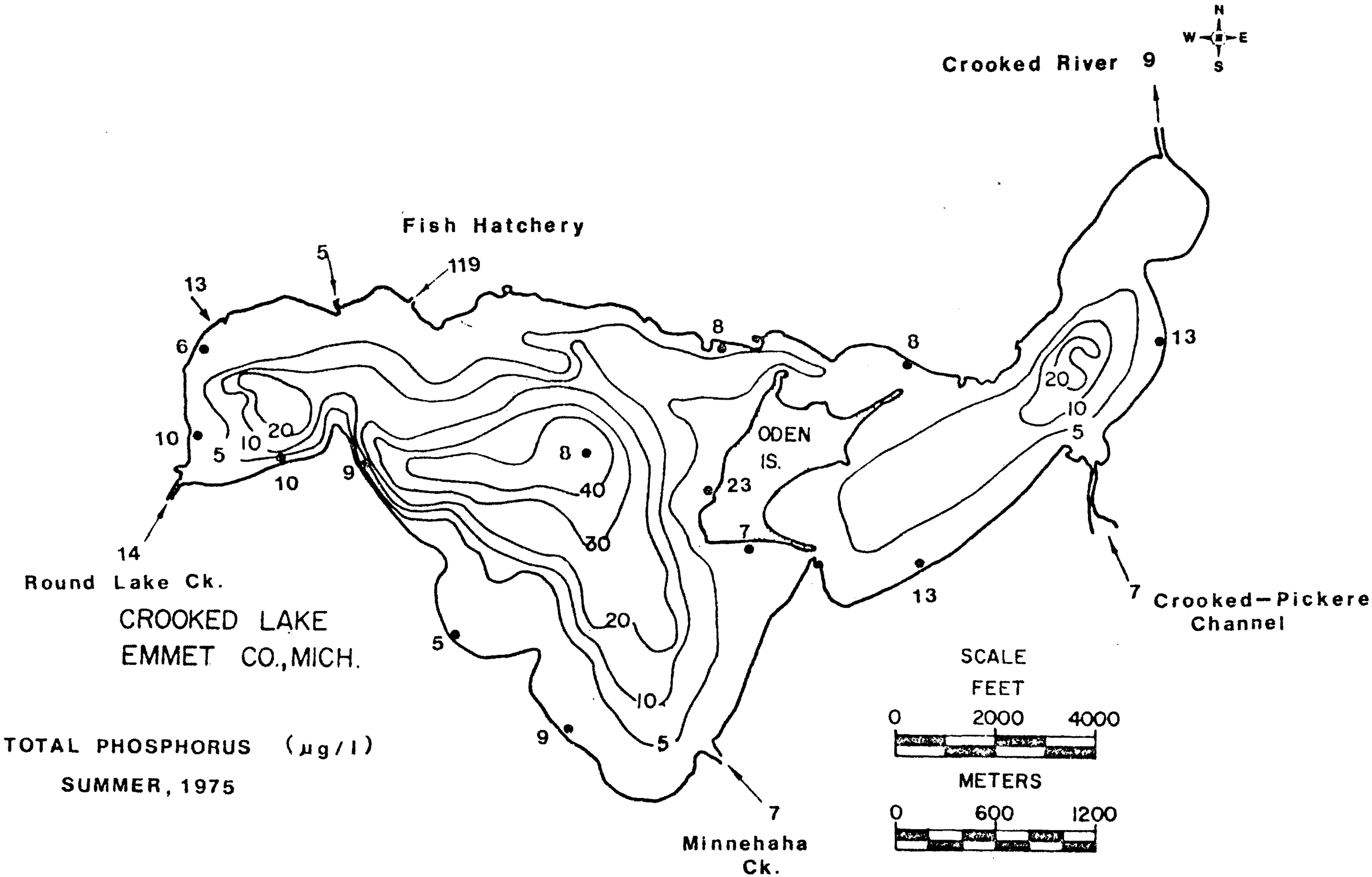


Fig. 5 Comparison of total phosphorus concentrations (µg/l) between the central station and selected near-shore locations in Crooked lake during summer, 1975.

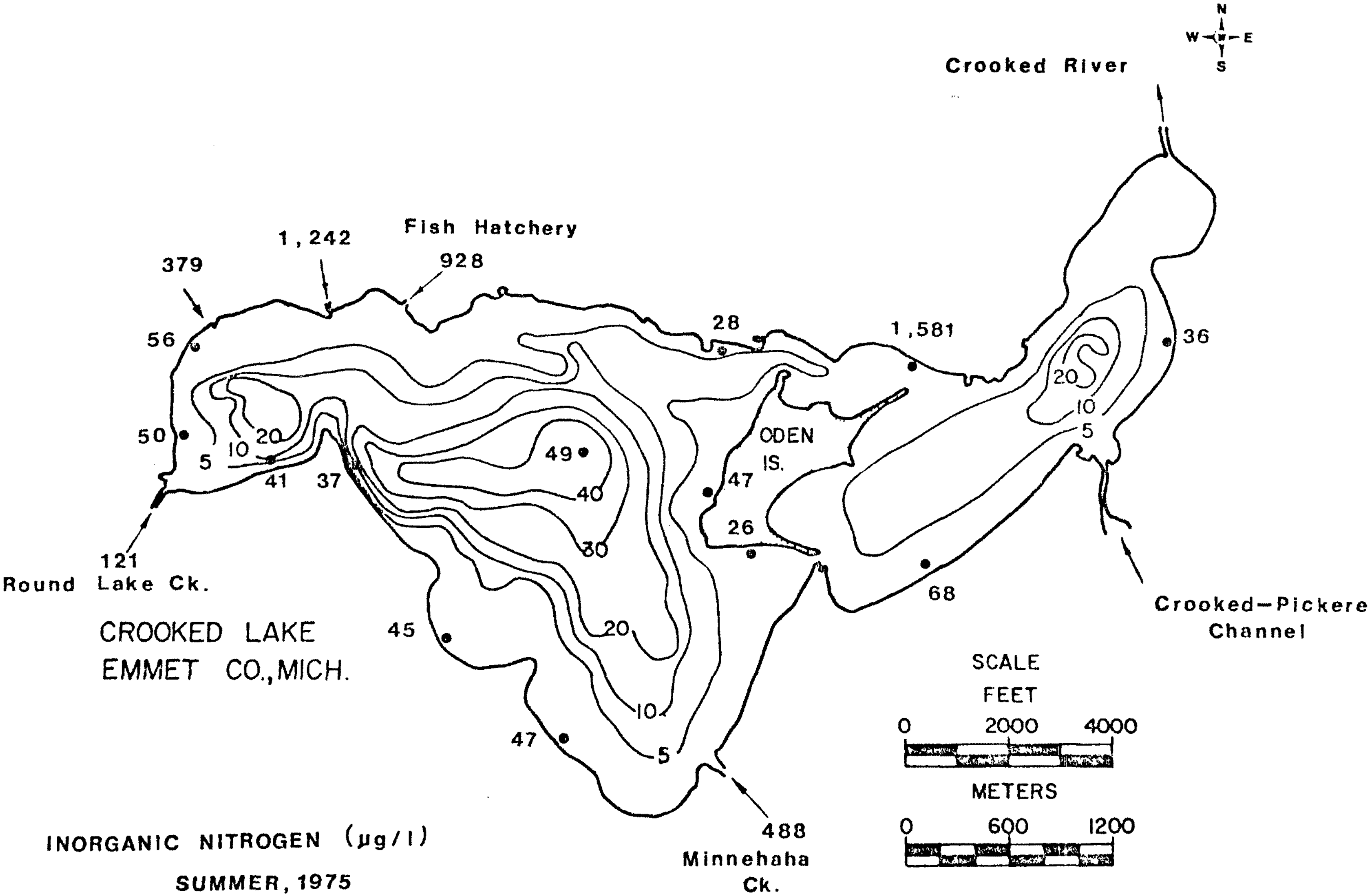


Fig. 6 Comparison of inorganic nitrogen (NO_2-N, NO_3-N and NH_3-N) concentrations (µg/l) between the central station and selected near-shore locations in Crooked Lake during summer, 1975.

Coliform bacteria data were obtained only in Summer, 1975. Only the station near Conway was contaminated with fecal coliform bacteria (1600 colonies/ml).* Low bacterial counts were observed elsewhere along the shores of Crooked Lake (Fig. 7).

In contrast to Crooked Lake, concentrations of phosphorus and nitrogen in the near-shore areas of Pickerel Lake were almost identical with central station values during all seasons although only Summer data are presented here (Figs. 8 and 9). A relatively high concentration of inorganic nitrogen was recorded only once at Station No. 15 (Fig. 9). Fecal coliform bacteria counts in Summer, 1975 were low throughout Pickerel Lake and did not indicate any sources of human contamination (Fig. 10).

Biology

Detailed phytoplankton data are not available for Crooked and Pickerel Lakes. Qualitative observations indicate that both lakes are in a healthy water quality condition. Although filamentous blue-green algae are present in both lakes, they rarely form a predominate component of the algal community.

---

* The Michigan Department of Health considers waters with fecal coliform bacteria counts greater than 200/ml to be polluted and unfit for bodily contact, such as swimming.

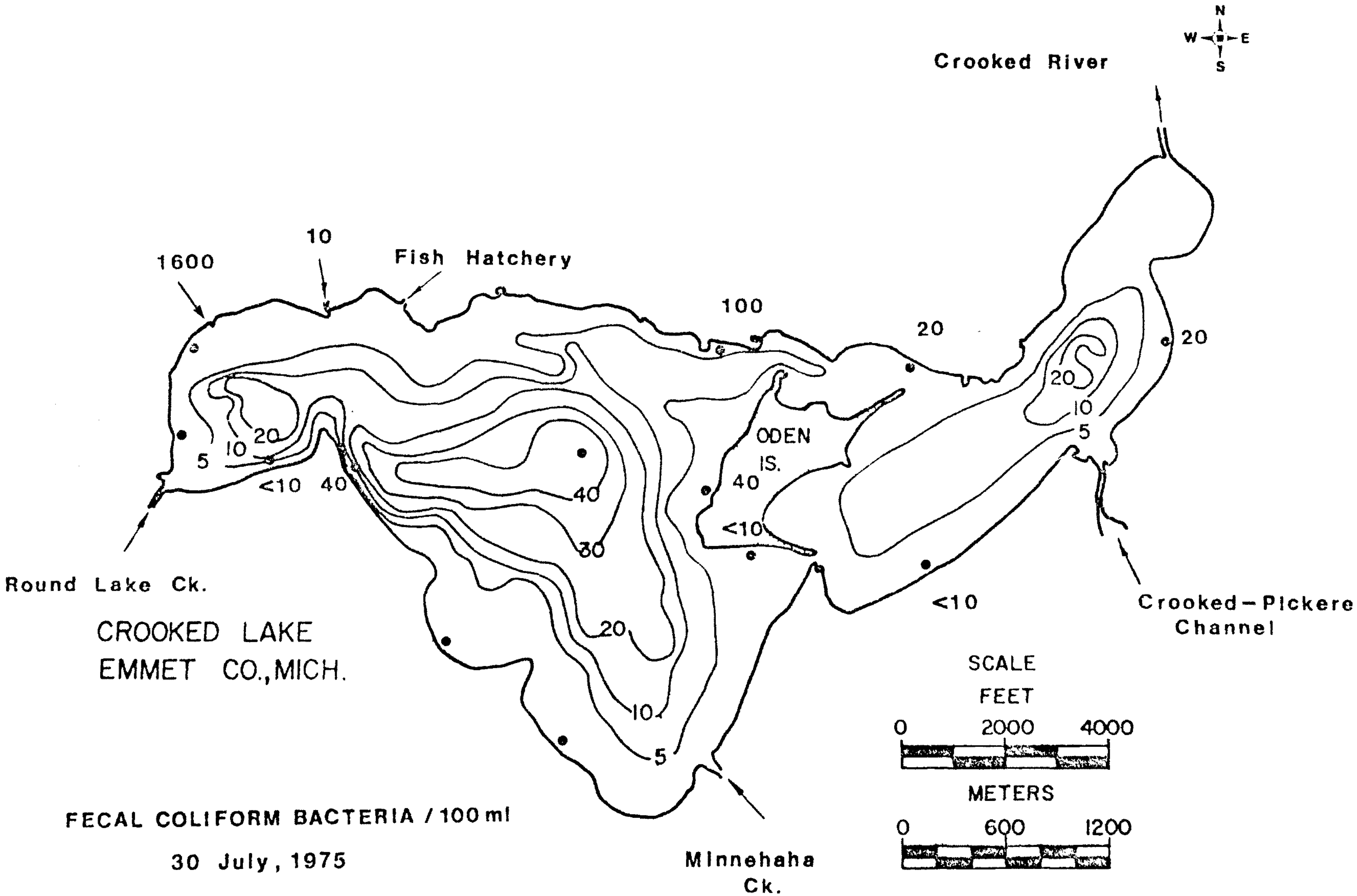


Fig. 7 Fecal coliform bacteria (number of colonies/100 ml) at selected near-shore locations in Crooked Lake during July, 1975).

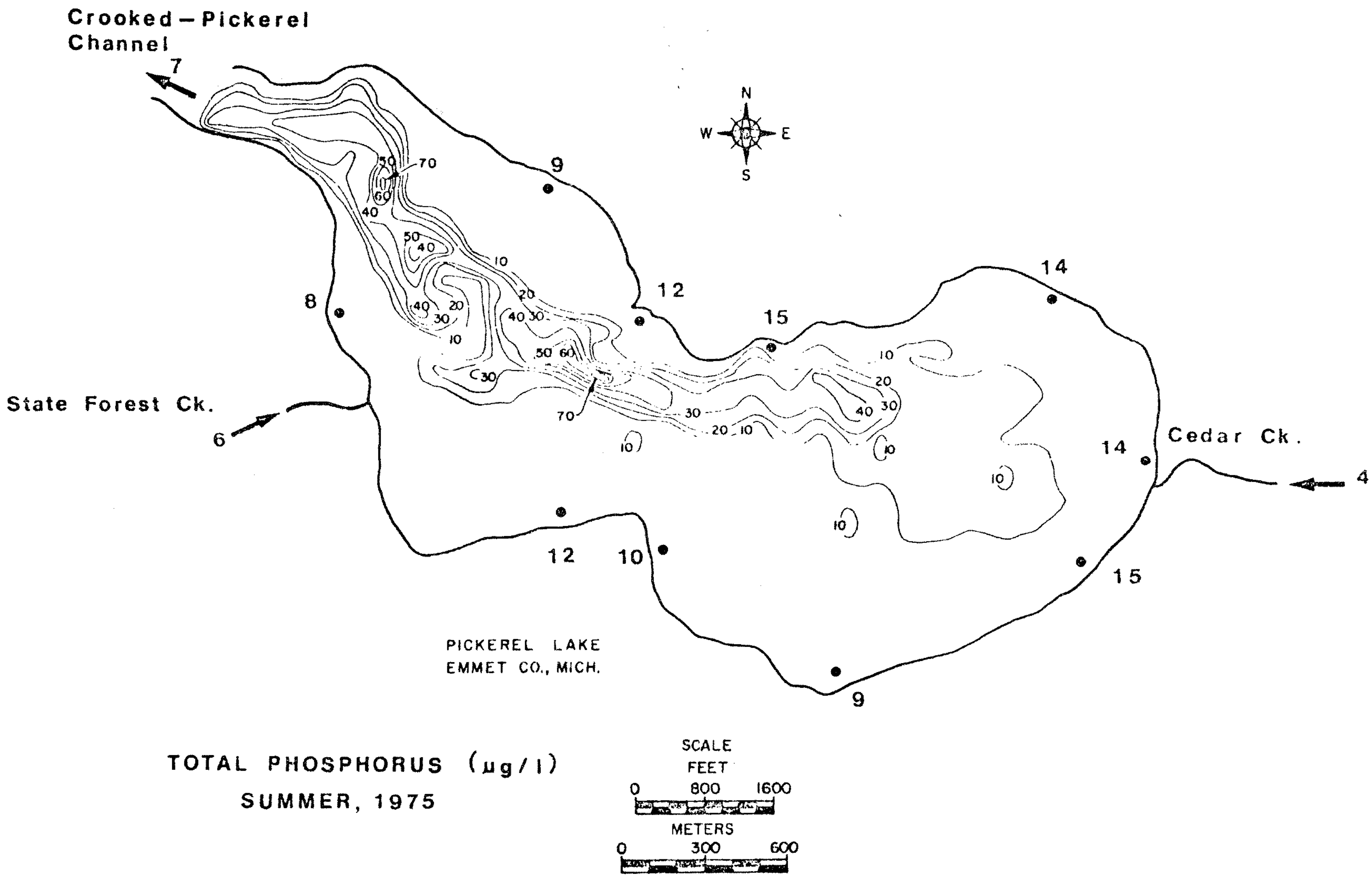


Fig. 8 Comparison of total phosphorus concentrations (µg/l) between the central station and selected near-shore locations in Pickerel Lake during Summer, 1975.

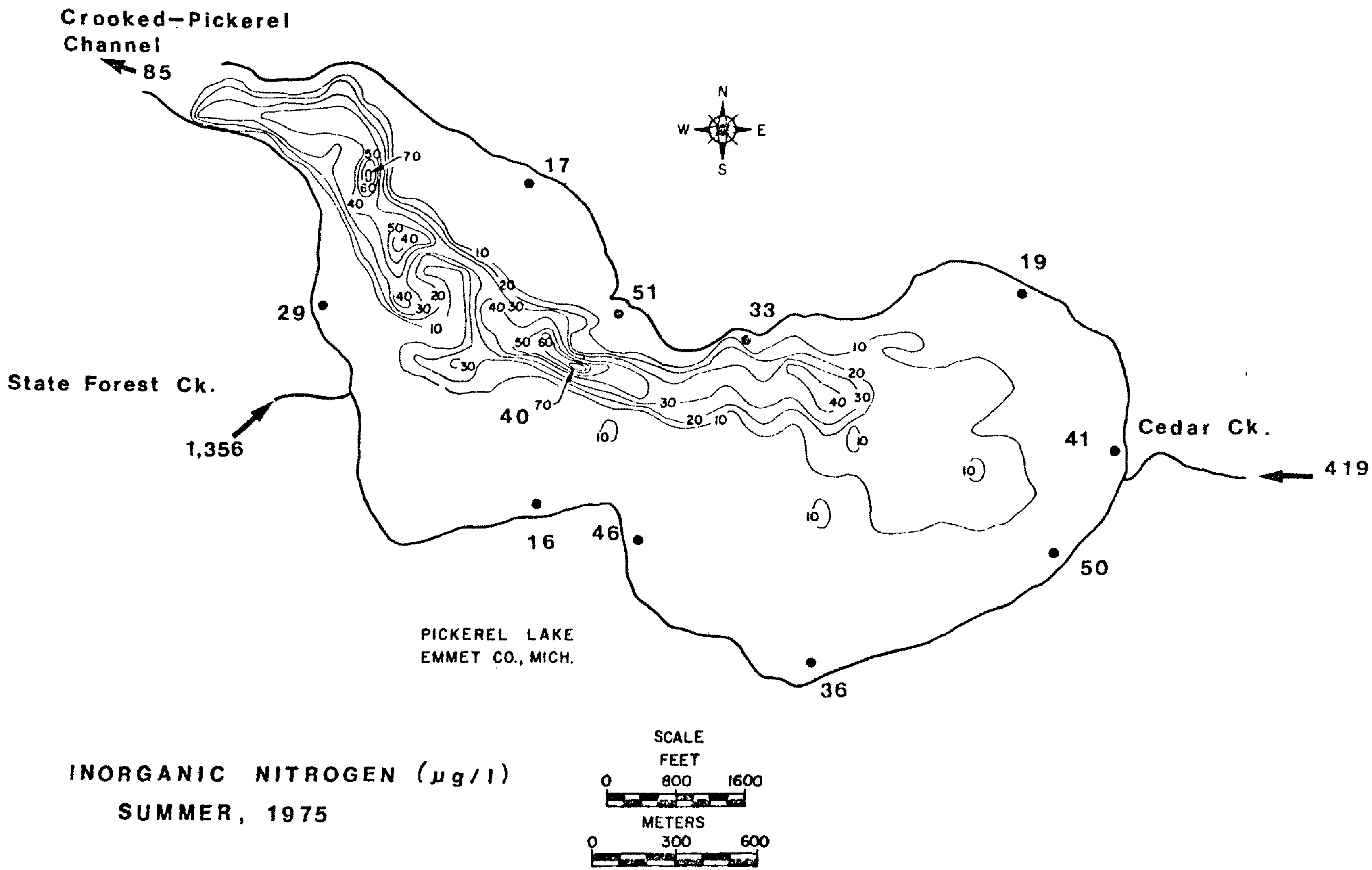


Fig. 9 Comparison of inorganic nitrogen concentrations (µg/l) between the central station and selected near-shore locations in Pickerel Lake during Summer, 1975.

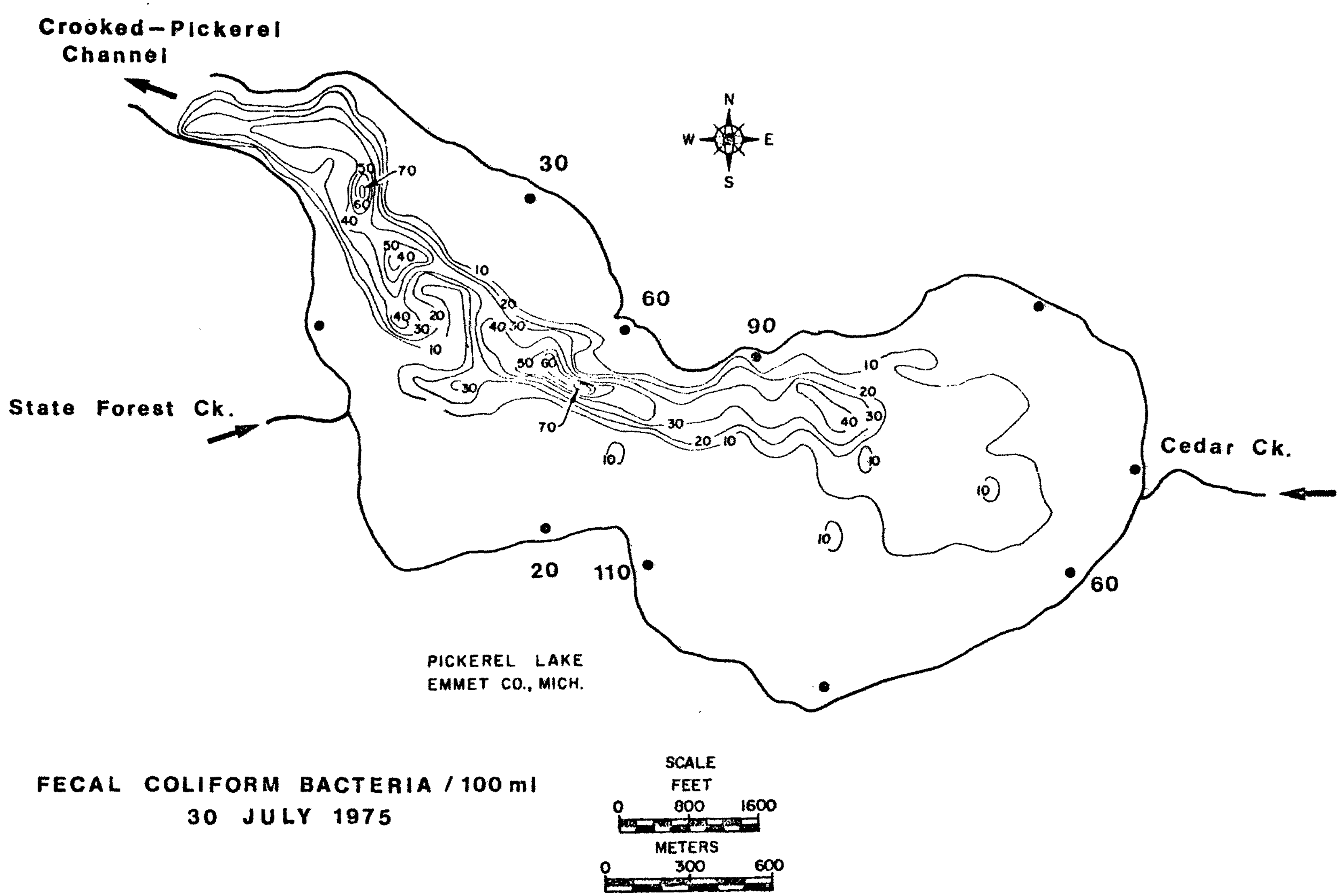


Fig. 10 Fecal coliform bacteria (number of colonies/100 ml) at selected near-shore locations in Pickerel Lake during July, 1975.

Substantial algal blooms have not been observed in Pickerel Lake. In contrast, algal blooms, usually consisting of diatoms and *Dinobryon*, have been noticeable in Crooked Lake.

Chlorophyll *a*, a measure of the quantity of algae, was slightly higher in Crooked Lake than in Pickerel Lake (Table 4). Although chlorophyll *a* averaged near 3.0 μg/l in the photic zone during Summer for both lakes, the maximum recorded value was higher for Crooked Lake (8.9 μg/l in Fall, 1974) than for Pickerel Lake (4.2 μg/l in Spring, 1974). Phytoplankton composition and chlorophyll *a* indicate that the waters of both Crooked and Pickerel Lakes are oligo-mesotrophic, with Crooked Lake slightly closer to the eutrophic side of the trophic continuum.

Species composition of zooplankton was basically similar in Crooked and Pickerel Lakes. There was a general absence of species indicative of extreme oligotrophic or eutrophic waters in both lakes and, therefore, zooplankton composition was most characteristic of mesotrophic conditions. The greater relative abundance of the cladoceran, *Chydorus sphaericus*, in Crooked Lake indicates that the waters of Crooked Lake are slightly more eutrophic than Pickerel Lake (Bricker and Gannon, unpublished data). Crooked Lake contained the oligo-mesotrophic indicator rotifers, *Notholca foliacea*, *N. michiganensis*, and *Synchaeta asymmetrica*, as well as the eutrophic indicators, *Polyarthra euryptera* and *Trichocerca multicrinis*. Similarly, the oligo-mesotrophic indicative rotifers, *Conochiloides natans*, and *N. michiganensis*, as well as the eutrophic species, *P. euryptera* and *T. multicrinis*, occurred in Pickerel Lake (Stemberger, unpublished data).

Similarly, the composition of the benthic organisms in Crooked and Pickerel Lakes were indicative of water bodies mesotrophic in character. Both lakes contained oligotrophic indicators such as the burrowing mayfly nymph, *Hexagenia*, and fingernail clams, *Sphaerium*. Likewise, eutrophic indicators such as the oligochaete worm, *Limnodrilus hoffmeisteri*, and several genera of chrionomid midge larvae were observed in both lakes. The Shannon-Weiner species diversity index was slightly higher in Pickerel Lake (0.57) than in Crooked Lake (0.43), and is indicative of slightly more oligotrophic conditions in Pickerel Lake than in Crooked Lake (Weid, unpublished data).

An examination of Michigan Department of Natural Resources records reveals that both Crooked and Pickerel Lakes contain fish populations indicative of healthy water quality conditions. Desirable species, such as northern pike, walleye, black bass, yellow perch, and bluegill are prevalent in both lakes. Growth rates of these fishes are near state-wide averages in both Crooked and Pickerel Lakes.

Trophic State

It is readily apparent from the preceding limnological inventory that Crooked and Pickerel Lakes are in good water quality condition. Physiochemical data and biological indices of water quality suggest that both lakes border between oligotrophy and mesotrophy (i.e., oligo-mesotrophic) on the trophic continuum of lake types, with Crooked Lake somewhat more mesotrophic than Pickerel Lake. In other words, Crooked Lake is only slightly poorer in water quality than Pickerel Lake. Better definition of the trophic status of these lakes can be obtained by applying some simple criteria and indices of trophic condition.

Summer average chlorophyll *a*, total phosphorus, and Secchi disc transparency have frequently been used to establish the trophic state of lakes. Although the actual values differentiating trophic levels are somewhat subjective, criteria established by EPA (1974b) have been widely used in recent years. Using EPA (1974b) criteria, Crooked and Pickerel Lakes are both oligotrophic based on chlorophyll *a*. Crooked Lake is mesotrophic based on total phosphorus and Secchi disc transparency, and Pickerel Lake is oligo-mesotrophic using these variables (Fig. 11). Chlorophyll and total phosphorus are probably better than transparency in assessing the trophic condition in these lakes. Transparency is affected by suspension of marl floc as well as by algal turbidity in both lakes. Therefore, Secchi disc readings are not sufficiently accurate for predicting trophic conditions in such lakes. Nevertheless, all three variables indicate that Crooked Lake is slightly closer to the eutrophic end of the trophic continuum than Pickerel Lake.

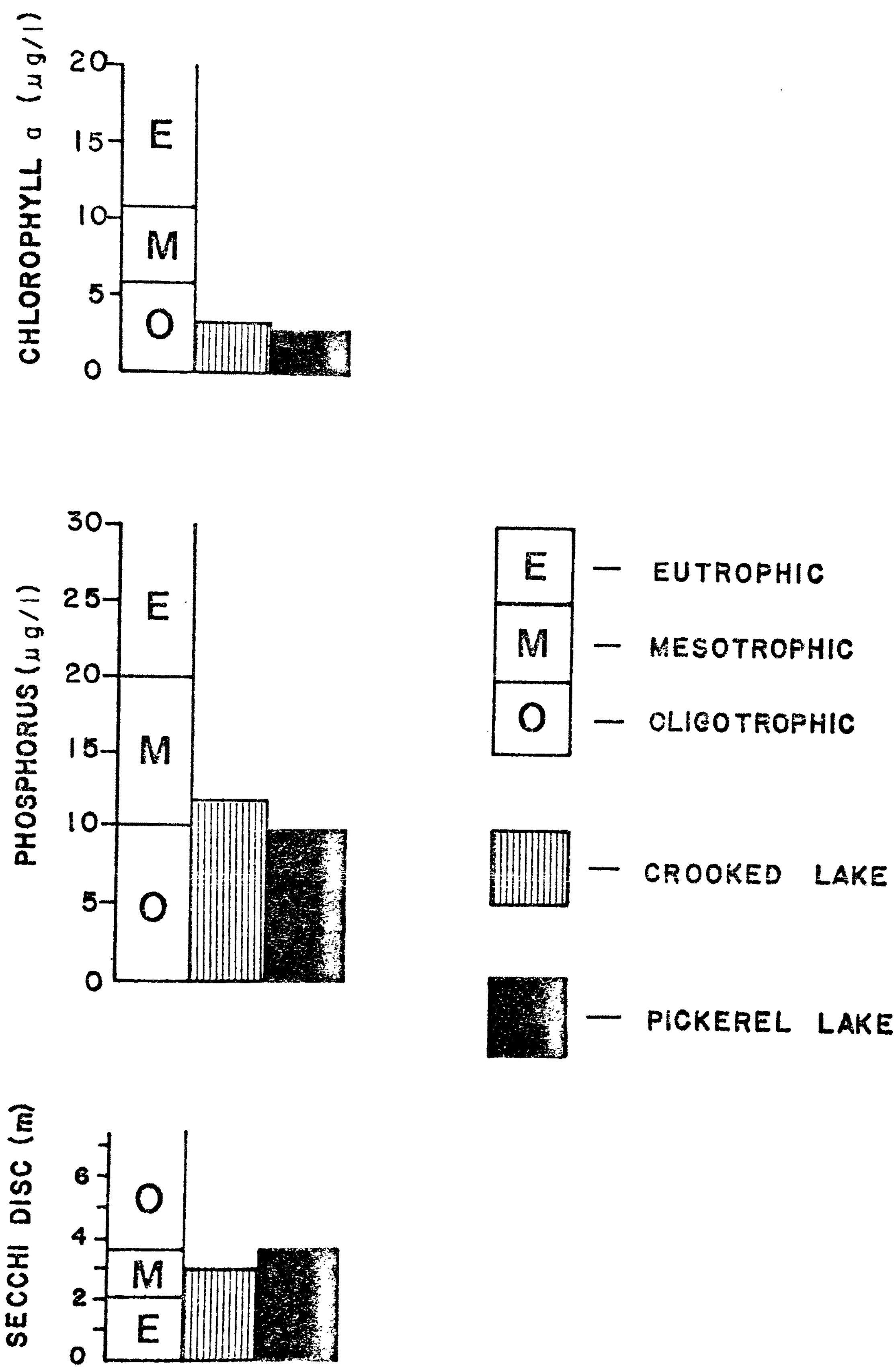


Fig. 11 Trophic classification of Crooked and Pickerel Lakes based on three limnological variables and using criteria established by EPA (1974b).

Recognizing the relationships of chlorophyll *a*, total phosphorus and Secchi disc transparency to trophic condition, Carlson (1977) developed a trophic state index (TSI) based on these variables. Lakes are rated on a scale of 1-100 with higher numbers representing more eutrophic waters. Carlson's index can be computed for the three variables independently or a weighted combination of all three can be employed. Because Secchi disc readings can be misleading in marl lakes and because other nutrients besides phosphorus can sometimes become limiting to algal growth in Summer, I have chosen to use Carlson's index based on chlorophyll *a* for Crooked and Pickerel Lakes. Both lakes are classified as oligotrophic using this method, although Crooked Lake is closer to mesotrophy than Pickerel Lake. In comparison with other lakes in Cheboygan and Emmet Counties, Pickerel and Crooked Lakes rank second and fifth highest, respectively, in water quality of 39 lakes investigated (Fig. 12).

The above criteria concerns only the near-surface, offshore waters of lakes. Uttermark and Wall (1975) developed a subjective lake condition index (LCI) that uses easily detectable measures of eutrophication, many of which are observable from the shoreline, including presence or absence of algal blooms and excessive weed growths. Lakes are rated on a scale of 0-23, higher values indicating poorer (more eutrophic) water quality. Although the LCI is not strictly related to trophic states, a

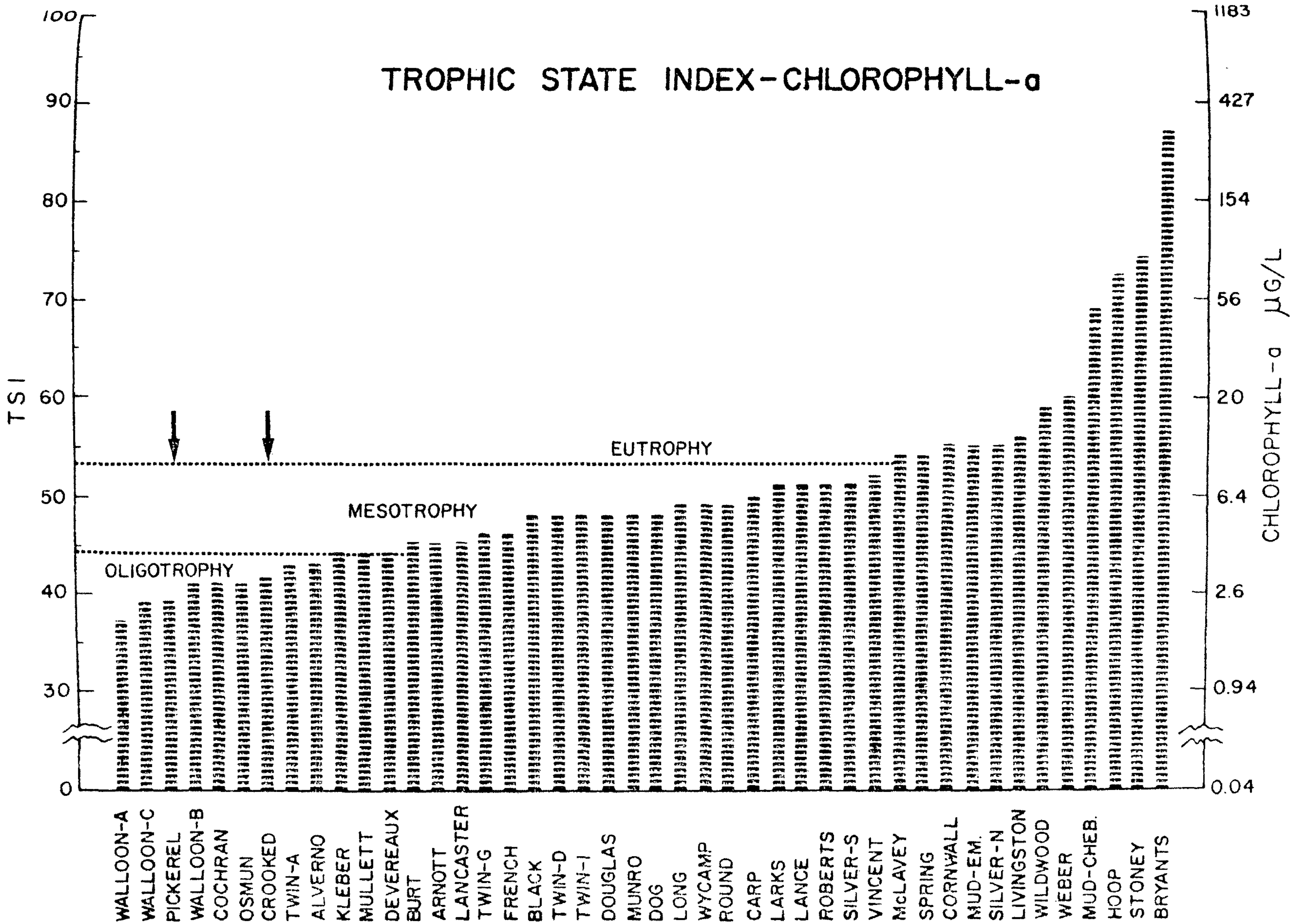


Fig. 12 Classification of lakes in Cheboygan and Emmet Counties, Michigan, using Carlson's (1977) trophic state index (TSI) for chlorophyll *a*. The positions of Crooked and Pickerel Lakes are identified by arrows. The divisions between oligotrophy and eutrophy are estimations that appear to be most suitable for the study area.

reasonable comparison between LCI and trophic classification was obtained in Wisconsin lakes (Uttermork and Wall, 1975). Crooked and Pickerel Lakes were determined to have LCI values of 7 and 5, respectively. Consequently, both lakes are classified as mesotrophic by this method with Crooked Lake again being closer to the eutrophic side of the trophic spectrum than Pickerel Lake (Fig. 13).

Nutrient loading

It is important to emphasize that nutrient loading determinations are relatively new to science and, therefore, they still are largely estimations. The values presented here are considered to be the best estimations with the available data for Crooked and Pickerel Lakes and information from the literature on nutrient loading. The greatest uncertainties are in the nutrient contributions from land cover. The amount of nutrients actually reaching the lakes from forest, agricultural, and urban areas is difficult to predict without better knowledge of run-off and groundwater flow patterns. Use of soils data has improved our ability to estimate nutrient contributions from septic systems. However, important variables such as, direction of groundwater flow, slope of land, age and condition of the septic system, and its distance from the lakeshore, were not known and, consequently, were not used in the nutrient loading analysis. However, several of these variables are

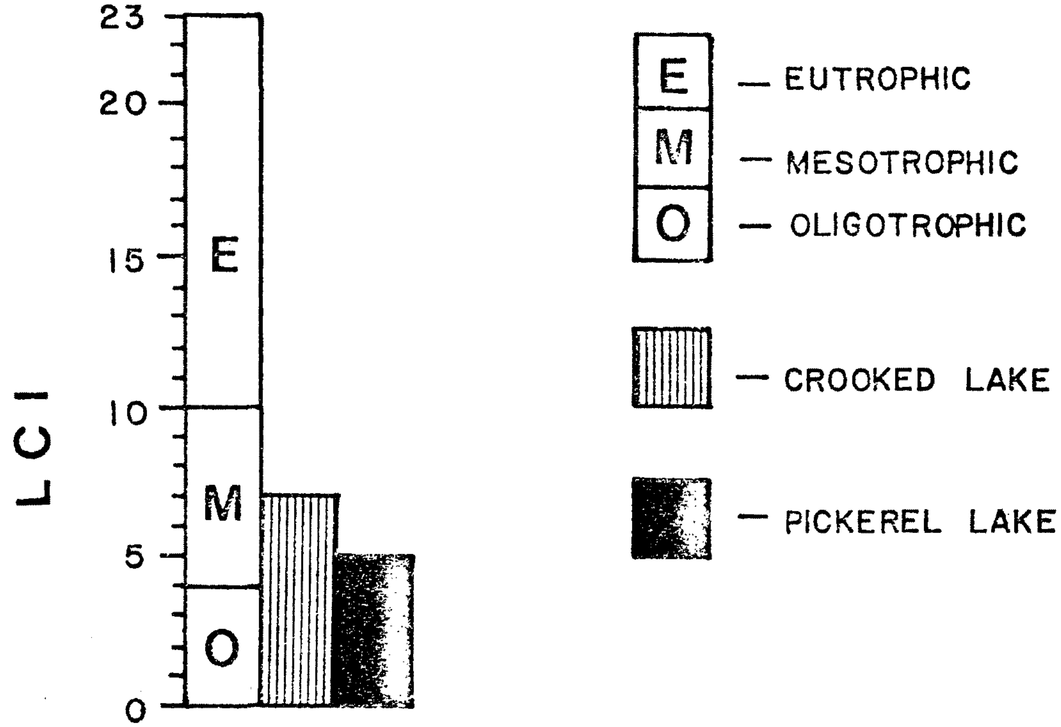


Fig. 13 Trophic classification of Crooked and Pickerel Lakes based on the lake condition index (LCI) of Uttormark and Wall (1975).

considered on the soil suitability maps (Gold and Gannon, 1979). Estimates of nutrient loading from lakeside lawn fertilization were not available for the study area, but this nutrient source is at least partially included in the coefficient for nutrient export from urban land cover.

Phosphorus loading was considerably higher to Crooked Lake than to Pickerel Lake in 1975-76 (Table 5). The discharge of nutrient-laden water from the Oden Fish Hatchery constituted the major man-induced source of phosphorus to Crooked Lake, representing 14.1% of total phosphorus loading. Considering all inflowing creeks, the stream from the fish hatchery contributed 69% of the phosphorus during the year and as high as 80% during Summer. Septic systems were another major human source of phosphorus, representing 9.4% of total phosphorus loading. In contrast, septic systems only contributed 4.0% of total phosphorus loading to Pickerel Lake. Nutrient loading was highest from forested lands in both lakes since the greatest portion of land in both watersheds is wooded.

Crooked Lake also received higher quantities of nitrogen than Pickerel Lake (Table 6). Major sources of nitrogen to both lakes were from forests and agricultural lands. Fish Hatchery and Minnehaha Creeks were also important sources of nitrogen to Crooked Lake. Because of the higher proportion of nitrogen loading from land cover, the contribution of nitrogen

TABLE 5. SOURCES AND QUANTITIES OF TOTAL PHOSPHORUS (P) FOR CROOKED AND PICKEREL LAKES, 1975-1976

CROOKED LAKE			PICKEREL LAKE		
Sources	Kg/yr.	%	Sources	Kg/yr.	%
Creeks			Creeks		
Round	26.6	1.2	Cedar	47.4	3.1
Conway	7.6	0.4	State Forest	10.8	0.7
Crooked	5.0	0.2			
Fish Hatchery	303.8	14.1			
Minnehaha	97.8	4.6			
Precipitation	321.7	14.9	Precipitation	143.2	9.2
Septic Systems	201.7	9.4	Septic Systems	61.9	4.0
Land Cover			Land Cover		
Forest	748.2	34.7	Forest	1,063.0	68.4
Agriculture	368.4	17.1	Agriculture	195.6	12.6
Urban	72.9	3.4	Urban	31.7	2.0
TOTAL	2,153.7	100.0	TOTAL	1,553.6	100.0

TABLE 6. SOURCES AND QUANTITIES OF TOTAL NITROGEN (N) FOR CROOKED AND PICKEREL LAKES, 1975-1976

CROOKED LAKE			PICKEREL LAKE		
Sources	Kg./yr.	%	Sources	Kg/yr.	%
Creeks			Creeks		
Round	1,301.6	1.7	Cedar	4,076.0	6.3
Conway	445.4	0.6	State Forest	550.6	0.8
Crooked	2,320.2	3.1			
Fish Hatchery	5,056.3	6.7			
Minnehaha	8,533.0	11.2			
Precipitation	7,973.3	10.5	Precipitation	3,548.4	5.5
Septic Systems	2,357.2	3.1	Septic Systems	494.2	0.8
Land Cover			Land Cover		
Forest	34,539.0	45.5	Forest	49,069.2	76.1
Agriculture	11,865.0	15.6	Agriculture	6,300.0	9.8
Urban	1,538.7	2.0	Urban	468.3	0.7
TOTAL	75,929.7	100.0	TOTAL	64,506.7	100.0

to both lakes from septic systems was relatively minor. However, nitrogen loading from septic systems was five times higher to Crooked Lake than Pickerel Lake.

Since phosphorus is the limiting nutrient for plant growth in Crooked and Pickerel Lakes, phosphorus loading is the most critical factor to the present and future water quality of these lakes. The importance of lake morphometry, i.e. mean depth and water residence time, to the susceptibility of lakes to phosphorus loading has been developed into a simple model by Vollenweider (1975). When data for Crooked and Pickerel Lakes are placed on the Vollenweider phosphorus loading plot, the trophic state and potential rate of eutrophication can be assessed (Fig. 14). Crooked and Pickerel Lakes are both classified as oligo-mesotrophic by this method, with Crooked Lake slightly closer to the eutrophic end of the trophic continuum. This is in agreement with other methods of trophic state determinations that were discussed previously. Both lakes are below the "permissible" loading level as determined by Vollenweider, i.e., water quality of both lakes should not appreciably change given the phosphorus loading levels of 1975-1976. However, Crooked Lake is nearly exceeding the "permissible" level and, therefore, may decline in water quality at a slightly faster rate than Pickerel Lake (Fig. 14).

Two events have occurred since 1975-1976 that apparently have reduced phosphorus loading to Crooked Lake from human

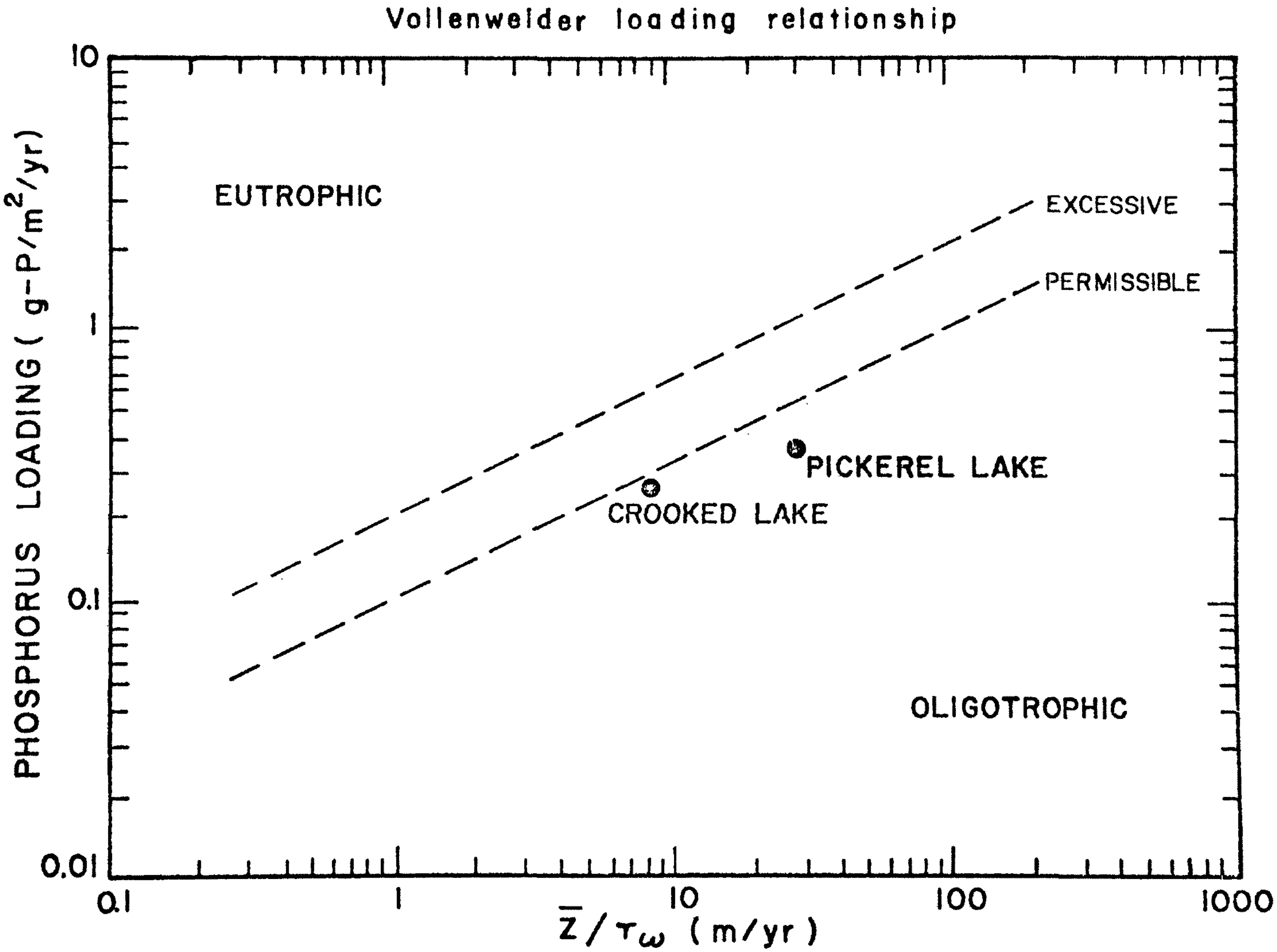


Fig. 14 Positions of Crooked and Pickerel Lakes on the Vollenweider (1975) theoretical phosphorus loading plot based on 1975-76 data.

sources. Dwellings on Crooked Lake's north shore have been serviced by a sewer and central sewage treatment system since Fall, 1976. Consequently, nutrients from wastewater that formerly entered the lake from septic systems have been diverted out of the watershed. In addition, the Oden Fish Hatchery, recognizing its pollution problems, changed its fish culture operation to reduce nutrient loading to Crooked Lakes. The lowermost raceways were converted to settling ponds to act as nutrient traps and a decision was made to shift the hatchery from fish production to brood stock maintenance.

Unfortunately, comprehensive nutrient budget data for 1977 are not available for Crooked Lake and, therefore, the impact of these changes on water quality improvement cannot be properly assessed. However, limited data on phosphorus loading from the fish hatchery was obtained in Summer, 1977. If phosphorus contributions from precipitation, other creeks, and land cover are assumed to be the same in 1975 and 1977, then an indication of the amount of phosphorus reduction from elimination of north shore septic systems and changes in fish hatchery operations can be obtained. The amount of phosphorus discharged from the fisn hatchery was nearly three times lower in 1977 than in 1975. Similarly, it was estimated that phosphorus from septic systems was reduced by a factor of three (Table 7).

Another event in 1977 should have had a slight effect in reducing phosphorus in Crooked and Pickerel Lakes. A ban on

TABLE 7. COMPARISON OF SOURCES AND QUANTITIES OF TOTAL PHOSPHORUS (P) ENTERING CROOKED LAKE DURING SUMMER, 1975 AND SUMMER, 1977*.

Sources	1975 Kg.	1975 %	1977 Kg.	1977 %
Fish Hatchery Creek	87.6	14.9	33.3	6.7
Septic Systems	50.4	8.6	16.2	3.2
Other **				
Precipitation	131.8	22.4	131.8	26.4
Land Cover	297.4	50.6	297.4	59.5
Other Creeks	20.8	3.5	20.8	4.2
TOTAL	588.0	100.0	499.5	100.0

* Summer is a three-month period (June, July and August).

** These data were obtained only in 1975, and phosphorus contributions from these sources were assumed to be the same in 1975 and 1977.

phosphates in detergents went into effect throughout the State of Michigan on October 1, 1977. We estimate that the phosphate ban should reduce phosphorus loading to septic systems by about 34%.

CONCLUSIONS

The present water quality of Crooked and Pickerel Lake is good. Both lakes are classified as oligo-mesotrophic with water quality slightly better (more oligotrophic) in Pickerel Lake than in Crooked Lake.

Phosphorus is the limiting nutrient to plant growth in both lakes. Consequently, the rate of change in water quality can largely be influenced by controlling phosphorus loading rates. We have little or no control over nutrient inputs from natural sources (i.e., precipitation on the lake surface, runoff and groundwater inflow from the watershed, aquatic birds, leaves, pollen, etc.). However, nutrient inputs from cultural sources (i.e., runoff from residential and agricultural land, lakeshore lawn fertilization and sewage) can be reduced. Total phosphorus loading was within theoretical "permissible" limits for both lakes in 1975-76. Indications are that a reduction in phosphorus loading from north shore dwellings and the Oden Fish Hatchery has occurred on Crooked Lake since 1975-76. The ban on phosphates in detergents, that took effect in Fall, 1977, will also reduce phosphorus loading to both lakes.

Further reductions in phosphorus loading should be encouraged to protect and maintain water quality in these lakes. Reduction in lakeshore lawn fertilization and construction of lakeshore greenbelts are recommended. Septic systems located on soils suitable for on-site wastewater treatment should be properly maintained. For dwellings located on soils unsuitable for on-site sewage treatment, the ecological and economic consequences of any wastewater management alternatives should be carefully considered.

ACKNOWLEDGEMENTS

The entire research staff at the University of Michigan Biological Station contributed to the field and laboratory work on Crooked and Pickerel Lakes in numerous ways. Their assistance is gratefully acknowledged. We especially thank Art Gold for input on the nutrient loading determinations. Gerald Krausse performed the chemical analyses. We also thank Marilyn Munger for document preparation.

REFERENCES CITED

Alfred, S. D., A. G. Hyde, and R. L. Larson. 1973. *Soil survey of Emmet County, Michigan.* U. S. Dept. Agriculture, Soil Conservation Serv., Washington, D. C., 99 p.

American Public Health Association. 1971. *Standard methods for the examination of water and wastewaters.* 13th ed., APHA, N. Y., 874 p.

Carlson, R. E. 1977. A trophic state index for lakes. *Limnol. Oceanogr.* 22:361-369.

Environmental Protection Agency. 1974a. *Methods for chemical analysis of water and wastes.* EPA Nat. Envir. Res. Center, Cincinnati, OH, 312 p.

______. 1974b. *The relationships of phosphorus and nitrogen to the trophic state of northeast and north-central lakes and reservoirs.* Nat. Eutrophication Surv., Working Paper No. 23, 28 p. & App.

______. 1975. *Report on Lake Charlevoix, Charlevoix County, Michigan.* Nat. Eutrophication Surv., Working Paper No. 188, 14 p. & App.

Foster, W. L. 1976. *Profile of the land: Natural features of the Inland Water Route region of northern lower Michigan.* Univ. Michigan Biol. Sta., Info. Report. No. 2, 29 p.

Gales, M., Jr., E. Julian, and R. Kroner, 1966. Method for quantitative determination of total phosphorus in water. *J. Amer. Waterworks Assoc.* 58:1363.

Gannon, J. E. and M. W. Paddock. 1974. *Investigations into ecological and sociological determinants of land use decisions - A study of inland lake watersheds in northern Michigan.* Univ. Michigan Biol. Sta., Tech. Report No. 1, 314 p.

______ and D. J. Mazur. 1976. Sources of nutrients (phosphorus and nitrogen) for Crooked Lake, Emmet County, Michigan. Univ. Michigan Biol. Sta., Unpubl. Report, 14 p.

Gold, A. and J. E. Gannon. 1979. The suitability of soils for on-site wastewater disposal, Pickerel and Crooked Lakes, Emmet County, Michigan. Univ. Michigan Biol. Sta., Tech. Report No. 8, Part II, 18 p.

Hutchinson, G. E. 1957. *A treatise in limnology. Vol. I. Geography, Physics, and Chemistry.* Wiley, New York, 1015 p.

Marans, R. W. and J. D. Wellman. 1977. *The quality of non-metropolitan living: Evaluations, behaviors, and expectations of northern Michigan residents.* Univ. Michigan, Inst. Social Res., 428 p.

Mentzel, D. W. and N. Corwin. 1965. The measurement of total phosphorus on seawater based on the liberation of organically bound fraction by persulfate oxidation. *Limnol. Oceanogr.* 10:280-288.

Müller, R. and O. Widemann. 1955. Nitratbestimmung in Seewasser. *Jahrbuch V. Wasser* 22:247-271.

Omernik, J. M. 1976. *The influence of land use on stream nutrient levels.* Environmental Protection Agency, Report No. EPA-600/3-76-014, 106 p.

O'Neil, W. 1977. *This land and man: An historical look at the use of land and natural resources in the Inland Water Route region of northern Michigan.* Univ. Michigan Biol. Sta., Info. Report No. 3, 21 p.

Pelz, D. C. 1977. *Utilization of environmental knowledge on northern Michigan.* Univ. Michigan, Inst. Social Res., 174 p.

______ and J. E. Gannon. 1978. Utilization of environmental knowledge for watershed management in northern Michigan. *Envir. Manag.* 3:in press.

Project CLEAR. 1978. *Environmental features of Walloon Lake and its' watersheds (Emmet and Charlevoix Counties, Michigan), with special reference to nutrient management.* Univ. Michigan Biol. Sta., Tech. Report No. 6, 81 p.

Richardson, C. J. 1978. *Investigations into ecological and sociological determinants of land-use decisions. Part II: Influence of land-use patterns, geology, and precipitation chemistry on nutrients in groundwater and lake water quality.* Univ. Michigan Biol. Sta., Tech. Report No. 4, 190 p.

Rogers, R. H. 1977. *Application of LANDSAT to the surveillance of lake eutrophication in the Great Lakes basin.* Bendix Aerospace Div., Ann Arbor, MI.

Say, E. W., M. W. Paddock, J. E. Gannon, and W. L. Foster. 1975. *Inland lake protection in northern Michigan*. Univ. Michigan Biol. Sta., Educ. Ser., Publ. No. 1, 40 p.

Schmid, M. and H. Ambühl. 1965. Die bestimmung geringster Mengen von Gesamtphosphor in Wasser von Binnenseen. *Schweiz. Z. Hydrol.* 27:184-192.

Schneider, I. F. and A. E. Erickson. 1972. *Soil limitations for disposal of municipal wastewaters*. Michigan State Univ., Agri. Exp. Sta., Res. Report No. 195, 54 p.

Solorzano, L. 1969. Determination of ammonia in natural waters by the phenolhypochlorite method. *Limnol. Oceanogr.* 14:799-801.

Technicon. 1972-73. Industrial Methods. Technicon Instruments Corp., Tarrytown, NY.

Tierney, D. P., R. Powers, T. Williams, and S. C. Hsu. 1976. *Actinomycete distribution in northern Green Bay and the Great Lakes: Taste and odor relationships in eutrophication of nearshore waters and embayments*. Environmental Protection Agency, Report No. EPA-905/9-74-007, 167 p.

Uttormark, P. D. and J. P. Wall. 1975. *Lake classification - A trophic characterization of Wisconsin lakes*. Environmental Protection Agency, Report No. EPA-660/3-75-033, 165 p.

Vollenweider, R. A. 1968. Scientific fundamentals of the eutrophication of lakes and flowing waters, with particular reference to nitrogen and phosphorus as factors in eutrophication. Organization Econ. Co-op. Devel., Paris, 159 p. & 34 figs.

Vollenweider, R. A. 1975. Input-output models with special reference to the phosphorus loading concept in limnology. *Schweiz. Z. Hydrol.* 37:53-84.

Welch, P. S. 1948. *Limnological methods*. Blakiston, Philadelphia, PA, 381 p.

APPENDIX A

DATA USED IN ESTIMATING NUTRIENT LOADING TO CROOKED AND PICKEREL LAKES FROM SEPTIC SYSTEMS

TABLE A-1. TOTAL PHOSPHORUS AND TOTAL NITROGEN EXPORT (kg/km^2/yr.) FROM LAND COVER. VALUES ARE MEANS FOR THE NORTH AND NORTHEASTERN UNITED STATES (OMERNIK, 1976), AND WERE USED IN THE CROOKED AND PICKEREL LAKES NUTRIENT LOADING CALCULATIONS.

Land Cover	Phosphorus	Nitrogen
Forest	8.6	397
Agriculture (mostly)	16.3	525
Urban	31.7	669

TABLE A-2. ESTIMATED PHOSPHORUS (P) AND NITROGEN (N) INPUTS FROM SEPTIC SYSTEMS TO CROOKED LAKE'S NORTH SHORE IN 1975. THIS PORTION OF THE LAKE HAS BEEN SERVICED BY A SEWER SINCE 1976.

Soil Type	Percent Reaching Lake P(%)	N(%)	Number of Dwellings* Y-R	PY-R	S	Amt. Reaching Lake P(kg/yr)	N(kg/yr)
Au Gres loamy sand (AuB)	35	65	50	1	84	61.6	815.6
Deford fine loamy sand (Df)	75	50	2	0	0	3.7	17.5
Carbondale muck (Ca)	75	50	0	0	2	0.9	4.4
Kalkaska loamy sand (KaB)	25	65	19	0	16	14.1	262.4
Made land (Ma)	35	50	34	0	20	33.6	342.2
Roscommon mucky sand (Rc)	75	50	1	0	4	3.7	17.6
Rubicon sand (RuB)	25	65	2	0	4	1.9	34.2
Tawas muck (Ta)	75	50	8	0	3	16.1	76.8
Wet alluvial land (Wt)	75	50	0	0	2	0.9	4.4
TOTAL			116	1	135	136.5	1,575.1

* Y-R is year-round occupancy; PY-R is possible year-round occupancy; S is seasonal occupancy.

TABLE A-3. ESTIMATED PHOSPHORUS (P) AND NITROGEN (N) INPUTS FROM SEPTIC SYSTEMS TO THE SOUTH SHORE OF CROOKED LAKE, INCLUDING ODEN ISLAND, IN 1975. THIS PORTION OF THE LAKE CONTINUES TO BE SERVICED BY SEPTIC SYSTEMS.

Soil Type	Percent Reaching Lake		Number of Dwellings			Amt. Reaching Lake	
	P(%)	N(%)	Y-R	PY-R	S	P(kg/yr)	N(kg/yr)
Au Gres loamy sand (AuB)	35	65	13	0	9	13.1	174.0
Au Gres sand (ArB)	35	65	0	0	3	0.7	8.6
Blue Lake loamy sand (B1B)	65	65	1	0	1	2.0	14.3
Blue Lake loamy sand (B1F)	65	65	0	0	4	1.6	11.4
Brevort mucky loamy sand (Br)	55	50	10	0	11	17.3	111.9
Bruce fine sandy loam (By)	35	50	2	0	0	1.7	17.6
Emmet sandy loam (EmB)	25	65	4	0	0	2.5	45.6
Iosco loamy fine sand (I1B)	55	65	0	1	1	0.3	2.9
Johnswood cobbly loam (JoC)	25	85	9	2	9	7.5	182.7
Kalkaska sand (KaB)	25	65	0	1	7	1.4	25.7
Kalkaska sand (KaC)	25	65	3	0	1	2.0	37.1

Continued

TABLE A-3 Cont.

Soil Type	Percent Reaching Lake P(%)	N(%)	Number of Dwellings Y-R	PY-%	S	Amt. Reaching Lake P(kg/yr)	N(kg/yr)
Made land (Ma)	35	50	2	0	0	1.7	17.5
Roscommon mucky sand (Rc)	75	50	2	0	1	4.2	19.7
Sandy lake beaches (Sb)	35	65	5	1	0	4.7	62.7
Thomas loam (ToA)	35	50	3	1	9	4.5	50.4
TOTAL			54	5	56	65.2	782.1

TABLE A-4. ESTIMATED PHOSPHORUS (P) AND NITROGEN (N) INPUTS FROM SEPTIC SYSTEMS TO PICKEREL LAKE IN 1975.

Soil Type	Percent Reaching Lake		Number of Dwellings			Amt. Reaching Lake	
	P(%)	N(%)	Y-R	PY-R	S	P(kg/yr)	N(kg/yr)
Au Gres loamy sand (ArB)	35	65	0	0	7	1.5	20.0
Carbondale muck (Ca)	75	50	0	0	4	1.8	8.8
East Lake loamy sand (EaB)	25	65	1	0	4	1.2	22.8
Kalkaska loamy sand (KaB)	25	65	7	0	20	7.4	135.9
Roscommon mucky sand (Rc)	75	50	5	0	20	18.4	87.8
Saugatuck sand (ScB)	35	50	3	0	18	6.5	65.8
Tawas muck (Ta)	75	50	1	0	12	7.4	35.1
Thomas mucky loam (Tm)	35	50	0	0	4	0.9	8.8
Thomas loam (ToA)	35	65	0	0	16	3.4	45.6
Warners mucky loam (Wm)	75	50	4	2	9	13.4	63.6
TOTAL			21	2	114	61.9	494.2

LIMNOLOGICAL FEATURES

OF

CROOKED AND PICKEREL LAKES, EMMET COUNTY, MICHIGAN

PART II. THE SUITABILITY OF SOILS FOR ON-SITE WASTEWATER DISPOSAL [1]

by

Arthur Gold

and

John E. Gannon [2]

Technical Report No. 8
Biological Station
The University of Michigan
Pellston, Michigan 49769

April, 1979

---

1 This report is based on research funded by the National Science Foundation (Grant No. AEN72-03483). Preparation of the report was supported by the Environmental Protection Agency as a sub-contract to a prime contract (EPA-No. 08-01-4612) to WAPORA, Inc.

2 Present address: State University Research Center, Oswego, NY 13126.

CONTENTS

FIGURES

BACKGROUND

Septic systems rely on the soil to purify domestic wastewater. However, soil types vary considerably in their capacity to effectively treat wastewater. Septic systems operating in ill-suited soils can be a threat to public health and can have adverse effects on water quality of nearby lakes and streams. Soil suitability for wastewater disposal is primarily determined by slope, permeability, depth to seasonal high groundwater level, and phosphorus adsorption capacity. Depth to bedrock can also be a factor where overlying soils are extremely shallow. One of these variables, or more likely the integrating influence of a combination of them, may restrict the use of on-site waste disposal by septic systems.

Septic systems, if properly designed and carefully installed, may function adequately on sites with slopes up to 12% (Warshall, 1976). Slopes up to 15% grade present moderate limitations for wastewater disposal if engineering modifications of the drain field such as serial distribution are employed. Systems on severe slopes may experience problems with prematurely failing drain fields or ponding effluent. Installation of septic systems on steep slopes will require additional expense and attention to eliminate the potential for accelerated erosion and sedimentation.

Permeability is the rate at which water moves through the soil, and is a major consideration in on-site inspection for septic system permits. Permeability usually changes with each soil horizon and various on-site disposal systems use different horizons for wastewater treatment. Drain field trenches are generally placed two feet below the surface, which diminishes the importance of soil permeability above that level. Mounds and raised drain fields developed in Wisconsin rely on the permeability of the surface soil layers (Converse et al., 1976).

Depth to seasonal high groundwater is a primary consideration in on-site analysis for septic tank permits. The highest levels of purification are achieved when the wastewater passes through unsaturated soils. Effluent moves through spaces between soil particles, increasing the contact of the effluent with the soil and increasing the time before the liquid reaches groundwater (Baker and Bouma, 1975). This enhances the potential of the soil for phosphorus adsorption and for the physical screening of bacteria (McCoy and Ziebell, 1975). Under saturated conditions, wastewater flows through the largest soil spaces, minimizing contact between the effluent and soil particles.

Phosphorus adsorption capacity differs with soil types and is a major factor in the ability of a soil to purify wastes. Limnological data indicates that phosphorus is the limiting nutrient for aquatic productivity in Crooked and Pickerel Lakes (See Part I of this report). Septic systems are one source of phosphorus loading to the lakes.

A series of overlay maps have been prepared to provide guidelines for future wastewater management planning on the shorelines of Crooked and Pickerel Lakes, Emmet County, Michigan. The maps integrate information on soil suitability and illustrate the capacity of the land near these lakes to purify septic system effluent. An overlay map depicting depth to bedrock was not constructed since bedrock is not found close to the surface in the study area. When presently existing septic systems need replacing, new septic systems or other on-site wastewater management alternatives should be designed to compensate for any site specific soil limitations. Of course, the use of the overlay maps should not preclude on-site inspection for suitability of wastewater disposal.

METHODS

Overlay maps for slope, permeability, depth to seasonal high groundwater, and phosphorus adsorption capacity were prepared, based on development capability criteria established by the U. S. Soil Conservation Service (1966) and Schneider and Erickson (1972). The classification and distribution of soil types in the watersheds of Crooked and Pickerel Lakes were obtained from Alfred et al. (1973).

Location of dwelling units in the study area was acquired from Williams and Works (1976)*. On 20 February 1978 we visually surveyed the dwellings within 300 feet of the lakeshore to estimate the number of permanent and seasonal residences. Over three feet of snow existed on the ground at the time of the survey. Criteria used to determine year-round occupancy

* At least eight additional dwellings were built since 1976 and were included on the map.

included recently plowed drives, fresh tire tracks, trash containers, and chimney smoke. Indications of occasional occupancy were recorded as possible seasonal use in winter.

The phosphorus adsorption capacities depicted on the overlay map are as follows (Schneider and Erickson, 1972):

Rate Class	Pounds per acre in upper three feet of soil
High	>1,600
Medium	1,300 to 1,600
Low	<1,300

Phosphorus adsorption data were unavailable for four soil types in the study area. The following estimates were provided by Forrest (personal communication*):

Soil Series	Phosphorus Adsorption Capacity
Dighton Series, fine subsoil variant	High
Saugatuck Series	High
Johnswood Series	High
Blue Lake Series	Low

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

Slope (Percent)	Depth to Seasonal High Groundwater (feet)	Permeability (inches per hour)
0-6	>4	6.3 - 20.0
6-12	2-4	2.0 - 6.3
12-18	<4	0.63 - 2.0
>18		<0.63

* Forest, Michael, Soil Scientist, U.S. Soil Conservation Service, Gaylord, MI 49735.

permeability values represent the lowest rate that occurs in the upper five to six feet of soil.

Each variable is depicted on a separate transparency that lies on two base maps, one showing location of total dwelling units and the other indicating year-round residences. Increasing degrees of shading are employed to indicate greater restriction imposed by each variable on development and on-site wastewater disposal. When all four transparencies are viewed together, greater restrictions for wastewater disposal are indicated by the darkest areas.*

A limited number of booklets (23" X 17") containing the transparent overlays and base maps were prepared and deposited at Emmet County governmental offices and at the University of Michigan Biological Station. Prints of the overlays on the base map of year-round residences appear in Appendix A.

RESULTS AND DISCUSSION

Dwelling Units

Based on our visual survey and data from Williams and Works (1976), we estimate that 112 dwelling units are located within 300 feet of the shore on the south side of Crooked Lake and on Oden Island and 134 on Pickerel Lake. Approximately 55% of these dwellings on Crooked Lake indicated year-round occupancy. In contrast, 21% of the residences on Pickerel Lake appeared

* Those soils exhibiting high groundwater and rapid permeability may be more limited in their capacity to treat wastewater than these overlays actually depict.

to be year-round. Frequency of year-round dwellings was especially low (10%) along the north shore and at Botsford Landing.

Slope

Emmet County's Health Code does not specifically restrict on-site disposal systems based on slope characteristics (Michigan District Health Department No. 3, 1968). However, county sanitarians consider slope in their inspection of suitability of a site for septic treatment.

Gently sloping terrain characterizes most of the shoreline of Crooked and Pickerel Lakes and does not limit the functioning of septic systems in most of the study area. The only exception is the eastern side of Graham Point on Crooked Lake where slopes greater than 12% are located.

Permeability

Permeability of less than 1.0 inch per hour is considered too slow to allow for adequate treatment (Goldstein and Moberg, 1973). The Emmet County Sanitary Code requires a permeability rate greater than 2.0 inches per hour by the percolation test (Michigan District Health Department No. 3, 1968). No restriction is imposed on soils with extremely rapid permeability (i.e., greater than 10 inches per hour). However, coarse soils with very rapid permeability can introduce contaminants to groundwater.

Approximately one-half of the dwelling units on the south shore of Crooked Lake are situated on Au Gres sands and Thomas loamy sands (Alfred et al., 1973) which have permeability too slow for adequate septic treatment. Nineteen residences southeast of Graham Point are located on Johnswood cobbly loam.

The moderately slow permeability of this soil type should be recognized when considering on-site disposal alternatives.

Sixty homes bordering Pickerel Lake are underlain by soils with permeability below all acceptable standards for septic treatment (Goldstein and Moberg, 1973). Approximately one-half of these homes, located on Ellsworth Point, are situated on Saugatuck sands which have extremely slow permeability in the upper horizons. Kalkaska sands on the southeast shore of Pickerel Lake exhibit permeability adequate for septic treatment.

Depth to Seasonal High Groundwater

Sites with high groundwater levels (permanent or seasonal) are not suitable for septic system use. The groundwater level during the wettest season should be at least four feet below the bottom of the trenches in a subsurface tile absorption field and four feet below the pit floor in a field using seepage pits (Goldstein and Moberg, 1973). Emmet County requires that finish grade be at least six feet above the known high groundwater level (District Health Department No. 3, 1968). The county allows some filling to obtain this distance.*

Mounds may be used for safe and effective disposal of septic tank effluent where depth to seasonal high groundwater level is greater than two feet from the surface (Converse et al., 1976). Areas with seasonal high groundwater levels less

---

* The soils of Emmet County have been interpreted to a depth of five feet (Alfred, et al., 1973). However, the depth to seasonal high groundwater was not recorded if the water table was more than four feet from the surface. Knowledge of soil types and depth of groundwater to at least six feet below the surface would be useful for on-site wastewater management decisions.

than two feet from the surface are severely limited for on-site disposal (Goldstein and Moberg, 1973).

Seasonal high groundwater levels occur within two feet of the surface in most of the lakeside soils of Crooked and Pickerel Lakes. Consequently, adequacy of septic treatment is severely limited during periods of high groundwater for the majority of riparian dwelling units. Notable exceptions are the Emmet sandy loams on Oden Island and the Kalkaska sands underlying some of the dwelling units on Pickerel Lake's Ellsworth Point and Botsford Landing.

Phosphorus Adsorption Capacity

The phosphorus adsorption capacity of most soils around Crooked Lake is adequate for septic treatment. However, Blue Lake loamy sand and Roscommon muck, underlying a few residences on the south shore, and Emmet sands, under most dwellings on Oden Island, have low phosphorus adsorption capacities.

Approximately 30% of the dwellings on Pickerel Lake are on Warners mucky loam, Tawas muck, or Roscommon mucky sands which exhibit low phosphorus adsorption capacities. However, adjacent inland soils near the south shore consist of Kalkaska sands with higher phosphorus adsorption capacities.

CONCLUSIONS

Most of the dwelling units on the south shore of Crooked Lake are located on soils with characteristics severely limiting their capacity to treat wastewater from conventional septic systems. High seasonal groundwater levels are the major constraint along most of the shoreline. In addition, soils with low permeability rates underly approximately one-half of the existing dwellings. Residences on Oden Island are situated on soils with some limitations but on-site waste treatment such as mounds or other innovations could be instituted. More than 50% of the dwellings on the south shore of Crooked Lake and on Oden Island are year-round. This factor should be considered when reviewing wastewater management alternatives.

Much of the development surrounding Pickerel Lake is on soils not capable of effectively treating septic system wastes. Seasonal high groundwater levels are again the major constraint, although low permeability and phosphorus adsorption problems also exist. Therefore, alternative on-site methods of wastewater disposal should be considered. For example, a large tract of Kalkaska sands located south of developments at Botsford Landing and Ellsworth Point are highly suitable for on-site wastewater treatment. This method may not be feasible on the north side since only small, scattered parcels of suitable soils are available there. Holding tanks for pump-out disposal offer a possible on-site alternative. Only 21% of the dwellings around Pickerel Lake are year-round residences. This factor may influence the choice of wastewater management methods.

The Crooked-Pickerel Channel area is one of the largest and most important wetlands in the watershed of Crooked and Pickerel Lakes. Soils in this area consist largely of Tawas and Carbondale muck which exhibit serious limitations to development and on-site wastewater disposal. The wetland functions as an important breeding and nursery ground for game fish and other aquatic organisms, provides habitat for game birds and animals, and protects the quality of surface and groundwater resources. Retainment of the soils and vegetation of the Crooked-Pickerel Channel area in their natural condition is ecologically sound and worthy of consideration.

ACKNOWLEDGEMENTS

We thank M. Secrest and B. Burley for assistance in preparing the soil maps, D. Mazur for help on the visual survey of year-round dwelling units, and M. Munger for typing the manuscript.

REFERENCES CITED

Alfred, S. D., A. G. Hyde, and R. L. Larson. 1973. Soil Survey of Emmet County, Michigan. U.S. Dept. of Agriculture, in cooperation with Michigan Agricultural Experiment Station, 99 p.

Baker, F. G. and J. Bouma. 1975. Measurment of soil hydraulic conductivity and site selection for liquid waste disposal. *In*: Individual on-site wastewater systems, Proc. Nat. Conf., National Sanitation Foundation, Ann Arbor, MI.

Converse, J.C., R. J. Otis, J. Bouma, W. Walker, J. Anderson, and D. Stewart. 1976. Design and construction procedures for mounds in slowly permeable soils with or without seasonally high water tables. Univ. Wisconsin, Unpubl. mimeo., 35 p.

Goldstein, S. N. and W. J. Moberg, Jr. 1973. Wastewater treatment systems for small communities. Commission on Rural Water, Washington, D.C., 340 p.

McCoy, E. and W. A. Ziebell. 1975. Effects of effluents on groundwater. *In*: Individual on-site wastewater systems, Proc. Nat. Conf., National Sanitation Foundation, Ann Arbor, MI.

Michigan District Health Department No. 3. 1968. Emmet County Sanitary Code, Emmet County, Michigan, 4 p.

Schneider, I. F. and A. E. Erickson. 1972. Soil limitations for disposal of municipal wastewaters. Michigan State University Agricultural Experiment Station, East Lansing, in cooperation with Michigan Water Resources Commission, Farm Science Research Report No. 195, 54 p.

U.S. Soil Conservation Service. 1966. Land-capability classification. Dept. of Agriculture, Handbook No. 210, 21 p.

Warshall, P. 1976. *Septic tank practices.* Mesa Press, Bolinas, CA 76 p.

Williams and Works. 1976. Little Traverse Bay Area Facility Plan, Springvale-Bear Creek area segment for wastewater collection and treatment. Emmet County, Michigan, Williams and Works, Inc., Grand Rapids, Michigan.

APPENDIX A

Maps of the Crooked and Pickerel Lakes area, depicting variables that influence adequacy of soils for on-site wastewater disposal.

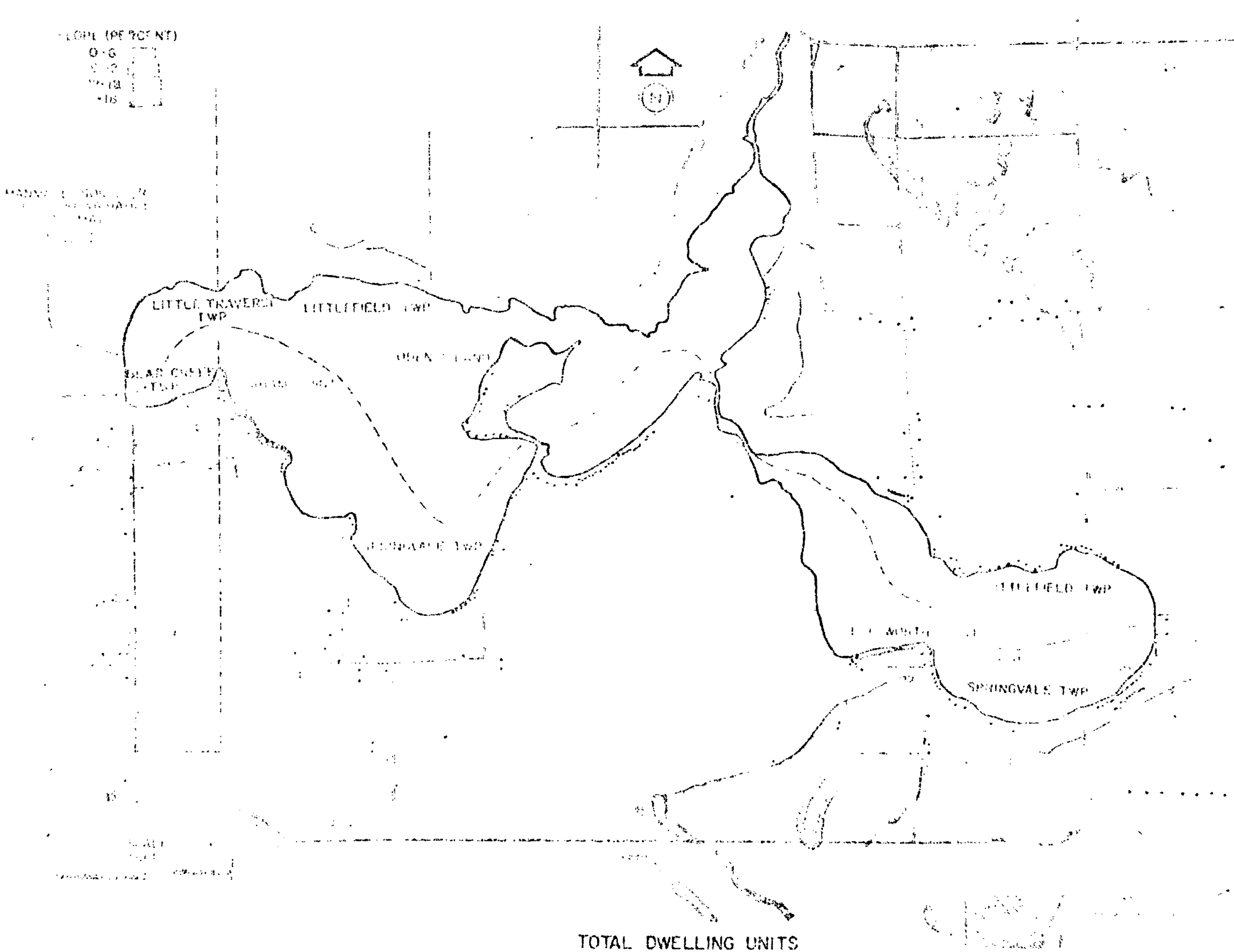


Fig. A-1 Slope. Darker shading indicates more severe limitations to on-site wastewater disposal on Figures A-1 through A-5

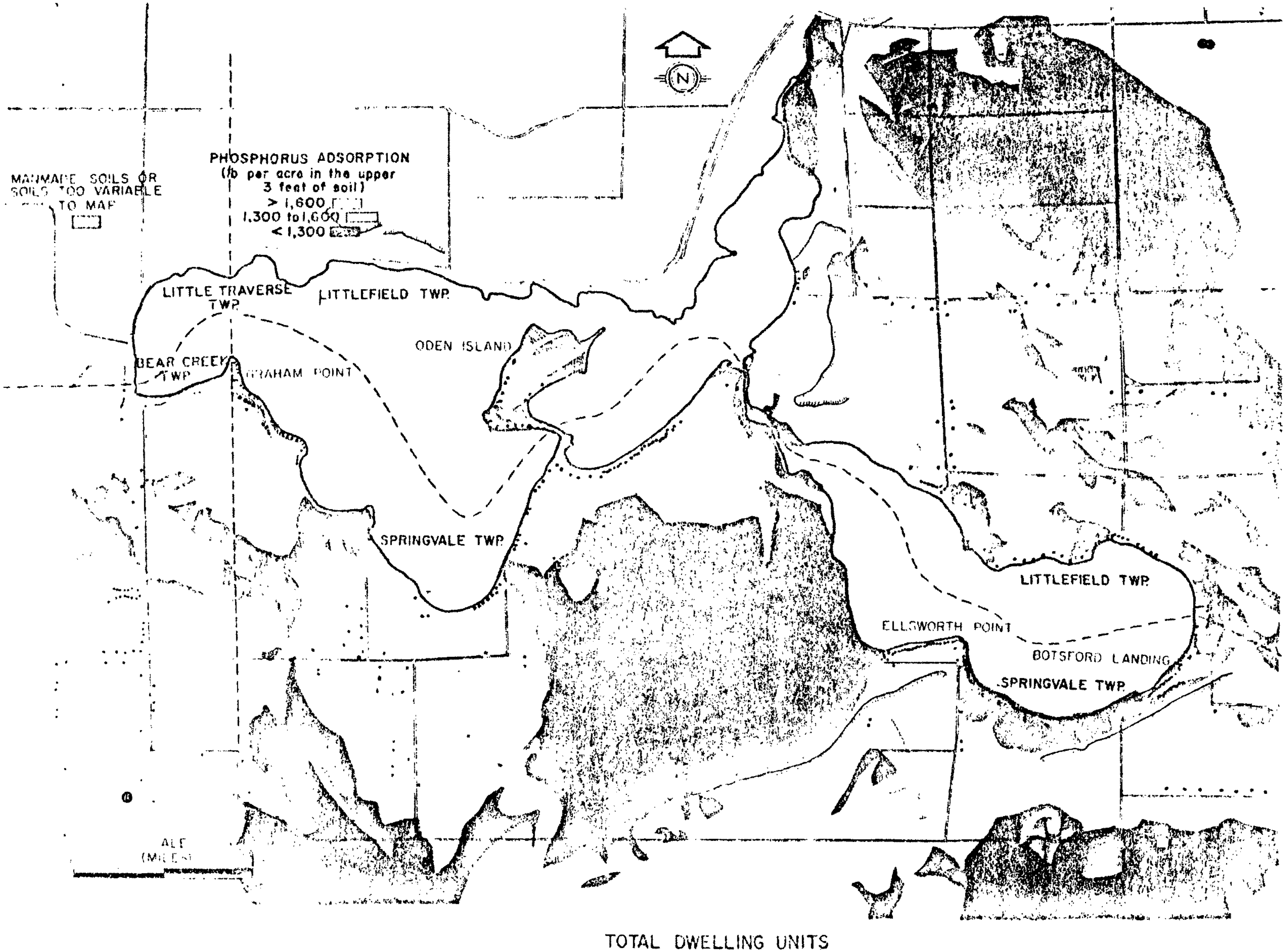


Fig. A-2 Phosphorus adsorption capacity

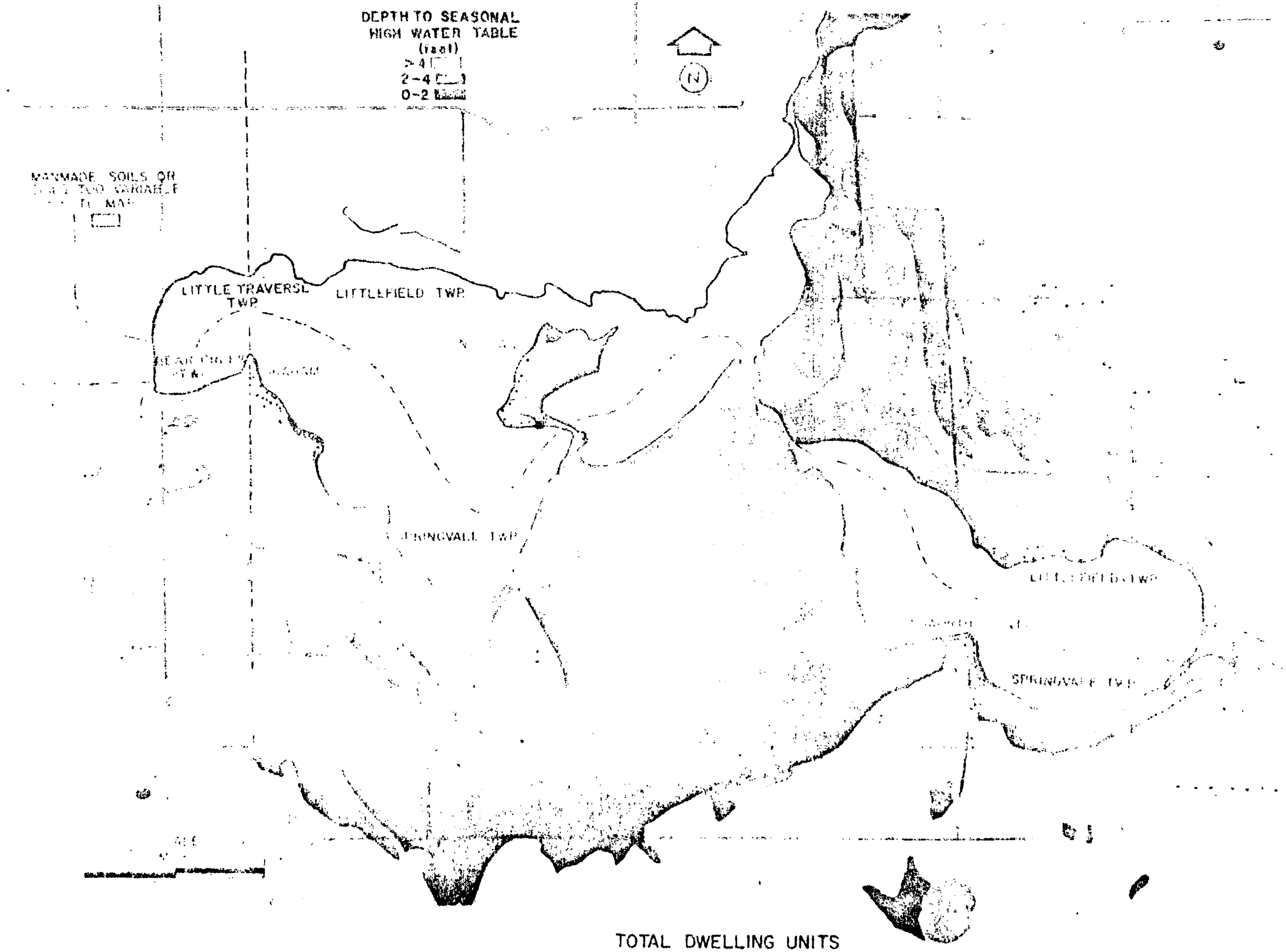


Fig. A-3 Depth to seasonal high groundwater

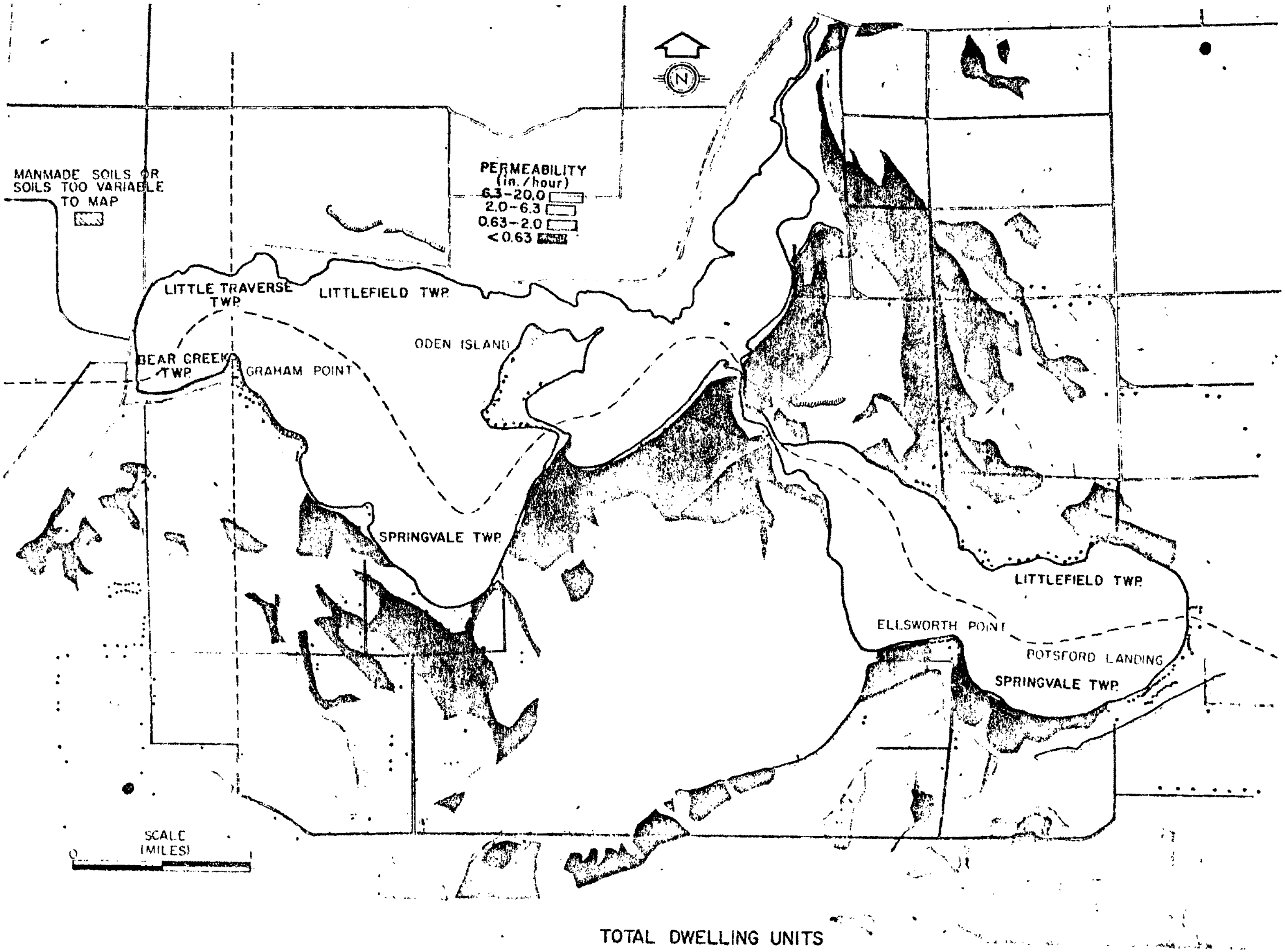


Fig. A-4 Permeability

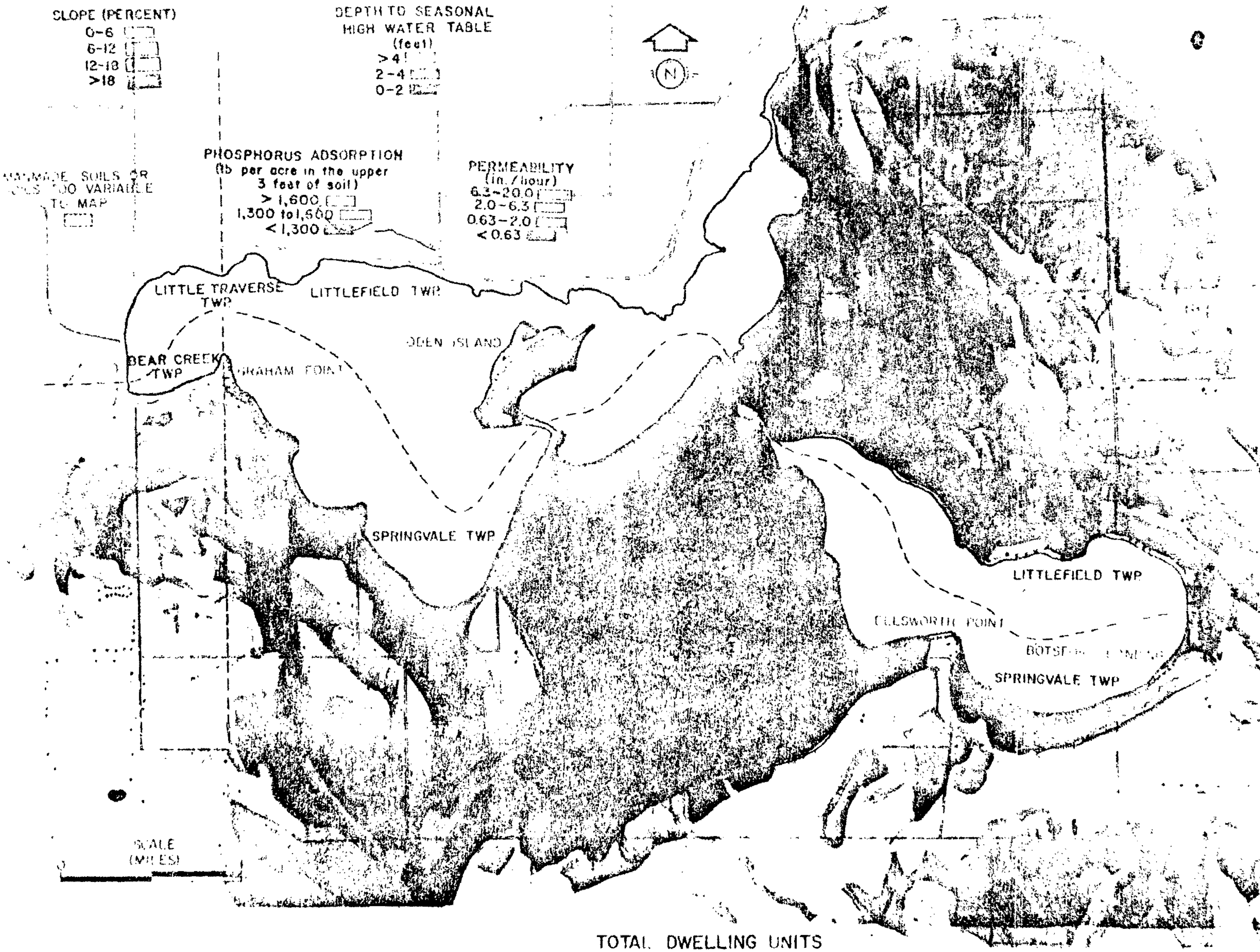


Fig. A-5 A composite map of the four variables that affect suitability of soils for on-site wastewater disposal

SIMPLIFIED ANALYSIS OF LAKE EUTROPHICATION

Introduction

Two basic approaches to the analysis of lake eutrophication have evolved:

1) A complex lake/reservoir model which simulates the interactions occurring within ecological systems; and

2) the more simplistic nutrient loading model which relates the loading or concentration of phosphorus in a body of water to its physical properties.

From a scientific standpoint, the better approach is the complex model; with adequate data such models can be used to accurately represent complex interactions of aquatic organisms and water quality constituents. Practically speaking, however, the ability to represent these complex interactions is limited because some interactions have not been identified and some that are known cannot be readily measured. EPAECO is an example of a complex reservoir model currently in use. A detailed description of this model has been given by Water Resources Engineers (1975).

In contrast to the complex reservoir models, the empirical nutrient budget models for phosphorus can be simply derived and can be used with a minimum of field measurement. Nutrient budget models, first derived by Vollenweider (1968) and later expanded upon by him (1975), by Dillon (1975a and 1975b) and by Larsen - Mercier (1975 and 1976), are based upon the total phosphorus mass balance. There has been a proliferation of simplistic models in eutrophication literature in recent years (Bachmann and Jones, 1974; Reckhow, 1978). The Dillon model has been demonstrated to work reasonably well for a broad range of lakes with easily obtainable data. The validity of the model has been demonstrated by comparing results with data from the National Eutrophication Survey (1975). The models developed by Dillon and by Larsen and Mercier fit the data developed by the NES for 23 lakes located in the northeastern and northcentral United States (Gakstatter et al 1975) and for 66 bodies of water in the southeastern US (Gakstatter and Allum 1975). The Dillon model (1975b) has been selected for estimation of eutrophication potential for Crystal Lake and Betsie Lake in this study.

Historical Development

Vollenweider (1968) made one of the earliest efforts to relate external nutrient loads to eutrophication. He plotted annual total phosphorus loadings ($g/m^2/yr$) against lake mean depth and empirically determined the transition between oligotrophic, mesotrophic and eutrophic loadings. Vollenweider later modified his simple loading mean depth relationship to include the mean residence time of the water so that unusually high or low flushing rates could be taken into account.

Dillon (1975) further modified the model to relate mean depth to a factor that incorporates the effect of hydraulic retention time on nutrient retention.

The resulting equation, used to develop the model for trophic status, relates hydraulic flushing time, the phosphorus loading, the phosphorus retention ratio, the mean depth and the phosphorus concentration of the water body as follows:

$$L \frac{(1-R)}{\rho} = zP$$

where: L = phosphorus loading ($gm/m^2/yr.$)
R = fraction of phosphorus retained
ρ = hydraulic flushing rate (per yr.)
z = mean depth (m)
P = phosphorus concentration (mg/l)

The graphical solution, shown in Figure E-4-a, is presented as a log-log plot of $L \frac{(1-R)}{P}$ versus z.

The Larsen-Mercier relationship incorporates the same variables as the Dillon relationship.

In relating phosphorus loadings to the lake trophic condition, Vollenweider (1968), Dillon and Rigler (1975) and Larsen and Mercier (1975, 1976) examined many lakes in the United States, Canada and Europe. They established tolerance limits of 20/ug/l phosphorus above which a lake is considered eutrophic and 10 mg/l phosphorus above which a lake is considered mesotrophic.

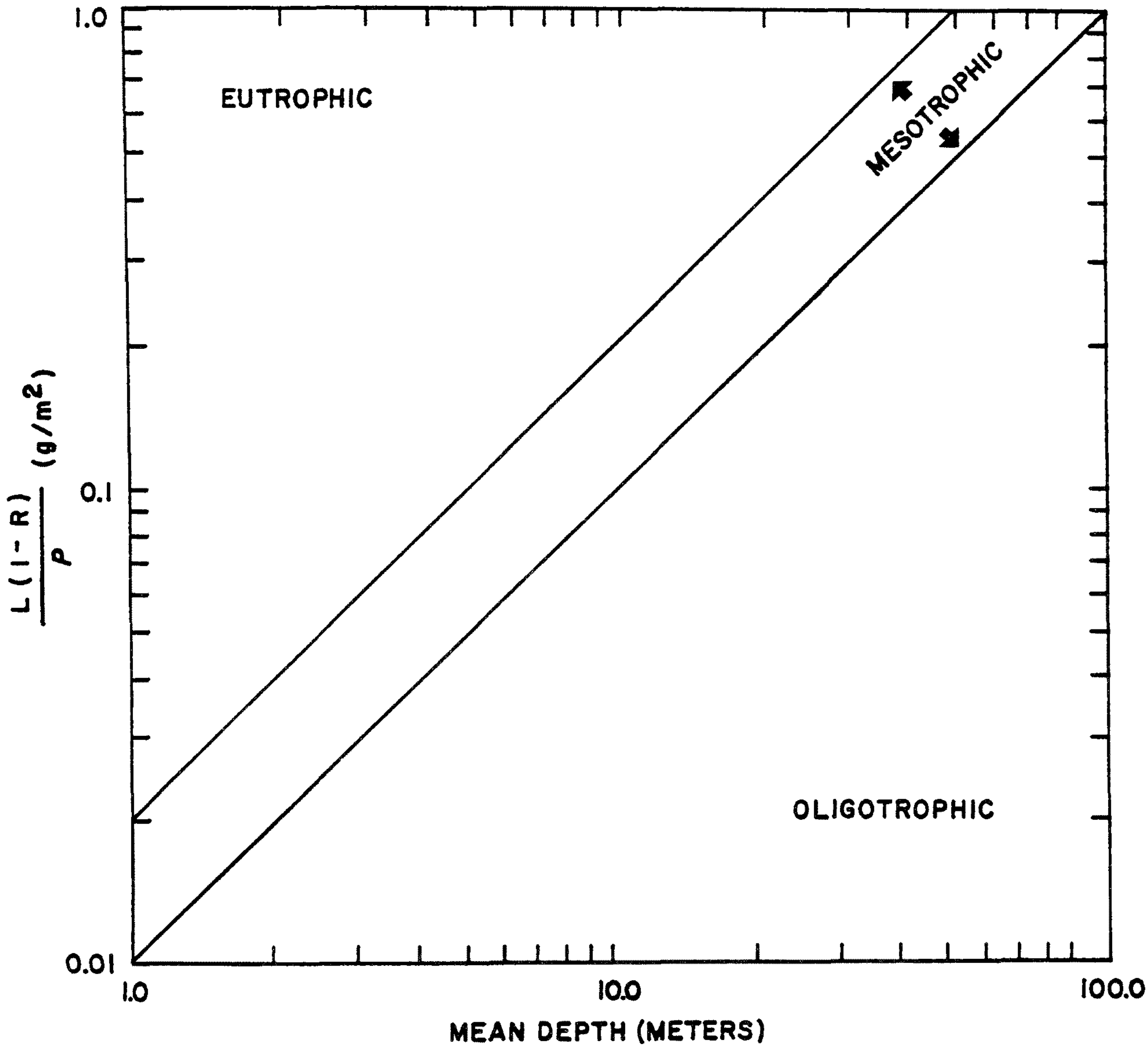
Assumptions and Limitations

The Vollenweider-Dillon model assumes a steady state, completely mixed system, implying that the rate of supply of phosphorus and the flushing rate are constant with respect to time. These assumptions are not totally true for all lakes. Some lakes are stratified in the summer so that the water column is not mixed during that time. Complete steady state conditions are rarely realized in lakes. Nutrient inputs are likely to be quite different during periods when stream flow is minimal or when non-point source runoff is minimal. In addition, incomplete mixing of the water may result in localized eutrophication problems in the vicinity of a discharge.

Another problem in the Vollenweider-Dillon model is the inherent uncertainty when extrapolating a knowledge of present retention coefficients to the study of future loading effects. That is to say, due to chemical and biological interactions, the retention coefficient may itself be dependent on the nutrient loading.

The Vollenweider/Dillon model or simplified plots of loading rate versus lake geometry and flushing rates can be very useful in describing the general trends of eutrophication in lakes during the preliminary

FIGURE E-4-a



L= AREAL PHOSPHORUS INPUT ($g/m^2/yr$)
R= PHOSPHORUS RETENTION COEFFICIENT (DIMENSIONLESS)
ρ= HYDRAULIC FLUSHING RATE (yr^{-1})

planning process. However, if a significant expenditure of monies for nutrient control is at stake, a detailed analysis to calculate the expected phytoplankton biomass must be performed to provide a firmer basis for decision making.

NON-POINT SOURCE MODELING - OMERNIK'S MODEL

Because so little data was available on non-point source runoff in the Study Area, which is largely rural, empirical models or statistical methods have been used to derive nutrient loadings from non-point sources. A review of the literature led to the selection of the model proposed by Omernik (1977). Omernik's regression model provides a quick method of determining nitrogen and phosphorus concentrations and loading based on use of the land. The relationship between land use and nutrient load was developed from data collected during the National Eutrophication Survey on a set of 928 non-point source watersheds.

Omernik's data indicated that the extent of agricultural and residential/urban land vs. forested land was the most significant parameter affecting the influx of nutrient from non-point sources. In the US, little or no correlation was found between nutrient levels and the percentage of land in wetlands, or range or cleared unproductive land. This is probably due to the masking effects of agricultural and forested land.

Use of a model which relates urban/residential and agricultural land use to nutrient levels seems appropriate where agricultural and/or forest make up the main land-use types.

The regression models for the eastern region of the US are as follows:

$$\text{Log } P = 1.8364 + 0.00971A + \sigma_P \text{ Log } 1.85 \quad (1)$$

$$\text{Log } N = 0.08557 + 0.00716A - 0.00227B + \sigma_N \text{ Lot } 1.51 \quad (2)$$

where:

P = Total phosphorus concentration - mg/1 as P

N = Total nitrogen concentration - mg/1 as N

A = Percent of watershed with agricultural plus urban land use

B = Percent of watershed with forest land use

σ_P = Total phosphorus residuals expressed in standard deviation units from the log mean residuals of Equation (1). Determined from Omernik (1977), Figure 25.

σ_N = Total nitrogen residuals expressed in standard deviation units from the log mean residuals of Equation (2). Determined from Omernik (1977), Figure 27.

1.85 = f, multiplicative standard error for Equation 1.

1.51 = f, multiplicative standard error for Equation (2).

The 67% confidence interval around the estimated phosphorus or nitrogen consideration can be calculated as shown below:

$$\text{Log } P_L = \text{Log } P \pm \text{Log } 1.85 \quad (3)$$

$$\text{Log } N_L = \text{Log } N \pm \text{Log } 1.51 \quad (4)$$

where:

P_L = Upper and lower values of the 67% phosphorus confidence limit - mg/l as P

The 67% confidence limit around the estimated phosphorus or nitrogen concentrations indicates that the model should be used for purposes of gross estimations only. The model does not account for any macro-watershed* features peculiar to the Study Area.

INVESTIGATION OF SEPTIC LEACHATE DISCHARGES INTO CROOKED LAKE AND PICKEREL LAKE, MICHIGAN

November, 1978

Prepared for

WAPORA, Inc.
Washington, D. C.

Prepared by

K-V Associates, Inc.
Falmouth, Massachusetts
January, 1979

TABLE OF CONTENTS

INTRODUCTION

Septic Leachate Plumes - Types and Characteristics

In porous soils, groundwater inflows frequently convey wastewaters from nearshore septic units through bottom sediments and into lake waters, causing attached algae growth and algal blooms. The lake shoreline is a particularly sensitive area since: 1) the groundwater depth is shallow, encouraging soil water saturation and anaerobic conditions; 2) septic units and leaching fields are frequently located close to the water's edge, allowing only a short distance for bacterial degradation and soil adsorption of potential contaminants; and 3) the recreational attractiveness of the lakeshore often induces temporary overcrowding of homes leading to hydraulically overloaded septic units. Rather than a passive release from lakeshore bottoms, groundwater plumes from nearby on-site treatment units actively emerge along shorelines, raising sediment nutrient levels and creating local elevated concentrations of nutrients (Kerfoot and Brainard, 1978). The contribution of nutrients from subsurface discharges of shoreline septic units has been estimated at 30 to 60 percent of the total nutrient load in certain New Hampshire lakes (LRPC, 1977).

Wastewater effluent contains a mixture of near UV fluorescent organics derived from whiteners, surfactants and natural degradation products which are persistent under the combined

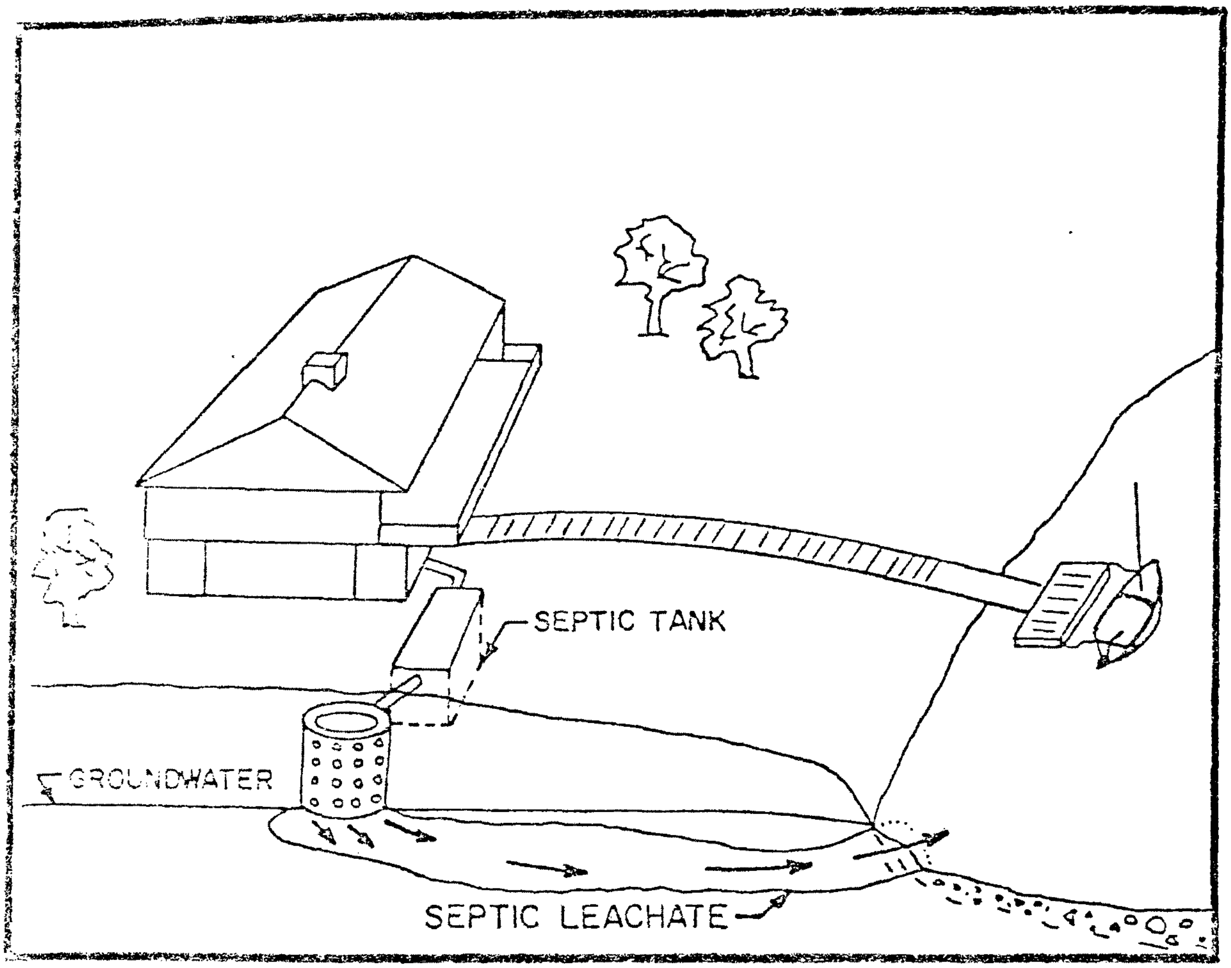


FIGURE 1. Excessive Loading of Septic Systems on Porous Soils Causes the Development of Plumes of Poorly-treated Effluent Which Move Laterally with Groundwater Flow and May Discharge Near the Shoreline of Nearby Lakes.

conditions of low oxygen and limited microbial activity. Figure 2 shows two samples of sand-filtered effluent from the Otis Air Force Base sewage treatment plant. One was analyzed immediately and the other after having sat in a darkened bottle for six months at 20°C. Note that little change in fluorescence was apparent, although during the aging process some narrowing of the fluorescent region did occur. The aged effluent percolating through sandy loam soil under anaerobic conditions reaches a stable ratio between the organic content and chlorides which are highly mobile anions. The stable ratio (cojoint signal) between fluorescence and conductivity allows ready detection of leachate plumes by their conservative tracers as an early warning of potential nutrient breakthroughs or public health problems.

The Septic Leachate Detector (ENDECO Type 2100 "Septic Snooper") consists of the subsurface probe, the water intake system, the analyzer control unit, and the graphic recorder (Figure 3). Initially the unit is calibrated against stepwise increases of wastewater effluent, of the type to be detected, added to the background lake water. The probe of the unit is then placed in the lake water along the shoreline. Groundwater seeping through the shoreline bottom is drawn into the subsurface intake of the probe and travels upwards to the analyzer unit. As it passes through the analyzer, separate conductivity and specific fluorescence signals are generated and sent to a signal processor which registers the separate signals on a

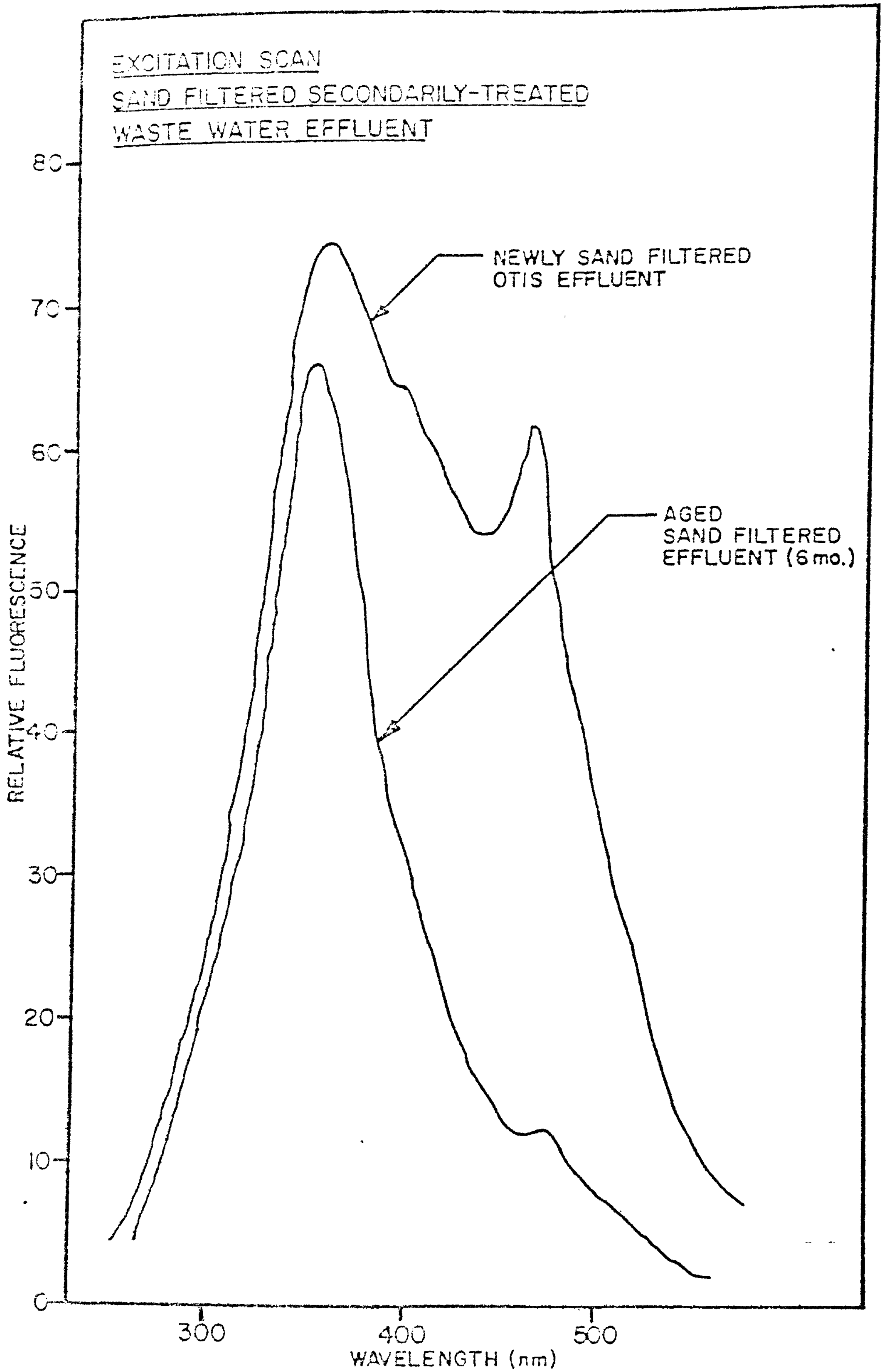
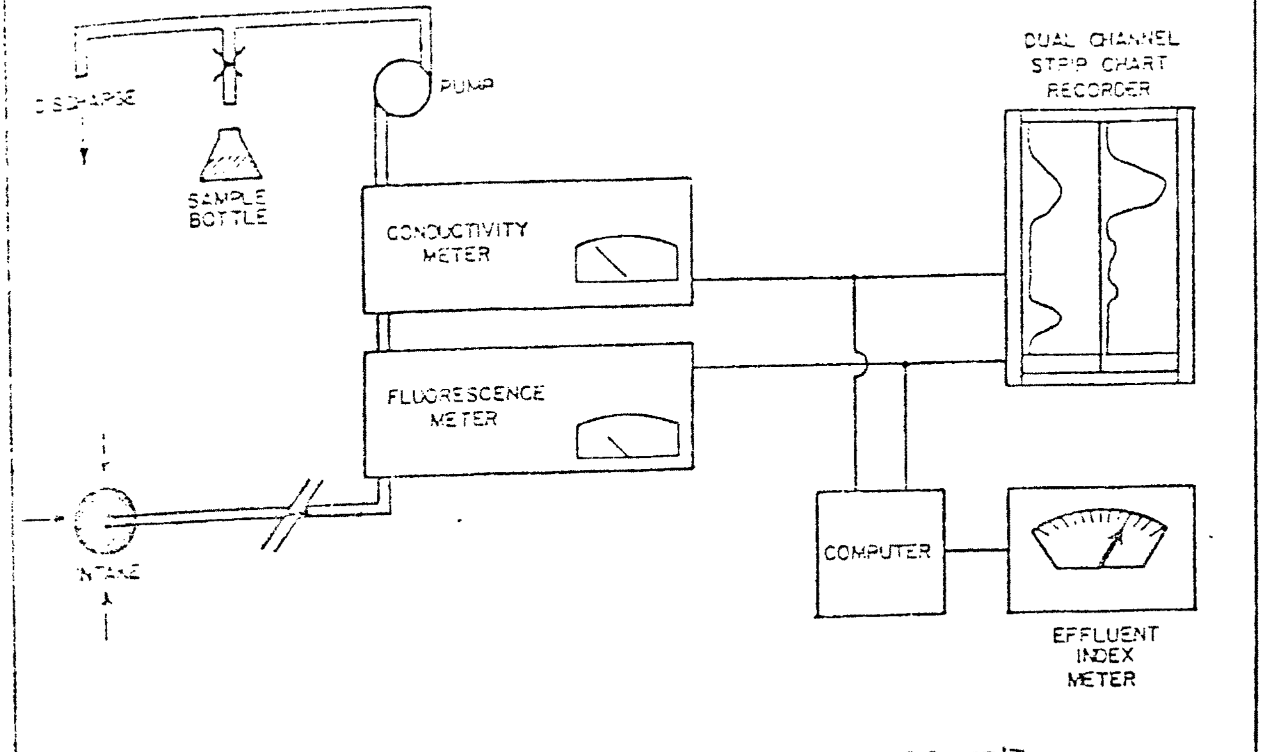


FIGURE 2. Sand-filtered Effluent Produces a Stable Fluorescent Signature, Here Shown Before and After Aging.



ENDECO® SEPTIC LEACHATE DETECTOR (SEPTIC SNOOPER™) SYSTEM DIAGRAM

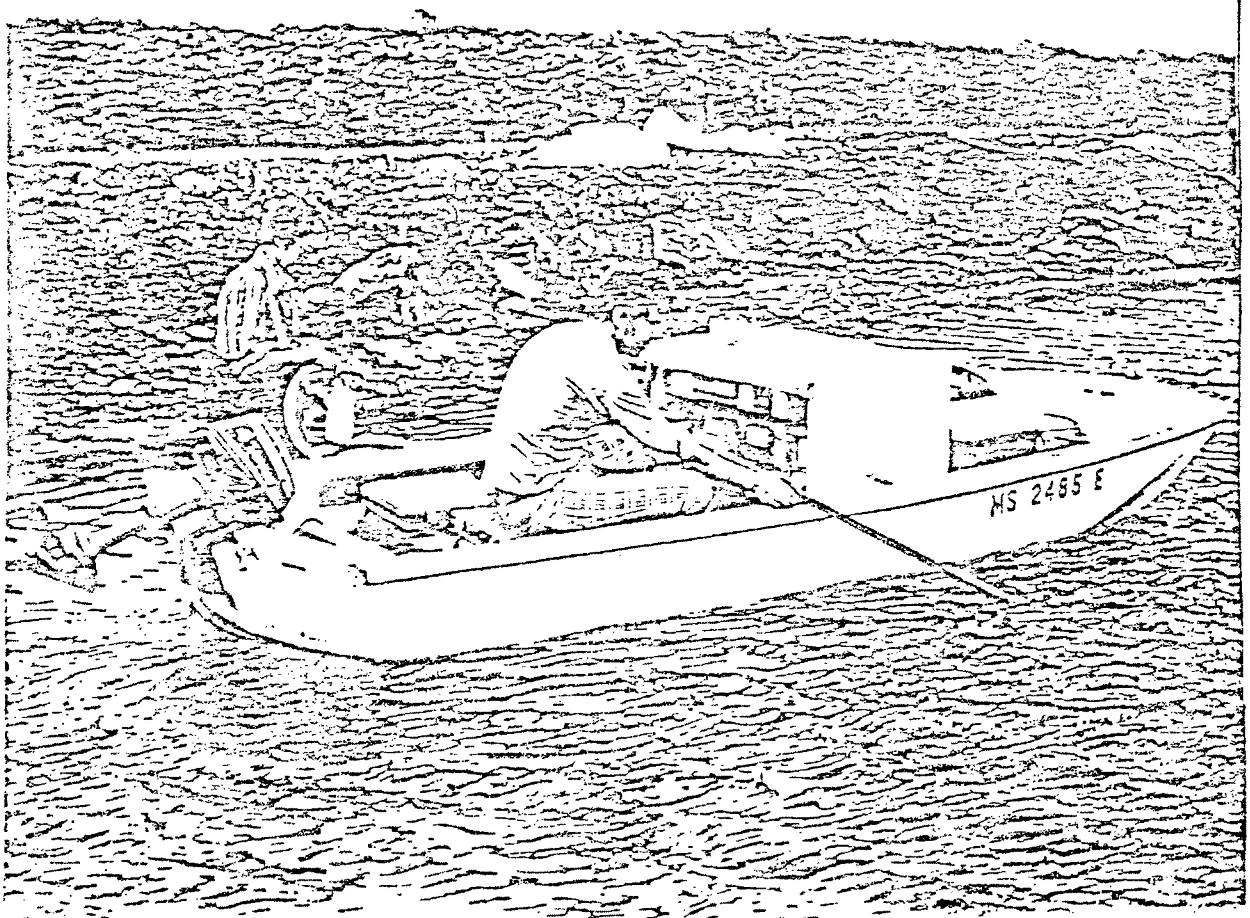


FIGURE 3. The Type 2100 "SEPTIC SNOOPER™" Consists of Combined Fluorometer/Conductivity Units Whose Signal is Adjusted to Fingerprint Effluent. The Unit is Mounted in a Boat and Piloted Along the Shoreline. Here the Probe is Shown in the Water with a Sample Being Taken at the Discharge of the Unit for Later Detailed Analysis.

strip chart recorder as the boat moves forward. The analyzed water is continuously discharged from the unit back into the receiving water.

Types of Plumes

The capillary-like structure of sandy porous soils and horizontal groundwater movement induces a fairly narrow plume from malfunctioning septic units. The point of discharge along the shoreline is often through a small area of lake bottom, commonly forming an oval-shaped area several meters wide when the septic unit is close to the shoreline. In denser subdivisions containing several overloaded units the discharges may overlap, forming a broader increase.

Three different types of groundwater-related wastewater plumes are commonly encountered during a septic leachate survey: A) erupting plumes, B) passive plumes, and C) stream source plumes. As the soil becomes saturated with dissolved solids and organics during the aging process of a leaching on-lot septic system, a breakthrough of organics occurs first, followed by inorganic penetration (principally chlorides, sodium, and other salts). The active emerging of the combined organic and inorganic residues into the shoreline lake water describes an erupting plume. In seasonal dwellings where wastewater loads vary in time, a plume may be apparent during late summer when shoreline cottages sustain heavy use, but retreat during winter during low flow conditions. Residual organics from the wastewater often still remain attached to soil particles in the vicinity of the previous erupting plume, slowly releasing into the shoreline waters. This dormant plume indicates a previous breakthrough, but sufficient treatment of the plume exists under current conditions so that no inorganic discharge is apparent. Stream source plumes refer to either groundwater leachings of nearstream septic leaching fields or direct pipe discharges into streams which then empty into the lake.

2.0 METHODOLOGY - SAMPLING AND ANALYSIS

Water sampling for nutrient concentrations along the shoreline are coordinated with the septic leachate profiling to clearly identify the source of effluent. The shoreline of Crooked/Pickerel Lake consists predominantly of sandy loam soils. A profile of the shoreline for emergent plumes was obtained by manually towing the septic leachate detector along the lee side of the shoreline in a 5 meter fiberglass rowboat. As water was drawn through the probe and through the detector, it was scanned for specific organics and inorganics common to septage leachate.

Whenever elevated concentrations of leachate were indicated on the continual chart recorder, a search was made of the area to pinpoint the location of maximum concentration. At that time 1) a surface water sample was taken from the discharge of the detector for later nutrient analysis, 2) an interstitial groundwater sample was taken with a hand-driven well-point sampler to a depth of .3 meter and 3) finally a surface water sample for bacterial content (total and fecal coliform) was also taken. The combination of the triple sampling served to identify the source of effluent. If the encountered plume originated from groundwater seepage, the concentration of nutrients would be considerably elevated in the well-point sample. If the source were surface effluent runoff, a low nutrient groundwater content would exist with an elevated bacterial content. If a stream source occurred, an isolated single plume would not be found during search, but instead a broadening plume traced back to a surface water inlet. Ground-water samples taken in the vicinity of the surface outflow would also not show as high a nutrient content as the surface water samples.

Water samples taken in the vicinity of the peak of plumes were analyzed by EPA Standard Methods for the following chemical constituents:

Conductivity (cond.)
Ammonia-nitrogen (NH_4-N)
Nitrate-nitrogen (NO_3^--N)
Total phosphorus (TP)
Orthophosphate phosphorus (PO_4-P)

A total of 29 water samples were obtained at locations of selected plumes for analysis. The samples were placed in polyethylene containers, chilled, and frozen for transport and storage. Conductivity was determined by a Beckman (Model RC-19) conductivity bridge, ammonium-nitrogen by phenolate method, nitrate-nitrogen by the brucine sulfate procedure, and orthophosphate-phosphorus and total phosphorus by the single reagent procedures following standard methods (EPA, 1975)

Water samples for bacterial analysis were placed in sterilized 150 ml glass containers obtained from the Emmet County Health Department and mailed to the Michigan Department of Public Health, Bureau of Laboratories at Grand Rapids for analysis. Analyses were performed for total coliform bacteria and fecal coliform by the membrane filter method.

3.0 PLUME LOCATIONS

Crooked and Pickerel Lakes are shallow recreational lakes in the northern tip of Michigan near Little Traverse Bay on Lake Michigan. Crooked Lake averages 3.05 m in depth and Pickerel Lake maintains a greater mean depth of 3.96 m. The elevation of both lakes is controlled by the locks of the inland waterway system. Prior to the period of the survey, November 18 to 23, the elevation of the lakes was lowered approximately one meter to lessen shoreline winter ice damage. Poorly drained, nearly level organic and sandy soils dominate the shoreline areas of the two lakes. With the low relief of the shore, it was not unusual to encounter only one meter depths at distances over 50 meters out from shore.

A total of 51 plumes were observed along the accessible southern shore of Crooked Lake and the Pickerel Lake shoreline (Figure 4). Solid circles indicate erupting plumes, open circles are dormant plumes, and solid squares represent stream source plumes. A line is drawn from each symbol to the location along the shoreline where the plume was encountered. The highest plume concentration per shoreline length was observed in Pickerel Lake in the vicinity of Ellsworth Point and Botsford Landing. While 11 plumes are indicated in the Ellsworth Point region, the broader signals may represent composites of leachate from nearby fields and not entirely individual sources. Many were remarkable by the distance from shore at which they could still be detected. Near Botsford Landing, an individual plume was still detectable 50 m from the shoreline. Occassionally doublet plumes were observed which may evidence double drainage fields oriented parallel to the groundwater flow towards the lake. One such noticeable peak occurred on the approach to Botsford Landing.

Only 7 dormant plumes (organic signal only), often indicative of seasonal loading, were found. Most of these (5) were found on the north shore of Pickerel Lake.

A broad discharge of bog leachate was emitted from an extensive region of hardwood forest on Carbondale muck soils into Pickerel Lake (Figure 4). The outflow of water had occassional sufficient upflow through the bottom sediments to fluidize the sandy loam and create "soft" spots into which a leg could easily sink. Although fluorescent, the organic discharge was easily characterized by its different spectral emission, its reduced conductance of 150 µmhos, and low nutrient content.

Beginning with the Ellsworth Point region and continuing along the remaining expanse of shoreline, particularly on the southern and eastern shores, a high ratio of plumes to housing units was apparent. Sanitary surveys of the southern shore of Crooked Lake and periphery of Pickerel Lake have described severe soil and groundwater limitations for septic tank disposal fields within 100 meters of the shoreline. Depth to seasonal high groundwater is 0 - 2 feet for all lots on Crooked Lake within the survey area east of segment 19 (Figure 5). Only 19 lots in Pickerel Lake were identified with depth to seasonal groundwater greater than 1.3 m (4 ft.). The soils are poorly or somewhat poorly drained with a seasonal high groundwater table, rapid moderate and moderately slow permeability (USDA, 1973).

A low density of plumes was observed around the periphery of Oden Island despite the unsuitable soils condition. As an island, the area may have very low rates of groundwater flow since recharge would be restricted to rainfall received by the island area. The reduction of groundwater drainage rates may reduce the breakthrough of plumes from the leaching fields.

Certain shorelines were not included in the continuous transects due to heavy ice formation during the latter days of the survey. Sampling through ice holes placed from 3 to 6 meters from shoreline along the Henry-Channel region revealed noticeable quantities of effluent in the lakewater under the ice (Figure 7). Analysis of the nutrient content of all samples showed a significant correlation between plume strength and soluble phosphorus, clearly indicating that plume emergence is affecting the quality of surface water.

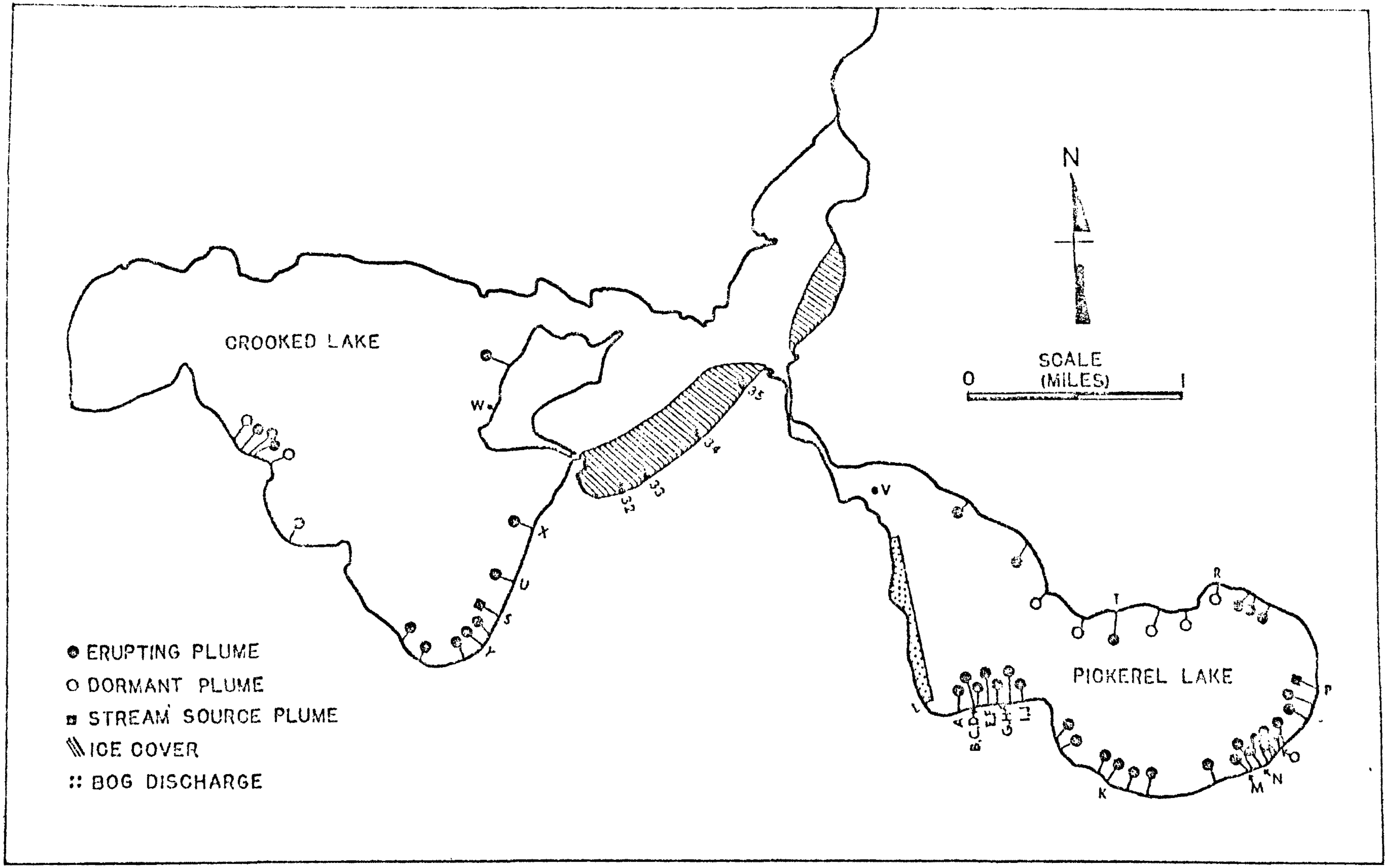


Figure 4. Plume locations on Crooked Lake and Pickerel Lake.

4.0 NUTRIENT ANALYSES

Completed analyses of the chemical content of 28 samples taken along the Crooked/Pickerel Lakes shoreline are presented in Table 1. The sample letters refer to the locations given in Figure 4. The symbol "S" refers to surface water sample and the symbol "G" to groundwater sample. Freezing temperatures limited the groundwater samples to only four. Air temperatures of 20°-25°F would freeze the samples in the stainless steel well-point before the sample could be transferred to a receiving flask.

The conductivity of the water samples as conductance (μmhos/cm) is given in the second column. The nutrient analyses for orthophosphorus (PO_4-P), total phosphorus (TP), ammonium-nitrogen (NH_4-N), and nitrate-nitrogen (NO_3-N) are presented in the next four columns in parts-per-million (ppm - mg/l).

Table 1. Analysis of surface water (S) and groundwater (G) samples taken in the vicinity of wastewater leachate plumes observed on the Crooked/Pickerel Lake shoreline.

Sample Number		Cond.	Concentration (ppm - mg/l) PO_4-P	TP	NH_4-N	NO_3-N	Ratio C	P	N	Breakthrough Efficiency P	N
A	S	410	.009	.012	.024	.080					
B	S	360	.002	.005	.014	.162					
C	G	400	.010	.028	.209	.008	- - -	- - -	- - -	- - -	- - -
D	algae and sediment core										
E	S	350	.005	.007	.023	.062					
F	G	465	.029	.031	.224	.006	65	.03	.22	2%	7%
G	S	350	.003	.007	.020	.041					
H	G	513	.133	.215	.806	.008	113	.210	.80	10%	14%
I	S	(lost in transit - cracked)									
J	G	500	.179	.567	1.646	.016	100	.567	1.6	28%	32%
K	S	310	.001	.008	.025	.234					
L*	S	150	.0003	.005	.023	.053					
M	S	392	.002	.003	.013	.347					
N	S	270	.001	.004	.218	.270					
O	S	290	.001	.010	.057	.210					
P	S	295	.002	.006	.021	.304					
Q	no sample										
R	S	285	.001	.016	.021	.113					
S	S	300	.001	.007	.030	.415					
T	S	288	.002	.007	.035	.095					
U	S	300	.002	.006	.042	.234					
V	S	370	-	.018	.178	-					
W	S	345	.002	.004	.014	.115					
X	S	420	-	.607	.287	-					

(continued next page)

Table 1. (continued)

Sample Number		Cond.	Concentration (ppm - mg/l) PO_4-P	TP	NH_4-N	NO_3-N	Ratio C	P	N	Breakthrough Efficiency P	N
Y	S	405	.002	.005	.014	.162					
32	S	469	.007	.009	.021	.115					
33	S	418	.003	.004	.016	.120					
34	S	411	.004	.005	.018	.124					
35	S	435	.002	.004	.019	.134					
Background concentration (G)		400		.004	.014	.010					
Effluent (lagoon)**		167	.121	1.930	4.148	.267					
Local effluent							+400	+8	+20		
Surface water influence							NH_4-N + NO_3-N				
Corr. coeff. (r) cond. as X			.64	.23	.05	-.13	.20				
z value at $3\sigma_z$			.758±.75								
significance			sig.	insig.	insig.	insig.	insig.				

* bog

** apparently diluted by rainfall

5.0 NUTRIENT RELATIONSHIPS

By the use of a few calculations, the characteristics of the wastewater plumes can be described. Firstly, a general background concentration for conductance and nutrients is determined. The concentration of nutrients found in the plume is then compared to the background and to wastewater effluent from the lake region to determine the percent breakthrough of phosphorus and nitrogen to the lake water. Because the well-point sampler does not always intercept the center of the plume, the nutrient content of the plume is always partially diluted by surrounding ambient background groundwater or seeping lake-water concentrations. To correct for the uncertainty of location of withdrawal of the groundwater plume sample, the nutrient concentrations above background values found with the groundwater plume are corrected to the assumed undiluted concentration anticipated in standard sand-filtered effluent and then divided by the nutrient content of raw effluent. Computational formulae can be expressed:

for the difference between background (C_o) and observed (C_i) values:

$C_i - C_o = \Delta C_i$	conductance
$TP_i - TP_o = \Delta TP_i$	total phosphorus
$TN_i - TN_o = \Delta N_i$	total nitrogen (here sum of NO_3-N and NH_4-N)

for attenuation during soil passage:

$$\left(\frac{\Delta C_{ef}}{\Delta C_i}\right)\frac{\Delta P_i}{\Delta P_{ef}} = \%\text{ breakthrough of phosphorus}$$

$$\left(\frac{\Delta C_{ef}}{\Delta C_i}\right)\frac{\Delta N_i}{\Delta N_{ef}} = \%\text{ breakthrough of nitrogen}$$

where C_o = conductance of background groundwater (μmhos/cm)

C_i = conductance of observed plume groundwater (μmhos/cm)

ΔC_{ef} = conductance of sand-filtered effluent minus the background conductance of municipal source water (μmhos/cm)

TP_o = total phosphorus in background groundwater (ppm - mg/l)

TP_i = total phosphorus of observed plume groundwater (ppm - mg/l)

TN_o = total nitrogen content of background groundwater, here calculated as NO_3-N + NH_4-N (ppm - mg/l)

TN_i = total nitrogen content of observed plume groundwater, here calculated as NO_3-N + NH_4-N (ppm - mg/l)

5.1 Assumed Wastewater Characteristics

Local samples of effluent obtained at the Benzonia County and Emmet County sewage treatment plants exhibited a conductance : total phosphorus : total nitrogen ratio of 700:8:20; subtracting the background lake water concentration of 300 μmhos/cm gives a ΔC:ΔTP:ΔTN ratio of 400:8:20 representing the change in concentration to source water by household use in the Crooked/Pickerel Lakes region. Of note, the addition of total dissolved solids (as indicated by ΔC) tends to be higher than soft water regions which often show a $\Delta C:\Delta TP:\Delta TN$ ratio of 200:8:20 (Kerfoot and Brainard, 1978; Kerfoot, et. al., 1976). The common use of water softeners in the hard water areas may be a partial contributing factor.

5.2 Assumed Background Levels

Little information exists on background groundwater concentrations in the Crooked/Pickerel Lake area. Generally, the interstitial lake bottom groundwater tended to be slightly higher in dissolved solids and therefore conductance, than the raw lake water. Sample W which was taken away from plume regions exhibited a conductance of 345 μmhos/cm compared to 300 μmhos/cm for normal lake water in the Pickerel Lake region. Surface water samples taken near ice or under ice in Crooked Lake showed a conductance over 400 μmhos/cm. All samples exhibited elevated ammonia nitrogen levels, presumably due to water-logged soils with organic content which promotes reducing conditions. The total phosphorus content of sample W was low at .004 mg/l, although all groundwater plume samples taken had elevated phosphorus levels, again indicative of lessened binding under the more acid soil substrate and chemically reducing conditions. Nitrate-nitrogen values were quite variable and the average background for groundwater samples was found to be about .010 ppm.

Table 2. Background groundwater levels for chemical constituents in interstitial water of Crooked/Pickerel Lake sediments.

Constituent	Cond. (μmhos/cm)	Nutrient Conc. (mg/l) TP	NH_4-N	NO_3-N
Value	400	.004	.014	.010

5.3 Attenuation of Nitrogen Compounds

On the basis of observed ratios of total nitrogen found in the limited sampled groundwater plumes, breakthrough of nitrogen content ranged from a high of 32% to a low of 7% of that expected from the typical effluent (Table 1). A mean of 18% penetration was observed based upon the three samples with sufficiently high conductance for meaningful analysis. The dominant nitrogen species was NH_4-N, consistent with water-logged, saturated soils.

5.4 Attenuation of Phosphorus Compounds

Similarly, analysis of the observed ratios of total phosphorus found in groundwater plumes indicated a high of 28% and a low of 2% breakthrough of phosphorus content. A mean penetration of 13% was calculated from the observed groundwater samples. A regression analysis was performed to indicate if any positive correlation existed between the strength of plumes, as indicated by absolute conductance, and the presence of nutrient species. Correlation coefficients (r) calculated for conductance and orthophosphorus, total phosphorus, NH_4-N, NO_3-N and combined NH_4-N and NO_3-N were, respectively, .64, .23, .05, -.13, and .20. A noticeable correlation between soluble orthophosphorus (inorganic P) and plume strength, significant at the $3\sigma_z$ level, indicated that plume emergence was having a detectable effect on lake surface water phosphorus concentrations.

6.0 COLIFORM LEVELS IN SURFACE WATERS

A series of water samples were analysed for total and fecal coliform content (Table 3) to determine the contribution of septic leachate plumes to bacterial content. Crooked/Pickerel Lake is considered a recreational lake with surface waters classified for total body contact recreation. The Michigan Water Resources Commission has stated that fecal coliforms shall not exceed 200 organisms per 100 ml in five or more consecutive samples. Although source is indicated, all are surface water samples.

Table 3. Bacterial content of plumes.

Location	Type of Plume	Coliform Content (#/100 ml) Total	Fecal
E	Groundwater	100	<10
I	Groundwater	<100	<10
K	Groundwater	600	<10
L	Groundwater	900	<10
M	Groundwater	100	<10
N	Groundwater	200	<10
O	Groundwater	200	<10
P	Surface water (Berry Creek)	200	<10
Q	Groundwater	1100	<10
S	Surface water (Minne Creek)	<100	<10
T	Groundwater	<100	<10
U	Groundwater	<100	<10
V	Background	100	<10

No samples were found in excess of the State standards for recreational water use. Previous water testing has consistently shown no apparent penetration of bacteria from plumes passing through medium sandy soil (Kerfoot and Brainard, 1978).

7.0 RELATIONSHIP OF ATTACHED PLANT GROWTH TO PLUMES

A Crooked/Pickerel Lakes sanitary survey conducted by the University of Michigan Biological Station (UMBS, 1978) included a visual observation of the shoreline area for *Cladophora*, a microscopic, bright green filamentous algae which often forms dense patches of growth in the presence of high nutrients. The *Cladophora* study revealed a high correlation between *Cladophora* growth and residents who use water excessively, residents who feed waterfowl and residents who do not maintain their septic systems by cleaning them at least every eight years.

On-site inspections and questions about performance and history of the sewage treatment systems established that 38% of those on Pickerel Lake had a history of problems such as ponding of effluent, backing up, odor, etc. (UMBS, 1978). Approximately 54% of the residences on Crooked/Pickerel Lakes which had suitable *Cladophora* substrates in the beach shoreline area had algae growth. On Pickerel Lake, 52% of lots which have *Cladophora* growth are closer than the existing 50-foot separation of distance in the Michigan State Sanitary Code. No significant correlation existed between *Cladophora* growth and whether the residence was year-round or seasonal.

The relationship between the nutrient loading per shoreline area, estimated from plume emergence, and that of *Cladophora* occurrence is presented in Table 4. The plume frequency is divided into different segments along the shoreline shown in Figure 6. Plumes were observed associated with a mean of 29% (1/3) of the shoreline housing units, a rather high percentage. The nutrient loading per segment was computed using the mean observed frequency of breakthrough of N and P observed for the average plume times a per-swelling loading of 9.1 kg/yr N and 3.6 kg/yr P. In segments 3 through 6, 10 through 12, 14, and 16 where the projected phosphorus loading exceeded 2.4 kg/yr/mi, a substantial number of lots experienced *Cladophora* growth. The *Cladophora* patches approached carpet-like thickness in segment 16, indicative of a high rate of nutrient input. The limited groundwater samples taken in the area showed substantially elevated phosphorus levels with mean concentrations of .088 soluble phosphorus (PO_4-P) and .210 total phosphorus (TP). In addition, a significant correlation existed between plume strength indicated by conductance recorded by the septic leachate detector and soluble phosphorus in the overlying surface water.

The poor soil conditions, aided by (a) excessive water use which increases flow rate and reduces residence time in the soil column and (b) the closeness of drainage fields to the shoreline area, results in the groundwater transport via subsurface plumes from individual septic units of sufficient nutrient loads to sustain *Cladophora* growths along the shoreline where suitable substrate exists.

Table 4. Calculated phosphorus loading per shoreline length based upon observed frequency of plumes and % breakthrough of nutrients.

Segment	Housing Units (R)	# of Major Plumes (P)	Frequency (%)	Nutrient Loading (kg/yr) P	Nutrient Loading (kg/yr) N	Approx. Shoreline Length (mi)	P Loading/ Shoreline Length (kg/yr/mi)	Recorded Lots with Cladophora (UMBS, 1978)
1	3	0	0	0	1.6	.5	0	1?
2	3	2	67	.9	3.3	1.0	.9	0
3	10	3	30	1.4	4.9	.3	4.7 }	
4	10	3	30	1.4	4.9	1.1	1.3 }	14
6	28	+	?	-	-	.9	+ }	
5	18	1	6	.5	1.6	1.0	.5	5
7	4	-	-	-	-	.7		-
8	5	-	-	-	-	.4	-	-
9	0	0	-	0	0	.7	0	-
10	15	3	20	1.4	4.9	.6	2.3 }	
11	14	4	29	1.9	6.6	.8	2.4 }	6
12	16	4	25	1.9	6.6	.6	3.2 }	
13	14	2	14	.9	3.3	.5	1.8	-
14	34	9	26	4.2	15.8	.5	8.4	4
15	3	3	100	1.4	4.9	.6	2.3	-
16	61	11*	18	5.2	18.0	.9	5.7	13
17	3	1	33	.5	1.6	1.3	.4	0
18	4	1	25	.5	1.6	.5	1.0	1?
19	37	5	14	2.4	8.2	.8	3.0	-

*some may be composite scans

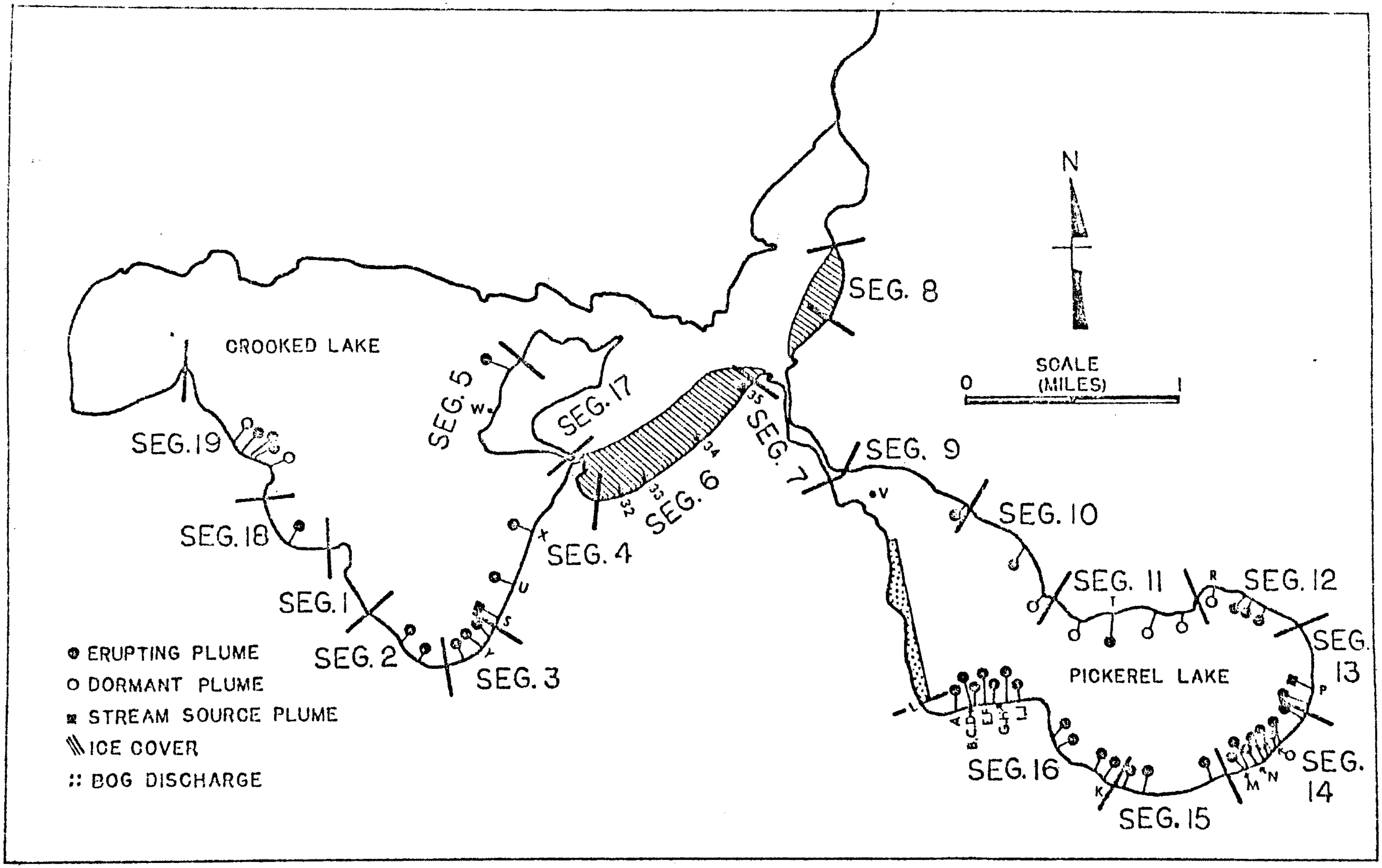


Figure 5. Segmentation of Crooked Lake and Pickerel Lake shorelines for nutrient loading.

8.0 CONCLUSIONS

A septic leachate survey was conducted along the south shore of Crooked Lake and the entire shoreline of Pickerel Lake during November, 1978. The following observations were obtained from the shoreline profiles, analyses of groundwater and surface water samples, evaluation of groundwater flow patterns, and comparison of attached algae growth with plume location:

1. Over 51 groundwater plumes of wastewater origin were observed along the accessible southern shore of Crooked Lake and the Pickerel Lake shoreline.

2. A high mean frequency of 29% of the residential units surveyed exhibited shoreline plumes. The highest density of plumes per shoreline length were found in the regions of Ellsworth Point, Botsford Landing and Henry-Channel Roads.

3. A high correlation existed between the location of emergence of plumes and attached algae growth, particularly Cladophora. Groundwaters obtained near peak concentrations of the outflow of the observed plumes contained sufficient nutrients to support attached algae and aquatic weed growth.

4. Poor removal of phosphorus and nitrogen in the wastewater occurs during passage through the shoreline soils. An observed mean breakthrough of phosphorus was 13% and nitrogen, principally in the ammonium form, was 18%.

5. A noticeable correlation between soluble orthophosphorus (inorganic P) and plume strength, significant at the $3\sigma_z$ level, indicated that plume emergence was having a detectable effect on lake surface water phosphorus concentrations.

6. No bacterial samples were found in excess of State standards for recreational use, indicating no apparent surface overflows of shoreline septic units.

REFERENCES

EPA, 1975. Methods for chemical analysis of water and wastes. Environmental Protection Agency, NERC, Analytical Control Laboratory, Cincinnati, Ohio 45268.

Kerfoot, W. B., B. H. Ketchum, P. Kallio, P. Bowker, A. Mann, and C. Scolieri, 1976. Cape Cod waste water renovation and retrieval system - a study of water treatment and conservation, Technical Report WHOI-76-5, Woods Hole Oceanographic Institution, Woods Hole, MA.

Kerfoot, W. B. and E. C. Brainard, 1978. Septic leachate detection - a technological breakthrough for shoreline on-lot system performance evaluation. In: State of Knowledge in Land Treatment of Wastewater, H. L. McKim (ed.) International Symposium at the Cold Regions Research and Engineering Laboratory, Hanover, New Hampshire.

LRPC, 1977. Discussion of nutrient retnetion coefficients, Draft Report 6F2 from Phase II Nonpoint Source Pollution Control Program, Lakes Region Planning Commission, Meredith, New Hampshire.

UMBS, 1978. Sanitary systems of Crooked and Pickerel Lakes, Emmet County, Michigan: an on-site survey. Technical report to the USEPA, Water Division Region V. Prepared by the Biological Station, University of Michigan, Pellston, Michigan.

USDA, 1973. Soil survey of Emmet County, Michigan. United States Department of Agriculture, Soil Conservation Service and Michigan Agrecultural Experiment Station. Soil Conservation Service, U.S.D.A., Washington, D.C. 20250

APPENDIX

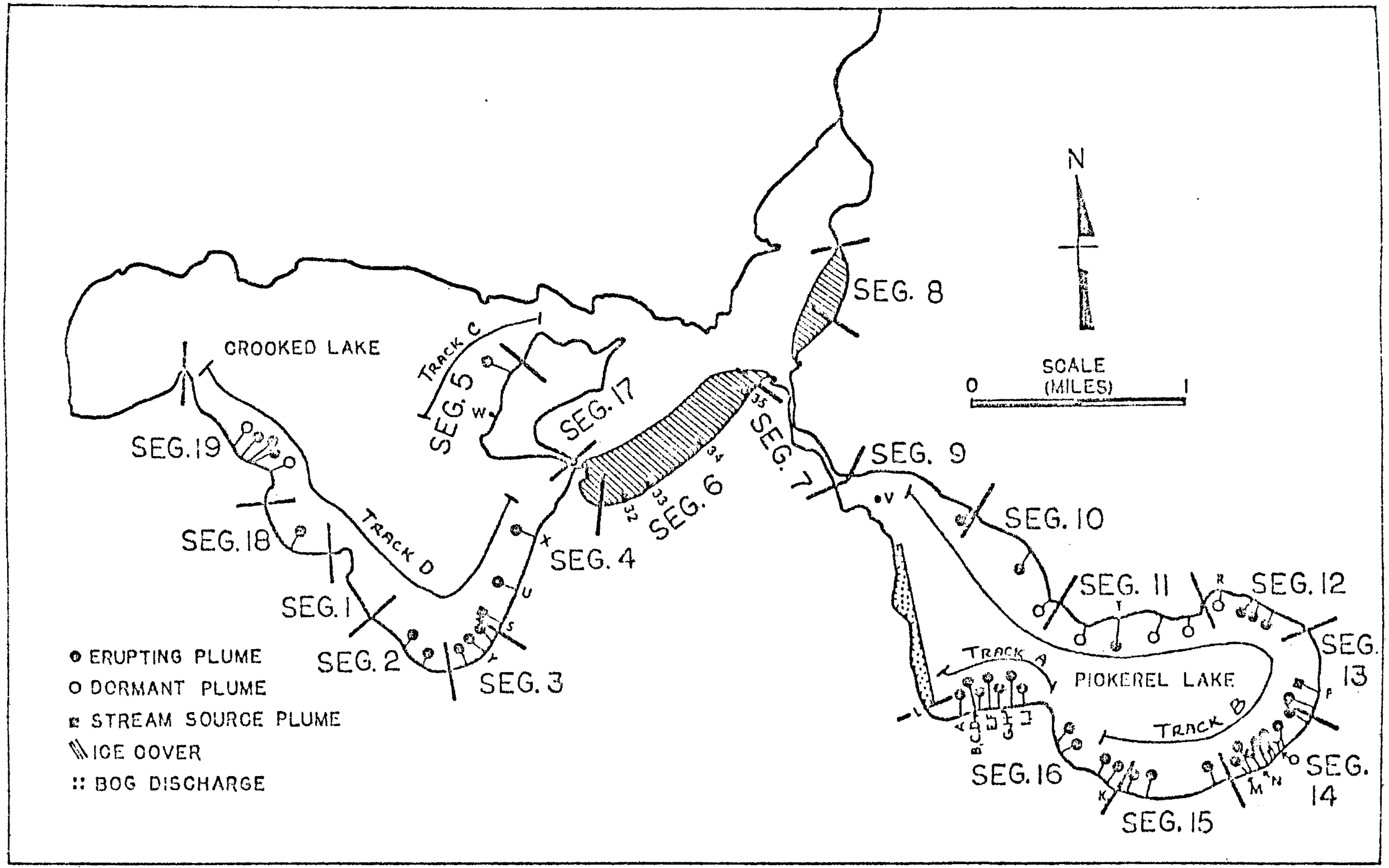
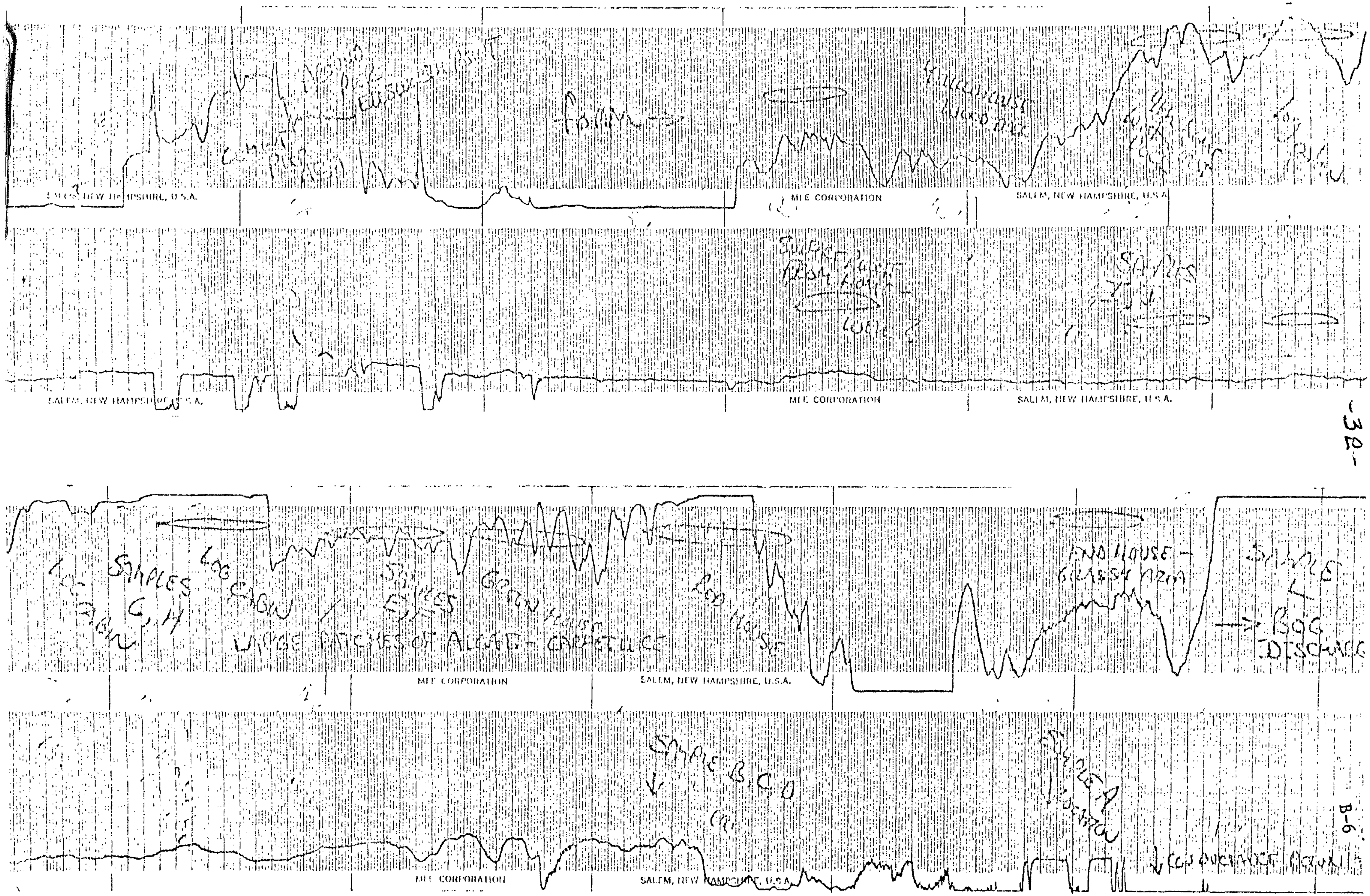


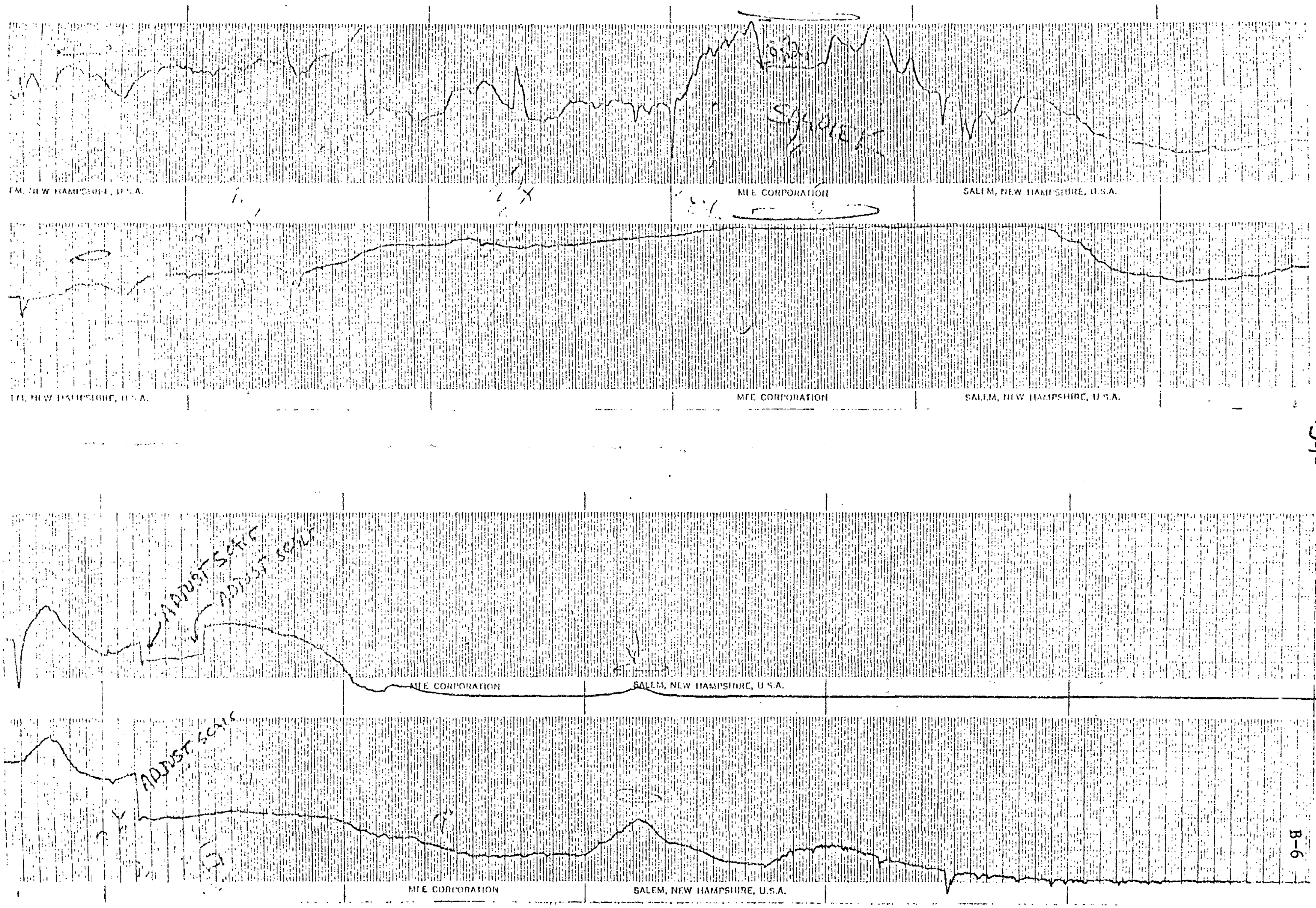
Figure 6. Sampling tracks.

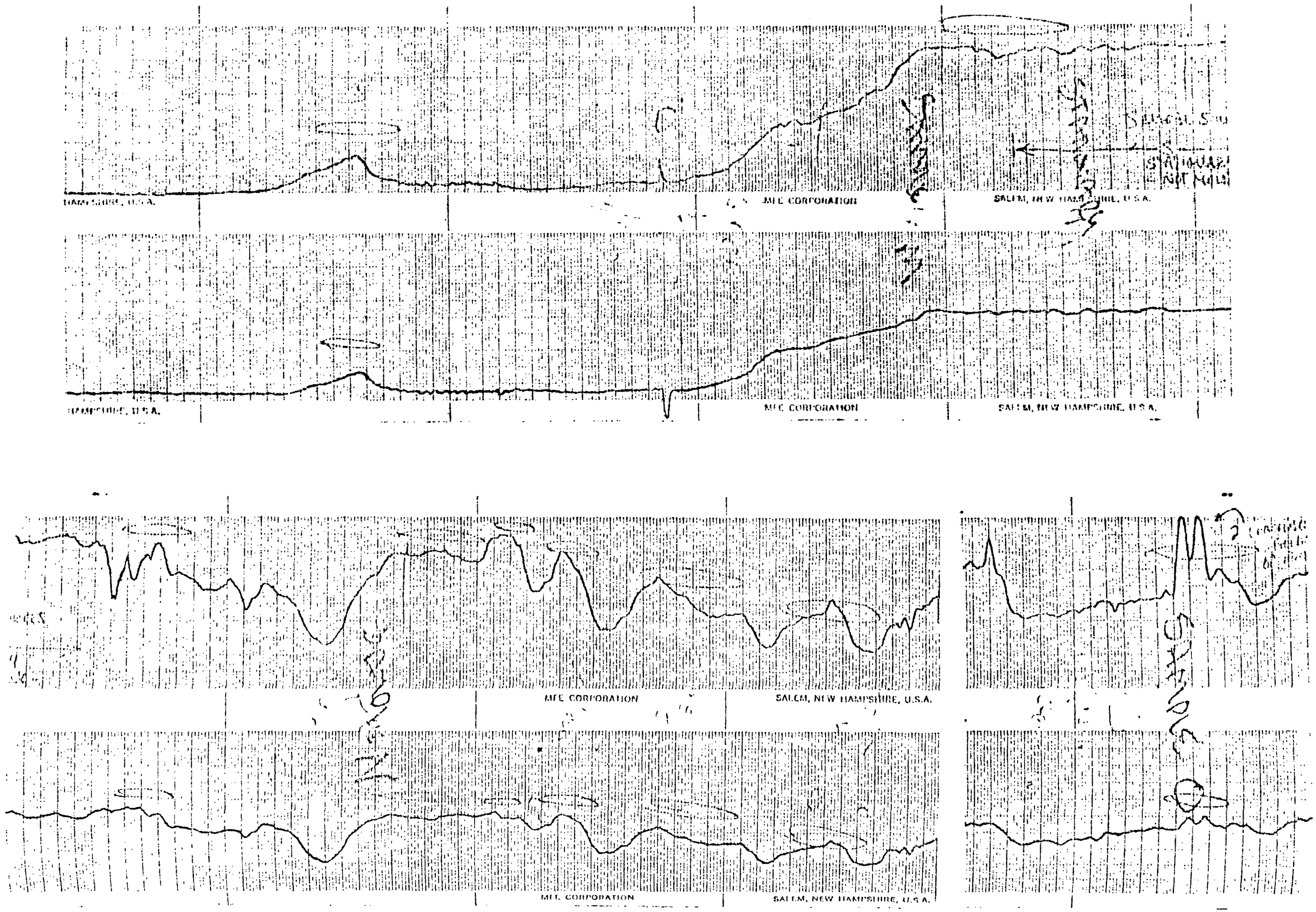
Track A
Segment 16

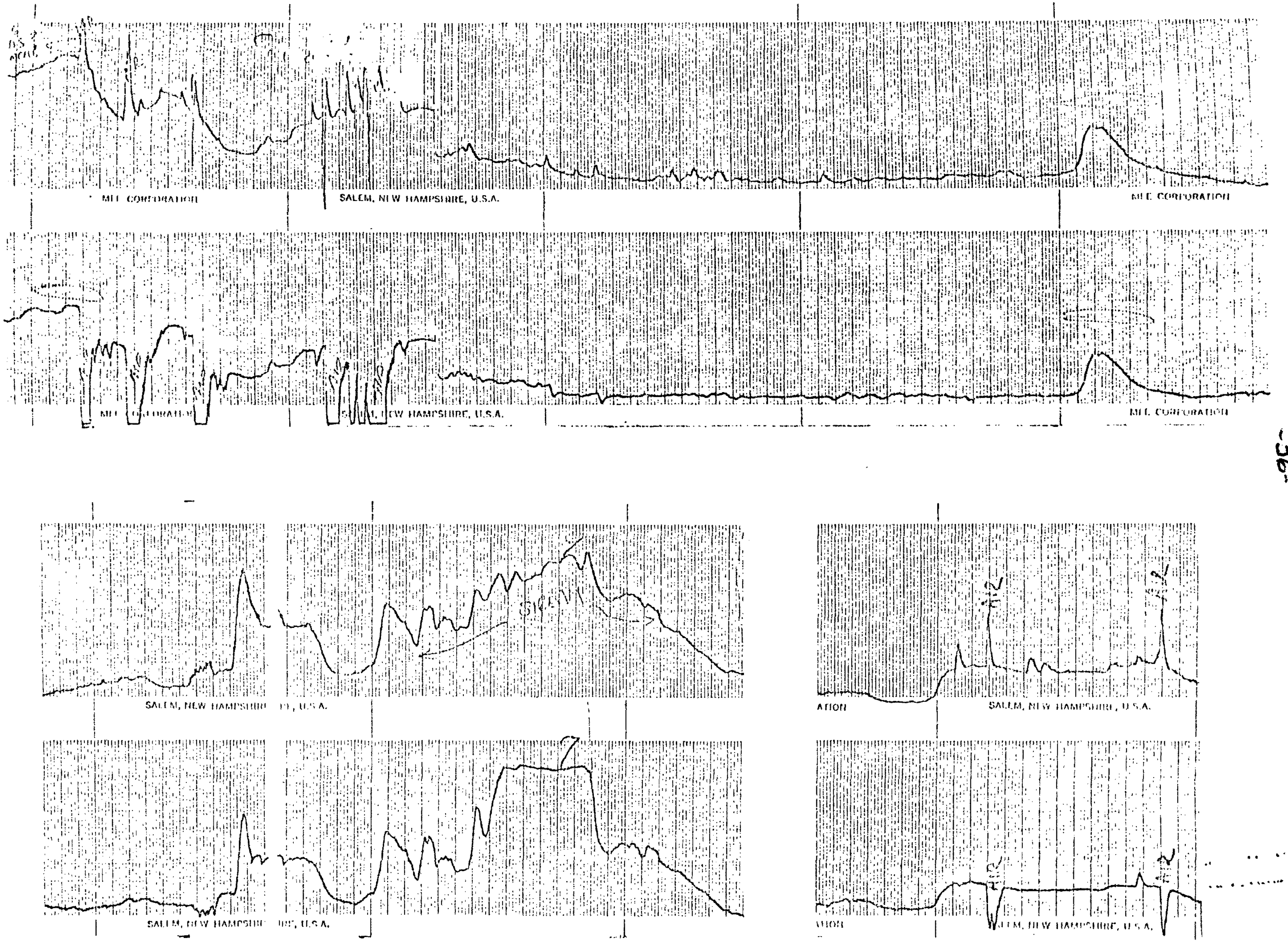

SALEM, NEW HAMPSHIRE, U.S.A.
MFE CORPORATION
SAMPLES G, H
LARGE PATCHES OF ALGAE
SAMPLE B, C, D
BOG DISCHARGE

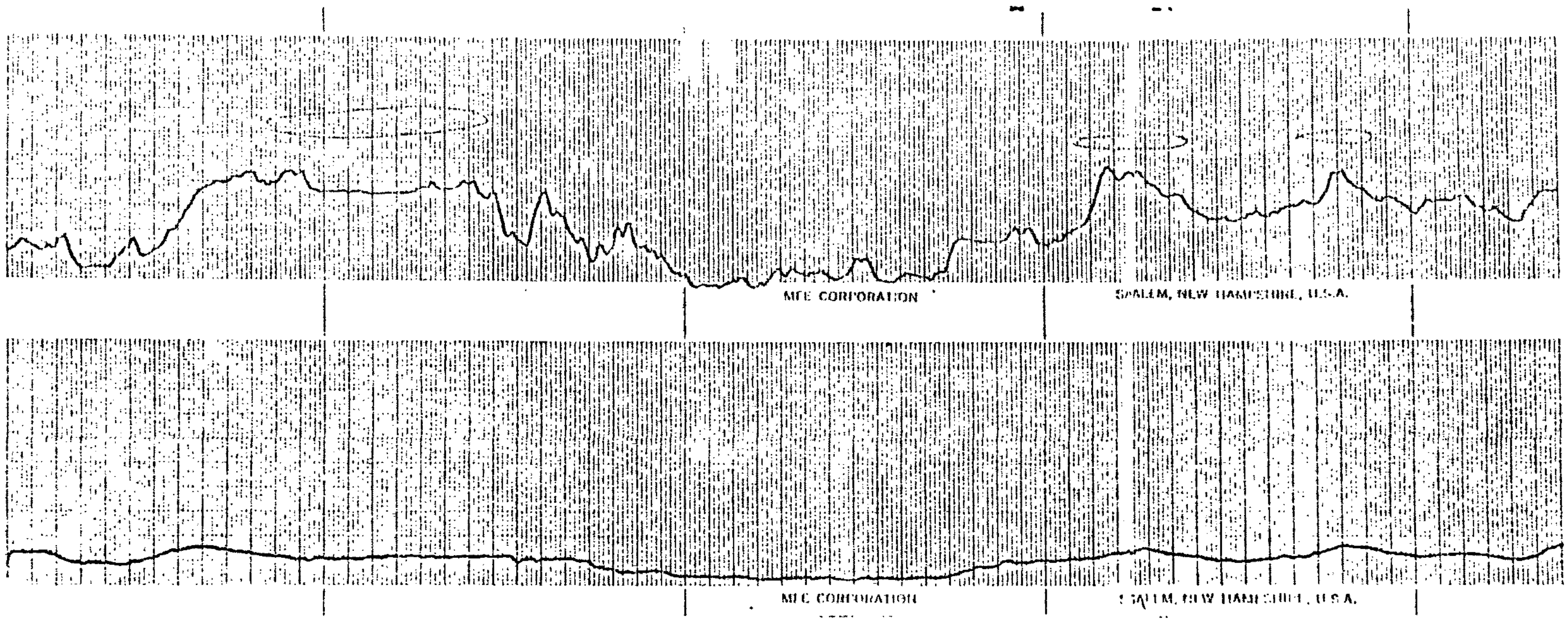
B-6

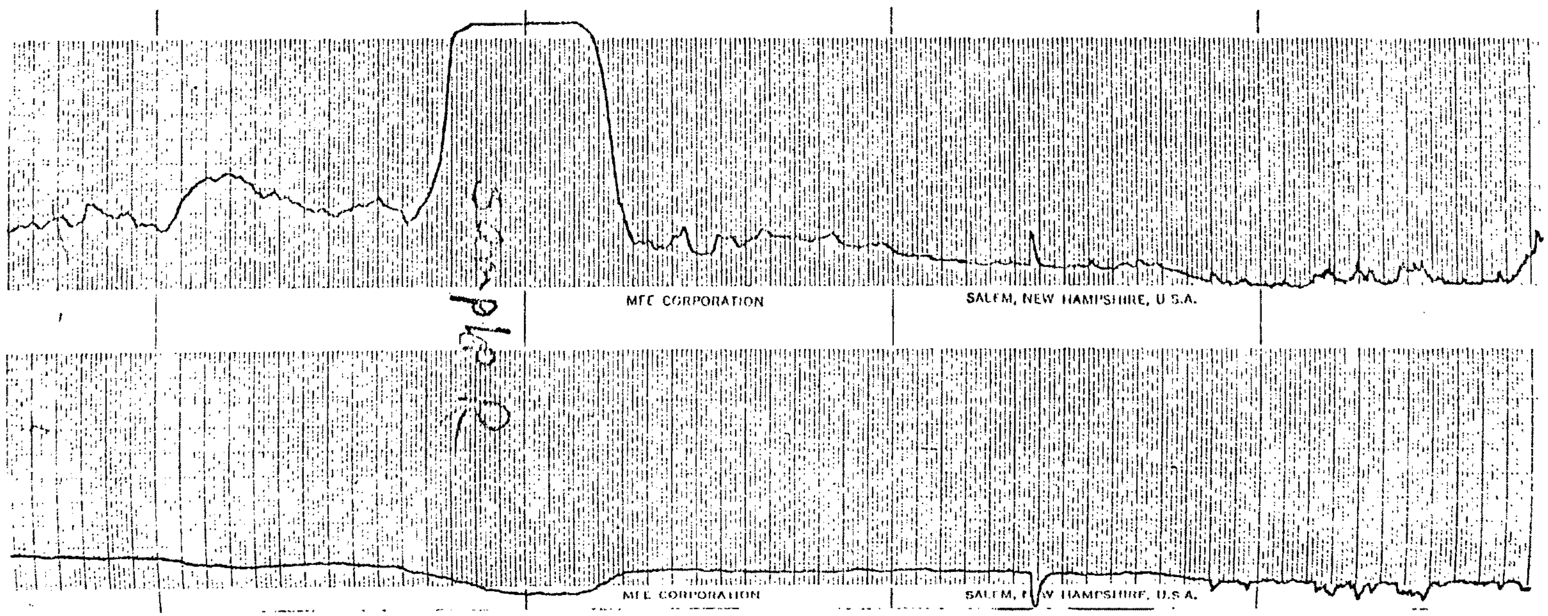
Track B
Segments 9, 10, 11, 12, 13, 14, 15

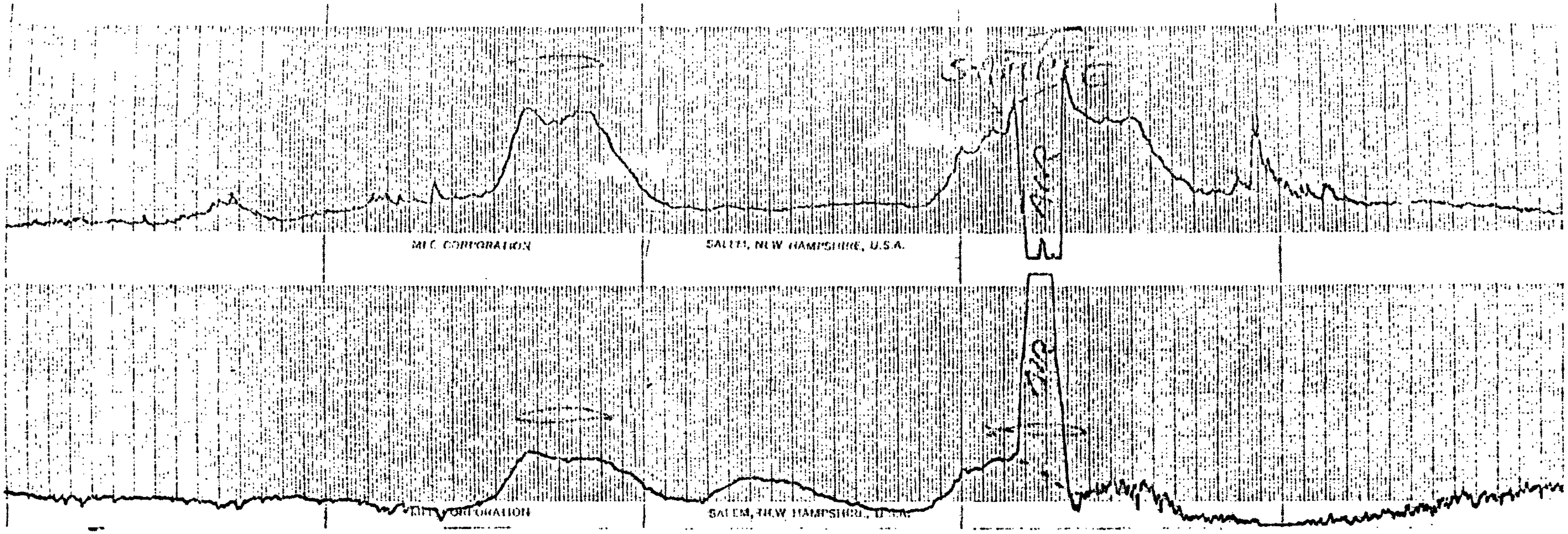

MFE CORPORATION
SALEM, NEW HAMPSHIRE, U.S.A.
MFE CORPORATION
SALEM, NEW HAMPSHIRE, U.S.A.
ADJUST SCALE
ADJUST SCALE
MFE CORPORATION
SALEM, NEW HAMPSHIRE, U.S.A.
ADJUST SCALE
MFE CORPORATION
SALEM, NEW HAMPSHIRE, U.S.A.
B-6

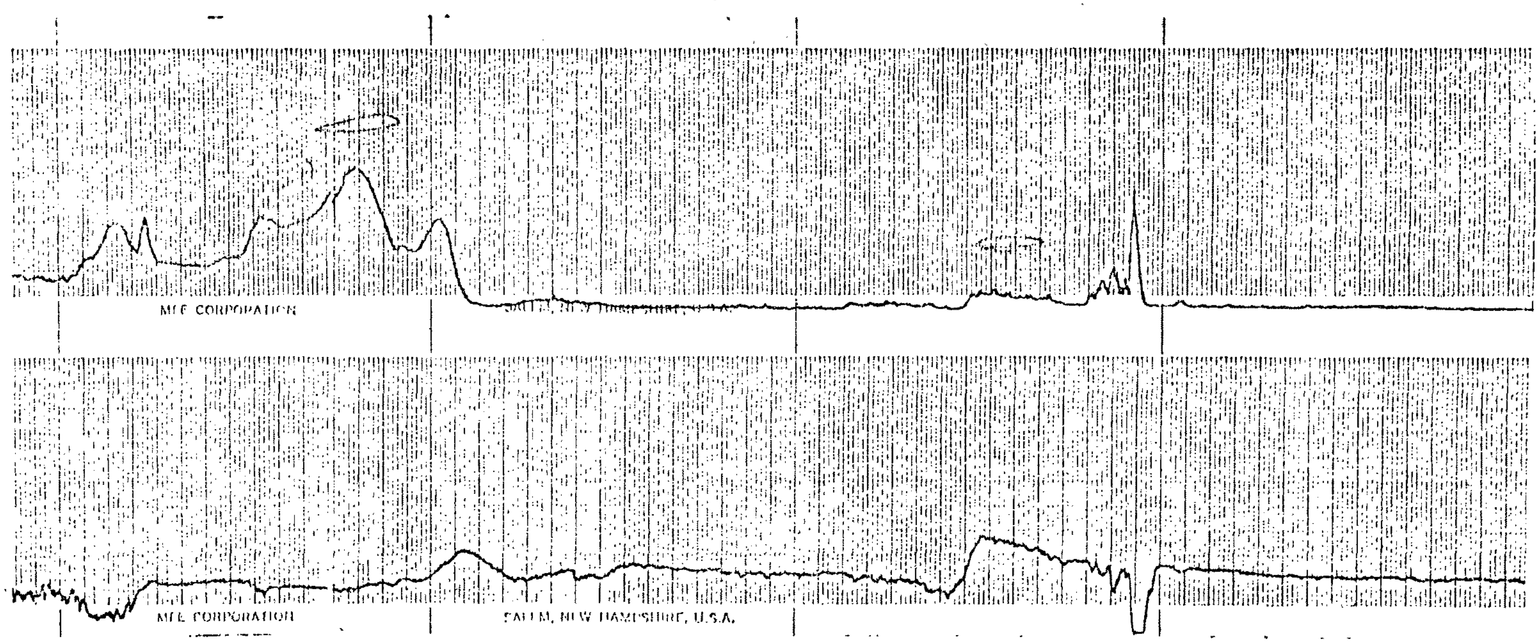

HAMPSHIRE, U.S.A.
MFE CORPORATION
SALEM, NEW HAMPSHIRE, U.S.A.

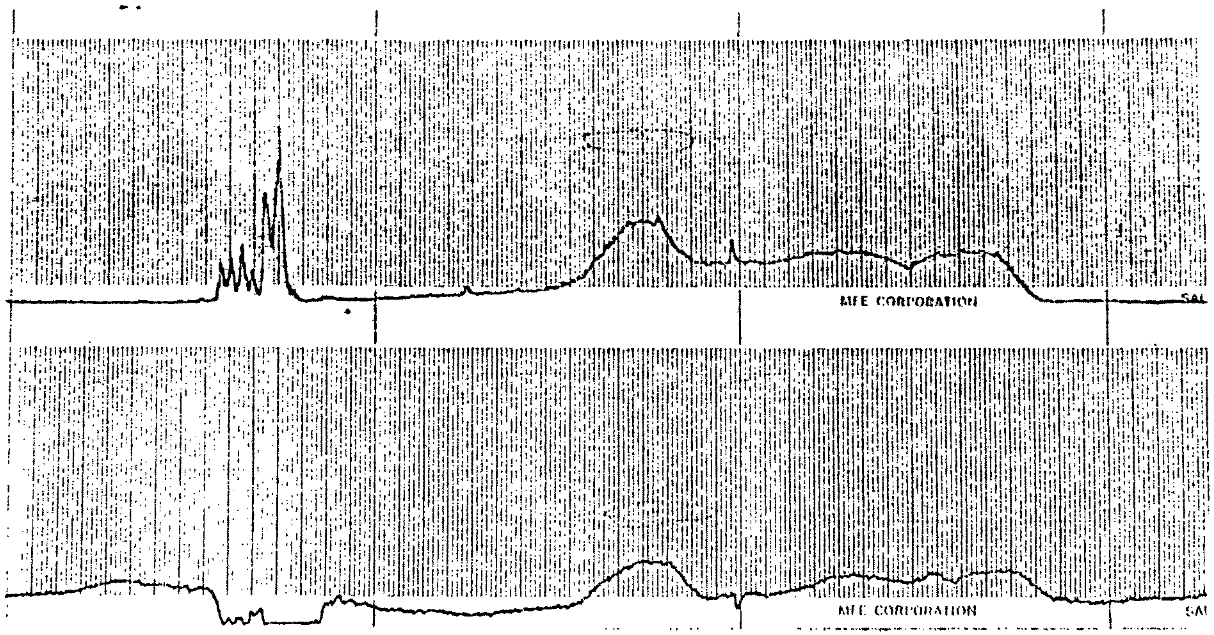

MEE CORPORATION
SALEM, NEW HAMPSHIRE, U.S.A.
MEE CORPORATION


MFE CORPORATION
SALEM, NEW HAMPSHIRE, U.S.A.
MFE CORPORATION
SALEM, NEW HAMPSHIRE, U.S.A.

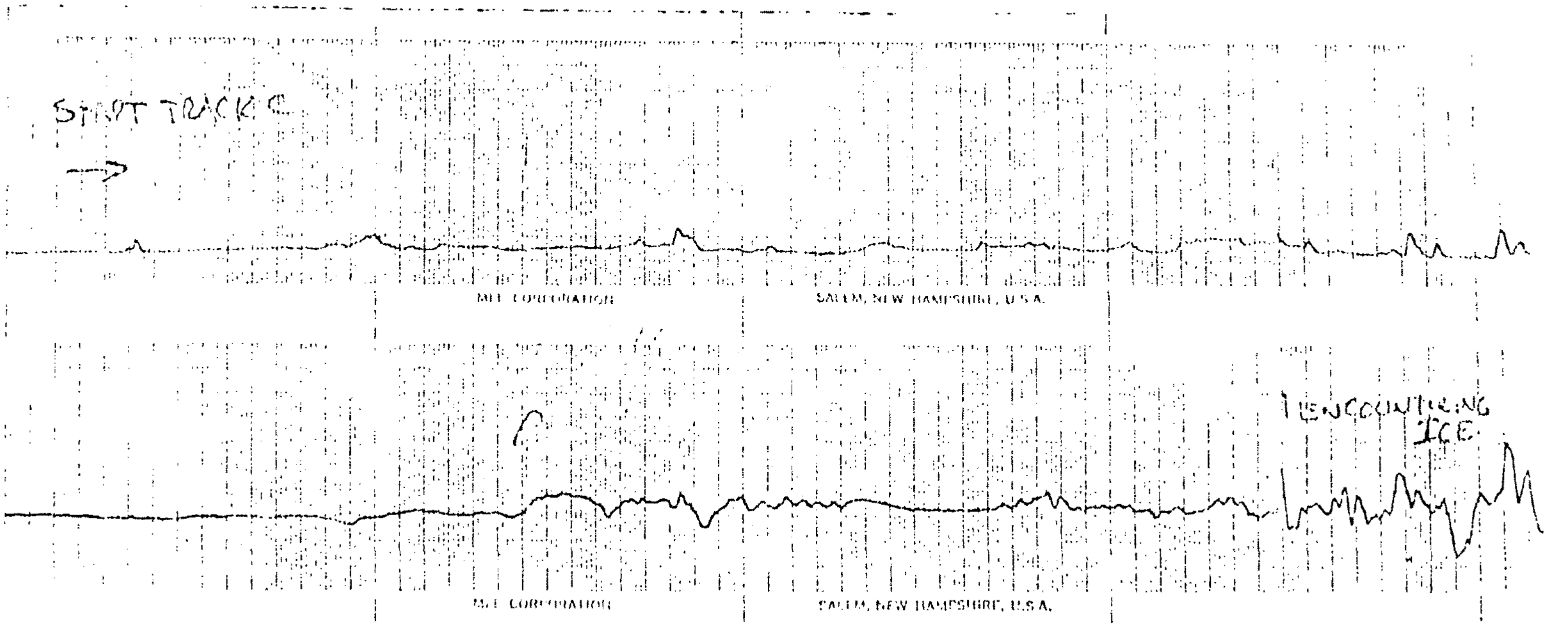

MFE CORPORATION
SALEM, NEW HAMPSHIRE, U.S.A.
MFE CORPORATION
SALEM, NEW HAMPSHIRE, U.S.A.

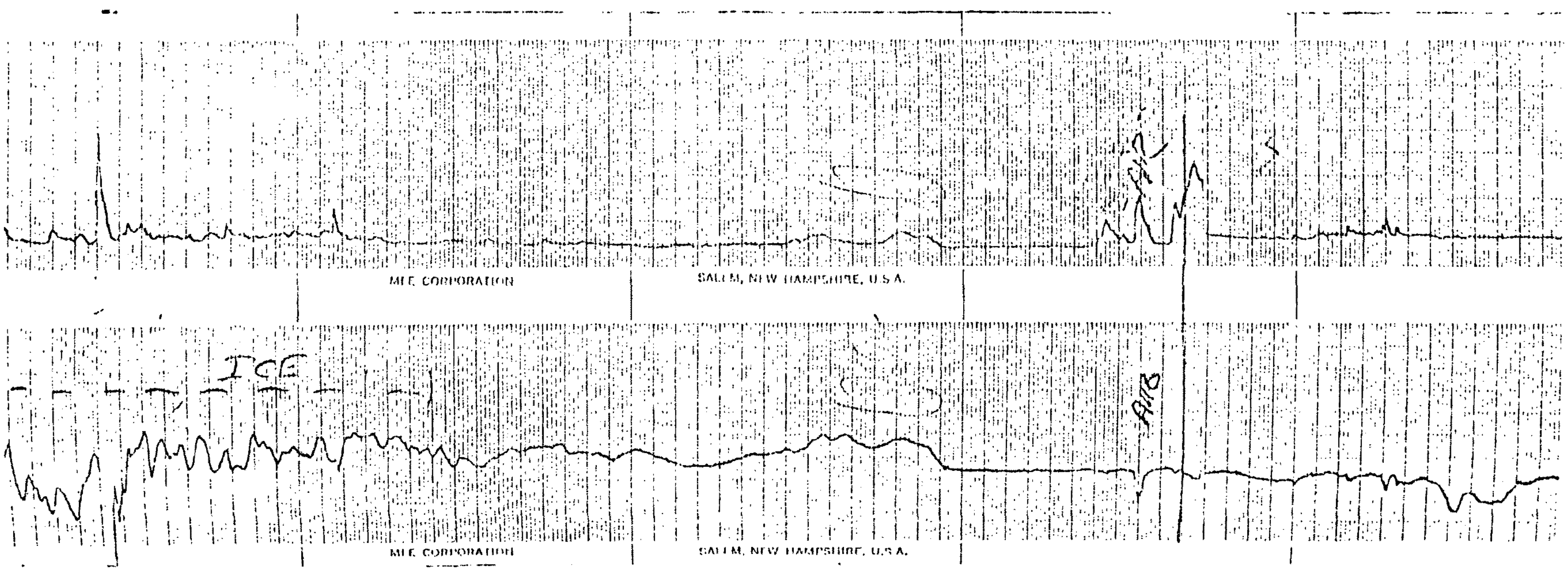

MFE CORPORATION
SALEM, NEW HAMPSHIRE, U.S.A.

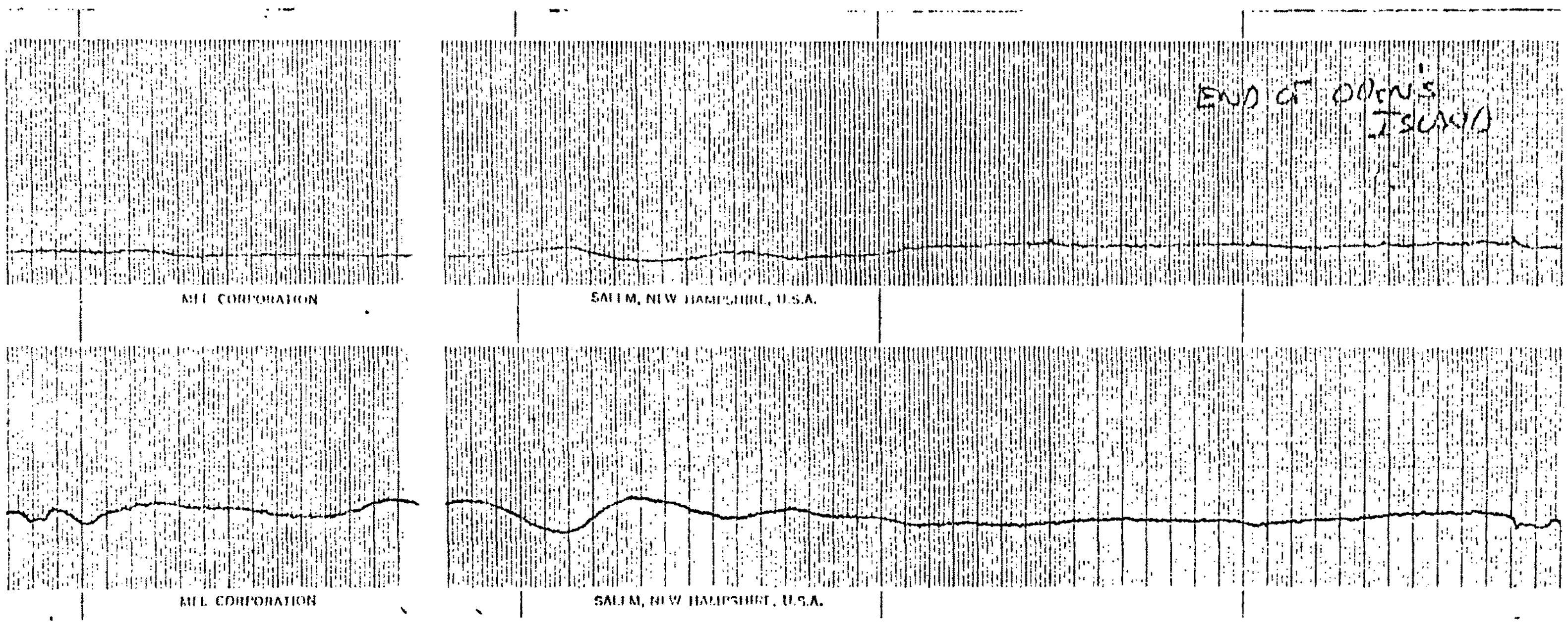

MFE CORPORATION
SALEM, NEW HAMPSHIRE, U.S.A.


MFE CORPORATION
MFE CORPORATION

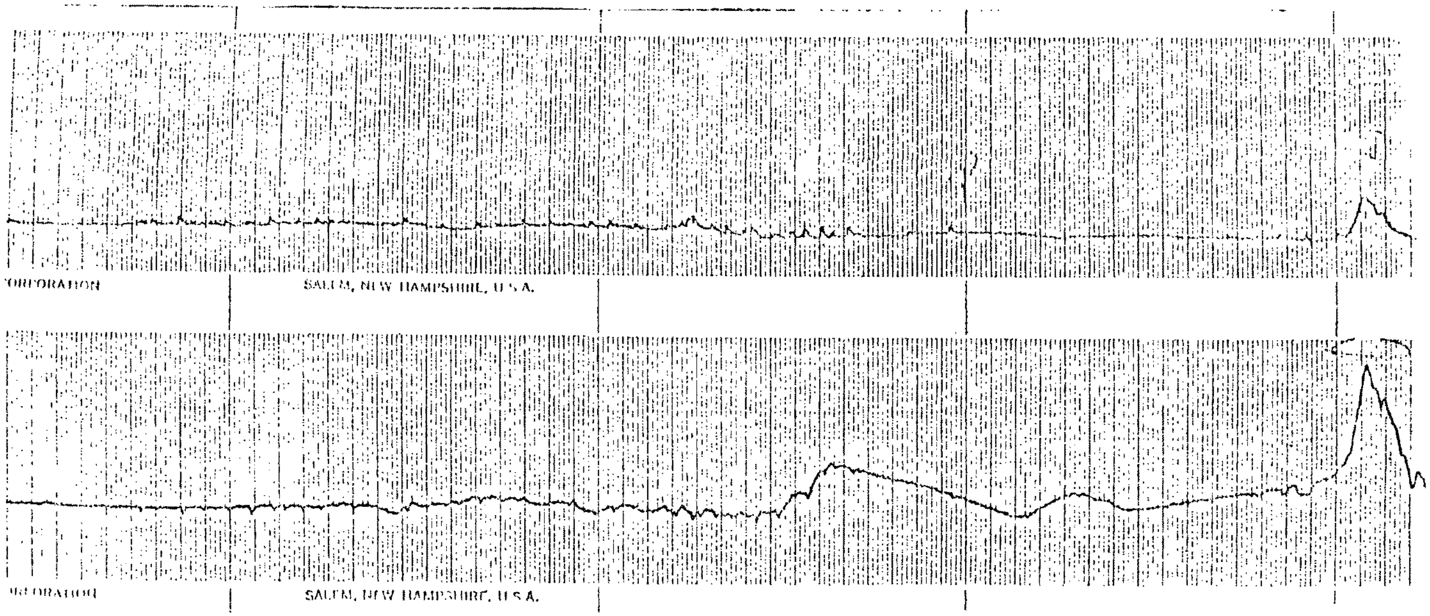
Track C
Segments 5 and 17

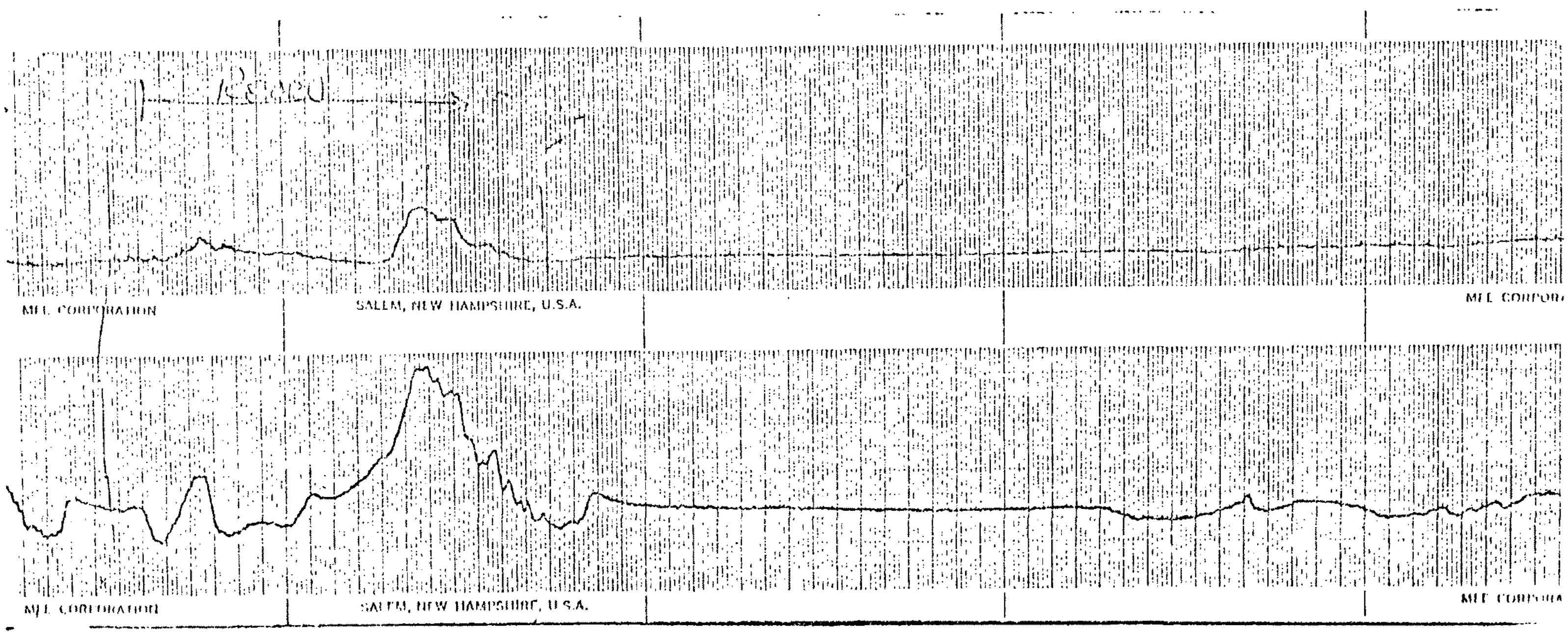

START TRACK C
ENCOUNTERING ICE
MEE CORPORATION
SALEM, NEW HAMPSHIRE, U.S.A.

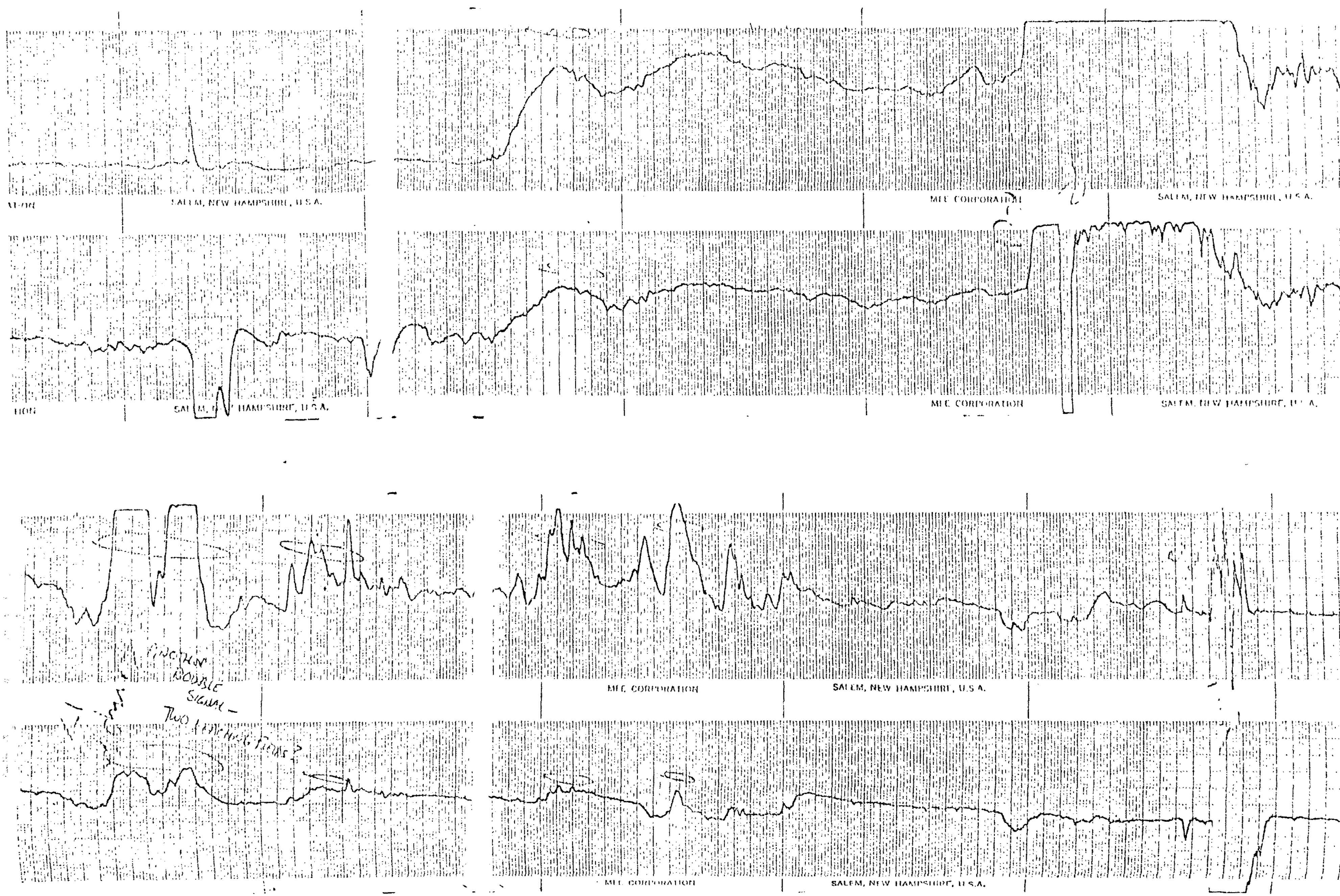

MEE CORPORATION
SALEM, NEW HAMPSHIRE, U.S.A.
ICE
AIR

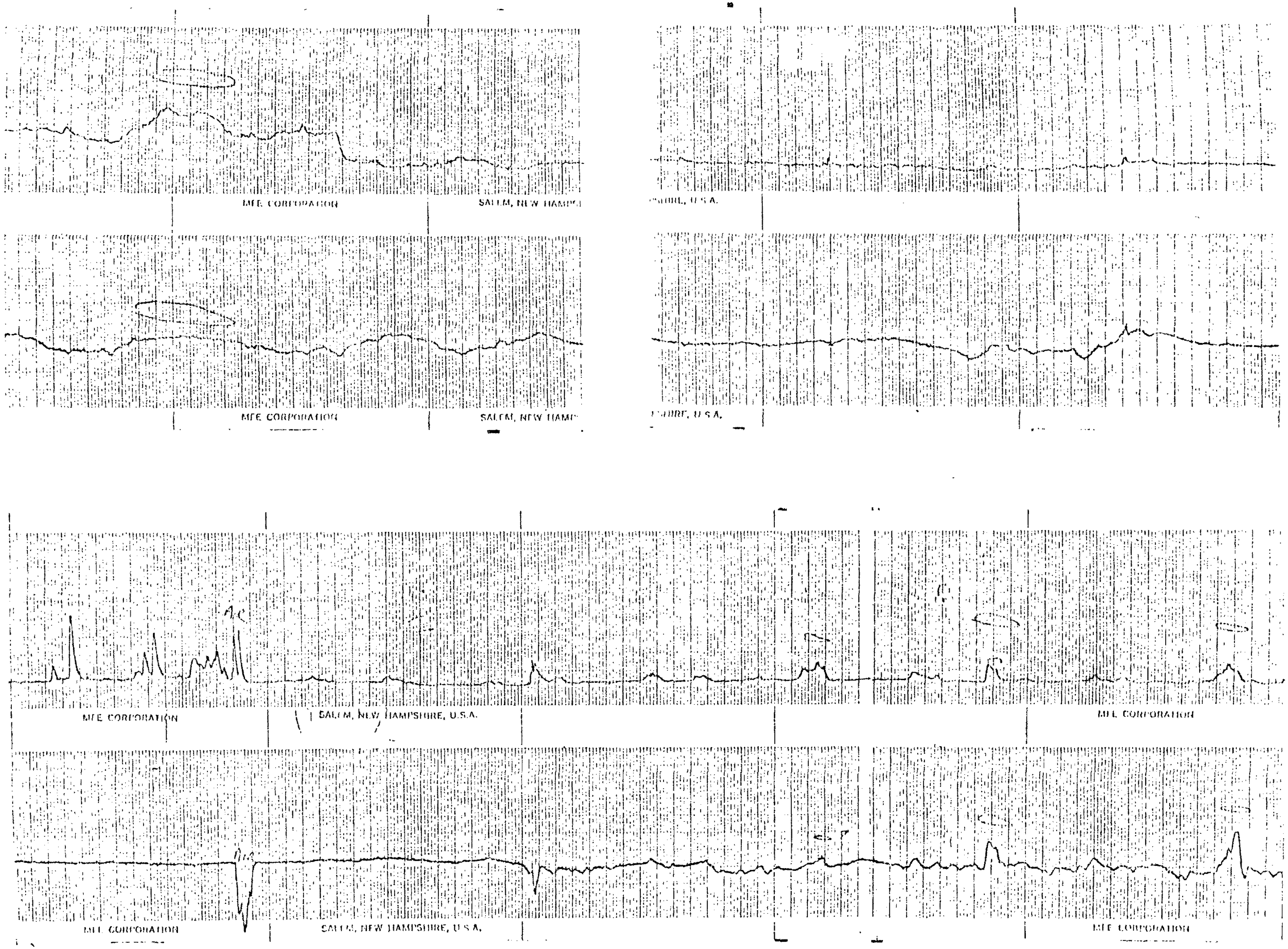

MFE CORPORATION
SALEM, NEW HAMPSHIRE, U.S.A.
MFE CORPORATION
SALEM, NEW HAMPSHIRE, U.S.A.

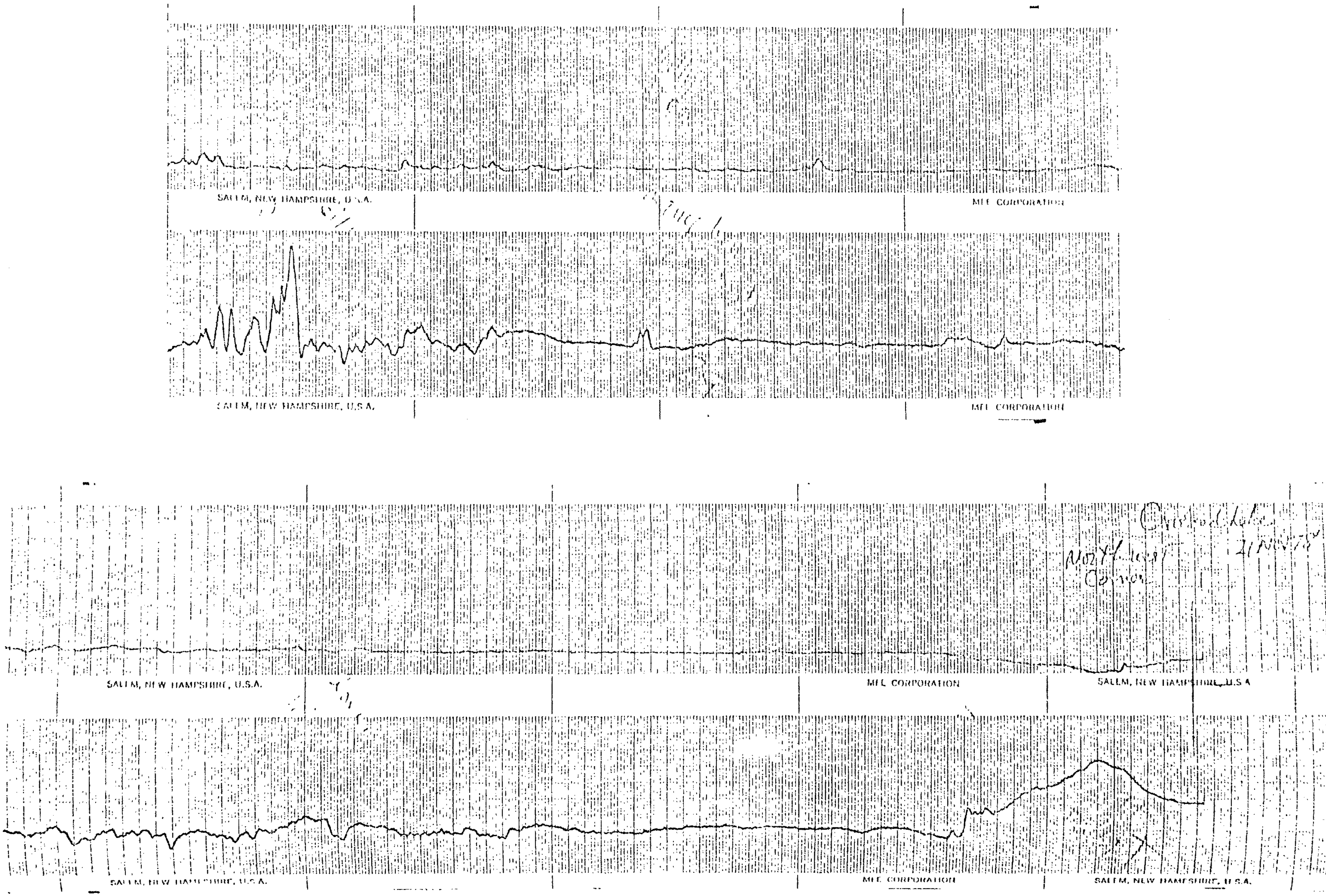
Track D
Segmenta 1, 2, 3, 4, 18, 19


CORPORATION
SALEM, NEW HAMPSHIRE, U.S.A.
SALEM, NEW HAMPSHIRE, U.S.A.


MFE CORPORATION
SALEM, NEW HAMPSHIRE, U.S.A.
MFE CORPOR
MFE CORPORATION
SALEM, NEW HAMPSHIRE, U.S.A.
MFE CORPOR


MFE CORPORATION
SALEM, NEW HAMPSHIRE, U.S.A.


MFE CORPORATION
SALEM, NEW HAMPSHIRE, U.S.A.


SALEM, NEW HAMPSHIRE, U.S.A.
MEE CORPORATION

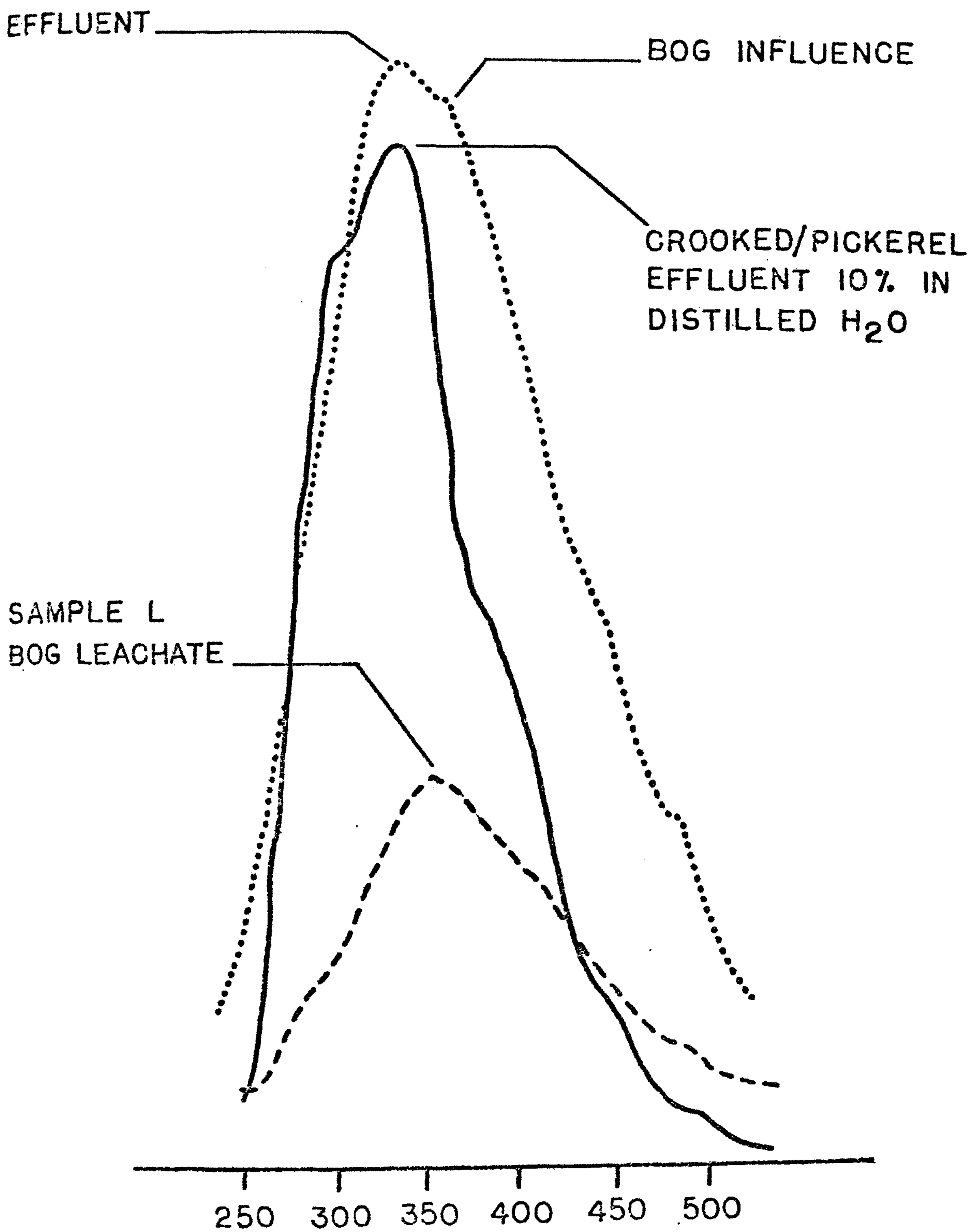


Figure 7. Synchronous fluorescent scans of effluent, bog leachate and sample 35 showing presence of effluent leachate in surface water.

APPENDIX
B-7

Sanitary Systems of Crooked and Pickerel Lakes, Emmet County Michigan: An On-Site Survey

Technical Report to the
United States Environmental Protection Agency
Water Division Region V

From
The University of Michigan
Biological Station
Pellston, Michigan

November 1978

TABLE OF CONTENTS

Introduction

A project to obtain site-specific qualitative and quantitative information by an approximately 300 home wastewater treatment systems was conducted in and near Crooked and Pickerel Lakes, Emmet County, northern lower Michigan. This rural wastewater planning area of Springvale and Littlefield townships is being considered for on-site technology as an alternative approach wastewater treatment--provided suitable soil and ground water conditions exists. This project also tested and evaluated the adequacy of surveys in obtaining and recording information on sewage disposal adequacy in planning areas. The sanitary survey compiles area wide data for on-site facility characterists and identifies individual systems that may be creating public health and environmental problems through malfunctioning and that require improvement.

The actual survey took place during the period August 29-September 8, 1978 by Samuel Ehlers, Kevin Hughes, Sharon Mills and Joan Schumaker of the Biological Staion. Mr. Ehlers was manager of the survey teams. The project was directed by Mark Paddock.

I. The Household Survey

A. Survey Form:

The sanitary survey form used in the Crooked/Pickerel Lakes planning area is modeled after the "Sanitary Survey for Construction Grants Application" follwing the procedures and methods set forth by Wapora, Inc. The survey form also includes parts used in other on-site wastewater evaluations. These surveys are the Marshall-Farnsworth Septic Tank Survey of Bolinas, California and the Wastewater Management Questionnaire used on Walloon Lakes, Emmet County by the University of Michigan Biological Station project CLEAR in 1977. The survey form covers six main topics:

1. Location and description of property
2. Resident occupancy. Size of household, duration of occupancy, intended use and additions.
3. Sewage disposal system descrition
4. Service history of the systems
5. Use and description of water facilities
6. Site characteristics
7. Sketch of property and facility

A copy of the survey form is included in Appendix A.

B. Survey Process :

The location of the dwellings in the survey area were acquired from Williams and Works' Little Traverse Bay Area-Charlevoix and Emmet Counties-planning maps (1976). A news release announcing the survey work was submitted to Petoskey newspapers and local radio stations. A "Flier", designed to leave on a front door when a resident was absent. This flier explained who the surveyor was, the purpose of the survey and that further attempts would be made to contact the resident. A sample flier is found in Appendix D.

Between August 20th and September 3rd surveyors conducted resident interviews and facility inspections at dwellings on Crooked/ Pickerel Lake. Contact was attempted with each owner or resident three times. After the first unsuccessful visit, neighbors were contacted to obtain information about the absent resident. Often neighbors would know plans of seasonal residents or could tell the surveyor when to expect the person at home. Names were taken from mail boxes and telephone calls were placed in the evening to schedule visits.

Surveyors gave brief introductions similar to those written in the "flier" (appendix B) and requested to speak with the person most familiar with the dwelling and facility. Interviews averaged 20 to 30 minutes in length. Additional times was required to make the on-site inspection and travel between residences. A surveyor could expect to complete from 10-12 surveys per day.

If the residents could not answer questions (this was especially true about septic system construction and history) surveyor recorded this response as D.K. (don't know). Or information was sought from other sources--an absent member of the household, relatives, neighbors, former owners, caretakers, or professional people such as septic system cleaners, installers, building contractors, and county personnel. When the residents could not be contacted and no other source was available to obtain information, it was recorded as N.A. (not available).

The survey area encompassed approximately 50 miles of road. A team of two surveyors per vehicle covered a given section of road, but only one surveyor per resident was needed so the team split up once the area was reached. Four clusters of dwellings were identified.

1. Crooked Lake, south and east shore: Hency Road, Core and Driftwood Drive, Oden Island, Oden Island Drive, Sunset Drive, Channel Road, Stanley Court and Oden Island Drive (mainland section)
2. Crooked Lake, northeast shore: Burley Road
3. Pickerel Lake, south shore: Ellsworth Point, Artesian Lane, Trails End, Ellsworth Road and Rupp Road. Botsford Landing, Botsford Road and Lane, Camp Petosega and Camp Petosega Road.
4. Pickerel Lake, north shore: Mission Road, Felder Road, Lakeview Road, McCarthy Road.

Two hundred and thirty four dwellings were located within the planning area. The location and lot number of each dwelling is mapped and the names of the owners is kept on file cards with the University of Michigan Biological Station (See Appendix C).

Investigations of dwelling sites were conducted following the residential interview. The purpose of the inspection is to identify existing or potential public health problems related to sewage disposal. Both the physical layout of the lot, with distances noted between water sources, the dwelling, sewage disposal system, adjacent lots, and natural environmental features such as vegetation, toppgraphy, and drainage were mapped.

The Crooked/Pickerel Lakes sanitary survey also included visual observation of the shoreline beach or breakwater area for locating a microscopic, bright-green, filamentous algae called Cladophora. This algae grows only in presence of high nutrients or as patches near artesian well overflows, it grows only on a suitable rock, concrete, decayed wood or metal substrates in the "wash" area of the shoreline. A study conducted by Tom Weaver, Northwest Michigan Regional Planning and Development Commission (Traverse City) indicated a high correlation between "poorly maintained" or malfunctioning sewage disposal systems, lawn fertilization, or wildfowl feeding, and algae blooms. We incorporated a "*Cladophora* Survey" into this study to determine if such correlation occurred also on Crooked/Pickerel Lakes.

Data was later removed from the original survey forms and placed on tables (appendix F). Information most pertinent to the analysis of on-site wastewater treatment is presented in the *Results* section or as tables in Appendix E.

II. Results

A. Dwelling Units :

It was determined that 234 dwellings exist within 300 feet of Crooked/Pickerel Lakes in the survey area. Of these, 172 or 73.5% were sampled only 62 or 26.5% were not available. Table 1. Dwelling Occupancy:

Seasonal occupancy (SEA) if a dwelling occurs when the residents are away continuously for a period longer than two months. Year-round occupancy (Y.R.) is considered when the dwelling is occupied for a period longer than ten months.

Table 1

Dwelling Occupancy

Crooked Lake	Seasonal	Year-round	Not Available	Total
Number	26	42	10	78
%	33.3	53.8	12.9	100
Pickerel Lake				
Number	88	15	52	155
%	56.8	9.7	33.5	100
Total Both Lakes				
Number	114	57	62	344
%	49	24	27	100

As may be assumed, summer is the preferred period for seasonal residents. Most of these homes were occupied for a full three or four months, but about 25% of the population stayed on from spring through fall. (See Tables 2 and 3 Appendix F.)

A sizeable portion or 19.3% of the seasonal residents indicated an interest in becoming permanent residents (See Table 4 Appendix E). Also, 25% of the seasonal residents are considering fundamental changes in their dwelling such as additional bedrooms and bathrooms. These changes also would effect use of waste water systems in the future.

B. Sewage Disposal Systems :

Sewage disposal systems on Crooked Lake are generally older than those on Pickerel Lake: 63.2% of the systems on Crooked Lake are over 10 years old compared to 48.5% on Pickerel Lake. (Table 6 Appendix E.) On both lakes about 16.5% of the systems are older than 20 years of age.

There is a significant difference between sewage disposal system design on Crooked and Pickerel Lakes: nearly 87% of the systems on Crooked Lake are gravity-fed, dosed or pumped into adsorption fields; compared to 69% of the systems on Pickerel Lake which are similarly designed. This means that nearly one-third of the systems on Pickerel Lake compared to one-tenth on Crooked Lake are either dry wells, combined septic tank and dry well, or pit privy. (See Table 7, Appendix F.) Detailed information on sewage disposal designs is given in Table 8, Appendix E.

From the inception of the Emmet County Sanitary Code in the spring of 1968, all construction of dwelling requires by law a permit issued by the County Sanitarian that approves the design and construction of a sewage disposal system. Construction standards for sewage disposal systems are as follows:

Minimum Capacities for Septic Tanks

Number of Bedrooms	Minimum Liquid Capacity (gals.)
2 or less	750
3 or 4	1000
Each Additional bedroom beyond 4, additional	250

Note: the capacities in this table provide for a single family residence including an automatic diswasher, mechanical garbage grinder and dishwasher.

Minimum Distance in Feet

	Septic Tank	Tile Field	Seepage Pit
Well	50	50	50
Lake or Stream	50	50	50

Sewage disposal systems which were installed prior to this

Sanitary Code are exempt. Therefore, some older systems are undersized and improperly situated. About 9% of the Crooked Lake systems and 28% of the Pickerel Lake systems are undersized when compared to the code (Table 8, Appendix F). Based on the codes' minimum separation distances, 26% on Crooked Lake and 43% on Pickerel Lake do not comply.

The on-site inspections and questions about performance and history of the sewage disposal systems established that 38% of those on Pickerel Lake had a history of problems such as ponding of effluent, backing up, odors, etc. (Table 9, Appendix E.)

Of the 26 dwellings on Crooked Lake that were identified with problems, 4 clearly had effluent ponding, 13 had histories of ponding, 4 had a history of backups, and 4 more had a history of odors. 14 dwellings on Pickerel Lake were identified with problems: 5 had a history of ponding, 6 a history of backups, and 2 a history of odors.

There are five basic reasons for septic system problems: old age, excessive water use, septic tank undersizing, poorly maintained systems, and inadequate soil and groundwater characteristics. (Table 9, Appendix E). On Crooked Lake, low permeability rates ($<$ 0.68 in./hr.) contributed to problems of 15 out of 16 problem systems on Hency-Channel Roads; 3 others were identified on Burley Road. Thirteen residences on Crooked Lake exhibited excessive water use*, two residences had septic systems aged 30 and 25 years, and 3 residences had never cleaned their septic tanks despite the

* existence of 2 out of 3 excessive water using devices such as washing machine, diswasher, or garbage disposal

fact that their systems were older than ten years.

On Pickerel Lake six residences in the Ellsworth Point area had "problem" sewage disposal systems due to low soil permeability rates. Only 2 residences, on Mission-McCarthy Roads, exhibited heavy water use and four sewage disposal systems were found undersized. None of the systems on Pickerel Lake were poorly maintained.

C. Environmental Features:

1. Cladophora Study

The Cladophora study reveals a very strong correlation between cladophera growth and residents who use water excessively, residents who feed waterfowl and residents who do not maintain their septic systems by cleaning them at least every eight years. (Recommended cleaning of septic tanks is every 1-3 years depending on the type of household, amount of water use, number of residents, etc.) There does not appear to be any significant correlation between cladophera growth and whether it is a year-round or seasonal dwelling. Approximately 54% of the residences on Crooked/Pickerel Lakes which had suitable cladophora substrates in the beach/shoreline area, had algae growth. On Crooked Lake, the algae growth appears due to excessive water use and waterfowl feeding. On Pickerel Lake, the algae appears to be caused by waterfowl feeding and poorly maintained systems. Other factors which might cause cladophora growth are septic systems sited too close to the lake or one undersized. Pickerel Lake has a high percentage of systems which don't comply with minimum separation distances. On Pickerel Lake, 52% of the lots which have Cladophera growth are closer than the existing 50 foot separation distance in the code, and only 13% are not too close to the lake. (Table 10, Appendix E.)

2. Soil Conditions

According to Gold and Gannon overlay maps (1978) and the Soil Survey of Emmet County, Michigan there are severe soil and ground water limitations for septic tank disposal fields within 300 feet of the Crooked/Pickerel Lakes. Depth to seasonal high ground water is 0-2 feet for all lots on Crooked Lake within the survey area. Only 19 lots in Pickerel lake were identified with depth to high seasonal ground water greater than 4 feet. These were found on Ellsworth Point. (Lots 111-120) and on Botsford Landing (Lots 144-149, 165, 166-171).

Criteria for Emmet County Sanitary Code approval specify that construction of sewage disposal will not be approved "where the maximum ground water level (or seasonal high ground water) is less than 6 feet from the ground surface, or in the case of property adjoining lakes, lagoons, rivers, or similar bodies of water, the finish grade is less than 6 feet above the known high water mark". All the lots within the Crooked/Pickerel Lakes survey area have a slope of 0-6%. This means that 100 feet in a horizontal direction will have a 6 foot rise vertically. Consequently, many of the 18 dwellings on Crooked Lake and 44 on Pickerel Lake that don't comply with the minimum separation distance between sewage disposal systems and the lakes, including others which are between 50' and 100' of the lake may not have legal depth to high ground water installations.

There are few exceptions to the generally severe soil limitations. The soils are commonly poorly or somewhat poorly drained with a high seasonal high ground water table, rapid moderate and moderately slow permeability (Table 11, Appendix E). The poorly drained soils, with moderately slow permeability are associated with slope and ground water factors:

Slope %	Depth to Seasonal High Ground Water	Permeability (inches/hr)
0-6	0-2	< 0.63
	2-4	0.63-2.0
	> 4	2.0-6.3, 6.3-20.0

The "severe" limitations of the soils are either due to too rapid permeability, or too slow permeability when combined with high water tables. This includes the sands (AcB, KaB, ScB), loamy sands (AuB, BIB, EaB) and mucky sands (Br,Rc), the loams (Tm) and mucky and sandy loams (By, EuB, EmB, ToA, Wr), and the mucks (Ta). Table 11, Appendix E). The soils listed with "slight" limitations are BIB, EmB, EaB, and KaB, because the soil classification doesn't acknowledge that these have high ground water tables. However, the sands have rapid permeability and thus BIB, EaB, and KaB may cause "possible continuation of shallow water supplies".

III. Discussion

A. The Survey Process:

In order to facilitate such surveys and make them more efficient we suggest the following routine:

1) Use township, county or engineer's planning maps to record the dwelling locations within the survey area and use road maps to plan out the survey team's field approach.

2) Work quickly through the area initially and attempt to make contact at every dwelling in the survey area.

3) If contact is not made initially, leave a flier expressing the interest of the survey and some indication of how the surveyor will try to make contact within the survey time period.

4) Seek information from neighbors as to the name, whereabouts and plans of the absent owner. If possible, obtain a phone number of the residence and call to set up an appointment.

5) Second and third attempts to make contact with the residence should involve tactics such as surveying during weekends and weekday evenings.

A technique recommended by Robert Marans, ISR, Ann Arbor, is for the survey team to operate in pairs or groups for the first day. One member conducts the interview and the others observe. This technique encourages standardized approach, language, and recording of information.

B. The Survey Area:

The small size of the Crooked/Pickerel Lakes area and the clusters of dwellings reduced the survey time. It was therefore possible to visit dwelling four to five times without serious inefficiencies. In these clusters of homes, lots were only 50-75 feet wide making door to door surveying quite rapid.

The resort communities were established in the 1940's and '50's. Neighbors often knew each othere well enough to provide information about an absent neighbor, including, at times, enough information to actually complete the survey and lead the on-site inspection to their neighbor's lot.

C. Responses:

Responses to the survey questions by residents were reliable because they knew their properties, they understood the intent of the survey, and they were cooperative. In general, it seemed residents either built their own dwelling or had lived in it more than ten years and knew its history. Most residents were cooperative and the majority of these were somewhat familiar with local waste.

water facility planning and water quality management-primarily due to earlier studies on the lakes by The University of Michigan Biological Station. We believe this awareness increases the survey's reliability.

We found that professional resources such as septic tank clearners, installers, building contractors, county personnel were not as informative or useful as we had earlier believed. Educated guesses were normal, records were either incomple or non-existent.

For example, information obtained from District Health Department No. 3 files for dwellings constructed after April 30, 1968 (the effective date, Emmet County Sanitary Code) was incomplete. The issuance of permits didn't take full effect until the arrival of a county sanitarian in 1970 or 1971; the records for the first 2 years are few and in the years following 1970 or 1971 a few constructed dwellings were "bootlegged-in" according to William Henne, Emmet County Sanitarian. Furthermore, the permits that are issued specify minimum septic tank and adsorption field sizes for the planned dwelling. For small additional cost, many owners installed larger septic tanks (not drainfields).

These changes do not show on the records. Also, permits give inadequate descriptions of lot locations especially lacking street addresses.

D. On-Site Inspections:

Relief of the land, soil, water, and regetative characteristics were mapped during the on-site investigation in an attempt to identify improper sewage treatment or public nuisances (sewage-odors). Such problems were invariably due to insufficient protective distances between water sources and sewage disposal systems, or undersized systems.

Unnaturally lush vegetation, called "selective fertility", may signify that the area over or near an adsorption field receives higher nutrients from some source such as a malfunctioning sewage disposal system. However, this symptom may be caused by more reasons than sewage disposal problems and therefore, wasn't reliable. For instance, old adsorption fields may develop an impermeable mat from scum and suds deposits and cause the effluent to be pocketed in the upper soil layers, thus promoting greener growth. Heavy soils which have a high capacity for adsorbing nutrients and exchanging them as plant food, may be causing more lush vegetation. The true condition can be determined by inspecting the soil and the stone in the adsorption field. A closer inspection on questionable problem sites is advisable.

Inspections for Cladophora, a bright green filamentous algae which grows at the shoreline in the presence of high nutrients, is being proposed as fairly reliable indicator of environmental conditions. The process needs only short additional recordings such as the presence of a suitable substrate, existence of artificially fed waterfowl or indication of the owners' use of lawn fertilizer.

Sewage disposal systems which are not in compliance with sanitary codes need replacement. However, the sanitary code is only enforced for new and recently constructed dwellings. Hence, the use of this information is limited by the restricted powers of the code.

Often respondents didn't know the location of their septic system. Careful observation of the dwelling may reveal septic tank "venting" in the roof above a ground floor bathroom, exposed access covers at ground level, "breezers", lush vegetation and local settling or grading of the area where the adsorption field is found.

Natural vegetation on the lot or adjacent land is an indicator of the local soil and soil moisture or ground water qualities of the site. Without training and a practiced eye for identifying woody or herbaceous species that typify soil conditions, the mapping is not thorough. "Wet-loving" species such as black ash, red and silver maple, weeping willow, white cedar, alder and ninebark indicate medium to poorly drained, wet, organic or "heavy" soils. Well drined, dry sites of sand or loamy sand and coarse textured soil may have natural stands of red oak, red maple, red pine, staghorn sumac, serviceberry and bracken fern. They survey team did not follow standard procedures for noting vegetation, so the results are not a reliable source of data for Crooked/Pickerel Lakes.

E. Recommendations for Future Surveys:

It is recommended that a standardized survey form be established and that methods for running the sanitary survey and ways of evaluating the data be explicit and well established. The survey team should be knowledgeable regarding the EPA's approach and position for planning and design of rural waste water systems for the area being surveyed. The addition of an introductory note on the survey form explaining the procedures of the US-EPA, plus a straightforward survey which can be answered without the aid of the surveyor, is recommended. The survey or should expect to field questions regarding current EPA policies and procedures or provide new information, mailing addresses or forms, dates of public hearings, etc. This is a very effective way to solicit public participation.

On-site inspections of sewage disposal is critical to the total sanitary system evaluation and standardized training with established methods are needed. The on-site inspection is not as thorough enough with only observation of drainage, topography, and location of facilities and vegetation. We recommend that the survey also includes removal of sod from the adsorption field to check for "matting" due to detergents and scum and actual septic tank inspection from access covers to check sludge and water levels, scum or suds buildup, general condition and size of septic tanks. Soil auguring to determine local soil and ground water characteristics would also be valuable. Natural vegetation can also be very helpful in determining soil and ground water conditions.

IV. Summary of Survey Results

A. Crooked Lake:

1. 53.8% of the Crooked Lake dwellings were used year-round vs. 33.3% which are seasonal.
2. 8.8% of the seasonal residents plan to make their cottages into year-round dwellings.
3. 65% of all sewage disposal systems on the Lake are older than 10 years.
4. 35% of the sewage disposal systems on Crooked Lake do not meet the Emmet County Sanitary Code.
5. Problems were found on 38.2% of the septic systems.
6. Problems were caused by: excessive water use, poor maintenance, unsuitable site conditions, old systems or the fact that the systems were too small.
7. Half of the dwellings had suitable substrate for growth of Cladophora and of these, 57% had Cladophora present. Excessive water use and/or feeding of water fowl appeared to be the principal causes for Cladophora growth in front of dwellings.

B. Pickerel Lake:

1. Only 9.7% of the dwellings were used year-round.
2. 15.5% of the seasonal residents expect to live permanently on the lake in the future.
3. 48.5% of the sewage disposal systems are older than 10 years of age.
4. 71% of the septic systems do not meet existing sanitary codes.
5. Only 15.6% of the dwellings exhibited problems.
6. Of the lots with substrates suitable for Cladophora growth (44.6%) only 23% showed presence of the algae. The causes appeared to be feeding of water fowl and poor maintenance of septic systems.
7. Pickerel Lake had 19 lots with good depth to seasonal high water table characteristics, i.e., greater than four feet.

V. Suggestions for Specific Areas

A. Crooked Lake:

Henry Road Area:

These 3 residences, 2 of them year-round, do not show general sewage disposal problems: only one has a history of problems. However, they are located on unsuitable soils (a mucky sand) and a high water table. Together with the 3 residences on Cove Road and Driftwood Drive, Henry Road residences should be hooked to a cluster system and pumped to higher elevation and coarser sands to the south east.

Cove Drive and Driftwood Lane:

Three year-round residences with well maintained fifteen year old systems, that show no problems, are situated on moderately permeable soils. One system is too close to the lake and not in compliance with sanitary codes. These residences do not need to upgrade their existing sewage disposal systems. However, it is recommended that the one in non-compliance be moved and tha a mound be used for the adsorption field. An alternative to upgrading existing on-site systems would be to hook into a cluster system on Henry or Channel Road.

Stanley Court, Channel Road, and Oden Island Road (mainland section):

This part of south Crooked Lake should be hooked on to a main collector sewer system with a pressure or gravity main and the sewage transported to a treatment plant. The area has poor soils and a history of problems with existing on-site sewage systems. The soil permeability ($<$0.63 in/hr) is extremely low, depth to high seasonal ground water listed is 0-2 feet, and the soils are mucky loams and sands. Seasonal residents comprise only half the number of year-round residents. It is known that numerous seasonal residents as well as the permanent residents commute to nearby Petoskey and Harbor Springs for jobs and many seasonal residents had winter homes in either of those two cities and will spend summers or weekends on Crooked Lake. There, the sewage disposal systems are used heavily. Not surprisingly, there is high proportion of problem systems and four of these show "ponding" of effluent. There are four old pit privies which may be a serious problem in the high ground water. Systems are generally older than elsewhere, many don't comply with sanitary codes, some are poorly maintained and the density of dwellings is the highest for Crooked Lake area.

However, a central sewer system could pose a threat to some adjacent undeveloped areas. For instance, the east side of Channel

Road is currently undeveloped. Much of this land is in hardwood and cedar swamp including the sensitive and ecologically valuable Minnehaha Creek wetlands. These wetlands are currently undeveloped primarily due to the high water table and associated problems with on-site waste water disposal. A large collector system may eliminate the waste water system restrictions and encourage development.

Oden Island:

Dwellings on Oden Island are half seasonal and half year-round. Four of the six systems which showed problems were used year-round, so excessive water use could be the biggest factor. Lake frontages average 190 feet, the average age of the dwellings and their sewage disposal systems is 12 years. Most of the systems were septic tank and adsorption field type and all complied with Emmet County Sanitary Codes. The only sign of problems was Cladophora growth on five lots. Oden Island property owners have an active Association and good septic system maintenance records. We recommend that these systems be upgraded on site, perhaps with adsorption fields mounded, or a cluster system using the interior of the sandy island.

Burley Road:

Four of the five dwellings have problems with their septic systems which are created by the high ground water and wet loam. So suitable site appears to be available for a cluster system disposal area. Therefore, we recommend an upgrading of the existing systems. We do not recommend extending a centralized sewer line from the southeast shore of Crooked Lake across the Crooked Lake channel to Burley Road. The adjacent lands on each side of the channel are very sensitive with Carbondale and Warner's mucks which have severe building limitations.

B. Pickerel Lake:

Ellsworth Point, Artesian Lane, Trails End and Ellsworth Road:

Good soils for parts of Ellsworth Point were identified and no sewage disposal system exhibited problems nor was there Cladophora growth in this area of Kalkaska sand. The only problem sewage disposal systems were 6 that appeared to be caused by low permeability soils. There were however, a large number of sewage disposal systems which don't comply with existing Emmet County Sanitary Codes for minimum septic system size (11 systems) and separation distance from the lake (26 systems). This may be due to the fact that a number of them were septic tank-drywell combinations (16). Cladophora growth is due to waterfowl feeding and poorly maintained systems found here.

Because of the close grouping of houses on the Ellsworth Point area the average age of sewage systems (15 years old), the poor record of maintenance among that group of dwellings, and the change in local soil conditions, it is recommended that the dwellings in the western half and along Ellsworth Road be connected to a cluster systems. The density of the Trails End and Artesian Lane area is high with the average lake frontage of 88 feet per dwelling. There is not enough lot size remaining for upgrading existing on-site systems. Suitable soils for an adsorption field may be found near Pickerel Lake Road in sands at higher elevation, to the east and west of Ellsworth Road and south of Pickerel Lake Road.

Ellsworth and Rupp Roads:

Of the 4 dwellings on Rupp Road, east of Ellsworth Road, 2 are seasonal and are coupled together with a private cluster system. One of the sewage disposal systems show problems and only one shows excessive water use.

Although ground water is quite high and there is low permeability, on-site sewage system should remain as exists on Rupp Road. The soils in this area are Warner's muck and are poor for home construction. Extension of a cluster system from Ellsworth Point or creation of cluster system for Rupp aoad is not recommended.

Botsford Landing:

Botsford Landing is approximately 30 years old. Because of the age of the systems about half of them comply with Emmet County Sanitary Codes. Only two systems exhibited "problems", and there are less severe site limitations. Several lots are located on Kalkaska sand with depth to high seasonal ground water of more than four feet. These soils have moderate permeability. The only indication of environmental problems is that 4 out of 5 dwellings had growth of Cladophora. These were located to the east of the Landing on lots with muck soils.

Recommendations for the Botsford Landing area are to improve existing on-site systems or to create a cluster system and pump effluent to the sandy soils to the south of the Landing nearer the Pickerel Lake Road. Because the small average lot size is approximately 100 feet wide, improvements of existing on-site systems depends on whether residents will be able to place adsorption fields on back lots south of Botsford Lane (currently, 14 back lots have been built on).

Camp Petosego:

The owners at the time of the survey had plans for a cluster system for the 14 vacant buildings in the camp area. The adsorption field for this was planned for suitable soils east of the camp. The 12 dwellings existing for the camp owner had a recently rebuilt system. No improvements are required.

Mission, Lakeview, Feldman and McCarthy Roads:

There are 6 reported "problem" systems on the north shore of Pickerel Lake, due to excessive water use and low soil permeabilities. The soil types are loam and muck. The average age of sewage disposal systems is about 13 years and more than two thirds of the systems don't comply with code. There is only 1 year-round resident.

Because of the small number of year-round residents, it is recommended that the most cost effective alternative be considered. Clustering of systems on Felder Road and of the camp-resort community to the west of Lakeview Road with disposal on suitable soils (sands) at a higher elevation is recommended. These lots have on the average 80-100 feet of lake frontage. The McCarthy Road lots have an average lake frontage of 260 feet and thus improvement of existing systems is recommended.

VI. References Cited

Alfred, S. D., A. G. Hyde and R. L. Larson. 1973. Soil Survey of Emmet County, MI. U.S. Department of Agriculture in cooperation with the Michigan Agricultural Experiment Station. 99 p.

Gold, A. et al. 1978. Environmental Features of Walloon Lake and its Watershed (Emmet and Charlevoix Counties, MI.) with special reference to Nutrient Management. The University of Michigan Biological Station, Pellston, MI. An investigation supported by the Walloon Lake Association. 81 p.

Gold, A., J. E. Gannon. 1978. The suitability of Soils for On-Site Wastewater Disposal, Pickerel and Crooked Lakes. The University of Michigan Biological Station, Pellston, MI. A study supported by the Environmental Protection Agency. 14 p.

Marans, Robert W., J. D. Wellman, S. J. Newman, J. A. Kruse. 1976. Waterfront Living: A Report on Permanent and Seasonal Residents in Northern Michigan. Institute for Social Research, Ann Arbor, MI 230 p.

Michigan District Health Department No. 3. 1968. Emmet County Sanitary Code. Emmet County, MI 4 p.

Wapora, Inc. 1978. A Sanitary Survey Methodology for Use in Planning Small Waste Flow Systems. An unpublished report.

Weaver, T., C. Grant. 1978. Unpublished Cladophora study on Lake Lelanau, Leelanau County, MI.

APPENDIX A

Crooked/Pickerel Lakes Septic System Survey Form

OPTIONAL

Resident's Name ______________________________

Owner's Name _________________________________

Mailing Address of Property:

Street Address of Property:

Phone Number:

CROOKED-PICKEREL LAKES SEPTIC SYSTEM SURVEY

Unanswered Questions

Residence Number:

Survey or date:

Township: Littlefield/Springvale; Lake: Crooked/Pickerel

Lot Location: Graham Rd./Channel Rd./Oden Island

Ellsworth Pt./Botsford Landing/Lakeview Rd.

County Rd./Sadler's Landing/Other ________________

Lake frontage: yes/no

Lot size: ______ acres (1 acre = 200x200 sq. feet)

Was additional soil used to fill your site when your home was constructed?

____

I. Resident/Occupancy

1. Who is the owner of this property? ______________________________

(If occupant is not owner)

Can you give the name of the owner and how that person can be located? ____

Can you provide any information regarding the use of this house and the condition of the septic system? yes/no

2. Are you a year-round resident or a seasonal resident?

year-round (10 mos. or more)__________

seasonal (less than 10 mos.)__________

If year-round:

a. How many residents live here year-round? __________

b. Does this number change during the year? yes/no

c. At what time of year? spring/summer/fall/winter

d. For how long? 4-10 months/3-4 months/4-8 weeks/2-4 weeks/ 1 week/1 weekend

e. What is the peak number of residents at any one time? ________

If seasonal:

a. What time of year do you reside here? spring/summer/fall/winter

b. For how long? 4-10 months/3-4 months/4-8 weeks/2-4 weeks/1 week/ weekends

c. What is the average number of residents residing here during this time? _______

d. What is the peak number of residents at any one time? _______

e. Do you have plans to move here permanently? yes/no

If yes, when? 1 year/3-5 years/5-10 years/more than 10 years

3. How many bedrooms does this house have? __________

4. Do you/owner expect to add on or modify your home to:
   a. increase its capacity by adding on bedrooms or bathrooms? yes/no
   b. extend its yearly use? yes/no (winterization)

II. Describe System

1. What is the age of your house? 0-5 yrs/5-10 yrs/10+ yrs

2. What is the age of your present septic system? 0-5 yrs/5-10 yrs/10+ yr

3. What type of system do you now have?

septic tank + drainfield/dry well/mound/other _______/Don't know

a. If "don't know", who would know? ____________________________

b. If it is a septic tank and drainfield or mound, what type of drainfield is it?

pumped (to drainfield)/gravity-fed (no pumping of wastewater/ dosing (different time periods)/ distribution box (different sides of drainfield)/ alternate drainfields

(CIRCLE ALL APPLICABLE)

c. What is the size of your septic tank or dry well? _________gallons

d. What is the size of your drainfield(s)? __________square feet

e. Do you have access covers or risers to the septic tank/drywell?

____

4. Do you have plans to enlarge/improve your system in the next 5 years? yes/no Describe:

III. Service History

1. Has the septic system ever been inspected? yes/no/don't know
   If yes, when? (give dates) ______________________________

2. Has the tank/dry well ever been pumped? yes/no/don't know

   If yes, a) how long ago: this year/1-2 years/3-5 years/more than 5 yrs

   b) how often is tank pumped: every year/1-2 years/every 3-4 years
   other ____________________

   If "don't know" for 1.) and 2.), who would know more?

   ____
   (installer-pumper/caretaker/neighbor/former owner/other)

3. Any history of:

	How often?	What time of year?	When did it last happen?
Back-ups			
Surfacing effluent			
Odors			
Other			

4. Have you repaired your system in the last 1-2 years/3-5 years/ 5-10 years/10 or more years?

   Describe:

IV. Use

1. Number of water using fixtures: (note w.c. if designed to conserv

_______showers
_______toilets
_______sinks
_______clothes washing machine
_______softener
_______bathtubs
_______garbage disposal
_______dishwasher

2. Do you fertilize your lawn: yes/no

(optional) Type of fertilizer? _______________
How many times/year? _______________

3. How often do you water your lawn? 3 or more times/week _____
1-2 times/week _____
less than once/week _____

4. Drainage facilities:

a. basement sump yes/no/don't know
b. footing drains yes/no/don't know
c. roof drains yes/no/don't know
d. driveway runoff yes/no/don't know

5. Water supply source: community/shared well _______
on-lot well _______
other (describe) _______________________

don't know _____

a. well depth _____feet total/don't know
_____feet to drainfield/don't know

b. If "don't know" for any of the above, who would know more?

____

Additional Comments:

survey continued

V. ADDITIONAL SITE CHARACTERISTICS

Slope: restricted/acceptable

Depth to seasonal high ground water: less than 2 feet
2-6 feet
greater than 6 feet

Phosphorus retention: Poor
Moderate
Good

Permeability: Too slow
Adequate

Is home located in high density area: yes/no

VI: PROPERTY AND FACILITY SKETCH

Include: Surface Water
Signs of selective fertility
Vegetation present
Distance of tank and drainfield from house and lake (feet)

CLADOPHERA SURVEY

Suitable substrate present: yes/no

Cladophera present: yes/no

Describe abundance and location:

Do residents feed ducks: yes/no

Oh No, We Missed You!!

We are a group of four researchers from the University of Michigan Biological Station, on Douglas Lake, in Pellston, Michigan. You may have heard of us before, because we all worked under a National Science Foundation grant this summer, calling ourselves Project CLEAR. Now that the Project work has ended, four of us are continuing work in your area with funds from the Environmental Protection Agency.

As you may already know, the EPA is in the process of preparing an Environmental Impact Statement (EIS) which will evaluate the environmental, social, and ecomomic effects of alternatives for sewage collection and/or treatment in Springvale and Littlefield Townships in the Crooked and Pickerel Lake planning area.

An information and participation meeting to describe the alternatives, costs, and other information was scheduled for Thursday, August 24, 1978 at the Petoskey High School.

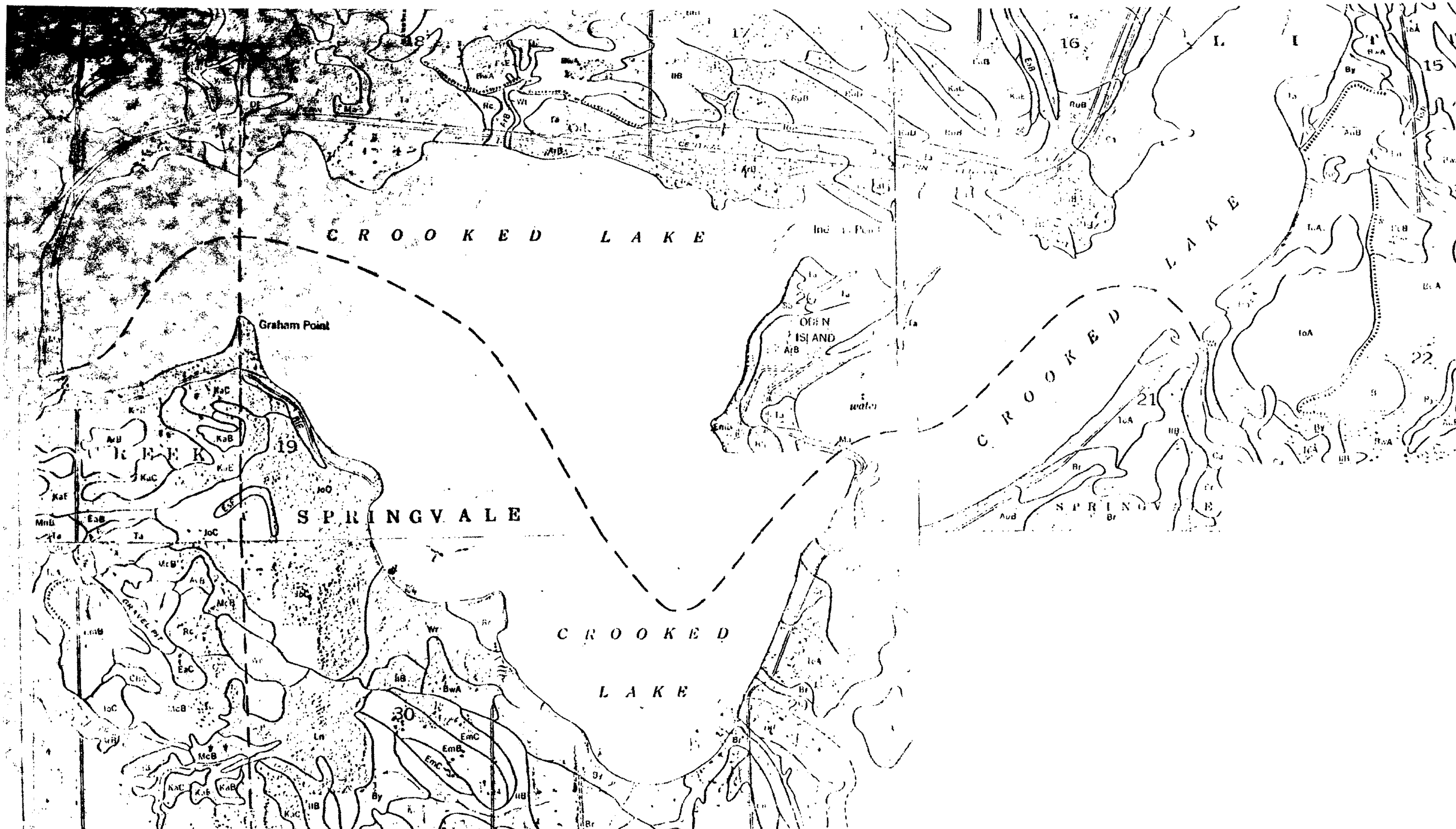
Our work in the next 3 weeks is to survey all the homesites in the Crooked and Pickerel planning area so that an assessment of the overall on-site wastewater treatment systems (ie. septic systems) can be made. We would appreciate your help in completing this survey.

Since we have missed you today, we'll try to return a call or visit and schedule an appointment time before September 10th. Or, please call us in the evening at:

UM Bio-Station, Pellston, MI, (616) 539-8406

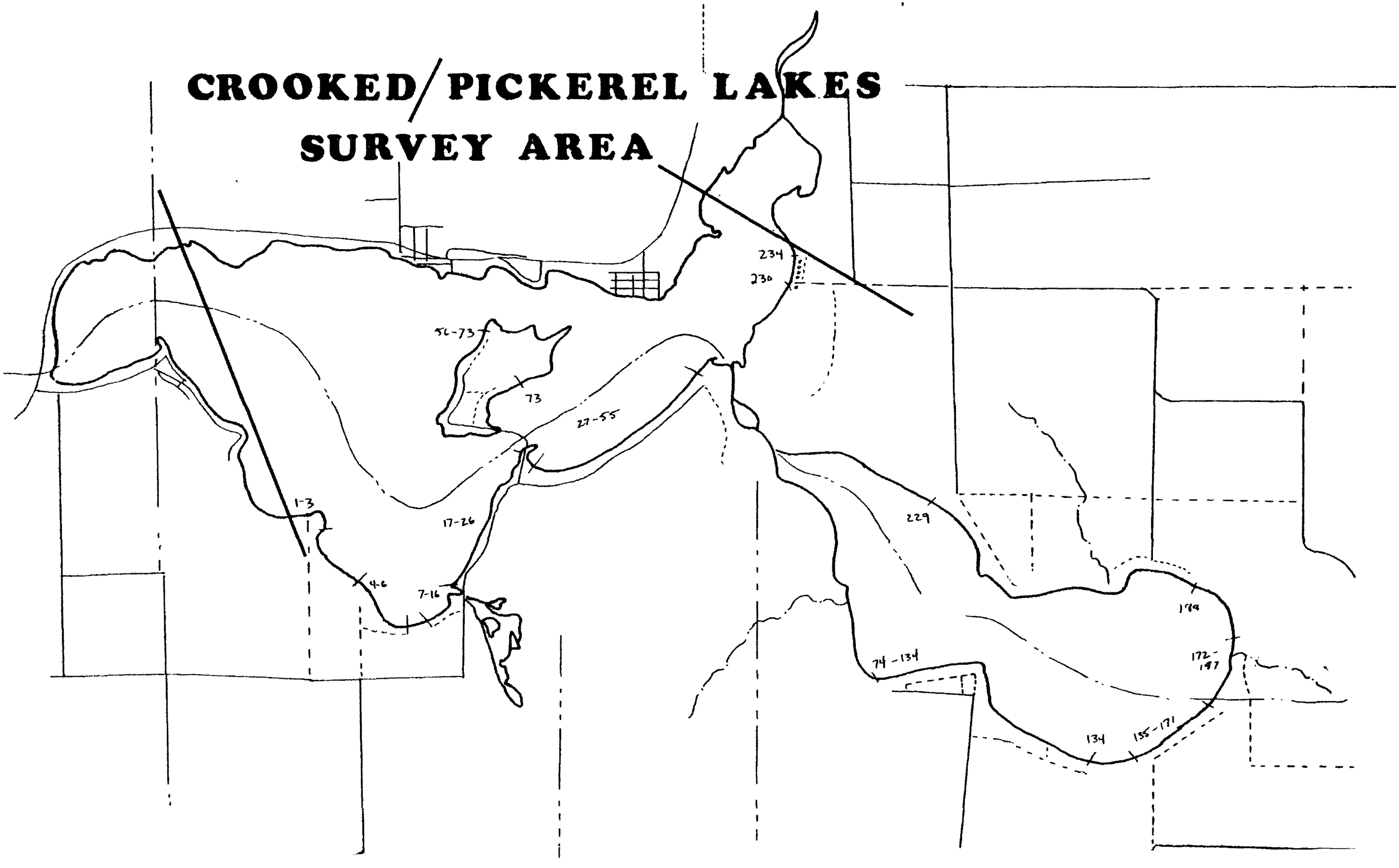
APPENDIX C

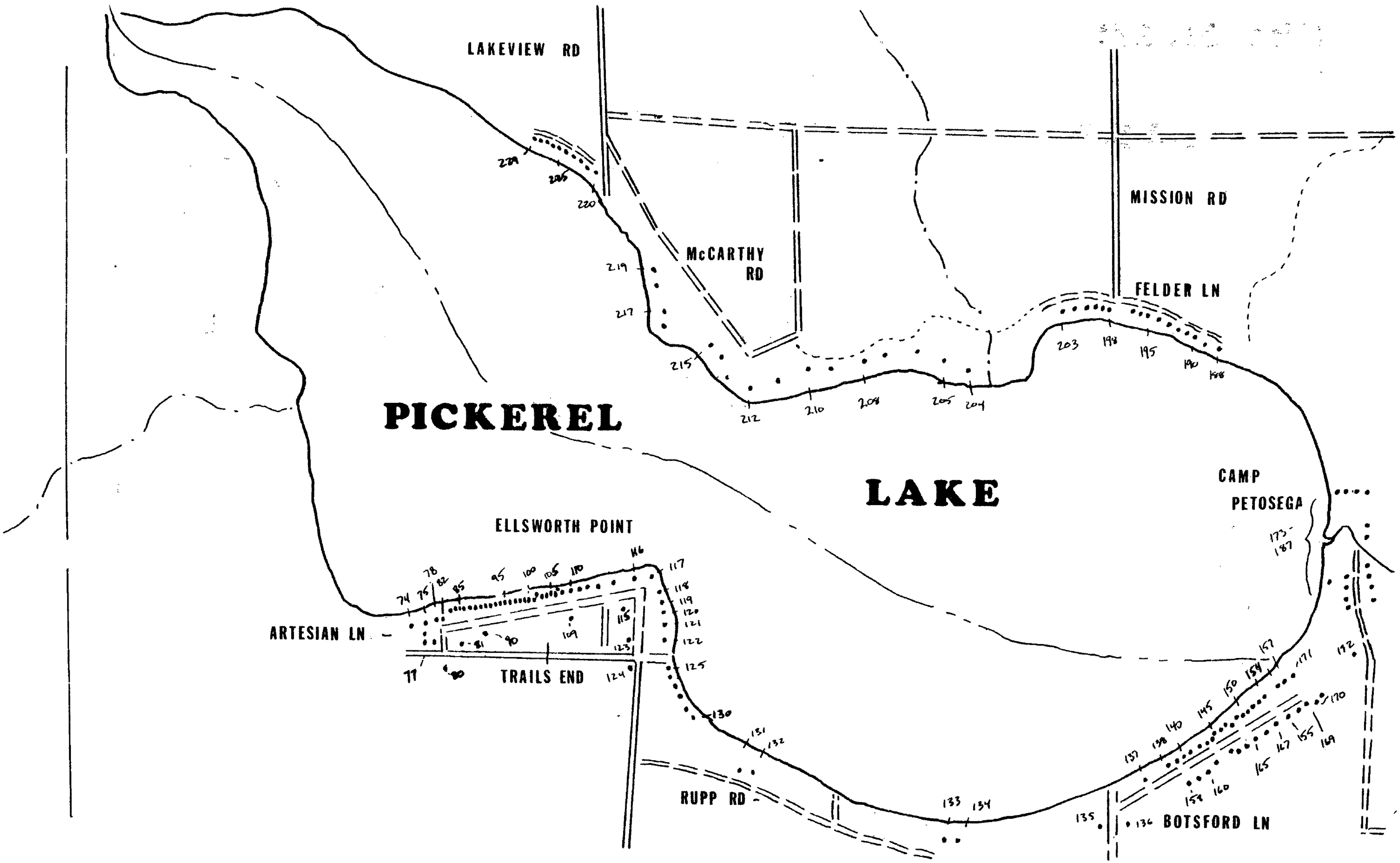
Soil Maps of Survey Areas


C R O O K E D L A K E
Graham Point
S P R I N G V A L E
C R O O K E D
L A K E
C R O O K E D L A K E
S P R I N G V A L E
16
15
17
19
21
22
30

A-8-

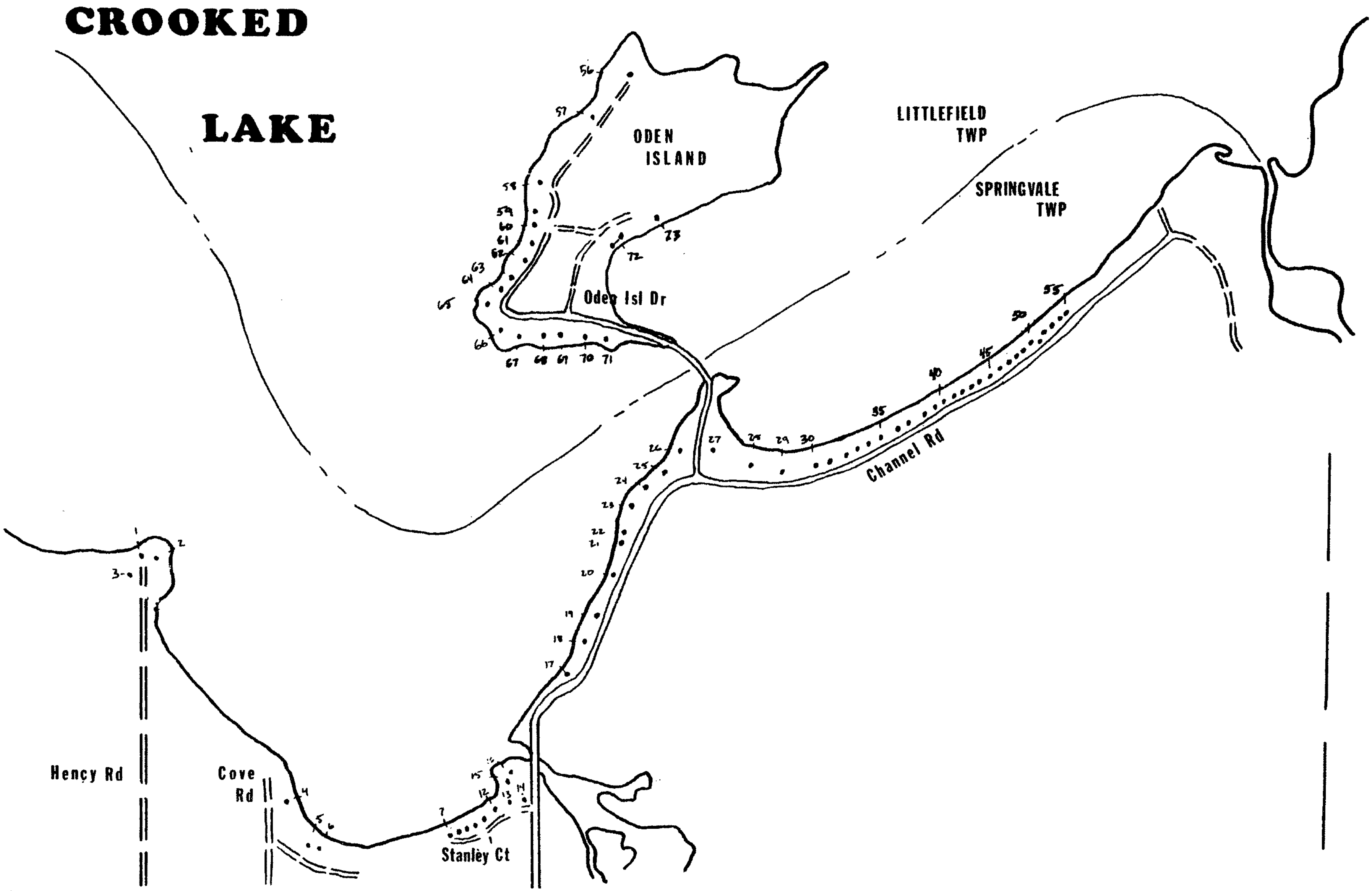
CROOKED/PICKEREL LAKES SURVEY AREA



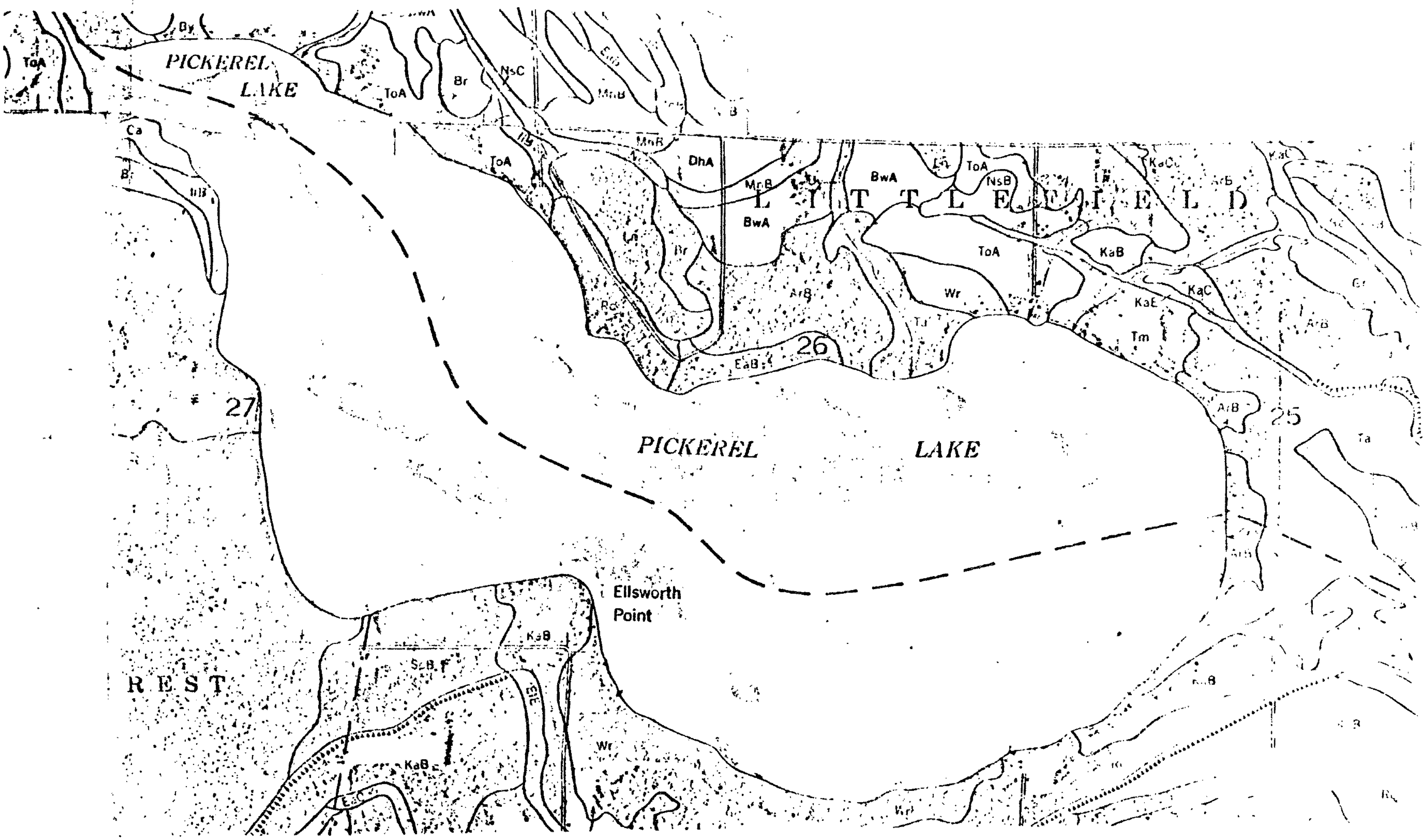

LAKEVIEW RD
McCARTHY RD
MISSION RD
FELDER LN
PICKEREL
LAKE
CAMP PETOSEGA
ELLSWORTH POINT
ARTESIAN LN
TRAILS END
RUPP RD
BOTSFORD LN

B-7

A-11



CROOKED
LAKE
ODEN
ISLAND
LITTLEFIELD
TWP
SPRINGVALE
TWP
Oden Isl Dr
Channel Rd
Hency Rd
Cove
Rd
Stanley Ct


PICKEREL
LAKE
LITTLEFIELD
PICKEREL
LAKE
Ellsworth
Point
REST
25
26
27
ToA
Br
NsC
MnB
DhA
BwA
ArB
Wr
KaB
KaC
KaE
Tm
EaB
Ca
SaB
By

A -12-

APPENDIX D

Press Release and "Flier"

THE UNIVERSITY OF MICHIGAN
BIOLOGICAL STATION
ANN ARBOR, MICHIGAN 48109
(313) 763-4461

DAVID M. GATES, DIRECTOR

ADDRESS, JUNE 15 TO SEPTEMBER 1
PELLSTON, MICHIGAN 49769

August 23, 1978

FOR IMMEDIATE RELEASE

FOR FURTHER INFORMATION
CONTACT: SAM EHLERS
616-539-8406 or
616-539-8408

SEPTIC SYSTEM SURVEY BEGINS ON CROOKED-PICKEREL LAKES

(Pellston, MI) Beginning August 21st, researchers from the University of Michigan Biological Station will be conducting a door-to-door survey on Crooked-Pickerel Lakes.

The information gathered will be used by the Environmental Protection Agency in the preparation of an Environmental Impact Statement for Crooked-Pickerel Lakes. The EIS will evaluate the environmental, social and economic effects of alternatives for sewage collection and/or treatment in Springvale and Littlefield Townships.

Descriptions of these alternatives, costs and other information will be presented at a public hearing on Thursday, August 24th, 7:30 p.m. in the Cafeteria of Petoskey Senior High School on E. Mitchell Road.

Residents' cooperation is requested to facilitate the completion of the survey. For further information, contact the Biological Station, Pellston, MI 49769 (616) 539-8406.

Oh No, We Missed You!!

We are a group of four researchers from the University of Michigan Biological Station, on Douglas Lake, in Pellston, Michigan. You may have heard of us before, because we all worked under a National Science Foundation grant this summer, calling ourselves Project CLEAR. Now that the Project work has ended, four of us are continuing work in your area with funds from the Environmental Protection Agency.

As you may already know, the EPA is in the process of preparing an Environmental Impact Statement (EIS) which will evaluate the environmental, social, and ecomomic effects of alternatives for sewage collection and/or treatment in Springvale and Littlefield Townships in the Crooked and Pickerel Lake planning area.

An information and participation meeting to describe the alternatives, costs, and other information was scheduled for Thursday, August 24, 1978 at the Petoskey High School.

Our work in the next 3 weeks is to survey all the homesites in the Crooked and Pickerel planning area so that an assessment of the overall on-site wastewater treatment systems (ie. septic systems) can be made. We would appreciate your help in completing this survey.

Since we have missed you today, we'll try to return a call or visit and schedule an appointment time before September 10th. Or, please call us in the evening at:

UM Bio-Station, Pellston, MI, (616)539-8406

APPENDIX E

Tables of Results

TABLE 2

Seasonal Preferences By Part-Time Residents

	Summer Only	Two Seasons	Three Seasons	All Seasons
:rooked Lake	12	-	8	6
'ickerel Lake	47	7	19	14
TOTAL NUMBER	59	7	27	20
'ercent of Total	52%	6%	24%	18%

Table 3

Duration of Occupancy Among Part-Time Residents

	Weekends	2-4 wks.	4-8 wks.	3-4 mos.	4-10 mos.	N.A
Crooked Lake	9	-	2	7	7	1
Pickerel Lake	7	9	27	25	17	3
TOTAL NUMBER	16	9	29	32	24	4
Percent of Total	14%	8%	25%	28%	21%	4$

TABLE 4

Future Plans of Permanent Occupancy By Part-Time Residents

	Yes	No	N.A.
Crooked Lake	6	18	2
Pickerel Lake	16	67	5
TOTAL NUMBER	22	85	7
Percent of Total	19%	75%	6%

TABLE 5

Projected Additions To Dwellings By Permanent and Seasonal Residents

	Yes	No	N.A.
Crooked Lake	8	42	18
Pickerel Lake	18	83	2
TOTAL NUMBER	26	125	20
Percent of Total	15%	78%	12%

TABLE 6

Age of Sewage Disposal Systems

	0-5 yrs.	5-10 yrs.	≥10 yrs.	≥20 yrs.	N.A.
Crooked Lake					
Hency-Chanel	1	10	25	6	5
Oden Island	-	-	16	-	1
Burley Road	-	1	2	1	-
TOTAL NUMBER	1	11	43	7	6
Percent of Total	20%	16%	63%	10%	9%
Pickerel Lake					
Ellsworth Point	2	10	20	11	5
Botsford-Petosego	6	3	14	1	1
Mission-Lakeview	2	5	16	5	2
TOTAL NUMBER	10	18	50	17	8
Percent of Total	10%	17%	49%	16%	8%
TOTAL BOTH LAKES	11	29	93	24	14
Percent of Total	6%	18%	54%	14%	8%

TABLE

Design of Sewage Disposal Systems

Area	Septic Tank or Alternatives								Drain Field or Alternatives								
	a^1	a^2	a^3	b	c	d	e	f	g^1	g^2	g^3	h	i	j	k	l	m
Crooked Lake																	
Heney-Channel	34	4	1	1	1	4	1	2	32	3	1	2,1,0	9	27,3,1	4	2,1,0	11
Oden	16									14		2		12	3	1	
Burley	3		(3)						3		(3)			(3) 3			
Pickerel Lake																	
Ellsworth	23	5	(3) 1	(4) 1	16		1		34	5	1	(3)		(3)		(3)	
Botsford-Petosega	19			1,1,0	4				21	1	0	1	2	15,1,0	2	3	4
Mission-Lakeview	20	1	1		4,1,0		2	1	21	1	0	3	3	22,1,1		2	3

LEGEND

a^1 = Single Septic Tank
a^2 = Double Septic Tank
a^3 = Triple Septic Tank
b = Drywell or Grease Trap
c = Combination Drywell and Septic Tank
d = Pit Privy
e = Pit Privy and Drywell
f = Not Available

g^1 = Single Drain Field
g^2 = Double Drain Field
g^3 = Triple Drain Field
h = Mounded System
i = Without Adsorption Field
j = Gravity Fed Adsorption Field
k = Dosed Effluent to Field
l = Pumped Effluent to Field
m = Not Available

(3) Two Dwellings Having Separate Septic Tanks But Common Field.

(4) A Dwelling Had 5 Drywells.

TABLE 8

Sewage Disposal System Compliance With Emmet County Sanitary Code

Area	Based on Sewage System Size Alone			Based on Minimum Separation Distances		
Crooked Lake	Yes	No	N.A.	Yes	No	N.A.
Hency-Channel	20	6	21	27	16	5
Oden-Burley	11	0	10	14	2	4
TOTAL NUMBER	31	6	31	41	18	9
Percent of Total	45%	9%	45%	60%	26%	14%
Pickerel Lake						
Ellsworth	17	11	20	19	26	3
Botsford-Petosega	10	10	4	12	7	5
Mission-Lakeview	9	8	13	18	11	1
TOTAL NUMBER	36	29	37	49	44	9
Percent of Total	35%	29%	36%	48%	43%	9%
TOTAL BOTH LAKES	67	35	68	90	62	18
Percent of Total	39%	20%	40%	53%	36%	11%

TABLE 9

Problem Sewage Disposal Systems and Possible Causes for Poor Performance

Lot No.	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
Crooked Lake: Hency-Channel															
3	x		8			x	6.3-2.0			x			x('78)		
12		x	>10			x	<0.63				x		x('78)		
15		x	>10			x (never)	<0.63		x('77)						
16	x						<0.63	x							x
18	x		>10	x		x	<0.63		x	x('76)	x	x('76)	x('78)	x	
21	x		12			x	<0.63		x('78)				x('78)		
22	x		5-10	x		x	<0.63		x('77)			x('77)	x('77)		
28	x		5-10	x		x	<0.63	x			x('78)		x('76)		
32	x		5-10	x		x	<0.63		x('66)		x('76)	x('76)	x('74)		
33	x		12	x		x	<0.63		x('74)		x (ev.yr.)		x('74)		
35	x		9	x		x	<0.63				x (ev.yr.)		x (ev.yr.)		
42	x		>10	x		x	<0.63				x	x('67)	x('76)		x
47	x		6	x		x	<0.63			x(wet)		x('63)	x('74)		x
50		x	30	x		x	<0.63		x('76)			x('76)	x('76)	x	x
54	x		13	x		x	<0.63	x	x (ev.yr.)	x (ev.yr.)	x (ev.yr.)			x	x
55	x		17			x	<0.63	x	x	x	x			x	x

B-7

Problem Sewage Disposal Systems and Possible Causes for Poor Performance

Lot No.	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
Crooked Lake (continued):															
Oden Island															
61	x		<10	x		x					x		x('76)		
62		x	<10	x		x				x			x('76)		
64		x	<10	x		x	0.63-2.0			x			x('77)	x	
68	x		<10	x		x	0.63-2.0		x('73)			x('73)	x('78)		
70		x	<10	x		x	2.0-6.3		x	x			x('76)		
73		x	<10			x	6.3-20.0		x('73)				x('73)	x	
Burley															
231	x		25			x	<0.63		x (ev.sp.)	x		x('68)	x('73)		
232] 233]		x	<10			x	<0.63		x (ev.sp.)	x			x('73)		
234		x	<10			x (never)	<0.63		x (ev.sp.)	x					
Pickerel Lake:															
Ellsworth Pt.															
85		x	15			x	<0.63		x ('74,75)	x			x('75)	x	
86	x		14			x	<0.63					x('73)	x('78)	x	
106		x	<10				<0.63		x						
124	x					x	<0.63			x			x('76)		

TABLE 9 (continued)

Problem Sewage Disposal Systems and
Possible Causes for Poor Performance

Lot No.	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
Pickerel Lake (continued): Ellsworth Pt. (continued)															
127		x					<0.63			x				x	x
128		x	5-10	x		x	<0.63		x	x	x		x('77)		x
Botsford-Petosego															
159		x	<10			x	6.3-20.0			x('73)			x('73)		
171		x	<10			x	6.3-20.0				x		x('76)	x	
Mission-Lakeview															
200		x	0-5			x	<0.63		x (ev.yr.)		x (ev.yr.)		x('78)	x	
212	x		<10	x		x	6.3-20.0		x('76)	x (ev.yr.)	x (ev.yr.)	x ('73)	x('78)		
218		x	15	x	x	x	6.3-20.0			x			x('75)		
225] 226]		x	<10			x	<0.63			x		x ('76)	x('78)	x	
227		x	<10			x	<0.63			x('76)		x ('76)	x('78)	x	

TABLE 10

Cladophora Study

	Suitable Solid Substrates (No.of Lots)	Presence of Cladophora on Lots with Suitable Substrates	Dwellings with Excessive Water-Using Devices + Ratio Y.R./Season	Ratio of Year-Round to Seasonal Residents of Those with Cladophora	No. of Residences which Feed Water-Fowl at the Lake Shore	No. of Residences Whose Septic Tanks were Poorly Maintained, i.e., not Pumped in the Last 8-10 Years	No.of Residences with Cladophera which Don't Comply with Emmet County Sanitary Code Min. Size & Sep Don't Comp	N.A.
Crooked Lake:								
Hency-Channel	27	14 (5 extensive)	12 (10/2)	12/2	10	4	1	5
Oden	7	5	2 (1/1)	2/3	1	0	1	0
Burley	1	1	1 (1/0)	1/0	1	1	0	0
TOTAL NUMBER	35	20	15	15/5	12	5	2	5
Percent of Total	100%	57%	75%	75%/25%	60%	25%	10%	25%
Pickerel Lake:								
Ellsworth	25	13	1 (1/0	3/10	8	9	5	6
Botsford Petosego	5	4	0	0/4	2	0	3	0
Mission-Lakeview	16	6	1	0/6	3	5	4	2
TOTAL NUMBER	46	23	2	3/20	13	14	12	8
Percent of Total	100%	50%	9%	13%/87%	57%	61%	52%	35%

TABLE 11

Soil Classifications For Lots Within Crooked/Pickerel Survey Area

Soil Classification	Lot Numbers
Crooked Lake	
Arb - Au Gres Sand	70-72
AuB - Au Gres Loamy Sand	23,24,27-40
Br - Brevort Mucky Loamy Sand	7-12,15-17,21,22,25,26, 40-43
BlB - Blue Lake Loamy Sand	68,69
By - Bruce Fine Sandy Loam	4-6
EmB - Emmet Sandy Loam	13,14,63-67
Rc - Roscommon Mucky Sand	1-3
Sb - Sandy Lake Beaches	56-62
Tm - Thomas Loam, Medium Wet Variant	18-20
TOA - Thomas Mucky Loam	43,45,230-235
Pickerel Lake	
ArB - Au Gres Sand	173-187,206-209
EaB - East Lake Loam Sand	209-215
KaB - Kalkaska Sand	110-118,140-155,160-167
Rc - Roscommon Mucky Sand	135-140,158,159, 155-172, 215-219
SuB - Saugatuck Sand	74-110
Ta - Tawas Muck	204,205
Tm - Thomas Loam, Medium Wet Variant	188-195
TOA - Thomas Mucky Loam	196-200,220-229
Wr - Warner's Mucky Loam	118-132,200-203

APPENDIX B-8

EMMET COUNTY SANITARY CODE - DESIGN STANDARDS

SECTION V

CONSTRUCTION STANDARDS for SEWAGE DISPOSAL SYSTEMS

The following specifications as shown in the tables shall be the minimum design criteria and apply in determining the minimum size of the sewage disposal systems required for houses. In the case of larger houses, public and semi-public buildings such as apartments, motels, gas stations, restaurants, etc.: plans and specifications shall be submitted to the Health Officer. If in his judgment the plans are adequate, a permit will be issued.

ITEM 1 SEPTIC TANKS

Design and construction methods shall be approved by the Health Officer prior to construction or installation. In general design specifications found in the "Manual of Septic-Tank Practice", U.S. Public Health Service Publication No. 526, as amended will apply as a guide.

TABLE I
MINIMUM CAPACITIES FOR SEPTIC TANKS

Number of Bedrooms	Minimum Liquid Capacity (gals.)
2 or less	750
3 or 4	1,000
Each additional bedroom beyond 4, add	250

Note: The capacities in this table provide for the plumbing fixtures and appliances used in a single family residence including an automatic washer, mechanical garbage grinder and dishwasher.

TABLE II
MINIMUM DISTANCE IN FEET

All distances measured horizontally from any vertical point below grade.

FROM	TO					
		SEWERS				
*	Absorption Bed	Cast Iron Soil Pipe	Oth.	Septic Tank	Tile Field	Seepage Pit
Wells or suction lines	50	10	50	50	50	50
Water Pressure Lines (buried)	10	10	10	10	10	10
Property Line	10	2	2	10	10	10
Foundation Wall	10		5	5	10	20
Drop-off	20	5	10	10	15	25
Lake or stream	50	10	50	50	50	50

*See Michigan Department of Health "Regulations for Certain Water Supplies" regarding suction lines (Section 4.3).

TABLE III
SIZE AND MINIMUM SPACING FOR TILE FIELD TRENCHES

Width of Trench at Bottom (inches)	Minimum Spacing of Trenches Center to Center (feet)
18 to 24	6.5
24 to 30	7.0
30 to 36	7.5

TABLE IV
MINIMUM REQUIRED TRENCH BOTTOM AREA PER BEDROOM FOR TILE FIELDS

Percolation Rate	Type of Soil	Absorption Area
Less than 5 minutes	Coarse sand & gravel	115 square feet
5 to 10 minutes	Fine sand & sandy clay	165 square feet
10 to 15 minutes	Sandy clay	190 square feet
15 to 30 minutes	Clay	250 square feet
Over 30 minutes - unsuitable		

TABLE V
TILE FIELD CONSTRUCTION DETAILS

Items	Maximum	Minimum
Number of Lateral Trenches		2
Length of Trenches	100 ft.	....
Width of Trenches	36 in.	18 in.
Depth of Tile Lines (bottom) below finish grade	30 in.	18 in.
Slope of Tile Lines	6 in./100 ft.	2 in./100 ft.
Depth of Aggregate		
Under tile	....	6 in.
Over tile	....	2 in.
Under tile located within root area of trees	....	12 in.
Size of Aggregate*	1½ in.	½ in.
Depth of Straw or Hay Cover	....	3 in.

*Standard 10 A. Stone Spec. Acceptable

TABLE VI
MINIMUM REQUIRED BOTTOM AREA PER BEDROOM FOR ABSORPTION BEDS

Percolation Rate	Type of Soil	Absorption Area
Less than 5 minutes	Coarse Sand & Gravel	230 square feet
5 to 10 minutes	Fine Sand & sandy clay	330 square feet
10 to 15 minutes	Sandy Clay	380 square feet
15 to 30 minutes	Clay	500 square feet
Over 30 minutes - unsuitable		

TABLE VII
ABSORPTION BED CONSTRUCTION DETAILS

Same as Table V except as follows:

Item	Maximum	Minimum
Distance between distribution lines	4 ft.	....
Distance between distribution lines & wall	1½ ft.	6 in.

SUMMARY FOR ON-SITE SYSTEMS WITH OCCASSIONAL OR RECURRING PROBLEMS

Map Number	Location	Age (Years)	Type System	Problem	Frequency	System Undersized	Site Limitation	Maintenance	Pumping Frequency	Last Time Pumped
3	Hency Road	8	ST & DF Dosing	Backup	1x Summer 78	No	Severe	None	3 or 4 yr.	78
12	Stanley Court	10	ST & DF	Odors	In the past	No	Severe	None	DK	78
15	Channel Road	>10	ST & DF	Ponding	One Season	DK	Severe	None	None	None
18	Channel Road	>10	ST & DF	Backup & Ponding	Frequent before repair	No	Severe	New Drainfield 1976	Yearly	78
21	Channel Road	12	ST & LF	Backup	Summer 78	No	Severe	None	3 to 4 yrs.	78
22	Channel Road	5-10	ST & DF & DW	Backup & Ponding	One Season 77	No	Severe	Enlarged Drainfield 1977	DK	77
28	Oden Road	5-10	2ST & 2DF	Ponding & Odors	76	No	Severe	None	DK	76
32	Oden Road	12	ST & DF	Ponding & Odors	66	Yes	Severe	Enlarged Drainfield 1966	3 to 4 yrs.	73-75
33	Oden Road	9	ST & DF	Ponding & Odors	74-75	No	Severe	Filled in low area	5 yrs.	73-75
35	Oden Road	>10	ST & DF	Odors	Every year	Yes	Severe	Cleaned pipes	Every yr.	78
38	Oden Road	>10	ST & DF	Backup	Every 5 yrs. or so	No	Severe	None	5 yrs.	DK

ST - Septic Tank
DF - Drainfield
DK - Don't know

Map Number	Location	Age (Years)	Type System	Problem	Frequency	System Undersized	Site Limitation	Maintenance	Pumping Frequency	Last Time Pumped
42	Oden Road	11	ST & Dosing & Mound	Backups & Ponding	Spring 76	No	Severe	Replaced Drainfield 67	3 or 4 yr.	76-77
44	Oden Road	>10	ST & DF	Odors	Not Available	DK	Severe	None	Infrequent	72
47	Channel Road	30	ST & DF	Backup	When it Rains	Yes	Severe	New Drainfield 63	1 to 2 yr.	78
54	Channel Road	13	ST & DF	Backup Odors Ponding	Every year	No	Severe	None	Every yr.	76-77
62	Oden Island	>10	ST & DF	Backups	Once	DK	Severe	None	DK	76-77
68	Oden Island	>10	ST & Mound	Ponding	4 to 5 yrs. ago	No	Severe	None	Yearly	77
70	Oden Island	10	ST & DF	Backup & Ponding	Once per year	No	Severe	None	2 to 3 yrs.	77
73	Oden Island	>10	ST & DF	Ponding	1x	DK	Severe	None	Infrequent	3-5
75	Trails End	15	ST & DF & DW	Backup & Ponding	1-2x 3 to 4 yrs.	Yes	Severe	None	Once, more than 5 yrs. ago	DK
86	Trails End	14	ST & DF & DW	Odors & Backups	3 to 5 yrs. ago and this Spring	Yes	Severe	Added tile stones to Drainfield	Added tile stones to Drainfield	78
106	Trails End	>10	ST & DF	Ponding	When it Rains	Yes	Severe	None	Once	73

Map Number	Location	Age (Years)	Type System	Problem	Frequency	System Undersized	Site Limitation	Maintenance	Pumping Frequency	Last Time Pumped
124	Artesian Lane	25	ST & DF	Backup	Yearly	No	Severe	None	2 yrs.	76
127	Ellsworth Road	DK	ST & DF & DW	Backup	DK	DK	Severe	None	DK	DK
128	Ellsworth Road	5-10	ST & DF	Backup & Ponding	Rain; heavy Use	DK	Severe	None	3 to 4 yr.	77
171	Botsford Lane	>10	ST & DF & Dosing	Backup & Odors	1x	No	Severe	None	None	None
200	Misson Road	0-5	ST & DF	Ponding & Odors	With High Use	Yes	Severe	None	Yearly	77-78
212	McCarthy Road	>10	ST & DF & DW	Backup & Ponding	Every Year	No	Slight	Repaired pipe	2X/yr.	78
225 - 226	Lakeview Road	>10	ST & DF & DW	Backup	1 to 2x per yr.	Yes	Moderate	Remove roots from Drainfield	1 yr.	78
227	Lakeview Road	>10	ST & DF	Backup	1x 2 yrs. ago	DK	Severe	Repair root damage	Irregular	73
231	Burley Road	25	ST & DF	Ponding	DK	No	Severe	Repair root damage	Irregular	73
232 - 233	Burley Road	>10	ST & DF	Ponding	DK	No	Severe	None	Irregular	73

APPENDIX C

BIOTA

SUBMERGED AND EMERGENT AQUATIC PLANTS

Common name	Scientific name
Waterweed	*Anacharis canadensis*
Coontail	*Ceratophyllum*
Water milfoil	*Myriophyllum*
Bushy pondweed	*Najas flexilis*
Water lily	*Nymphaea odorata*
Yellow water lily	*Nuphar advenum*
Large-leaf pondweed	*Potamogeton amplifolius*
Whitestem pondweed	*P. praelongus*
Sage pondweed	*P. pectinatus*
Flat-stemmed pondweed	*P. zosteriformus*
Floating-leaf pondweed	*P. natans*
Arrowhead	*Sagittaria*
Softstem bulrush	*Scirpus validis*
Bulrush	*S. americanus*
Common cattail	*Typha latifolia*
Bladderwort	*Utricularia purpurea*
Tapegrass or wild celery	*Vallisneria spiralis*

SOURCE: Michigan DNR. Variously dated.

INVERTEBRATE INDICATOR ORGANISMS
FOUND IN CROOKED AND PICKEREL LAKES

Common Name	Scientific Name	Lake	Indication of Water Quality
Zooplankton			
Cladoceran	Chydorus spaericus	P,C	Greater abundance in Crooked Lake indicates that waters slightly lower trophic status than Pickerel
Rotifers	Conochiloides natans	P	oligo-mesotrophic indicators
	Notholca foliacea	C	
	Northolca michiganensis	P,C	
	Synchaeta asymmetrica	C	
	Polyarthra euryptera	P,C	Eutrophic Indicators
	Trichochocerca multicrinus	P,C	
Benthic			
Mayfly nymph	Hexagenia	P,C	Oligotrophic indicators more common in Pickerel Lake
Findernail clams	Sphaerium	P,C	
Oligochaete worm	Limnodrilus hoffmeistesi	P,C	Eutrophic indicators
Chrionamid Midge larvae	Mixed Sp.	P,C	

P - Pickerel Lake
C - Crooked Lake

Source: Gannon, 1978.

USE OF DIVERSITY INCICES

Diversity indices are frequently used as a supplement to water quality data to provide additional information as to whether the waters under consideration are being degraded. The Diversity Indices are dimensionless terms used to express the relative aboundance of selected indicator organisms.

The rationale for utilizing the diversity index as a measure of water quality change is based on the fact that changes in environmental conditions lead to changes in distribution and abundance of particular species. For an individual to be a useful indicator organism it must have a rather narrow range of suitable environmental conditions and must respond in a quantitative fashion to the environmental factor(s) under consideration.

For this Crooked/Pickerel Lakes S udy performed by Gannon in 1978 the Shannon-Weiner diversity index $\bar{H}$ was calculated as follows:

$$\bar{H} = \frac{3.3219}{N} (N \ Log_{10} \ N - \Sigma_{ni} \ Log_{10} \ ni)$$

Where: N = total # of organisms collected

ni = # of individuals per species

3.3219 = is a constant used to change base 10 to base 2.

FISH SPECIES SURVEY OF PICKEREL LAKE

Common Name	Scientific Name
Game fishes	
Yellow perch	*Perca flavens*
Northern pike	*Esox lucius*
Rock bass	*Ambloplites rupestris*
Smallmouth bass	*Micropterus dolomieui*
Walleye	*Stizostedion vitreum*
Largemouth bass	*Micropterus Salmoides*
Brown trout	*Salmo trutta*
Pumpkinseed	*Lepomis megalotis*
Bluegill	*Lepomis macrochirus*
Warmouth	*Lepomis gulosus*
Coarse fishes	
White sucker	*Catostomus commersoni*
Yellow Bullhead	*Ictalurus natalis*
Brown bullhead	*Ictalurus nebulosus*

SOURCE: Michigan DNR, 1971

Common Name	Scientific Name
Forage fishes	
Alewife	*Alosa pseudoharengus*
Sand shiner	*Notropis stramineus*
Common shiner	*Notropis cornutus*
Bluntnose minnow	*Pimephales notatus*
Banded Killifish	*Fundulus diaphanus*
Logperch	*Percina caprodes*
Johnny darter	*Etheostoma nigrum*
Iowa darter	*Etheostoma exile*
Slimy sculpin	*Cottus cognatus (Cedar Creek)*
Shore minnow	*Notropis deliciousus*
Pearl dace	*Semotilus margarita*
Other fishes	
Longnose gar	*Lepisosteus osseus*
Bowfin	*Amia calva*
Carp	*Cyprenus carpio*

FISH SPECIES OF CROOKED LAKE

Common Name	Scientific Name
	Game fishes
Yellow perch	*Perca flavens*
Rock bass	*Ambloplites rupestris*
Bluegill	*Lepom's macrochirus*
Walleye	*Stizostedion vitreum*
Largemouth bass	*Micropterus salmoides*
Smallmouth bass	*Micropterus dolemieui*
Northern pike	*Esox lucius*
	Forage fishes
Common shiner	*Notropis cornutus*
Bluntnose minnow	*Pimephales notatus*
Logperch	*Percina caprodes*
Spottail shiner	*Notropis hudsonius*
Johnny darter	*Etheostoma migrum*
Mimic shiner	*Notropis volucellus*
Central mudminnow	*Umbra limi*
Sailfin	
	Coarse fishes
Suckers	*Catostomidae*
Brown bullhead	*Ictalurus nebulosus*
Yellow Bullhead	*Ictalurus natalis*
	Other fishes
Longnose gar	*Lepisosteus osseus*

SOURCE: Michigan DNR, 1954

APPENDIX
C-6

CHECK LIST OF RESIDENT BIRDS OF MICHIGAN (NORTHWESTERN LOWER PENINSULA MICHIGAN) DURING HEIGHT OF BREEDING SEASON (MID JUNE TO END OF FIRST WEEK OF JULY) WITH SUMMER NESTING RECORDS AND SPECIES ABUNDANCE

by William and Edith Overlease, Biolity
Department, West Chester State College,
West Chester, Pa. 19380, revised July 1978

Breeding records: nest **, young traveling with adults *

Abundance records: A - abundant, F - frequent, C - common though often present in small numbers, 0 - occasional, R - rare

** Common Loon O
** Pied-billed Grebe R
Great Blue Heron O
** Green Heron C
** Least Bittern O
American Bittern O
** Mute Swan C
** Canada Goose O
** Mallard F
** Black Duck O
* Blue-winged Teal O
** Wood Duck C
Hooded Merganser R
** Common Merganser O
Turkey Vulture C
** Goshawk O
** Sharp-shinned Hawk O
Cooper's Hawk O
* Red-tailed Hawk O
** Red-shouldered Hawk O
** Broad-winged Hawk C
** Bald Eagle O
Marsh Hawk O
** Osprey R
American Kestrel R
** Ruffed Grouse F
King Rail R
** Virginia Rail O
** Sora O
* Common Gallinule O
American Coot O
** Piping Plover R
** Killdeer F
** American Woodcock C
Common Snipe R
** Upland Plover O
** Spotted Sandpiper C
Short-billed Dowitcher R
Herring Gull F
Ring-billed Gull A
Caspian Tern O
** Black Tern O
** Mourning Dove C
Yellow-billed Cuckoo O
** Black-billed Cuckoo O
Screech Owl R
Great-horned Owl O
* Barred Owl O
Whip-poor-will O
** Common Nighthawk C
Chimney Swift C
** Ruby-throated Hummingbird C
** Belted Kingfisher F
** Common Flicker F
** Pileated Woodpecker C
** Red-headed Woodpecker O
** Yellow-bellied Sapsucker C
** Hairy Woodpecker F
** Downy Woodpecker F
** Eastern Kingbird F
Western Kingbird R
** Great Crested Flycatcher F
** Eastern Phoebe C
Yellow-bellied Flycatcher R
Traill's Flycatcher C
** Least Flycatcher F
** Eastern Wood Pewee F
** Olive-sided Flycatcher O
** Horned Lark C
** Tree Swallow F
** Bank Swallow A
** Rough-winged Swallow C
** Barn Swallow F
** Cliff Swallow O
** Purple Martin F

**Blue Jay F
**Common Crow F
**Black-capped Chickadee F
*Tufted Titmouse R
*White-breasted Nuthatch C
*Red-breasted Nuthatch C
*Brown Creeper O
**House Wren C
*Winter Wren C
**Long-billed Marsh Wren O
Short-billed Marsh Wren O
**Mockingbird O
**Catbird F
**Brown Thrasher F
**American Robin A
**Wood Thrush F
**Hermit Thrush C
**Swainson's Thrush R
**Veery F
**Eastern Bluebird C
*Golden-crowned Kinglet O
Loggerhead Shrike R
**Starling F
*Yellow-throated Vireo O
Solitary Vireo R
**Red-eyed Vireo A
Philadelphia Vireo R
Warbling Vireo F
**Black and White Warbler F
* Golden-winged Warbler O
** Nashville Warbler C
Northern Parula R
** Yellow Warbler F
Magnolia Warbler O
Black-throated Blue Warbler C
Yellow-rumped Warbler O
** Black-throated Green Warbler F
* Blackburnian Warbler C
Chestnut-sided Warbler F
* Pine Warbler F
** Prairie Warbler C
** Ovenbird A
Northern Waterthrush C
Louisiana Waterthrush R
** Mourning Warbler C
** Yellowthroat F
**Canada Warbler C
**American Redstart A
**House Sparrow F
*Bobolink C
**Eastern Meadowlark F
Western Meadowlark O
**Red-winged Blackbird A
**Baltimore Oriole (Northern Oriole) F
**Brewer's Blackbird R
**Common Grackle A
**Brown-headed Cowbird F
*Scarlet Tanager F
**Cardinal C
**Rose-breasted Grosbeak F
**Indigo Bunting F
Dickcissel O
*Purple Finch C
Pine Siskin R
**American Goldfinch F
**Red Crossbill R
*Rufous-sided Towhee C
Savannah Sparrow C
Grasshopper Sparrow C
Henslow's Sparrow O
**Vesper Sparrow F
Dark-eyed Junco R
**Chipping Sparrow A
* Field Sparrow C
**White-throated Sparrow F
Swamp Sparrow F
**Song Sparrow A
**Clay-colored Sparrow O

The authors are grateful to the following contributors of nesting records for the county: Carl Freeman, Harold Gall, James Laubach, Alan Marble, Donald McBeath, Lyle Pratt, Sergej Postupalsky, Arvid Tesaker, Keith Westphal

Totals - 153 species,

Breeding records for 111 species

MAMMALS WITH A HABITAT RANGE IN THE STUDY AREA

White-tail deer	Dama virginianus
Black bear	Ursus americanus
Beaver	Castor canadensis
Botcat	Lynx rufus
Red fox	Vulpes fulva
Mink	mustela vison
Muskrat	Ondatra zibethica
Opossum	Didelphis marsupialis
Weasel	Mustela sp.
River otter	Lutra canadensis
Snowshoe hare	Lepus americanus
Racoon	Prycon lotor
Red squirrel	Tamiasciurus hudsonicus
Gray squirrel	Sciurus carolinensis
Fox squirrel	Sciurus niger
Bats	Several species
Woodchuck	Marmota monax
Chipmunk	Tamias striatus
Coyote	Canis latrans
Porcupine	Erethizon dorsatum

Several species of small rodents (mice, shrews, pooles)

MICHIGAN'S RARE AND ENDANGERED MAMMALS

WHOSE HABITAT RANGE INCLUDES THE STUDY AREA

Classification	Common Name	Scientific Name	Habitat
Threatened	Pine Vole	Microtus pinetorum	Grasses, borders of woodlands
Threatened	Southern bog Lemming	Synaptomys cooperi	Moist grasses
Rare	Water Shrew	Sorex palustris	Stream and swamp edges
Rare	Badger	Taxidea taxus	Grasslands
Peripheral	Gray Fox	Urocyon cinereoargenteus	Woodland and open open lands
Rare	Thompson's pigmy shrew	Microsorex thompsoni	Dry or moist grassy and forested areas

SOURCE: Michigan's Endangered and Threatened Species Program. DNR. 1976.

MICHIGAN'S THREATENED BIRD SPECIES WHOSE HABITAT RANGE INCLUDES THE STUDY AREA

Common Name	Scientific Name	Habitat
Osprey	Pandion haliaetus	Range restricted to river banks and lake edges
Bald eagle	Hlaliacetus leucophalus	Aquatic, along river banks and lake edges
Piping plover	Charadrius melodius	Lake shores and wetlands
Loggerhead shrike	Lanius ludovicianus	Borders of woodlands
Marsh hawk	Circus cyaneus	Marshlands, grassy swales and fields
Red-shouldered hawk	Buteu lineatus	Lowland woodlands along rivers and creeks

SOURCE: Michigan's Endangered and Threatened Species Program.

RARE & THREATENED PLANT SPECIES

OF MICHIGAN FOUND IN THE STUDY AREA

Common Name	Scientific Name
Blunt-lobed or large woodsia	*Woodsia obtusa*
Bald-rush	*Psilocarya scirpoides*
Calypso orchid	*Calypso bulbosa*
Ram's-head lady's-slipper	*Cypripedium arietinum*
Small round-leaved orchis	*Orchis rotundifolia*
Grass	*Agropyron dasystachym*
Slough-grass	*Beckmannia szygachne*
Grass	*Bromus pumpellianus*
Wild Rice	*Zizania aquatica vars interior and aquatica*
Potamogeton pondweed	*Potamogeton Hillii*
Thistle	*Cirsium Pitcheri*
Goldenrod	*Solidago Houghtonii*
Lake Huron tansy	*Taniacetum huronense*
Pine-drops	*Pterospora andromedea*
Butterwort	*Pinguicula vulgaris*
Queen-of-the-prairie	*Filipendula rubra*

APPENDIX D

METHODOLOGY FOR PROJECTING THE PROPOSED
CROOKED/PICKEREL LAKES SERVICE AREA
PERMANENT AND SEASONAL POPULATION, 1978 AND 2000

APPENDIX D

Methodology For Projecting the Proposed Crooked/Pickerel Lakes Service Area Permanent and Seasonal Population, 1978 and 2000

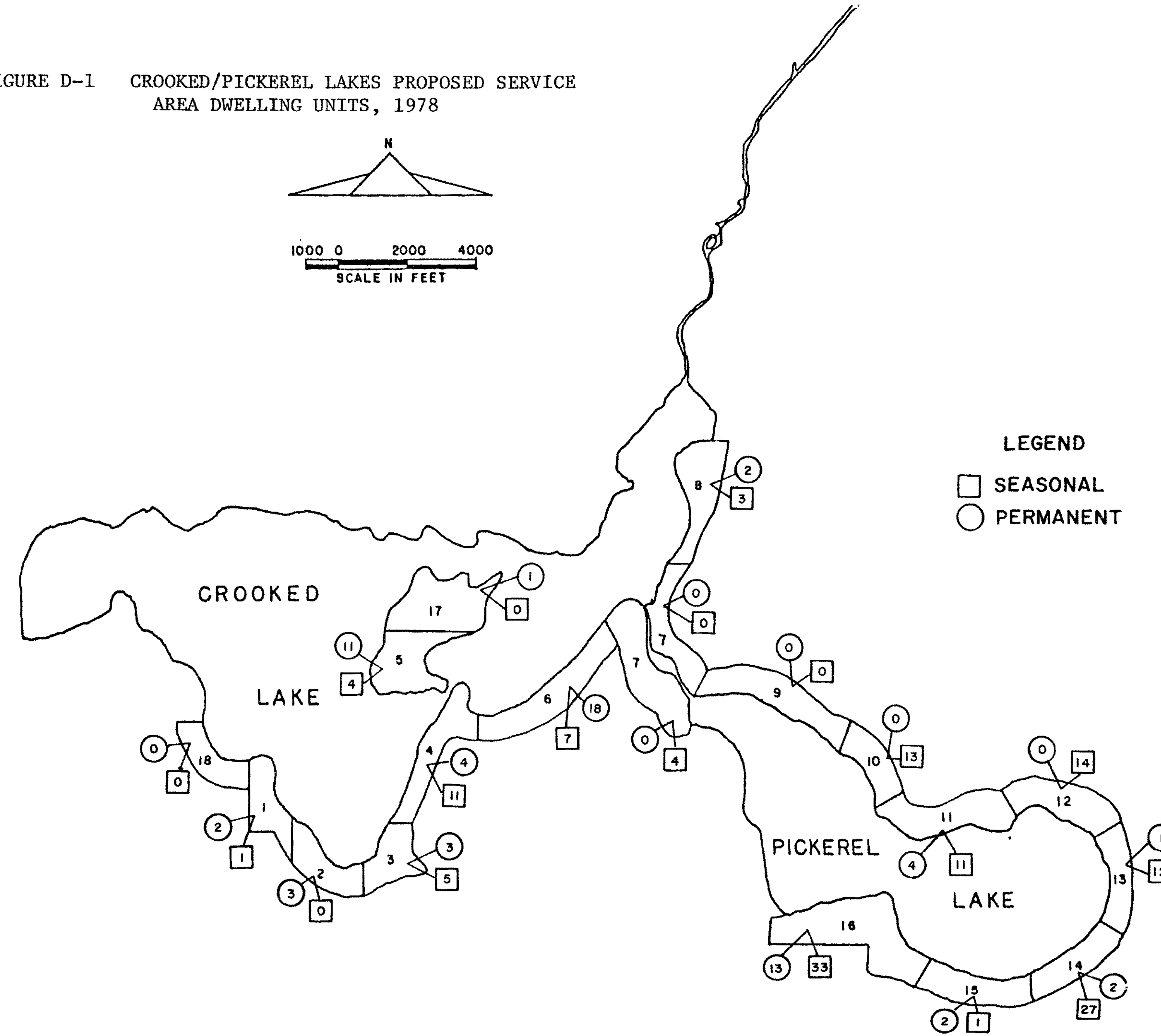
1978 Population Estimate

The 1978 population estimate for the Crooked/Pickerel Lakes Proposed Service Area was based on an analysis of 1975 aerial photography and a review of the Springvale-Bear Creek Area Segment of the Little Traverse Bay Area Facility Plan (Williams and Works, 1976) and the Suitability of Soils For On-site Wastewater Disposal, Pickerel and Crooked Lakes, Emmet County, Michigan (Gold and Gannon, 1978). The Proposed Service Area is located within portions of two townships (Littlefield and Springvale), both in Emmet County. The area was divided into eighteen segments for the purpose of projecting future population. As indicated in Figure D-1, Littlefield Township has eight segments plus part of a ninth (Segment 7) and Springvale Township has nine segments plus part of a tenth.

The total population figure of 840 for 1978 was derived from the following information:

- Dwelling unit count for the Proposed Service Area (Gannon and Gold) and a dwelling unit count by segments (aerial photographs);

FIGURE D-1 CROOKED/PICKEREL LAKES PROPOSED SERVICE AREA DWELLING UNITS, 1978



- A count of permanent and seasonal dwelling units in each segment (Gannon and Gold); and

- A permanent and seasonal occupancy rate (persons per dwelling unit) based on 1970 Census Data.

As indicated in Table D-1, there were 212 dwelling units in the Proposed Service Area consisting of 66 permanent units and 146 seasonal units. Gannon and Gold, in their survey of the Proposed Service Area (see Figure D-1), estimated the number of permanent units based on recently plowed drives, fresh tire tracks, trash containers, and chimney smoke. Based on this dwelling unit count and permanent/ seasonal occupancy breakdown, an occupancy rate for permanent units (3.25 persons per unit) and seasonal units (4.25 persons per unit) was applied to each dwelling unit type. The final calculation resulted in an estimate of 305 people in Littlefield Township and 535 people in Springvale Township. The Proposed Service Area had 617 seasonal residents (73.5%) with Littlefield Township having 79.7% (243) and Springvale Township having 69.9% (374).

Year 2000 Population Projections

A review of the Facility Plan population projections for the Crooked/Pickerel Lakes Proposed Service Area found these projections to be based on several assumptions which served to inflate the totals (See next section for a discussion of the difference between the EIS and Facility Plan population projections). Consequently, other population

Table D-1

EXISTING POPULATION AND DWELLING UNITS FOR THE CROOKED/PICKEREL PROPOSED SERVICE AREA (1978)

	1978					
	Population			Dwelling Units		
Municipality	Total	Permanent	Seasonal	Total	Permanent	Seasonal
Littlefield Township						
5	53	36	17	15	11	4
7 (part)	0	0	0	0	0	0
8	20	7	13	5	2	3
9	0	0	0	0	0	0
10	55	0	55	13	0	13
11	60	13	47	15	4	11
12	60	0	60	14	0	14
13	54	3	51	13	1	12
17	3	3	0	1	1	0
Subtotal	305	62	243	76	19	57
Springvale Township						
1	11	7	4	3	2	1
2	10	10	0	3	3	0
3	31	10	21	8	3	5
4	60	13	47	15	4	11
6	89	59	30	25	18	7
7 (part)	17	0	17	4	0	4
14	128	13	115	29	2	27
15	7	7	0	3	2	1
16	182	42	140	46	13	33
18	0	0	0	0	0	0
Subtotal	535	161	374	136	47	89
TOTAL	840	223	617	212	66	146

projections which encompassed the Proposed Service Area were evaluated. However, none of these projections was made at the Proposed Service Area level.

As a result, independent permanent and seasonal baseline population projections were produced for the year 2000 which considered the three growth factors influencing future population levels in the Proposed Service Area. These factors are: (1) the rate of growth or decline of the permanent population; (2) the rate of growth or decline of the seasonal population; and (3) the potential conversion of seasonal to permanent dwelling units. The best available information regarding each of these factors was utilized and resulted in the following assumptions:

- Based on discussions with local officials (Emmet County Planning Department, 208 Planning Agency, Williams and Works) and an analysis of recent growth trends, (U.S. Census data, building permit records) it appears that the Proposed Service Area is in the initial stages of a transitional period in which it is changing from a primarily seasonal area to an area which will serve largely as a bedroom community for the Petoskey area. Consequently, population projections based on past population trends will not accurately forecast the future population, particularly in terms of permanent and seasonal residents.

- All of the population projections available for the Proposed Service Area or larger geographical areas were based on an analysis of past population growth trends. While these projections provided control totals for the rate of population growth, the projections could not be used for the analysis of wastewater management alternatives.

- The growth dynamics of the Proposed Service Area (i.e., the transition from a primarily seasonal to a primarily bedroom community area) dictated that the population projections based on an analysis of past dwelling unit growth trends which more accurately depicted the type of population growth occurring in the Proposed Service Area.

- The analysis of dwelling unit growth found that between 1970 and 1978, the Facility Plan Study Area, Springvale Township, Littlefield Township, and the Proposed Service Area all had annual dwelling unit increases of 2.0% to 3.0%. (U.S. Census Bureau, Emmet County Planning Department). In addition, it was determined that permanent dwelling units in Springvale Township were increasing by approximately 4.0% per year while Littlefield Township was incurring a 5.5% increase in permanent dwelling units annually.

- Based on the past pattern of seasonal dwelling unit conversions, (Emmet County tax records 1979) it was assumed that existing seasonal dwelling units will convert at a rate of approximately 1.0% per year (15.8% during the planning period) while new seasonal dwelling units constructed after 1978 will convert to permanent units at a rate of 1.0% per year (10.6% during the planning period).

- Based on the national trend toward smaller family sizes, it was assumed that the occupancy rate for permanent dwelling units will decrease to 3.0 persons per unit and that the seasonal dwelling unit occupancy rate would decrease to 4.0 persons per unit.

Based on these assumptions, the dwelling unit projections for the Proposed Service Area by Township were developed using the 1978 estimates as a base. As indicated in Table D-2, the population projections resulted in a Proposed Service Area population of 1,263 people consisting of 603 permanent residents (47.7%) and 660 seasonal residents (52.3%). The total in-summer population for the year 2000 represents a 50.4% increase over the 1978 figure. Littlefield Township is projected to increase by 167 people (54.8%) and Springvale Township is projected to increase by 256 people (47.9%). These figures are in line with the Northwest Michigan Regional Planning Commission's (208 planning agency) projected growth for Littlefield Township (43.2%) and Springvale Township (30.4%). The permanent population in Littlefield Township will increase by nearly 250% while Springvale Township's permanent population is projected to increase by over 140%. The increase in seasonal population is anticipated to be of compartively smaller magnitudes with only a 5.3% increase in Littlefield Township and a 8.0% increase in Springvale Township.

Using the Township totals for the Proposed Service Area, the new dwelling units and the conversion of seasonal to permanent dwelling units were dissaggregated to the eighteen segments comprising the

Table D-2

PROJECTED POPULATION AND DWELLING UNITS FOR THE CROOKED/PICKEREL PROPOSED SERVICE AREA (2000)

	2000					
	Population			Dwelling Units		
Municipality	Total	Permanent	Seasonal	Total	Permanent	Seasonal
Littlefield Township						
5	64	48	16	20	16	4
7 (part)	0	0	0	0	0	0
8	37	21	16	11	7	4
9	0	0	0	0	0	0
10	93	33	60	26	11	15
11	103	51	52	30	17	13
12	90	42	48	26	14	12
13	82	18	64	22	6	16
17	3	3	0	1	1	0
Subtotal	472	216	256	136	72	64
Springvale Township						
1	13	9	4	4	3	1
2	12	12	0	4	4	0
3	37	21	16	11	7	4
4	103	51	52	30	17	13
6	159	123	36	50	41	9
7 (part)	22	6	16	6	2	4
14	148	36	112	40	12	28
15	52	24	28	15	8	7
16	245	105	140	70	35	35
18	0	0	0	0	0	0
Subtotal	791	387	404	230	129	101
TOTAL	1,263	603	660	366	201	165

Service Area. The disaggregations were made based on the amount of developable land available in each segment (areas containing wetlands, poor soils, or potential flood hazard areas were not considered as developable) the desirability of the developable land for potential development and the availability of infrastructure. Second tier residential development was also considered in those segments where backlot development was already occurring. Based on these parameters and the provisions of the relevant zoning ordinances, the disaggregation by segment was made as indicated in Table D-2.

Areas of major dwelling unit and population growth include Segments 10, 11, 12, and 13 in Littlefield Township and Segments 4, 6, 14, 15, and 16 in Springvale Township. These segments represent nearly the entire shoreline around Pickerel Lake and southeastern shoreline of Crooked Lake.

Comparison of EIS and Facility Plan Population Totals

The 1978 population estimates for the Proposed Service Area prepared for this EIS are equal to the Facility Plan estimates. However, the two estimates are based on different dwelling unit totals (259 dwelling units in the Facility Plan estimate) and different assumptions regarding seasonal population. The EIS estimate assumed that there were 146 seasonal dwelling units while the Facility Plan used a figure of 182 seasonal dwelling units.

In addition, the Facility Plan assumed that seasonal households would have the same occupancy rate (3.25 persons/unit) as permanent units. The EIS estimate used a higher seasonal occupancy rate (4.25 persons/units) to reflect the findings of numerous studies which found that seasonal units generally had significantly higher occupancy rates. Although these different assumptions did not affect the 1978 population estimates, they did affect the difference between the EIS and the Facility Plan year 2000 projections.

The EIS year 2000 projection of 1,263 people is nearly 40% lower than the Facility Plan projection of 2,080 people. The difference of 817 people is in large measure attributable to the assumption in the Facility Plan that wastewater treatment service would be available in the Proposed Service Area to open to development previously undevelopable land. Under this assumption and the higher existing dwelling unit base, the Facility Plan projected a 147.6% increase in population in the Service Area. The EIS projection, based solely on past growth trends in the Service Area, projected only a 50.4% increase in population which is more closely in line with the 208 planning agency's (Northwest Michigan Regional Planning Commission) projected growth for Littlefield Township (43.2%) and Springvale Township (30.4%).

It must be recognized that the forecasts of future seasonal population growth presented here are highly tentative. This is partly the result of assumptions which must be made concerning seasonal population such as occupancy rate. In addition, seasonal population change is likely to respond much more to a variety of social factors influencing the number of second homes that Americans own. Most important among these volatile factors are changes in disposable personal income which influence the ability to afford second residences and changes in gasoline availability and prices which influence the ability of persons to travel long distances to second homes.

APPENDIX E

FLOW REDUCTION

Flow Reduction and Cost Data for Water Saving Devices

Device	Daily Conservation (gpd)	Daily Conservation (hot water) (gpd)	Capital Cost	Installation Cost	Useful Life (yrs.)	Average Annual O&M
Toilet modifications						
Water displacement device—plastic bottles, bricks, etc.	10	0	0	H-O[a]	15	0
Water damming device	30	0	3.25	H-O	20	0
Dual flush adaptor	25	0-	4.00	H-O	10	0
Improved ballock assembly	20	0-	3.00	H-O	10	0
Alternative toilets						
Shallow trap toilet	30	0-	80.00	55.20	20	0
Dual cycle toilet	60	0-	95.00	55.20		0
Vacuum toilet	90	0-				
Incinerator toilet	100	0				
Organic waste treatment system	100	0				
Recycle toilet	100	0				
Faucet modifications						
Aerator	1	1	1.50	H-O	15	0
Flow control device	4.8	2.4	3.00	H-O	15	0
Alternative faucets						
Foow control faucet	4.8	2.4	40.00	20.70		0
Spray tap faucet	7	3.5	56.50	20.70	15	0
Shower modification						
Shower flow control insert device	19	14	2.00	H-O	15	0
Alternative shower equipment						
Flow control shower head	19	14	15.00	H-O or 13.80	15	0
Shower cutoff valve			2.00	H-O		0
Thermostatic mixing valve			62.00	13.80		0

[a] H-O = Homeowner-installed; cost assumed to be zero.

CONSIDERATION OF RESIDENTIAL FLOW REDUCTION MEASURES IN WASTEWATER FACILITIES PLANNING FROM THE HOMEOWNER'S PERSPECTIVE

A wastewater management option available for all publicly owned treatment works (POTW) is reduction of wastewater flow by installation of flow reduction devices in private residences. The typical 201 Facilities Plan, however, gives passing attention to this option, ignores it altogether, or finds that is it not implementable and not cost-effective. It is true that there is little hard data on implementation and success of municipality-wide flow reduction programs. Facilities planners are not disposed to reduce their wastewater flow projections on the basis of unquantifiables, and so the flow reduction option is usually eliminated.

When domestic flow reduction is analyzed for cost-effectiveness, the same result is obtained. The calculated costs of residential flow reduction devices are compared to the cost to treat the increment of wastewater that would be saved. Particularly in metropolitan areas, where costs to treat per unit flow are low, this cost comparison generally favors eliminating the flow reduction option from further consideration. However, this type of analysis is incomplete. The benefits of residential flow reduction also include reduced costs for water supply, energy savings from reduced hot water requirements, and reduced design sizes of future water supply mains, collector sewers, and interceptors. Rigorous estimation of these cost benefits would require disaggregation of relevant public utility costs to items which are not flow-dependent (such as right-of-way easements, fixed operation and maintenance costs, amortization of prior capitalization) and those which are flow-dependent (peak hydraulic capacity of water and wastewater treatment plants and pumping stations, variable operation and maintenance costs). The effort required to prepare such an analysis could equal the effort to prepare the remainder of the facilities plan.

As a means of providing a comprehensive cost-effective analysis without committing disproportionate effort to it, the homeowner's perspective on the economics of flow reduction can be assumed. Six cost estimates are included in the analysis from the homeowner's perspective:

- cost of wastewater treatment,
- cost of water supply,
- cost of energy for water heating,
- capital cost of the device,
- installation cost of the device, and
- operation and maintenance cost of the device.

Annual savings in wastewater treatment, water supply, and energy costs due to use of a device are compared to annualized capital and installation costs plus annual operation and maintenance cost.

Calculation of savings in utility costs requires that a baseline of water consumption characteristics be assumed. Relying on analysis by Bailey, et al. (1969), total daily household water consumption for a family of four is generated as shown in Table 1. Hot water usage assumptions are also listed. Except for hot water usage by laundry and dishwashing machines, hot water

Table 1. Average daily household total and hot water usage for a family of four by sewage generating source.

Source	Cold and hot water usage (gpd)	Hot water usage (gpd)
Bathing	80	40
Lavatory	8	4
Kitchen faucet	12	6
Utility sink	5	2
Laundry	35	30[a]
Dishwashing	15	15[a]
Toilet	100	--
	255	97
Per capita per day	63.75 gpcd	24.25 gpcd
Annual household (90% occupancy)	83,800 gallons	31,800 gallons

[a]Author's assumptions. Remainder of data from Bailey, et al. (1969).

estimates are based upon Bailey's assumption that 50% of contact water is heated. To calculate annual total and hot water consumption, a 90% occupancy rate is assumed. The standard household, therefore, uses approximately 84,000 gallons of water per year, of which approximately 32,000 gallons are heated.

In regard to the capital, installation, and O&M costs of water conservation devices, two cases are considered:

Case I -- Installation in new homes or as a necessary replacement.

Case II -- Retrofitting or replacement of old equipment or installation where there is no equivalent standard equipment.

To formulate the flow reduction analysis, the general equation is:

$$A = C_o - C_d$$

where:

A = annual homeowner savings due to a flow reduction device

C_o = annual costs without device

C_d = annual costs with the device.

Annual costs without the device are further defined as:

Case I: Installation in new homes or as necessary replacement

$$\begin{aligned} C_{oI} = {} & 84 \times W \\ & + 32 \times P \\ & + 84 \times WW \\ & + (\text{Capital}_s + \text{Installation}_s)(A/P, i, n) \\ & + (\text{O\&M}_s) \end{aligned}$$

where:

W = \$/1,000 gallons for water supply

P = \$/1,000 gallons for heating water to $140^{\circ}F$

WW = \$/1,000 gallons for wastewater treatment

Capital_s = cost of standard device

Installation_s = installation cost of standard device

$\text{O\&M}_s$ = average annual operation and maintenance cost

$(A/P, i, n)$ = capital recovery factor at i percent interest for useful life of the standard device, n.

Case II: Retrofitting or no equivalent standard equipment

$$C_{oII} = 84W + 32P + 84WW$$

Annual costs with the device are further defined as:

$$\begin{aligned} C_d = & \left[84 - \left(\frac{328 \times T}{1,000}\right)\right]W \\ & + \left[32 - \left(\frac{328 \times H}{1,000}\right)\right]P \\ & + \left[84 - \left(\frac{328 \times T}{1,000}\right)\right]WW \\ & + (Capital_d + Installation_d)(A/P,i,n) \\ & + (O\&M_d) \end{aligned}$$

where: W, P, WW as above

T = Total daily household water saving for a flow reduction device

H = Hot water daily household water savings for a flow reduction device

$Capital_d$ = Cost of flow reduction device

$Installation_d$ = Installation cost of flow reduction system

$O\&M_d$ = Average annual operation and maintenance device

Substituting these cost factors into the generalized equation and cancelling, the annual homeowner savings due to a flow reduction device, A, for the two cases can be calculated as:

Case I:

$$A = (Capital_s + Installation_s)(A/P,i,n) + (O\&M_s)$$

$$+ .328 (T \cdot W + H \cdot P + T \cdot WW)$$

$$- (Capital_d + Installation_d)(A/P,i,n)$$

$$- (O\&M_d)$$

Case II:

$$A = .328 (T \cdot W + H \cdot P + T \cdot WW)$$

$$- Capital_d + Installation_d (A/P,i,n)$$

$$- (O\&M_d)$$

All of the terms in these last two equations except W, P, and WW, are specific to the flow reduction device under consideration, or, in Case I, to standard devices having similar functions. Values found in the literature for the device-specific terms typically show a wide range. Typical values for these terms are presented in Table 2 for a number of flow reduction devices. No installation cost is assumed where a device can be easily installed by the homeowner. A labor cost of $13.80 per hour is assumed in Table 2 for devices which would require installation by a licensed plumber.

The terms W, P, and WW are costs which would be based on local data. Appropriate methods for calculating these costs are described in Table 3.

If the annual homeowner's savings, A, as calculated by this method, is positive, then a device can be assumed to be cost-effective on its own merits. Other factors must be taken into consideration prior to revising waste flow projections in facilities planning. The most significant factors are method of implementation and effectiveness of a planning area-wide flow reduction campaign. For some devices, public acceptance may also be a significant factor.

For purposes of facilities planning, it is generally not necessary to design a method of implementation which will yield short-term water savings. The important design factor is per capita flow in the design year. In most planning areas, this allows 20 years for the flow reduction measures to be successfully implemented. At the least, phasing of wastewater facilities would allow 5 years to achieve the design per capita flow.

Table 3. Water supply, power, and wastewater treatment costs for cost-effective analysis of residential flow reduction devices

Cost of Water Supply - W

- Municipal, Metered Water -- Use water billing rate per 1,000 gallons for an 80,000 gallons per year user
- Municipal, Fixed Rate -- Divide annual billing rate for 84,000 gallon per year user by 80.
- Well Supply -- Assume that well installation and repair costs are not variable according to expected flow reductions. Flow variable cost is only the cost of electricity for pumping from well to storage by the equation:

$$\frac{\text{Total head in feet} \times ¢/\text{KWH}}{\text{Overall pump efficiency} \times 3.185} = \text{Cost in } ¢/1{,}000 \text{ gallons}$$

Example: $\frac{125' \times 3¢}{.60 \times 3.185} = 2¢/1{,}000$ gallons

Cost of Heating Water - P

- Electric Water Heater -- Water heated by 100°F requires 1.0 KWH per 4 gallons heated. At 3¢/KWH, cost is .75¢ per gallon or 750¢ per 1,000 gallons.
- Natural Gas Water Heater -- Not determined.
- LP Gas Water Heater -- Not determined.

(NOTE: Cost savings for devices which reduce flow in lavatories, showers, and kitchen faucets will be very sensitive to assumptions about water heating costs. More work is required in this area.)

Cost of Wastewater Treatment -- WW

- For Alternatives Analysis in Facilities Planning -- Determination of the appropriate cost is at the analyst's discretion. To maintain the homeowner's perspective, the average annual local cost for transport, treatment, and disposal of wastewaters for the various alternatives would be reduced by the amortized worth of anticipated footage or connection charges, and then divided by the design year, service area flow (without residential flow reduction) in mgd and multiply by 0.365. A simpler effort with a result that will increase the calculated annual homeowner's saving would be to divide the average annual cost of the alternative by the design year service area flow and multiply by 0.365.
- Centralized Sewer System, Metered Water Supply -- Use sewerage billing rate per 1,000 gallons for an 80,000 gallons per year user.

Table 3. Water supply, power, and wastewater treatment costs for cost-effective analysis of residential flow reduction devices (Concluded).

- On-Lot, Soil-Dependent System -- Assume that the useful life of drain field, seepage pit, or Indian mound is dependent on flow. Divide the estimated cost of soil system rehabilitation or replacement by its estimated useful life in years times 80:

$$\$/1{,}000 \text{ gallons} = \frac{\text{Cost of replacement or rehabilitation}}{\text{Useful life x 80}}$$

- Holding Tank -- Use cost for transport and treatment per 1,000 gallons.

FLOW REDUCTION FOR EIS ALTERNATIVE 4

a)

Alt. Item	Year	Capital	O&M	Sal. Val.	Capital PW	O&M PW	Sol. Vol. P.W.	Total PW
Treatment	1980	761.5	15.7	320.6	761.5	171.3	88.9	
Collection	1980	2012.85	18.61	814.16	2012.85	203.0	225.7	
Collection	1980-2000	87.09	1.17* *Gradient	807.95	950.1	95.0	224.0	
Total					3724.4	469.3	538.5	3655.2

Savings in T.P.W. = 3775.6 = (Beard Alt. 1) - 3655.2
= 120.4

-Costs of Devices
(see Appendix E-3) = 20.2
100,200/301 houses = $333/house in P.W. of wastewater savings

b) 20-year homeowner savings, including water and heating bills.

Assume family of 4.
Then total water consumption = 83,800 gallon/yr.
Then hot water consumption = 31,800 gallons/yr.

W. = Pumped water costs (125 ft) = $\frac{125' \times \$.03}{c)\% \text{ eff} \times 3.185}$ = $ .02/1000 gallons

P = Heated water costs (100^{o}F/$.03/KWH = $7.50/1000 gallons

WW = Wastewater treatment cost (assume 50% of eligibility of gravity sewage)

= $\frac{0.365 \times 230.8}{0.13}$ (see p 2/3)

= 648.0

Device	T(total daily saving)	H(hot water saving)	Capital	$ Installation
dual-cycle toilet	25	0	95	55.20
Shower control valve	19	14	15	13.80
Lavatory faucet control valve	4.8	2.4	40	20.70
Total	48.8	16.4	150	89.70

Annual savings = 0.328 (T.W + H.P + T. WW) - Capital + Instl. - O&M (= 0 in all cases)
= 0.328 (48.8.0.02 + 7.5.16.4 = 48.8.648.0) - 239.70
= 09412.8 - 239.7
= 10173
savings/user = 10173/301
= 33.8

Treatment (100% eligible) = 827.3
(incl. contingency)

Collection pressure
hookups = 70.4
pumps = 313.3
pipe = 338.1
cleanouts = 39.3
valves = 6.4
767.5+25% contg. = 191.9
= 959.4 (100% eligible

Collection-gravity
pipe = 324.6
force main 313.9
ARV 8.1
Tee 3.2
pump stations 84.0
hookups 95.8
833.6+25% contg. = 208.4
1042.0 (50% eligible)

at gravity 50% eligibility, treatment + collection = 2307.7 (74% of all coll. eligible)

Analyzed Local cost = CRF (10% of project cost + Avg. O&M)
= 0.0917 (230.8 + 87.3) + 39.1 + 1.2
= 29.2 + 40.3
= 69.5
Annual Cost/yser = $\frac{69,500}{301}$
= 230.8 = WW

Incremental Capital Costs of Flow Reduction
in the Crooked/Pickerel Lake Study Area

Dual cycle toilets:

$20/toilet x 2 toilets/permanent dwelling x 301 permanent dwellings in year 2000	= $12,040
$20/toilet x 1 toilet/seasonal dwelling x 165 seasonal dwellings in year 2000	= 3,300
Shower flow control insert device:	
$2/shower x 2 shower/permanent dwelling x 301 permanent dwellings in year 2000	= 1,204
$2/shower x 1 shower/seasonal dwelling x 165 seasonal dwellings in year 2000	= 330
Faucet flow control insert device:	
$3/faucet x 3 faucets/permanent dwelling x 301 permanent dwellings in year 2000	= 2,709
$2/faucet x 2 faucets/seasonal dewlling x 165 seasonal dwellings in year 2000	= 660
Total	= $20,243

Note: The $20 cost for dual cycle toilets is the difference between its full purchase price of $95 and the price of a standard toilet, $75.

APPENDIX F

FINANCING

COST SHARING

The Federal Water Pollution Control Act of 1972 (Public Law 92-500, Section 202), authorized EPA to award grants for 75% of the construction costs of wastewater management systems. Passage of the Clean Water Act (P. L. 95-217) authorized increased Federal participation in the costs of wastewater management systems. The Construction Grants Regulations (40 CFR Part 35) have been modified in accordance with the later Act. Final Rules and Regulations for implementing this Act were published in the Federal Register on September 27, 1978.

There follows a brief discussion of the eligibility of major components of wastewater management systems for Federal funds.

Federal Contribution

In general, EPA will share in the costs of constructing treatment systems and in the cost of land used as part of the treatment process. For land application systems the Federal government will also help to defray costs of storage and ultimate disposal of effluent. The Federal share is 75% of the cost of conventional treatment systems and 85% of the cost of systems using innovative or alternative technologies. Federal funds can also be used to construct collection systems when the requirements discussed below are met.

The increase in the Federal share to 85% when innovative or alternative technologies are used is intended to encourage reclamation and reuse of water, recycling of wastewater constituents, elimination of pollutant discharges, and/or recovering of energy. Alternative technologies are those which have been proven and used in actual practice. These include land treatment, aquifer recharge, and direct reuse for industrial purposes. On-site, other small waste systems, and septage treatment facilities are also classified as alternative technologies. Innovative technologies are those which have not been fully proven in full scale operation.

To further encourage the adoption and use of alternative and innovative technologies, the Cost Effectiveness Analysis Guidelines in the new regulations give these technologies a 15% preference (in terms of present worth) over conventional technologies. This cost preference does not apply to privately owned, on-site or other privately owned small waste flow systems.

States that contribute to the 25% non-Federal share of conventional projects must contribute the same relative level of funding to the 15% non-Federal share of innovative or alternative projects.

Individual Systems (Privately or Publicly Owned)

P.L. 95-217 authorized EPA to participate in grants for constructing privately owned treatment works serving small commercial establishments or one or more principal residences inhabited on or before December 27, 1977 (Final Regulations, 40 CFR 35.918, September 27, 1978). A public body must apply for the grant, certify that the system will be properly operated and maintained, and collect user charges for operation and maintenance of the system. All commercial users must pay industrial cost recovery on the Federal share of the system. A principal residence is defined as a voting residence or household of the family during 51% of the year. Note: The "principal residence" requirement does not apply to publicly owned systems.

Individual systems, including sewers, that use alternative technologies may be eligible for 85% Federal participation, but privately owned individual systems are not eligible for the 115% cost preference in the cost-effective analysis. Acquisition of land on which a privately owned individual system would be located is not eligible for a grant.

Publicly owned on-site and cluster systems, although subject to the same regulations as centralized treatment plants, are also considered alternative technologies and therefore eligible for an 85% Federal share.

EPA policy on eligibility criteria for small waste flow systems is still being developed. It is clear that repair, renovation or replacement of on-site systems is eligible if they are causing documentable public health, groundwater quality or surface water quality problems. Both privately owned systems servicing year-round residences (individual systems) and publicly owned year-round or seasonally used systems are eligible where there are existing problems. Seasonally used, privately owned systems are not eligible.

Several questions on eligibility criteria remain to be answered and are currently being addressed by EPA:

- For systems which do not have existing problems, would preventive measures be eligible which would delay or avoid future problems?

- Could problems with systems other than public health, groundwater quality or surface water quality be the basis for eligibility of repair, renovation or replacement? Examples of "other problems", are odors, limited hydraulic capacity, and periodic backups.

- Is non-conformance with modern sanitary codes suitable justification for eligibility of repair, renovation or replacement? Can non-conformance be used as a measure of the need for preventive measures?

- If a system is causing public health, groundwater quality or surface water quality problems but site limitations would prevent a new on-site system from satisfying sanitary codes, would a non-conforming on-site replacement be eligible if it would solve the existing problems?

In this EIS estimates were made of the percent repair, renovation or replacement of on-site systems that may be found necessary during detailed site analyses. Those estimates are felt to be conservatively high and would probably be appropriate for generous resolutions of the above questions.

Collection Systems

Construction Grants Program Requirements Memorandum (PRM) 78-9, March 3, 1978, amends EPA policy on the funding of sewage collection systems in accordance with P.L. 95-271. Collection sewers are those installed primarily to receive wastewaters from household service lines. Collection sewers may be grant-eligible if they are the replacement or major rehabilitation of an existing system. For new sewers in an existing community to be eligible for grant funds, the following requirements must be met:

- Substantial Human Habitation -- The bulk (generally 67%) of the flow design capacity through the proposed sewer system must be for wastewaters originating from homes in existence on October 18, 1972. Substantial human habitation should be evaluated block by block, or where blocks do not exist, by areas of five acres or less.

- Cost-Effectiveness -- New collector sewers will only be considered cost-effective when the systems in use (e.g. septic tanks) for disposal of wastes from existing population are creating a public health problem, violating point source discharge requirements of PL 92-500, or contaminating groundwater. Documentation of the malfunctioning disposal systems and the extent of the problem is required.

  Where population density within the area to be served by the collection system is less than 1.7 persons per acre (one household per two acres), a severe pollution or public health problem must be specifically documented and the collection sewers must be less costly than on-site alternatives. Where population density is less than 10 persons per acre, it must be shown that new gravity collector sewer construction and centralized treatment is more cost-effective than on-site alternatives. The collection system may not have excess capacity which could induce development in environmentally sensitive areas such as wetlands, floodplains or prime agricultural lands. The proposed system must conform with approved Section 208 plans, air quality plans, and Executive Orders and EPA policy on environmentally sensitive areas.

- Public Disclosure of Costs -- Estimated monthly service charges to a typical residential customer for the system must be disclosed to the public in order for the collection system to be funded. A total monthly service charge must be presented, and the portion of the charge due to operation and maintenance, debt service, and connection to the system must also be disclosed.

Elements of the substantial human habitation and cost-effectiveness eligibility requirements for new collector sewers are portrayed in Figure 1 in a decision flow diagram. These requirements would apply for any pressure, vacuum or gravity collector sewers except those serving on-site or small waste flow systems.

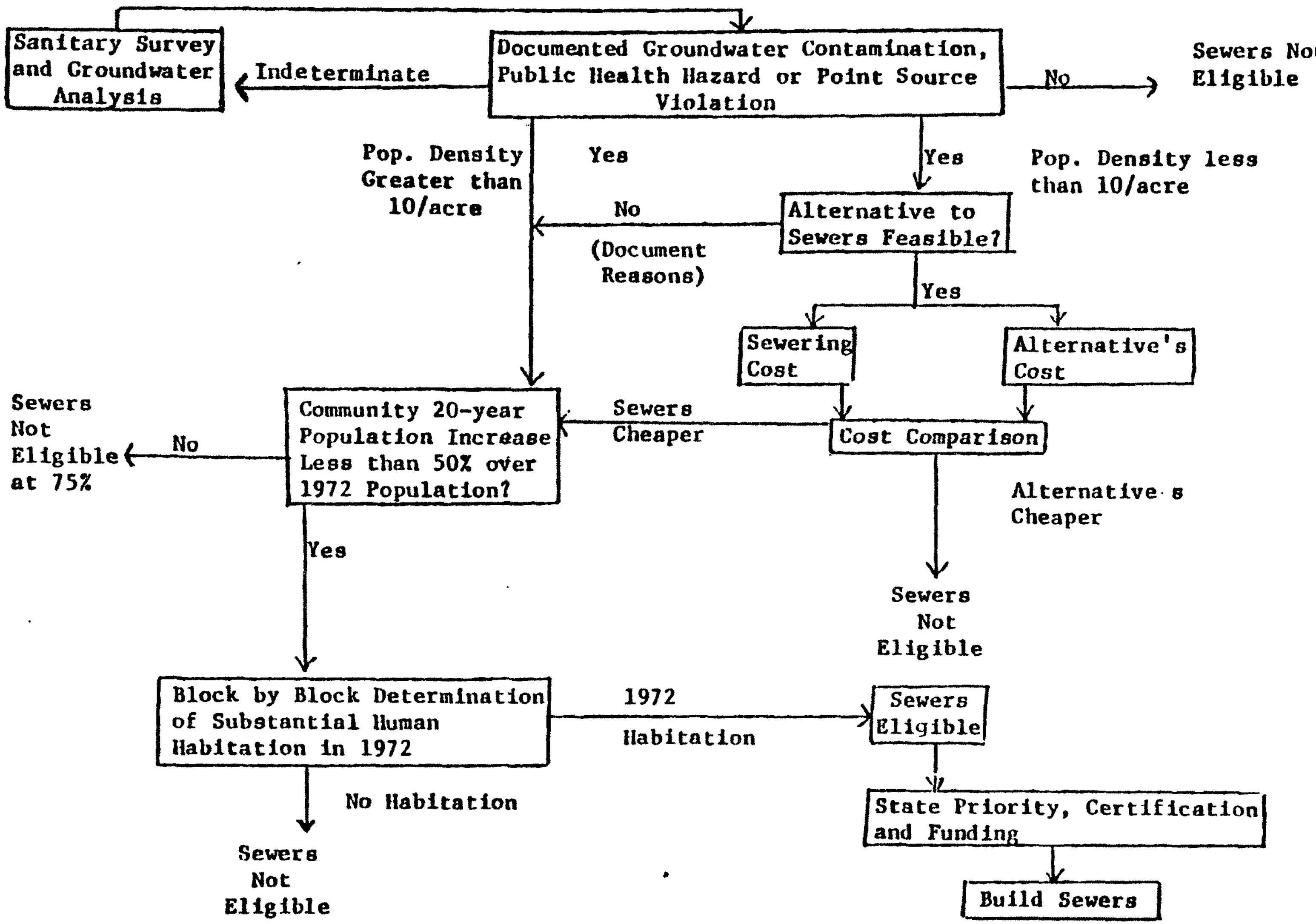
Household Service Lines

Traditionally, gravity sewer lines built on private property connecting a house or other building with a public sewer have been built at the expense of the owner without local, State or Federal assistance. Therefore, in addition to other costs for hooking up to a new sewer system, owners installing gravity household service lines will have to pay about $1,000, more or less depending on site and soil conditions, distance and other factors.

Pressure sewer systems, including the individual pumping units, the pressure line and appurtenances on private property, however, are considered as part of the community collection system. They are, therefore, eligible for Federal and State grants which substantially reduce the homeowner's private costs for installation of household service lines.

FIGURE J-3-a

Collector Sewer Eligibility - Decision Flow Diagram
Based on PRM 78-9



ALTERNATIVES FOR FINANCING THE LOCAL SHARE OF WASTEWATER TREATMENT FACILITIES IN EMMET COUNTY, MICHIGAN

ALTERNATIVES FOR FINANCING THE LOCAL SHARE OF WASTEWATER TREATMENT FACILITIES IN EMMET COUNTY, MICHIGAN

The financing of wastewater facilities requires a viable strategy. In exercising the authority delegated to them by the state to finance local activities, local governments need not only expertise in budgeting and debt administration but also a general knowledge of the costs and benefits of various complex financial tools and alternative investment strategies.

This section reviews several possible ways to fund the Proposed Action or alternative wastewater management systems in Emmet County, Michigan. It will:

- Describe options available for financing both the capital and the operating costs of the wastewater facilities; and
- Discuss institutional arrangements for financing and examine the probable effects of various organizational arrangements on the marketability of the bond.

FINANCING CAPITAL COSTS: OPTIONS

The several methods of financing capital improvements include: (1) pay-as-you-go methods; (2) special benefit assessments; 3) reserve funds; and (4) debt financing.

The pay-as-you-go method requires that payments for capital facilities be made from current revenues. This approach is more suitable for recurring expenses such as street paving than for one-time long-term investments. As the demand for public services grows, it becomes increasingly difficult for local governments to finance capital improvements on a pay-as-you-go basis.

In situations where the benefits to individual properties from capital improvements can be assessed, special benefit assessments in the form of direct fees or taxes may be used to apportion costs.

Sometimes reserve funds are established to finance capital improvements. A part of current revenues is placed in a special fund each year and invested in order to accumulate adequate funds to finance needed capital improvements. Although this method avoids the expense of borrowing, it requires foresight on the part of the local government.

Debt financing of capital facilities may take several forms. Local governments may issue short-term notes or float one of several types of bonds. Bonds are generally classified by both their guarantee of security and method of redemption.

GUARANTEE OF SECURITY

General Obligation (G.O. Bonds)

Debt obligations secured by the full faith and credit of the municipality are classified as general obligation bonds. The borrower is pledging the financial and economic resources of the community to support the debt. Because of the advantages of this approach to debt financing, general obligation bonds have funded over 95% of the water and sewer projects in the State of Michigan. Following are some of the advantages:

- Interest rates on the debt are usually lower than on revenue or special assessment bonds. With lower annual debt service charges, the cash flow position of the jurisdiction is improved.
- G.O. bonds for sewerage offer financial flexibility to the municipality since funds to retire them can be obtained through property taxes, user charges or combinations of both.
- When G.O. bonds are financed by ad valorem property taxes, households have the advantage of a deduction from their Federal income taxes.
- G.O. bonds offer a highly marketable financial investment since they provide a tax-free and relatively low-risk investment venture for the lender.
- In the State of Michigan, a municipality may issue G.O. bonds without the consent of the electorate. However, there is a bill in the legislature that would require all bonds to be subjected to a referendum.

A disadvantage to a general obligation approach is the State constitutional restriction on the total amount of debt outstanding. Michigan law requires that a municipality's total indebtedness not exceed 10% of its assessed valuation. This restriction may lead small rural areas like Crooked/Pickerel Lakes to seek alternative regional institutional arrangements for financing the capital costs of wastewater/treatment systems.

Revenue Bonds

Revenue bonds differ from G.O. bonds in that they are not backed by a pledge of full faith and credit from the municipality and therefore require a higher interest rate. The interest is usually paid, and the bonds eventually retired, by earnings from the enterprise.

A major advantage of revenue bonds over general obligation bonds is that municipalities can circumvent constitutional restrictions on borrowing. Although revenue bonds have become a popular financial alternative to G.O. bonds in financing wastewater facilities, they have traditionally been avoided as a financing mechanism in Michigan for several reasons.

- High Interest Rates. Since the bonds are payable only from the earnings of the enterprise and are not supported by the full faith and credit of the jurisdictions, the risk of default is greater than on a general obligation issue.

- Margin of Risk*. The bond market requires earnings to be some multiple of total debt service charges in order to protect investors from possible default. The current risk margin for Michigan revenue bonds is 50%. For the Study Area this high margin requirement may provide two scenarios. First, since 60% of the households in the Study Area have incomes under $10,000, investors might consider the returns on the investment to be less than the risks of possible default; should this be the case, the bonds would be unmarketable. Alternatively, if the bond be marketable, then the additional margin requirements* would be charged to households, thereby increasing the cost burden imposed by debt service obligations.

- Administrative Costs. Issuance of a revenue bond obligates the municipality to provide separate funding and accounting procedures to distinguish the sewer charges from general revenue accounts.

Special Assessment Bond

A special assessment bond is payable only from the collection of special assessments, not from general property taxes. This type of obligation is useful when direct benefits are easily identified. Assessments are often based on front footage or area of the benefited property. This type of assessment may be very costly to individual property owners, especially in rural areas. Agricultural lands may require long sewer extensions and thus impose a very high assessment on one user. Furthermore, not only is the individual cost high, but the presence of sewer lines places development pressures on the rural land and often portends the transition of land from agriculture to residential/commercial use. Because the degree of security is lower than with G.O. bonds, special assessment bonds represent a greater investment risk and therefore carry a higher interest rate.

METHODS OF REDEMPTION

Two types of bonds are classified according to their method of retirement -- (1) serial bonds and (2) term bonds. Serial bonds mature in annual installments while term bonds mature at a fixed point in time.

Serial Bonds

Serial bonds provide a number of advantages for financing sewerage facilities. First, they provide a straightforward retirement method by maturing in annual installments. Secondly, since some bonds are retired each year, this method avoids the use of sinking funds.* Third, serial bonds are attractive to the investor and offer wide flexibility in marketing and arranging the debt structure of the community. Serial bonds fall into two categories (1) straight serials and (2) serial annuities.

Straight Serial Bonds provide equal annual payments of principal for the duration of the bond issue. Consequently, interest charges are higher in the early years and decline over the life of the bond. This has the advantage of 'freeing up' surplus revenues for future investment. The municipality has the option of charging these excess revenues to a sinking or reserve fund or of lowering the sewer rates imposed on households.

Serial Annuities provide equal annual installment payments of principal and interest. Total debt service charges in the early years of the bond issue are thus equal to the charges in later years. The advantage to this method of debt retirement is that the total costs of the projects are averaged across the entire life of the bond. Thus, peak installment payments in the early years are avoided, and costs are more equitably distributed than with straight serial bonds.

Although straight and annuity serials are the most common types of debt retirement bonds, methods of repayment may vary. Such "irregular" serial bonds may result in:

- Gradually increasing annual debt service charges over the life of the issue;
- Fluctuating annual installments producing combinations of rising then declining debt service; or
- Large installments due on the last years of the issue. These are called "ballooning" maturity bonds.

Statutory limitations restrict the use of irregular serial bonds in the State of Michigan. According to the Revenue Bond Act, "all bonds shall not mature at one time, they shall mature in annual series beginning not more than two years from such probable date of beginning of operation and ending as provided herein above for the maturity of bonds maturing at one time, and the sum of the principal and interest to fall due in each year shall be as nearly equal as is practicable."

Term Bonds

Term bonds differ from serial issues in that term bonds mature at a fixed point in time. The issuing entity makes periodic payments (including interest earned on investments) to a sinking fund which will be used to retire the debt at maturity. The major disadvantage to this approach to financing is management of the sinking fund -- a complex operation requiring expertise in national and regional monetary markets to insure maximum return on investment. Mismanagement of the fund could lead to default on the bond.

Until recently, term bonds requiring a sinking fund were illegal in the State of Michigan. In 1977, the Michigan legislature passed a resolution allowing the use of term bonds by requiring annual payments to a sinking fund for use in purchasing or redeeming bonds to retire the debt. There is an advantage to this method of debt retirement, particularly for revenue-producing wastewater treatment facilities. If revenues or user charges from the facilities are estimated to vary widely from year to year, then the community has the option of retiring a greater or lesser portion of the debt in any given year.

OPERATING COSTS

In most cases, operating costs are financed through service charges. Service charges are generally constructed to reflect the physical use of the system. For example, charges may be based on one or a combination of the following factors:

- Volume of wastewater
- Pollutional load of wastewater
- Number or size of connections
- Type of property serviced (residential, commercial, industrial).

Volume and pollutional load are two of the primary methods for determining service charges. Basing service charges on volume of wastewater requires some method for measuring or estimating volume. Because metering of wastewater flows is expensive and impractical, many communities utilize existing water supply meters and, often, fix wastewater volume at a percentage of water flows. When metering is not used, a flat rate system may be employed, charging a fixed rate for each connection based on user type.

INSTITUTIONAL ARRANGEMENTS

The townships and municipalities within the Study Area have available a number of organizational arrangements in financing wastewater facilities. This section discusses these arrangements and reviews the financial effects of various institutional structures on the marketability of the bond.

Organization Structure

Michigan Public Act (P.A.) 129 of 1943, (Michigan Compiled Laws 1970, Section 123.231-236 and subsequent amendments) provides for the following institutional arrangements to administer and finance wastewater facilities.

1. Municipal Ownership. Ownership, operation and administration are conducted by a single community as a service to its residents.

2. Joint Ownership. Two or more communities jointly construct, operate and own the facilities. Each government entity retains title to the facilities in proportion to its share of capital expenditures. The political subdivisions may borrow money and issue joint revenue or general obligation bonds in the name of the participating jurisdictions.

3. Contracting for Service. One entity provides sewer services to an area outside its boundaries on the basis of a contractual agreement. P.A. 129 of 1943, Section 2 states that "any such contracts shall be authorized by the legislative body of each contracting political subdivision and shall be effective for such term as shall be prescribed therein not exceeding 50 years."

4. Special Purpose District (Sanitary Districts). A number of local governments cooperate. This arrangement differs from joint ownership in that a separate governing body is established and embodied with the power to administer the financing and operation of the project. Debt is issued in the name of the district authority, but repayment obligations are the responsibility of all communities in the district.

5. Multi-Purpose Districts. These are similar to the special purpose district, but, in contrast, multi-purpose districts have more than one function. For example, a multi-purpose district may provide water services, sewer services, irrigation and flood control for a specified area. In Michigan, P.A. 40 of 1956, states that a county may, upon petition, establish a drainage board, whose composition it specifies, which is then authorized to create a drainage district for draingage, water and sewer facilities.

FINANCIAL EFFECTS OF INSTITUTIONAL ARRANGEMENTS FOR THE CROOKED/PICKEREL LAKES STUDY AREA

Water quality problems and proposed solutions in the Crooked/Pickerel Lakes area extend beyond municipal boundaries. Of the five arrangements listed above, joint contracts, special purpose districts, and contractual agreements would be the most suitable for the Study Area. The organization arrangement that is selected to administer, finance and implement the project will affect (1) the marketability of the bond, and (2) the administrative costs of the project. These alternative institutional arrangements are discussed below.

Joint Ownership and Special Purpose Districts

Both the joint ownership and special district arrangements provide a means for each participating township to share in the costs and benefits provided by the wastewater management system but would be acceptable only if the combined entities can devise a financial structure that will insure the marketability of the bond at a desirable interest rate. For the Study Area, there are some disadvantages in the use of these institutional arrangements.

Previous bond issues for Littlefield Township and Springvale Township have been for small improvements in water systems, streets, and highways--too small for Moody's Bond Record and Standard and Poor's to rate. Therefore, an investor's ability to evaluate the community's resources to meet periodic principal and interest payments is impaired. In the Socioeconomic Study Area a large proportion of the population with incomes below the poverty level are elderly or retired with limited or fixed incomes. In 1970, the date of the latest available statistics, approximately 20 per of all persons in the Study Area were 55 years or older. These characteristics will tend to reduce the ability of the community to meet debt service charges under adverse economic conditions.

CONCLUSIONS

Alternatives for financing a wastewater management system in the Study Area and a range of investment strategies for policymakers to employ at the local level were outlined above. This section summarizes these options and recommends a strategy for financing the Crooked/ Pickerel Lakes system.

Institutional Arrangement

Municipal ownership, joint ownership, and special purpose districts should be avoided as an organizational approach to financing the proposed facilities in the Study Area. The best solution would enable the county to issue the bond, operate the system and charge the participating political subdivision for wastewater services. The major advantage of this approach is that the county can issue debt pledging the full faith and credit of its economic resources to support the issue. Such an arrangement would both make possible a lower interest rate and would most improve the marketability of the bond.

Capital Costs

The alternative sewerage systems considered in this EIS are expensive and per capita costs are high. Pay-as-you-go financing strategies would clearly be inappropriate to finance the start-up costs for the facilities. (However, pay-as-you-go techniques might be used in the future to finance capital improvements. The future state of the economy, the cash flow position of the County and the nature of anticipated expenditures will be critical variables in determining whether capital improvements can be financed from current revenues.)

Reserve funds are usually intended to finance capital improvements at some future date. Still, a combination of capital reserve and pay-as-you-go approaches could finance construction of new low-cost facilities. However, unless Emmet County has a reserve fund earmarked for sewer and water expenditures, this method of financing current capital costs is presently not feasible for the Study Area.

Special benefit assessments would provide a viable way to finance improvements to those households that would benefit most directly from sewerage facilities. Or, the County could finance the collection component of these facilities with a special assessment tax and fund the remaining capital costs through a series of user charges.

The County should use general obligation bonds to finance the local share of system capital costs. This method will provide the lowest interest rate among alternative forms of debt financing. In addition, a serial bond should be tied to the general obligation bond to gain greater flexibility in marketing and arranging the County's debt structure.

Table 1

FINANCIAL CHARACTERISTICS OF THE LOCAL GOVERNMENTS
IN THE CROOKED/PICKEREL LAKES STUDY AREA

	Emmet (1) County	Littlefield (2) Township	Springvale (3) Township
State Equalized Valuations	$202,942,911	$10,850,481	$6,766,800
Total Revenues	4,310,588	449,869	240,397
Total Expenditures	4,020,529	411,628	244,834
Current Expense	3,926,993	N/A	N/A
Capital Outlay	93,536	N/A	N/A
Total Long-Term Debt	-0-	110,000	N/A

Notes: (1) State of Michigan, Department of Treasury, Michigan County Government Financial Report, for the year ended December 31, 1974.

(2) Hill, Woodcock and Distel, Certified Public Accounts, Audited Financial Statements - Littlefield Township, March 23, 1976.

(3) Hill, Woodcock and Distel, Certified Public Accountants, Audited Statements of Cash Receipts and Disbursements, Springvale Township, March 22, 1977.

APPENDIX G

MANAGEMENT OF SMALL WASTEWATER SYSTEMS

SOME MANAGEMENT AGENCIES FOR DECENTRALIZED FACILITIES

Central management entities that administer non-central systems with various degrees of authority have been established in several States. Although many of these entities are quasi-public, few of them both own and operate each component of the facility. The list of small waste flow management agencies that follows is not comprehensive. Rather, it presents a sampling of what is currently being accomplished. Many of these entities are located in California, which has been in the vanguard of the movement away from conventional centralized systems to centrally managed decentralized systems to serve rural areas (State of California, Office of Appropriate Technology, 1977).

Westboro (Wisconsin Town Sanitary District)

Sanitary District No. 1 of the Town of Westboro represents the public ownership and management of septic tanks located on private property. In 1974 the unincorporated community of Westboro was selected as a demonstration site by the Small Scale Waste Management Project (SSWMP) at the University of Wisconsin to determine whether a cost-effective alternative to central sewage for small communities could be developed utilizing on-site disposal techniques. Westboro was thought to be typical of hundreds of small rural communities in the Midwest which are in need of improved wastewater treatment and disposal facilities but are unable to afford conventional sewerage.

From background environmental data such as soils and engineering studies and groundwater sampling, it was determined that the most economical alternative would be small diameter gravity sewers that would collect effluents from individual septic tanks and transport them to a common soil absorption field. The District assumed responsibility for all operation and maintenance of the entire facility commencing at the inlet of the septic tank. Easements were obtained to allow permanent legal access to properties for purposes of installation, operation, and maintenance. Groundwater was sampled and analyzed during both the construction and operation phases. Monthly charges were collected from homeowners. The system, now in operation, will continue to be observed by the SSWMP to assess the success of its mechanical performance and management capabilities.

Washington State

Management systems have been mandated in certain situations in the State of Washington to assist in implementing the small waste flow management concept. In 1974 the State's Department of Social and Health Services established a requirement for the management of on-site systems: an approved management system would be responsible for the maintenance of sewage disposal systems when subdivisions have gross densities greater than 3.5 housing units or 12 people per acre (American Society of Agricultural Engineers 1977). It is anticipated that this concept will soon be applied to all on-site systems.

Georgetown Divide (California) Public Utility District (GDPUD)

The GDPUD employs a full-time geologist and registered sanitarian who manage all the individual wastewater sytems in the District. Although it does not own individual systems this district has nearly complete central management responsibility for centralized systems. The Board of Directors of the GDPUD passed an ordinance forming a special sewer improvement district within the District to allow the new 1800-lot Auburn Lake Trails subdivision to receive central management services from the GDPUD. The GDPUD performs feasibility studies on lots within the subdivision to evaluate the potential for the use of individual on-site systems, designs appropriate on-site systems, monitors their construction and installation, inspects and maintains them, and monitors water quality to determine their effects upon water leaving the subdivision. If a septic tank needs pumping, GDPUD issues a repair order to the homeowner. Service charges are collected annually.

Santa Cruz County (California) Septic Tank Maintenance District

This district was established in 1973 when the Board of Supervisors adopted ordinance No. 1927, "Ordinance Amending the Santa Cruz County Code, Chapter 8.03 Septic Tank System Maintenance District." Its primary function is the inspection and pumping of all septic tanks within the District. To date 104 residences in two subdivisions are in the district, which collects a one-time set-up fee plus monthly charges. Tanks are pumped every three years and inspected annually. The County Board of Supervisors is required to contract for these services. In that the District does not have the authority to own systems, does not perform soil studies on individual sites, or offer individual designs, its powers are limited.

Bolinas Community (California) Public Utility District (BCPUD)

Bolinas, California is an older community that faced an expensive public sewer proposal. Local residents organized to study the feasibility of retaining many of their on-site systems, and in 1974 the BCPUD Sewage Disposal and Drainage Ordinance was passed. The BCPUD serves 400 on-site systems and operates conventional sewerage facilities for 160 homes. The District employs a wastewater treatment plant operator who performs inspections and monitors water quality. The County health administration is authorized to design and build new septic systems.

Kern County (California) Public Works

In 1973 the Board of Supervisors of Kern County, California, passed an ordinance amending the County Code to provide special regulations for water quality control. County Service Area No. 40, including 800 developed lots of a 2,900-lot subdivision, was the first Kern County Service Area (CSA) to arrange for management of on-site disposal systems. Inspections of installations are made by the County Building Department. Ongoing CSA responsibilities are handled by the Public Works Department. System design is provided in an Operation and Maintenance Manual.

Marin County (California)

In 1971 the Marin County Board of Supervisors adopted a regulation, "Individual Sewage Disposal Systems," creating an inspection program for all new installations (Marin County Code Chapter 18.06). The Department of Environmental Health is responsible for the inspection program. The Department collects a charge from the homeowner and inspects septic tanks twice a year. The homeowner is responsible for pumping. The Department also inspects new installations and reviews engineered systems.

LEGISLATION BY STATES AUTHORIZING MANAGEMENT OF SMALL WASTE FLOW DISTRICTS

In a recent act, the California legislature noted that then-existing California law authorized local governments to construct and maintain sanitary sewerage systems but did not authorize them to manage small waste flow systems. The new act, California Statutes Chapter 1125 of 1977, empowers certain public agencies to form on-site wastewater disposal zones to collect, treat, and dispose of wastewater without building sanitary sewers or sewage systems. Administrators of such on-site wastewater disposal zones are to be responsible for the achievement of water quality objectives set by regional water quality control boards, protection of existing and future beneficial uses, protection of public health, and abatement of nuisances.

The California act authorizes an assessment by the public agency upon real property in the zone in addition to other charges, assessments, or taxes levied on property in the zone. The Act assigns the following functions to an on-site wastewater disposal zone authority:

- To collect, treat, reclaim, or dispose of wastewater without the use of sanitary sewers or community sewage systems;
- To acquire, design, own, construct, install, operate, monitor, inspect, and maintain on-site wastewater disposal systems in a manner which will promote water quality, prevent the pollution, waste, and contamination of water, and abate nuisances;
- To conduct investigations, make analyses, and monitor conditions with regard to water quality within the zone; and
- To adopt and enforce reasonable rules and regulations necessary to implement the purposes of the zone.

To monitor compliance with Federal, State and local requirements an authorized representative of the zone must have the right of entry to any premises on which a source of water pollution, waste, or contamination including but not limited to septic tanks, is located. He may inspect the source and take samples of discharges.

The State of Illinois recently passed a similar act. Public Act 80-1371 approved in 1978 also provides for the creation of municipal on-site wastewater disposal zones. The authorities of any municipality (city, village, or incorporated town) are given the power to form on-site wastewater disposal zones to "protect the public health, to prevent and abate nuisances, and to protect existing and further beneficial water use." Bonds may be issued to finance the disposal system and be retired by taxation of property in the zone.

A representative of the zone is to be authorized to enter at all reasonable times any premise in which a source of water pollution, waste, or contamination (e.g., septic tank) is located, for the purposes of inspection, rehabilitation and maintenance, and to take samples from discharges. The municipality is to be responsible for routinely inspecting the entire system at least once every 3 years. The municipality must also remove and dispose of sludge, its designated representatives may enter private property and, if necessary, respond to emergencies that present a hazard to health.

MANAGEMENT CONCEPTS FOR SMALL WASTE FLOW DISTRICTS

Several authors have discussed management concepts applicable to decentralized technologies. Lenning and Hermason suggested that management of on-site systems should provide the necessary controls throughout the entire lifecycle of a system from site evaluations through system usage. They stressed that all segments of the cycle should be included to ensure proper system performance (American Society of Agricultural Engineers 1977).

Stewart stated that for on-site systems a three-phase regulatory program would be necessary (1976). Such a program would include: 1) a mechanism to ensure proper siting and design installation and to ensure that the location of the system is known by establishing a filing and retrieval system; 2) controls to ensure that each system will be periodically inspected and maintained; and 3) a mechanism to guarantee that failures will be detected and necessary repair actions taken.

Winneberger and Burgel suggested a total management concept, similar to a sewer utility, in which a centralized management entity is responsible for design, installation, maintenance, and operation of decentralized systems (American Society of Agricultural Engineers 1977). This responsibility includes keeping necessary records, monitoring ground and surface water supplies and maintaining the financial solvency of the entity.

Otis and Stewart (1976) have identified various powers and authorities necessary to perform the functions of a management entity:

- To acquire by purchase, gift, grant, lease, or rent both real and personal property;
- To enter into contracts, undertake debt obligations either by borrowing and/or by issuing bonds, sue and be sued. These powers enable a district to acquire the property, equipment, supplies and services necessary to construct and operate small flow systems;
- To declare and abate nuisances;
- To require correction or private systems;
- To recommend correction procedures;
- To enter onto property, correct malfunctions, and bill the owner if he fails to repair the system;
- To raise revenue by fixing and collecting user charges and levying special assessments and taxes;
- To plan and control how and when wastewater facilities will be extended to those within its jurisdiction;
- To meet the eligibility requirements for loans and grants from the State and Federal government.

APPENDIX H

CROOKED/PICKEREL LAKE ENVIRONMENTAL IMPACT STATEMENT
ENGINEERING REPORT

APPENDIX
H-1

CROOKED/PICKEREL LAKE ENVIRONMENTAL IMPACT STATEMENT

ENGINEERING REPORT

arthur beard engineers, Inc.
CONSULTING ENGINEERS

Revised
JUNE 1979

arthur beard engineers, Inc.
6900 WISCONSIN AVE. CHEVY CHASE, MD. 20015 - 301/657-3660

June 18, 1979

WAPORA, Inc.
6900 Wisconsin Avenue
Chevy Chase, MD 20015

Attention: Mr. Ross Pilling
Project Manager

Reference: Task Order No.1
Contract No.68-01-4612, DOW #4

Gentlemen:

This will transmit three copies of the revised report for the Crooked/Pickerel Lake area of Michigan. These modified costs reflect changes in population numbers and distribution as received from WAPORA, Inc. on June 4, 1979. No problems nor difficulties were encountered during the preparation of this report.

If you have any questions regarding the information contained in this report, do not hesitate to contact us.

Very truly yours,

ARTHUR BEARD ENGINEERS, INC.

David C. Wohlscheid, P.E.
Project Manager

DCW:net

Enclosure

arthur beard engineers, Inc.
6900 WISCONSIN AVE, CHEVY CHASE, MD. 20015 - 301/657-3660

June 18, 1979

WAPORA, Inc.
6900 Wisconsin Avenue
Chevy Chase, MD 20015

Attention: Mr. Ross Pilling
Project Manager

Reference: Seven Lakes Project
EPA-Contract No.68-01-4612, DOW #4
Task Order No.1

Gentlemen:

This letter will transmit for your review and approval our analysis of the Springvale/Littlefield area.

This package is composed of eight specific alternates followed by the general Appendix sections. Each alternate is subdivided in the following manner: (1) a narrative description with graphics; and (2) a cost estimate summary sheet for both treatment and collection.

The Appendices includes information used for all the alternatives investigated, including: (1) general assumptions and details; (2) unit cost data; (3) the analysis of the various collection system investigated; (4) cost backup for each alternate; and (5) treatment system cost and backup information.

The General Assumption section includes population projections, and assumptions used in the various treatment processes. The Collection System backup information includes all information on the proposed collection system, as well as backup data on the alternate systems investigated (e.g., cluster systems).

For your information the following table compares the upgraded proposed alternates with the six alternates on a total 1980 capital cost basis as well as O&M and Salvage Values. This table is useful as a summary for the information presented in this submittal:

WAPORA, Inc.
PAGE TWO
June 18, 1979

TABLE I

SPRINGVALE/LITTLEFIELD
Costs x $1,000

Alternate	1980 Capital	1980 O&M	Salvage Value
Facility Plan Proposed			
Old Population	$3,938.98	$17.99	$1,919.69
New Population	3,776.75	17.13	1,888.58
Alternate 1	1,791.94	27.08	727.87
Alternate 2	2,632.15	36.40	1,069.92
Alternate 3	2,662.64	29.97	1,146.48
Alternate 4	2,866.39	34.11	1,193.05
Alternate 5	1,955.68	30.80	806.30
Alternate 6	858.50	14.93	397.71

To accurately compare alternative costs an economic analysis should be performed to obtain the total life cycle cost of each alternate.

The facility plan proposed system and WAPORA alternate number 3 have no costs for treatment since the collected wastewater will be treated at the existing treatment plant located in Petoskey. An extra cost has been included for a gravity interceptor sewer, 17,700 feet in length, required for transmission of the wastewater to the Petoskey Plant.

The costs presented in this report have been upgraded to current dollar figures using an EPA SCCT Index of 145 and an ENR figure of 3000.

If you have any questions regarding this material do not hesitate to contact us.

Very truly yours,

ARTHUR BEARD ENGINEERS, INC.

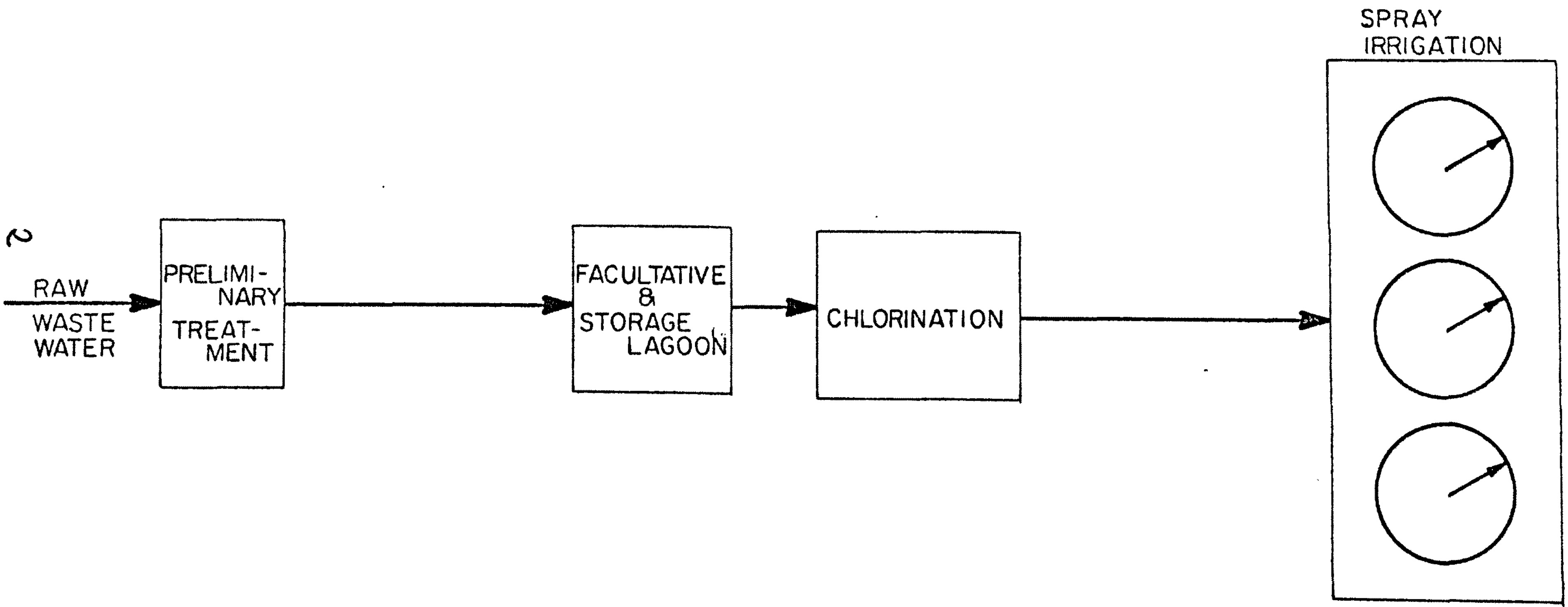
David Wohlscheid

David C. Wohlscheid, P.E.
Project Manager

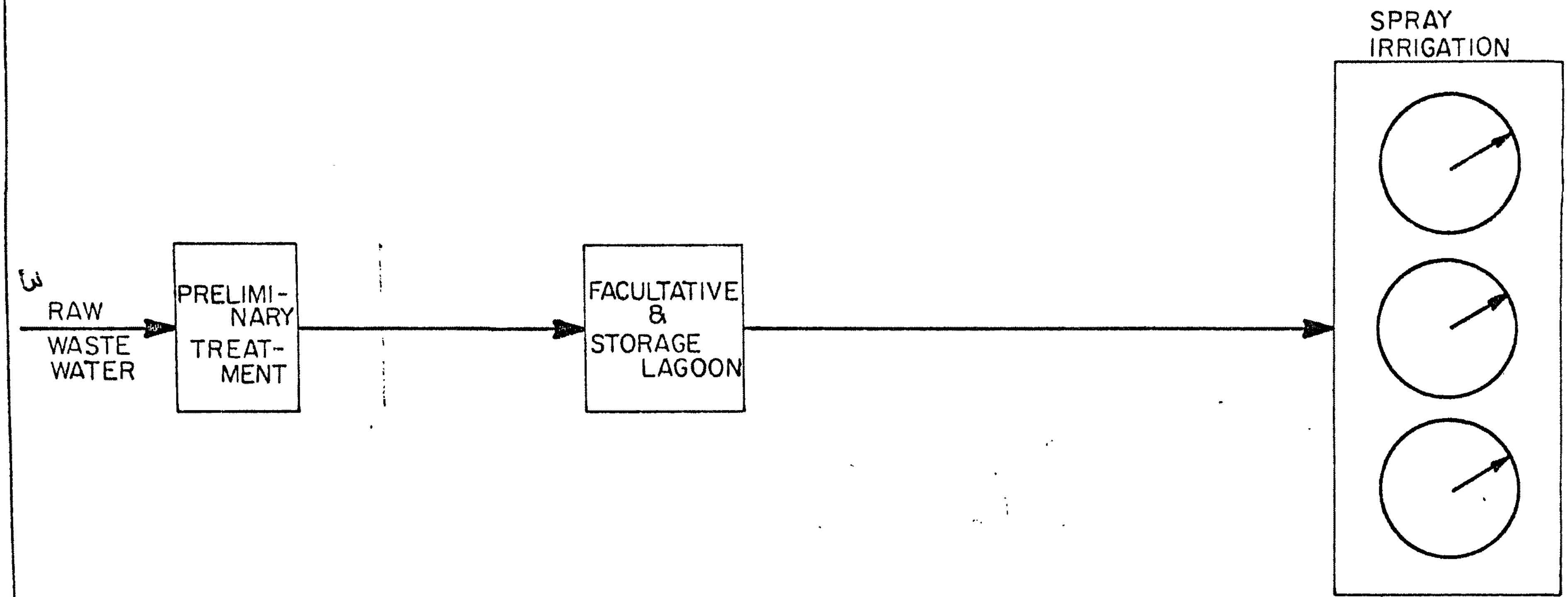
TABLE OF CONTENTS

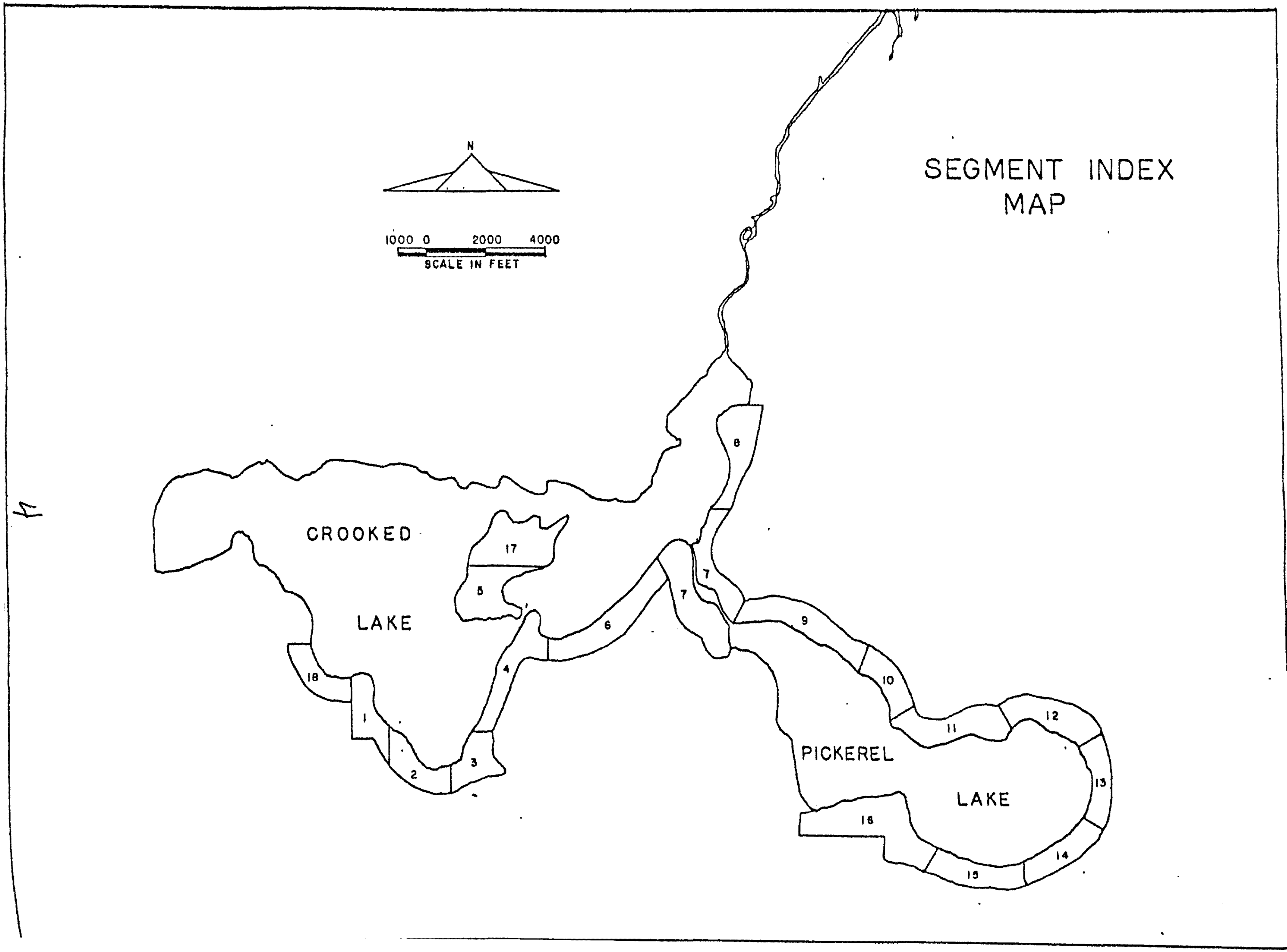
The following sections are narrative descriptions of each alternative analyzed. Summarized costs for each alternative are presented in Appendix A. Each alternate is broken down further and itemized in Appendices D and E. The following diagram illustrates how the study area was broken down into eighteen segments to aid in population projections and collection systems design. The next two figures are the flow diagrams for wastewater treatment using land application. The Northern site flow scheme shows chlorination being required, this is due to the close proximity of surrounding population.

LAND APPLICATION
SPRAY IRRIGATION
NORTHERN SITE



LAND APPLICATION
SPRAY IRRIGATION
SOUTHERN SITE




SEGMENT INDEX MAP
N
1000 0 2000 4000
SCALE IN FEET
CROOKED
LAKE
PICKEREL
LAKE
1
2
3
4
5
6
7
7
8
9
10
11
12
13
14
15
16
17
18

FACILITY PLAN PROPOSED ALTERNATE

NARRATIVE DESCRIPTION

The proposed alternate in the existing Facility Plan for the Springvale/Littlefield service area is a regional collection system with centralized treatment. Regional collection is accomplished through a system of gravity sewers and pump stations with 29 of the serviced homes being connected to the system by low pressure sewers.

The collection system begins on the south side of Pickerel Lake and runs east around the lake. Each area is collected by gravity to a central lift station where it is lifted and transported to the next central area. Each area is connected in series by the lift stations which transport the waste around Pickerel Lake to the south shore of Crooked Lake. The last lift station pumps the waste to the gravity interceptor leading to the existing Petoskey Wastewater Treatment Plant.

Populations for the facility Plan Area have been separated nto 18 segments supplied by WAPORA and as shown on the Segment Index Map. Each segment has a present and future population projection as shown in Tables E-1 and E-2 in the General Assumptions of Appendix B.

The Proposed Alternate graphic illustrates the conveyance system proposed for this alternate. The conveyance design is based on a 20-year growth period for sizing of the system. The 20-year design figures presented by WAPORA along with a decrease in the per capita flow, from 100 gallons per capita per day (gpcd) to 60 gpcd, has resulted in some line size changes.

The low pressure sewer system used for costing this alternate has been changed slightly in order to maintain assumptions and unit costs used in the other alternates. The original design called for low pressure sewers utilizing grinder pumps. This system has been altered to a septic tank effluent pump (STEP) system. Both systems work equally well and are very cost competitive, however, to insure that all alternates are cost comparable the STEP system was used. It should be emphasized that both systems should be considered in the final design phase.

Components of the proposed system will remain similar in process, however, sizes and unit costs utilized will be those based on ABE calculations for both the upgraded facility plan as well as for the new alternates proposed by WAPORA.

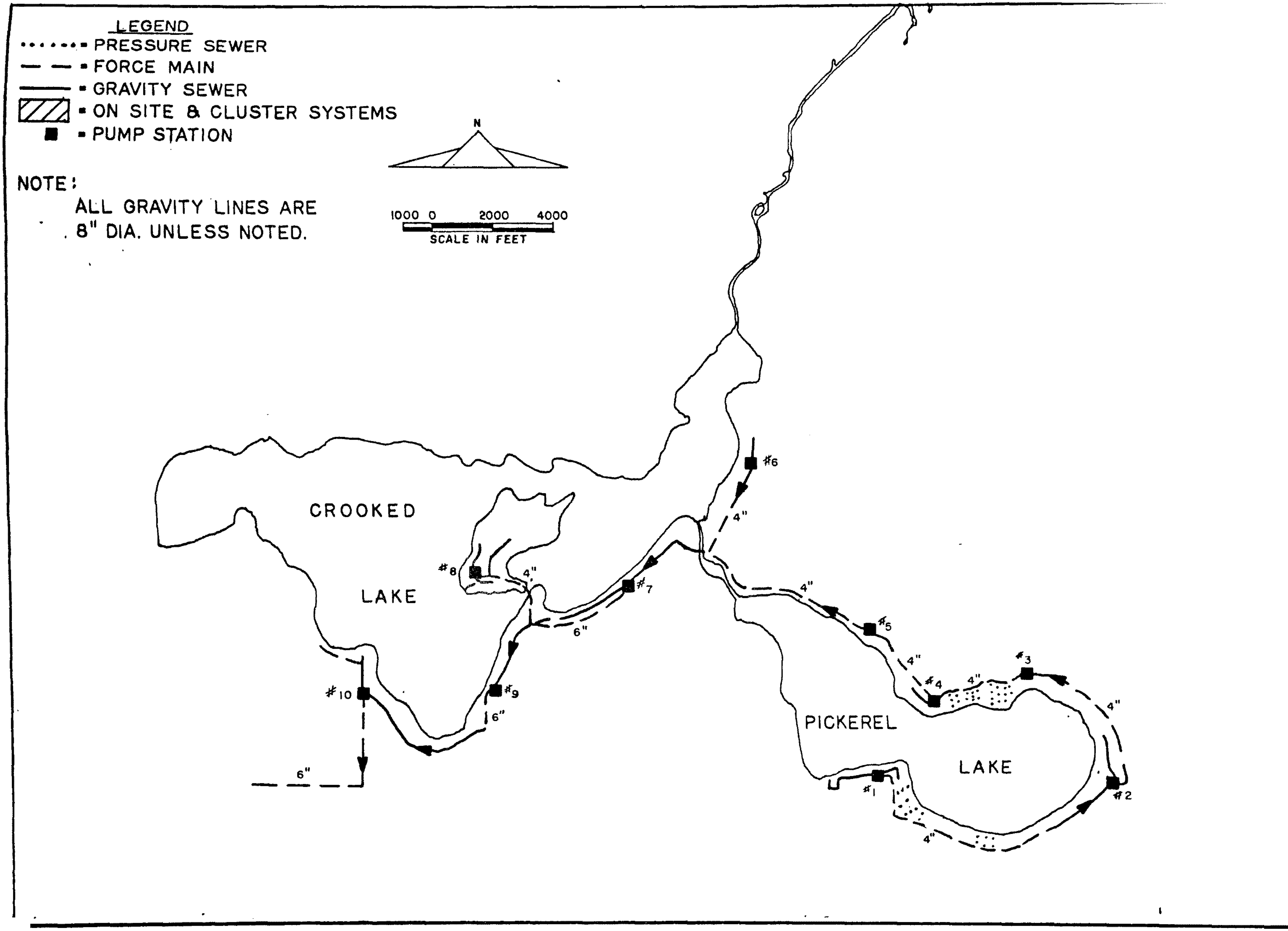
Two cost estimates have been performed for the proposed alternate, one using population projections supplied to Arthur Beard Engineers by WAPORA for the first Crooked/Pickerel Report of July 1978, the second using the new population projections that will be used throughout this report. The change in population projections are:

	TOTAL POPULATION		TOTAL DWELLINGS	
	Present	Future	Present	Future
1978 Report	840	2,080	259	642
1979 Report	840	1,263	212	366

The total 1980 capital costs, annual operation and maintenance costs, and the salvage value for the Proposed Alternate are summarized below:

	Capital Costs	Annual O&M Costs	Salvage Value
Old Population	$3,938,980	$17,990	$1,919,690
New Population	3,776,750	17,130	1,888,580

Detailed cost information for the Proposed Alternate may be found in Appendix A and Appendix D.



PROPOSED ALTERNATE H-1

ALTERNATE 1

NARRATIVE DESCRIPTION

The first new alternate for the Springvale/Littlefield area investigates the feasibility of serving the entire study area by group cluster systems. Due to poor soils and a high seasonal ground water table around the lakes there is no economically feasible method for individual on-site systems, therefore this alternate represents a decentralized treatment option.

Figure 1-1 presents the eleven cluster systems used in the Crooked/Pickerel Lake area and their locations.

Each cluster system includes an eight inch gravity line which conveys each home's sewage to a central pump station. The pump station then lifts the sewage and transports it to land outside the cluster area where soils are more suitable for a drainage field system.

Each cluster system has been designed for the year 2000 with the present portion of this cost being based primarily on a ratio of the present population to the future population.

The next section indicates the cost estimate for collection and treatment of the eleven cluster systems.

Costs include land for the drainage field as well as a duplicate piece of land which would be used as a standby area in case the first drainage field becomes overloaded or slugged up. The estimate does not include the costs for materials and labor to construct the backup system.

The total 1980 capital costs, annual operation and maintenance costs, and the salvage value for Alternate 1 are summarized below:

Capital Costs	Annual O&M Costs	Salvage Value
$1,791,940	$27,080	$727,870

Detailed information for Alternate 1 may be found in Appendices A and D.

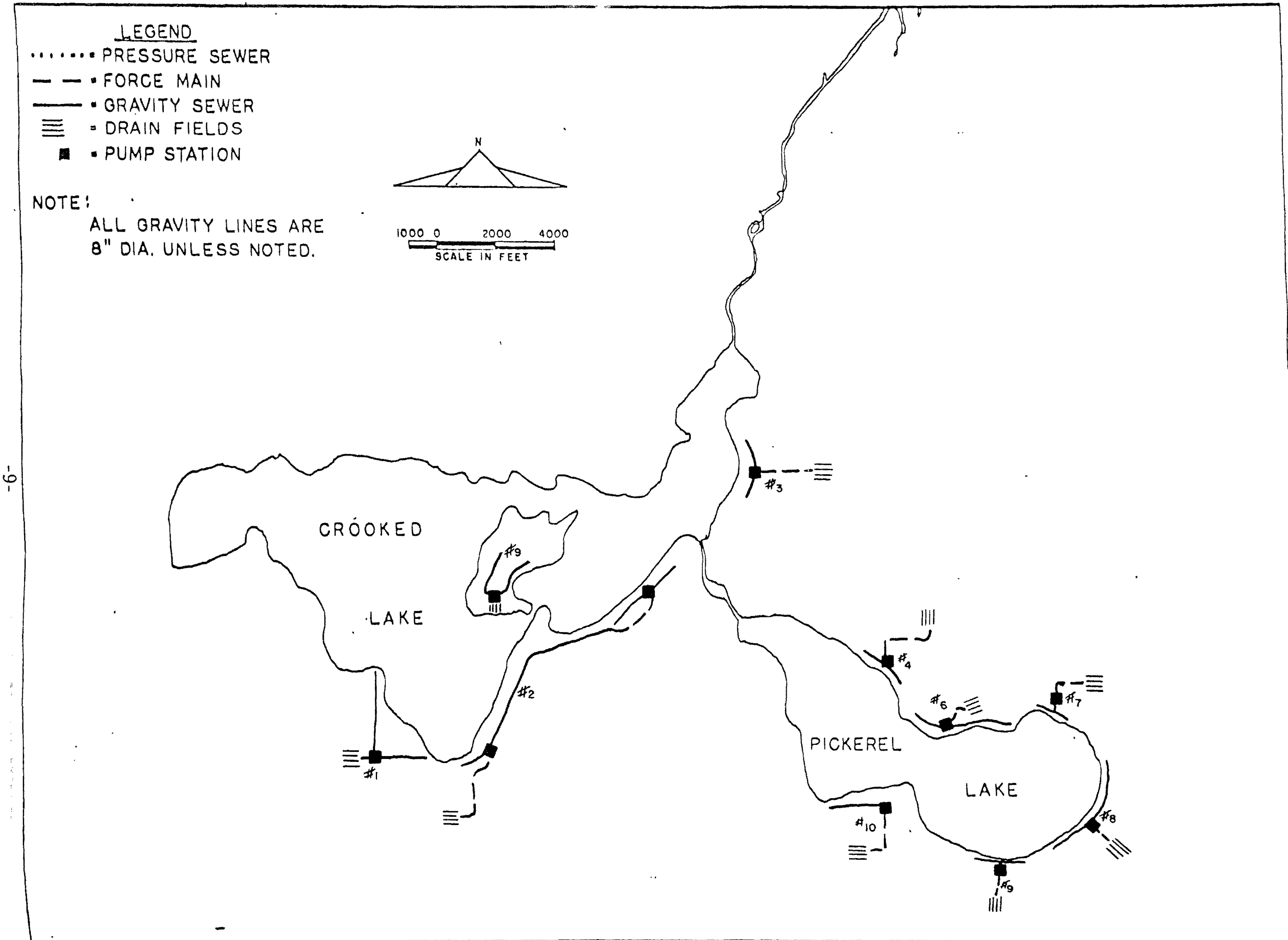

LEGEND
PRESSURE SEWER
FORCE MAIN
GRAVITY SEWER
DRAIN FIELDS
PUMP STATION
NOTE:
ALL GRAVITY LINES ARE
8" DIA. UNLESS NOTED.
N
1000 0 2000 4000
SCALE IN FEET
CROOKED
LAKE
PICKEREL
LAKE
#1
#2
#3
#4
#6
#7
#8
#9
#10

FIG. I-I

ALTERNATE 2

NARRATIVE DESCRIPTION

The second alternate for the Springvale/Littlefield area combines two central collection systems with remaining segments to be incorporated as cluster systems.

The Crooked Lake area is comprised of segments 18, 1, 2, 3, 4 and 6. A combination of pressure, using the STEP system, and gravity sewers will service the area. Treatment will be land application utilizing a spray irrigation system. The service area and treatment site are indicated on Figure 2-1. In order to secure soils suitable for this method of treatment and remain a suitable distance from existing developments, it was necessary to utilize lands within the Hardwood State Forest boundaries. Discussion with State representatives has not eliminated the feasibility of the alternative and would therefore necessitate further investigation should this prove to be a cost effective method for collection and treatment.

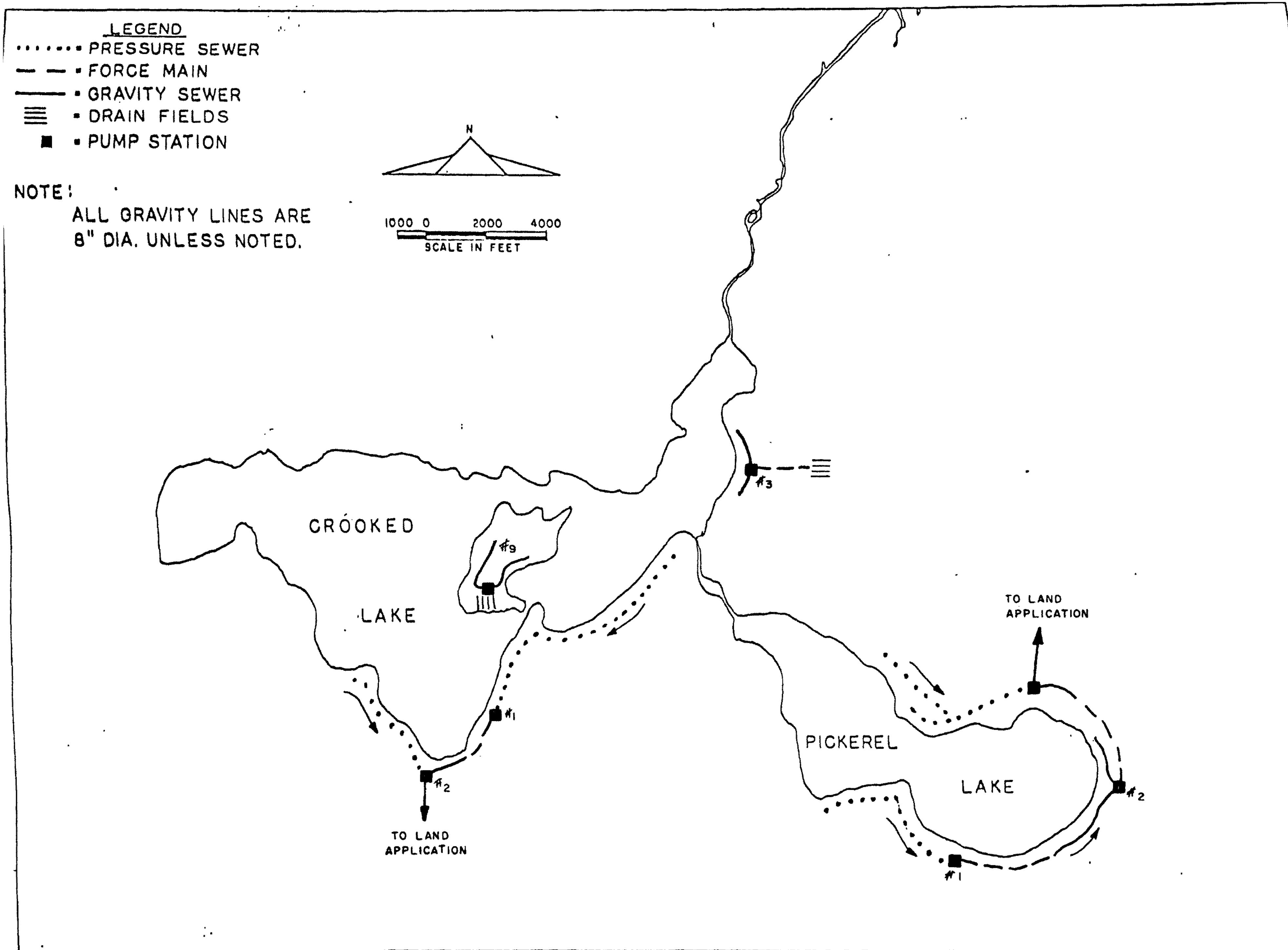
The Pickerel Lake area is comprised of segments 10, 11, 12, 13, 14, 15 and 16. A combination of pressure and gravity sewers will collect the area for land treatment utilizing spray irrigation. The service area and treatment site are indicated in Figure 2-1.

The remaining segments are treated through means of various cluster systems. Poor soils and high seasonal ground water rule out on-site treatments as septic tank-soil absorption field systems. Instead effluent wastewater from the septic tanks are collected within each cluster system and pumped to absorption fields where suitable soils exist.

The total 1980 capital costs, annual operation and maintenance costs, and the salvage value for Alternate 2 are summarized below:

Capital Costs	Annual O&M Costs	Salvage Value
$2,632,150	$36,400	$1,069,920

Detailed cost information for Alternate 2 may be found in Appendices A, D and E.



LEGEND
PRESSURE SEWER
FORCE MAIN
GRAVITY SEWER
DRAIN FIELDS
PUMP STATION
NOTE:
ALL GRAVITY LINES ARE
8" DIA. UNLESS NOTED.
N
1000 0 2000 4000
SCALE IN FEET
CROOKED
LAKE
#9
#3
#1
#2
TO LAND
APPLICATION
PICKEREL
LAKE
TO LAND
APPLICATION
#2
#1

FIG. 2-1

ALTERNATE 3

NARRATIVE DESCRIPTION

The third alternate for the Springvale/Littlefield area investigates the possibility of reducing the total collection sewer service area by utilizing cluster systems for those segments located around Pickerel Lake. The remaining area of Crooked Lake and Oden Island shall be collected for treatment at the Petoskey Plant. The service area is indicated on Figure 2-1.

A combination of gravity and pressure sewers using the STEP system will be utilized to accomplish collection in the Crooked Lake area.

Soils adjacent to both Pickerel Lakes are found unsuitable for on-site treatment due to high seasonal ground water. Therefore, it is necessary to employ cluster systems for the areas where collection is not the chosen alternate. These systems collect effluent from individual septic tanks and convey it by gravity to a pump station. It is necessary to pump the effluent several thousand feet to soils suitable for on-site disposal away from the lakes. The cluster systems vary in size and have been based on segment groupings.

The total 1980 capital costs, annual operation and maintenance costs, and the salvage value for Alternate 3 are summarized below:

Capital Costs	Annual O&M Costs	Salvage Value
$2,662,640	$29,970	$1,146,480

Detailed cost information for Alternate 3 may be found in Appendices A and D.

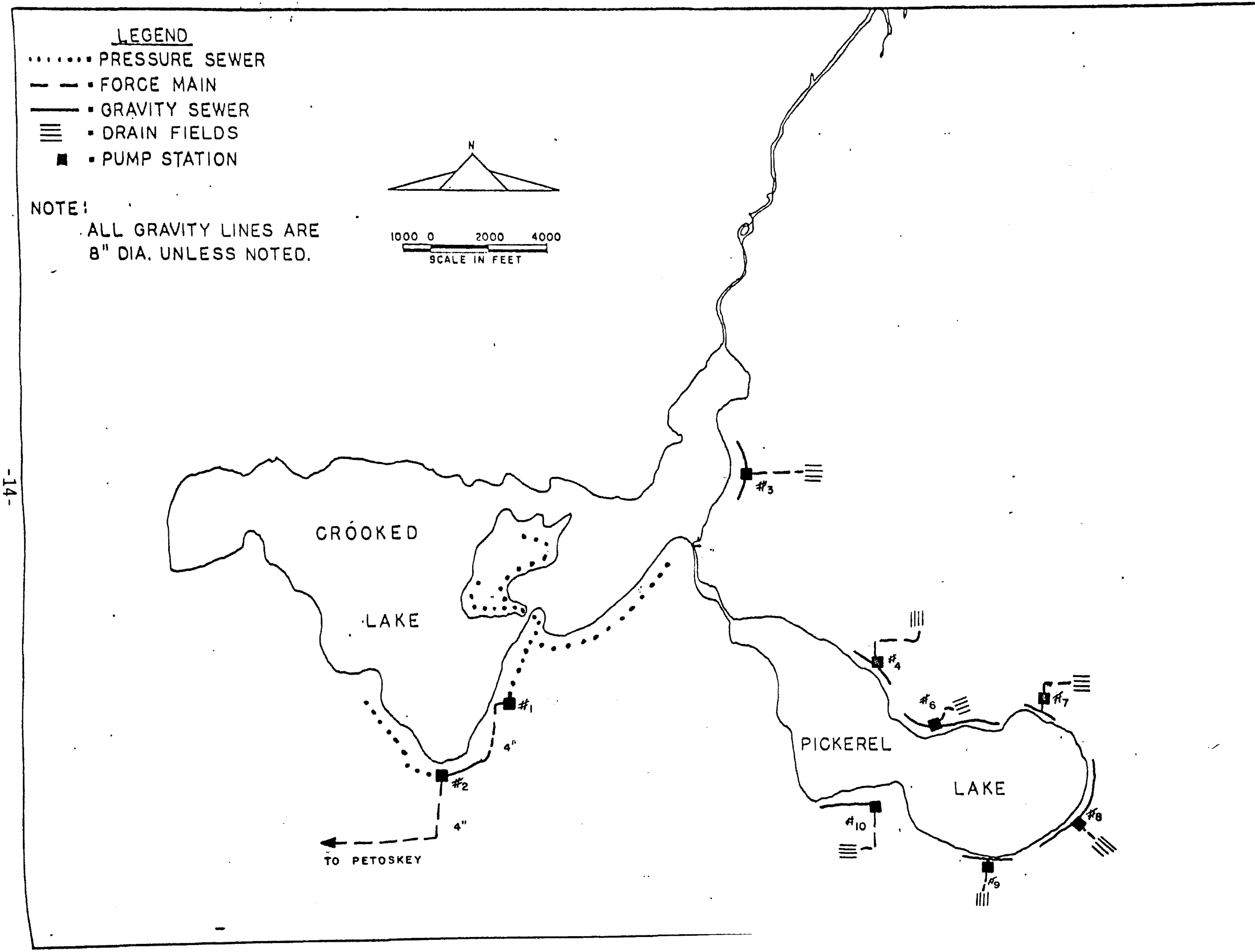

LEGEND
PRESSURE SEWER
FORCE MAIN
GRAVITY SEWER
DRAIN FIELDS
PUMP STATION
NOTE:
ALL GRAVITY LINES ARE 8" DIA. UNLESS NOTED.
N
1000 0 2000 4000
SCALE IN FEET
CROOKED LAKE
PICKEREL LAKE
#1
#2
#3
#4
#6
#7
#8
#9
#10
4"
4"
TO PETOSKEY

FIG. 3-1

ALTERNATE 4

NARRATIVE DESCRIPTION

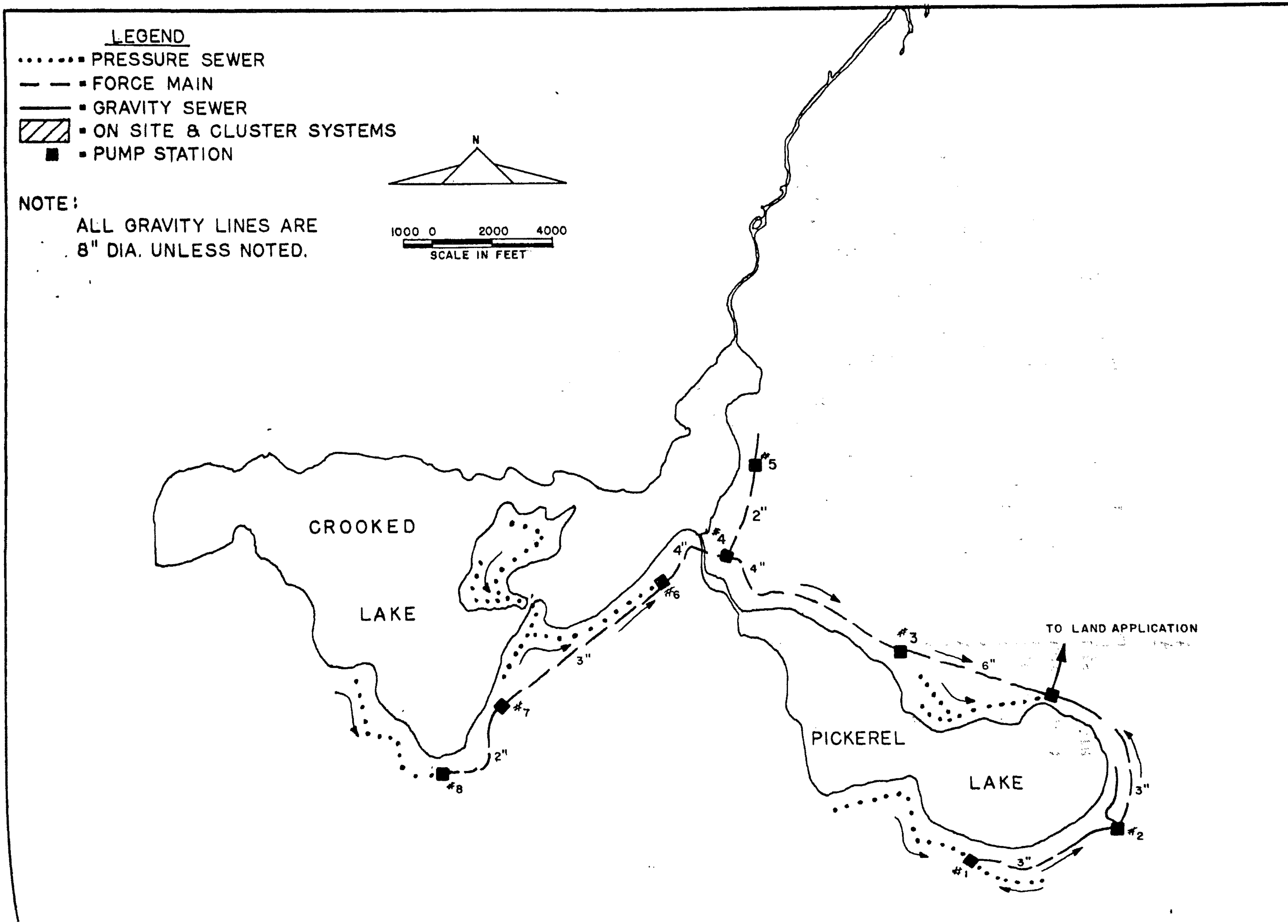
The fourth alternate for the Springvale/Littlefield area considers collection for the entire service area with a central land application site located just north of Pickerel Lake as indicated in Figure 4-1.

A combination of pressure using the STEP system, and gravity sewers will be utilized in collection. Treatment is to be accomplished through spray irrigation. Surface discharge as an alternate method of treatment was discarded due to stringent state requirements necessitating a sophisticated level of treatment to be obtained if the availability of land for land treatment was limited, or non-existent.

The total 1980 capital costs, annual operation and maintenance costs, and the salvage value for Alternate 4 are summarized below:

Capital Costs	Annual O&M Costs	Salvage Value
$2,866,390	$34,110	$1,193,050

Detailed cost information for Alternate 4 may be found in Appendices A, D and E.



LEGEND
PRESSURE SEWER
FORCE MAIN
GRAVITY SEWER
ON SITE & CLUSTER SYSTEMS
PUMP STATION
NOTE:
ALL GRAVITY LINES ARE
8" DIA. UNLESS NOTED.
N
1000 0 2000 4000
SCALE IN FEET
CROOKED
LAKE
PICKEREL
LAKE
TO LAND APPLICATION
#1
#2
#3
#4
#5
#6
#7
#8
2"
4"
4"
6"
3"
3"
3"
2"

FIG. 4-1

H-1

ALTERNATE 5

NARRATIVE DESCRIPTION

The fifth alternate for the Springvale/Littlefield area considers collection for the Crooked Lake area, excluding Oden Island. Oden Island and the remaining areas around Pickerel Lake are to be on cluster systems.

Collection is to be accomplished through a combination of pressure, using the STEP system, and gravity sewers. Land application utilizing a spray irrigation system will serve those areas to be collected. The service area and land application site are indicated on Figure 5-1. In order to secure soils suitable for this method of treatment and remain a suitable distance from existing developments, it was necessary to utilize lands within the Hardwood State Forest boundaries. Discussion with State representatives has not eliminated the feasibility of the alternative and would therefore necessitate further investigation should this prove to be a cost effective alternate for both collection and treatment.

The total 1980 capital costs, annual operation and maintenance costs, and the salvage value for Alternate 5 are summarized below:

Capital Costs	Annual O&M Costs	Salvage Value
$1,955,680	$30,800	$806,300

Detailed cost information for Alternate 5 may be found in Appendix A and Appendix D.

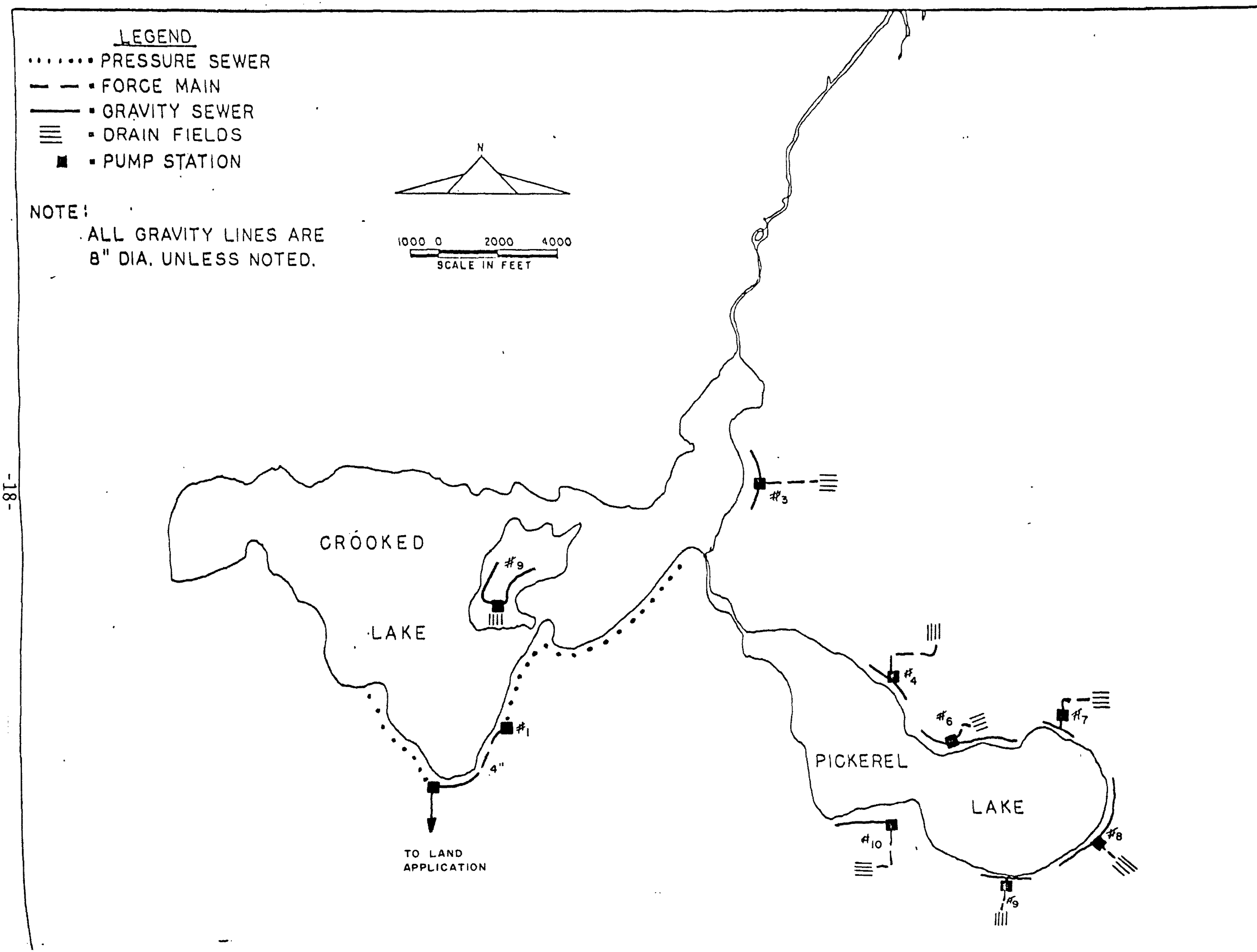

LEGEND
PRESSURE SEWER
FORCE MAIN
GRAVITY SEWER
DRAIN FIELDS
PUMP STATION
NOTE:
ALL GRAVITY LINES ARE
8" DIA. UNLESS NOTED.
N
1000 0 2000 4000
SCALE IN FEET
CROOKED
LAKE
PICKEREL
LAKE
#1
#3
#4
#6
#7
#8
#9
#9
#10
4"
TO LAND
APPLICATION

FIG. 5-1

ALTERNATE 6

NARRATIVE DESCRIPTION

The sixth alternate for the Springvale/Littlefield area is the "limited action" alternate. For this alternate all units remain with some form of on-site systems and no central collection or central treatment system is proposed.

Populations for the Facility Plan area have been separated into 18 segments supplied by WAPORA and as shown on the Segment Index Map. Each segment has a present and future population projection as shown in Tables E-1 and E-2 in the General Assumptions of Appendix B.

Two of the segments for this alternate incorporate cluster systems and are shown on Figure 6-1. These systems incorporate portions of segments 14 and 16 and include a total of 57 homes. These were chosen by WAPORA for several reasons including: (1) septic snooper studies found active flumes within the area; (2) housing density is high; and (3) there is an unusually thick amount of eucaryotic algae within the area indicating additional nutrient input.

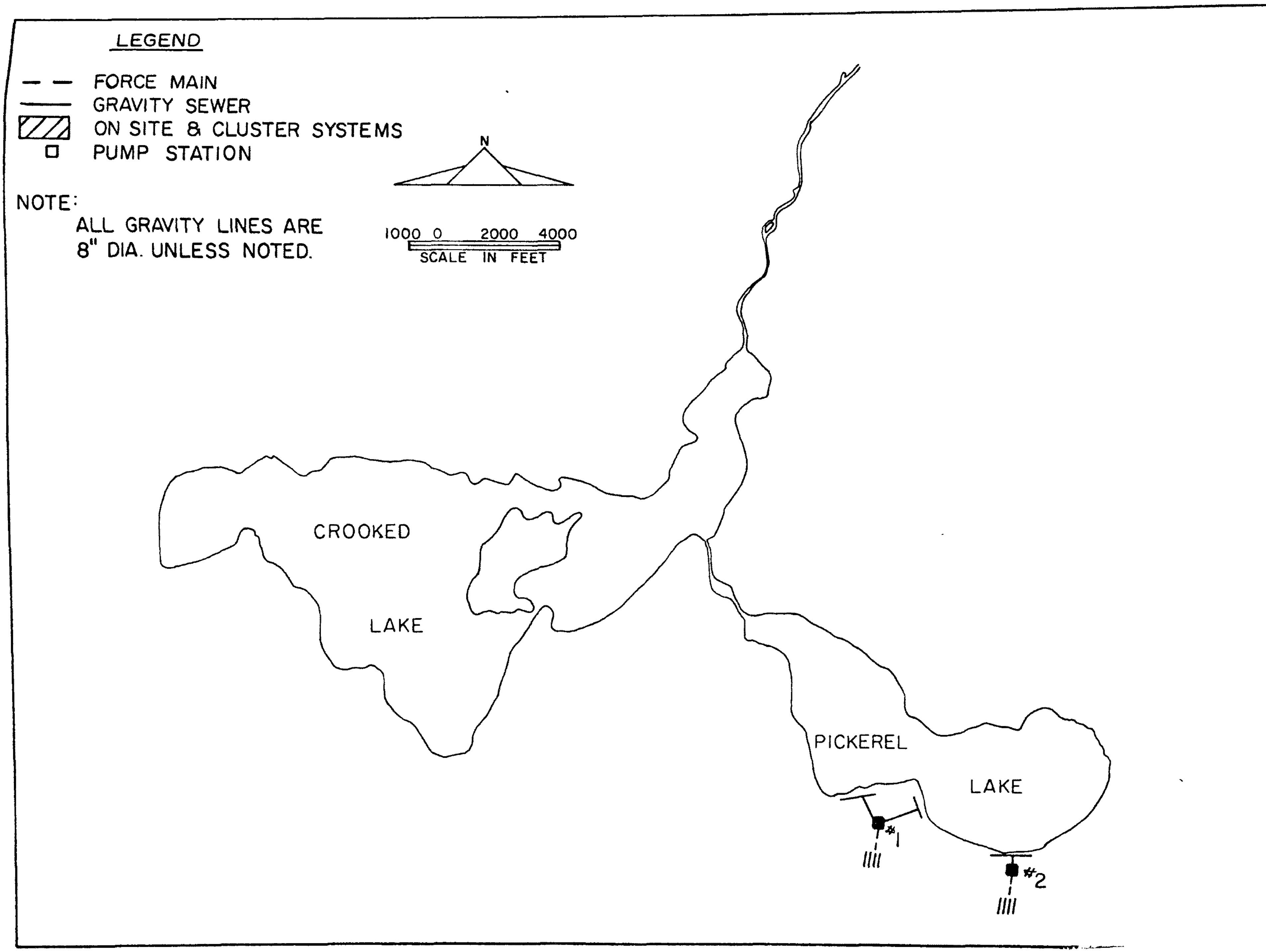
The remainder of the study area remains with on-site systems with the exception of four homes which are placed on holding tanks. It was assumed for these homes that waste conservation devices would be installed reducing the daily flow to 44 gpcd.

Of the remaining home systems, 77 would require replacement of drainfields, 42 would need new septic tanks (note that some homes will have both septic tank and drainfields replaced), 25 would require mound drainfields, and 21 will require drainfield renovation using a hydrogen peroxide treatment.

The total 1980 capital costs, annual operation and maintenance costs, and the salvage value for Alternate 6 are summarized below:

CAPITAL COSTS	ANNUAL O&M COSTS	SALVAGE VALUE
$858,500	$14,930	$397,710

Detailed cost information for Alternate 6 may be found in Appendix A and Appendix C.



LEGEND
FORCE MAIN
GRAVITY SEWER
ON SITE & CLUSTER SYSTEMS
PUMP STATION
NOTE:
ALL GRAVITY LINES ARE
8" DIA. UNLESS NOTED.
N
1000 0 2000 4000
SCALE IN FEET
CROOKED
LAKE
PICKEREL
LAKE
#1
#2

FIG. 6-

H-1

FLOW REDUCTION

The effect of using conservative devices in each home was analyzed on the basis of flow reduction and the monetary savings that could be realized in the collection and treatment of this reduced flow. The flow reduction figure obtained from WAPORA amounted to 16 gpcd for both commercial and residential areas.

To determine the capital and operation and maintenance cost savings for flow reduction an analysis was conducted on an alternative which involved centralized treatment and collection. The alterntive, alternate 4, collects the entire service area of Springvale and Littlefield Townships for land application via spray irrigation to a site located north of Pickerel Lake. This alternate was chosen because centralized collection and treatment is more sensitive to a per capita flow reduction than a decentralized system.

Treatment capital costs for both alternates were analyzed utilizing the new design flow which was reduced from 0.13 MGD to 0.10 MGD. The following analysis of these alternates is divided in areas relating to both treatment and collection and is summarized with an economic analysis comparing flow reduction versus non-flow reduction for these alternates.

COLLECTION

The collection system can be broken down into three parts: (1) the home pump station (STEP, or grinder); (2) the collection piping (pressure or gravity); (3) the lift stations and force mains. Each of these will be analyzed separately below.

The home pump system, whether STEP or grinder, will not alter in design due to flow reduction. These are package units which only alter in the horsepower available. The cycle time will change but this would have no measurable effect on operational maintenance expenses of the units.

COLLECTION (Contd.)

The low pressure piping system is based on probabilities of homes operating their pumping systems at the same time, thus resulting in a peak flow contribution. Flow reduction on a per capita basis with the same pump system does not alter piping sizes until a large number of homes are on that system (approximately 100 homes). This does not occur for our alternates and therefore no savings can be accomplished within the low pressure piping system using flow reduction.

For the gravity sewers, flow reduction will only effect the interceptor sewers and their capital costs. All other collection lines for this project are eight inches in diameter, which is the minimum line size allowed and cannot be reduced. There has been some speculation that the reduced flow may cause an increase in the required maintenance for the gravity collectiom system due to deposition resulting from low velocities in the lines. However, this cost is impractical to calculate if indeed there is an extra cost.

Lift stations, force mains and gravity interceptor sewers are sensitive to flow variations since they are associated primarily with large numbers of dwellings. The more service connections per pump station or interceptor sewer the greater the effect flow reduction will have.

For Springvale and Littlefield Townships the only change was found in the reduction in size of one pump station, with a capital cost savings of $12,000. This is a minimal savings and is negligible for an economic analysis. This is not to say that water conservative devices are not cost effective when energy and home owners expenses are considered.

TREATMENT

The treatment process being considered is central land treatment via spray irrigation. The capital, O&M, and Salvage Costs were calculated with the new flows. Table 1 summarizes these costs.

TABLE 1

CROOKED/PICKEREL

COST ESTIMATE

LAND TREATMENT - SPRAY IRRIGATION

Alternate - Flow Reduction

Costs in 1979 Dollars
x $1,000
EPA SCCT INDEX = 145

PROCESS	CAPITAL COST	O&M COSTS	SALVAGE VALUE
Influent Pump Station	22.50	1.05	6.75
Influent Pipe	104.60	0.10	62.76
Preliminary Treatment	24.00	1.20	10.80
Storage Lagoon	71.25	0.10	42.75
Onsite Pipe	54.00	0.10	32.40
Land: 50 Acres	62.50	-	112.88
Application - Spray	240.00	8.10	36.00
Crop Revenue	-	(-2.15)	-
TOTAL	$601.90	$8.55	$304.31

25% Engr. Contingencies included within process costs

SEASONAL VARIATION

The Springvale and Littlefield Townships study area has an average 59% seasonal population which for each alternate results in a given seasonal variation in flow. The largest fluctuations in seasonal population are located around the northern and eastern shores of Pickerel Lake. These areas have a variation in population of up to 88%. More permanent areas are spread throughout the two lake shore regions and on Oden Island.

Cluster systems, when employed around the lake areas, will see a positive effect resulting from the seasonal variation in flows. For this type of system the seasonal variation will enhance treatment by allowing the distribution field to rest and drain.

For alternates utilizing a comprehensive collection system with centralized treatment at Petoskey, the effective percent seasonal variation in flow is decreased. The variation in flow amounts to a reduction of 55% of the total seasonal flow. However, this total represents only five percent of the design flow for the Petoskey Plant. This reduction will therefore have little or no effect on plant operation.

For collection systems, the seasonal flows will have a minimal effect on cost. A decrease in flow of 88% for one pump station will mean an increase in detention time in the wet well. To avoid this problem the lift stations should be designed for easy adjustment of the water and level controls in the wet well. It would then be a simple operation for the maintenance crew to calibrate the controls for the two seasonal flows.

For alternatives employing land treatment, spray irrigation is used. The seasonal variation is ideal for land treatment as the low flows reduce the capacity needed for winter storage and thus the capital costs. This factor has been incorporated in the cost estimates for this item.

Seasonal flow will affect the individual effluent or grinder systems. Manufacturers recommend these units be removed during winter months if use is not anticipated on a periodic basis. Therefore, a maintenance program should be established to remove these units from home systems that would not be occupied during the winter season. This would also be an ideal time to perform any service that may be required to the pumps or any other elements contained in the pump basin. The costs involved in removing these units would be offset by the increased operating life experienced by the pumps.

The conclusion of this evaluation is that by designing the collection and treatment systems with seasonal variations in mind, in conjunction with a well planned operation and maintenance program, no difficulties should arise from seasonal variations in flow.

APPENDIX A

CROOKED/PICKEREL - COLLECTION

COST ESTIMATE

ALTERNATE - Proposed
Old Population

Costs in 1979 Dollars
x $1,000
ENR INDEX = 3000

SERVICE AREA	CAPITAL COST	O&M COSTS	SALVAGE VALUE
1980			
Central Collection	2,403.89	16.65	1,151.36
Gravity Interceptor	747.29	1.34	448.38
	3,151.18	17.99	1,599.74
25% Engr. and Cont.	787.80	-	@ 20% 319.95
TOTAL	3,938.98	17.99	1,919.69
1980-2000			
Central Collection	21.52		
25% Engr. and Cont.	5.38		
	26.90		

CROOKED/PICKEREL - COLLECTION

COST ESTIMATE

ALTERNATE - Proposed
New Population

Costs in 1979 Dollars
x $1,000
ENR INDEX = 3000

SERVICE AREA	CAPITAL COST	O&M COSTS	SALVAGE VALUE
1980			
Central Collection	2,274.11	15.79	1,125.44
Gravity Interceptor	747.29	1.34	448.38
	3,021.40	17.13	1,573.82
25% Engr. and Cont.	755.35	-	@ 20% 314.76
TOTAL	3,776.75	17.13	1,888.58
1980-2000			
Central Collection	8.65		
25% Engr. and Cont.	2.16		
	10.81		

CROOKED/PICKEREL - COLLECTION

COST ESTIMATE

ALTERNATE - 1

Costs in 1979 Dollars
x $1,000
ENR INDEX = 3000

SERVICE AREA	CAPITAL COST	O&M COSTS		SALVAGE VALUE
1980				
Cluster Systems	1,433.55	27.08		606.56
25% Engr. and Cont.	358.39	-	@ 20%	121.31
Total	1,791.94	27.08		727.87
1980-2000				
Cluster Systems	52.88*	0.53/yr*		405.67
25% Engr. and Cont.	13.22	-	@ 20%	81.14
	66.10	0.53/yr*		486.81

*gradient per year over 20-year period

CROOKED/PICKEREL - COLLECTION

COST ESTIMATE

ALTERNATE - 2

Costs in 1979 Dollars
x $1,000
ENR INDEX = 3000

SERVICE AREA	CAPITAL COST	O&M COSTS		SALVAGE VALUE
1980 - Crooked Lake Area				
Segments 1, 2, 3, 4, 6	398.76	5.63		140.61
Pickerel Lake Area				
Segments 10-16	845.43	10.31		310.72
Cluster Systems 3, 5, 11				
Segments 5, 7, 8, 9, 17	216.01	8.76		96.77
	1,460.20	24.70		548.10
25% Engr.	365.05	-	@ 20%	109.62
TOTAL	1,825.25	24.70		657.72
1980-2000				
Collection	23.74/yr*	0.44/yr*		114.71
Cluster	5.39/yr	0.17/yr		43.86
	29.13/yr	0.61/yr		158.57
25% Engr.	7.28/yr	-	@ 20%	31.71
TOTAL	36.41/yr	0.61/yr		190.28

*gradient per year over a 20-year period

CROOKED/PICKEREL

COST ESTIMATE

LAND TREATMENT - SPRAY IRRIGATION

CROOKED LAKE AREA

Alternate - 2

Q = 0.023 MGD

Costs in 1979 Dollars
x $1,000
EPA SCCT INDEX = 145

PROCESS	CAPITAL COST	O&M COSTS	SALVAGE VALUE
Influent Pump Station	5.62	0.95	1.70
Influent Pipe	71.88	0.10	43.13
Preliminary Treatment	22.50	0.35	10.12
Storage Lagoon (1.73 MG)	37.50	0.10	22.50
Onsite Pipe	19.40	0.10	11.64
Land: 26 Acres	32.50	-	58.70
Application - Spray	80.80	2.50	12.12
Crop Revenue	-	(*0.80)	-
TOTALS	$270.20	$3.30	$141.30

. 25% Engr. Contingnecies included within process costs

CROOKED/PICKEREL

COST ESTIMATE

LAND TREATMENT - SPRAY IRRIGATION

PICKEREL LAKE AREA

ALTERNATE - 2

Q = 0.059 MGD

Costs in 1979 Dollars
x $1,000
ENR INDEX = 3000

SERVICE AREA	CAPITAL COST	O&M COSTS	SALVAGE VALUE
Influent Pump Station	45.00	2.10	13.50
Influent Pipe	104.60	0.10	62.76
Preliminary Treatment	23.25	1.00	10.46
Chlorination	17.00	0.90	6.80
Storage Lagoon (4.83 MG)	58.75	0.10	35.25
Onsite Pipe	35.60	0.20	21.40
Land @ 40 Acres	50.00	-	90.30
Application: Spray	202.50	6.00	30.40
Crop Revenue	-	(1.99)	-
TOTALS	$536.70	$8.40	$270.90

25% Engr. Contingencies included within process costs

CROOKED/PICKEREL - COLLECTION

COST ESTIMATE

ALTERNATE - 3

Costs in 1979 Dollars
x $1,000
ENR INDEX = 3000

SERVICE AREA	CAPITAL COST	O&M COSTS	SALVAGE VALUE
1980 - Crooked Lake Area			
Segments 1, 2, 3, 4, 5, 6, 17, 18	570.04	8.74	198.36
Clusters 3, 4, 6-10 and Holding Tanks	785.78	19.89	308.66
Segments 7-16			
Gravity Interceptor	774.29	1.34	448.38
	2,130.11	29.97	955.40
25% Engr. and Cont.	532.53	-	@ 20% 191.08
TOTAL	2,662.64	29.97	1,146.48
1980-2000			
Crooked Lake	8.36/yr*	0.24/yr*	41.85
Clusters	33.42/yr	0.40/yr	247.42
	41.78/yr	0.64/yr	289.27
25% Engr. and Cont.	10.44/yr	-	@ 20% 57.85
TOTAL	52.22/yr	0.64/yr*	347.12

*gradient per year over a 20-year period

CROOKED/PICKEREL - COLLECTION

COST ESTIMATE

ALTERNATE - 4

Costs in 1979 Dollars
x $1,000
ENR INDEX = 3000

SERVICE AREA	CAPITAL COST	O&M COSTS	SALVAGE VALUE
1980			
Central Collection	1,809.11	24.36	710.67
25% Engr. and Cont.	452.28	-	@ 20% 142.13
TOTAL	2,261.39	24.36	852.80
1980-2000			
Central Collection	21.20/yr*	0.51/yr*	188.71
25% Engr. and Cont.	5.30/yr	-	@ 20% 37.74
TOTAL	26.50/yr	0.51/yr	226.45

*gradient per year over a 20-year period

CROOKED/PICKEREL
COST ESTIMATE
LAND TREATMENT - SPRAY IRRIGATION

Alternate - 4
Q = 0.084 MGD

Costs in 1979 Dollars
x $1,000
EPA SCCT INDEX = 145

PROCESS	CAPITAL COST	O&M COSTS	SALVAGE VALUE
Influent Pump Station	22.50	1.05	6.75
Influent Pipe	111.75	0.10	67.00
Preliminary Treatment	25.50	1.50	11.50
Storage Lagoon (8.24 MG)	85.00	0.70	51.00
Onsite Pipe	57.40	0.20	34.40
Land @ 60 Acres	75.00	-	135.45
Application: Spray	227.85	9.00	34.18
Crop Revenue	-	(-2.80)	
TOTALS	605.00	9.75	340.25

25% Engr. Contingencies included within process costs

CROOKED/PICKEREL - COLLECTION

COST ESTIMATE

ALTERNATE - 5

Costs in 1979 Dollars
x $1,000
ENR INDEX = 3000

SERVICE AREA	CAPITAL COST	O&M COSTS	SALVAGE VALUE
1980			
Crooked Lake			
Area - Segments 1, 2, 3, 4, 6	398.76	5.63	140.61
Cluster Systems 3-10	949.62	21.87	376.53
	1,348.38	27.50	517.14
25% Engr. and Cont.	337.10	-	@ 20% 129.29
TOTAL	1,685.48	27.50	646.43
1980-2000			
Crooked Lake	7.52/yr*	0.21/yr*	75.15
Cluster Systems	35.98/yr	0.41/yr	267.97
	43.50/yr	0.62/yr	343.12
25% Engr. and Cont.	10.88/yr	-	@ 20% 68.62
TOTAL	54.38/yr	0.62/yr	411.74

*gradient per year over a 20-year period

CROOKED/PICKEREL

COST ESTIMATE

LAND TREATMENT - SPRAY IRRIGATION

CROOKED LAKE AREA

Alternate - 5
Q = 0.023 MGD

Costs in 1979 Dollars
x $1,000
EPA SCCT INDEX = 145

PROCESS	CAPITAL COST	O&M COSTS	SALVAGE VALUE
Influent Pump Station	5.62	0.95	1.70
Influent Pipe	71.88	0.10	43.13
Preliminary Treatment	22.50	0.35	10.12
Storage Lagoon (1.73 MG)	37.50	0.10	22.50
Onsite Pipe	19.40	0.10	11.64
Land: 26 Acres	32.50	-	58.70
Application: Spray	80.80	2.50	12.12
Crop Revenue	-	(-0.80)	-
TOTAL	270.20	3.30	159.87

25% Engr. Contingencies included within process costs

CROOKED/PICKEREL

COST ESTIMATE

Alternate: 6
Limited Action Alternate

1980

ITEM	CAPITAL COST	O&M COST	SALVAGE VALUE
Replace Septic Tank	18.9	1.89	11.3
Replace Drainfield	92.4	-0-	55.4
Mound Drainfield*	218.4	2.56	131.0
Holding Tank	8.4	5.44	5.0
H_2O_2 Renov.	9.4	-0-	-0-
Cluster System	339.3	5.04	115.5
25% Engr. and Cont.	171.7	-	79.54
TOTAL	858.5	14.93	397.71

* Without Septic Tank

1980-2000

Conv. Septic System	8.42/yr	0.23/yr	134.6
Mound System	13.0/yr	0.15/yr	208.8
Cluster	5.4/yr	0.05/yr	40.1
25% Engr. and Cont.	6.71	-	76.7
TOTAL	33.53/yr	0.43/yr	460.2

APPENDIX B

SPRINGVALE/LITTLEFIELD

General Assumptions Made by ABE for All New Alternatives

This section will expand and/or list certain general assumptions used for all new alternatives investigated during this phase of the project. Basic assumptions were broken down into two main categories, treatment and collection. Each of these categories will now be addressed separately:

COLLECTION

1. All sewer lines are to be placed at or below 6 feet of depth, due to frost penetration in the Springvale/Littlefield area. Gravity lines are assumed to be placed at an average depth of 12 feet.

2. Thirty percent shoring was used for all gravity lines. Ten percent less shoring is required for force mains and low pressure sewers due to their shallower average depth.

3. All pressure sewer lines and force mains 8 inches in diameter or less will be PVC SDR26, with a pressure rating of 160 psi. Those force mains larger than 8 inches in diameter will be constructed of ductile iron with mechanical joints.

4. A minimum velocity of 2 fps will be maintained in all pressure sewer lines and force mains to provide for scouring.

5. Cleanouts in the pressure sewer system will be placed at the beginning of each line, and one every 500 feet of pipe in line. Cleanout valve boxes will contain shut-off valves to provide for isolation of various sections of line for maintenance and/or repairs.

COLLECTION (Contd.)
Page Two

6. The pumping units investigated for the pressure sewer system utilized effluent and grinder pumps. Both units include a 2 by 8 foot basin with discharge at 6 feet, control panel, visual alarm, mercury float level controls, valves, rail system for removal of pump, antifloatation device, and the pump itself. The grinder pump is a 2 hp pump with a total dynamic head of 90 feet. The effluent pump is manufactured in a 1, 1½ or 2 hp pump. For the Springvale/Littlefield area the 1 hp pump proved to be impractical as its total dynamic head is only 60 feet, and insufficient for long runs of pressure lines. The 1½ and 2 hp pumps reach a total dynamic head of 80 and 120 feet respectively.

7. On-site and effluent pumping units (STEP) require the use of septic tanks. Due to undersize and faulty units, a 50 percent replacement of all septic tanks was assumed. All units are to be 1,000 gallon concrete septic tanks.

8. An even distribution of population was primarily assumed along collection lines for all alternatives indicated.

9. A peaking factor for design flows of the various systems investigated was based on the Ten State Standards in concurrence with the Springvale/Littlefield Facility Plan.

10. All flows are based on a 60 gallon per capital day (gpcd) design flow for residential areas. Infiltration for new sewers is based on a rate of 200 gallons per inch - mile of gravity sewer lines.

COLLECTION (Contd.)
Page Three

11. The costs presented for each alternate are comparable costs to each other. However, the costs generated may not reflect actual construction costs due to the degree of accuracy utilized in preparation of these estimates.

TREATMENT

Land Application, Spray Irrigation

1. Several sites for land application were suggested by WAPORA. The two sites chosen by ABE were determined to offer the best soil conditions with enough area to accommodate the treatment system.

2. The application technique is spray irrigation for crop production. Spray irrigation is the only treatment technique strongly endorsed by the State for lake areas. With this type of application there is an added benefit of income from crop revenues which defrays part of the yearly operation and maintenance expense.

3. An application rate of 1.6 "/wk was determined after calculating the nitrogen loading rate limit and noting that there would be no need for underdrainage at this rate. Higher loading rates may produce poor crop growth.

4. Alfalfa was the chosen crop since alfalfa allows a higher application rate and because it is a perennial crop with its growing season limited solely by climatic factors. In addition, alfalfa has a high nitrogen uptake which is a most desirable characteristic.

5. The storage period is based primarily on basic guidelines provided by the Michigan Department of Natural Resources. The State recommends 6 months storage in the northern half of the state which would include the Springvale/Littlefield area.

Task Order No. 1
Contract No. 68-01-4612, DOW #4

The following analysis shall be performed by Arthur Beard Engineers, Inc. (ABE) on the Crooked/Pickerel Lakes portion of the Springvale-Bear Creek Area Segment Facility Plan. Items one (1) through five (5) will be submitted to WAPORA, Inc. within 15 calendar days from notice to proceed on this Task Order.

1. Recalculate the proposed facility plan collection and treatment alternative upgrade using the new (EIS) population and flow projections and distributions to be supplied by WAPORA, Inc.

2. Recalculate the proposed facility plan collection and treatment alternatives using the population and flow figures presented in the ABE Engineering Report of the Springvale/Littlefield area dated July 19, 1978 in conjunction with the unit costs and methodology as developed by ABE.

3. Recalculate EIS alternatives one through five as presented in the previously submitted report using the revised population and flow projections and distributions.

4. Recalculate one alternative (EIS alternative #4) using flow reduction methodology with actual flow reduction figures determined by WAPORA.

5. Recalculate EIS alternative #6 (the "limited action" alternative) upon receipt of pertinent design data from WAPORA.

Using the new population data, will recalculate collection systems sizings and costs for all alternatives. In addition, treatment alternatives will also be recalculated based on revised flow data. Land application alternatives will be revised to reflect a lesser degree of pretreatment prior to application on the land to conform to EPA PRM 79-3, dated 15 November 1978. Decentralized alternatives for segment 7 will be revised to include the use of holding tanks.

All information specified above will be submitted to WAPORA in report form using a format similar to that used for the Aurora, Illinois report prepared by ABE.

All costs will be upgraded to June 1979 costs using an ENR construction cost figure of 3000, or an EPA SCCT Index of 145, (estimated from third quarter '78 of 140).

Estimated person hours for performance of this task are:

Engineering and Drafting	160 person/hours
Secretarial and Clerical Support	16 person/hours

Labor Category	Effort	Cost
Engineering and Drafting	160 person/hours	$4,148.80
Secretarial and Clerical Support	16 person/hours	$ 252.64
TOTAL TASK ORDER		$4,401.44

WAPORA, Inc. will supply ABE with all maps, regulations, population information and flow projections.

William A. King
Corporate Secretary

Gerald O. Peters
Director of Research

J. Ross Pilling, II
Project Manager

Dave Wahlstrand NBE

PROJECT NO. 662 F

CLIENT EPA V

SUBJECT Year 2000 Population and Design Flow

WAPORA, Inc.

Environmental/Energy/Economic Studies

OFFICE Wash Reg'l

Facility Plan Design Flow 0.1248 mgd (2050 population)

SHEET ____ OF ____

PREPARED BY Ross Pilling

DATE 6/2/79

CHECKED BY

DATE

Segment	Seasonal	Population Year 2000 Permanent	total	Flow mgd
1	4	9	13	.00078
2	0	12	12	.00072
3	16	21	37	.00222
4	52	51	103	.00618
5	16	48	64	.00384
6	36	123	159	.00954
7	16	6	22	.00132
8	16	21	37	.00222
9	0	0	0	0
10	60	33	93	.00558
11	52	51	103	.00618
12	48	42	90	.0054
13	64	18	82	.00456
14	112	36	148	.00888
15	28	24	52	.00312
16	140	105	245	.0147
17	0	3	3	.00018

Table E-1

EXISTING POPULATION AND DWELLING UNITS FOR THE CROOKED/PICKEREL PROPOSED SERVICE AREA (1978)

	1978					
	Population			Dwelling Units		
Municipality	Total	Permanent	Seasonal	Total	Permanent	Seasonal
Littlefield Township						
5	53	36	17	15	11	4
7 (part)	0	0	0	0	0	0
8	20	7	13	5	2	3
9	0	0	0	0	0	0
10	55	0	55	13	0	13
11	60	13	47	15	4	11
12	60	0	60	14	0	14
13	54	3	51	13	1	12
17	3	3	0	1	1	0
Subtotal	305	62	243	76	19	57
Springvale Township						
1	11	7	4	3	2	1
2	10	10	0	3	3	0
3	31	10	21	8	3	5
4	60	13	47	15	4	11
6	89	59	30	25	18	7
7 (part)	17	0	17	4	0	4
14	128	13	115	29	2	27
15	7	7	0	3	2	1
16	182	42	140	46	13	33
18	0	0	0	0	0	0
Subtotal	535	161	374	136	47	89
TOTAL	840	223	617	212	66	146

Table E-2

PROJECTED POPULATION AND DWELLING UNITS FOR THE CROOKED/PICKEREL PROPOSED SERVICE AREA (2000)

	2000					
	Population			Dwelling Units		
Municipality	Total	Permanent	Seasonal	Total	Permanent	Seasonal
Littlefield Township						
5	64	48	16	20	16	4
7 (part)	0	0	0	0	0	0
8	37	21	16	11	7	4
9	0	0	0	0	0	0
10	93	33	60	26	11	15
11	103	51	52	30	17	13
12	90	42	48	26	14	12
13	82	18	64	22	6	16
17	3	3	0	1	1	0
Subtotal	472	216	256	136	72	64
Springvale Township						
1	13	9	4	4	3	1
2	12	12	0	4	4	0
3	37	21	16	11	7	4
4	103	51	52	30	17	13
6	159	123	36	50	41	9
7 (part)	22	6	16	6	2	4
14	148	36	112	40	12	28
15	52	24	28	15	8	7
16	245	105	140	70	35	35
18	0	0	0	0	0	0
Subtotal	791	387	404	230	129	101
TOTAL	1,263	603	660	366	201	165

Table II-10

PERMANENT AND SEASONAL POPULATION OF THE
PROPOSED CROOKED PICKEREL LAKES SERVICE AREA (1978)*

Segment	Total	Permanent	Seasonal	Percent Permanent	Percent Seasonal
1	11	7	4	63.6	36.4
2	10	10	0	100.0	0.0
3	31	10	21	32.3	67.7
4	60	13	47	21.7	78.3
5	53	36	17	67.9	32.1
6	89	59	30	66.3	33.7
7	17	0	17	0.0	100.0
8	20	7	13	35.0	65.0
9	0	0	0	0.0	0.0
10	55	0	55	0.0	100.0
11	60	13	47	21.7	78.3
12	60	0	60	0.0	100.0
13	54	3	51	5.6	94.4
14	128	13	115	10.2	89.8
15	7	7	0	100.0	0.0
16	182	42	140	23.1	76.9
17	3	3	0	100.0	0.0
18	0	0	0	0.0	0.0
TOTAL	840	223	617	26.5	73.5

*The methodology utilized to develop these population estimates is found in Appendix D.

Table II-11

PERMANENT AND SEASONAL POPULATION OF THE PROPOSED CROOKED-PICKEREL LAKES SERVICE AREA (2000)[1]

Segment	Total	Permanent	Seasonal	Percent Permanent	Percent Seasonal
1	13	9	4	69.2	30.8
2	12	12	0	100.0	0.0
3	37	21	16	56.8	43.2
4	103	51	52	49.5	50.5
5	64	48	16	75.0	25.0
6	159	123	36	77.4	22.6
7	22	6	16	27.3	72.7
8	37	21	16	56.8	43.2
9	0	0	0	0.0	0.0
10	93	33	60	35.5	64.5
11	103	51	52	49.5	50.5
12	90	42	48	46.7	53.3
13	82	18	64	22.0	78.0
14	148	36	112	24.3	75.7
15	52	24	28	46.2	53.8
16	245	105	140	42.9	57.1
17	3	3	0	100.0	0.0
18	0	0	0	0.0	0.0
TOTAL	1,263	603	660	47.7	52.3

[1]The methodology utilized to develop these projections is found in Appendix D.

APPENDIX C

H-1 DWS
6/4/79

Updating Costs

Item	ENR 2669	ENR 3000 (1.124)
Gravity Sewers		
6"	15.95 /LF	17.93
8"	17.03 "	19.14
10"	18.59 "	20.90
12"	20.72 "	23.29
Force Mains		
1"	7.00 / LF	7.87
1¼"	7.25 "	8.15
1½"	7.50 "	8.43
2"	8.00 "	9.00
2½"	8.50 "	9.55
3"	9.00 "	10.12
4"	10 00 "	11.24
6"	11.00 "	12.36
8"	15.10 "	16.97
10"	19.50 "	21.92
Lift Stations		
0-50 gpm	4,000 ea.	4,500
50-200	16,000 "	18,000
200-500	40,000 "	45,000
500-1500	100,000 "	113,000

 DWS 6/4/79

Updating Costs Con't

Item	ENR 2669	ENR 3000 (1.124)
Dwelling pumping units	*1958 ea	2,200
Septic Tanks	265 ea	300
Hook ups		
pressure	751 ea	844-45=799
gravity	1000 ea	1124-36=1088
Pressure Sewer Appurt.		
clean outs in-line	682 ea	767
end-line	649 ea.	730
Curb valve	40 ea.	45
Air Release Valve (ARV)	1622 ea.	1823
gravity tee	32 ea.	36
Drain fields		
Trench	1.55/LF	1.74
4" perforated pipe	1.50/LF	1.69
back fill	0.50/LF of trench	0.56
gravel fill	8.60/CY	9.67
distribution box	185 ea	210
Cleanouts	200 ea	225
4" gravity pipe	4.60/LF	5.17
Hydrogeologic Survey	8,500	9554
Monitoring Wells	2,700	3035

* Effluent Pump Costs

Simplex Rail Package

2'x5' basin (Fiberglass) NEMA 3 Electrical panel, Alarm, 1 HP pump, Valves, level controls	-	1,279.00
3' Additional depth @$48/V.F.	-	144.00
Add Additional 1 HP to pump		100.00
installation		435.00
		$1,958.00

PROJECT WAPORA PROJ NO. 442A
SUBJECT ON SITE SYSTEMS CLIENT WAPORA

COMP BY DLS DATE 6/11/79 CKD BY ______ DATE ______ SHEET 1 OF 2

UNIT COSTS

H_2O_2 (HYDROGEN PEROXIDE) TREATMENT

PER TREATMENT, $400 × 3000/2670 (ENR ADJ.) = 449.6

SAY $450/TREATMENT
O&M = 0 FOR FIELD.

HOLDING TANK

SEASONAL POP NOW = 840
212 UNITS ⇒ 4 PEOPLE/UNITS
SAY 5 PEOPLE FOR SAFETY.
5 × 44 gpcd** = 220 gpd
Pumping 2 × per month ⇒
16 × 220 = 3,520 gal. STORAGE REQ'D.
USE 2 – 2,000 GAL TANKS IN SERIES
COST PER TK = $600* + EXCAVATION
(15 CY @ 1.90*) = $30 FOR BOTH
+ H_2O CONSER. DEVICES = $50.00
+ PIPING – SAY 60' 4" GRAV. @ $5.17/LF = $310.00
1 – HIGH WATER ALARM – $500
TOTAL COST PER HOLDING UNIT $2090 SAY $2,100

** ASSUMED H_2O CONSERVATION USED WITH HOLDING TANK ∴ 44 gpcd USAGE

* MEANS '79, UPGRADED TO ENR 3000.

PROJECT Crooked Pick	PROJ NO. 44EA
SUBJECT ON SITE SYS - UNIT COSTS O+M	CLIENT Winford
COMP BY DWS DATE 6/11/79 CKD BY ____ DATE ____	SHEET 2 OF 2

HOLDING TANK - O+M

Treatment Cost - $10/1000 gal.

ANNUAL FLOW: 180 x 220 gpd = 39,600
185 x 132 gpd = 24420

64,000 g per year

= $640/yr TREAT.

HAULING COSTS: ASSUME 1 HR/TRIP @ $30/hr
INC. LABOR, & TRUCK (per K&K SEPTAGE
INC DEP., INS., OH etc)

ANNUAL COST:
24 TRIPS/YR $30 = $720/YR.

TOTAL O&M HOLDING: $1360/YR.

SEPTIC SYSTEM

Pump 1 TIME EVERY 5 YR @ $50

=> $10/YR.

MOUNDS

SEPTIC TANK - $15
PUMPING UNIT - 53.50
$68.50/YR.

CLUSTERS SEE CLUSTER SECTION

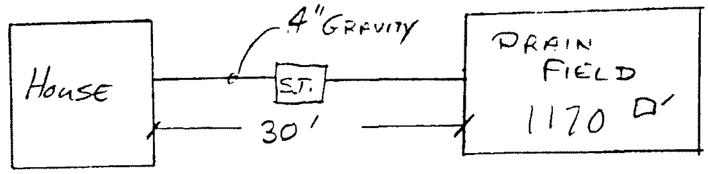
VARIES

arthur beard engineers, Inc.

PROJECT Camrez/Pick — PROJ NO. 448A

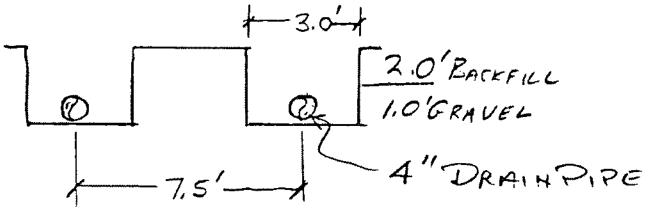
SUBJECT On Site Systems – STSAS — CLIENT WAFOPA

COMP BY Dew — DATE 6/11/79 — CKD BY ______ DATE ______ — SHEET 1 OF 2



Typ House = 3 Bedroom
Drainfield Sizing:

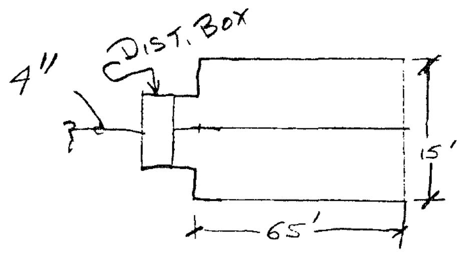
190 ft² Trench / Bedroom



Trench Configuration

For a 3 Bedroom:

Ft² Trench = 190 × 3 = 570 Ft² or 190 LF



Use 3 Trenches, 65' Long

Total Length 4" Pipe =
3 × 65 + 15 misc =
210 LF

Total Area Field
Say 20 × 75 = 1500 Ft²
(For Seeding)

Total Trench Excav. = 195 LF

Backfill = 195 LF

Gravel Fill = $\frac{195\text{ LF} \times 3' \times 1'}{27} = 21.7$ CY

C-6

PROJECT Crooked/Pick. | PROJ NO. 448A
SUBJECT On Site | CLIENT
STSAS Costs

COMP BY DCL DATE 6/11/79 CKD BY ______ DATE ______ | SHEET 2 OF 2

SEPTIC TANK AND DRAIN FIELD COSTS

ITEM	QUANTITY	UNIT COST	TOTAL COST
DISTRIBUTION BOX	1 EA.	210	210.00
TRENCH EXCAV.	195 LF	1.74	339.30
DRAIN PIPE (4")	195 LF	1.69	329.55
STONE FILL	21.7 CY	9.67	209.84
BACKFILL	195 LF	0.56	109.20
SEPTIC TANK	1 EA	300.00	300.00
4" GRAVITY LINE	30 LF	5.17	155.10
			$1652.99

SAY $1650/HOME FOR NEW SYSTEMS

FOR JUST DRAINFIELD REPLACEMENTS ON EXIS SYS.

$1,650 − 300.00 − 155.10 = $1194.90

SAY $1200

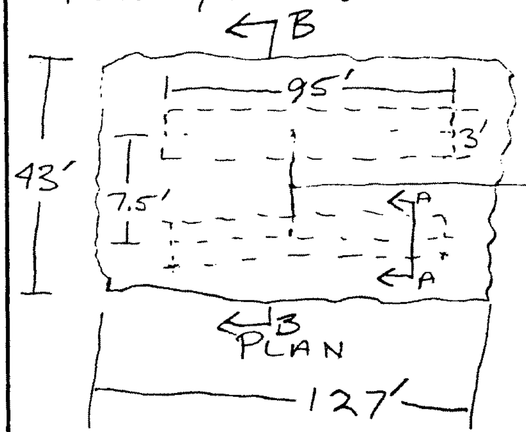
FOR JUST SEPTIC TANK REPLAC. ON EXIST. SYSTEMS

$300 + $155.10 = 455.10

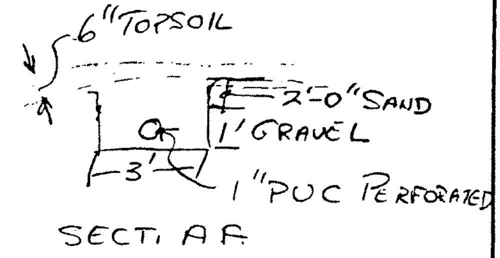
SAY $450

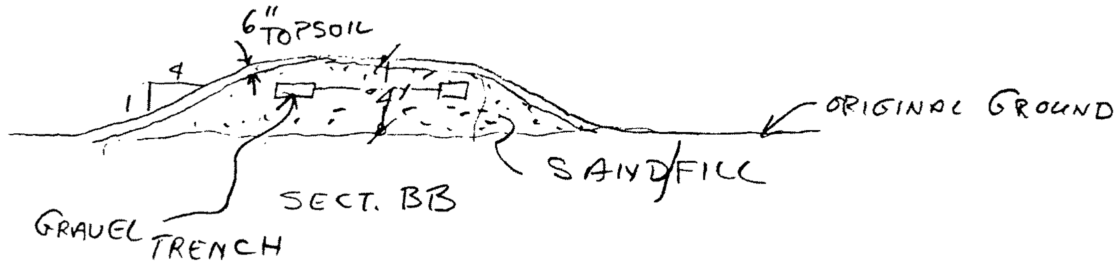
PROJECT: Crooked Pickerel	PROJ NO.: 449 A
SUBJECT: On Site Systems — Mound Systems	CLIENT: Wapora
COMP BY: DGF DATE: 6/1/79 CKD BY: ____ DATE: ____	SHEET 1 OF 2

For Typ. Dwelling : 3 Bedroom, 190 ft Trench Req'd



NTS





Quantity Calcs :

Gravel :

$$\frac{(2)(3')(1')(95')}{27} = 21.1\ cy$$

Topsoil :

$$V = [(10.5')(95') + (16.5')(43+43+95+95)]\ 6''$$

(276')

$$= \frac{[997.5 + 4554]\ 6''}{27}$$

$x / 16$

$x = \sqrt{(16)^2 + (4^2)}$

$x = 16.5'$

$V = 103\ cy$

Sand :

$$V = \frac{[(3.5')(95')(10.5') + \tfrac{1}{2}(15.5)(3.5)(276)']}{27} - 21.1\ cy$$

$V = 386\ cy$

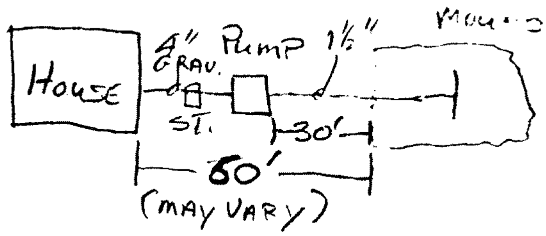
Seeding : 5550 ft^2

C-8

arthur beard engineers, Inc

PROJECT [illegible] H-1
SUBJECT Mounds
PROJ NO. 412A
CLIENT WAPORA

COMP BY DGT DATE 6/11 CKD BY ______ DATE ______ SHEET 2 OF 2



QUANTITY CALCS

1½" PVC –

30' + 16' + 50' + 10' = 106

SAY 120 LF 1½" INC. FITTINGS

1" PERF. PVC :
2 x 95' = 190' SAY
200 LF WOULD INCLUDE COST FOR FITTINGS

COST SUMMARY

ITEM	QUANTITY	UNIT COST	TOTAL COST
4" GRAV. LINE	30 LF	$5.17	155.10
EFFLUENT PUMP UNIT	1 L.S.	2200.00	2,200.00
1½" PVC	120 LF	7.75 *	930.00
1" PERF. PVC	200 LF	6.15 *	1230.00
GRAVEL	21.1 CY	9.67	204.04
SAND	386 CY	7.00 *	2702.00
TOPSOIL	103 CY	9.00 *	927.00
SEEDING	5500 FT²	10.50/1000 SF *	57.75
		TOTAL	$ 8405.89
		SAY	$ 8400.00

PER HOME W/O SEPTIC TANK REPLAC.

* FROM MEANS ('79) UPGRADED TO ENR 3000.

arthur beard engineers, Inc.

PROJECT CROOKED PICKERAL | PROJ NO. 448A
SUBJECT SALVAGE VALUES | CLIENT WAPORA
COMP BY DGS DATE 6/11/79 CKD BY ____ DATE ____ | SHEET 1 OF 1

The following service life was used for salvage value calculations. All salvage values are given for the year 2,000; eg what the equipment will be worth in that year. For future salvage values, it was assumed all development takes place in the year 1990 – this is in effect an average salvage value for the future connections. All mechanical items have a 20 year life; structural items a fifty (50) year life.

Item	USEFUL LIFE
PIPE	50 YR
PUMPING STATIONS	½ 50 yr, ½ 20 yr
SEPTIC TANKS	50 yr.
DRAIN FIELDS	50 yr.
MOUND SYSTEMS	50 yr.

PROJECT Crooked / Pickerel

SUBJECT Collection Pipe Costs

PROJ. NO. 446

CLIENT

COMP BY DWS DATE 6/5/78 CKD BY DATE SHEET OF

Average Cost of 8" gravity line @ 30% shoring.

$19.14 /LF X 70% length "y" = 13.40 y

$91.95 /LF X 30% length "y" = 27.59 y

$40.99 y = $41.00

10" = $42.22

PVC @ 20% shoring (Figured same way)

1½"	$ 12.00
2"	$ 12.46
2½"	$ 12.90
3"	$ 13.36
4"	$ 14.25
6"	$ 15.15

PROJECT Crooked / Pickerel
SUBJECT Shoring / Costs
PROJ NO. 448
CLIENT WAPORA
COMP BY DWS DATE 6/5/79 CKD BY ______ DATE ______
SHEET ______ OF ______

Because of soil and site conditions around the Crooked / Pickerel Study Area assumptions had to be made on conditions for excavation. At this stage of design it is very difficult to predict site conditions. OSHA requires sheeting and shoring for all excavation below 4 feet unless a 1:1 slope is cut on the trenches. Initial cost estimates for sheeting & shoring vs. restoration of all roads, private yards etc. due to the large trench opening required from no sheeting and shoring, indicate that the final costs are very close for each. We chose sheeting and shoring because of its reduced environmental impact from construction.

ABE has estimated that 30% of all sewers laid will require sheeting & shoring and ~~[illegible]~~ 20% of all force mains.

The average cost for 8" sewer is now $41.00 / L.F.

APPENDIX D

The analysis of the collection system for the Springvale/ Littlefield area was based on a cost effective study of three systems; the combination gravity/pressure system used in the proposed system of the facility plan, the combination gravity-pressure system used by ABE, and cluster systems. The systems were analyzed on an area basis utilizing comparable costs for each. Included in the analysis were capital costs for collection, hook-up expenses and salvage values.

The first system analyzed was the facility plan proposed alternate. This system combines a conventional gravity/force main system with a low pressure sewer system. The low pressure sewer system utilized grinder pumps and was used for servicing those homes that were below the elevation of the gravity system. In the facility plan, the low pressure sewer lines were connected directly to the pump station force mains of the gravity/force main system causing some concern as to its feasibility as this would be an innovative and as yet untried system. In upgrading of the proposed plan however, ABE decided to cost out the plan as shown assuming no problems would be encountered. However, for all the other alternatives a more conservative design was developed. This system will utilize a dual piping system with the low pressure system not pumping directly into the force main. ABE recognizes the potential for cost savings if the single line low pressure system is feasible and suggests more detail be given this consideration during the Step II, or design phase of this project. When comparing this to a system with additional pressure collection, ABE replaced the grinder pumps with effluent pumps, utilizing a STEP pressure system for both alternatives.

The decision to utilize a STEP system as opposed to a pressure system sewer utilizing grinder pumps is based solely on an assumption of a 50% replacement of septic tanks within the service area. On this basis, the STEP system was found more cost effective by a very slight margin. The cost between employing STEP systems versus grinder pumps are extremely competitive. ABE recommends that both of these systems be reviewed by the design engineer when employing pressure sewer systems for a specific service area. In this way, the existing conditions of the service area, the availability of the units, and the quantity of the units to be provided, will produce an accurate cost evaluation of both systems.

The third system analyzed was the use of several cluster systems each serving small groups of homes. Each home is connected to a gravity line which conveys the wastewater to a pump station. From here it is pumped to the nearest available land which is suitable for on-site treatment using a distribution field.

A comparison of cluster systems versus collection to a central land treatment site was conducted for the area around Pickerel Lake, and the cluster system proved to be more cost effective. This area was therefore served by cluster systems for all alternatives.

PROJECT Crooked / Pickerel

SUBJECT Proposed Alternate – Collection

PROJ NO. 44EA

CLIENT WAFORA

COMP BY DWS DATE 6/6/79 CKD BY ______ DATE ______

SHEET ______ OF ______

Old Population Projection

Capital

Item	Quantity	Unit Cost	Total Cost
8" gravity	27,400 LF	41.00	1,123,400
4" FM	29,000 LF	14.25	413,250
6" FM	10,500 LF	15.15	159,075
pump stations			
0-50 gpm	2 ea	4,500	9,000
50-200	5 "	18,000	90,000
200-500	3 "	45,000	135,000
Pumping Units	29	2,200	63,800
Septic Tanks	6	300	1,800
PVC 1½"	8,700	12.00	104,400
Cleanouts Inline	-0-	—	—
Endline	29	730	21,170
ARV	-0-	—	—
Hook-ups			
gravity	230	1088	250,240
pressure	29	799	23,171
Curb Valve	29	45	1,305
Gravity Tee	230	36	8,280
			$2,403,891

PROJECT Crooked / Pickerel
SUBJECT Proposed Alternate - Collection
PROJ NO. 448A
CLIENT WAFCRA
COMP BY DWS DATE 6/11/79 CKD BY ____ DATE ____
SHEET ____ OF ____

Old Population Projection

O&M

Item	Quantity	Unit Cost	Total Cost
gravity line	27,400 LF	400/mi/yr.	2,076
Force main	48,200 LF	100/mi/yr.	913
pumping units	29 ea	50/yr.	1,450
Power	29 ea	3.50/yr.	102
pump stations			
0-50	2	940	1,880
50-100	5	1050	5,250
100-200	-0-	1177	-0-
200-500	3	1226	3,678
septic tanks	29	10/yr	290
			$15,639/yr

SALVAGE

Collection	1,800,125	X 0.6	1,080,075
Pump Stations	234,000	X 0.3	70,200
septic tanks	1,800	X 0.6	1,080
			$ 1,151,355

PROJECT Crooked / Pickerel
PROJ NO. 448A
SUBJECT Proposed Alternate Collection
CLIENT WAPORA
COMP BY DWS DATE 6/11/79 CKD BY ______ DATE ______
SHEET ______ OF ______

New Population Projection

Item	Quantity	Unit Cost	Total Cost
8" gravity	27,400	41.00	1,123,400
4" FM	39,500	14.25	562,875
6" FM	-0-	15.15	-0-
pump stations			
0-50 gpm	3	4,500	13,500
50-200	6	18,000	108,000
200-500	1	45,000	45,000
pumping units	29	2,200	63,800
septic tanks	6	300	1,800
pvc 1½"	8,700	12.00	104,400
Cleanouts Inline	-0-	—	-0-
Endline	29	730	21,170
ARV	-0-	—	-0-
Hook-ups			
gravity	183	1088	199,104
pressure	29	799	23,171
Curb valve	29	45	1,305
Gravity Tee	183	36	6,588
			$ 2,274,113

PROJECT Crooked / Pickerel PROJ NO. 446A

SUBJECT Proposed Alternate - Collection CLIENT WAPORA

COMP BY DWS DATE 6/11/79 CKD BY ______ DATE ______ SHEET ____ OF ____

New Population Projecti

O&M

Item	Quantity	Unit Cost	Total Cost
gravity line	27,400	400/mi/yr	2,076
force main	48,200	100/mi/yr	913
pumping units	29	50	1,450
power	29	3.50	102
pump stations			
0-50	3	940	2,820
50-100	1	1050	1,050
100-200	5	1177	5,885
200-500	1	1226	1226
septic tanks	6	10/yr	60
			$ 15,582/y

Salvage

Collection	1,790,675	X0.6	1,074,405
pump Stations	166,500	X 0.3	49,950
septic tanks	1,800	X 0.6	1,080
			$ 1,125,435

PROJECT Crooked / Pickerel | PROJ NO. 446A
SUBJECT Proposed Alternate - Collection | CLIENT WAFCRA
COMP BY DWS DATE 6/11/79 CKD BY ____ DATE ____ | SHEET ____ OF ____

Gravity Interceptor to Petoskey

Capital

10,900 LF incomplete
6,800 LF No funds Available
17,700 LF

10" pipe @ 42.22 X 17,700 = $747,294

O&M

17,700 LF X 400 mi/yr = $1,340

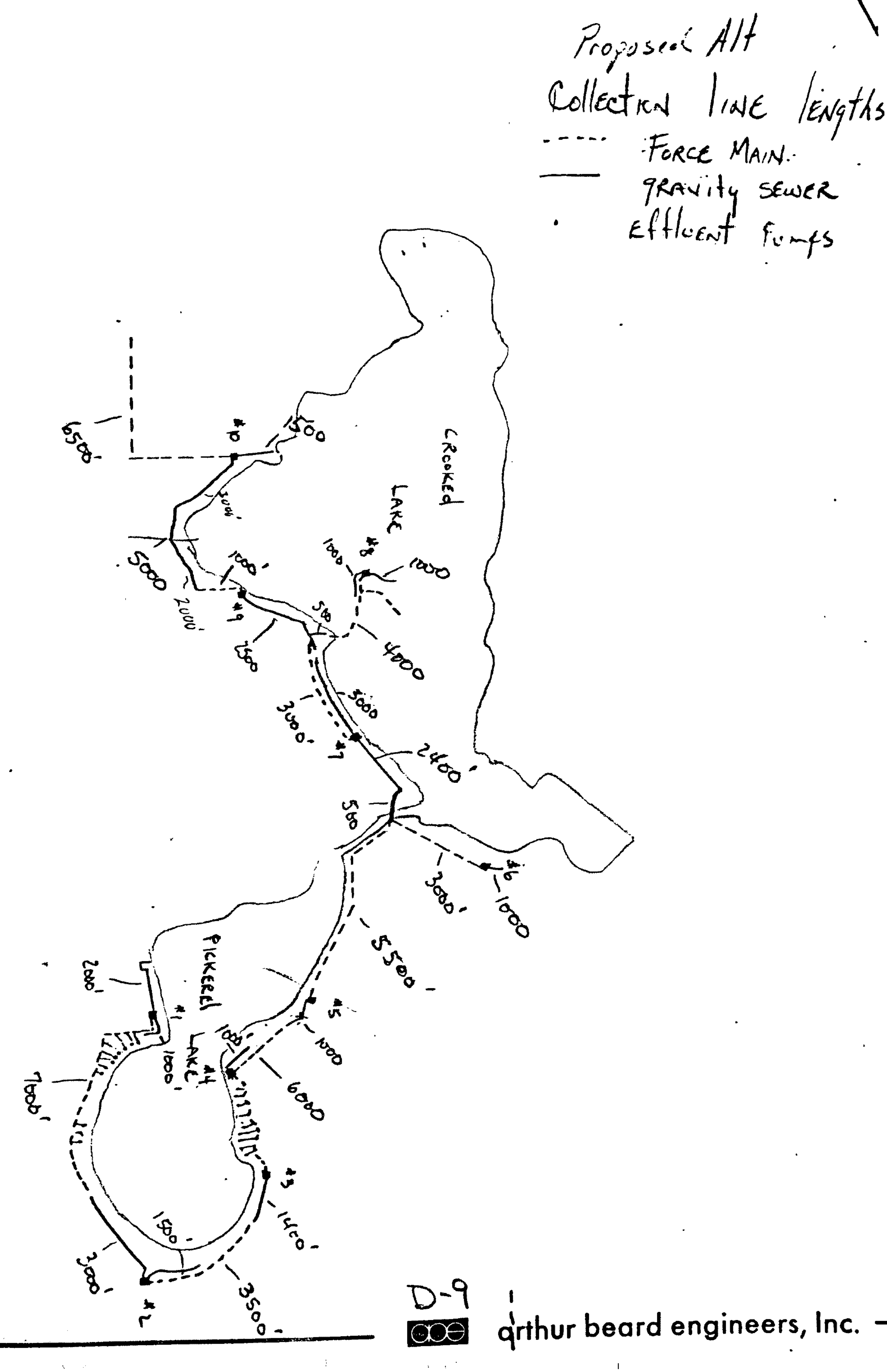
Salvage

747,294 X 0.6 = $448,376

PROJECT	Crooked / Pickerel	PROJ NO.	448A
SUBJECT	Proposed Alternate - Collection	CLIENT	WAPORA
COMP BY	DWS	DATE	6/1/79
CKD BY		DATE	
SHEET		OF	

Pump Stations

Number	Population	Flow (gpm)	F.M.	Cost
1	202	34	4"	4,500
2	445	74	4"	18,000
3	617	103	4"	18,000
4	720	120	4"	18,000
5	813	136	4"	18,000
6	37	10	4"	4,500
7	1031	172	4"	18,000
8	67	11	4"	4,500
9	1201	200	4"	18,000
10	1263	211	4"	45,000



arthur beard engineers, Inc.

PROJECT Crooked / Pickerel	PROJ NO. 446
SUBJECT Cluster Systems	CLIENT WAPORA
COMP BY DWS DATE 6/6/79 CKD BY ____ DATE ____	SHEET ____ OF ____

Because of time constraints some assumptions had to be made. One of these assumptions is the present and future costs for the cluster systems. How the sewers and drainfields will be phased in final design is unknown.

ABE decided to estimate the cluster system size for the future dwelling units and then figure from this total cost a cost per home. Using this cost per home we can then find the estimated cost for the present number of homes.

O&M and salvage values were figured on the same ratio basis for septic tanks and collection lines, all the other items are present costs.

Shoring costs for the force mains were not included because most of the lines are going away from the lake and its related poor soil.

CROOKED/PICKEREL - COLLECTION

COST ESTIMATE

ALTERNATE: 1

Costs in 1979 Dollars

ENR INDEX = 3000

		PRESENT			FUTURE		
Cluster	Segments	Capital	O&M	Salvage	Capital	O&M	Salvage
1	1, 2 & 18	170,196	1,584	89,152	56,732	178	28,906
2	3, 4 & 6	313,728	3,630	134,877	281,048	2,215	108,801
3	8	43,765	1,339	17,847	52,518	316	18,395
4	10	51,259	1,725	26,852	51,259	625	22,433
5	5 & 17	163,840	1,981	73,878	51,200	294	22,105
6	11	125,370	1,885	56,035	125,370	835	51,073
7	12	79,632	1,777	29,000	68,256	593	20,938
8	13 & 14	207,564	3,110	68,100	98,840	970	28,019
9	15	36,618	1,253	19,258	146,472	732	64,410
10	16	233,174	3,360	86,524	121,656	1,180	37,233
11	7	8,400	5,440	5,040	4,200	2,720	3,360
		1,433,546	27,084	606,563	1,057,551	10,658	405,673
25% Engr. & Const.		358,387	-	121,312	264,388	-	81,135
		1,791,933	27,084	727,875	1,321,939	10,658	486,808

CROOKED/PICKEREL
CLUSTER SYSTEMS

ARTHUR BEARD ENGINEERS, INC.
JOB 448

CLUSTER NO. 1 SEGMENTS 1, 2 & 18 PRESENT HOMES: 6
FUTURE HOMES: 8

CAPITAL COST

ITEM	QUANTITY	UNIT COST	TOTAL COST
8 in. gravity	4,665 LF	41.00	191,265
Force main	100 LF	8.43	843
Pump Station	1 ea.	4,500	4,500
Septic tanks	2	300	600
Trench	1,520 LF	1.74	2,645
4" perforated pipe	1,520 LF	1.69	2,569
Backfill	1,520 LF	0.56	851
Gravel fill	169 CY	9.67	1,634
Distribution box	1 ea.	210	210
4" gravity pipe	120 LF	5.17	620
Land	.6 Ac.	1,000	600
Hydrogeologic survey	L.S.	9,554	9,554
Monitoring well	L.S.	3,035	3,035
Sub-Total			$ 218,926
Cost/Home			27,366
Homeowners Hook-up Cost	8 ea.	1,000	8,000
TOTAL			$226,926

O&M

Monitoring wells	1 set	100/yr.	100
Pump Station	1 ea.	950/yr.	950
Gravity line	0.88 mi.	400/mi/yr.	352
Force main	-	100/mi/yr.	0
Septic tanks	8	10/yr.	80
TOTAL			$1,482

SALVAGE

Collection	192,108	x 0.6	115,265
Septic tanks	600	x 0.6	360
Pump stations	4,500	x 0.3	1,350
TOTAL			$116,974

CROOKED/PICKEREL
CLUSTER SYSTEMS

ARTHUR BEARD ENGINEERS, INC.
JOB 448

CLUSTER NO. 2

SEGMENTS: 3, 4 & 6 PRESENT HOMES: 48
FUTURE HOMES: 91

CAPITAL COST

ITEM	QUANTITY	UNIT COST	TOTAL COST
8 in. gravity	8,200 LF	41.00	336,200
Force main	4,000 LF	8.43	33,720
Pump Station	1 ea.	4,500	4,500
Septic tanks	53 ea.	300	15,900
Trench	17,290 LF	1.74	30,085
4" perforated pipe	17,290 LF	1.69	29,220
Backfill	17,290 LF	0.56	9,682
Gravel fill	1,921 CY	9.67	18,576
Distribution box	1	210	210
4" gravity pipe	1,365	5.17	7,057
Land	6 Ac.	1,000	6,000
Hydrogeologic survey	L.S.	9,554	9,554
Monitoring well	L.S.	3,035	3,035
Sub-Total			$503,739
Cost/Home			5,536
Homeowners Hook-up Cost	91	1,000	91,000
TOTAL			$594,739

O&M

Monitoring wells	1	100/yr.	100
Pump Station	1	950/yr.	950
Gravity line	1.55 mi.	400/mi/yr.	620
Force main	0.8 mi.	100/mi/yr.	80
Septic tanks	91	10/yr.	910
TOTAL			$2,660

SALVAGE

Collection	369,920	x 0.6	221,952
Septic tanks	15,900	x 0.6	9,540
Pump stations	4,500	x 0.3	1,350
TOTAL			$232,842

CROOKED/PICKEREL
CLUSTER SYSTEMS

ARTHUR BEARD ENGINEERS, INC.
JOB 448

CLUSTER NO. 3

SEGMENTS: 8

PRESENT HOMES: 5
FUTURE HOMES: 11

CAPITAL COST

ITEM	QUANTITY	UNIT COST	TOTAL COST
8 in. gravity	1,000 LF	41.00	41,000
Force main	1,500 LF	8.43	12,645
Pump Station	1 ea.	4,500	4,500
Septic tanks	7 ea.	300	2,100
Trench	2,090 LF	1.74	3,637
4" perforated pipe	2,090 LF	1.69	3,532
Backfill	2,090 LF	0.56	1,170
Gravel fill	232 CY	9.67	2,243
Distribution box	1 ea.	210	210
4" gravity pipe	165 LF	5.17	853
Land	0.8 Ac.	1,000	800
Hydrogeologic survey	L.S.	9,554	9,554
Monitoring well	L.S.	3,035	3,035
Sub-Total			$85,279
Cost/Home			7,753
Homeowners Hook-up Cost	11	1,000	11,000
TOTAL			$96,279

O&M

Monitoring wells	1 set	100/yr.	100
Pump Station	1 ea.	950/yr.	950
Gravity line	0.2 mi.	400/mi/yr.	80
Force main	0.3 mi.	100/mi/yr.	30
Septic tanks	11	10/yr.	110
TOTAL			$1,270

SALVAGE

Collection	53,645	x 0.6	32,187
Septic tanks	2,100	x 0.6	1,260
Pump stations	4,500	x 0.3	1,350
TOTAL			$34,797

CROOKED/PICKEREL
CLUSTER SYSTEMS

ARTHUR BEARD ENGINEERS, INC.
JOB 448

CLUSTER NO. 4 SEGMENTS: 10 PRESENT HOMES: 13
FUTURE HOMES: 26

CAPITAL COST

ITEM	QUANTITY	UNIT COST	TOTAL COST
8 in. gravity	1,200 LF	41.00	49,200
Force main	2,500 LF	8.43	21,075
Pump Station	1 ea.	4,500	4,500
Septic tanks	15 ea.	300	4,500
Trench	4,940 LF	1.74	8,596
4" perforated pipe	4,940 LF	1.69	8,349
Backfill	4,940 LF	0.56	2,766
Gravel fill	549 CY	9.67	5,309
Distribution box	1 ea.	210	210
4" gravity pipe	390	5.17	2,016
Land	1.7 Ac.	1,000	1,700
Hydrogeologic survey	L.S.	9,554	9,554
Monitoring well	L.S.	3,035	3,035
Sub-Total			$76,530
Cost/Home			2,943
Homeowners Hook-up Cost	26	1,000	26,000
TOTAL			$103,473

O&M

Monitoring wells	1 set	100/yr.	100
Pump Station	1 ea.	950/yr.	950
Gravity line	0.2 mi.	400/mi/yr.	80
Force main	0.5 mi.	100/mi/yr.	50
Septic tanks	26 ea.	10/yr.	260
TOTAL			$1,440

SALVAGE

Collection	70,275	x 0.6	42,165
Septic tanks	4,500	x 0.6	2,700
Pump stations	4,500	x 0.3	1,350
TOTAL			$46,215

CROOKED/PICKEREL
CLUSTER SYSTEMS

ARTHUR BEARD ENGINEERS, INC.
JOB 448

CLUSTER NO. 5 SEGMENTS: 5 & 17 PRESENT HOMES: 16
FUTURE HOMES: 21

CAPITAL COST

ITEM	QUANTITY	UNIT COST	TOTAL COST
8 in. gravity	3,665 LF	41.00	150,265
Force main	100 LF	8.43	843
Pump Station	1 ea.	4,500	4,500
Septic tanks	8 ea.	300	2,400
Trench	3,990 LF	1.74	6,943
4" perforated pipe	3,990 LF	1.69	6,743
Backfill	3,990 LF	0.56	2,234
Gravel fill	443 CY	9.67	4,284
Distribution box	1 ea.	210	210
4" gravity pipe	315 LF	5.17	1,629
Land	1.4 Ac.	1,000	1,400
Hydrogeologic survey	L.S.	9,554	9,554
Monitoring well	L.S.	3,035	3,035
Sub-Total			$194,040
Cost/Home			9,240
Homeowners Hook-up Cost	21	1,000	21,000
TOTAL			$215,040

O&M

ITEM	QUANTITY	UNIT COST	TOTAL COST
Monitoring wells	1 set	100/yr.	100
Pump Station	1 ea.	950/yr.	950
Gravity line	0.7 mi.	400/mi/yr.	280
Force main	-	100/mi/yr.	0
Septic tanks	21	10/yr.	210
TOTAL			$1,540

SALVAGE

Collection	151,108	x 0.6	90,665
Septic tanks	2,400	x 0.6	1,440
Pump stations	4,500	x 0.3	1,350
TOTAL			$93,455

CROOKED/PICKEREL
CLUSTER SYSTEMS

ARTHUR BEARD ENGINEERS, INC.
JOB 448

CLUSTER NO.6 SEGMENTS : 11 PRESENT HOMES: 15
FUTURE HOMES: 30

CAPITAL COST

ITEM	QUANTITY	UNIT COST	TOTAL COST
8 in. gravity	4,000 LF	41.00	164,000
Force main	100 LF	8.43	843
Pump Station	1 ea.	4,500	4,500
Septic tanks	18 ea.	300	5,400
Trench	5,700 LF	1.74	9,918
4" perforated pipe	5,700 LF	1.69	9,633
Backfill	5,700 LF	0.56	3,192
Gravel fill	633 CY	9.67	6,121
Distribution box	1 ea.	210	210
4" gravity pipe	450 LF	5.17	2,327
Land	2 AC	1,000	2,000
Hydrogeologic survey	L.S	9,554	9,554
Monitoring well	L.S	3,035	3,035
Sub-Total			$220,733
Cost/Home			7,358
Homeowners Hook-up Cost	30	1,000	30,000
TOTAL			$250,733

O&M

Monitoring wells	1 set	100/yr.	100
Pump Station	1 ea.	950/yr.	950
Gravity line	0.8 mi.	400/mi/yr.	320
Force main	-	100/mi/yr.	0
Septic tanks	30	10/yr.	300
TOTAL			$1,670

SALVAGE

Collection	164,843	x 0.6	98,906
Septic tanks	5,400	x 0.6	3,240
Pump stations	4,500	x 0.3	1,350
TOTAL			$103,496

CROOKED/PICKEREL
CLUSTER SYSTEMS

ARTHUR BEARD ENGINEERS, INC.
JOB 448

CLUSTER NO. 7 SEGMENTS 12 PRESENT HOMES: 14
FUTURE HOMES: 26

CAPITAL COST

ITEM	QUANTITY	UNIT COST	TOTAL COST
8 in. gravity	1,500 LF	41.00	61,500
Force main	1,170 LF	8.43	9,863
Pump Station	1 ea.	4,500	4,500
Septic tanks	15 ea	300	4,500
Trench	4,940 LF	1.74	8,596
4" perforated pipe	4,940 LF	1.69	8,349
Backfill	4,940 LF	0.56	2,766
Gravel fill	549 CY	9.67	5,309
Distribution box	1 ea.	210	210
4" gravity pipe	390 LF	5.17	2,016
Land	1.7 AC	1,000	1,700
Hydrogeologic survey	L.S	9,554	9,554
Monitoring well	L.S	3,035	3,035
Sub-Total			$121,898
Cost/Home			4,688
Homeowners Hook-up Cost	26	1,000	26,000
TOTAL			$147,898

O&M

Monitoring wells	1 set	100/yr.	100
Pump Station	1 ea.	950/yr.	950
Gravity line	.3	400/mi/yr.	120
Force main	.3	100/mi/yr.	30
Septic tanks	26	10/yr.	260
TOTAL			$1,460

SALVAGE

Collection	71,363	x 0.6	42,818
Septic tanks	4,500	x 0.6	2,700
Pump stations	4,500	x 0.3	1,350
TOTAL			$46,868

CROOKED/PICKEREL
CLUSTER SYSTEMS

ARTHUR BEARD ENGINEERS, INC.
JOB 448

CLUSTER NO. 8 SEGMENTS 13 & 14 PRESENT HOMES: 42
FUTURE HOMES: 62

CAPITAL COST

ITEM	QUANTITY	UNIT COST	TOTAL COST
8 in. gravity	3,333	41.00	136,653
Force main	100	8.43	843
Pump Station	1 ea.	4,500	4,500
Septic tanks	28 ea.	300	8,400
Trench	11,780 LF	1.74	20,497
4" perforated pipe	11,780 LF	1.69	19,908
Backfill	11,780 LF	0.56	6,597
Gravel fill	2,618 CY	9.67	25,316
Distribution box	1 ea.	210	210
4" gravity pipe	930 LF	5.17	4,808
Land	4.1 AC	1,000	4,100
Hydrogeologic survey	1	9,554	9,554
Monitoring well	1	3,035	3,035
Sub-Total			$244,421
Cost/Home			3,942
Homeowners Hook-up Cost	62	1,000	62,000
TOTAL			$306,421

O&M

ITEM	QUANTITY	UNIT COST	TOTAL COST
Monitoring wells	1 set	100/yr.	100
Pump Station	1	950/yr.	950
Gravity line	0.6 mi.	400/mi/yr.	240
Force main	-	100/mi/yr.	0
Septic tanks	62	10/yr.	620
TOTAL			$1,910

SALVAGE

ITEM	QUANTITY	FACTOR	TOTAL
Collection	137,496	x 0.6	82,498
Septic tanks	8,400	x 0.6	5,040
Pump stations	4,500	x 0.3	1,350
TOTAL			$88,888

CLUSTER NO. 9 | SEGMENTS 15 | PRESENT HOMES: 3
FUTURE HOMES: 15

CAPITAL COST

ITEM	QUANTITY	UNIT COST	TOTAL COST
8 in. gravity	3,000 LF	41.00	123,000
Force main	900 LF	8.43	7,587
Pump Station	1 ea.	4,500	4,500
Septic tanks	12 ea.	300	3,600
Trench	2,850 LF	1.74	4,959
4" perforated pipe	2,850 LF	1.69	4,817
Backfill	2,850 LF	0.56	1,596
Gravel fill	317 CY	9.67	3,065
Distribution box	1 ea.	210	210
4" gravity pipe	225 LF	5.17	1,163
Land	1 Ac.	1,000	1,000
Hydrogeologic survey	L.S	9,554	9,554
Monitoring well	L.S	3,035	3,035
Sub-Total			$168,086
Cost/Home			11,206
Homeowners Hook-up Cost	15	1,000	15,000
TOTAL			$183,086

O&M

Monitoring wells	1 set	100/yr.	100
Pump Station	1 ea.	950/yr.	950
Gravity line	0.6 mi.	400/mi/yr.	240
Force main	0.2 mi.	100/mi/yr.	20
Septic tanks	15	10/yr.	150
TOTAL			$1,460

SALVAGE

Collection	130,587	x 0.6	78,352
Septic tanks	3,600	x 0.6	2,160
Pump stations	2,500	x 0.3	1,350
TOTAL			$81,862

CROOKED/PICKEREL
CLUSTER SYSTEMS

ARTHUR BEARD ENGINEERS, INC.
JOB 448

CLUSTER NO. 10

SEGMENTS 16

PRESENT HOMES: 46
FUTURE HOMES: 70

CAPITAL COST

ITEM	QUANTITY	UNIT COST	TOTAL COST
8 in. gravity	4,150 LF	41.00	170,150
Force main	1,200 LF	8.43	10,116
Pump Station	1 ea.	4,500	4,500
Septic tanks	33 ea.	300	9,900
Trench	13,300 LF	1.74	23,142
4" perforated pipe	13,300 LF	1.69	22,477
Backfill	13,300 LF	0.56	7,448
Gravel fill	1,478 CY	9.67	14,292
Distribution box	1 ea.	210	210
4" gravity pipe	1,050 LF	5.17	5,428
Land	4.6 Ac.	1,000	4,600
Hydrogeologic survey	L.S	9,554	9,554
Monitoring well	L.S	3,035	3,035
Sub-Total			284,852
Cost/Home			4,069
Homeowners Hook-up Cost	70	1,000	70,000
TOTAL			$354,852

O&M

Monitoring wells	1 set	100/yr.	100
Pump Station	1 ea	950/yr.	950
Gravity line	0.8	400/mi/yr.	320
Force main	0.2	100/mi/yr.	20
Septic tanks	70	10/yr.	700
TOTAL			$2,090

SALVAGE

Collection	180,266	x 0.6	108,159
Septic tanks	9,900	x 0.6	5,940
Pump stations	4,500	x 0.3	1,350
TOTAL			$115,449

PROJECT Holding Tanks, Segment 7 | PROJ NO. 448-A
SUBJECT Costs — Alt. #1 | CLIENT WAMDA
COMP BY DEW DATE 6/79 CKD BY ______ DATE ______ | SHEET 1 OF 1

HOLDING TANKS, SEGMENT 7

CURRENT DU = 4
FUTURE ADD = 2
6 TOTAL

1980

CAP. = 2100/UNIT × 4 = $8,400
O+M = 1360/UNIT × 4 = 5,440
SALVAGE = 1260/UNIT × 4 = 5040

1980 – 2000

CAP = 4200 / 20 = $210/yr
O+M = 2720/20 = 136/YR
SAL = $3,360

PROJECT Crooked / Pickerel

SUBJECT Alternate 2 - "Crooked Lake Collection"

PROJ NO. 448A

CLIENT WAFORA

COMP BY DWS DATE 6/6/79 CKD BY ______ DATE ______

SHEET ______ OF ______

Dwelling Units Served

Segment	1978	2000
1	3	4
2	3	4
3	8	11
4	15	30
6	25	50
18	0	0
Total	54	99

Segment 5 will be a cluster system

PROJECT Crooked / Pickerel
SUBJECT Alternate 2 - "Crooked Lake Collection"
PROJ NO. 448 A
CLIENT WAPORA
COMP BY DWS DATE 6/6/79 CKD BY ______ DATE ______
SHEET ______ OF ______

Cost Analysis

Capital

Item	Quantity	Unit Price	Total Cost
PVC Pipe			
2"	2,000 LF	12.46	24,920
2½"	8,000 LF	12.90	103,200
Gravity Pipe			
8"	2,000 LF	41.00	82,000
Force Main			
2"	1,000 LF	12.46	12,460
Pump Station	1 ea.	4,500	4,500
ARV	3 ea	1823	5,469
Cleanouts			
Inline	22 ea	767	16,874
Endline	2 ea	730	1,460
Curb Valves	44 ea.	45	1,980
Gravity Tees	10 ea	36	360
Pumping Units	44 ea	2,200	96,800
Septic Tanks	9 ea	300	2,700
Hook-ups			
Pressure	44 ea	799	35,156
Gravity	10 ea	1088	10,880
			398,759

PROJECT Crooked / Pickerel
SUBJECT Alternate 2 - Crooked Lake Collection
PROJ NO. 448 A
CLIENT WAPCRA
COMP BY DWS DATE 6/11/79 CKD BY ____ DATE ____ SHEET ____ OF ____

O&M

Item	Quantity	Unit Price	Total Cost
Collection			
gravity	2000 LF	400/mi/yr	152
F.M.	11,000 LF	100/mi/yr	208
Pumping units	44 ea.	53.50/yr	2354
septic tanks	44 ea.	10/yr	440
pump station	1 ea	940/yr.	940
			$ 4,094

Salvage

Collection	222,580	x0.6	133,548
Septic tanks	2,700	x0.6	1,620
pump stations	4,500	x 0.3	1,350
			$ 140,612

Future Hook-ups

pressure	45
gravity	0

arthur beard engineers, Inc.

PROJECT Holding Tanks, Segment 7 PROJ NO. 448-A
SUBJECT Costs – Alt. #2 CLIENT WAPDA

COMP BY Dw DATE 6/79 CKD BY ______ DATE ______ SHEET 1 OF 1

HOLDING TANKS, SEGMENT 7

CURRENT DU = 4
FUTURE ADD = 2
6 TOTAL

1980

CAP. = 2100/UNIT × 4 = $8,400
O+M = 1360/UNIT × 4 = 5,440
SALVAGE = 1260/UNIT × 4 = 5040

1980 – 2000

CAP = 4200 / 20 = $210/yr
O+M = 2720/20 = 136/YR
SAL = $3,360

PROJECT Crooked / Pickeral
SUBJECT Alternate 2 - "Pickerel Lake Collecti...
PROJ NO. 448A
CLIENT WAFCRA

COMP BY DWS DATE 6/11/79 CKD BY ______ DATE ______
SHEET ______ OF ______

Dwelling Units Served

Segment	1978	2000
10	13	26
11	15	30
12	14	26
13	13	22
14	29	40
15	3	15
16	46	70
Total	133	229

PROJECT Crooked / Pickerel
SUBJECT Alternate 2 - Pickerel Lake Collection
PROJ NO. 448A
CLIENT WAPORA

COMP BY DWS DATE 6/11/79 CKD BY ______ DATE ______ SHEET ______ OF ______

Cost Analysis

Capital

Item	Quantity	Unit Cost	Total Cost
gravity 8"	5,900	41.00	241,900
PVC			
1½"	2,500	12.00	30,000
2"	5,000	12.46	62,300
2½"	7,500	12.90	96,750
F.M.			
2"	2,500	12.46	31,150
3"	3,500	13.36	46,760
ARV	2	1823	3,646
Cleanouts			
inline	25	767	19,175
endline	4	730	2,920
Curb Valve	77	45	3,465
Gravity Tee	56	36	2,016
Pump Stations	2	4,500	9,000
Pumping units	77	2,200	169,400
Septic tanks	15	300	4,500
Hook-ups			
pressure	77	799	61,523
gravity	56	1088	60,928
			845,43?

D-28

PROJECT Crooked / Pickerel
SUBJECT Alternate 2 - Pickerel lake Collecti
PROJ NO. 445A
CLIENT WAPORA

COMP BY DWS DATE 6/12/79 CKD BY ______ DATE ______
SHEET ______ OF ______

O&M

Item	Quantity	Unit Price	Total Cost
Collection			
gravity	5,900 Lf	400/mi/yr	447
F.M.	21,000 Lf	100/mi/yr	398
Pumping Units	77	53.50/yr.	4,120
Septic Tanks	77	10/yr	770
pump Stations	2	940/yr	1,880
			$ 7,615

Salvage

Collection	508,860	x 0.6	305,316
Septic tanks	4,500	x 0.6	2,700
pump Stations	9,000	x 0.3	2,700
			$ 310,716

PROJECT Crooked / Pickerel
SUBJECT Alternate 2 "Future Collection"
PROJ NO. 408A
CLIENT WAPORA
COMP BY DWS DATE 6/12/79 CKD BY ______ DATE ______
SHEET ____ OF ____

Segment	Capital	O&M	Salvage
1	3,344	0	810
2	3,344	0	810
3	10,032	190	2,430
4	50,160	953	12,600
6	83,600	1,588	21,000
10	43,472	825	8,710
11	50,160	953	12,600
12	43,472	825	8,710
13	30,096	572	7,560
14	36,784	699	9,240
15	40,128	762	10,080
16	80,256	1,404	20,160
	$474,848	$8,771	$114,710
	$23.74/YR	0.44/YR	114.71

Clusters

Cluster	Capital	O&M	Salvage
3	52,518	104	18,396
5	51,200	118	22,105
11	26,306	0	9,795
12	0	0	0
	130,024	222	50,296

PROJECT Crooked / Pickerel
SUBJECT Alternate 3

PROJ NO. 449A
CLIENT WAPORA

COMP BY DWS DATE 6/12/79 CKD BY ________ DATE ________ SHEET ______ OF ______

Dwelling Units Served

Segment	1978	2000
1	3	4
2	3	4
3	8	11
4	15	30
5	15	20
6	25	50
17	1	1
18	0	0
Total	70	120

PROJECT Crooked / Pickerel
SUBJECT Alternate 3

PROJ NO. 448 A
CLIENT WAPORA

COMP BY DWS DATE 6/12/79 CKD BY ______ DATE ______ SHEET ______ OF ______

Cost Analysis

Capital

Item	Quantity	Unit Price	Total Cost
PVC 1½"	500 LF	12.00	6,000
2"	4500 LF	12.46	56,070
2½"	4500 LF	12.90	58,050
gravity 8"	2000 LF	41.00	82,000
F.M. 4"	7,500 LF	14.25	106,875
ARV	3 ea	1823	5,469
Cleanouts			
inline	25 ea	767	19,175
endline	4 ea	730	2,920
Curb valves	60 ea	45	2,700
Gravity Tees	10 ea	36	360
Pump Stations	2 ea	18,000	36,000
Pumping units	60 ea	2200	132,000
Septic tanks	12 ea	300	3,600
Hook-ups			
gravity	10	1088	10,880
pressure	60	799	47,940
			$ 570,039

arthur beard engineers, Inc

PROJECT Crooked / Pickerel
SUBJECT Alternate 3

PROJ NO. 448A
CLIENT WAPORA

COMP BY DWS DATE 6/12/79 CKD BY ______ DATE ______ SHEET ______ OF ______

O & M

Item	Quantity	Unit Cost	Total Cost
Collection			
gravity	2,000 LF	400/mi/yr.	152
pressure	17,000 LF	100/mi/yr.	322
pumping units	60	53.50/yr	3,210
septic tanks	60	10/yr.	600
pump stations	2	1177	2,354
			$ 6,638

Salvage

Collection	308,995	X 0.6	185,397
Septic tanks	3,600	X 0.6	2,160
pump stations	36,000	X 0.3	10,800
			$ 198,357

arthur beard engineers, Inc.

PROJECT Holding Tanks, Segment 7 PROJ NO. 448-A
SUBJECT Costs – Alt. #3 CLIENT WAPDA

COMP BY DW DATE 6/79 CKD BY ______ DATE ______ SHEET 1 OF 1

HOLDING TANKS, SEGMENT 7

CURRENT DU = 4
FUTURE ADD = 2
6 TOTAL

1980

CAP. = 2100/UNIT × 4 = $8,400
O+M = 1360/UNIT × 4 = 5,440
SALVAGE = 1260/UNIT × 4 = 5040

1980 – 2000

CAP = 4200/20 = $210/yr
O+M = 2720/20 = 136/YR
SAL = $3,360

PROJECT Crooked / Pickerel | PROJ NO. 445A
SUBJECT Alternate 3 | CLIENT WAFORA
Future Collection

COMP BY DWS DATE 6/12/79 CKD BY ______ DATE ______ SHEET ____ OF ____

Crooked Lake

Segment	Capital	O&M	Salvage
1	3,344	0	810
2	3,344	0	810
3	10,032	190	2,430
4	50,160	953	12,600
5	16,720	318	4,200
6	83,600	1,588	21,000
17	0	0	0
18	0	0	0
Total	$ 167,200	$ 3,049	$ 41,850

Clusters

Cluster	Capital	O&M	Salvage
3	52,518	104	18,396
4	51,259	170	22,433
6	125,370	310	51,073
7	68,256	175	20,938
8	98,840	275	28,019
9	146,472	312	64,410
10	121,656	347	38,794
11	26,306	0	9,795
12	0	0	0
	$ 690,677	$ 1,693	$ 253,858

PROJECT Crooked / Pickerel
SUBJECT Alternate 4

PROJ NO. 448A
CLIENT WAPORA

COMP BY DWS DATE 6/13/79 CKD BY ______ DATE ______

SHEET ______ OF ______

Hook-ups

Segment	Gravity present	Gravity future	Pressure present	Pressure future
1	0	0	3	1
2	0	0	3	1
3	8	3	0	0
4	0	0	15	15
5	0	0	15	5
6	0	0	25	25
7	0	0	4	2
8	5	6	0	0
9				
10	0	0	13	13
11	0	0	15	15
12	14	12	0	0
13	13	9	0	0
14	29	11	0	0
15	0	0	3	12
16	0	0	46	24
17	0	0	1	0
18				
	69	41	143	113

PROJECT Crooked / Pickerel
SUBJECT Alternate 4

PROJ NO. 448
CLIENT WAPORA

COMP BY DWS DATE 6/12/79 CKD BY ______ DATE ______ SHEET ______ OF ______

Cost Analysis

Capital

Item	Quantity		Unit Price	Total Cost
PVC 1½"	5,000	LF	12.00	60,000
2"	10,500	"	12.46	130,830
2½"	12,000	"	12.90	154,800
Gravity 8"	8,900	"	41.00	364,900
F.M. 2"	5,000	"	12.46	62,300
3"	10,000	"	13.36	133,600
4"	9,500	"	14.25	135,375
6"	5,000	"	15.15	75,750
ARV	5	ea	1823	9115
Cleanouts				
inline	50	"	767	38,350
Endline	8	"	730	5,840
Curb Valves	143	"	45	6,435
Gravity Tee	69	"	36	2,484
Pump Stations				
0-50	4	"	4,500	18,000
50-200	3	"	18,000	54,000
200-500	1	"	45,000	45,000
Pumping Units	143	"	2200	314,600
Septic Tanks	28	"	300	8,400
Hook-ups				
gravity	69	"	1088	75,072
pressure	143	"	799	114,257
				$ 1,809,108

arthur beard engineers, Inc.

PROJECT Crooked / Pickerel PROJ NO. 448A
SUBJECT Alternate 4 CLIENT WAFORA
COMP BY DWS DATE 6/12/79 CKD BY DATE SHEET OF

O&M

Item	Quantity	Unit Cost	Total Cost
Collection			
gravity	8900 LF	400/mi/yr	674
pressure	57,000 LF	100/mi/yr	1,080
Septic tanks	143	10/yr	1,430
Pump stations			
0-50	4	940	3,760
50-200	3	1177	3,531
200-500	1	1226	1226
Pumping units	143	53.50/yr	7651
			$19,352

Salvage

Collection	1,117,555	X 0.6	670,533
Pump stations	117,000	X 0.3	35,100
Septic tanks	8,400	X 0.6	5,040
			$710,673

PROJECT Crooked / Pickerel
SUBJECT Alternate 4 "Future Collection"
PROJ NO. 445A
CLIENT WAFCRA
COMP BY DWS DATE 6/13/79 CKD BY ______ DATE ______
SHEET ______ OF ______

Future Costs

Segment	Capital	O&M	Salvage
1	3,344	0	1,670
2	3344	0	1,670
3	3,372	0	0
4	50,160	953	25,050
5	16,720	318	8,350
6	83,600	1,588	41,750
7	6,688	0	3,340
8	6,744	0	0
9	0	0	0
10	43,472	825	21,710
11	50,160	953	25,050
12	13,488	0	0
13	10,116	0	0
14	12,364	0	0
15	40,128	762	20,040
16	80,256	1,404	40,080
17	0	0	0
18	0	0	0
	$ 423,956	$ 6,803	$ 188,710

PROJECT Crooked / Picklrel
SUBJECT Alternate 5

PROJ NO. 448A
CLIENT WAPORA

COMP BY DWS DATE 6/14/78 CKD BY ______ DATE ______ SHEET ______ OF ______

Collection

Crooked Lake to Land Application
(Same as Alternate 2)
Segments 1, 2, 3, 4, 6

Pickerel Lake on Cluster Systems
Clusters 3-11

Cluster Present Costs

Cluster	Capital	O&M	Salvage
3	43,765	1,166	16,401
4	51,259	1,270	23,782
5	163,840	1,422	71,350
6	125,370	1,360	52,423
7	79,632	1,285	25,930
8	207,564	1,635	60,876
9	36,618	1,148	17,452
10	233,174	1,743	76,655
11	52,612	1,210	20,944
	993,834	12,239	365,813

PROJECT Holding Tanks, Segment 7 PROJ NO. 448-A
SUBJECT Costs – Alt. #5 CLIENT WAPORA

COMP BY DW DATE 6/79 CKD BY ____ DATE ____ SHEET 1 OF 1

HOLDING TANKS, SEGMENT 7

CURRENT DU = 4
FUTURE ADD = 2
6 TOTAL

1980

CAP. = 2100/UNIT × 4 = $8,400
O+M = 1360/UNIT × 4 = 5,440
SALVAGE = 1260/UNIT × 4 = 5040

1980 – 2000

CAP = 4200 / 20 = $210/yr
O+M = 2720/20 = 136/YR
SAL = $3,360

PROJECT Crooked / Pickerel
SUBJECT Alternate 5
PROJ NO. 448A
CLIENT WAPORA
COMP BY DWS DATE 6/14/79 CKD BY DATE SHEET OF

Future Collection Costs

Segment	Capital	O&M	Salvage
1	3,344	0	1,670
2	3,344	0	1,670
3	10,032	190	5,010
4	50,160	953	25,050
6	83,600	1588	41,750
	$ 150,480	$ 2,731	$ 75,150

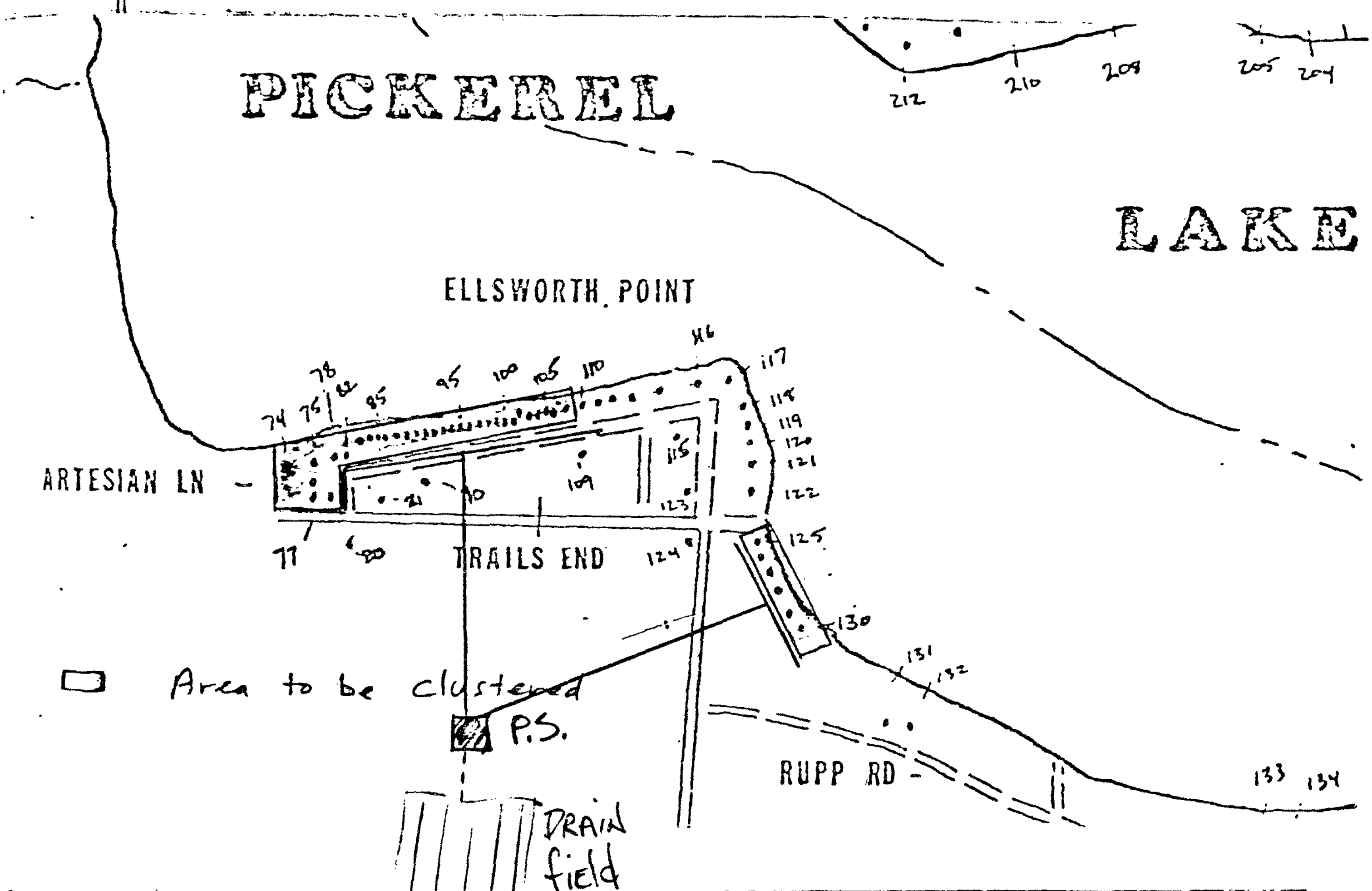
Cluster Systems

Cluster	Capital	O&M	Salvage
3	52,518	104	18,396
4	51,259	170	22,433
5	51,200	118	22,105
6	125,370	310	51,073
7	68,256	175	20,938
8	98,840	275	28,019
9	146,472	312	64,410
10	121,656	347	38,794
11	26,306	0	9,795
	$ 741,877	$ 1,811	$ 275,963

Alternate 6
Cluster Systems

Cluster Systems

① Ellsworth Point - (a) cluster system (s) may be required for approximately 39 houses located in two different areas as shown below



The reasons that these areas may have to be clustered are as follows:

1. Septic snooper studies found 9 active plumes within the area of the clustered segments

CROOKED/PICKEREL
CLUSTER SYSTEMS

ARTHUR BEARD ENGINEERS, INC.
JOB 448

ALTERNATE - 6

SEGMENTS: 16

PRESENT HOMES: 39
FUTURE HOMES: 45

CAPITAL COST

ITEM	QUANTITY	UNIT COST	TOTAL COST
8 in. gravity	4,414 LF	4,100	180,974
Force main	0	0	0
Pump Station	1 ea.	4,500	4,500
Septic tanks	14 ea.	300	4,200
Trench	8,550 LF	1.74	14,877
4" perforated pipe	8,550 LF	1.69	14,450
Backfill	8,550 LF	0.56	4,788
Gravel fill	950 CY	9.67	9,187
Distribution box	1 ea.	210	210
4" gravity pipe	675 LF	5.17	3,490
Land	3 Ac.	1,000	3,000
Hydrogeologic survey	1 ea.	9,554	9,554
Monitoring well	1 ea.	3,035	3,035
Sub-Total			$252,265
Cost/Home			5,606
Homeowners Hook-up Cost			45,000
TOTAL			$297,265

O&M

Monitoring wells	1 set	100/yr	100
Pump Station	1 ea.	950/yr	950
Gravity line	.84	400/mi/yr	336
Force main	0	0	0
Septic tanks	45	10/yr	450
TOTAL			$1,836

SALVAGE

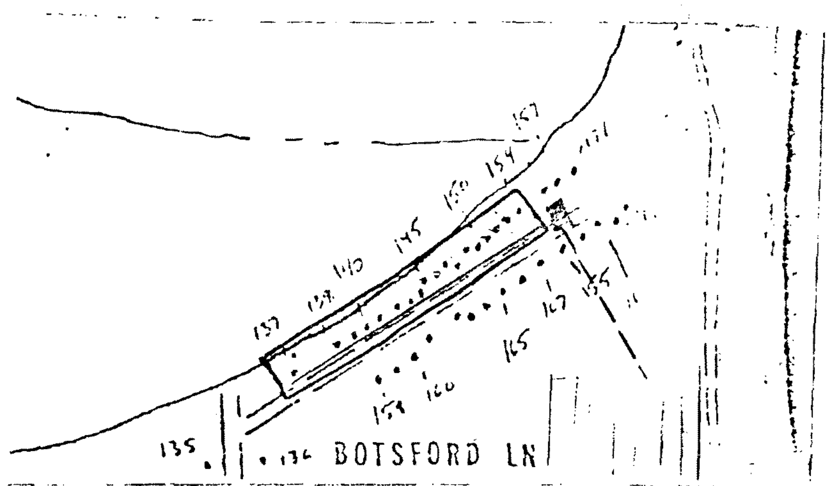
Collection	180,974	x 0.6	108,584
Septic tanks	4,200	x 0.6	2,520
Pump stations	4,500	x 0.3	1,350
TOTAL			$112,454

nutrient input.

3. Keerfoot calculated that segment 16 has the highest P and N loading of any of the 19 segments.

4.

(2) East Side of Pickerel Lake in Segment 14
Approximately 18 houses within segment 14 may have to be clustered as shown below:



Reasons:

1. House density is relatively high - approx. 90 feet of lake frontage per house.
2. The number of plumes detected by

CROOKED/PICKEREL
CLUSTER SYSTEMS

ARTHUR BEARD ENGINEERS, INC.
JOB 448

ALTERNATE - 6

SEGMENTS: 14

PRESENT HOMES: 18
FUTURE HOMES: 33

CAPITAL COST

ITEM	QUANTITY	UNIT COST	TOTAL COST
8 in. gravity	1,300 LF	41.00	53,300
Force main	500 LF	8.43	4,215
Pump Station	1 ea.	4,500	4,500
Septic tanks	18 ea.	300	5,400
Trench	6,270 LF	1.74	10.910
4" perforated pipe	6,270 LF	1.69	10,596
Backfill	6,270 LF	0.56	3,511
Gravel fill	697 CY	9.67	6,740
Distribution box	1 ea.	210	210
4" gravity pipe	495 LF	5.17	2,560
Land	2.2 Ac	1,000	2,200
Hydrogeologic survey	1	9,554	9,554
Monitoring well	1	3,035	3,035
Sub-Total			$116,731
Cost/Home			3,537
Homeowners Hook-up Cost		1,000	33,000
TOTAL			$149,731

O&M

Monitoring wells	1	100/yr.	100
Pump Station	1	950/yr.	950
Gravity line	.25	400/mi/yr.	100
Force main	1	100/mi/yr.	10
Septic tanks	33	10/yr.	330
TOTAL			$1,490

SALVAGE

Collection	57,515	x 0.6	34,509
Septic tanks	5,400	x 0.6	3,240
Pump stations	4,500	x 0.3	1,350
TOTAL			$39,099

PROJECT Concord / Pickerel PROJ NO. 448A
SUBJECT Future Collection CLIENT WAFCRA

COMP BY DWS DATE 6/12/79 CKD BY ______ DATE ______ SHEET 1 OF 6

Segment 1 Increase 1

Capital - 3,344
O&M - -0-
Salvage - 1,670

Segment 2 Increase 1

Capital - 3,344
O&M - -0-
Salvage - 1,670

Segment 4 Increase 15

Capital -	pump	33,000
	Curb Valve	675
	Septic Tank	4,500
	Hook-up	11,985
		$ 50,160
O&M -	pump	803
	Septic tank	150
		$ 953
Salvage -	pump	21,450
	Septic tank	3,600
		25,050

PROJECT	Crooked / Pickerel	PROJ NO.	448A
SUBJECT	Future Collection	CLIENT	WAPORA
COMP BY DWS	DATE 6/12/79	CKD BY ____ DATE ____	SHEET 2 OF 6

Segment 3 INCREASE -3

Capital -

Pump	6,600
Curb valve	135
Septic Tank	900
Hook-up	2,397
	$ 10,032

O&M -

Pump	160
Septic Tank	30
	$ 190

Salvage -

Pump	4,290
Septic Tank	720
	$ 5,010

Segment 5 INCREASE -5

Capital -

Pump	11,000
Curb value	225
Septic Tank	1,500
Hook-up	3,995
	$ 16,720

O&M -

Pump	268
Septic Tank	50
	$ 318

Salvage -

Pump	7,150
Septic Tank	1,200
	8,350

PROJECT Crooked / Pickerel
SUBJECT Future Collection

PROJ NO. 448A
CLIENT WAPORA

COMP BY DWS DATE 6/12/79 CKD BY ______ DATE ______

SHEET 3 OF 6

Segment 6 Increase 25

Capital -

pump	55,200
curb valve	1,125
septic tank	7,500
hook-up	19,975
	$ 83,600

O&M -

pump	1338
septic tank	250
	$ 1,588

Salvage -

pump	35,750
septic tank	6,000
	$ 41,750

Segment 7 Increase 2

Capital — $ 6,688
O&M — -0-
Salvage — $ 3,340

Segment 8 Increase 6

Capital -

pump	13,200
curb v.	270
septic T.	1,800
hook-up	4,794
	$ 20,064

O&M -

pump	321
septic	60
	$ 381

Salvage

pump	8,580
septic	1,440
	$ 10,020

PROJECT Crooked / Pickerel PROJ NO. 448A
SUBJECT Future Collection CLIENT WAFCRA
COMP BY DWS DATE 6/12/79 CKD BY ____ DATE ____ SHEET 4 OF 6

Segment 9 Increase 0

Segment 10 Increase 13

Capital –	pump	28,600
	septic tank	3,900
	Curb valve	585
	Hook-up	10,387
		$ 43,472
O&M –	pump	695
	septic t.	130
		$ 825
Salvage	pump	18,590
	septic t.	3,120
		$ 21,710

Segment 11 Increase 15

Capital – 50,160
O&M – 953
Salvage 25,050

Segment 12 Increase 13

Capital – $ 43,472
O&M – $ 825
Salvage – $ 21,710

PROJECT: Crooked / Pickerel		PROJ NO.: 448A	
SUBJECT: Future Collection		CLIENT: WAFCRA	
COMP BY: DWS	DATE: 6/12/79	CKD BY:	DATE:
SHEET 5 OF 6			

Segment 13 Increase 9

Capital -

Pump	19,800
Septic T.	2,700
Curb V.	405
Hook-up	7,191
	$30,096

O&M

Pump	482
Septic T.	90
	$572

Salvage

Pump	12,870
Septic	2,160
	$15,030

Segment 14 Increase 11

Capital

Pump	24,200
Septic	3,300
Curb V.	,495
Hook-up	8,789
	$36,784

O&M

Pump	589
Septic	110
	$699

Salvage

Pump	15,730
Septic	2,640
	$18,370

PROJECT Crooked / Pickerel		PROJ NO. 448	
SUBJECT Future Collection		CLIENT WAFCRA	
COMP BY DWS DATE 6/12/79	CKD BY DATE	SHEET 6 OF 6	

Segment 15 Increase 12

Capital - Pump 26400
Septic 3600
Curb V. 540
Hook-up 9,588
$40,128

O&M - Pump 642
Septic 120
$762

Salvage - Pump 17,160
Septic 2,880
$20,040

Segment 16 Increase 24

Capital Pump 52,800
Septic 7,200
Curb V. 1,080
Hook-up 19,176
$80,256

O&M Pump 1284
Septic 120
$1,404

Salvage Pump 34,320
Septic 5,760
40,080

Segment 17 Increase 0

Segment 18 Increase 0

APPENDIX E

FLOWS: CROOKED - PICKEREL LAKES
@ YEAR 2000

MENT NO.	TOTAL POP.	PERMANENT WINTER POP	TOTAL FLOW*	PERMANENT WINTER FLOW	FLOW REDUCTION** TOTAL	FLOW REDUCTION** WINTER
1	13	9	0.00078	0.00054	0.00057	0.00039
2	12	12	0.00072	0.00072	0.00052	0.00052
3	37	21	0.00222	0.00126	0.00162	0.00092
4	103	51	0.00618	0.00306	0.00453	0.00224
5	64	48	0.00384	0.00288	0.00281	0.00211
6	159	123	0.00954	0.00738	0.00691	0.00541
7	22	6	0.00132	0.00036	0.00096	0.00026
8	37	21	0.00222	0.00126	0.00162	0.00092
9	-0-	-0-	0	0	0	0
10	93	33	0.00558	0.00198	0.00409	0.00145
11	103	51	0.00618	0.00306	0.00453	0.00224
12	90	42	0.0054	0.00252	0.00396	0.00184
13	82	18	0.00492	0.00108	0.00360	0.00079
14	148	36	0.00888	0.00216	0.00651	0.00158
15	52	24	0.00312	0.00144	0.00228	0.00105
16	245	105	0.0147	0.0063	0.01078	0.00462
17	3	3	0.00018	0.00018	0.00013	0.00013
18	-0-	-0-	0	0	0	0
SUB	1263	603	0.07578	0.0362	0.0556	0.0265
I/I			0.0083	0.0083	0.0083	0.0083
TOTAL			0.08408	0.0445	0.0639	0.0348

* Derived by using 60 gpcpd, resulting in MGD

** Derived by using 44 gpcpd, resulting in MGD

TREATMENT ALTERNATIVE:

LAND TREATMENT: TOTAL Q = 0.08408 MGD
WINTER Q = 0.0445 MGD
Avg 0.045 MGD

TECHNIQUE: Spray Irrigation

STORAGE: 6 Months ⇒ 183 days × (0.045 MGD) = 8.24 MG
= 25.28 Ac-ft

Assume a 6' depth ⇒ 4.21 Acres

Use Alfalfa - high N uptake 200-480 #/acre-yr

use average of 340 #/acre year

Using uptake of 340 # /acre year, Calculate the ....
Application Rate for Spray Irrigation using
nitrogen as limiting factor:

(continued on next sheet)

$$L_n = U + D + 2.7\, W_p C_p \quad ^{*} \qquad (5\text{-}2)$$

where
L_n = wastewater nitrogen loading, lb/acre-yr
U = crop nitrogen uptake lb/acre-yr
D = denitrification
W_p = percolating water
C_p = design percolate N concentration

Also: $W_p = L_w + (P_r - ET)$

where
L_w = wastewater hydraulic loading
P_r = precipitation
E_T = evapotranspiration

From EPA* page 3-6, Potential Evapotranspiration Versus Mean Annual Precipitation,

$$(P_r - E_T) = -5,$$

then

$$W_p = L_w - 5$$

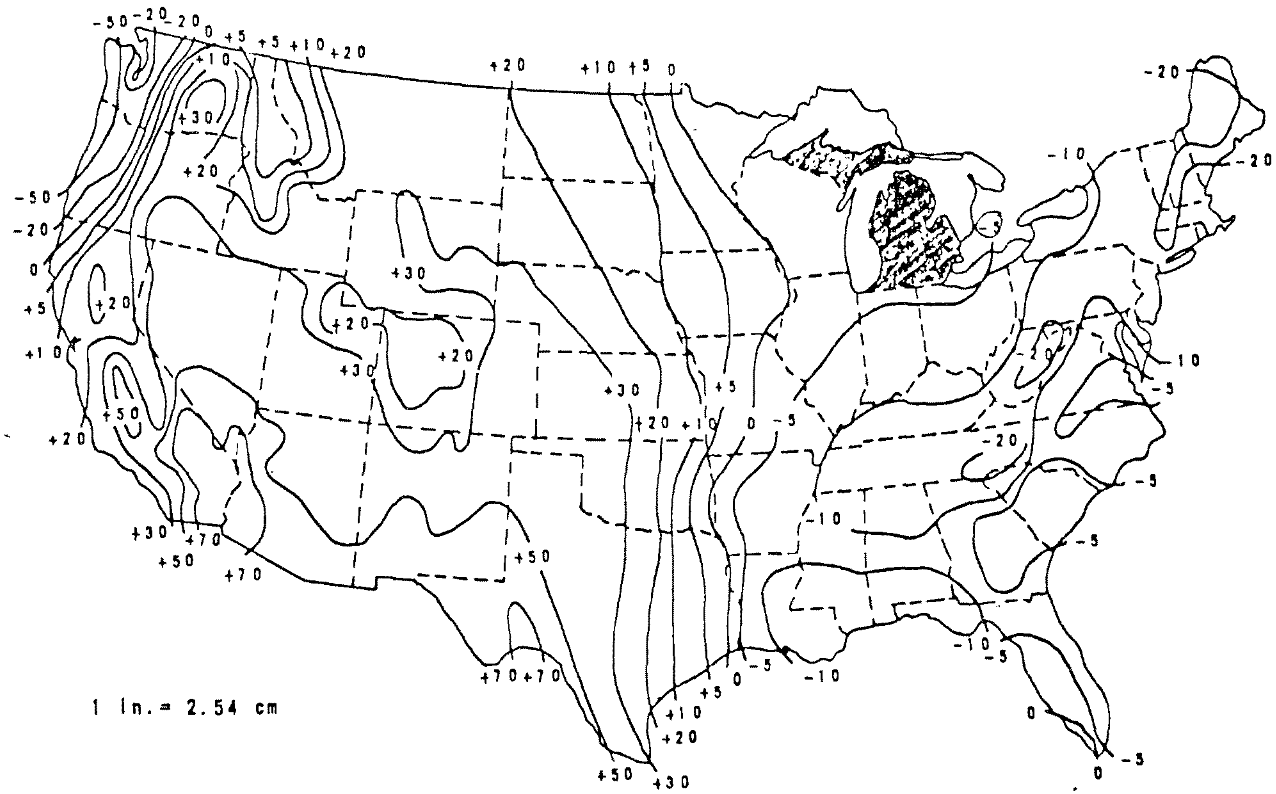
Substituting into above equation for W_p,

---

* From EPA manual for Land Treatment of Municipal Wastewater, October 1977, page 8-17

FIGURE 3-2

POTENTIAL EVAPOTRANSPIRATION VERSUS MEAN ANNUAL PRECIPITATION [1]
Inches



+ POTENTIAL EVAPOTRANSPIRATION MORE THAN MEAN ANNUAL PRECIPITATION

– POTENTIAL EVAPOTRANSPIRATION LESS THAN MEAN ANNUAL PRECIPITATION and assuming that

$$C_p = 10 \text{ mg/l}$$
$$D = 0.2 \ L_n$$

$$L_n = 340 + 0.2 L_n + 2.7(L_w - 5) 10$$

=

Now:

$$L_n = 2.7 \ C_n L_w^{*} \quad (5-3)$$

where C_n = applied nitrogen concentration, mg/l
L_w = wastewater hydraulic loading ft/yr

assume: C_n = medium strength sewage = 40 mg/l**
From PRM-79-3, Attachment E,
Guidance for Assessing Level of Preapplication Treatment, use I.A.
Primary treatment ⇒ no stabilization pond

therefore, $L_n = 2.7(40) L_w$
$= 108 \ L_w$
or $L_w = 0.0093 \ L_n$

---

* From EPA manual for Land Application of Municipal Wastewater, October 1977, page 8-18

** Metcalf and Eddy, Wastewater Engineering, 1972 page 231 attached.

from domestic usage, from the addition of highly mineralized water from private wells and ground water, and from industrial usage. Domestic and industrial water softeners also contribute to the observed mineral pickup; in some areas, they may represent the major source of mineral pickup. Occasionally, water added from private wells and ground water infiltration will, because of its high quality, serve to dilute the mineral concentration in the wastewater.

TABLE 7·3 TYPICAL COMPOSITION OF DOMESTIC SEWAGE
(All values except settleable solids are expressed in mg/liter)

Constituent	Concentration: Strong	Medium	Weak
Solids, total	1,200	700	350
Dissolved, total	850	500	250
Fixed	525	300	145
Volatile	325	200	105
Suspended, total	350	200	100
Fixed	75	50	30
Volatile	275	150	70
Settleable solids, (ml/liter)	20	10	5
Biochemical oxygen demand, 5-day, 20°C (BOD_5-20°)	300	200	100
Total organic carbon (TOC)	300	200	100
Chemical oxygen demand (COD)	1,000	500	250
Nitrogen, (total as N)	85	40	20
Organic	35	15	8
Free ammonia	50	25	12
Nitrites	0	0	0
Nitrates	0	0	0
Phosphorus (total as P)	20	10	6
Organic	5	3	2
Inorganic	15	7	4
Chlorides*	100	50	30
Alkalinity (as $CaCO_3$)*	200	100	50
Grease	150	100	50

* Values should be increased by amount in carriage water.

Data on the chemical composition of a typical water supply and the resultant wastewater effluent composition after treatment are shown in Table 7·4. In this case, the effect of the use of some local well water and the intensive use of water softeners on the total mineral pickup can be assessed by comparing the local incremental pickup values reported in col. 2 to the national average range given in col. 3.

Then

$$L_n = 340 + 0.2 L_n + 2.7(0.0093 L_n - 5)10$$
$$= 340 + 0.2 L_n + 0.251 L_n - 135$$
$$L_n = 205 + 0.451 L_n$$
$$0.549 L_n = 205$$
$$L_n = 373.4 \text{ lb/acre-yr}$$

and

$$L_w = 0.0093 L_n$$
$$= 0.0093 (373.4 \text{ lb/acre-yr})$$
$$= 3.47 \text{ ft/yr}$$

Using Michigan State standard of 6 month storage – 6 month application period,
Application period = 26 weeks

$$\therefore \frac{3.47 \text{ ft}}{\text{yr}} \times \frac{1 \text{ yr}}{26 \text{ weeks}} \times \frac{12 \text{ in}}{\text{ft}}$$

$$L_w = 1.60 \text{ in/week}$$

__Area of Application__: North of Pickerel Lake

Soil: LdB → well suited for alfalfa
Leelanau loamy sand @ 2-6% slopes
> 4' to seasonal high water table
permeability = 2.0 - 6.3 in/hr
and approximately 140 acres available

Field Area required:

$$F = \frac{36.8Q}{LR} \quad * \qquad (6-1)$$

where F = Field area in acres
Q = Annual flow, M gal/year
L = period of application, weeks/yr
R = rate of application, in/week

then $F = \frac{36.8 (30.68 \text{ mg/year})}{26 \text{ weeks} \times 1.60 \text{ in/week}}$

F = 27.14 Acres

Total Area = 27.14 + 5.6 + 2 (for plant, etc)
= 34.74 Acres

Total Area w/ 200' Buffer ≈ 60 Acres **

Crop Revenue: From soil survey of Emmett County, Michigan, output:

---

* EPA manual for Land Treatment of Municipal Wastewater, October 1977, page 6:10

** ibid, page 3-11

output = 1.6 TONS/ACRE/YEAR Alfalfa @ $65.00/TON

then 27 ~~Acres~~ x 1.6 TONS/~~Acre~~ = 43.20 Tons

and 43.20 tons x $65.00/~~Ton~~ = $2800.00/YEAR

Pumping: Influent Pipe to pump station

0.08408 MGD = 58.38 gpm @ 2.5 p.f. = 145.97 gpm
Say = 150 gpm
1 pump station @ 150 gpm = 18000 + Engr.
5700' of 6" force main

20% Shoring ⇒ 1140' of force main @ 34.40/l.f. = 39,200
4560' of f.m. @ 11.00/l.f. = 50,200

$ 89,400 + Engr.

LAND TREATMENT : Pickerel Area only

Segments included: 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17

TOTAL Q =	0.0563	WINTER Q =	0.0232
I/I =	0.003	I/I =	0.003
	0.0593 MGD		0.0264 MGD

STORAGE : 6 Months ⇒ 183 days × (0.0264 MGD)

= 4.83 MG.
= 14.78 acre-feet

Assume 6' depth ⇒ 2.46 acres

APPLICATION RATE : Same as for Total Area

L_w = 1.60 in/week

AREA OF APPLICATION :

$$F = \frac{36.8\ Q}{L\ R}$$

$$= \frac{36.8\,(21.65\ \text{MG/year})}{(26\ \text{weeks}) \times (1.60\ \text{in/week})}$$

= 19.15 Acres

Total Area = 19.15 + 1.13 + 2 = 22.28 Acres
Total w/200' Buffer = 40 Acres

CROP REVENUE;

19.15 Acres x 1.6 Tons/Acre = 30.64 TONS

30.64 Tons x $65.00/Ton = $1990.00/year

INFLUENT PIPE & PUMP STATION:

0.0593 MGD = 41 gpm @ 2.5 p.f. = 102.5 gpm

5700 ft of 4" Force Main

2 lift stations needed, each @ $18,000 + Engr.

20% shoring: 1140' @ 33.40 = 38,100
4560' @ 10.00 = 45,600
83,700 + Engr.

LAND TREATMENT : Crooked Area Only

Segments included: 1, 2, 3, 4, 6, 18

Total Q =	0.0194	WINTER Q =	0.0056
I/I =	0.0039	I/I =	0.0039
	0.0233 MGD		0.0095 MGD

STORAGE: 6 Months ⇒ 183 days x 0.0095 MGD

= 1.73 MG

= 5.308 acre-feet

Assume 6' depth ⇒ 0.88 acres

APPLICATION RATE: Same as for Total Area

L_w = 1.60 in/week

AREA OF APPLICATION:

$$F = \frac{36.8\,Q}{LR}$$

$$= \frac{36.8\,(8.50\ MG/year)}{(26\ week) \times (1.60\ in/week)}$$

= 7.51 Acres

Total Area = 7.51 + 2 + 2 = 11.51 Acres
Total w/200' Buffer = 26 Acres

CROP REVENUE :

7.51 Acres × 1.6 tons/acre = 12.03 TONS

12.03 TONS × $65.00/TON = $780.00/year

INFLUENT PIPE & PUMP STATION :

0.0233 MGD = 16.18 gpm @ 2.5 p.f. = 40 gpm

4200' of 3" FORCE Main

1 pump station @ $4,500.00 + Engr.

20% shoring : 840' @ $32.40 = 27,200
3360' @ 9.00 = 30,300

$ 57,500 + Engr.

FLOW REDUCTION:

$Q = 0.064$ MGD

Storage: 6 months ⇒ 183 days × (0.0348 MGD)

= 6.36 MG

= 19.5 Acre-feet

Assume 6' depth ⇒ 3.25 Acres

APPLICATION RATE: Same as for total area

$L_w = 1.60$ in/week

AREA OF APPLICATION:

$$F = \frac{36.8\,Q}{2R}$$

$$= \frac{36.8\,(23.36\ \text{MG/yr})}{(26\ \text{week})(1.60\ \text{in/week})}$$

$$= 20.66\ \text{acres}$$

Total Area = 20.66 + 4.3 + 2 = 27 acres

w/ Buffer = 50 acres.

CROP REVENUE:

$$20.66 \text{ acres} \times 1.6 \frac{\text{tons}}{\text{acre}} = 33.05 \text{ tons}$$

$$33.05 \text{ tons} \times \$65.^{00}/\text{ton} = \$2150.^{00}/\text{year}$$

DESIGN AND COSTING ASSUMPTIONS

Treatment

(1) Land Application

- Facilities for treatment and storage of wastewaters prior to land application are based on EPA design parameters (EPA, 1977).
- Two possible land application sites were identified (see Figure III-3). Alternative costs were developed based on conveying wastewater to both sites.
- Design assumptions -

    storage period - 6 weeks per year
    application rate - 1.6 inches per week
    application technique - spray irrigation, alfalfa.

(2) Cluster Systems

- Clusters costed and designed separately.
- Design assumptions -

    flow - 60 gpcd - peak flow 45 gpm
    3.5 persons/home - 3-bedroom home
    20% of existing septic tanks need to be replaced with new 1000-gallon tanks

- Collection of wastewaters is by a gravity sewer to one pump station which lifts effluent to the cluster field.
- Cluster system includes the following requirements of the State of Michigan.

    monitoring wells
    hydrogeological survey be performed for the potential area

- Pump Station (50 gpm) required for transmission, 60-foot static head assumed from pump station to distribution box.

Collection

- All sewer lines are to be placed at or below 6 feet of depth to allow for frost penetration in the Springvale/Littlefield area. Gravity lines are assumed to be placed at an average depth of 12 feet.
- Thirty percent shoring of all gravity collection lines is required, due to prevalent high groundwater as well as unsuitable soils.

- A minimum velocity of 2 fps will be maintained in all pressure sewer lines and force mains to provide for scouring.
- Peaking factor used for design flows was based on the Ten States Standards in concurrence with the Facility Plan.
- All pressure sewer lines and force mains 8 inches in diameter or less will be PVC SDR26, with a pressure rating of 160 psi. Those force mains larger than 8 inches in diameter will be constructed of ductile iron with mechanical joints.
- When possible, force mains and pressure sewer collectors will be placed in a common trench.
- Cleanouts in the pressure sewer system will be placed at the beginning of each line, with one every 500 feet of pipe in line. Cleanout valve boxes will contain shut-off valves to provide for isolation of various sections of line for maintenance and/or repairs.
- Individual pumping units for the pressure sewer system include a 2- by 8-foot basin with discharge at 6 feet, control panel, visual alarm, mercury float level controls, valves, rail system for removal of pump, antiflotation device, and the pump itself (see Figure III-2).
- Effluent pumps are 1-1/2 and 2 HP pumps which reach a total dynamic head of 80 and 120 feet respectively.

Analysis of Cost Effectiveness

- Quoted costs are in 1979 dollars
- EPA Sewage Treatment Plant (STP) Index of 145 (2nd Quarter 1979) and Engineering News Record Index of 3000 (July 1979) used for updating costs.
- i, interest rate = 6-5/8%
- Planning period = 20 years
- Life of facilities, structures - 50 years
  Mechanical components - 20 years
- Straight line depreciation
- Land for land application site valued at $1000/acre
- Land surrounding Crooked/Pickerel Lakes for locating cluster systems valued at $1000/acre.

APPENDIX I

EXECUTIVE ORDER 11990:
PROTECTION OF WETLANDS

Executive Order 11990 May 24, 1977

PROTECTION OF WETLANDS

By virtue of the authority vested in me by the Constitution and statutes of the United States of America, and as President of the United States of America, in furtherance of the National Environmental Policy Act of 1969, as amended (42 U.S.C. 4321 et seq.), in order to avoid to the extent possible the long and short term adverse impacts associated with the destruction or modification of wetlands and to avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative, it is hereby ordered as follows:

Section 1. (a) Each agency shall provide leadership and shall take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands in carrying out the agency's responsibilities for (1) acquiring, managing, and disposing of Federal lands and facilities; and (2) providing Federally undertaken, financed, or assisted construction and improvements; and (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities.

(b) This Order does not apply to the issuance by Federal agencies of permits, licenses, or allocations to private parties for activities involving wetlands on non-Federal property.

Sec. 2. (a) In furtherance of Section 101(b)(3) of the National Environmental Policy Act of 1969 (42 U.S.C. 4331(b)(3)) to improve and coordinate Federal plans, functions, programs and resources to the end that the Nation may attain the widest range of beneficial uses of the environment without degradation and risk to health or safety, each agency, to the extent permitted by law, shall avoid undertaking or providing assistance for new construction located in wetlands unless the head of the agency finds (1) that there is no practicable alternative to such construction, and (2) that the proposed action includes all practicable measures to minimize harm to wetlands which may result from such use. In making this finding the head of the agency may take into account economic, environmental and other pertinent factors.

(b) Each agency shall also provide opportunity for early public review of any plans or proposals for new construction in wetlands, in accordance with Section 2(b) of Executive Order No. 11514, as amended, including the development of procedures to accomplish this objective for Federal actions whose impact is not significant enough to require the preparation of an environmental impact statement under Section 102(2)(C) of the National Environmental Policy Act of 1969, as amended.

Sec. 3. Any requests for new authorizations or appropriations transmitted to the Office of Management and Budget shall indicate, if an action to be proposed will be located in wetlands, whether the proposed action is in accord with this Order.

Sec. 4. When Federally-owned wetlands or portions of wetlands are proposed for lease, easement, right-of-way or disposal to non-Federal public or private parties, the Federal agency shall (a) reference in the conveyance those uses that are restricted under identified Federal, State or local wetlands regulations; and (b) attach

2

other appropriate restrictions to the uses of properties by the grantee or purchaser and any successor, except where prohibited by law; or (c) withhold such properties from disposal.

Sec. 5. In carrying out the activities described in Section 1 of this Order, each agency shall consider factors relevant to a proposal's effect on the survival and quality of the wetlands. Among these factors are:

(a) public health, safety, and welfare, including water supply, quality, recharge and discharge; pollution; flood and storm hazards; and sediment and erosion;

(b) maintenance of natural systems, including conservation and long term productivity of existing flora and fauna, species and habitat diversity and stability, hydrologic utility, fish, wildlife, timber, and food and fiber resources; and

(c) other uses of wetlands in the public interest, including recreational, scientific, and cultural uses.

Sec. 6. As allowed by law, agencies shall issue or amend their existing procedures in order to comply with this Order. To the extent possible, existing processes, such as those of the Council on Environmental Quality and the Water Resources Council, shall be utilized to fulfill the requirements of this Order.

Sec. 7. As used in this Order:

(a) The term "agency" shall have the same meaning as the term "Executive agency" in Section 105 of Title 5 of the United States Code and shall include the military departments; the directives contained in this Order, however, are meant to apply only to those agencies which perform the activities described in Section 1 which are located in or affecting wetlands.

(b) The term "new construction" shall include draining, dredging, channelizing, filling, diking, impounding, and related activities and any structures or facilities begun or authorized after the effective date of this Order.

(c) The term "wetlands" means those areas that are inundated by surface or ground water with a frequency sufficient to support and under normal circumstances does or would support a prevalence of vegetative or aquatic life that requires saturated or seasonally saturated soil conditions for growth and reproduction. Wetlands generally include swamps, marshes, bogs, and similar areas such as sloughs, potholes, wet meadows, river overflows, mud flats, and natural ponds.

Sec. 8. This Order does not apply to projects presently under construction, or to projects for which all of the funds have been appropriated through Fiscal Year 1977, or to projects and programs for which a draft or final environmental impact statement will be filed prior to October 1, 1977. The provisions of Section 2 of this Order shall be implemented by each agency not later than October 1, 1977.

Sec. 9. Nothing in this Order shall apply to assistance provided for emergency work, essential to save lives and protect property and public health and safety, performed pursuant to Sections 305 and 306 of the Disaster Relief Act of 1974 (88 Stat. 148, 42 U.S.C. 5145 and 5146).

Sec. 10. To the extent the provisions of Sections 2 and 5 of this Order are applicable to projects covered

4

by Section 104(h) of the Housing and Community Development Act of 1974, as amended (88 Stat. 640, 42 U.S.C. 5304(h)), the responsibilities under those provisions may be assumed by the appropriate applicant, if the applicant has also assumed, with respect to such projects, all of the responsibilities for environmental review, decisionmaking, and action pursuant to the National Environmental Policy Act of 1969, as amended.

Jimmy Carter

THE WHITE HOUSE,
May 24, 1977

[FR Doc.77-15123 Filed 5-24-77;1:44 pm]

5

APPENDIX J

AMBIENT AIR QUALITY SUMMARIES IN PETOSKEY, MICHIGAN

AMBIENT AIR QUALITY SUMMARIES IN PETOSKEY, MICHIGAN

Suspended Particulate Summary ($\mu g/m^3$)

Site Location County, City, Address	Year	No. mo. Sampled	No. of Samples	Max. 24-hr.	2nd High 24-hr.	Annual Mean	Standards Exceeded Primary Ann.	Standards Exceeded Primary 24-hr.	Standards Exceeded Secondary 24-hr.
Emmet, Petoskey	1975	12	54	109	97	32G	0	0	0
Emmet Co. Bldg.	1976	12	55	345	229	32G	0	1	2
Emmet, Petoskey	1975	12	55	181	156	46G	0	0	2
Scorrer Home	1976	12	56	413	178	65G	0	1	4

Sulfur Dioxide Summary ($\mu g/m^3$)

Site Location County, City, Address	Year	No. mo. Sampled	No. of Samples	Max. 24-hr.	2nd High 24-hr.	Annual Mean	Standards Exceeded Primary Ann.	Standards Exceeded Primary 24-hr.	Standards Exceeded Secondary 24-hr.
Emmet, Petoskey	1975	12	55	50	40	0A	0	0	0
Emmet Co. Bldg.	1976	12	18	40	20	10A	0	0	0
Emmet, Petoskey	1975	12	55	40	30	10A	0	0	0
Scorrer Home	1976	12	21	30	20	10A	0	0	0

Nitrogen Dixoide Summary ($\mu g/m^3$)

Site Location County, City, Address	Year	No. mo. Sampled	No. of Samples	Max. 24-hr.	2nd High 24-hr.	Annual Mean	Standards Exceeded, Primary and Secondary
Emmet, Petoskey	1975	12	55	50	--	20*A	0
Emmet Co. Bldg.	1976	5	22	40	--	20*A	0
Emmet, Petoskey	1975	12	56	30	--	10*A	0
Scorrer Home	1976	5	20	30	--	10*A	0

*The air quality standard was not violated unless the specified 24-hour concentration was exceeded at least two times.

G = Geometric Mean
A = Arithmetic Mean

Source: Michigan Department of Natural Resources, Air Quality Division. Air quality reports, 1975 and 1976.

APPENDIX J

APPENDIX K

ALTERNATIVE WASTEWATER TREATMENT TECHNOLOGY TO MITIGATE ROUND LAKE WATER QUALITY PROBLEMS

When the Springvale-Littlefield portion (Crooked & Pickerel Lake) of the Springvale-Bear Creek segment became the subject of an Environmental Impact Statement, the grant application for the adjoining Bear Creek interceptor continued with little interruption. The removal of Crooked and Pickerel Lake area population from its design sizing, however, caused some changes in its routing and sizing. Among those areas losing sewer service as a result of these changes were the twelve dwellings on the eastern shore of Round Lake, on either side of Hendricks Road.

Correspondence and telephone conversations with Round Lake residents (Mrs. J. Ann Hazel, Mr. Keith Hall, and others July 1979) suggest the presence of some definite public health problems on individual septic tanks and filter fields. Among the problems reported were surface ponding and back-ups, particularly in the spring, and high water tables. At least some residents were described as having badly deteriorated septic tanks, and doubt was expressed as to the existence of filter fields on some other systems. At least six of the twelve families affected indicated interest in possible improvement of their wastewater treatment facilities.

Should the Springvale-Bear Creek Sewage Disposal Authority wish to do so, the twelve Round Lake dwellings could easily be made the subject of the same kind of detailed Step 2 design work as on Crooked and Pickerel Lakes. This would require the acquisition of the easements required by 40 CFR 35.918-1(h), if there is to be any Federal funding. Once the easements were obtained, design work could proceed as an amendment to either the Bear Creek Interceptor or the Springvale-Littlefield grant application. Should the Step 2 work indicate definite need, repair or replacement of problem systems could proceed with 90 percent State and Federal funding of the costs. Possible responses to the identified problems include actual repair of existing on-site systems (including a new septic tank or filter field) or installation of such systems where absent.

Where groundwater nitrate contamination problems exist, the combination of an ultra-low flow toilet (the "Microphor" type using compressed air for a two-quart flush) with a holding tank for human wastes only could be effective. Human wastes account for 90 percent of the nitrates in wastewater, and between 40 and 70 percent of the phosphorus. The existing system, if adequate, could be used for the treatment of the "greywater" from shower, sink and laundry.

Any service to the Round Lake area by off-site system such as clusters or sewers should be carefully weighed by the Sewage Disposal Authority. At least two Round Lake residents have substantial real estate holdings near the lake. Provision of off-site service could trigger large-scale growth in the vicinity of Round Lake. The Authority might wish to discuss the long-term future of Round Lake with local zoning and other officials before deciding what action to take.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1979 652-243