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Region V
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Water Division

EPA

Environmental Impact Statement

Draft

Alternative Waste Treatment Systems for Rural Lake Projects

Case Study Number 1
Crystal Lake Area Sewage Disposal Authority
Benzie County, Michigan

DRAFT ENVIRONMENTAL IMPACT STATEMENT
CRYSTAL LAKE FACILITY PLANNING AREA
CRYSTAL LAKE, MICHIGAN

Prepared by

US Environmental Protection Agency, Region V

Comments concerning this document are invited and should be received by AUG 20 1979.

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Abstract

A 201 Facility Plan was prepared for the Crystal Lake Facility Planning Area. The Facility Plan concluded that extensive sewering would be required to correct malfunctioning on-site wastewater disposal systems and to protect water quality.

Concern about the high proposed costs of the Facility Plan Proposed Action prompted re-examination of the Study Area and led to preparation of this EIS. This EIS concludes that existing wastewater treatment plants in the area should be replaced, but complete abandonment of on-site systems is unjustified. An alternative to the Facility Plan Proposed Action has therefore been presented and is recommended by this Agency.

VOLUME I

DRAFT ENVIRONMENTAL IMPACT STATEMENT

ALTERNATIVE WASTEWATER TREATMENT SYSTEMS FOR RURAL LAKE PROJECTS

CASE STUDY No. 1: CRYSTAL LAKE AREA SEWAGE DISPOSAL AUTHORITY

BENZIE COUNTY, MICHIGAN

Prepared by the

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

REGION V, CHICAGO, ILLINOIS

AND

WAPORA, INCORPORATED
WASHINGTON, D.C.

Approved by:

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June, 1979

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SUMMARY

CONCLUSIONS

Most on-site systems around Crystal Lake and in the Village of Benzonia are operating satisfactorily. Approximately 90 effluent plumes entering Crystal Lake and a few surface malfunctions have been identified. Periodic backup of sewage in the systems also occurs. On-site systems do not appear to be a significant contributor of nutrients to Crystal Lake -- of the total input of phosphorus, 6.7% or less comes from effluent plumes. Where plumes do emerge, however, they appear to be supporting localized growths of *Cladophora*, a green alga.

The only improvement in Crystal Lake water quality likely to result from the Facility Plan Proposed Action or any of the EIS alternatives would be the possible reduction in number and density of localized growths of *Cladophora* along the shoreline. This could occur if on-site systems along the shoreline were abandoned and cluster systems or centralized sewers used. No alternative is expected to affect either adversely or beneficially the water quality of the main body of Crystal Lake through the year 2000.

Future development in the Crystal Lake watershed is primarily a function of how many new lots can be developed and the density of future development. Alternatives that rely on continued use of on-site systems would restrict both the number of new lots and their density as compared to extensive sewering around the lake. One effect of these limitations would be to preserve the present character of the community.

There are large differences in the present worth and user costs among the alternatives. Both costs increase in direct proportion to the extent of new centralized sewers provided. In the more expensive alternatives, high local user charges would result in substantial displacement pressure for the permanent population and pressure for conversion of seasonal residences to permanent use. Proportionate improvements in water quality would not occur.

The recommended action in this EIS is the Limited Action Alternative. The alternative would provide:

- construction of new sewers and a new rotating biological contactor (RBC) treatment plant to serve Frankfort and Elberta;
- sewer system evaluation surveys and rehabilitation of the existing sewers in Frankfort and Elberta;
- design and implementation of a small waste flow district for the rest of the Study Area;
- site-specific environmental and engineering analyses of existing on-site systems in the unsewered parts of the Proposed Service Area;

- o repair and replacement of on-site systems as required; and
- o cluster systems or other off-site treatment for the northeast and southeast shorelines.

The recommended action will result in an improvement in water quality similar to any of the other alternatives. Its present worth, however, is only about a third, and its tentative local costs one sixteenth, those of the Facility Plan Proposed Action.

If the action recommended by the EIS were accepted at the State and local levels, it would be equivalent to a revised Facility Plan Proposed Action. EPA would recommend that Step II and Step III construction grants for Frankfort and Elberta be made independently of action taken in the remainder of the Study Area.

With respect to the rest of the Study Area, State and local concurrence with the Recommended Alternative in the EIS would imply that three additional steps would be taken with respect to formation of a small waste flow district. As part of the Step I process, the applicant would:

- o certify that the project will be constructed and an operation and maintenance program established to meet local, State, and Federal requirements including those protecting present or potential underground potable water sources.
- o obtain assurance (such as an easement or covenant running with the land) of unlimited access to each individual system at all reasonable times for such purposes as inspection, monitoring, construction, maintenance, operation, rehabilitation, and replacement. An option would satisfy this requirement if it could be exercised no later than the initiation of construction.
- o establish a comprehensive program for regulation and inspection of individual systems before EPA approves the plans and specifications. Planning for this comprehensive program would be completed as part of the facility plan. The program would include, as a minimum, periodic testing of water from existing potable water wells in the area. Where a substantial number of on-site systems exist, appropriate additional monitoring of the aquifer(s) would be provided.

Following completion of these steps, the Applicant could proceed with Step II design of facilities for the small waste flows district.

HISTORY

In November 1976, the Crystal Lake Area Sewage Disposal Authority, consisting of Benzonia and Crystal Lake Townships, prepared a 201 Facility Plan for wastewater disposal. The Authority also represented the City of Frankfort, the Villages of Elberta, Beulah, and Benzonia, and Lake Township, all located in Benzie County, Michigan. At the time, the City of Frankfort and the Village of Elberta had already been sewered and were operating their own sewerage facilities. The Proposed Service Area in the Facility Plan included all the jurisdictions above. The Village of Beulah, although included in the Facility Plan Study Area, was not finally incorporated into the Proposed Service Area.

With respect to wastewater treatment and collection facilities in the Study Area the Facility Plan reached the following conclusions:

- Continued use of the existing septic tank systems would lead to continued deterioration of water quality.
- Capacity at the Beulah treatment facility would be sufficient through the year 1998 and that adequate treatment levels could be attained provided:
  1) excessive infiltration and inflow were removed
  2) additional flood irrigation area were available, if required
- Upgrading and/or expansion of the treatment facilities at Frankfort and Elberta was infeasible and those facilities should be abandoned.
- Collection and centralized treatment of all wastewaters in the Proposed Service Area would be necessary.

EIS ISSUES

Cost Effectiveness

Capital cost of the Proposed Action was estimated to be $18.4 million. In terms of total net present worth these costs were judged to be high. In addition, since approximately 80% of the project cost would be for collection, examination of alternatives to conventional gravity sewers would have been desirable. The Facility Plan rejected continued use of septic systems, particularly along the shorelines of Crystal Lake.

Water Quality

Two earlier studies of the water quality in Crystal Lake documented the presence of localized growth of aquatic vegetation near the shoreline. Neither the studies nor the Facility Plan quantified the probable impacts of sewers upon water quality.

With respect to Betsie Lake, the Facility Plan estimated that the phosphorus load would decrease by approximately 40% if sewers were constructed. However, the Plan did not describe the relationship between such a reduction and eutrophication of the lake. In addition, the new, and perhaps larger discharges of effluent that would follow population growth were not considered.

Economic Impact

The estimated user charge for the Facility Plan Proposed Action was $175 per year for each residence or residential equivalent in the new sewer service area around Crystal Lake. This charge would amount to 1.9% of the average annual income of the permanent residents. Crystal Lake service area homeowners would pay an initial $1500 for stub fee and connection charge. In addition, there would be an additional homeowner cost for installation of a house sewer connecting individual household plumbing with the public sewer.

These sewerage costs could encourage seasonal and fixed income residents to sell their properties or to convert from seasonal use to permanent residency.

Induced Growth and Secondary Impacts

While the high costs of wastewater collection might force some current residents to move, the availability of sewers in the Crystal Lake watershed would make possible construction of new dwellings in greater number and in higher densities than is presently feasible. The potential for significant future development is indicated by the substantial number of undeveloped platted shoreline, second tier and subdivision lots in the watershed.

The rate and type of development supported by a central sewer system could have undesirable impacts. In particular, housing construction on steep slopes could accelerate soil erosion which, in turn, would increase inputs of nutrients to Crystal Lake or Betsie Lake. In addition, the density and type of future development feasible with a central sewer system could be considerably different from that presently typical of the Crystal Lake area.

ENVIRONMENT

Soils

In general, soils on sites set back from Crystal Lake are suitable for on-site disposal of wastewater. Steep slopes are the major limitation of such soils.

Opinions differ on the suitability of soils on shoreline sites for on-site disposal of wastewater. The Tri-County Health Department has evaluated such sites and determined that over half the vacant lots are suitable for septic systems. The Soil Conservation Service considers excessive permeability to be a limitation to on-site systems. Thus, soils acceptable to one agency may be rejected by the other. However, the difference alone does not account for the large discrepancy between the two sets of soils data. One explanation may be that the seasonal high water table may not be so high as was suggested to SCS in their surveying.

Surface Water Resources

Crystal Lake, the centerpiece of the Study Area, occupies approximately 15 square miles; its primary tributary is Cold Creek. Betsie Lake occupies approximately 0.4 square miles. Its primary tributary is the Betsie River and it is itself tributary to Lake Michigan.

The hydrology of the lakes directly affects their quality. Crystal Lake, despite a retention time greater than 60 years, is generally clean, clear and oligotrophic. At a distance from the shoreline, the Lake has shown little change in productivity in 10 years. Conversely, Betsie Lake, with a retention time of 2 days, is eutrophic. For both lakes, phosphorus has been identified as the limiting nutrient.

Groundwater Resources

Groundwater serves as the source of drinking water for Beulah, Elberta and Frankfort. Water supplies in the remainder of the Study Area consist of individual and small community wells. Water is generally plentiful and of good quality, although hard. A 1969 survey of 165 wells around Crystal Lake indicated no contamination by indicator bacteria; nitrates were generally present at concentrations ranging from 0-2 mg/l. The concentration of nitrate in 2 wells exceeded the Drinking Water Standard of 10 mg/l.

Additional Studies

Because of the scarcity of recent data, three additional studies were performed in connection with this EIS.

1) An aerial survey was performed by the Environmental Photographic Interpretation Center (EPIC) during the summer of 1978. Few surface malfunctions of on-site sewage disposal systems were found, but foliage may have hidden from view some failing systems. The densest growths of submerged aquatic vegetation were found along the northeastern and eastern shores.

2) A sanitary survey was conducted by the University of Michigan during September and October of 1978. The results indicated that over half the lakeshore on-site systems were violating the sanitary code. Few of the systems, however, had recurring problems with backups or ponding. Heavy shoreline algal growth was associated with about 10% of the sites.

3) A study of septic leachate intrusion into Crystal Lake was performed during November 1978. Approximately 90 septic systems were determined to be leaching into the Lake. Growth of submerged vegetation was correlated with effluent discharge.

An analysis of the additional data provided by these studies indicates that septic tank effluents contribute to the growth of algae along the lakeshore. Malfunctions generally consist of backups of sewage rather than surface ponding. Groundwater data are inconclusive. Of the problems with backups, most relate to inadequate maintenance, rather than insufficient soil absorptive capacity. In addition, it was estimated on the basis of computer models that 6.7% or less of the total phosphorus loading to Crystal Lake was contributed by septic systems.

Existing Population and Land Use

Approximately 60% of the Proposed Service Area population consists of seasonal residents, located primarily in the unsewered areas surrounding Crystal Lake. The permanent resident population, located throughout the Proposed Service Area, is characterized by a relatively low income that is below the average income for all of Michigan. Retirement age population, often consisting of persons on fixed incomes, makes up 17% of the Service Area's population. The proportion of the Service Area's retirement age population is more than twice the proportion for the State of Michigan.

Land use in the Service Area consists of: three small urban centers (Frankfort, Elberta, and Benzonia); permanent and seasonal single family residences; agricultural areas devoted to row crops and orchards; and open land consisting of woodlands, wetlands, and sand dunes. The aesthetic appeal of the area has resulted in substantial residential development around Crystal Lake. Most commercial areas are located in the village centers and along major highways.

ALTERNATIVES

Based upon the high cost of conventional technology and questions concerning the eligibility of the new sewers for Federal funding, 7 new alternatives were evaluated in this EIS along with the Facility Plan Proposed Action. These alternatives incorporated alternative collection systems (pressure sewers), treatment techniques (land application), individual and multi-family septic systems (cluster systems), and water conservation.

Limited Action Alternative

New treatment plant serving Frankfort and Elberta, upgraded and new sewers for Frankfort and Elberta. Cluster systems for the northeast shore of Crystal Lake and the Benzonia Village shoreline. Repair and rehabilitation of on-site systems throughout the remainder of the Study Area.

EIS Alternative 1

Same as Facility Plan Proposed Action, except that pressure sewers would be substituted for gravity sewers.

EIS Alternative 2

Same as EIS Alternative 1, except that land application of wastewater would be substituted for RBC treatment.

EIS Alternative 3

Frankfort, Elberta, and the southwest shore would discharge their wastes to a new RBC plant in Frankfort. Wastewaters from Benzonia Township and Benzonia Village would be treated by land application. Collection of wastewater by pressure sewers from the northeast shore and treatment by land application. The remainder of the Study Area would be served by a combination of cluster systems and on-site systems suitable to local conditions.

EIS Alternative 4

Same as EIS Alternative 3, except that land application of wastewater would be substituted for RBC treatment.

EIS Alternative 5

The same decentralized treatment as in EIS Alternative 3. Flows from other parts of the Study Area, the northeast shore and from the Crystalia-Pilgrim area would be treated at a new RBC plant located in Frankfort.

EIS Alternative 6

Same as EIS Alternative 5, except that wastewater from the Crystalia-Pilgrim area would be treated by rehabilitated on-site systems. Extensive use of cluster systems assumed to be unnecessary in contrast to EIS Alternatives 3, 4, and 5.

Project costs were most directly related to the extent of sewering. No cost advantage would obtain for pressure sewers.

Implementation

Local jurisdictions have the legal and financial capability to implement small waste flow districts. Although the concept of public management of septic systems has not been legally tested in Michigan, present sanitary codes have been interpreted as authorizing such management by local governments. Some, but not many local jurisdictions have experience in the organization and operation of small waste flows districts. California and Illinois provide some specific examples.

IMPACTS OF THE ALTERNATIVES

Five major categories of impacts were relevant in the selection of an alternative. These categories included: surface water; groundwater; environmentally sensitive areas; population and land use; and socio-economics.

Surface Water

None of the wastewater management alternatives would have significant impact on the trophic status of Crystal Lake in terms of the open water quality, which would continue to be good. The problem of Cladophora growth in shoreline areas, however, would remain unless the shoreline homes are sewered.

Betsie Lake is expected to benefit significantly from all the EIS alternatives, as well as the Facility Plan Proposed Action, with substantially reduced phosphorus input to the lake. Total phosphorus concentration in the lake would decrease from the present level as a result of any of the alternatives except the No Action Alternative. The classification of Betsie Lake as eutrophic will not change although some reduction in aquatic plant growth is likely.

Groundwater

No significant primary or secondary impacts on groundwater quanity are anticipated either as a result of the short-term construction activities or long-term operation of any of the various alternatives. This is mainly because all of the water quantities associated with the alternative are almost miniscule in comparison with the estimated groundwater storage, recharge from all other sources, and available groundwater yield.

No significant short-term impacts on groundwater quality are anticipated to result from the construction activities of any of the alternatives. Conclusions with respect to long-term groundwater quality impacts are as follows:

- Impacts on bacterial quality are expected to be insignificant for all alternatives.
- Continued use of septic tank/soil absorption systems (ST/SAS) particularly on the northeastern lake shore may result in minor impacts associated with shoreline algal growths.
- No significant impacts on nitrate concentrations are anticipated providing the density of ST/SASs complies with generally accepted standards. Only the No Action Alternative is likely to result in significant adverse impacts.

Environmentally Sensitive Areas

Any of the alternatives may allow development on steep slopes around Crystal Lake. This would result in erosion, sedimentation, and transfer of nutrients to the lake. The Facility Plan Proposed Action and EIS Alternatives 1 and 2 might have a somewhat greater impact in this respect than would the Limited Action or EIS Alternatives 3, 4, 5 or 6.

Population and Land Use

It is estimated that the centralized alternatives would permit a 19% increase above standard population projections for the Service Area. The Limited and No Action Alternatives would result in population growth 7% below standard projections while EIS Alternatives 3, 4, 5, and 6 would generate population growth 4% above the standard projections.

Acreage in residential use would increase 77% (No Action Alternative) to 88% (centralized alternatives) of land available. The provision of sewers would allow the present demand for land development along the Crystal Lake shoreline to be met. The decentralized, No Action, and Limited Action alternatives would increase the value of existing residential property by restricting the amount of additional land that could be developed. Centralized facilities might result in increased development pressure. The No Action, Limited Action, and decentralized alternatives would tend to maintain existing community character.

Economic Impacts

Annual user charges are much higher for the centralized alternatives than the decentralized alternatives with respect to the currently unsewered portion of the Study Area. User charges for the centralized alternatives are somewhat lower in Frankfort and Elberta. The centralized alternatives place a significant financial burden and displacement pressure on housholds in the unsewered areas. Only the Limited Action Alternative and EIS Alternatives 5 and 6 are not high-cost for the unsewered area. None of the alternatives have been identified as a high-cost project with respect to Frankfort and Elberta. Significant financial burden and displacement pressure are much lower in Frankfort and Elberta as compared to the remainder of the Service Area.

CONTENTS

Page

TABLES

FIGURES

SYMBOLS AND ABBREVIATIONS

*	An asterisk following a word indicates that the term is defined in the Glossary at the end of this report. Used at the first appearance of the term in this EIS.
<	less than
>	greater than
ρ	Rho
μ	Mu, micro
ν	Nu
σ	Sigma

TECHNICAL ABBREVIATIONS

AWT	advanced wastewater treatment
BOD	biochemical oxygen demand
DO	dissolved oxygen
ft^2	square foot
fps	feet per second
$g/m^2/yr$	grams per square meter per year
GP	grinder pump
gpcd	gallons per capita per day
gpm	gallons per minute
I/I	infiltration/inflow
kg/yr	kilograms per year
kg/cap/yr	kilograms per capita per year
kg/mile	kilograms per mile
lb/cap/day	pounds per capita per day
mgd	million gallons per day
mg/l	milligrams per litre
ml	millilitre
msl	mean sea level--implies above msl unless otherwise indicated
MPN	most probable number
N	nitrogen
NH_3-N	ammonia nitrogen
NO_3-N	nitrate nitrogen
NPS	non-point source

O&M	operation and maintenance
P	phosphorus, or "as phosphorus"
pH	measure of acidity or basicity; <7 is acidic; >7 is basic
PO_4	phosphate
ppm	parts per million
psi	pounds per square inch
RBC	rotating biological contactor
SS	suspended solids
STEP	septic tank effluent pumping
STP	sewage treatment plant
ST/SAS	septic tank/soil absorption system
TKN	total Kjeldahl nitrogen
TP-P	total phosphorus as phosphorus
μg/l	micrograms per liter
EPAECO	name of a mathematical model

NON-TECHNICAL ABBREVIATIONS

DNR	Michigan Department of Natural Resources
EIS	Environmental Impact Statement
EPA	United States Environmental Protection Agency
EPIC	Environmental Photographic Interpretation Center (of EPA)
FWS	Fish and Wildlife Service, United States Department of the Interior
GT-L-BHD	Grand Traverse-Leelanau-Benzie District Health Department
HUD	United States Department of Housing and Urban Development
NOAA	National Oceanic and Atmospheric Administration, United States Department of Commerce
NES	National Eutrophication Survey
NPDES	National Pollutant Discharge Elimination System
SCS	Soil Conservation Service, United States Department of Agriculture
STORET	STOrage and RETrieval (data base system of EPA)
USDA	United States Department of Agriculture
USGS	United States Geological Survey, Department of the Interior

CHAPTER I

INTRODUCTION, BACKGROUND AND ISSUES

A. PROJECT HISTORY AND DESCRIPTION

1. LOCATION

The subject of this Environmental Impact Statement (EIS) is requested Federal funding of proposed wastewater collection and treatment facilities in the Crystal Lake area of Benzie County, Michigan. The "Crystal Lake Area Facility Plan - Wastewater Collection and Treatment" recommended construction of the facilities which will be described later in this chapter. The new wastewater facilities would be located in the City of Frankfort, the Villages of Beulah, Elberta and Benzonia, and the Townships of Benzonia, Crystal Lake and Lake. Together these communities make up the Facility Planning Area, approximately one-fifth of the land area of Benzie County, which is located in the northern part of the Lower Peninsula on the eastern shore of Lake Michigan. The combined year-round population of the areas proposed prepared for sewering (i.e., the Proposed Service Area) is estimated to be 4,400, a figure which swells to about 8,300 in the vacation season. Figure I-1 shows their location within the State of Michigan. Figure I-2 delineates the Study Area.

2. HISTORY OF THE CONSTRUCTION GRANT APPLICATION

Water quality problems and wastewater management needs of the Study Area have for several years been a concern of both area citizens and governmental agencies. The following chronology lists actions that were taken before and during the preparation of this Environmental Impact Statement.

March, 1970 — "Crystal Lake Water Quality Investigation" completed by Dr. John J. Gannon of the School of Public Health, University of Michigan, for the Keep Crystal Clear Committee.

April, 1974 — National Pollutant Discharge Elimination System (NPDES) permits issued to City of Frankfort and Village of Elberta by State of Michigan, Department of Natural Resources (DNR).

November, 1974 — NPDES permit issued to Village of Beulah by Michigan DNR.

March, 1975 — "Report on Betsie Lake, Benzie County, Michigan, Working Paper#185" published by United States Environmental Protection Agency (EPA) Region V, as part of the National Eutrophication Survey (NES).

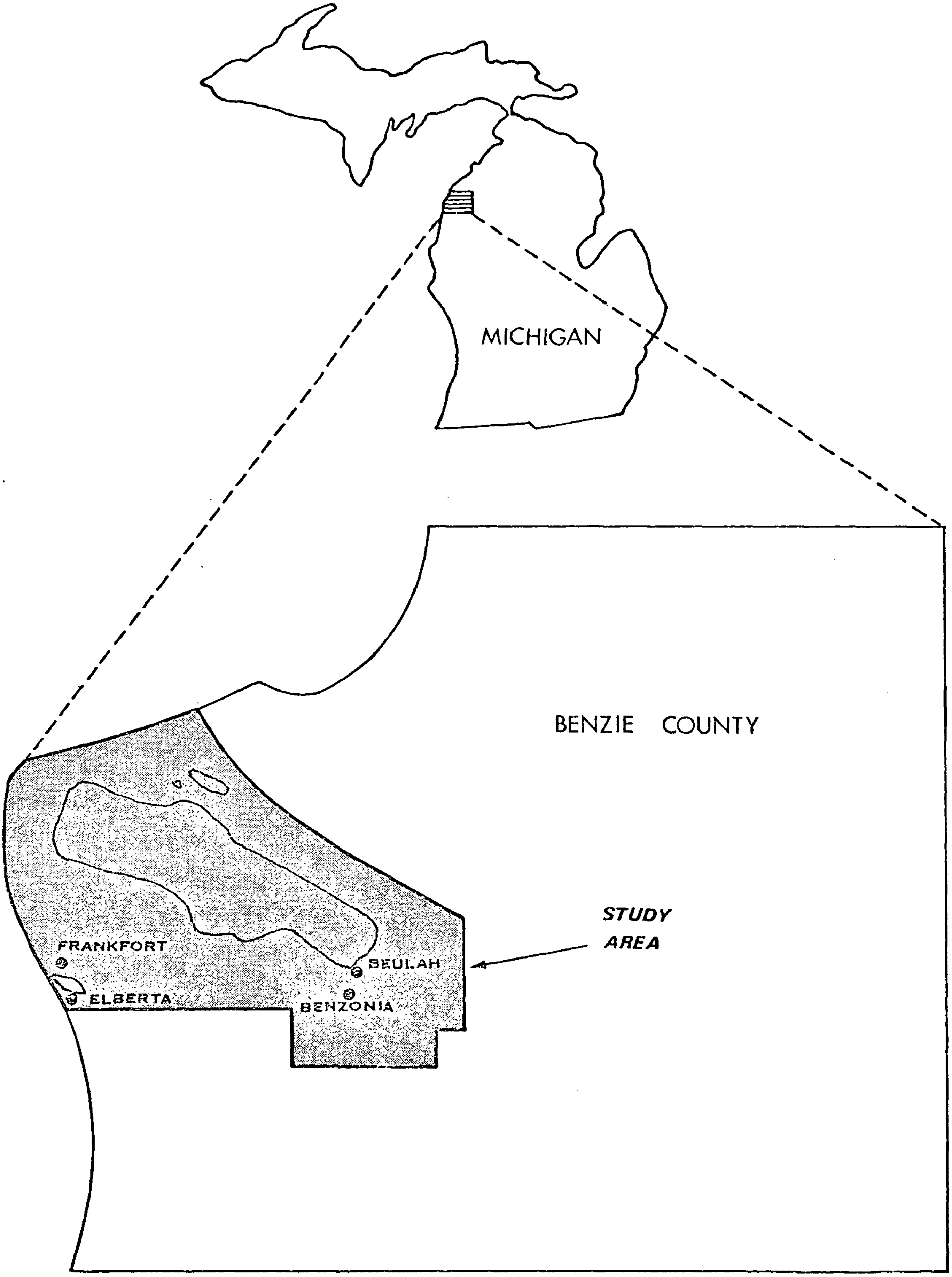


Figure I-1: Location of Crystal Lake Study Area

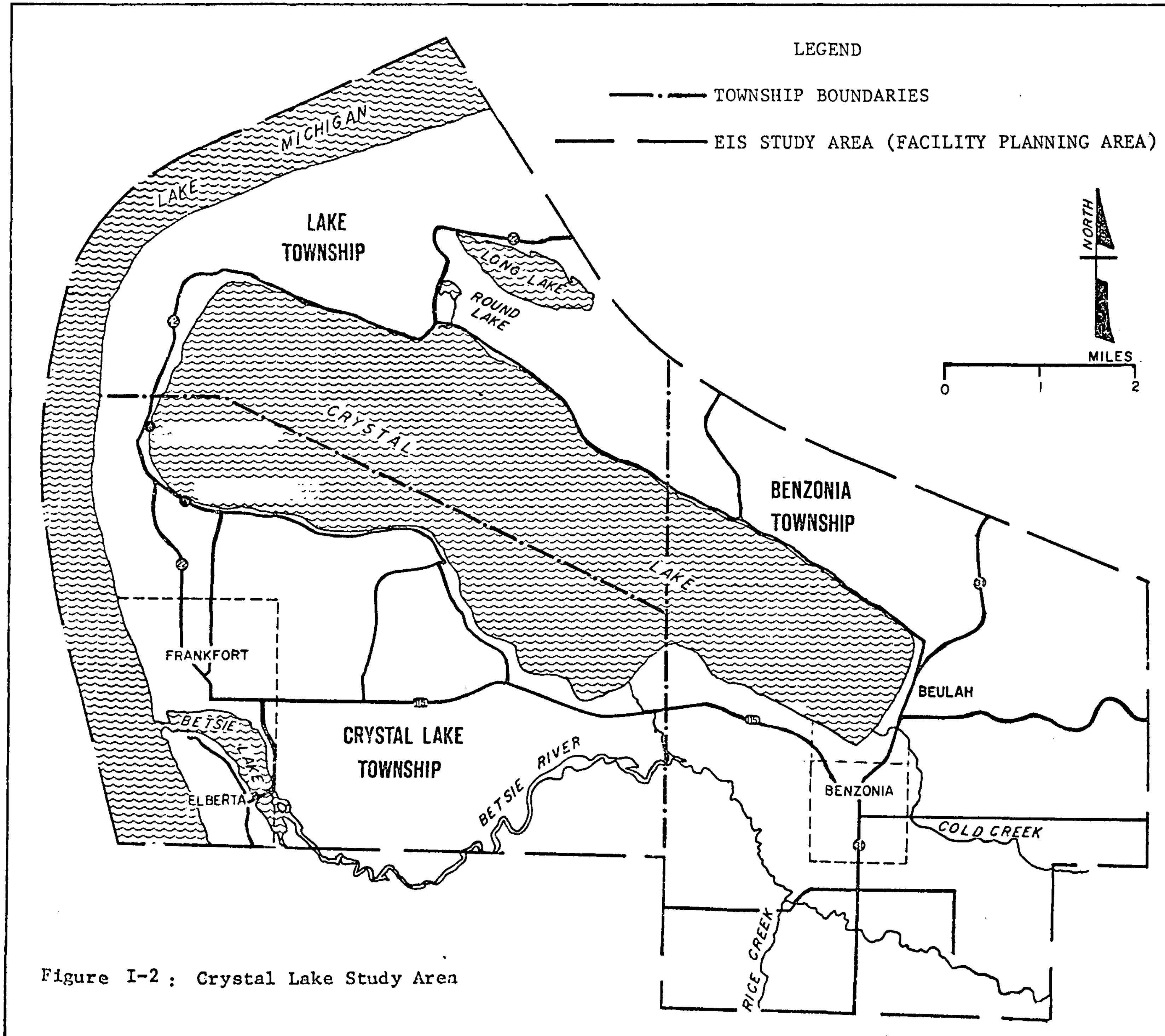


Figure I-2 : Crystal Lake Study Area

August- November, 1975	Resolutions passed by local units of government designating the Crystal Lake Area Sewage Disposal Authority as the lead agency to prepare a facility plan in application for an EPA construction grant.
December, 1975	Notice of Noncompliance with NPDES permit issued to Village of Beulah by Michigan DNR.
October, 1976	Notice of Noncompliance and Order to Comply with NPDES permit issued to Village of Beulah by Michigan DNR.
November, 1976	Michigan DNR proposed discharge limitations for Betsie Lake, recommended that discharges not be made to Betsie River or to Lake Michigan, and recommended land disposal if possible.
December, 1976	Engineering study of wastewater treatment alternatives, "Crystal Lake Area Facility Plan--Wastewater Collection and Treatment," completed by Williams and Works, Inc.; McNamee, Porter, and Seeley; and Perla Stout Associates for the Crystal Lake Area Sewage Disposal Authority.
December, 1976	Hearing held by Crystal Lake Area Sewage Disposal Authority on proposed Facility Plan.
June, 1977	Crystal Lake Area Sewage Disposal Authority and the Michigan DNR formally request an EIS.
July, 1977	Declaration of Intent by EPA Region V to prepare an EIS.
October, 1977	Work begun by WAPORA, Inc., on the EIS for the Crystal Lake area.
December, 1977	First EIS public information meeting.
February, 1978	"Final Summary Report on Crystal Lake Water Quality Study" completed by Mr. Fred J. Tanis for the Crystal Lake Property Owners Association.
June 15, 1978	Second EIS public information meeting.

3. THE CRYSTAL LAKE AREA FACILITY PLAN

In December 1976 the Crystal Lake Area Facility Plan was completed and was subsequently submitted to EPA by the Benzie County Department of Public Works, acting as the applicant for funding under the EPA Construction Grants Program. The Plan, which proposed construction of new wastewater collection and treatment facilities, had been developed for the Crystal Lake Area Sewage Disposal Authority by three consulting firms: Williams and Works, Inc., the lead consultant; McNamee, Porter, and Seeley; and Perla Stout Associates.

This section describes wastewater treatment facilities now existing in the Study Area, summarizes the existing water quality problems presented in the Facility Plan, and discusses the alternative solutions and recommended course of action (the Proposed Action) developed there in the Facility Plan. Conclusions reached in the Facility Plan and summarized in this Section are not necessarily those reached in this EIS.

a. Existing Wastewater Treatment Facilities

Three communities in the Study Area--the City of Frankfort, Elberta Village, and Beulah Village--presently have some type of centralized wastewater collection and treatment facilities. Crystal Lake Township, Lake Township, Benzonia Township and Benzonia Village do not have collection facilities. Wastewater in the latter areas is treated on-site, principally by septic tank-soil absorption systems (ST/SAS). Figure I-3 shows the locations of existing community treatment facilities, the boundaries of the sewer service areas, and the points of effluent disposal.

Frankfort Primary Plant. The Frankfort primary treatment plant, which was constructed in 1939, has a design capacity of 0.26 million gallons per day (mgd). The plant serves almost all of the population of Frankfort and also treats wastes from Pet, Inc., the only significant source of industrial wastewater in the Study Area. Effluent from the Frankfort plant is discharged into Betsie Lake. A description of the treatment facilities at the City of Frankfort, Elberta Village and Beulah Village and evaluation of the treatment performance are contained in Chapter 4 of the Facility Plan.

Plant records indicate that the average daily flow to the Frankfort plant for the period July 1974 to June 1976 was 0.27 mgd; the peak flow reached 0.436 mgd. Treatment has provided removal of approximately 25% of the biochemical oxygen demand (BOD) and 40% of the suspended solids (SS). Maintenance costs have increased and some equipment, such as the chlorination system and the comminutor*, needs repair or replacement. Problems exist which are related to the age and condition of the equipment and the plant cannot meet the proposed limitations on discharge into Betsie Lake. Further, infiltration* and inflow* hydraulically overload the plant, as documented in the Infiltration/ Inflow Analysis (I/I) conducted for the City.

Elberta Primary Plant. The Elberta primary treatment plant, built in 1957 with an average design flow of 0.10 mgd, also discharges effluent into Betsie Lake. This plant serves most of the population in the Village.

From July 1974 to June 1976 average daily flow to the treatment plant was 0.126 mgd; the peak flow reached 0.225 mgd. The plant has averaged approximately 35% removal of BOD and 50% removal of SS. The

*See Glossary.

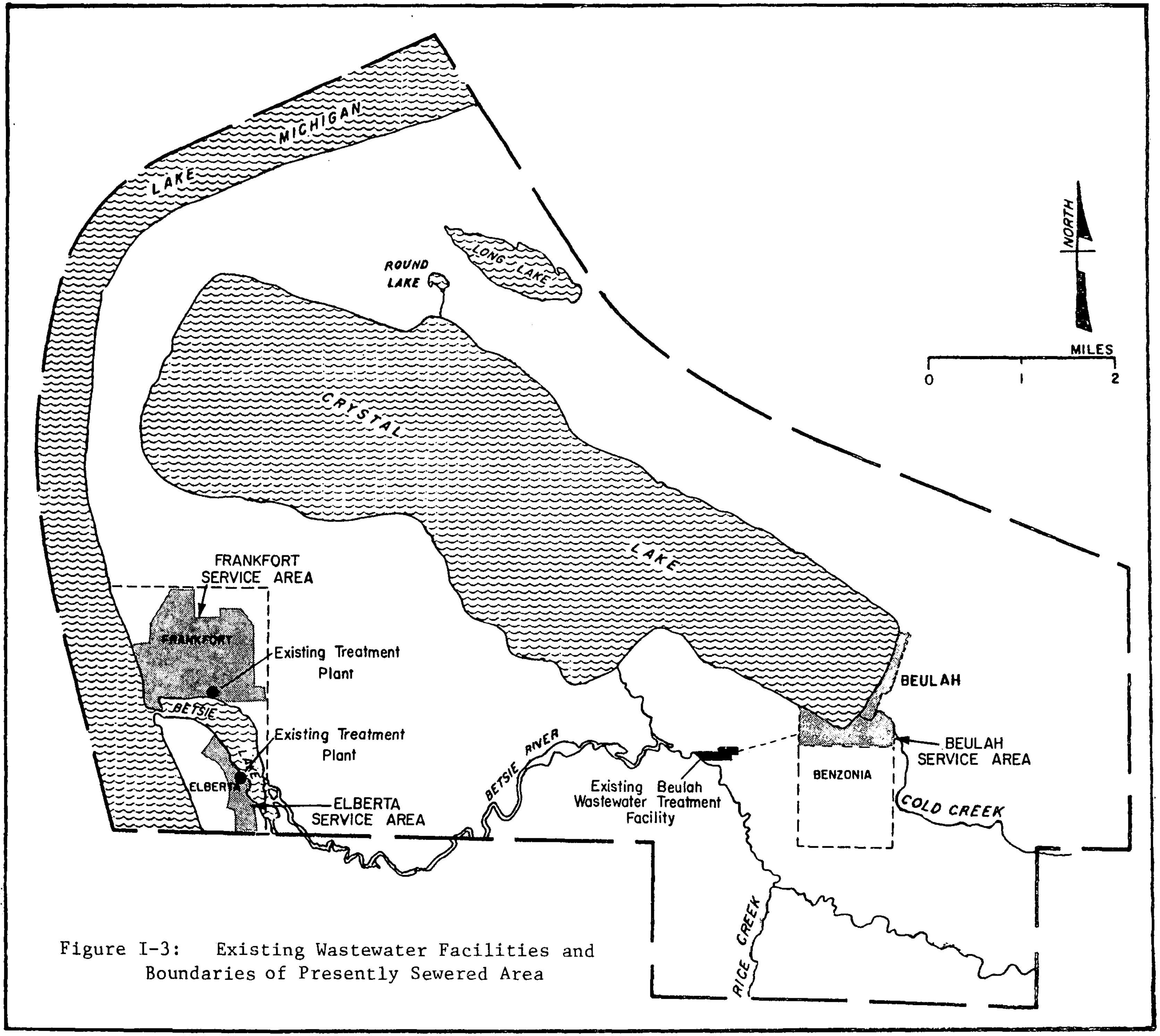


Figure I-3: Existing Wastewater Facilities and Boundaries of Presently Sewered Area cost of maintaining the Elberta plant, like the Frankfort plant, is increasing. The Infiltration/Inflow Analysis for the Village of Elberta concluded that the existing sewer system is subject to significant infiltration.

Beulah Oxidation Ponds. The Village of Beulah treatment facility was designed to handle an average annual flow of 0.1 mgd. The system serves the entire Village plus a mobile home park with approximately 40 trailers in the northwestern corner of the Village of Benzonia.

The facility employs four oxidation ponds and two seepage cells.* The plant, constructed in 1971, was originally designed to dispose of all effluent through the seepage cells, but during the last five years it has been necessary to discharge some of the effluent into the Betsie River when the cells become hydraulically overloaded. The NPDES permit to discharge semi-annually to the Betsie River states that effluent may not contain more than 30 mg/l of BOD, 30 mg/l of SS and 200 coliforms/ 100 ml. However, stipulations in the permit that the treatment facility be monitored and improved have not been met. Monitoring wells have been provided to detect whether seepage from the cells pollutes the groundwater.

The annual average flow to the Beulah treatment facility is approximately 0.081 mgd. It has periodically been necessary to discharge treated wastewaters from the final seepage cell to the Betsie River because the hydraulic capacity of the seepage cells is 4,500 gpd less than the present wastewaster flows.

Influent to the treatment system is not sampled prior to treatment. Consequently, the present waste loadings and treatment efficiency are not known. However, the Facility Plan estimated the average waste loading to the plant at 70 pounds per day of both BOD and SS. The Infiltration/Inflow Analysis for the Village of Beulah indicated that the sewer system is subject to significant infiltration.

On-Site Treatment Systems. On-site wastewater systems, most commonly the conventional septic tank-soil absorption system (ST/SAS), serve all remaining parts of the Study Area. There are also a number of systems in which wastewaters are disposed of in earth-covered, gravel-filled pits in the ground. A few holding tanks have been installed in the area in recent years.

The Facility Plan claims that on-site sewage disposal systems contribute to the degradation of water quality in Crystal Lake.

b. Existing Problems with Water Quality and Wastewater Treatment Facilities

As a preliminary step in the development of wastewater management alternatives, the Facility Plan cites the following problems.

Betsie Lake. An analysis of Betsie Lake (National Eutrophication Survey 1975) indicated that excessive nutrient loading is causing eutrophic conditions. In 1972, 48% of the phosphorus load to the Lake was contributed by the two primary treatment plants serving Frankfort and Elberta. These plants are incapable of meeting effluent standards proposed by the State of Michigan for effluent discharges to Betsie Lake. Table I-1 compares the proposed effluent limitations with effluent characteristics of the plants in 1975.

Significant infiltration was detected in the three sewer systems. Storm sewers connected to the sanitary sewers in Frankfort are the source of inflow in that system. The Facility Plan recommended sewer system evaluation surveys for Frankfort and Elberta; rehabilitation of Beulah's sewers was also recommended, but without such a survey.

Crystal Lake. During the preparation of the Facility Plan the primary source of data on water quality in Crystal Lake was a report titled "Crystal Lake Water Quality Investigations" by Dr. John J. Gannon of the University of Michigan (1970). The Gannon report concluded that:

- the most important source of pollution in Crystal Lake was the inflow from Cold Creek. Several business establishments and houses along its north branch contribute phosphates to Cold Creek.

- the highest coliform levels and algal concentrations existed in the waters adjacent to the north shore toward the east end of the lake.

- wells along the northeast shore showed significantly higher concentrations of nitrate than did wells in other areas. Nitrate levels in this area generally ranged from 1 to 6 mg/l as N.* (EIS Note: of the 99 wells sampled on the northeast shore, 45 had nitrate concentrations less than 1 mg/l as N, 50 had concentrations between 1 and 6 mg/l and 5 had concentrations greater than 6 mg/l.)

- Crystal Lake is oligotrophic; dissolved oxygen concentrations in the deep areas are 7.2 mg/l or greater.

- the algal mass in Crystal Lake will increase three times in a period of 7 to 10 years.

- sanitary sewage should be collected by means of a sewer system that would encircle the lake; this sewage should then be treated and discharged outside the basin.

A letter was included in the Facility Plan from Mr. Lyle Livasy, R.S., staff sanitarian with the Grand Traverse-Leelanau Benzie District Health Department, citing severe soil limitations around the lake for on-site sewage disposal and high coliform bacteria counts at two houses on the northeast shore.

Table I-1

COMPARISON OF PROPOSED AND OBSERVED EFFLUENT PARAMETERS FOR FRANKFORT AND ELBERTA

Parameter (30-day average)	Proposed	Observed	
		Frankfort[a]	Elberta[b]
BOD_5 (mg/l)	10	140	119
SS (mg/l)	15	128	110
Fecal Coliform (MPN/100 ml)	200	440	N/A
pH	6.5-9.5	7.1	N/A
Total P (mg/l)	1.0 (or 80% removal, whichever is stricter)	11.0	N/A

---

[a]Survey performed 8/75.

[b]Calculated from removal efficiencies.

The Crystal Lake Area Facility Plan reviewed existing data on water quality problems in Crystal Lake and the quality of surrounding groundwater, as well as information on site conditions such as soil types around the lake. The "Crystal Lake Water Quality Investigation" (Gannon 1970) and the experience of Grand Traverse-Leelanau-Benzie District Health Department were the major sources of information on the problem referenced in the Facility Plan. The Facility Plan concluded that high water tables, small lots and poor soil provided sufficient evidence to link on-site systems and subsequent water quality problems and, therefore, to warrant sewering the Crystal Lake shoreline.

c. Proposed Solutions: Alternatives Addressed in the Facility Plan

The Facility Plan developed four alternative wastewater management plans for meeting effluent requirements and alleviating problems associated with the existing collection and treatment systems in the Facility Planning Area. Selection of the Proposed Action from among these alternatives was based on analyses of costs, environmental impacts and implementability of each.

Collection and treatment facilities were sized for the year 1998 and were based on discharge of 100 gallons of wastewater per capita per day (gpcd) for permanent residents and 60 gpcd for seasonal residents. Commercial and industrial flows were included in the estimates. Projected flow for the City of Frankfort included 0.049 mgd from Pet, Inc. Also included is residual infiltration/inflow based on values determined in the I/I analyses that had been conducted previously for the Frankfort, Elberta and Beulah collection systems (See Table I-2).

The Facility Plan concluded that the capacity at the Beulah treatment facility would be sufficient through 1998 and that adequate treatment levels could be attained if (a) the I/I problem were corrected and (b) an additional flood irrigation area were to be provided if required. Each of the alternatives presented in the Facility Plan assumed that wastewater from the Village of Beulah would be treated at the local treatment plant and that I/I would be corrected. The Plan also determined that it was not feasible to upgrade and expand the existing primary plants at Frankfort and Elberta and recommended abandonment of these facilities.

Finally, the Facility Plan concluded that collection and centralized treatment of all wastewaters in the Proposed Service Area shown in Figure I-4 would be necessary.

In developing the alternatives presented in the Facility Plan, several elements were considered:

- Optimum operation of existing facilities,
- Flow and waste reduction,
- Collection systems,
- Wastewater treatment and disposal, and
- Sludge disposal.

Table I-2

PROJECTED 1998 DESIGN FLOWS, CRYSTAL LAKE AREA FACILITY PLAN

Community	Yearly average flow	Average summer flow	Flow on peak day
Benzonia	0.046 mgd	0.048 mgd	0.058 mgd
Benzonia Township	0.128 mgd	0.141 mgd	0.182 mgd
Crystal Lake Township	0.122 mgd	0.183 mgd	0.210 mgd
Elberta	0.068 mgd	0.068 mgd	0.117 mgd
Frankfort	0.257 mgd	0.257 mgd	0.401 mgd
Lake Township	0.035 mgd	0.059 mgd	0.070 mgd

Williams & Works; McNamee, Porter and Seeley; and Perla Stout Associates. 1976. Crystal Lake area facility plan for wastewater collection and treatment, Benzie County, Michigan.

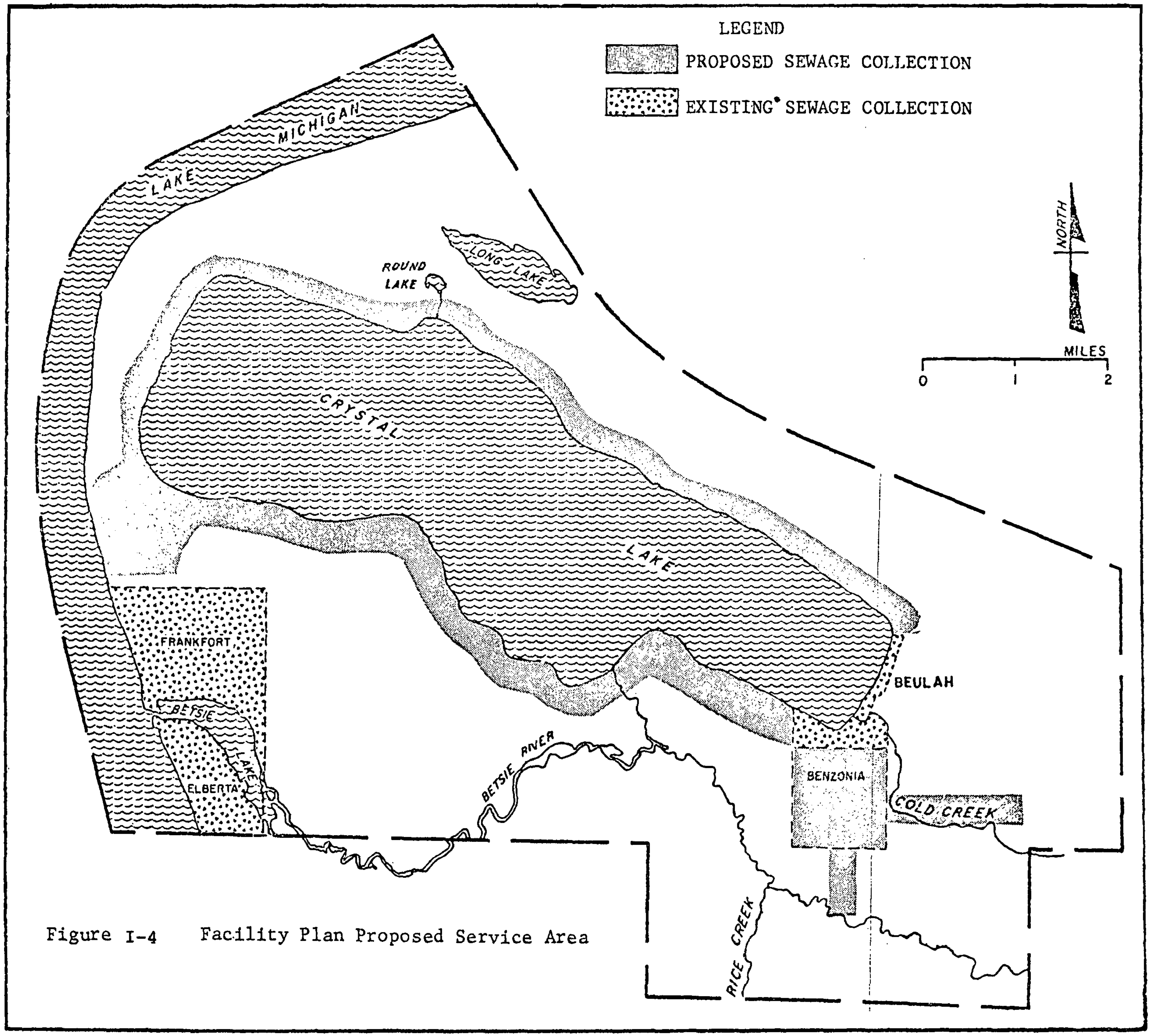


Figure I-4 Facility Plan Proposed Service Area

Plans for correcting I/I problems were incorporated into the alternatives, but no other structural flow- or waste-reduction measures were analyzed. Also recommended by the Plan was the non-structural approach of increasing sewer use charges as a tool to encourage conservation. The sewerage systems consisted of conventional gravity collectors with a combination of force main and gravity interceptors; routing of sewers varied with each alternative plan, depending on location and number of treatment facilities. Treatment of centrally collected wastewaters by processes such as activated sludge and physical-chemical techniques and by land application after aeration in lagoons were examined. Methods investigated for disposal of sludge were: (1) digestion, with disposal of liquid sludge on land; (2) digestion, with disposal of dewatered sludge on land; and (3) digestion and landfilling of dewatered sludge.

The four wastewater management alternatives developed by the Facility Plan were:

<u>Alternative No. 1</u>. Treatment of wastewaters from Frankfort, Elberta, Lake Township, and Crystal Lake Township at a new rotating biological contactor (RBC) plant located in Frankfort and discharging to Betsie Lake. Treatment of wastewaters from Benzonia and Benzonia Township at a new land disposal facility located in Benzonia Township.

<u>Alternative No. 2</u>. Treatment of all wastewaters at a new RBC plant in Frankfort, on land previously purchased by the City, and discharge of the effluent to Betsie Lake.

<u>Alternative No. 3</u>. Treatment of all wastewaters at a new land disposal facility.

<u>Alternative No. 4</u>. Treatment of wastewaters from Frankfort and Elberta at a new land disposal facility.

Table I-3 shows the estimated project construction costs and operation and maintenance costs and salvage values in terms of present worth and sums the total present worth for each of the four alternatives. An interest rate of 6-1/8% and a 20-year planning period were used in developing the costs presented in the table.

d. The Facility Plan Proposed Action

Alternative No. 2 was selected. It included improvement of the operation of the Beulah plant plus entirely new centralized facilities to collect and treat wastewaters. Flow would originate not only from Frankfort and Elberta but also from new areas--Benzonia Village, additional areas of Benzonia Township and Crystal Lake Township and from Lake Township. The sewer service area proposed in Figure I-2 in the Facility Plan is shown in Figure I-4.

The RBC system was selected over activated sludge and physical-chemical treatment on the bases of cost and ease of operation. The plant would include facilities for chemical addition and microstraining to provide advanced treatment.

Table I-3

PRESENT WORTH COMPARISON OF EIS ALTERNATIVES, CRYSTAL LAKE AREA FACILITY PLAN

Facility	Regional alternative			
	No. 1	No. 2	No. 3	No. 4
Collection system				
Total project cost	$ 14,714,000	$ 14,919,000	$ 17,133,000	$ 14,556,000
Salvage value (PW)	(-) 2,039,000	(-) 2,037,000	(-) 2,187,000	(-) 1,968,000
O&M (PW)	(+) 912,000	(+) 1,069,000	(+) 1,219,000	(+) 1,100,000
Net present worth	13,587,000	13,951,000	15,165,000	13,688,000
Wastewater treatment system				
RBC plant				
Total project cost	3,274,000	3,485,000	N.A.	2,746,000
Salvage value (PW)	(-) 189,000	(-) 201,000		(-) 158,000
O&M (PW)	(+) 1,051,000	(+) 1,187,000		(+) 972,000
Net present worth	4,136,000	4,471,000		3,560,000
Land disposal facility				
Total project cost	1,034,000	N.A.	3,097,000	1,737,000
Salvage value (PW)	(-) 59,000		(-) 182,000	(-) 102,000
O&M (PS)	(+) 270,000		(+) 611,000	(+) 384,000
Net present worth	1,425,000		3,526,000	2,019,000
Total net present worth	18,968,000	18,422,000	18,691,000	19,267,000

Williams & Works; McNamee, Porter and Seeley; and Perla Stout Associates. 1976. Crystal Lake area facility plan for wastewater collection and treatment, Benzie County, Michigan.

B. ISSUES OF THIS EIS

The Environmental Protection Agency's review of the Facility Plan Proposed Action identified the following issues as warranting the preparation of this EIS.

1. COST EFFECTIVENESS

Capital cost for the Facility Plan Proposed Action was estimated in the Plan to be $18.4 million. This equates to an investment of $2207 per person and $8654 per existing dwelling unit within the Proposed Service Area. These per-person and per-household investments would be among the highest in EPA Region V.

Eighty-one percent of the estimated capital cost would be for new collector and interceptor sewers. Extensive use of pressure sewers as a potentially less expensive alternative to gravity sewers was considered by the Facility Plan consultants but at the insistence of the State of Michigan was not evaluated in the Plan. Reliance on septic tank systems to reduce the new areas to be sewered was briefly considered but was not incorporated into any of the Facility Plan alternatives. Use of other on-lot sewage disposal methods or small-scale technologies was not considered.

2. IMPACTS ON WATER QUALITY

The likely impacts of the Facility Plan Proposed Action and alternatives to it on water quality were not satisfactorily addressed in the Plan. Of principal concern are eutrophication of Crystal Lake and Betsie Lake and nearshore plant growth in Crystal Lake.

Citizen concern over growth of aquatic plants in scattered shoreline areas of Crystal Lake resulted in local funding of two limnological investigations of the Lake: by Gannon in 1970 and Tanis in 1978. Both studies documented the presence near some shorelines of aquatic plants growing on the lake bottom. The earlier report by Gannon predicted that substantial increases in plant growth would occur at existing nutrient loading rates. The report recommended that a sanitary sewer be built around the lake to collect sewage for treatment and export from the Crystal Lake watershed. The conclusions and recommendations of this report and statements of the local sanitarian (Livasy n.d.) were cited in the Facility Plan as the basis for not relying on septic tank systems around Crystal Lake in the future. The later report by Tanis, showed that plant productivity had not increased as predicted and suggested that "an alternative which addresses specific problem areas may be more appropriate" than complete sewering of the shoreline. Neither the Facility Plan nor the limnological reports evaluated quantitatively the probable impacts on water quality of sewering or not sewering the shoreline of Crystal Lake.

A 41% reduction in phosphorus load to Betsie Lake, resulting in removal of phosphorus from Frankfort and Elberta wastewater, was cited in the Facility Plan. However, the Plan did not describe the relationship between such a reduction and lake eutrophication. Nor were calculations made of an increase in the nutrient load from new discharges of Crystal Lake area wastewaters and from larger discharges of effluent which would follow population growth.

3. ECONOMIC IMPACT

The estimated user charge for the Facility Plan Proposed Action was $175 per year for each residence or residential equivalent in the new sewer service area around Crystal Lake. This charge would amount to 1.9% of the permanent residents' average annual income. Crystal Lake Proposed Sewer Service Area homeowners would pay an initial $1500 for stub fee* and connection charge. In addition, the homeowner would pay for installation of a house sewer connecting his household plumbing with the public sewer.

The effect of these sewerage costs could be to encourage seasonal and fixed income residents to sell their properties or to convert from seasonal use to permanent residency.

4. INDUCED GROWTH AND SECONDARY IMPACTS

While the high costs of wastewater collection might force some current residents to move, the availability of sewers in the Crystal Lake watershed would make possible construction of new dwellings in greater number and in higher densities than is presently feasible. The potential for significant future development is indicated by the substantial number of undeveloped platted shoreline, second tier and subdivision lots in the watershed.

The rate and type of development supported by a central sewer system could have undesirable impacts. In particular, housing construction on steep slopes could accelerate soil erosion which, in turn, would increase nutrient impacts to Crystal Lake or Betsie Lake. In addition, the density and type of future development feasible with a central sewer system could be considerably different from what is presently typical of the Crystal Lake area.

C. NATIONAL PERSPECTIVE ON THE RURAL SEWERING PROBLEM

These EIS issues, that have been discussed above, are not unique to the proposed plan for wastewater management in the Crystal Lake Study Area but are typical of concerns raised by a large number of wastewater projects for rural and developing communities that have been submitted to EPA for funding. The scope of the problem has grown in the last few years as controversy has mounted over the high costs and possible impacts of providing conventional sewerage facilities to small communities across the country.

1. SOCIOECONOMICS

To assess the magnitude of the cost burden that many proposed wastewater collection projects would impose on small communities and the reasons for the high costs, EPA studied over 250 facilities plans from 49 states for pending projects for communities under 50,000 population (Dearth 1977). EPA found that, even with substantial State and Federal construction grants, the costs of conventional sewering are sometimes beyond the means of families in rural and semi-rural areas. This was particularly true for those communities where the completely new facilities proposed would result in annual user charges of more than $200 per household.

The Federal government has developed criteria to identify high-cost wastewater facilities projects (The White House Rural Development Initiatives 1978). Projects are considered to place a financial burden on rural community users when annual user charges (debt service plus operation and maintenance) would exceed:

- 1.5% of median household incomes less than $6,000;
- 2.0% of median household incomes between $6,000 and $10,000; or
- 2.5% of median household incomes over $10,000.

Annual user charges exceeding these criteria would materially affect the households' standard of living. Federal agencies involved in funding wastewater facilities will work with the community to achieve lower project costs through a change in the project's scope or design. If the project's scope or design is not changed, the agencies will work with the community until they are assured that the community is aware of the financial impacts of undertaking the high-cost project.

It is the collection system that is chiefly responsible for the high costs of conventional sewerage facilities for small communities. Typically, 80% or more of the total capital cost for newly serviced rural areas is spent for collection system. Figure I-5 indicates that the costs per residence for gravity sewers increase exponentially as population density decreases. Primary factors contributing to this cost/density relationship were found to be:

- greater length of sewer pipe per dwelling in lower-density areas;

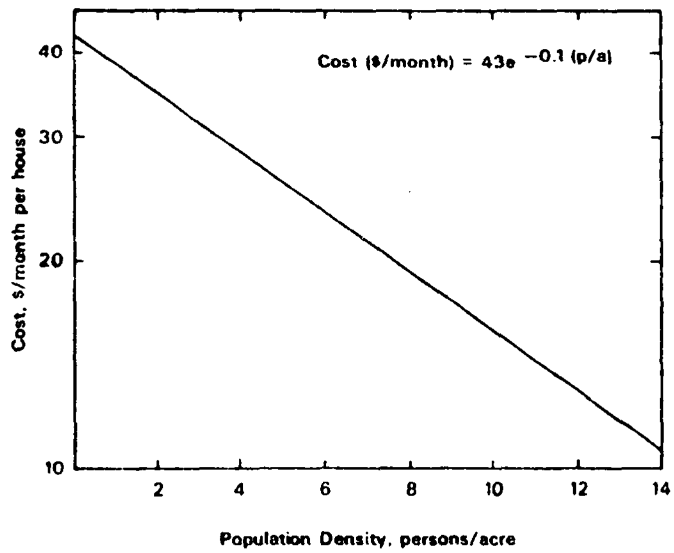
- more problems with grade, resulting in more lift stations or excessively deep sewers;

- regulations or criteria which set eight inches as the smallest allowable sewer pipe diameter; and

- inability of small communities to spread capital costs among larger populations sewered previously.

In addition to the comparatively high costs of sewers, facilities were sometimes found to be more expensive than necessary due to:

Figure I-5



Monthly Cost Of Gravity Sewers

Dearth, K.H. 1977. In proceedings of EPA national conference on less costly wastewater treatment systems for small communities, April 12-14, 1977, Reston, VA.

- o oversophistication in design, with accompanying high chemical usage, large energy requirements, and costly maintenance and operator expense, when simpler methods would do.
- o use of expensive construction materials such as non-locally produced brick and block and terrazzo when a prefab steel and concrete building would perform satisfactorily.
- o abandonment of existing treatment works without economic justification.

2. SECONDARY IMPACTS

Installation of centralized collection and treatment systems in previously unsewered areas can have dramatic effects on development and, hence, on the economy, demography and environment of rural communities. These effects can be desirable, or they may substantially offset community objectives for water resource improvement, land use planning and environmental protection.

In broad terms, a community's potential for recreational, residential, industrial, commercial or institutional development is determined by economic factors such as the availability of land, capital, skilled manpower and natural resources. However, fulfillment of the potential can be limited by the unavailability of facilities or services called infrastructure elements, such as water supply, sewerage, electric power distribution and transportation. If a missing infrastructure element is supplied, development of one type or another may take place, depending upon prevailing local economic factors. Such development is considered to be "induced growth" and is a secondary impact of the provision of the essential infrastructure element.

Conflicts between induced growth and other types of existing or potential development are also termed secondary impacts as are induced growth's effects on existing water resources, land use, air quality, cultural resources, aesthetic features and environmentally sensitive areas.

Secondary impacts of new wastewater facilities may be highly desirable. For example, diversification of the local employment base may be possible only when sufficient wastewater collection and treatment capacity is provided for commercial or industrial development. On the other hand, new commercial or industrial development may not be compatible with existing recreational or agricultural interests. Residential development accompanying expansion of the employment base may take place on prime agricultural land, steep slopes or wetlands, or may otherwise infringe on valued natural features.

3. THE NEED FOR MANAGEMENT OF DECENTRALIZED ALTERNATIVE SYSTEMS

A promising alternative to expensive centralized sewer systems in rural areas is a decentralized wastewater management system. Both engineering and management are integral parts of such a system, and "decentralized alternatives," as used in this EIS, incorporate both engineering and management elements.

Briefly, the engineering element consists of the use of existing and new on-site systems, rehabilitation or replacement of those systems where necessary, and construction of small-scale off-site systems where existing on-site systems are not acceptable.

The management element consists of continuing supervision of the systems' installation, maintenance, rehabilitation and appropriate monitoring of the systems' environmental impacts.

While other factors such as soil characteristics, groundwater hydrology and lot configurations are highly important, adequate management may be critical to the success of decentralized alternatives in many communities. Similarly, lack of adequate management undoubtedly contributed to past failures of many on-site wastewater facilities and, therefore, the lack of trust in which they are held by local public health officials and consulting engineers.

Historically, state and local health officials were not empowered even to regulate installation of on-site systems until after World War II. They usually acted in only an advisory capacity. As the consequences of unregulated use of the septic tank-soil adsorption systems became apparent in the 1950s and 1960s, health officials were granted new authority. Presently most health officials have authority for permitting and inspecting or denying new installations, and they can require renovation and replacement of on-site systems. However, their role in the operation and maintenance of on-site systems remains largely advisory. There is seldom either a budget or the authority to inspect or monitor a system.

In the 1970's, the Congress recognized the need for continuing supervision and monitoring of on-site systems in the 1977 Clean Water Act. Now, EPA regulations implementing that Act require that, before a construction grant for on-site systems may be made, the applicant must meet a number of requirements and must:

- Certify that it will be responsible for properly installing, operating and maintaining the funded systems;
- Establish a comprehensive program for regulation and inspection of on-site systems that will include periodic testing of existing potable water wells and, where a substantial number of on-site systems exists, more extensive monitoring of aquifers; and
- Obtain assurance of unlimited access to each individual system at all reasonable times for inspection, monitoring, construction, maintenance, operation, rehabilitation and replacement.

In some cases, implementation of these requirements by municipalities may be hindered by lack of state enabling legislation for small waste flow management districts and by lack of adequately trained manpower. The municipality may have no control over the former and be at a disadvantage because of the latter. Other implementation factors, over which municipalities should have control, are discussed in Section III.D of this EIS.

D. PURPOSE AND APPROACH OF THE EIS AND CRITERIA FOR EVALUATION OF ALTERNATIVES

1. PURPOSE

This EIS documents EPA's review and analysis of the application for EPA Step II funding of the Facility Plan Proposed Action. Based upon this review, the Agency will take one of several actions:

- Approve the grant application, possibly with recommendations for design changes and/or measures to mitigate impacts of the Facility Plan Proposed Action;

- Return the application with recommendations for additional Step I analysis;

- Reject the grant application; or

- With the applicant's and State's concurrence, approve Step II funding for an alternative to the Facility Plan Proposed Action, as presented in this EIS.

The review and analysis focused on the issues identified in Section I.B and was conducted with an awareness of the more general considerations of rural sewering problems discussed in Section I.C. Major emphasis has been placed on developing and evaluating alternative wastewater management approaches to be compared with the Facility Plan Proposed Action.

2. APPROACH

The review and analysis reported in this EIS included a series of tasks, which were undertaken in approximately the following sequence:

a. Review of Available Data

Data presented in the Facility Plan and other sources were reviewed for applicability in development and/or evaluation of the Plan Proposed Action and of the new alternatives developed for the EIS (EIS Alternatives). Sources of data are listed in this Bibliography.

b. Segment Analysis

As a basis for revised population projections and for development of alternatives the Proposed Service Area was partitioned into a number of segments. The number of dwellings in each segment was counted from black and white aerial photographs. Available information on soils, depth to groundwater, water quality problems, environmentally sensitive areas and land use capabilities was tabulated for each segment and the tabulations used to make preliminary estimates of the need for off-site wastewater disposal.

c. Review of Wastewater Design Flows

Available population projections were revised on the basis of the segment house counts. New EPA guidelines for estimating design wastewater flows were then used to revise the year 2000 wastewater flow projections.

d. Development of Alternatives

First, technologies that might potentially reduce project costs or minimize adverse impacts while still solving existing problems were examined. Four categories of alternative technologies -- flow reduction, low-cost sewers, decentralization, and land application -- were considered according to their functions in a wastewater management system. Next, several specific areawide alternatives were developed, combining the alternative technologies into complete wastewater management systems that would serve the Proposed Service Area. The technologies and the alternatives are described in Chapter III.

e. Estimation of Costs for Alternatives

In order to assure comparability of costs between the Facility Plan Proposed Action and EIS alternatives, all alternatives were designed to serve a fixed design year population. Total present worth and local user charge estimates were based upon unit costs listed in a separate engineering report (Arthur Beard Engineers, Inc. 1978)

f. Evaluation of the Alternatives

The new alternatives were developed with a knowledge of the local environmental setting and with the understanding that they will be evaluated under criteria from several disciplines. The general criteria for evaluating both the Facility Plan Proposed Action and the EIS alternatives are listed in Section I.D.3 below.

g. Needs Documentation

The need for improved treatment of Frankfort's and Elberta's wastewater is clear and is not at issue in this EIS. However, the effects of lakeshore on-site systems on Crystal Lake, groundwaters and public health had not been clearly documented in the Facility Plan. Because determination of eligibility for Federal funding of a substantial portion of the Facility Plan Proposed Action will be based on the documentation of these effects, several supplemental studies were conducted:

- an aerial survey of visible septic tank system malfunctions using low-altitude color and infrared photography by EPA's Environmental Photographic Interpretation Center;

- estimation of the existing Crystal Lake nutrient budget and empirical modeling of the lake's eutrophication status;

- a sanitary survey of lakeside residences conducted by the University of Michigan Biological Station to evaluate usage, design and condition of on-site systems;

- a "Septic Snooper" survey to locate and sample septic tank leachate plumes entering Crystal Lake from nearby on-site systems; and

- evaluation by the Soil Conservation Service of soil suitability for on-site systems.

The results of these needs documentation studies were not available for consideration in the initial development of alternatives. The results of each study have required continuing modification of the alternatives as initially designed and have been the basis for necessary refinements in the determination of the eligibility of any new sewers around Crystal Lake for Federal funding.

3. MAJOR CRITERIA FOR EVALUATION OF ALTERNATIVES

While the high cost of sewering rural communities is a primary reason for examining alternative approaches to wastewater management, cost is not the only criterion. Trade-offs between cost and other major impacts will have to be made. The various criteria are defined below.

a. Cost

With some exceptions for innovative technologies, EPA construction grant regulations allow funding of only the most cost-effective alternatives. Cost effectiveness has been measured here as the total present worth of an alternative, including capital costs for facilities needed now, capital costs for facilities required later in the 20-year planning period, and operation and maintenance costs for all wastewater facilities. Salvage value for facilities expected to be in service after 20 years has been deducted. Analyses of cost effectiveness do not recognize differences between public and private expenditures.

The responsible municipality or sanitary district will recover operation, maintenance and local debt retirement costs through periodic sewage bills. The local economic impact of new wastewater facilities will be felt largely through associated residential user charges. Only publicly financed costs were included in residential user charges. Salvage value was not factored into residential user charges.

No assumptions were made here about frontage fees or hook-up charges that might be levied by the municipalities. Therefore, the user charges reported here for the alternatives are not directly comparable to those reported in the Facility Plan, where each newly sewered residence would pay $1,500 in connection and stub fees.

Some homeowners may incur costs that they would have to pay directly to contractors. Installation of gravity house sewers on private land and renovation or replacement of privately owned on-lot systems for seasonally occupied dwellings are not eligible for Federal funding and are seldom financed by municipalities. These private costs are identified for each alternative.

b. Significant Environmental and Socioeconomic Impacts

The system selected for the Proposed Service Area will impact on environmental and socioeconomic resources within the Study Area. Following a comprehensive review of possible impacts of the Facility Plan Proposed Action and the EIS alternatives, several types of impacts were determined to warrant in-depth evaluation and discussion in this EIS. These impacts are classified as follows:

- o Surface Water Quality Impacts,
- o Groundwater Impacts,
- o Population and Land Use Impacts including Infringement on Environmentally Sensitive Areas, and
- o Economic Impacts.

c. Reliability

Reliability criteria for the alternatives include both ability to remedy existing water quality problems and prospects of protecting water quality in the future. This first criterion was applied in the analysis of surface and groundwater impacts of the alternatives presented in Chapter IV. That analysis assumed that the collection, treatment and disposal units of each alternative would operate effectively as designed. The second criterion recognizes that all structural, mechanical and electrical facilities are subject to failure. Types of possible failures and appropriate remedies and preventive measures were reviewed for selected components of the alternatives.

d. Flexibility

The capability of an alternative to accommodate increasing wastewater flows from future development in the Proposed Service Area is referred to as its flexibility. In order to demonstrate the relative levels of investment for different alternatives, all were designed and costed to provide service for the same population -- the design year population projected in Chapter II. However, factors such as the amount of land that could be developed using on-lot systems or the ability to increase the capacity of a treatment plant might have a significant effect on future development in the Study Area. The capability of the alternatives to accomodate increased wastewater flows is reviewed in Chapter III. The effects of the alternatives' flexibility on population growth are predicted in Chapter IV.

CHAPTER II
ENVIRONMENTAL SETTING

INTRODUCTION

The abundant water resources and their many recreational opportunities make the Crystal Lake Study Area a pleasant place to live and an inviting vacation spot.

The centerpiece of the region is Crystal Lake, more than 8 miles long, very deep and very clear. Framed by wooded morainic cliffs, it is one of the major scenic attractions of northern Michigan. The surrounding landscape ranges from sand dunes and rolling terraces to steep hills and ridges rising 300 feet above lake level. Marshes and (wet) woodlands are home to a variety of animal and plant life. The Lake is a notable cold water fishery, "managed" for game fishing.

Part of the free-flowing Betsie River, which passes through the Study Area, has merited designation by the State of Michigan as a "natural river," and preservation of its aesthetic values is thus safeguarded. The link between the River and Lake Michigan is Betsie Lake, which is not only an important recreational asset but also furnishes harboring, docking and mooring for Great Lakes shipping.

Lake Michigan, which moderates weather and climate in the area and brings commerce to its port, offers more recreational opportunity.

Still another outstanding resource is Round Lake and its environs, which have been included in the Sleeping Bear Dunes National Lakeshore Park.

The original hardwood forests have long since been logged. Early settlers cleared the land, and agriculture predominated in the region for many years. Today there are patches of woods, and prime agricultural land in row crops or orchards, but now agriculture employs only 7.2% of the permanent population. The largest single employer is Pet, Inc., but service and retailing, oriented largely toward vacationers, are the major occupations.

The Crystal Lake area is a well-established recreation center. Boating, swimming, sailing and water skiing are popular, as is fishing. The Betsie River, a year-round fishing stream, is a spawning ground for trout and salmon and contains other game species as well. Just to the north are a fine salmon fishery and a wilderness area, and wildlife offers recreation to both hunter and observer. Hang gliding, other air sports and, in the winter, nearby skiing add to the diversity of recreation available.

The Study Area also serves as a gateway and a service area for visitors to these other recreational attractions as it lies between them and major population centers to the south. It is a role that is likely to grow, expecially with the planned expansion of facilities for the Sleeping Bear Dunes Park.

The vacation population now approaches, and may surpass the Study Area's year-round population by the end of the century, when a total of 12,000 is projected. The only city in the area, Frankfort, had a permanent population of 1,822 in 1975. No income data are available on the seasonal population, but information on Benzie County indicates that the range of incomes of the permanent population is below the State average while the proportion of retired or elderly persons is higher than the State average. Throughout the area, residential structures are primarily single-family dwellings.

Evaluation of the courses of action open to EPA must start from an analysis of the existing situation. This chapter offers an inventory of baseline conditions, divided into such categories as soils, groundwater, surface water, and biology. Social and economic aspects of the human environment are discussed, as is the functioning of wastewater treatment facilities presently in operation.

Use was made of existing data, but it was necessary to undertake additional field work in order to obtain better information and to resolve such key issues as the need to sewer Crystal Lake's entire shore. The new studies included: a sanitary survey; a sampling of leachate plumes from nearby septic systems; an aerial survey of visible septic tank malfunctions; a soils survey; estimation of nutrient loads entering Crystal Lake; and modeling of the Lake's eutrophication status. In general, data given in the tables are not repeated in the text, and readers wishing more information should use the Appendixes for fuller explanations and details.

Research has revealed striking contrasts between Crystal Lake and Betsie Lake. The watershed acreage that drains into Crystal Lake is only twice as large as the surface area of that lake; for Betsie Lake, this ratio is 627:1. Similarly, it is estimated that water entering Crystal Lake remains for 63 years, but water entering Betsie Lake flows out within 2 days. Although its depth and water retention time make Crystal Lake a "nutrient trap," and although there are some algal growths near portions of the shore, its quality is excellent. Betsie Lake, despite its heavy outflow, is eutrophic, and it may be difficult to correct this condition.

A. PHYSICAL ENVIRONMENT

1. PHYSIOGRAPHY

The landscape of the Crystal Lake Area has its origin in the events of the glacial age that shaped the entire northern part of the United States. The major features in the Study Area that were formed by that glaciation are the following:

- Lake Michigan -- the area's western boundary. Mean lake elevation is 580 feet above mean sea level (msl).

- Crystal Lake -- the center of the Facility Planning Area, with a surface area of approximately 9700 acres. It is roughly rectangular in shape. Its long axis is 8.14 miles, running northwest to southeast.

- Lake-bed sands, outwash* materials, sand dunes and exposed lake terrace -- primarily to the east and west of Crystal Lake. Relatively narrow lake terraces are on the north and south shores.

- Morainic hills and ridges -- north and south of Crystal Lake. With elevations of over 900 feet above msl, the hills and ridges are the highest points in the Study Area. Some slopes in moraine areas exceed 30%.

- The Betsie River -- to the south of Crystal Lake. The River widens into Betsie Lake prior to entering Lake Michigan.

Other features of the area include the broad, flat floodplains of Round Lake, Long Lake, and Rush Lake to the north of Crystal Lake. At one time a pond was formed in the floodplain of the Betsie River, in the southeast corner of the Study Area, by construction of Homestead Dam, but it disappeared when the dam was removed.

An interesting feature of the Crystal Lake shoreline is the sandy lake terrace on the north and south, which was exposed in 1873 by the inadvertent lowering of the water level, thereby providing a strip of land on which roads and houses have been built.

The town of Beulah lies on the lake-bed sands and outwash plains east of Crystal Lake; there is also agricultural use. The towns of Frankfort and Elberta are located in relatively level areas north and south of Betsie Lake, and the rolling topography of the dunes area between Crystal Lake and Lake Michigan has also attracted residential development. Benzonia, at the southeast corner of Crystal Lake, is the only major area developed on the moraines.

The entire Study Area is drained by the Betsie River, which empties into Lake Michigan through Betsie Lake.

Topographic relief of the Study Area is illustrated in Figure II-1; topographic features that are sensitive to development, e.g., slopes greater than 15%, are identified there.

2. GEOLOGY

Sediments of glacial origin, characterized by sandy, hilly moraines, alluvial and eolian sands, and glacial outwash overlie Devonian limestones and shales in the Study Area. The bedrock limestone of the Traverse formation generally borders Lake Michigan and is approximately 1700 feet thick (see Figure II-2). It underlies most of the Study Area, extending to the eastern limit of Crystal Lake. Immediately east of the Traverse limestones and lapping over them are the black Antrim shales which average as much as 100 feet in thickness (Martin 1957). The surficial geology of the Study Area is shown in Figure II-3.

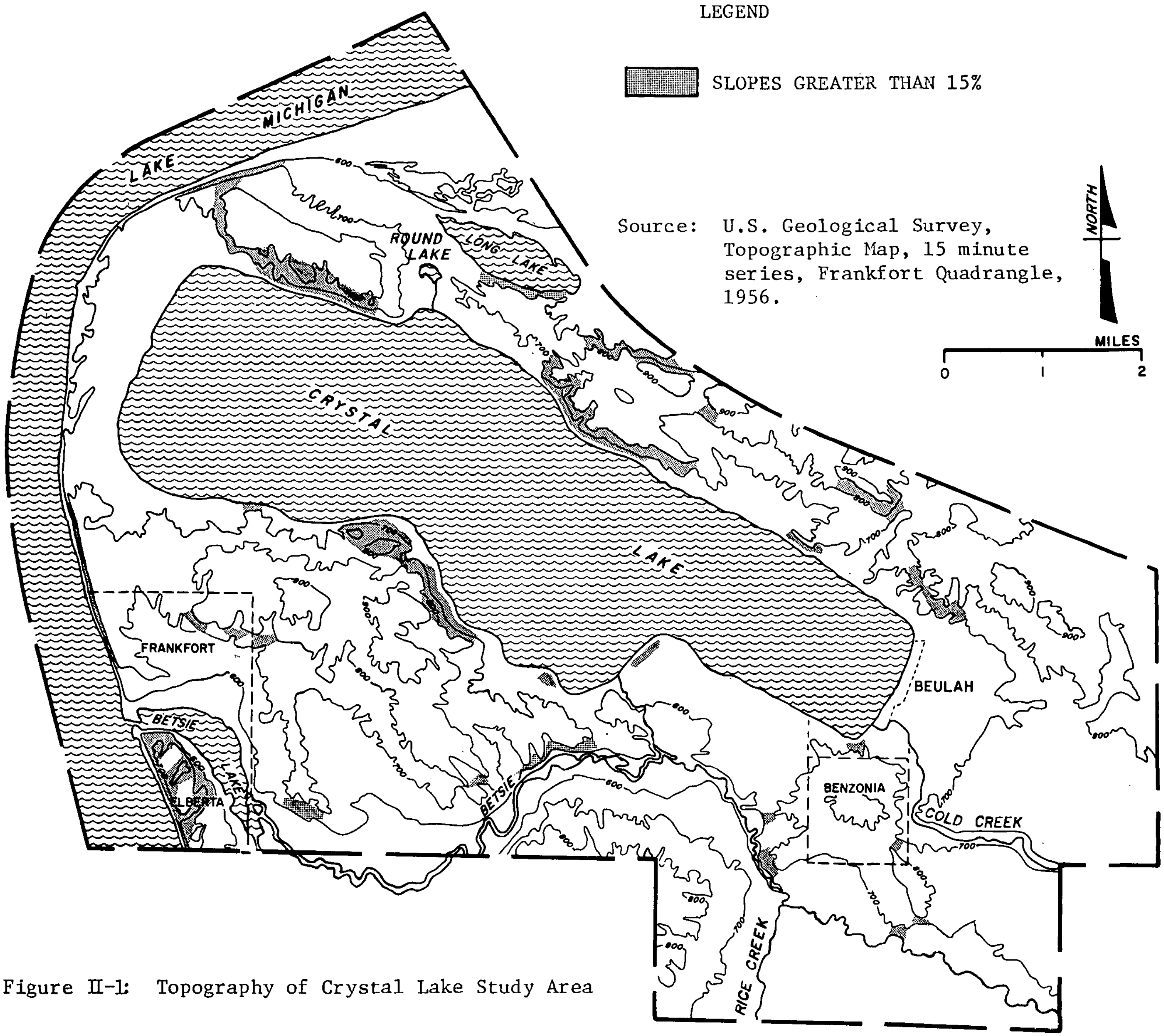


Figure II-1: Topography of Crystal Lake Study Area

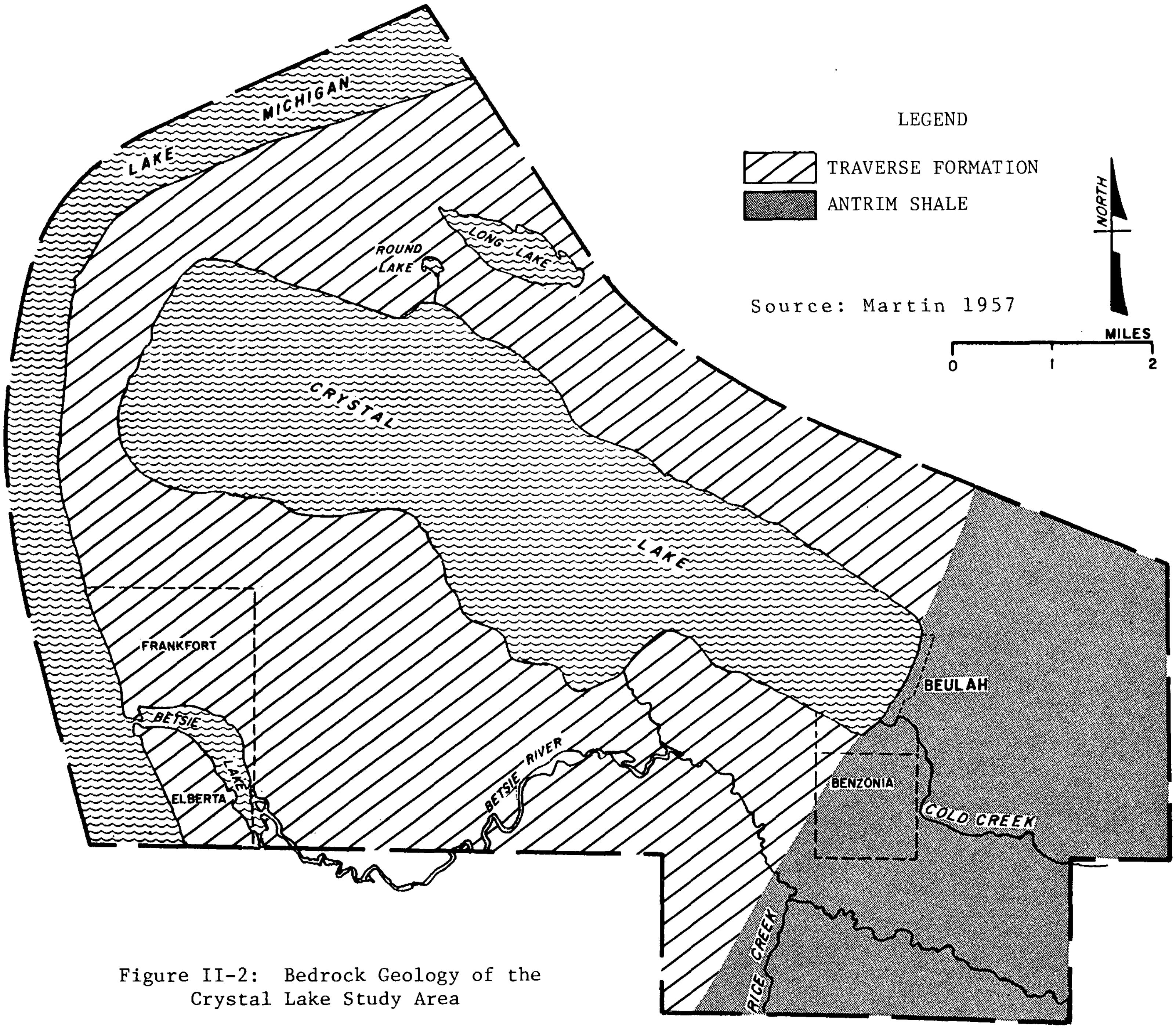


Figure II-2: Bedrock Geology of the Crystal Lake Study Area

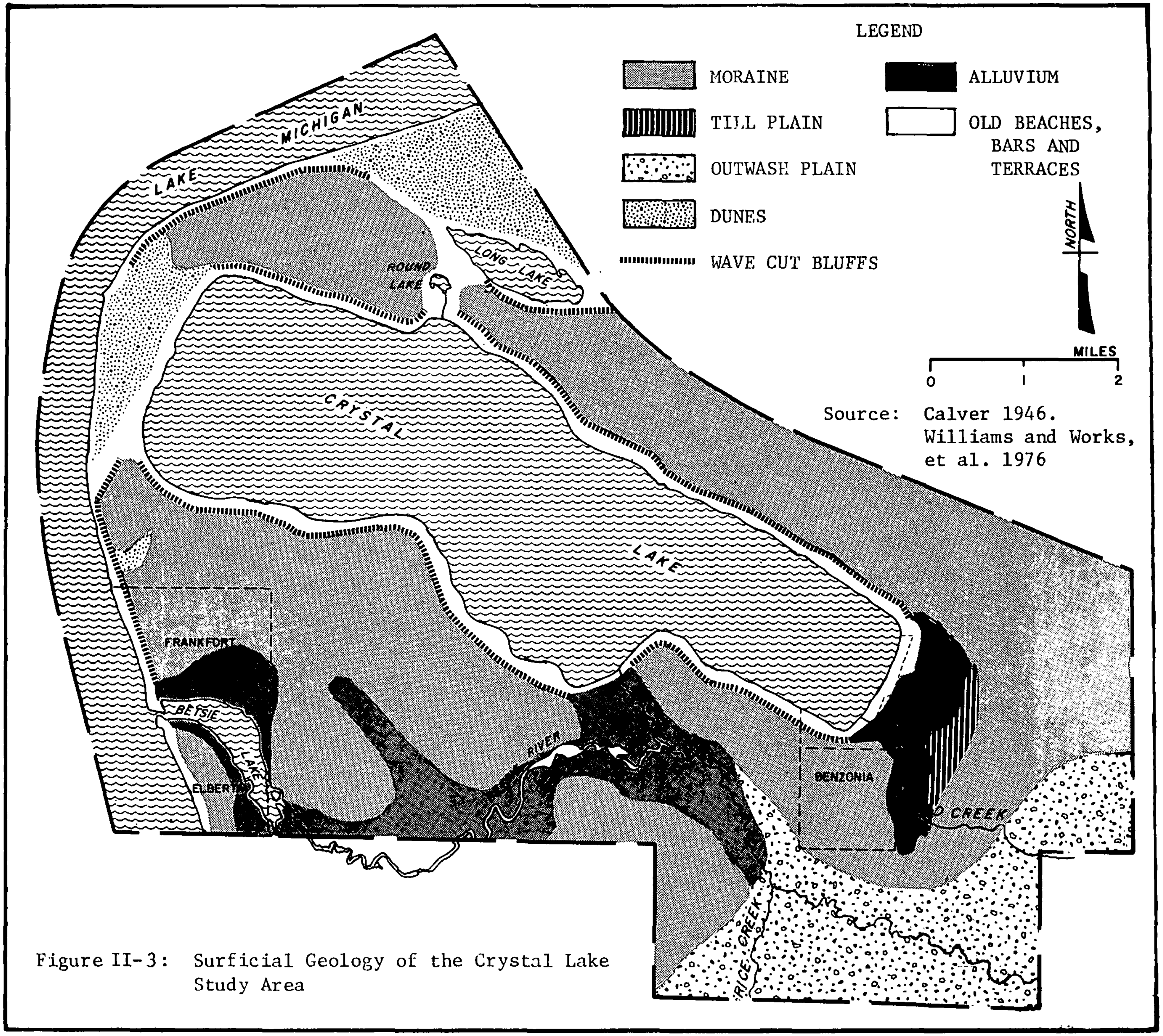


Figure II-3: Surficial Geology of the Crystal Lake Study Area

3. SOILS

The soils in Benzie County were formed primarily from materials deposited by glaciers. The major soil associations shown in Figure II-4 generally reflect the surficial geology carved during glacial advance and retreat. The characteristics of these associations are as follows:

- o Nester-Iosco-Emmit Association -- Well to intermediately drained shallow loams and sandy loams developed along the Betsie River floodplain.
- o Wexford-Emmit-Kalkaska Association -- Well drained, deep, dry sands on the sand moraines in the area.
- o Kalkaska-Rubicon Association -- Well drained, deep, dry sands on outwash plains to the east of Crystal Lake.
- o Eastport Association -- Poorly drained, deep sands characterized by high water table and occasional pockets of peat accumulations.
- o Bridgeman Association -- Well drained, very deep dune and lacustrine sands developed along the Lake Michigan shoreline west of Crystal Lake.

a. Soils Suitability for Septic Tank Absorption Fields

Suitability of soils for septic tank absorption fields is based primarily on slope, permeability, depth to seasonal high water table and hydraulic conductivity. The role of these factors in determining whether or how well effluent can percolate through the soil is discussed in Appendix A-2. Appendix A-3 shows ranges for these parameters which place slight, moderate or severe limitations on soils for on-site disposal systems.

The Soil Conservation Service (SCS) is currently in the process of performing a soils survey for Benzie County. The SCS has indicated that currently available information on soils is limited in scope and accuracy and should be used for general planning purposes only (by letter, Steve Utic, SCS). A discussion of the available soils data can be found in Appendix A-1.

In order to provide a general indication of soils suitability in the Study Area, the SCS used the existing soils data to formulate the Land Resources Inventory Map (1972) shown in Figure II-5. The SCS emphasized that the existing data are neither complete nor very accurate.

The Land Resources Inventory Map shows extensive areas that are limited in suitability by slopes (S), wetness, (W) and slow permeability (T). Soils designated "L" on Figure II-5 are most suitable for on-site systems or cluster systems. Generally these soils have slopes of less than 12% and rapid permeability, but some wet soils and steeply sloping soils are known to be present. "L" soils appeared to be suitable for

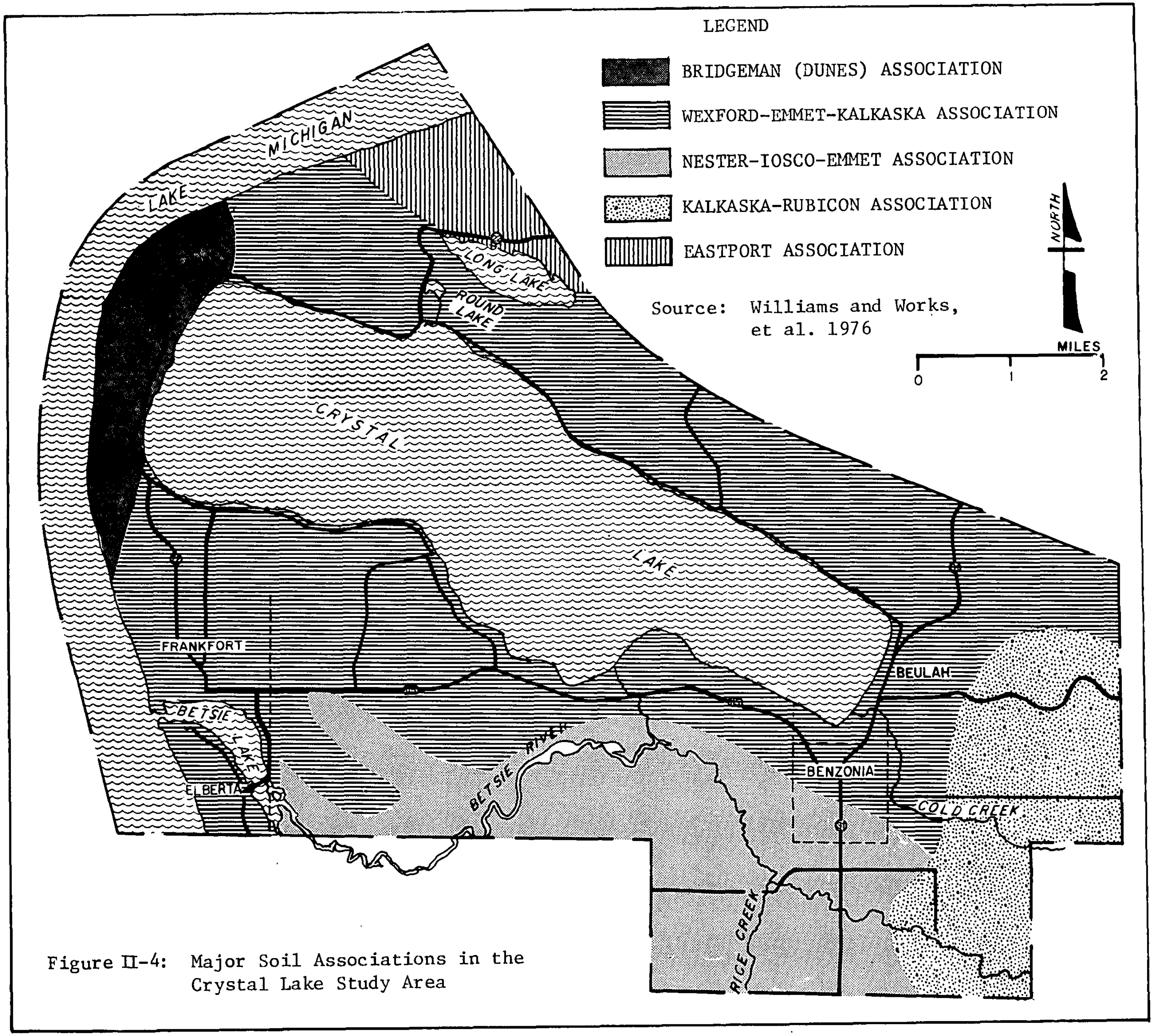


Figure II-4: Major Soil Associations in the Crystal Lake Study Area

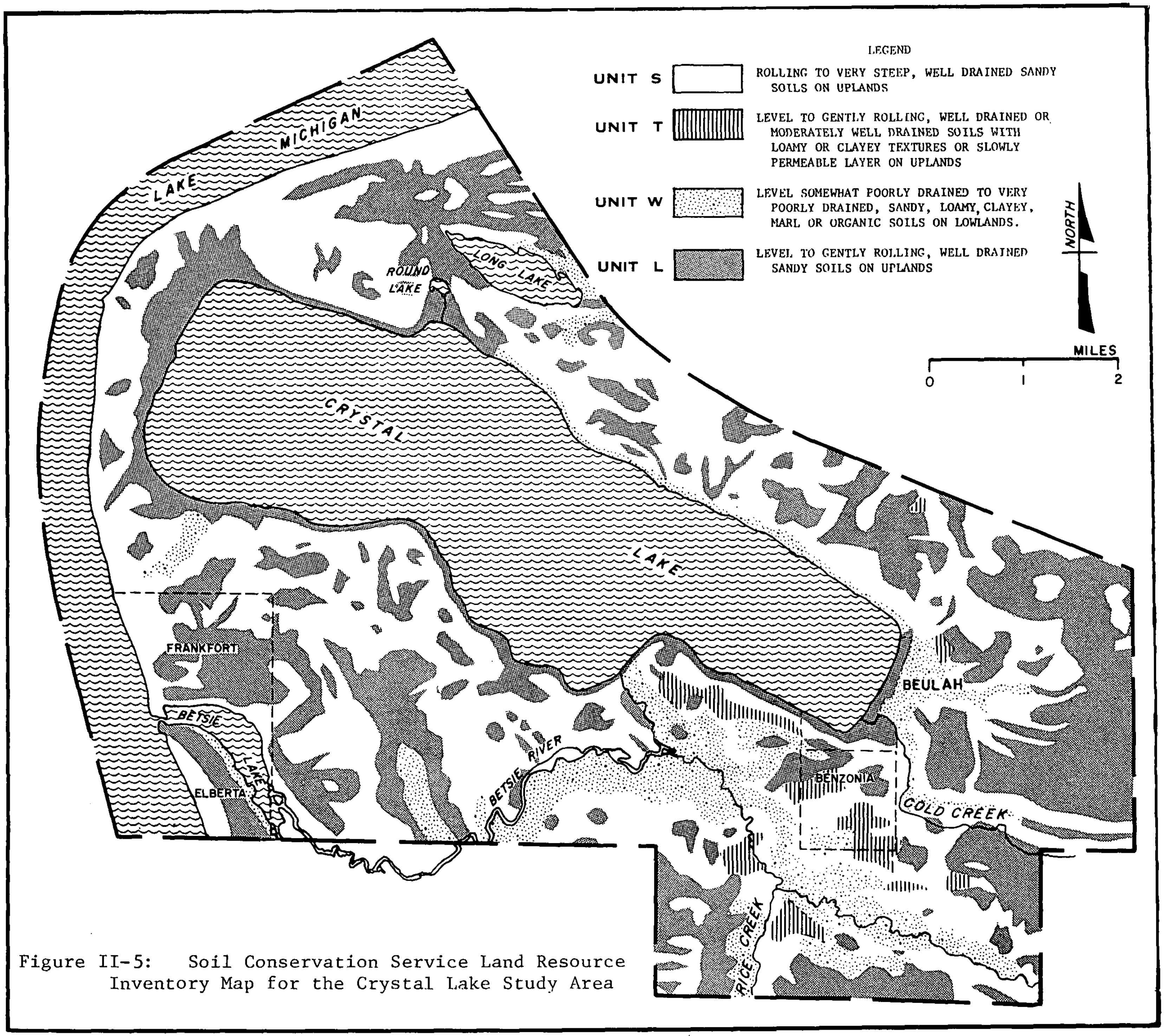


Figure II-5: Soil Conservation Service Land Resource Inventory Map for the Crystal Lake Study Area on-site systems provided that 1) these systems were not located on steep slopes or wet soils or 2) systems were designed to account for these limitations. Since the extent and location of these wet and steep soils were not known, EPA requested that SCS field check selected "L" soils to determine their suitability for on-site systems along the shoreline and on land with a minimum set back distance of 100 feet from shore.

Sites set back from lake. The "L" type soils included suitable sites for cluster systems on land set back from the shore. Within the "L" soils were found scattered areas with steep slopes, particularly to the north of Crystal Lake. Pockets of wet soils were also found, but they are rare and mostly limited to the area adjacent to the southeast shore (by letter, R. Larson SCS, 1 December 1978). Steep slopes are the major soils limitation for on-site systems located more than 100 feet from the shore. These soils could be used for on-site or cluster systems provided that the systems were designed to prevent sidehill seepage of effluent. On sloping ground, drop boxes in a serial system provided the best method of distributing the effluent.

Shoreline Sites. Soils borings taken by the SCS in Autumn 1978 (by letter, R. Larson, 1 December 1978) from shoreline sites showed that all 74 sites sampled were unsuitable due to a seasonal high water table, although for some sites, a hazard to nearby water supplies or slow permeability were the limiting factors. Figure II-6 shows the approximate location of the soil borings and the specific limitation for each site. Table II-1 summarizes the results by township.

The Health Department, however, has found that soils on over half of the vacant lots in the Proposed Service Area evaluated between 1972-1977 were suitable for septic tanks. The distribution of suitable sites in the lakeshore townships is also shown in Table II-1.

In general, suitability was limited by depths to the seasonal high water table (<4 feet). Less frequently, poor permeability due to high clay content was the limiting factor (Sections 15, 16 and 21 of Benzonia Township and Sections 15 and 19 of Crystal Lake Township) (GT-L-BHD December 1977)

The SCS and the Health Department use somewhat different criteria in determining soils suitability. The Health Department does not deny a permit application for a septic tank on highly permeable soils. SCS, however, considers highly permeable soils to be a severe limitation if the systems are located near operating wells. However, this difference alone does not account for the large discrepancy between SCS data and the data from the Health Department. Most of the sites determined to be unsuitable by SCS had a seasonal high groundwater table; this is an important criterion used by the Health Department, as well. The SCS indicated that the seasonal high water table was difficult to determine in many instances; since Crystal Lake was lowered some 100 years ago, a natural soils profile has not had sufficient time to develop (by letter, R. Larson 1978). Therefore, one explanation for the discrepancy may be that the seasonal high water table may not be as high as was suggested to SCS in their surveying.

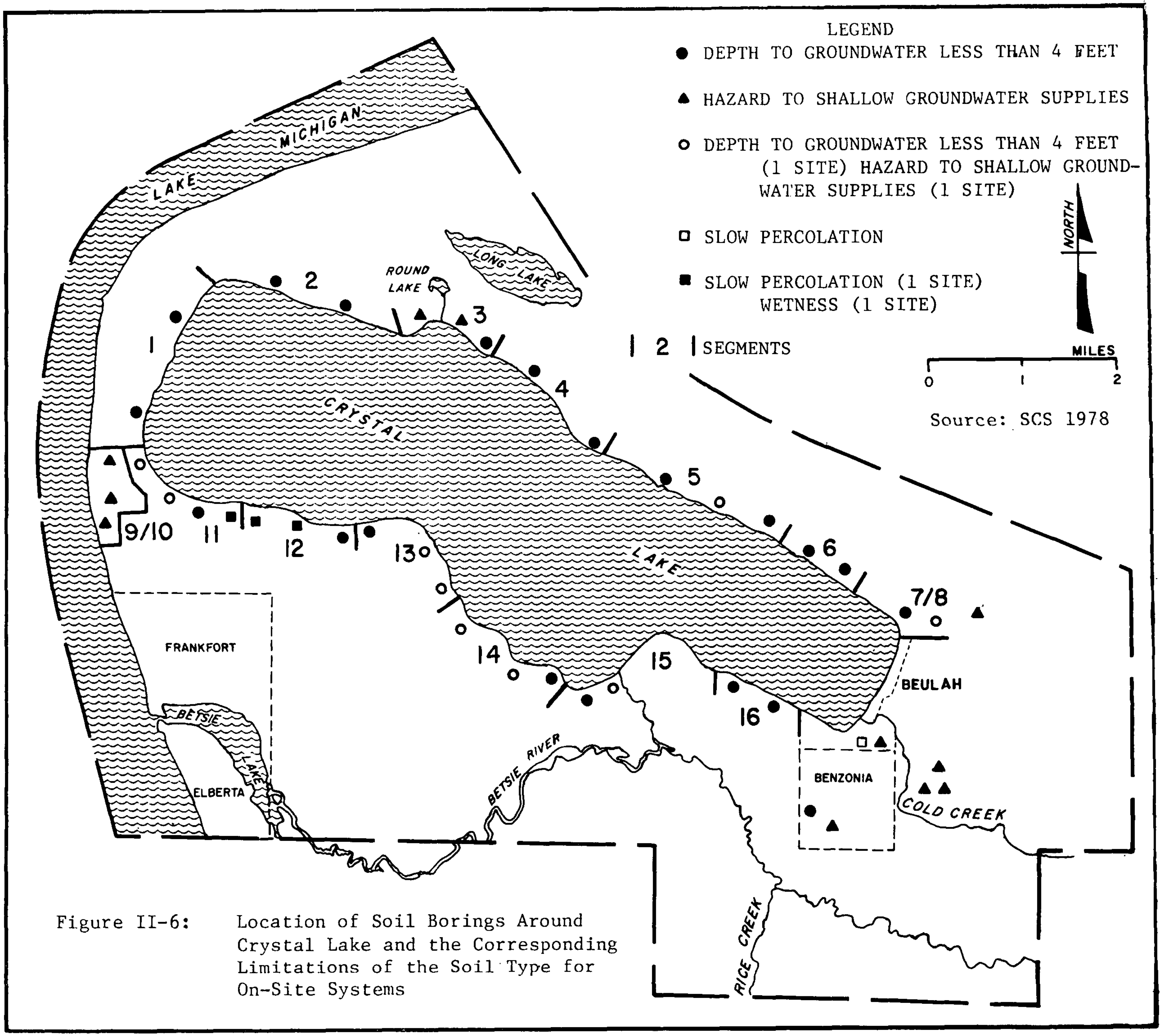


Figure II-6: Location of Soil Borings Around Crystal Lake and the Corresponding Limitations of the Soil Type for On-Site Systems

Table II-1

SOILS SUITABILITY FOR ON-SITE SYSTEMS AROUND CRYSTAL LAKE

SCS Ratios of Selected Lakeshore Site Soils (See Figure II-6):

Township	Seasonal High Water Table	Limitations for Other Sites
Benzonia North Shore	11 out of 15 (73%)	All others pose a threat to nearby water supplies
South Shore	4 out of 4 (100%)	-
Crystal Lake	22 out of 38 (58%)	Steep slope, slow percolation and hazard to nearby water supply
Lake Shore	12 out of 17 (71%)	All others pose a threat to nearby water supplies

By letter, Richard L. Larson, Soil Scientist, SCS, 1 December 1978.

Grand Traverse - Leelanau - Benzie District Health Department Evaluation of Site Suitability for On-Site Systems 1972 - 1977:

	Benzonia	Crystal Lake	Lake	Total
Suitable	8 (27%)	22 (85%)	9 (64%)	39 (56%)
Unsuitable	22 (73%)	4 (15%)	5 (36%)	31 (44%)
Total	30	26	14	70

By phone, W. Crawford, Sanitarian, GT-L-BHD. 28 July 1978.

Despite the extent of unsuitable soils along the lakeshore, very few existing systems experience the problems that might be anticipated from unsuitable soils. (See Section II.C for discussion of this point.)

b. Soils Suitability for Land Application

Major soils characteristics limiting land application include permeability, depth to groundwater and slope. Soils suitability varies with the type of land application process (rapid infiltration, overland flow or slow rate); Appendix A-4 shows suitable soil characteristics for the major land application processes. Based on the Land Resources Inventory Map (1972) (Figure II-5) the most suitable soils are those designated "L", the nearly level well drained, sandy soils. SCS (by letter, R. Larson, SCS, 1 December 1978) performed a soils survey on potential land application sites in "L" type soils of Crystal Lake (see Figure II-7 for site locations). The survey indicated that the soils were sands and loamy sands, with a seasonal high groundwater table more than 6.0 feet below the ground surface. The survey also indicated that these soils were rapidly permeable and may be more suitable for rapid infiltration than spray irrigation. Further on-site testing would be required to confirm the suitability of these soils. Steep slopes located on these sites would require extensive earthwork to be made suitable. Therefore, application sites would be limited to level or slightly sloping areas.

c. Prime Agricultural Lands

The Soil Conservation Service, of the United States Department of Agriculture, has set forth general guidelines for a national program of inventorying prime and unique farmlands (SCS 1977). Prime and unique farmlands have been designated as those lands which can produce present and future food and fiber supplies with the least use of energy, capital and labor and with minimal environmental impact. Figure II-8 shows the extent of prime agricultural lands within the Study Area.

4. ATMOSPHERE

a. Climate

Lake Michigan has a very decided effect upon the area's weather and climate. The prevailing west and southwest winds tend to moderate the temperature, resulting in warmer winter temperatures and cooler summer temperatures than occur further inland. Precipitation also is moderate.

Climatological data collected in Frankfort are sparse, so data from the nearest US weather station, in Manistee, Michigan, 30 miles south of the Study Area, were also utilized in developing the temperature and precipitation normals, which are given in Table II-2.

Summer temperatures often reach 90°F during July and August but very seldom rise above it. Winter minimum temperatures are commonly

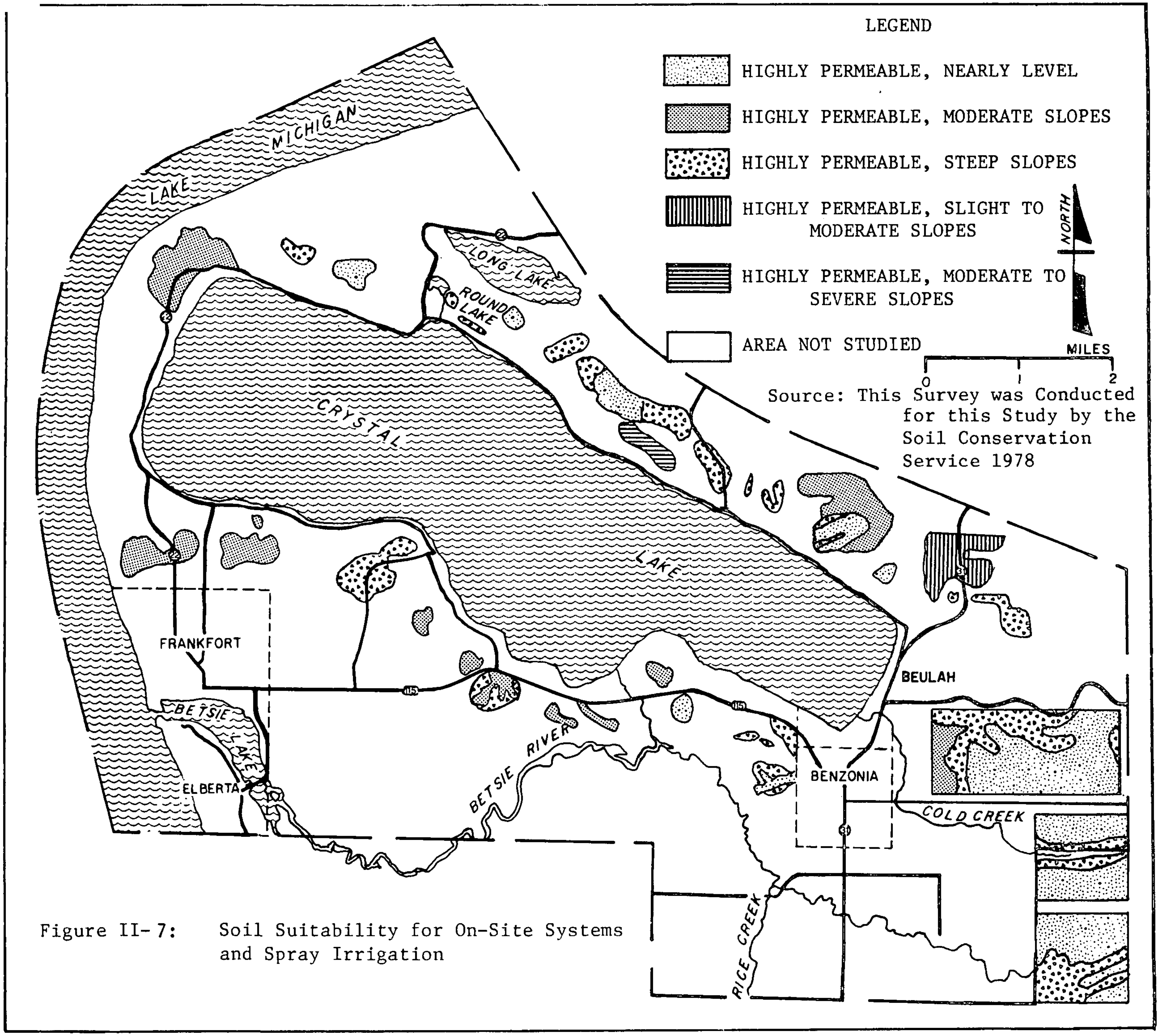


Figure II-7: Soil Suitability for On-Site Systems and Spray Irrigation

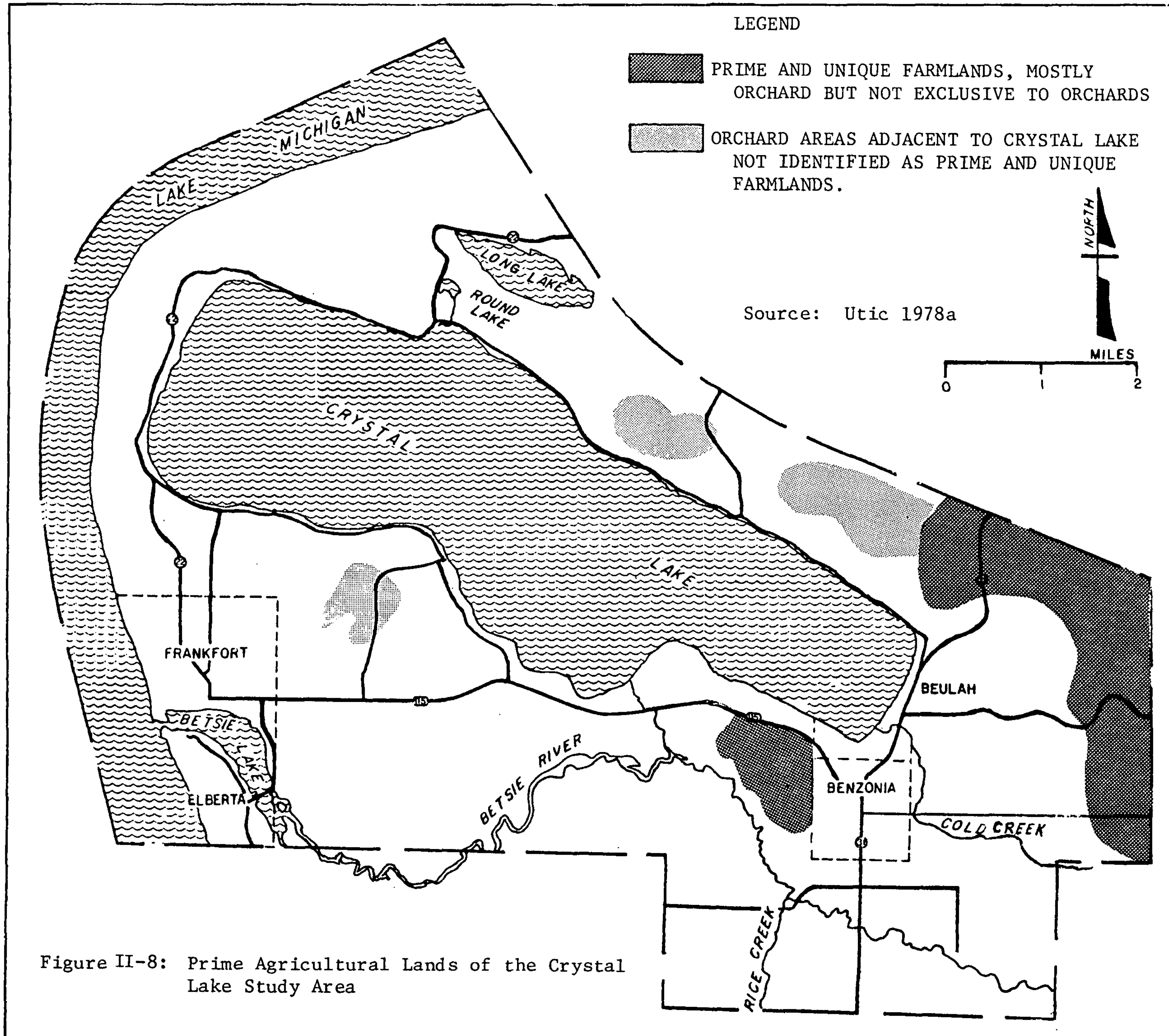


Figure II-8: Prime Agricultural Lands of the Crystal Lake Study Area

Table II-2
CLIMATOLOGICAL SUMMARIES FOR THE CRYSTAL LAKE AREA

Station*		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
1	Temperature (°F)	23.4	24.1	31.7	44.3	54.3	64.3	69.1	68.4	61.1	51.6	38.9	28.3	46.6
	Precip. (in.)	2.02	1.64	1.54	2.81	2.73	3.01	2.72	2.66	3.66	2.74	2.97	2.12	30.92
	Wind direction	NW			WNW			WSW			W			
	Wind speed (mph)	11			12			8			9			
2	Temperature (°F)	22.5	26.7	30.9	40.7	53.0	64.5	68.2	65.9	56.5	48.6	36.4	23.4	44.8
	Precip. (in.)	3.26	2.58	4.10	2.04	4.26	2.99	1.97	3.85	3.01	1.54	2.74	1.73	32.6
	Wind direction	NW			WNW			WSW			W			
	Wind speed (mph)	11			12			8			9			

*1 - Manistee, Manistee County, Michigan
(30 miles south of the Study Area)
2 - Frankfort, Benzie County, Michigan

NOAA. 1973, 1977.
USGS. 1970. The National Atlas of the United States. Department of the Interior.

below 20°F. The mean date for the last freezing temperature (32°F) is May 15, while the mean date for the first 32°F temperature is October 10. The growing season lasts approximately 150 days.

During the summer months, precipitation occurs primarily as scattered showers and thunderstorms. Annual snowfall averages 75 inches, with one inch or more of snowfall occurring at least 30 days during the year, according to the US Geological Survey (USGS) (1970). Mean annual relative humidity is 70%, and the mean annual dew point temperature is 37°F (USGS 1970). Prevailing wind directions and speed are shown in Table II-2.

b. Noise

Outside of highway or road noises and motorboat noises, the Study Area has no known intensive noise sources.

c. Odors

Inasmuch as no letters from local residents complaining about odors have been reported, it is assumed that no objectionable odors of long duration are present in the Study Area. During the recent sanitary survey (University of Michigan 1978) six of the 249 residents interviewed mentioned odor problems of short duration associated with ST/SAS operation during wet weather or heavy use of their systems.

d. Air Quality

The State of Michigan does not maintain monitoring sensors in Benzie County, but data collected at nearby stations in Manistee County and Wexford County indicate that the air in the County is of high quality and that National Ambient Air Quality Standards (Appendix B) are being met.

Benzie County is part of the Upper Michigan Air Quality Control Region. Maintenance of the air quality within the County is the responsibility of the DNR's Air Quality Division, District Office No. 9, in Cadillac.

B. WATER RESOURCES

1. WATER QUALITY MANAGEMENT

Water resource management is a complex of many elements, in which the Federal government, the State and the locality all have an interest. To name just a few of these elements -- irrigation, municipal water supply, maintenance of navigable waters and protection of the productivity of the soil -- illustrates the broad range of activities under this heading. Among the most important, however, is preservation or restoration of the quality of US waters. In the Federal Water Pollution Control Act (PL 92-500, 1972) and the Clean Water Act that amended it in 1977 (PL 95-217) Congress outlined a framework for comprehensive water quality management which applied to groundwater as well as to surface waters.

a. Clean Water Act

Water quality is the responsibility of the United States Environmental Protection Agency (EPA) in coordination with the appropriate State agency, in this case the Michigan Department of Natural Resources (DNR). However, with passage of the Clean Water Act, all Federal agencies were instructed to safeguard water quality standards in carrying out their respective missions. As the lead agency, EPA coordinates the national effort, sets standards, and reviews the work of other agencies, some of which are assigned responsibilities in line with their traditional missions. For example, the Army Corps of Engineers maintains its jurisdiction over dredging permits in commercially navigable waters and their adjacent wetlands and in coastal waters but now must also consider water quality. The Coast Guard keeps its jurisdiction over oil spill cleanup. The Act officially draws certain other agency activities into the water pollution control effort: for example, it authorizes Federal cost-sharing in agricultural projects designed to improve water quality by controlling farm runoff. In the case of the Soil Conservation Service (SCS), these new responsibilities may be in addition to, or as the case may be, may dovetail with SCS programs to reduce soil erosion, or to construct headwaters impoundments for flood control.

In delineating the responsibilities of the various levels of government for water quality, Congress recognized the rights of the States with regard to their waters. It authorized aid to the States in funding the development of plans for control of pollution, development of State water quality standards (which may be more restrictive than Federal standards), and research. When a State meets certain criteria, it is certified by EPA as the entity responsible for administration of the activity in question. The EPA may deny certification, and in all cases it retains power of enforcement of established standards, State or Federal. The State of Michigan is one of the states which has been granted certification by EPA.

Among the goals and deadlines set in the Clean Water Act are these:

> "it is the national goal that the discharge of pollutants into the navigable waters be eliminated by 1985...
>
> "an interim goal of water quality which provides for the protection and propagation of fish, shellfish, and wildlife and provides for recreation in and on the water [is to] be achieved by July 1, 1983".

This landmark legislation requires that publicly owned treatment works discharging effluent to surface waters must at least provide secondary treatment, i.e., biological oxidation of organic wastes. It directed that municipalities must provide the "best available technology" by 1983 and that in appraising their options localities must address both the control of all major sources of stream pollution (including combined sewer overflows and agricultural, street and other surface runoff) and the cost effectiveness of various control measures. The use of unconventional technologies must also be considered.

The key provisions on water quality planning stipulate that to receive aid a State must provide a continuing planning process. Part of Section 208 requires the States to inventory all the sources of pollution of surface and ground waters, both point* and non-point*, and to establish priorities for the correction of substantial water quality problems within a given area. The 208 plans are intended to provide an areawide and, taken together, a statewide, framework for the more local decisions on treatment facilities.

Section 201 of the Act (under which the Crystal Lake area application for funds was made) authorizes EPA to make grants to localities toward the improvement or construction of facilities for treatment of existing water quality problems. EPA may determine whether an Environmental Impact Statement is required on a proposed project (see Section I.B), and even where the State has been certified and assumes responsibility for water quality, EPA retains authority to approve or reject applications for construction funds for treatment facilities.

The local political jurisdiction has traditionally been responsible for meeting the wastewater treatment needs of the community. Local jurisdictions now have the benefit of Federal and State assistance in meeting water quality standards and goals.

b. Federal Agency Responsibilities for Study Area Waters

EPA

Administers the Clean Water Act

Sets Federal water quality standards

EPA Region V

Administers the grant program described above for the Great Lakes Region.

Provides partial funding for preparation of the Crystal Lake Area Facility Plan. Region V's responsibilities in the construction grant program in general and specifically toward the application made in the Facility Plan are discussed in Section I.B.

US Army Corps of Engineers

Controls dredging and construction activities in commercially navigable streams, their 100-year floodplains and adjacent wetlands through a permit system.

US Department of Agriculture

Under the Rural Clean Water Program will provide cost sharing for soil conservation practices designed to improve water quality. (This program will probably be assigned to SCS.)

Soil Conservation Service (SCS)

Agency's mission is to control wind and water erosion, to sustain the soil resource base and to reduce deposition of soil and related pollutants into the water system.

Conducts soil surveys. Prepared Land Resources Inventory Map. Drew up guidelines for inventorying prime or unique agricultural lands.

Works with farmers and other land users on erosion and sedimentation problems

Gathers information at the county level as part of program of study and research to determine new methods of eliminating pollution from agricultural sources.

In the Study Area has performed some stream bank stabilization on the Betsie River and built a sediment basin (trap) in Cold Creek approximately 300 yards upstream from the Creek's entrance to Crystal Lake.

Fish and Wildlife Service

Provides technical assistance in development of 208 plans.

US Geological Survey

Has in the past monitored surface water flows in the Betsie River but does not do so in the Study Area at present.

c. State Responsibilities in the Crystal Lake Study Area

Pertinent Michigan Laws

Environmental Protection Act (P.A. 127 of 1970). Provides for legal action by the Attorney General or any person or legal entity for protection of the air, water, and other natural resources and the public trust therein.

Natural Rivers Act of 1970 (P.A. 231 of (1972). Protects the public trust in Michigan inland lakes and streams and protects riparian rights. Is implemented at the State level. For a discussion of pertinent provisions, see Section II.E.4.

Soil Erosion and Sedimentation Control Act (P.A. 347 of 1972). Provides for control of soil erosion and sedimentation. (See Section II.E.4 for discussion of provisions.) Is administered at the county level. The Soil Conservation district administers the Act in the case of agricultural activities.

State Agencies

Department of Natural Resources (DNR)

Is responsible for establishing water quality standards for the surface waters of the State appropriate to several classifications, and for regulating discharges of waste that affect water quality, including those from sewage treatment plants. (See Appendix D-1 for classification of Study Area streams and lakes and Appendix D-2 for associated water quality standards.)

Has authority to issue permits to discharge pollutants into surface waters under the National Pollutant Discharge Elimination System (NPDES). The Water Resources Commission, which reports to DNR, sets permissible discharge levels and may approve applications for permits. Details of permits granted to Frankfort City and Elberta for discharge of wastewater treatment effluent to Betsie Lake and to Beulah are contained in Appendix D-4.

Administers Natural Rivers Act. DNR has issued zoning regulations for the Betsie River Natural River (see Appendix D-3) and has, with citizen participation, devised a management plan for that River.

Administers Inland Lakes and Streams Act.

Northwest Michigan Regional Planning and Development Commission

Has prepared a plan for Michigan's Region X, which includes the Crystal Lake Study Area, with guidance of EPA and DNR, pursuant to Section 208 of the Clean Water Act.

"Clean Waters - A Water Management Plan for Northwest Michigan" has been approved by the State, subject to conditions centering around the need for more work. Within Benzie County, Betsie Lake was rated first as a "plan of study area," a higher priority than assigned to Crystal Lake because the former is eutrophic and because of the extensive work done on the latter (including this EIS). The Commission was named as Coordinator for Lake Management Activities in the region. It works with lake associations and develops tools to help them assess the problems of their lakes. The Commission plans some groundwater assessment and also some work on non-point sources of nutrients -- agricultural, stormwater, duck feeding, excessive lawn fertilization, and on-site systems.

Michigan Department of Public Health

Has authority to regulate on-site sewage disposal systems and makes initial determinations on subdivisions, campgrounds, commercial developments, etc.

d. Local Agencies

Grand Traverse-Leelanau-Benzie District Health Department (GT-L-BHD)

Has authority to regulate individual residential on-site waste disposal systems. Has authority delegated by the State Health Department to regulate non-residential on-site disposal systems.

See Section II.C.3 for discussion of sanitary code applicable in the Study Area.

Frankfort City, Beulah and Elberta

Own and operate municipal wastewater treatment plants. Types, conditions and operations of these facilities are described in the Crystal Lake Area Facility Plan and in Sections I.A.3.a and b, above.

Benzie County

May enforce Soil Erosion and Sedimentation Control Act for non-agricultural activities

2. GROUNDWATER USE

a. Municipal and Individual Use

The public water supplies for Frankfort City, Elberta, Beulah, and Benzonia are obtained from wells, which tap the groundwater in the sand deposits of the glacial moraine. The supply of water is more than adequate to serve domestic needs through the year 2000. (Wilbur Smith and Associates 1974). However, the County Development Plan indicates that the existing water supply systems are inadequate with respect to distribution capabilities and storage capacity for emergency situations and future population demands (Wilbur Smith and Associates 1974). The number of wells and the capacity of the holding tanks for municipalities in the Study Area are shown in Table II-3.

Table II-3

MUNICIPALITIES USING GROUNDWATER FOR DRINKING SUPPLIES IN THE STUDY AREA

Municipality	Number of Wells	Depth of Wells (feet)	Capacity of Holding tanks (gallons)
Frankfort city	2	70 and 100	2 tanks - 60,000 and 125,000
Elberta	2	70	1 tank - capacity unknown
Beulah	1	150	1 tank - 50,000
Benzonia	2	125	1 tank - 35,000

By telephone, 28 July 1978, Mr. William Crawford, Sanitarian, GT-L-BHD.

Annual pumpage for the city of Frankfort was reported to be 102 x 10^6 gallons in 1976 with a daily maximum of 607,000 gpd (Huffman 1977). Pumpage records for the other municipalities were not available.

Most of the residents around Crystal Lake have individual or group wells. There are several community well systems along the south and southwest shoreline and two community systems on the north side of the lake (GT-L-BHD December 1977).

b. Industrial

Pet, Incorporated, located in Frankfort City, owns wells that tap local groundwaters for food processing operations. During the peak food processing months Pet, Inc. uses from 40,000 to 56,000 gallons of water per day for processing fruit. (Williams and Works 1976).

c. Irrigation

Orchard owners and farmers in the area tap the groundwater aquifers to irrigate their orchards and fields during drought conditions and to provide suitable drinking water for their livestock. The amount of groundwater used for these purposes has not been determined.

3. GROUNDWATER HYDROLOGY

Groundwater in the Study Area is found under both water table and artesian conditions. Under water table conditions no upper impermeable confining layer exists above the aquifer. Precipitation and wastewater is therefore free to percolate downwards through the soil to the saturated zone in the aquifer, the top of which is known as the water table. However, under artesian conditions an impermeable layer such as clay overlies the aquifer, confining it and effectively sealing out percolating waters immediately above it. Because artesian aquifers are confined, top and bottom, the water in them is under pressure and will rise in wells to levels above the top of the aquifer, sometimes above land surface. Wastewater applications to land over aquifers therefore pose threats to water table aquifers, but generally not to artesian aquifers.

Water table and artesian aquifers within the Study Area are not clearly delineated. As is customary in glacial deposits, except outwash plains, confining clay layers are irregularly distributed in the Study Area. These layers may be thick and extensive in some areas but thin and of limited extent in others. No detailed studies of the local aquifers and their characteristics have been undertaken. However, the Health Department reports "The drinking water aquifers in Benzonia Township, for the most part, have at least a 10-foot clay barrier. The Crystal Lake Township and Lake Township well logs often indicate no protective over-burden, and wells of generally less depth." (GT-L-BHD December 1977).

Since, in most instances, drillers have not been recording pumping rates and water levels on well logs, the specific capacities of the wells are generally unknown. Well yields as reported by Leverett et al. (1907) are very small, less than 10 gallons per minute (gpm) except for a very deep well (2200 feet) in Frankfort which yielded 480 gpm. Limited data on recent well logs supplied by the Benzie Health Department indicate yields up to 15 gpm. The moraine deposits of the area are probably poorly sorted angular materials varying in size from boulder through gravel and sand to silt and clay with resulting low water yields. The outwash deposits to the southeast of the Study Area are likely to be better sorted with consequently higher yielding wells.

The average depth and the range of depths for the wells in the various lakeshore areas are shown below.

		Depth (ft)	
Township(s)	Location	Range	Average
Lake	Northwest	20-350	81
Lake/Crystal Lake	West	20-159	67
Crystal Lake	Southwest	30-313	68
Benzonia	Southeast	27-160	69
Benzonia	Northeast	10-166	47

(University of Michigan 1978)

Evidence of some hydraulic continuity of the aquifer(s) with Crystal Lake exists in the form of underwater springs in the northeastern part of the lake (Gannon 1970). Based upon the location of groundwater plumes entering Crystal Lake mainly on the northeastern and, to a lesser extent the southeastern shores, Kerfoot (1978) has suggested the flow pattern shown in Figure II-9. He proposes that groundwater levels to the east of the lake are higher than the lake level which is in turn higher than groundwater levels west of the lake. The general direction of groundwater flow is therefore into the lake at the eastern end and out of the lake at the western end.

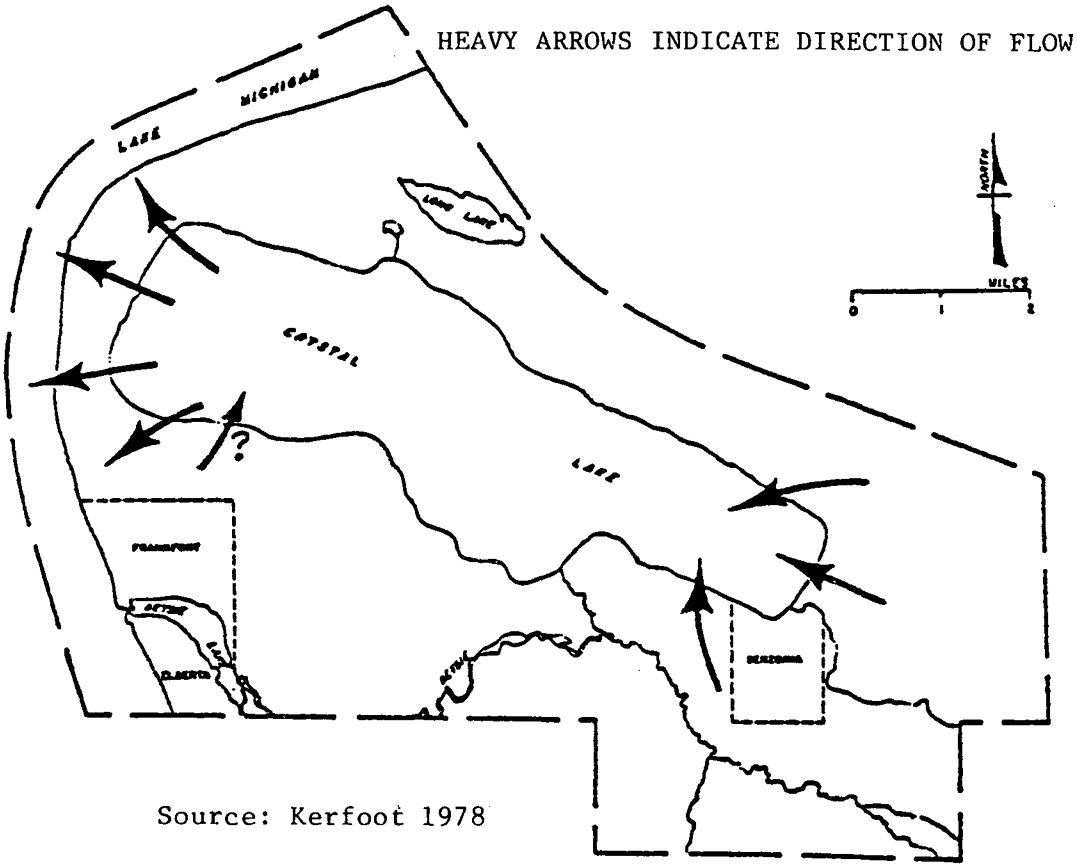
The depth to groundwater and the thickness and extent of confining or protective clay layers are important factors in determining groundwater yield and protection of groundwater quality. The hills that surround Crystal Lake consist of loosely consolidated drift with irregular beds of clay. Clay layers are thin and irregular at high elevations and thick at lower elevations (Leverett 1907). As was indicated in Table II-3 the municipal wells in the hillside townships are generally deep and the water table in these morainic regions is at a low level.

4. GROUNDWATER QUALITY

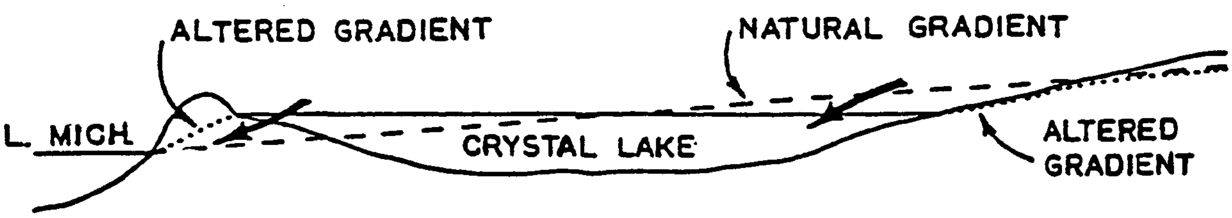
The natural groundwater quality in the Study Area was investigated by Leverett (1907). Well water is generally very hard, ranging as high as 360 ppm ($CaCO_3$). Maximum chloride concentraction is about 34 ppm, and iron is generally absent from the water. The water supplied from these wells is excellent for drinking but is not good for laundry unless softeners are used.

More recently, studies were undertaken by Gannon (1970) and Kerfoot (1978) to learn whether groundwater supplies were being contaminated with leachate from septic tanks. Gannon et al. (1970) surveyed 165 wells around Crystal Lake for total and fecal coliforms and nitrates (NO_3). The final results showed that all wells tested were negative for coliforms. Forty-three wells tested positive for nitrates; twenty-two of these showed nitrate-nitrogen levels greater than 2 milligrams per liter (mg/l), six showed levels greater than 4 mg/l, and one exceeded the US Public Health Service Drinking Water Standard of 10 mg/l. Although the samples that tested positive were evenly distributed around Crystal Lake, "a significantly higher percentage of the north shore samples had nitrate-nitrogen concentrations greater than 2 mg/1." (Gannon 1970) All samples whose concentrations of nitrate-nitrogen exceeded 4 mg/l also came from the north shore.

A follow-up survey of the north shore wells was subsequently undertaken. Locations whose concentrations of nitrate-nitrogen exceeded 1.0 mg/l in the preliminary study were sampled. Figure II-10 shows the average and maximum concentrations for sampling points with highest levels of nitrates. The locations of highest concentrations correspond to areas of high population and high ST/SAS density, suggesting a correlation between population density and high nitrate levels. Only two samples, however, showed nitrate levels that equalled or exceeded



OVERVIEW OF GROUNDWATER FLOW
ARROWS INDICATE DIRECTION OF FLOW



VERTICAL SCHEMATIC OF GROUNDWATER FLOW
(VERTICAL SCALE EXAGGERATED)

Figure II-9: Groundwater Flow Patterns for Crystal Lake

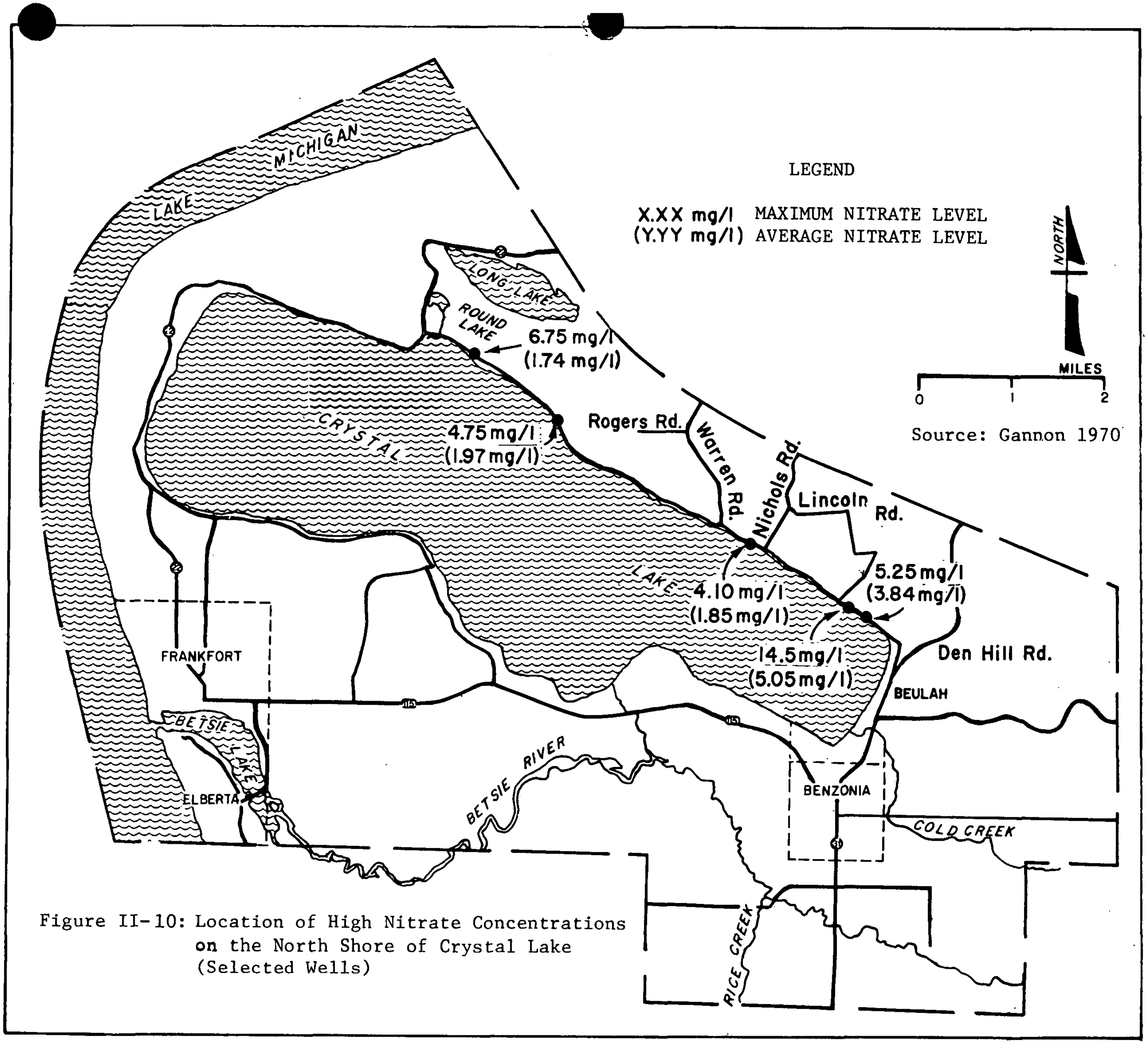


Figure II-10: Location of High Nitrate Concentrations on the North Shore of Crystal Lake (Selected Wells) the Drinking Water Standard. The generally low levels of nitrates elsewhere indicate that groundwater contamination was not widespread.

Data showing the localized effects of septic tank leachate* on interstitial* groundwater and surface water of the Lake were collected during a 1978 survey of the Crystal Lake shoreline employing a Septic Leachate Detector*, dubbed "Septic Snooper"* (Kerfoot 1978) (Appendix C). Septic tank effluent plumes entering the Lake were located and the interstitial groundwater associated with each leachate plume was sampled one foot below the lake bottom. Concentrations of nitrate, ammonia and total phosphorus were measured.

Despite the proximity of each sampling point to the ST/SAS, none of the samples taken along the northeast, southeast and southwest shoreline indicated violations of the Drinking Water Standard for nitrates. While there is a possibility that the interstitial groundwater samples do not accurately reflect true groundwater quality, the nitrate concentration data are consistent with Gannon's findings (1970) for nitrate levels in wells along the northwest, southeast and southwest shores. Unfortunately, interstitial groundwater samples were not collected in effluent plumes along the northeastern shore where well water nitrate levels were found by Gannon (1970) to be the highest.

Although phosphorus levels in the groundwater plumes are low, there may be sufficient phosphorus loading to cause localized algal blooms along the northeast and southeast shore where groundwater inflow is significant. These plumes may channel nutrient-rich water to the vegetation, in effect acting as a hydroponic culture. However, ST/SAS may not be the sole source of phosphorus for the algae. Phosphorus in drinking water is not a health hazard to humans; the only concern is excessive loading of nutrients into the Lake. This issue is further addressed in Section II.B.6.

5. SURFACE WATER HYDROLOGY

Cold Creek, Crystal Lake, the Betsie River and Betsie Lake are major surface water resources located in the Study Area. Cold Creek originates approximately five miles east of Benzonia and is the primary tributary entering Crystal Lake. The Betsie River originates in western Traverse County, flows southwest into Benzie County and then into Manistee County. Upon nearing the southern end of Crystal Lake, the River receives the overflow of that lake. Continuing westerly, the River empties into Betsie Lake and eventually Lake Michigan via Frankfort Harbor. The total water system drains almost the entire Study Area, with the exception of a small area to the north of Crystal Lake (see Figure II-11).

Physical characteristics pertaining to the hydrology of the surface waters serve to describe and differentiate the lakes and streams in the Study Area. Specific hydrologic and morphologic characteristics of the lake or stream not only form the surface water system in which chemical and other factors operate and interact but are themselves major factors in that interaction. Size of drainage basin, tributary flow, lake volume and hydraulic retention time directly influence the quantity and quality of surface water resources.

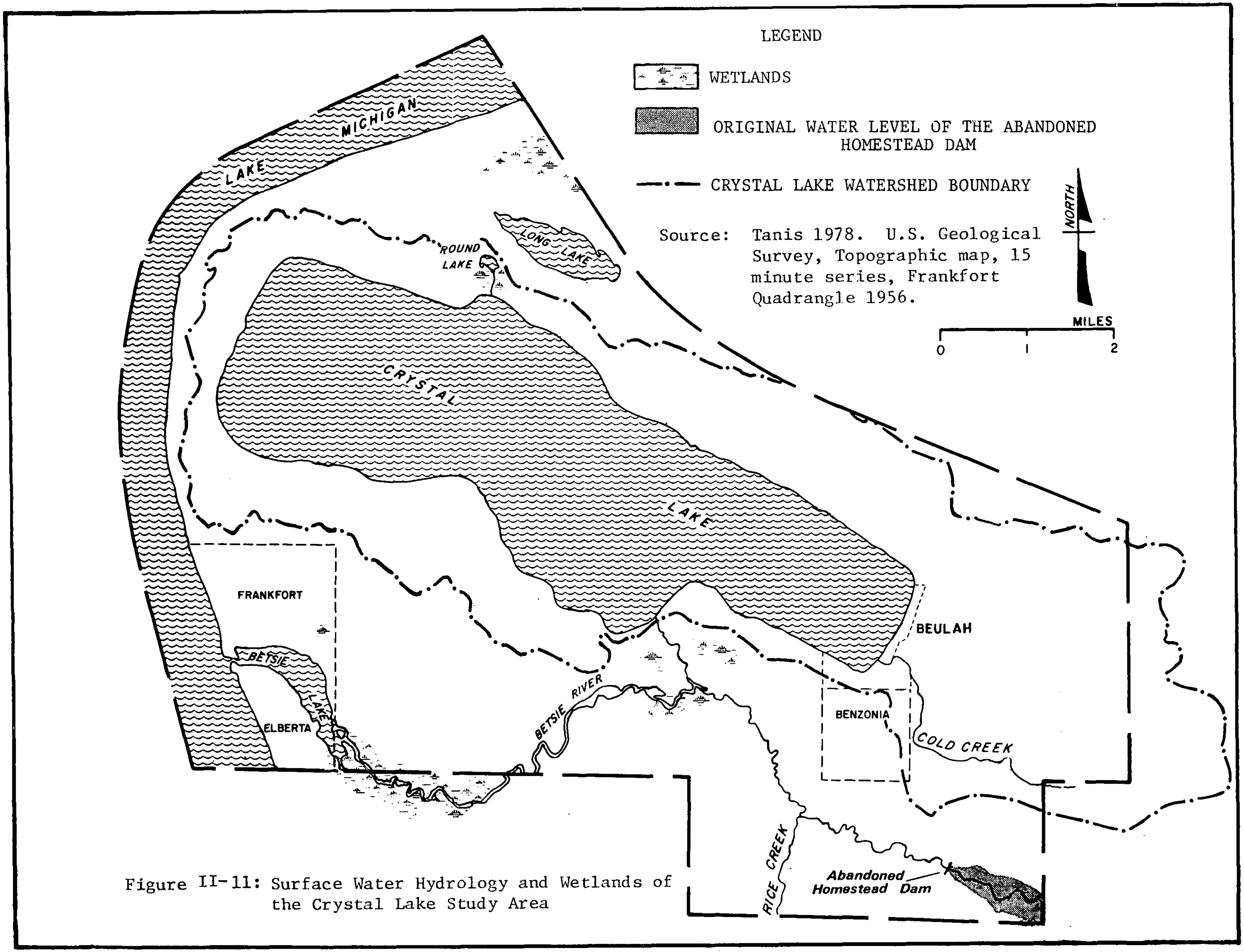


Figure II-11: Surface Water Hydrology and Wetlands of the Crystal Lake Study Area

a. Size of Drainage Basins

Betsie Lake's drainage basin is more than six times that of Crystal Lake (245 square miles vs. 32 square miles): the larger watershed acts as a significant catchment of precipitation, which is transferred as runoff to that lake. Crystal Lake occupies a larger portion of its total watershed than does Betsie Lake: Betsie Lake's drainage basin-to-lake surface area ratio is 627:1 while that of Crystal Lake is 2:1.

b. Tributary Flow

There are two major tributaries in the Study Area: Cold Creek and Betsie River.

There are no continuously recording stream flow gauges in the Study Area within the Betsie River watershed. However, because collection of stream flow data has been intermittent at several locations on the Betsie River, approximate hydrologic characteristics of the streams and lakes could be derived.

Cold Creek. Cold Creek is an intermittent stream that occurs on a plateau composed of moraine and outwash plain. It becomes a permanent stream with an average flow of 8.2 cfs (0.23 m^3/s) at Beulah. Principal contributors to stream flow are surface water runoff or groundwater input.

Betsie River. Fifteen measurements of stream flow were made during the National Eutrophication Survey from October 1972 to October 1973 at the outlet of Betsie Lake and also on the Betsie River approximately 2 miles above Betsie Lake. These data plus normalized monthly and annual flows for the two stations were reported by EPA (1975). The average annual flow was determined to be 349 cfs (9.88 m^3/s) at the inlet of Betsie Lake.

Outflow from Crystal Lake joins the Betsie River. Flows where they join were measured four times a year from 1944 to 1950 by the US Geological Survey. Outlet flow was also measured during 1976 and 1977 by Tanis (1978). His information showed that maximum outlet flows occurred during and after the spring thaw in the months of April, May and June. Minimum flows, including two instances of zero flow, occurred during December and January. Minimum flow conditions may persist through February and March, but the data were not conclusive on this point. Analysis of 44 flow measurements by Tanis (1978) over a one-year period indicated that the average outlet flow was 13.5 cfs (0.38 m^3/s).

c. Lake Hydraulic Retention Time

Assuming complete mixing, the retention time of a lake is the time required for natural processes to replace the entire volume of its water. Betsie Lake has a relatively short retention time of about 2 days (Knutilla 1974) while Crystal Lake has a far longer retention time of 63.1 years (Tanis 1978). Hydrological and morphological factors -- total tributary flow and volume -- account for the difference. Table II-4 summarizes the physical characteristics of these lakes.

Table II-4
PHYSICAL CHARACTERISTICS OF BETSIE LAKE AND CRYSTAL LAKE

Parameter	Betsie Lake	Crystal Lake
Lake surface area (in acres)	250	9792
Mean depth (ft. (m))	6 (1.8)	63 (19.2)
Maximum depth (ft.(m))	22 (6.7)	180 (54.9)
Volume (acre - ft.)	1543	616,896
Drainage area (mi^2(km^2))	245 (630)	32 (82)
Inflow (cfs (m^3/s))	349 (9.9)	13.5 (0.38)
Retention time (years)	0.006	63.1

6. SURFACE WATER USE AND CLASSIFICATION

Surface waters in the Study Area, although used primarily for recreation, also are used to assimilate wastewater effluent, harbor commercial ships and pleasure boats, and provide habitats for fish and wildlife. These waters are not used for domestic water supply.

The State of Michigan has classified uses of its surface waters (Appendix D-1) and assigned appropriate classifications to each body of water. Water quality standards for the classifications and uses appear in Appendix D-2. For a lake or stream classified for two or more uses, the more restrictive standards apply.

a. Lakes

Crystal Lake and Betsie Lake are classified B-I for total body contact recreation. In addition to swimming areas, both lakes support valuable fisheries (see Aquatic Biology, Section II.D.1). Further, Betsie Lake has non-recreational uses, as reported in Table II-5.

b. Streams

Some of the streams in the Study Area have been given multiple classifications. As an example, the Betsie River has been classified C-I, cold water fish, and that portion from the Manistee/Benzie County line to the outlet stream of Crystal Lake, has been further proclaimed a "natural river" under Michigan's Natural Rivers Act (Public Act 231 of 1970). Subsequent to the Act, the Michigan Department of Natural Resources established zoning, effective June 11, 1977, to preserve the values of the natural river district, protect its resources, free flowing conditions and water quality, and to prevent ecological, economic or flood damages. (See Appendix D-3.)

7. SURFACE WATER QUALITY

A general discussion of changes in lake water quality may be found in Appendix E-1. In the present section the existing water quality of Crystal Lake is discussed first, followed by a discussion of Betsie Lake. Both discussions are presented in two main parts. The first of these involves tributary-related considerations, e.g. concentrations and loadings of contaminants. Contaminant loads from direct municipal and industrial discharges and from tributary background and non-point sources are quantified separately in this part.

The second part of the discussion involves lake-related considerations, e.g. spatial, seasonal and long-term trends in lake water quality. Those sections deal with dimensional characteristics of lake chemistry and biology, focusing primarily on major algal growth nutrient and phytoplankton* biomass levels, because the latter materials are expected to change as a result of the proposed wastewater management program.

Table II-5
NON-RECREATIONAL WATER USES OF BETSIE LAKE

Type of Use	User(s)	Additional Information
Wastewater[1] Treatment	Frankfort City	Primary treatment plant (Design flow - 0.26 mgd actual flow - 0.266 mgd Residential and industrial wastewater)
Wastewater	Elberta	Primary treatment plant (Design flow - 0.10 mgd actual flow - 0.13 mgd Residential wastewater)
Harbor[2]	Viking Car Ferry	Commercial water transport boat from Frankfort, Michigan to Kewaunee, Wisconsin
	Tanker "Saturn"	Asphalt tanker
	Boat Marinas	Jacobson's, at Frankfort; Elberta
	Coast Guard	Mooring facilities near Frankfort
Habitat	Fish and Wildlife	Hunters, fishermen, and non-consumptive users

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1 Williams and Works, Crystal Lake Area Facility Plan, 1976.

2 By phone, S. T. Sherman (US Coast Guard, BM-2), 1978.

An evaluation of spatial and seasonal trends in major nutrients for phytoplankton growth is fundamental to an understanding of variation in plankton population. In order to determine if changes in water quality would result from the proposed sewer project, the relation of these trends to the annual cycles in the lake must be studied. Inasmuch as the vertical distribution of chemical and biological species is closely related to seasonal phenomena, spatial and seasonal characteristics will be discussed together. A brief discussion of the biological characteristics of each lake and summaries of specialty studies (where applicable) is presented.

a. Crystal Lake

Tributary-Related Considerations. The average concentrations of some water quality parameters at the mouth of Cold Creek (the inlet of Crystal Lake) during the summer months of 1969 were 0.07 mg P/l as total phosphorus and 0.03 mg P/l as orthophosphate, 8.1 mg/l dissolved oxygen, and pH of 7.8 (Gannon 1970).

The average concentration of total phosphorus measured at the mouth of Cold Creek in 1976-1977 (Tanis 1978) was 0.09 mg P/l, and the average concentration of soluble orthophosphate was 0.02 mg P/l. Figure II-12 presents the month-to-month variation in Cold Creek's phosphorus levels from July 1976 to July 1977. According to the study, the most significant contributions of phosphorus to Cold Creek originate from the Village of Beulah and the surrounding area (Tanis 1978). Tanis believed the sources of phosphorus to be:

- Beulah's storm water runoff, which is routed directly to Cold Creek
- Sediment carried via runoff from the muck soil adjacent to Beulah
- Possible leaks or seepage from the present wastewater disposal systems.

The average concentration of total phosphorus measured by Tanis at the outlet of Crystal Lake during the same period was 0.01 mg P/l, considerably lower than the level at the inlet (mouth of Cold Creek). This result indicates that a significant amount of phosphorus has been retained by the Lake.

In Cold Creek, total coliforms range from 900 MPN/100 ml to 11,000 MPN/100 ml, while fecal coliforms ranged from 50 MPN/100 ml to 200 MPN/100 ml during the summer months of 1969 (Gannon 1970).

Nutrient Loading Characteristics. Nutrient loads to Crystal Lake originate from its tributary (Cold Creek), precipitation, septic tank leakage and non-point source runoff. The nutrient load from Cold Creek was calculated by multiplying monitored river concentrations by the specific daily flow as given by Tanis (1978). The focus of the (loading) calculations is on phosphorus because this element is believed to be the limiting nutrient most likely to be affected by the wastewater management project. The Cold Creek flow, phosphorus concentrations and phosphorus loads are plotted in Figure II-12.

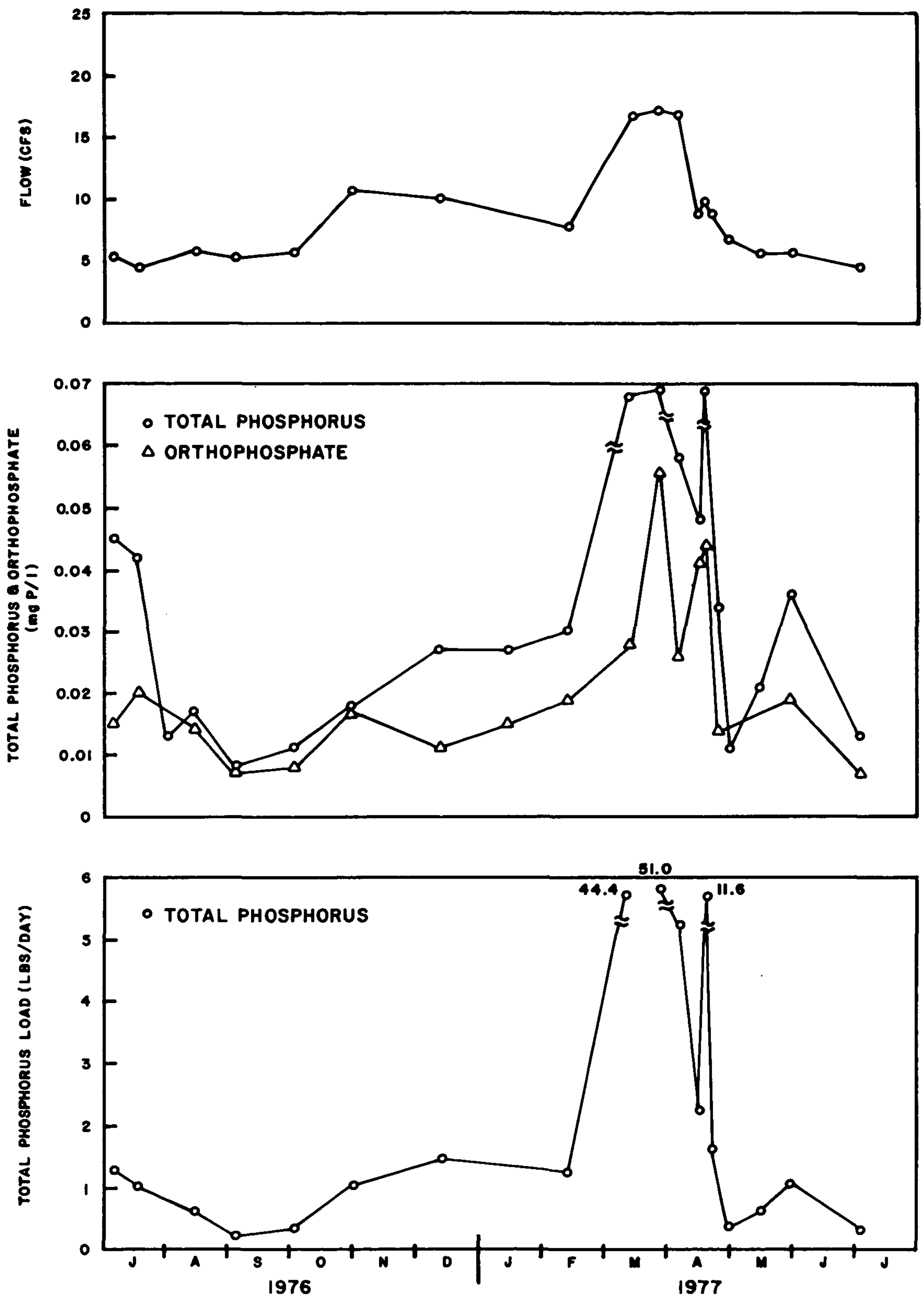


FIGURE II-12: FLOW, PHOSPHORUS CONCENTRATION AND PHOSPHORUS LOADS IN THE COLD CREEK (1976-1977)

Some patterns were observed in the seasonal variation of phosphorus loads from Cold Creek. Phosphorus loads were closely correlated with flow. During periods of high flow, concentrations increased because higher non-point source runoff had increased, and the associated phosphorus load also showed a dramatic increase. From these results, an average total phosphorus load of 1,533 lb P/yr (679 kg/yr) was calculated for the period from July 1976 to June 1977. The result also indicates that non-point sources are important contributors to Cold Creek's phosphorus load.

As mentioned earlier, precipitation is a major source of nutrients for Crystal Lake because the lake's surface area is large in relation to its drainage area. A combination of snow and rainfall samples collected during the 1976-1977 study (Tanis 1978) produced a mean concentration of 0.032 mg P/l as total phosphorus. The total precipitation in the same period amounted to 24 inches (61 cm), according to Tanis (1978). As a result, the total phosphorus load due to precipitation during the study period was 1,690 lbs P/yr (767 kg/yr).

In this EIS phosphorus inputs from septic tank systems were calculated using assumptions developed by EPA (1975): 0.25 lb/capita/year of total phosphorus will leach from soil disposal system to the lake. In the Study Area, there are 511 homes within 300 feet of Crystal Lake currently served by on-site systems, as indicated by aerial photographs and planning maps. Using the unit loading and the population characteristics derived above, the phosphorus input currently contributed from septic tank leakage is approximately 263 lb/yr (120 kg/yr).

Phosphorus loads to Crystal Lake from the drainage area immediately surrounding the lake were estimated using regression models developed by Omernik (1977) and approximated overland runoff flows. A detailed description of the model and the methodology used in this study are included in Appendix E-2. The total phosphorus load attributed to non-point sources from the immediate drainage area is 465 lb/yr (210 kg/yr). Table II-6 summarizes the phosphorus loading levels to Crystal Lake together with the areal loading and percentage loading for each category.

Table II-6
TOTAL PHOSPHORUS LOADS TO CRYSTAL LAKE

	(lb/yr)	(kg/yr)	$(g/m^2/yr)$	%
Precipitation	1690	767	.019	42.8
Septic Tanks	263	120	.003	6.7
Cold Creek	1533	695	.017	38.8
Non-Point Source Runoff-Immed. Watershed	465	210	.005	11.7
Total	3951	1792	.044	100.0

Cold Creek and precipitation have been identified as the major nutrient sources to Crystal Lake. These two sources supply over 80% of the total phosphorus load to the lake. The above estimated septic tank load represents 6.7% of the total load. Recent data from Kerfoot (1978) indicate a significantly lower phosphorus load from septic tanks (23 kg/yr). This low level may be due to the sampling time (November 1978) when the population was substantially lower than the annual average population equivalents. Nevertheless, the septic tank loads in Table II-6 can consequently be considered a conservative estimate.

Lake Water Quality. Water quality data have been collected during two extensive studies of Crystal Lake by the University of Michigan (Gannon 1970) and Tanis (1978), respectively. The earlier study indicated that levels of some key water quality parameters such as ammonia, nitrate, orthophosphate, and total phosphorus in the open water were below the detection limits of the instrumentation available at that time. The primary productivity rate (at which available inorganic carbon is converted to organic material by phytoplankton photosynthesis) was measured and found to range between 169 to 188 mg C/m^2/day. The recent survey by Tanis shows that the water quality in the open water of Crystal Lake is relatively good and may be considered one of the highest in Michigan (see the key water quality parameter values tabulated in Table II-7). Tanis (1978) also reported the primary productivity rate in the summer of 1977 at 139 mg C/m^2/day, which is lower than the rate measured by the University of Michigan in 1969. There is no indication in any of the results that the quality of Crystal Lake water deteriorated significantly over the last seven or eight years and the deterioration of open lake waters, if any, appears to be progressing at a relatively slow rate.

Deterioration of the lake has only been observed along the shoreline in localized areas where nutrient influx is a problem. Concerns have become accentuated along portions of the north shore near Beulah and also along the southwest shore (Tanis 1978). Growth of algae in the forms of *Cladophora* attached to rocks and other hard surfaces at the shoreline has been consistently observed during the summer months. The results of a special dye study to determine the cause of shoreline pollution proved to be inconclusive (University of Michigan 1970). Recent results from Kerfoot (1978), who measured the leachate plumes from septic tanks in Crystal Lake, indicate nutrient flux into the shoreline waters. A high correlation existed between the location of emergence of plumes and attached plant growth, particularly *Cladophora* (Kerfoot 1978). Groundwaters obtained near the peak concentrations of the outflow of the observed plumes contained sufficient nutrients to support attached algae and aquatic weed growth.

In general, Crystal Lake water quality concerns have not been associated with public health, as only a few cases of coliform bacterial contamination have been reported by the Tri-County Department of Public Health (GT-L-BHD) (Tanis 1978). By showing fecal coliform levels lower than the 200 MPN/100 State Standard, Kerfoot's (1978) results concur with previous studies. Fecal coliform counts in the surface waters directly affected by leachate plumes were well below the 200 MPN/100 ml allowable in total body contact recreational waters.

Table II-7
WATER QUALITY OF CRYSTAL LAKE

Year	Chlorophyll *a* (μg/l)	Primary Productivity (mg C/m^2 /day)	Dissolved Oxygen at lake bottom (% saturation)	Secchi Depth (m)	Total Phosphorus (mg P/l)
1969[1]					
July 3 - July 25			84 and 68	6.22	-
July 25 - July 29		178			
August 19			89 and 56		
1976[2]					
August 4	0.65 (mean)	139		5.69 (mean)	
September 5	0.29-1.6 (range)		102 and 45	4.9-7.0 (range)	
1977[2]					
April 30					0.006
July 5	0.70 (mean)		100, 100, and 73	6.14 (mean)	

[1]Gannon, J.J. 1970. Crystal Lake water quality investigation. University of Michigan, Ann Arbor MI.

[2]Tanis, F.J. 1978. Final summary report on Crystal Lake water quality study.

b. Betsie Lake

Tributary-Related Considerations. Various water quality parameters were monitored in the Betsie River by the Environmental Protection Agency (EPA 1975). The average concentrations of water quality parameters for the Betsie River during the study period, the summer of 1973, were 0.02 mg P/l total phosphorus, 0.01 mg P/l orthophosphate, 0.057 mg N/l ammonia, 0.68 mg N/l total kjeldahl nitrogen (TKN), 0.18 mg N/l nitrate plus nitrite. According to the NES study, non-point sources of nutrients are responsible for significant contributions of phosphorus to the river. For this reason, it was suggested that point source phosphorus inputs to the Betsie River and Betsie Lake should be minimized to the greatest extent practicable (EPA 1975).

Nutrient loads to Betsie Lake originate from tributary (Betsie River), precipitation, surface water runoff and municipal wastewater treatment plants. Data collected in 1972 (EPA 1975) have been analyzed and loadings have been summarized in Table II-8 below. Once again, only phosphorus loadings are tabulated since phosphorus has been identified as the limiting nutrient for algal growth (EPA 1975).

Table II-8
TOTAL PHOSPHORUS LOADS TO BETSIE LAKE (1972-73)*

	(lb/yr)	(kg/yr)	($g/m^2/yr$)	%
Tributaries (non-point source) Betsie River	14,240	6,460	6.38	51.5
Minor tributaries and immediate drainage (non-point source)	150	68	0.07	0.5
Municipal STP's	13,200	5,990	5.92	47.8
Precipitation	40	18	0.02	0.2
Total	27,630	12,530	12.39	100.0

*EPA. 1975

Data from the National Eutrophication Survey (EPA 1975) in Table II-8 indicate an average total phosphorus load of 14,240 lbs P/yr during the period from October 1972 to October 1973. The Betsie River exerts a significant influence on Betsie Lake's condition. Two major point sources --the Elberta and Frankfort municipal sewage treatment plants -- furnish another significant portion of the nutrient loadings to the lake.

EPA (1975) estimated that 40 lbs P/yr is contributed by direct precipitation to Betsie Lake. This load is relatively insignificant compared with other contributions. Other nutrient sources of Betsie

Lake such as septic tank leakage and industrial wastewater were not documented (EPA 1975).

EPA (1975) also estimated the total nitrogen inputs to Betsie Lake at 701,150 lbs/yr of which 588,590 lbs/yr is discharged into Lake Michigan.

Lake-Related Considerations. Betsie Lake was sampled three times during the 1972 eutrophication study. Data were collected at one open water station at three different depths. The average water quality can be summarized in terms of the following physical, chemical and biological characteristics: 145 mg/l of alkalinity; 304μmhos of conductivity; 1.0 m of Secchi disc depth; 0.026 mg P/l of total phosphorus; 0.175 mg N/l of inorganic nitrogen; and 4.6 μg/l of chlorophyll a. As indicated, the open water quality can be described as nutrient-rich, productive and, therefore, eutrophic (EPA 1975).

EPA conducted an algal bioassay to determine the limiting nutrient for algal growth. The results showed that Besie Lake was phosphorus-limited at the time the assay sample was collected on September 15, 1972. The lake data indicated phosphorus limitation in June and November of 1972 as well (EPA 1975). Based on this finding, the effort of assessing potential eutrophication has been concentrated on phosphorus (see Section IV.A.1.a).

Because the lake was monitored only once, it is not possible to say how Betsie Lake has changed since the EPA survey in 1972. However, it is significant to note that the lake is shallow, has a short hydraulic retention time and a large drainage basin-to-lake surface area ratio. Should point source discharge to Betsie Lake be minimized, the trophic status of the lake would be likely to improve slightly. If existing discharges should continue unabated, the combined effects of lake morphology and hydrology, non-point source nutrient and point source nutrient loads are likely to result in the continued degradation of the quality of Betsie Lake's water.

A list of studies of water quality of Crystal Lake is contained in Appendix E-3.

8. Flood Hazard Areas

Figure II-13 delineates the flood hazard areas located along the shorelines of the Betsie River and the five lakes in the Study Area (HUD 1975, 1976). The areas delineated show the 100-year floodplain, i.e. a flood of such magnitude can be expected to occur with a frequency of once every 100 years. In reality such a flood could occur at any time.

The flood hazard areas along the Betsie River are protected by the Betsie River Natural River Zoning Act. That act precludes any cutting, filling or building on the land in the floodplain and requires a minimum setback distance of 200 feet.

Under the existing sanitary code and zoning ordinances for the townships around Crystal Lake, a minimum setback distance of 50 feet

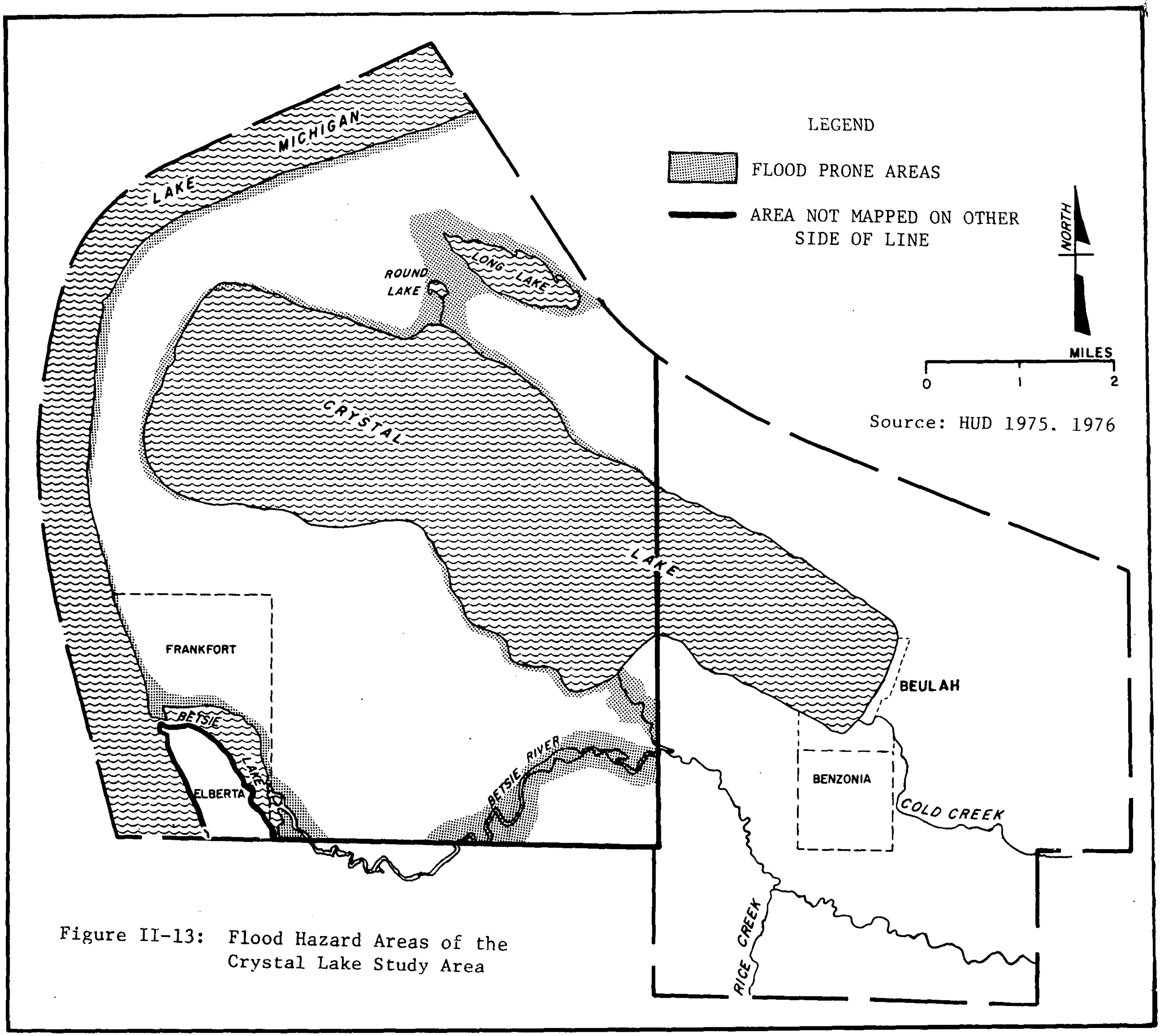


Figure II-13: Flood Hazard Areas of the Crystal Lake Study Area from the lakeshore is required for any construction activities. Because Crystal Lake is not fed by any large-volume streams and because the ratio of its watershed area to lake surface area is only 2:1, the flood hazard area is very narrow -- almost non-existent along parts of the lakeshore. Consequently the 50-foot requirement is adequate to protect flood-prone areas along the Lake.

C. EXISTING SYSTEMS

There are three centralized collection and treatment systems within the Study Area. They serve the City of Frankfort and the Villages of Beulah and Elberta. These systems have been discussed in the Facility Plan and are summarized in Chapter I. Their location and the extent of the areas they serve are shown in Figure I-3.

The Townships of Crystal Lake, Lake and Benzonia and the Village of Benzonia are not served by a centralized treatment system; wastewater is treated by on-site systems. When the Facility Plan was prepared, very little information was available on the existing on-site systems on which to base an evaluation of their adequacy. Three studies were undertaken during preparation of this EIS to provide information regarding the type, the nature and frequency of problems, and the adequacy of these systems in meeting the wastewater treatment needs of the Study Area.

1. SUMMARY OF DATA ON EXISTING SYSTEMS

This discussion briefly summarizes the studies that were recently undertaken to evaluate existing systems. Results of these studies are discussed elsewhere in this EIS as well (surface and groundwater quality, soils analysis).

a. "Investigation of Septic Discharges into Crystal Lake" (William Kerfoot 1978)

This study was undertaken in November 1978 to determine whether groundwater plumes from nearby septic tanks were emerging along the lakeshore causing elevated concentrations of nutrients. Septic tank leachate plumes were detected with an instrument referred to as a "Septic Snooper." The instrument is equipped with analyzers to detect both organics and inorganic chemicals from domestic wastewaters; it is towed along the shoreline to obtain a profile of septic leachate plumes discharging to the surface water. Surface and groundwater sampling for nutrient and bacteria (surface water only) were coordinated with the septic leachate profile to clearly identify the source of the leachate.

The "Septic Snooper" detected 90 plumes of wastewater origin entering Crystal Lake. This corresponds to approximately 18% of the 500 existing lakeside systems, i.e. those within approximately 300 feet of the lake. The location of these plumes is shown in Figure II-14. A high correlation was found between the location of the plumes and the attached algal growth. While there is sufficient breakthrough of nutrients to the surface water to support algal growth in the immediate

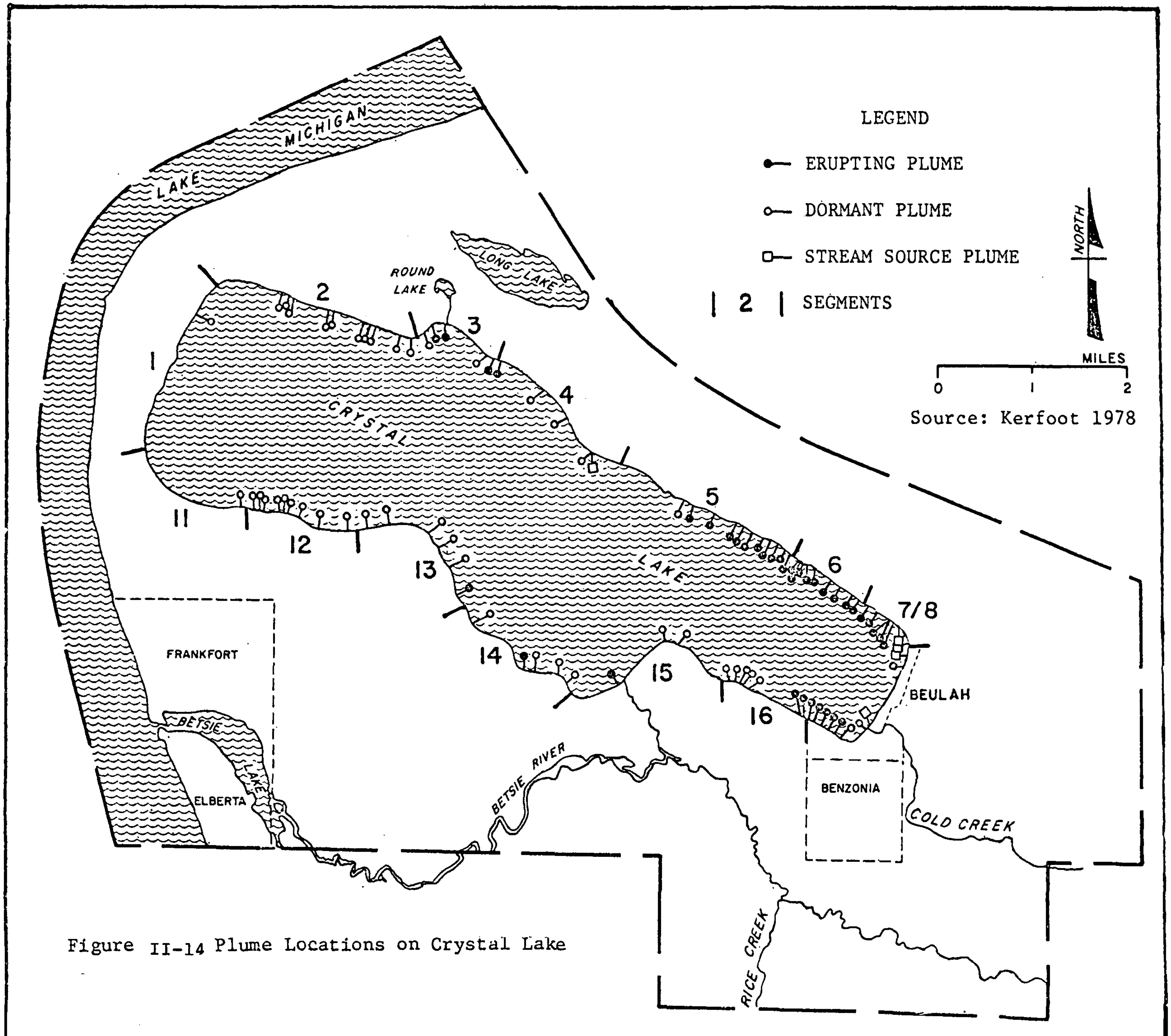


Figure II-14 Plume Locations on Crystal Lake vicinity of plume emergence, overall lake water quality has not been significantly impacted by septic leachate plumes. Appendix C contains the Kerfoot study.

b. "Sanitary Systems of Crystal Lake, Benzie County, Michigan: An On-site Survey" (University of Michigan, 1978)

The sanitary survey of lakeside on-site systems in Crystal Lake, Lake and Benzonia Townships was conducted during September and October of 1978. This survey provided information regarding the types of on-site systems, the nature and extent of problems with these systems, and the nature and extent of violations of the existing sanitary code. The technical report on the sanitary survey is included in Appendix F-1. Table II-9 summarizes some of the significant data.

The results indicated that over 50% of the systems were violating the sanitary code. Despite the large number of violations, very few of the systems had recurring problems with backups or ponding. Attached algal growth was associated with 34% of the homes surveyed, although only about 10% of the sites had heavy algal growth. Heavy algal growth was most frequent on the northeast shore.

c. EPIC Survey (EPA 1978)

An aerial photographic survey was conducted by EPA's Environmental Photographic Interpretation Center (EPIC) to locate failing septic systems throughout the Study Area and to locate patches of aquatic vegetation along Crystal Lake. The results of this study are shown in Figure II-15. Very few surface failures of septic tank systems were located in the Study Area. The failures that were detected were mainly in and around Benzonia Village. Photographs indicated that the northeastern and eastern shores had the densest growth of submerged vegetation, although field verifications were not done. Very little growth was observed on the northwestern and western shores.

The aerial photographic survey was conducted during the summer; foliage may have prevented the detection of some malfunctioning systems.

2. TYPES OF SYSTEMS

Based on data obtained during the sanitary survey (University of Michigan 1978), 98% of the 1,090 residences in the unsewered parts of the Proposed Service Area are estimated to have septic tanks and some type of subsurface absorption system (ST/SAS). The remaining 2% have permits for holding tanks only. Fifty-eight percent of the ST/SAS employed a drainfield, 41% employed a drywell and only 1% of the systems had no soil absorption system.

No information is available on the types of on-site systems in use in Benzonia. There are, however, about 279 homes using on-site treatment systems in the Village.

Table II-9

PARAMETERS INFLUENCING SEPTIC TANK PERFORMANCE ALONG CRYSTAL SHORELINE AREAS

Lake Shore Area	Number of Houses Sampled	Estimated Total Number	Housing Density units/shoreline (mile)	Seasonal Population # (%)	Systems Which Do Not Meet Requirements # (%)	Systems with Drywells # (%)	Systems Which Were Sized Too Small # (%)*	Systems With *Cladophora* Growth # (%)	Systems More Than 10 Years Old # (%)	Systems Less Than 15.3m (50 ft) to Lake # (%)	Systems Less Than 15.3m (50 ft) to Well # (%)
Northeast	69	270	37.6	173 (64)	43 (62)	27 (43)	19 (35)	47 (69)	54 (82)	13 (19)	32 (46)
Northwest	61	146	19.8	124 (85)	33 (54)	23 (41)	23 (48)	11 (18)	48 (69)	10 (16)	3 (5)
Southeast	39	188	15.0**	111 (59)	23 (59)	20 (56)	12 (41)	18 (45)	45 (80)	1 (3)	6 (15)
Southwest	56	230	34.6	202 (88)	24 (43)	15 (32)	12 (40)	19 (35)	30 (81)	2 (4)	10 (18)
West	24	256	23.7	235 (92)	11 (46)	9 (41)	4 (31)	1 (4)	17 (74)	1 (4)	5 (21)
TOTAL	249	1090	26.1**	846 (78)	134 (53)	94 (40)	70 (39)	96 (34)	194 (77)	27 (11)	56 (22)

* 37% could not be determined
**Without Beulah

University of Michigan. 1978. Sanitary systems of Crystal Lake, Benzie County, Michigan: An on-site survey. Pelston MI.

Kerfoot, William. 1978. Investigation of septic leachate discharges into Crystal Lake, Michigan. K-V Associates, Falmouth MA for WAPORA, Inc.

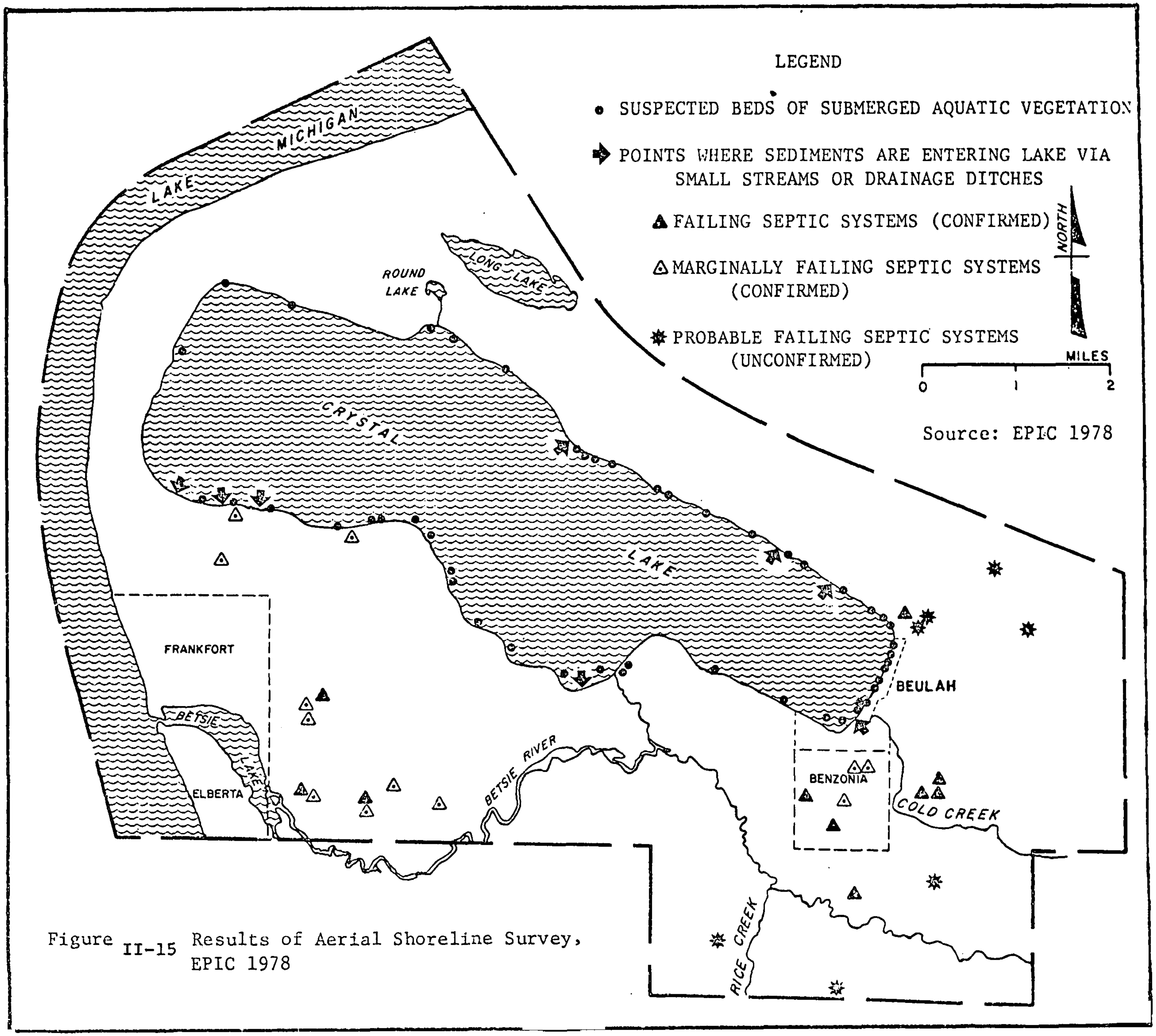


Figure II-15 Results of Aerial Shoreline Survey, EPIC 1978

3. COMPLIANCE WITH THE SANITARY CODE

In 1964, GT-L-BHD issued the first sanitary code for the townships along the Crystal Lake shoreline. Prior to this, there were little or no restrictions regarding the construction and use of on-site systems. Although the Health Department began issuing permits in 1964, it was not until 1971 that site evaluations and installation inspections were begun. Consequently, the sanitary code was not enforced prior to 1971. In 1972, the code was revised to incorporate more stringent measures to ensure adequate treatment of household wastewaters. Notably, the revisions provided for denial of a permit if the site did not meet criteria established for suitable soils and depth to groundwater. In addition, the revised code increased isolation distances between septic systems and surface water from 25 to 50 feet. The vertical distance between the drainfield and the high water table was also increased to 4 feet. "Selections from the Sanitary Code of Minimum Standards" and the Code are attached as Appendixes F-2 and F-3 respectively.

Since the Health Department began performing site evaluations in 1972, 44% of the sites in the Proposed Service Area have been found to be unsuitable. A 1978 soils survey conducted by SCS indicated that 100% of the soils examined were unsuitable. The discrepancies in these data are discussed in Section II.A.3.a.

At sites where the soils are unsuitable because of slow permeability or high groundwater table, a holding tank permit may be issued in lieu of a septic tank permit. The various permits issued for the lakeshore townships between 1970 and 1977 are summarized in Table II-10. The trend has been towards an increased issuance of permits for holding tanks and pump systems. Drywell permits are no longer granted because there is an increased potential for groundwater contamination with these deeper systems.

Table II-10
PERMITS ISSUED IN THE PROPOSED SERVICE AREA
BY GT-L-BHD BETWEEN 1970-1977 INCLUDING
REPAIRS AND NEW INSTALLATIONS

	Benzonia	Crystal Lake	Lake	Total
Drainfields	103	79	90	272
Holding Tanks	6	6	3	15
Pump Systems	3	2	5	10
Drywells	10	10	9	32
	125	97	107	329

Crawford 1977

Because the 1964 sanitary code was not enforced and because the 1972 provisions are even more stringent, many of the existing systems are in violation of the sanitary code. Of the 249 homes surveyed in the sanitary survey, 53% did not comply with regulations. Violations fall into one or more of the following categories:

o Septic tank less than 15.3 meters (50 feet) to the lake	11%
o Septic tanks less than 15.3 meters (50 feet) to the well	23%
o Septic tanks smaller than recommended size (septic tank size was not available for 37% of the homes)	41%
o Systems with drywells	40%
o Soil absorption systems too small to meet regulations (30% have no record)	39%

No information was available on violations of the sanitary code in the Village of Benzonia.

4. PROBLEMS CAUSED BY EXISTING ON-SITE SYSTEMS

Despite the fact that more than half the systems do not comply with existing regulations, very few are causing potential public health or water quality problems. Where problems do occur they have generally been associated with older systems. Many of these were poorly maintained before 1971 when site inspections were begun. Many backups were associated with systems that had rarely (if ever) been pumped or that had roots growing in the drywells. Nearly 80% of the systems that are undersized are older than 10 years; similarly those older than 10 years have more violations of the distance requirements from wells or the lakeshore.

The distinction should be made between nuisance or community improvement problems on the one hand, and public health and water quality problems on the other. Public health problems may result from recurrent backups, ponding of the effluent on the soil surface, and contamination of the groundwater supply in excess of drinking water standards. The existing systems around Crystal Lake have been examined to determine whether they are contributing to public health and water quality problems.

a. Ponding

Ponding may result if percolation of effluent through the soil is too slow, if the system was installed to close to the soil surface or if a high groundwater table prevents percolation through the soils.

Ponding may also result from hydraulically overloading otherwise suitable soils; continuous inundation of the soil may lead to clogging. Only 3% of the systems surveyed have had problems with ponding more than once; these problems may have resulted from poor maintenance rather than unsuitable soils. The problems with ponding occurred with systems over 15 years old; several of these had never been pumped until 1976-1978.

EPIC, a branch of the Environmental Monitoring and Support Laboratory (EMSL), conducted a survey (1978) to determine surface malfunctions by aerial imagery. Only two surface malfunctions were detected along the lakeshore (Figure II-15) but several failing systems were found in and near the Village of Benzonia. Soils in the area have a relatively high clay content, which may contribute to ponding (Leverett 1907; Crawford 1977). Some sections of Crystal Lake Township (Figure II-15), distant from the lakeshore, had several surface malfunctions, suggesting a high clay content in these soils as well.

b. Backups

Several of the systems around Crystal Lake have backed up on occasion as the result of hydraulic overloading, roots growing into the drywell, pump failures or lack of septic tank maintenance. Unsuitable soils may cause backups as well, if the effluent cannot percolate through the soil. Based on results of the sanitary survey, 20% of the existing systems have had backups. Only about 6% of these backups could not be attributed to an occasional hydraulic overload or a maintenance problem that has since been corrected (e.g. roots in the drywell or pump failure). The causes of recurring backups in 5% of the systems is not clear. These systems were generally old, and information on the size of the septic tank or soil absorption system was lacking. Most of these systems are drywells, although this may be only coincidental. Nevertheless, the data indicate that recurring problems with backups are not common in the Proposed Service Area.

c. Groundwater Contamination

In view of the large number of septic tanks using a drywell as the soil absorption unit and because several septic tanks are too close to the wells to meet regulations, there is concern about potential groundwater contamination with nitrates. However, a study conducted by Gannon (1970) (see Section II.B.4 for more detail) indicated that concentrations of nitrates in wells along the western, northwestern and southern shores of Crystal Lake were considerably below the drinking water standard of 10 mg/l. Only two samples, taken from adjacent wells along the northeastern shore, showed concentrations of nitrate equal to or greater than the standard. The source of nitrates in these wells can only be assumed to be nearby on-site systems since no follow-up evaluation of the wells was reported.

d. Surface Water Quality Problems

Septic tanks do not seem to be contributing significantly to water quality deterioration. Crystal Lake receives a sufficiently low nutrient input to maintain an oligotrophic status. Septic tanks contribute a small percentage of that input compared to non-point source runoff (see Table II-6 and discussion in Section II.B.7.a). Kerfoot observed that only 18% of the lakeshore homes were leaching detectable nutrients into Crystal Lake. These data indicated that the per capita phosphorus load (based on a population of 574 during November when the survey was taken) was 0.036 kg/cap/yr (0.08 lb/cap/yr). In contrast, the National Eutrophication Survey estimated that phosphorus loads, leaching from septic tanks into surface waters generally average 0.11 kg/cap/yr (0.25 lb/cap/yr). Even if this higher load were realized from all lakeshore homes, septic tank leachate would contribute a maximum of 6.7% of the total phosphorus input to Crystal Lake.

e. Other Problems

Other problems exist which do not pose a potential health threat or the potential for water quality degradation. Odors associated with septic tanks are considered a nuisance. However, this problem occurs infrequently in the lakeshore townships. Only six residents or 2.5% of those surveyed in the University of Michigan sanitary survey in 1978 complained of odor problems.

Attached algal growth (*Cladophora*) is also a nuisance problem. The growth has not been found to be indicative of overall lake eutrophication; the main problem with the algae is that the growth is aesthetically displeasing and may interfere with certain recreational activities.

Available data on the extent and distribution of *Cladophora* vary depending upon how the survey was conducted. Results of a study performed during the sanitary survey indicate that *Cladophora* growth is associated with 34% of the existing homes and septic tanks. By contrast, Tanis detected *Cladophora* growth by aerial photography along only 5% of the homes (Figure II-16). This method can only detect relatively dense patches of growth, while the sanitary survey located even slight patches by visual inspection.

f. Problems in Individual Sections Around Crystal Lake

The information reviewed above suggests that even though many systems do not comply with regulations, groundwater and surface water quality are generally good and that problems with existing systems could be minimized by proper maintenance. However, the various sections of Crystal Lake are each unique, and their on-site systems should be considered individually.

Northeast Shore. Data presented in Table II-9 (see Section II.C.1.b above) indicate that the northeast shore has the greatest number of systems that do not meet regulations (62%). This area is more prone to failure and water pollution problems than other lakeshore areas for three reasons:

- The area has a high seasonal groundwater table (see Section II.B.3) and many systems could not meet regulations even with upgrading.

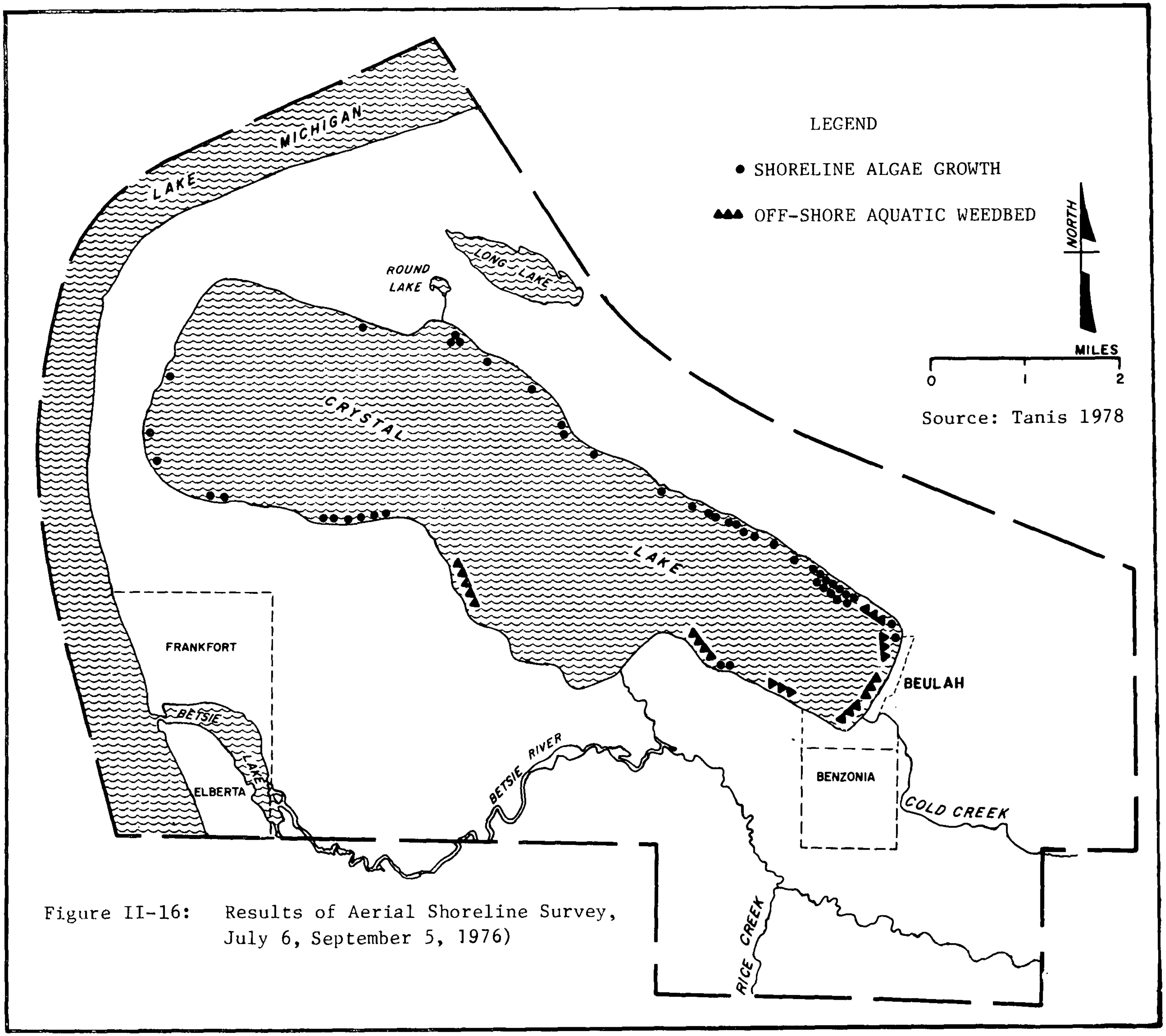


Figure II-16: Results of Aerial Shoreline Survey, July 6, September 5, 1976)

- It is the most densely populated shoreline area (38 homes per shoreline mile).

- It has the most systems violating the regulations on distance to lakeshore and distance to wells (Table II-9).

Despite the potential problems related to high groundwater table, and the number of undersized systems, only 13% of the on-site systems along the northeast shore have had recurring problems with backups and ponding. Only 1 of 9 problem systems was less than 10 years old. Many of the older systems are undersized and were not maintained properly prior to 1971. There were a number of other systems that experienced backups and ponding on one occasion; however, these problems could clearly be attributed to poor maintenance or overuse.

Leaching of wastewater-related nutrients to lake water is most extensive on the northeast shore. Growth of Cladophora attributed to the leaching of nutrients from septic tanks was associated with 69% of the homes surveyed along the northeast shore, although only 24% of the algal growth was heavy. Kerfoot estimated that 34% of the phosphorus leached from septic tanks came from the northeast shore (1978). Poor soil absorption capacity, the large number of homes close to the shore and the high groundwater table encourage the leaching of nutrients. However, as was mentioned previously, nutrient loads are significantly less than would be expected based on NES data.

Groundwater quality along the northeast shore is discussed in Section II.B.4. It is unlikely that drywells alone are responsible for the localized nitrate contamination of groundwater observed by Gannon in 1969 (Gannon 1970). (Two wells indicated nitrate concentrations greater or equal to 10 mg/l.) Drywells make up a large percentage of the soil treatment units along other parts of the lakeshore where nitrate concentrations in well water were found to be low. Several factors may contribute to high groundwater nitrate levels; these include the location of septic tanks close to the wells, the high groundwater table, and the undersized systems, as well as the use of drywells.

Southeast. Soils along the southeast shore are generally well-drained and more suitable for on-site treatment. Of the 39 systems surveyed, only 2 had more than an occasional problem with backups or ponding. There is no clear indication that these problems resulted from unsuitable soils rather than improper maintenance. For 59% of the systems, failure to comply with the sanitary code results primarily from widespread use of drywells and a large number of undersized systems. Very few systems violate the regulations concerning distance to the lakeshore since a privately owned greenbelt has prevented development close to the lake.

Despite the large number of drywells and the fact that 15% of the systems are located within 15.3 meters (50 ft.) of a well, no wells were observed with concentrations of nitrate in excess of 4.0 mg/l (Gannon 1970).

Although most of the homes are set back at least 100 feet from the shoreline, dense patches of Cladophora growth are associated with 10% of the homes and an additional 24% of the homes have slight patches of Cladophora growth along the adjacent shoreline. EPIC (1978) was able to detect only a few patches of aquatic vegetation, further suggesting that the growth along this shore is generally sparse. Kerfoot (1978) observed a high concentration of septic tank effluent plumes along the southeast shore. The nutrient load was, however, very unevenly distributed (see Figure II-16) with most of the plumes coming from a narrow unsewered section of Beulah.

Northwest. Although 54% of the existing systems do not meet regulations, recurring problems with backups were reported for only one septic tank of the 61 surveyed during the 1978 sanitary survey. A few additional systems backed up on one or two occasions, but these backups were clearly associated with poor maintenance or overuse.

Although 16% of the systems surveyed were less than 50 feet from the lake and 48% of the systems were undersized, Cladophora growth is scarce along the northwest shore.

This area has a high seasonal population, which partly accounts for the low nutrient influx and consequently for the low Cladophora growth observed (Tanis 1978; EPIC 1978; University of Michigan 1978). The northwest shore was found to contribute 24% of the wastewater-related phosphorus load to Crystal Lake. In contrast, the northeast shore, which has 20% less shoreline, was found to contribute 34% of the phosphorus load (Kerfoot 1978).

The northwest shore had the fewest systems that violate the regulations concerning distance from wells. Despite numerous drywells and a high percentage of undersized systems groundwater contamination does not appear to be a problem.

Western Shore. Of the systems along the western shore, 46% violate the existing sanitary code. This area has the smallest percentage of undersized systems. However, based on the sanitary survey, only 2 systems of the 24 have had recurring problems with backups. The 22 systems that experienced backups on occasions were generally poorly maintained; roots growing in the drywells were the most prevalent causes of occasional backups.

Available data indicate that Cladophora growth is minimal along the western shore. Aerial photography detected only one patch of aquatic vegetation on the western shore (EPIC 1978). The sanitary survey indicated that Cladophora grew along the shoreline adjacent to 5% of the homes on the western shore but that none of the growth was heavy. Per capita phosphorus discharges are lowest along the western shore; although the western shore accounts for approximately 9% of the total residences, only about 1% of the total phosphorus from septic tank leachate comes from this area. This can be explained by the groundwater flow patterns, which encourage septic tank effluent from the western shore to flow towards Lake Michigan rather than into Crystal Lake. (See Figure II-9.)

Contamination of groundwater with nitrates is not a problem along the western shore despite the large number of systems that violate the regulations concerning minimum distance to wells and/or regulations concerning use of drywells.

Southwest Shore. The southwest shore has the fewest number of systems that are in violation of the sanitary code. This area has the smallest percentage of drywells, although they still account for a large number of violations. Other major violations include undersized systems and systems located too close to wells.

While there have been occasional problems with backups because of poor maintenance (i.e., systems that needed pumping or contained roots in the drywell) only 3 systems of the 56 surveyed had recurring problems with backups or ponding.

Available data indicate that *Cladophora* growth is prevalent along the southwestern shore. *Cladophora* growth was observed along the shoreline adjacent to 34% of the homes during the sanitary survey, and 16% of this growth was dense (University of Michigan 1978). Aerial photography detected several beds of aquatic vegetation (Tanis 1978; EPIC 1978). Housing density is quite high along the southwest shore with 35 houses per shoreline mile (lakeshore average is 16 houses per shoreline mile). Nevertheless, phosphorus loadings monitored by Kerfoot (1978) were significantly less than those detected along the northeast shore with a similar housing density (2.3 kg of phosphorus per mile on the northeast shore compared to 1.1 kg/mile on the southwest shore). Lower nutrient loads along the southwest shore may be attributed to: a) fewer systems close to the lake; b) presence of sandy, well-drained soils in contrast to wet soils along the northeast; and c) a lower year-round population.

Village of Benzonia. The only data available on the performance of septic tanks in the Village of Benzonia are those from EPIC aerial photographs (1978). This survey detected 5 surface malfunctions in the Village. This corresponds to approximately 2% of the existing systems. No information is available on problems with backups. While it is probable that many of these systems do not meet regulations with respect to sizing, ponding may be the result of poor soil absorption capacity, as well. It is known that thick clay barriers do exist in areas of the Village and consequently effluent may not readily percolate through the soil.

D. BIOTIC RESOURCES

1. AQUATIC BIOLOGY

a. Crystal Lake

The low nutrient levels that characterize oligotrophic lakes such as Crystal Lake support very little plant growth. A study of Crystal Lake water quality conducted in 1969, showed that there were only a few species of aquatic macrophytes* and that they were nowhere abundant (Gannon 1970). At that time bullrush was the dominant emergent aquatic plant; bullrush growth was found along the southeastern shoreline and less extensively along the southwestern and western shores. Submerged plants included chara, water star grass and curly pondweed. In the area where Cold Creek discharges into Crystal Lake, large beds of chara and potamogeton (pond weed) were found (Michgan DNR, various years). Cold Creek receives high nutrient loads from non-point source runoff and leaks or seepage from the present sanitary systems; as a result it supports abundant plant growth within its own bed and where it enters Crystal Lake.

The filamentous algae, Cladophora, has been observed growing attached to rocks in front of the cottages along the shore of Crystal Lake. In Crystal Lake, where the nutrient supply is naturally low, the presence of this growth is a strong indication of nutrient contamination from localized sources (Tanis 1978; Gannon 1970; Kerfoot 1978).

Tanis (1978) conducted an aerial survey of Crystal Lake in 1976 and found that about 5% of the existing lakeshore homes had Cladophora growth along the adjacent shoreline. The level and frequency of the growth were reported to be comparable to that observed in 1969. Figure II-16 indicates that the heaviest growth occurred along the northeast shore.

In a recent sanitary survey (University of Michigan 1978) the extent and distribution of Cladophora growth were determined by on-site investigations, which permitted even slight patches of Cladophora to be detected. The study indicated that, of the sites investigated (23% of the residences in the Proposed Service Area around Crystal Lake), 35% had Cladophora growth although only about 11% of the growth was categorized as heavy. Table II-11 shows the distribution of growth with respect to the shoreline area.

Table II-11
DISTRIBUTION OF CLADOPHORA GROWTH
ALONG CRYSTAL LAKE SHORELINE AS PERCENT
OF SITES INVESTIGATED

Shoreline	Slight Growth	Moderate Growth	Heavy Growth
	%	%	%
Northeast	14	31	24
Northwest	15	2	7
West	0	5	0
Southwest	11	8	16
Southeast	24	10	10

(University of Michigan 1978)

In agreement with Tanis' study, growth was found to be heaviest along the northeast shore. The more frequent growth reported in the sanitary survey as compared to Tanis' survey may have resulted from the different survey methods used (on-site survey versus aerial survey).

Several studies have tried to correlate the frequency of Cladophora growth with certain variables related to septic tank performance. Gannon (1970) observed a correlation between housing and septic tank density and Cladophora growth. The sanitary survey (1978) found that Cladophora growth correlated best with proximity of systems to the lake shores, length of residence (seasonal vs. year round), and age of the system. The systems which were installed prior to 1971 were not required to conform to a sanitary code and consequently the older systems are frequently in violation of the existing code.

Kerfoot (1978) observed a correlation between Cladophora growth and septic tank leachate plumes, suggesting that septic tanks are the localized nutrient sources supporting algal growth.

Studies on the macroinvertebrate* populations in Crystal Lake show a diversity of species and a surprising abundance considering the limited nutrient supply (Gannon 1970). Macroinvertebrates are the main source of food for the large fish population in Crystal Lake.

Such clean water organisms as the mayfly nymph, the caddisfly larvae and amphipods were found in the littoral zone. Benthic organisms were very abundant; at a depth of 70 feet, the density of organisms was 100 organisms/$ft.^2$ (Gannon 1970).

Crystal Lake supports a large and valuable fish population. The Lake is particularly suited to cold water species and has been managed for game fish since the 1920s. The lake has been stocked periodically with rainbow trout, lake trout, brown trout, steelhead and splake. All species were stocked as recently as 1973 and trout were stocked again in 1975-1976. Smallmouth bass, perch and largemouth bass have not been stocked since the 1930s and 1940s (Michigan DNR 1973). These species do not thrive as well as trout in the low water temperatures.

b. Betsie River

Betsie River supports a much more abundant and diversified vegetative population than does Crystal Lake. Detritus* from decaying grasses and vegetation along the shoreline supply the river with nutrients for plant growth. Dense filamentous algae and weed beds have been observed at various stream segments (Michigan DNR 1973). "Clean water" invertebrates such as caddis larvae, mayfly larvae and crustaceans are natural food sources for the fish population as are the more population tolerant worms (Michigan DNR 1973).

The Betsie River is a popular year-round sport fishing stream. The river is an spawning stream for trout, chinook salmon, coho and steelheads (by telephone, Tom Doyle, Michigan DNR, November 1977; Michigan DNR 1973). A 1965 stream survey (DNR) showed a diversified resident fish population. Appendix Table G-2 shows fish species collected during this study. The warm temperatures in the Betsie River do not favor trout, but several species of coarse or rough fish are present.

c. Betsie Lake

No information on the aquatic biology of Bestie Lake was available other than the records from the Michigan Department of Conservation on fish stocked there. Brown trout and rainbow trout were stocked in Betsie lake in 1972.

2. WETLANDS

Wetlands are highly productive but fragile ecosystems, where flora and fauna require saturated or seasonally saturated soils for growth and reproduction. Figure II-11 shows the location of wetlands in the Study Area. Wetlands are found along the Betsie River, along the shores of Round Lake and in an area northwest of Long Lake. No wetlands exist along the shoreline of Crystal Lake. Wetland formation is probably deterred here by wave action and the scouring action of ice.

The wetland types in the Study Area are mainly wooded swamps and cattail marshes. These wetlands are characterized in Table II-12 with respect to flora, fauna and their location.

In natural resource production and preservation wetlands serve to assimilate pollutants by acting as settling and/or filtering basins and to collect sediments as a result of their shoaling* characteristics. Wetlands also act as a natural buffer against water quality problems associated with shore development. Furthermore, wetlands serve as flood water retention areas and also as prime natural recharge areas for groundwater.

Wetlands are currently afforded Federal protection under Executive Order 11990, which mandates that no construction project granted Federal funds may adversely affect wetlands unless reasonable alternatives do not exist.

In the State of Michigan wetlands are under the jurisdiction of the Department of Natural Resources. The extensive wetland areas along the Betsie River are protected from certain types of development by the Betsie River Natural River Zoning Act (Appendix D-3). Several Michigan laws, including the Inland Lakes and Streams Act, and the Soil Erosion and Sedimentation Control Act, also protect wetland areas.

3. TERRESTRIAL BIOLOGY

As a result of agricultural and residential expansion, the present forest consists largely of second- or later-generation sugar maple, elm, yellow birch, beech and basswood; it also contains a variable admixture of hemlock and white pine throughout, as well as occasional stands of aspen and birch. Stands of red pine have been planted in some open areas and abandoned fields (Michigan DNR 1973).

Wildlife in the area provides many hours of recreation for the hunter, sightseer and naturalist. White-tail deer, cottontail rabbits,

Table II-12

CHARACTERIZATION OF WETLAND AREAS IN THE CRYSTAL LAKE STUDY AREA

Wetland Type	Location	Flora	Fauna
Wooded Swamp	banks of the Betsie River	black oak, red maple, spruce, larch balsam, willows, alders	beaver, muskrat, mink, rabbit, grouse, woodcock, white tailed deer, wood ducks, black ducks, blue-wing teal. Suitable habitat for bald eagle.
Cattail Marshes	shore of Round Lake, Northwest	characterized by emergent vegetation such as cattails, bullrushes, arrowheads, sedges and grasses	muskrat, beaver, shore-birds, wading birds, mallards, black ducks, wood ducks, several small mammals; also a suitable habitat for the bald eagle.

Michigan DNR. 1973. Natural river report: Betsie River.

ruffed grouse and woodcock are common, especially in the lowland brush and coniferous areas along the Betsie River. Beaver, muskrat, mink, and other small mammals have been observed along the entire length of the Betsie River. Squirrels, chipmunks, woodchucks, and an occasional red fox occupy the woodlands and open fields above the Betsie River. Many species of small rodents such as mice and voles inhabit both lowlands and uplands of the Study Area.

The many streams and lakes offer numerous stopover points for both ducks and geese on their autumn and spring migrations. There is a resident flock of Canada geese near Elberta; mallards, black ducks, blue-wing teal, wood ducks and coots are other common waterfowl hunted along the entire Betsie River (Michigan DNR 1973). A list of vertebrates whose ranges include the Study Area is provided in Appendix G-1.

4. THREATENED OR ENDANGERED SPECIES

Michigan has an active endangered and threatened species program complementing that of the Federal government and has published lists of animal and plant species it would classify as endangered or threatened. Michigan Public Act 203 of 1974, provides protection for species classified Endangered* or Threatened* on the Federal list or listed and confirmed for protection by the State. The Act authorizes a full range of conservation management programs for these plants and animals. The Michigan program recognizes two other categories -- rare or scarce, and peripheral -- but species in these categories have no legal status under the Michigan Act (Michigan DNR 1976). A list of Endangered, Threatened or rare species of wild flora and fauna that occur or may occur in the Study Area is included in Appendix G-2.

No species of fish, reptiles, or amphibians known to occur in the area has been classified by either the US Fish and Wildlife Service (FWS) or the DNR as Endangered or Threatened (by telephone, Mr. Bernard Ylkanen, District Fisheries Biologist, DNR, Cadillac Division, 26 June 1978).

Although no mammalian species in the area has been classified by the State or FWS as Endangered (by letter, Mr. Robert Huff, District Wildlife Biologist, DNR, Cadillac Division, 5 July 1978; FWS 1978), the Study Area lies within the range of several species of mammals listed by the State as Threatened or rare. According to Mr. Huff, some of the smaller birds and mammals on the Michigan list may occur occasionally in this area, but up-to-date population data are not available for these species.

There is an active bald eagle nest on the headwaters of the Betsie River, and an active osprey nest nearby in Grand Traverse County. Neither nest is in the Study Area, but the birds may find prey in area waters, which are in easy flying distance. Both species are classified by FWS and DNR as Threatened. The area is also within the range of the peregrine falcon, classified as Endangered, which may visit on rare occasions.

The Study Area lies within the range of several plant species classified by Federal and State agencies as Threatened. They were not identified during on-the-ground surveys conducted in 1977 and 1978. However, local residents have identified and confirmed the existence of three such plant species in the Study Area --ram's head lady slipper, pitcher's thistle, and broom rape (by telephone, Mr. Rick Habert and Mr. Arvid Tesker, Frankfort City, Michigan, 7 August 1979). Because there is some danger in disclosing the locations of rare plants the sites have not been publicized. However, the habitats of these rare plants are outside any proposed construction area.

Failure to observe most of these species during the surveys does not dispel the possibility of their presence in the Study Area. The Michigan Endangered Species Program is presently engaged in inventorying and mapping endangered, threatened, and rare animal and plant species in the State. If this, or other studies should reveal the presence of a listed species during on-the-ground investigations, the appropriate protective provisions of Federal and State laws would come into effect.

E. POPULATION AND SOCIOECONOMICS

The existing information on population, employment, income, poverty level, and housing has been published separately for each municipal jurisdiction in the Study Area. Taken together, these data describe the "Socioeconomic Study Area," an area that is somewhat larger than the Study Area. The "Proposed Service Area," which is made up of those areas proposed in the Facility Plan for sewering, is also smaller than the Study Area, covering only portions of the three Townships in the Study Area, Lake, Crystal Lake and Benzonia (see Figure I-4). Consequently, the published information cited in this section generally describes, but cannot precisely reflect characteristics of the actual populations of either the Study Area or the Proposed Service Area.

1. POPULATION

a. Historic Trends

Historic trends in permanent (year-round) population for the Socioeconomic Study Area and for Benzie County as a whole are presented by decade from 1940 to 1975 in Table II-13, which reveals that 87% of the population growth in the County during this period took place in the three townships of the Socioeconomic Study Area. The region approximating the Proposed Service Area had an average annual growth rate of 1.4%, with the highest absolute change in population occurring in Benzonia Township.

More recently, between 1970 and 1975, average annual rates of growth of the permanent population of some political units of the Crystal Lake Study Area have been higher than 1.4%, illustrating the increasing popularity of Crystal Lake as a year-round residential area. The exception was Crystal Lake Township, which showed almost no net change in permanent population in that period.

Table II-13

PERMANENT POPULATION TRENDS
(1940 - 1975)

Area	1940	1950	1960	1970	1975	Historical Average Annual Growth Rate (1940-1975)	Absolute Change in Population 1940-1975
Benzie County	7,800	8,306	7,834	8,583	9,870	0.67%	2,070
• Benzonia Township* (excluding villages)	1,576	1,848	1,847	2,071	2,599	1.46%	1,032
- Benzonia Village*	340	407	407	412	484	1.01%	144
- Beulah Village*	378	458	436	461	542	1.03%	164
• Crystal Lake Township*	421	426	450	534	537	0.69%	116
- Frankfort City	1,642	1,605	1,690	1,660	1,823	0.3%	180
- Elberta Village	617	850	552	542	498	-0.61%	-119
• Lake Township*	102	222	259	377	452	4.35%	350

* Indicates areas which closely approximate the Proposed Sewer Service Area. This area had an average annual growth rate of 1.43% with an absolute change in population of 1,806.

US Census of Population 1940, 1950, 1960, 1970.

US Census, Current Population Reports (Series P-25) May 1977.

There are no data available on the seasonal population of the Study Area before 1972. In that year, it was estimated that the Study Area attracted over 6,200 seasonal residents. This population grew to 8,300 in 1975 (Wilbur Smith and Associates 1973; Grand Traverse Area Data Center 1975, 1977), reflecting an average annual growth rate of almost 10%. Of the 1975 total, 48% of the seasonal population resided within the Proposed Service Area.

The permanent/seasonal population split varied considerably among jurisdictions. Frankfort City, Elberta Village and Benzonia Village were each composed almost entirely of permanent population. Lake Township and Crystal Lake Township, on the other hand, had large seasonal populations, 89% and 82%, respectively, of their total in-summer populations, plus the highest increases in absolute numbers. These increases underscore the attractiveness of the two areas for recreation and second-home development.

b. Population Projections

The assumptions and methodology used in preparing the projections for the Proposed Service Area are provided in Appendix H. The population projections are based on historic housing and population characteristics and trends. Other factors that influence actual growth, such as aesthetics, availability of services and housing sites, changes in housing types, and regional economics, were not incorporated.

The total in-summer population of the Proposed Service Area in the year 2000 is projected to be approximately 12,500, a 47% increase over the 1975 figure. The average annual growth rate for the 28-year period from 1972 to 2000 is expected to be 1.5%, slightly higher than the historical rate of 1.4%. The largest absolute increase in combined permanent and seasonal population is projected for Crystal Lake Township -- nearly 2,000 additional persons or 83% by 2000 -- while Benzonia Village, Beulah Village and the City of Frankfort are expected to increase by only 10-20% in that time.

Summary estimates of permanent and seasonal population and average annual growth rates for the years 1975 to 2000 for the Proposed Service Area are presented in Table II-14. This information is given by minor civil divisions in Table H-2 in Appendix H.

Table II-14

POPULATION PROJECTIONS AND AVERAGE ANNUAL
GROWTH RATES FOR CRYSTAL LAKE PROPOSED SEWER SERVICE AREA

Population Component	1975	2000	Average Annual Growth Rate (1975-2000)	Absolute Change (1975-2000)
o Seasonal	4,098	6,742	2.0%	2,644
o Year-round	4,420	5,748	1.1%	1,328
o Total	8,518	12,490	1.5%	3,972

Because the various communities within the Proposed Service Area are not expected to grow at equal rates, each locality's percentage of the total population will change slightly over this period. Also, for the entire Proposed Service Area, the proportion of permanent population is projected to decrease from 52% of the 1975 total in-summer population to 46% in the year 2000.

In summary, all the communities are expected to grow during the planning period. Population growth will be greatest in those communities that are presently the most populous. However, the 1975 distribution of population within the Proposed Service Area is not projected to change greatly by 2000, and the permanent/seasonal population split and the relative size of the population in each community will change only slightly.

2. CHARACTERISTICS OF THE POPULATION: EMPLOYMENT AND INCOME

a. Permanent Population

This section presents information on the income levels, poverty population, elderly population and employment characteristics of the Study Area. These characteristics were chosen because of their relevance to the financial impacts of wastewater treatment alternatives on households in the area.

The Crystal Lake Socioeconomic Study area is characterized by relatively low income levels for the permanent population. The mean family income was $9,163 in 1970 in the Study Area and $8,659 in Benzie County, 75% and 71% respectively, of the mean income for the State of Michigan. In that year, the most recent for which data are available, only 37.8% of the families in the Study Area had incomes over $10,000, as compared to 57.1% of families in the State (US Census 1970). Despite the relatively low income level in the Socioeconomic Study Area, however, a comparatively small proportion of the population fell below Federally established poverty levels -- 6.0% as compared to 7.3% of the State population (Table II-15). An important factor in the income levels of the area is its predominantly rural character and relative remoteness from large employment centers.

Table II-15

POVERTY STATUS-FAMILIES 1970

Area	Number of Families Below Poverty Level	Percent of Families Below Poverty Level
Michigan	160,034	7.3
Benzie County	245	11.2
Study Area	102	6.0
Benzonia Township	43	4.3
Crystal Lake Township	12	9.9
Frankfort City	42	8.9
Lake Township	5	4.9

US Census of Population and Housing, Fifth Count Summary Data, 1970.
US Census of Population - 1970, Supplementary Report issued December 1975.

Retirement population (age 65 and over) made up 17% of the Study Area's population in 1970, as compared to 8% of the State of Michigan (Department of Commerce, Bureau of Economic Analysis 1970). Many persons in this retirement age group are living on low or fixed incomes.

Service occupations have represented a steadily increasing proportion of Benzie County employment since 1950. By 1970, such vocations formed the largest employment sector, accounting for 28.3% of all employed persons. Increases in the service and retail trade sectors have been the response to the growing importance of tourism in the area; much of the total retail sales in Benzie County have been attributed to the tourist industry. Tourist expenditures as a percentage of retail sales grew from 26% in 1967 to 45% in 1972 (Michigan Department of Commerce 1975). Employment in agriculture has declined since 1940 to only 7.2% of the labor force in 1970. The only large industrial plant in the Study Area is Pet, Inc.

b. Seasonal Population

Most seasonal residents in the Crystal Lake Area appear to come from other parts of Michigan. A survey of summer visitors to Benzie County by the Data Research Center (1978) indicated that 64.3% came from southern Michigan, 10.1% came from Canada, 13.0% came from Great Lakes states other than Michigan, and 5.8% came from other areas. The survey also indicated that most seasonal visitors come to the area regularly and that the aesthetic quality of the area, its location convenient to metropolitan centers in southern Michigan, and the presence of friends and relatives are major attractions (by telephone, Nancy Hayward, Data Research Center, February 1979). Establishment of the Sleeping Bear Dunes National Lakeshore Park has contributed to a large recent increase in seasonal use of the area and is expected to bring about further increases in the near future.

No direct data on the age, income, or occupational characteristics of summer residence owners in the Study Area or Proposed Service Area are available. The value of the seasonal homes in the area (generally in the $50,000 to $60,000 range in 1979) indicates that most seasonal residents are upper or upper middle income. From the limited data available, it appears that seasonal residents generally have higher per-family and per-capita incomes than permanent residents of the area.

3. HOUSING

In 1970, the Crystal Lake Socioeconomic Study Area contained 3,647 dwelling units. Of these units, 1,946 (53%) were occupied year round, and 1,701 (47%) were occupied on a seasonal basis. More than 82% of the permanent dwellings in the Study Area were owner-occupied in 1970 and over half (55.6%) were built before 1940 (Table II-16). Median values of permanent residences in Benzie County were considerably lower than in the State of Michigan in 1970: $10,882 vs. $17,589. These lower values reflect the rural nature of the area, the age of the permanent housing stock, and the lower level of family income.

Table II-16

HOUSING CHARACTERISTICS OF THE SOCIOECONOMIC STUDY AREA (1970)

	Number	Percent
Total Dwelling Units	3,647	
Permanent	1,946	53.3
Seasonal	1,701	46.6
Of the Permanent Units:		
Occupied Units	1,574	80.9
Vacant Units	372	19.1
Of the Occupied Units:		
Owner-Occupied	1,304	82.8
Renter-Occupied	270	17.2
Age of Permanent Housing Stock:		
Built after 1965	184	9.5
Built between 1939 and 1964	680	34.9
Built before 1940	1,082	55.6

US Census of Housing. 1970. Summary Data.
US Census of Housing. 1970. Fifth Count Summary Data.

Dwellings outside presently sewered areas were counted from aerial photographs in 1976. The count revealed that there were 1,093 dwellings in the presently unsewered parts of the Proposed Service Area and that about 500 or 46%, of these were within 300 feet of Crystal Lake. The study also indicated that there were about 100 vacant lots within 300 feet of the Lake which could be developed with septic tanks.

Despite continued county-wide growth, in the four years from 1974 to 1977 issuance of septic tank permits for the Crystal Lake area fell 26% from the previous four years (Health Department 1977). Reasons for this change have not been explained but it is presumed to be due to the more stringent permit requirements implemented in 1972.

4. LAND USE

a. Present Land Use

Current use of land in the Study Area is shown in Figure II-17. Major uses include the following:

- Small urban centers, including the communities of Frankfort, Benzonia, Beulah, and Elberta with a core of residential and commercial uses
- Single family seasonal and permanent residential areas around Crystal Lake, Lake Michigan, Long Lake, and along major roads
- Agricultural areas devoted to row crops and orchards
- Woodlands
- Open land consisting of wet woodlands, wetlands and sand dunes.

The patterns of non-agricultural development in the Crystal Lake region have been shaped by a combination of topography, aesthetic amenities, transportation and such characteristics of the soils as slope, drainage and permeability which determine the suitability of land for development. Outstanding recreational opportunities and scenery -- lakes, streams, woods and hills -- have stimulated considerable residential development. Although building to the north and south of Crystal Lake is limited by steep slopes to a single tier in some locations, off the Lake there are grid patterns of development on the rolling sand dunes west of Crystal Lake and in the Village of Beulah at the eastern end.

Most commercial areas are in village centers or along the main highway, US 31. Commercial development elsewhere includes local convenience stores such as groceries and tourist-oriented facilities including lodging. Industrial areas occupy a small portion of the Proposed Service Area along US Route 31. The largest industrial establishment in the area is Pet, Inc.

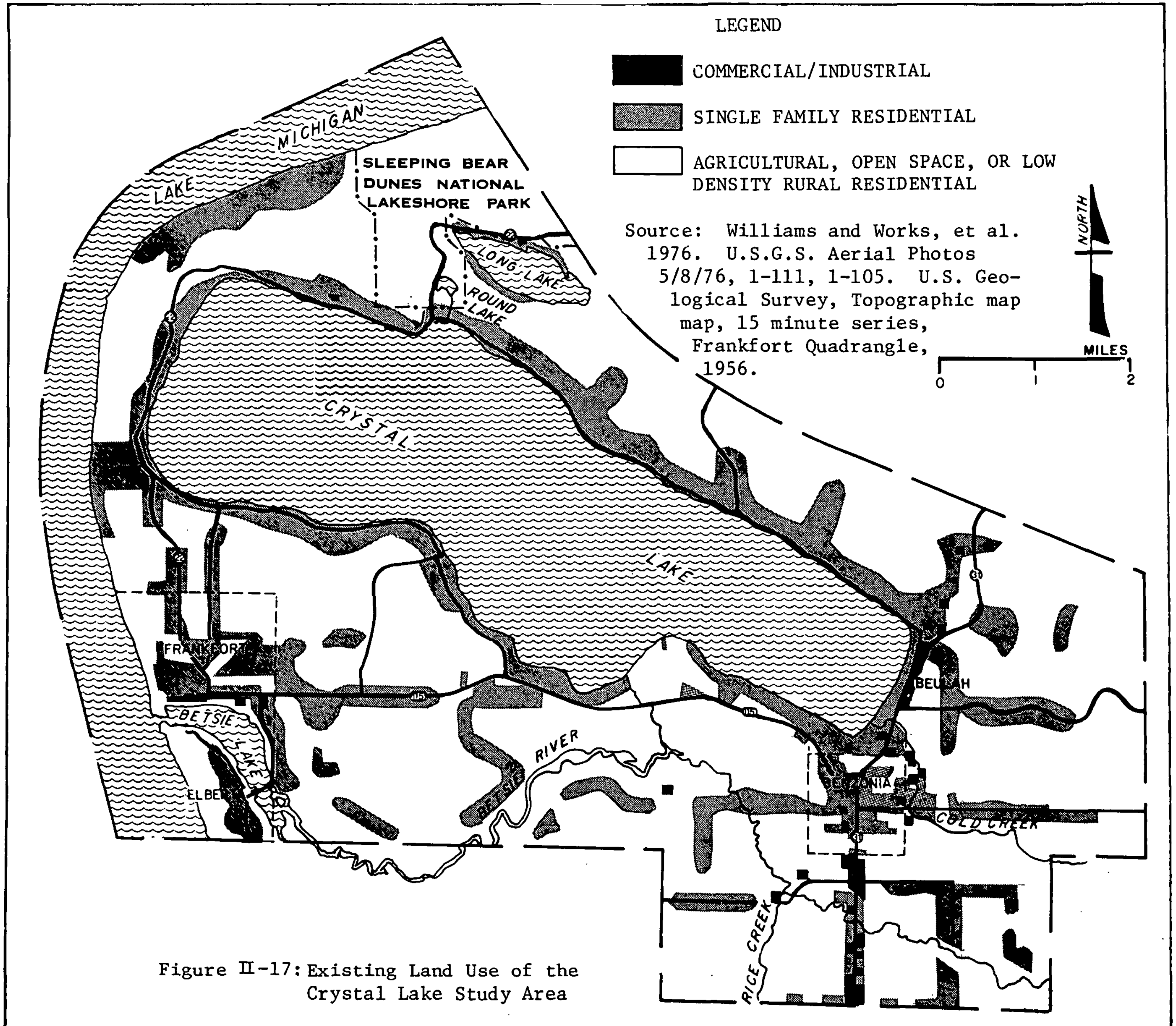


Figure II-17: Existing Land Use of the Crystal Lake Study Area

The greatest potential for future commercial development within the Proposed Service Area exists along the land adjoining the access routes between the Sleeping Bear Dunes National Lakeshore Park north of Crystal Lake and the more populous areas to the south of the Study Area. Increased tourism in the Lakeshore Park and expanding permanent and seasonal populations are expected to swell the volume of traffic along US Route 31 and Michigan Routes 22 and 115. The area also includes the Betsie River, designated "a natural river" by the State (see Section II.B.1, II.B.6 and Appendix D-3).

b. Growth Management Policies and Regulations

Development within the Study Area is regulated by State, county, and local ordinances. The most important regulatory measures affecting development in lakeshore areas are:

- o The Inland Lakes and Streams Act, Michigan State Act 346 (1972);
- o The Soil Erosion and Sedimentation Control Act, Michigan State Act 347 (1972);
- o The Comprehensive Development Plan for Benzie County; and
- o Zoning ordinances for the Townships of Benzonia, Crystal Lake and Lake and the Village of Beulah.

The Inland Lakes and Streams Act sets general guidelines and requires persons wishing to build on submerged lands, i.e., on areas lying below the ordinary high water mark, to obtain a permit. Should it be necessary, DNR may sue in the circuit court of the appropriate county to enforce compliance with the terms of the permit.

Under the Soil Erosion and Sedimentation Control Act, all construction activities that would disturb one or more acres of land, all construction activities within 500 feet of the shore of a lake, river or stream, and any construction activity that would cause sedimentation in surface waters are regulated through a permit system administered by designated county agencies, in this case the Benzie County Community Development Department. The Act imposes limitations upon tree cutting, removal of vegetative cover, and cut and fill operations. Mitigating measures to control runoff from construction sites must be taken, and designated officials may enter and inspect sites at reasonable times. The DNR must conduct an on-going appraisal of soil erosion control programs to ensure compliance; a permit may be revoked upon a finding of a violation (R 323.1704 Permit Requirements, Rule 704(1), Michigan 1974 Annual Administrative Code Supplement).

The Comprehensive Development Plan for Benzie County classifies the following types of areas as environmentally sensitive:

- o Excessive slope areas
- o Dune formations and major sand areas
- o Areas with other soil limitations

- Marshland areas
- Riverine areas
- Lake Michigan and inland lake shorelines.

In the Plan, these areas were combined into a "zone" that traverses other land use boundaries. Although this special critical area designation does not dictate how land may be used, it does set restrictions that must be considered in planning any future developments. In any environmentally sensitive areas already under development, the Plan stated that new development must be designed to minimize impact on environmental quality.

In the County's Plan, most of the land surrounding Crystal Lake was designated as medium density residential. This category set expansion areas of "suburban" density for major growth centers based on anticipated population levels for each village or area. A range of densities from 1 unit per 3 acres to 1 unit per acre (near the major growth centers) was established for these developmental buffer areas, which are intended to provide adequate land for single family development of a lower density than in villages without encouraging the spread of higher densities into the rural areas of the County.

Most of the remaining land in the Study Area, largely rural, has been designated rural/agricultural density residential. Densities in this category were set still lower -- at less than 1 unit per 3 acres. These densities are designed to discourage haphazard development of prime agricultural lands and to encourage denser development near the villages, which often already have public services.

Benzie County allows townships and villages to adopt local zoning ordinances which support county zoning within their jurisdictions. Varying ordinances are in effect in Benzonia Township, Crystal Lake Township, Lake Township and the Village of Beulah. The only zoning district common to all areas is the one-family residential district. Even within this district minimum lot sizes, shoreline setbacks, and permissible uses differ (see Table II-17). Furthermore, Crystal Lake Township allows only single family dwellings and accessory buildings, but harvesting of forest products in residential areas is permitted. Lake Township also allows churches, schools, and non-commercial recreational facilities in residential areas. Benzonia Township is the least restrictive of the local jurisdictions: allowing multiple-family dwellings, resorts and tourist homes in residential areas. The variations among township ordinances present possible problems in future planning and provision of sewer capacity in the Crystal Lake area. Provision of sewers might attract condominium type development to those areas in which it is permitted.

The variations among the townships' definitions and allowances of uses may present a problem in future planning for the Crystal Lake area. It may be necessary for the townships to coordinate their growth management activities in order to ensure that continuing development activity will be consistent with established water quality objectives for Crystal Lake.

Table II-17

MINIMUM SHORELAND ORDINANCE STANDARDS

Township	District	Lot Size (Sq. Ft.)	Building Setback from Shoreland (feet)
Benzonia	Residential	6,000	Front Building Line*
	Agricultural-Residential	6,000	
		-	
Crystal Lake	Residential	8,500	5
	Commercial-Resort	5,000	5
	Summer Camp-Recreational	-	5
	Retail	-	5
Lake	Residential	15,000	2

*Front Building Line is defined as the average distance from the lakeshore to the front wall or portions thereof of all dwellings fronting on the same lakeshore, which are within 100 feet of both sides of the proposed building.

c. Recreation

The Crystal Lake area is a well-established recreational center based upon diversified scenic and sports amenities. Crystal Lake itself is a center for sailing, water skiing, fishing and swimming. Lake Michigan is also a water sports center. Betsie Bay is a marina for Lake Michigan craft and is the site of the historic Betsie Bay Lighthouse. The Platte River, just to the north of the Proposed Service Area is an outstanding salmon fishery. A variety of non-water based recreational opportunities are also found in the area. These include facilities based on the rolling topography of the area and manmade sightseeing attractions. Crystal Mountain Ski Resort attracts winter visitors, while the annual National Soaring and Gliding Festival at Frankfort attracts summer visitors. Other tourist attractions include tours of a paper factory and a pottery factory. Benzonia, Beulah, and Frankfort have a total of 14 motels (Western Michigan Tourist Association 1978).

The most important factor in future recreational development and tourist visitation to the Crystal Lake area is the Sleeping Bear Dunes National Lakeshore, located immediately north of the Proposed Service Area. The National Lakeshore was first proposed in 1950 and designated by Congress in 1970. The Park was formally established in 1977. The Park is still in its early stages of development, and much of the land within the Park boundary is still privately held. The establishment and development of the Park have been the subject of a great deal of controversy. Many local citizens opposed establishment of the Lakeshore, while proposals for wilderness areas (1974) and a scenic corridor and road (1977) have also been controversial. The Platte River Wilderness, just to the north of the Crystal Lake area, is one of six wilderness areas proposed in the National Lakeshore. The National Park Service favors the designation of the Platte River area as a wilderness. Such designation would make pressure from population growth in the Crystal Lake area especially critical. One alternative development plan for the Park includes a scenic corridor and low speed scenic highway (comparable to the Blue Ridge Parkway) for the Crystal Lake Highlands area (National Park Service 1978). A study produced in 1977 defining the scenic corridor and highway was issued in 1977 but was withdrawn by the National Park Service as a result of local controversy and lawsuits (League of Women Voters 1978).

Total visitation at the Sleeping Bear Dunes Lakeshore in 1978 was estimated at 800,000 visitor days. Enough land has been purchased by the Park Service in the last few years to permit development of more extensive hiking and skiing trails. As a result, visitation has been increasing by about 10% per year. Development of a visitor center, interpretive center, and scenic corridor route are still at least 8 to 10 years away, however, because of budgetary limitations (by telephone, Mr. Max Holden, Sleeping Bear Dunes National Lakeshore, 9 April 1979). A study by the Upper Great Lakes Commission (1972), although somewhat out-of-date, did classify the portion of the Crystal Lake area west of US Route 31 as an area of "high development potential" as the result of creation of the National Lakeshore. However, traffic generated by the National Lakeshore in the Crystal Lake area is not believed to be a problem in the foreseeable future.

5. ARCHAEOLOGICAL AND HISTORICAL RESOURCES

One site within the Study Area, the Mills Community House, has been listed on the National Register of Historic Places. Built in 1900 as the women's dormitory of Benzonia College, it is a two-and-a-half-story structure located on the southeast corner of Michigan and Walker Avenues in the Village of Benzonia. The building was remodeled in 1925 and is now used as a library and community center (by telephone, Mrs. Sherwood, the Historic Conservation and Recreation Service, 1 February 1979).

Four possible archaeological sites within the Study Area boundaries have been recorded by the Great Lakes Branch of the University of Michigan, Museum of Archaeology. Three of these, in Lake Township, may have been early villages. The fourth, in Crystal Lake Township, may be an Indian mound or series of mounds. According to John Halsey of the Michigan State History Division, the actual locations and compositions of the sites are not known, and remains may have been destroyed long ago. Mr. Halsey has indicated that an archaeological survey will be required by his agency prior to any construction to verify the existence of any sites that may be impacted by the selected alternative (by telephone, 24 January 1979).

CHAPTER III

ALTERNATIVES

A. INTRODUCTION

1. GENERAL APPROACH

New alternative systems were developed for wastewater collection and treatment in the Proposed Crystal Lake Service Area. This chapter presents eight "EIS Alternatives". It compares designs and project costs to those of the Proposed Action of the Crystal Lake Area Facility Plan (Williams and Works, et al. 1976), described in Chapter I, above. Chapter IV assesses the environmental and socioeconomic impacts of all these systems.

The EIS alternative has focused on those aspects and implications of the proposed wastewater management plan for the Proposed Service Area which (a) have been identified as major issues or concerns, or (b) were not adequately addressed in the Facility Plan.

Chapter I of this EIS, emphasized that an important issue is the overall need for the project proposed in the Facility Plan. Documenting a clear need for new wastewater facilities may, on occasion, be difficult, requiring evidence that the existing on-lot systems are directly related to water quality and public health problems. Such a need is shown when one or more of the following conditions exist (Illinois Environmental Protection Agency 1977):

- Standing pools of septic tank effluent or raw domestic sewage in yards or public areas where direct contact with residents is likely.
- Sewage in basements from inoperable or sluggish sewage disposal systems.
- Contaminated private wells clearly associated with sewage disposal systems.

The Proposed Service Area exhibits some indirect evidence of the unsuitability of site conditions for on-site soil disposal systems. The evidence includes high groundwater, slowly permeable soils, small lot sizes, proximity to lakeshores and substandard setback distances between wells and private wastewater facilities. Available information on these factors were, in fact, used early in the preparation of this EIS to develop the decentralized alternatives designated EIS Alternatives 3, 4 and 5.

Indirect evidence is insufficient to justify Federal funding, however. Federal water pollution control legislation and regulations require documentation of actual water quality or public health problems. Section II.C summarizes the extensive efforts mounted during the preparation of this EIS to document and quantify the need for improved facilities around Crystal Lake.

The dollar cost of the Facility Plan Proposed Action and its impact on area residents make cost effectiveness as serious as need documentation. Since the collection system accounts for the major share of the construction costs in the Facility Plan Proposed Action, the extent of sewer lines needed and the use of newer technologies for wastewater collection have been investigated in detail here, as have alternative wastewater treatment systems. The technologies assessed are listed below:

WASTEWATER MANAGEMENT COMPONENTS AND OPTIONS

Functional Component	Options
Flow and Waste Load Reduction	- household water conservation measures - ban on phosphorus - rehabilation of existing sewers to reduce infiltration and inflow
Collection of Wastewaters	- limited service area - pressure sewers - vacuum sewers - gravity sewers
Wastewater Treatment Processes	- conventional centralized treatment plus chemical treatment to reduce phosphorus concentrations - land application - on-site treatment - cluster systems - rotating biological contactor
Effluent Disposal	- subsurface disposal - land application - discharge to surface waters - greywater recycling
Sludge Handling	- anaerobic digestion - dewatering

Sludge Disposal	-	land application
	-	landfilling
	-	composting

Next, appropriate options were selected and combined into alternative systems. Design criteria in the pertinent state and local codes, given in Appendix F, were followed. The alternatives were then compared. The last section of this chapter considers implementation, administration and financing of the alternatives.

2. COMPARABILITY OF ALTERNATIVES: DESIGN POPULATION

The various alternatives for wastewater management in the Service Area must provide equivalent or comparable levels of service if their designs and costs are to be properly compared. In the following comparison of alternatives the design population of 12,490 has been assumed (see Section C.1.c below and Appendix H).

The same year 2000 design population has been used as the basis for all the EIS alternatives and the Facility Plan Proposed Action in the interest of equitable comparison; it must be recognized, however, that each alternative carries its own constraints and that the wastewater management system chosen may determine much of the Crystal Lake area's actual population in the year 2000.

3. COMPARABILITY OF ALTERNATIVES: FLOW AND WASTE LOAD PROJECTIONS

Design flows for centralized treatment facilities and for the cluster systems are based on a design domestic sewage flow of 60 gpcd in residential areas for both permanent and seasonal residents. This figure increases to 70 gpcd for Frankfort, Benzonia Village and Elberta. The reasons for these per capita design flows are outlined in Section C.1.b of this chapter. Infiltration and inflow (I/I) into gravity sewers was added to the calculated sewage flow in appropriate alternatives.

The design flow used in the Facility Plan for the Proposed Action was 100 gpcd, including I/I. To compare costs properly in this EIS, it was necessary to re-calculate flows for the Proposed Action using flows developed for the EIS alternatives; this was done.

B. <u>COMPONENTS AND OPTIONS</u>

1. FLOW AND WASTE REDUCTION

Methods that reduce the flow or pollutant loads can provide the following benefits to a wastewater management program:

- Reduce the sizes and capital costs of new sewage collection and treatment facilities;

- o Delay the time when future expansion or replacement facilities will be needed;
- o Reduce the operational costs of pumping and treatment; and
- o Mitigate the sludge and effluent disposal impacts.

In the Proposed Service Area residential flow reduction devices and a ban on phosphorus detergent are techniques that may be used to achieve these benefits.

a. Residential Flow Reduction

Appendix I discusses a number of residential flow reduction devices. Of these, dual-flush toilets and flow-restriction devices for shower heads and faucets reduce flow the most for the least cost. Proper use of these devices can reduce consumption of water by an estimated 16 gpcd. EIS Alternative 2 (see Section III.C.2.e) was re-designed and recosted using a design flow based on 44 gpcd to evaluate the cost-effectiveness of widespread use of these devices. Section C.5 discusses the engineering and economic significance of flow reduction.

Briefly, use of these devices in sewered residences saves sufficient capital costs to be cost-effective locally. Use of flow reduction devices reduces water supply and heating costs. If these savings are added to applicable savings in operation and maintenance costs, the Crystal Lake homeowner could save of $112 annually. Appendix I-1 reviews the technical basis of these savings calculations.

Flow reduction devices are also useful with on- or off-site soil disposal systems. Such systems may last longer because hydraulic loading is reduced. Because no long-term evaluation has been undertaken, the increased lifespan and the resultant economic benefit cannot now be quantified. Installation of these devices should be attractive to residents, reducing their own water supply and hot water heating costs as well as wastewater disposal costs.

Several other flow reduction measures providing even greater reductions in sewage generation are available. As an example, some residences require holding tanks because the soils are unsuited to subsurface wastewater disposal and other methods of disposal are not available. In such cases, wastewater flow may be reduced to 15 - 30 gpcd by the following methods:

- o Reduce lavatory water usage by installing spray tap faucets.
- o Replace standard toilets with dual cycle or other low volume toilets.
- o Reduce shower water use by installing thermostatic mixing valves and flow control shower heads. Use of showers should be encouraged rather than baths whenever possible.

- o Replace older clothes washing machines with those equipped with water-level controls or with front-loading machines.

- o Eliminate water-carried toilet wastes by use of in-house composting toilets.

- o Use recycled bath and laundry wastewaters to sprinkle lawns in summer. The feasibility of this method would have to be evaluated on a trial basis in the planning area because its general applicability is not certain.

- o Recycle of bath and laundry wastewaters for toilet flushing. Filtering and disinfection of bath and laundry wastes for this purpose has been shown to be feasible and aesthetically acceptable in pilot studies (Cohen and Wallman 1974; McLaughlin 1968). This is an alternative to in-house composting toilets that could achieve the same level of wastewater flow reduction.

- o Commercially available pressurized toilets and air-assisted shower heads using a common air compressor of small horsepower would reduce sewage volume from these two largest household sources up to 90%.

b. Michigan Ban on Phosphorus

Phosphorus is frequently the nutrient controlling algae growth in surface waters and is therefore an important influence on lake or stream eutrophication. Enrichment of the waters with nutrients encourages the growth of algae and other microscopic plant life; decay of the plants increases biochemical oxygen demand, decreasing dissolved oxygen in the water. Addition of nutrients encourages higher forms of plant life, thereby hastening the aging process by which a lake evolves into a bog or marsh. Normally, eutrophication is a natural process proceeding slowly over thousands of years. However, human activity can greatly accelerate it. Phosphorus and other nutrients, contributed to surface waters by human wastes, laundry detergents and agricultural runoff, often result in over-fertilization, over-productivity of plant matter, and "choking" of a body of water within a few years. Section II.B.7 and Appendix E-4 discuss the process and data pertinent for the Crystal Lake Study Area.

In 1971 the Michigan legislature limited the amount of phosphorus in laundry and cleaning supplies sold in Michigan to 8.7% (Michigan-Public Act 226, Cleaning Agent Act). To reduce phosphorus concentrations in wastewater further, the Michigan Department of Natural Resources subsequently banned statewide the use and sale of domestic laundry detergents containing more than 0.5% phosphorus. By May 1978, according to monitoring data, influent phosphorus concentrations at 20 wastewater treatment plants had decreased from an average of 6.5 mg/l to 4.3 mg/l (by telephone, Mr. Mike Stiffler, DNR, Water Quality Division, 1 August 1978). These figures corresponded to a 35% reduction in phosphorus entering the plants. Figure III-1 illustrates these data.

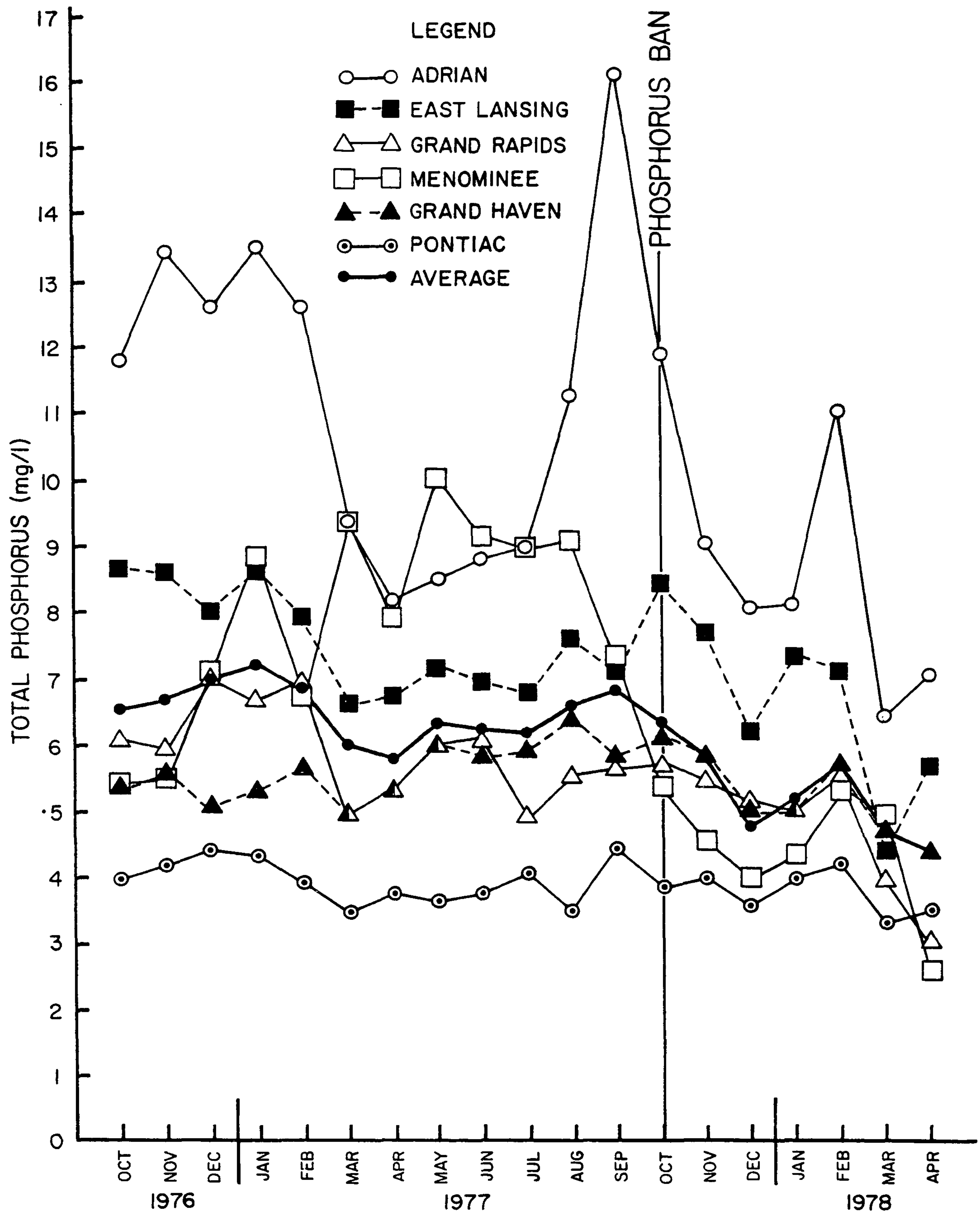


Figure III-1: Phosphorus Loadings at Michigan Treatment Plants

Treatment plants and on-site disposal facilities in the Study Area could experience a similar reduction in phosphorus concentration. However, such characteristics of the Crystal Lake area as the number of residential laundry facilities may differ from those in the communities where data were collected. Clearly, the extent of phosphorus reduction can only be determined by a survey of the characteristics of the Study Area. One approach to the reduction of phosphorus is to require that household detergents be free of phosphates.

Reduction of phosphorus by control of detergents will not achieve the effluent discharge limits of 1 mg/l set for Betsie Lake (see Appendix D-4 for Effluent Limits). Consequently, provision of facilities for phosphorus removal in treatment plant operation is required. The phosphorus ban would not affect on-site systems because the effluent limitation only applies to treatment plants discharging into surface waters.

c. Rehabilitation of Existing Sewers To Reduce Infiltration and Inflow

Infiltration/Inflow Analyses conducted in Frankfort and Elberta for the Facility Plan revealed that infiltration was substantial in both sewer systems and that combined sewers in Frankfort result in significant inflow. Rehabilitation of sewers in both municipalities, beginning with sewer system evaluation surveys (SSES), were recommended in the Facility Plan. The costs and projected flow reduction for the rehabilitation effort are incorporated in all EIS Alternatives except No Action.

While this EIS is not evaluating alternatives for Beulah, leakage of sewage from its sewers may be one of the causes for high nutrient loads and bacterial contamination in Cold Creek. This possibility should be investigated.

2. COLLECTION

The collection system proposed in the Facility Plan is estimated to cost $14 million -- 76% of the total cost of the proposed action -- and is the single most expensive portion of the sewerage facilities. Since not all parts of collection systems are eligible for Federal and State funding, the costs of the collection system impact the local community more than other components of the project. There is, therefore, considerable incentive at local, state and national levels to choose less expensive alternatives to conventional sewer systems.

Alternative means of wastewater collection are:

- pressure sewers (including grinder pumps or STEP systems);
- vacuum sewers; and
- small diameter gravity sewers (Troyan and Norris 1974).

An alternative collection system may economically sewer areas with site conditions that increase the cost of conventional sewerage, such as shallow depth to bedrock, high groundwater table, or hilly terrain. Housing density also affects the relative costs of conventional and alternative wastewater collection techniques.

The alternative most extensively studied is collection by a pressure sewer system. The principles behind the pressure system and the gravity flow system are opposite to each other. The water system consists of a single point of pressurization and a number of user outlets. Conversely, the pressure sewer system has inlet points of pressurization and a single outlet. Pressurized wastewater is generally discharged to the treatment facility or to a gravity sewer.

The two major types of pressure sewer systems are the grinder pump (GP) system and the septic tank effluent pumping (STEP) system. The differences between the two systems are in the on-site equipment and layout. The GP system employs individual grinder pumps to convey raw wastewater to the sewer. In the STEP system septic tank effluent from individual households is pumped to the pressure main.

The advantages of pressure sewer systems are:

- o elimination of infiltration/inflow;
- o reduction of construction cost; and
- o use in varied site and climatic conditions.

The disadvantages include relatively high operation and maintenance cost, and the requirement for individual home STEP systems or grinder pumps.

Vacuum sewers provide similar advantages. Their major components are vacuum mains, collection tanks and vacuum pumps, and individual home valve connection systems. A recent review of vacuum sewer technology, however, noted significant differences among design of four major types of current systems (Cooper and Rezek 1975).

As a third alternative to conventional gravity sewers, small diameter (4-inch) pipe can be used if septic tank effluent, rather than raw waste, is collected. Such pipe may result in lower costs of materials, but the systems retain some of the disadvantages of larger sewers. The need for deep excavations and pump stations is unaffected.

This document analyzed the reliability, site requirements, and costs of the alternative sewer systems considered for the Crystal Lake area. The STEP-type low-pressure sewer system was found the most advantageous of the three alternatives. A preliminary STEP system serving residents around Crystal Lake was, therefore, developed to determine the differences in project costs if it were substituted for the gravity system specified by the Facility Plan. Assumptions regarding the design and cost of the low pressure sewer system are listed in Appendix J-1. Figure III-2 illustrates the arrangement of the STEP system house pump and sewer line connection.

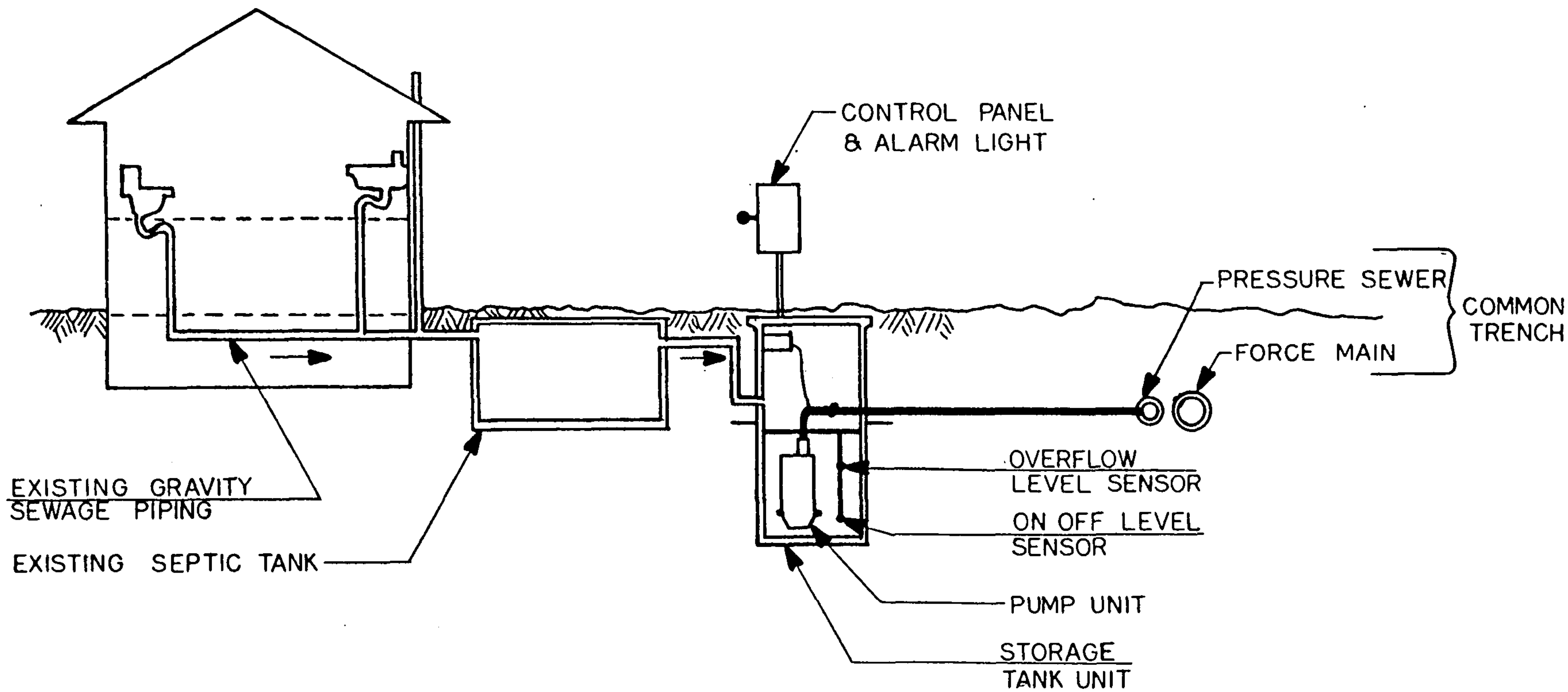


Figure III-2:

TYPICAL PUMP INSTALLATION FOR PRESSURE SEWER

3. WASTEWATER TREATMENT

Wastewater treatment options include three categories: centralized treatment prior to discharge into surface water; centralized treatment prior to disposal on land; and decentralized treatment.

Centralized treatment means the treatment at a central site of wastewater collected by a single system and transported to a central location. Centralized treatment systems may serve all or a part of the service area. Centrally treated effluent may be discharged to surface waters or applied to the land; the method and site of disposal affect the treatment process requirements.

"Decentralized treatment" defines those systems processing a relatively small amount of wastewater; options include "package plants", cluster systems, and individual septic systems. This EIS will assess the technical feasibility, relative costs, environmental impacts, and implementability in the Crystal Lake Study Area of these approaches to wastewater treatment.

a. Centralized Treatment --Discharge to Surface Water

The Frankfort and Elberta primary treatment plants cannot meet the State of Michigan's effluent standards for Betsie Lake. Aside from excessive hydraulic and organic loadings, much of the equipment at the two plants needs repair or replacement. In assessing the potential for expansion and upgrading of these two plants, the Facility Plan concluded that expansion and upgrading of the plants were not feasible, principally because of insufficient land for remodeling or additions. It proposed a new treatment facility, designed around rotating biological contactors. Such a facility, complete with suitable addition of chemicals, could meet appropriate effluent limitations.

b. Centralized Treatment -- Land Disposal

Land treatment of municipal wastewater uses vegetation and soil to remove many constitutents of wastewater. Several processes are available that can achieve many different objectives of treatment: water reuse, nutrient recycling and crop production. The three principal types of land application systems are:

- o Slow rate (irrigation)
- o Rapid infiltration (infiltration-percolation)
- o Overland flow. (EPA 1977)

The quality of effluent required for land application in terms of BOD and suspended solids is not so high as that for stream discharge. Preliminary wastewater treatment is needed to prevent health hazards, maintain high treatment efficiency by the soil, reduce soil clogging, and insure reliable operation of the distribution system. The Michigan Department of Natural Resources (DNR) requires the equivalent of secondary treatment prior to land disposal. (Personal communication, Steve Eldridge, DNR, 30 March 1978).

A recent memorandum from EPA may alter Michigan's approach to pretreatment prior to land application. To encourage both land treatment and land disposal of wastewater, EPA has indicated that:

> "A universal minimum of secondary treatment for direct surface discharge... will not be accepted because it is inconsistent with the basic concepts of land treatment.
>
> ...the costs of the additional preapplication increment needed to meet more stringent preapplication treatment requirements [than necessary] imposed at the State or local level would be ineligible for Agency funding and thus would be paid for from State or local funds." (EPA 1978)

Land treatment systems require wastewater storage during periods of little or no application caused by factors such as unfavorable weather. In Michigan storage facilities for the winter months are necessary.

The EPA policy has important ramifications for land treatment alternatives. By allowing Federal funding of land used for storage and underwriting the risk of failure for certain land-related projects the policy promotes their consideration.

The land application component of the alternatives in this EIS includes the treatment and storage facilities provided by the Facility Plan (see Figure III-3), but woodland spray irrigation is the method of final disposal in the new system. Considerations in selecting the method of land application and a potential site are discussed in Section II.A.3.b.

c. Decentralized Treatment

Figure I-4 shows the Facility Plan proposed centralized collection and treatment of wastewaters for the entire Service Area. The costs for the proposed wastewater management plan, evaluated in terms of individual households, were high. Because most of those costs were due to sewers, this EIS examines methods of wastewater treatment not dependent on extensive sewer systems.

Several technologies can provide decentralized treatment at or near the point of generation. These are:

- Alternative toilets

    Composting toilets

    Toilets using filtered and disinfected bath and laundry wastewater

    Waterless toilets using oils to carry and store wastes

    Incineration toilets

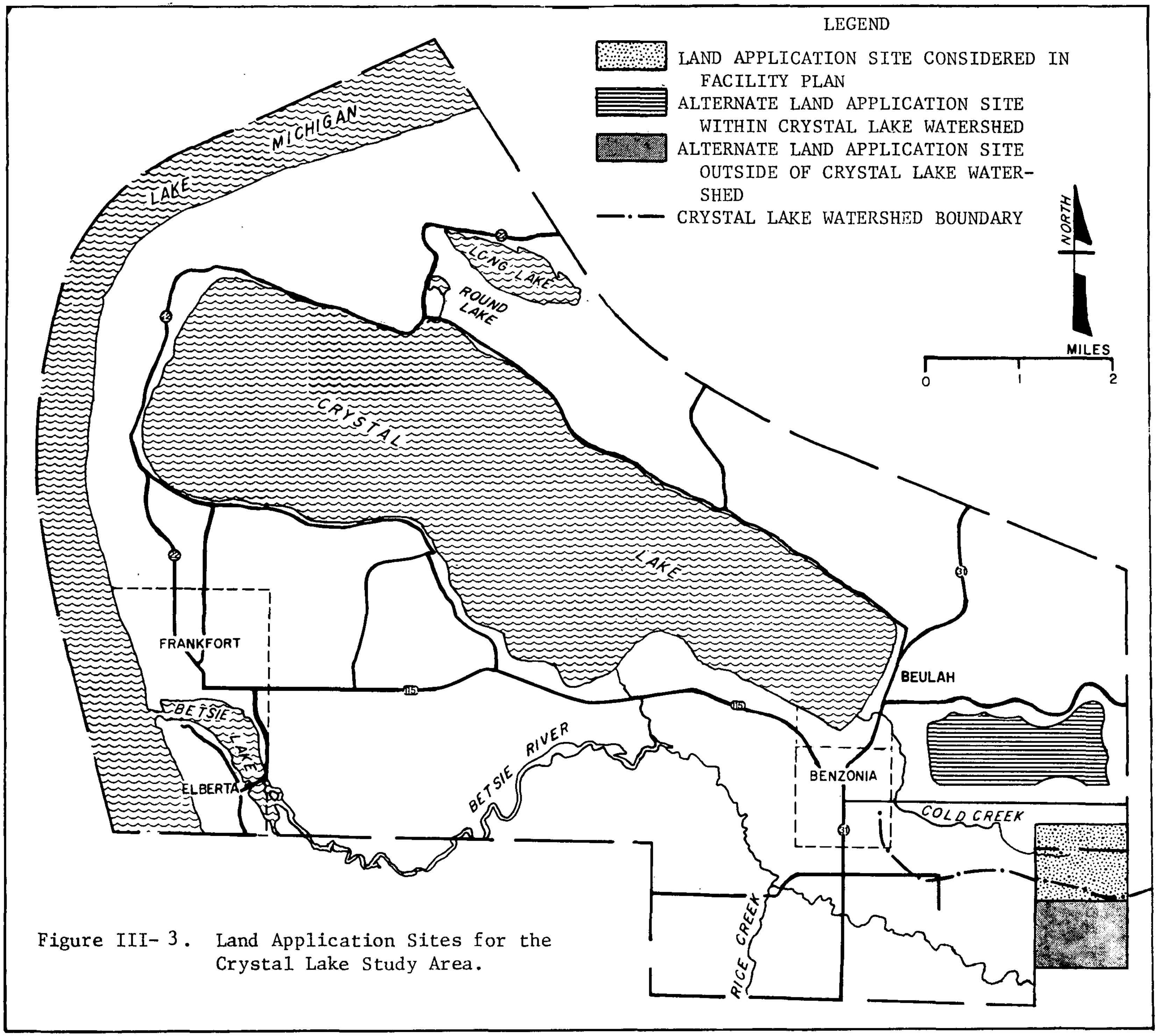


Figure III-3. Land Application Sites for the Crystal Lake Study Area.

- On-lot treatment and disposal

    Septic tank and soil-disposal systems

    Septic tank and dual, alternating soil-disposal system

    Aerobic treatment and soil-disposal system

    Septic tank or aerobic treatment and sand filter with effluent discharge to surface waters

    Septic tank and evapotranspiration system

    Septic tank and mechanical evaporation system

    Septic tank and elevated sand mound system

- Off-lot treatment and disposal

    Cluster systems (multiple houses served by a common soil-disposal system)

    Community septic tank or aerobic treatment and sand filter with effluent discharge to surface water

    Small-scale lagoon with seasonal effluent discharge to surface water

    Small-scale lagoon with effluent discharge at rapid-infiltration land application site

    Small-scale lagoon with seasonal effluent discharge at slow-rate land application site

    Small-scale, fabricated activated sludge (package) treatment plants with effluent discharge to surface waters.

To assess decentralized alternatives first requires comparison with centralized alternatives. The feasibility analysis, design, and construction cost estimation of decentralized alternatives is entirely different from the centralized systems. Most decentralized alternatives depend to a large extent on such environmental constraints as topography, geology, groundwater, climate, and soil conditions within the Service Area. (Conversely, sewers are both feasible and reliable in nearly all settings where construction is possible; environmental factors primarily affect constructions costs.) In addition, the selection and design of decentralized alternatives must be site-specific, particularly with respect to existing buildings. The feasibility analysis and design of sewers may be performed with less site data than the decentralized alternatives because standard design criteria are unlikely to be voided by site conditions.

The importance of site-specific factors implies that design and estimates of feasibility of decentralized alternatives are less certain than for centralized alternatives. Quantitative statements will not be available until the engineering of decentralized alternatives becomes better established and more experience in their management and monitoring has been gained.

4. FLEXIBILITY

Flexibility measures system ability to accommodate growth or future changes in requirements. This section examines the flexibility of the components within each alternative and the operational restraints on each and design of the facilities. These are discussed in terms of their impacts upon choices of systems and decisions of planning and design.

a. Transmission and Conveyance

For gravity and pressure sewer systems, flexibility is the ability to handle future increases in flow. The ability to handle flows greater than the original design flow is generally low, and an increase in capacity is an expensive process. Also, the layout of the system depends upon the location of the treatment facility. Relocation or expansion of a finished facility would require costly redesign and addition of sewer.

Both gravity and pressure sewers require minimum sewage velocities to prevent deposition of solids which could cause blockage. The velocity of the fluid in gravity sewers depends mainly upon pipe slope. Contour of the ground surface largely determines pipe slope and depth, and consequently, construction costs. Pressure sewers, however, can carry sewage uphill under pressure, not depending upon slope to maintain the flow velocity; they offer the designer somewhat more flexibility than gravity flow pipe.

b. On-Site Septic Systems

Septic systems are flexible in that they can be custom designed for each user. As long as spatial and environmental parameters are met, the type of system can be chosen according to individual requirements. This flexibility is useful in some rural areas where centralized treatment would be neither cost effective nor desirable.

Existing septic systems can be expanded by adding tank and drainfield capacity, if suitable land is available. Flow can then be distributed to an added system with little disturbance of the existing one.

Cluster systems are septic systems treating wastewater from more than one house, usually 15 to 24. The flexibility for design and expansion of such a system is somewhat less than for a standard septic system. Sizes of cluster systems range from one-quarter to one-half acre, a substantial increase compared to a standard septic system (of about 1000 square feet). Right-of-way requirements for piping must be considered because the system crosses property boundaries and may cross public property. The location of other underground utilities such as water, electricty, gas, and telephone must also be considered in the design.

An alternative system for on-site sewage treatment, such as an elevated sand mound, is required where siting restrictions prohibit the use of standard septic system and centralized collection of sewage is not available. In these cases future expansion may be difficult or impossible. Stipulations of the health codes restrict the potential of the alternative systems for alteration or expansion.

c. Rotating Biological Contactor (RBC)

The use of rotating biological contactors to treat wastewater is relatively new in the United States. The RBC rotates circular discs covered with a film of aerobic bacteria in a basin through which wastewater flows. The disc is usually 40% submerged for aerobic treatment.

RBCs are simple to operate. They are similar in theory to trickling filters, used in the United States since 1908. The RBC units do not require sludge recycling, nor maintenance of a suspended microbial culture like by activated sludge. The relatively simple operation, therefore, makes operational flexibility high for RBC plants.

The modular nature of RBC reactors makes expansion or upgrading of the plant relatively easy. With proper design of other components and proper planning of the facility layout, the cost and effort required for expansion may be relatively small. RBCs are therefore well suited for projects to be constructed in phases over an extended period.

RBCs require relatively shallow basin depths (6-8 feet) -- another advantage. Less structural strength is required for the basin because water volume per square foot of basin area is reduced. Therefore, there is more leeway in choosing a site because structural requirements are lower, and a greater variety of soil types and ground conditions are available for locating the RBC units.

There are several disadvantages to the RBC reactor. The many discs usually required limit design flows to the range of 0.1 to 20 mgd. This limitation results from the large requirements for land. The mechanical components have relatively low salvage value, and converting the RBC units to another type process may be costly if these components can not be reused or sold.

d. Land Application

To be flexible, a land application system should operate efficiently under changing conditions, and should be easily modified or expanded. These factors depend largely upon geographical location.

The ability to handle changes in treatment requirements and wastewater characteristics is a specific measure of flexibility for a land application facility. Furthermore, the level of treatment provided by the land application system will in part determine whether it can handle possible increases in flows in the future. Wastewater in the Crystal Lake Study Area consists primarily of domestic sewage and future changes in composition of the wastewater are not likely to occur. If industrial wastewater were added in the future, pretreatment at the industrial source may be required.

Expandability is an important element of flexibility. Efficient and economical land acquisition for future flow increases depends upon the proximity of the facility to populated areas, design and layout of the system, additional transmission requirements, and the type of application system used. A number of application mechanisms are available -- spray, overland flow, or rapid infiltration. Sites can be forest land, cropland, or open fields. Attention must be paid, however, to characteristics of the surrounding land, and to possible future changes in land use. Also, requirements are strict concerning the hydraulic and geologic conditions of the proposed site. When initially planning the facility, all of the above mentioned conditions should be taken into consideration if maximum flexibility for future expansion is desired.

Cost of the land accounts for much of the capital cost for a land application facility, and greatly affects the possibility of expansion or ease of discontinuing the site. Because land normally appreciates in value, the final salvage value of the site may be very high after the expected 20-year design life. If the site is abandoned, much of the initial capital cost of the facility may be recovered by reselling the land at the appreciated price. Note, however, that the public may be reluctant because of its former use to use the land; this would depend largely upon the appearance of the land at the time of resale.

Finally, operational flexibility of land application systems is highly dependent upon climate. When heavy rains saturate the soil or flooding occurs, treatment efficiency is greatly reduced. Where cold temperatures might make land application unusable, storage facilities are required. Very cold climates require up to six months of storage capacity. Rapid infiltration is the only land application technique used successfully in very cold temperatures.

5. RELIABILITY

a. Sewers

Gravity Sewers. When possible, sewer systems allow wastewater to flow downhill by force of gravity. This type of system, known as gravity sewer, is highly reliable. Designed properly, such systems require little maintenance. They consume no energy and have no mechanical components to malfunction.

Problems associated with gravity sewers include clogged pipes, leading to sewer backups; infiltration/inflow, increasing the volume of flow beyond the design level; and broken or misaligned pipes. Major contributors to these problems are improperly jointed pipes and the intrusion of tree roots into the sewer, which tend to be more prevalent in older systems.

Where ground slope is opposite to the direction of sewage flow, it may be necessary to pump the sewage through sections of pipe called force mains. The pumps add a mechanical component which increases operation and maintenance (O&M) requirements and decreases the system reliability. To assure uninterrupted operation of the system, two pumps are generally installed, providing a backup in case one malfunctions. Each is usually able to handle at least twice the peak flow. A standby generator is usually provided to ensure operation of the pumps in case of a power failure.

Because the flow through force mains is intermittent, solids may be deposited during periods of no flow. In addition, when the pumps shut off, the sudden cessation of flow may cause the hydraulic conditions known as "water hammer" in the force main, a phenomenon marked by sudden sharp surges in water pressure that may result in burst pipes. However, both deposition of solids and water hammer may be controlled through proper design procedures. The reliability of properly designed force mains is comparable to that of gravity sewers.

Pressure Sewers. Pressure sewers transmit wastewater uphill when ground topography does not allow gravity flow. Because the system is always under pressure pumping is required to force the wastewater into the sewer

Grinder Pumps. Grinder pumps are used primarily to grind and pump raw domestic sewage from an individual house to the collection system and occasionally for small lift stations. They are either of the semi-positive displacement or the centrifugal type, depending upon the mode of operation. The reliability of both types is high.

One problem may arise during a power failure. Standby power for a grinder pump would not usually be available at an individual house and the residence would be without sewage removal. This is a lesser problem than might be supposed, for a power failure would curtail many operations that generate wastewater.

There were problems in the operation of the first generation of grinder pumps when pressure to pump wastewater or power to grind solids was insufficient. Modifications have been made in their design and construction, and the second generation of these pumps is appreciably more reliable. Periodic maintenance is required to clean or replace parts of the grinder pump.

STEP Pumps. It is sometimes desirable to pump wastewater from an existing septic tank rather than directly from the house, using septic tank effluent pumps* (STEP) rather than a grinder pump. In this way difficulties associated with suspended solids are largely avoided. STEP pumps are relatively simple modifications of conventional sump pumps.

The reliability of STEP pumps made by experienced manufacturers is good. Newer entries into the field have not yet accumulated the operating experience necessary to demonstrate conclusively the reliability of their products. In the event of failure of a STEP system, an overflow line may be provided, which permits passage of the septic tank effluent to the old drainfield for emergency disposal.

Pipes. Pressure sewer pipes are subject to the same problems as force mains, discussed above. As with force mains, proper design can prevent clogging and breaking of pipes, the most common cause of sewer problems. Because pressure sewer piping has no mechanical components, the reliability is high.

b. Centralized Treatment

Conventional. The reliability of conventional wastewater treatment has been tested by time. Most unit processes have been used for many years, and there is consequently much information on their design and operation in nearly all climates. In general, the larger the treatment facility, the more reliable its operation, because the large volumes of flow require multiple units per treatment process. For instance, a large facility will have several primary clarifiers, and if one malfunctions, the remaining units can handle the entire load. Therefore, difficulties that arise as a result of failure of a single unit process, or of severe weather conditions such as heavy rain or very cold temperatures, are less likely to affect operations. Conventional wastewater treatment plants can be designed to handle most problems.

Advanced Treatment. Advanced treatment serves primarily to remove toxic substances and nutrients that would stimulate biological activity. The technology is relatively new; experience in design and operation of advanced treatment processes is therefore limited. However, when designed properly, the reliability of these processes is high.

Land Application. Application of treated sewage effluent to the land is still infrequent in the United States, but its use is growing steadily. Local climatic conditions such as heavy rains or very low temperatures may make the technique unsuitable in a particular area.

Potential problems with land application include: groundwater contamination; dispersal of microbial mass by airborne transport; odors; surface water contamination; accumulation of metals in the vegetation; and possible toxic effects upon local animals. These problems can be minimized with proper design, but there is not yet the extensive practical experience required to develop advanced design technology.

c. On-Site Treatment

Septic Tanks. The design and operation of modern septic tanks have benefited from long experience. Properly designed and maintained, septic systems will provide satisfactory service with minimum maintenance. Care must be taken not to put materials in the system that may clog it. The principal maintenance requirement is periodic pumping of the tank, usually every two or three years.

Problems of septic systems include heavy rain saturating the ground, clogged drainfields caused by full septic tanks, clogged or frozen pipes, and broken pipes. Current environmental laws -- restricting sites according to soil suitability, depth to groundwater and bedrock, and other factors -- are limiting the cases where septic systems can be used.

Sand Mounds. Elevated sand mounds four or five feet above original ground level are an alternative drainage mechanism where siting restrictions do not allow the use of standard drainfields. Because they do not always provide satisfactory service and are considerably more expensive than conventional drainfields, they have not been universally accepted.

d. Cluster Systems

Cluster systems are localized wastewater disposal mechanisms servicing several residences. The reliability is similar to that of a septic system, except that a malfunction affects not just one, but a number of residences. Because a cluster system requires more piping to connect individual houses to the treatment tank than does a series of individual systems, there is a greater chance for pipes to break or clog, or for I/I to occur during heavy rain. If pumping is required, the reliability of the system declines because of the mechanical nature of the pumps and their dependence upon electricity for power.

6. EFFLUENT DISPOSAL

Three approaches exist for disposal of treated wastewater. Reuse, perhaps the most desirable of the three, implies recycling of the effluent by industry, agriculture or groundwater recharge. Land application takes advantage of the absorptive and renovative capacities of soil to improve effluent quality and reduce the quantity of wastewater requiring disposal. Discharge to surface water generally implies the use of streams or impoundments for ultimate disposal of treated effluent.

a. Reuse

Industry Reuse. There is limited industrial development in the Study Area. The only industry that consumes significant quantities of water is Pet, Inc. Located in Frankfort, Pet uses only potable water. There are no industries in the area that use a significant amount of non-potable water, consequently industrial reuse does not seem to be a feasible means of effluent disposal.

Agricultural Irrigation. The use of treated wastewaters for irrigation is addressed in Section III.6.b.

Groundwater Recharge. Groundwater supplies all of the potable water in the Study Area. The availability of ample quantities of water from sand and gravel deposits is a significant resource of the area. There is no evidence that these resources are being depleted to the extent that supplemental recharge is necessary. Wastewater reuse by groundwater recharge has therefore not been evaluated.

b. Land Application

Two types of land application are relevant to the Study Area, rapid infiltration/percolation and agricultural irrigation. Rapid infiltration/percolation is presently used for final treatment and disposal of wastewaters for Beulah. Expansion of this facility or construction of similar facilities on sites within the watershed directly tributary to the Betsie River may be feasible for other parts of the Study Area. With proper selection of sites and design of facilities, wastewater could be renovated to a degree which would meet or exceed the quality of effluent generated by more conventional treatment processes. It would be necessary to collect renovated wastewater and discharge it to the Betsie River.

The Facility Plan evaluated agricultural irrigation at a site within Section 31 of Benzonia Township. This site, located in the Crystal Lake watershed, is divided by Cold Creek and its stream valley. This EIS considered two additional sites: one within the Crystal Lake watershed, north of the proposed site in Township Sections 25 and 30; and the other outside the Crystal Lake watershed and south of the proposed site. Figure III-3 shows the locations of the sites. Soils at all three sites are moderately to rapidly permeable.

Surface runoff could be controlled by a system of berms and storage cells; renovated wastewater by recovery wells. The necessity of such management would depend upon a careful evaluation of the site. Costs associated with site management and silviculture of white pine in Township Sections 25 and 30 have been incorporated in the evaluation of land application alternatives. Detailed site investigations for the land application alternatives should consider all three sites. All approaches to recovery of renovated wastewater would include transport to the Betsie River for discharge.

c. Discharge to Surface Waters

Effluent from the Frankfort and Elberta plants is now being discharged into Betsie Lake. In the Proposed Action, a new RBC plant would discharge to Betsie Lake from land purchased by the City of Frankfort. It would be expected to meet DNR effluent limitations for discharge to Betsie Lake (see Appendix D-4). The DNR has recommended that there be no discharges to the Betsie River or to Lake Michigan (by letter, Mr. Kenneth J. Burta, DNR, 17 November 1976).

7. SLUDGE HANDLING AND DISPOSAL

Two types of sludge would be generated by the wastewater treatment options considered above: chemical/biological sludges from the proposed RBC plant; and solids pumped from septic tanks. The residues from treatment by lagoons and land application are grit and screening.

The Facility Plan evaluated several options for handling and disposing of sludge from by the proposed RBC plant. These included:

- o Incineration and landfill of the resulting ash.
- o Digestion followed by liquid disposal on land.
- o Digestion and landfill of the dewatered sludge.
- o Digestion and land application of the dewatered sludge.

For maximum flexibility in disposal of digested sludges, the Facility Plan recommended structural measures accommodating disposal by any of the above methods. Sludge drying beds would allow land application of dewatered sludge under most conditions and would result in reduced transportation costs. Liquid digested sludge could be applied to land to conserve drying bed capacity. The Facility Plan also recommended including sufficient capacity in the sludge digesters for six months of winter storage. Sites for landfill or surface application of digested sludge were not selected but a potential site for land application on Graves Road in Crystal Lake Township was identified.

Alternatives using residential septic tanks for on-lot systems, cluster systems, or STEP sewer systems must provide for periodic removal and disposal of sludge. For the purposes of designing centralized wastewater treatment by a RBC plant, processes for conditioning and treatment of septage were provided. In alternatives including centralized treatment by lagoon and land application, septage would be applied to the land.

C. EIS ALTERNATIVES

1. INTRODUCTION

a. Approach

The preceding section described options for the functional components of wastewater management systems for the communities in the Study Area. This section examines alternative wastewater management plans -- alternative courses of action for the Study Area, including a No Action and a Limited Action Alternative.

The four alternatives developed in the Facility Plan (described earlier) provided for centralized collection and treatment of wastewater. In response to questions about the need for and expense of the Proposed Action, the development of EIS alternatives emphasizes decentralized and alternative or innovative technologies: alternative collection systems, decentralized treatment and land disposal of wastewaters. The EIS alternatives would manage wastewaters in the same Service Area as the Facility Plan Proposed Action, but five of the EIS alternatives use decentralized treatment to avoid the costs of sewers.

Because of the high cost of collection in the Proposed Action, the cost effectiveness of pressure sewers, vacuum sewers, and small-diameter gravity sewers was compared. Pressure sewers proved to be the most cost-effective, alternative method for collection of wastewater. These sewers were, therefore, incorporated into the design of two completely centralized systems, one calling for an RBC plant, the other for land application.

Where site conditions such as soils and topography are favorable, land disposal of wastewater offers advantages over conventional biological treatment systems that discharge to surface waters: the land is used as a natural treatment facility system; reduced operation and maintenance may result from relatively simple operations; and savings in capital and operating costs are possible.

Analysis of decentralized treatment technologies and site conditions showed feasible alternatives to sewering the entire Crystal Lake shoreline. It would be possible to combine multi-family filter fields (cluster systems) with rehabilitated and new on-site treatment systems to meet the wastewater treatment needs in this part of the Study Area.

The various alternatives are compared after the discussion below of projections of design populations and flow and waste load which are the same for all alternatives.

Appendix J-1 presents the assumptions used in design and costing of alternatives are presented in Appendix (J-1). Table III-1 lists the major features of the Proposed Action, the Limited Action Alternative, and the EIS Alternatives.

b. Flow and Waste Load Projections

The domestic sewage generation rate depends upon the mix of residential, commercial, and institutional sources in the area. Studies on residential water usage (Witt, Siegrist, and Boyle 1974; Bailey et al. 1969; Cohen and Wallman 1976) reported individual household water consumptions varying widely between 20 and 100 gpcd. However, averaged values reported in those studies generally ranged between 40-56 gpcd. On a community-wide basis, non-residential domestic (commercial, small industrial, and institutional) water use increases per capita flows. The extents of such increases are influenced by:

- o the importance of the community as a local or regional trading center;
- o the concentration of such water-intensive institutions as schools and hospitals; and
- o the level of small industrial development.

For communities with populations of less than 5,000, EPA regulations allow design flows in the range of 60 to 70 gpcd where existing per capita flow data is not available. In larger communities, and in communities within Standard Metropolitan Statistical Areas, the maximum allowable flow ranges up to 85 gpcd.

Table III-1
ALTERNATIVES - SUMMARY OF MAJOR COMPONENTS*

Alternative	Centralized Treatment	Treatment Plant Siting	Effluent Disposal	On-lot & Cluster Systems	Alternative Collection Method
Limited Action	RBC plant serving Frankfort and Elberta	Frankfort City owned land	Discharge to Betsie Lake	Continued reliance on on-lot and cluster systems in remaining parts of Study Area	No
Facility Plan Proposed Action	RBC plant serving entire proposed sewer service area	Frankfort City owned land	Discharge to Betsie Lake	No	No
EIS Alternative 1	RBC plant serving entire proposed sewer service area	Frankfort City owned land	Discharge to Betsie Lake	No	Use of low pressure collection system around Crystal Lake
EIS Alternative 2	Aerated lagoon-land application system serving entire proposed sewer service area	Benzonia Township Sections 25 & 30	Land application by spray irrigation with recovery of renovated wastewater and discharge to Betsie River	No	Use of low pressure collection system around Crystal Lake
EIS Alternative 3	RBC plant serving Frankfort, Elberta & Crystalia-Pilgrim area	Frankfort City owned land	Discharge to Betsie Lake	On-lot and cluster system serving remaining portions of Crystal Lake shoreline	
	Aerated lagoon-land application system serving Benzonia Village area & northeast shore of Crystal Lake	Benzonia Township Sections	Land application by spray irrigation with recovery of renovated wastewater discharge to Betsie River		

* In all of the EIS alternatives it is assumed that wastewaters from Beulah will continue to be treated in the Villages' existing treatment facility.

Alternative	Centralized Treatment	Treatment Plant Siting	Effluent Disposal	On-lot & Cluster Systems	Alternative Collection Method
EIS Alternative 4	Aerated lagoon-land application system serving Frankfort, Elberta, Benzonia Village area, Crystalia-Pilgrim area, & northeast shore of Crystal Lake	Benzonia Township Section	Land application by spray irrigation with recovery of renovated wastewater and discharge to Betsie River	On-lot and cluster systems serving remaining portions of Crystal Lake shorelines	No
EIS Alternative 5	RBC plant serving Frankfort, Elberta, Benzonia Village area, Crystalia-Pilgrim area & northeast shore of Crystal Lake	Frankfort City owned land	Discharge to Betsie Lake	On-lot and cluster systems serving remaining portions of Crystal Lake shoreline	No
EIS Alternative 6	RBC plant serving Frankfort and Elberta. Aerated Lagoon-land application system serving Benzonia Village area & N.E. shore of Crystal Lake	Frankfort City owned land Benzonia Township Section	Discharge to Betsie Lake Land application by spray irrigation with recovery of renovated wastewater and discharge to Betsie River	Cluster systems serving S.E. shore of Crystal Lake. Continued reliance in remaining parts of Study Area	No

The Facility Plan reported wastewater flows in the Crystal Lake Facility Planning Area to be 65 gpcd for Elberta (including Ann Arbor Railroad and Gustafson Oil Company) and 74 gpcd for Frankfort (including commercial flows, other than Pet, Inc.). These figures relate well to the range of domestic flows determined by EPA to be applicable for small communities.

For these reasons, this EIS assumes on a 70 gpcd design flow of domestic sewage for permanent residents in Frankfort, Benzonia, and Elberta; these municipalities have several commercial and institutional water users. In primarily residential areas, including the presently unsewered areas around Crystal Lake, a flow of 60 gpcd has been assumed.

Water consumption by seasonal users varies much more than consumption by permanent residents. The actual rates of consumption depend upon such factors as type of accommodations in the area and type of recreation areas available. EPA regulations (EPA 1978) suggest that seasonal population can be converted to equivalent permanent population by using the following multipliers:

Day-use visitor	0.1 to 0.2
Seasonal visitor	0.5 to 0.8

A multiplier of 1.0 was applied to the projected seasonal population to account for both day-use and seasonal visitors. Considering the possible error in projecting future seasonal populations, the preponderance of present seasonal visitors using well-equipped private dwellings and the lack of data on day-use visitors, this multiplier was thought generous, i.e., it probably overestimates flows to some degree.

The two design flow figures of 70 and 60 gpcd do not reflect reductions in flow from a program of water conservation. Residential water conservation devices, discussed in Section III.B.1, could reduce flows by 16 gpcd. Later in this chapter, to demonstrate probable impacts of such reduction in flow, one of the alternatives has been redesigned and recosted.

c. Population Projections

The design population of 12,490 is that population projected to reside in the Proposed Service Area (Figure I-4) in the year 2000. (This area includes the immediate service area and a future service area.) The methodology used to develop this estimate is presented in Appendix H, Table H-2.

In the interests of comparability, the same population projections have been incorporated into design and costing of all alternatives. In fact, however, the type of sewer service provided, that is, whether it is centralized or decentralized, may influence the actual design year population. Chapter IV discusses the importance of this factor.

d. Development of Decentralized Options

Although two of the alternatives offered in this EIS would extend central sewers throughout the Study Area, four would dispose of wastewater by decentralized options. The approach used to develop the latter included the following:

Identification of sites where existing on-lot systems are known or are implied to be failing. The failure of on-lot systems may be evidenced in several ways: effluent may rise to the surface; sewage may not drain properly into the system; or the soil may not renovate* the wastewater. Section II.C reviews problems with the existing on-site systems around Crystal Lake.

Identification of local environmental characteristics which would limit the feasibility of soil-dependent effluent disposal. Sections II.A.3 and II.C present information on soil depth to groundwater and lot size as they affect the feasibility of soil disposal systems.

Screening of technologies for their applicability in non-sewered portions of the Proposed Service Area. Section III.B.3 lists the technologies capable of providing decentralized treatment of wastewater. Those which imply direct discharge to Crystal Lake or its tributaries have been rejected and the remainder evaluated as part of two different schemes. Implicit in both is the assumption that on-site disposal of wastewaters would rely upon septic systems, off-site disposal, and cluster systems. The two schemes described below generate a range of costs associated with application of the various technologies on a site-by-site basis.

- Partial Sewering and Reliance on Cluster Systems. Sewers would extend:

  - from Benzonia Village along Eldridge Hill Road (to serve the northeast shore of Crystal Lake) to approximately the Benzonia Township-Lake Township line, and

  - from Frankfort along Route 22 to Crystalia and Pilgrim at the southwest corner of Crystal Lake.

  It is assumed that sixteen cluster systems serving 20-25 dwellings each would serve scattered groups of residences along the lakeshore. Other residences would continue to use on-lot septic systems. Rehabilitation of undersized and failing on-lot systems would be undertaken and new on-site systems which compensate for poor soil conditions, such as mound systems, would be constructed where necessary to replace conventional on-site systems. A management agency, with the authority to acquire land for cluster systems and easements for access to on-lot systems, to monitor groundwater impacts of the systems, and to perform routine and emergency maintenance, would be required. Design assumptions of a typical cluster system are presented in Appendix J-1.

- o Continued Reliance on On-lot Systems. Detailed site investigations (sanitary survey, groundwater analyses, and soil studies) may indicate that partial sewering and off-lot technologies are not necessary to remedy water quality problems. If so, only rehabilitation of failing on-lot systems would be needed.

Selection of the most reliable technologies on the basis of specificity to the site(s).

2. ALTERNATIVES

The action proposed by the Facility Plan has been compared with the "do-nothing" (no action) alternative, a "limited action" alternative, and six new approaches developed in this EIS. The alternatives, discussed below, are summarized in Table III-1, and Table III-2 lists the cost-effectiveness of each.

a. No Action

The EIS process must evaluate the consequences of not taking action. This "no action" alternative implies that EPA would not provide funds to support new construction, upgrading, or expansion of existing wastewater collection and treatment systems. Presumably, no new facilities would be built; wastewater would still be treated in existing plants and on-site systems.

If this course of action were taken, additional flows to the primary treatment plants at Frankfort and Elberta would be prohibited because the plants are already overloaded and have difficulty meeting effluent discharge standards. Existing on-site systems in the Study Area would continue to be used in their present conditions.

The No Action Alternative is unlikely to be selected. It implies that the treatment plants at Frankfort and Elberta would violate NPDES discharge conditions when interim limitations expired. Consequently, new facilities to adequately treat wastewaters from Frankfort and Elberta would be needed in the near future.

b. Limited Action

The "limited action" alternative includes a new treatment facility for treating wastewaters from Frankfort and Elberta. This consists of:

- o Treatment of wastewaters from Frankfort and Elberta at a new RBC plant in Frankfort discharging to Betsie Lake. Design flow for the plant would be 0.33 mgd.
- o Treatment of wastewaters from Beulah at the Village's existing treatment facility.
- o Decentralized collection and treatment in all other parts of the Study Area. Where appropriate, malfunctioning on-lot systems would be repaired or replaced. For the northeast and

Table III-2

COST-EFFECTIVE ANALYSIS OF ALTERNATIVES

	Facility Plan Proposed Action	Limited Action	ALTERNATIVES					
			EIS 1	EIS 2	EIS 3	EIS 4	EIS 5	EIS 6
Present Project Cost	17,302.7	4,563.6	17,037.8	15,636.9	11,358.3	11,005.8	12,080.9	8,267.0
Future Project Cost	2,467.4	1,076.0	2,717.1	2,717.1	1,885.0	1,885.0	1,885.0	1,550.9
Total Present Worth	18,320.5	7,449.2	19,574.6	17,640.3	13,202.7	12,265.6	13,972.4	10,524.4
Average Annual Equivalent Cost	1,678.2	682.3	1,793.1	1,615.9	1,209.3	1,123.5	1,279.8	963.9

southeast shore of Crystal Lake, detailed engineering and environmental studies, performed during the design phase, would indicate the most appropriate technology. It may be that these parts of the Study Area are most suited for continued reliance upon septic systems, or that cluster systems may be required. Alternatively, pressure sewers may be required to connect the northwest and southeast shoreline areas to the existing sewerage system in Beulah. The costs developed for this Limited Action Alternative are predicated on the assumption that cluster systems will be required for the northeast and southeast shorelines.

This alternative would require formation of a managing agency to acquire rights-of-way and easements, to provide routine inspection and maintenance, to periodically monitor groundwater, and to collect service fees.

c. Facility Plan Proposed Action

The Facility Plan recommended treatment of all wastewaters in the Proposed Service Area at an RBC treatment facility handling 0.89 mgd. The plant, located in Frankfort, would discharge effluent to Betsie Lake. The plant would use chemical addition and microstraining for removal of nutrients. See Chapter I for a brief description of the Proposed Action. The design of the proposed facilities was outlined in detail in Chapter 8 of the Crystal Lake Area Facility Plan (Williams and Works 1976).

The Proposed Service Area and location of the proposed RBC plant are illustrated in Figure I-4. A list of the facilities included in the design of the plant may be found in Appendix J-2.

d. EIS Alternative 1

EIS Alternative 1 proposes centralized collection and treatment of wastewaters as with the Facility Plan, but with pressure sewers, rather than gravity, as the collection system around Crystal Lake. The Service Area would be identical to that proposed by the Facility Plan.

The pressure sewer system, collecting approximately 26% of the projected design flow, would discharge into a force main north of Frankfort. The area to be served by the system, the treatment plant location, and the transmission line routing are shown in Figure III-4.

e. EIS Alternative 2

EIS Alternative 2 also modifies an alternative in the Facility Plan to use pressure sewers around Crystal Lake. In this alternative pressure sewers have been applied to Facility Plan Alternative 3, consisting of the centralized collection of 0.89 mgd of wastewater, treatment in an aerated lagoon and disposal by land application. Although the service area is the same as for EIS Alternative 1, the

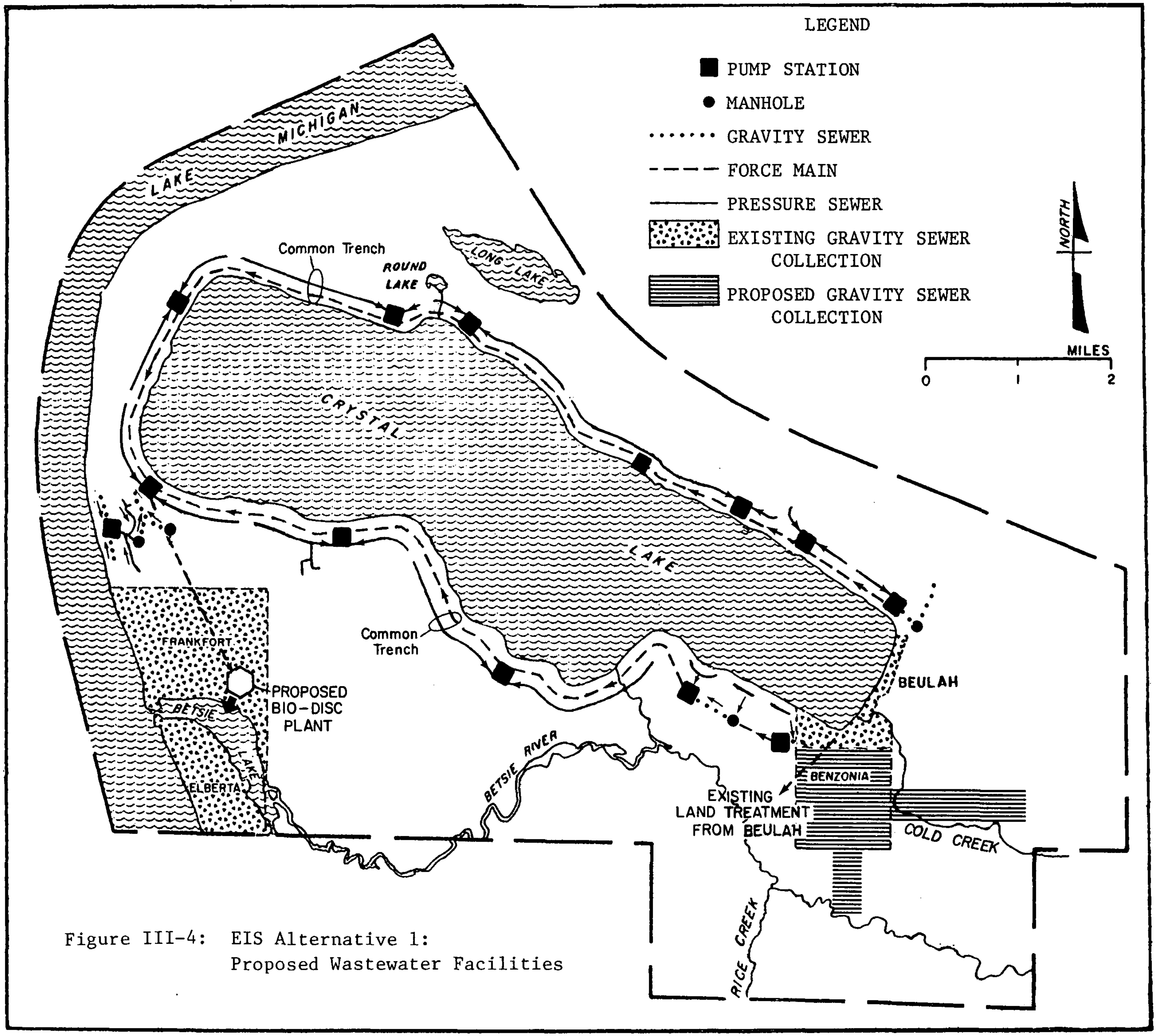


Figure III-4: EIS Alternative 1:
Proposed Wastewater Facilities

configuration differs. In EIS Alternative 2, wastewaters are conveyed to the eastern part of the Study Area; the previous alternative routed wastewater to the west.

Wastewaters in the Study Area would be conveyed to Benzonia, as shown in Figure III-5, and treated in an aerated lagoon. Treated effluent would be applied to the land by spray irrigation. A solid-set irrigation system for commercially farming white pine was incorporated into the design and cost of this alternative.

Three possible locations for the land application system are identified in Figure III-3. Design and costing assumptions used in developing this EIS alternative are presented in Appendix J-1. Major components of the alternative and the costs of these components are listed in Appendix J-2.

f. EIS Alternative 3

EIS Alternative 3 is based on decentralized treatment of wastewater in part of the Study Area. However, site conditions along the northeast and southwest shore of Crystal Lake are assumed to be unfavorable for septic systems, so wastewater from these areas would be collected by pressure sewers as shown in Figure III-6.

Frankfort, Elberta, and the southwest Crystal Lake shore area would discharge their wastes to a new RBC plant in Frankfort. Wastewaters from Benzonia Township and Benzonia Village would be treated in lagoons and applied to the land. The RBC plant would have a hydraulic capacity of 0.45 mgd; the land application system would be able to treat 0.18 mgd.

The remaining portions of the Crystal Lake shoreline would be served by a combination of cluster systems and on-site systems suitable to local soil conditions. These areas are shown in Figure III-6. The preliminary design, comparison, and assessment of decentralized systems were based upon the following assumptions:

Cluster Systems. Cluster systems would be used for those parts of the Proposed Service Area where small lot sizes or soil limitations preclude on-site systems. Sixteen cluster systems are assumed to be needed; suitable soils exist at the sites for which these systems are proposed. The costs developed were based on a "typical" cluster system that would serve 23 residences located along the south shore of the Lake.

On-lot Systems. Residences not served by sewers or cluster systems would use on-lot systems. This alternative would include a program of replacement and rehabilitation of malfunctioning systems in order to insure compliance with local health codes.

The specific requirements for upgrading existing on-lot systems were estimated by analysis of the data presented in the Crystal Lake sanitary survey, the "Septic Snooper" investigation, and other environmental data. Based upon these, the following upgrading assumptions (by

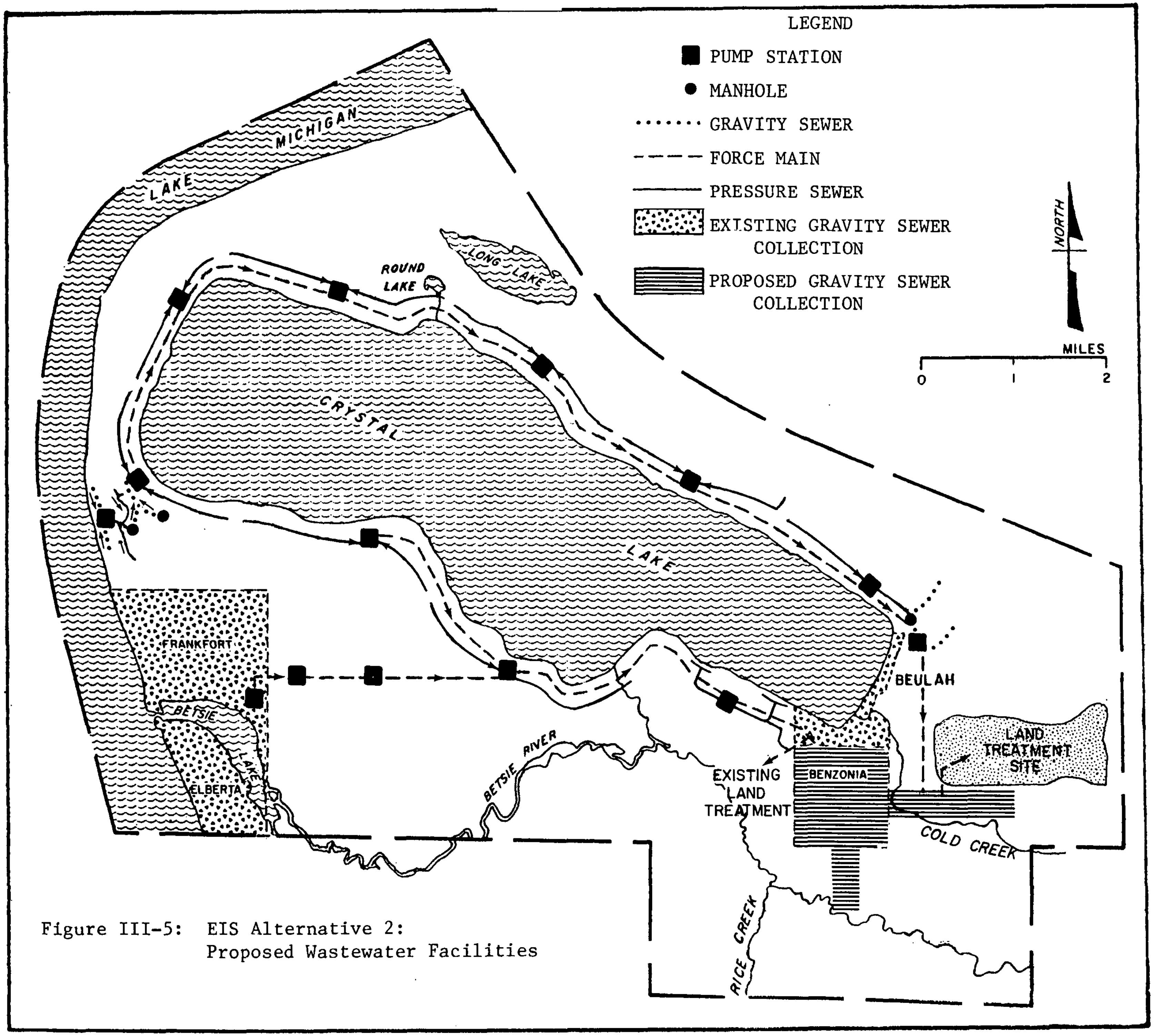


Figure III-5: EIS Alternative 2:
Proposed Wastewater Facilities

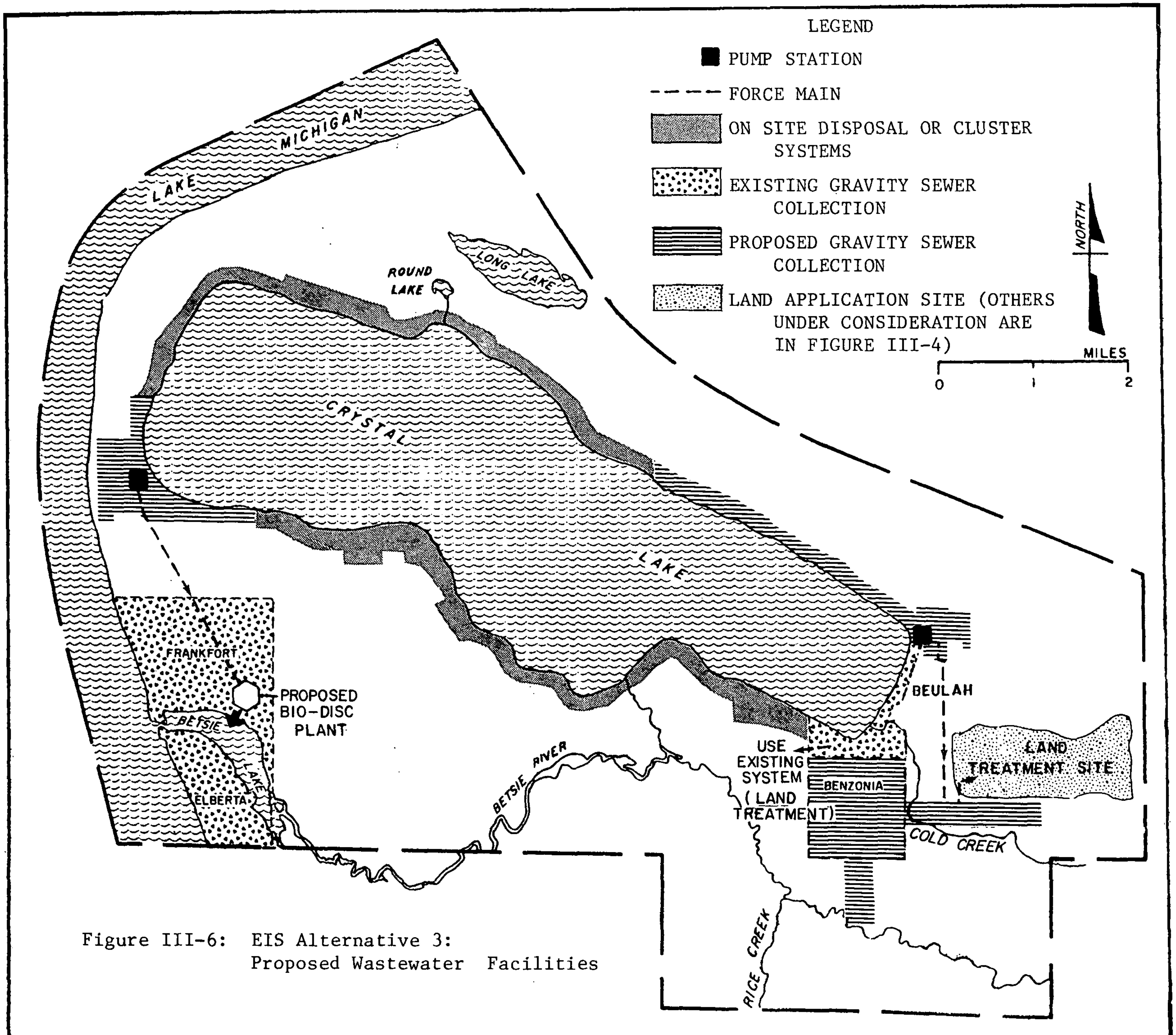


Figure III-6: EIS Alternative 3:
Proposed Wastewater Facilities

shoreline area) were used in the design and costing of alternatives involving continued use of on-site systems:

Existing Systems

	Shoreline Area				
	NE	NW	W	SW	SE
Replace septic tanks	50%	50%	20%	60%	60%
Replace drainfields	60%	50%	30%	40%	50%
Hydrogen peroxide renovation of drainfield	10%	10%	10%	10%	10%

Future Systems

	1980-2000
Conventional septic tank and drainfield	55%
Improved performance system (e.g, dosing system)	20%
Mound systems	25%
Hydrogen peroxide renovation	2% per year

Design and costing assumptions used in developing EIS Alternative 3 are presented in Appendix J-1. Major components of EIS Alternative 3 and their costs are listed in Appendix J-2.

g. EIS Alternative 4

The fourth EIS alternative for the Crystal Lake area includes decentralized treatment of wastewater for the same portions of the Crystal Lake shoreline as in EIS Alternative 3. All other centrally collected wastewaters would be treated by a land application system. EIS Alternative 4 is illustrated in Figure III-7.

The central land application system is similar to that described for EIS Alternative 2 but the hydraulic capacity has been decreased to 0.65 mgd.

Design and cost assumptions used in developing this alternative are presented in Appendix J-1. Major components of the alternative and their costs are listed in Appendix J-2.

h. EIS Alternative 5

EIS Alternative 5 proposes the same partially decentralized treatment of wastewater as EIS Alternative 3. Flows from other parts of the Proposed Sewer Area, the northeast shore, and from the Crystalia-Pilgrim area would be treated at a new RBC plant located in Frankfort. As in Alternative 3, the plant design would include advanced treatment for nutrient removal and discharge of plant effluent to Betsie Lake. This alternative is illustrated in Figure III-8.

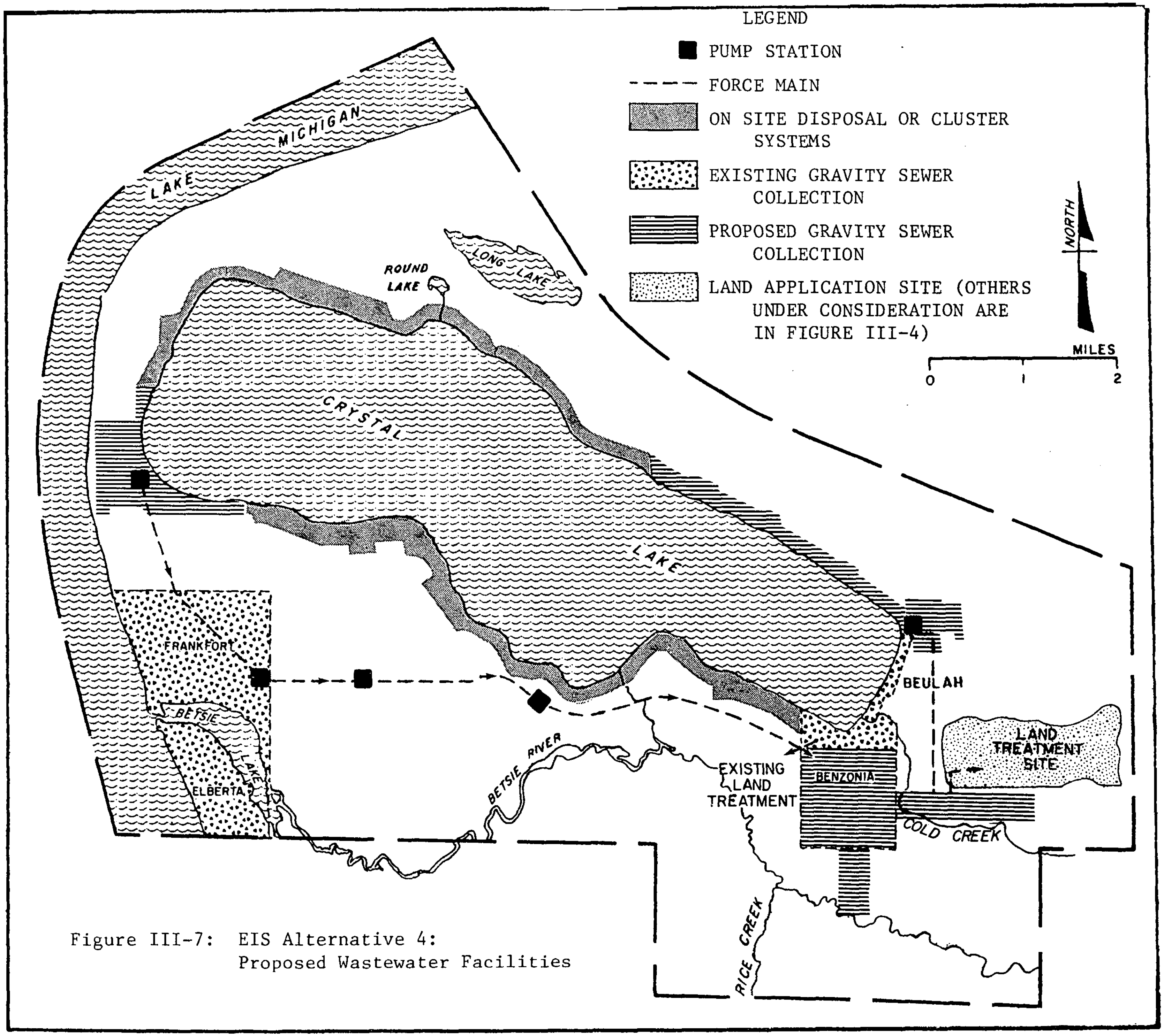


Figure III-7: EIS Alternative 4: Proposed Wastewater Facilities

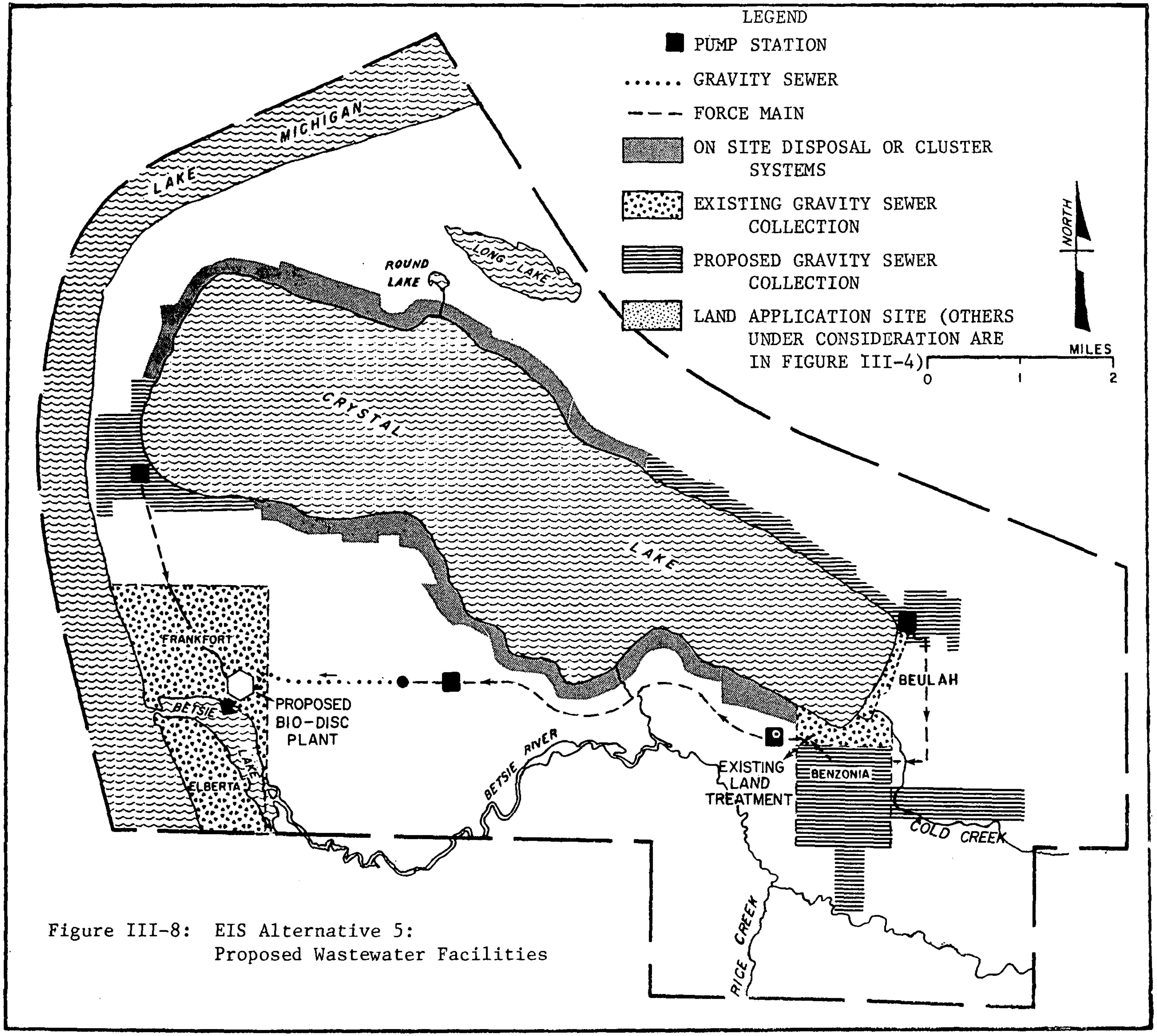


Figure III-8: EIS Alternative 5:
Proposed Wastewater Facilities

The RBC facility would be designed along lines similar to those developed in the Facilty Plan but the design flow would be 0.65 mgd. Design and costing assumptions used in developing this alternative are presented in Appendix J-1. Major components of the alternative and their costs are listed in Appendix J-2.

i. EIS Alternative 6

EIS Alternative 6 proposes treatment similar to that of Alternative 3. A new RBC plant, located in Frankfort, would serve Frankfort and Elberta. The plant would be designed to remove nutrients; 0.33 mgd of effluent would be discharged to Betsie Lake. An aerated lagoon land application system would serve the Benzonia Village area and the northeast shore of Crystal Lake. Wastewater renovated by land application would be recovered and 0.18 mgd discharged to the Betsie River.

Cluster systems would serve groups of houses along the southeast shore of Crystal Lake. In the remaining part of the Study Area continuing emphasis would be placed upon restoring and rehabilitating septic systems. This alternative is illustrated in Figure III-9. Major components of the alternative and their costs are listed in Appendix J-2; Appendix J-1 contains the design and cost assumptions used in developing this alternative.

3. FLEXIBILITY

a. No Action

The No Action Alternative maintains the existing conditions and places no additional planning and design restrictions upon the treatment of wastewater. Because no action is taken at present, the flexibility for future planning is high compared to an alternative recommending an extensive commitment of resources.

b. Limited Action

A new RBC plant at Frankfort to serve the Frankfort and Elberta areas would replace existing primary treatment plants. Existing on-site septic systems would be repaired and upgraded, and cluster systems or other collection techniques would be employed for the northeast and southeast shores. The main benefit of the Limited Action Alternative is that it would meet environmental requirements, while leaving maximum flexibility for future planning and design changes in the unsewered sections of the Study Area.

c. Facility Plan Proposed Action

A centralized treatment facility for all wastewater flows within the Proposed Service Area would reduce the flexibility for future planning and design changes concerning wastewater treatment. This alternative would relegate the entire Proposed Service Area to one treatment scheme and involve an extensive commitment of resources. However, the modular characteristic of the RBC plant does allow some capacity for expansion if future demands warrant it.

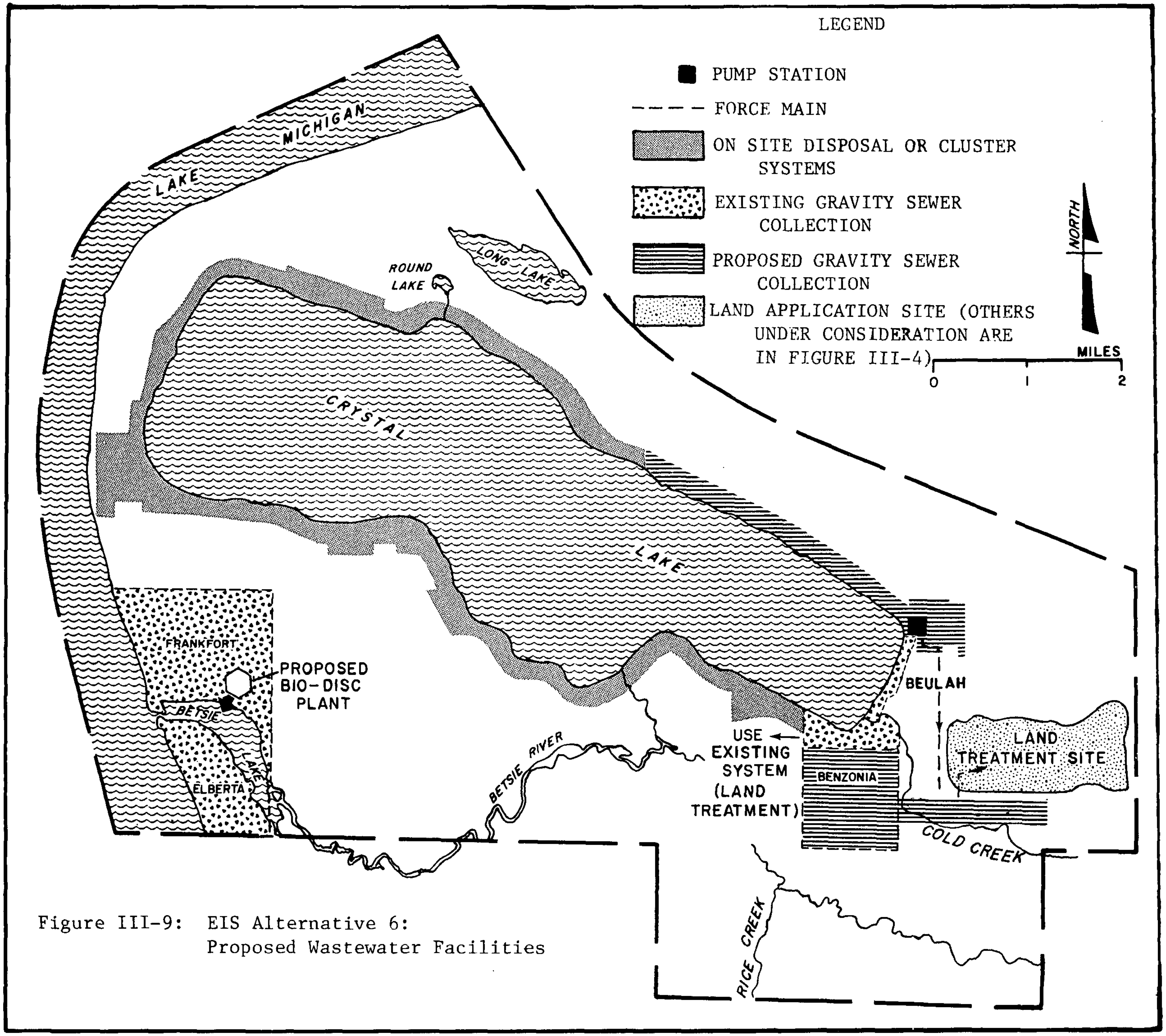


Figure III-9: EIS Alternative 6:
Proposed Wastewater Facilities

d. EIS Alternatives 1 and 2

EIS Alternatives 1 and 2 both employ collection by low pressure and gravity sewers and centralized treatment of all wastewaters within the same proposed Service Area as in the Facility Plan Proposed Action. In Alternative 1 wastewater is treated by an RBC plant located in Frankfort. In Alternative 2 land application near Benzonia is used for treatment of wastewater. As with the Facility Plan Proposed Action, these alternatives would relegate the entire Proposed Service Area to a single treatment scheme. The resulting commitment of resources and reduction in future planning and design flexibility would be significant.

e. EIS Alternative 3

EIS Alternative 3 allows for future expansion and change in treatment technique using a combination of conventional, land, and on-site treatment. Only those areas not suitable for on-site treatment would be sewered, thus reducing capital costs. This alternative provides flexibility for future expansion because of the many modes of treatment used. Also, the decentralized nature of the alternative allows the flexibility to base future decisions concerning land use development upon local conditions.

f. EIS Alternatives 4 and 5

Alternatives 4 and 5 would serve the same sewered area as suggested in Alternative 3. In Alternative 4, all sewered wastewater would be routed to a land application site in Benzonia. With Alternative 5, sewered wastewater would be routed to a RBC plant in Frankfort. Like Alternative 3, Alternatives 4 and 5 would rely upon on-site systems to treat wastewater in areas deemed suitable. The flexibility of Alternatives 4 and 5 is slightly less than Alternative 3 because of the reduced number of suggested treatment mechanisms and the reduced decentralization. Future expansion would be slightly more difficult to plan and design.

g. EIS Alternative 6

Alternative 6 calls for centralized treatment of wastewater for Frankfort, Elberta, Benzonia, and the northeast shore of Crystal Lake. Remaining areas around Crystal Lake would use cluster systems and upgraded septic systems. This alternative provides a fair degree of flexibility for future expansion because a combination of conventional and land application facilities are recommended, making two modes of treatment available for future expansion. Also, because the entire Proposed Service Area is not being sewered, the immediate commitment of resources is not as great as the Proposed Action in the Facility Plan. This allows some ability for future expansion and changes in localized planning. On the other hand, the absence of centralized facilities limits the opportunities for development of additional building sites.

4. COSTS OF ALTERNATIVES

a. Total Project Costs

Project costs were grouped by capital expenses, operating and maintenance expenses, and salvage values of the equipment for each alternative. A contingency fund amounting to approximately 25% of capital and salvage value was included to provide for such expenses as engineering and legal fees, acquisition of rights-of-way, and administration. The methodology and assumptions used in the analyses are described in Appendix J-1. Detailed costs for each alternative are presented in Appendix J-2.

Table III-2 summarizes present and future project costs for each of the alternatives. The analyses of total present worth and annual equivalent costs of each alternative are also presented there. (Debt service on financing the local share is not included.)

b. Federal/State Cost Sharing and Remaining Local Costs

The Proposed Rules and Interim Regulations for the Clean Water Act of 1977 (EPA 1978) address Federal funding of wastewater collection, treatment, and related facilities. Appendix J-3 summarizes these proposals and regulations. The 1977 Act differs significantly from the Water Pollution Control Act of 1972. For example, Federal funding of facilities using innovative and alternative technologies has been increased from 75% to 85%.

Michigan's share of the capital costs of pollution control facilities is related to Federal eligibility requirements. In the past, the State has funded 5% of those project costs eligible for Federal funds. With respect to facilities eligible for 85% Federal funding, the State has decided to maintain the same 5% funding as before. Consequently, the remaining local costs would be 20% for conventional facilities and 10% for alternative or innovative ones.

Some uncertainties about local costs will remain until the extent of the collection system that would be eligible for Federal funding and until the nature of the management system that would be instituted if on-lot and cluster systems were part of the wastewater management plan are known.

The RBC plant should be eligible for 75% Federal funding as the plant represents a conventional treatment technology. Land application, however, is an alternative technology eligible for 85% Federal funding. Interceptor sewers connecting Frankfort and Elberta to the RBC plant, and a collector sewer for the northeast shore were assumed eligible for 75% Federal funding.

Rehabilitation and replacement of existing on-site systems and construction of cluster systems would be eligible for 85% Federal funding. Under private ownership the only systems eligible for Federal funds would be those serving permanent residents. If the systems were publicly owned, both seasonal and permanent residents could benefit from Federal and State funding.

5. ENGINEERING AND ECONOMIC ANALYSIS OF FLOW REDUCTION DEVICES

Economies could be effected through use of household flow reduction devices. A listing of devices used for reducing residential flows is presented in Appendix I-3. This Appendix also contains cost data, equipment lifetimes, and indication of the potential savings of water associated with each device.

The incremental costs of flow reduction are presented in Appendix I-2. Implicit in this Appendix is the assumption that installation costs would be approximately equal for conservation-oriented and conventional devices.

Design flows for the Facility Plan Proposed Action and for EIS Alternatives 1 and 2 could be reduced from 0.89 mgd to 0.71 mgd if dual cycle toilets and flow control valves for shower heads and lavatory faucets were installed in all sewered residences.

This reduction of flow would reduce capital expenses and operation and maintenance costs for facilities. To estimate this cost savings, Alternative 2 was re-examined on the basis of the lower design flow. Savings in the pressure sewer system are attributable primarily to size reductions for new force mains. The capital costs for land application treatment processes are also reduced. The total savings associated with flow reduction for Alternative 2 amounted to $567,000 in capital expenditure and approximately $8,000 per year in operation and maintenance costs. In terms of economics the present worth* of flow reduction ($596,000) would amount to 3.4% of the total present worth of Alternative 2.

To achieve these savings local plumbing codes would have to require flow reduction devices in new housing and, as necessary, for replacement of old fixtures. The approximate savings over the 20-year design period is $410,000, equivalent to $112 per design-year dwelling unit.

Although costs of flow reduction have not been analyzed in detail for the other alternatives, total annual homeowner savings in the range of $100 to $125 have been estimated for dwellings in the sewered areas. As discussed in Section IV.B.1.a, decreased water consumption and heating costs are included in these savings for the homeowner.

In unsewered areas the savings are harder to calculate. The parameters that determine whether or not soil disposal systems operate properly are not well understood. Consequently, conservative, empirical criteria for design are used. Although reduced design flows may justify smaller soil disposal systems, most state agencies are conservative with respect to such changes.

Flow reduction measures probably improve the operation of soil disposal systems and, therefore, may serve as insurance against early failures. Where rehabilitation of septic systems is necessary, flow reduction devices such as composting and recycling toilets, which may not be cost effective, may be required to forestall repeated failure.

D. IMPLEMENTATION

How a wastewater management plan is to be implemented depends upon whether the selected alternative relies primarily upon centralized or decentralized components. Since most sanitary districts have in the past been designed around centralized collection and treatment of wastewater, there is a great deal of information about the implementation of such systems. Decentralized collection and treatment is, however, relatively new and there is little management experience on which to draw.

Regardless of whether the selected alternative is primarily centralized or decentralized, four aspects of the implementation program must be addressed:

- There must be legal authority for a managing agency to exist and financial authority for it to operate.

- The agency must manage construction, ownership and operation of the sanitary district.

- A choice must be made between the several types of long-term financing that are generally required in paying for capital expenditures associated with the project.

- A system of user charges to retire capital debts, to cover expenditures for operation and maintenance, and to provide a reserve for contingencies must be established.

In the following sections, these requirements are examined first with respect to centralized sanitary districts, then with respect to decentralized districts.

1. CENTRALIZED DISTRICTS

a. Authority

The Crystal Lake Area Facility Plan identified the Benzie County Board of Commissioners as the legal authority for implementing the Plan's Proposed Action. The Benzie County Department of Public Works would be the operating division which would construct, operate and maintain the wastewater management system. Under Act 185 of the Michigan Public Acts of 1957 as amended, the County has the authority to implement this system and to contract with the villages, townships and Frankfort City for services.

b. Managing Agency

The role of the managing agency has been well defined for centralized sanitary districts. In general, the agency constructs, maintains and operates the sewerage facilities. Although in fact different contractual relationships exist between the agencies and their service areas, for the purposes of this document ownership of the facilities may be assumed to reside with the agency. For gravity sewers, such ownership has traditionally extended to the private property. For STEP or grinder pump stations connected to pressure sewers several options exist:

- o The station may be designed to agency specifications, with the responsibility for purchase, maintenance and ownership residing with the homeowner.

- o The station may be specified and purchased by the agency, with the homeowner repurchasing and maintaining it.

- o The station may be specified and owned by the agency, but purchased by the homeowner.

- o The station may be specified, purchased and owned by the agency. Regardless, however, of the option selected, all residences are treated equally.

c. Financing

Capital expenses associated with a project may be financed by several techniques, which are discussed in detail in Appendix J-4. Briefly, they are:

- o pay-as-you-go methods;
- o special benefit assessments;
- o reserve funds; and
- o debt financing.

The Facility Plan recommended debt financing in the form of 40-year revenue bonds for the Proposed Action. As indicated in Appendix J-4, revenue bonds generally have not been used in Michigan; General Obligation bonds have been more widely offered.

d. User Charges

User charges are set at a level that will provide for repayment of long-term debt and cover operating and maintenance expenses. In addition, prudent management agencies frequently add an extra charge to provide a contingency fund for extraordinary expenses and replacement of equipment.

The implementation program proposed by the Facility Plan is an example of a scheme calling for a County to recover the costs of wastewater management from the local municipalities. The municipalities would, in turn, charge the users of the system. Because of the potential economic impacts, the charges must be carefully allocated among various classes of users. Recognized classes of users include:

- o Permanent residents/Seasonal residents

- o Residential/Commercial/Industrial users
- o Presently sewered users/Newly sewered users
- o Low- and fixed-income residents/Active income producers

Each class of user imposes different requirements on the design and cost of each alternative, receives different benefits, and has different financial capabilities. To illustrate the allocation of techniques available, three possible user-charge schemes have been examined in Appendix J-5.

2. SMALL WASTE FLOW DISTRICTS

Regulation of on-lot sewage systems has evolved to the point where most new facilities are designed, permitted and inspected by local health departments or other agencies. After installation, local government has no further responsibility for these systems until malfunctions become evident. In such cases the local government may inspect and issue permits for repair of the systems. The sole basis for government regulation in this field has been its obligation to protect public health.

Rarely have governmental obligations been interpreted more broadly to include monitoring and control of other effects of on-lot system use or misuse. The general absence of information concerning septic system impacts on ground and surface water quality has been coupled with a lack of knowledge of the operation of on-site systems.

Methods of identifying and dealing with the adverse effects of on-lot systems without building expensive sewers are being developed. Technical methods include both the wastewater treatment and disposal alternatives discussed in Section III.B and improved monitoring of water quality. Managerial methods have already been developed and are being applied in various communities as discussed in Appendix K-1.

As with any centralized district, the issues of legal and fiscal authority, agency management, project financing, and user charges must all be resolved by small waste flow districts.

a. Authority

Michigan presently has no legislation which explicitly authorizes governmental entities to manage wastewater facilities other than those connected to conventional collection systems. However, Michigan Statutes Sections 123.241 _et seq_. and 323.37 _et seq_. have been interpreted as providing counties, townships, villages and cities with sufficient powers to manage decentralized facilities (Otis and Stewart 1976).

California and Illinois, to resolve interagency conflicts or to authorize access to private properties for inspection and maintenance of wastewater facilities, have passed legislation specifically intended to facilitate management of decentralized facilities. These laws are summarized in Appendix K-2.

b. Management

The purpose of a small waste flow district is to balance the costs of management with the needs of public health and environmental quality. Management of such a district implies formation of a management agency and formulation of policies for the agency. The concept of such an agency is relatively new. Appendix K-3 discusses this concept in detail.

The range of functions a management agency may provide for adequate control and use of decentralized technologies is presented in Table III-3. Because the level of funding for these functions could become an economic burden, their costs and benefits should be considered in the development of the management agency. Major decisions which have to be made in the development of this agency relate to the following questions:

- o Should engineering and operations functions be provided by the agency or by private organizations under contract?
- o Would off-site facilities require acquisition of property and right-of-way?
- o Would public or private ownership of on-site wastewater facilities be more likely to provide cost savings and improved control of facilities operation?
- o Are there environmental, land use, or economic characteristics of the area that would be sensitive to operation and construction of decentralized technologies? If so, would special planning, education and permitting steps be appropriate?

Five steps are recommended to implement an efficient, effective program for the management of wastewater in unsewered areas:

- o Develop a site-specific environmental and engineering data base
- o Design the management organization
- o Agency start-up
- o Construction and rehabilitation of facilities
- o Operation of facilities

Site Specific Environmental and Engineering Data Base. The data base should include groundwater monitoring, a house-to-house investigation (sanitary survey), soils and engineering studies, and a survey of available technologies likely to function adequately in the area. This baseline information will provide the framework for the systems and technologies appropriate to the district.

Table III-3

SMALL WASTE FLOW MANAGEMENT FUNCTIONS BY OPERATIONAL COMPONENT AND BY BASIC AND SUPPLEMENTAL USAGE

Component	Basic Usage*	Supplemental Usage*
Administrative	User charge system Staffing Enforcement	Grants administration Service contracts supervision Occupancy/operating permits Interagency coordination Property and right-of-way acquisition Performance bonding requirements
Engineering	Adopt design standards* Review and approval of plans* Evaluate Existing systems/ design rehabilitation measures Installation inspection* On-site soils investigations* Acceptance for public management of privately installed facilities	Design and install facilities for public ownership Contractor training Special designs for alternative technologies Pilot studies of alternative technologies Implementing flow reduction techniques
Operations	Routine inspection and maintenance Septage collection and disposal Groundwater monitoring	Emergency inspection and maintenance Surface water monitoring
Planning		Land use planning Public education Designate areas sensitive to soil-dependent systems Establish environmental, land use and economic criteria for issuance or non-issuance of permits

* Usage normally provided by local governments at present.

A program for monitoring groundwater should include sampling of existing wells and possibly additional testing of the aquifer. Such monitoring should be instituted early enough to provide data useful in selecting and designing wastewater disposal systems.

The sanitary survey should include interviews with residents and inspections of existing systems. A trained surveyor should record information on lot size and location; age and use of dwelling; location, age, and type of sewage disposal system; adequacy of the maintenance of the existing system; water-using fixtures; and problems with the existing system.

Detailed site analyses may be required to evaluate operation of the effluent disposal fields and to determine the impacts of effluent disposal upon local groundwater. These studies may include probing the disposal area; boring soil samples; and the installation of shallow groundwater observation shafts. Sampling of the water table downhill from leach fields aids in evaluating the potential for transport of nutrients and pathogens through the soil. Soil classifications near selected leach fields may improve correlations between soils and leach field failures. An examination of the reasons for the inadequate functioning of existing wastewater systems may avoid such problems with the rehabilitation or construction of new systems.

Design the Management Organization. Both the Facility Plan and the EIS have recommended Benzie County as the agency best suited to managing wastewater facilities in both unsewered and sewered areas of the Study Area. An analysis of the County's technical and administrative capabilities as outlined in Table III-3, should proceed concurrently with development of the environmental and engineering data base. The role of organizations such as the Department of Health should be examined with respect to avoiding interagency conflicts and duplication of effort and staffing.

Determination of the basic and supplementary management functions to be provided will be influenced by the technologies appropriate to the Study Area. In this respect, the questions raised earlier regarding formulation of management policies must be resolved.

The product of these analyses should be an organizational design in which staffing requirements, functions, interagency agreements, user charge systems and procedural guidelines are defined.

Agency Start-Up. Once the structure and responsibilities of the management agency have been defined, public review is advisable. Additional personnel required for construction and/or operation should be provided. If necessary, contractual arrangements with private organizations should be developed. Acquisition of property should also be initiated.

Construction and Rehabilitation of Facilities. Site data collected for the environmental and engineering data base should support selection and design of appropriate technologies for individual residences. Once construction and rehabilitation begin, site conditions may be revealed that suggest technology or design changes. Since decentralized technologies generally must be designed to operate within site limitations instead of overcoming them, flexibility should be provided. Personnel authorized to revise designs in the field would provide this flexibility.

Operation of Facilities. The administrative planning, engineering, and operations functions listed in Table III-3 are primarily applicable to this phase. The role of the management agency would have been determined in the organizational phase. Experience gained during agency start-up and facilities construction may indicate that some lower or higher level of effort will be necessary to insure long term reliability of the decentralized facilities.

c. Financing

The financing of a small waste flows district is similar to that of a centralized district. Such financing was discussed in Section II.D.1.c.

d. User Charges

Although renovation and replacement costs for on-site systems owned by permanent residents are eligible for Federal funding, such costs incurred by seasonal residents are not. The major difference in the financing of the two systems arises from the question of seasonals' ownership of on-site systems. With respect to the Study Area, where a significant proportion of the users would be seasonal, the absence of Federal funding would transfer a large fraction of the project costs to the local users. This would be reflected in either 1) capital outlays by the users for construction, 2) increased user charges covering increased local costs or 3) both.

User charges and classes have been discussed in Section III.D.1.d. The significance of decentralized districts lies in the creation of an additional class of users. Since residents of such districts may be differentiated in terms of centrally sewered areas and decentralized areas, user charges may differ. As a result many different management functions are conjoined. For example, permanent users on septic systems may be charged less than those on central sewers. Seasonal users on pressure sewers may have high annual costs associated with amortization of capital expenses; permanent users of pressure sewers may be charged less than seasonal users, because Federal funding reduced their share of the capital costs. Alternatively, the management agency may choose to divide all costs equally among all users. For the analyses in this EIS, public ownership of permanent and seasonal on-site systems has been assumed.

Problems such as these have not been adequately addressed by the historical sources of management information. Development of user charges by small waste flows districts will undoubtedly be complicated by the absence of such historical records. EPA is preparing an analysis of equitable means for recovering costs from users in small waste flow districts and combined sewer/small waste flow districts.

CHAPTER IV

IMPACTS

A. SURFACE WATER

1. PRIMARY IMPACTS

a. Eutrophication Potential Analysis

This section discusses the effect of nutrient loading associated with different wastewater management alternatives upon the trophic status of open waters in Betsie Lake and Crystal Lake. To evaluate the impact of each alternative, nutrient loading levels for phosphorus were calculated. Phosphorus is the limiting nutrient for algal growth in most temperate zone lakes. Phosphorus is also more easily controllable than nitrogen.

The major sources of phosphorus for Crystal Lake and Betsie Lake were identified earlier as:

- precipitation
- septic tank leachate
- tributary
- non-point source runoff including drainage from the immediate area around the lake
- wastewater treatment plant discharge.

Other sources known to contribute to nutrient loading including groundwater, detritus, waterfowl, and release from sediments are less significant in the Study Area in terms of the time scales considered.

This analysis first used simple mathematical models to establish the existing trophic status of Betsie and Crystal Lakes in terms of total areal phosphorus loading levels. Then future phosphorus loading scenarios based on wastewater management alternatives were derived. Next a Vollenweider/Dillon model projected the trophic status of the lakes using derived phosphorus loading levels. The model used in this analysis is detailed in Appendix E-4.

Summary of Existing Trophic Status. Given such hydrological features of the lake as hydraulic retention time and depth, the model generates a "permissible" phosphorus loading limit above which a lake is considered mesotrophic and a "dangerous" phosphorus loading limit above which the lake is considered eutrophic. The phosphorus loading tolerance limits for Betsie Lake and Crystal Lake are summarized in Table IV-1. Existing phosphorus loading levels derived in Chapter II are included for purpose of comparison.

Table IV-1

PHOSPHORUS LOADING LIMITS ($g/m^2/yr$)

	Betsie Lake	Crystal Lake
Permissible	3.23	0.064
Dangerous	6.46	0.132
Existing	12.39	0.044

Betsie Lake can assimilate greater phosphorus loads per unit area because of its relatively high flushing rate (hydraulic retention time of 2 days) compared with that of Crystal Lake (63 years).

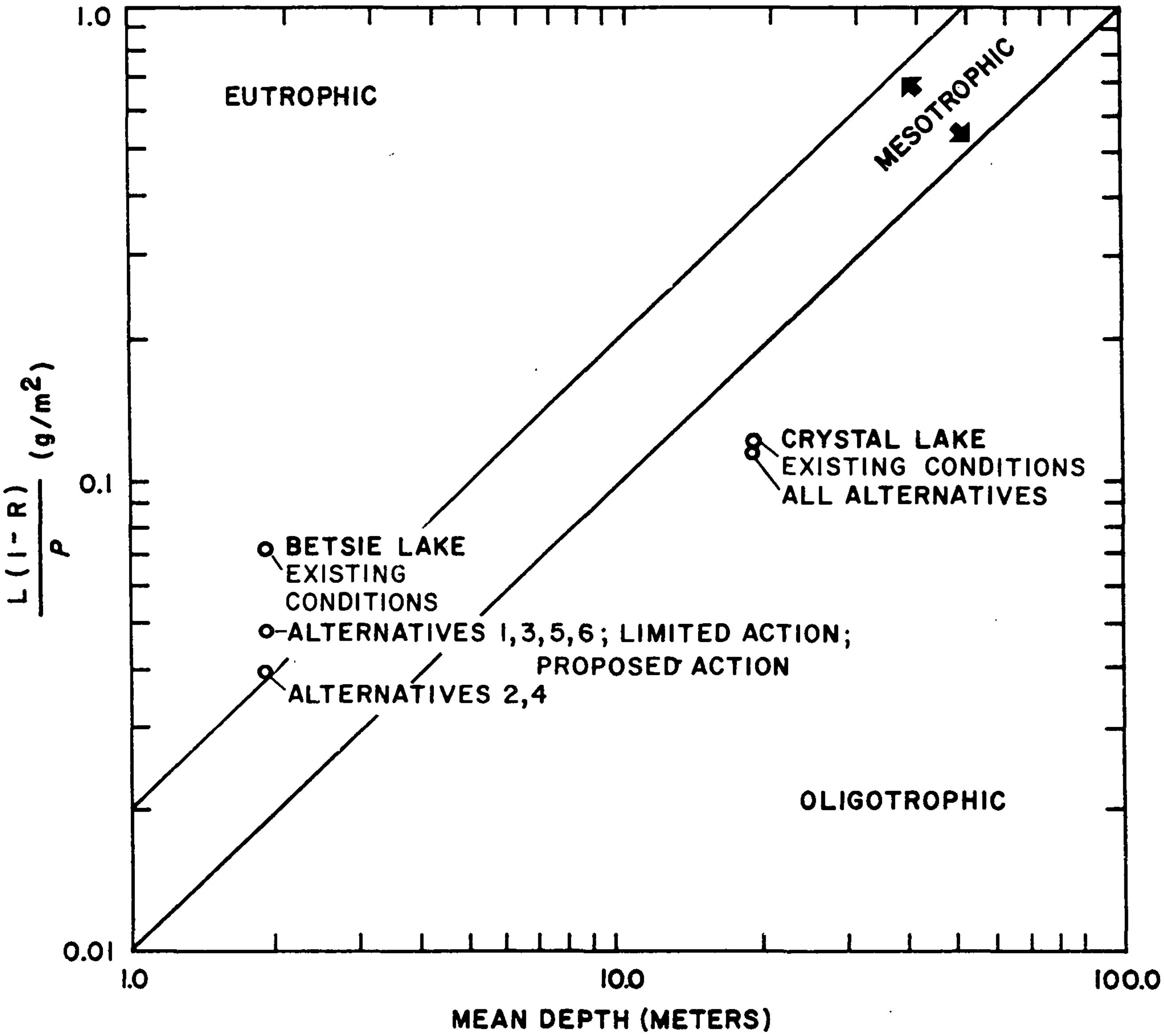
The current status of eutrophication of these lakes can best be summarized in Figure IV-1. It shows that Crystal Lake is currently in the oligotrophic category while Betsie Lake is eutrophic.

Future Load Scenario: Betsie Lake. Table IV-2 shows estimates of phosphorus inputs for Betsie Lake for each wastewater alternative. Non-point source runoff was assumed to remain constant until the year 2000, because future land use was uncertain. These estimated phosphorus inputs for the alternatives indicate that loads could be reduced by 43-48%, below existing conditions. The reduction in phosphorus loads is similar for all wastewater management alternatives (except No Action) because (1) over 50% of the phosphorus load is from nonpoint sources and will not be controlled by wastewater management alternatives and (2) effluent discharged from the treatment plant or land application is low in phosphorus (1 mg/l and 0.3 mg/l respectively). Three options are available for reducing the phosphorus to Betsie Lake.

- o Elimination of wastewater discharge from the Elberta and Frankfort plants into Betsie Lake. The land application alternatives (2 and 4) which eliminate discharge to Betsie Lake have the greatest potential for reducing phosphorus loads. Reduction in phosphorus loads of about 48% are anticipated with Alternatives 2 and 4.

- o Chemical precipitation. Design for the RBC plant specifies phosphorus removal by chemical precipitation. Phosphorus levels in the effluent discharge with this method will be less than 1.0 mg/l. EIS Alternative 1 and the Facility Plan Proposed Action would treat the wastewater from the entire Study Area and the phosphorus loading to Betsie Lake will be only about 10% greater than if land application is used for the entire Study Area.

- o A combination of chemical precipitation of phosphorus and reduction of wastewater flow. EIS Alternatives 3, 4, and 6 propose the use of on-site systems for various sections of the Crystal Lake shoreline and treatment of the remaining wastewater at the RBC plant or by land application. These alternatives are intermediate in hydraulic and nutrient loads.



L= AREAL PHOSPHORUS INPUT ($g/m^2/yr$)

R= PHOSPHORUS RETENTION COEFFICIENT (DIMENSIONLESS)

P= HYDRAULIC FLUSHING RATE (yr^{-1})

FIGURE IV-1 TROPHIC STATUS OF BETSIE LAKE AND CRYSTAL LAKE

Table IV-2

ESTIMATES OF PHOSPHORUS LOADS TO BETSIE LAKE
FOR THE WASTEWATER TREATMENT ALTERNATIVES

ALTERNATIVES	PHOSPHORUS LOAD $gm/m^2/Yr$ (Lb/Yr)	% ABOVE DANGEROUS LIMIT	% REDUCTION OVER EXISTING CONDITIONS
Alternatives 2 & 4	6.47 (14.4×10^3)	0.2	48%
Limited Action	6.91 (15.40×10^3)	6.4	44
Alternative 6	6.96 (15.51×10^3)	7.0	44
Alternative 3	7.0 (15.71×10^3)	7.0	44
Alternative 5	7.1 (15.80×10^3)	9.8	43
Alternative 1 and Proposed Action	7.1 (16.55×10^3)	8.8	43
Existing Conditions and No Action	12.39 (27.6×10^3)	48	-

Phosphorus loads would be reduced by 43-44% as compared to with present conditions.

With any of the available options the phosphorus reduction is not significant enough to change the trophic status of the lake from eutrophic to mestrophic according to Dillon's model; in all instances the loads are slightly greater than Dillon's "tolerance limits" of 6.46 $g/m^2/yr$ for Betsie Lake. However, the reduction in phosphorus input (43% - 48%) provided by the wastewater treatment alternatives represents a significant achievement in correcting the eutrophication problem in Betsie Lake. Phosphorus concentration in the lake will be lowered as a result of the proposed project. Unfortunately, data deficiency prevents the prediction of the subsequent decline in algal growth at this time. In any case, the proposed action is the first step towards restoring Betsie Lake.

Future Load Scenario: Crystal Lake. In marked contrast to Betsie Lake, Crystal Lake has been shown to be oligotrophic under existing conditions. Inasmuch as total phosphorus loads shown in Figure IV-1 are well within the "permissible" limits and because phosphorus loads from on-site systems are but a small portion (6.7% or less) of the total, none of the alternatives is anticipated to have a significant effect on the quality of the open water. Localized shoreline eutrophication resulting from septic tank leachate and non-point sources is discussed in Section IV.A.1.b.

Table IV-3 shows estimated phosphorus loads for the existing conditions, decentralized, and centralized alternatives. The following assumptions were made in deriving the nutrient loads:

- Phosphorus loads from ST/SAS were assumed to be 0.25 lb/cap/day and corrected for seasonal residency. A 14% increase in nutrient loads from ST/SAS was anticipated for the year 2000. This figure was based on the calculated number of homes and ST/SAS which could be constructed on half acre lots where soils are suitable for ST/SAS. Based upon results of the "Septic Snooper" survey (Kerfoot 1978) the septic tank load estimate is considered to be conservatively high.

- Phosphorus loads from Cold Creek were based upon data provided by Tanis (1978).

- Phosphorus loads resulting from changes in land use were estimated by using Omernik's regression model. This model, detailed in Appendix E-2 approximates the total phosphorus (and nitrogen) concentration in surface water runoff based upon the influence of agricultural, residential/urban, and forested land in the watershed.

The estimated loads readily show unchanged trophic status of Crystal Lake regardless of the alternative. Phosphorus loadings should remain 30-35% below the permissible limit of 0.064 $g/m^2/yr$. Because the contribution of total nutrients from septic tanks is small, the ban on phosphorus will not significantly reduce the total Crystal Lake phosphorus load.

Table IV-3

CRYSTAL LAKE PHOSPHORUS INPUT

EXISTING CONDITIONS	Loading Rate (lbs/yr)	(kg/yr)	Areal Loading Rate ($g/m^2/yr$)	Percentage %
Precipitation	1,690	767	.019	42.8
Septic Tanks	263	120	.003	6.7
Cold Creek	1,533	695	.017	38.8
Non-Point Source Runoff-Immed. Watershed	465	210	.005	11.7
TOTAL	3,951	1,792	.004*	100.0
1975 - WITHOUT SEPTIC TANKS				
Precipitation	1,690	767	.019	45.8
Septic Tanks	--	--	--	--
Cold Creek	1,533	695	.018	41.6
Non-Point Source Runoff	465	210	.005	12.6
TOTAL	3,688	1,672	.041*	100.0
CENTRALIZED ALTERNATIVES				
Precipitation	1,690	767	.019	44.0
Septic Tanks	0	0	0	--
Cold Creek	1,533	695	.017	40.0
Non-Point Source Runoff	614	279	.007	16.0
TOTAL	3,837	1,741	.043*	100.0
YEAR 2000 DECENTRALIZED (No Phosphorus Ban)				
Precipitation	1,690	767	.019	42.0
Septic Tanks	176	80	.002	4.4
Cold Creek	1,533	695	.017	38.2
Non-Point Source Runoff	614	279	.007	15.4
TOTAL	4,013	1,821	.045	100.0
WITH PHOSPHORUS BAN				
Precipitation	1,690	767	.019	43.0
Septic Tanks	88	40	.001	2.3
Cold Creek	1,533	695	.017	39.0
Non-Point Source Runoff	614	279	.007	15.7
TOTAL	3,925	1,781	.044	100.0

*Dillon's permissible load = 0.064 $g/m^2/yr$.
Tanis 1978; Omernik 1977; EPA, NES 1975.

b. Lakeshore Eutrophication

The colonization of Cladophora in localized areas along the Crystal Lake shoreline has been attributed to nutrient influx from human activity. Cladophora requires high nutrient concentrations which are not naturally available in nutrient poor, oligotrophic lakes such as Crystal Lake. Several studies have been made in an effort to determine the cause and extent of Cladophora growth along the lake shore. Under existing conditions, correlations have been found between housing density and shoreline vegetation (Tanis 1978 and Gannon 1970) and between several variables associated with septic tank performance (University of Michigan 1978) including:

- length of home occupancy
- age of septic tanks
- proximity of septic tanks to the lake shore

The data strongly suggest that Cladophora growth is at least, in part, the result of nutrient leachate from septic tanks. Septic tank plumes may channel nutrient rich waters to the vegetation, in effect acting as a hydroponic culture.

The data supplied by these studies suggest that the frequency and density of Cladophora growth may increase slightly if additional permits for shoreline septic systems are granted. However, the availability of nutrients for algal growth could be reduced along the southwestern, southeastern, and northwestern shorelines if the ST/SAS were upgraded. Many of the existing systems are undersized or are located too close to the lakeshore. Nutrients from ST/SAS along the northeastern shore and a small part of the southeast shore may not be reduced by upgrading because of expected high rates of groundwater inflow to the lake.

The centralized alternatives (Facility Plan Proposed Action and EIS Altternatives 1 and 2) are most likely to reduce the concentration of nutrients contributing to shoreline eutrophication. Alternatives 3, 4, 5 and 6 which propose sewering the northern shore where Cladophora growth is heaviest, may effectively reduce the major nutrient source for growth.

There is no guarantee that sewering the Study Area will eliminate the growth of Cladophora. With 51% of the phosphorus coming from non-point source runoff and tributaries, it is conceivable that some localized growth may result from these sources. This is particularly true along the northeastern shore where groundwater flow patterns may channel nutrients to localized areas.

c. Bacterial Contamination

Effluent discharges to Betsie from the proposed new treatment plant in Frankfort should not result in significant bacterial contamination of surface waters. Disinfection facilities are included in the design of the RBC plant. However, the efficiency of disinfection is a function of mixing, contact time and plant operation. Regular sampling to measure fecal coliform and residual disinfectant should provide an indication of disinfection effectiveness. Plant malfunctions would not severely affect Betsie Lake unless the Lake were used for water contact recreation. Centralized treatment of wastewater by land application will not impact surface waters; the land application sites are located at a distance from Crystal and Betsie Lakes.

Pumping stations malfunctions could occur with centralized Alternatives 1 and 2, resulting in contamination of surface waters. Rigorous inspection and maintenance of pumping stations would minimize this possibility.

Bacterial contamination of Crystal Lake surface water should not be a problem with the decentralized alternatives. Available data suggest that bacteria are removed even by the medium sandy soils along the lakeshore. The results of the bacterial sampling surveys performed by Kerfoot (1978) and Gannon (1970) are discussed in section II.B.7 and II.C.1. Kerfoot observed that bacterial concentration did not exceed Michigan's primary contact standards (200 organisms/100 ml) even when the samples were collected at the site of a leaching septic tank plume.

d. Non-Point Source Nutrient Loads

Primary impacts on surface water quality related to the construction of ST/SAS systems and the replacement of old systems is likely to result in increased soil erosion. Similarly, installation of sewers, especially those that pass under the many small drainage ways leading to Crystal Lake, will accelerate erosion.

Compliance with state and local soil erosion control requirements could substantially reduce the erosion problem and the subsequent impact on water quality.

2. SECONDARY IMPACTS

The potential productivity of Crystal Lake and Betsie Lake is determined to a large extent by the type of land over which the runoff drains. Current estimates of nutrient loadings indicate that the non-point source runoff contributes roughly 52% of the total phosphorus to Betsie Lake and 50% of the total phosphorus to Crystal Lake.

Increased shoreline housing, a secondary impact of sewering Crystal Lake, might increase sediment and nutrient loads. Conversion of forested land to residential or agricultural use tends to increase non-point source loadings significantly (Omernik 1977).

Any nutrient loading estimates for non-point sources have a low confidence limit. (See Omernik's Model, Appendix E-2.) They cannot account for particularly sensitive features of the Study Area or for specific land use purposes.

For purposes of land use planning, increases in nutrient loads from non-point source runoff must be considered. Increased loads could result from:

- increased runoff from construction of impervious surfaces such as rooftops and parking areas;
- lawn and garden fertilization creating unnaturally high nutrient levels in the runoff; and
- soil disruption by human activities, (i.e., housing construction, leveling of forested area etc.).

Any of these could result in increased nutrient and sediment loss especially in areas with steep slopes or in drainage ways leading to Crystal Lake.

The topography of the Crystal Lake watershed suggests that certain large areas may be particularly vulnerable to increased non-point source runoff. The Cold Creek watershed lies in an upland area that slopes towards the lake. Approximately 36% of the area is forested now. Development of this land will increase runoff to the lake. Tanis (1978) has demonstrated that forested areas of the Cold Creek watershed produce runoff with fewer nutrients than runoff from land used for agricultural or residential purposes.

The remainder of the Crystal Lake watershed consists mainly of bluffed areas around the Lake. These areas are about 50% forested and their runoff water is characterized by low phosphorus concentration (0.016 mg/l). Residential development encouraged by sewering could increase runoff phosphorus concentrations and sediment loadings. The potential for increased development is much greater along the Crystal Lake shoreline than that of Betsie Lake. Since Betsie Lake is already sewered, the wastewater management alternatives are not likely to induce growth in the Betsie Lake area.

3. MITIGATIVE MEASURES

The impact analysis has indicated that non-point source runoff contributes a large percentage of the total Crystal Lake nutrient load. The Benzie County Development Plan has made several recommendations to control such runoff. These recommendations should be enforced by the townships through zoning, performance standards and ordinances for control of non-point sources.

Erosion and sedimentation resulting from construction of wastewater collection systems should be minimized by adhering to the requirements of the Soil Erosion and Sedimentation Control Act of 1972. Enforcement of this act is the responsibility of Benzie County Community Development Department. Construction permits can be revoked for violations of the standards set forth in this act.

The two major non-point sources have been identified as the lower Cold Creek watershed and the lake bluffs. The use and development of land in the lower Cold Creek watershed should be restricted to compatible uses. Alternatives to the current practice of routing Beulah's stormwater to Cold Creek should be investigated. Sources of wastewater entering Cold Creek should be identified and dealt with appropriately. Any development on the bluffs around the lakeshore should require individual plan approval, the developer being required to ensure that sedimentation and erosion can be controlled and structural failures will not occur. Although septic tanks have been shown to be a minor source of nutrients, several mitigative measures could minimize the nutrient load from this source. Cladophora growth along the Crystal Lake shoreline has been attributed to localized nutrient sources. Several measures are available which may minimize Cladophora growth. These include upgrading the existing on-site systems, use of off-site systems or composting toilets and minimizing the use of phosphorus-containing fertilizers.

These improvements in septic tanks are intended to reduce nutrients for algal growth along the shoreline. There is no guarantee that Cladophora growth would be eliminated by these mitigative measures, however. As a last resort Cladophora growth which does occur may be controlled by adding copper sulfate locally. Used in properly low concentrations, this chemical will interact with polypeptides secreted by the algae. This will kill the algae but make the copper unavailable for uptake (and toxicity) to other organisms.

There is some possibility that the approximately 25 dormant effluent plumes along the western third of Crystal Lake may be influenced by the prevailing direction of groundwater flow (see Figure II-8), which is away from the lake and toward Lake Michigan. Should this be the case, under conditions of peak flows, the plumes may have hydraulic loadings sufficient to overcome the normal groundwater flow and force a plume out into the lake. As system use declines (when seasonal residents leave) leachate would again tend to move in the direction of the groundwater. These unusual conditions may allow use of flow reduction devices as mitigative measures, because reduced flow would result in lower hydraulic loadings and fewer plume extensions into the lake.

B. GROUNDWATER IMPACTS

Groundwater impacts fall into two categories, those affecting the available quantity of the resource, and those affecting its quality.

1. GROUNDWATER QUANTITY IMPACTS

No significant primary or secondary impacts on groundwater quality should come from any of the various alternatives. This is mainly because all of the water quantities associated with the alternatives are relatively miniscule in comparison with the estimated groundwater storage, recharge from all other sources, and available groundwater yield.

The conversion from sewage disposal practices based on individual soil absorption systems to central sewered treatment systems without effluent land disposal can result in the loss of groundwater recharge. The significance of this loss hinges upon its relationship to the recharge from all other sources; these include downward infiltration and percolation from precipitation and surface water bodies, and adjacent aquifer inflow. Precise definition of this depends upon an accurate knowledge of the aquifer(s), and its hydrology (e.g., precipitation, runoff, evapotranspiration, discharge) and hydraulic characteristics (e.g., transmissivity, and storage coefficients). There is insufficient data with which to undertake such precise quantification.

Study Area groundwater extraction is currently very small, being limited mainly to small wells serving individual homes, except in municipalities. It is on an order of magnitude as the total Study Area wastewater flows, perhaps 0.89 mgd (equivalent to approximately 620 gpm) by the year 2000. The 500-foot thick sediments in the area, even with allowance for their expected discontinuity and low specific yields, should have a safe yield several orders of magnitude greater than the total wastewater effluents available for groundwater recharge. This is particularly true of the outwash deposits southeast of the Study Area. Failure to return the relatively small quantities of wastewater flows as recharge is not expected to have a significant impact upon groundwater quantity. Because of the small water quantities involved, land effluent disposal or soil absorption systems will show only minute impact reductions over the other alternatives.

The short-term construction impacts on groundwater quantity will be even less discernible since still smaller quantities of water will be involved. Also, in no case will construction activities be likely to result in the sealing of enough recharge area to create a significant adverse effect upon groundwater quantity.

Increased groundwater demands, arising from Study Area induced growth, may cause groundwater quantity impacts. Decentralized alternatives should do this less than centralized sewer system alternatives. Study Area population growth from centralized systems use may be about 19% by the year 2000. A corresponding 19% increase in water use would amount to about 0.17 mgd. This increased demand is so small compared to the aquifer capacity that it will not create a significant impact. The County Development Plan shows that available groundwater supplies are more than adequate for demands through the year 2000 (Wilbur Smith and Associates 1974). However, existing municipal storage and distribution facilities are inadequate for future needs.

2. GROUNDWATER QUALITY IMPACTS

No significant short-term impacts on groundwater quality should result from the construction of any of the alternatives. Long-term impacts would be as follows:

- Impacts on bacterial quality are expected to be significant for all alternatives;
- Continued use of ST/SAS particularly on the northeastern lakeshore may result in minor impacts associated with shoreline algal growths;

- No significant impacts on nitrate concentrations are anticipated providing the density of ST/SASs complies with generally accepted standards. Only the No Action alternative is likely to result in significant adverse impacts.

These conclusions are discussed in more detail in the sections that follow.

Soil erosion is the chief short-term construction impact. Compliance with the regulations of the Erosion and Sedimentation Control Act can minimize such erosion. The clayey soils found throughout the area are an effective barrier against sediments reaching the aquifers by filtration and adsorption. No significant impacts are thus expected from any of the alternatives.

Long-term impacts on groundwater quality are mainly associated with the following three types of pollutants: (1) bacteria, organics, and suspended solids, (2) phosphorus, and (3) nitrogen in the form of nitrates.

Bacteria and suspended organics are readily removed by filtraztion and adsorption onto soil particles. Five feet of soils are ample to remove bacteria except in very coarse grained, highly permeable material. Available data show that bacterial well water contamination is not a problem for Crystal Lake shoreline residents. The upland soils in Benzonia and Beulah Townships have varying degrees of clay for adsorbing bacteria; and aquifer water levels are low, providing ample distance for bacterial removal. The sandy and loamy-sand lakeshore soils are effectively removing bacteria from ST/SAS despite the general absence of soil clay (Gannon 1970; Kerfoot 1978).

Land wastewater application on upland soils should not cause groundwater bacterial contamination. Land application site soils are chosen for their effectiveness in removing bacteria and suspended solids. Pretreatment and subsequent die-off due to dehydration will greatly reduce viable bacteria.

Groundwater phosphorus is important because of the potential role in lake eutrophication. Jones (1977) reviewed relevant studies on this subject for the Environmental Protection Agency concluding that:

> ... it is very unlikely that under most circumstances, sufficient available phosphate would be transported from septic tank wastewater disposal systems to significantly contribute to the excessive aquatic plant growth problems in water courses recharged by these waters.

Field studies, they point out, have shown that most soils, even medium sandy soils typically remove over 95% of phosphates within short distances from effluent sources. The review shows the two primary factors in the removal of phosphates applied to the land. The first is phosphorus absorption on small amounts of clay minerals, iron oxide and aluminum oxide in soil and aquifer materials. The second is hard water calcium carbonates and precipitation of phosphate as hydroxyapatite.

Jones et al. (1977) have also indicated several studies in areas similar to the Study Area (loamy, clayey soils over glacial moraine and outwash deposits) where the soil has essentially removed all of the phosphorus present in septic tank effluents. They also stated that in hard water areas such as those of the southern half of Michigan, the "likelihood of significant phosphate transport from septic tank wastewater disposal system effluent to the surface waters is greatly reduced because of the calcium carbonate present in the soil and subsoil systems."

Because the soils and subsoil systems throughout the Study Area are clayey to varying degrees and the groundwaters are also very hard (up to 360 mg/l as $CaCO_3$) very little phosphate transport from groundwaters to surface waters should take place in the Study Area.

This was confirmed by the "Septic Snooper" survey of groundwater leachate plumes entering Crystal Lake (Kerfoot 1978). Only 90 of the 1090 existing shoreline dwellings showed detectable septic tank leachate plumes. Of the plumes sampled, an estimated 0.7% of the total phosphorus in septic tank effluents reached the lake by way of groundwater. This phosphorus was too small to affect Crystal Lake surface water eutrophication (see II.B.7.a) but sufficient to stimulate algal growth within localized plume emergence areas. Only the No Action Alternative, relying on on-site systems along the northeast shore, could potentially worsen the localized lakeshore eutrophication problem. Mitigating measures such as localized chemical treatment or mechancial algae removal might even solve this problem.

Groundwater nitrates are of concern, at high concentrations causing methemoglobinemia in infants consuming foods prepared with such waters. The National Interim Primary Drinking Water Regulations (40 CFR 141) of the Safe Drinking Water Act Pl 93-523 set a limit of 10 mg/l of nitrates as nitrogen (NO_3 - N). Chapter II contains a discussion on the well water levels of nitrates around Crystal Lake.

Septic tank/soil absorption unit density is often the most important parameter influencing groundwater levels of nitrates (Scalf et al. 1977). However, the same source indicates that currently available "information has not been sufficiently definitive nor quantitative to provide a basis for density critera" (Scalf et al. 1977).

The Sanitary Code of the Grand Traverse-Leelanau-Benzie District Health Department (GT-L-BHD) requires that septic tank systems be located at least 50 feet from any potable water supply, well, spring, etc. This distance usually provides ample water travel time within an aquifer to reduce initially excessive nitrate concentrations (more than 10 mg/l as NO_3 - N) to less than 2 mg/l. Minnesota field studies by Schroepfer and Polta (1969) show a reduction from 12.6 mg/l to 1.7 mg/l within 30 feet at depths of less than 15 feet in a water table aquifer. Most sanitary codes reflect the general acceptance of a 50-foot separation of wells and septic tank systems as the best available yardstick for assessing likely adverse impacts of ST/SASs. A minimum lot size of 1/3 acre usually ensures the observance of the 50-foot separation of wells and ST/SASs. The Grand Traverse-Leelanau-Benzie

District Health Department considers that the alternatives satisfying this density criterion, among others in the code, create no significant groundwater nitrate impact.

Multi-tier or grid type residential development can create greater potential groundwater nitrate impacts from ST/SAS use than can single tier development. Depending on the direction of groundwater, flow and pumping rates of wells, nitrate contributions from individual ST/SASs may become cumulative in multi-tier developments. It is thus more important to enforce existing density codes and set-back distances to wells in such developments than in single tier ones.

The existing situation within the Service Area as established by the sanitary survey is that 23 percent of all ST/SASs is located closer than the required 50-feet from wells. Five (5) percent of all ST/SASs, or nearly one-fourth of these violating the 50-foot criterion, is located within 25 feet of wells. Gannon (1970) found focal points of high nitrate concentrations (>4 mg/l) in wells along the northshore, and particularly along the northeastern shore of the lake. These focal points are located in the areas of high ST/SAS density. In two cases, on the northeastern shore, nitrate concentrations exceeded the standard criterion of 10 mg/l NO_3-N. In many other areas Gannon found no nitrates, or concentrations that were less than 1 mg/l. The implications are that while the source was not identified, high nitrate concentrations well in excess of background levels were associated with high density development in the Service Area.

The No Action Alternative will perpetuate and may possibly worsen this situation with a resulting increased violation of the drinking water standard. It is not a recommendable action.

The Limited Action alternative tentatively proposes the use of cluster systems to overcome the problem but it would be subject to the findings of detailed studies to be undertaken during the design phase of the project. No significant adverse impacts on water quality are therefore expected to result from the Limited Action Alternative.

Cluster system soil absorption fields are designed like to septic tank fields to ensure an adequate areal distribution of the effluent and depth to groundwater for satisfactory treatment. Nitrate levels entering groundwater should be equivalent to those of leachate from ST/SASs. Locating the soil absorption fields of cluster systems at greater distances from residential developments (500 feet adopted for EIS Alternative design) provides more than ample room for dilution of nitrate concentrations below drinking water limits prior to interception by wells. Cluster system alternatives should therefore produce no significant groundwater nitrate impacts.

EPA recognizes almost all types of land treatment alternatives as being capable of producing final effluent nitrate nitrogen (NO_3 - N) concentrations of 10 mg/l and less prior to entry into groundwaters. Table IV-4 shows irrigation (spray) and overland flow methods produce effluents of 2.5 mg/l of NO_3 - N) while for infiltration percolation (rapid infiltration) 10 mg/l may be expected (EPA 1975). Dilution

Table IV-4

EFFLUENT QUALITY COMPARISON FOR LAND TREATMENT AND AWT SYSTEMS

System	Effluent quality parameter, mg/l					
	BOD	SS	NH -N	NO N	Total N	P
Aerated lagoon	35	40	10	20	30	8
Activated sludge	20	25	20	10	30	8
Irrigation	1	1	0.5	2.5	3	0.1
Overland flow	5	5	0.5	2.5	3	5
Infiltration-percolation	5	1	--	10	10	2
AWT-1	12	15	1	29	30	8
AWT-2	15	16	--	--	3	8
AWT-3	5	5	20	10	30	0.5
AWT-4	5	5	--	--	3	0.5

Cost-Effective Comparison of Land Application and Advanced Wastewater Treatment (EPA-430/9-75-016).

within aquifers by groundwater flow further reduces these concentrations. No signficant impacts on groundwater quality are therefore expected from alternatives using land application techniques. While spray irrigation and overland flow techniques will produce effluents of better quality, rapid infiltration will produce a satisfactory one. Selection of land application alternatives would require a detailed site analysis including a geohydrologic survey, soils classification and soil chemistry survey.

3. MITIGATIVE MEASURES

Groundwater quality should be carefully monitored for all alternatives involving the use of ST/SASs, cluster systems and land application system. This will verify that water quality is not being significantly degraded, and to warn of malfunctions, inadequate treatment and the need for corrective action.

The proposed detailed groundwater studies scheduled for implementation during the project design phase will ensure that the implemented alternative poses no significant adverse threat to groundwater quality.

C. POPULATION AND LAND USE IMPACTS

Population and land use impacts associated with various system alternatives are evaluated in this section. These impacts are summarized below:

- Different alternatives will result in significantly different rates of population increase. Provision of centralized facilities would result in a 19% increase above standard projections for the drainage basin, while reliance upon existing on-lot systems in unsewered areas (the Limited and No Action Alternatives) will hold population growth 7% below standard projections. Decentralized alternatives will generate population growth 4% above current projections.

- Residential land acreage will increase regardless of the alternative selected. Increases will range from 77% (No Action Alternative) to 88% (fully centralized alternatives).

- Availability of sewers would allow present demand for land development along the shore of Crystal Lake to be met. This would result in residential densities averaging 25% above the No Action Alternative and possible multifamily development. No Action, Limited Action, and decentralized alternatives will increase values of existing residential properties around the Lake because they will limit the amount of additional land which may be developed.

- Provision of centralized sewerage facilities will result in increased development pressure. Adoption of the Limited or No Action Alternatives will tend to maintain existing community character. Decentralized alternatives will be nearly as effective as the No Action Alternative in maintaining existing community character.

1. INTRODUCTION

The capacity of an area to support development varies with the degree to which wastewater facilities are site-related. On-lot wastewater treatment facilities are extremely site-related because they are limited to sites with suitable soils. Sewers allow development to be much more independent of site characteristics because the soil permeability, slope, and drainage are not such strong constraining factors. Thus, sewers increase the inventory of developable land. Sewers also increase the possible density of development. The amount of additional growth actually occurring in the area if sewers are provided is dependent not only upon increases in development potential but also upon demand for additional residential development in the area. This demand reflects the residential amenity of the area in comparison to other areas and the reduction in the cost of residential land when the supply of developable land is increased.

Population and land use impacts are estimated here for completely centralized and completely decentralized (No Action) alternatives. Impacts are also estimated for EIS Alternatives 3, 4, and 5, which incorporate partial sewering and cluster systems. These alternatives, while described as decentralized, are actually hybrid or intermediate systems in terms of population and land use impacts.

2. POPULATION

If centralized facilities were provided, population in the Service Area would be anticipated to increase 19% above baseline projections for the year 2000. This increase in population growth above regional baseline trends is referred to as induced growth. Completely decentralized facilities (No Action Alternative) might limit Service Area population growth 7% below baseline projections for the year 2000. Centralized facilities would concentrate growth within the nearshore segments of the Crystal Lake Proposed Service Area. With site-dependent, decentralized facilities, nearshore areas would be developed at a lower density or might not be developed at all, resulting in more development in areas further from the lakeshore areas.

3. LAND USE

Significant increases in residential acreage would be likely within the proposed Crystal Lake Service Area regardless of the treatment alternative adopted. Residential acreage is projected to increase by 77% by the year 2000 even under the completely decentralized (No Action) alternative. Residential acreage might increase by 88% with the provision of centralized systems. The increase in residential acreage with centralized facilities would not match the increase in population because new development would be of higher density.

The major differences in future development patterns between centralized and decentralized alternatives relate to the amount of nearshore development. With centralized facilities, the nearshore areas, undevelopable with decentralized facilities because of site restrictions, would become high-development-potential areas.

4. TRANSPORTATION IMPACTS

No population growth resulting from the proposed wastewater treatment facilities is expected to have significant impact on the local transportation system by requiring new road construction or other infrastructural investment. Increased visitation to the Sleeping Bear Dunes National Lakeshore, which is immediately north of the Proposed Service Area, will increase through traffic, as that area lies between the National Lakeshore and major population centers to the south. The through traffic is not likely to have a significant impact on the adequacy of local transportation facilities (by telephone, Mr. Max Holden, Sleeping Bear Dunes National Lakeshore).

Traffic counts obtained from the Benzie Count Road Commission indicate that present traffic volumes in the area are quite low. The counts indicate no consistent pattern of increase in traffic volumes for the years 1970 to 1978. Average daily traffic (ADT) volumes on Michigan Routes 22 and 115 were under 1,000 cars for all recording stations from 1970 to 1978. The ADT on US Route 31 was higher -- 2,900 vehicles for 1978. Benzie County has no current plans to widen or reconstruct roads in the area for at least the next 5 years (by letter, James R. Thompson, Manager, Benzie County Road Commission, 11 May 1979).

5. CHANGES IN COMMUNITY COMPOSITION AND CHARACTER

Centralized facilities would moderately influence the composition and character of the Crystal Lake community. Additional costs of wastewater treatment would displace some lower income permanent and seasonal residents. Provisions of centralized facilities would also make feasible the development of higher-density forms of residences, including townhouses and apartments. These developments would appeal: to older persons who have had single-family summer residences in the area in the past and want fewer maintenance responsibilities; to younger couples without children; and to persons who want to share the use of a summer residence. Condominium apartment developments have occurred in some nearby areas, notably Traverse City, and some local residents have expressed an interest in condominium development if centralized wastewater treatment facilities are constructed. In the long run, however, the impacts of proposed wastewater facilities on the area may be overshadowed by national trends in gasoline availability and cost. Rising gasoline prices or shortages in gasoline supply may probably curtail seasonal population growth in the Crystal Lake area because of the long auto trip from metropolitan areas. Reduction in seasonal population growth would also depress the local economy and thus limit permanent population growth. Growth of seasonal population is also highly responsive to changes in disposal personal income, with any curtailment in the growth of personel income producing a marked drop in the number of second (seasonal) home owners.

The rural character of the area would be diminished with the additional land devoted to residential and uses associated with centralized facilities and with higher density development. Change in the character of the area could also occur with EIS Alternatives 3, 4, and 5 because substantial population growth and land development would take place in areas serviced by sewers and the numerous cluster systems.

Adoption of the Limited or No Action Alternatives would encourage preservation of the area's prevailing community character and composition. There would be very little economic displacement pressure in the Crystal Lake area, and land-use patterns would be unlikely to change except in the amount of residential use.

D. ENCROACHMENT ON ENVIRONMENTALLY SENSITIVE AREAS

Construction activities related to the various wastewater treatment alternatives and secondary impacts from induced growth may be felt in certain environmentally sensitive areas. The Benzie County Development Plan has designated extensive areas of critical environmental concern. The areas extend through large tracts of land which are already undergoing development. The "critical concern" designation does not dictate land use but recommends restrictions which should be considered prior to further development.

1. WETLANDS

a. Primary Impacts

The wetlands located south of Round Lake and near the Crystal Lake outlet to the Betsie River may be subject to sedimentation during construction of a sewer collection system (Alternatives 1, 2, 4, 5, and the Facility Plan Proposed Action). Water circulation patterns may be modified by these activities. These construction-related impacts may be minimized by adhering to the regulations in the Soil Erosion and Sedimentation Control Act. This Act regulates construction activities within 500 feet of a shore through a permit system administered by the County.

b. Secondary Impacts

The wetland areas surrounding Round Lake are state-owned and development will not occur in these wetlands. The wetlands associated with the Betsie River are protected to some extent by the Betsie River Natural River Zoning Act of 1973 (see Appendix D-3). The Act requires a minimum setback distance of 200 feet from the River. It also designates a Natural River District, which is a strip of land 400 feet wide on each side of and parallel to the designated river and tributaries. This District is not under State ownership, however, and it merely defines an areas within which certain types of development will be controlled. Some development may occur in these wetlands regardless of the wastewater management alternative selected.

c. Mitigative Measures

The County should strictly enforce the regulations provided by the Sediment and Erosion Control Act to prevent sedimentation which would destroy the filtering capacity of wetlands. Local zoning regulations for Benzonia and Crystal Lake Townships should be revised to protect wetland areas. Ideally, these areas should be zoned for open space. Development near wetland areas should provide an adequate buffer zone.

2. SAND DUNES

a. Primary Impacts

The County Development Plan has characterized the sand dunes as having "unique natural features worthy of protection." The Sleeping Bear Dunes Park, north of Crystal Lake is currently protected from development. However, the dunes west and southwest of Crystal Lake are not afforded such protection. A sewage collection system that would convey wastewater from the western shore to the Frankfort Plant (Alternatives 1, 2, 3, 4, 5, and the Facility Plan Proposed Action) should be carefully located so that the dunes southwest of Crystal Lake are not disturbed.

b. Secondary Impacts

Implementation of a decentralized wastewater management alternative is more likely to encourage development in sand dunes since a scattered, low-density development pattern would result from decentralization. However, these soils are generally sandy with slopes more than 12%; these characteristics present structural problems to development.

c. Mitigative Measures

The County should undertake a study of the ecosystems of the sand dunes and the impact which development might have on these areas. Lake Township should implement appropriate zoning regulations to protect these areas.

3. STEEP SLOPES

a. Primary Impacts

The difficulties of installing on-lot systems on steep slopes appears to be one of the factors historically limiting home construction to lakeshore and other level to rolling sites. However, sewers and suitably designed on-site systems may be constructed on steep slopes. Where construction does occur, adherence to the Sediment and erosion Control Act of 1972 should minimize the impacts of erosion.

b. Secondary Impacts

The availability of off-lot treatment systems as provided by cluster systems or sewers, along with the apparent demand for residential development may result in construction activity on steep sloped areas. Accelerated soil erosion particularly on the steep bluffs surrounding the Lake and in the lower Cold Creek watershed can result in additional non-point source runoff into Crystal Lake.

c. Mitigative Measures

The municipalities should adopt performance standards with specific slope-density provisions. Developers would then have to meet the performance standards which require proof that the sloped areas are not a hazard to development. Zoning ordinances should limit growth in steep sloped areas.

If cluster systems or septic tanks are placed in areas with steep slopes, a series of drop boxes should be used. With this method, no hillside seepage should occur unless the sewage flow exceeds the design capacity.

4. PRIMARY AGRICULTURAL LANDS

a. Primary Impacts

"Prime and unique" farmlands are not likely to be impacted by the construction of cluster systems or sewers, since these areas are not located near the proposed location for collection systems.

b. Secondary Impacts

Some farmland acreage development is likely regardless of the wastewater management alternative. A centralized treatment system would encourage less development by concentrating growth in sewered areas close to the lakeshore.

c. Mitigative Measures

Agricultural lands should be protected by following the Development Plan's recommendation for favorable farm tax credits to encourage the retention of prime farmland for agricultural purposes. Zoning ordinances should discourage scattered development which converts large tracts of farmland into residential lands.

5. FLOOD HAZARD AREAS

No primary impacts on flood hazard areas are anticipated with any of the alternatives. The sanitary code and local zoning ordinances preclude any construction within 50 feet of the Crystal Lake shoreline, which is ample to protect the narrow flood prone areas around the lake. The minimum setback distance of 200 feet stipulated by the Betsie River Zoning Act of 1973 should preclude floodplain development.

6. CRITICAL AND UNIQUE HABITATS

The Michigan Department of Natural Resources is currently in the process of identifying critical and unique habitat areas. Impacts cannot be identified until these areas are located.

E. ECONOMIC IMPACTS

1. INTRODUCTION

This section evaluates the economic impacts of the alternative wastewater systems proposed for Crystal Lake. These impacts include: financial burden on system users; financial pressure on residents to move from the service area; financial pressure to convert seasonal residences to full-year residences; and the net benefits of water quality on the economy of the Crystal Lake area.

2. USER CHARGES

Users charges are the costs billed periodically to the wastewater system customers. Total annual user charges have been estimated for the eight alternatives. The user charge consists of three parts: debt service (repayment of principal and interest), operation and maintenance costs, and a reserve fund allocation assumed to equal 20% of the debt service amount. Annual user charges are presented in Table IV-5. The first column shows the user charges if all users in the Study Area paid equal amounts. The second and third columns show the charges if costs were prorated between sewered (Frankfort and Elberta) and unsewered portions of the Proposed Service Area.

a. Eligibility

Eligibility refers to that portion of wastewater facilities costs determined by EPA to be eligible for a Federal wastewater facilities construction grant. Capital costs of wastewater facilities are funded under Section 201 of the 1972 Federal Water Pollution Control Act Amendments. Section 201 enables the EPA to fund 75% of total eligible capital costs of conventional systems and 85% of the eligible capital costs of innovative and alternative systems. Innovative and alternative systems considered in the EIS Alternative includes land treatment, pressure sewers, cluster systems, and septic tank rehabilitation and replacement. The State of Michigan funds 5% of the capital costs of both conventional and innovative/alternative wastewater facilities. The funding formula in Michigan thus requires localities to pay 20% of the capital costs of conventional systems and 10% of the capital costs of innovative/alternative systems. Operation and maintenance costs are not funded by the Federal government and must be paid by the users of the facilities.

The percentage of capital costs that is elegible for Federal and State funding greatly affects the cost that local users must bear. The capital costs of treatment as Crystal Lake were assumed to be fully eligible for grant funding; the costs of construction of the collection system were subject to the terms of Program Requirements Memorandum (PRM) 78-9. This PRM establishes three main conditions that must be satisfied before collector sewer costs may be declared eligible:

- o Systems in use for disposal of wastes from the existing population are creating a public health problem, contaminating groundwater or violating point source discharge requirements.

Table IV-5

ANNUAL USER CHARGES

Alternative	Costs Distributed Evenly Over Entire System	Frankfort/Elberta	Unsewered Area
1. Facility Plan Proposed Action	440	110	720
2. Limited Action	60	100	50
3. EIS Alternative 1	400	90	650
4. EIS Alternative 2	350	60	590
5. EIS Alternative 3	170	110	220
6. EIS Alternative 4	150	100	180
7. EIS Alternative 5	170	90	240
8. EIS Alternative 6	150	100	190

- o Two thirds of the design population (year 2000) served by a sewer must have been in residence on October 18, 1972.

- o Sewers must be shown to be cost-effective when compared to decentralized or on-site alternatives.

The Construction Grants Management branch of EPA Region V evaluated the eligibility of the sewers proposed by the Facility Plan and of the EIS Alternatives. This evaluation, based upon the two-thirds criterion of PRM 79-3, concluded that approximately 40% of the sewers proposed by the Facility Plan would be eligible; of the collection systems proposed in EIS Alternatives 1 and 2, approximately 33% would be eligible. Local costs for EIS Alternative 3 through 6 assume public ownership and 100% eligibility of upgrading on-site treatment systems. Table IV-5 presents local costs based upon the EPA determination of eligibility.

The Michigan Department of Natural Resources will prepare the final determination of the eligibility of project costs. This determination, which will be based upon Step II plans and specifications for the alternative to be funded, will differ in two respects from the EPA determination:

- o EPA did not have plans and specification upon which to base its computation. Consequently a detailed sewer-by-sewer determination was impossible.

- o In estimating collector sewer eligibilities, EPA did not compare the alternatives to one another in regard to cost-effectiveness or to their probable success in satisfying documented public health, groundwater or point source problems. Each alternative was considered on its own merits only, and on the ability of its collector sewers to meet the "two-thirds" rule.

After selection of a recommended alternative (discussed in Chapter V), that alternative will serve as a baseline for determining cost-effectiveness and, thus, eligibility. Collection and treatment costs of other alternatives would not be eligible to the extent that they exceed costs for comparable facilities in the recommended alternative. User charges for actions more expensive than the recommended alternative would, therefore, be even higher than shown in Table IV-5.

b. Calculation of User Charges

The user charges presented in Table IV-5 have been calculated for two different conditions: 1) the costs of the system were divided equally throughout the currently sewered (Frankfort and Elberta) and unsewered areas 2) the costs were prorated between the sewered and unsewered portions of the Service Area. It should be pointed out that the Facility Plan does not propose to spread costs over the entire system; such a comparison is made only for the purposes of illustration. To be equitable, the costs for areas served by existing sewers have been segregated from those associated with the unsewered areas. This prevents the situation wherein sewered areas, such as Frankfort and Elberta, subsidize the construction and operation of sewerage facilities in the unsewered areas.

The calculation of the user charges was based on local capital costs being paid through the use of a 30 year bond at 6 7/8% interest. Some communities may be eligible for a 40 year loan at 5% from the Farmers Home Administration to reduce the annual financial burden of local capital costs.

The centralized alternatives (Proposed Action, EIS Alternative 1, and EIS Alternative 2) are the most costly to users in unsewered areas (and all users if spread out over the entire system). Total annual user charges for each household range from $350 to $440 for the entire system, $590 to $720 for the unsewered areas, and $60 to $110 for Frankfort and Elberta. The large variations between the sewered and unsewered areas' costs are related to the ineligibility of much of the collector sewers in the unsewered areas. Neither the Facility Plan nor the data collected for preparation of this EIS, document sufficient need for collector sewers around Crystal Lake or in the Village of Benzonia. Costs for most collector sewers would therefore be met entirely at the local level, should Limited Action be the alternative finally recommended and application be made for any other.

EIS Alternatives 3, 4, and 5 combine centralized and decentralized components and are less costly than the centralized alternatives. Annual user charges range from $150 to $170 for the entire system, from $90 to $110 for Frankfort and Elberta, and $180 to $240 for the unsewered areas.

The least expensive alternatives for the entire system as well as the unsewered areas are the two most decentralized ones: EIS Alternative 6 and the Limited Action Alternative. Annual user charges for the entire system are $150 for EIS Alternative 6 and $60 for the Limited Action Alternative. Frankfort and Elberta's annual cost would be approximately $100 for both alternatives. User charges would be $190 for the unsewered areas under EIS Alternative 6 and $50 under the Limited Action Alternative. Clearly, the decentralized alternatives involve the least amount of sewering and have the lowest amount of ineligible costs.

In addition to user charges, households in newly sewered areas would have to pay the capital costs (approximately $1,000 for each connection) of a house sewer on their property to connect to gravity collector sewers. Seasonal homeowners may also have to pay the full price for the replacement or rehabilitation of their on-site systems (septic tanks and soil absorption systems) if they do not cede these sytems to the local wastewater management agency. Assuming, however, a reasonably high proportion of public on-site system ownership Alternatives 3, 4 and 5 would offer substantial, and Alternatives 6 and Limited Action, an almost total, reduction in private costs. Overall, additional costs would vary from household to household due to differences in the distance to the collection sewer and the condition of on-site systems.

3. LOCAL COST BURDEN

a. Significant Financial Burden

High-cost wastewater facilities may place an excessive financial burden on users of the system. Such burdens may cause families to alter their spending patterns substantially by diverting money from their normal expenditure categories. The Federal government has developed criteria to identify high-cost wastewater projects (The White House Rural Development Initiatives 1978). A project is identified as high-cost when the annual user charges are:

- 1.5% of median household incomes less than $6,000
- 2.0% of median household incomes between $6,000 and $10,000
- 2.5% of median household incomes greater than $10,000.

The 1978 median household income for the service area has been estimated to be $13,000 for permanent residents. (No data are available for seasonal resident income characteristics.) According to the Federal criteria, annual user charges should not exceed 2.5% ($326) of the $13,000 median household income figure. Any alternative having annual user charges exceeding $326 is identified as a high-cost alternative and is likely to place a financial burden on users of the system. Table IV-6 identifies the alternatives that are classified as high-cost according to the Federal criteria.

Significant financial burden is determined by comparing annual user charges with the distribution of household incomes. Families not facing a significant financial burden are the only families able to afford the annual wastewater user charges. Table IV-7 shows the percentage of households estimated to face a significant financial burden under each of the alternatives. The centralized alternatives (the Facility Plan Proposed Action, EIS Alternative 1, and EIS Alternative 2) imply annual user charges that would place a significant financial burden on 60-85% of the households in the entire system if costs were distributed equally, 5-25% of the households in Frankfort and Elberta, and 85-98% of the households in the unsewered area. EIS Alternatives 3, 4, and 5 would place a significant burden on 15-30% of the households in the entire system (costs distributed equally), 10-25% of Frankfort and Elberta households, and 30-40% of the households in the unsewered area. EIS Alternative 6 would place a significant burden on 15-25% of total system households, 15-25% of Frankfort and Elberta households, and 25-30% of the households in the unsewered area. The Limited Action Alternative would place the least financial burden on households in the total system (costs distributed equally) and the unsewered areas. Only 5-10% of the households in these areas would face a significant financial burden under the Limited Action Alternative. The Limited Action Alternative would place a significant financial burden on 15-25% of the households in Frankfort and Elberta.

b. Displacement Pressure

Displacement pressure is the stress placed upon families to move away from the service area as a result of costly user charges. Displacement is measured by determining the percent of households having

Table IV-6

HIGH-COST ALTERNATIVES (ANNUAL USER CHARGES EXCEED 2.5% OF MEDIAN HOUSEHOLD INCOME)

Alternative	Entire System	Frankfort/Elberta	Unsewered Areas
1. Facility Plan Proposed Action	High-cost		High-cost
2. Limited Action			
3. EIS Alternative 1	High-cost		High-cost
4. EIS Alternative 2	High-cost		High-cost
5. EIS Alternative 3			
6. EIS Alternative 4			
7. EIS Alternative 5			
8. EIS Alternative 6			

Table [illegible]7

FINANCIAL BURDEN AND DISPLACEMENT PRESSURE

Alternative	Entire System	Frankfort/Elberta	Unsewered Area
1. Facility Plan Proposed Action			
. Displacement Pressure	20-25%	1-5%	50-60%
. Financial Burden	60-85%	15-25%	85-98%
. Can Afford	15-40%	75-85%	2-15%
2. Limited Action			
. Displacement Pressure	<1	1-5%	<1
. Financial Burden	5-10%	15-25%	5-10%
. Can Afford	90-95%	75-85%	90-95%
3. EIS Alternative 1			
. Displacement Pressure	25-30%	1-5%	50-60%
. Financial Burden	60-85%	10-15%	85-98%
. Can Afford	15-40%	85-90%	2-15%
4. EIS Alternative 2			
. Displacement Pressure	15-25%	<1	40-50%
. Financial Burden	50-60%	5-10%	60-85%
. Can Afford	40-50%	90-95%	15-40%
5. EIS Alternative 3			
. Displacement Pressure	5-10%	1-5%	5-10%
. Financial Burden	25-30%	15-25%	30-40%
. Can Afford	70-75%	75-85%	60-70%
6. EIS Alternative 4			
. Displacement Pressure	1-5%	1-5%	5-10%
. Financial Burden	15-25%	15-25%	25-30%
. Can Afford	75-85%	75-85%	70-75%
7. EIS Alternative 5			
. Displacement Pressure	5-10%	1-5%	10-15%
. Financial Burden	25-30%	10-15%	30-40%
. Can Afford	70-75%	85-90%	60-70%
8. EIS Alternative 6			
. Displacement Pressure	1-5%	1-5%	5-10%
. Financial Burden	15-25%	15-25%	25-30%
. Can Afford	75-85%	75-85%	70-75%

annual user charges exceeding 5% of their income. The pressure induced by each of the alternatives is listed in Table IV-7.

Displacement pressure is highest under the centralized alternatives. In the unsewered area, 40-60% of the households will face displacement pressure under the centralized alternatives. EIS Alternatives 3, 4, and 5 have displacement pressures of 5-15% in the unsewered areas. The decentralized alternatives may cause up 1-10% of the unsewered households to be displaced. Displacement pressure is not as severe in Frankfort and Elberta: approximately 1-5% of the households may potentially be displaced under each of the alternatives. When the costs are distributed equally throughout the service area, displacement pressure ranges from 15-30% under centralized alternatives to 1-5% under the decentralized alternatives.

c. Conversion Pressure

Wastewater facilities costs are likely to encourage the trend, already underway, of converting seasonal residences to permanent residences. The requirements would impose a relatively heavier cost burden on seasonal residences of capital expenses than on permanent ones. These residences would typically be used only three or four months during the year but would be charged for capital costs throughout the year. This may place a financial burden on seasonal residents who are maintaining a full-time residence in addition to their seasonal residence. The higher cost burden of centralized alternatives will exert more conversion pressure than the cost burden of the decentralized alternatives. Because of the apparent high income of seasonal residents (based on visual inspection of seasonal residences) the number of seasonal-to-permanent residential conversions as a result of the wastewater user charges is likely to be small in any case.

4. MITIGATIVE MEASURES

The significant financial burden and displacement pressure on users in the unsewered areas may be mitigated by selection of a lower cost decentralized alternative. The local wastewater management authority may seek to obtain a loan or grant from the Farmers Home Administration Such a loan would decrease annual user charges by spreading out the payment of the local share over a longer period of time with a lower interest rate. The impacts of the high costs to seasonal users may be mitigated by not charging for operation and maintenance during the months that seasonal residences are vacant.

F. IMPACT MATRIX

IMPACT CATEGORY	IMPACT	IMPACT TYPE & DEGREE	IMPACT DESCRIPTION
Surface Water Quality	Nutrient loading (Phosphorus)	Primary: Long Term	Crystal: All Alternatives: None of the alternatives will have a significant impact on phosphorus loading since only 7% of existing nutrient load comes from septic tanks in contrast to 93% from non-point sources and precipitation. Lake trophic status will not be changed. Betsie: All Alternatives: All alternatives will reduce phosphorus load by 43-48% by eliminating plant discharge or by chemically removing phosphorus in the RBC plant. No change in trophic status as predicted by model.
	Shoreline Eutrophication; *Cladophora* growth	Primary: Long Term	Crystal: Alternatives 1, 2 and Proposed Action: These alternatives would have the greatest potential for eliminating lakeshore eutrophication by eliminatint septic tanks as a source of nutrients for *Cladophora* growth. Alternatives 3, 4, 5, 6: Would eliminate the major sources of nutrients from septic tanks by sewering the northeast shore. However, some on-site systems will continue to leach nutrients for localized algal growth along the northwest. (Alt. 3, 4, 5 + 6) and southeast shore (3, 4 + 5) Limited Action: On-site systems will continue to provide nutrients for shoreline *Cladophora* growth.
	Non-Point Source Runoff	Primary: Short term	Crystal: Alternatives 1, 2, Proposed Action: A temporary increase in soil erosion and sedimentation will occur as the result of sewering Alternative 3, 4, 5, 6: Increased soil erosion and sedimentation will be less than with the centralized alternatives. Betsie: All Alternatives: Construction-related impacts will be minimal.
		Secondary: Long Term	Alternatives 1, 2, Proposed Action: Induced growth is likely to be greatest as a result of these alternatives and growth will be concentrated along the shoreline. This may result in increased non-point source runoff Alternatives 3, 4, 5, 6, Limited Action: Growth is consistent with baseline projections and development is scattered. Therefore in comparison to centralized alternatives, increased non-point source runoff is less.
Groundwater	Groundwater Quantity	Primary: Long Term	All Alternatives (except Limited Action): Failure to return wastewater flows to groundwater results in neglibible loss of groundwater recharge to local aquifer(s)
		Secondary: Long Term	All Alternatives: Loss of aquifer recharge area as the result of development of impervious surface cover is minimal.

IMPACT CATEGORY	IMPACT	IMPACT TYPE & DEGREE	IMPACT DESCRIPTION
	Groundwater Quality	Primary: Long Term	Limited Action: With the continued reliance on septic tanks, there is the possibility of localized high groundwater nitrate concentrations. Phosphorus from septic tanks will continue to leach in concentrations sufficient to support localized algal growth. Alternatives 3, 4, 5 and 6: The potential for nitrate contamination of groudwater is minimized by sewering the northeast shore, since this is the only lakeshore area with known localized groundwater problems. Similarly, phosphorus availability for localized algal growth is minimized. Alternatives 1, 2, Proposed Action: Sewering entire lakeshore area eliminates septic tanks as a source of (1) nitrates for localized groundwater contamination and (2) phosphorus as a nutrient source for localized algal growth.
Environmentally Sensitive Areas	Floodplain	Secondary: Long Term	All Alternatives: Impacts on flood hazard areas are expected to be minimal.
	Wetland	Primary: Short or Long Term	Alternatives 1, 2, 4, 5, and Proposed Action: Construction-related impacts will be unavoidable. Whether they are short- or long-term depends upon the extent to which the original configuration is restored.
		Secondary: Long Term	All Alternatives: Some growth may occur in wetlands adjacent to Betsie River, regardless of the wastewater management alternative.
	Steep SLopes	Primary: Short Term	All Alternatives: Some temporary increases in erosion and sedimentation may occur as a result of construction. These impacts would be most significant for Alternatives 1, 2, and Proposed Action.
		Primary: Long Term	Alternatives 3, 4, 5, 6; Limited Action: Impacts associated with the use of decentralized systems on steep slopes will be minimal; only systems designed specifically for steep slopes will be used.
		Secondary: Long Term	Limited Action: Development on steep slopes will be miminal and scattered. Alternatives 1, 2, Proposed Action: Possible impacts to steep slopes along shoreline may occur with increased residential development. This may result in increased erosion and sedimentation which contributes to non-point source runoff. Alternatives 3, 4, 5, 6: Less growth and development of steeply slopes areas will result from these alternatives as compared to 1, 2 and Proposed Action.
	Prime Agricultural Lands	Primary: Short Term	All Alternatives: Direct impacts from construction of wastewater management alternatives will be minimal.
		Secondary: Long Term	Limited Action: Development of some prime agricultural land may result since large lot scattered develop is encouraged. Alternatives 1, 2, Proposed Action: Development of prime agricultural land is less likely since growth is concentrated along the shore. Alternatives 3, 4, 5, 6: Some development of prime agricultural land may result.

IMPACT CATEGORY	IMPACT	IMPACT TYPE & DEGREE	IMPACT DESCRIPTION
Environmentally Sensitive Areas	Sand Dunes	Primary: Short Term	<u>All Alternatives</u>: Primary impacts on sand dunes will be minimal.
		Secondary: Long Term Impacts	<u>Alternatives 3, 4, 5, 6, Limited Action</u>: Some development may occur on unprotected sand dunes. <u>Alternatives 1, 2, Proposed Action</u>: Development is likely to occur close to the shoreline as a result of sewering. Consequently development on unprotected sand dunes is less likely.
Population	Rate of Growth	Secondary: Long Term	<u>Limited Action</u>: Projected study area population would be 7% below design population for the year 2000. <u>Alternatives 3, 4, 5, 6</u>: Growth anticipated to increase 4% above baseline projections. <u>Alternatives 1, 2, Proposed Action</u>: Growth anticipated to increase 19% above baseline projections.
Land Use	Developable Acreage: Growth Patterns	Secondary: Long Term	<u>Limited Action</u>: Residential acreage is anticipated to increase by 77% even if no centralized treatment is provided. This alternative encourages scattered, low-density development. <u>Alternative 3, 4, 5 6</u>: Residential acreage would increase by about 85%. Development would be less scattered and some high density development would be found in sewered areas. <u>Alternative 1, 2, Proposed Action</u>: Residential acreage would increase by 88% or 630 acres. Higher density development close to the shoreline would result.
Local Economy	Local Cost Burden	Primary: Long Term	<u>Limited Action</u>: Average annual cost per resident would be $100 for residents of Frankfort and Elberta and $50 for the residents in unsewered areas. <u>Proposed Action</u>: Annual cost per resident would be $110 for residents of Frankfort and Elberta; and $720 for residents of unsewered areas. One-time household charge for hook up to the sewer would be approximately $1,000/household. <u>Alternative 1, 2</u>: Annual cost per resident would te $90 or $60 for residents of Frankfort and Elberta for Alternative 1 and 2 respectively; residents of currently unsewered areas would pay $650 or $590 annually, respectively. <u>Alternative 3, 4, 5</u>: Annual cost per resident would be $110, $100, or $90 for residents of Frankfort and Elberta for Alternatives 3, 4, and 5 respectively. Residents from currently unsewered areas would pay $220, $180, or $240 annually for Alternatives 3, 4, or 5 respectively. One time household charge for gravity sewer connection approximately would be $1,000 per household. <u>Alternative 6</u>: Annual change for residents of Frankfort and Elberta would be $100, while the charge for residents of the currently unsewered areas would be $190. One-time household charge would be approximately $1,000.

IMPACT CATEGORY	IMPACT	IMPACT TYPE & DEGREE	IMPACT DESCRIPTION
Local Economy	Financial Burden; Displacement Pressure	Primary: Long Term	Limited Action: Displacement pressure is lowest with the limited action Alternative; 1-5% of the residents of Frankfort and Elberta would be threatened with displacement while less than 1% of residents of unsewered areas would feel displacement pressure. A financial burder would be experienced by about 25% of Frankfort/Elberta residents and 10% of residents of unsewered areas. Alternatives 1, 2, Proposed Action: Displacement pressure (50-60%) and financial burden (85-98%) are high for residents of currently unsewered areas. About 1-5% of the residents of Frankfort and Elberta would feel displacement pressure while up to 15% of the population would experience a financial burden with Alternative 1 and 2 and 25% with proposed action. Alternatives 3, 4, 5: Displacement pressure of 1-5% for residents of Frankfort and Elberta and 5-15% for residents of unsewered areas. The financial burden would be 15-25% for residents of Frankfort and Elberta and 25-40% for residents of unsewered areas with Alternatives 3 and 4. With Alternative 5 the financial burden would be 10-15% for Frankfort and Elberta and 30-40% for residents of unsewered areas. Alternative 6: Displacement pressure of 1-5% for residents of Frankfort and Elberta and 5-10% for residents of unsewered areas. Financial burden would be 15-25% for residents of Frankfort and Elberta and 25-30% for residents of unsewered areas.
	Community Composition and Character		Limited Action: Minimal impact on existing composition and character. Alternative 3, 4, 5, 6: Some loss of lower income population base due to displacement pressure. Alternative 1, 2, Proposed Action: Significant loss of lower income population base; potential disruption of community composition and character.

CHAPTER V

RECOMMENDED ACTION

As discussed in Section I.D.1, EPA has several possible choices about the Facility Plan Proposed Action. The Agency may:

- Approve the original grant application, possibly with recommendations for design changes and/or measures to mitigate impacts of the Facility Plan Proposed Action;

- Return the application with recommendations for additional Step I analysis;

- Reject the grant application;

- With the applicant's and State's concurrence, approve Step II funding for an alternative to the Facility Plan Proposed Action.

The choice of one of these options depends on how the EIS alternatives compare to the Facility Plan Proposed Action.

The new recommended alternative, described in this chapter, is an approach to meeting the problem of water quality in the Study Area. Selection of this alternative is tentative: the applicant, the public, and State, local and Federal agencies are expected to provide input regarding its impacts, funding and implementation.

A. SELECTION OF THE RECOMMENDED ALTERNATIVE

1. EVALUATION RESULTS

Four primary criteria were used in selecting the recommended alternative: costs, impact; reliability; and flexibility. Within each category several factors were compared. Costs, for example, included present worth, centralized user charges, small waste flow district user charges, and total 1980 private costs. Impacts which EPA considers to be decisive in alternative selection are identified and considered. Alternative reliability is measured against centralized collection and treatment as the standard.

A matrix provides a simple method of visualizing the relations between alternatives and the criteria applied in evaluating them. By tabulating each alternative and the factors that influence the range of choices, one can quickly compare the effect of each alternative upon that factor. Section IV.F contains a matrix relating alternatives to environmental impacts. Table V-1 presents a matrix summarizing the relationship between the alternatives and their costs, environmental impacts, reliability and flexibility.

Table V-1

ALTERNATIVE SELECTION MATRIX

	COSTS				ENVIRONMENTAL IMPACTS	
	PRESENT WORTH (X$1000)	FRANKFORT/ ELBERTA USER CHARGE $	SMALL WASTE FLOW DISTRICT USER $	ONE TIME HOUSEHOLD CHARGE	SURFACE WATER QUALITY IMPACTS	GROUNDWATER QUALITY IMPACTS
LIMITED ACTION	7,449.2	100	50		• Little change in total phosphorus load to Crystal Lake; no change in trophic status. • Reduced nutrient supply for shoreline algal growth. • Some increase in non-point source runoff resulting from planned growth. • 44% decrease in phosphorus load to Betsie Lake; no change in trophic status.*	Potential for localized groundwater contamination by nitrates is minimized due to use of cluster systems and by upgrading existing systems. Similarly, nutrient availability for localized algal growth is reduced.
FACILITIES PLAN PROPOSED ACTION	18,320.5	110	720	Gravity Sewer Approx. $1,000/ Household	• Less than 7% decrease in phosphorus load to Crystal Lake; no change in trophic status. • Eliminate septic tanks as a source of algal growth. • Slightly higher non-point source loads. • ~40% decrease in phosphorus load to Betsie Lake; no change in trophic status.*	Eliminates septic tanks as a source of nitrates for localized groundwater contamination and phosphorus as a source of nutrient for localized algal growth.
ALTERNATIVE #1	19,574.6	90	650		SAME AS PROPOSED ACTION	SAME AS PROPOSED ACTION
ALTERNATIVE #2	17,640.3	60	590		• Slightly greater decrease in phosphorus load to Betsie Lake (~48%), but otherwise the same as proposed action.	SAME AS PROPOSED ACTION
ALTERNATIVE #3	13,202.7	110	220	Gravity Sewer Approx. $1,000/ Household	As compared to proposed action impacts are similar except: • Nutrients from septic tanks will be reduced but not eliminated (by sewering northeast and southwest shores), and • Non-point source nutrient loads will be slightly less.	Leaching of nitrates and phosphorus from septic tanks significantly reduced but not eliminated.
ALTERNATIVE #4	12,265.6	100	180	Gravity Sewer Approx. $1,000/ Household	*SIMILAR TO ALTERNATIVE #3*	*SAME AS ALTERNATIVE #3*
ALTERNATIVE #5	13,972.4	90	240	Gravity Sewer Approx. $1,000/ Household	SIMILAR TO ALTERNATIVE #3	SAME AS ALTERNATIVE #3
ALTERNATIVE #6	10,524.4	100	190	Gravity Sewer Approx. $1,000/ Household	SIMILAR TO ALTERNATIVE #3	SAME AS ALTERNATIVE #3

*Trophic status for each wastewater management alternative was determined using Dillon Model. Due to short hydraulic retention time in Betsie lake, this model may not give accurate picture of trophic status.

Alternative Selection Matrix

	ENVIRONMENTALLY SENSITIVE AREAS	SOCIOECONOMIC IMPACTS						FLEXIBILITY	RELIABILITY
		POPULATION IMPACTS	LAND USE	FINANCIAL BURDEN %		DISPLACEMENT PRESSURE %			
				FRANKFORT/ ELBERTA	SMALL WASTEFLOW DISTRICT	FRANKFORT/ ELBERTA	SMALL WASTEFLOW DISTRICT		
LIMITED ACTION	• Some increased development on steep slopes; • Possibly increased development in sand dunes and prime agricultural lands is likely to occur even if growth is not induced.	Growth 7% less than expected	560 acres developed; near shore areas developed at lower density or not at all.	15-25%	5-10%	1-5%	<1.0	Flexibility for future planning and design of wastewater management alternatives is high.	Limited. Proper maintenance of on-site and cluster systems should improve reliability of these systems. Systems located in areas of marginal soils or geology may be subject to failure. Reliability of systems serving Frankfort and Elberta should be high.
PROPOSED ACTION	• Short-term impacts to wetlands as a result of sewering. • Increased development on steep slopes. • More development along the shoreline and less on prime agricultural lands.	19% induced growth	630 acres developed; growth concentrated in near shore sewered areas.	15-25% of population	85-98% of population	1-5%	50-60%	Reduced flexibility in terms of design changes but there is flexibility for added treatment capacity.	High. Centralized collection and treatment has been tested and proven. Pumps may be subject to failure.
ALTERNATIVE #1	SAME AS PROPOSED ACTION	19% induced growth	630 acres developed; growth concentrated in near shore sewered areas.	10-15%	85-98%	1-5%	50-60%	SAME AS PROPOSED ACTION	High, but not as good as Proposed Action. Large number of pumps increases opportunities for failure.
ALTERNATIVE #2	SAME AS PROPOSED ACTION	19% induced growth	630 acres developed; growth concentrated in near shore sewered areas.	5-10%	60-85%	<1.0%	40-50%	SAME AS PROPOSED ACTION	Same as EIS Alternative #1, if soils for land application are suitable.
ALTERNATIVE #3	• Similar to limited action; • Possibly further increased development of steep slopes.	4% induced growth	601 acres developed; near shores areas developed at lower densities than centralized alternatives resulting in more development in areas remote from lakeshore.	15-25%	30-40%	1-5%	5-10%	Flexibility for future land use planning is good because of decentralized nature of the alternative; flexibility for adding treatment capacity is also good.	Fair. Reliability of systems using sewers should be comparable to EIS Alternative #1. Rest of area should be comparable to Limited Action Alternative.
ALTERNATIVE #4	• Possible short-term impact on wetlands. • Otherwise similar to limited action except that development on steep slopes may be further increased.	4% induced growth	601 acres developed; near shore areas developed at lower densities than centralized alternatives resulting in more development in areas remote from lakeshore.	15-25%	25-30%	1-5%	5-10%	Flexibility for future land planning is slightly less than with Alternative #3 but flexibility for adding treatment capacity is good.	SAME AS EIS ALTERNATIVE #3
ALTERNATIVE #5	SAME AS ALTERNATIVE #4	4% induced growth	601 acres developed; near shore areas developed at lower densities than centralized alternatives resulting in more development in areas remote from lakeshore.	10-15%	30-40%	1-5%	10-15%	SAME AS ALTERNATIVE #4	SAME AS EIS ALTERNATIVE #3
ALTERNATIVE #6	SAME AS ALTERNATIVE #3	Little or no induced growth	Developed land will be slightly higher than that anticipated with limited action alternative. Near shore areas will be developed at low density except for Northeast Shore.	15-25%	25-30%	1-5%	5-10%	SAME AS ALTERNATIVE #3	SAME AS EIS ALTERNATIVE #3

Table V-1 ranks the alternatives according to their total present worth. This is done for several reasons:

- o Costs are easily quantifiable, perhaps the least subjective measure of value.

- o Non-capital costs impact other factors influencing the decision-making process: user charges, displacement pressures, and conversion pressures.

- o EPA Construction Grants regulations require selection of the most cost-effective alternative. That is, the one meeting the project goals with the least total present worth and acceptable environmental and socioeconomic impacts.

Selection of the cost-effective alternative requires identification of trade-offs between costs and other relevant criteria. The evaluation factors included with total present worth in Table V-1 are those EPA determined to be most important in identifying trade-offs.

2. CONCLUSIONS

Most of the on-site systems around Crystal Lake and in the Village of Benzonia are working well. Approximately 90 effluent plumes entering Crystal Lake and a few surface malfunctions have been identified. Periodic sewage backup in some systems also occurs. On-site systems do not appear as a significant contributor of nutrients to Crystal Lake -- of the total input of phosphorus, 6.7% or less comes from effluent plumes. Where plumes do emerge, however, they appear to be supporting localized growths of <u>Cladophora</u>.

The only surface water quality improvement in Crystal Lake likely to result from the Facility Plan Proposed Action or any of the EIS alternatives would be the possible reduction in number and density of localized growths of <u>Cladophora</u> along the shoreline. This could occur if on-site systems along the shoreline were abandoned and cluster systems or centralized sewers used. It also could occur for certain kinds of on-site upgrading, such as mound systems. No alternative should affect either adversely or beneficially the water quality of the main body of Crystal Lake through the year 2000.

Future development in the Crystal Lake watershed depends on how many new lots can be developed and the density of future development. Alternatives relying on continued use of on-site systems would restrict both the number of new lots and their density as compared to extensive sewering around the lake. One effect of these limitations would be to preserve the present character of the community.

There are large differences in the present worth and user cost among the alternatives. Both costs increase with sewer centralization. In the more expensive alternatives, high local user charges would result in substantial displacement pressure for the permanent population and pressure for conversion of seasonal residences to permanent use. Proportionate increases in water quality would not occur.

Because of the high costs and limited benefits to water quality with the centralized alternatives (Facility Plan Proposed Action and EIS Alternatives 1 and 2), they are not cost-effective and are not recommended.

The No Action Alternative was unacceptable for three reasons:

- Existing treatment plants at Frankfort and Elberta do not comply with effluent requirements and contribute substantially to high productivity in Betsie Lake.
- There are some on-site system problems in the remainder of the Proposed Service Area. These problems can be addressed through monitoring, improved maintenance of the existing and future systems, residential water conservation, and renovation or replacement of existing systems.
- Improved surveillance and regulation of on-site systems in the Crystal Lake watershed is justified to maintain its unique scenic and recreational values.

Those sections of the Proposed Service Area that would be sewered in EIS Alternative 3, 4 and 5, showed insufficient need for sewering except for areas of high groundwater along the northeast and southeast shorelines. For the two shoreline areas, off-site treatment by land application (EIS Alternative 6) or by cluster systems (Limited Action Alternative) could remedy local problems.

In addition to providing off-site treatment for the northeast and southeast shorelines, EIS Alternative 6 would also sewer the Village of Benzonia. The costs for sewering Benzonia are high and do not appear to be justified by the presence of only 5 surface malfunctions. Joint land application by Benzonia and Beulah has been discussed by officials of the two municipalities. In the event that such an approach is proposed by them for Federal funding, a redesigned Alternative 6 may be appropriate.

The Recommended Action in this draft EIS is the Limited Action Alternative described below (see Figure V-1).

B. <u>DRAFT EIS RECOMMENDED ALTERNATIVE</u>

1. DESCRIPTION

The Recommended Alternative includes:

- a new treatment plant to serve Frankfort and Elberta and necessary interceptor sewers;
- sewer system evaluation surveys and rehabilitation of sewer systems in Frankfort and Elberta;

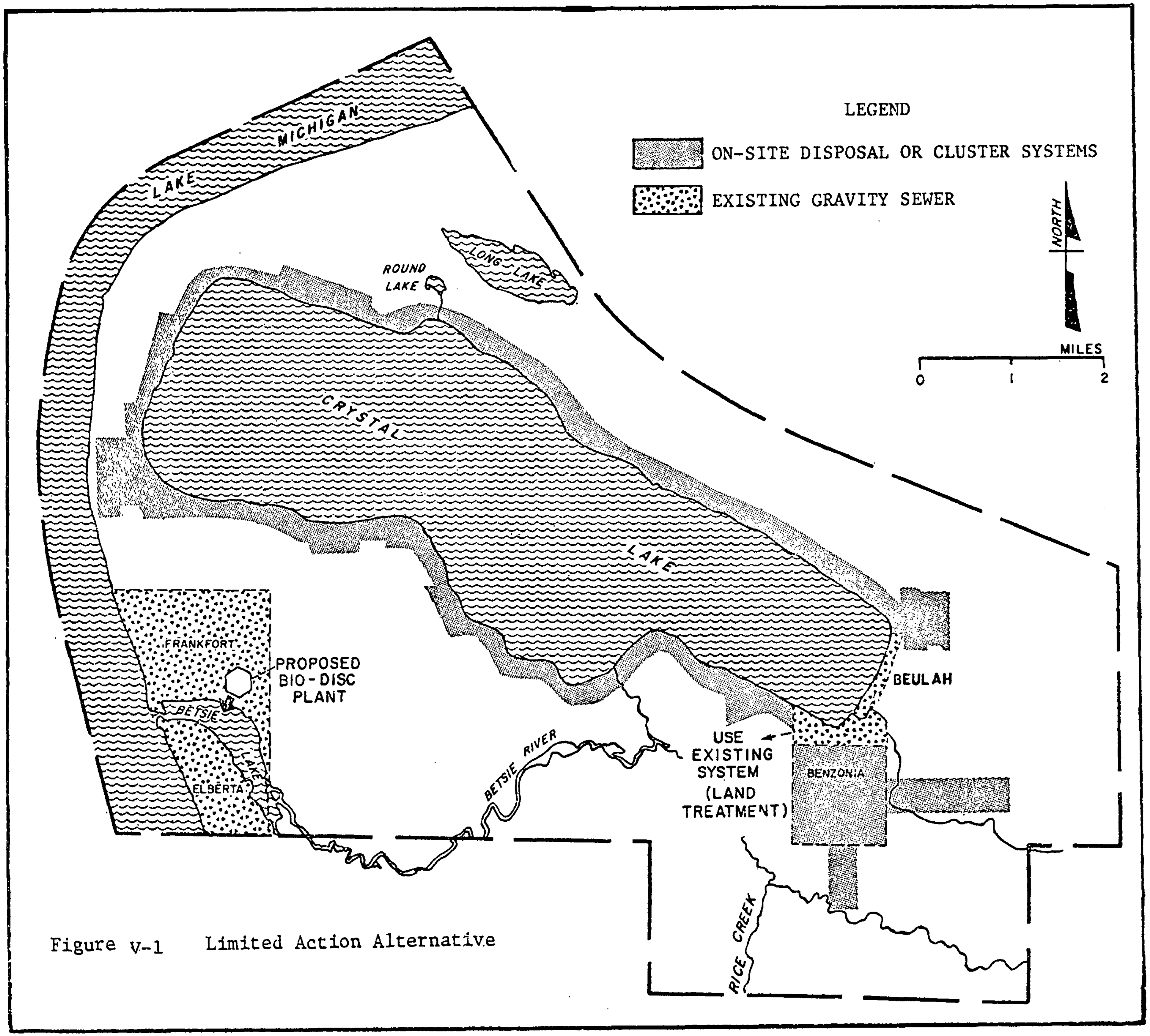


Figure V-1 Limited Action Alternative

- o design and implementation of a small waste flow district;
- o site-specific environmental and engineering analysis of existing on-site systems in the unsewered parts of the Proposed Service Area;
- o repair and renovation of on-site systems as needed;
- o cluster systems or other off-site treatment for the northeast and southeast shorelines. Additional small scale, off-site treatment units may be eligible for funding if warranted by the site-specific analysis of existing on-site systems and relevant cost-effective analysis performed during Step II;
- o survey of effluent discharges to Cold Creek to detect leakage from Beulah sewers (Kerfoot 1978; Tanis 1976), followed by replacement or repair of leaking pipes; and
- o survey of Crystal Lake groundwater flow and direction to allow final assessment of flow reduction as an aid to treatment for the western third of Crystal Lake.

Section III.C.2.b presents a fuller description of the Limited Action Alternative. Discussions of its components are presented in Section III.B.

2. IMPLEMENTATION

Design and construction of the interceptors and treatment plant for Frankfort and Elberta would proceed according to established 201 Construction Grants regulations. Step II and III funding for these facilities should be applied for and granted independently from grants for unsewered portions of the Proposed Service Area. Management of centralized facilities in the Crystal Lake Study Area was discussed in Section III.D.1.b.

Management of decentralized facilities was discussed in Section III.D.2.b and Appendix K. Several specific aspects of implementing the Recommended Alternative are discussed below.

a. Compliance with State and Local Standards in the Small Waste Flows District

As discussed in Section II.C. many existing on-site systems do not conform to current design standards for site, design or distance from wells or surface waters. For some systems, such as those with undersized septic tanks, non-conformance can be remedied relatively easily and inexpensively. In other cases the remedy may be disruptive and expensive. Obviously, extraordinary renovation or replacement should be undertaken only where the need is clearly identified. Data on the effects of existing systems indicate that many nonconforming systems, as well as future repairs that still may not conform to design standards, may operate satisfactorily. Where compliance with design standards is either 1) in-feasible, or too expensive or 2) site monitoring of ground and surface waters shows that acceptable impacts are attainable, then a variance procedure to allow renovation and continued use is recommended. Decisions to grant variances should be based on site-specific data or on a substantial history of similar sites in the area.

Local and state decisions on variance procedures would likely be influenced by the degree of authority vested in the small waste flows district. If the district has sufficient financial backing to correct errors, and trained personnel to minimize errors in granting variances, variance procedures may be more liberal than if fiscal and professional resources are limited. Higher local costs, caused by unnecessary repairs or abandonment of systems is expected to result from very conservative variance guidelines, or none at all. Conversely, ill-conceived or improperly implemented variance procedures would cause frequent water quality problems and demands for more expensive off-site technologies.

b. Ownership of On-Site Systems Serving Seasonal Residences

Construction Grants regulations allow Federal funding for renovation and replacement of publicly owned on-site systems serving principal or seasonally occupied residences and of privately owned on-site systems serving principal residences. Privately owned systems serving seasonally occupied residences are not eligible for Federally funded renovation and replacement.

Depending on the extent and costs of renovation and replacement necessary for seasonal residences, the municipalities or a small waste flow district may elect to accept ownership of the on-site systems. Rehabilitation of these systems would then be eligible for Federal assistance, resulting in a drastic (90%) drop in local costs for seasonal residents. Any decision to accept ownership on a community-wide basis should await the conclusions of the site-specific environmental and engineering analyses and preliminary determination of the functions of the management agency. Ownership of seasonally used systems may create responsibilities that the agency does not want.

c. Completion of Step I (Facilities Planning) Requirements for the Small Waste Flow District

If the applicant, local municipalities and the State concur in the Recommended Alternative, Construction Grants regulations for individual systems ("Privately owned alternative wastewater treatment works... serving one or more principal residences...") require the applicant to take the following actions before award of a Step II grant (40 CFR 35.918):

- o Certify that the project be constructed and an operation and maintenance program established to meet local, State and Federal requirements.
- o Obtain assurance of unlimited access to each individual system at all reasonable times for such purposes as inspections, monitoring, construction, maintenance, operations, rehabilitation and replacement.

- Plan for comprehensive program of regulation and inspection for individual systems.

These actions would have to be taken by the applicant prior to requesting Step II funds.

d. Scope of Step II for the Small Waste Flow District

A five step program for wastewater management in small waste flow districts was suggested in Section III.D.b. The first three would appropriately be completed in Step I. These are:

- Develop a site-specific environmental and engineering data base,
- Design the management organization, and
- Agency start-up

EPA will assist the applicant in defining specific objectives and tasks for Step II work, both before and after the Step II grant.

3. IMPACTS OF THE RECOMMENDED ALTERNATIVE AND MITIGATING MEASURES

Impact	Mitigating Measures
Soil erosion and resulting sedimentation and nutrient transport during construction of on-site and cluster systems, Frankfort-Elberta interceptors and STP, new housing and roads.	Compliance with provisions of the Soil Erosion and Sedimentation Control Act. Require individual plan approval for construction on steep slopes and adopt performance standards with specific slope-density provisions.
44% reduction in phosphorus input to Betsie. Trophic status may improve.	Maintaining or improving on this reduction will require careful control and monitoring of wastewater treatment processes.
Colonization of *Cladophora* in localized areas along Crystal Lake shoreline will continue. Increase in number and density is possible but not predictable.	Residential flow reductions, use of non-phosphate detergents, control of lawn fertilization, rehabilitation or replacement of ST/SAS, off-site treatment, use of composting toilets, local application of copper sulfate. EPA will conduct field studies on effluent/soil/groundwater/*Cladaphora* relationships at Crystal Lake in summer, 1979.
Potential for localized nitrate standard violations in private wells around Crystal Lake. Potential will increase as densities of wells and ST/SAS increase.	Detailed groundwater hydrology investigation during STEP II. Design and operate well and aquifer monitoring system during Step II. Develop reserve fund for future off-site treatment facilities or community wells.

Impact	Mitigating Measures
Potential for bacterial, organic and nutrient contamination of Betsie Lake from pump station or treatment plant malfunction.	Can be minimized by adequate operation and maintenance procedures and funding.
Potential for bacterial, organic and nutrient contamination of Crystal Lake from cluster system or pressure sewer pump malfunctions.	Periodic inspection and maintenance of pump systems. Emergency repair service.
Control of apparent wastewater discharges to Cold Creek from Beulah is not included in the Recommended Action.	The Village should, independently or with grant, identify and control these discharges.
Water supply demands of increasing population in Frankfort and Elberta will exceed capacity of existing storage and distribution facilities.	Institue waste conservation plan and/or expand facilities.
Design year population of Proposed Service Area will be 7% less than EIS trend projection.	--
Residential land acreage will increase perhaps 77% during the planning period.	--
Existing properties in Crystal Lake watershed will appreciate due to limitations on amount of developable land.	--
Existing community composition and character will change less rapidly with other alternatives.	--
Limitation on developable acreage resulting from Recommended Alternative may shift development pressure to sand dunes west and southwest of Crystal Lake.	Benzie County should study the ecosystems of the dunes and the impact that development may have on them. Lake Township should provide zoning that protects the dunes.
Average annual user charges for residents of Frankfort and Elberta may be $100. 20 to 25% of the residents will face financial burdens. 1 to 5% may relocate to avoid paying increased costs.	--
Average annual user charges in the small waste flow district may be $50. 5 to 10% of the residents will face financial burdens. 1 to 5% may relocate or convert to permanent occupancy to avoid paying charge.	--
Private costs for renovations or repair of seasonally used systems may be high due to ineligibility for grant.	Cede seasonally used systems to small waste flow district.

CHAPTER VI

THE RELATIONSHIP BETWEEN SHORT-TERM USE AND LONG-TERM PRODUCTIVITY

A. SHORT-TERM USE OF THE STUDY AREA

Crystal Lake has been, and will continue to be used as a residential/recreational area. The site was initially disturbed when construction of houses first began.

Disturbance of the site by routine residential/recreational activities will continue. Implementation of either the action proposed by the Facility Plan or recommended in this EIS is not expected to alter these disturbances.

B. IMPACTS UPON LONG-TERM PRODUCTIVITY

1. COMMITMENT OF NON-RENEWABLE RESOURCES

If the Facility Plan Proposed Action were implemented, the increased potential for development might result in some loss of terrestrial habitat. Such would be expected to a lesser extent by implementation of the Recommended Alternative of this EIS.

Non-renewable resources associated with either action would include concrete for construction. Consumption of electric power by pumps may also increase. Manpower would also be committed to the construction, operation and management of new or rehabilitated facilities.

2. LIMITATIONS ON BENEFICIAL USE OF THE ENVIRONMENT

Neither the Proposed Action nor the Recommended Action will have any significant effect on beneficial use of the environment. Existence of the community has predetermined the uses to which the environment can be put.

Chapter VII

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

Those resources associated with construction and maintenance of wastewater systems would be committed. These were discussed in Section VI.B.1.

In addition the growth expected in the Study Area would require a commitment of resources to the construction of new dwellings and commercial establishments, construction or improvement of roads, and facilities associated with water sports. Besides construction materials, such as lumber, steel, concrete and glass, electricity and manpower would also be committed to new development.

Human resources would include construction personnel and, perhaps infrastructural personnel to service the added community needs.

Chapter VIII

PROBABLE ADVERSE IMPACTS WHICH CANNOT BE AVOIDED

If the action proposed by the Facility Plan were implemented, some destruction of terrestrial habitat would result from construction of new dwellings. Such would be true, but to a lesser extent, if the Recommended Alternative in this EIS were implemented. If the Recommended Alternative were selected, some reduced localized growth of Cladophora might be expected along the shoreline of Crystal Lake.

GLOSSARY

ACTIVATED SLUDGE PROCESS. A method of secondary wastewater treatment in which a suspended microbiological culture is maintained inside an aerated treatment basin. The microbial organisms oxidize the complex organic matter in the wastewater to carbon dioxide, water, and energy.

ADVANCED WASTE TREATMENT. Wastewater treatment beyond the secondary or biological stage that includes removal of nutrients such as phosphorus and nitrogen and a high percentage of suspended solids. Advanced waste treatment, also known as tertiary treatment, is the "polishing stage" of wastewater treatment and produces a high quality of effluent.

AEROBIC. Refers to life or processes that occur only in the presence of oxygen.

ALGAL BLOOM. A proliferation of algae on the surface of lakes, streams or ponds. Algal blooms are stimulated by phosphate enrichment.

ALKALINE. Having the qualities of a base, with a pH of more than 7.

ALLUVIAL. Pertaining to material that has been carried by a stream.

ALTERNATIVE TECHNOLOGY. A technology whose use has been widely supported by experience, but is not a variant of conventional biological or physical/chemical treatment.

AMBIENT AIR. The unconfined portion of the atmosphere; the outside air.

ANAEROBIC. Refers to life or processes that occur in the absence of oxygen.

AQUATIC PLANTS. Plants that grow in water, either floating on the surface, or rooted emergent or submergent.

AQUIFER. A geologic stratum or unit that contains water and will allow it to pass through. The water may reside in and travel through innumerable spaces between rock grains in a sand or gravel aquifer, small or cavernous openings formed by solution in a limestone aquifer, or fissures, cracks, and rubble in such harder rocks as shale.

ARTESIAN AQUIFER. A water-filled layer that is sufficiently compressed between less permeable layers to cause the water to rise above the top of the aquifer. If the water pressure is great, water will flow freely from artesian wells.

ARTESIAN WELL. A well in which flow is sustained by the hydrostatic pressure of the aquifer. See Artesian Aquifer.

BACTERIA. Any of a large group of microscopic plants living in soil, water or organic matter, important to man because of their chemical effects as in nitrogen fixation, putrefaction, or fermentation, or as pathogens.

BAR SCREEN. In wastewater treatment, a screen that removes large floating and suspended solids.

BASE FLOW. The rate of movement of water in a stream channel which occurs typically during rainless periods when stream flow is maintained largely or entirely by discharges of groundwater.

BASIC USAGE. In regard to functions of small waste flow districts, those which would be required to comply with EPA Construction Grants regulations governing individual on-site wastewater systems.

BEDROCK. The solid rock beneath the soil and subsoil.

BIOCHEMICAL OXYGEN DEMAND (BOD). A measure of the amount of oxygen consumed in the biological processes that decompose organic matter in water. Large amounts of organic waste use up large amounts of dissolved oxygen; thus, the greater the degree of pollution, the greater the BOD.

BIOMASS. The weight of living matter in a specified unit of environment. Or, an expression of the total mass or weight of a given population of plants or animals.

BIOTA. The plants and animals of an area.

BOD_5. See "Biochemical Oxygen Demand." Standard measurement is made for 5 days at 20°C.

BOG. Wet, spongy land; usually poorly drained, and rich in plant residue, ultimately producing highly acid peat.

CAPITAL COSTS. All costs associated with installation (as opposed to operation) of a project.

CAPITAL EXPENDITURES. See Capital Costs.

CHLORINATION. The application of chlorine to drinking water, sewage or industrial waste for disinfection or oxidation of undesirable compounds.

COARSE FISH. See Rough Fish.

COLIFORM BACTERIA. Members of a large group of bacteria that flourish in the feces and/or intestines of warm-blooded animals, including man. Fecal coliform bacterial, particularly Escherichia coli (E. coli), enter water mostly in fecal matter, such as sewage or feedlot runoff. Coliform bacteria apparently do not cause serious human diseases, but these organisms are abundant in polluted waters and they are fairly easy to detect. The abundance of coliform bacteria in water, therefore, is used as an index to the probability of the occurrence of such diease-producing bodies (pathogens) as Salmonella, Shigella, and enteric viruses. These pathogens are relatively difficult to detect.

COLIFORM ORGANISM. Any of a number of organisms common to the intestinal tract of man and animals whose presence in wastewater is an indicator of pollution and of potentially dangerous bacterial contamination.

COMMINUTOR. A machine that breaks up wastewater solids.

CONNECTION FEE. Fee charged by municipality to hook up house connection to lateral sewer.

CUBIC FEET PER SECOND (cfs). A measure of the amount of water passing a given point.

CULTURAL EUTROPHICATION. Acceleration by man of the natural aging process of bodies of water.

DECIDUOUS. The term describing a plant that periodically loses all of its leaves, usually in the autumn. Most broadleaf trees in North America, and a few conifers, such as larch and cypress, are deciduous.

DECOMPOSITION. Reduction of the net energy level and change in chemical composition of organic matter by action of aerobic or anaerobic microorganisms. The breakdown of complex material into simpler substances by chemical or biological means.

DETENTION TIME. Average time required to flow through a basin. Also called retention time.

DETRITUS. (1) The heavier debris moved by natural watercourses, usually in bed loam form. (2) The sand, grit, and other coarse material removed by differential sedimentation in a relatively short period of detention.

DISINFECTION. Effective killing by chemical or physical processes of all organisms capable of causing infectious disease. Chlorination is the disinfection method commonly employed in sewage treatment processes.

DISSOLVED OXYGEN (DO). The oxygen gas (O_2) dissolved in water or sewage. Adequate oxygen is necessary for maintenance of fish and other aquatic organisms. Low dissolved oxygen concentrations generally are due to presence of excessive organic solids having high BOD in inadequately treated wastewater.

DRAINAGE BASIN. (1) An area from which surface runoff is carried away by a single drainage system. Also called catchment area, watershed, drainage area. (2) The largest natural drainage area subdivision of a continent. The United States has been divided at one time or another, for various administrative purposes, into some 12 to 18 drainage basins.

DRAINAGEWAYS. Man-made passageways, usually lined with grass or rock, that carry runoff of surface water.

EFFLUENT. Wastewater or other liquid, partially or completely treated, or in its natural state, flowing out of a reservoir, basin, treatment plant, or industrial treatment plant, or part thereof.

EFFLUENT LIMITED. Any stream segment for which it is known that water quality will meet applicable water quality standards after the application of effluent limitations.

ELEVATED MOUND. A mound, generally constructed of sand, to which settled wastewater is applied. Usually used in areas where conventional on-site treatment is inadequate.

ENDANGERED SPECIES (FEDERAL CLASSIFICATION). Any species of animal or plant declared to be in known danger of extinction throughout al or a significant part of its range. Protected under Public Law 93-205 as amended.

ENDANGERED SPECIES (STATE CLASSIFICATION). Michigan's list includes those species on the Federal list that are resident for any part of their life cycle in Michigan. also includes indigenous species the State believes are uncommon and in need of study.

ENDECO. Type 2100 Septic Leachate Dector. See "Septic Snooper".

ENVIRONMENT. The conditions external to a particular object, but generally limited to those conditions which have a direct and measurable effect on the object. Usually considered to be the conditions which surround and influence a particular living organism, population, or community. The physical environment includes light, heat, moisture, and other principally abiotic components. The components of the biotic environment are other living organisms and their products.

ENVIRONMENTAL IMPACT STATEMENT. A document required by the National Environmental Policy Act (PL 91-190, 1969) that is used in the decision-making process to evaluate the effects (impacts) of a proposed action on the human, biological, and physical environment.

EPILIMINION. The upper layer of more or less uniformly warm, circulating, and fairly turbulent water in lakes during the spring heating season.

EROSION. The process by which an object is eroded, or worn away, by the action of wind, water, glacial ice, or combinations of these agents. Sometimes used to refer to results of chemical actions or temperature changes. Erosion may be accelerated by human activities.

EUTROPHIC. Waters with a relatively large concentration of nutrients and hence a large production of organic matter, often shallow, with periods of oxygen deficiency.

EUTROPHIC LAKES. Shallow lakes, weed-choked at the edges and very rich in nutrients. The water is characterized by large amounts of algae, low water transparency, low dissolved oxygen and high BOD.

EUTROPHICATION. The normally slow aging process by which a lake evolves into a bog or marsh, ultimately assumes a completely terrestrial state and disappears. During eutrophication the lake becomes so rich in nutritive compounds, especially nitrogen and phosphorus, that algae and plant life become superabundant, thereby "choking" the lake and causing it eventually to dry up. Eutrophication may be accelerated by human activities.

EVAPOTRANSPIRATION. A process by which water is evaporated and/or transpired from water, soil, and plant surfaces.

FECAL COLIFORM BACTERIA. The group of organisms common to the intestinal tracts of man and of animals. The presence of fecal coliform bacteria in water is an indicator of pollution and of potentially dangerous bacterial contamination.

FLOE. A sheet of floating ice.

FORCE MAIN. Pipe designed to carry wastewater under pressure.

GLACIAL DEPOSIT. A mass of rock, soil, and earth material deposited by a melting glacier. Such material was originally picked up and carried along its path by the glacier, and usually varies in texture from very fine rock flour to large boulders. Named according to their location and shape.

GLACIAL DRIFT. Material which has been deposited by a glacier or in connection with glacial processes. It consists of rock flour, sand, pebbles, cobbles, and boulders. It may occur in a heterogeneous mass or be more or less well-sorted, according to its manner of deposition.

GRAVITY SYSTEM. A system of conduits (open or closed) in which no liquid pumping is required.

GROUNDWATER. Water that is below the water table.

GROUNDWATER RUNOFF. Groundwater that is discharged into a stream channel as spring or seepage water.

HABITAT. The specific place or the general kind of site in which a plant or animal normally lives during all or part of its life cycle.

HOLDING TANK. Enclosed tank, usually of fiberglass or concrete, for the storage of wastewater prior to removal or disposal at another location.

HYDROPONIC. Refers to growth of plants in a nutrient solution, perhaps with the mechanical support of an inert medium such as sand.

HYPOLIMNION. Deep, cold and relatively undisturbed water separated from the surface layer in lakes.

IGNEOUS. Rock formed by the solidification of magma (hot molten material).

INDIAN MOUND SYSTEM. See Elevated Mound.

INFILTRATION. The flow of a fluid into a substance through pores or small openings. Commonly used in hydrology to denote the flow of water into soil material.

INFILTRATION/INFLOW. Total quantity of water entering a sewer system. Infiltration means entry through such sources as defective pipes, pipe joints, connections, or manhole walls. Inflow signifies discharge into the sewer system through service connections from such sources as area or foundation drainage, springs and swamps, storm waters, street wash waters, or sewers.

INTERCEPTOR SEWERS. Sewers used to collect the flows from main and trunk sewers and carry them to a central point for treatment and discharge. In a combined sewer system, where street runoff from rains is allowed to enter the system along the sewage, interceptor sewers allow some of the sewage to flow untreated directly into the receiving stream, to prevent the treatment plant from being overloaded.

INNOVATIVE TECHNOLOGY. A technology whose use has not been widely documented by experience and is not a variant of conventional biological or physical/chemical treatment.

LAGOON. In wastewater treatment, a shallow pond, usually man-made, in which sunlight, algal and bacterial action and oxygen interact to restore the wastewater to a reasonable state of purity.

LAND TREATMENT. A method of treatment in which the soil, air, vegetation, bacteria, and fungi are employed to remove pollutants from wastewater. In its most simple form, the method includes three steps: (1) pretreatment to screen out large solids; (2) secondary treatment and chlorination; and (3) spraying over cropland, pasture, or natural vegetation to allow plants and soil microorganisms to remove additional pollutants. Much of the sprayed water evaporates, and the remainder may be allowed to percolate to the water table, discharged through drain tiles, or reclaimed by wells.

LEACHATE. Solution formed when water percolates through solid wastes, soil or other materials and extracts soluble or suspendable substances from the material.

LIMITING FACTOR. A factor whose absence, or excessive concentration, exerts some restraining influence upon a population.

LOAM. The textural class name for soil having a moderate amount of sand, silt, and clay. Loam soils contain 7 to 27% of clay, 28 to 50% of silt, and less than 52% of sand.

LOESS. Soil of wind-blown origin, predominantly silt and fine sand.

MACROPHYTE. A large (not microscopic) plant, usually in an aquatic habitat.

MELT WATER. Water which is formed from the melting of snow, rime, or ice.

MESOTROPHIC. Waters with a moderate supply of nutrients and no significant production of organic matter.

MESOTROPHIC LAKE. Lakes of intermediate characteristics between oligotrophic and eutrophic. They contain a moderate supply of nutrients and plant life.

METHEMOGLOBINEMIA. The presence of methemoglobin in the blood. Methemoglobin is the oxidized form of hemoglobin and it is unable to combine reversibly with oxygen.

MICROSTRAINER. A device for screening suspended solids that are not removed by sedimentation.

MILLIGRAM PER LITER (mg/l). A concentration of 1/1000 gram of a substance in 1 liter of water. Because 1 liter of pure water weighs 1,000 grams, the concentration also can be stated as 1 ppm (part per million, by weight). Used to measure and report the concentrations of most substances which commonly occur in natural and polluted waters.

MORPHOLOGICAL. Pertaining to Morphology.

MORPHOLOGY. The form or structure of a plant or animal, or of a feature of the earth, such as a stream, a lake, or the land in general. Also, the science that is concerned with the study of form and structure of living organisms. Geomorphology deals with the form and structure of the earth.

NON-POINT SOURCE. A general source of pollution not originating from a single controllable source. Surface water runoff is an example of a non-point source that is not easily controlled.

NUTRIENT BUDGET. The amount of nutrients entering and leaving a body of water on an annual basis.

NUTRIENTS. Elements or compounds essential as raw materials for organisms growth and development, e.g. carbon, oxygen,, nitrogen, and phosphorus.

OLIGOTROPHIC. Waters with a small supply of nutrients and hence an insignificant production of organic matter.

OLIGOTROPHIC LAKES. Deep lakes that have a low supply of nutrients and thus contain little organic matter. Such lakes are characterized by high water transparency and high dissolved oxygen.

ORDINANCE. A municipal or county regulation.

OUTWASH. Drift carried by melt water from a glacier and deposited beyond the marginal moraine.

OUTWASH PLAIN. A plain formed by material deposited by melt water from a glacier flowing over a more or less flat surface of large area. Deposits of this origin are usually distinguishable from ordinary river deposits by the fact that they often grade into moraines and their constituents bear evidence of glacial origin. Also called frontal apron.

PARAMETER. Any of a set of physical properties whose values determine characteristics or behavior.

PERCOLATION. The downward movement of water through pore spaces or larger voids in soil or rock.

PERMEABILITY. The property or capactiy of porous rock, sediment, or soil to transmit a fluid, usually water or air; it is a measure of the relative ease of flow under unequal pressures. Terms used to describe the permeability of soil are: slow, less than 0.2 inch per hour; moderately slow, 0.2 to 0.63 inch; moderate, 0.63 to 2.0 inches; moderately rapid. 2.0 to 6.3 inches; and rapid, more than 6.3 inches per hour. A very slow class and a very rapid class also may be recognized.

PETROGLYPH. An ancient or prehistoric carving or inscription on a rock.

PHOSPHORUS LIMITED. Of all the primary nutrients necessary to support algal growth, phosphorus is in the shortest supply and therefore can limit additional algal growth.

PHYTOPLANKTON. Floating plants, microsopic in size, that both supply small animals with food and give polluted water its green color and bad taste.

POINT SOURCE. A stationary source of a large individual emission. This is a general definition; point source is legally and precisely defined in Federal regulations.

POVERTY LEVEL. An index providing a range of poverty income cutoffs adjusted by such factors as family size, sex of family head, number of children under 18 years of age, and farm or non-farm residence.

PREHISTORIC. A term which describes the period of human development that occurred before the advent of written records. More generally, any period in geologic time before written history.

PRESENT WORTH. The sum of money that must be set aside at the beginning of the planning period in order to amortize the costs of a project over the planning period.

PRESSURE SEWER SYSTEM. A wastewater collection system in which household wastes are collected in the building drain and conveyed therein to the pretreatment and/or pressurization facility. The system consists of two major elements, the on-site or pressurization facility, and the primary conductor pressurized sewer main.

PRIMARY PRODUCTION. Growth of green plants resulting from solar energy being fixed as sugar during photosynthesis.

PRIMARY TREATMENT. The first stage in wastewater treatment in which substantially all floating or settleable solids are mechanically removed by screening and sedimentation.

RAPID INFILTRATION. A form of land treatment where wastewater is placed into spreading basins and applied to the land to undergo percolation into the soil.

RARE SPECIES. A species not Endangered or Threatened but uncommon and deserving of further study and monitoring. Peripheral species, not listed as threatened, may be included in this category along with those species that were once "threatened" or "endangered" but now have increasing or protected, stable populations.

RECHARGE. The process by which water is added to an aquifer. Used also to indicate the water that is added. Natural recharge occurs when water from rainfall or a stream enters the ground and percolates to the water table. Artificial recharge by spreading water on absorptive ground over an aquifer or by injecting water through wells is used to store water and to protect groundwater against the intrusion of sea water.

ROTATING BIOLOGICAL CONTACTOR (RBC). A device, consisting of plastic disks that rotate alternately through wastewater and air, used for secondary treatment of wastewater.

ROUGH FISH. Those fish species considered to be of low sport value when taken on tackle, or of poor eating quality; e.g. gar, suckers. Rough fish are more tolerant of widely changing environmental conditions than are game fish. Also called coarse fish.

RUNOFF. The portion of rainfall, melted snow or irrigation water that flows across the ground surface and eventually is returned to streams. Runoff can pick up pollutants from the air or the land and carry them to the receiving waters.

SANITARY SEWERS. Sewers that transport only sanitary wastewater. Storm water runoff is carried in a separate system. See sewer.

SANITARY SURVEY. A method used to determine possible sources of water quality and public health problems and to locate inadequately functioning wastewater systems by making site-specific investigations of existing lots and systems.

SCENIC EASEMENT. A partial transfer of land rights to preserve the aesthetic attractiveness of the land by restricting activities such as the removal of trees, placement of billboards, or development incompatible with the scenic qualities of the land. Just compensation is given to owners for rights lost. The right of legal trespass is generally not included as part of this easement.

SECCHI DISK. A round plate, 30 cm (1 foot) in diameter, that is used to measure the transparency of water. The disk is lowered into the water until it no longer can be seen from the surface. The depth at which the disk becomes invisible is a measure of transparency.

SECONDARY TREATMENT. Wastewater treatment in which bacteria consume the organic parts of the wastes. This biochemical action is accomplished by use of trickling filters or the activated sludge process. Effective secondary treatment may remove approximately 90% of both BOD_5 and suspended solids.

SEEPAGE CELLS. Unlined wastewater lagoons designed so that all or part of wastewater percolates into the underlying soil.

SEPTIC SNOOPER. Trademark for the ENDECO (Environmental Devices Corporation) Type 2100 Septic Leachate Detector. This instrument consists of an underwater probe, a water intake system, an analyzer control unit and a graphic recorder. Water drawn through the instrument is continuously analyzed for specific fluorescence and conductivity. When calibrated against typical effluents, the instrument can detect and profile effluent-like substances and thereby locate septic tank leachate or other sources of domestic sewage entering lakes and streams.

SEPTIC TANK. An underground tank used for the collection of domestic wastes. Bacteria in the wastes decompose the organic matter, and the sludge settles to the bottom. The effluent flows through drains into the ground. Sludge is pumped out at regular intervals.

SEPTIC TANK EFFLUENT PUMP (STEP). Pump designed to transfer settled wastewater from a septic tank to a sewer.

SEPTIC TANK SOIL ABSORPTION SYSTEM. A system of wastewater disposal in which large solids are retained in a tank; fine solids and liquids are dispersed into the surrounding soil by a system of pipes.

SEWER, COMBINED. A sewer, or system of sewers, that is used to collect and conduct both sanitary sewage and storm-water runoff. During rainless periods, most or all of the flow in a combined sewer is composed of sanitary sewage. During a storm, runoff increases the rate of flow and may overload the sewage treatment plant to which the sewer connects. At such times, it is common to divert some of the flow, without treatment, into the receiving water.

SEWER, INTERCEPTOR. See Interceptor Sewer.

SEWER, LATERAL. A sewer designed and installed to collect sewage from a limited number of individual properties and conduct it to a trunk sewer. Also known as a street sewer or collecting sewer.

SEWER, SANITARY. See Sanitary Sewer.

SEWER, STORM. A conduit that collects and transports storm-water run-off. In many sewerage systems, storm sewers are separate from those carrying sanitary or industrial wastewater.

SEWER, TRUNK. A sewer designed and installed to collect sewage from a number of lateral sewers and conduct it to an interceptor sewer or, in some cases, to a sewage treatment plant.

SHOALING. The bottom effect that influences the height of waves moving from deep to shallow water.

SINKING FUND. A fund established by periodic installments to provide for the retirement of the principal of term bonds.

SLOPE. The incline of the surface of the land. It is usually expressed as a percent (%) of slope that equals the number of feet of fall per 100 feet in horizontal distance.

SOIL ASSOCIATION. General term used to describe taxonomic units of soils, relative proportions, and pattern of occurrence.

SOIL TEXTURAL CLASS. The classification of soil material according to the proportions of sand, silt, and clay. The principal textural classes in soil, in increasing order of the amount of silt and clay, are as follows: sand, loamy sand, sandy loam, loam, silt loam, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. These class names are modified to indicate the size of the sand fraction or the presence of gravel, sandy loam, gravelly loam, stony clay, and cobbly loam, and are used on detailed soil maps. These terms apply only to individual soil horizons or to the surface layer of a soil type.

STATE EQUALIZED VALUATION (SEV). A measure employed within a State to adjust actual assessed valuation upward to approximate true market value. Thus it is possible to relate debt burden to the full value of taxable property in each community within that State.

STRATIFICATION. The condition of a lake, ocean, or other body of water when the water column is divided into a relatively cold bottom layer and a relatively warm surface layer, with a thin boundary layer (thermocline) between them. Stratification generally occurs during the summer and during periods of ice cover in the winter. Overturns, of periods of mixing, occur in the spring and autumn. This condition is most common in middle latitudes and is related to weather conditions, basin morphology, and altitude.

STUB FEE. See Connection Fee.

SUCCESSION. The ecological process by which terrestrial and aquatic environments age.

SUPPLEMENTAL USAGE. In regard to functions of small waste flow districts, those which are not required to comply with EPA Construction Grants regulations governing individual, on-site wastewater systems. May be necessary to achieve administrative or environmental objectives.

SUSPENDED SOLIDS (SS). Small solid particles that contribute to turbidity. The examination of suspended solids and the BOD test constitute the two main determinations for water quality performed at wastewater treatment facilities.

TERTIARTY TREATMENT. See Advanced Waste Treatment.

THREATENED SPECIES (FEDERAL CLASSIFICATION). Any species of animal or plant that is likely to become an endangered species within the foreseeable future throughout all or a significant part of its range. Protected under Public Law 93-205, as amended.

TILL. Deposits of glacial drift laid down in place as the glacier melts. These deposits are neither sorted nor stratified and consist of a heterogeneous mass of rock flow, sand, pebbles, cobbles, and boulders.

TOPOGRAPHY. The configuration of a surface area including its relief, or relative evaluations, and the position of its natural and manmade features.

TRICKLING FILTER PROCESS. A method of secondary wastewater treatment in which the biological growth is attached to a fixed medium, over which wastewater is sprayed. The filter organisms biochemically oxidize the complex organic matter in the wastewater to carbon dioxide, water, and energy.

TROPHIC LEVEL. Any of the feeding levels through which the passage of energy through an ecosystem proceeds. In simplest form, trophic levels are: primary producers (green plants) herbivores, omnivores, predators, scavengers, and decomposers.

WATER QUALITY. The relative condition of a body of water as judged by a comparison between contemporary values and certain more or less objective standard values for biological, chemical, and/or physical parameters. The standard values usually are based on a specific series of intended uses, and may vary as the intended uses vary.

WATER TABLE. The upper level of groundwater that is not confined by an upper impermeable layer and is under atmospheric pressure. The upper surface of the substrate that is wholly saturated with groundwater.

WATERSHED. The area drained by a stream.

WELL LOG. A chronological record of the soil and rock formations encountered in the operation of sinking a well, with either their thickness or the elevation of the top and bottom of each formation given. It also usually includes statements about the lithologic composition and water-bearing characteristics of each formation, static and pumping water levels, and well yield.

ZONING. The regulation by governmental action (invested by the State to cities, townships, or counties) of the use of the land, the height of buildings, and/or the proportion of the land surface that can be covered by structures.

DOCUMENTS CITED IN THIS REPORT

Arthur Beard Engineers, Inc. 1978. Correspondence regarding: 1) unit prices and collector sewer construction costs; 2) wastewater flow projections for Crystal Lake; and 3) "typical" cluster system, Crystal Lake. Chevy Chase, MD.

Bailey, J.R., R.J. Benoit, J.L. Dodson, J.M. Robb, and H. Wallman. 1969. A study of flow reduction and treatment of wastewater from households. Cincinnati, OH. US Government Printing Office (GPO).

Calver, J.L. 1947. The glacial and post-glacial history of the Platte and Crystal Lake depressions, Benzie County, Michigan. Michigan Geological Survey Publication 45. Ph.D. thesis, 1942, Department of Geology, University of Michigan, Ann Arbor, MI.

Clean Water Act of 1977. Public Law 95-217. (33 U.S.C. 466 et seq.)

Cohen, S., and H. Wallman. 1974. Demonstration of waste flow reduction from households. Environmental Protection Agency, National Environmental Research Center, Cincinnati, OH.

Cooper, I.A., and J.W. Rezek. 1977. Septage treatment and disposal. For EPA, Technology Transfer.

Crawford, W.A. 1977. Findings in the proposed Crystal Lake sewer project area. Contract No. C-262844-01. Grand Traverse-Leelanau-Benzie District Health Department, Traverse City, MI.

Dearth, K.H. 1977. Current costs of conventional approaches. Presented at EPA National Conference on Less Costly Wastewater Treatment Systems for Small Communities, 12-14 April 1977, Reston, VA.

Environmental Photographic Interpretation Center (EPIC). 1978. Crystal Lake septic tank system analysis. EPA, Environmental Monitoring and Support Laboratory, Cincinnati, OH.

EPA (United States Environmental Protection Agency). 1975. Cost-effective comparison of land application and advanced wastewater treatment. EPA-430/9-75-016.

EPA. 1975. Report on Betsie Lake, Benzie County, Michigan. National Eutrophication Survey, Working Paper No. 185.

EPA. 1977. National interim primary drinking water regulations of the Safe Drinking Water Act. 40 CRF 141.

EPA. 1977. Process design manual for land treatment of municipal wastewater. EPA-625/1-77-008. Technology Transfer.

EPA. 1978. Construction grants program requirements memorandum 78-9. 3 March 1978.

EPA. 1978. Grants for construction of treatment works - Clean Water Act (40 CFR 35 Part E): Rules and regulations. 43 FR 44022, 27 September 1978.

EPA. 1978. Construction grants program requirements memorandum 79-3. 15 November 1978.

Federal Water Pollution Control Act Amendments of 1972, Public Law 92-500.

Gannon, J.J., et al. 1970. Crystal Lake water quality investigation. Contract No. 33304-1-F. School of Public Health, University of Michigan, Ann Arbor, MI.

Huffman, G.C. 1977. Groundwater data for Michigan, 1976. USGS, in cooperation with Michigan DNR.

Illinois Environmental Protection Agency. 1977. Issuance of final Illinois guidelines for the preparation of facilities plans for unsewered communities. Memorandum, 16 September 1977.

Jones, R.A., and G.F. Lee. 1977. Septic tank disposal systems as phosphorus sources for surface waters. EPA-600/3-77-129. Robert S. Kerr Environmental Research Laboratory.

Kerfoot, W. 1978. Investigation of septic leachate discharges into Crystal Lake, Michigan. K-V Associates, Inc., Falmouth, MA.

Knutilla, R.L. 1974. Compilation of miscellaneous streamflow measurements in Michigan through September 1970. Water Information Series Report No. 5. USGS, in cooperation with Michigan DNR. Lansing, MI.

League of Women Voters. 1978. A background summary of the planning process and major issues identified by the League of Women Voters of the Grand Traverse Area for the Sleeping Bear Dunes National Lakeshore. Traverse City, MI., 4 p.

Leverett, F., et al. 1907. Flowing wells and municipal water supplies in the middle and northern portions of the southern peninsula of Michigan. Water Supply and Irrigation Paper No. 183; Series O, Underground Waters, 63. USGS, Washington, DC.

Livasy, L.L. No date. Documentation for the Crystal Lake area authority for treatment works--construction grant application. Grand Traverse-Leelanau-Benzie District Health Department, Traverse City, MI.

Martin, H.M. 1957. Outline of the geologic history of the Grand Traverse region. Michigan Geological Survey (brochure), 9 p.

McLaughlin, E.R. 1968. A recycle system for conservation of water in residences. Water and Sewage Works 115(4):175-176.

Michigan DNR (Department of National Resources). 1973. National river report: Betsie River, Benzie and Manistee Counties. Office of Planning Services, 10 August 1973 revision.

Michigan DNR. 1977. Betsie River natural river zoning. Division of Land Resource Programs.

Michigan DNR. 1978. Michigan's endangered and threatened species program: 1976-1978.

Michigan DNR. Variously dated. Lake and stream management records and biological data: Crystal Lake (unpublished reports).

Michigan DNR. Variously dated. Lake and stream management records and biological data: Betsie Lake (unpublished reports).

Michigan DNR. Variously dated. Lake and stream management records and biological data: Long Lake (unpublished reports).

National Park Service, Sleeping Bear Dunes National Lakeshore. 1978. Citizens voice concerns and hopes about future of National Lakeshore. Department of the Interior, Frankfort, MI., 14 p.

Omernik, J.M. 1977. Non-point source stream nutrient level relationships: A nationwide survey. EPA-600/3-77-105. National Environmental Research Laboratory, Corvalis, OR.

Otis, R.J., and D.E. Steward. 1976. Alternative wastewater facilities for small unsewered communities in rural America. Annual report to the Upper Great Lakes Region Commission.

Scalf, M.R., and W.J. Dunlap. 1977. Environmental effects of septic tanks. EPA-600/3-77-096. Robert S. Kerr Environmental Research Laboratory, Ada, OK.

Schroepfer, G.J., and R.C. Polta. 1967. Travel of nitrogen compounds in soils. Sanitary Engineering Report 166-5. Sanitary Engineering Division, Department of Civil Engineering, University of Minnesota, in cooperation with US Public Health Service.

SCS (Soil Conservation Service). 1972. Land resource inventory map, Benzie County, Michigan. US Department of Agriculture, National Cooperative Soil Survey, in cooperation with Michigan Agricultural Experiment Station.

SCS. 1977. Proposed rule, Prime and unique farmlands: Important farmland inventory. 42 FR 42359, 23 August 1977.

SCS. 1978. Benzie County soil conservation district map.

Siegrist, R., M. Witt, and W.C. Boyle. 1976. Characteristics of rural household wastewater. Journal of the Environmental Engineering Division, American Society of Civil Engineers, No. EES, Proceedings Paper 12200: 533-548.

Tanis, F.J. 1978. Final summary report on Crystal Lake water quality study (revised). For the Crystal Lake Property Owners Association. Ann Arbor, MI.

The White House Rural Development Initiatives. August 1978. Making water and sewer programs work.

Troyan, J.J., and D.P. Norris. March 1977. Cost-effectiveness analysis of alternatives for small wastewater treatment systems. For the Environmental Protection Agency Technology Transfer, Municipal Design Seminar on Small Wastewater Treatment Systems, Seattle, WA.

University of Michigan. 1978. Sanitary systems for Crystal Lake, Benzie County, Michigan: An on-site survey. Pelston, MI.

Upper Great Lakes Commission. 1972. Environmental implications of recreation associated development of private land surrounding federal recreation areas in the Upper Great Lakes Area - Michigan. 59 p. and 6 maps.

US Bureau of the Census. 1970. Fifth count summary data. Department of Commerce, Census of Population and Housing, Washington, DC.

US Bureau of the Census. 1970. General social and economic characteristics. Department of Commerce, Washington, DC.

US Bureau of the Census. 1970. Regional employment by industry: 1940-1970. Department of Commerce, Bureau of Economic Analysis, Washington, DC.

US Bureau of the Census. 1970. Summary data. Department of Commerce, Census of Population and Housing, Washington, DC.

US Bureau of the Census. 1975. Census of Population - 1970, supplementary report. Department of Commerce, Washington, DC.

USGS (United States Geological Survey). 1956. Topographic map, 15 minute series, Frankfort, Michigan quadrangle. Department of the Interior.

USGS. 1970. The national atlas of the United States. Department of the Interior.

West Michigan Tourist Association. 1978. West Michigan carefree days. Grand Rapids, MI., 208 p.

Wilbur Smith and Associates. 1974. Comprehensive development plan, Benzie County, Michigan. For Benzie County Planning Commission.

Williams & Works; McNamee, Porter and Seeley; and Perla Stout Associates. 1976. Crystal Lake area facility plan for wastewater collection and treatment. Benzie County, Michigan. Contract No. C-26-2844-01.

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